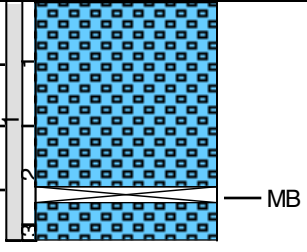
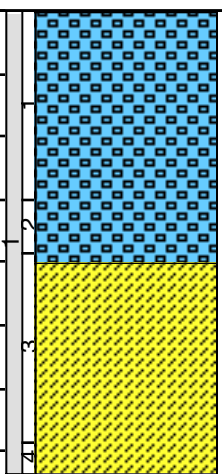


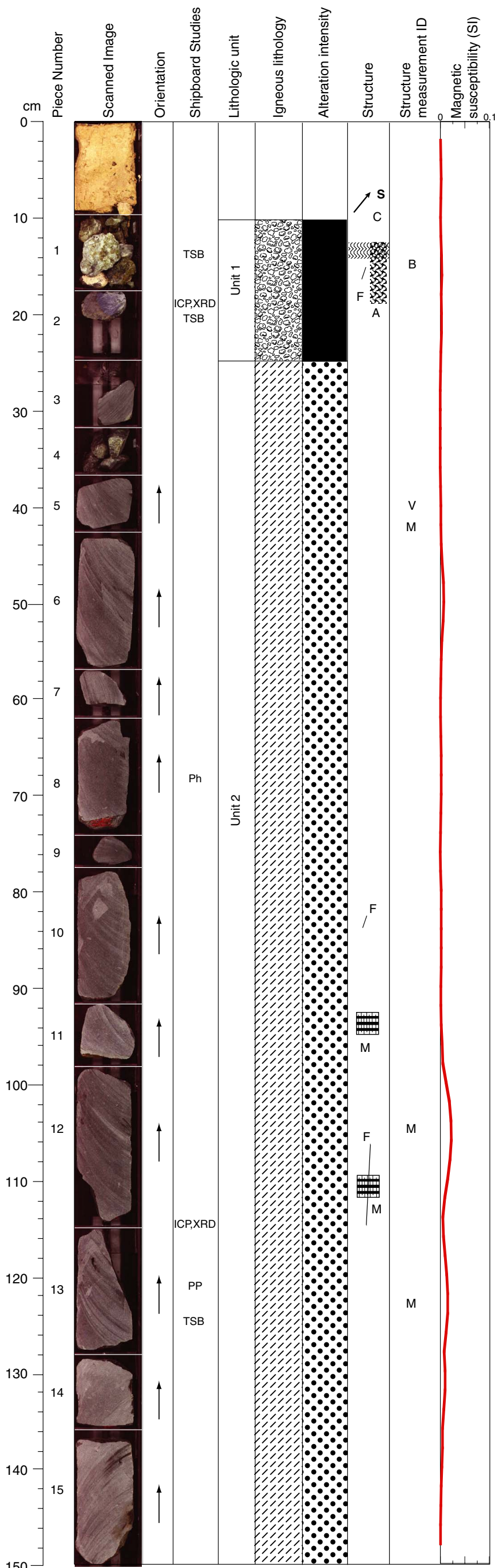
Core Photo

Site U1309 Hole A Core1R Cored 0–2.00 mbsf				
METERS	CORE AND SECTION	GRAPHIC LITH.	SAMPLE	DESCRIPTION
1				<p>← CALCAREOUS OOZE. Upper 25 cm is normally graded drilling slurry, with subcentimeter chips of basalt and serpentinite and mineral grains near the base of the interval. From 25 cm to the base of Section 2 is tacky, light tan (Munsell 10YR 8/3) calcareous ooze with abundant microfossils. Core catcher is completely disturbed, but also contains subcentimeter chips of basalt and serpentinite.</p>

Core Photo

Site U1309 Hole B Core 1R Cored 0–15.50 mbsf				
METERS	CORE AND SECTION	GRAPHIC LITH.	SAMPLE	DESCRIPTION
1 2 3 4				<p>CALCAREOUS OOZE. Upper 120 cm is normally graded drilling slurry, with mm sized chips of basalt, serepentine, and possibly carbonate. 120-135 cm is soupy. To 10 cm in Section 3 is light tan (Munsell 10YR 8/3) ooze with abundant microfossils. Below 10 cm is basalt (see hard rock descriptions).</p>

Core Photo



304-U1309B-1R-3 (Section top: 1.90 mbsf)

UNIT-1: Mixed Rubble
Pieces 1-3

PRIMARY MINERALOGY:
COMMENTS: Unit 1 consists of a mixture of out-of-place rock fragments including: talc-tremolite schist, microgabbro and basalt. All show a high degree of alteration.

UNIT-2: Plagioclase-phyric basalt
Pieces 4-16

PRIMARY MINERALOGY:

	Groundmass	Phenocrysts
Olivine	Modal 1% Size 0.5 mm Shape anhedral	
Plagioclase	Modal 50% Size 0.1-1 mm Shape subhedral	Modal 2% Size 3-10 mm Shape euhedral
Clinopyroxene	Modal 40% Size 0.1-1 mm Shape anhedral	
Oxides	Modal 7%	

COMMENTS: Unit 2 is composed of plagioclase-phyric, fine-grained basalt that coarsens to medium-grained down section. Phenocrysts are larger and more abundant between 61 cm and 114 cm. A small hydrothermal vein crosses at 127 cm. Sulfides occur along fractures and in trace amounts within the matrix. Oxides are dispersed in the matrix.

SECONDARY MINERALOGY: The upper part of the section is gravel and larger loose fragments, some of them drilled and some manganese oxide-encrusted. This gravel probably represents a considerable drilled depth interval as well as pebbles exposed at some time on the seafloor. Fragments include several pieces of talc-tremolite-chlorite schist, including a "drilled piece". These contain chromite, apatite and rutile as accessory phases, suggesting an intimately mixed ultramafic/mafic protolith. Other pieces include a basalt containing an intrusive contact, and various pieces of diabase/basalt/gabbro altered in the greenschist facies. Piece 3 contains undeformed "cusped texture" rock, in which green-gray talc-tremolite rock replaces dark magnetite-rich material. This rock was a serpentinized harzburgite (confirmed by ICP-AES analysis) before talc-tremolite alteration, with the dark cusped areas representing orthopyroxene pseudomorphed by talc and magnetite. The rest of the section consists of moderately altered basalt in which plagioclase is fresh, and pyroxene is partially altered to actinolite and rare chlorite (confirmed by thin section at 124 cm).

VEIN ALTERATION: Piece 3 contains small talc veins cut at a high angle by two generations of pyrite-bearing veins and by serpentine veins. The metabasalt in the lower part of the section is cut by a few 2 mm chlorite/amphibole veins.

THIN SECTIONS:

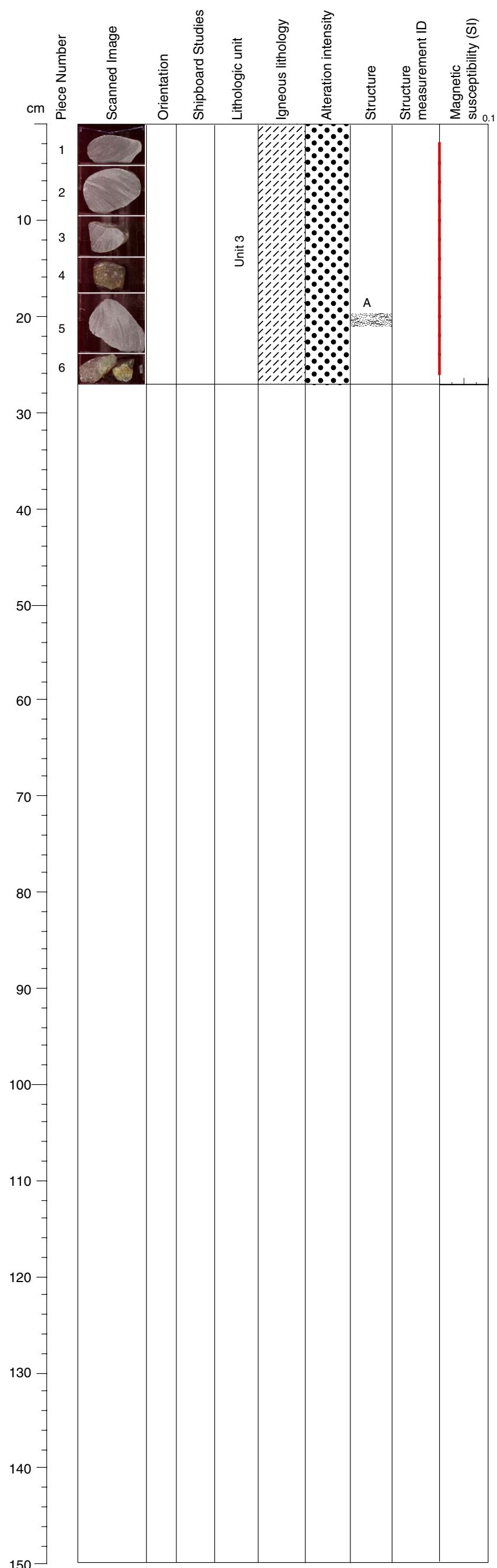
- 304-U1309B-1R-3, 10-17 cm (Chip A)(#2)
- 304-U1309B-1R-3, 10-17 cm (Chip B)(#3)
- 304-U1309B-1R-3, 10-17 cm (Chip C)(#4)
- 304-U1309B-1R-3, 10-17 cm (Chip D)(#5)
- 304-U1309B-1R-3, 17-21 cm (#6)
- 304-U1309B-1R-3, 124-125 cm (#7)

STRUCTURE: Loose pebbles in the top of the section (Piece 2), possibly from seafloor, some possibly were "in place". One pebble (2a) is a tremolite-chlorite schist with mineral lineation(s) on the surface. Others (2b and 2c) also contain schistose and semi-brittle (C) textures. Another pebble (2d) contains a basaltic chilled margin cut by white fractures (F). The next piece down is a soft, altered (A) ultramafic rock also containing white fractures. The pebbles at the top of the core are anomalous with respect to the rest: fine-grained diabase with roughly 4 white fractures (F) — the largest parallel to +Z, the others inclined — and a very weak magmatic foliation (M) defined by preferred orientation of plagioclase laths.

CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-1R-3, 62-73 cm
- 304-U1309B-1R-3, 116-128 cm WET

Core Photo



304-U1309B-1R-4 (Section top: 3.40 mbsf)

UNIT-3 : Plagioclase-phyric basalt
Pieces 1-6:

PRIMARY MINERALOGY:
Phenocryst
Plagioclase Modal 1%
Size 2-4 mm
Shape euhedral

COMMENTS: Unit 3 consists of sparsely plagioclase-phyric basalt with a fine-grained matrix. It is possibly a fine-grained continuation of Unit 2. A small hydrothermal vein crosses at 20 cm.

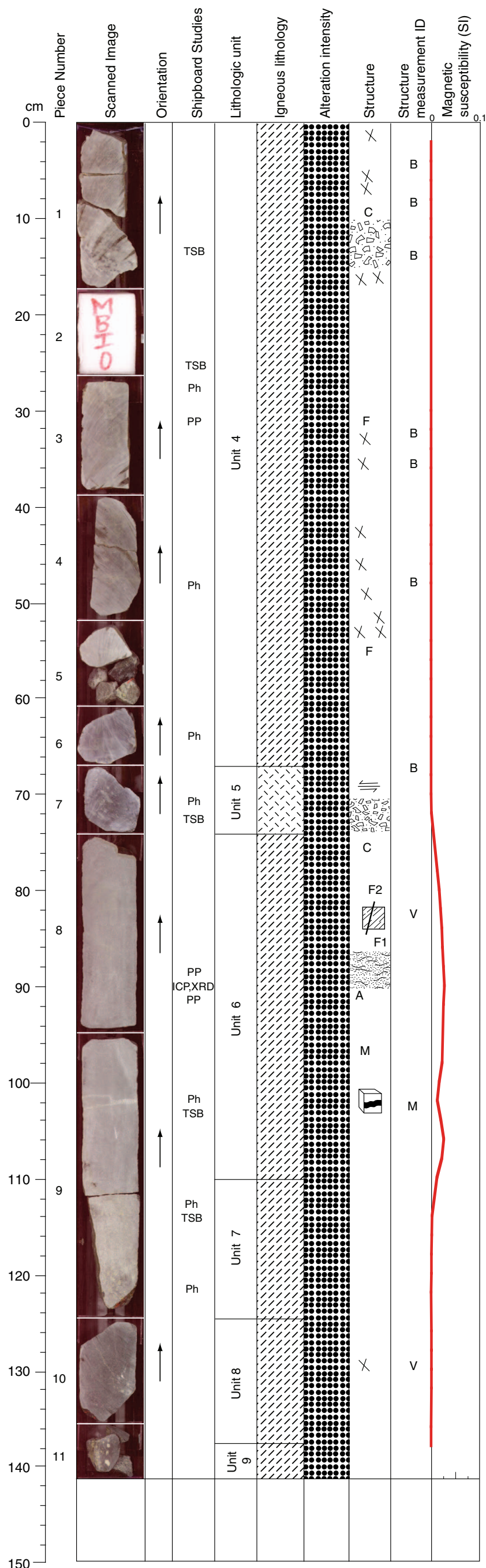
SECONDARY MINERALOGY: This core consists of basaltic rocks with fresh plagioclase and pyroxenes that are partially altered to actinolite. Chlorite is minor and epidote is not present.

VEIN ALTERATION: Rare chlorite/amphibole veins are present

STRUCTURE: No oriented samples; one dark fracture/alteration (A) plane (a mineral "seam").



Core Photo



304-U1309B-2R-1 (Section top: 15.5 mbsf)

UNIT-4 : Brecciated basalt
Pieces 1-6

PRIMARY MINERALOGY:

Plagioclase Modal 45%
 Size 0.2-1 mm
 Shape subhedral

Clinopyroxene Modal 53%
 Size 0.3 mm
 Shape too altered

Oxides Modal 1-2%

COMMENTS: Unit 4 is in-situ brecciated fine-grained basalt with alteration halos along fractures.

UNIT-5 : Cataclastic gabbro
Piece 7

PRIMARY MINERALOGY:

Plagioclase Modal 40%

Clinopyroxene Modal 60%

COMMENTS: Unit 5 is composed of strongly deformed gabbro with plagioclase cataclasts. The matrix includes black, parallel to subparallel, foliated alteration minerals.

UNIT-6 : Sparsely plagioclase-phyric basalt
Pieces 8-9A

PRIMARY MINERALOGY:

Olivine	Groundmass Modal 2% Size 0.3 mm Shape anhedral	Phenocryst Modal <1% Size <4 mm Shape euhedral
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Plagioclase Modal 48%
 Size 0.5 mm
 Shape subhedral

Clinopyroxene Modal 40%
 Size 0.3 mm
 Shape too altered

Oxides Modal 7%

COMMENTS: Unit 6 consists of fine-grained, very sparsely plagioclase-phyric basalt that is crosscut by a subhorizontal dike at 101 cm. The dike was probably derived from Unit 7 at the time of emplacement of Unit 7, indicating an intrusive contact. An isolated plagioclase lath of about 15 mm occurs at 105 cm.

UNIT-7 : Olivine-phyric basalt
Piece 9B

PRIMARY MINERALOGY:

Olivine	Groundmass Modal 10% Size 0.5-1 mm Shape anhedral	Phenocryst Modal <1% Size 1 mm Shape anhedral
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Plagioclase Modal 45%
 Size 0.2-1 mm
 Shape subhedral

Clinopyroxene Modal 45%
 Size too altered
 Shape too altered

Oxides Modal <1%

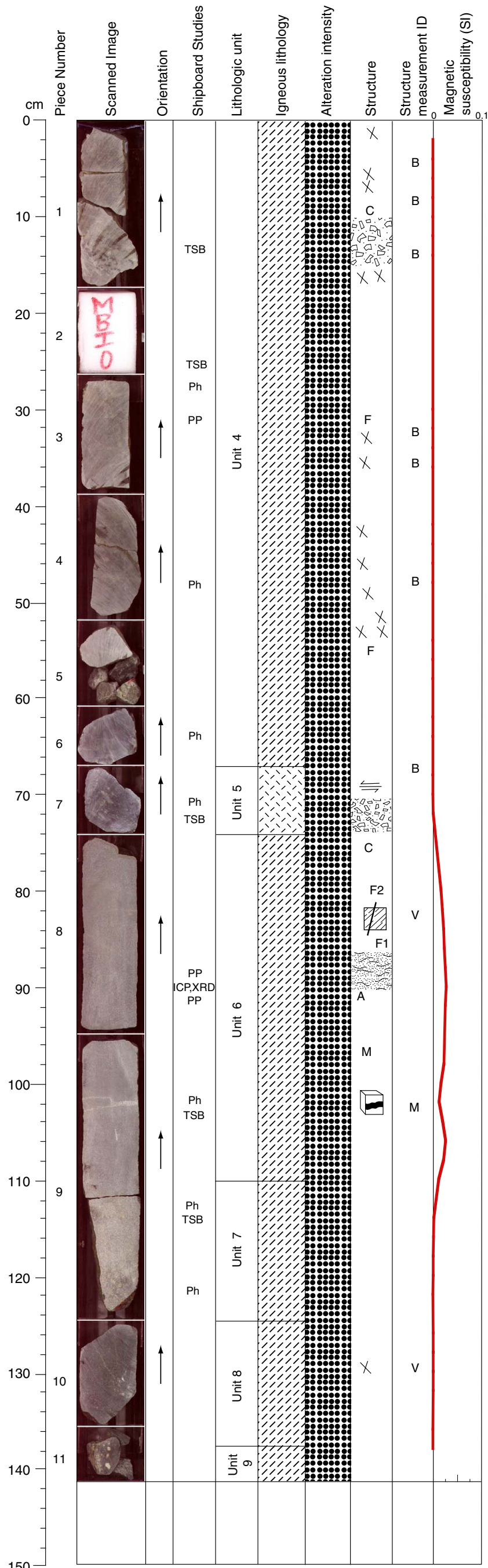
COMMENTS: Unit 7 consists of medium-grained, sparsely olivine-phyric basalt. A 4 cm wide interval contains large anhedral olivine phenocryst of about 6 mm size at the bottom of Piece 9B.

UNIT-8 : Aphyric basalt
Piece 10

COMMENTS: Unit 8 (Piece 10) is a medium-grained basalt with subophitic texture.



Core Photo



304-U1309B-2R-1 (continued) (Section top: 15.5 mbsf)

UNIT-9 : Olivine-plagioclase-phyric basalt
 Piece 11

COMMENTS: Unit continues in 2R-00 2 where it is described. Several large anhedral olivine phenocrysts in Piece 11 have been completely replaced by soft light brown clay. Smaller pieces of rubble appear to belong to Unit 8 and are likely out of place.

SECONDARY MINERALOGY: Most of the rock in this core contains fresh plagioclase although the pyroxenes are mostly altered to actinolite and minor chlorite. An intense cataclastic zone in Piece 7 is almost completely altered to actinolite. Various minor faults show a similar alteration. In Pieces 9, 10, and especially 11, circular to elliptical patches up to 8 mm in size contain fine grained actinolite, chlorite and sometimes sphene and/or oxide. These are most likely pseudomorphs after olivine or pyroxene phenocrysts.

VEIN ALTERATION: A number of veins containing either chlorite/actinolite or soft white minerals (zeolite?) occur throughout the section.

THIN SECTIONS:

- 304-U1309B-2R-1, 12-14 cm (#8)
- 304-U1309B-2R-1, 27-30 cm (#9)
- 304-U1309B-2R-1, 70-73 cm (#10)
- 304-U1309B-2R-1, 100-104 cm (#11)
- 304-U1309B-2R-1, 116-119 cm (#12)

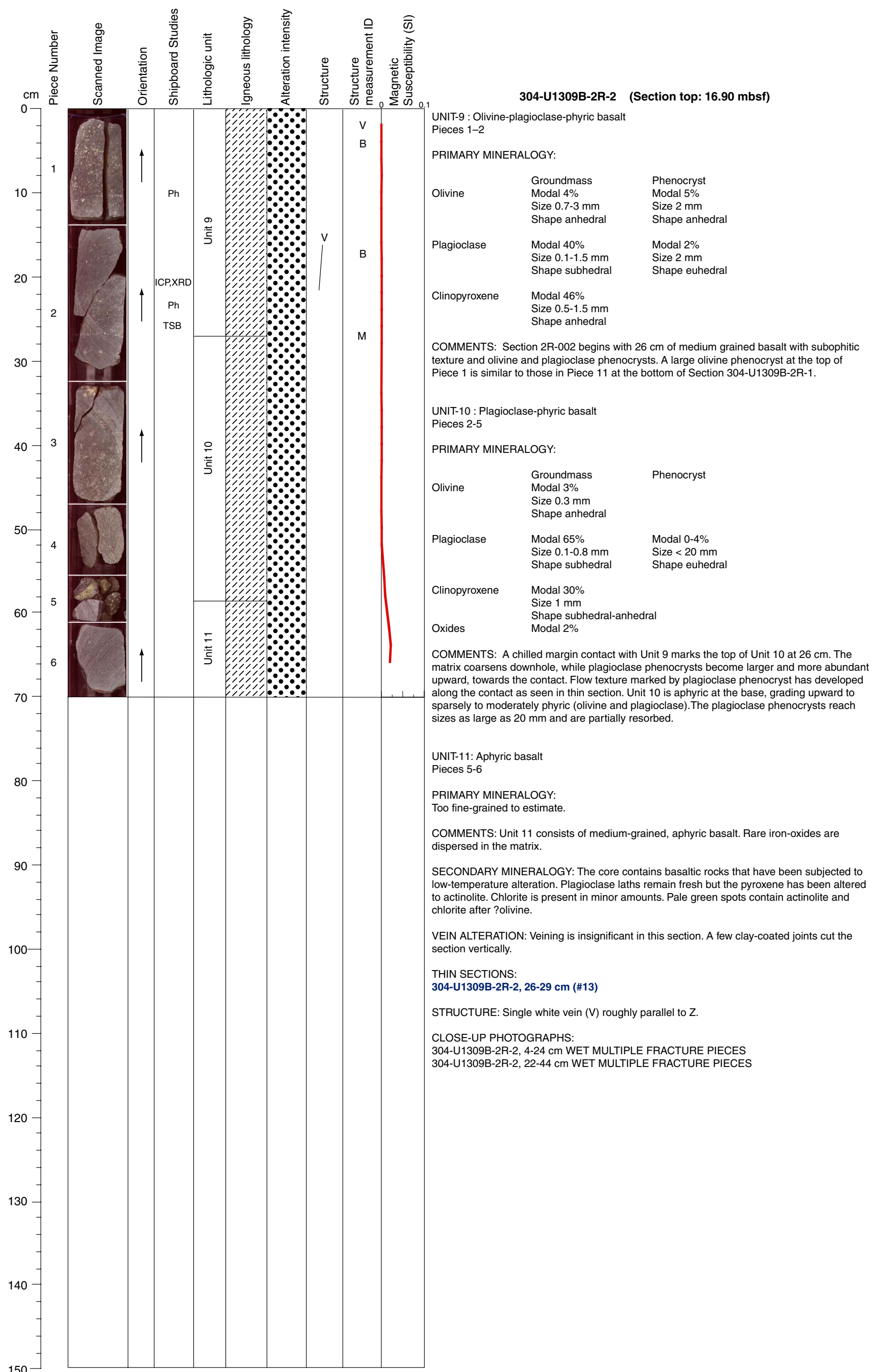
STRUCTURE: Several sets of cataclastic zones (C), faults, fracture sets (F), and associated alteration (A) characterize this diabasic/basaltic core. Several features could be measured for orientation and some for sense of shear. Cataclasites have fuzzy grain boundaries, altered matrix, and other dissolution-precipitation features - consistent with the term "healed cataclasites." One cataclastic zone (at 70cm) contains an inclusion of mylonitic gabbro. Fractures have a conjugate angle of ~60°(F). Greenish fractures (F2) coincide with, but may also cut, white fractures (F1). Fractures could be coeval with, or just pre-date, some of the cataclastic deformation. (i.e. The fractures do not cut across cataclasites, but do offset shear zone boundaries (in places).) Toward the base of the core a coarser grained and more felsic intrusive (magmatic vein) (M) cuts subhorizontally across. Timing is therefore approximately: M>F1=C>A =F2.

CLOSE-UP PHOTOGRAPHS:

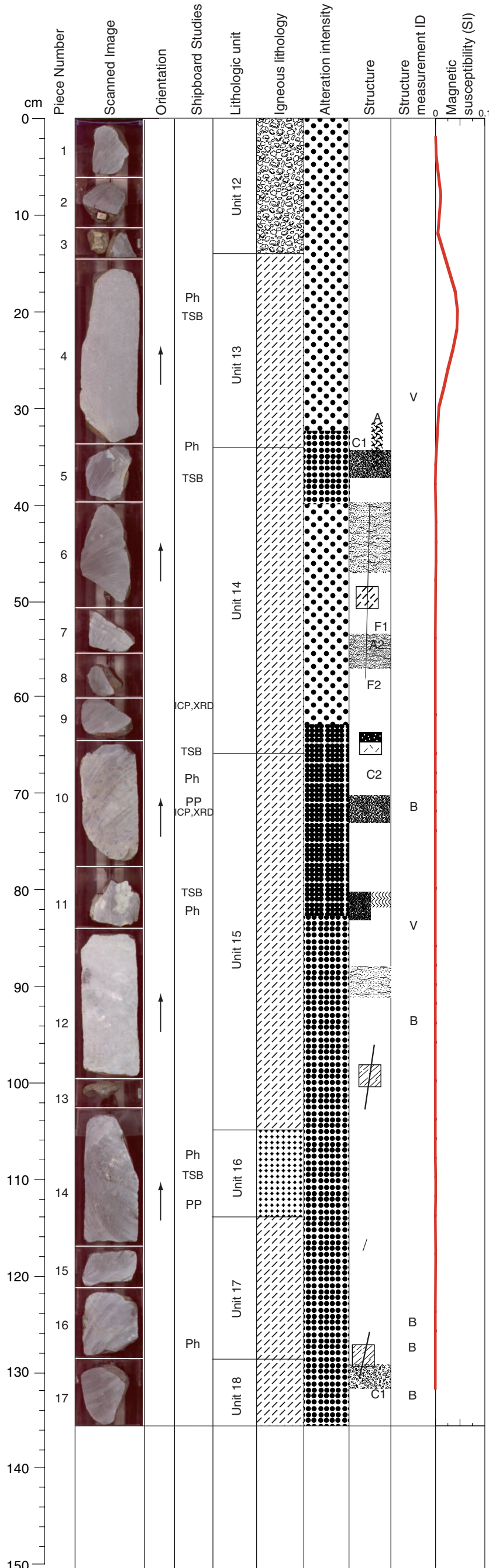
- 304-U1309B-2R-1, 25-30 WET
- 304-U1309B-2R-1, 45-50 WET
- 304-U1309B-2R-1, 61-66 WET
- 304-U1309B-2R-1, 67-73 WET
- 304-U1309B-2R-1, 97-107 WET
- 304-U1309B-2R-1, 112-123 WET
- 304-U1309B-2R-1, 118-123 WET



Core Photo



Core Photo



304-U1309B-3R-1 (Section top: 20.00 mbsf)

UNIT-12 : Mixed rubble
 Pieces 1-3
 Unit 12 consists of mixed rubble that is presumed to be out of place.

UNIT-13 : Sparsely plagioclase-olivine-phyric basalt
 Piece 4
PRIMARY MINERALOGY:

Olivine	Groundmass Modal 3% Size 0.5-4 mm Shape anhedral	Phenocrysts Modal <1% Size 3 mm Shape anhedral
Plagioclase	Modal 42% Size 0.1-0.5 mm Shape euhedral	Modal 1% Size 2-5 mm Shape euhedral
Clinopyroxene	Modal 50% Size 0.1 mm Shape anhedral	

COMMENTS: Unit 13 is composed of fine-grained, almost aphyric basalt with rare, isolated olivine and plagioclase phenocrysts as large as 5 mm. Finely dispersed magnetite occurs in the matrix.

UNIT-14 : Aphyric basalt
 Pieces 5-10
PRIMARY MINERALOGY:
 Too fine-grained to estimate.

COMMENTS: Unit 14 consists of microcrystalline aphyric basalt with rare, isolated plagioclase laths as large as 5 mm. At the top of Piece 5, an intrusive contact with breccia as seen in thin section occurs. Unit 13 and 14 differ in grain size but are similar in phenocryst types and abundances. Alteration halos occur around small veinlets.

UNIT-15 : Basalt breccia
 Pieces 10-14
PRIMARY MINERALOGY:
 Too fine-grained to estimate.

COMMENTS: Unit 15 is separated from Unit 14 by a sharp contact at 65 cm. The unit consists of hydrothermally altered, highly fractured and brecciated basalt and diabase clasts. Several intrusive contacts with minor related brecciation are distinguished in thin section.

UNIT-16 : Olivine-gabbro
 Piece 14
PRIMARY MINERALOGY:

Olivine	Modal 10% Size 2 mm Shape anhedral
Plagioclase	Modal 50% Size 2 mm Shape subhedral
Clinopyroxene	Modal 40% Size 2 mm Shape anhedral

COMMENTS: Unit 16 is a modally heterogeneous, coarse-grained gabbro.

UNIT-17 : Basalt breccia
 Piece 14-16
PRIMARY MINERALOGY:
 Too fine-grained to estimate.

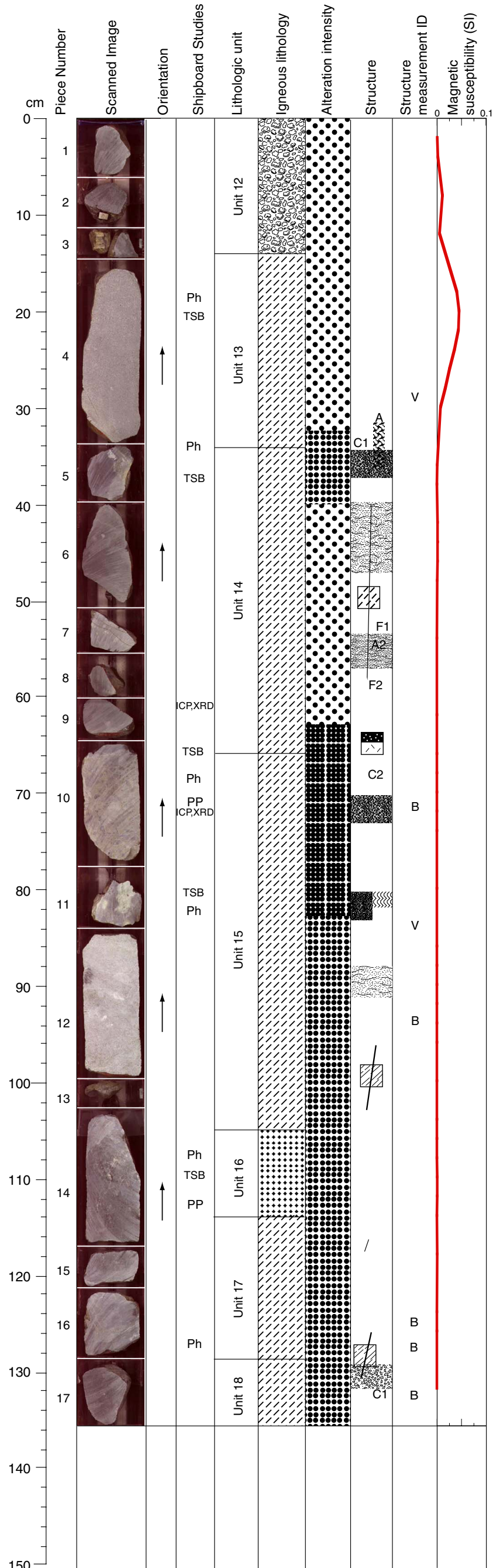
COMMENTS: Unit 17 is a clast-supported, in-situ breccia with large angular basalt fragments as large as 40 mm.

UNIT-18 : Aphyric basalt
 Piece 17
PRIMARY MINERALOGY:
 Too fine-grained to estimate.

COMMENTS: Unit 18 is a piece (Piece 17) of fine-grained aphyric basalt with subophitic texture.



Core Photo



304-U1309B-3R-1 (continued) (Section top: 20.00 mbsf)

SECONDARY MINERALOGY:
 The core consists of fine-grained altered basalt (0-32 cm, 40-64 cm, and 82-135 cm) interlayered with hydrothermally altered breccia zones (30-39 cm and 62-84 cm). The fine-grained basalt appears to have intruded and been chilled against the breccia. The basaltic rocks contain fresh plagioclase with the ferromagnesian minerals altered to actinolite. The breccia zones are more intensely altered and locally (78-84 cm) contain chromite-bearing tremolite schist. Some plagioclase laths remain.

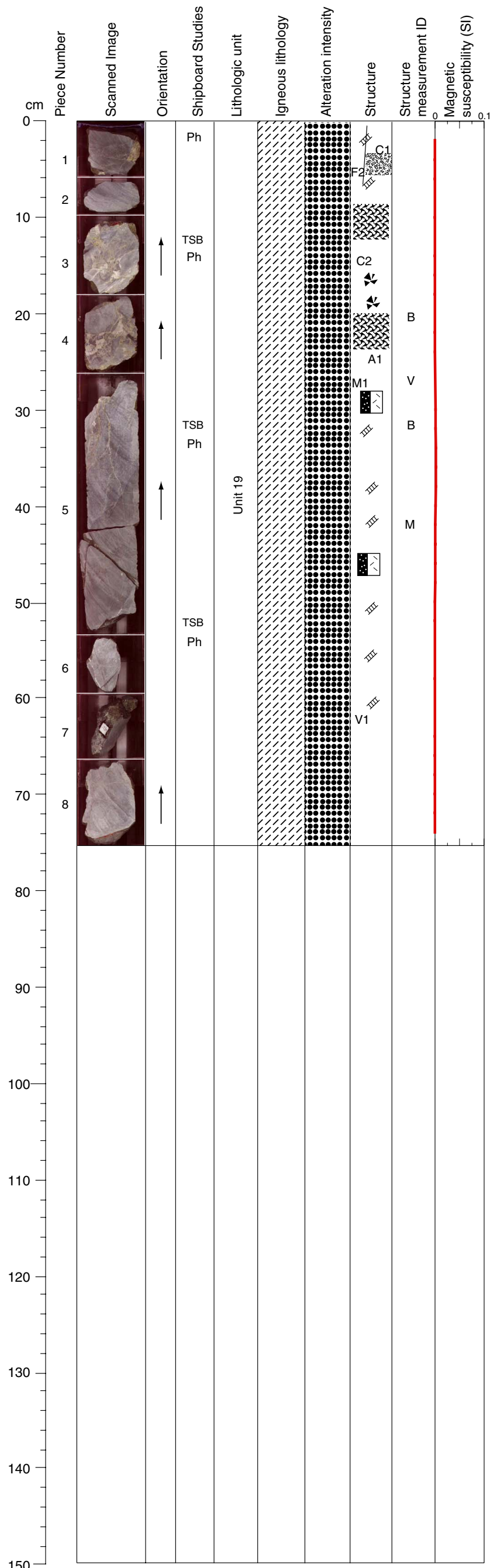
VEIN ALTERATION: White/green veins dominated by chlorite (mm-thick) are observed in the upper part of this section (Pieces 1-7). They are cut by rare tiny white veins of soft material. Within the lower part of the core subhorizontal white/green veins (chlorite/albite?) of few millimeters show an alteration halo.

THIN SECTIONS:
 304-U1309B-3R-1, 18-19 cm (#14)
 304-U1309B-3R-1, 36-38 cm (#15)
 304-U1309B-3R-1, 65-68 cm (#16)
 304-U1309B-3R-1, 80-82 cm (#17)
 304-U1309B-3R-1, 109-111 cm (#18)

STRUCTURE: Multiple sets of white, yellow, and green fractures, dark mineral "seams" (A2) healed cataclasites (C) and associated alteration (A). Also present are patchy, possibly magmatic (M) features, similar to veins, that are possibly affected by dissolution. Cross-cutting features are not abundant, but green fractures locally cut white fractures. An inclusion of green, metamorphic fault rock (talc-tremolite schist with a foliation from earlier deformation), is cut by white fractures. Interestingly, the significant cataclastic zones contain clasts with internal white fractures and earlier cataclasites. Therefore, relative timing includes inclusion of an older fault rock (C1), cut by white fractures (F1), cut by green fractures (F2), cut by cataclasites (C2): C1>F1>F2>C2. Lastly, basalt (from 36-38 cm) intrudes the breccia including the schistose clast.

CLOSE-UP PHOTOGRAPHS:
 304-U1309B-3R-1, 15-32 cm WET
 304-U1309B-3R-1, 34-40 cm WET
 304-U1309B-3R-1, 64-75 cm WET
 304-U1309B-3R-1, 64-69 cm WET
 304-U1309B-3R-1, 77-82 cm WET
 304-U1309B-3R-1, 103-116 cm WET
 304-U1309B-3R-1, 103-116 cm DRY
 304-U1309B-3R-1, 123-127 cm WET

Core Photo



304-U1309B-4R-1 (Section top: 24.50 mbsf)

UNIT-19 : Fine-grained basalt
Pieces 1-8

PRIMARY MINERALOGY: Too altered to estimate.

COMMENTS: Unit 19 consists of fine-grained basalt with a brecciated interval (Pieces 3-4). It includes several generations of dikes, between which the contacts are sharp and either straight (Piece 6) or wavy (Pieces 1 and 5) with some fine narrow reaction zones (Pieces 5-6). Breccias appear to be associated with intrusive contacts and are generally composed of angular fragments of fine-grained aphyric basalt, ranging from those that are matrix supported (Pieces 3-4) to those that are fractured with individual pieces more-or-less in place (Pieces 5-8). White reaction zones cross-cut the brecciated regions as well. Piece 5A of the working half contains an intrusive contact of plagioclase-phyric basalt intruding into cataclastic gabbro. The matrix of breccia Piece 6 does not contain plagioclase phenocrysts and therefore is not directly related to the formation of Piece 5.

SECONDARY MINERALOGY: This section consists of a number of fine-grained basalt intrusions into highly altered and locally intensely brecciated gabbro. In thin section the basalts contain fresh plagioclase phenocrysts in an aphanitic matrix which is probably totally altered to actinolite, chlorite etc. The degree of alteration is comparable to that seen in fine-grained basalts elsewhere in the section (eg. in 3R-001 at 35 cm). Brecciation is most intense in the metagabbro unit suggesting brecciation and hydrothermal alteration before basalt intrusion. The major alteration mineral is actinolite, although relict hornblende occurs locally in the gabbro.

VEIN ALTERATION: Numerous fractures are filled by light green tremolite.

THIN SECTIONS:

- 304-U1309B-4R-1, 13-16 cm (#19)
- 304-U1309B-4R-1, 30-31 cm (#20)
- 304-U1309B-4R-1, 50-51 cm (#21)

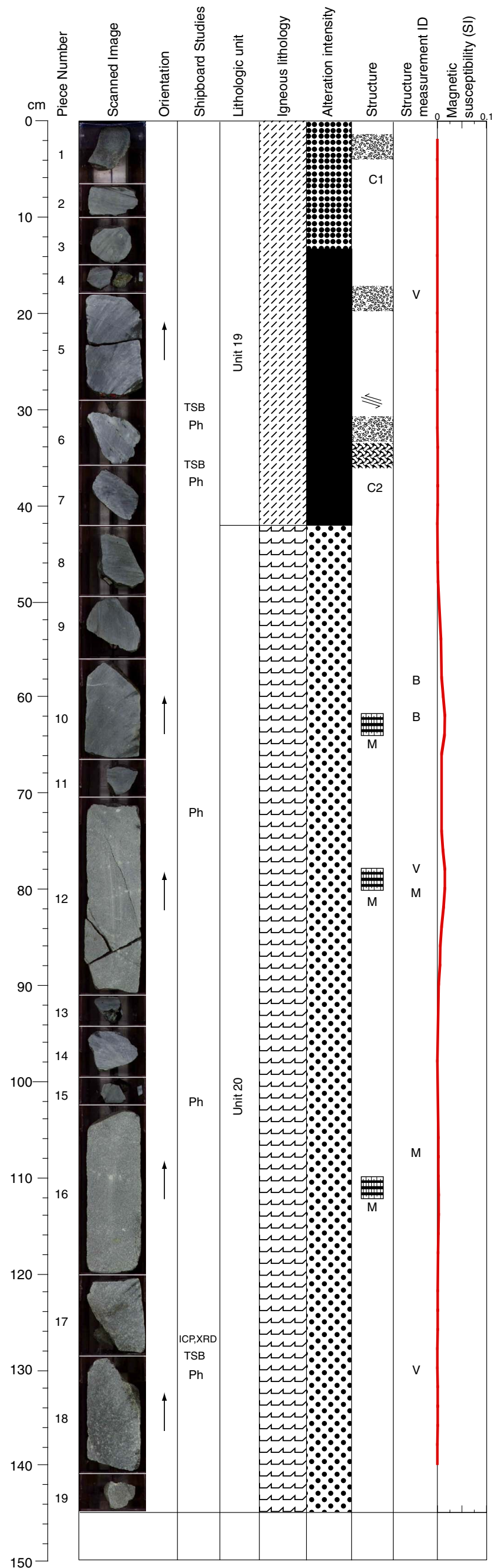
STRUCTURE: Several brittle structures have crosscutting relationships. Numerous white fractures (F), dipping towards 90°, cut all other features. Throughout the core, but particularly toward the top, patchy alteration includes vuggy and mineralized veins (V1) and an earlier set of white fractures (F). The alteration "heals" a set of breccias (C1 and C2) that are particularly prominent from 10-35 cm. These breccias appear to be younger than a narrow well-healed cataclasis at 4 cm in the section. An intrusive (M) contact near thirty cm and 40 cm is associated with a brown, vuggy vein at the contact, and a wider, greener vein that is roughly vertical near the center of the sample. Roughly, from youngest to oldest the structures are: white fractures (F2), patchy alteration (A1), significant brecciation (C2), veining (V1), intrusion (M1), local cataclasis (C1): C1>M1>V1>C2>A1>F1.

CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-4R-1, 0-5 cm WET
- 304-U1309B-4R-1, 10-26 cm WET
- 304-U1309B-4R-1, 26-40 cm WET
- 304-U1309B-4R-1, 54-57 cm WET



Core Photo



304-U1309B-5R-1 (Section top: 29.50 mbsf)

UNIT-19 : Fine-grained basalt
Pieces 1-7

PRIMARY MINERALOGY:
Piece 7

- Plagioclase Modal 50%
 Size 0.05-0.5 mm
 Shape subhedral
- Clinopyroxene Modal 45%
 Size too altered
 Shape too altered
- Oxides Modal 3-5%

COMMENTS: Section 5R-1 is the continuation of Unit 19 and consists of slightly brecciated to fractured fine-grained basalts. A single piece of tremolite schist (Piece 6) with trains of elongated magnetite at the bottom of this section occurs. Piece 7 is a brecciated diabase-basalt contact with gabbro relicts. Thin section analysis suggests that the basalt represents the chilled margin of the following diabase unit.

UNIT-20 : Oxide-diabase
Pieces 8-19

- PRIMARY MINERALOGY:
- Olivine Modal 5%
 Size 1-2 mm
 Shape too altered
 - Plagioclase Modal 50%
 Size 0.5-2 mm
 Shape subhedral
 - Clinopyroxene Modal 40%
 Size too altered
 Shape too altered
 - Oxides Modal 5%

COMMENTS: Unit 20 is composed of very sparsely olivine-plagioclase-phyric diabase. Grain size increases downhole from fine-grained (Piece 8) to medium-grained at the end of the section. Sparse, subhorizontal trains of large anhedral olivines as large as 5 mm occur at 76 cm, 80 cm and 109 cm. Rare, isolated plagioclase phenocrysts 7-9 mm in length, occur throughout the section. Oxides are disseminated in the matrix. Pieces 11, 13, 14 and 15 are lithologically similar to Unit 19 and are presumed to be out of place.

SECONDARY MINERALOGY: Plagioclase in this section of the core is relatively fresh. Actinolite is the major alteration mineral. Chlorite is less common. Between 15 cm and 29 cm there is a brecciated zone and between 29 cm and 42 cm there is a foliated zone. The foliated zone is pale green and mainly tremolitic amphibole with porphyroclasts of oxide (partially hematized) and minor chlorite. It is possible that it is of partly ultramafic protolith. In these zones alteration is complete.

VEIN ALTERATION: The upper 70 cm contain a low intensity of dark green chlorite veins and white albite veins. Beneath this section are minor fractures filled with green clay minerals. A clay covered joint surface separates Piece 17 from Piece 18.

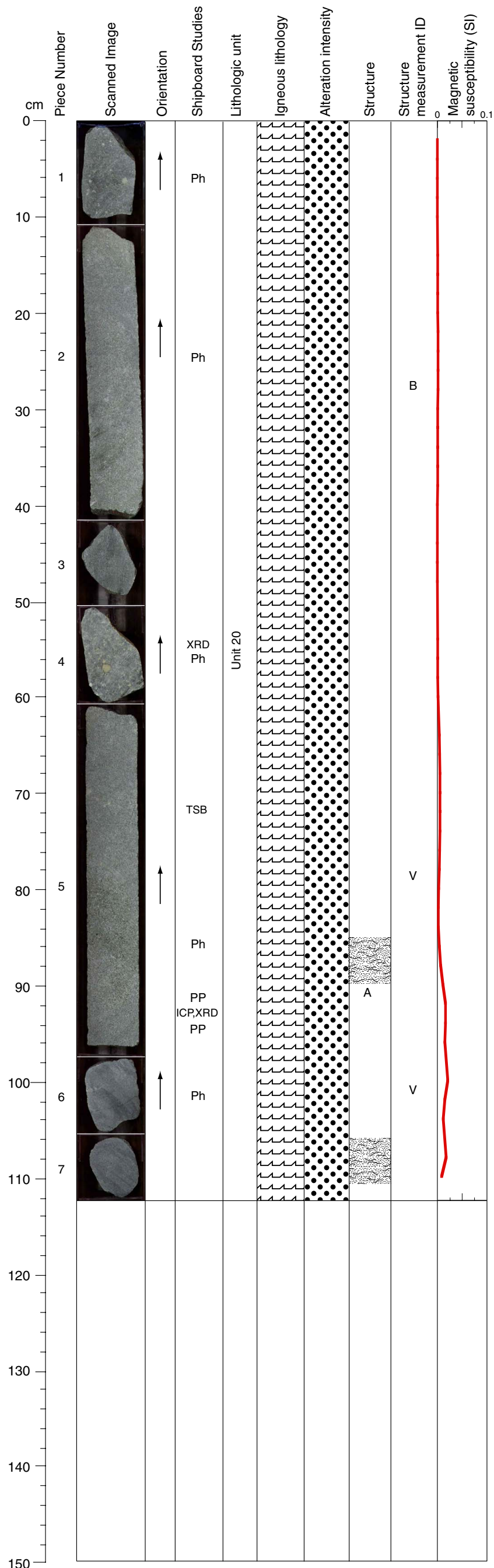
THIN SECTIONS:
[304-U1309B-5R-1, 29-31 cm \(#22\)](#)
[304-U1309B-5R-1, 36-38 cm \(#23\)](#)
[304-U1309B-5R-1, 129-130 cm \(#24\)](#)

STRUCTURE: Patchy alteration overprints and heals cataclastic zones. This section contains a "type" example of a healed cataclasite or healed breccia at roughly 10 cm. Narrow (< 10 cm) zones with shear zone boundaries contain weakly foliated cataclastic material (C1 and C2). Unlike young breccias and cataclasites, however, the grain boundaries are fuzzy, and the matrix is not particulate. There are several healed cataclasites in this section, and they all overprint a weak magmatic layering, remarkable for layers of large olivine grains dipping shallowly toward 270°. Timing: M>C1>C2.

CLOSE-UP PHOTOGRAPHS:
 304-U1309B-5R-1, 30-35 cm WET
 304-U1309B-5R-1, 30-36 cm WET
 304-U1309B-5R-1, 36-42 cm WET
 304-U1309B-5R-1, 70-90 cm WET
 304-U1309B-5R-1, 102-120 cm WET
 304-U1309B-5R-1, 128-140 cm WET
 304-U1309B-5R-1, 128-140 cm DRY BACKSIDE OF CORE



Core Photo



304-U1309B-5R-2 (Section top: 30.94 mbsf)

UNIT-20 : Oxide-diabase
Pieces 1-7

PRIMARY MINERALOGY:

Olivine Modal 5%
 Size 1 mm
 Shape anhedral

Plagioclase Modal 50%
 Size 0.1-2.5 mm
 Shape subhedral

Clinopyroxene Modal 40%
 Size 0.5-3 mm
 Shape anhedral

Oxides Modal 5%

COMMENTS: Section 5R-2 is the continuation of Unit 20. Medium grain sizes observed at the bottom of the previous section persist and only minor localized variation occurs. Ophitic texture is best developed in Pieces 6 and 7. Large anhedral olivine phenocrysts are present. Plagioclase laths are rare and occasionally show a preferred orientation that is dipping downhole at a small angle (see outside of Piece 2).

SECONDARY MINERALOGY: Fresh plagioclase laths are present but most of the pyroxenes have altered to actinolite. Minor chlorite is present, but epidote is absent. In thin section green spots contain fine intergrowths of actinolite and chlorite with grains of oxide and sphene around the margins. These are probably olivine pseudomorphs.

VEIN ALTERATION: A vein of chlorite is at the bottom of the section (Piece 5) and another vein, which was yellow, has been shown by XRD to contain saponite.

THIN SECTIONS:

304-U1309B-5R-2, 70-72 cm (#25)

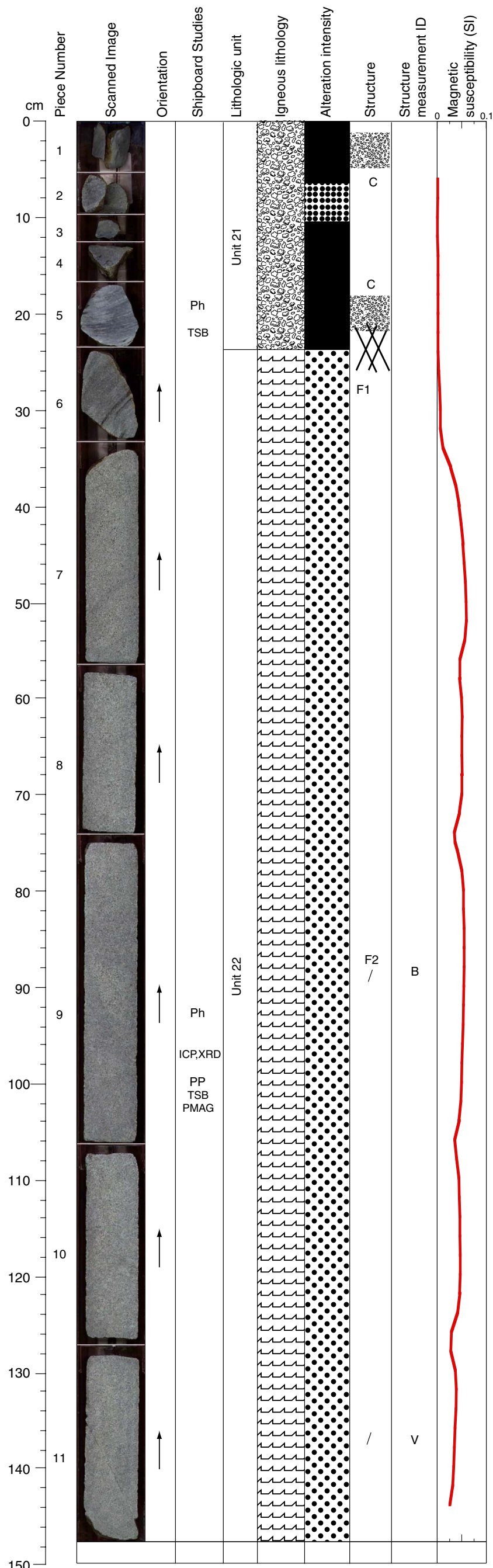
STRUCTURE: Two poorly defined veins (V) and one weakly brecciated region are the only structures identified in this relatively intact basalt/fine-grained diabase. Some inter-granular alteration (A) is present.

CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-5R-2, 0-10 cm WET
- 304-U1309B-5R-2, 16-36 cm WET
- 304-U1309B-5R-2, 16-36 cm DRY BACKSIDE NEAR TAGS
- 304-U1309B-5R-2, 50-60 cm WET
- 304-U1309B-5R-2, 80-96 cm WET
- 304-U1309B-5R-2, 97-111 cm WET



Core Photo



304-U1309B-6R-1 (Section top: 33.2 mbsf)

UNIT-21 : Mixed rubble
Pieces 1-5

PRIMARY MINERALOGY:
 Piece 1: Brecciated aphanitic basalt
 Piece 2: Diabase
 Piece 3: Aphanitic basalt
 Piece 4: Diabase
 Piece 5: Deformed plagioclase-phyric basalt with fractures

Presumed to be out of place.

UNIT-22 : Oxide-diabase
Pieces 6-11

PRIMARY MINERALOGY:

Olivine	Modal 4% Size 0.5-1.7 mm Shape anhedral
Plagioclase	Modal 45% Size 0.-2.3 mm Shape subhedral
Clinopyroxene	Modal 50% Size 0.1-2.4 mm Shape anhedral
Oxides	Modal 2%

COMMENTS: Unit 22 appears to be the continuation of Unit 20. Grain size increases down the section. Oxides are disseminated in the matrix.

SECONDARY MINERALOGY: Plagioclase is fresh and shows diabasic texture. The pyroxenes are partially replaced by actinolite. Minor chlorite may also be present. At 1 to 5 cm and 10 to 24 cm the rock is brecciated. No relict igneous texture remains, and alteration of pyroxene is complete.

VEIN ALTERATION: There are a few thin actinolite veins in this section

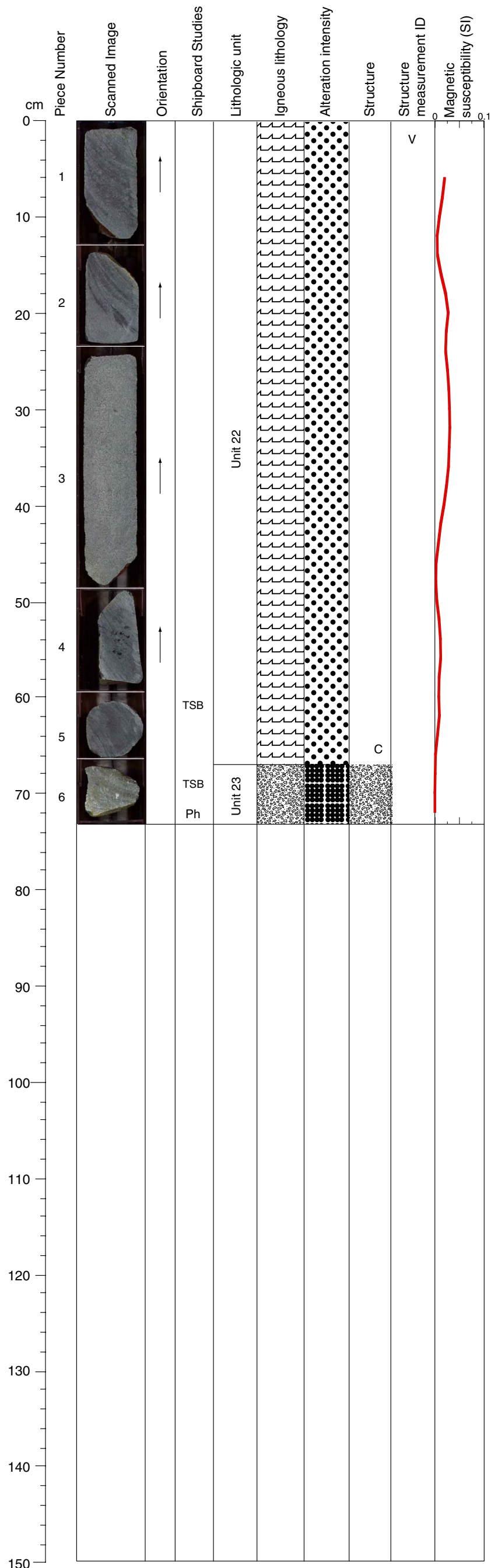
THIN SECTIONS:
 304-U1309B-6R-1, 20-22 cm (#26)
 304-U1309B-6R-1, 102-105 cm (#27)

STRUCTURE: Below 34 cm, there are only one or two poorly defined fractures (F2) (one drilling induced). Above 34 cm there is a zone of well-defined healed cataclasites (C). The grains within the cataclasites contain white fractures, indicating an early fracture set (F1). The separate (younger) set of white and green veins cut across all other features (F2).
 Timing: F1>C>F2.

CLOSE-UP PHOTOGRAPHS:
 304-U1309B-6R-1, 18-24 cm WET
 304-U1309B-6R-1, 84-100 cm WET
 304-U1309B-6R-1, 84-100 cm DRY BACKSIDE



Core Photo



304-U1309B-6R-2 (Section top: 34.70 mbsf)

UNIT-22 : Oxide-diabase
Pieces 1-5

PRIMARY MINERALOGY:

- Olivine Modal 1%
Size 0.5-0.8 mm
Shape anhedral
- Plagioclase Modal 40%
Size 0.1-2.5 mm
Shape subhedral
- Clinopyroxene Modal 56%
Size 0.1-2.5 mm
Shape subhedral-anhedral
- Oxides Modal 3%

COMMENTS: Medium-grained diabase from the previous section continues to 23 cm. From Piece 2 until the end of the section at 66 cm grain sizes are finer and magnetite contents are higher.

UNIT-23 : Cataclasite/Fault gouge
Piece 6

PRIMARY MINERALOGY:

- Plagioclase Modal 60%
Size 0.1-0.7 mm
Shape subhedral
- Clinopyroxene Modal 40%
Size 0.8-1.4 mm
Shape subhedral

COMMENTS: Unit 23 consists of a single piece of cataclasite with fragments of gabbro in an altered matrix.

SECONDARY MINERALOGY: Fresh plagioclase laths are still present. Pyroxenes are partially altered to actinolite. Chlorite may also be present. At the base of the section (67-73 cm) there is a breccia zone that is yellow-green where alteration is complete.

VEIN ALTERATION: There are no veins in this section.

THIN SECTIONS:

- 304-U1309B-6R-2, 61-63 cm (#29)
- 304-U1309B-6R-2, 66-69 cm (#28)

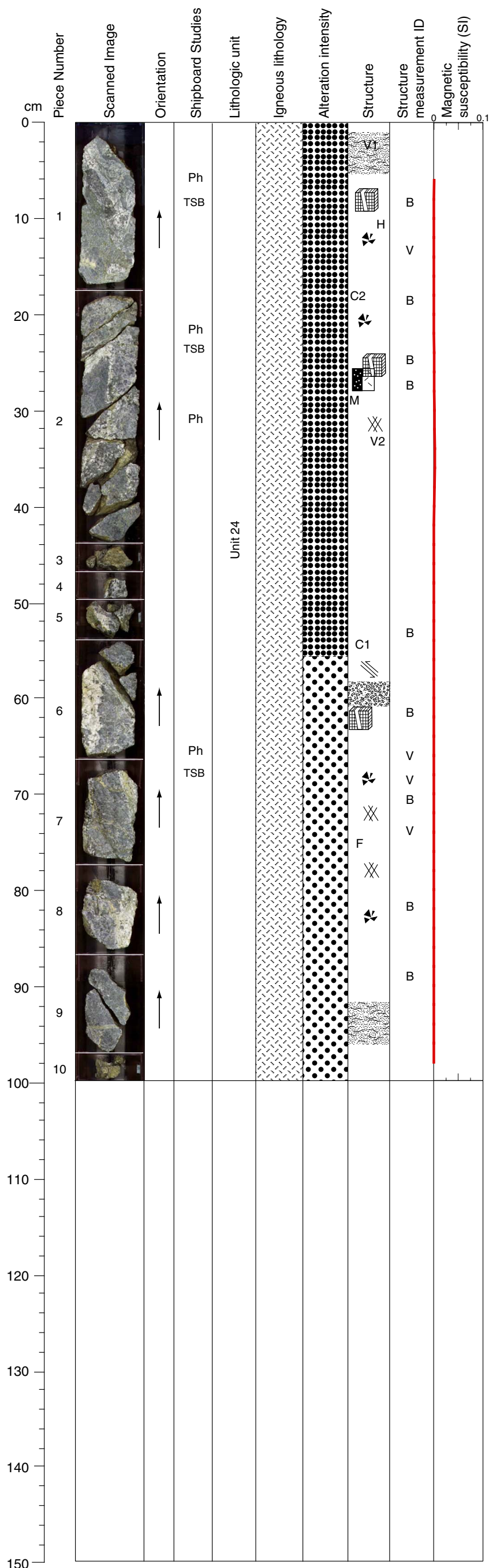
STRUCTURE: The base of this intact basalt/diabase has a partly healed cataclastic shear zone (C).

CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-6R-2, 67-72 cm WET



Core Photo



304-U1309B-7R-1 (Section top: 38.00 mbsf)

UNIT-24 : Gabbro
Pieces 1-10

PRIMARY MINERALOGY:

Plagioclase Modal 70%
 Size 1-5 mm
 Shape subhedral

Clinopyroxene Modal 30%
 Size 1-10 mm
 Shape subhedral

Olivine Modal <1%
 Size 1 mm
 Shape anhedral

COMMENTS: Unit 24 consists of generally coarse-grained gabbro with local variations in grain size. Olivine occurs localized in fine-grained areas with as much as 2% and is heterogeneously distributed, sometimes deformed and stretched. An anorthitic vein transects between 57 and 85 cm parallel to the edge of the core. Apatite and zircon occur as inclusions in brown hornblende along the melt-infiltrated zones.

SECONDARY MINERALOGY:

- a) Hornblende
- b) actinolite, chlorite, epidote, albite
- c) clay minerals

COMMENTS: This section consists entirely of gabbro that shows various degrees of alteration. The alteration records three events. An amphibolite facies event is marked by brown hornblende rims on pyroxene and locally by hornblende veins. The second event is recorded in green veins/alteration zones that are locally abundant, and commonly show cataclastic textures. Mineralogy of these zones is dominantly actinolite with minor chlorite. A third generation is recorded in clay-bearing veins, which locally cut the green veins.

VEIN ALTERATION: Thin hornblende veins occur around 9 cm. Good examples of the green veins are found at 11-17 cm, 57 cm, and 94 cm. Examples of yellow veins occur on the right edge of the core (looking up section) at 58 cm and on the left edge of the core at 67-70 cm.

THIN SECTIONS:

- 304-U1309B-7R-1, 6-8 cm (#30)
- 304-U1309B-7R-1, 24-25 cm (#31)
- 304-U1309B-7R-1, 67-69 cm (#32)

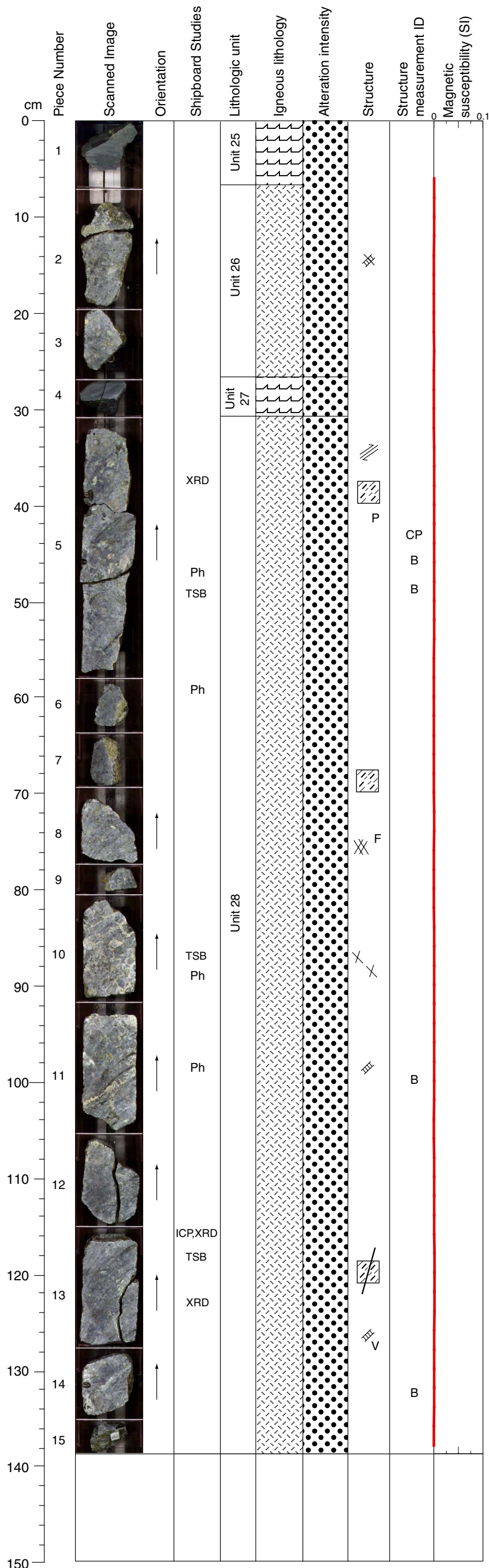
STRUCTURE: Structures within this coarse-grained gabbro are cataclastic and hydrothermal in nature. Dark veins (V1) at the top of the section are intergranular and associated with centimeter-sized grains of a dark mineral (amphibole?). A hydrothermal contact (H) places the gabbro against a cataclastic domain (C2), both green with alteration (A). Near 30 cm, a magmatic (intrusive) (M) contact is altered to a green, cataclastic texture, and cut by green veins (V2). A similar unit and structural relationship is present at ca. 60 cm, although this hydrothermal/intrusive domain is sharply cut by a contact that has properties of a vein and a cataclastic fault (C1), that has possible reverse-sense indicators. Below this 60 cm interval, numerous veins, fractures, and cataclastic regions coincide with fractures and cataclastic regions (F) cutting several early veins. Timing (note many intervals could be coeval): M>C1>H>V1>A>C2>V2>F.

CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-7R-1, 0-16 cm WET
- 304-U1309B-7R-1, 18-38 cm WET
- 304-U1309B-7R-1, 22-28 cm WET
- 304-U1309B-7R-1, 30-34 cm WET
- 304-U1309B-7R-1, 67-76 cm WET



Core Photo



304-U1309B-8R-1 (Section top: 43.00 mbsf)

UNIT-25 : Micro-diabase
 Piece 1

PRIMARY MINERALOGY:
 Too fine-grained to estimate.

COMMENTS: Fine-grained diabase with subophitic texture occurs at the top of Section 8R-001. It is possibly out of place.

UNIT-26 : Gabbro
 Pieces 2-3

PRIMARY MINERALOGY:

Plagioclase	Modal 50%
	Size 2-7 mm
	Shape subhedral

Clinopyroxene Modal 50%

 Size 2-10 mm

 Shape subhedral

Oxide Modal <1%

COMMENTS: The interval between 8 cm and 20 cm consist of coarse-grained gabbro. Grain sizes are coarser and pyroxene contents higher than in Unit 24. Disseminated oxides occur in the matrix.

UNIT-27 : Micro-diabase
 Piece 4

PRIMARY MINERALOGY:
 Too fine-grained to estimate.

COMMENTS: Fine-grained micro-diabase with subophitic texture occurs between 27 cm and 31 cm.

UNIT-28 : Gabbro
 Pieces 5-15

PRIMARY MINERALOGY:

Plagioclase	Modal 50%
	Size 2-7 mm
	Shape subhedral

Clinopyroxene Modal 50%

 Size 2-10 mm

 Shape subhedral

COMMENTS: Unit 28 is composed of coarse-grained gabbro. Pervasive infiltration by an anorthositic melt occurs between 80 and 90 cm in Piece 10 and zircons occur in thin sections. An anorthositic dike with an interfingering contact crosscuts the section at 100 cm. Minute grains of disseminated oxides occur in the feldspar and sulfides are heterogeneously distributed.

SECONDARY MINERALOGY: The core consists of weakly altered gabbro. The alteration records at least three events. Locally the pyroxenes are altered to a brown hornblende, indicating rather high-T alteration. The second event is recorded in green veins that are locally abundant. Mineralogy of these veins is dominantly actinolite. A third generation is recorded in yellow clay-bearing veins, which crosscut the green veins. Pale green patches of fine alteration are mainly actinolite with minor chlorite (XRD at 37 cm), probably after olivine.

VEIN ALTERATION: Examples of the yellow actinolite vein networks occur in the upper part of the section (e.g. at 11 cm), and also between 80 cm and 108 cm.

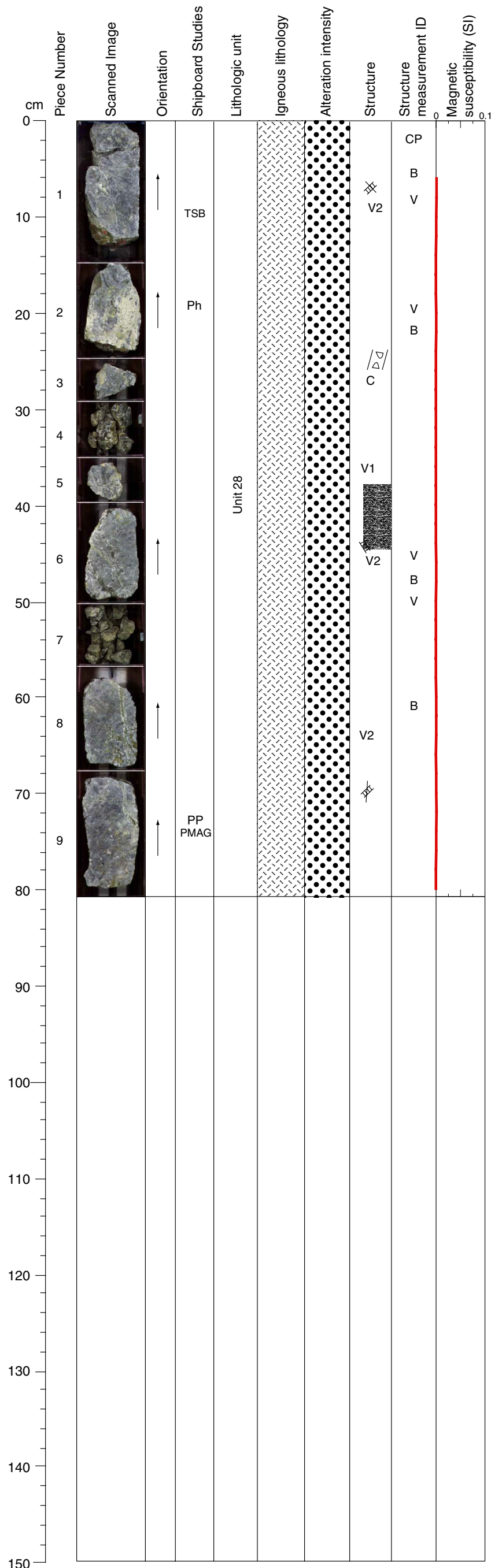
THIN SECTIONS:
[304-U1309B-8R-1, 48-52 cm \(#33\)](#)
[304-U1309B-8R-1, 84-87 cm \(#34\)](#)
[304-U1309B-8R-1, 118-119 cm \(#35\)](#)

STRUCTURE: A few conjugate fractures (F) near 85 cm are the only truly brittle features in this gabbro aside from a set of veins (V) that, while they cut grains in places, take on a more intergranular texture. Such veins are thin, green, although in one place a vein is wide, branching, vuggy, and slightly yellow. Most remarkable is the occurrence of crystal plastic deformational fabrics (P), weakly defined in two places, but in one place well developed and providing a thrust-sense (SOS) across a narrow shear zone. Veins cut the crystal plastic fabric. Timing: P>V>F

CLOSE-UP PHOTOGRAPHS:
 304-U1309B-8R-1, 46-50 cm WET
 304-U1309B-8R-1, 56-66 cm WET
 304-U1309B-8R-1, 58-74 cm WET
 304-U1309B-8R-1, 88-90 cm WET
 304-U1309B-8R-1, 92-104 cm WET



Core Photo



304-U1309B-8R-2 (Section top: 44.39 mbsf)

UNIT-28 : Gabbro
Pieces 1-9

PRIMARY MINERALOGY:

Plagioclase Modal 55%
 Size 0.5 – 7 mm
 Shape subhedral

Clinopyroxene Modal 45%
 Size 2-10 mm
 Shape subhedral

Orthopyroxene Modal 1%
 Size 6 mm
 Shape subhedral

COMMENTS: Section 8R-2 consists of the continuation of the coarse-grained gabbro of Unit 28. Orthopyroxene occurs in thin section. An anorthositic vein crosses between 17 cm and 24 cm.

SECONDARY MINERALOGY: The section consists mainly of gabbro that is moderately altered. The alteration records at least three events. Locally pyroxene is rimmed by hornblende indicating an amphibolite facies event. The second event is recorded in green actinolite veins. A possible third generation is recorded in yellow clay-bearing veins, which locally cut the green veins. Plagioclase is locally altered to milky ?albite.

VEIN ALTERATION: An example of the green veins can be found at 44 cm and examples of the yellow veins occur at 22 cm and 45 cm. The clay alteration also occurs as a clot (rather than a discrete vein) at 22 cm.

THIN SECTIONS:

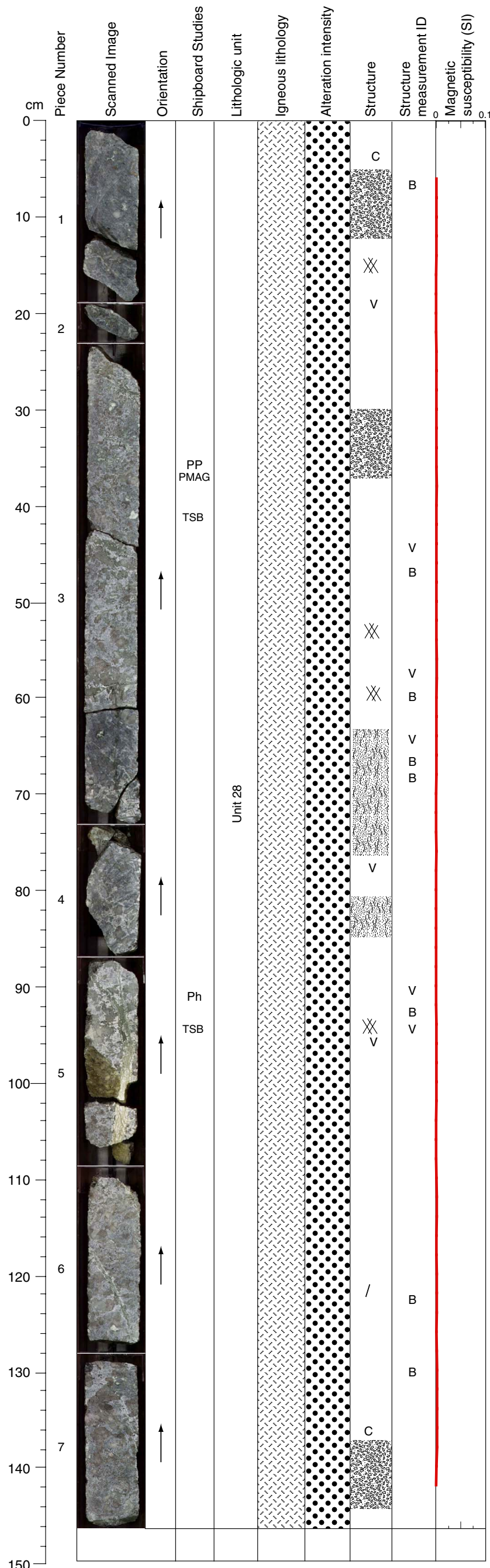
304-U1309B-8R-2, 8-10 cm (#36)

STRUCTURE: Continuous, wide, green and wide veins (V1) with internal structure are semi-continuous across the Z direction of this section. The veins branch and in places have conjugates, and are locally (e.g., at 20 cm) associated with cataclastic regions (C). The veins are cut by a later set of narrow, dark green veins (V2). Timing: V1>C>V2

CLOSE-UP PHOTOGRAPHS:

304-U1309B-8R-2, 15-24 cm WET

Core Photo



304-U1309B-9R-1 (Section top: 47.5 mbsf)

UNIT-28 : Gabbro
Pieces 1-7

PRIMARY MINERALOGY:

Plagioclase Modal 60%
 Size 1-15 mm
 Shape subhedral-anhedral

Clinopyroxene Modal 40%
 Size 1-20 mm
 Shape anhedral

COMMENTS: Section 9R-1 consists of the continuation of the coarse-grained gabbro of Unit 28. Pyroxene grain sizes increase to as large as 20 mm below 40 cm.

SECONDARY MINERALOGY: This section consists of moderately fresh gabbro. Plagioclase is unaltered. Pyroxene commonly is fresh, but locally is altered to actinolite. Chlorite is rare. A possible third generation of alteration is recorded by clay-bearing veins.

VEIN ALTERATION: Good examples of green actinolite breccia veins are found at 44 cm and 121 cm. A good example of a yellow vein (possibly containing albite and clay minerals) occurs at 21 cm. In Piece 5 (87-108 cm), a prominent 1 cm wide vein changes mineralogy from albite-rich to actinolite-rich up the core, branching at 92 cm (see close up photo)

THIN SECTIONS:

- 304-U1309B-9R-1, 38-41 cm (#37)
- 304-U1309B-9R-1, 94-97 cm (#38)

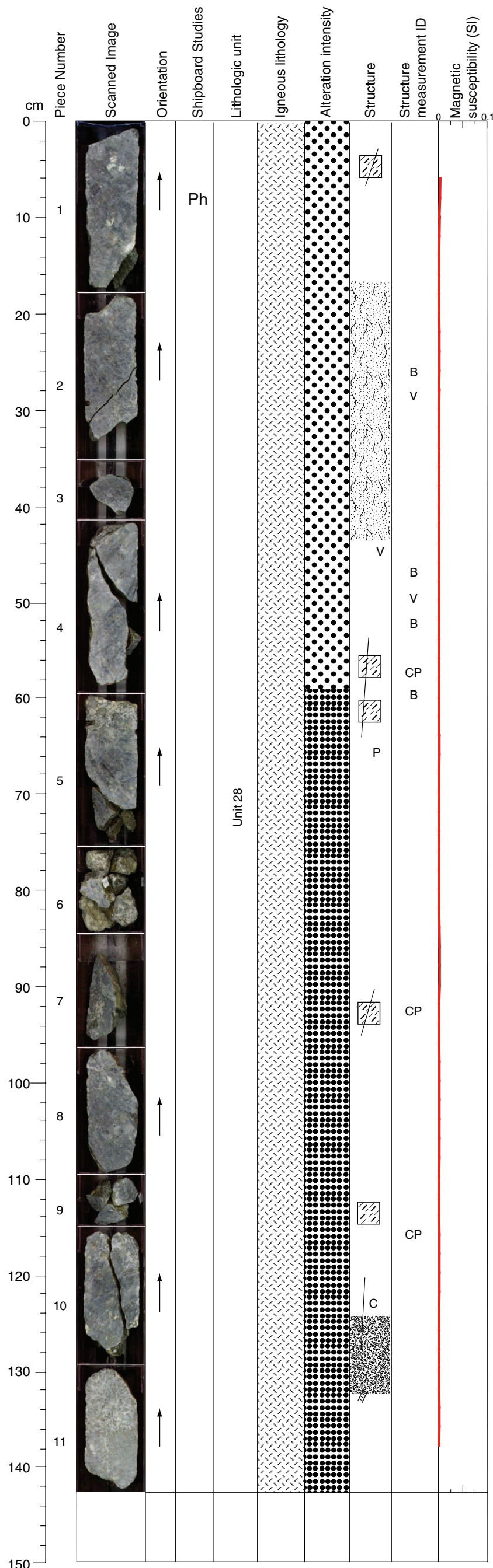
STRUCTURE: This section presents a type example of brittle deformation (C) in the gabbros overprinting earlier magmatic (M) and crystal plastic (P) textures (not indicated in barrel sheets). A weak crystal plastic fabric dips gently to 270°. The crystal plastic fabric intensifies between 18 cm and 25 cm, and then falls off through the rest of the section. The crystal plasticity is differentiated from earlier magmatic textures by the flattening of pyroxene grains, stretching of plagioclase, elimination of triple junctions and other magmatic grain contacts and an overall similarity and fining of grain size - all best observed on the drilled rather than fresh face. Obscuring views of the crystal plastic fabric is a high density of grain-scale microcracks (C) that do not appear to greatly strain (e.g., change the shape of) grains. All grain scale structures are cut by a network of veins - both the green and white branching vein networks and the thin dark green veins (V). Timing: M>P>C>V

CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-9R-1, 44-48 cm WET
- 304-U1309B-9R-1, 88-108 cm WET



Core Photo



304-U1309B-9R-2 (Section top: 48.96 mbsf)

UNIT-28 : Gabbro
Pieces 1-11

PRIMARY MINERALOGY:

Plagioclase Modal 60%
 Size 4-12 mm
 Shape subhedral

Clinopyroxene Modal 40%
 Size 2-16 mm
 Shape subhedral

COMMENTS: Section 9R-2 consists of the continuation of the coarse-grained gabbro of Unit 28. In this section grain sizes decrease to as small as 15 mm and crystal-plastic deformation occurs. A strong lineation is observed in some rubble (Piece 9). Weak deformation occurs until 114 cm. On the drilled side of Piece 7 undeformed domains with elongated mineral grains can be observed.

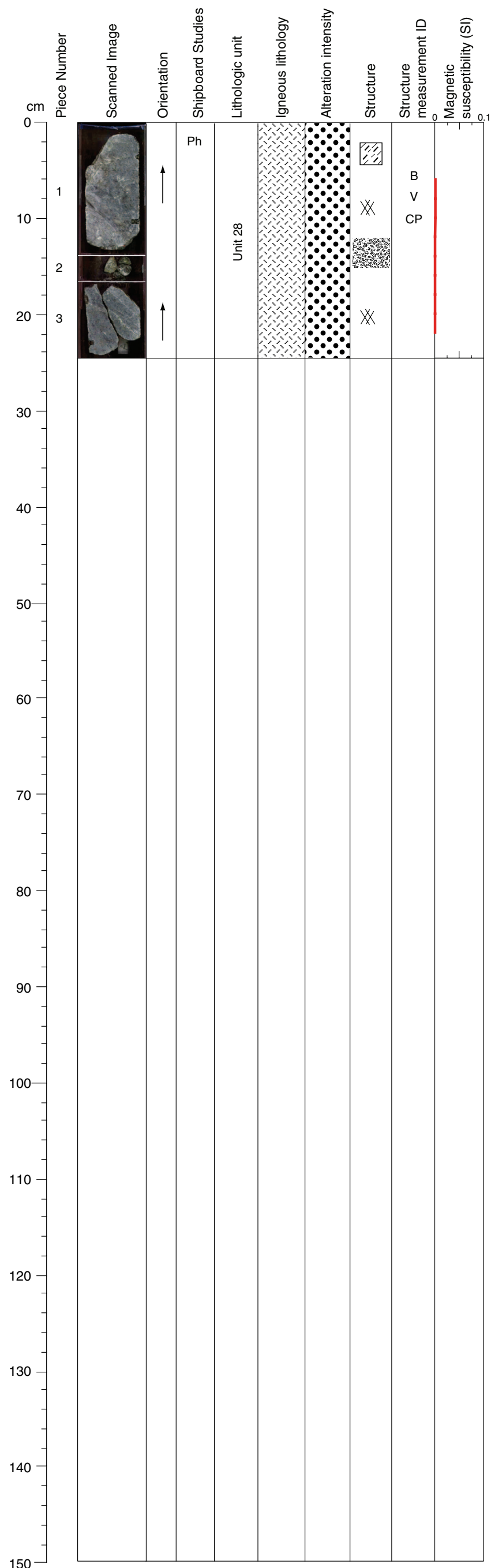
SECONDARY MINERALOGY: The gabbro in this section shows various degrees of alteration. It is relatively fresh near the top of the section and becomes more altered downward. Plagioclase is unaltered, except adjacent to actinolite veins where milky secondary plagioclase is seen. Ferromagnesian minerals may be fresh or partially altered to actinolite. Chlorite is rare. Two types of veins are found: green veins that contain actinolite and yellow veins that contain both actinolite and clays, probably due to late alteration.

VEIN ALTERATION: An example of the green veins can be found at 60 cm. An example of the yellow alteration occurs as a clot at 90 cm.

STRUCTURE: Like the surrounding gabbros, the effects of veins and alteration overprint microcracking at the grain scale, which in turn overprints earlier magmatic and crystal plastic textures. There are three areas of relatively intense crystal plastic fabrics (C) at ca. 60 cm, ca. 90 cm, and ca. 120 cm, and a weaker fabric near the top of the section. The crystal plastic fabrics are all cut by veins (V). P(and M)>C>V

CLOSE-UP-PHOTOGRAPHS:
304-U1309B-9R-2, 0-17 cm BACKSIDE DRY

Core Photo



304-U1309B-9R-3 (Section top: 50.38 mbsf)

UNIT-28: Gabbro
Pieces 1-3

PRIMARY MINERALOGY:

- Plagioclase Modal 60%
 Size 3-10 mm
 Shape subhedral
- Clinopyroxene Modal 40%
 Size 3-10 mm
 Shape subhedral

COMMENTS: Section 9R-3 is the continuation of the coarse-grained gabbro of Unit 28. A lineation is defined by elongated pyroxenes as large as 10 mm.

SECONDARY MINERALOGY: The section consists mainly of weakly altered gabbro. Plagioclase grains are fresh and pyroxenes are locally altered to actinolite. This alteration is also recorded in green veins.

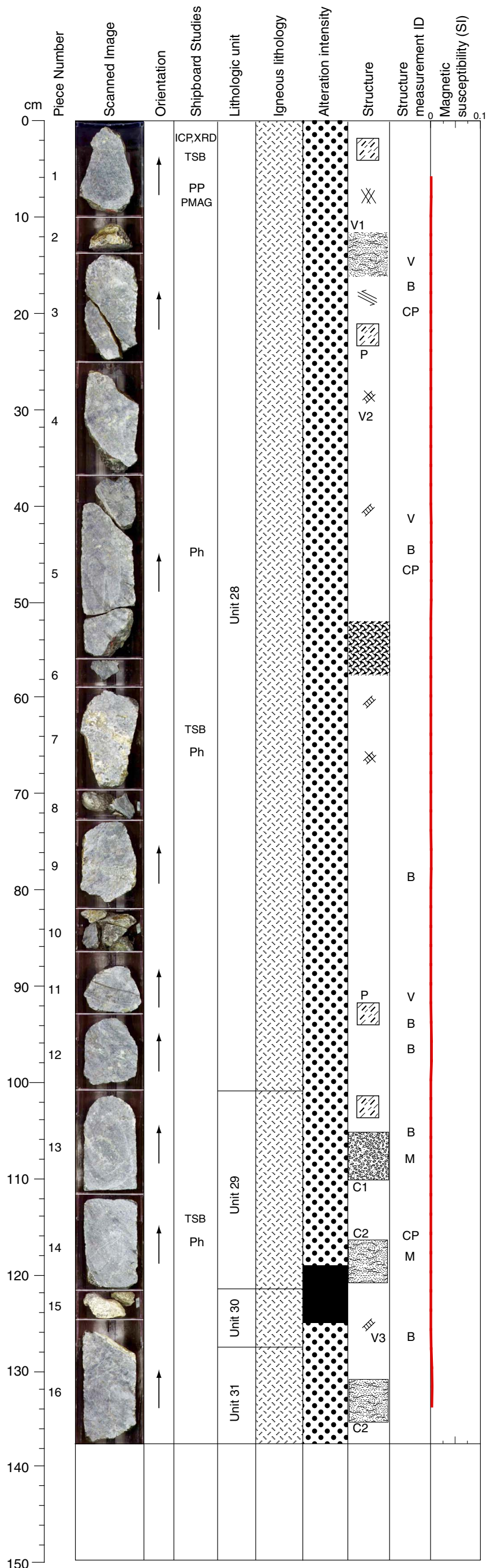
VEIN ALTERATION: An example of the green actinolite veins can be found at 6 cm.

STRUCTURE: A weak crystal plastic fabric dips gently toward two-hundred-seventy degrees (C). Thin green and white veins (V) follow grain boundaries and are in places cut by fine-grained, dark alteration minerals (A). C>V>A

CLOSE-UP PHOTOGRAPHS:
304-U1309B-9R-3, 0-12 cm BACKSIDE DRY CENTER OF CORE



Core Photo



304-1309B-10R-1 (Section top: 52.5 mbsf)

UNIT-28 : Gabbro
Pieces 1-12

PRIMARY MINERALOGY:

Plagioclase Modal 60%
 Size 3 – 12 mm
 Shape subhedral

Clinopyroxene Modal 40%
 Size 3-16 mm
 Shape subhedral

COMMENTS: Section 10R-1 starts as the continuation of the coarse grained gabbro of Unit 28. Olivine could be present in low modal percentages. Foliation is visible to 68 cm. A small, 4 mm-10 mm thick zone of cataclasis with angular plagioclase clasts in a greenish matrix occurs at 77 cm (Piece 9).

UNIT-29 : Cataclasitic gabbro
Pieces 13-14

PRIMARY MINERALOGY:

Olivine	Gabbro	Troctolite Modal 40% Size 3-5 mm Shape anhedral
Plagioclase	Modal 50% Size 1-4 mm Shape subhedral	Modal 60% Size 1-6 mm Shape anhedral
Clinopyroxene	Modal 50% Size 1-8 mm Shape anhedral	

COMMENTS: Unit 29 consists of cataclasitic gabbro with layers of troctolite.

UNIT-30 : Fault gouge
Pieces 15-16

PRIMARY MINERALOGY:
Too fine-grained to estimate.

COMMENTS: Unit 30 is a fault gouge of unknown protolith.

Unit 31 : Gabbro
Piece 16

PRIMARY MINERALOGY:

Plagioclase Modal 50%
 Size 4-15 mm
 Shape subhedral

Clinopyroxene Modal 50%
 Size 4-20 mm
 Shape subhedral

COMMENTS: Unit 31 consists of coarse-grained gabbro similar to the gabbro of Unit 28.

SECONDARY MINERALOGY: The core consists mainly of weakly altered gabbro. Plagioclase is fresh and pyroxene is locally altered to actinolite. Green actinolitic veins are also present. They are cut by yellow clay-bearing veins and by a yellow zone in Piece 15. Isolated pale green (probably actinolite) and yellow (possibly clay) patches occur locally in the core

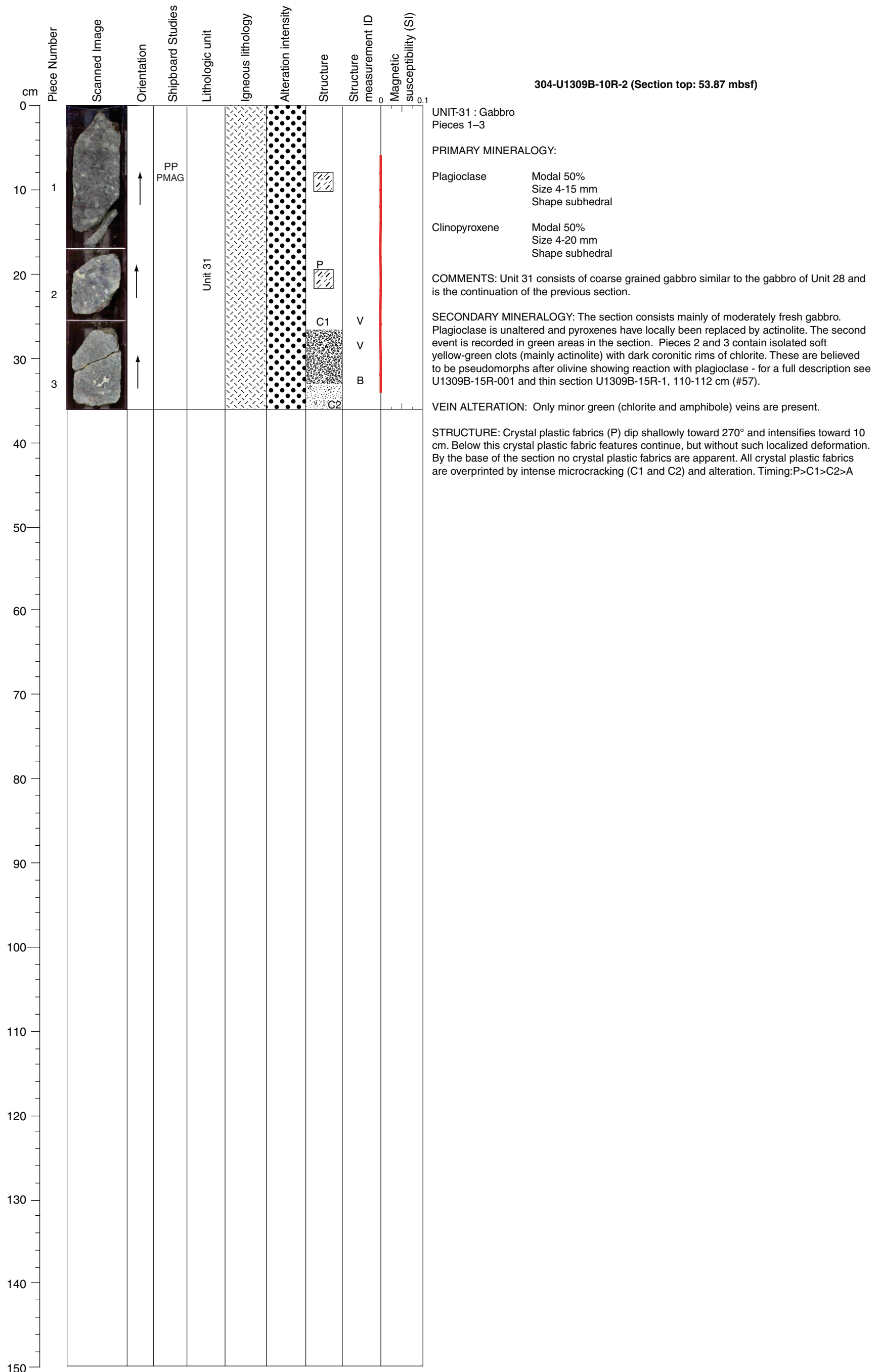
VEIN ALTERATION: An example of the green actinolite breccia veins occurs at 100-120 cm. An example of the yellow actinolite + clay type of alteration occurs at 65 cm.

THIN SECTIONS:
[304-U1309B-10R-1, 3-4 cm \(#39\)](#)
[304-U1309B-10R-1, 64-66 cm \(#40\)](#)
[304-U1309B-10R-1, 111-113 cm \(#41\)](#)

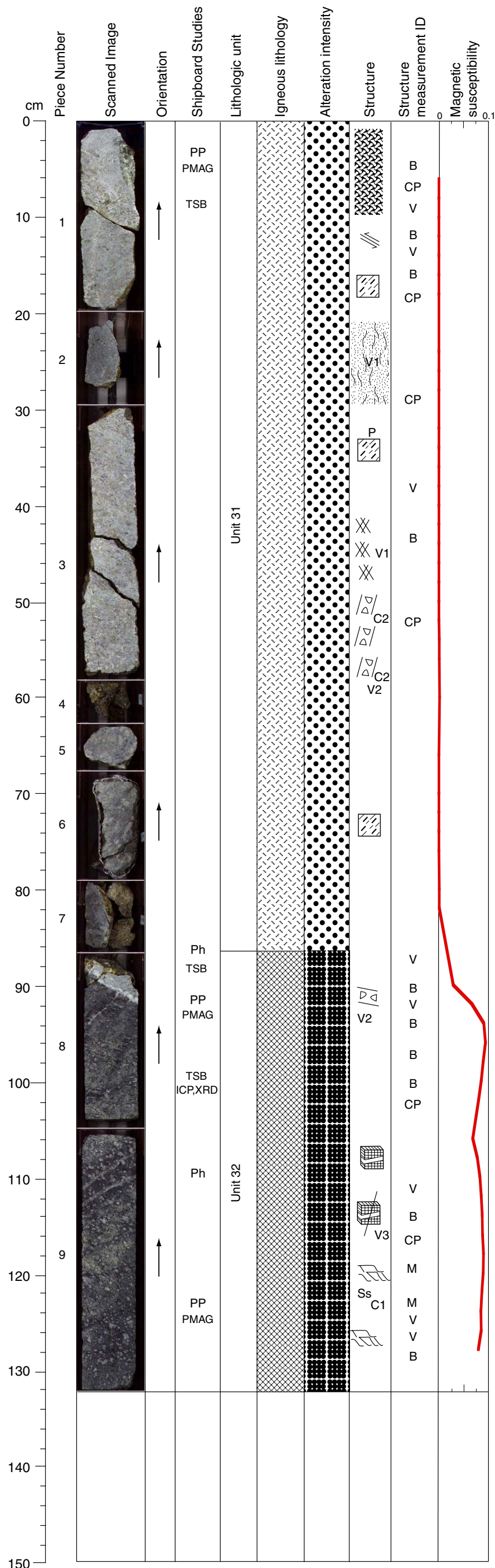
STRUCTURE: The top of core 10R-001 is a type example of where microcracking (C1) imparts a fabric that, in hand sample, appears similar to a crystal plastic fabric. In fact, crystal plastic strain (P) is weak except for some stretched grains between 10 cm and 30 cm, including a reverse-sense (SOS) shear zone at roughly twenty cm (indicators include microfolds and asymmetric shapes). Green veins (V1) cut the crystal plastic fabrics, although they (coincidentally?) attain a Riedel orientation near the shear zone. Several vein types occur throughout the core with internal structures and surrounding alteration zones. Two noteworthy types are an internally textured and thick brown vein roughly 65 cm (V2) and a partly cataclastic vein (C2) roughly 126 cm (possibly a fault zone). Surrounding the vein/fault at 126 cm white veins impart a web-like texture to the gabbro (V3). Timing: P>C1>V1>V2>C2>V3



Core Photo



Core Photo



304-U1309B-11R-1 (Section top: 57.0 mbsf)

UNIT-31 : Gabbro
Pieces 1-7

PRIMARY MINERALOGY:

Plagioclase Modal 50%
 Size 1-7 mm
 Shape subhedral

Clinopyroxene Modal 50%
 Size 1-10 mm
 Shape subhedral

COMMENTS: Section 11R-1 starts with the continuation of coarse-grained gabbro from Unit 31.

UNIT-32 : Harzburgite
Pieces 8-9

PRIMARY MINERALOGY:

Olivine Modal 75%
 Size too altered

Orthopyroxene Modal 22 %
 Size 4 mm
 Shape rounded

Spinel Modal <1%
 Size <1 mm
 Shape equant-interstitial

COMMENTS: This unit consists of a protogranular harzburgite that is in direct contact with the gabbro from Unit 31. Both are separated by a millimeter-wide whitish talc-tremolite-carbonate zone that intrudes further into the peridotite along cracks. Two further narrow dikes crosscut the harzburgite at 109 cm and 111 cm. Texturally, a 2 cm wide reaction zone away from the contact is visible with different style in serpentinization and pyroxenes with magmatic textures.

SECONDARY MINERALOGY: The upper part of this section consists of gabbro that shows various degrees of alteration. Plagioclase is fresh and pyroxenes are partially altered to actinolite. Below 90 cm the core consists of harzburgite that variably serpentinized. Some areas are almost unaltered, but most of the section is 90-100% serpentinized. The contact between the gabbro and peridotite is marked by 2 cm wide pale green zone that contains aragonite (?) veinlets, tremolite, chlorite and talc.

VEIN ALTERATION: Veins are not abundant in the core. A green vein, probably tremolite bearing, cuts serpentinite at 92 cm and two talc-bearing veins cut serpentinite at 109 cm and 111 cm.

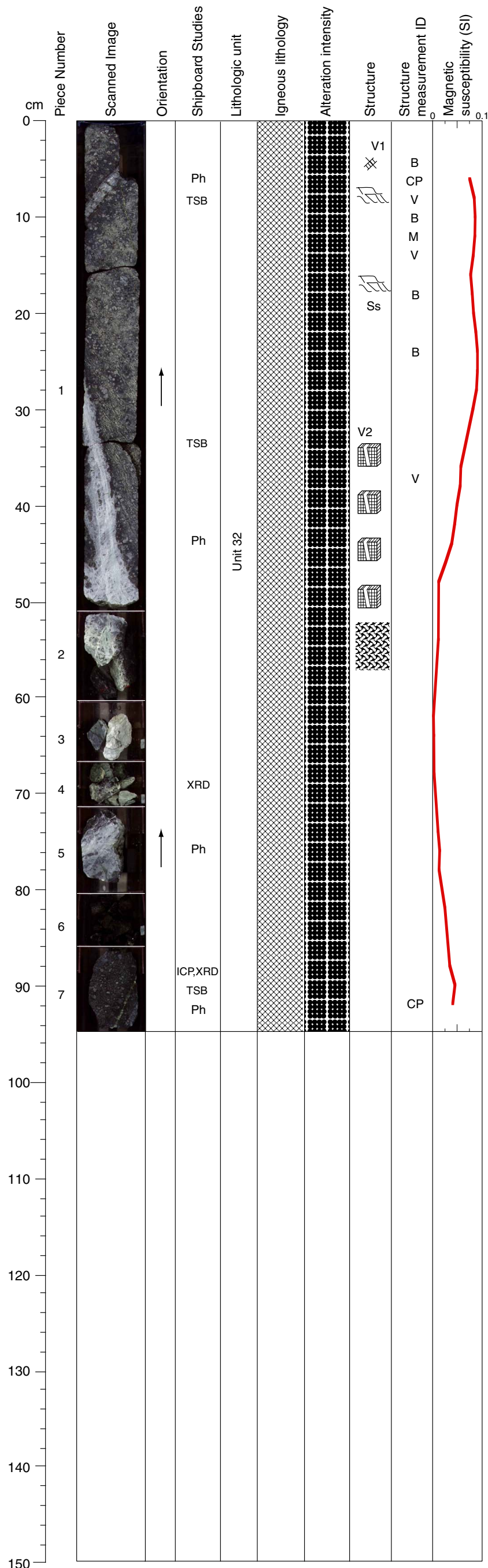
THIN SECTIONS:
304-U1309B-11R-1, 7-10 cm (#42)
304-U1309B-11R-1, 87-90 cm (#43)
304-U1309B-11R-1, 98-100 cm (#44)

STRUCTURE: Three horizons of crystal plastic fabric (P): at roughly 10 cm a shear zone with reverse-sense indicators (microfolds and asymmetric grains are indicators), a weak foliation near 36 cm, and a very weak fabric near 76 cm - all dip toward 270°. Several veins and vein networks are intergranular and associated with more widespread alteration (V1), although others cross grains (V2). (note: a report of prehnite at ca. six cm). At roughly 54 cm there are small, fractured quartz grains (C2) associated with veins. At 90 cm is the contact with serpentinite. The contact is "milky" white and green with micro-veins filled with green and brown minerals. Below the contact is the serpentinite mesh texture (Ss). The texture is named for veins of serpentine that anastomose and intertwine with one another - in this section dipping toward 270°. Local cataclasis and brecciation (C1) is associated with the mesh texture, although there are no shear-bands or other indicators of non-coaxial strain present. Two blue veins (V3) crosscut the mesh texture at one-hundred and twelve cm and dip gently toward ninety degrees. Timing: Gabbros: P>V1>V2=C2; Serpentinite: Ss=C1>V3

CLOSE-UP PHOTOGRAPHS:
304-U1309B-11R-1, 0-12 cm WET
304-U1309B-11R-1, 48-52 cm WET
304-U1309B-11R-1, 86-96 cm WET
304-U1309B-11R-1, 104-124 cm WET
304-U1309B-11R-1, 106-112 cm WET



Core Photo



304-U1309B-11R-2 (Section top: 58.50 mbsf)

UNIT-32 : Harzburgite
Pieces 1-7

PRIMARY MINERALOGY:
Harzburgite

- Olivine Modal 75%
 Size too altered
 Shape too altered
- Orthopyroxene Modal 22 %
 Size 4 mm
 Shape equant
- Spinel Modal <1%
 Size <1-2 mm

COMMENTS: Section 11R-2 continues the protogranular harzburgite from 11-R1. The unit continues to 79 cm with a fault zone between 60 cm and 70 cm. At 43 cm (Piece 10) two closely spaced dikes with diffuse to interfingering contacts crosscut the core with a maximum alteration width of 50 mm.

SECONDARY MINERALOGY: The section consists of heavily serpentinized peridotite. Locally a few primary olivine grains remain. Evidence of pyroxene, probably mostly orthopyroxene, is preserved as bastites and talc-magnetite pseudomorphs. magnesite is locally present replacing microlithons in serpentine ribbon texture (thin section at 32 cm). Talc-tremolite alteration is described below.

VEIN ALTERATION: Between 30 cm and 70 cm the serpentinite is cut by a spectacular steeply dipping pale green vein of tremolite and talc with a schistose texture and reverse sense shear on talc layers (visible in thin section). Where the margins of the vein are preserved, an undeformed talc reaction zone lies between the tremolite vein and host serpentinite. Bastites (serpentine + magnetite) are preserved within the reaction zone but pyroxenes outside the reaction zone are often pseudomorphed by talc + magnetite giving "pseudoschistose" textures. The talc tremolite vein roots in a poorly recovered interval containing highly altered gabbro, serpentinite, and tremolite schist, possibly a fault zone in mafic rocks.

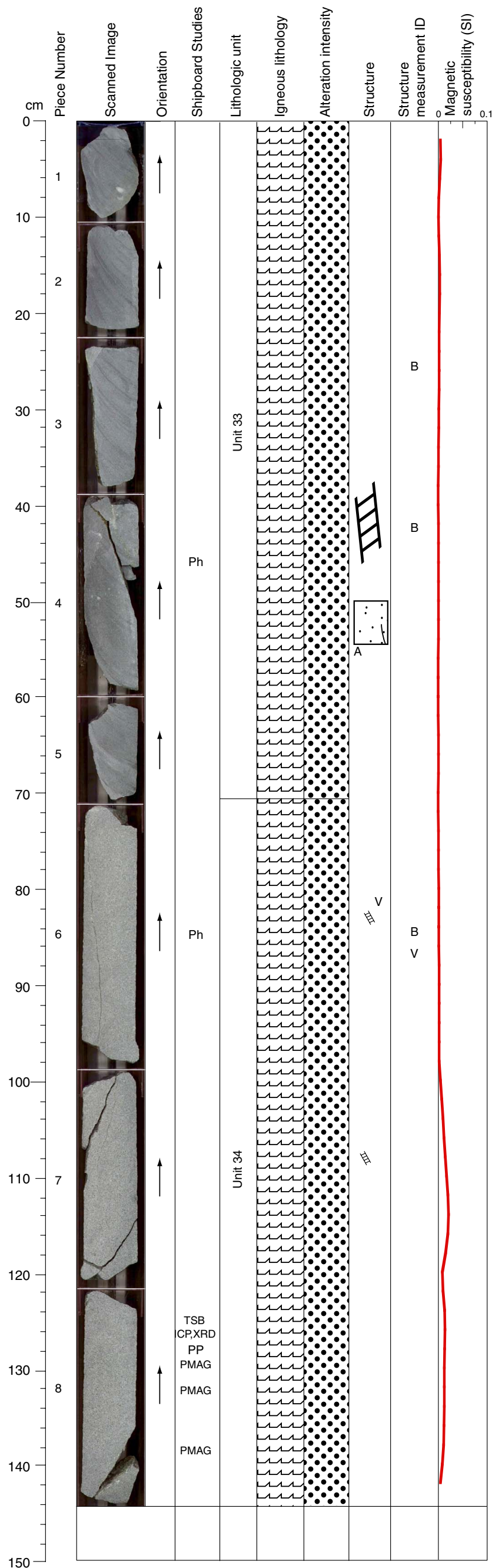
THIN SECTIONS:
[304-U1309B-11R-2, 8-10 cm \(#45\)](#)
[304-U1309B-11R-2, 32-34 cm \(#46\)](#)
[304-U1309B-11R-2, 88-90 cm \(#47\)](#)

STRUCTURE: Classic serpentine mesh texture (Ss) inclined shallowly toward 270°. Cut by local cross-veins (V1), and several wide, composite veins (V2) with carbonate rims (locally). Alteration zone along vein boundaries, and cross-fractures cut across the veins.
Ss>V1>V2

CLOSE-UP PHOTOGRAPHS:
 304-U1309B-11R-2, 0-15 cm WET
 304-U1309B-11R-2, 25-50 cm WET
 304-U1309B-11R-2, 72-79 cm WET
 304-U1309B-11R-2, 88-94 cm DRY
 304-U1309B-11R-2, 88-94 cm WET



Core Photo



304-U1309B-12R-1 (Section top: 61.60 mbsf)

UNIT-33 : Micro-diabase
Pieces 1-5

PRIMARY MINERALOGY:
Too fine-grained to estimate.

COMMENTS: The section begins with a very sparsely plagioclase-phyric micro-diabase. A narrow 3 mm wide dike transects at 40 cm almost parallel to the core edges. The dike consists of less than 1 mm large euhedral plagioclase crystals that grow from the dike walls in an actinolite matrix. A train of anhedral olivine phenocrysts of varying size (1-3 mm) is located at 49 cm.

UNIT-34 : Oxide-diabase
Pieces 6-8

PRIMARY MINERALOGY:

- Olivine Modal 5%
 Size <1 mm
 Shape anhedral
- Plagioclase Modal 45%
 Size 0.5-2 mm
 Shape subhedral
- Clinopyroxene Modal 43%
 Size too altered
 Shape anhedral
- Oxides Modal 7%
 Size 0.5 mm
 Shape equant

COMMENTS: Unit 34 consists of medium-grained diabase with ophitic texture. The diabase contains pyroxene-rich domains and finely dispersed magnetite in the matrix.

SECONDARY MINERALOGY: Plagioclase laths in this section are unaltered whereas pyroxenes are partially replaced by actinolite (50% replaced in thin section at 122-125 cm).

VEIN ALTERATION: A few green actinolite veins are present in the section.

THIN SECTIONS:

304-U1309B-12R-1, 122-125 cm (#48)

STRUCTURE: Oriented diabase/basalt with grain size finning on each side of the lithologic interval. At 40 cm and 52 cm there are minor veins and mineral "seams" (A). A vertically dipping 0.5 cm wide green vein (V) occurs at 74 cm, and continues into the lower pieces of the section.

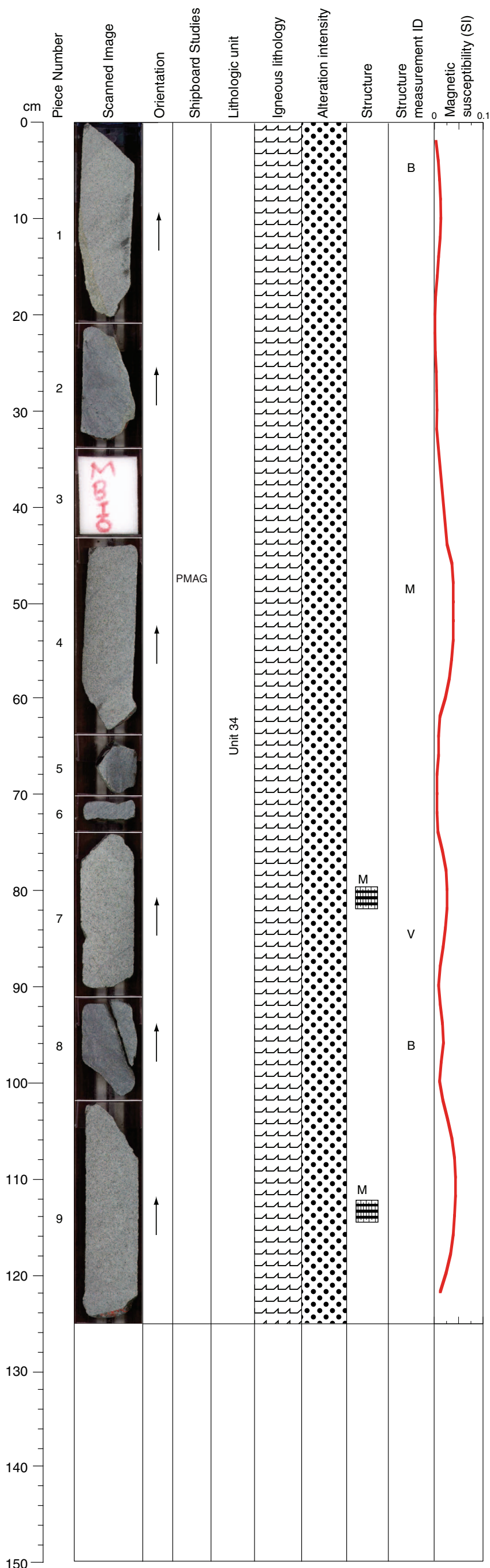
CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-12R-1, 40-46 cm DRY
- 304-U1309B-12R-1, 40-46 cm WET
- 304-U1309B-12R-1, 75-90 cm WET
- 304-U1309B-12R-1, 75-90 cm DRY BACKSIDE



Core Photo

304-U1309B-12R-2 (Section top: 63.04 mbsf)



UNIT-34 : Oxide-diabase
Pieces 1-9

PRIMARY MINERALOGY:

- Olivine Modal 5%
 Size <1 mm
 Shape anhedral
- Plagioclase Modal 45%
 Size 0.5-2 mm
 Shape subhedral
- Clinopyroxene Modal 43%
 Size too altered
 Shape anhedral
- Oxides Modal 7%
 Size 0.5 mm
 Shape equant

COMMENTS: Section 12R-2 is the continuation of the medium-grained oxide diabase with ophitic texture of the previous section. A train of anhedral olivine transects the core at 29 cm.

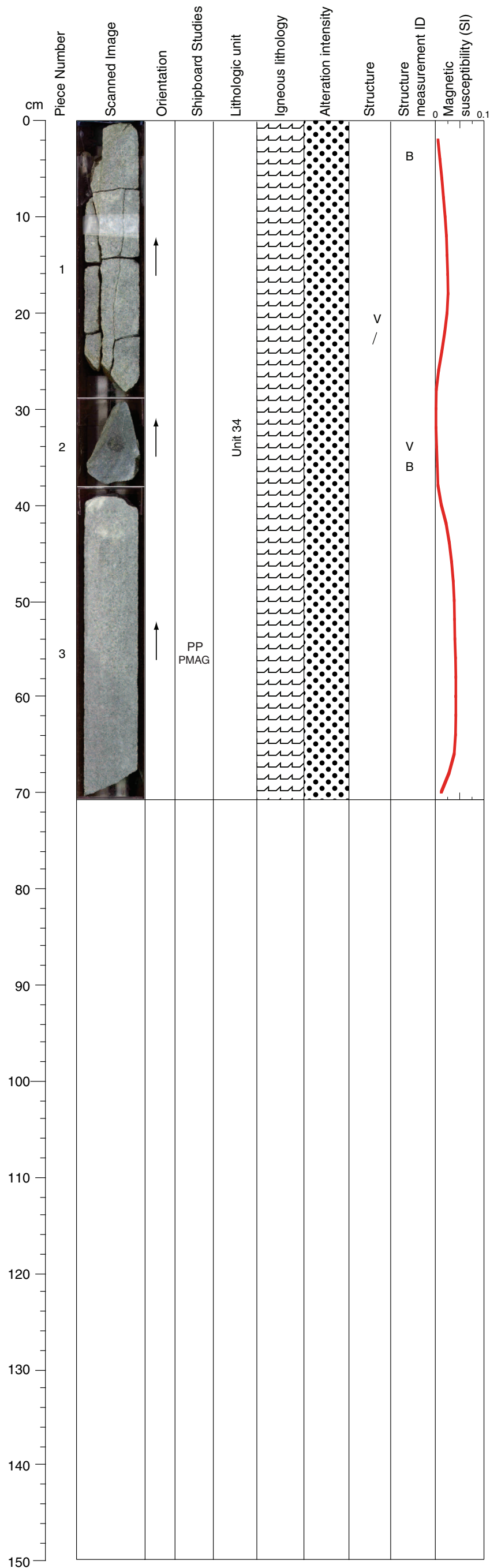
SECONDARY MINERALOGY: The section consists of moderately altered diabase. Plagioclase laths are fresh but the pyroxenes are partially altered to actinolite. Chlorite is scarce.

VEIN ALTERATION: There are no veins.

STRUCTURE: Diabase (and basaltic) intrusive, with a weak magmatic (M) fabric (layer of altered olivine crystals) and one poorly defined vein.



Core Photo



304-U1309B-12R-3 (Section top: 64.29 mbsf)

UNIT-34 : Oxide-diabase
Pieces 1-3

PRIMARY MINERALOGY:

- Olivine Modal 5%
 Size <1 mm
 Shape anhedral
- Plagioclase Modal 45%
 Size 0.5-2 mm
 Shape subhedral
- Clinopyroxene Modal 43%
 Size too altered
 Shape anhedral
- Oxides Modal 7%
 Size 0.5 mm
 Shape equant

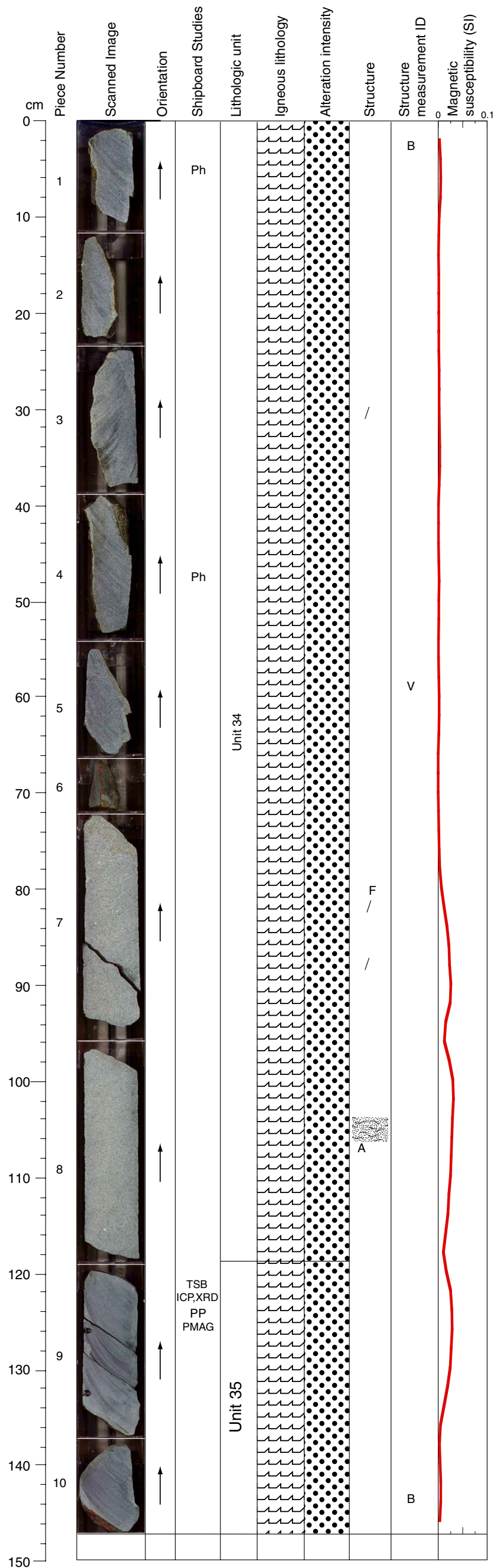
COMMENTS: Section 12R-3 is the continuation of the medium-grained oxide diabase with ophitic texture of the previous section.

SECONDARY MINERALOGY: The section consists of fine grained diabase that shows moderate amounts of alteration. Plagioclase is unaltered. The pyroxenes have altered to varying extent to actinolite. Chlorite is not common.

VEIN ALTERATION: There is a single, vertical vein that runs from 10 to 30 centimeters in the section, and contains chlorite with albitized margins.

STRUCTURE: Drilling induced fractures and one poorly defined vein (V) with altered margins have a sub-vertical dip.

Core Photo



304-U1309B-13R-1 (Section top: 66.10 mbsf)

UNIT-34 : Oxide diabase
Pieces 1-8

PRIMARY MINERALOGY:

- Olivine Modal 5%
 Size <1 mm
 Shape anhedral
- Plagioclase Modal 45%
 Size 0.5-2 mm
 Shape subhedral
- Clinopyroxene Modal 43%
 Size too altered
 Shape anhedral
- Oxides Modal 7%
 Size 0.5 mm
 Shape equant

COMMENTS: Section 13R-1 is the continuation of the medium-grained oxide diabase with subophitic texture from Unit 34 of the previous three sections. Trains of anhedral olivine become more frequent towards the bottom of the unit at 77 cm, 83 cm, 90 cm, 110 cm, and 113 cm.

UNIT-35 : Micro-diabase
Pieces 9-10

PRIMARY MINERALOGY:

- Plagioclase Modal 55%
 Size 0.1-2 mm
 Shape subhedral
- Clinopyroxene Modal 40%
 Size 0.1-1 mm
 Shape anhedral
- Oxides Modal 5%
 Size 0.1-0.5 mm
 Shape equant

COMMENTS: Unit 35 consists of fine-grained diabase with very sparse, euhedral plagioclase phenocrysts of 2 mm size.

SECONDARY MINERALOGY: This section consists entirely of moderately altered diabase. Plagioclase laths are fresh. Pyroxene is variably altered to actinolite.

VEIN ALTERATION: Apart from a few vertical fractures near the top of the section coated with brown oxidation, there are no veins. The fractures have oxidized brown halos up to 2 cm wide.

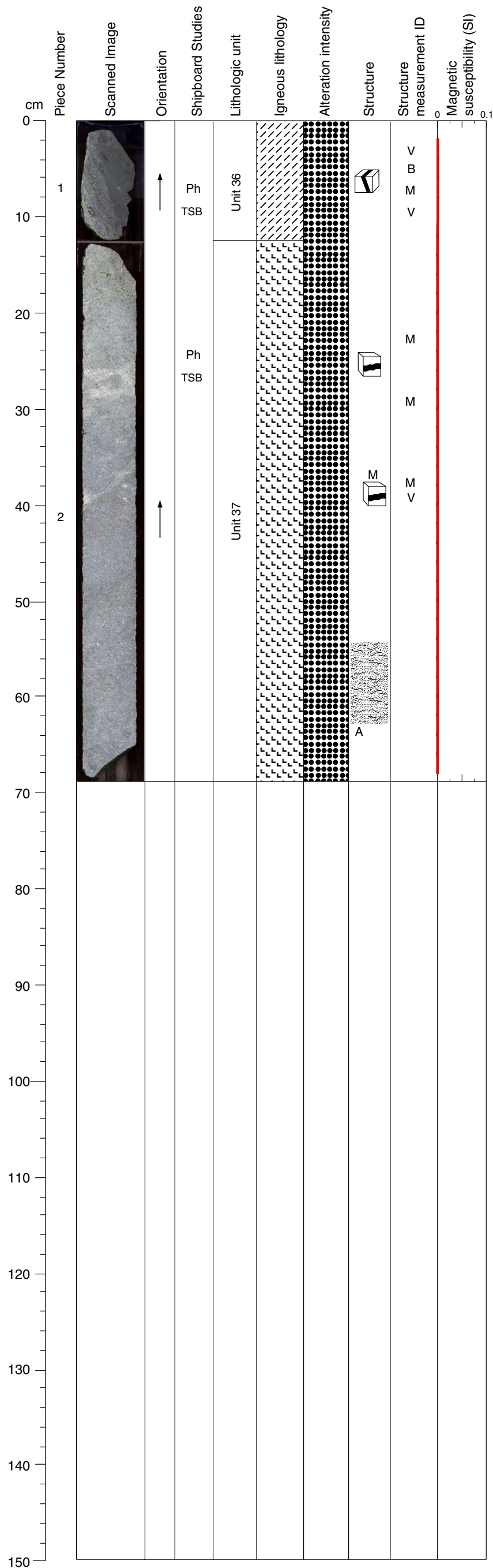
THIN SECTIONS:
304-U1309B-13R-1, 120-121 cm (#49)

STRUCTURE: Four to five white fractures (F) and one dark mineral seam (A). A weak alteration fabric dips shallowly towards 270°.

CLOSE-UP PHOTOGRAPHS:
304-U1309B-13R-1, 0-12 cm WET
304-U1309B-13R-1, 40-60 cm WET



Core Photo



304-U1309B-13R-2 (Section top: 67.56 mbsf)

UNIT-36 : Sparsely plagioclase-phyric basalt
Piece 1

PRIMARY MINERALOGY:
Too fine-grained to estimate.

COMMENTS: Unit 36 consists of fine-grained, sparsely plagioclase-phyric basalt.

UNIT-37 : Troctolitic gabbro
Piece 2

PRIMARY MINERALOGY:

Plagioclase Modal 60%
 Size 0.2 - 4 mm
 Shape subhedral - anhedral

Olivine Modal 25%
 Size 0.2 - 4 mm
 Shape anhedral

Clinopyroxene Modal 15%
 Size 0.2 - 4 mm
 Shape anhedral

COMMENTS:

In contact with the basalt from Unit 36 is a troctolitic gabbro with medium grain size. It crosscut by diffuse and pervasive anorthositic dikes at 25 cm, 43 cm, 53 cm, and 55 cm. The first and the latter two dikes are subhorizontal.

SECONDARY MINERALOGY: This core contains contains fresh plagioclase, apart from local milky secondary plagioclase near veins, but the pyroxenes are almost entirely altered to actinolite.

VEIN ALTERATION: The rock contains green actinolite veins (1-2 %), particularly in Pieces 1 and 2. Some veins are rimmed by albite.

THIN SECTIONS:

- 304-U1309B-13R-2, 9-10 cm (#50)
- 304-U1309B-13R-2, 23-26 cm (#51)

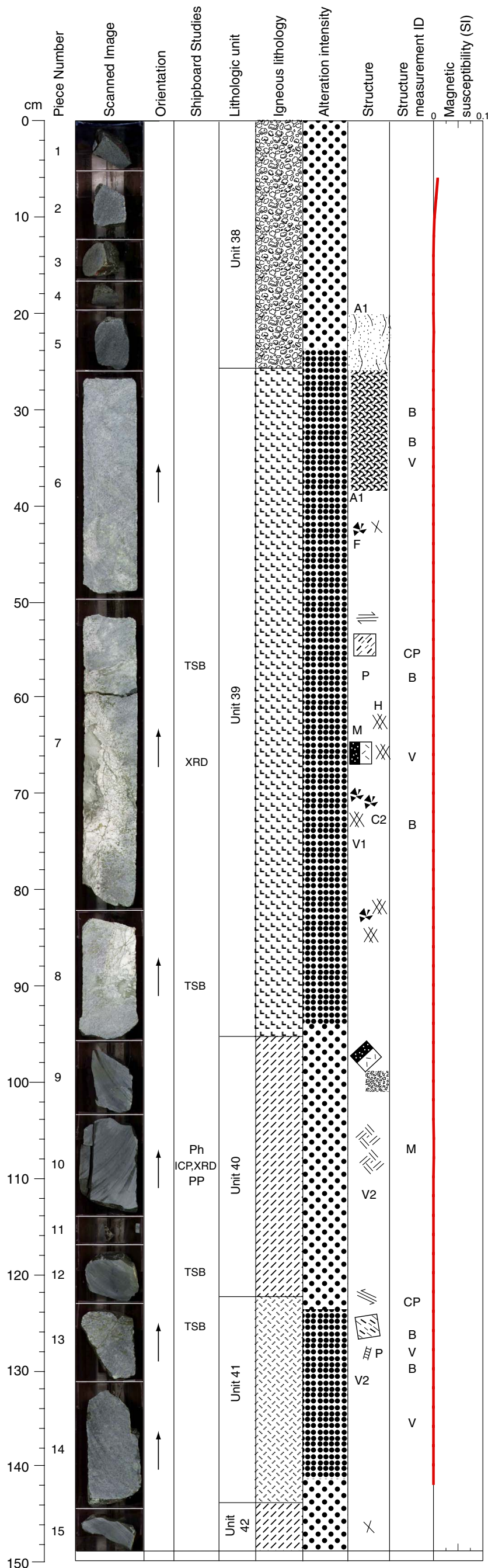
STRUCTURE: Intrusive contact of fine-grained basalt against gabbro, dips steeply toward 270°. Gabbro contains interconnected white veins (magmatic) (M), dipping slightly to 90°. Penetrative networked chlorite alteration (A).

CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-13R-2, 2-12 cm WET
- 304-U1309B-13R-2, 24-30 cm WET



Core Photo



304-U1309B-14R-1 (Section top: 71.10 mbsf)

UNIT-38 : Mixed rubble
Pieces 1-5

PRIMARY MINERALOGY:
COMMENTS: Unit 38 consists of mixed rubble presumed to be out of place.
Piece 1-2; 5: fine-grained diabase
Piece 3-4: medium-grained diabase with moderate alteration

UNIT-39 : Troctolitic gabbro
Pieces 6-8

PRIMARY MINERALOGY:

Olivine	Modal 40%
	Size 1 mm
	Shape anhedral
Plagioclase	Modal 50%
	Size 4 mm
	Shape anhedral
Clinopyroxene	Modal 10%
	Size 3 mm
	Shape anhedral
Sulfides	Modal <1%

COMMENTS: Unit 39 consists of medium-grained troctolitic gabbro. Few oxides and relatively abundant sulfides are disseminated in the matrix. Between 41 cm and 90 cm (Pieces 6-8), an intensively altered area occurs at the edge of the core. Here, a zone or former cavity with wavy outlines of tremolite surrounded by a white rim composed of plagioclase. At the contact, a partly brecciated zone appears. At 55 cm, a shear zone occurs and is crosscut perpendicular by the feature described above.

UNIT-40 : Plagioclase phyric basalt
Pieces 9-12

PRIMARY MINERALOGY:

Plagioclase	Modal < 1%
	Size 20 mm
	Shape euhedral
Olivine	Modal Trace
	Size 0.5 mm
	Shape anhedral
Clinopyroxene	Modal Trace
	Size 0.5 mm
	Shape rounded

COMMENTS: Unit 40 consists of an aphyric to moderately plagioclase-phyric (outside Piece 10, modal content 2%) basalt. A single euhedral plagioclase phenocryst is 20 mm long. A cataclastic zone with angular plagioclase clasts continues downhole to Piece 9. Hydrothermal alteration has affected the samples and changed the color to green.

UNIT-41 : Gabbro
Pieces 13-14

PRIMARY MINERALOGY:

Plagioclase	Modal 60%
	Size < 3 mm
	Shape subhedral
Clinopyroxene	Modal 40%
	Size 0.5 - 6 mm
	Shape subhedral
Sulfides	Modal <1%

COMMENTS: Unit 41 consists of coarse-grained gabbro that is affected by crystal-plastic deformation.

UNIT-42 : Basalt
Piece 15

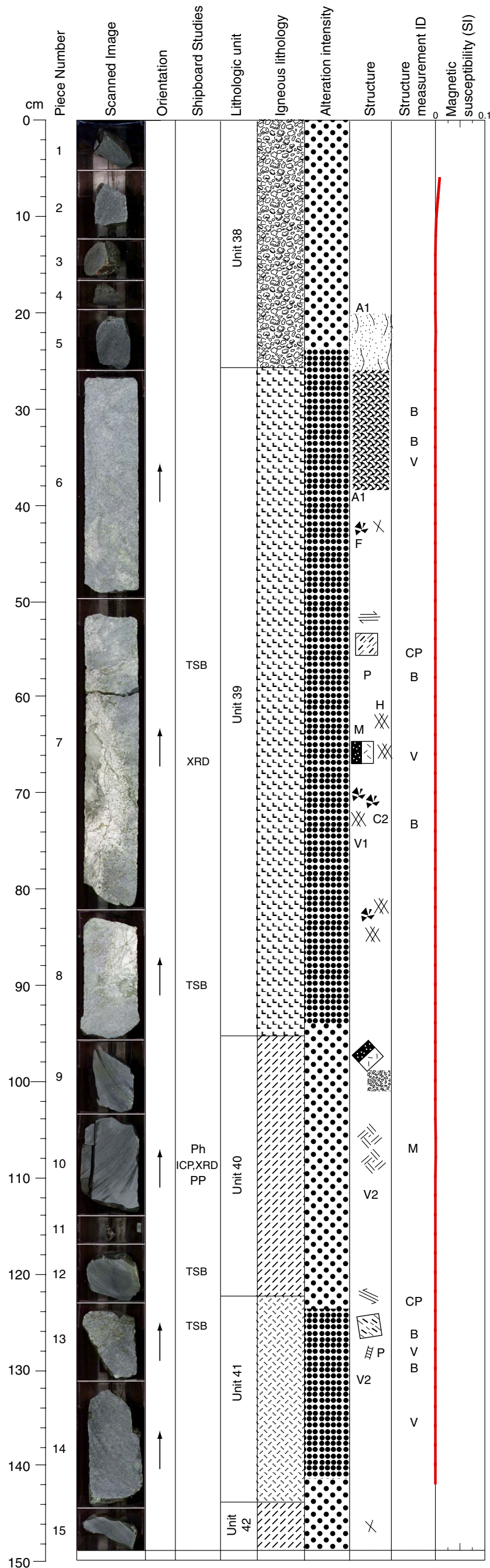
PRIMARY MINERALOGY:
Too fine-grained to estimate.

COMMENTS: Unit 42 consists of aphyric to sparsely plagioclase-phyric basalt similar to Unit 40 but with smaller phenocryst sizes.

SECONDARY MINERALOGY: The ferromagnesian phases in the gabbro and basalt are strongly altered to actinolite. Plagioclase appears to be fresh. Coronitic textures with actinolite (+/- talc) rimmed by chlorite represent reaction of olivine with plagioclase, and are sparsely developed in Units 39 and 41. Intense hydrothermal alteration is present between 60 cm and 90 cm. A green patch on the side of the core is composed mainly of actinolite with traces of clay (XRD). A similar, darker patch at 90 cm is composed of actinolite with relict clinopyroxene (thin section). The patches are mantled by an anorthositic zone which appears to be an igneous intrusion since it truncates high temperature ductile fabrics in the gabbro at 57 cm (thin section). The anorthositic patch is milky within 1 cm of the patches due to alteration to turbid albite full of soild and fluid inclusions with actinolite sprays along grain boundaries. The precise origin of the actinolite patches is unclear, but they clearly enjoyed significant flow of hydrothermal fluid.



Core Photo



304-U1309B-14R-1 (continued) (Section top: 71.10 mbsf)

VEIN ALTERATION: Veins with chlorite and actinolite are common in the gabbro but absent in the diabase.

- THIN SECTIONS:
 304-U1309B-14R-1, 55-58 cm (#52)
 304-U1309B-14R-1, 89-91 cm (#53)
 304-U1309B-14R-1, 118-119 cm (#54)
 304-U1309B-14R-1, 123-126 cm (#55)

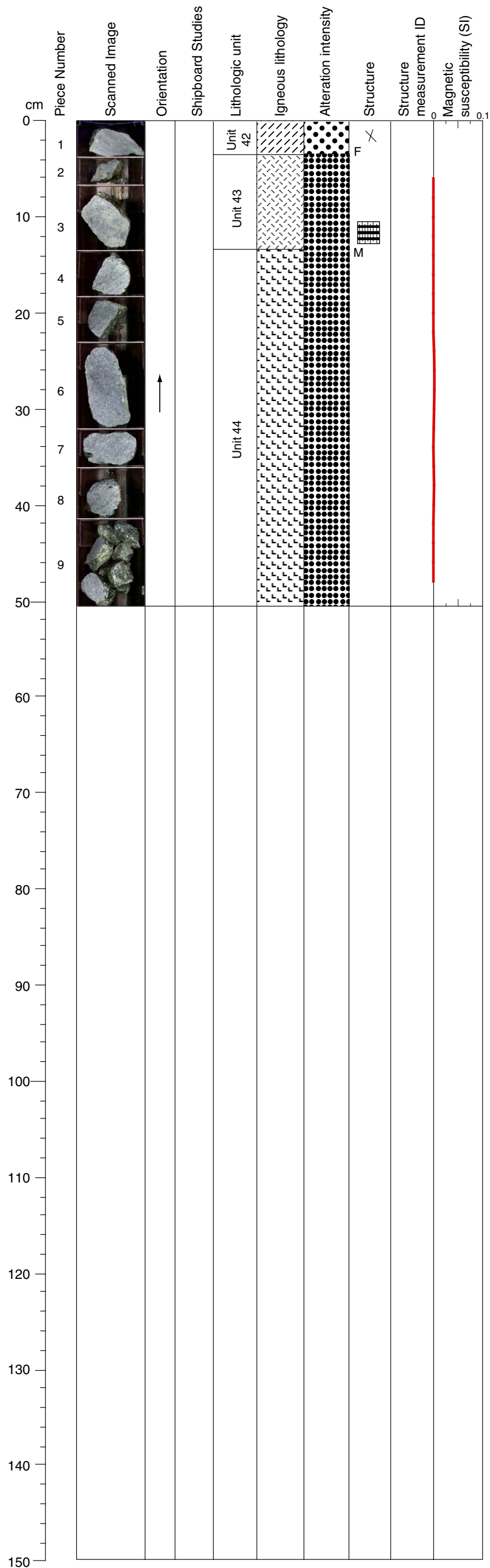
STRUCTURE: Mixed basaltic and gabbroic lithologies are evidence for a protracted intrusive history in this section. Basalts are clearly younger, with late white conjugate fractures (F) and an earlier white-green anastomosing vein network (A). In one place the basalt contains a clast (magmatically included) that has an internal (early) cataclastic texture (C1, not shown). The gabbros have three crystal plastic zone (P) one with a reverse sense. The crystal plastic zones are cut by green, planar veins (V2). The veins are associated with local cataclasis (C2). Complicating the veins and cataclasis is a local intrusive contact (M) with basalt surrounded by hydrothermal alteration (H), including dark, sinuous vein networks (V1).
 Timing: P>C1>M>H>V1>C2>V2>F

Note that Piece 8 was exchanged with the working half (because the alteration zones did not match up) after the photo was taken.

- CLOSE-UP PHOTOGRAPHS:
 304-U1309B-14R-1, 52-72 cm WET
 304-U1309B-14R-1, 60-76 cm WET
 304-U1309B-14R-1, 103-112 cm WET
 304-U1309B-14R-1, 104-113 cm WET-WORKING HALF
 304-U1309B-14R-1, 123-126 cm WET



Core Photo



304-U1309B-14R-2 (Section top: 72.60 mbsf)

UNIT-42 : Basalt
Piece 1

PRIMARY MINERALOGY:
Too fine-grained to estimate.

COMMENTS: A single piece of basalt completes Unit 42.

UNIT-43 : Gabbro
Pieces 2-3

PRIMARY MINERALOGY:

Plagioclase Modal 50%
 Size 10 mm
 Shape subhedral

Clinopyroxene Modal 50%
 Size 10 mm
 Shape subhedral

COMMENTS: Unit 43 consists of coarse-grained gabbro.

UNIT-44 : Troctolitic gabbro
Pieces 4-9

PRIMARY MINERALOGY:

Olivine Modal 25%
 Size 1 mm
 Shape anhedral

Plagioclase Modal 65%
 Size 2 mm
 Shape subhedral

Clinopyroxene Modal 10%
 Size 2 mm
 Shape subhedral

COMMENTS: Unit 44 consists of medium-grained, troctolitic gabbro with well-developed corona texture caused by dark chlorite rims around relict olivine. A foliation is developed in all samples.

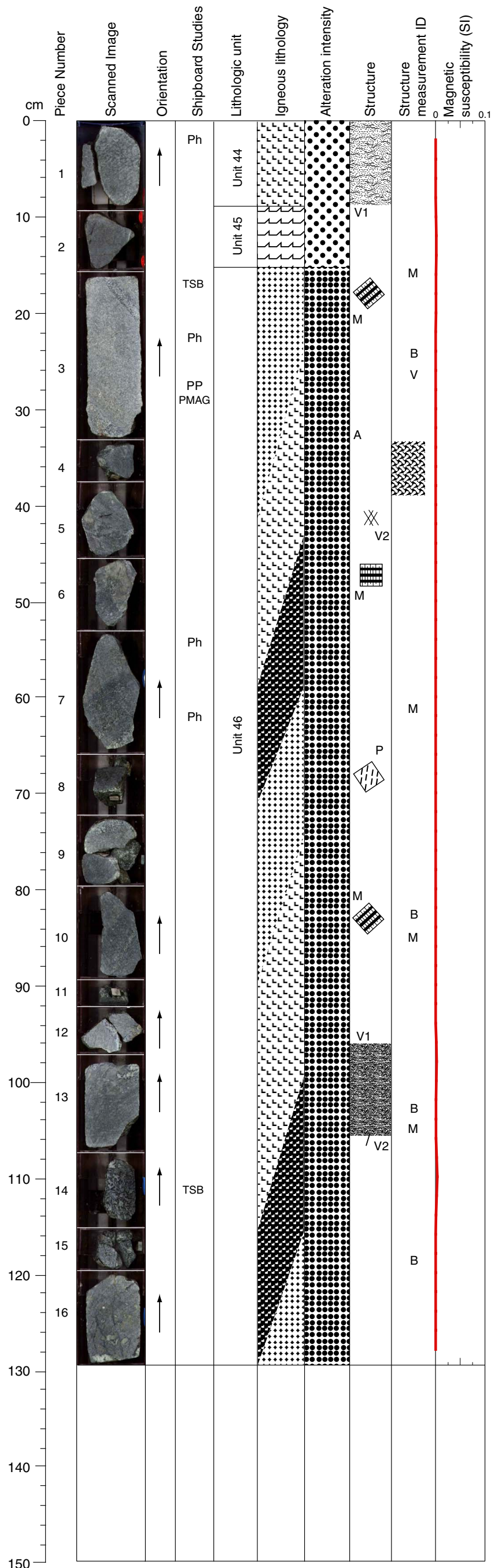
SECONDARY MINERALOGY: Plagioclase in the gabbro and diabase is fresh but the pyroxenes have mostly altered to actinolite. Actinolite-chlorite (+/- talc) corona textures after olivine are present.

VEIN ALTERATION: Apart from a few actinolite veins in Piece 3 veins are absent from the core.

STRUCTURE: Perhaps slightly flattened magmatic texture (M) and two or three white and green crossing fractures (F) (white cuts green) are the only structural features in this rock.



Core Photo



304-U1309B-15R-1 (Section top: 75.60 mbsf)

UNIT-44 : Troctolitic gabbro
Piece 1

PRIMARY MINERALOGY:

Olivine Modal 25%
Size 1 mm
Shape anhedral

Plagioclase Modal 65%
Size 2 mm
Shape subhedral

Clinopyroxene Modal 10%
Size 2 mm
Shape subhedral

COMMENTS: Unit 44 continues from Section 14R-2.

UNIT-45 : Diabase
Piece 2

PRIMARY MINERALOGY:
Too fine-grained to estimate.

COMMENTS: Unit 45 consists of medium-grained diabase with subophitic texture.

UNIT-46 : Layered troctolite and olivine-gabbro
Pieces 3-16

PRIMARY MINERALOGY:

Mineral	Olivine-gabbro	Troctolitic gabbro (Piece 3)	Troctolite (Piece 14)
Olivine	Modal 35%	Modal 15%	Modal 40%
	Shape anhedral	Shape anhedral	Shape anhedral
Plagioclase	Modal 60%	Modal 65%	Modal 60%
	Size 3-6 mm	Size 0.5 - 2 mm	Size 5-10 mm
	Shape subhedral	Shape subhedral-anhedral	Shape anhedral
Clinopyroxene	Modal 3%	Modal 20%	
	Size 3-20 mm	Size 0.5 - 2 mm	
	Shape anhedral	Shape anhedral	

COMMENTS: The whole section is heterogeneous in grain size and modal composition. Layers of olivine gabbro, troctolitic gabbro and troctolite occur with generally gradational contacts. Corona texture is widespread throughout the section. Piece 6 contains an intrusive contact between coarse- and medium-grained gabbro. Piece 10 contains alternating olivine-rich and plagioclase-rich layers. Grain sizes increase downhole. Piece 16 is very coarse-grained with poikilitic clinopyroxene as large as 20 mm.

SECONDARY MINERALOGY: Plagioclase is fresh in the gabbro and slightly altered by reaction with the olivine in the troctolite. Pyroxene is locally altered to actinolite. Corona textures spectacularly developed in Piece 14 and are present throughout the troctolitic units. In thin section the sequence of zones olivine - talc+magnetite - tremolite/actinolite (or sometimes cummingtonite) - chlorite - plagioclase is seen. Pyroxene and plagioclase show little or no mutual reaction. Where olivine is no longer present, talc is not usually seen, presumably because of continued reaction to amphibole and chlorite.

VEIN ALTERATION: A few chlorite-bearing veins are present, they have no halos.

THIN SECTIONS:

- 304-U1309B-15R-1, 16-17 cm (#56)
- 304-U1309B-15R-1, 110-112 cm (#57)

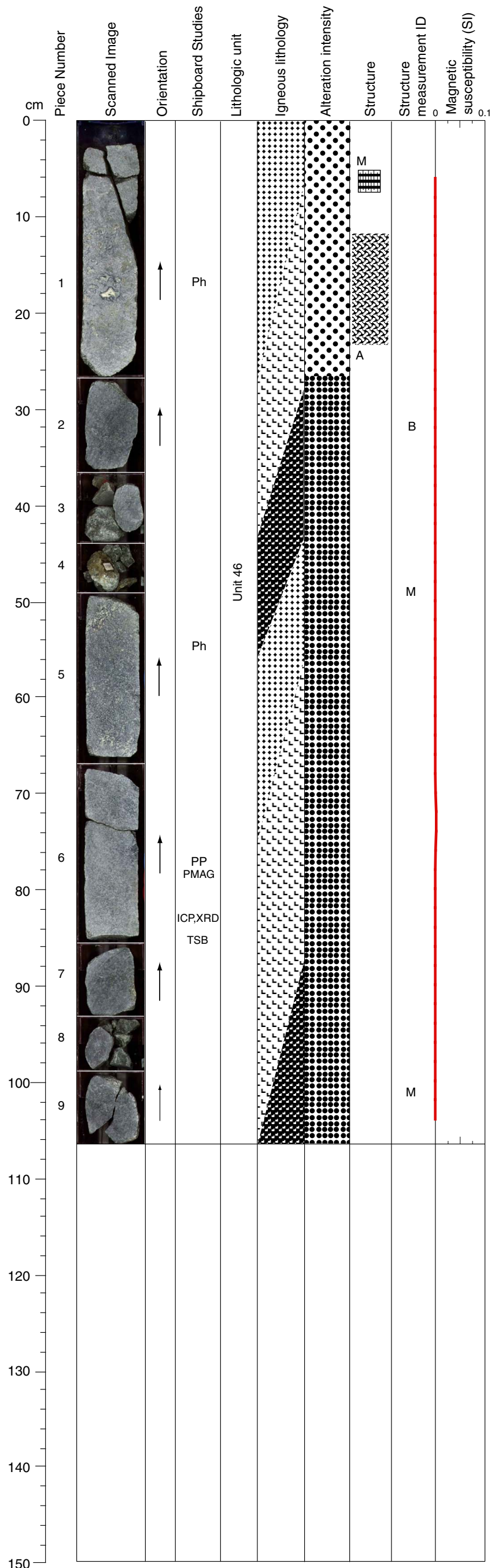
STRUCTURE: The top half of this core is altered with dark mineral seams, a distributed alteration via vein-like (V1) textures that are intergranular, and a vein set that cuts across grains (V2), most pronounced across pyroxene cleavage planes. The alteration texture (A) gives way to a texture dominated by gabbroic layering (of an "Oman" type) (M), although alteration and veining continues in this section. Although not in context because it occurs only in a small, unoriented chip, there is a beautifully developed L-tectonite (P) at ca. 70 cm. Timing: M>V1>V2

CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-15R-1, 0-9 cm WET
- 304-U1309B-15R-1, 16-33 cm WET
- 304-U1309B-15R-1, 53-65 cm WET
- 304-U1309B-15R-1, 66-69 cm WET
- 304-U1309B-15R-1, 107-113 cm WET
- 304-U1309B-15R-1, 119-128 cm WET



Core Photo



304-U1309B-15R-2 (Section top: 76.88 mbsf)

UNIT-46 : Layered troctolite and olivine gabbro
Pieces 1-9

PRIMARY MINERALOGY:

Mineral	Olivine gabbro	Troctolitic gabbro (Piece 6)
Olivine	Modal 35%	Modal 18%
	Shape anhedral	Shape anhedral
Plagioclase	Modal 60%	Modal 74%
	Size 3-6 mm	Size 1 - 4 mm
	Shape subhedral	Shape subhedral
Clinopyroxene	Modal 3%	Modal 8%
	Size 3-20 mm	Size 1-3 mm
	Shape anhedral	Shape anhedral

COMMENTS: Section 15R-2 consists of layers of troctolite and olivine gabbro. At the top of the section, gradational layers of both increasing and decreasing grain size occur in Piece 1. Below 24 cm, medium grain sizes of 3-4 mm persist throughout the section and corona textures are common. Pyroxene content and grain size appear to be positively correlated. Elongated pyroxenes occur at the bottom of the section in Piece 9.

SECONDARY MINERALOGY: The entire core consists of altered gabbro. Plagioclase appears fresh but the ferromagnesian minerals have altered to actinolite and perhaps chlorite.

VEIN ALTERATION: There are no veins

THIN SECTIONS:

304-U1309B-15R-2, 84-85 cm (#58)

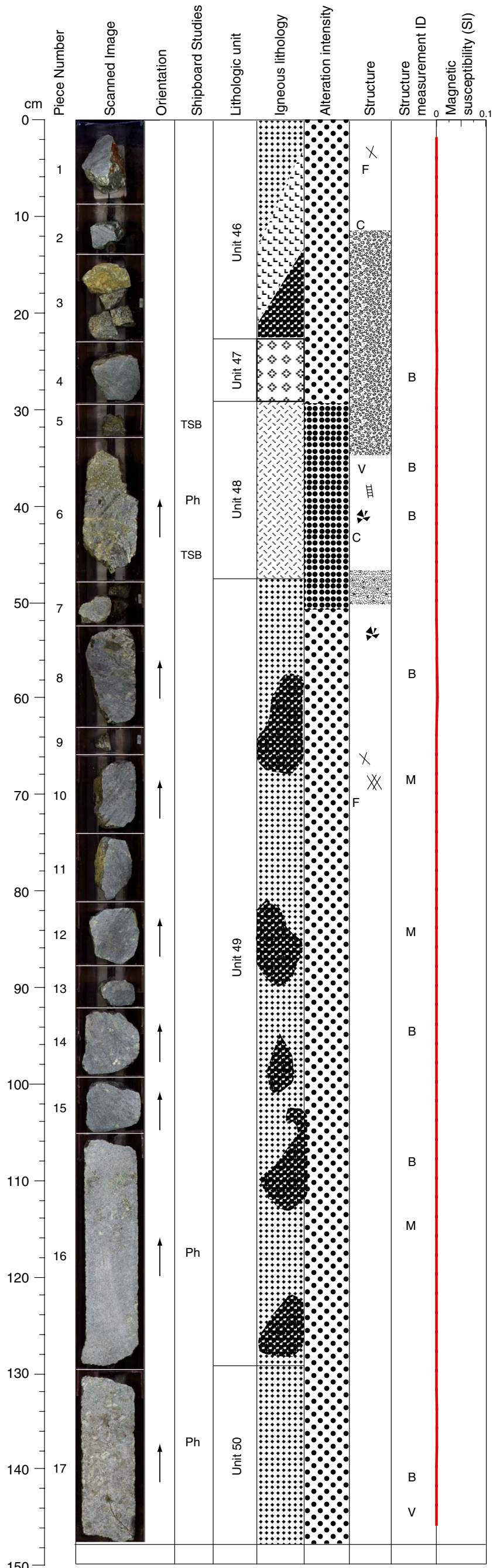
STRUCTURE: There is a weak magmatic layering (M) and alteration (A) dipping shallowly toward 90° - not typical of most of the core.

CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-15R-2, 4-25 cm WET
- 304-U1309B-15R-2, 49-66 WET
- 304-U1309B-15R-2, 83-84 cm WET



Core Photo



304-U1309B-16R-1 (Section top: 80.30 mbsf)

UNIT-46 : Layered troctolite and olivine gabbro
Pieces 1-3

PRIMARY MINERALOGY:

- Olivine Modal 35%
 Shape anhedral
- Plagioclase Modal 60%
 Size 3-6 mm
 Shape subhedral
- Clinopyroxene Modal 3%
 Size 3-20 mm
 Shape anhedral

COMMENTS: Section 16R-1 consists of the continuation of the layered troctolite and olivine gabbro of Unit 46.

UNIT-47 : Olivine microgabbro
Piece 4

PRIMARY MINERALOGY:

Too fine-grained to estimate true modal contents.

COMMENTS: Unit 47 consists of a single piece of olivine microgabbro.

UNIT-48 : Brecciated gabbro
Pieces 5-6

COMMENTS: Unit 48 consists of brecciated coarse-grained gabbro. Gabbroic clasts in the cataclasite show plastic deformation. One clast in Piece 6 contains oxides (overall 3%) that occur concentrated in the center. Multiple episodes of ductile and brittle deformation are visible in Piece 6.

UNIT-49 : Olivine gabbro and troctolite
Pieces 7-16

PRIMARY MINERALOGY:

- Olivine Olivine gabbro (Piece 16) Troctolite
 Modal 10% Modal 30%
 Size 7 - 8 mm
 Shape anhedral
- Plagioclase Modal 70% Modal 70%
 Size 7 mm
 Shape anhedral
- Clinopyroxene Modal 20%
 Size 5 mm
 Shape anhedral

COMMENTS: Unit 49 shows variations in composition from troctolitic to olivine gabbro in patches of 3 to 6 cm rather than layering. Grain sizes vary as well. Clinopyroxenes at the top of the unit record strong alteration maybe because of proximity to an alteration zone (not recovered).

UNIT-50 : Olivine gabbro
Piece 17

PRIMARY MINERALOGY:

- Olivine Modal 25%
- Plagioclase Modal 55%
- Clinopyroxene Modal 20%

COMMENTS: At the bottom of Section 16R-1 a coarse-grained olivine gabbro occurs.

SECONDARY MINERALOGY: Plagioclase is fresh in the gabbros but slightly altered by reaction with olivine in the troctolite. Amphibole-chlorite (+/- talc) corona textures after olivine are present. A breccia zone between 30 cm and 52 cm contains abundant actinolite, partially altered to yellow clay.

VEIN ALTERATION: Actinolite and clay-filled veins are common in the breccia, apart from that veins are rare.

THIN SECTIONS:

- 304-U1309B-16R-1, 31-33 cm (#59)
- 304-U1309B-16R-1, 45-46 cm (#60)

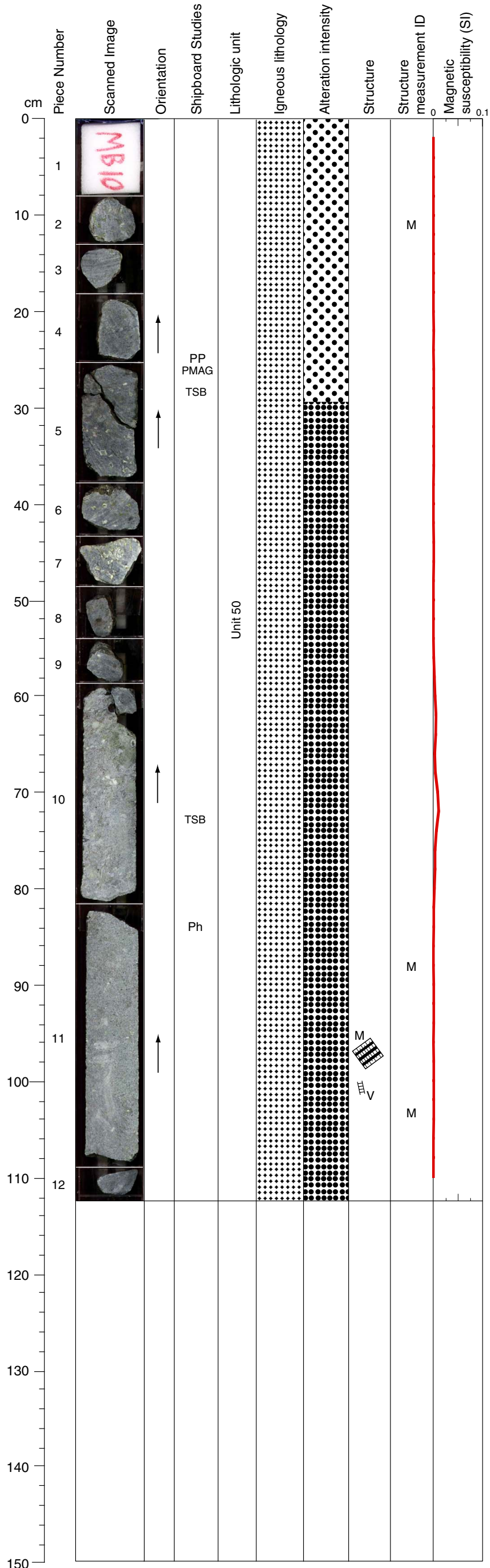
STRUCTURE: Brittle deformation is manifest as an early vein (V), a cataclastic fault zone (C) and late fractures (F). The cataclasite is localized near 40 cm and associated with yellow-brown alteration. Below the cataclasite is a zone of intense micro-cracking. However, the cataclasite does not preserve kinematic indicators.

CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-16R-1, 38-48 cm WET
- 304-U1309B-16R-1, 107-122 cm WET
- 304-U1309B-16R-1, 130-147 cm WET
- 304-U1309B-16R-1, 130-147 cm DRY BACKSIDE



Core Photo



304-U1309B-16R-2 (Section top: 81.77 mbsf)

UNIT-50 : Olivine gabbro
Pieces 1-12

PRIMARY MINERALOGY:

Mineral	Gabbro (Piece 5)	Olivine gabbro (Piece 10)
Olivine		Modal 33% Size 1-9 mm Shape subhedral-anhedral
Plagioclase	Modal 60% Size 5 - 8 mm Shape subhedral-anhedral	Modal 55% Size 1 - 9 mm Shape subhedral-anhedral
Clinopyroxene	Modal 40% Size 5 - 15 mm Shape anhedral	Modal 12% Size 1 - 20 mm Shape anhedral

COMMENTS: Section 16R-2 is the continuation of the previous section with a coarse-grained olivine gabbro with grain sizes as large as 15 mm. At about 80 cm, grain size decreases gradually to medium grained, with grains as large as 4 mm.

SECONDARY MINERALOGY: Amphibole-chlorite (+/- talc) corona textures after olivine are present in the olivine gabbro. Plagioclase appears fresh, except where reacted with olivine. Pyroxene is variably altered to actinolite.

VEIN ALTERATION: Only minor veins are present.

THIN SECTIONS:

- 304-U1309B-16R-2, 26-29 cm (#61)
- 304-U1309B-16R-2, 71-73 cm (#62)

STRUCTURE: Magmatic layering (M) that dips toward 90° is cut by a long (millimeter-wide), continuous green-brown vein (V).

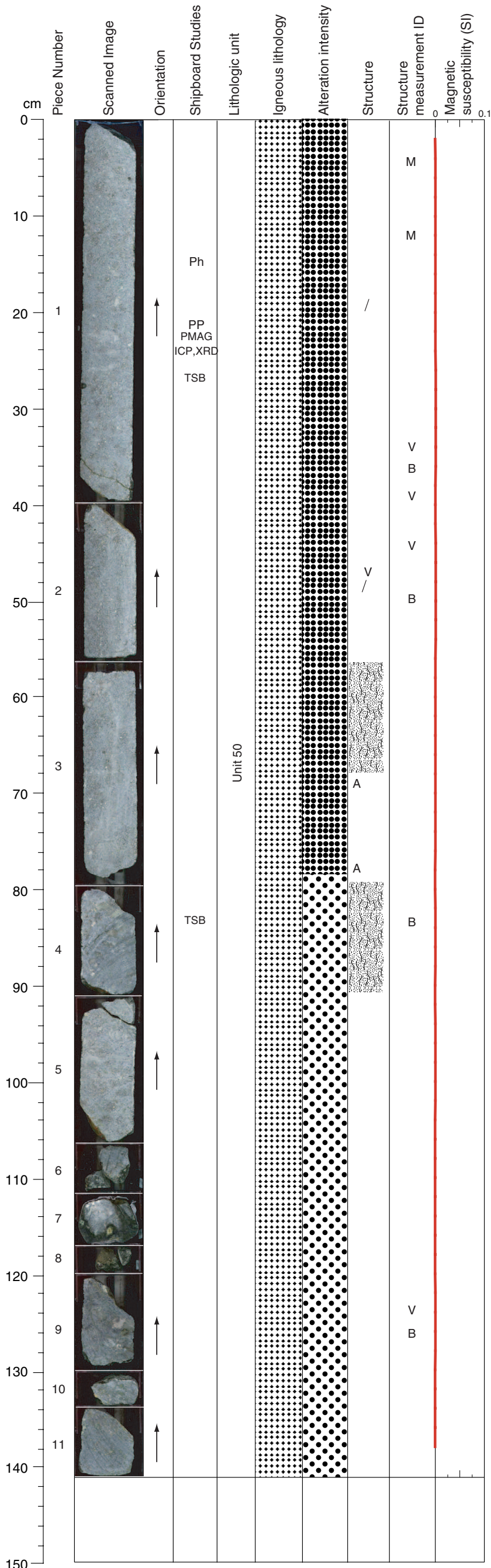
CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-16R-2, 25-35 cm WET
- 304-U1309B-16R-2, 59-79 cm WET
- 304-U1309B-16R-2, 59-79 cm DRY BACKSIDE
- 304-U1309B-16R-2, 65-75 cm WET



Core Photo

304-U1309B-16R-3 (Section top: 82.88 mbsf)



UNIT-50 : Olivine gabbro
Pieces 1-11

PRIMARY MINERALOGY:

Olivine Modal 25%
 Size 1-6 mm
 Shape anhedral

Plagioclase Modal 55%
 Size 1-12 mm
 Shape subhedral

Clinopyroxene Modal 20%
 Size 1-20 mm
 Shape anhedral

COMMENTS: Unit 50 persists through Section 16R-3 with medium grain size, except for a coarser interval between 56 cm and 60 cm. From 80 cm onward, coarser grain sizes as large as 20 mm reappear.

SECONDARY MINERALOGY: The section consists of altered gabbro. Amphibole-chlorite (+/- talc) corona textures after olivine are present (mineralogy confirmed by XRD at 115 cm). Plagioclase appears fresh, except where reacted with olivine.

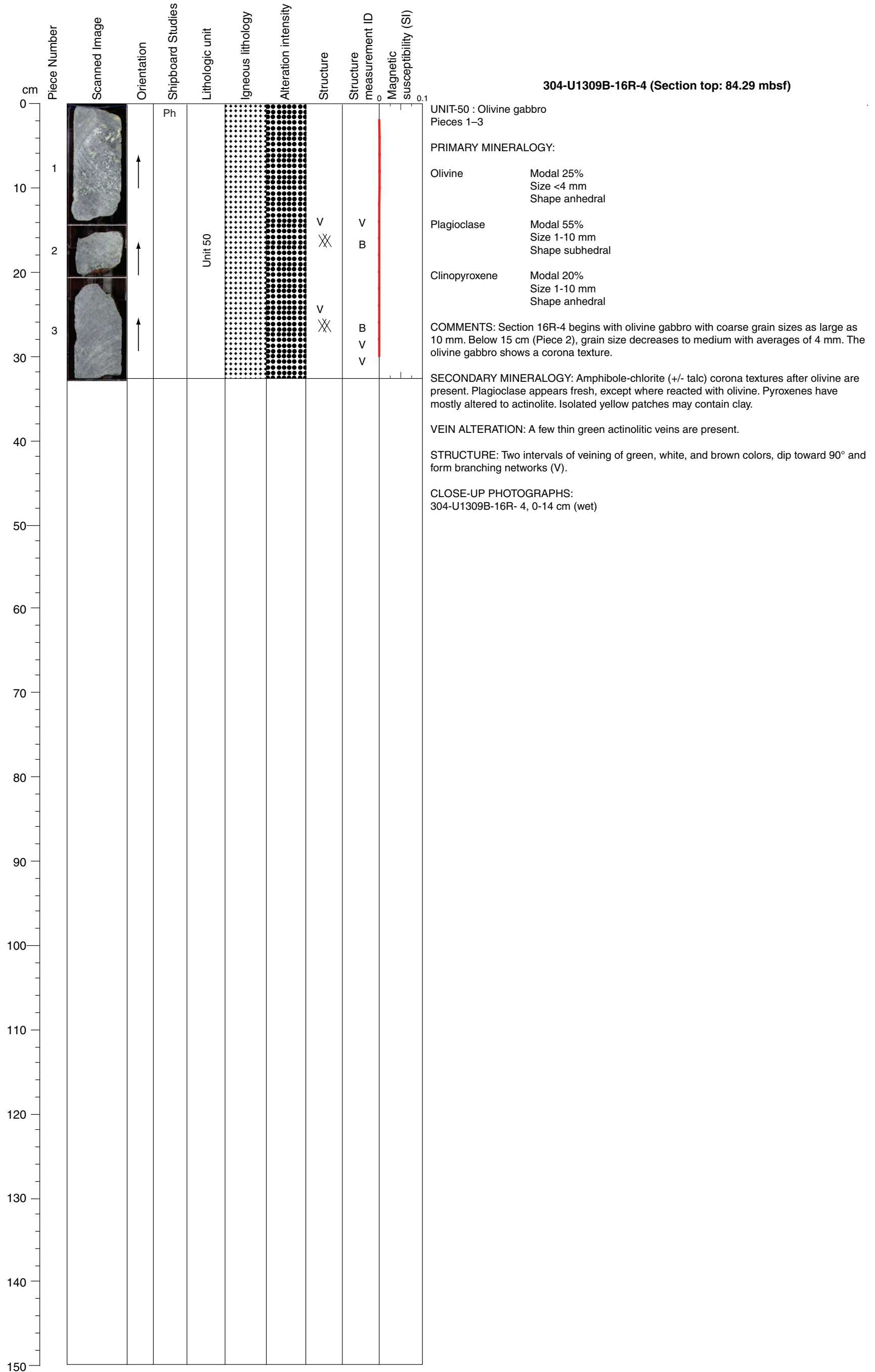
VEIN ALTERATION: A single yellow actinolite vein is present at 37 cm.

THIN SECTIONS:
304-U1309B-16R-3, 26-27 cm (#63)
304-U1309B-16R-3, 83-85 cm (#64)

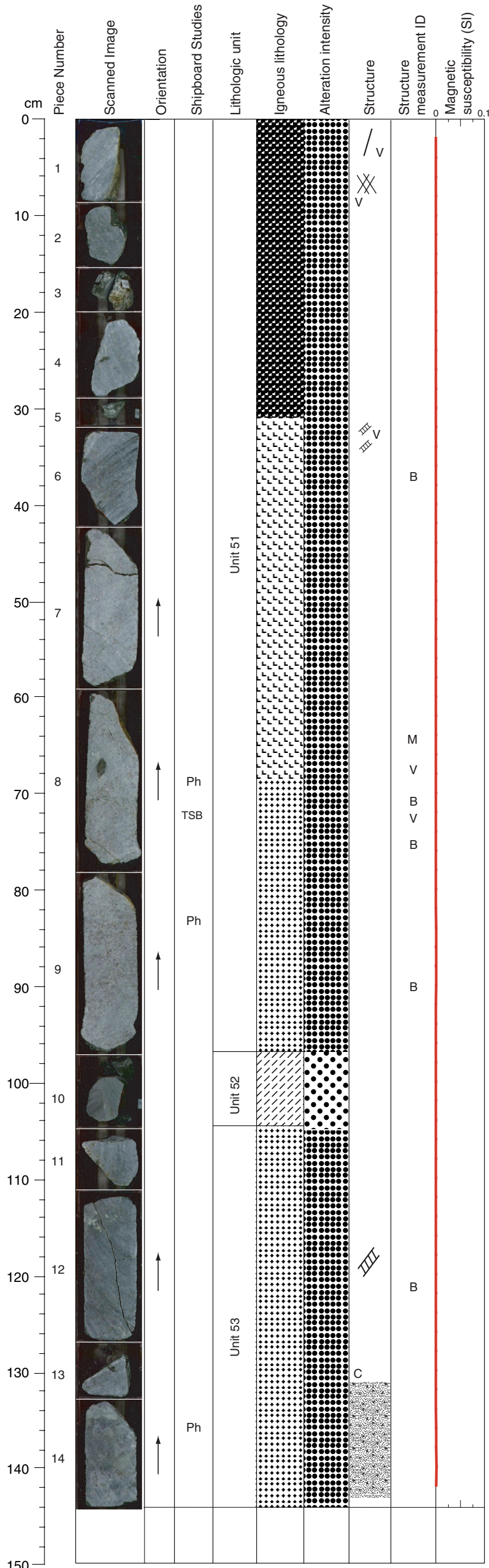
STRUCTURE: A single, subhorizontal, yellow-brown vein (V), a single green vein dipping steeply toward 270° and two zones of alteration (A) dipping toward 90° are the structures in this section.

CLOSE-UP PHOTOGRAPHS:
304-U1309B-16R-3, 10-20 cm WET
304-U1309B-16R-3, 79-89 cm WET

Core Photo



Core Photo



304-U1309B-17R-1 (Section top: 84.90 mbsf)

UNIT-51 : Troctolite and olivine gabbro
Pieces 1-9

PRIMARY MINERALOGY:

Olivine	Modal 40% Size 0.5-4 mm Shape anhedral	Olivine gabbro (Piece 8) Modal 20% Size 1-4mm Shape anhedral	Olivine gabbro Modal 30% Size 0.5-4 mm Shape anhedral
Plagioclase	Modal 60% Size 0.5-4 mm Shape anhedral	Modal 65% Size 1-6 mm Shape subhedral	Modal 50% Size 0.5-4 mm Shape anhedral
Clinopyroxene		Modal 15% Size 1-3.5 mm Shape anhedral	Modal 20% Size 0.5 - 5 mm Shape anhedral

COMMENTS: Downhole from the top of the section, there is a gradual transition from troctolite to olivine gabbro as pyroxene content increases. Troctolitic gabbro occurs between 31 cm and 68 cm, followed by olivine gabbro. At 68 cm a pyroxene-rich band with coarse grain size as large as 7 mm transects the core.

UNIT-52 : Sparsely plagioclase-phyric basalt
Piece 10

PRIMARY MINERALOGY:
Too fine-grained to estimate.

COMMENTS: Unit 52 consists of microcrystalline, sparsely plagioclase-phyric basalt. Euhedral plagioclase phenocrysts range in size from less than 1 mm to 4 mm.

UNIT-53 : Olivine gabbro
Pieces 11-14

PRIMARY MINERALOGY:

Olivine	Modal 15% Size 3 mm Shape anhedral
Plagioclase	Modal 50% Size 3 mm Shape anhedral
Clinopyroxene	Modal 35% Size 3 - 30 mm Shape anhedral

COMMENTS: Unit 53 consists of medium-grained gabbro with average grain size of 3 mm. Grain sizes increase dramatically between 133 cm and 143 cm (Piece 14) to just less than 30 mm.

SECONDARY MINERALOGY: Amphibole-chlorite (+/- talc) corona textures after olivine are present. Plagioclase appears fresh, except where reacted with olivine. The ferromagnesian minerals have mostly been replaced with tremolite. A basalt dike at 97-105 cm appears to be only weakly altered, judging from its black color.

VEIN ALTERATION: A few actinolite veins are present, e.g. at 76 cm.

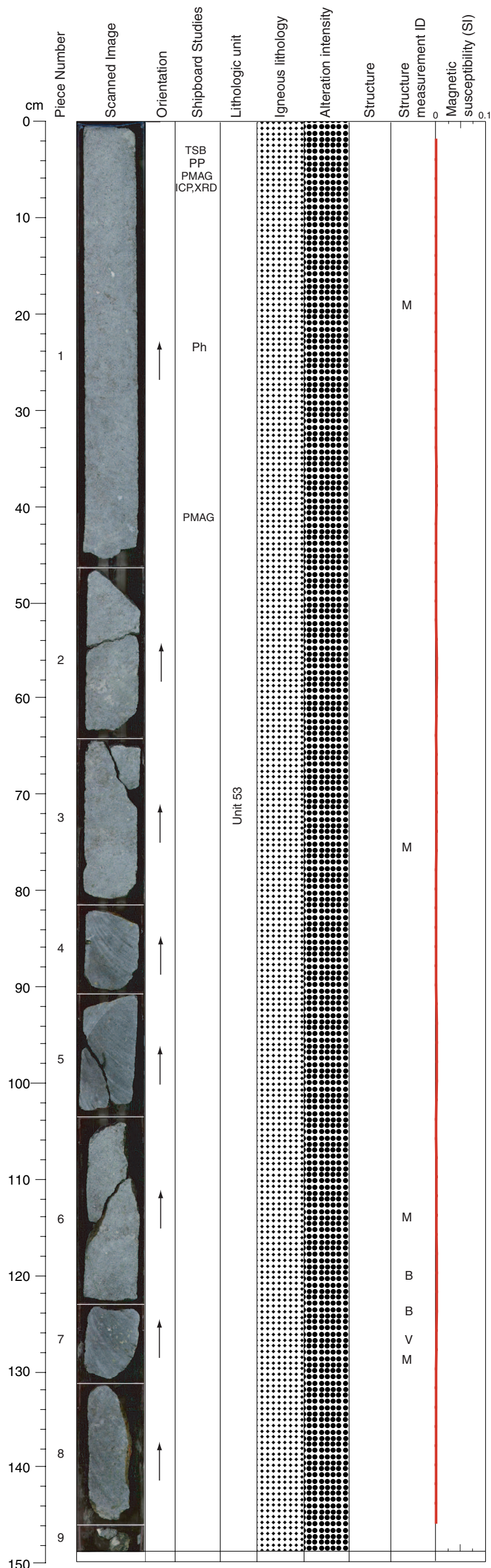
THIN SECTIONS:
304-U1309B-17R-1, 72-76 cm (#65)

STRUCTURE: Several intervals of veining - green, white, and yellow colors (V), all dipping toward 270°, typify this section. The veins coincide with steeply dipping zones of alteration. Intense microcracking (C) is best observed along cleavage planes in pyroxene grains.

CLOSE-UP PHOTOGRAPHS:
304-U1309B-17R-1, 68-78 cm WET
304-U1309B-17R-1, 78-96 cm WET
304-U1309B-17R-1, 133-144 cm WET
304-U1309B-17R-1, 133-144 cm DRY BACKSIDE



Core Photo



304-U1309B-17R-2 (Section top: 86.34 mbsf)

UNIT-53 : Olivine gabbro
Pieces 1-9

PRIMARY MINERALOGY:

- Olivine Modal 25%
 Size 1-4 mm
 Shape anhedral
- Plagioclase Modal 60%
 Size 1-7 mm
 Shape subhedral
- Clinopyroxene Modal 15%
 Size 0.5-3 mm
 Shape anhedral

COMMENTS: Section 17R-2 consists of medium-grained olivine gabbro. A single, large clinopyroxene (minimum grain size 18 mm, cut off by edge) at the upper edge of Piece 1 is identical to the very coarse grain sizes at the bottom of the previous section. Troctolitic and more pyroxene-rich areas alternate. An interval of coarser clinopyroxene as large as 9 mm appears between 56 and 69 cm and a pyroxene-rich band at 126 cm.

SECONDARY MINERALOGY: Amphibole-chlorite (+/- talc) corona textures after olivine are present. Plagioclase appears fresh, except where reacted with olivine. Pyroxenes have partially altered to actinolite. One or two zones of patchy alteration that have vein-like qualities are present in this section. Milky plagioclase is present at the base of the core in contact with a coarse pyroxenite/gabbro layer

VEIN ALTERATION: A few dark amphibole veins below 116 cm are probably actinolite.

THIN SECTIONS:
[304-U1309B-17R-2, 0-4 cm \(#66\)](#)

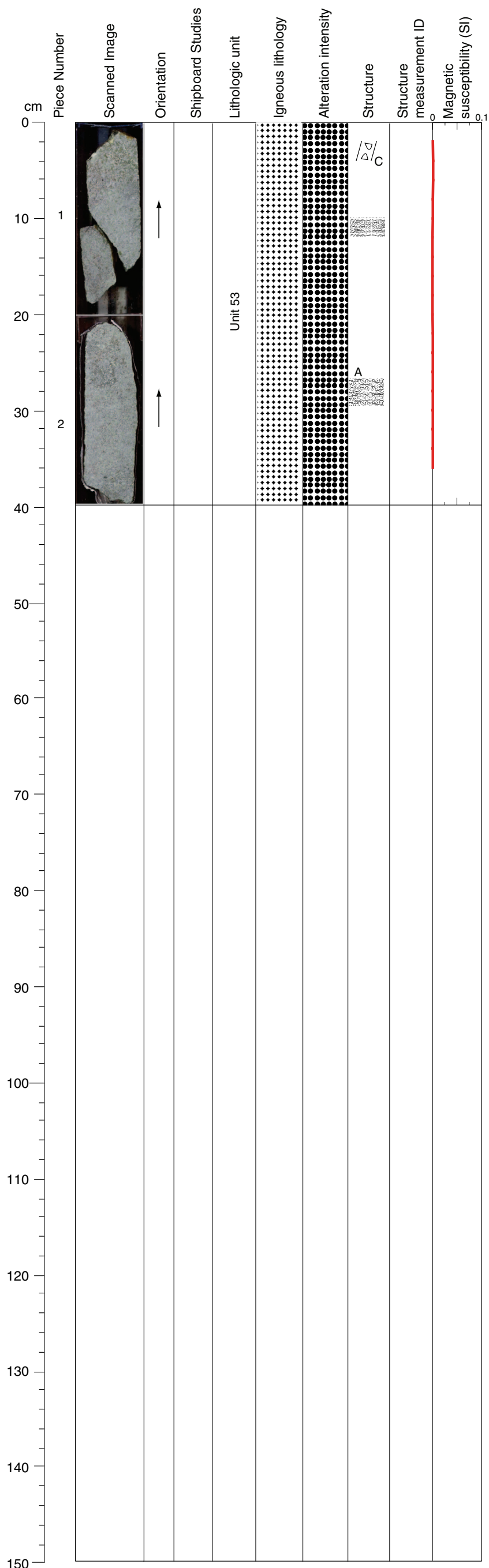
STRUCTURE: No additional structure other than that noted in the Structure measurement ID column.

CLOSE-UP PHOTOGRAPHS:
[304-U1309B-17R-2, 10-30 cm WET](#)



Core Photo

304-U1309B-17R-3 (Section top: 87.84 mbsf)



UNIT-53 : Olivine gabbro
Pieces 1-2

PRIMARY MINERALOGY:

- Olivine Modal 25%
 Size 3 mm
 Shape anhedral
- Plagioclase Modal 60%
 Size 3 mm
 Shape subhedral
- Clinopyroxene Modal 15%
 Size 3 mm
 Shape anhedral

COMMENTS: Section 17R-3 continues Unit 53.

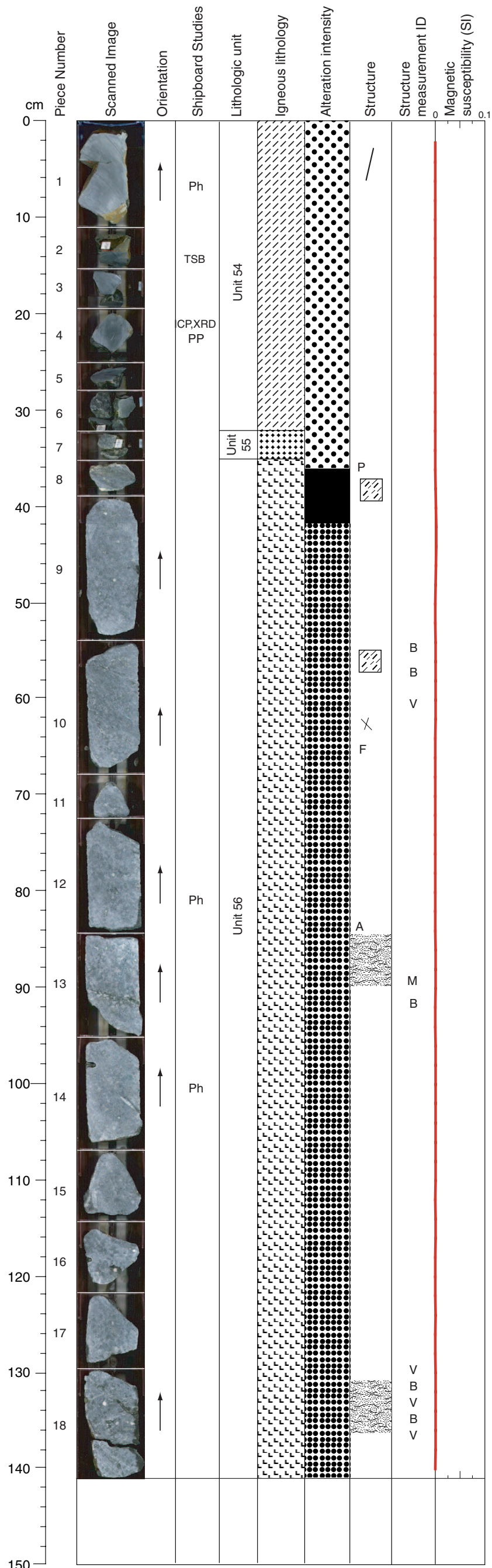
SECONDARY MINERALOGY: Amphibole-chlorite (+/- talc) corona textures after olivine are present. Plagioclase appears fresh, except where reacted with olivine. Pyroxenes appear to have altered to actinolite.

VEIN ALTERATION: An actinolite vein occurs near the top of the core. Fractures are coated by brown clays and oxide/hydroxide.

STRUCTURE: Small portions of weakly defined cataclasite (C) near the top of the section give way to more diffuse (dark green) alteration (A), in intergranular zones that dip toward 270°.



Core Photo



304-U1309B-18R-1 (Section top: 89.6 mbsf)

UNIT-54 : Sparsely plagioclase-phyric basalt
Pieces 1–6

PRIMARY MINERALOGY:

Plagioclase Modal 1%
 Size 1 mm
 Shape subhedral

COMMENTS: Unit 54 consists of microcrystalline, very sparsely plagioclase-phyric basalt. A chilled margin occurs in Piece 2 between two plagioclase-phyric basalts, one contains a single large plagioclase crystal as large as 9 mm.

UNIT-55 : Olivine gabbro
Pieces 7

PRIMARY MINERALOGY:

Too small and too deformed to estimate true modal contents.

COMMENTS: Unit 55 consists of several pieces of highly deformed gabbro.

UNIT-56 : Troctolitic gabbro and olivine gabbro
Pieces 8–18

PRIMARY MINERALOGY:

Olivine Modal 20%
 Size 5mm
 Shape anhedral

Plagioclase Modal 55%
 Size 4-9 mm
 Shape subhedral

Clinopyroxene Modal 20%
 Size 4-20 mm
 Shape subhedral

COMMENTS: Unit 56 shows a centimeter-scale layering of olivine and troctolitic gabbro but is dominated by olivine gabbro. Clinopyroxene content and grain size increase downsection with a maximum at 24-53 cm, then grade toward finer grain sizes again. A sub-horizontal gabbroic vein crosscuts at 91 cm.

SECONDARY MINERALOGY: The upper 35 cm of the core consists of aphanitic dark basalt that, based on its color, may be quite fresh. The rest of the core consists of a gabbro that is moderately altered. The major alteration mineral appears to be actinolite. Amphibole-chlorite (+/- talc) corona textures after olivine are present. Plagioclase appears fresh, except where reacted with olivine.

VEIN ALTERATION: A few veins are present. One type contains actinolite and another has sulfides.

THIN SECTIONS:

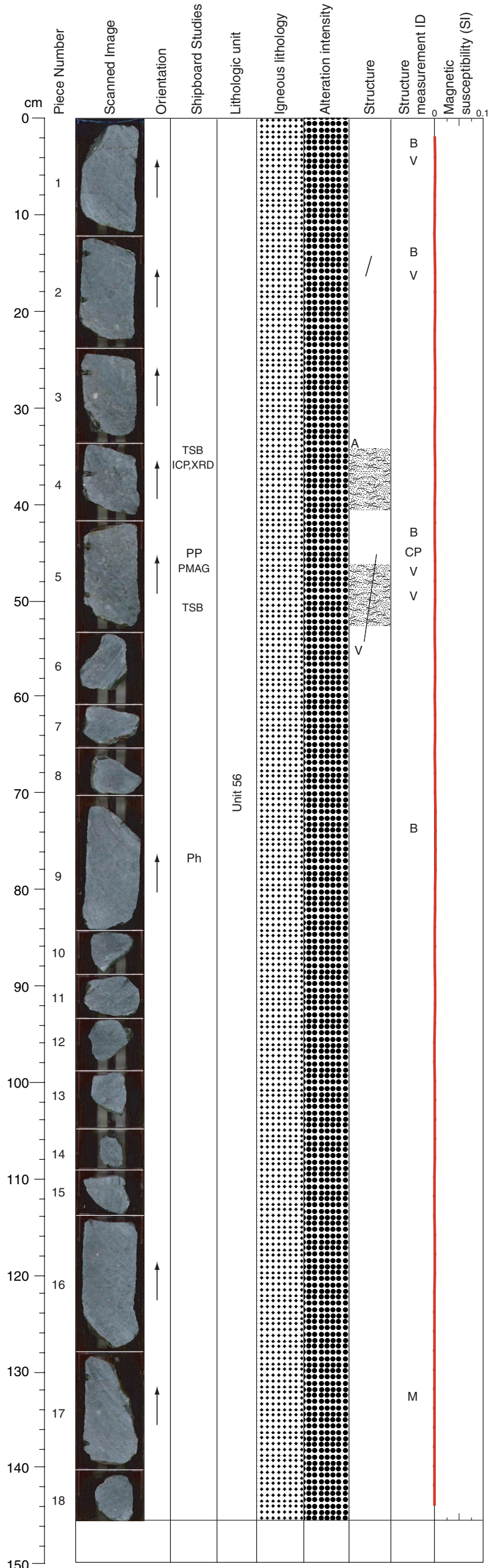
304-U1309B-18R-1, 13-15 cm (#67)

STRUCTURE: Two crystal plastic, probably semi-brittle, shear zones (P), one of which has a clear cataclastic component are present near 40 cm and 50 cm. Relatively little damage is present otherwise; some disseminated fracture (F) and alteration (A).

CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-18R-1, 0-11 cm WET
- 304-U1309B-18R-1, 75-94 cm WET
- 304-U1309B-18R-1, 95-105 cm DRY BACKSIDE

Core Photo



304-U1309B-18R-2 (Section top: 91.01 mbsf)

UNIT-56 : Troctolitic and olivine gabbro
Pieces 1-18

PRIMARY MINERALOGY:

Olivine	Olivine gabbro Modal 25% Size 3-8 mm Shape anhedral	Gabbro (Piece 4)
Plagioclase	Modal 55% Size 4-9 mm Shape anhedral	Modal 65% Size 1-5 mm Shape anhedral
Clinopyroxene	Modal 20% Size 4-12 mm Shape anhedral	Modal 35% Size 1-6 mm Shape anhedral

COMMENTS: This section represents the continuation from Unit 56. From 24 cm onward, grain sizes of as much as 4 mm and pyroxene content increase to as large as 10 mm at 53 cm to and decrease again to as large as 5-7 mm. No layering is observed in the hand samples but changes in modal compositions are apparent in thin sections.

SECONDARY MINERALOGY: Plagioclase appears to be fresh but ferromagnesian minerals have altered to actinolite. Amphibole-chlorite (+/- talc) corona textures after olivine are present locally.

VEIN ALTERATION: Minor chlorite veins are present.

THIN SECTIONS:

- 304-U1309B-18R-2, 34-35 cm (#68)
- 304-U1309B-18R-2, 50-52 cm (#69)

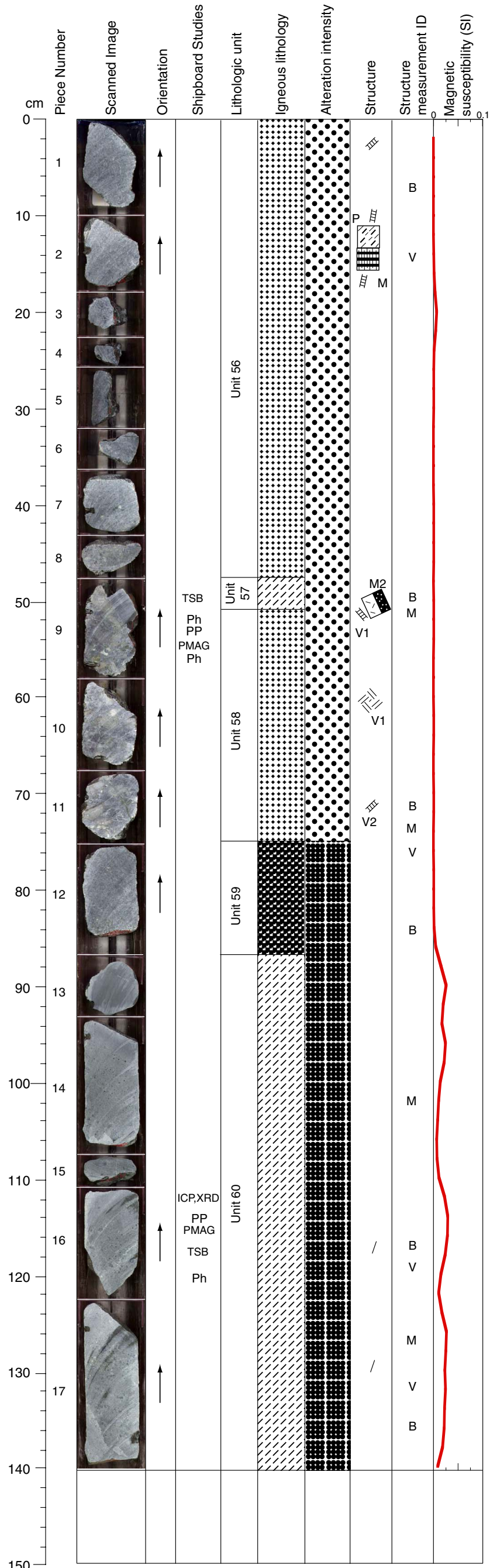
STRUCTURE: Dark, intergranular alteration (A) (veining), and a single, subhorizontal white vein (V) are present in this section.

CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-18R-2, 27-37 cm WET
- 304-U1309B-18R-2, 70-83 cm WET
- 304-U1309B-18R-2, 70-83 cm DRY BACKSIDE
- 304-U1309B-18R-2, 71-81 cm WET



Core Photo



304-U1309B-18R-3 (Section top: 92.47 mbsf)

UNIT-56 : Troctolitic and olivine gabbro
Pieces 1-8

PRIMARY MINERALOGY:

- Olivine Modal 25%
 Size 3-8 mm
 Shape anhedral
- Plagioclase Modal 55%
 Size 4-9 mm
 Shape anhedral
- Clinopyroxene Modal 20%
 Size 4-12 mm
 Shape anhedral

COMMENTS: Section 18R-3 begins with the continuation of the troctolitic and olivine gabbros of Unit 56.

UNIT-57 : Basalt
Piece 9

PRIMARY MINERALOGY:

- Plagioclase Modal 3%
 Shape euhedral-subhedral
 Size 0.05-0.85 mm
- Oxides Modal 2%

COMMENTS: Unit 57 consists of aphanitic basalt that is intruded into an olivine gabbro. Plagioclase phenocryst occur close to the contact. Oxides occur finely dispersed in the matrix as well as clots.

UNIT-58 : Olivine gabbro
Pieces 9-11

PRIMARY MINERALOGY:

- Olivine Modal 2%
 Size 4-7 mm
 Shape anhedral
- Plagioclase Modal 58 %
 Size 10-15 mm
 Shape anhedral
- Clinopyroxene Modal 40%
 Size 12-26 mm
 Shape anhedral

COMMENTS: This unit consists of very coarse-grained gabbro with distinctly lower olivine content compared to Unit 56.

UNIT-59 : Troctolite
Piece 12

PRIMARY MINERALOGY:

- Olivine Modal 25%
 Size 3 mm
 Shape anhedral
- Plagioclase Modal 70%
 Size 3 mm
 Shape subhedral
- Clinopyroxene Modal 5%
 Size 2 mm
 Shape anhedral

COMMENTS: This unit consists of medium-grained troctolite with schlieren of olivine gabbroic composition.

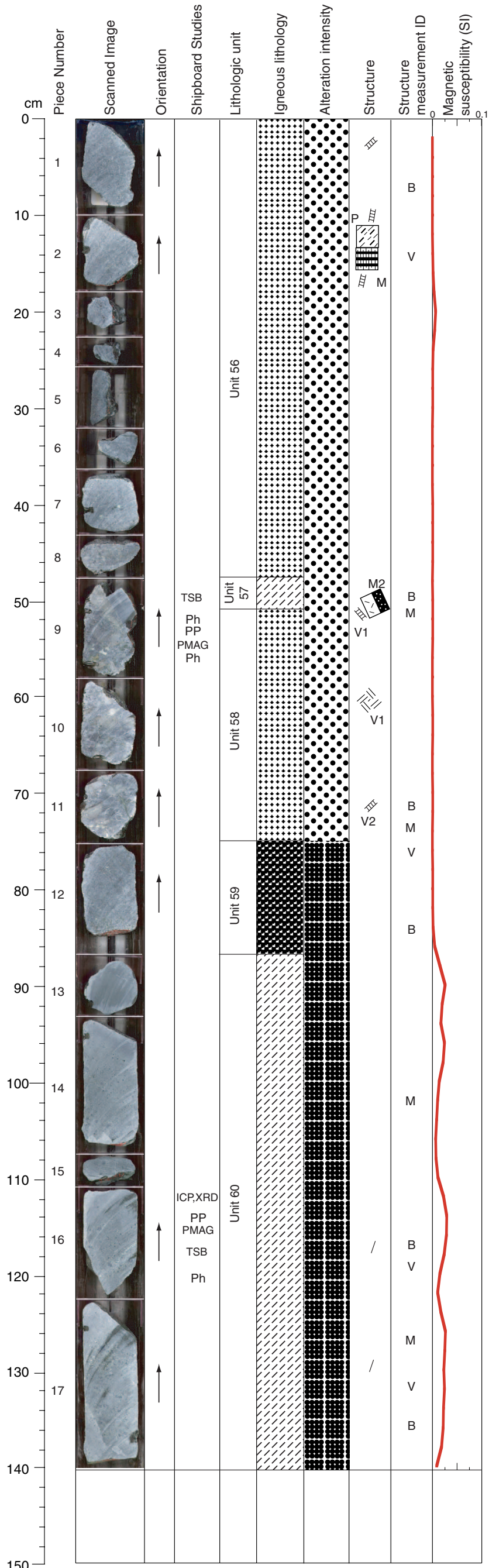
UNIT-60 : Troctolite
Pieces 13-17

PRIMARY MINERALOGY:

- Olivine Modal 25%
 Size 3 mm
 Shape anhedral
- Plagioclase Modal 70%
 Size 3 mm
 Shape subhedral
- Clinopyroxene Modal 5%
 Size 2 mm
 Shape anhedral

COMMENTS: This unit consists of medium-grained troctolite with schlieren of olivine gabbroic composition.

Core Photo



304-U1309B-18R-3 (continued) (Section top: 92.47 mbsf)

UNIT-60 : Sparsely plagioclase-phyric basalt
Pieces 13-17

PRIMARY MINERALOGY:

Mineral	Groundmass	Phenocryst
Olivine	Modal 10% Size 0.5-2 mm Shape subhedral	
Plagioclase	Modal 45% Size 0.2-1 mm Shape subhedral	Modal <1% Size <11 mm Shape subhedral
Clinopyroxene	Modal 35% Size 0.4 mm Shape too altered	
Oxides	Modal 8%	

COMMENTS: This unit consists of microcrystalline (Piece 13) to fine-grained (Pieces 14 to 17) basalt. Trains of anhedral olivines as large as 5 mm occur and their size and abundance increase downhole. Planar olivine trains in Pieces 14 and 17 dip approximately 45°.

SECONDARY MINERALOGY: Amphibole-chlorite (+/- talc) corona textures after olivine are present locally. Plagioclase appears fresh, except where reacted with olivine. Pyroxenes in both the basalt and the gabbros appear to have altered to actinolite.

VEIN ALTERATION: The gabbroic portion of the core contain a few chlorite/actinolite veins. There are no veins in the altered basalt.

THIN SECTIONS:

- 304-U1309B-18R-3, 48-51 cm (#70)
- 304-U1309B-18R-3, 118-119 cm (#71)

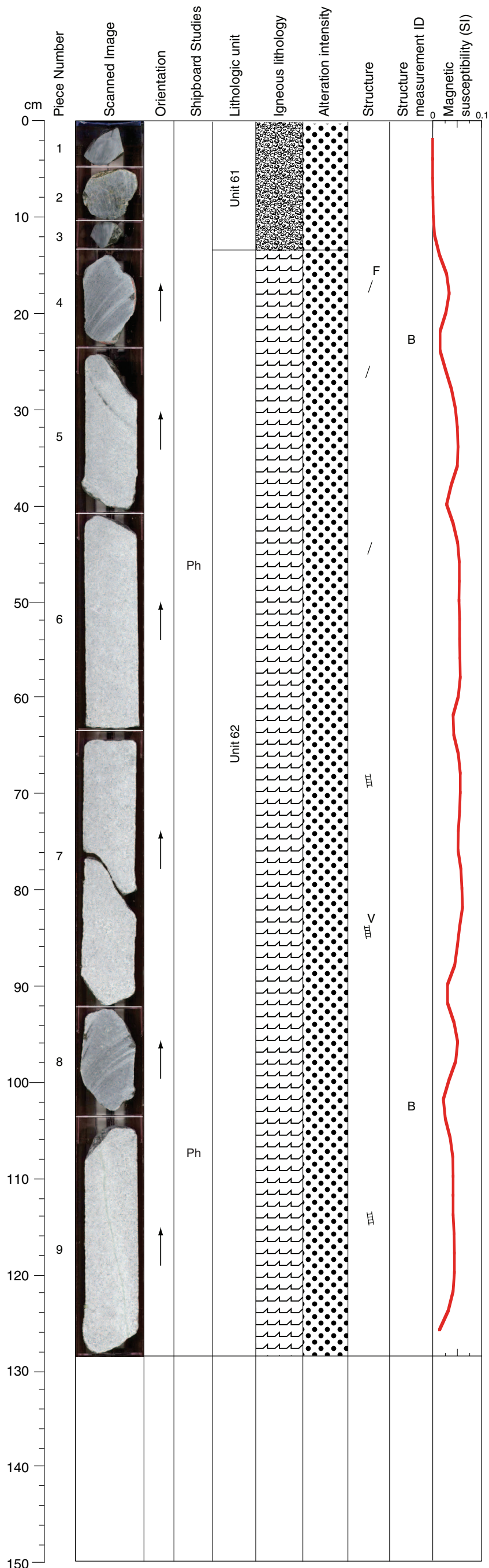
STRUCTURE: An early magmatic (M)/possibly crystal plastic fabric (P) to portions of this core include an intrusive (M2) contact with a basaltic fragment. The contact is cracked and veined (V1), however, part of a more widespread early set of branching, networked green veins. A later set of veins cuts all other features (V2). Timing: M1>M2>V1>V2

CLOSE-UP PHOTOGRAPHS:

- 304-U1309B-18R-3, 48-67 cm WET
- 304-U1309B-18R-3, 48-67 cm DRY BACKSIDE
- 304-U1309B-18R-3, 49-55 cm WET
- 304-U1309B-18R-3, 122-139 cm WET



Core Photo



304-U1309B-19R-1 (Section top: 94.30 mbsf)

UNIT-61 : Mixed rubble
Pieces 1-3

COMMENTS: Unit 61 consists of mixed rubble presumed to be out of place. Pieces 1 and 3 are microcrystalline, sparsely plagioclase-phyric basalt and Piece 2 is a medium-grained olivine gabbro.

UNIT-62 : Oxide-diabase
Pieces 4-9

PRIMARY MINERALOGY:

Plagioclase Modal 2%
Size 8 mm
Shape subhedral

Oxides Modal 2-3%

COMMENTS: Unit 62 consists of medium-grained diabase with subophitic texture. Rare and isolated plagioclase phenocrysts as large as 8 mm occur. Oxides are dispersed in the matrix.

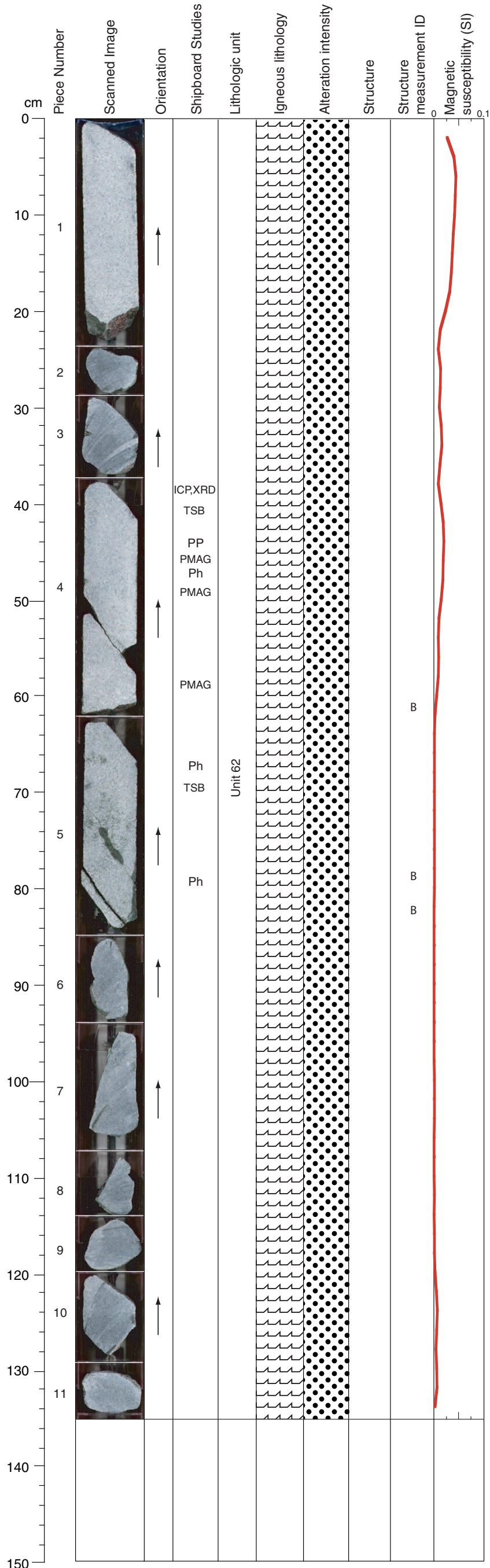
SECONDARY MINERALOGY: Plagioclase laths in the gabbro and basalt appear to be unaltered. Ferromagnesian minerals are partially altered to actinolite. Minor chlorite may also be present.

VEIN ALTERATION: The only vein is a chlorite-actinolite vein in Piece 9

STRUCTURE: Approximately three thin white fractures (F) on a steeply dipping green, and in another place brown, vein (V) that are transgranular and cause local alteration of the wall rock.

CLOSE-UP PHOTOGRAPHS:
304-U1309B-19R1, 41-61 cm WET
304-U1309B-19R1, 41-61 cm DRY BACKSIDE
304-U1309B-19R1, 107-125 cm WET

Core Photo



304-U1309B-19R-2 (Section top: 95.58 mbsf)

UNIT-62 : Oxide-diabase
Pieces 1-11

PRIMARY MINERALOGY:

Mineral	Groundmass	Phenocrysts
Olivine	Modal 1% Size 0.6 mm Shape anhedral	
Plagioclase	Modal 53 % Size 0.5-1.5 mm Shape subhedral	Modal 2% Size <8 mm Shape subhedral
Clinopyroxene	Modal 43% Size 0.8 mm Shape anhedral	
Oxides	Modal 2-3%	

COMMENTS: Section 19R-2 consists of the continuation of the oxide-diabase from Unit 62. Pieces 5-9 show a very low magnetic susceptibility and Piece 5 has altered magnetite in this section.

SECONDARY MINERALOGY: Plagioclase in the diabase appears to be fresh. The ferromagnesian minerals have been partially altered to actinolite. Chlorite is minor.

VEIN ALTERATION: No veins were found.

THIN SECTIONS:

- 304-U1309B-19R-2, 40-42 cm (#72)
- 304-U1309B-19R-2, 69-72 cm (#73)

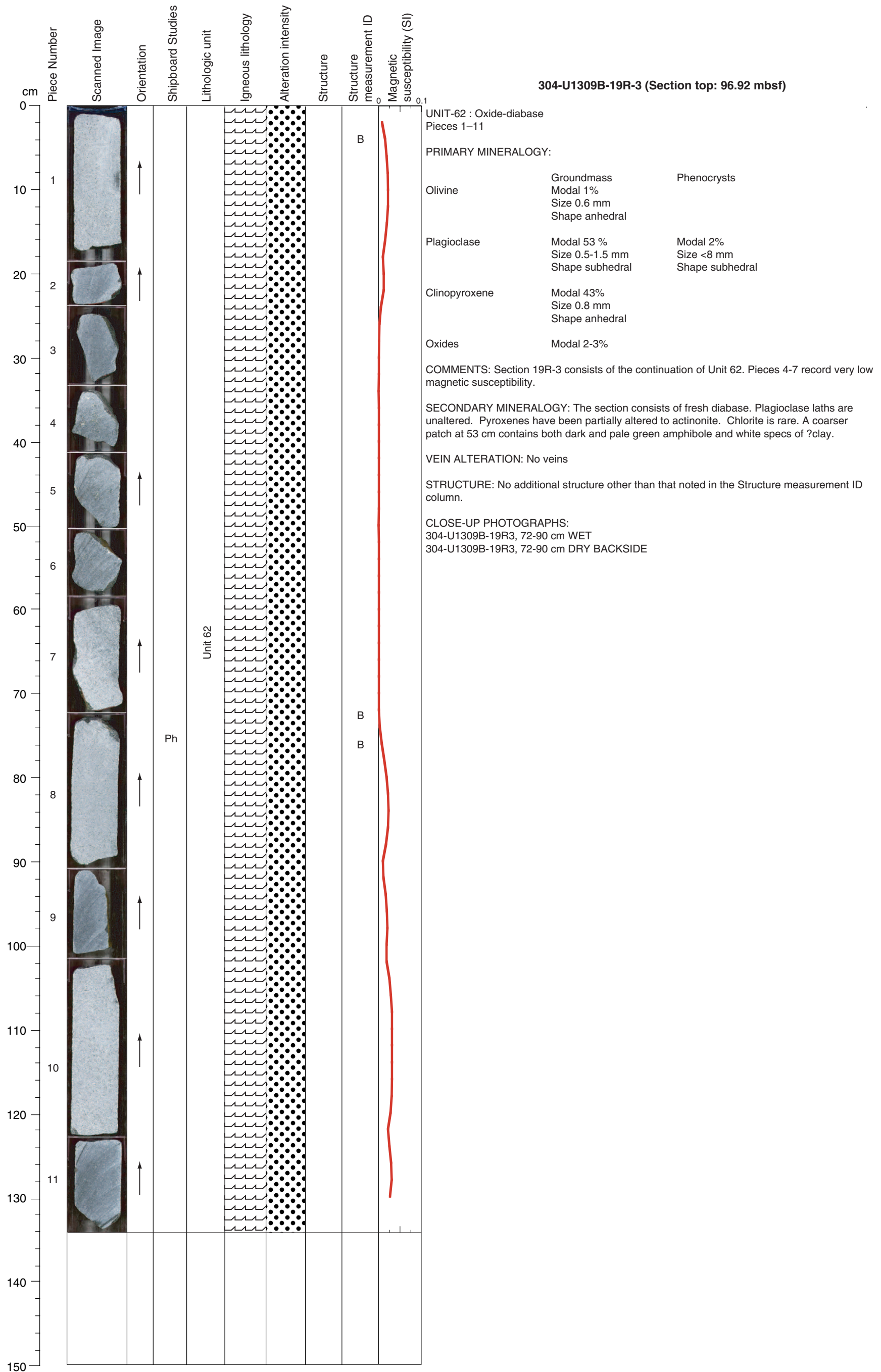
STRUCTURE: No additional structure other than that noted in the Structure measurement ID column.

CLOSE-UP PHOTOGRAPHS:

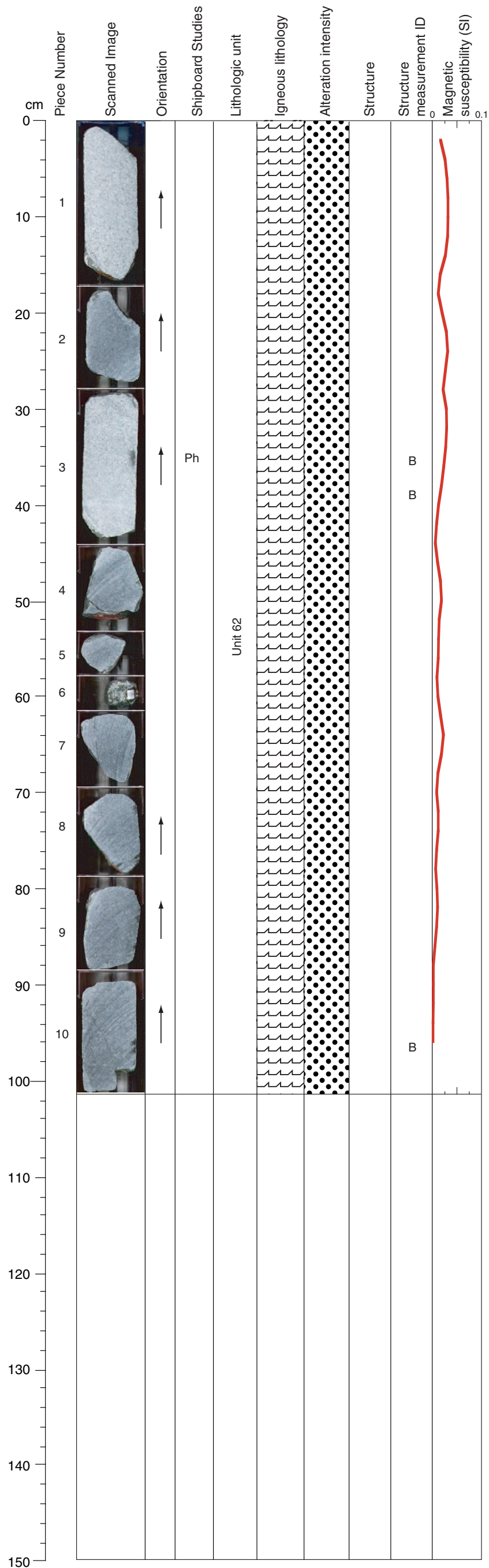
- 304-U1309B-19R-2, 42-60 cm WET
- 304-U1309B-19R-2, 66-80 cm WET



Core Photo



Core Photo



304-U1309B-19R-4 (Section top: 98.26 mbsf)

UNIT-62 : Oxide diabase
Pieces 1-10

PRIMARY MINERALOGY:

Olivine	Groundmass Modal 1% Size 0.6 mm Shape anhedral	Phenocrysts
Plagioclase	Modal 53 % Size 0.5-1.5 mm Shape subhedral	Modal 2% Size <8 mm Shape subhedral
Clinopyroxene	Modal 43% Size 0.8 mm Shape anhedral	
Oxides	Modal 2-3%	

COMMENTS: Continues from previous section.

SECONDARY MINERALOGY: The section consists of moderately fresh diabase. Plagioclase is unaltered and primary pyroxene has partially altered to actinolite. Minor chlorite is also present.

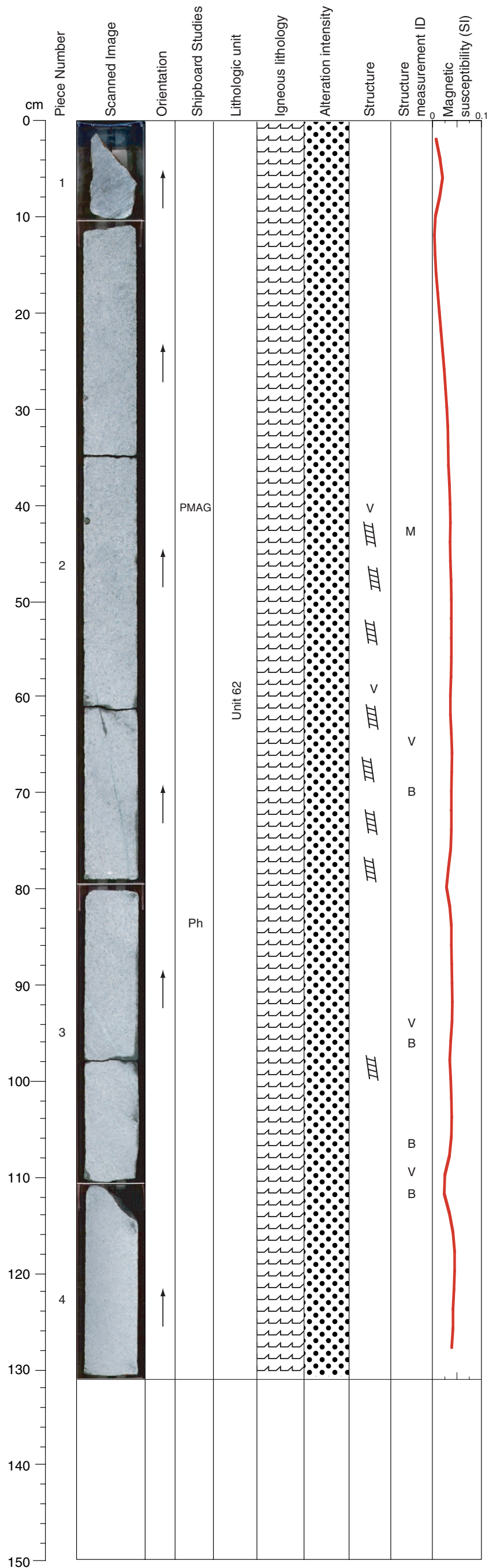
VEIN ALTERATION: One thin actinolite vein at 37 cm

STRUCTURE: No additional structure other than that noted in the Structure measurement ID column.

CLOSE-UP PHOTOGRAPHS:
304-U1309B-19R-4, 28-44 cm WET
304-U1309B-19R-4, 28-44 cm DRY BACKSIDE



Core Photo



304-U1309B-20R-1 (Section top: 99.00 mbsf)

UNIT-62 : Oxide diabase
Pieces 1-4

PRIMARY MINERALOGY:

	Groundmass	Phenocrysts
Olivine	Modal 1% Size 0.6 mm Shape anhedral	
Plagioclase	Modal 53 % Size 0.5-1.5 mm Shape subhedral	Modal 2% Size <8 mm Shape subhedral
Clinopyroxene	Modal 43% Size 0.8 mm Shape anhedral	
Oxides	Modal 2-3%	

COMMENTS: Continues from previous section.

SECONDARY MINERALOGY: The plagioclase in the diabase appears fresh whereas the pyroxenes have been partially altered to actinolite, with alteration intensity increasing down the core to nearly 100% below 90 cm. Chlorite is rare and epidote was not evident.

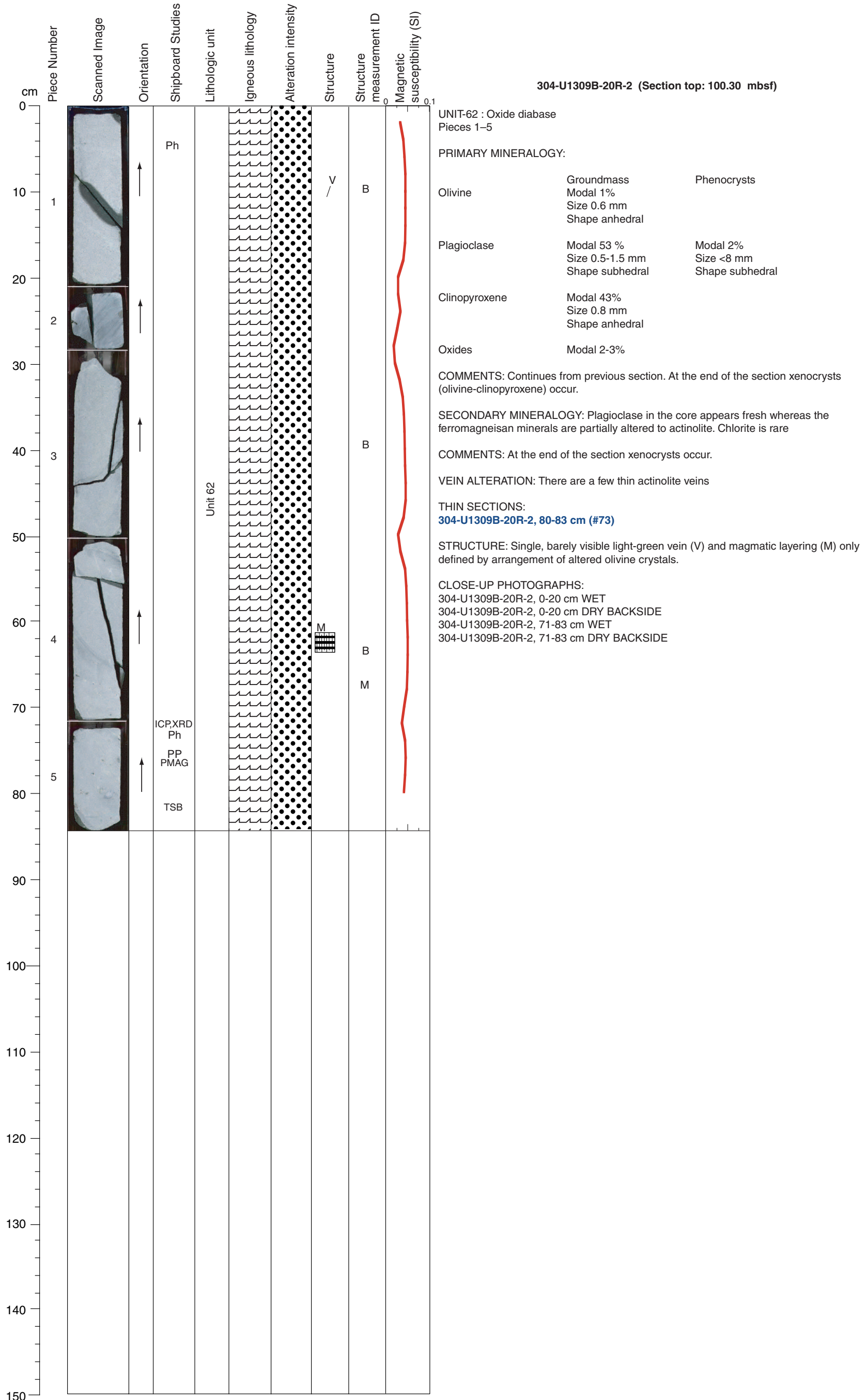
VEIN ALTERATION: The core contains no veins

STRUCTURE: Steeply dipping vein (V) with local wall-rock alteration. Another vein has an internal green-white structure.

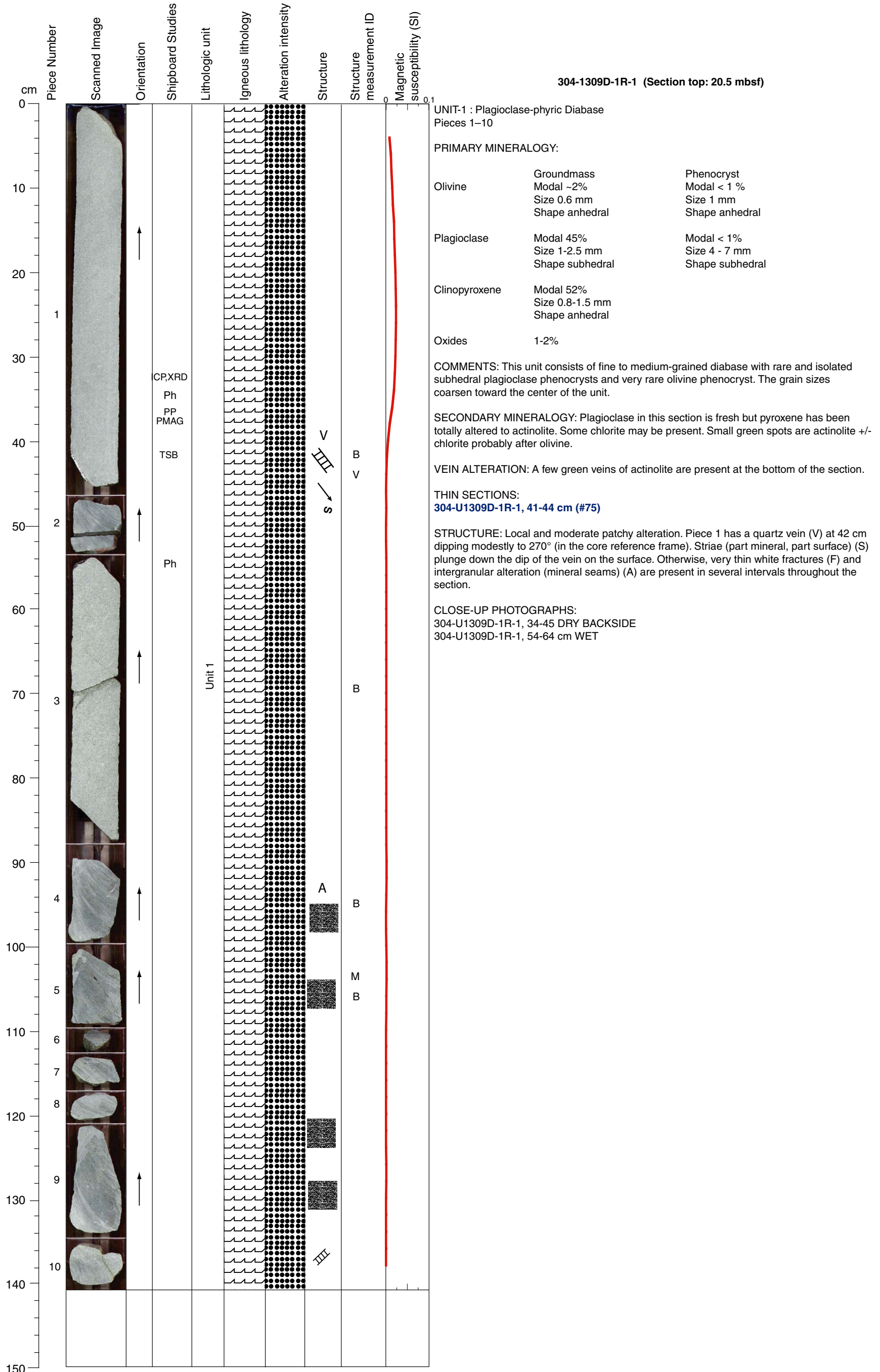
CLOSE-UP PHOTOGRAPHS:
304-U1309B-20R1, 79-90 cm WET
304-U1309B-20R1, 79-90 cm DRY BACKSIDE



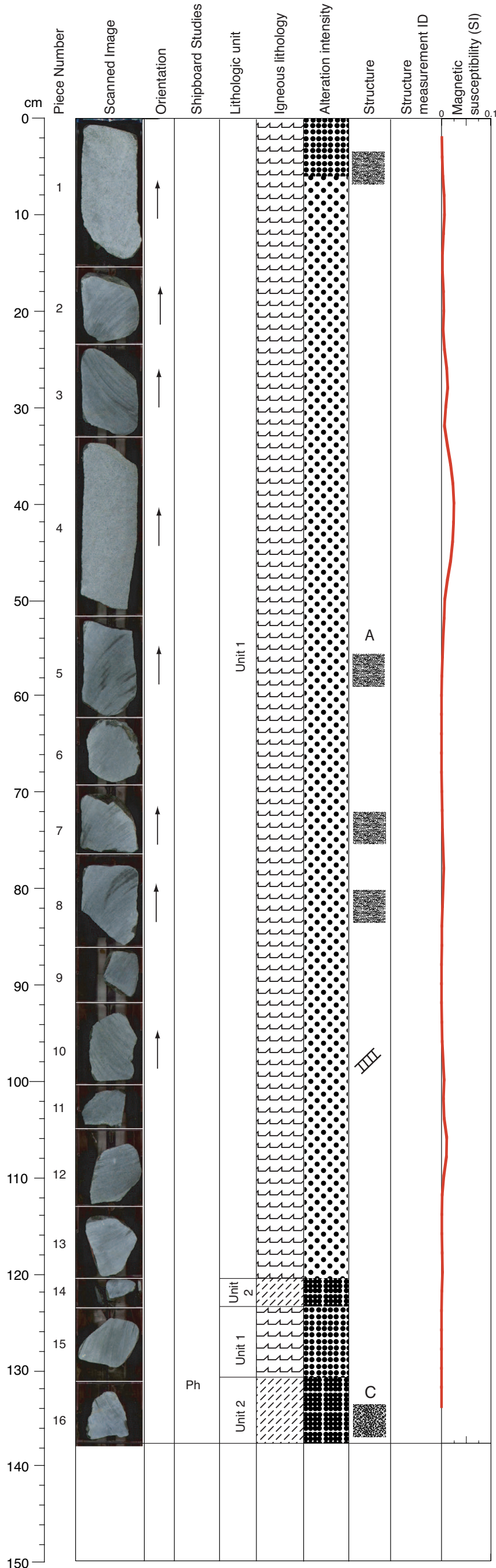
Core Photo



Core Photo



Core Photo



304-1309D-1R-2 (Section top: 21.9 mbsf)

UNIT-1 : Plagioclase-phyric Diabase
Pieces 1-13,15

PRIMARY MINERALOGY:

Olivine	Groundmass Modal ~2% Size 0.6 mm Shape anhedral	Phenocryst Modal < 1 % Size 1 mm Shape anhedral
Plagioclase	Modal 45% Size 1-2.5 mm Shape subhedral	Modal < 1% Size 4-7 mm Shape subhedral
Clinopyroxene	Modal 52% Size 0.8-1.5 mm Shape anhedral	
Oxides	Modal 1-2%	

COMMENTS: This unit represents the continuation of Unit 1 from Section 1R-1. From Piece 8 on, grain sizes decrease downhole.

UNIT-2 : Basalt Breccia
Pieces 14, 16

PRIMARY MINERALOGY:
Too fine-grained to estimate

COMMENTS: Unit 2 consists of a matrix-supported breccia of mostly microcrystalline basalt clasts. Clast sizes range between 0.5 mm and 15 mm. The matrix is made of aphanitic to plagioclase-phyric basalt with phenocrysts of 0.5 mm.

Piece 15 is presumed to be out of place and belongs to Unit 1.

SECONDARY MINERALOGY: Plagioclase is fresh throughout this section. In the upper 3 cm pyroxene is completely altered to actinolite. About 20% of the original pyroxene survives in the section down to 119 cm. Below this is a breccia zone that is probably 80-100% altered to amphibole + chlorite.

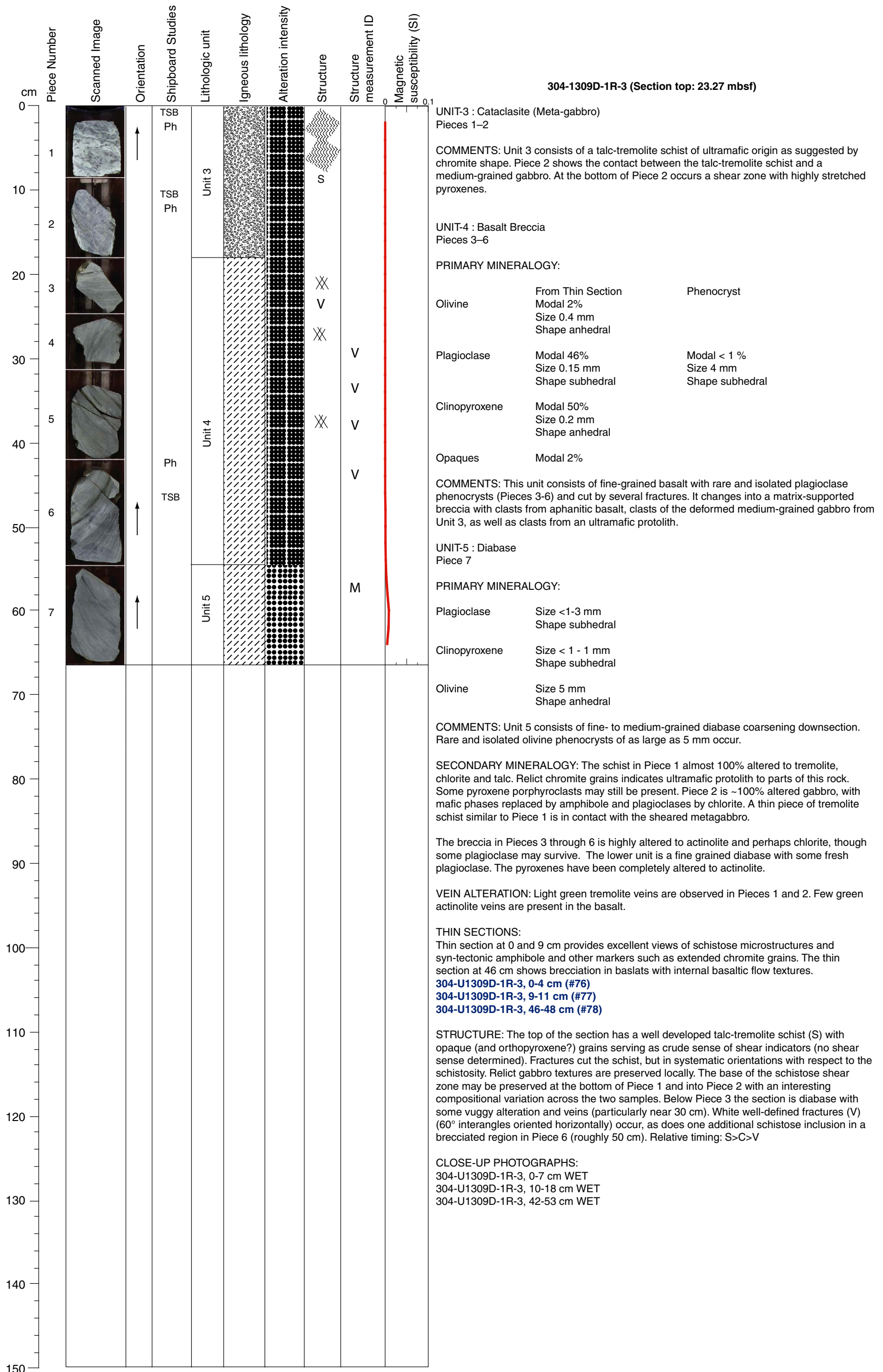
VEIN ALTERATION: A few green actinolite phyric veins are present at the bottom of the section.

STRUCTURE: Thin, dark, and patchy areas of alteration (A), some with subplanar characteristics (mineral seams, for example) dip toward 270° (in the core reference frame). At the base of the section some granular fault rock (breccia with rounded grains) occur in regions bound by thin fractures (C).

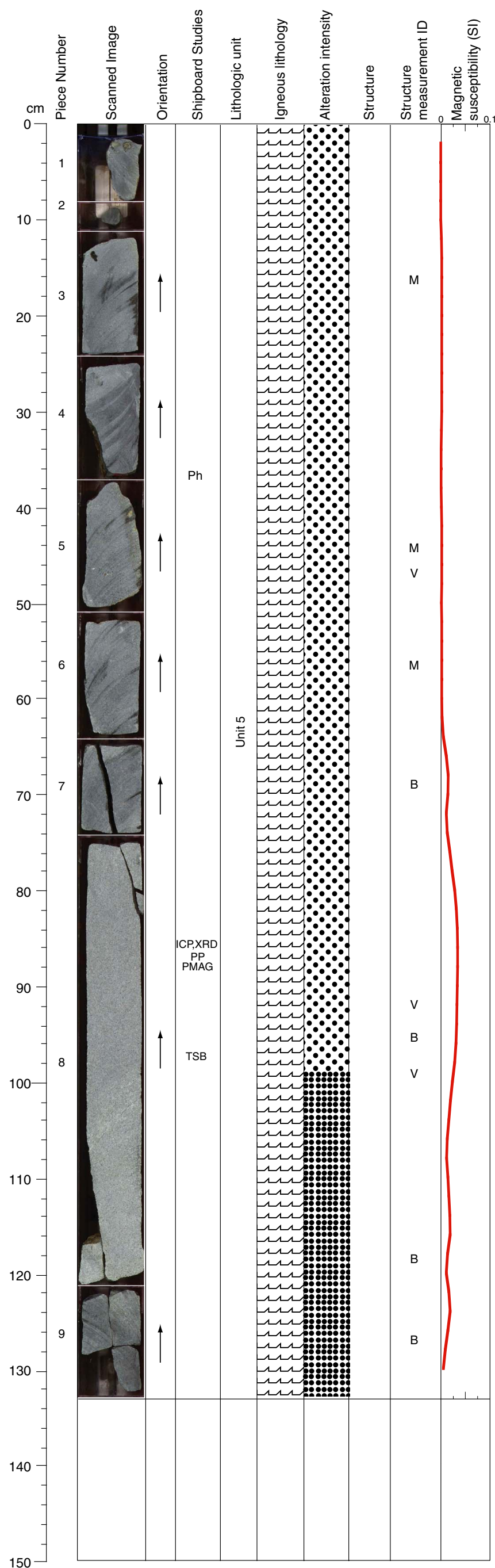
CLOSE-UP PHOTOGRAPHS:
304-U1309D-1R-2, 130-136 cm (wet)



Core Photo



Core Photo



304-1309D-2R-1 (Section top: 26.8 mbsf)

UNIT-5 : Diabase
Pieces 1-9

PRIMARY MINERALOGY:

Olivine	From Thin Section Modal 3% Size 1.2-1.4 mm Shape anhedral	Phenocryst
Plagioclase	Modal 49% Size 0.7-2.5 mm Shape subhedral	Modal <1% Size 5 mm Shape subhedral
Clinopyroxene	Modal 50% Size 1-2 mm Shape anhedral	
Opaques	Modal 3%	

COMMENTS: Continuation of diabase from Core 1.

SECONDARY MINERALOGY: This section comprises a single intrusion of medium-grained diabase. Plagioclase is fresh throughout the section. At the top and the base of the section pyroxenes and olivine have been completely altered to actinolite (and perhaps chlorite). About 40% of the pyroxenes survive in the middle of the unit. The transition from partially altered to completely altered diabase is gradational in the upper part of the section but is sharp at 99 cm in the lower portion of the section. Green and yellow-green spots at the top of the core are actinolite +/- chlorite, magnetite and sphene after olivine.



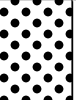



THIN SECTIONS:
304-U1309D-2R- 1, 97-100 cm (#79)

STRUCTURE: Weak magmatic layering and poorly defined green veins typify this section.

CLOSE-UP PHOTOGRAPH:
304-U1309D-2R-1, 36-49 cm WET



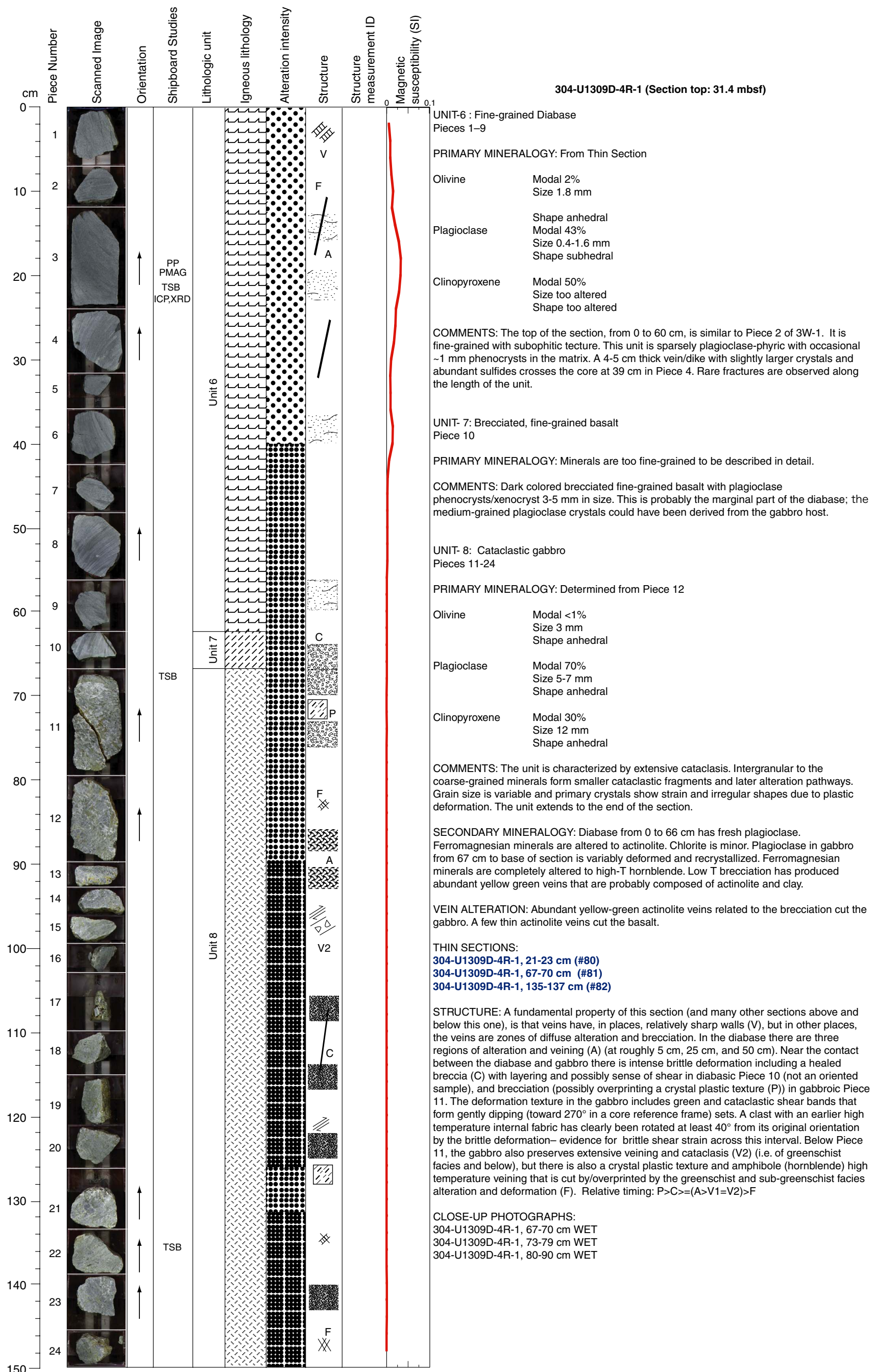
Core Photo

cm	Piece Number	Scanned Image	Orientation	Shipboard Studies	Lithologic unit	Igneous lithology	Alteration intensity	Structure	Structure measurement ID	Magnetic susceptibility (SI)	
0											
0	1				Unit 5						UNIT-5: Medium-grained Diabase Piece 1 PRIMARY MINERALOGY: To fine-grained to describe in hand specimen. COMMENTS: Rubble from washing.
0	2				Unit 6						UNIT-6: Fine-grained Diabase Piece 2 PRIMARY MINERALOGY: To fine-grained to describe in hand specimen. COMMENTS: Rubble from washing. SECONDARY MINERALOGY: Plagioclase is fresh in these pieces. Pyroxene has altered to actinolite (and perhaps minor chlorite). About 20% of the pyroxene survived alteration. VEIN ALTERATION: One thin actinolite vein present. STRUCTURE: Patchy alteration
10											
20											
30											
40											
50											
60											
70											
80											
90											
100											
110											
120											
130											
140											
150											

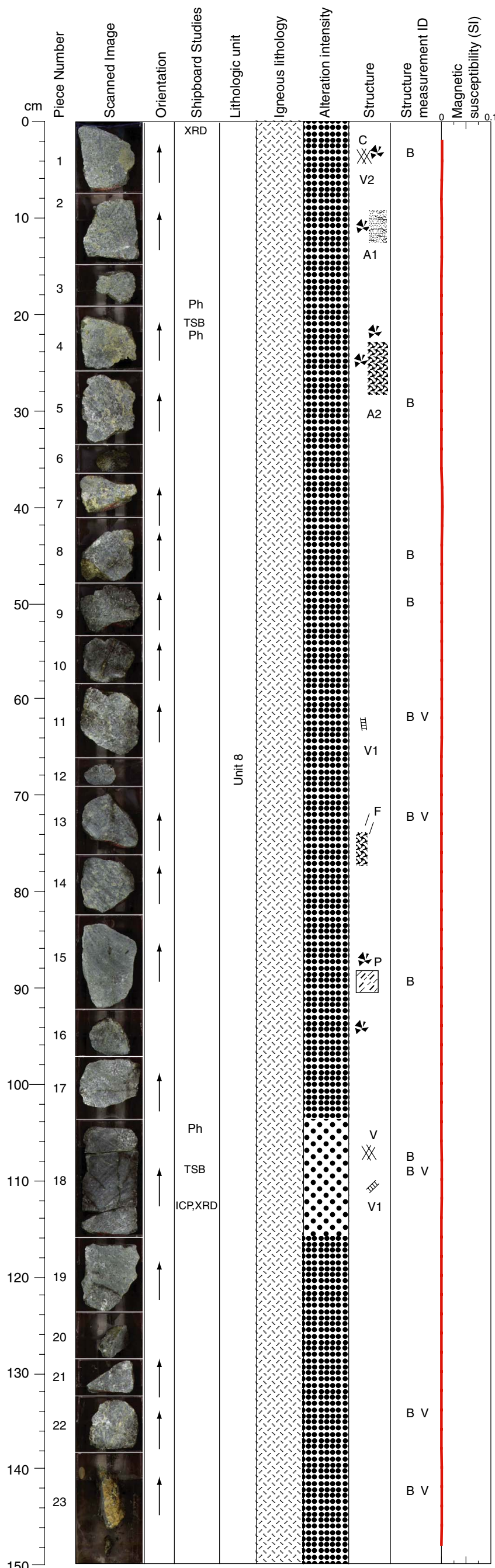
304-1309D-3W-1 (Section top: 31.3 mbsf)

Sample to small to obtain data.

Core Photo



Core Photo



304-U1309D-4R-2 (Section top: 32.9 mbsf)

UNIT-8: Cataclastic Gabbro
Pieces 1–24

PRIMARY MINERALOGY: Gabbro, Determined from Piece 23

Olivine Modal <1%
 Size <1 mm
 Shape anhedral

Plagioclase Modal 60%
 Size 10-15 mm
 Shape subhedral

Pyroxene Modal 40%
 Size 10-22 mm
 Shape anhedral

PRIMARY MINERALOGY: Troctolitic Gabbro interval, Pieces 13 and 14.

Olivine Modal 20%
 Size 3-5 mm
 Shape anhedral

Plagioclase Modal 68%
 Size 3-5 mm
 Shape subhedral

Pyroxene Modal 12%
 Size 3-5 mm
 Shape anhedral

COMMENTS: Extensive deformation along the entire length of the core. Cataclastic gabbros in the section have medium grain size (3-5 mm) due to deformation; undeformed sections have coarse-grained plagioclase and pyroxenes. A troctolitic gabbro interval occurs from 69 to 82 cm. This interval is also deformed, thus the grain size could be smaller than the original size, the same case with the gabbros.

Piece 23 shows a contact between undeformed coarse-grained gabbro and medium-grained cataclastic gabbro. The grain size change is abrupt but there is no sharp boundary and very slight difference in modal proportions (Plagioclase=68%, Pyroxene=30% and Olivine=2%). It also shows strong foliation.

SECONDARY MINERALOGY: Brecciated gabbros in this section are highly altered. Plagioclase is variably deformed with bent twin lamellae and recrystallized. Ferromagnesian minerals are almost completely altered to high-temperature hornblende. Chlorite is minor. Low-temperature brecciation has produced abundant yellow-green veins of probable actinolite and clay in the breccia matrix (matrix identified with XRD). These veins locally cut paler green veins of amphibole that might record an older brecciation episode (Piece 4).

VEIN ALTERATION: Yellow-green actinolite breccia veins occur throughout the section. Dark hornblende (?) veins are cut by actinolite veins in Piece 13.

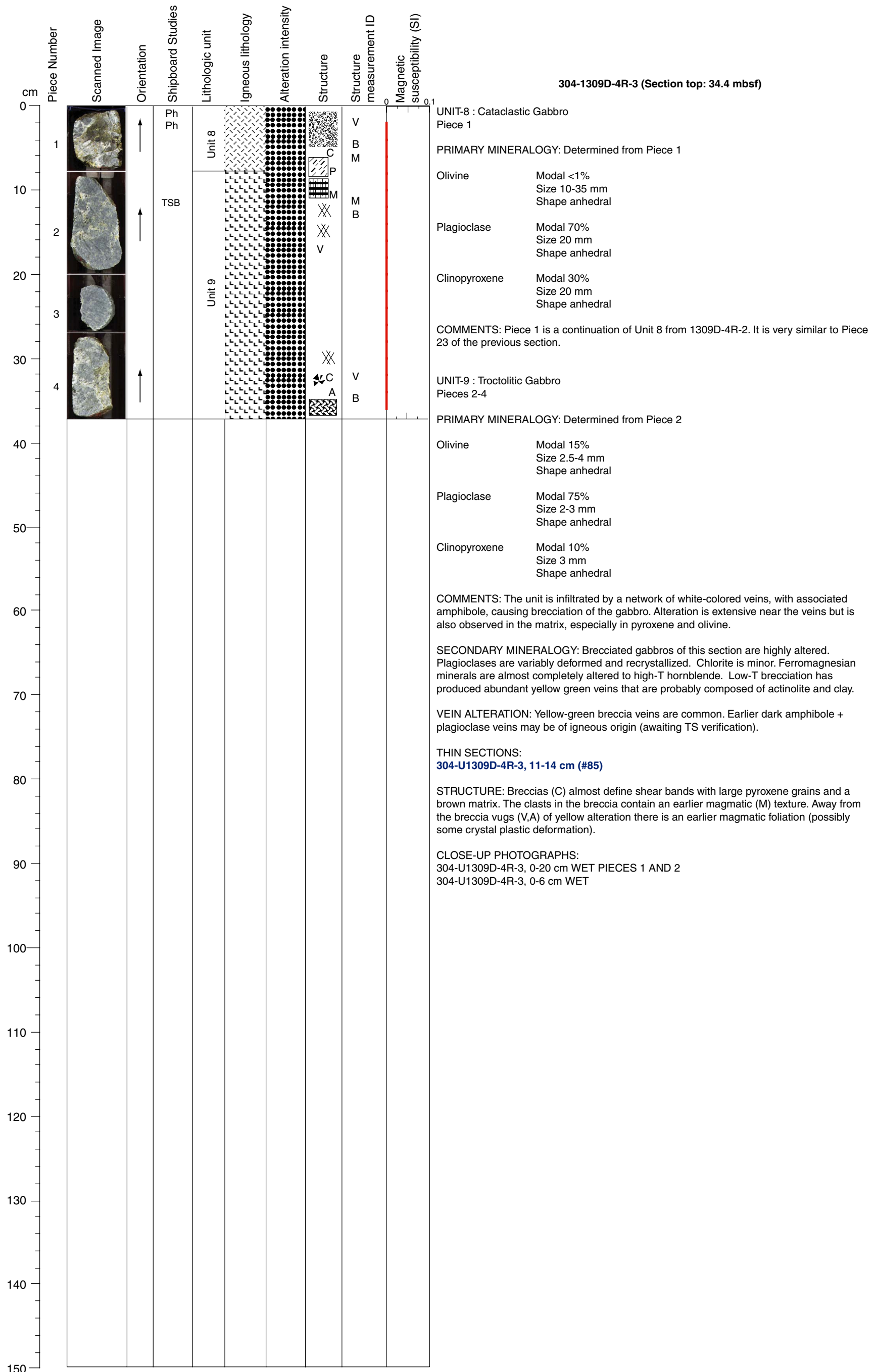
THIN SECTIONS:
[304-U1309D-4R-2, 20-23 cm \(#83\)](#)
[304-U1309D-4R-2, 108-110 cm \(#84\)](#)

STRUCTURE: Numerous veins associated with feldspar-rich domains and local cataclasis typify this section. Such "cataclastic veins" trace into more diffuse zones of brecciation and alteration (A1, A2, V2, C). A particularly important piece with respect to the (greenschist facies) alteration and brecciation is Piece 4 where there are two areas (boudins?) of unaltered gabbroic rock between 2 cm-scale domains of green breccia. The two breccia domains trace continuously into a large breccia region in the piece. However, subtle crosscutting relationships and differences in color suggest that there may be two intervals of deformation and alteration. The timing and dynamics of brecciation and alteration are therefore controversial, although one can clearly separate cataclastic veins from more diffuse brecciation. Interestingly, the different sets of brecciation and alteration almost define systematic orientations, one at a high angle to the core, and one at a low angle. Below Piece 4, in Piece 11, there are very local veins of a dark amphibole that could be hornblende (V1). Below this piece there are several intervals of crystal plastic deformation overprinted by cataclastic zones and even younger patches of vuggy alteration and fractures. There is therefore a nearly complete record of deformation and alteration in this section from: high-temperature magmatic to hydrothermal deformation and amphibole veining, one or two intervals of greenschist grade deformation and mineralization, followed by youngest fracture and vuggy alteration. Relative timing: V1>(A1>A2)=C>V2

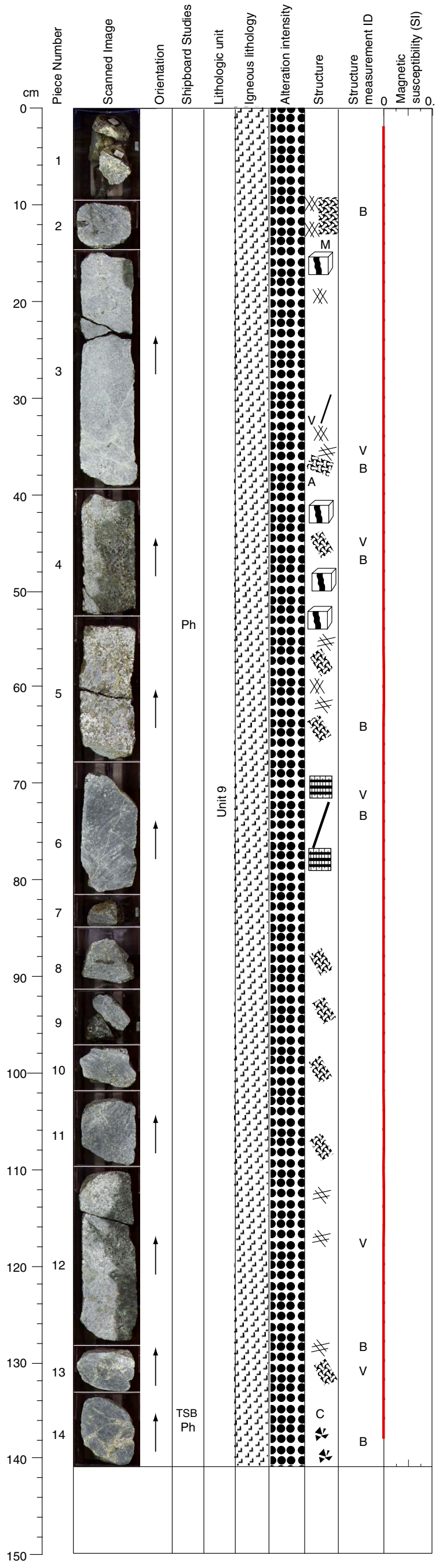
CLOSE-UP PHOTOGRAPHS:
304-U1309D-4R-2, 19-24 cm (wet)
304-U1309D-4R-2, 20-23 cm (wet)
304-U1309D-4R-2, 104-115 cm (wet)



Core Photo



Core Photo



304-U1309D-5R-1 (Section top: 36.0 mbsf)

UNIT-9 : Medium-grained Troctolitic Gabbro
 Pieces 1-14

PRIMARY MINERALOGY:

Olivine Modal 15%
 Size 2-4 mm
 Shape anhedral

Plagioclase Modal 75%
 Size 2-3 mm
 Shape anhedral

Clinopyroxene Modal 10%
 Size 2.5-4 mm
 Shape anhedral

COMMENTS: This section is the continuation of Unit 9 of 1309D-4R-3. Slight variability in modal composition and grain size is observed along the section but the main rock type is troctolitic gabbro (representative modal composition is given above). Corona texture is observed within the matrix of the samples. The unit is infiltrated by a sub-horizontal, "felsic" (white-colored) vein network with associated amphibole (15-20 mm average size) along the entire length of the core. Brecciation due to this vein is specially observed in Pieces 4, 5 and 12. A 50-60 mm angular block of host material is observed from 54 to 64 cm.

SECONDARY MINERALOGY: This section contains several rock types which have altered in different ways. Troctolitic gabbro shows typical amphibole + chlorite +/- talc corona textures after olivine. Pegmatitic gabbro (e.g. 52-66 cm) shows dark amphibole rims around pyroxenes. Plagioclase is altered to milky secondary feldspar around actinolite veins and breccia zones. Leucocratic veins also contain hornblende and milky plagioclase, and it is not clear how much of this is due to secondary alteration.

VEIN ALTERATION: Hornblende-bearing felsic veins (e.g. at 20 cm) are probably magmatic. Yellow-green breccia veins occur throughout the gabbro except in the troctolitic interval, where only thin amphibole/ chlorite veins are seen.

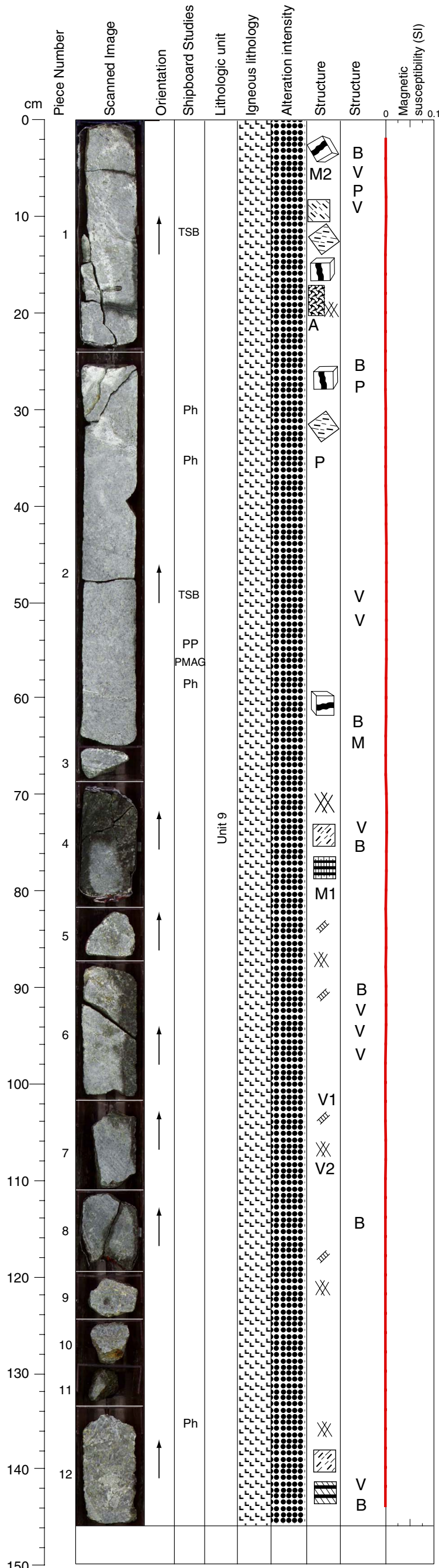
THIN SECTIONS:
304-U1309D-5R-1, 135-137 cm (#86)

STRUCTURE: Uneven distribution of patchy feldspar-rich portions (M) from either magmatic or high-temperature hydrothermal processes are interlaced with green and yellow alteration and associated brecciation, and veins (A,V,C). Below roughly 30 cm the vein/alteration network is inclined to 270° (in the core reference frame). Piece 14 at the bottom of the section is noteworthy for rounded clasts in a breccia with a yellow alteration matrix. Relative timing: M>C=A=V

CLOSE-UP PHOTOGRAPHS:
 304-U1309D-5R-1, 53-67 cm WET
 304-U1309D-5R-1, 53-67 cm WET BACKSIDE
 304-U1309D-5R-1, 135-137 WET



Core Photo



304-U1309D-5R-2 (Section top: 37.41 mbsf)

UNIT-9 : Medium-grained troctolitic gabbro
Pieces 1-12

PRIMARY MINERALOGY:

- Olivine Modal 15%
Size 2.5-4 mm
Shape anhedral
- Plagioclase Modal 75%
Size 4-5 mm
Shape anhedral
- Clinopyroxene Modal 10%
Size 2-3 mm
Shape anhedral

COMMENTS: This section is a continuation of Unit 9 of U1309D-5R-1. Grain size increases downhole; pyroxene can reach as much as 12 mm in the lower part of the section. The unit is still infiltrated by "felsic" (white-colored) veins and shows strong deformation, especially in Piece 1.

SECONDARY MINERALOGY: Piece 6 contains high-T ductile shear where plagioclase recrystallized. The sheared fabric is cut by thin irregular felsic veins of presumably magmatic origin and by hornblende veins. Green actinolite alteration occurs in veins and is also concentrated in the leucocratic patches in the rock that may either be felsic intrusion or areas of gabbro where plagioclase has altered to albite. The main part of the section is a troctolitic gabbro in which typical alteration coronas are formed by the reaction of plagioclase and olivine to give actinolite and chlorite +/- talc. Piece 12 displays the same textured gabbro as Piece 1 with hornblende coronas around pyroxene and later intense development of yellow-green actinolite breccia.

VEIN ALTERATION: Green breccia veins are rare in the top of the section but become increasingly common below 87 cm. Felsic magmatic veins occur throughout.

THIN SECTIONS:

- 304-U1309D-5R-2, 10-15 cm (#87)
- 304-U1309D-5R-2, 49-52 cm (#88)

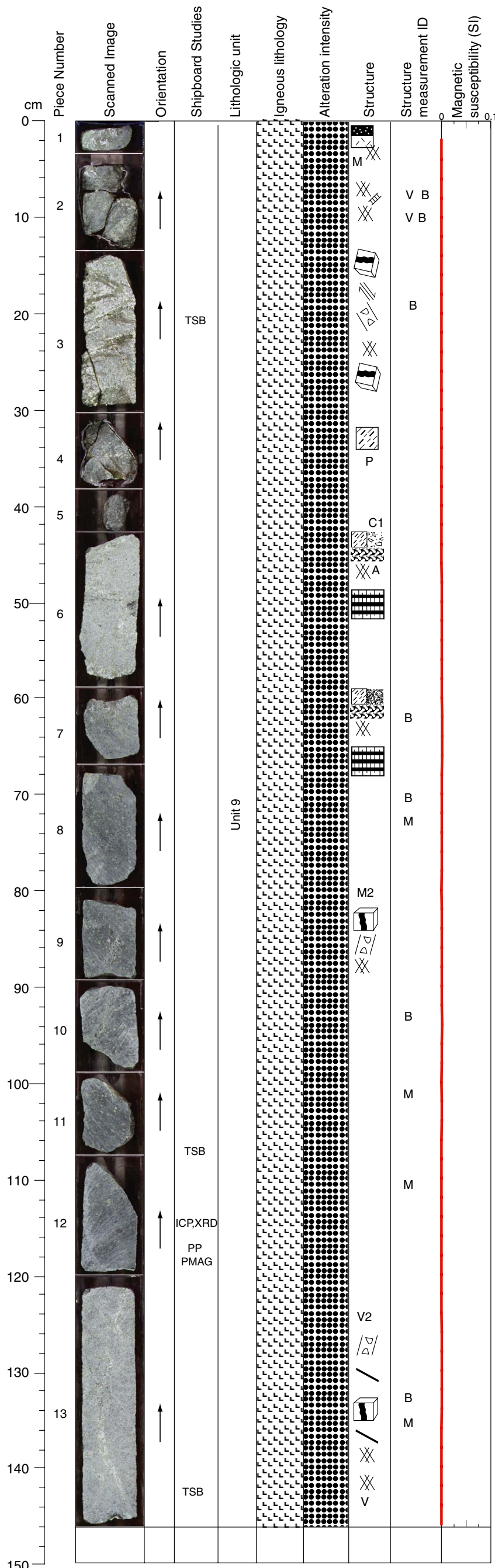
STRUCTURE: A noteworthy section for a space-time relationship between felsic-rich domains (M2) and crystal plastic shear zones (P). Near 10 cm there is a strong crystal plastic fabric defined by stretched feldspar domains. Near 30 cm the equivalent feature has far less strain, and near 60 cm there is a felsic vein that is undeformed. Below this portion of the section a weak, high-temperature (crystal plastic deformation on an earlier magmatic layering) (M1) is cut by thin hornblende (?) veins (V1), in turn cut by light green veins (V2) and alteration. Vuggy alteration of pyroxenes are of an uncertain age with respect to the vein-producing alteration. Relative timing: M1>P>M2>V1>V2=A

CLOSE-UP PHOTOGRAPHS:

- 304-U1309D-5R-2, 4-14 cm WET
- 304-U1309D-5R-2, 30-35 cm WET
- 304-U1309D-5R-2, 35-47 cm WET
- 304-U1309D-5R-2, 35-47 cm
- 304-U1309D-5R-2, 58-62 cm WET
- 304-U1309D-5R-2, 134-145 cm WET



Core Photo



304-U1309D-5R-3 (Section top: 38.87 mbsf)

UNIT-9 : Medium-grained Troctolitic Gabbro
Pieces 1-13

PRIMARY MINERALOGY:

- Olivine Modal 20%
 Size 2.5-6 mm
 Shape anhedral
- Plagioclase Modal 70%
 Size 4-7 mm
 Shape anhedral
- Clinopyroxene Modal 10%
 Size 2.5-4 mm
 Shape anhedral

COMMENTS: This section is a continuation of Unit 9 of U1309D-5R-2. Slight variation in modal composition and grain size is observed relative to the previous section, but the rock still has troctolitic gabbro composition. Piece 3 shows displaced sub-horizontal, 7-9 mm "felsic" (white-colored) veins. Downhole, the veins become nearly vertical. Gabbroic domains (2-3 cm wide) are observed in Pieces 6 and 7 (at 50 and 56-60 cm). The domains have slightly larger crystals (4 mm pyroxenes and 6 mm plagioclase).

SECONDARY MINERALOGY: From 14 to 37 cm plagioclase is recrystallized near dark hornblende veins. Elsewhere about 30% of the plagioclase is fresh. In the remainder of the section plagioclase has reacted with olivine to make chlorite and actinolite +/- talc.

VEIN ALTERATION: Hornblende veins are present in the whole section, but more developed in the upper part of the section, especially in Piece 3. The veins contain euhedral crystals. A late stage alteration is recorded by yellow-green veins. These are most abundant between 10 and 40 cm where they crosscut the early hornblende veins.

THIN SECTIONS:

- 304-U1309D-5R-3, 20-23 cm (#89)
- 304-U1309D-5R-3, 107-110 cm (#90)
- 304-U1309D-5R-3, 142-143 cm (#91)

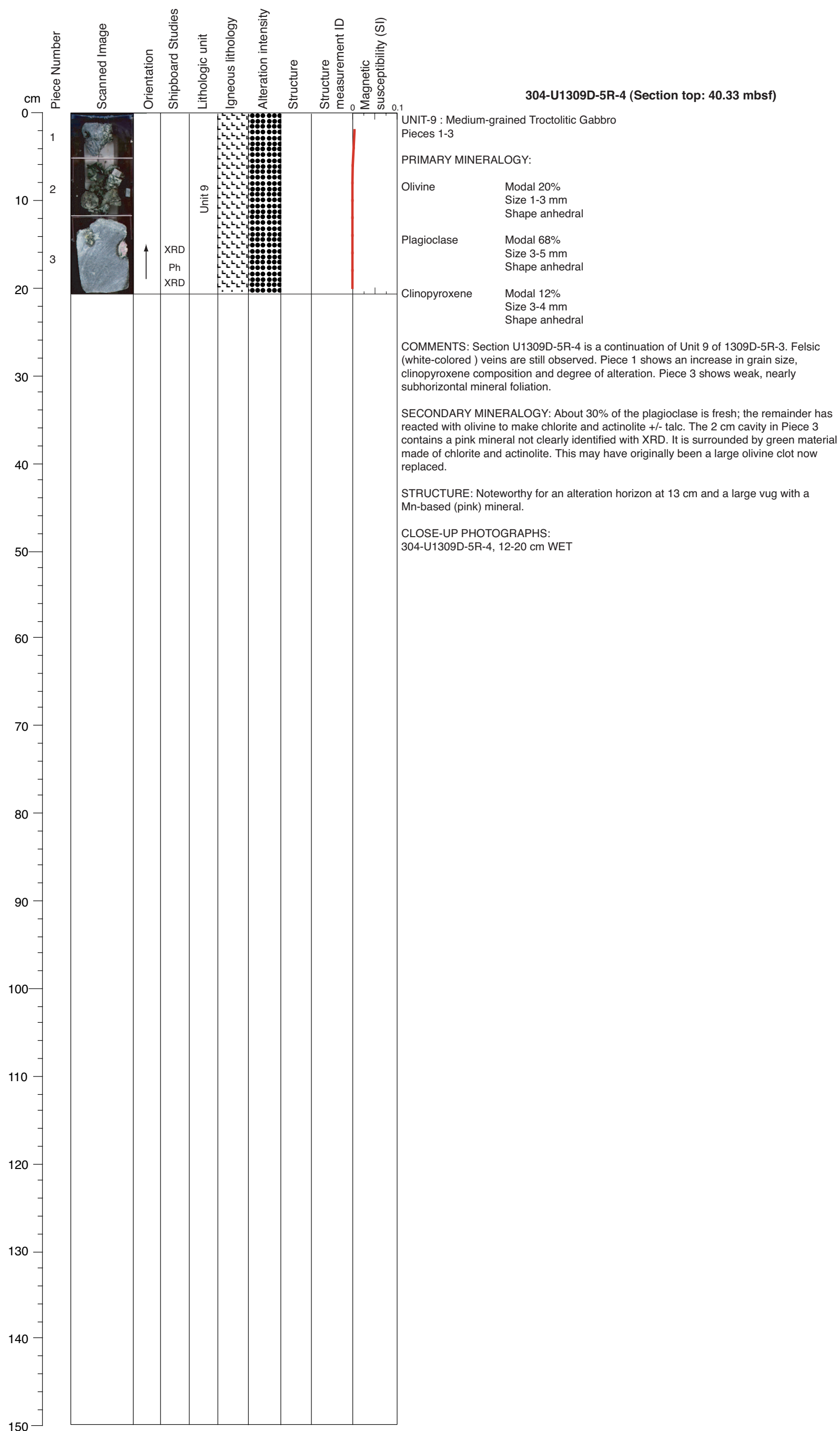
STRUCTURE: Throughout this and adjacent sections there is a complicated relationship between feldspar-rich domains, pyroxene (and pyroxene altered to amphibole)-rich domains, two to three intervals of veining, and associated brecciation and alteration. A cryptic crystal plastic (P) and/or magmatic fabric (M) is also present in very local (semi-brittle?) shear zones (C1). Layering in Piece 3 has bands of feldspar and (high-temperature?) amphibole alternate (M2). The internal texture of the amphibole bands is brecciated and altered (V1), and bladed amphiboles protrude into these domains. The layers are sharply cut by yellowish green veins with associated cataclasis (V2,C2,A). As elsewhere, the importance of (late) magmatic vs. amphibolite grade vs. greenschist grade processes in creating these textures is uncertain. Relative timing: P=M>M2(=C)>V1>V2=C2=A

CLOSE-UP PHOTOGRAPHS:

- 304-U1309D-5R-3, 14-30 cm DRY
- 304-U1309D-5R-3, 14-30 cm WET
- 304-U1309D-5R-3, 67-79 cm WET



Core Photo



304-U1309D-5R-4 (Section top: 40.33 mbsf)

UNIT-9 : Medium-grained Troctolitic Gabbro
Pieces 1-3

PRIMARY MINERALOGY:

- Olivine Modal 20%
 Size 1-3 mm
 Shape anhedral
- Plagioclase Modal 68%
 Size 3-5 mm
 Shape anhedral
- Clinopyroxene Modal 12%
 Size 3-4 mm
 Shape anhedral

COMMENTS: Section U1309D-5R-4 is a continuation of Unit 9 of 1309D-5R-3. Felsic (white-colored) veins are still observed. Piece 1 shows an increase in grain size, clinopyroxene composition and degree of alteration. Piece 3 shows weak, nearly subhorizontal mineral foliation.

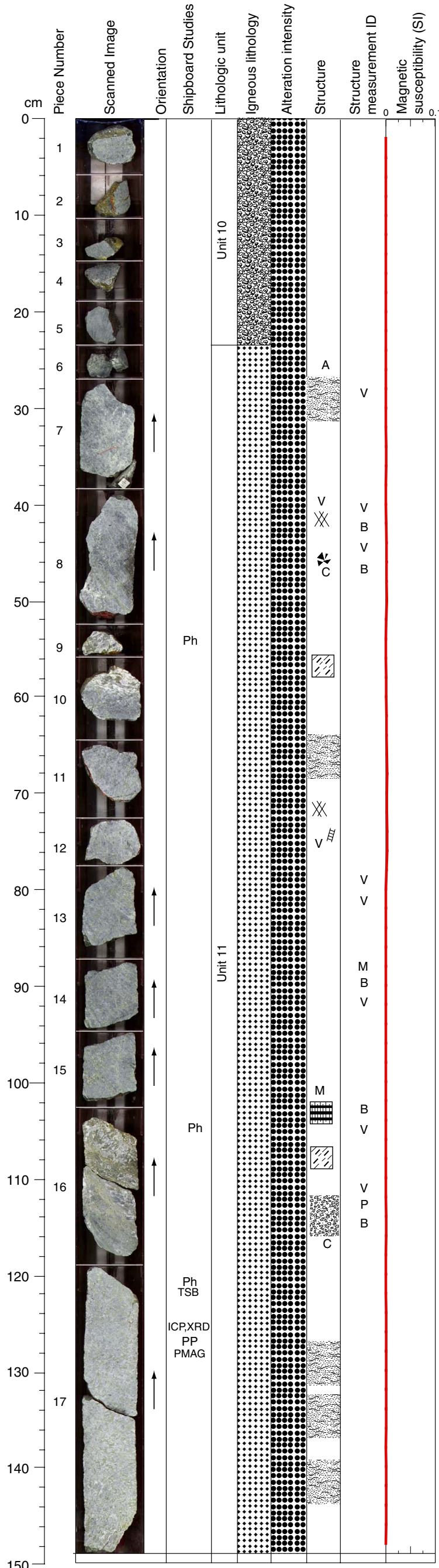
SECONDARY MINERALOGY: About 30% of the plagioclase is fresh; the remainder has reacted with olivine to make chlorite and actinolite +/- talc. The 2 cm cavity in Piece 3 contains a pink mineral not clearly identified with XRD. It is surrounded by green material made of chlorite and actinolite. This may have originally been a large olivine clot now replaced.

STRUCTURE: Noteworthy for an alteration horizon at 13 cm and a large vug with a Mn-based (pink) mineral.

CLOSE-UP PHOTOGRAPHS:
304-U1309D-5R-4, 12-20 cm WET



Core Photo



304-U1309D-6R-1 (Section top: 40.8 mbsf)

UNIT-10 : Mixed Rubble
Pieces 1-5

COMMENTS: Pieces 1 to 4 are composed of equigranular (2 mm average) medium-grained gabbro. Piece 5 is fine-grained basalt.

UNIT-11 : Olivine-gabbro
Pieces 6-17

PRIMARY MINERALOGY:

- Olivine Modal 30%
 Size 1-7 mm
 Shape anhedral
- Plagioclase Modal 55%
 Size 2-9 mm
 Shape subhedral
- Clinopyroxene Modal 15%
 Size 1.5-5 mm
 Shape anhedral

COMMENTS: The entire unit coarsens downhole, from medium-grained to coarse-grained. Gabbroic patches (40-52 mm size) occur at Piece 8 (40 to 52 cm interval). Weak foliation is observed from 77 to 148 cm. Olivine is completely altered and alteration veins are pervasive.

SECONDARY MINERALOGY: About 30% of the plagioclase is fresh; the remainder has reacted with olivine to make chlorite and actinolite. Plagioclase is strongly recrystallized and dark hornblende is well developed in a narrow zone of high T deformation from 54 to 63 cm. The same kind texture is observed in Piece 16, where it is overprinted by an actinolite breccia zone.

VEIN ALTERATION: Intense development of actinolitic veins at 108-116 cm.

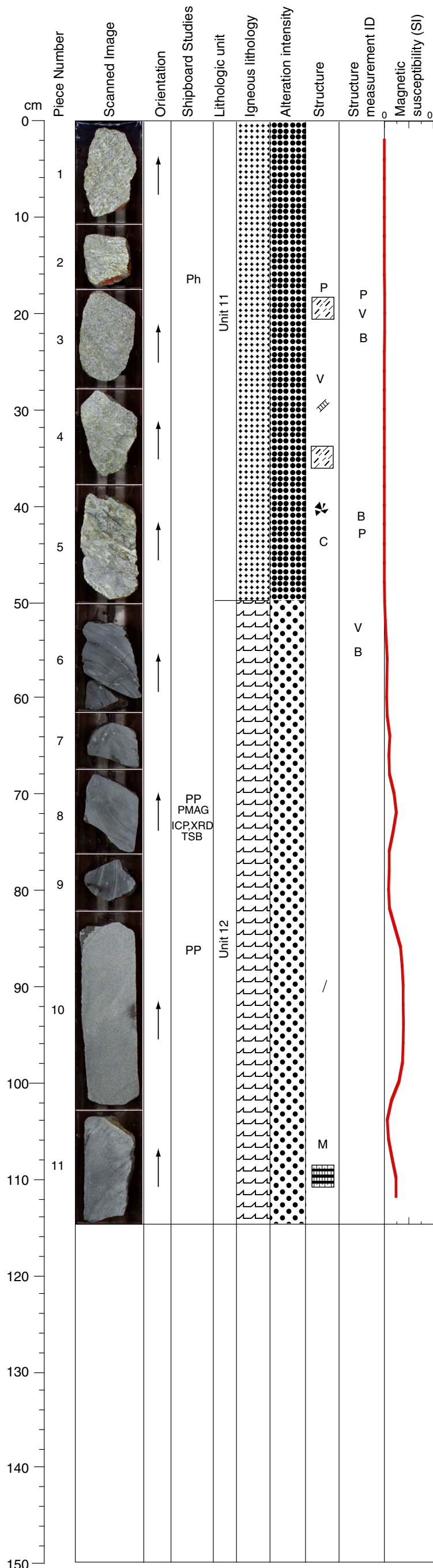
THIN SECTIONS:
304-U1309D-6R-1, 121-124 cm (#92)

STRUCTURE: Similar to adjacent sections with feldspar- and hornblende(?) - rich domains of possible hydrothermal or magmatic origin, superposed with alteration (A) and brecciation (C), some of which localizes in vein networks. Crystal plastic strain (P) (possibly superposed on magmatic fabric) is present at ~50 cm and 110 cm, although this strain could be semi-brittle and even cataclastic in places. Throughout the section green alteration is patchy, but forms networks that define a fabric with a dip toward 270° in the core reference frame. Possibly noteworthy is a conspicuous yellowish to rust color in some of the veins. Relative timing: M>=P>C>V=A

CLOSE-UP PHOTOGRAPHS:
304-U1309D-6R-1, 53-60 cm WET ACROSS TWO PIECES
304-U1309D-6R-1, 104-114 cm WET
304-U1309D-6R-1, 120-132 cm WET
304-U1309D-6R-1, 120-132 cm DRY BACKSIDE



Core Photo



304-U1309D-6R-2 (Section top: 42.3 mbsf)

UNIT-11 : Olivine Gabbro
Pieces 1-5

PRIMARY MINERALOGY: Determined from Piece 3

- Olivine Modal 25%
 Size <1-5 mm
 Shape anhedral
- Plagioclase Modal 60%
 Size 1-7 mm
 Shape anhedral
- Clinopyroxene Modal 15%
 Size 1-5 mm
 Shape anhedral

COMMENTS: Section U1309D-6R-2, 0 to 49 cm interval is a continuation of Unit 11 of 1309D-6R-1. The unit is coarse-grained and nearly equigranular. Very coarse plagioclase and pyroxene grains (12 mm) occur at Piece 5 (34-49 cm). Fabric shows magmatic foliation overprinted by brittle and ductile deformation becoming more intense toward the end of Piece 5.

UNIT-12 : Diabase
Pieces 6-11

PRIMARY MINERALOGY: Determined from Thin Section

- Olivine Modal 4%
 Size 0.6-1.4 mm
 Shape anhedral
- Plagioclase Modal 40%
 Size 0.1-1.2 mm
 Shape subhedral
- Clinopyroxene Modal 50%
 Size 0.4 mm
 Shape anhedral
- Magnetite/Ilmenite Modal 5%

COMMENTS: A well developed subophitic texture with gradational change in grain size from fine- to medium-grained downhole characterizes this unit. Pieces 6-7 are microcrystalline and sparsely plagioclase-phyric (1-4 mm in size, <1%). This interval is interpreted as the marginal part of the diabase intrusion.

SECONDARY MINERALOGY: The upper 45 cm consist of troctolite, in which about 30% of the plagioclase is fresh. The remainder has reacted with olivine to make chlorite and actinolite +/- talc. The pegmatitic gabbro in Piece 5 is relatively fresh but shows some high temperature deformation with alteration of pyroxene to hornblende. The rest of the core consists of diabase in which plagioclase is fresh and 30% of the pyroxenes is fresh (the rest is altered to actinolite).

VEIN ALTERATION: Yellow-green breccia veins are well developed in the upper 37 cm of the core, particularly from 28-37 cm where a cataclastic breccia zone is present.

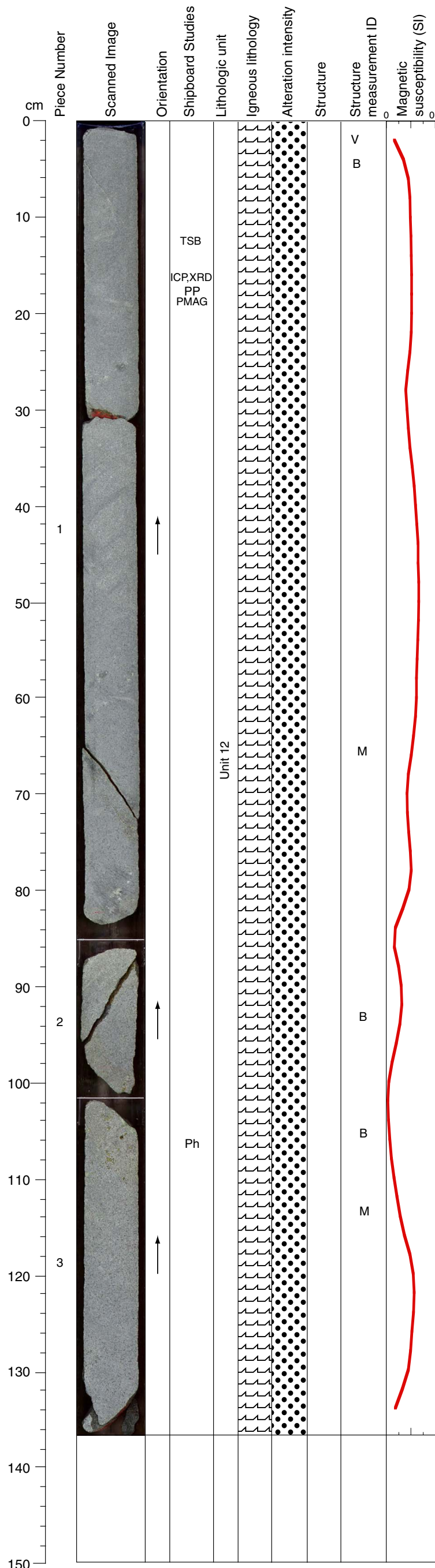
THIN SECTIONS:
304-U1309D-6R-2, 72-75 cm (#93)

STRUCTURE: Gabbroic portion: Increasing intensity of foliation towards 40 cm; adjacent to Piece 5 the foliation is produced by crystal plastic textures (P), overprinted by brecciation (C), and many sulfides - including at least one grain of pyrite (?). Basaltic portion: there is little to no structure aside from a weak magmatic foliation (M) dipping shallowly toward 270° (in the core reference frame) and two thin fractures. One vein has large feldspars and vein wall alteration. Relative timing: P>C; M>F=V

CLOSE-UP PHOTOGRAPHS:
304-U1309D-6R-2, 18-27 cm WET
304-U1309D-6R-2, 85-95 cm WET
304-U1309D-6R-2, 85-95 cm DRY BACKSIDE



Core Photo



304-U1309D-6R-3 (Section top: 43.44 mbsf)

UNIT-12 : Medium-grained diabase
Pieces 1-3

PRIMARY MINERALOGY: Determined from Thin Section

Olivine Modal 1%
 Size 0.5 mm
 Shape anhedral

Plagioclase Modal 50%
 Size 0.1-1.8 mm
 Shape subhedral

Clinopyroxene Modal 45%
 Size 0.1-1.2 mm
 Shape anhedral

Magnetite/Ilmenite Modal 5%

COMMENTS: Section U1309D-6R-3 is a continuation of Unit 12 of U1309D-6R-2. A downhole coarsening grain size trend is observed and primary minerals can reach as much as 3 mm in the lower part of the core. Concentrations of anhedral olivine phenocrysts (4-5 mm, <1%) occur at 27, 59, 82 and 106 cm along the length of the section. Thin section analysis shows that the interstitial liquid has a subophitic texture.

SECONDARY MINERALOGY: Most of the plagioclase in this section is fresh. About 30% of the pyroxenes are altered to amphibole. Pale-green (at 27, 60, and 80 cm) to yellow-green (at 104 cm) patches probably made of actinolite-chlorite-clays assemblages are observed after olivine.

VEIN ALTERATION: A few thin actinolite veins are observed. An oxide/hydroxide coated fracture is observed at 92 cm.

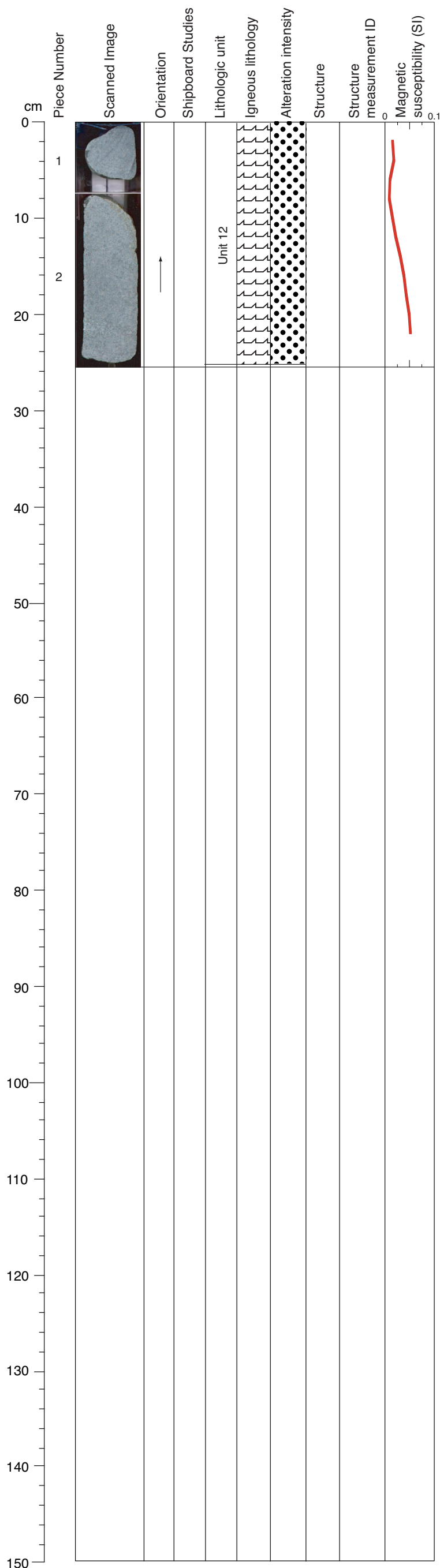
THIN SECTIONS:
304-U1309D-6R-3, 12-15 cm (#94)

STRUCTURE: None noted.

CLOSE-UP PHOTOGRAPHS:
304-U1309D-6R-3, 101-116 cm WET
304-U1309D-6R-3, 101-116 cm DRY BACKSIDE

Core Photo

304-U1309D-6R-4 (Section top: 44.79 mbsf)



UNIT-12 : Medium-grained diabase
 Pieces 1-2

PRIMARY MINERALOGY: Too fine-grained to describe in hand specimen.

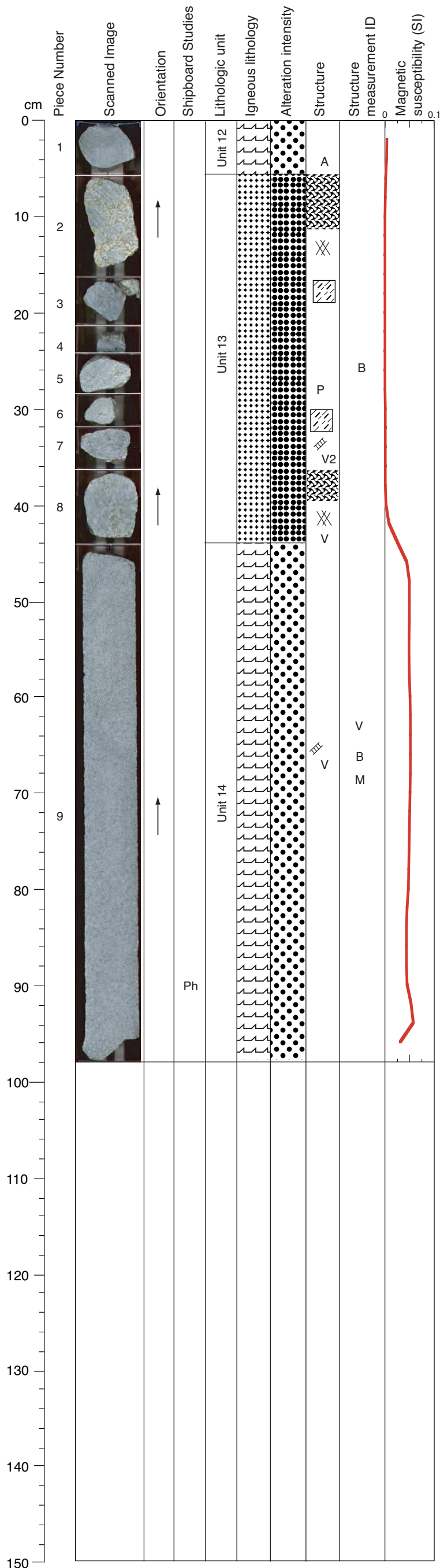
COMMENTS: Section U1309D-6R-4 is a continuation of Unit 12 of U1309D-6R-3. Anhedral olivine phenocrysts (4-5 mm, <1%) are observed along the length of the section.

SECONDARY MINERALOGY: Most of the plagioclase of this section are fresh. About 30% of the pyroxenes are altered to amphibole.

VEIN ALTERATION: No veins

STRUCTURE: None noted.

Core Photo



304-U1309D-7R-1 (Section top: 45.6 mbsf)

UNIT-12 : Medium-grained Diabase
 Piece 1

PRIMARY MINERALOGY:

Plagioclase	Modal ~43%
Clinopyroxene	Modal ~42%
Opaques	Modal 5%

COMMENTS: Section U1309D-7R-1, Piece 1 is a continuation of Unit 12 of U1309D-6R-4. The piece is mineralogically and texturally similar to the previous section.

UNIT-13 : Olivine Gabbro
 Pieces 2-8

PRIMARY MINERALOGY: Determined from Piece 8

Olivine	Modal 20%
	Size 5-8 mm
	Shape anhedral
Plagioclase	Modal 65%
	Size 2-7 mm
	Shape subhedral
Clinopyroxene	Modal 15%
	Size 3-5 mm
	Shape subhedral to anhedral

COMMENTS: The olivine gabbro is coarse-grained and nearly equigranular but slightly coarsening downhole. The whole unit is cross-cut by alteration veins. Pieces 3 to 7 show weak mineral foliation.

UNIT-14 : Medium-grained Diabase
 Piece 9

PRIMARY MINERALOGY:

Plagioclase	Modal 43%
Clinopyroxene	Modal 42%
Opaques	Modal 5%

COMMENTS: This diabase unit is composed of one long piece (Piece 9, from 44 to 98 cm interval) of nearly homogenous composition. Subophitic texture can be observed in the outside of the core. A coarser-grained diabase with gradational contacts at the end of the section starting at 95 cm and extending to ~6 cm at the upper end of Piece 1 in next section U1309D-7R-2 (see also thin section 304-U1309D-7R-2, 2-5 cm (#95)), which is also a long continuous piece. This suggests the continuity of the two pieces and the unit as well. Unit 14 may represent an internal magmatic segregation, in the middle part of the diabase unit. The diabase is also characterized by olivine phenocrysts (3-5 mm size).

SECONDARY MINERALOGY: In diabase (Piece 1 and 9), most of the plagioclase are fresh and about 30% of the pyroxenes are altered to pale amphibole. In the gabbros (from 5 to 44 cm) most of the plagioclase are about 20% altered to albite, particularly in halos around actinolite veins. Locally, coronitic textures in which olivine is replaced by actinolite, chlorite +/- talc. A schistose fabric with dark amphiboles is developed in Piece 7.

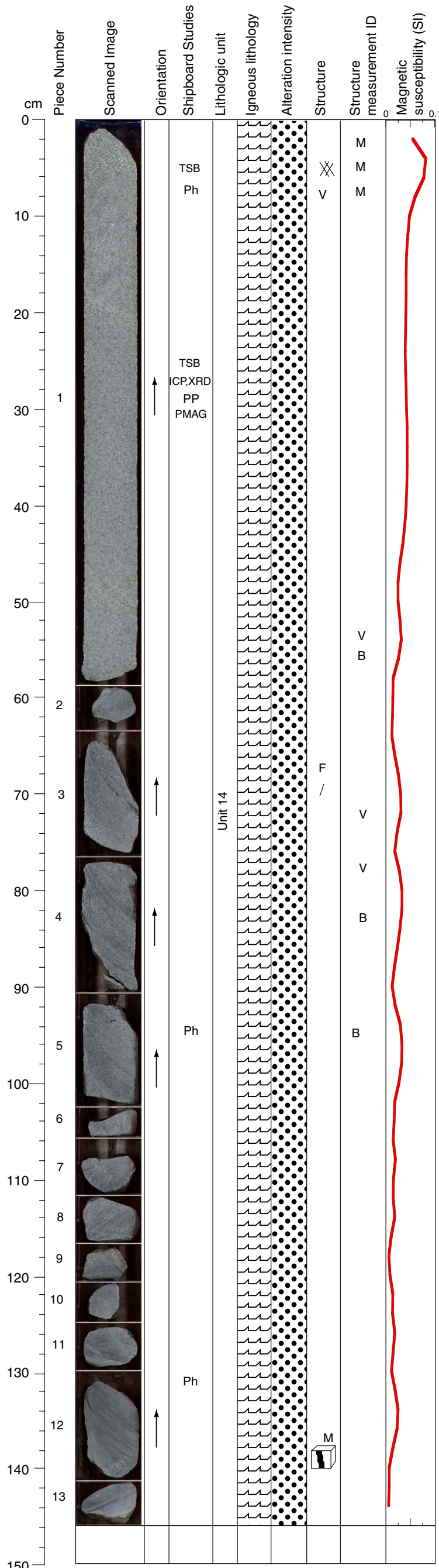
VEIN ALTERATION: Late alteration stage is recorded in the abundant yellow-green veins of probably actinolite +/- clay (e.g. in Piece 2). The diabase contains only rare actinolite veins.

STRUCTURE: Networked veins (V) and alteration (A) in feldspar-rich areas occur in the gabbro. Elsewhere (within Piece 3 and 7) a very weak crystal plastic fabric (P) and thin, short, dark amphibole (high-T hornblende?) veins (V2) are present. One almost invisible vein occurs in the diabase. Relative timing: P>V>V2=A

CLOSE-UP PHOTOGRAPHS:
 304-U1309D-7R-1, 87-97 cm ACROSS SECTION BOUNDARY 7R-2



Core Photo



304-U1309D-7R-2 (Section top: 46.58 mbsf)

UNIT-14 : Medium-grained Diabase
Pieces 1-13

PRIMARY MINERALOGY: Determined from Thin Section

Olivine	TS 7R-2, 2-5 cm	TS 7R-2, 24-26 cm Modal ~0.5% Size 0.2 mm Shape anhedral
Plagioclase	Modal 46% Size 0.2-3.2 mm Shape subhedral	Modal 48% Size 0.3-4 mm Shape subhedral
Clinopyroxene	Modal 46% Size 0.2-2.2 mm	Modal 48% Size 1.2-2 mm
Opagues	Modal 8%	Modal 1.5%

COMMENTS: The section is a continuation of Unit 14 from U1309D-7R-1. Piece 1 is continuous with Piece 9 of U1309D-7R-1, which shows a slightly coarser interval at the bottom of Section U1309D-7R-1 and top of U1309D-7R-2 cutting through the two long diabase cores. Piece 12 is fine-grained diabase, probably the marginal portion of the unit. A 10 mm dike of medium-grained gabbro with disseminated sulfides occurs at 140 cm.

SECONDARY MINERALOGY: Most of the plagioclase of this section are fresh. About 30% of the pyroxenes are altered to greenschist facies amphibole.

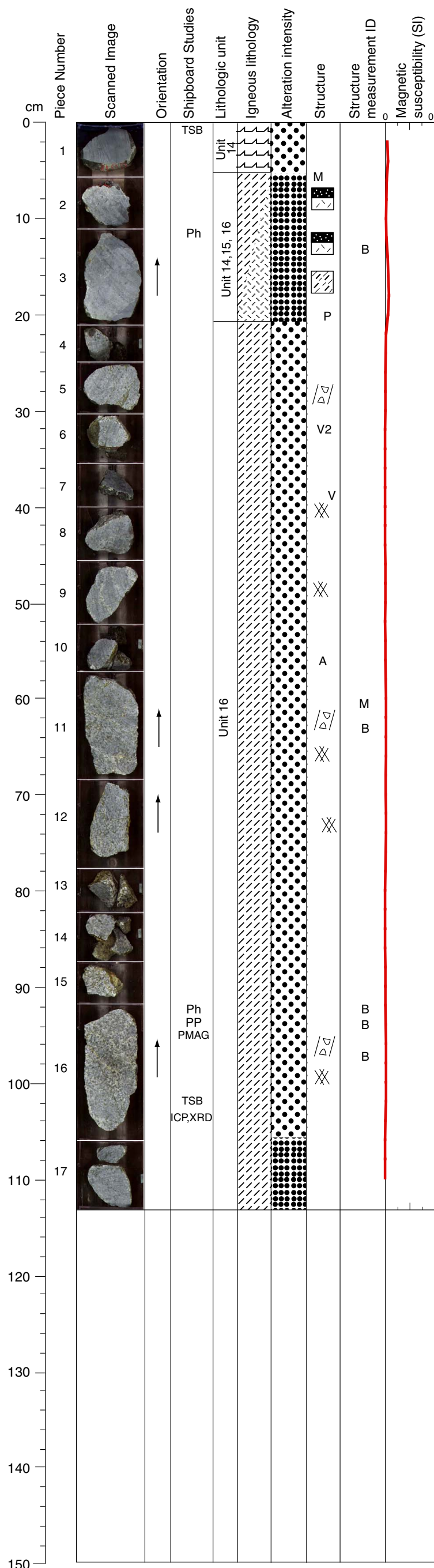
VEIN ALTERATION: A few amphibole veins are observed (e.g. cm 48).

THIN SECTIONS:
304-U1309D-7R-2, 2-5 cm (#95)
304-U1309D-7R-2, 24-26 cm (#96)

STRUCTURE: One green vein (V), some magmatic banding (M), and a few minor fractures (F) and veins.

CLOSE-UP PHOTOGRAPHS:
304-U1309D-7R-2, 0-10 cm ACROSS SECTION BOUNDARY 7R-1 WET
304-U1309D-7R-2, 91-101 cm WET
304-U1309D-7R-2, 91-101 cm DRY BACKSIDE
304-U1309D-7R-2, 129-140 cm WET

Core Photo



304-U1309D-7R-3 (Section top: 48.03 mbsf)

UNIT-14 : Fine-grained Diabase
Pieces 1, 3

PRIMARY MINERALOGY: Determined from Thin Section.

- Olivine Modal 1%
 Size 0.8 mm
 Shape anhedral
- Plagioclase Modal 42%
 Size 0.05-1 mm
 Shape subhedral
- Clinopyroxene Modal 50%
 Size 0.15 mm
 Shape anhedral
- Opaques Modal 7%

COMMENTS: Continuation of Unit 14 from U1309D-7R-2. Piece 1 is similar to the diabase in the previous section. In Piece 3, an irregular intrusive contact of diabase into gabbro is visible in the working half.

UNIT-15 : Basalt
Pieces 2-3

PRIMARY MINERALOGY: Too fine-grained to estimate composition in hand specimen.

COMMENTS: Aphanitic basalt intruding diabase, gabbro and cross-cutting the contact between the two. Working half clearly shows the intrusive nature of the aphanitic basalt. The dark colored intrusive has a characteristic fracturing pattern.

UNIT-16 : Medium-grained gabbro
Pieces 3-17

PRIMARY MINERALOGY: Determined from Piece 16

- Olivine Modal 1%
 Size 2-3 mm
 Shape anhedral
- Plagioclase Modal 79%
 Size 3.5-7 mm
 Shape subhedral
- Pyroxene Modal 20%
 Size 4-6 mm
 Shape anhedral

COMMENTS: The section is dominantly gabbro and varies to olivine gabbro in the bottom of the unit. Alteration veins cross-cut the section along its entire length.

SECONDARY MINERALOGY: Piece 1 is the continuation of Unit 14 from Section U1309D-7R-2. The gabbro unit (Pieces 2 and 3) show a higher alteration where pyroxenes are mainly replaced by pale amphibole and plagioclase show various degree of recrystallization.

From 21 to 116 cm, within the troctolite, plagioclase can be locally recrystallized, especially around veins (e.g. near 50 cm). Elsewhere, about 30% of the plagioclase is fresh. The rest has reacted with olivine to make chlorite and actinolite alteration. A late alteration episode in the troctolite is recorded by yellow-green veins of probably actinolite and clays.

VEIN ALTERATION: Yellow-green veins are abundant within the troctolite unit from 21 to 116 cm

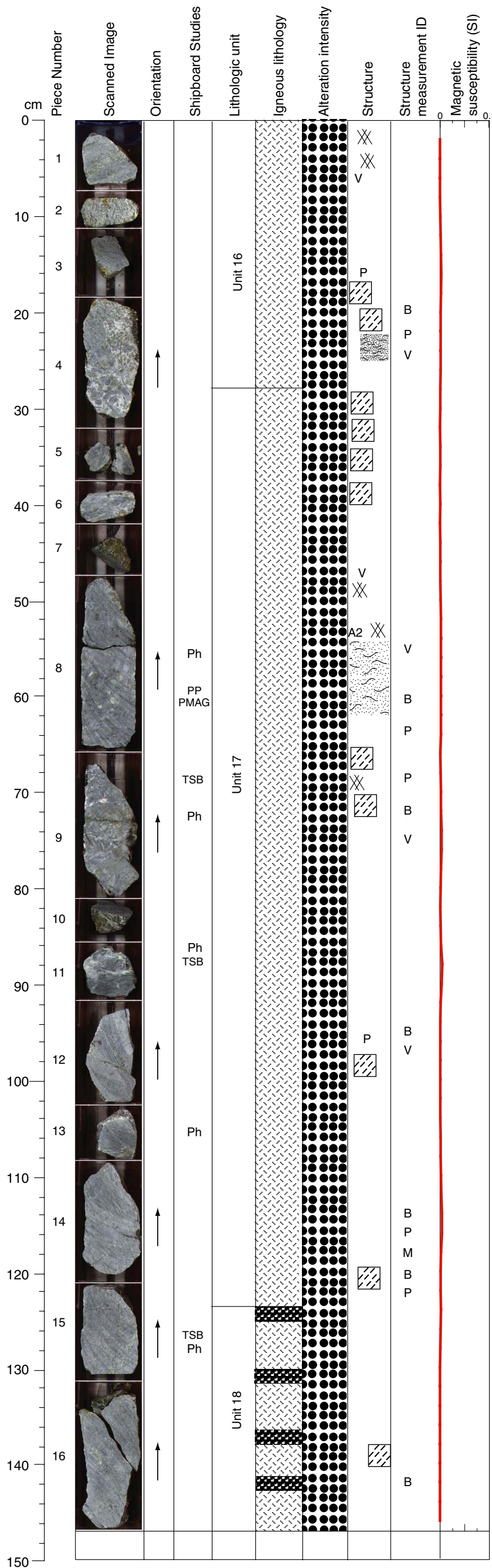
THIN SECTIONS:
304-U1309D-7R-3, 0-1 cm (#97)
304-U1309D-7R-3, 101-102 cm (#98)

STRUCTURE: Top of section preserves the intrusive contact of a thin basaltic dike cutting a gabbro with some earlier crystal plastic texture (P) and alteration (A) at the contact (note: the only way to observe the intrusive geometry is on the drilled side of the working half of Piece 3). There is therefore no requirement that the basalt in Pieces 2 and 3 are the exact continuation of the intrusives in Piece 1 and previous sections. The primary texture of the gabbro (i.e. little-to-no crystal plastic deformation) is preserved in the remainder of the section with a few high-T veins (?) (V1) and later cataclastic green veins (V2). The base of the section is olivine rich with typical olivine alteration to vugs of green minerals with dark, interconnected rims of dark alteration minerals. Relative timing: P=M(=A)>V1>V2=A (two intervals of alteration that are difficult to differentiate in hand sample).

- CLOSE-UP PHOTOGRAPHS:
304-U1309D-7R-3, 11-20 cm WET
304-U1309D-7R-3, 11-21 cm WET WORKING HALF BACKSIDE LEFT EDGE
304-U1309D-7R-3, 11-21 cm WET WORKING HALF BACKSIDE RIGHT EDGE
304-U1309D-7R-3, 11-21 cm WET WORKING HALF TOP
304-U1309D-7R-3, 11-21 cm WET WORKING HALF BACKSIDE
304-U1309D-7R-3, 91-104 cm WET



Core Photo



304-U1309D-8R-1 (Section top: 50.5 mbsf)

UNIT-16 : Medium-grained Gabbro
Pieces 1-4

PRIMARY MINERALOGY: Determined from Piece 3

- Olivine Modal 3%
 Size 2 mm
 Shape anhedral
- Plagioclase Modal 78%
 Size 2 mm
 Shape subhedral
- Pyroxene Modal 19%
 Size 2 mm
 Shape anhedral

COMMENTS: The contact between Unit 16 and 17 is in Piece 4 (24 cm interval). Gabbro abruptly changes into coarse-grained gabbro (Unit 17) without sharp contact.

UNIT-17 : Coarse-grained gabbro
Pieces 4-15

PRIMARY MINERALOGY: Determined from Piece 8B

- Olivine Modal 3%
 Size 0.7-20 mm
 Shape anhedral
- Plagioclase Modal 67%
 Size 10 mm
 Shape subhedral to anhedral
- Pyroxene Modal 30%
 Size 6 mm
 Shape anhedral

COMMENTS: Deformation increases downhole, from stretched minerals in the upper part to mylonite in the lower part. Coarse-grained pyroxenes that are more resistant to deformation become rounded as plagioclase and olivine is stretched. A felsic vein cuts horizontally Piece 9.

UNIT-18 : Deformed (mylonitic) Troctolite-Gabbro sequence
Pieces 15-16

PRIMARY MINERALOGY: Determined from Piece 15

- Olivine Modal 40%
 Size 2 mm
 Shape anhedral
- Plagioclase Modal 60%
 Size 2 mm
 Shape anhedral

COMMENTS: This unit consists of alternating gabbro and troctolite and marks the onset of occurrence of troctolitic layers within gabbro from Unit 17.

SECONDARY MINERALOGY: Pieces 6 through 15 (37 - 130 cm) consist of gneissic rock deformed and recrystallized in granulite or amphibolite facies. Plagioclase is intensely recrystallized (probably ductily) and ferromagnesian phases include both pyroxene and dark hornblende. Minor actinolite is present. Above 37 cm and below 130 cm alteration is mainly greenschist facies with actinolite and chlorite forming from olivine + plag.

VEIN ALTERATION: Major actinolite vein with recrystallized plagioclase at 3 cm and 72 cm.

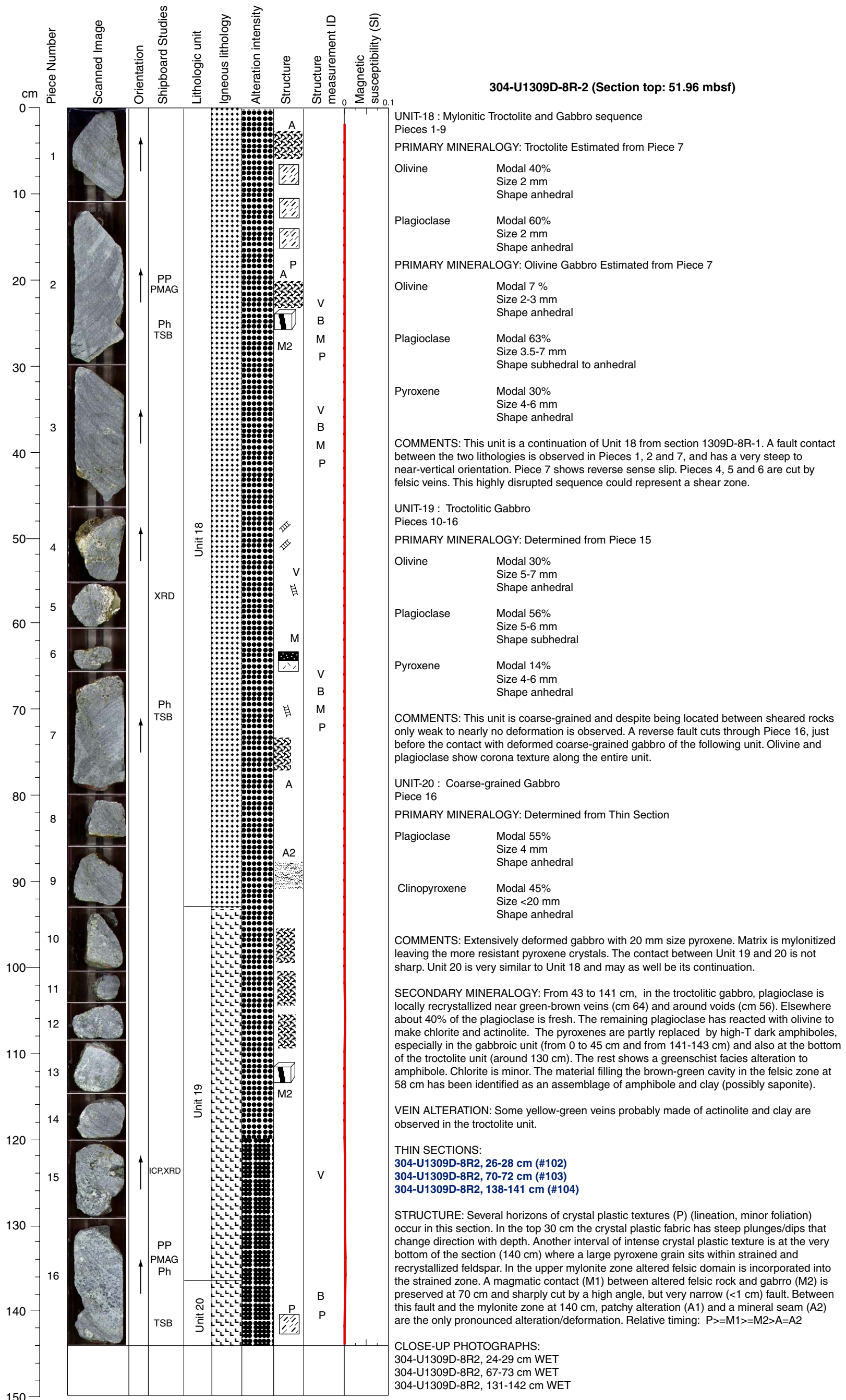
THIN SECTIONS:
304-U1309D-8R1, 68-71 cm (#99)
304-U1309D-8R1, 87-89 cm (#100)
304-U1309D-8R1, 125-127 cm (#101)

STRUCTURE: There are two thick and well-defined horizons with crystal plastic lineations (and possibly foliation) (P), exemplified in Pieces 4 and 12 -14, plunging moderately toward 180 degrees in the core reference frame. These strained intervals also contain very localized zones of alteration and veining (V), but relatively minor (relative to previous sections) low-temperature alteration. Between the intervals of large crystal plastic strain the style of alteration is high-temperature amphibole enrichment along grain boundaries of pyroxene (A2). Relative timing: P>V=A

CLOSE-UP PHOTOGRAPHS:
304-U1309D-8R1, 54-65 cm WET
304-U1309D-8R1, 54-65 cm DRY BACKSIDE
304-U1309D-8R1, 67-78 cm WET
304-U1309D-8R1, 87-89 cm WET
304-U1309D-8R1, 108-118 cm 3/4 VIEW
304-U1309D-8R1, 108-118 cm DRY BACKSIDE
304-U1309D-8R1, 108-118 cm WET CUT SURFACE
304-U1309D-8R1, 121-129 cm WET

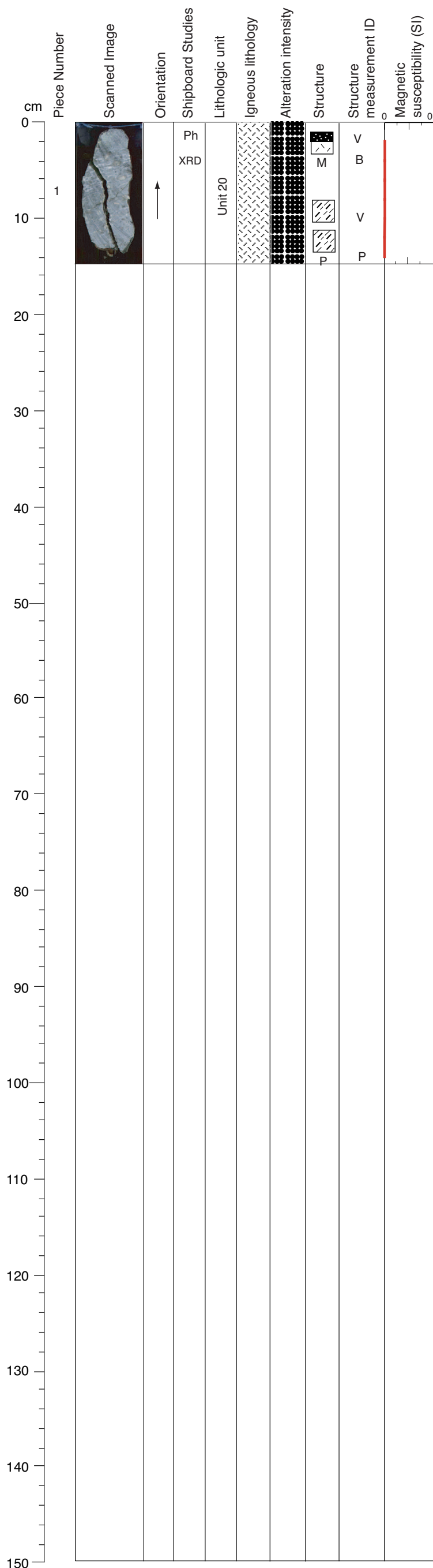


Core Photo



Core Photo

304-U1309D-8R-3 (Section top: 53.4 mbsf)



UNIT-20 : Mylonite
Piece 1

COMMENTS: The section consists of a single piece of extensively deformed gabbro with 20 mm size pyroxene. The upper part is troctolitic in composition. Matrix is mylonitic with porphyroclasts of pyroxene. Contact between the Unit 19 and 20 is also observed in the upper part of Piece 1. The contact is not sharp. This unit is very similar to Unit 18 and may as well be its continuation.

SECONDARY MINERALOGY: High grade amphibolite-granulite facies is recorded in this piece. Plagioclase seems recrystallized and pyroxenes are replaced by recrystallized pyroxene and high-T amphiboles.

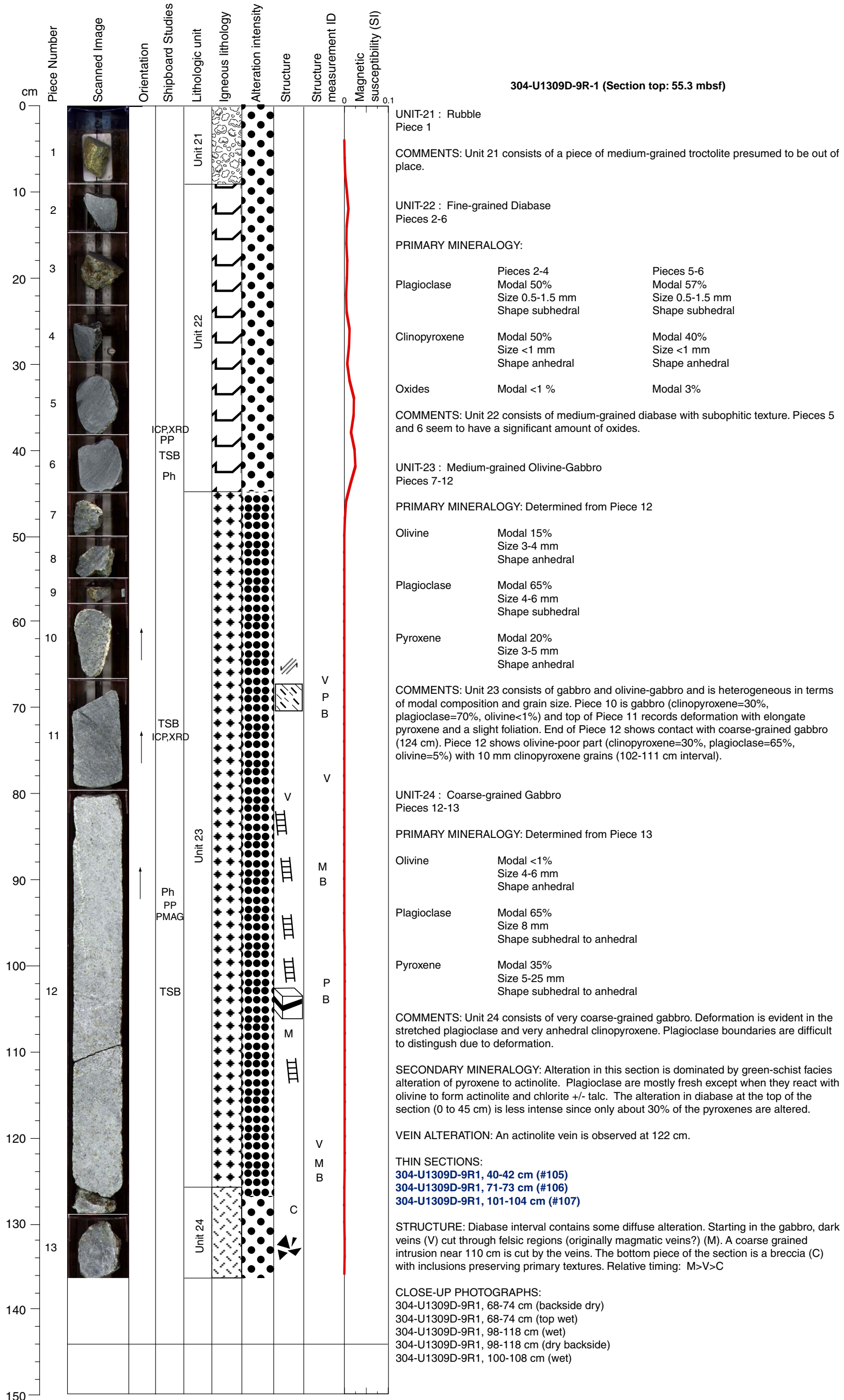
VEIN ALTERATION: A fracture with zeolites cuts this piece.

STRUCTURE: Well-developed mylonite (P) with large clasts of pyroxene below a magmatic contact (M) between the olivine-rich and olivine-poor intervals.

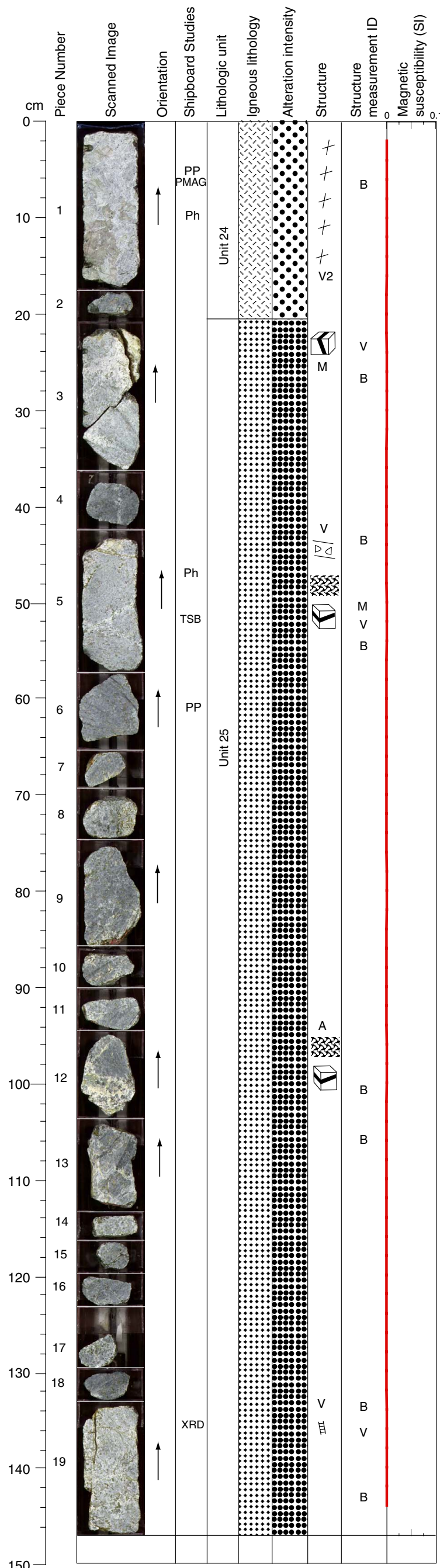
CLOSE-UP PHOTOGRAPHS:
304-U1309D-8R-3, 1-12 cm (wet)



Core Photo



Core Photo



304-U1309D-9R-2 (Section top: 56.66 mbsf)

UNIT-24 : Coarse-grained Gabbro
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 1

Olivine Modal <1%
 Size 4-6 mm
 Shape anhedral

Plagioclase Modal 65%
 Size 8 mm
 Shape subhedral to anhedral

Pyroxene Modal 35%
 Size 5-25 mm
 Shape subhedral to anhedral

COMMENTS: This unit is a continuation of Unit 24 from section U1309D-9R-1. Unit description is very similar to the previous section.

UNIT-25 : Medium-grained Olivine Gabbro
Pieces 3-19

PRIMARY MINERALOGY: Determined from Piece 9

Olivine Modal 15%
 Size 2 mm
 Shape anhedral

Plagioclase Modal 65%
 Size 3 mm
 Shape subhedral to anhedral

Pyroxene Modal 25%
 Size 3-5 mm
 Shape subhedral to anhedral

COMMENTS: Unit 25 consists of medium-grained olivine gabbro. It is a very heterogeneous unit with changes in modal composition, grain size and degree of deformation. Felsic veins cut the unit in Pieces 3A, 8 and 12 (20-116 cm interval).

SECONDARY MINERALOGY: Alteration in this section is dominated by greenschist facies alteration of pyroxene to actinolite. Plagioclase is mostly fresh except where it reacts with olivine to form actinolite and chlorite +/- talc (e.g. at 32 cm) in troctolitic layers. Secondary plagioclase is also developed around actinolite veins and in a zone of intense alteration with actinolite-/ clay-filled pockets at 20-28 cm. The alteration in the coarse-grained gabbro at the top of the section (0 to 21 cm) is lower since only about 20-30% of the pyroxenes are altered and plagioclase is essentially fresh.

VEIN ALTERATION: Small pale green veins of probable actinolite are observed to have various directions in the top gabbro. Late lower-temperature yellow-green veins cut the troctolite in the central part of the section. Brown veins in Piece 19 have been identified as an assemblage of amphibole and clays (possibly saponite) with some plagioclases and calcite by XRD analysis.

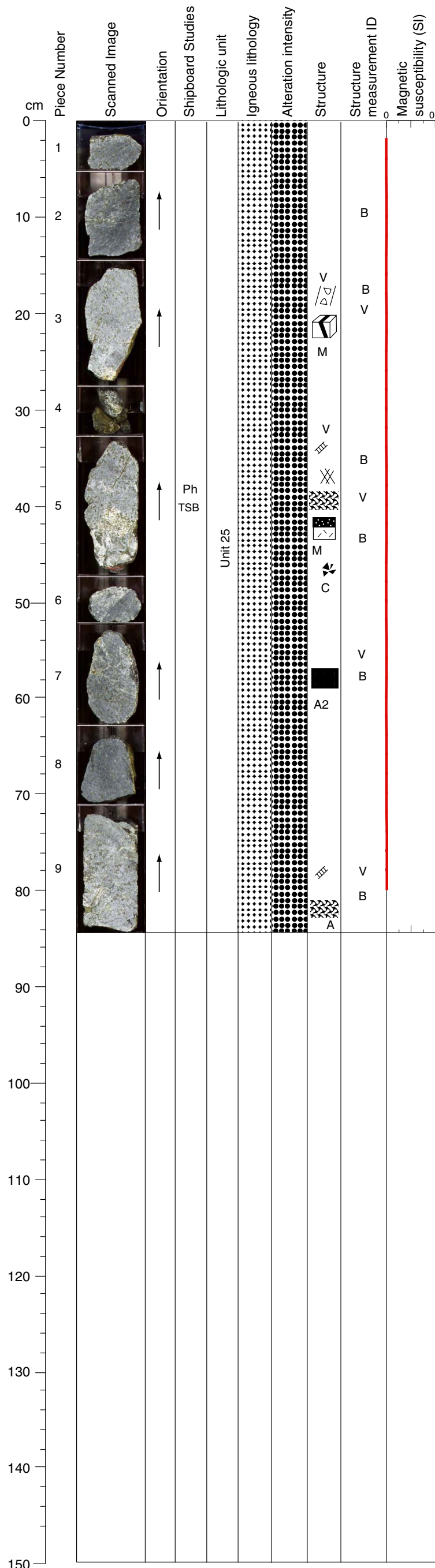
THIN SECTIONS:
304-U1309D-9R-2, 50-53 cm (#108)

STRUCTURE: Magmatic veins (M) of felsic material (trondjemitic/anorthositic) are reactivated by diffusive alteration (A) and localized green veins (V). Toward the top of the section the alteration includes systematically oriented fracture/vein sets (V2). Relative timing: M>A>V>V2

CLOSE-UP PHOTOGRAPHS:
304-U1309D-9R-2, 0-17 cm (wet)
304-U1309D-9R-2, 0-17 cm (dry backside)
304-U1309D-9R-2, 42-56 cm (wet)



Core Photo



304-U1309D-9R-3 (Section top: 58.11 mbsf)

UNIT-25 : Coarse-grained Olivine Gabbro
 Pieces 1-9

PRIMARY MINERALOGY: Determined from Piece 3

Olivine	Modal 15%
	Size 2 mm
	Shape anhedral
Plagioclase	Modal 65%
	Size 3 mm
	Shape subhedral to anhedral
Pyroxene	Modal 25%
	Size 3-5 mm
	Shape subhedral to anhedral

COMMENTS: This unit is a continuation of olivine gabbro from Unit 25 of section U1309D-9R-2. It is a very heterogenous unit with alteration veins cross-cutting the entire section. Very coarse-grained gabbro intervals with clinopyroxene grain sizes occur between 42- 43 cm (13-15 mm) and 74 - 82 cm (13-20 mm). Piece 6 shows contact between altered and less-altered rocks. Felsic veins are extensive in Pieces 5 and 9.

SECONDARY MINERALOGY: Plagioclase is mostly fresh except adjacent to actinolitic veins where milky albite (?) is developed, particularly at 41 cm. A few coronitic actinolite + chlorite +/- talc patches after olivine are present in Piece 9.

VEIN ALTERATION: A green amphibole vein is observed at 10 cm. Yellow-green veins of probable actinolite and clays, recording lower-T events are also present.

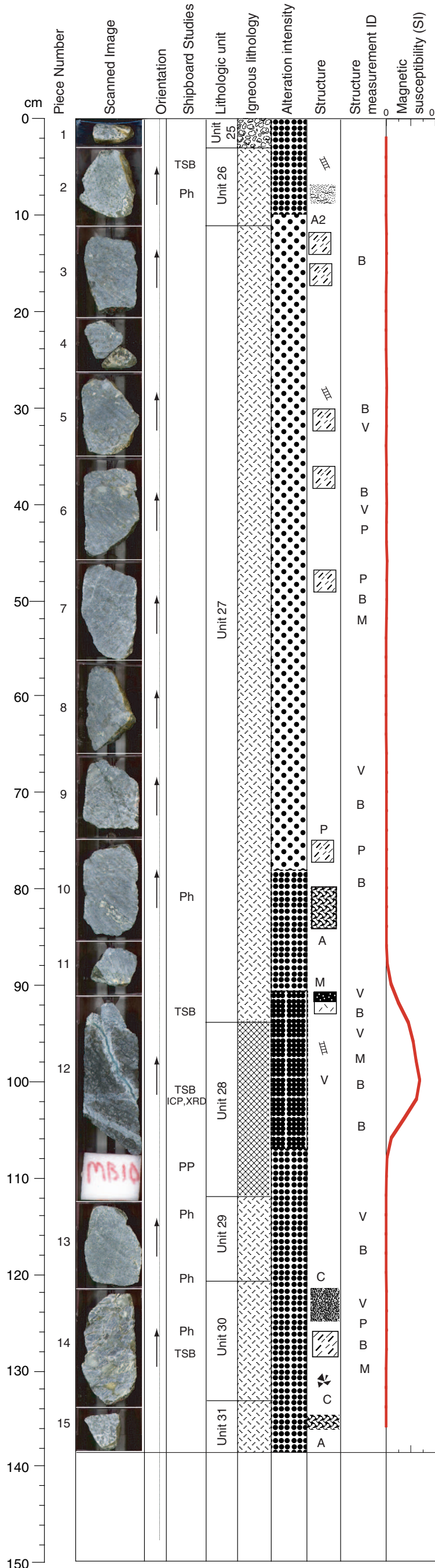
THIN SECTIONS:
[304-U1309D-9R-3, 50-53 cm \(#108\)](#)
[304-U1309D-9R-3, 39-42 cm \(#109\)](#)

STRUCTURE: Patchy, felsic domains occur in this section. Felsic veins (M) have an interesting internal structure with a combination of veining and brecciation/cataclasis (C). For example, in Piece 3 there is almost a flow texture to clasts within the felsic vein. The interval from 40 to 50 cm is a coarse grained intrusion with alteration (A) localized along the contacts. The remainder of the sample is marked by more diffusive alteration (A2), expressed primarily as small green veins (V) and vugs. Near 80 cm, a continuous vein cuts the sample and potentially was responsible for more distributed deformation that stretches the vugs. Relative timing: M>=C>A>A2=V

CLOSE-UP PHOTOGRAPHS:
[304-U1309D-9R-3, 38-46 cm WET](#)



Core Photo



304-1309D-10R-1 (Section top: 60.2 mbsf)

UNIT-25 : Rubble
 Piece 1
 PRIMARY MINERALOGY: Too small to determine modal composition.
 COMMENTS: Piece 1 at the top of the section is very similar to the felsic-vein zones from the previous Core 9R-3.

UNIT-26 : Medium-grained Gabbro
 Piece 2
 PRIMARY MINERALOGY: Determined from Piece 3
 Olivine Modal <1%
 Size ~1 mm
 Shape anhedral
 Plagioclase Modal 74%
 Size 4 mm
 Shape subhedral to anhedral
 Pyroxene Modal 25%
 Size 1-4 mm
 Shape subhedral to anhedral
 COMMENTS: Unit 26 consists of a single piece of medium-grained gabbro. It shows a shear zone at the top and all mineral phases are aligned in one orientation.

UNIT-27 : Coarse-grained Gabbro
 Pieces 3-11
 PRIMARY MINERALOGY:
 Olivine Modal <1%
 Size 2-7 mm
 Shape anhedral
 Plagioclase Modal 69%
 Size 6-10 mm
 Shape subhedral to anhedral
 Pyroxene Modal 30%
 Size 3-20 mm
 Shape subhedral to anhedral
 COMMENTS: Unit 27 consists mainly of coarse-grained gabbro. Deformation is visible with elongate pyroxene and increases downhole. A 10 mm wide troctolitic patch occurs at 82 cm in Piece 10. Piece 11 is troctolite (clinopyroxene=1%, 1-2 mm; plagioclase=74%, 1-7 mm; olivine=25%, 1-8 mm) that shows no deformation in hand sample.

UNIT-28 : Harzburgite/Lherzolite
 Piece 12
 PRIMARY MINERALOGY:
 Olivine Modal ~65%
 Size too altered to estimate
 Shape anhedral
 Pyroxene Modal 35%
 Size 4-9 mm
 Shape subhedral to anhedral
 COMMENTS: Unit 28 consists of a medium-grained ultramafic rock in contact with troctolite from the upper unit at 94 cm. Granular pyroxene with rounded edges is abundant. Fresh olivine is present in the partly serpentinized matrix. Contact with the gabbro is interfingering with what seems to be a narrow reaction zone. A 4 mm wide vein crosses the unit at 97 cm. A 5-10 mm wide pyroxene-rich band crosses horizontal at 101 cm and another amphibole-bearing vein crosses at 103 cm. The peridotite between 94 and 106 cm is strongly altered to serpentinite, with talc-rich reaction zone adjacent to troctolite.

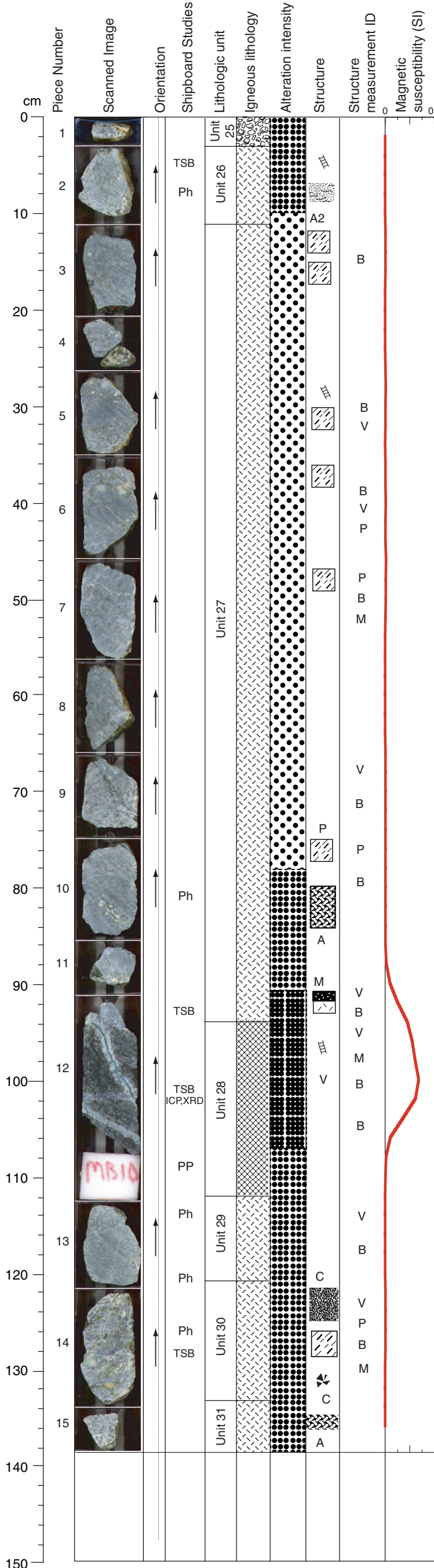
UNIT-29 : Medium-grained Gabbro
 Piece 13
 PRIMARY MINERALOGY:
 Olivine Modal <1%
 Size 1-2 mm
 Shape anhedral
 Plagioclase Modal 74%
 Size 2-4 mm
 Shape subhedral to anhedral
 Pyroxene Modal 25%
 Size 2-4 mm
 Shape subhedral to anhedral
 COMMENTS: Unit 29 consists of medium-grained gabbro with foliation.

UNIT-30 : Coarse-grained Gabbro
 Piece 14
 PRIMARY MINERALOGY:
 Olivine Modal <1%
 Size 1-12 mm
 Shape anhedral
 Plagioclase Modal 70%
 Size 10-30 mm
 Shape subhedral to anhedral
 Pyroxene Modal 30%
 Size 10-35 mm
 Shape subhedral to anhedral
 COMMENTS: Unit 30 consists of coarse-grained almost pegmatitic gabbro that is intersected by several fractures. It shares its characteristics with Unit 24.



Core Photo

304-1309D-10R-1 (continued) (Section top: 60.2 mbsf)



UNIT-31 : Medium-grained Gabbro
Piece 15

PRIMARY MINERALOGY:

- Olivine Modal <1%
Size <1 mm
Shape anhedral
- Plagioclase Modal 75%
Size 3 mm
Shape subhedral to anhedral
- Pyroxene Modal 25%
Size 2.5-4 mm
Shape subhedral to anhedral

COMMENTS: Unit 31 consists of foliated medium-grained gabbro that is very similar to Unit 26 and 29.

SECONDARY MINERALOGY: The upper 10 cm of this core consists of troctolite in which much of the plagioclase has altered by reaction with primary olivine to produce chlorite + actinolite and talc. The gabbro that occurs between 10 and 78 cm is much fresher, with fresh plagioclase and pyroxene that is only partially altered to actinolite.

VEIN ALTERATION: A distinctive vein of bluish green tremolite with a talc halo cuts the serpentinite. Thin carbonate veins appear to be cut by the tremolite. Actinolite breccia veins are present in Piece 14 and dark probable hornblende vein occurs in Piece 9.

THIN SECTIONS:

- 304-U1309D-10R-1, 5-7 cm (#110)
- 304-U1309D-10R-1, 91-94 cm (#132)
- 304-U1309D-10R-1, 99-102 cm (#133)
- 304-U1309D-10R-1, 127-129 cm (#111)

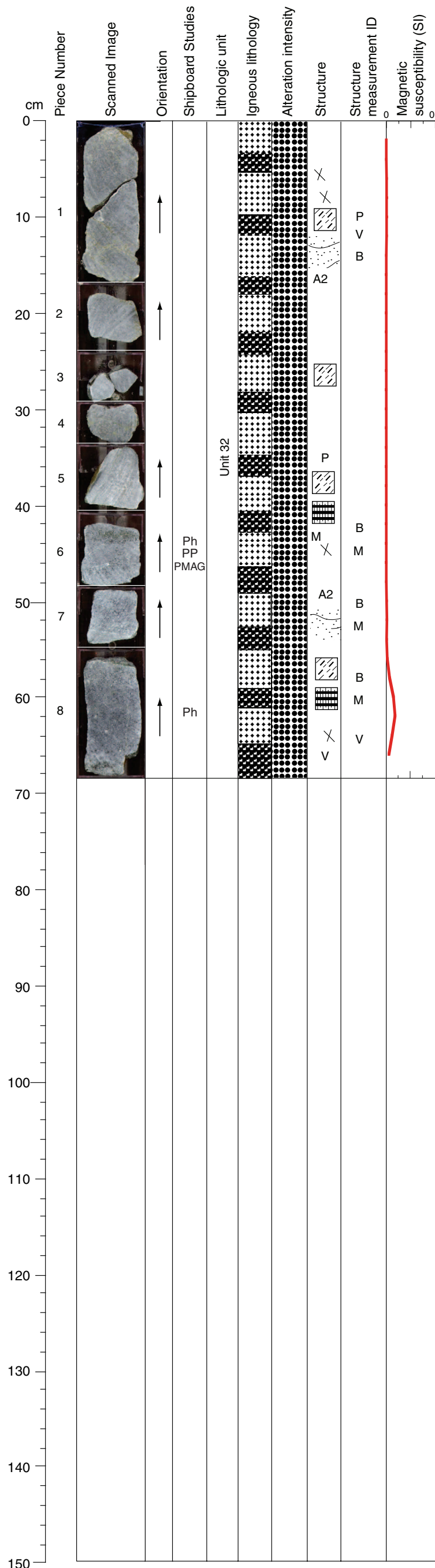
STRUCTURE: This section is remarkable in showing the intrusive contact at the top of ultramafic rock (M), but no preserved contact on the base, aside from some lenses of gabbroic material. The peridotite has a vein (V) and mesh texture. Above the peridotite is a pervasive crystal plastic fabric that intensifies in Piece 6 and 10. Altered olivine grains (green vugs) are incorporated into the texture (A). Dark veins (V2) and some mineral seams (A2) are present as well, including intergranular (high temperature, hornblende?) mineral enrichment. Below the peridotite is a relatively unaltered and undeformed fine-grained felsic gabbro, and a heavily brecciated (C) coarse grained gabbro, and associated alteration. Relative timing: M>A>V>A2=V2>C

CLOSE-UP PHOTOGRAPHS:

- 304-U1309D-10R-1, 3-10 cm WET
- 304-U1309D-10R-1, 3-10 cm DRY BACKSIDE
- 304-U1309D-10R-1, 80-106 cm DRY
- 304-U1309D-10R-1, 90-106 cm DRY
- 304-U1309D-10R-1, 90-106 cm WET
- 304-U1309D-10R-1, 90-106 cm DRY BACKSIDE
- 304-U1309D-10R-1, 91-107 cm WORKING HALF WET
- 304-U1309D-10R-1, 91-107 cm WORKING HALF DRY
- 304-U1309D-10R-1, 91-107 cm WORKING HALF DRY BACKSIDE
- 304-U1309D-10R-1, 112-119 cm WET
- 304-U1309D-10R-1, 120-132 cm WET
- 304-U1309D-10R-1, 120-132 cm DRY BACKSIDE
- 304-U1309D-10R-1, 126-133 cm WET



Core Photo



304-U1309D-10R-2 (Section top: 61.58 mbsf)

UNIT-32 : Layered Troctolite and Olivine Gabbro
Pieces 1-8

PRIMARY MINERALOGY: Troctolite - Determined from Piece 1

Olivine Modal 35%
Size 2 mm
Shape anhedral

Plagioclase Modal 65%
Size 3-4 mm
Shape subhedral to anhedral

PRIMARY MINERALOGY: Olivine Gabbro - Determined from Piece 1

Olivine Modal 5%
Size 2 mm
Shape anhedral

Plagioclase Modal 60%
Size 3 mm
Shape subhedral to anhedral

Pyroxene Modal 35%
Size 2-3 mm
Shape subhedral to anhedral

COMMENTS: Pieces 5 to 8 shows nearly horizontal layering of troctolite and olivine-gabbro with layer thickness from 10 to 50 mm. Piece 1 shows decreasing degree of deformation downhole. Piece 4 also shows some cataclastic deformation.

SECONDARY MINERALOGY: Plagioclase in this rock is fresh except where it has reacted with adjacent olivine to form chlorite + actinolite +/- talc (and possibly cummingtonite).

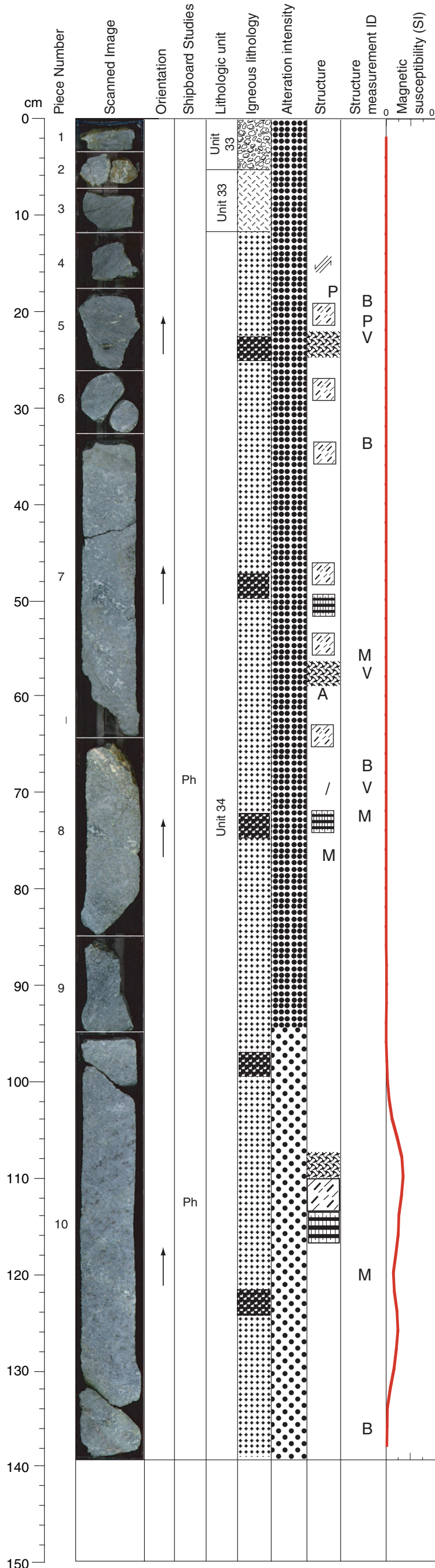
VEIN ALTERATION: Green breccia veins are present in Piece 1.

STRUCTURE: A crystal plastic (P) (partly superposed on a magmatic (M)) foliation is present in several intervals, and overprinted by late, brown veins (V). Grain boundaries of pyroxenes are rich in dark minerals that form interconnected alteration (A) (high-T hornblende?). In places (for example, near 14 cm) the alteration is of the mineral seam type (A2) (enrichment in oxides and other dark minerals). Relative timing: P=M>V>A>A2

CLOSE-UP PHOTOGRAPHS:
304-U1309D-10R-2, 41-47 cm WET
304-U1309D-10R-2, 55-67 cm WET



Core Photo



304-U1309D-11R-1 (Section top: 64.9 mbsf)

UNIT-32 : Rubble
Pieces 1-2b

COMMENTS: Unit 32 consists of small pieces of rubble of medium-grained olivine gabbro. They are presumed to be out of place.

UNIT-33 : Medium-grained Gabbro
Pieces 2a-3

PRIMARY MINERALOGY:

- Olivine Modal <1%
Size <1 mm
Shape anhedral
- Plagioclase Modal 75%
Size 3 mm
Shape anhedral
- Pyroxene Modal 25%
Size 2 mm
Shape anhedral

COMMENTS: Unit 33 consists of medium-grained equigranular foliated gabbro. It shows similarities to Units 26 and 29.

UNIT-34 : Layered Olivine Gabbro and Troctolite
Pieces 4-10

PRIMARY MINERALOGY: Troctolite - Determined from Piece 7

- Olivine Modal 35%
Size 4 mm
Shape anhedral
- Plagioclase Modal 65%
Size 3-6mm
Shape subhedral to anhedral
- Pyroxene Modal <1%
Size 3.5-7mm
Shape subhedral to anhedral

PRIMARY MINERALOGY: Olivine Gabbro - Determined from Piece 10B

- Olivine Modal 10%
Size 4 mm
Shape anhedral
- Plagioclase Modal 45%
Size 3-6mm
Shape subhedral to anhedral
- Pyroxene Modal 45%
Size 3.5-7mm
Shape subhedral to anhedral

COMMENTS: Unit 34 consists of layered olivine gabbro and troctolite. The layering is prominent and best seen between 95-138 cm. The boundaries are not sharp and the average thickness is 7 cm for gabbro layers and 2 cm for troctolite layers. Strong deformation with foliation from 12-32 cm interval is observed with a steep inclination of the foliation. A pyroxene-rich vein crosses at 135 cm (Piece 10).

SECONDARY MINERALOGY: Plagioclase is mostly fresh except where it has reacted with olivine to form chlorite and actinolite +/- talc. Olivine is completely altered. A few fresh pyroxene grains are present; most have reacted to actinolite.

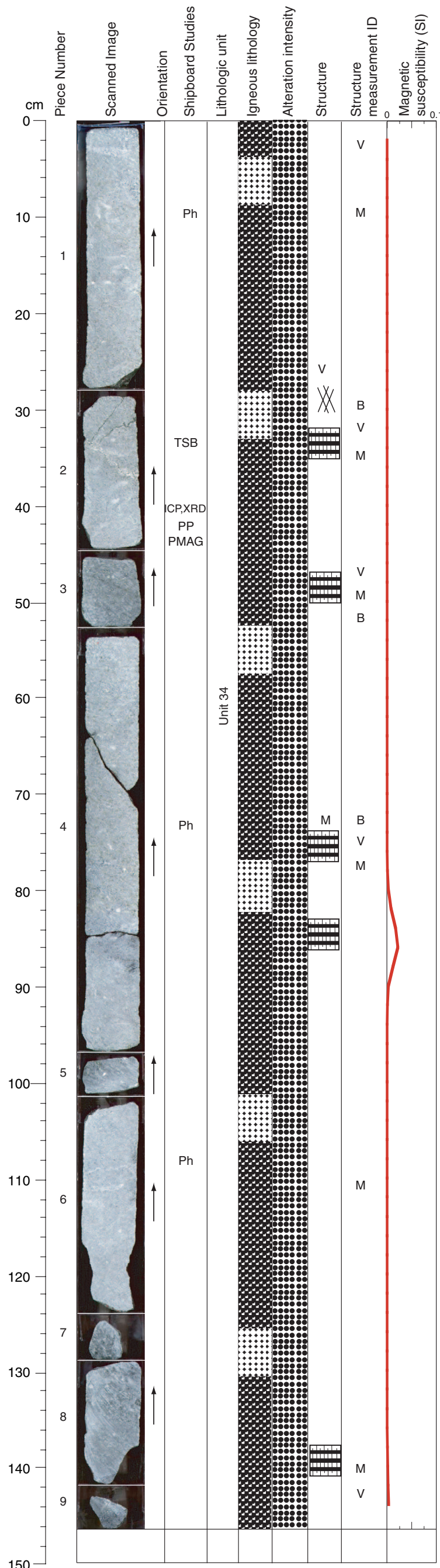
VEIN ALTERATION: A major yellow breccia vein is present at 65-70 cm.

STRUCTURE: Section is noteworthy for mylonitic shear zones and crystal plastic (P) textures. Altered olivine grains (troctolite-texture) are strewn throughout the shear zones and stretched - although the alteration is presumably younger than the crystal plastic deformation. Intensity of strain varies and is at a maximum in Piece 5 and the top of Piece 7. Magmatic felsic enrichment/veins (M) also provide markers for shear strain. Cataclasis and alteration (A) (aside from the olivine) is minimal. Relative timing: P>M>A

CLOSE-UP PHOTOGRAPHS:
304-U1309D-11R-1, 64-84 cm WET
304-U1309D-11R-1, 64-84 cm DRY BACKSIDE
304-U1309D-11R-1, 100-120 cm WET



Core Photo



304-U1309D-11R-2 (Section top: 66.29 mbsf)

UNIT-34 : Layered Olivine Gabbro and Troctolite
Pieces 1-9

PRIMARY MINERALOGY: Troctolite - Determined from Piece 1

Olivine Modal 35%
 Size 4 mm
 Shape anhedral

Plagioclase Modal 65%
 Size 3-6 mm
 Shape subhedral to anhedral

Pyroxene Modal <1%
 Size 3.5-7 mm
 Shape subhedral to anhedral

PRIMARY MINERALOGY: Olivine Gabbro - Determined from Piece 4

Olivine Modal 10%
 Size 4 mm
 Shape anhedral

Plagioclase Modal 45%
 Size 3-6 mm
 Shape subhedral to anhedral

Pyroxene Modal 45%
 Size 3.5-7 mm
 Shape subhedral to anhedral

COMMENTS: This unit is the continuation of Unit 34 in section U1309D-11R-1. Dominant lithology is troctolite with bands of olivine-gabbro. The interval between 82-87 cm provides a good type section. Corona texture in olivine is prominent. Alteration vein crosses at 35 and 48 cm interval.

SECONDARY MINERALOGY: Olivine-plagioclase contacts have altered to chlorite, actinolite, and maybe cummingtonite +/- talc. A few fresh pyroxenes are present; most have altered to actinolite.

VEIN ALTERATION: There is an actinolite-albite vein at 34 cm, cut by thin actinolite veins.

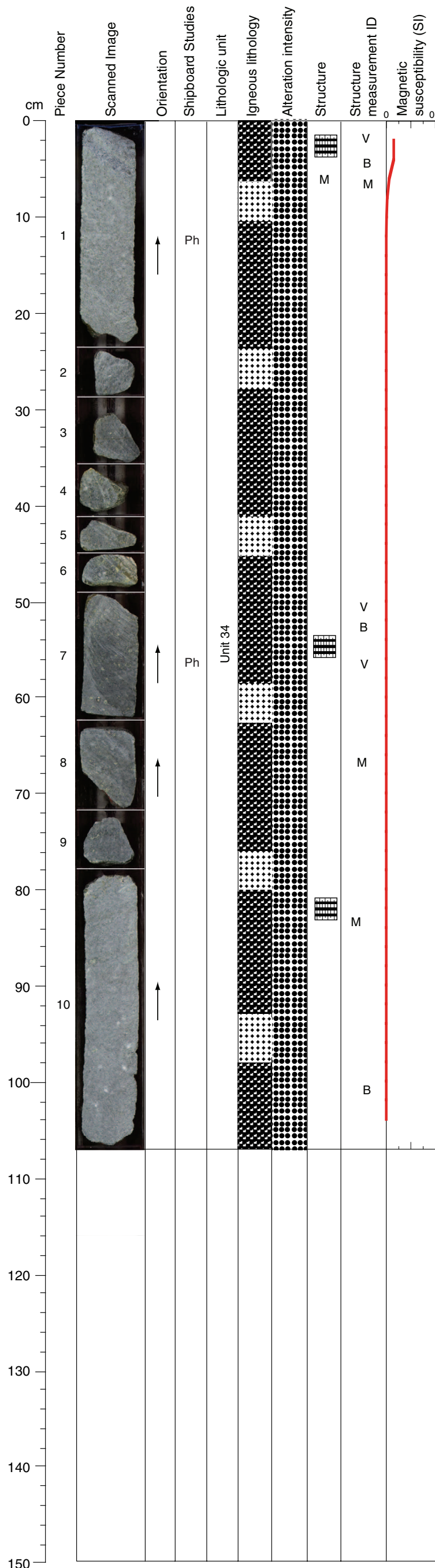
THIN SECTIONS:
[304-U1309D-11R-2, 32-35 cm \(#112\)](#)

STRUCTURE: Relatively undeformed/unaltered layered gabbro (M), perhaps with slight granulite-grade crystal plastic strain. Some green veins (V) connect with zones of alteration near 30 cm where there is enrichment of felsic material. Relative timing: M>V>A

CLOSE-UP PHOTOGRAPHS:
304-U1309D-11R-2, 0-20 cm WET
304-U1309D-11R-2, 28-38 cm WET
304-U1309D-11R-2, 74-94 cm WET
304-U1309D-11R-2, 100-120 cm WET



Core Photo



304-U1309D-11R-3 (Section top: 67.75 mbsf)

UNIT-34 : Layered Olivine Gabbro and Troctolite
Pieces 1-10

PRIMARY MINERALOGY: Troctolite

Olivine Modal 35%
 Size 4 mm
 Shape anhedral

Plagioclase Modal 65%
 Size 3-6 mm
 Shape subhedral to anhedral

Pyroxene Modal <1%
 Size 3.5-7 mm
 Shape subhedral to anhedral

PRIMARY MINERALOGY: Olivine Gabbro

Olivine Modal 10%
 Size 4 mm
 Shape anhedral

Plagioclase Modal 45%
 Size 3-6 mm
 Shape subhedral to anhedral

Pyroxene Modal 45%
 Size 3.5-7 mm
 Shape subhedral to anhedral

COMMENTS: This section consists of layered olivine gabbro and troctolite and is the continuation of the previous sections. Piece 1 (0-7 cm interval) shows gabbroic layering parallel to the foliation direction.

SECONDARY MINERALOGY: Olivine and plagioclase in the original rocks have reacted to give chlorite and actinolite (+ perhaps cummingtonite) +/- talc. Original clinopyroxene has altered to actinolite.

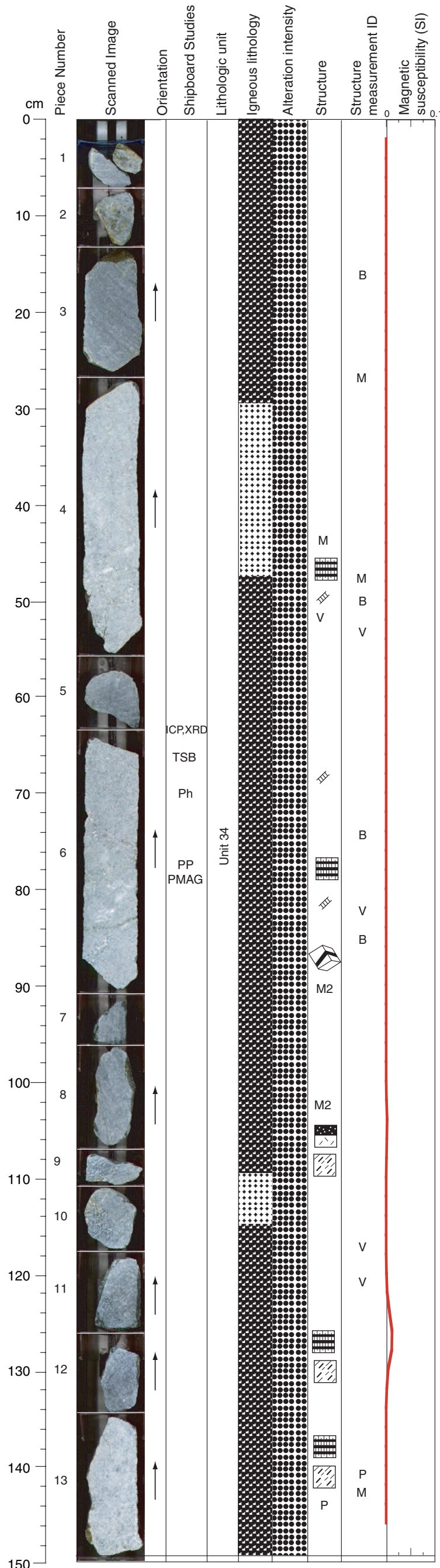
VEIN ALTERATION: Minor actinolite veins.

STRUCTURE: Some minor veins and alteration of olivine in troctolitic portions, alteration and deformation is very slight. Well-defined gabbroic layering (M) and perhaps a slight crystal plastic deformation, the layering is most intense from 1 to 4 cm, 55 cm, and 82 cm. Relative timing: M>V>A

CLOSE-UP PHOTOGRAPHS:
304-U1309D-11R-3, 0-20 cm WET
304-U1309D-11R-3, 44-61 cm WET
304-U1309D-11R-3, 44-61 cm DRY



Core Photo



304-U1309D-12R-1 (Section top: 69.8 mbsf)

UNIT-34 : Layered Olivine Gabbro and Troctolite
Pieces 1-13

PRIMARY MINERALOGY: Troctolite (Piece-6A)

Olivine Modal 30%
 Size 3 - 6 mm
 Shape anhedral

Plagioclase Modal 70%
 Size 4 - 7 mm
 Shape subhedral

Pyroxene Modal < 1%
 Size 2 mm
 Shape anhedral

PRIMARY MINERALOGY: Olivine-Gabbro (Piece-6A)

Olivine Modal 20%
 Size 3 - 6 mm
 Shape anhedral

Plagioclase Modal 55%
 Size 4 - 7 mm
 Shape subhedral

Pyroxene Modal 25%
 Size 2 mm
 Shape anhedral

COMMENTS: This unit is a continuation of Unit 34 from 1309D-11R-003. The rock is dominantly medium-grained troctolite with bands of olivine gabbro from 10-12 cm, 30-48 cm and 69-73 cm (see close-up photo 1309D-12R-001, 69-84). Clinopyroxene as large as 20 mm occurs in Pieces 2 and 6. The foliation is steeply inclined. Variable degrees of alteration occur within the section.

SECONDARY MINERALOGY: Where plagioclase and olivine are in contact they have reacted to chlorite and actinolite (\pm cummingtonite, \pm talc). Primary pyroxene has reacted to actinolite.

VEIN ALTERATION: Minor green actinolite veins in small samples at the top of the section. Otherwise a few thin actinolite veins cut the corona textures.

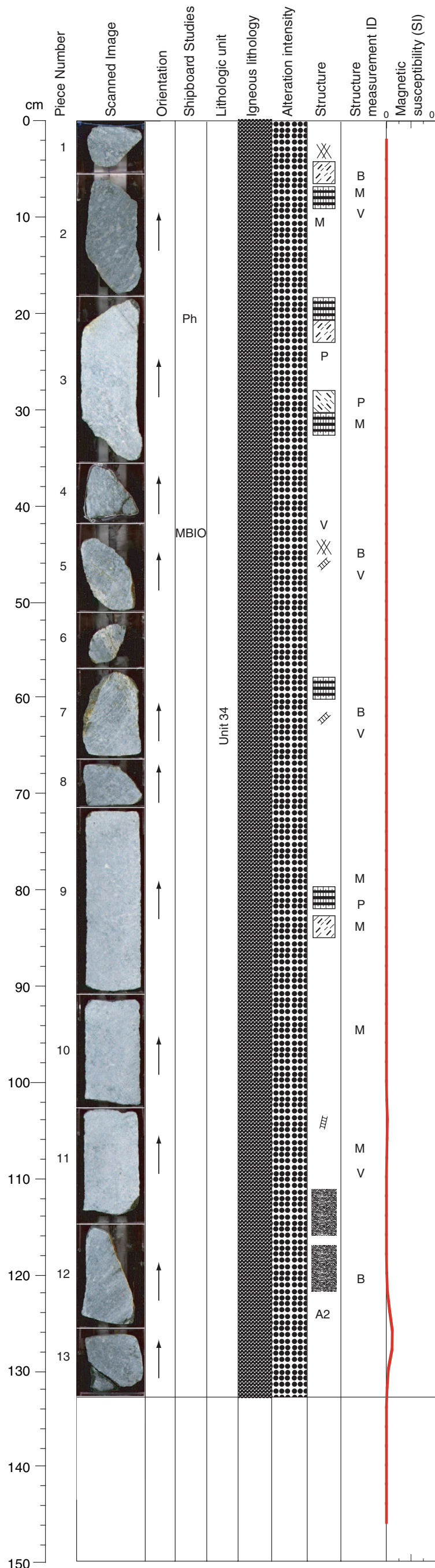
THIN SECTIONS:
304-U1309D-12R1, 65-67 cm (#113)

STRUCTURE: Igneous grain boundaries are preserved throughout the section, with a weak magmatic (gabbroic) layering (M). Two or three late green veins (V) are present, as are two or three magmatic (felsic) "veins"(M2). Towards Piece 10 (beneath a contact between more troctolitic and gabbroic rock at 110 cm), there is increased crystal plastic strain (P), best expressed in stretched altered olivine grains. Relative timing: M=P>M2>V

CLOSE-UP PHOTOGRAPHS:
304-U1309D-12R1, 69-84 cm (wet)
304-U1309D-12R1, 69-84 cm (dry backside)



Core Photo



304-U1309D-12R-2 (Section top: 71.27 mbsf)

UNIT-34 : Layered Olivine Gabbro and Troctolite
Pieces 1-13

PRIMARY MINERALOGY: Troctolite

Olivine Modal 30 %
Size 3 - 6 mm
Shape anhedral

Plagioclase Modal 70 %
Size 4 - 7 mm
Shape subhedral

Pyroxene Modal < 1 %
Size 2 mm
Shape anhedral

COMMENTS: This section is a continuation of Unit 34 from U1309D-12R-1. The section is composed entirely of troctolite (see close-up photo U1309D-12R-2, 18-35, for typical sample). Piece 2 shows a slight increase in grain size. Felsic veins (20 mm thick) with black amphiboles cut through Pieces 5, 6 and probably the upper part of Piece 7.

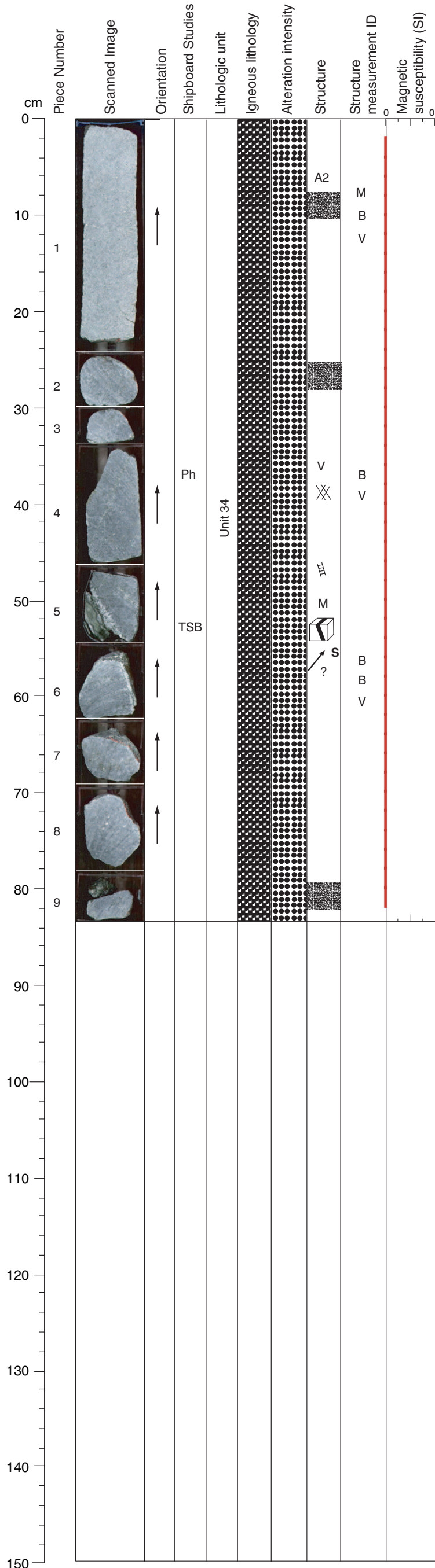
SECONDARY MINERALOGY: Only a small amount of plagioclase is fresh. Most of it has reacted with olivine to form chlorite + actinolite (cummingtonite, ± talc). Some fresh pyroxenes remain, although most have reacted to actinolite.

VEIN ALTERATION: Green breccia veins are present between 43 and 62 cm, isolated dark actinolite/chlorite veins occur locally.

STRUCTURE: Gabbroic layering (M) with an added small component of crystal plastic (P) stretch remains relatively unaltered and undeformed by local yellow-brown veins (V) and associated alteration (A). The layering is steeply inclined toward 270° (in the core reference frame) and then changes direction toward 90° at about ? cm. Near the bottom of the section (Pieces 9 through 11), the intergranular alteration (A2) (dark minerals around relict olivine and pyroxene) is particularly prominent. Relative timing: M=P>A; M = P> A2 ? A

CLOSE-UP PHOTOGRAPHS:
304-U1309D-12R-2, 18-35 cm WET

Core Photo



304-U1309D-12R-3 (Section top: 72.58 mbsf)

UNIT-34 : Layered Olivine Gabbro and Troctolite
Pieces 1-9

PRIMARY MINERALOGY: Troctolite

Olivine Modal 30%
 Size 3-6 mm
 Shape anhedral

Plagioclase Modal 70%
 Size 4-7 mm
 Shape subhedral

Pyroxene Modal < 1%
 Size 2 mm
 Shape anhedral

COMMENTS: This section is the continuation of Unit 34 from U1309D-12R-2 and composed of medium-grained troctolite. Less foliation intensity is observed in this section compared to section U1309D-12R-2. Intense alteration occurs in Pieces 5 and 6 where felsic veins pass through the core section. Piece 7A has a 10-20 mm wide pyroxenite crossing with pyroxenes as large as 7 mm. Alteration vein crosses at 40 cm in Piece 4 (see close up photo 1309D_12R3_34-46).

SECONDARY MINERALOGY: Little fresh olivine remains. Most of it has reacted with adjacent olivine to make chlorite + actinolite ± talc. Some original CPX remains, although most have reacted to actinolite.

VEIN ALTERATION: An intense steeply dipping alteration zone with milky plagioclase and "vuggy" actinolite occurs between 48 and 60 cm. It may be localised by a felsic vein. Isolated to branching actinolite veins occur sparsely in the core.

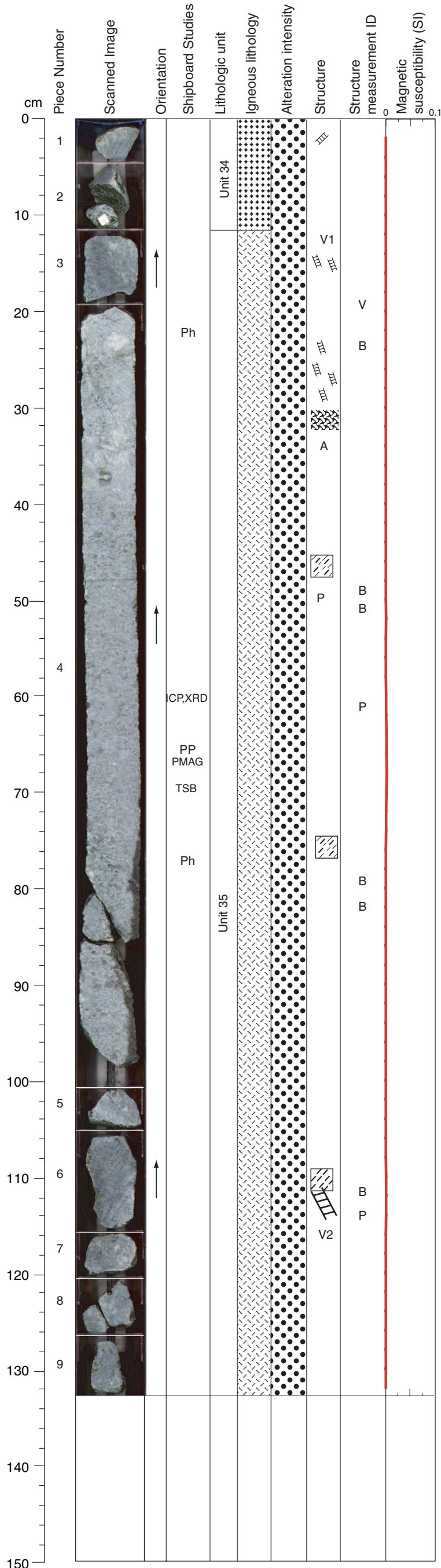
THIN SECTIONS:
304-U1309D-12R-3, 50-53 cm (#114)

STRUCTURE: Prominent veins (V, M), particularly near 50 cm, have composite structures with blocky plagioclase, intruding laths of amphibole (hornblende?) and internally fibrous amphibole (actinolite?). Above and below this interval of veining, the alteration is patchy (A), including grain boundary alteration (example, below seventy cm), or in vein-like regions of alteration (A2) (example, above 30 cm). Relative timing: M=V1>A2=V2

CLOSE-UP PHOTOGRAPHS:
304-U1309D-12R-3, 34-46 cm (wet)



Core Photo



304-U1309D-13R-1 (Section top: 74.5 mbsf)

UNIT-34 : Layered Olivine-Gabbro and Troctolite
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 2

Olivine Modal 15%
Size 1.5 mm
Shape anhedral

Plagioclase Modal 65%
Size 3 mm
Shape subhedral

Pyroxene Modal 20%
Size 2 mm
Shape anhedral

COMMENTS: Unit 34 consists dominantly of medium-grained olivine-gabbro. Although these samples are on top of the section and may be rubble (especially Piece 1), no significant difference from the troctolite and olivine gabbro of Unit 34 was observed. The samples are believed to be pieces from the previous section.

UNIT-35 : Coarse-grained Gabbro
Pieces 3-9

PRIMARY MINERALOGY: Determined from Piece 4

Olivine Modal <1%
Size 5-19 mm
Shape anhedral

Plagioclase Modal 55%
Size 6 mm
Shape subhedral

Pyroxene Modal 45%
Size 10-20 mm
Shape anhedral to subhedral

COMMENTS: Unit 35 consists of coarse-grained gabbro that shows strong deformation features, including mineral stretching (of plagioclase), with weak alignment of plagioclase and pyroxene. Olivines are altered. Between 50 to 107 cm, subhedral to anhedral orthopyroxene as large as 6 mm occur sporadically. In some cases the amount of orthopyroxene is higher than 5% (as seen in thin section). Those gabbro-noritic areas occur at 50-52 cm, 68-70 cm, 75-77 cm, 81-82 cm and 105-107 cm with a peak in modal orthopyroxene at 68 - 70 cm. Alteration veins cross at 28, 48 and 77 cm. Close up photos 304-U1309D-13R-1, 19-39 cm and 304-U1309D-13R-1, 19-39_2 show typical sections of the coarse-grained gabbro (Piece 4).

SECONDARY MINERALOGY: Plagioclase is mostly fresh in this section, except where it has reacted with minor olivine to form chlorite and actinolite ± talc. Primary pyroxene is largely fresh, although some grains are altered to actinolite.

VEIN ALTERATION: Dark actinolite veins with albitised halos occur at 32 cm. Thin actinolite/chlorite veins occur locally.

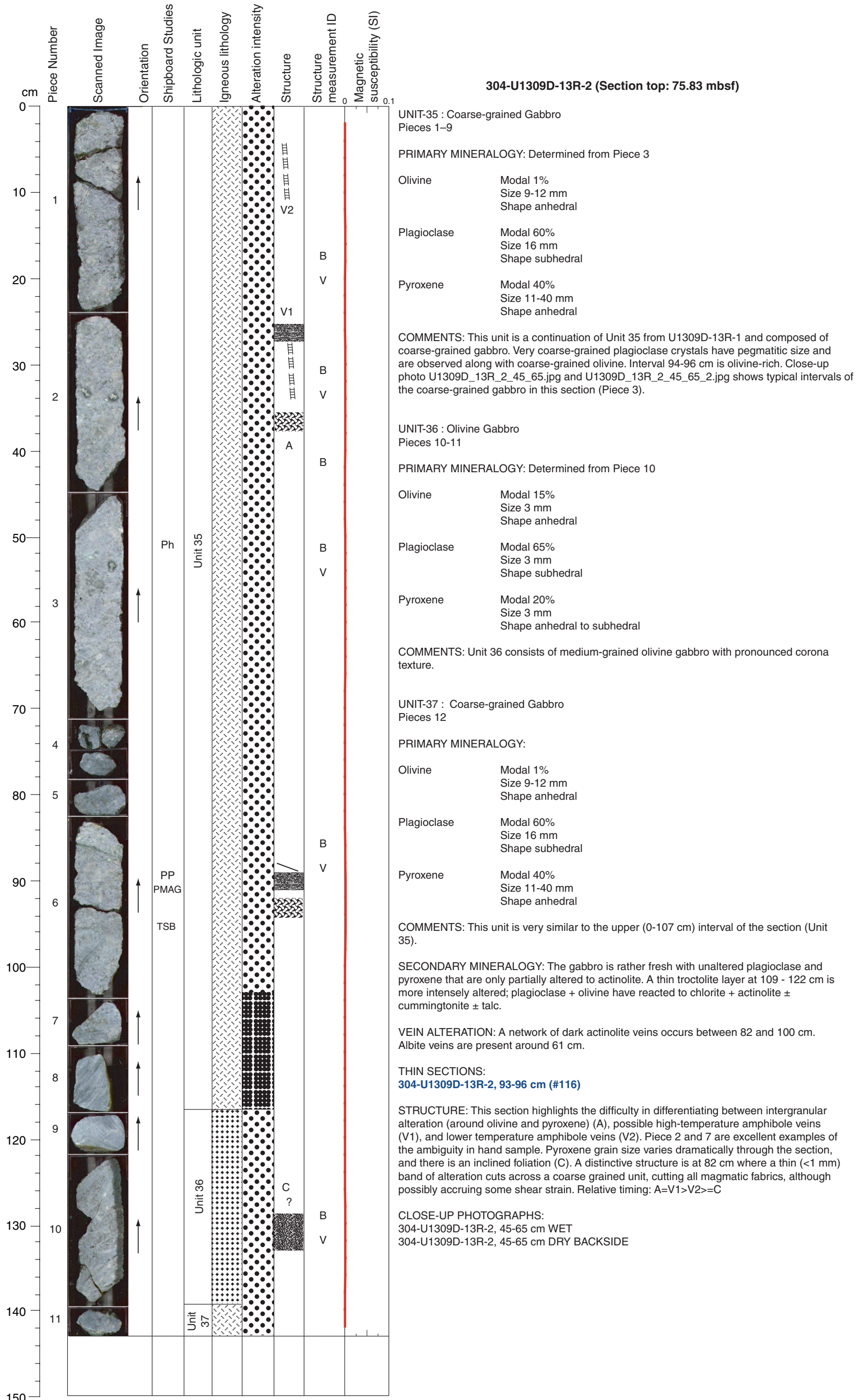
THIN SECTIONS:
304-U1309D-13R-1, 68-70 cm (#115)

STRUCTURE: Several intervals of well-developed crystal plastic fabric (P) (for example, 54 cm and 79 cm) and a well-developed crystal plastic lineation in Piece 6. Dark (high-temperature?) veins (V) locally cut the fabric. Green (lower temperature?) veins (V2) form prominent sets in the top few pieces of the section, including an interesting set near 30 cm that tips out in an area rich in altered pyroxene grains. Other alteration includes dark (oxide?) rich alteration (A) along grain boundaries in Piece 8. Relative timing: P>V>V2=A

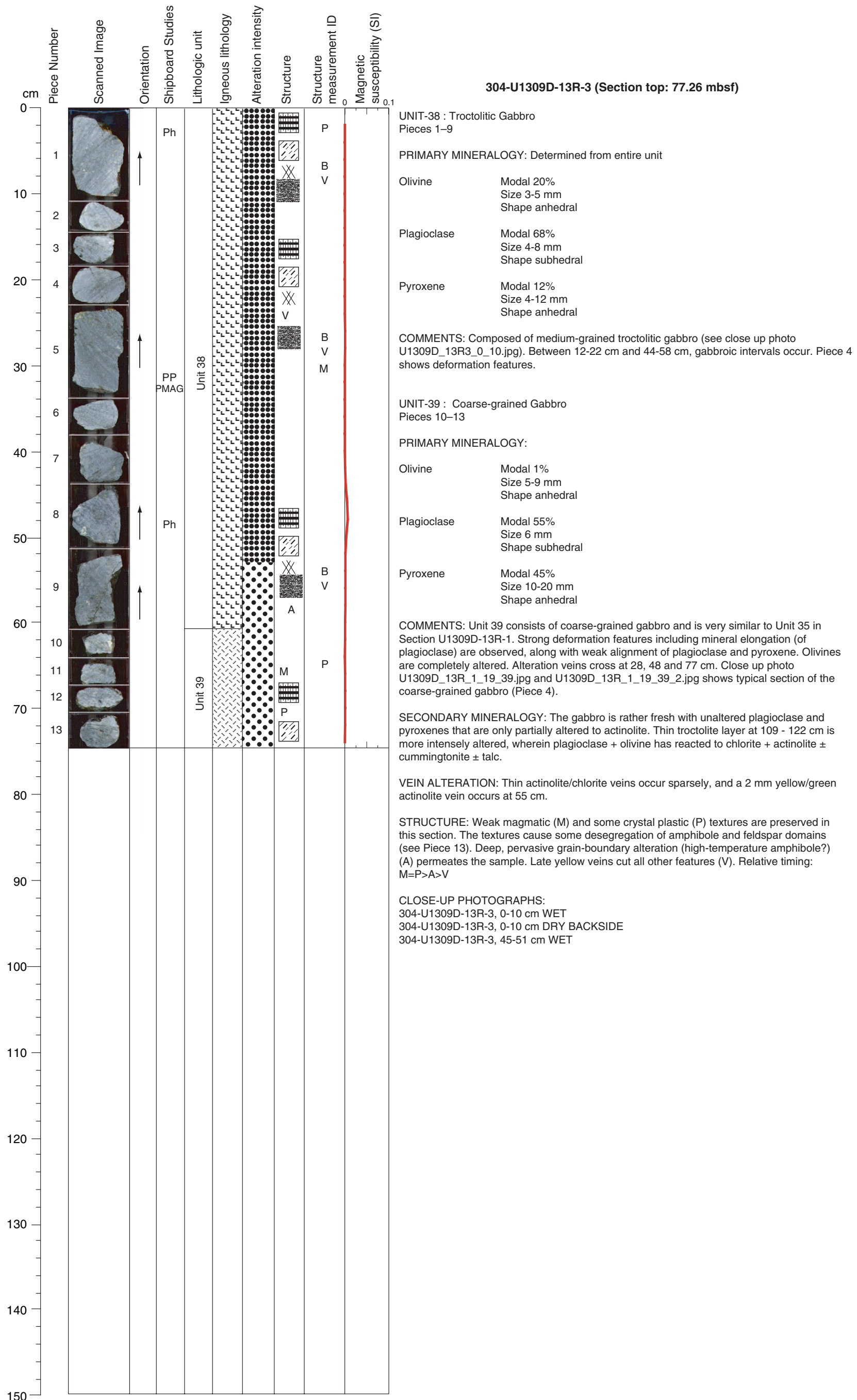
CLOSE-UP PHOTOGRAPHS:
304-U1309D-13R-1, 19-39 cm WET
304-U1309D-13R-1, 19-39 cm DRY BACKSIDE
304-U1309D-13R-1, 68-86 cm WET



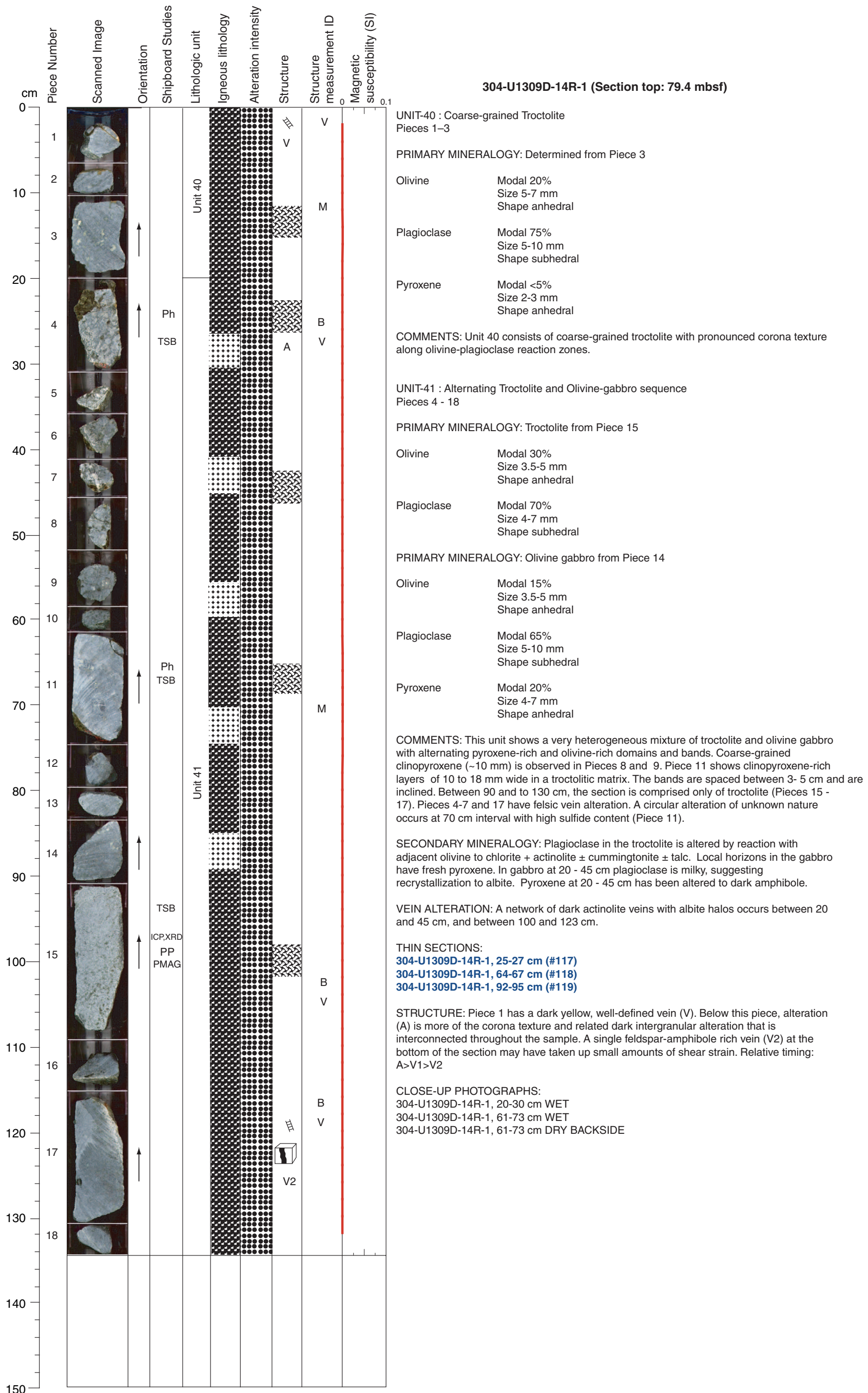
Core Photo



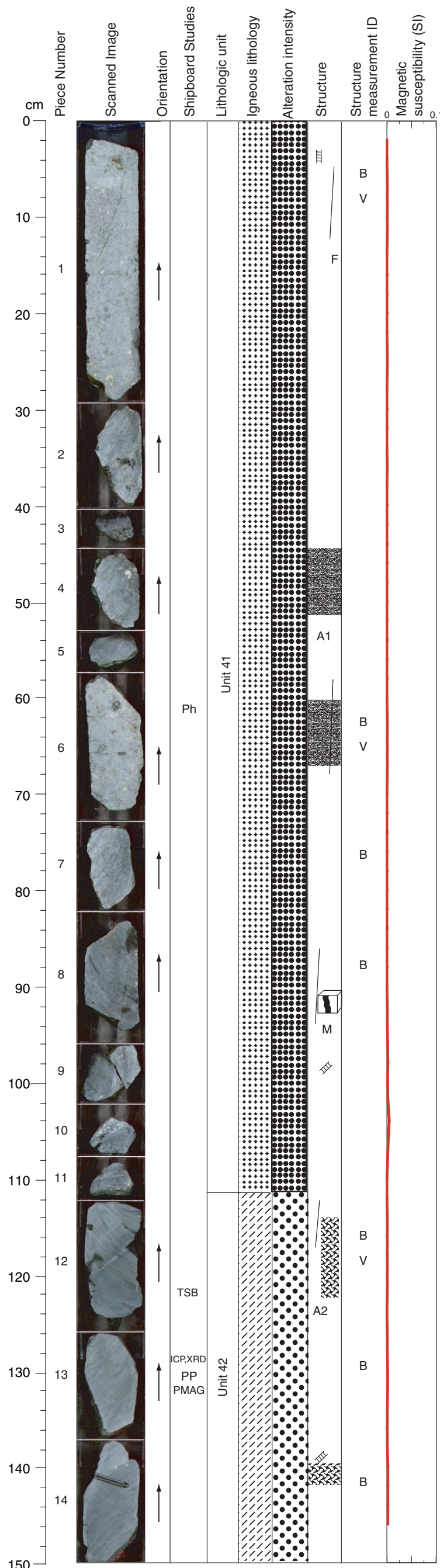
Core Photo



Core Photo



Core Photo



304-U1309D-14R-2 (Section top: 80.74 mbsf)

UNIT-41 : Alternating Troctolite and Olivine Gabbro
Pieces 1-11

PRIMARY MINERALOGY: Olivine Gabbro

- Olivine Modal 15%
 Size 3.5-5 mm
 Shape anhedral
- Plagioclase Modal 65%
 Size 5-10 mm
 Shape subhedral
- Pyroxene Modal 20%
 Size 4-7 mm
 Shape anhedral

COMMENTS: Unit 41 consists of coarse-grained olivine gabbro that is part of the alternating sequence of troctolite and olivine-gabbro. Mineral distribution is very heterogenous but grain size appears to coarsen downhole. Olivine is extensively altered in this section.

UNIT-42 : Basalt
Pieces 12-14

PRIMARY MINERALOGY: Too fine grained to estimate modal composition.

COMMENTS: Unit 42 consists of microcrystalline basalt except for Piece 12 that shows aphanitic texture. The basalt contains rare and isolated plagioclase phenocrysts as large as 3 mm. A slight increase in grain size downhole is noted. Alteration veins cross-cut the unit along its entire length.

SECONDARY MINERALOGY: Plagioclase in the troctolite is altered by reaction with adjacent olivine to chlorite + tremolite (± cummingtonite ± talc). Plagioclase is probably fresh in the chilled margin of the diabase, but all other minerals in it are altered to actinolite.

VEIN ALTERATION: A few thin actinolite/chlorite veins cut both the gabbro and the basalt.

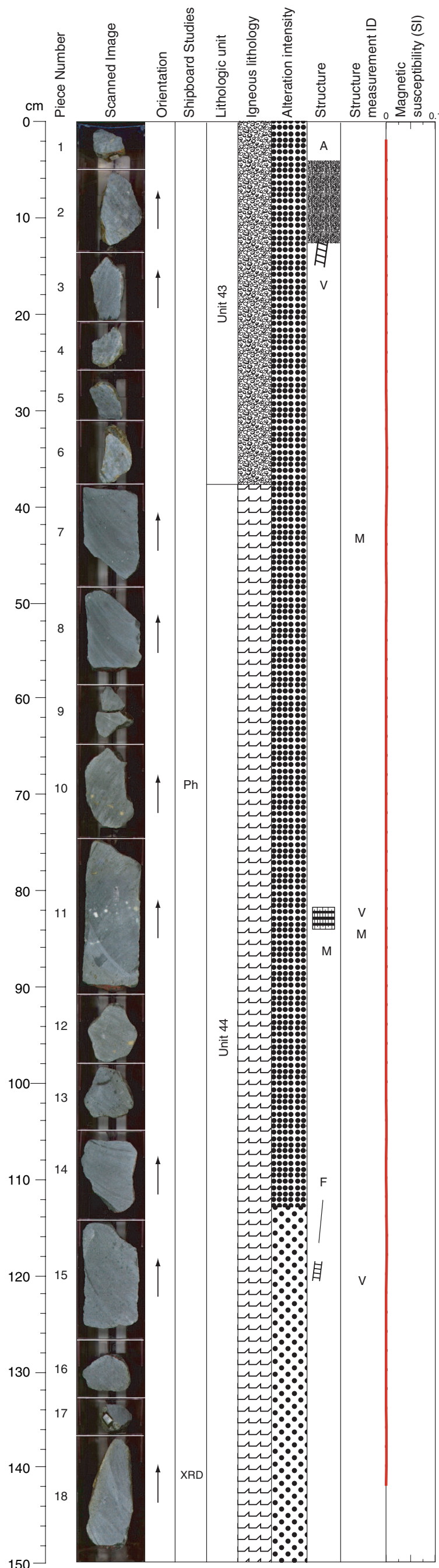
THIN SECTIONS:
304-U1309D-14R-2, 120-123 cm (#120)

STRUCTURE: Gabbroic interval of the section is noteworthy for the intergranular (troctolitic) alteration (A1) with dark minerals interconnected along grain boundaries. In places pyroxene grains are kinked and altered, but overall there is little strain. The interval of diabase (M) in the section has patchy alteration (A2) and interesting white fractures (F). Relative timing: A1>M>A2>=F

CLOSE-UP PHOTOGRAPHS:
304-U1309D-14R-2, 57-71 cm DRY BACKSIDE
304-U1309D-14R-2, 57-71 cm WET TOP



Core Photo



304-U1309D-15R-1 (Section top: 84.10 mbsf)

UNIT-43 : Rubble
Pieces 1-6

COMMENTS: Unit 43 consists of small pieces of coarse-grained gabbro and troctolitic gabbro that are presumed to be out of place.

UNIT-44 : Fine-grained Diabase
Pieces 7-18

PRIMARY MINERALOGY: Too fine-grained and altered to estimate modal composition in hand specimen.

COMMENTS: Unit 44 consists generally of microcrystalline diabase that coarsens downhole. Bands of large plagioclase (16 mm) and olivine grains occur. In Piece 7 (41 and 45 cm interval), bands of olivine and plagioclase are nearly horizontal. Between 79-85 cm, those bands are slightly inclined. From Piece 10 to 12, isolated olivine and clinopyroxene phenocrysts are observed. The diabase contains about 4% of opaque minerals.

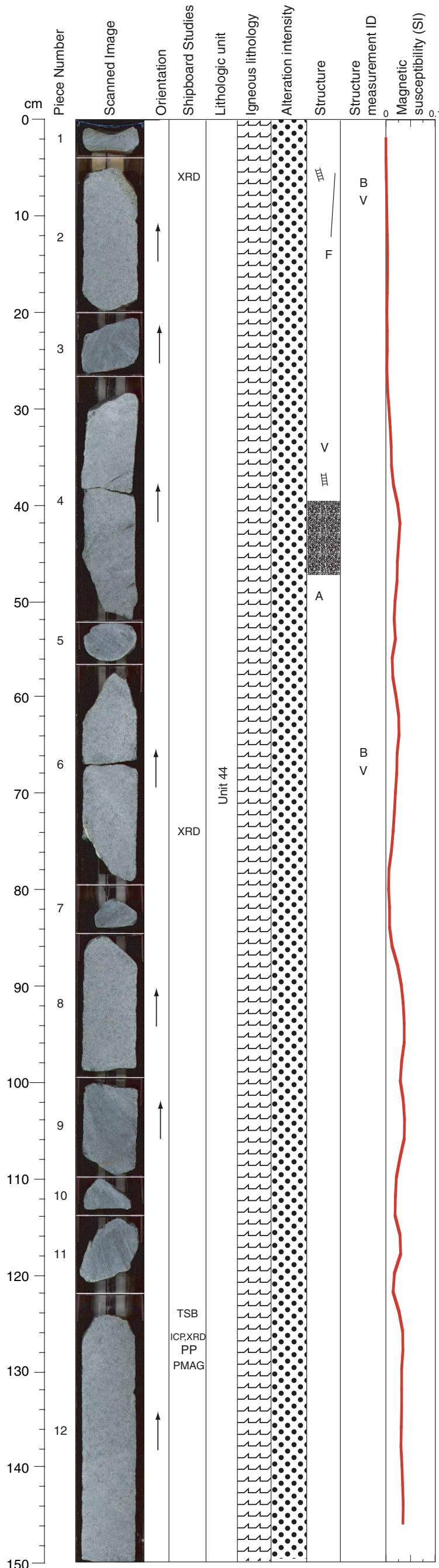
SECONDARY MINERALOGY: Plagioclase in the upper part of the section is partially altered by reaction with olivine to chlorite + actinolite ± cummingtonite. Alteration in the lower basalt becomes less intense as one moves down the section. Brown and green spots particularly in Piece 11 are assumed to be clay minerals + actinolite/chlorite after olivine. A plagioclase megacryst at 80 cm is fresh.

VEIN ALTERATION: An example of late stage alteration is given by the brown vein material on side of piece 18. This material have been identified with XRD as an assemblage of amphibole (actinolite?) and clays.

STRUCTURE: Gabbroic interval has interconnected, intergranular alteration (A), with one (high temperature?) dark amphibole vein (V). Diabase interval has magmatic layering (M) (from altered olivine) and subvertical veins and fractures (F). Relative timing: A>V>M>F

CLOSE-UP PHOTOGRAPHS:
304-U1309D-15R-1, 67-87 cm WET PIECES 10, 11

Core Photo



304-U1309D-15R-2 (Section top: 85.60 mbsf)

UNIT-44 : Medium-grained Diabase
Pieces 1-12

PRIMARY MINERALOGY: Determined from Thin Section.

Olivine Modal 1%
 Size 1-1.5 mm
 Shape anhedral

Plagioclase Modal 45%
 Size 0.2-3.5 mm
 Shape subhedral

Clinopyroxene Modal 50%
 Size 2-3 mm
 Shape anhedral

Opaques Modal 4%

COMMENTS: Section U1309D-15R-2 is the continuation of Unit 44 from U1309D-15R-1. The section is homogenous without plagioclase phenocrysts. Alteration vein crosses the section at 70 cm interval.

SECONDARY MINERALOGY: Plagioclase is fresh throughout the section. Approximately half the pyroxene is fresh. The remainder have altered to actinolite.

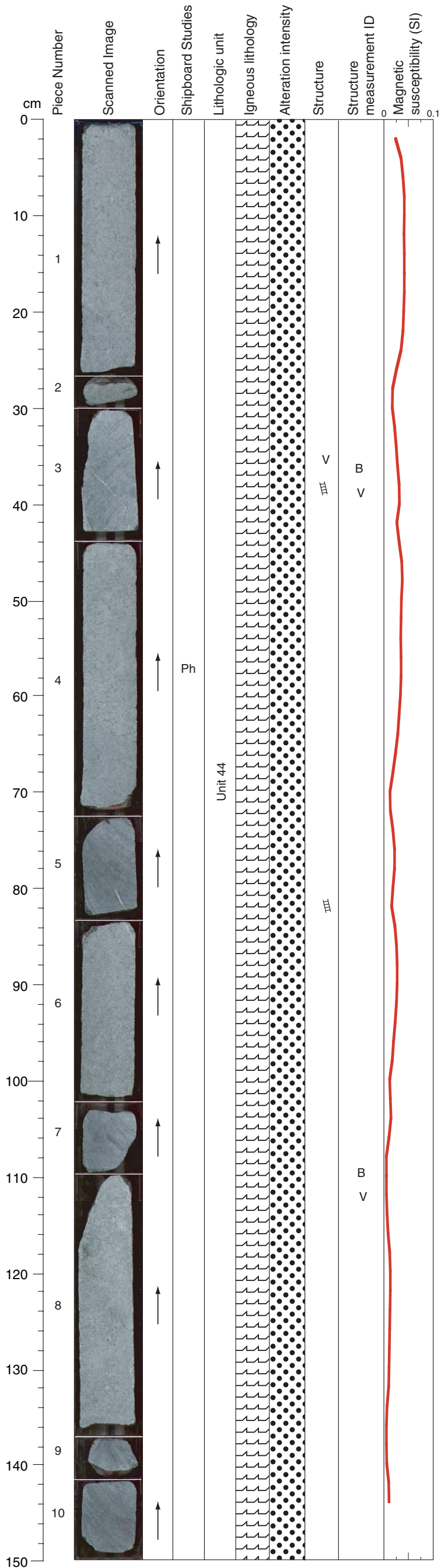
VEIN ALTERATION: A few thin actinolite/chlorite veins occur. A blue-green is also observed around 75 cm. The vein material could be amphibole (according to XRD). Late brown veins are observed on side of Piece 2. The filling minerals have been identified as almost pure clays by XRD (possibly saponite?).

THIN SECTIONS:
304-U1309D-15R-2, 122-125 cm (#121)

STRUCTURE: Two veins (V) and some fracture (F), as well as one interval (near 40 cm) where intergranular oxide enrichment (mineral seams) (A).

Core Photo

304-U1309D-15R-3 (Section top: 87.10 mbsf)



UNIT-44 : Medium-grained Diabase
 Pieces 1-10

PRIMARY MINERALOGY: Too fine-grained to estimate modal composition in hand specimen.

COMMENTS: Section U1309D-15R-3 is the continuation of Unit 44 from 1309D-15R-2 and appears homogenous without plagioclase phenocrysts. Alteration vein crosses the core at 39 and 84 cm.

SECONDARY MINERALOGY: Plagioclase is fresh throughout the section. Pyroxene is partially altered to actinolite. The degree of alteration decreases downward.

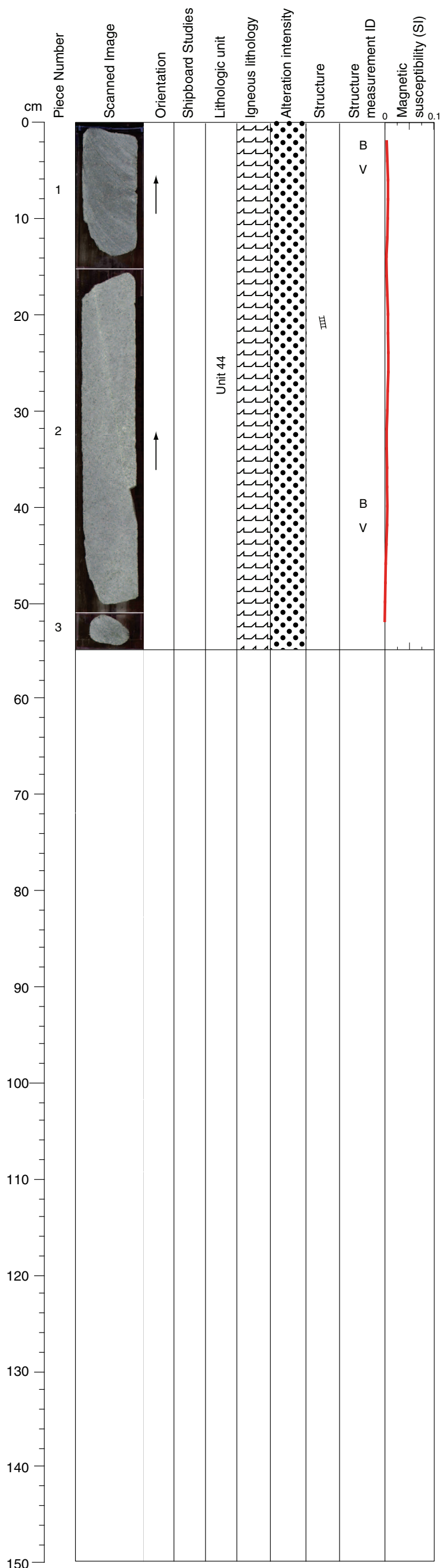
VEIN ALTERATION: Blue green veins (? actinolite, chlorite) with dark spots occur at 40 and 81 cm.

STRUCTURE: There are two long, white, continuous veins (V).

CLOSE-UP PHOTOGRAPHS:
 304-U1309D-15R-3, 55-69 cm WET
 304-U1309D-15R-3, 55-69 cm DRY BACKSIDE

Core Photo

304-U1309D-15R-4 (Section top: 88.60 mbsf)



UNIT-44 : Medium-grained Diabase
Pieces 1-3

PRIMARY MINERALOGY: Too fine-grained to estimate modal composition in hand specimen.

COMMENTS: The unit is a continuation of Unit 44 from U1309D-15R-3. The section appears homogenous without plagioclase phenocrysts. A nearly vertical alteration vein crosses Piece 2 at 29 cm.

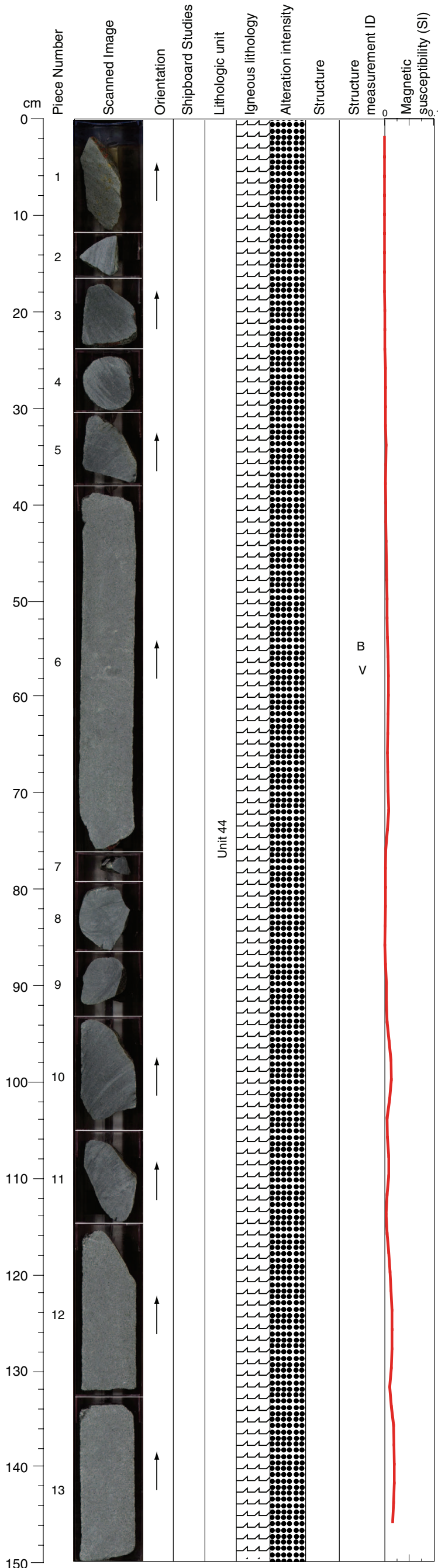
SECONDARY MINERALOGY: Plagioclase is fresh throughout the section. Pyroxene is partially altered to actinolite. Degree of alteration increases down the section.

VEIN ALTERATION: There is one steep thin late actinolite vein at 28 cm.

STRUCTURE: One long, continuous white vein.

Core Photo

304-U1309D-16R-1 (Section top: 89.0 mbsf)



UNIT-44 : Medium-grained Diabase
Pieces 1-13

PRIMARY MINERALOGY: Too fine-grained to estimate modal composition in hand specimen.

COMMENTS: Section U1309D-16R-1 is the continuation of Unit 44 from U1309D-15R-4. The diabase occasionally containing large plagioclase phenocrysts reaching as much as 8 mm (Piece 6). The section is homogenous. Pieces 1 and 2 are probably out of place. Piece 1 is fine-grained diabase with olivine phenocrysts, very similar to Piece 10 of U1309D-15R-1. Piece 2 is a small piece of olivine-gabbro.

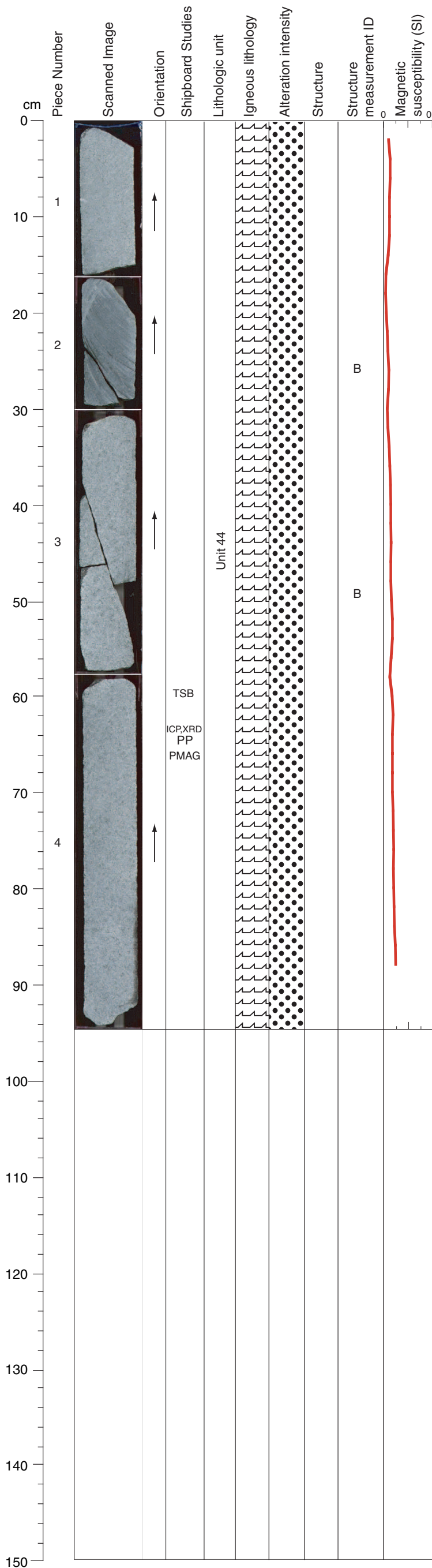
SECONDARY MINERALOGY: Plagioclase in this section is fresh. Ferromagnesian minerals have been altered to actinolite but some of the pyroxenes in this section have obviously survived this alteration.

VEIN ALTERATION: A few thin actinolite veins.

STRUCTURE: Patchy alteration and one mineral seam.

Core Photo

304-U1309D-16R-2 (Section top: 90.5 mbsf)



UNIT-44 : Medium-grained Diabase
 Pieces 1-4

PRIMARY MINERALOGY: Determined from Thin Section

Olivine	Modal <1%
Plagioclase	Modal 50% Size 0.2-4 mm Shape subhedral
Clinopyroxene	Modal 45% Size 0.1-0.4 mm Shape anhedral
Opaques	Modal 5%

COMMENTS: The section is a continuation of Unit 44 from U1309D-16R-1. The section is homogenous with rare and isolated plagioclase phenocrysts as large as 10 mm (Piece 1). Melt segregation can be observed in thin section with larger grains formed as a later crystallizing phase.

SECONDARY MINERALOGY: Plagioclase in this section is fresh. Ferromagnesian minerals have been altered to actinolite but most of the pyroxene in this section has survived this alteration.

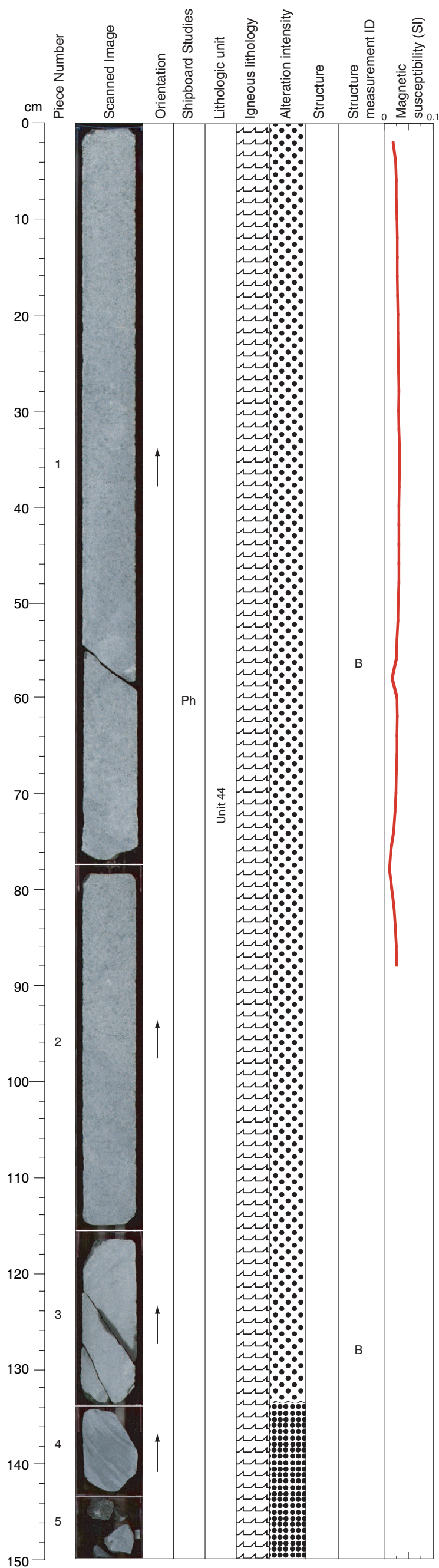
VEIN ALTERATION: No veins in this section.

THIN SECTIONS:
304-U1309D-16R-2, 58-61 cm (#122)

STRUCTURE: Grain size distribution changes (with chilled margin?) but no noteworthy structure.

Core Photo

304-U1309D-16R-3 (Section top: 91.43 mbsf)



UNIT-44 : Medium-grained Diabase
Pieces 1-5

PRIMARY MINERALOGY: Too fine-grained to estimate modal composition in hand specimen.

COMMENTS: Section U1309D-16R-3 represents the continuation of Unit 44 from U1309D-16R-2. The section is homogenous in composition but is fining downhole, starting at 115 cm (Piece 3). Piece 4 is fine-grained diabase. Occasional coarse-grained plagioclase phenocrysts occur, reaching as much as 15 mm in Piece 4.

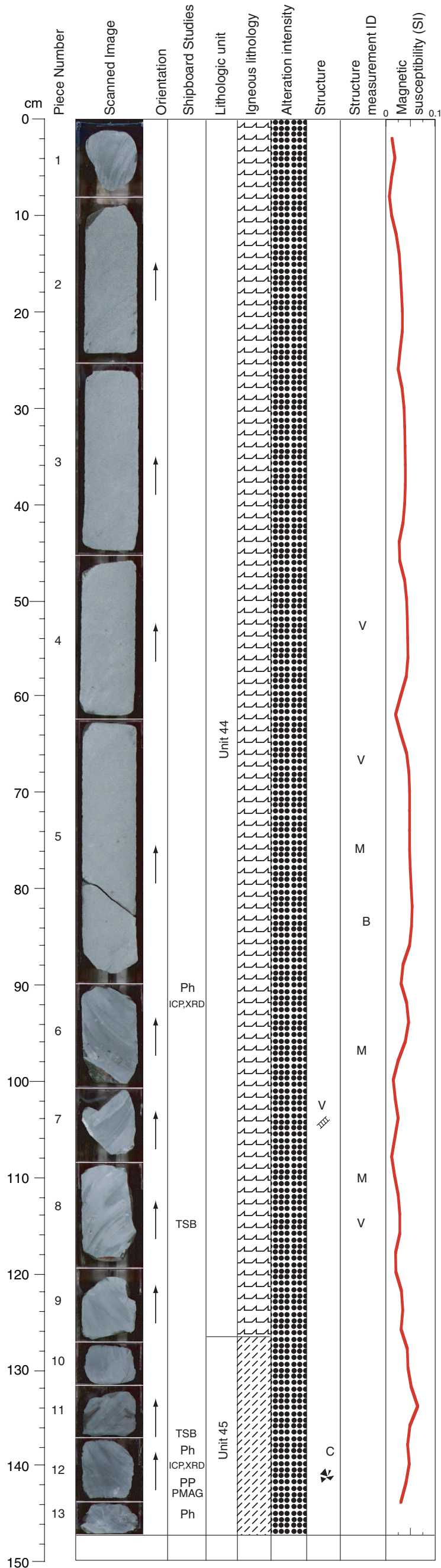
SECONDARY MINERALOGY: Plagioclase in this section is fresh but ferromagnesian minerals have altered to form actinolite. Some chlorite may be present. Most of the pyroxene appears in hand specimen to have survived alteration in the upper part of this section (0-133 cm). The degree of alteration seems to be greater in the lower part since only a few pyroxene relicts are present.

VEIN ALTERATION: No veins in this section.

STRUCTURE: No structure of note.

CLOSE-UP PHOTOGRAPHS:
304-U1309D-16R3, 57-77 cm WET
304-U1309D-16R3, 57-77 cm DRY BACKSIDE

Core Photo



304-U1309D-16R-4 (Section top: 92.93 mbsf)

UNIT-44 : Medium-grained Diabase
Pieces 1-9

PRIMARY MINERALOGY: Determined from Thin Section

- Olivine Modal 1%
 Size 2 mm
 Shape anhedral
- Plagioclase Modal 46%
 Size 0.05-0.55 mm
 Shape subhedral
- Clinopyroxene Modal 46%
 Size 0.15 mm
 Shape anhedral
- Opaques Modal 7%

COMMENTS: The upper part of Section U1309D-16R-4 is composed of the diabase of Unit 44 from U1309D-16R-3. It shows a general fining-downhole.

Several types of inclusions occur in Piece in thin section U1309D-16R-4, 113-116 cm

1. Plagioclase pheno/xenocryst (presence or absence of zoning)
2. Clinopyroxene phenocryst
3. Fresh gabbroic xenoliths with granular plagioclase and clinopyroxene
4. Altered gabbroic xenolith
5. Olivine

Inclusions visible in hand specimen occur in Piece 4 (52-59 cm), Piece 5 (74-83 cm), Piece 6 (subhorizontal layer from 96 to 99 cm), Piece 7 (104-106 cm) and all of Piece 8 (112-119 cm).

Flow-banding occurs in Piece 6 and a domain with coarse-grained, subhedral (~10 mm) plagioclase and pyroxene (4 mm) phenocrysts occurs at around 97 cm. Piece 7 shows a contact with a felsic to gabbroic dike.

UNIT-45 : Basalt
Pieces 10-13

PRIMARY MINERALOGY: Too fine-grained to estimate modal composition in hand specimen.

- Olivine Phenocryst
 Modal <1%
 Size 0.15 mm
 Shape anhedral
- Plagioclase Modal <1%
 Size 1.3 mm
 Shape subhedral

COMMENTS: Unit 45 consists of basalt that is in intrusive contact with diabase from Unit 44 in Piece 13. In thin section, two generations of emplacement are observed. The basalt shows a concordial fracture pattern due to this second event of emplacement. Sparse plagioclase phenocrysts (6 mm) occur in Piece 12.

SECONDARY MINERALOGY: Plagioclase in this section is fresh but most of the ferromagnesian minerals have been altered to actinolite. Some chlorite may be present. The last piece in this section may be more altered due to finer grain size of the primary minerals.

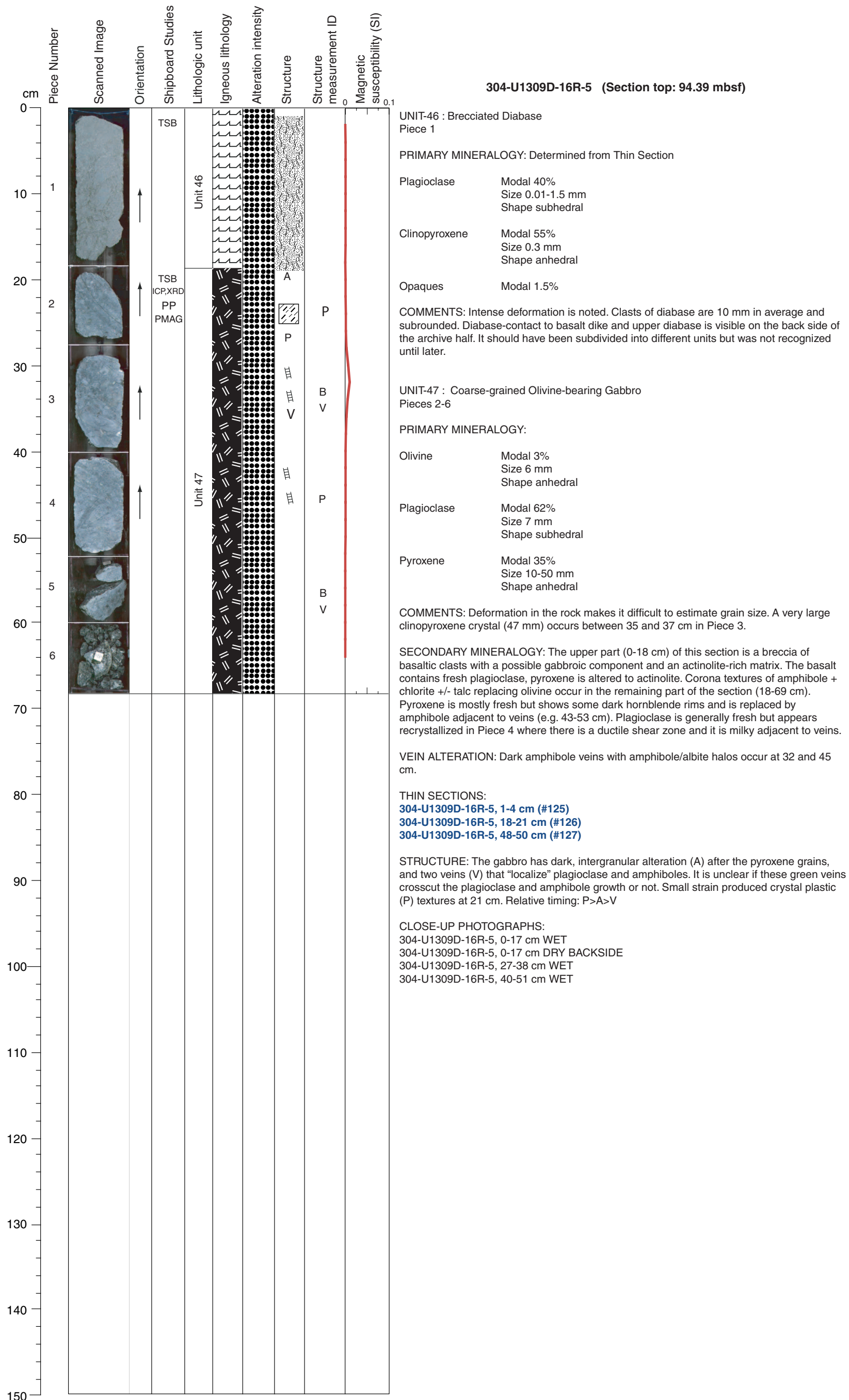
VEIN ALTERATION: There are no veins in the upper part of this section. In the fine grained zone below 100cm, thin actinolite/chlorite veins are present.

THIN SECTIONS:
304-U1309D-16R-4, 113-116 cm (#123)
304-U1309D-16R-4, 136-139 cm (#124)

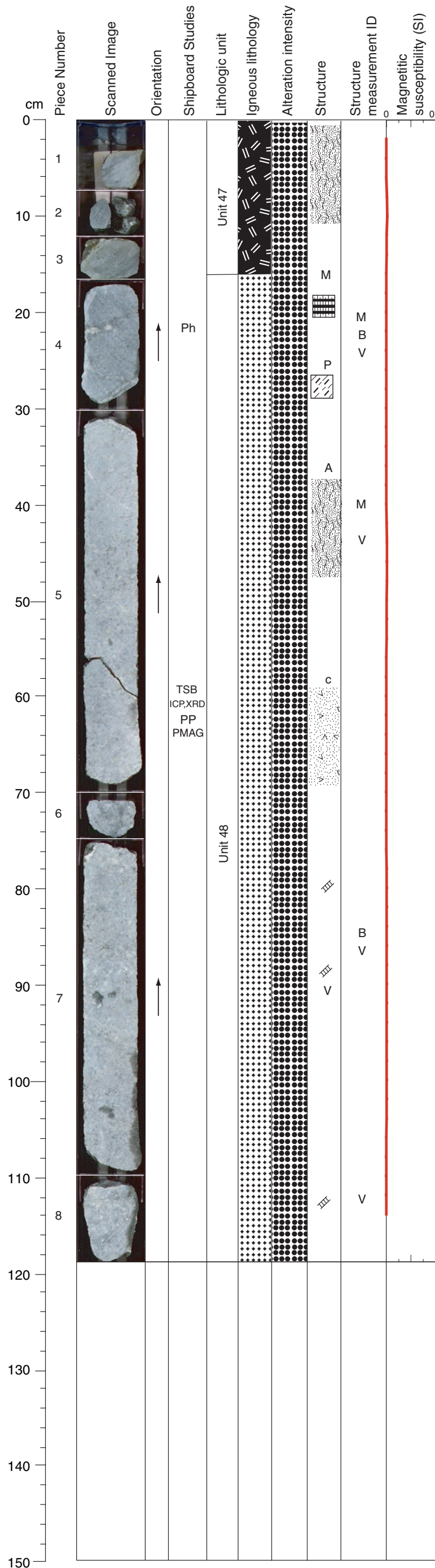
STRUCTURE: Felsic vein(?) (V) occurs on the edge of a piece at 104 cm, and there is a trace of breccia (C) toward the bottom of the section.

CLOSE-UP PHOTOGRAPHS:
304-U1309D-16R-4, 89-100 cm WET
304-U1309D-16R-4, 136-139 cm WET
304-U1309D-16R-4, 143-146 cm WET
304-U1309D-16R-4, 143-146 cm DRY BACKSIDE

Core Photo



Core Photo



304-U1309D-17R-1 (Section top: 98.7 mbsf)

UNIT-48 : Rubble
Pieces 1-3

PRIMARY MINERALOGY: Too fine-grained to estimate modal composition in hand specimen.

COMMENTS: Pieces 1 to 3 consists of diabase that may be out of place. The unit is fine-grained but still shows subophitic texture on the back side of the core.

UNIT-49 : Coarse-grained Olivine-Gabbro
Pieces 4-8

PRIMARY MINERALOGY: Determined from Piece 5

Olivine Modal 20%
 Size 4 mm
 Shape anhedral

Plagioclase Modal 60%
 Size 5 mm
 Shape subhedral

Pyroxene Modal 20%
 Size 5 mm
 Shape anhedral

COMMENTS: The unit has a very varying mineral distribution forming mineral domains along the length of the section. Slight deformation is noted. A vein-filled fracture occurs at 26 cm interval.

SECONDARY MINERALOGY: The section consists of moderately to highly altered diabase, troctolite and gabbro. Plagioclase is mostly fresh in the diabase of the upper part of the section (0-16 cm) but ferromagnesian minerals have been altered to actinolite with minor amounts of chlorite. Clay is present in a few amygdales where olivine seems to be replaced (these pieces are probably not in place). Pyroxene and especially olivine in troctolite and gabbro are altered to actinolite. Plagioclase grains adjacent to olivine are partly altered to chlorite +/- talc. The degree of alteration of the gabbro in the lower section (30-118 cm) is lower than that of the troctolite because of the presence of several fresh pyroxene cores.

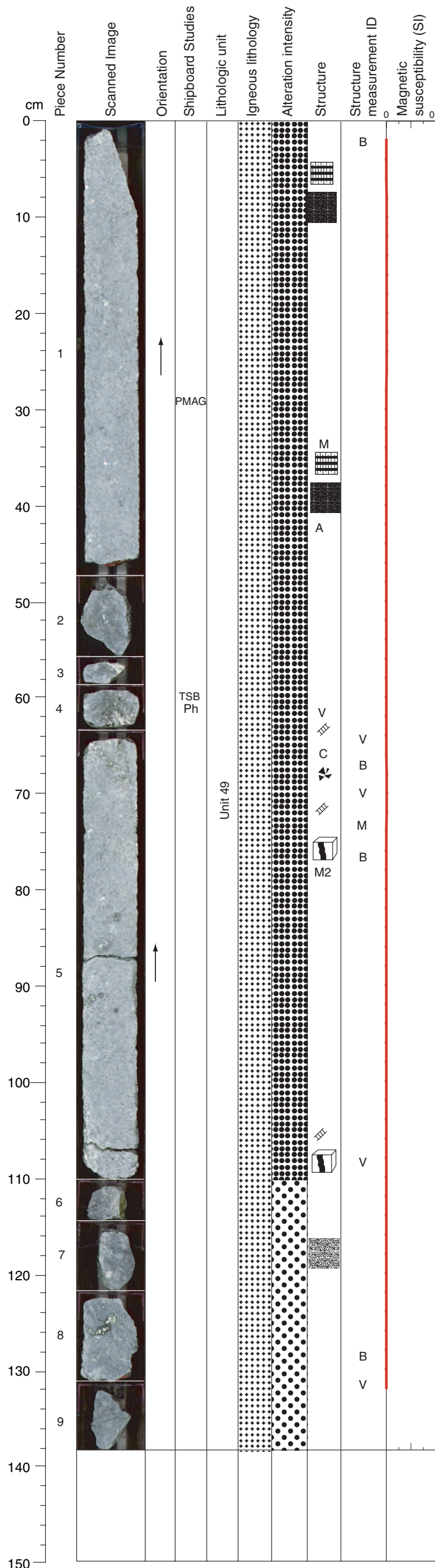
VEIN ALTERATION: Actinolite veins with albitized halos are present at 30 cm in the troctolite.

THIN SECTIONS:
304-U1309D-17R-1, 57-60 cm (#128)

STRUCTURE: Possibly minor crystal plastic deformation (P) near 30 cm although the interval might be more one of alteration on an early magmatic fabric (M). Late veining (V). Some intergranular alteration (e.g. troctolite alteration) (A). The interval from roughly 50 cm toward 70 cm has an increase in the degree of microcracking (c). Relative timing: P=M>A>C

CLOSE-UP PHOTOGRAPHS:
304-U1309D-17R-1, 17-29 cm WET
304-U1309D-17R-1, 17-29 cm DRY BACKSIDE

Core Photo



304-U1309D-17R-2 (Section top: 99.8 mbsf)

UNIT-49 : Coarse-grained Olivine-Gabbro
Pieces 1-9

PRIMARY MINERALOGY: Determined from Piece 1

- Olivine Modal <10%
 Size 4-10 mm
 Shape anhedral
- Plagioclase Modal 60%
 Size 5 mm
 Shape subhedral
- Pyroxene Modal 30%
 Size 5 mm
 Shape anhedral

COMMENTS: Section U1309D-17R-2 consists of olivine-bearing gabbro and represents the continuation of Unit 49 from 1309D-17R-1. This section seems to contain slightly lower modal olivine than the previous section. Coarse-grained olivine crystals reach as much as 10 mm.

SECONDARY MINERALOGY: This section consists of moderately altered gabbro. Relicts of fresh pyroxene are present throughout the section, however less common in the central part (55-109 cm). Plagioclase is fresh in the gabbros but slightly altered by reaction with olivine in the troctolite. Amphibole - chlorite (+/- talc) corona textures after olivine are present. The upper part of the section shows some large olivine pseudomorphs of amphibole rimmed by dark chlorite coronas. Secondary plagioclase is present around a major vein in the central part of the section.

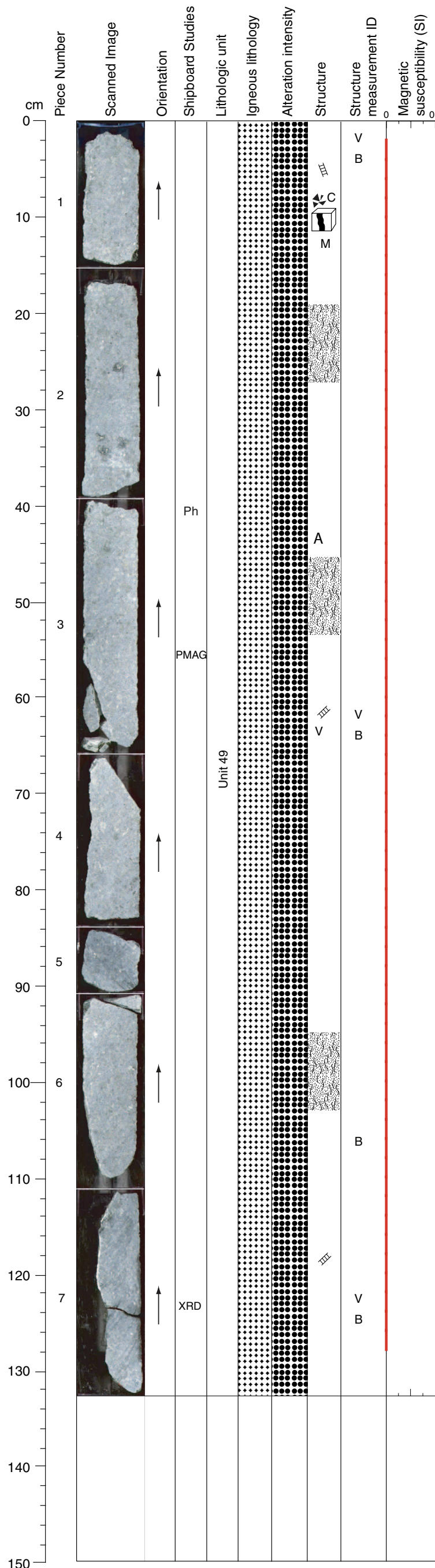
VEIN ALTERATION: Green breccia veins are observed between 55-70 cm and some dark actinolite veins elsewhere.

THIN SECTIONS:
[304-U1309D-17R-2, 59-61 cm \(#129\)](#)

STRUCTURE: Intergranular alteration (A) follows earlier magmatic layering (M). A change in orientation of the layering is found near twenty cm. Towards piece four this section is affected by increasing amounts of veining (V) and microcracking (C), including a complicated green vein in a feldspar-rich area (M2) near seventy cm. Relative timing: M>A>M2>=C>V

CLOSE-UP PHOTOGRAPHS:
[304-U1309D-17R-2, 59-61 cm WET](#)

Core Photo



304-U1309D-17R-3 (Section top: 101.26 mbsf)

UNIT-49 : Coarse-grained Olivine-Gabbro
Pieces 1-7

PRIMARY MINERALOGY: Determined from Piece 3

Olivine Modal 20%
 Size 4 mm
 Shape anhedral

Plagioclase Modal 60%
 Size 5 mm
 Shape subhedral

Pyroxene Modal 20%
 Size 8-12 mm
 Shape anhedral

COMMENTS: This unit is the continuation of Unit 49 from U1309D-17R-2. A slight increase in grain size (especially clinopyroxene), occurs compared to the previous sections. The section is nearly homogenous. A fault breccia is noted in Pieces 6 and 7.

SECONDARY MINERALOGY: The section consists of highly (~40%) altered olivine gabbro. Plagioclase is mostly fresh except where altered by reaction with olivine. Amphibole - chlorite (+/- talc) corona textures after olivine are present. Secondary plagioclase recrystallized along an amphibole (+/- chlorite?) vein at 110-123 cm.

VEIN ALTERATION: Steeply dipping talc-rich veins are observed at 60 cm and 115 cm.

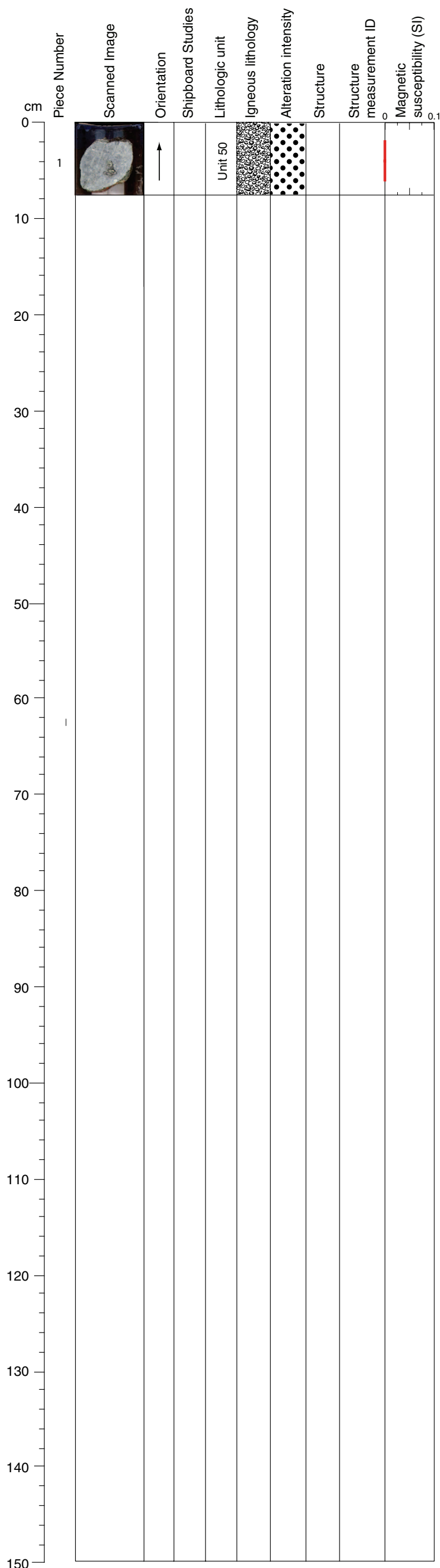
STRUCTURE: Subvertical, intergranular alteration (A) and several veins (V) characterize this section. One of the veins, in piece one, has a complicated internal structure and associated brecciation (C) of a feldspar rich (M) area. Relative timing: A>M>C>V

CLOSE-UP PHOTOGRAPHS:
304-U1309D-17R-3, 39-54 cm WET



Core Photo

304-U1309D-19R-1 (Section top: 112.4 mbsf)



UNIT-50 : Rubble
 Piece 1

PRIMARY MINERALOGY:

Olivine Modal 20%
 Size 4 mm
 Shape anhedral

Plagioclase Modal 60%
 Size 5 mm
 Shape subhedral

Pyroxene Modal 20%
 Size 10 mm
 Shape anhedral

COMMENTS: Unit 50 consists of coarse-grained olivine gabbro and is very similar to Unit 49. However, the two units are separated from each other by more than 10 meters of unrecovered core.

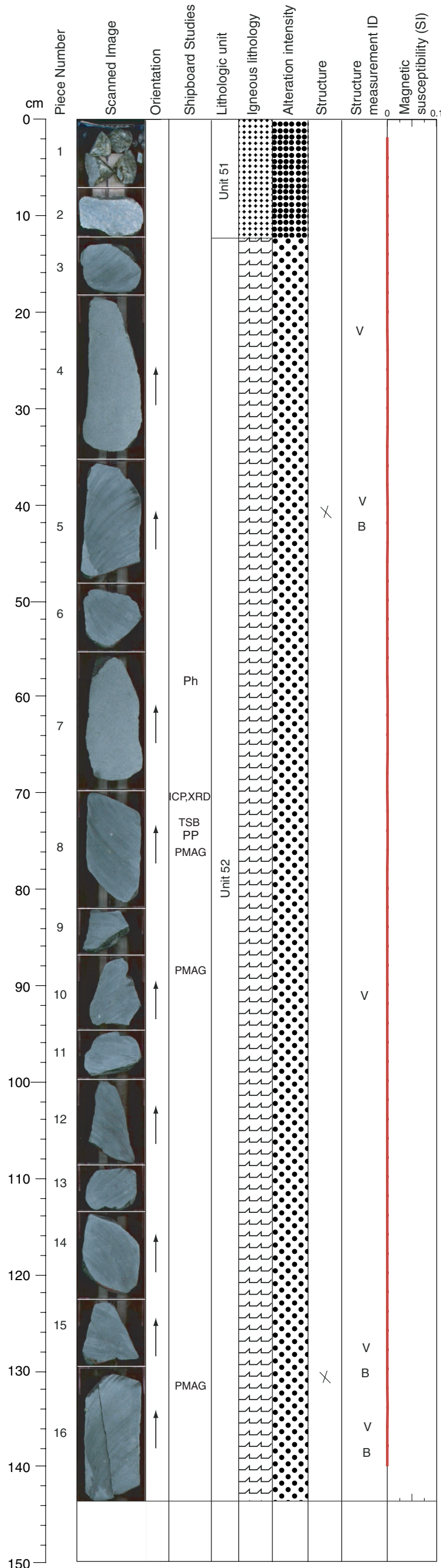
SECONDARY MINERALOGY: The section consists of highly (~40%) altered olivine gabbro. Plagioclase is mostly fresh except where altered by reaction with olivine. Amphibole - chlorite (+/- talc) corona textures after olivine are present.

VEIN ALTERATION: No veins.

STRUCTURE: None noted



Core Photo



304-U1309D-20R-1 (Section top: 117.1 mbsf)

UNIT-51 : Coarse-grained Olivine-Gabbro
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 2

Olivine Modal 15%
 Size 1.5 mm
 Shape anhedral

Plagioclase Modal 60%
 Size 4 mm
 Shape subhedral

Pyroxene Modal 25%
 Size 3-7 mm
 Shape anhedral

COMMENTS: Piece 1 is presumed to be out of place, Piece 2 may be core. This unit looks similar to Unit 49 from U1309D-17R-3. However, the two units are separated from each other by more than 10 meters of unrecovered core.

UNIT-52 : Fine-grained Diabase
Pieces 3-16

PRIMARY MINERALOGY: Determined from Thin Section

Olivine Modal 8%
 Size 0.9-2.3 mm
 Shape anhedral

Plagioclase Modal 40%
 Size 0.1-1.5 mm
 Shape subhedral

Clinopyroxene Modal 50%
 Size 0.2-0.8 mm
 Shape anhedral

Opaques Modal ~1%

COMMENTS: Unit 52 consists of diabase that is nearly homogenous throughout the entire section. It is characterized by a microcrystalline matrix with sparsely distributed plagioclase phenocrysts. Phenocrysts reach as much as 10 mm in size and are anhedral to rounded in shape.

SECONDARY MINERALOGY: The section consists of highly (~40%) altered gabbro in the upper part (0-12 cm) and moderately altered basalt. Plagioclase is fresh in the basalt and mostly fresh in the gabbro except where altered by reaction with olivine. Ferromagnesian minerals are altered to actinolite (+/- chlorite).

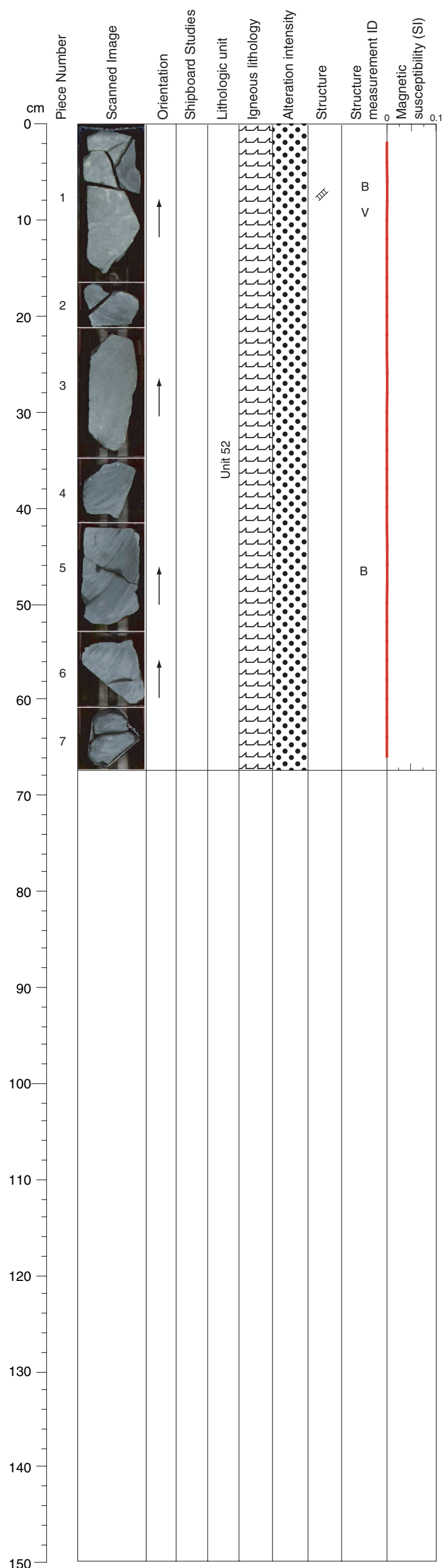
VEIN ALTERATION: Few small actinolite/chlorite veins are observed in the basalt.

THIN SECTIONS:
[304-U1309D-20R-1, 73-76 cm \(#130\)](#)

STRUCTURE: Patchy alteration, a few thin white fractures/veins (including a conjugate set with horizontal interangle - near 135 cm).

CLOSE-UP PHOTOGRAPHS:
[304-U1309D-20R-1, 55-69 cm WET](#)

Core Photo



304-U1309D-20R-2 (Section top: 118.53 mbsf)

UNIT-52 : Fine-grained Diabase
Pieces 1-7

PRIMARY MINERALOGY: Too fine-grained to estimate modal composition in hand specimen.

COMMENTS: Section U1309D-20R-2 consists of the continuation of Unit 52 from U1309D-20R-1. The diabase is homogenous along the entire length; sparsely distributed plagioclase and olivine phenocryst occur in the microcrystalline matrix. Plagioclase phenocrysts reach as much as 10 mm in size and are anhedral to rounded.

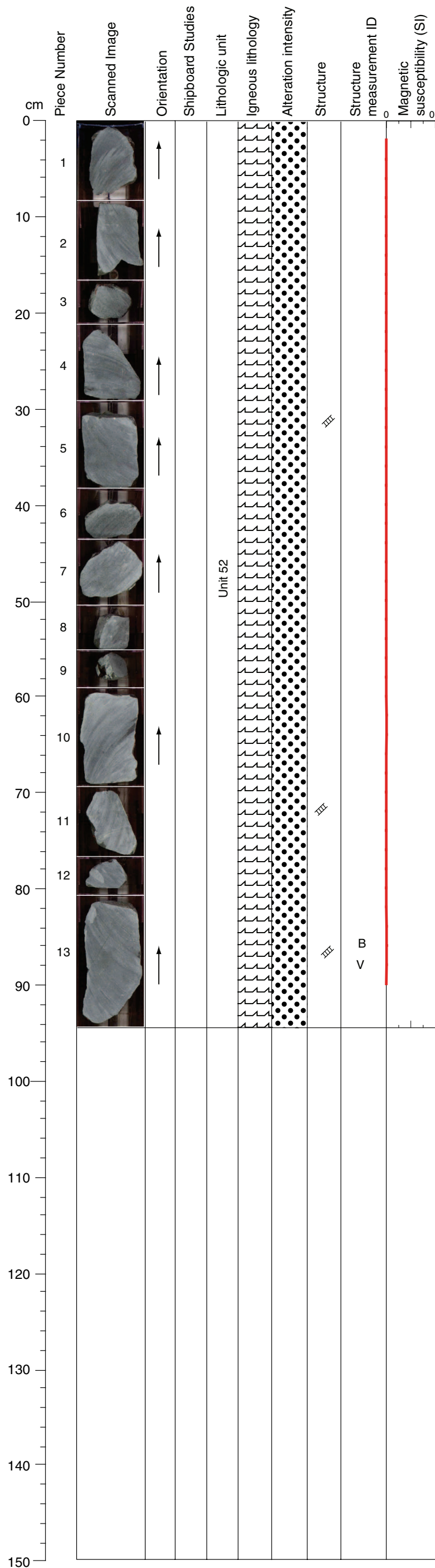
SECONDARY MINERALOGY: The core contains diabasic rocks that have been subjected to greenschist facies alteration. Plagioclase laths remain fresh but the pyroxene has been altered to actinolite. Chlorite is present in minor amounts.

VEIN ALTERATION: Few small actinolite/chlorite veins are observed.

STRUCTURE: Thin, white, wavy vein.



Core Photo



304-U1309D-21R-1 (Section top: 121.6 mbsf)

UNIT-52 : Fine-grained Diabase
Pieces 1-13

PRIMARY MINERALOGY: Too fine-grained to estimate modal composition in hand specimen.

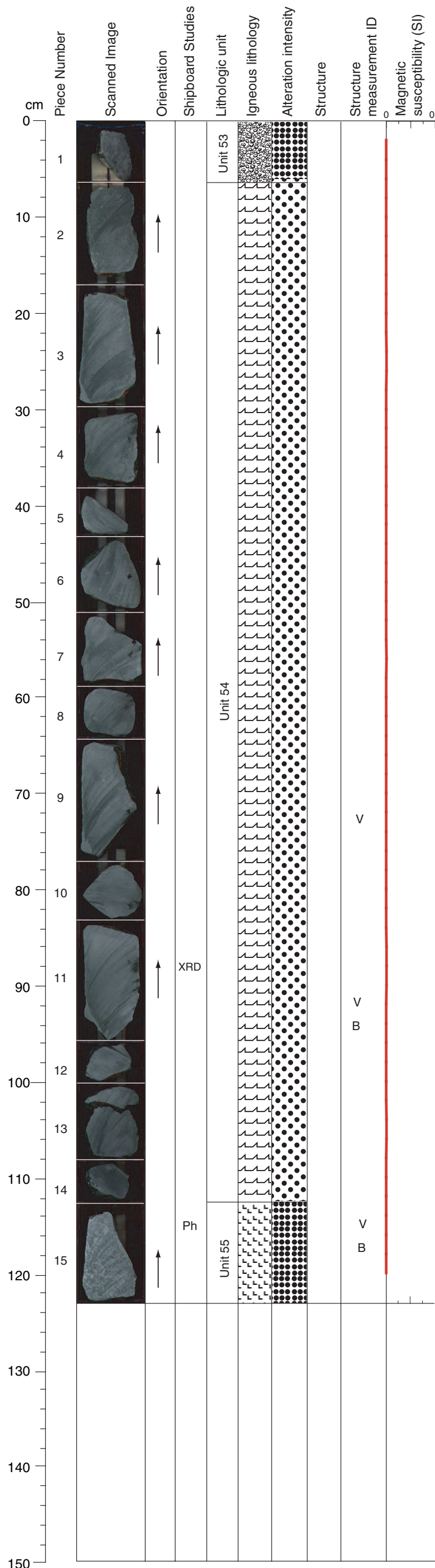
COMMENTS: Section U1309D-21-R-1 represents the continuation of Unit 52 from U1309D-20R-2. The diabase is homogenous along the entire length of the section and has a microcrystalline matrix with sparsely distributed plagioclase and olivine phenocrysts. Phenocrysts are anhedral to rounded, and up to 10 mm in size.

SECONDARY MINERALOGY: The core contains basaltic rocks that have been subjected to greenschist facies alteration. Plagioclase laths remain fresh but the pyroxene has been altered to actinolite. Minor chlorite is present.

VEIN ALTERATION: Few small actinolite/chlorite veins are observed.

STRUCTURE: Three thin, white veins.

Core Photo



304-1309D-22R-1 (Section top: 126.3 mbsf)

UNIT-53 : Rubble
 Piece 1

COMMENTS: Unit 53 consists of a single piece of coarse-grained gabbro presumed to be out of place.

UNIT-54 : Fine-grained Diabase
 Pieces 2-14

PRIMARY MINERALOGY: Too fine-grained to estimate modal composition in hand specimen.

COMMENTS: Unit 54 consists of diabase that is fining downhole, from Piece 2 to 14. As a whole, this diabase unit is mineralogically homogenous, except for rare plagioclase and olivine phenocrysts.

UNIT-55 : Medium-grained Troctolitic Gabbro
 Piece 15

PRIMARY MINERALOGY: Determined from Piece 15 (Troctolite)

Olivine Modal 30%
 Size 3 mm
 Shape anhedral

Plagioclase Modal 70%
 Size 4 mm
 Shape subhedral

COMMENTS: Piece 15 consists half of troctolite and half troctolitic gabbro with a gradational contact. Modal composition is given above for the troctolite section.

SECONDARY MINERALOGY: This core section consists of a highly altered gabbro in the upper part (0-6 cm), a moderately altered basalt in the central part (6-112 cm) and a highly altered troctolite in the lower part (112-121).

Plagioclase laths remain fresh in the basalt but ferromagnesian minerals have been altered to actinolite. Chlorite is present in minor amounts.

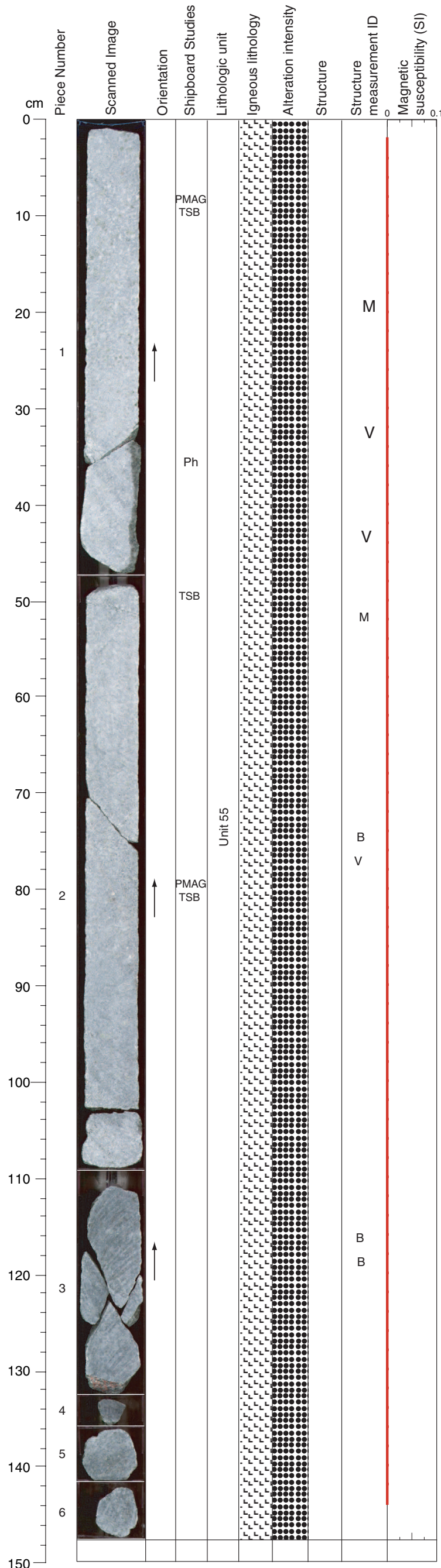
In the gabbro and troctolite, plagioclase is slightly altered by reaction with olivine. Pyroxene is locally altered to actinolite. Olivine is completely altered. Corona textures are present throughout the troctolite.

STRUCTURE: Undeformed troctolite (flattened relict olivine, now chlorite). A few thin veins in the diabase.

CLOSE-UP PHOTOGRAPHS:
 304-U1309D-22R-1, 112-122 cm WET



Core Photo



304-U1309D-22R-2 (Section top: 127.52 mbsf)

UNIT-55 : Medium-grained Troctolitic Gabbro
Pieces 1-6

PRIMARY MINERALOGY: Determined from Piece 1

Olivine	Modal 20%
	Size 2 mm
	Shape anhedral
Plagioclase	Modal 68%
	Size 5 mm
	Shape subhedral
Pyroxene	Modal 12%
	Size 4 mm
	Shape subhedral

COMMENTS: Unit 55 consists of medium-grained troctolitic gabbro. A weak magmatic foliation at nearly 45 degrees is noted in the section. Piece 2B shows a troctolite band about 50 mm thick (83-96 cm interval). It also shows a pyroxene-rich domain with a branching pyroxene-rich vein between 72 and 84 cm. Two types of pyroxene were also noted, one is dark colored in hand specimen, and the other has a brown rim and a pastel green-colored core. The latter is usually coarser-grained, reaching as much as 5-6 mm and has exsolution lamellae visible under the binocular microscope. Olivine has thin bands of chlorite forming a corona texture.

SECONDARY MINERALOGY: This core section consists of a highly altered olivine gabbro. Plagioclase is slightly altered by reaction with the olivine. Pyroxene is locally altered to actinolite. Olivine is completely altered. Corona textures are present throughout the olivine gabbro. More pyroxene is present within the lower part of the section (71-146), which is however altered to actinolite.

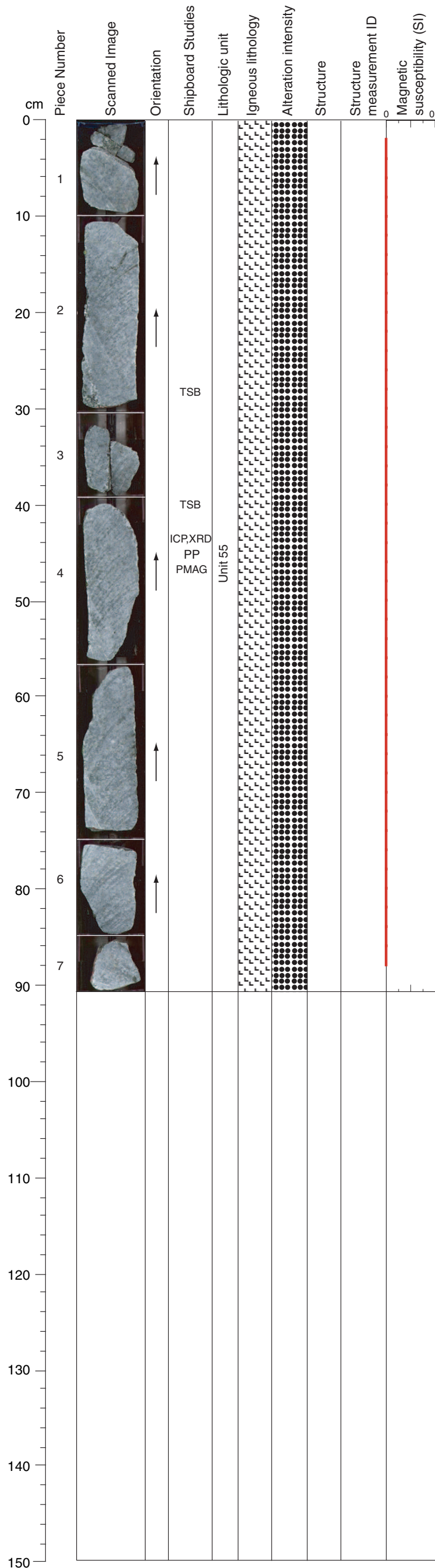
THIN SECTIONS:
[304-U1309D-22R-2, 8-10 cm \(#136\)](#)
[304-U1309D-22R-2, 48-51 cm \(#134\)](#)
[304-U1309D-22R-2, 79-81 cm \(#137\)](#)

STRUCTURE: None noted

CLOSE-UP PHOTOGRAPHS:
 304-U1309D-22R-2, 33-46 cm WET
 304-U1309D-22R-2, 33-46 cm DRY BACKSIDE



Core Photo



304-U1309D-22R-3 (Section top: 128.98 mbsf)

UNIT-55 : Medium-grained Troctolitic Gabbro
Pieces 1-7

PRIMARY MINERALOGY: Determined from Piece 1

Olivine Modal 20%
 Size 2 mm
 Shape anhedral

Plagioclase Modal 68%
 Size 5 mm
 Shape subhedral

Pyroxene Modal 12%
 Size 4 mm
 Shape subhedral

COMMENTS: This section consists of the continuation of Unit 55 from U1309D-22R_2. A weak magmatic foliation at nearly 45° is noted in the section. Two kinds of pyroxenes were noted, one is dark colored in hand specimen, and the other has a brown rim and a pastel green-colored core (for further description in thin section). The later is usually coarser-grained reaching as much as 5-6 mm. Olivine has thin bands of chlorite around the grains forming a corona texture. Alteration vein crosses Piece 2 at 26 cm interval.

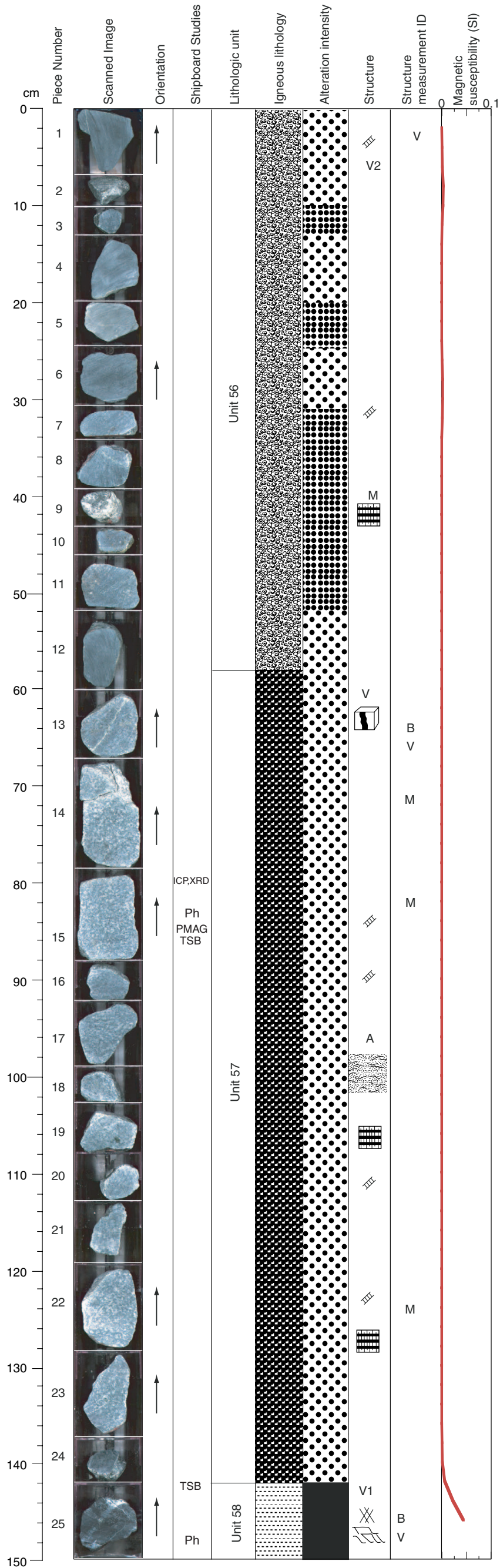
SECONDARY MINERALOGY: This core section consists of a highly altered olivine gabbro. Plagioclase is slightly altered by reaction with the olivine. Pyroxene is locally altered to actinolite. Olivine is completely altered corona textures are present throughout the olivine gabbro.

VEIN ALTERATION: A vein is present at 24-29 cm.

THIN SECTIONS:
[304-U1309D-22R-3, 27-30 cm \(#135\)](#)
[304-U1309D-22R-3, 39-42 cm \(#131\)](#)

STRUCTURE: None noted

Core Photo



304-U1309D-23R-1 (Section top: 131.00 mbsf)

UNIT-56: Mixed Rubble
Pieces 1-12

COMMENTS: Unit 56 consists of several pieces of rubble presumed to be out of place. Pieces 1 to 6 and 12 are fine-grained diabase, Pieces 7 to 11 are troctolite, and Piece 8 an olivine gabbro.

UNIT-57: Troctolite and Troctolitic Gabbro
Pieces 13-24

PRIMARY MINERALOGY: Determined from Piece13 (Troctolitic Gabbro)

Olivine Modal 25%
Size 1.5 mm
Shape anhedral

Plagioclase Modal 60%
Size 2 mm
Shape subhedral

Clinopyroxene Modal 15%
Size 2.5 mm
Shape anhedral

PRIMARY MINERALOGY: Determined from Piece15 (Troctolite)

Olivine Modal 30%
Size 2 mm
Shape anhedral

Plagioclase Modal 70%
Size 3 mm
Shape subhedral

Clinopyroxene Modal Trace
Size 2 mm
Shape anhedral

COMMENTS: Unit 57 consists of a series of medium-grained troctolite and troctolitic gabbros. Troctolitic gabbro occurs at the top and the bottom of the unit (Piece 13 and 24). In between, troctolites are present due to decreasing pyroxene abundance toward the middle of the unit. A very weak magmatic foliation is visible in Pieces 17 to 22.

UNIT-58: Ultramafic Ol-rich Troctolite
Piece 25

PRIMARY MINERALOGY:

Olivine Modal 93%
Size too altered
Shape too altered

Plagioclase Modal 2%
Size 1 mm
Shape anhedral

Clinopyroxene Modal 5%
Size 2 mm
Shape poikilitic

COMMENTS: A single piece of cumulate dunite with sparse poikilitic clinopyroxene and plagioclase trails occurs at the bottom of the section. A diffuse, 4-5 mm wide gabbroic vein crosses the sample. The piece is strongly serpentinized.

SECONDARY MINERALOGY: The upper 60 cm of this section (Pieces 1-12) consists of diabase and troctolite rubble altered under greenschist facies conditions. Plagioclase is fresh, but pyroxene has variably reacted to actinolite. Pieces 12 - 24 consist of troctolite in which plagioclase and pyroxene are fresh and olivine has altered to actinolite and chlorite. Piece 25 (143-148 cm) is a completely serpentinized peridotite in which olivine and pyroxene are altered to serpentine, talc, and chlorite.

VEIN ALTERATION: A few actinolite veins are present in the troctolite. Some talc-tremolite veins and small pyrite veins are present in the serpentinite.

THIN SECTIONS:

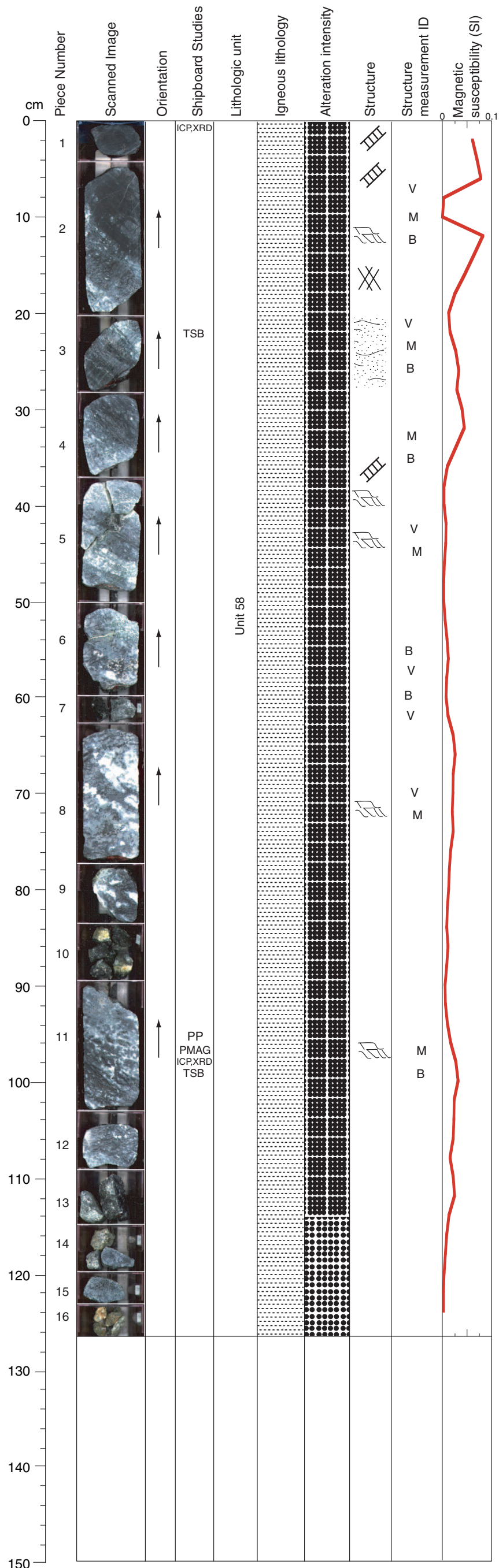
- 304-U1309D-23R-1, 84.0- 87.0 cm (#141)
- 304-U1309D-23R-1, 142.0- 145.0 cm (#142)

STRUCTURE: Through Piece 6 the pieces are rubble of diabase. White (albite-epidote?) veins are found in some of the diabase pieces (V2). Pieces 7 through 13 (to 60 cm) transition to "in place" pieces, with increasing amounts of troctolite with a weak magmatic fabric (M) and grain-boundary alteration (A) following the magmatic fabric. Feldspar-rich veins (V) cut the fabric and have the appearance of both magmatic (dioritic) and hydrothermal veins. The base of the section has a piece of serpentinite with serpentine veins cut by later white veins (V1). Relative timing: M>A>V>V1>V2.

CLOSE UP PHOTOGRAPHS:
1309D_23R_1_143_148.jpg



Core Photo



304-U1309D-23R-2 (Section top: 132.50 mbsf)

UNIT-58: Ol-rich troctolite
Pieces 1-16

PRIMARY MINERALOGY: Determined from Piece 11 (Troctolite)

Olivine Modal 35%
 Size 3 mm
 Shape anhedral

Plagioclase Modal 65%
 Size 4 mm
 Shape subhedral

COMMENTS: Unit 58 consists of a layered series grading from a totally serpentinized dunite with clinopyroxene as an intercumulus phase over a presumably wehrlitic area, into a troctolitic layer. Starting at Piece 8, the pieces have a high modal content of plagioclase and show plastic deformation. A clinopyroxene-rich zone with poikilitic textures occurs between 55-57 cm. Piece 1 to 4 represent one continuous section. Troctolite bands 10 to 15 mm thick occur at 19 cm, 34 cm, 47 cm and between 63-83 cm and 90-101 cm.

SECONDARY MINERALOGY: The upper part of this section (0-50 cm) consists of heavily serpentinized peridotite (dunite). In the central part (50-114 cm) the altered peridotite is impregnated by plagioclase-rich melts. Most of the plagioclase seems to be fresh, though alteration to turbid albite cannot be ruled out. Corona textures with tremolite (+/- talc) rimmed by chlorite are common in these zones and represent reaction of olivine with plagioclase. A highly altered troctolite with typical corona textures makes up the lower part of this section (115-120 cm).

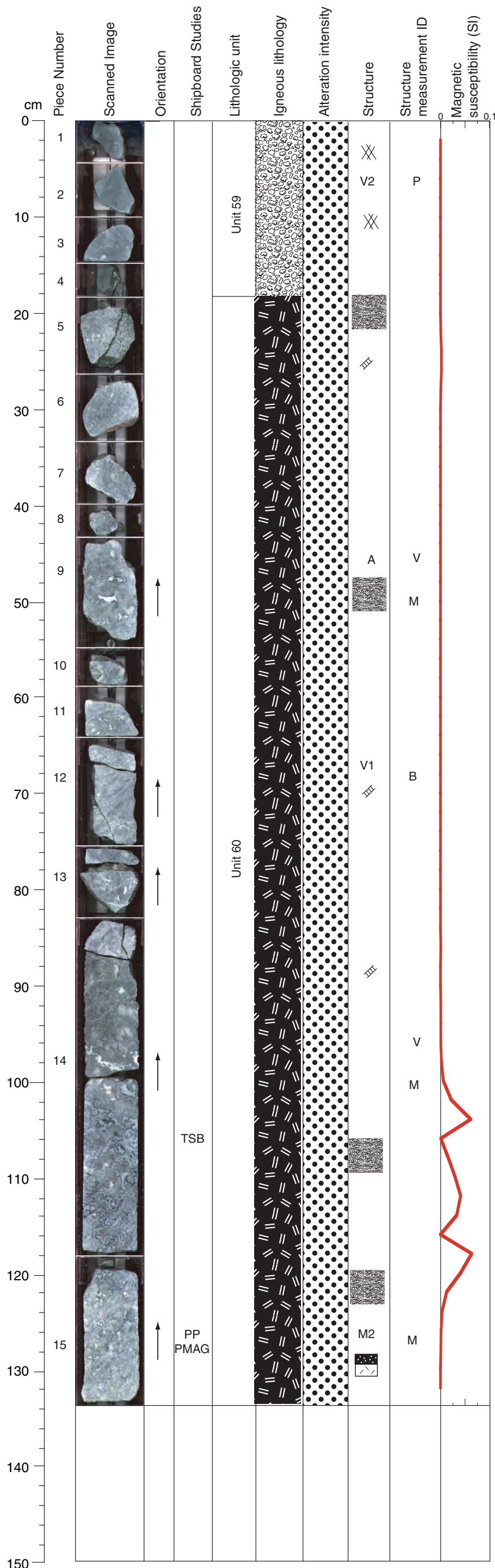
VEIN ALTERATION: Several talc-tremolite veins (e.g. at 40 cm), actinolite veins (e.g. 52 cm) and serpentine veins (e.g. 22 cm) are present in the serpentinite

THIN SECTIONS:
304-U1309D-23R-2, 21.0-24.0 cm (#148)
304-U1309D-23R-2, 96.0-101.0 cm (#143)

STRUCTURE: Serpentinite texture (S) dominates the section, although in places an earlier gabbroic texture is found. The serpentinite texture in places resembles a flow texture, although there is no evidence for shear strain. Two generations of veins - an early dark vein set (V1) with associated alteration texture (A) and a later white vein set (V2) - cut the serpentinite texture.

CLOSE-UP PHOTOGRAPHS:
1309D_23R_2_0_37.jpg
1309D_23R_2_5_19.jpg
1309D_23R_2_20_28.jpg
1309D_23R_2_98_101.jpg

Core Photo



304-U1309D-24R-1 (Section top: 137.90 mbsf)

UNIT-59: Mixed Rubble
Pieces 1-4

COMMENTS: Unit 59 consists of several pieces of fine-grained, plagioclase-phyric diabase presumed to be out of place.

UNIT-60: Olivine-bearing Gabbro
Pieces 5-15

PRIMARY MINERALOGY: Determined from Piece 14C (Olivine Gabbro)

Olivine Modal 35%
Size 20 mm
Shape anhedral

Plagioclase Modal 50%
Size subhedral
Shape 20 mm

Clinopyroxene Modal 15%
Size 22 mm
Shape anhedral

PRIMARY MINERALOGY: Determined from Piece 15 (Olivine-bearing Gabbro)

Olivine Modal 3%
Size 4 mm
Shape anhedral

Plagioclase Modal 50%
Size 7 mm
Shape subhedral

Clinopyroxene Modal 47%
Size 10 mm
Shape anhedral

COMMENTS: Unit 60 consists of medium- to coarse-grained, olivine-bearing gabbro. The unit starts with medium grain sizes that increase downward. Medium and coarse-grained domains are present in Piece 7. An olivine-rich area occurs between 100 and 120 cm and a shear zone cuts at 72 cm.

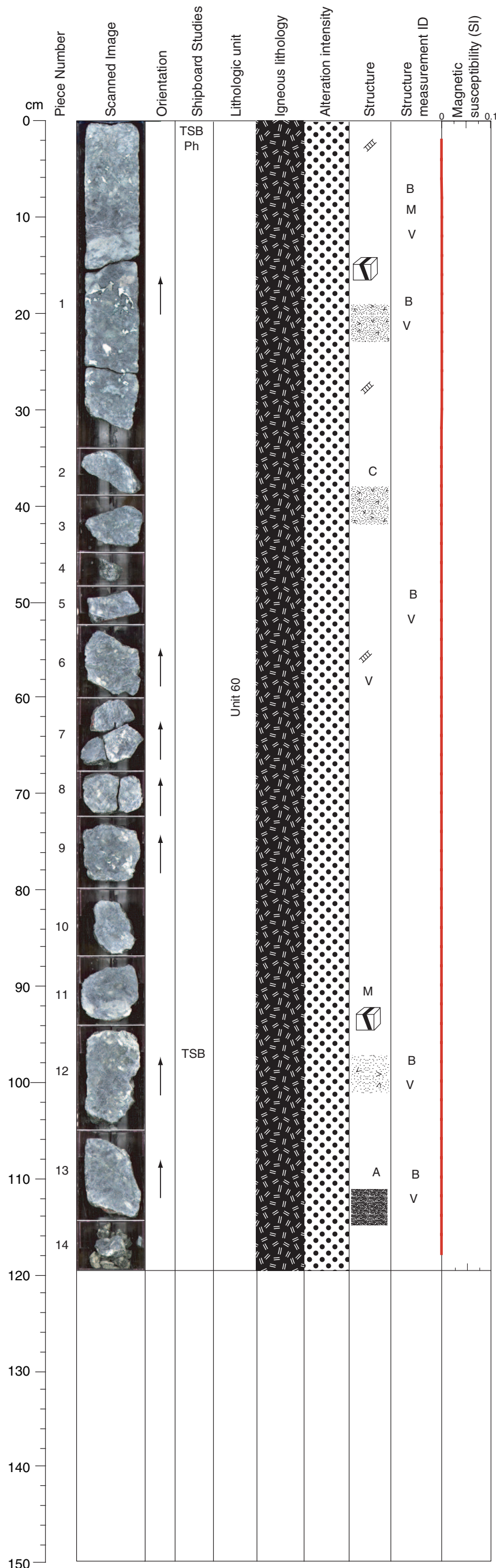
SECONDARY MINERALOGY: The upper part of this section (0-18 cm) consists of moderately altered diabase rubble in which the ferromagnesian minerals seem to be altered to actinolite (+/- chlorite). The remainder of this section (18-132 cm) consists of moderately altered olivine gabbro with some large coronitic patches of tremolite + chlorite +/- talc, rimmed by chlorite which replace olivine. Most of the plagioclase and pyroxene seem to be fresh.

THIN SECTIONS:
304-U1309D- 24R-1, 104.0-107.0 cm (#144)

STRUCTURE: Interesting alteration textures (A) along grain boundaries of olivine, feldspar, and pyroxene. The alteration texture follows an earlier magmatic fabric (M1 - not shown). Two vein sets - a late white vein set (V2) and an earlier, in places serpentine-bearing, vein set (V1). Below 120 cm there is a shallowly dipping intrusive (M2) contact between olivine gabbro and gabbro. Relative timing: M1>M2>A>V1>V2



Core Photo



304-U1309D-24R-2 (Section top: 139.23 mbsf)

UNIT-60: Olivine-bearing Gabbro
Pieces 1-14

PRIMARY MINERALOGY: Determined from Piece 1

Olivine Modal 10%
Size 8 mm
Shape anhedral

Plagioclase Modal 50%
Size 32 mm
Shape subhedral

Clinopyroxene Modal 40%
Size < 40 mm
Shape subhedral

PRIMARY MINERALOGY: Determined from Piece 9

Olivine Modal <1%
Size 8 mm
Shape

Plagioclase Modal 49%
Size 12 mm
Shape

Clinopyroxene Modal 50%
Size 12 mm
Shape

COMMENTS: Unit 60 consists of olivine-bearing gabbro with variable grain size. At the top of the section a gabbroic intrusion with pegmatitic grain sizes occurs in Piece 1. Coarse grain sizes are present in the remainder of the unit. A medium-grained interval occurs between 45-47 cm and a cataclastic domain between 92-94 cm.

SECONDARY MINERALOGY: The upper part of this section (0-32 cm) consists of moderately altered olivine gabbro with some large coronitic patches after olivine consisting of tremolite + chlorite +/- talc, rimmed by chlorite. Most of the plagioclase and pyroxene seem to be fresh. The remainder of this section (34-119 cm) consists of metagabbro in which ferromagnesian minerals are partially altered to actinolite +/- chlorite. Brown hornblende may be present.

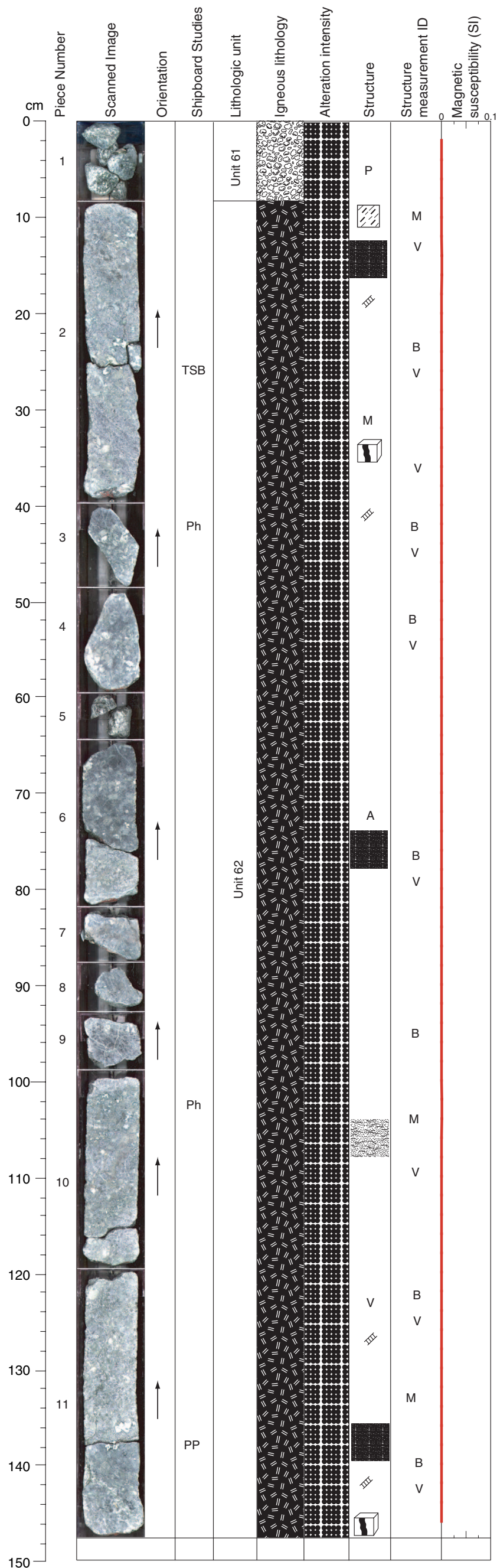
VEIN ALTERATION: Several actinolite +/- chlorite veins are present (e.g. at 57 cm). A brecciated yellow-green actinolite vein with plagioclase halo occurs at 95 cm

THIN SECTIONS:
304-U1309D- 24R-2, 0.0-2.0 cm (#145)
304-U1309D- 24R-2, 95.0-98.0 cm (#146)

STRUCTURE: Variable amounts of microcracks (C) and veins (V) are noted through the core. Veins are primarily light-green to white and superposed on plagioclase-rich areas of the gabbro. Earlier grain-boundary alteration (A) is found throughout the section. A coarse-grained magmatic intrusion (M) is found near 15 cm, and a dioritic intrusion near 90 cm. Relative timing: M(?)>A>C>V

CLOSE UP PHOTOGRAPHS:
1309D_24R_2_0_25.jpg

Core Photo



304-U1309D-25R-1 (Section top: 142.70 mbsf)

Unit 61: Rubble
Piece 1

COMMENTS: A single piece of troctolite sits at the top of the section, and is presumed to be out of place.

Unit 62: Olivine-bearing Gabbro
Pieces 2-11

PRIMARY MINERALOGY: Determined from Piece 10A

Olivine Modal 1%
 Size 3 mm
 Shape anhedral

Plagioclase Modal 44%
 Size 8 mm
 Shape anhedral

Clinopyroxene Modal 55%
 Size 7 mm average, 20 mm maximum
 Shape anhedral

COMMENTS: Unit 62 consists of coarse-grained olivine-bearing gabbro. Olivine is heterogeneously distributed. Olivine is completely altered and stands out as whitish-greenish grains. Talc-tremolite schists occur often throughout the section.

SECONDARY MINERALOGY: This section consists primarily of moderately to highly altered olivine gabbro with some large tremolite + chlorite +/- talc patches, rimmed by chlorite, and replacing olivine. The majority of plagioclase and pyroxene appears unaltered. Brown hornblende is probably present, especially in Piece 8. The uppermost 0-8 cm contains some small pieces of troctolitic rubble.

VEIN ALTERATION: Several actinolite +/- chlorite veins present. Breccia zone with brown hornblende, actinolite, and secondary plagioclase between 140 to 145 cm.

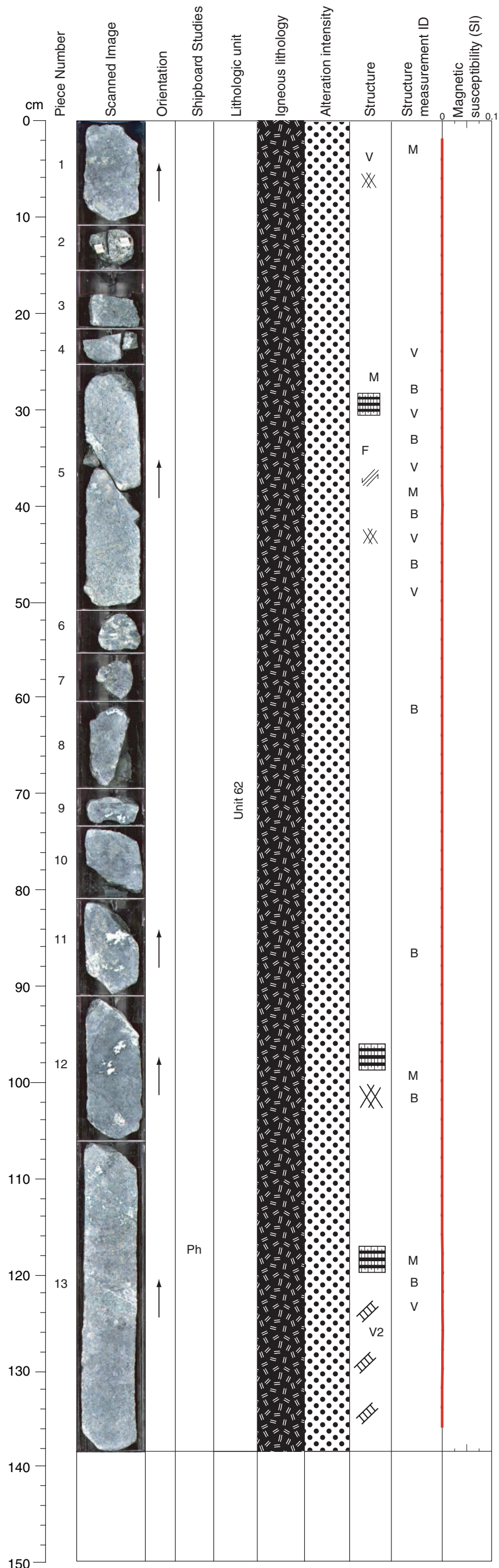
THIN SECTIONS:
304-U1309D- 25R-1, 24.0- 26.0 cm (#149)

STRUCTURE: Alteration rims (A), in places with a weak crystal plastic texture (P) is found in several intervals of this section. Veins (V) throughout the section have either a green color and are steeply dipping, or have a blue color and are gently dipping. The "blue" veins are soft and perhaps contain some talc. A fault (F) on the bottom of Piece 3 and the top of Piece 4 has talc with a mineral lineation indicating normal sense displacement. In places throughout the section (Piece 3, Piece 11) there are dioritic veins (M) that localize green alteration. Relative timing: P>M>A>F=V

CLOSE UP PHOTOGRAPHS:
1309D_2_1_40_45.jpg
1309D_25R_1_99_115.jpg



Core Photo



304-U1309D-25R-2 (Section top: 144.17 mbsf)

UNIT-62: Olivine-bearing Gabbro
Pieces 1-13

PRIMARY MINERALOGY: Determined from Piece 5 (Olivine-bearing Gabbro)

- Olivine Modal 2%
 Size 4-8 mm
 Shape anhedral
- Plagioclase Modal 53%
 Size 6 mm
 Shape anhedral
- Clinopyroxene Modal 45%
 Size 4 mm average, 15 mm maximum
 Shape anhedral

PRIMARY MINERALOGY: Determined from Piece 13 (123 to 133 cm interval)

- Plagioclase Modal 45%
 Size 6 mm
 Shape anhedral
- Clinopyroxene Modal 48%
 Size 4-5 mm
 Shape anhedral
- Orthopyroxene Modal 7%
 Size 4-5 mm
 Shape anhedral

COMMENTS: This section consists of coarse-grained, olivine-bearing gabbro. A gabbro-norite occurs between 123 and 133 cm.

SECONDARY MINERALOGY: This section consists of moderately altered olivine gabbro with some large coronitic patches of tremolite + chlorite +/- talc, rimmed by chlorite as pseudomorphs after olivine. Most of the plagioclase and pyroxenes seem to be fresh. Some brown hornblende relics may be present.

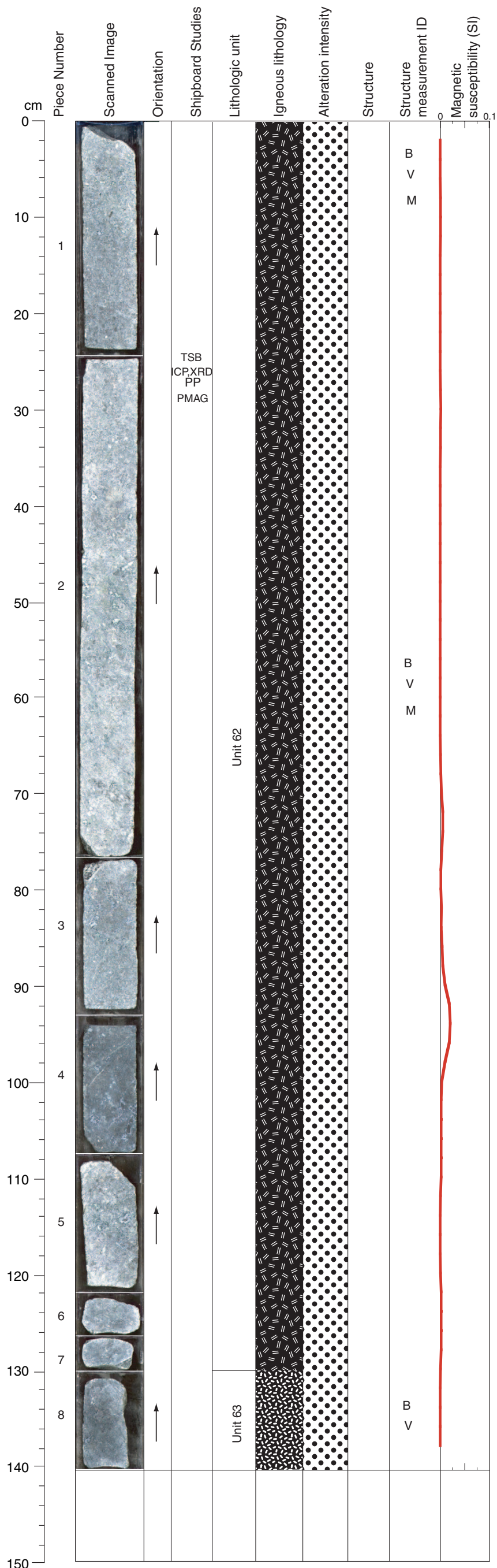
VEIN ALTERATION: Several actinolite + chlorite +/- talc veins are present.

STRUCTURE: Coarse-grained gabbro with green veins (V1) winding around the grains. Some of the blue veins cut across all of the grains (V2). The more olivine-rich portions of the section have an inclined fabric (M). Relative timing: M>V1>V2.

CLOSE UP PHOTOGRAPHS:
1309d_25r_2_115_138.jpg



Core Photo



304-U1309D-25R-3 (Section top: 145.55 mbsf)

UNIT-62: Olivine-bearing Gabbro
Pieces 1-7

PRIMARY MINERALOGY: Determined from Piece 2

- Olivine Modal 2%
 Size 4-8 mm
 Shape anhedral
- Plagioclase Modal 55%
 Size 6 mm average, 30 mm maximum
 Shape anhedral
- Clinopyroxene Modal 43%
 Size 6-10mm
 Shape anhedral

COMMENTS: This section consists of coarse-grained, olivine-bearing gabbro and is the continuation from the previous sections. Piece 3 shows smaller grain sizes than the remainder of the section.

UNIT-63: Orthopyroxene-bearing Gabbro
Piece 8

PRIMARY MINERALOGY: Determined from Piece 8

- Olivine Modal 1%
 Shape anhedral
- Plagioclase Modal 74%
 Size 6 mm
 Shape anhedral
- Clinopyroxene Modal 25%
 Size 6 mm
 Shape anhedral
- Orthopyroxene Modal 1%
 Size 10 mm
 Shape anhedral

COMMENTS: At the bottom of the section a single piece of coarse-grained, orthopyroxene-bearing gabbro occurs. Orthopyroxene grains reach sizes as large as 10 mm.

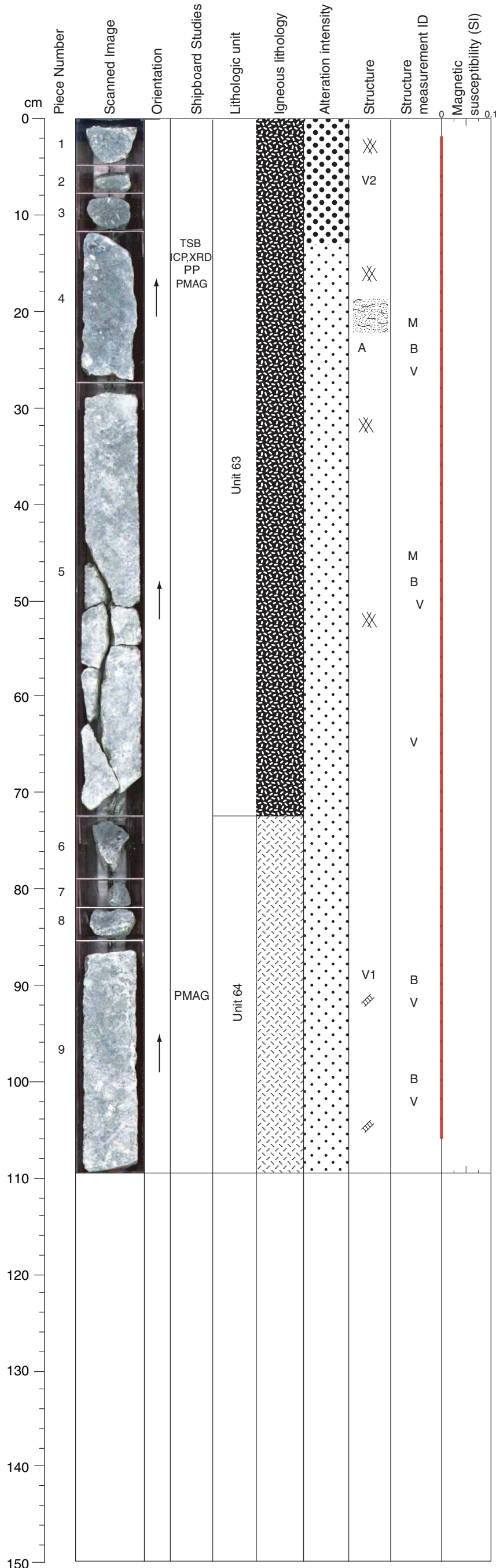
SECONDARY MINERALOGY: This section consists of moderately altered olivine gabbro with some coronitic patches of tremolite + chlorite +/- talc, rimmed by chlorite pseudomorphs after olivine (e.g. around 50 cm). Most of the plagioclase and pyroxene appear fresh.

THIN SECTIONS:
[304-U1309D- 25R-3, 24-25 cm \(#147\)](#)

STRUCTURE: A weak magmatic fabric is pervasive throughout the section; veins are present where measured in the structure measurement ID column.



Core Photo



304-U1309D-26R-1 (Section top: 147.60 mbsf)

UNIT-63: Orthopyroxene-bearing Gabbro
Pieces 1-5

PRIMARY MINERALOGY: Determined from Piece 5A

Olivine Modal 1%
Size 2-6 mm
Shape anhedral

Plagioclase Modal 51%
Size 5 mm
Shape anhedral

Clinopyroxene Modal 45%
Size 4-15mm
Shape anhedral

Orthopyroxene Modal 3%
Size 5 mm
Shape anhedral

COMMENTS: This section starts with the continuation of the orthopyroxene-bearing gabbro from Unit 63 at the bottom of the previous section. Piece 5A shows some pegmatitic pyroxene grains as large as 35 mm.

UNIT-64: Impregnated Gabbro
Pieces 6-9

PRIMARY MINERALOGY: Determined from Piece 9

Olivine Modal 3%
Size 3-6 mm
Shape anhedral

Plagioclase Modal 62%
Size 5-9 mm
Shape anhedral

Clinopyroxene Modal 35%
Size 5-16 mm
Shape anhedral

COMMENTS: This unit consists of coarse-grained gabbro where plagioclase shows a peculiar alteration that gives it a 'salt and pepper' appearance. Boundaries of Unit 64 and Unit 63 overlap and orthopyroxene occurs in the upper part of this unit. A vein crosses at 90 cm.

SECONDARY MINERALOGY: The upper part of this section (0-13 cm) consists of moderately altered olivine gabbro in which ferromagnesian minerals are partially altered to actinolite/tremolite + chlorite. Most of the plagioclase and pyroxene appear fresh. The lower part of the section (13-110 cm) consists of slightly altered (ca 20%) olivine gabbro and gabbro-norite. In thin section, small olivine grains are completely replaced by coronitic tremolite and chlorite. In addition, talc, serpentine, sulfide, and carbonate occur in the cores of larger coronas where relict olivine may also be present.

VEIN ALTERATION: A breccia vein is present at 85 - 100 cm with actinolite and a halo of secondary plagioclase. Chlorite veins are associated with corona textures after olivine.

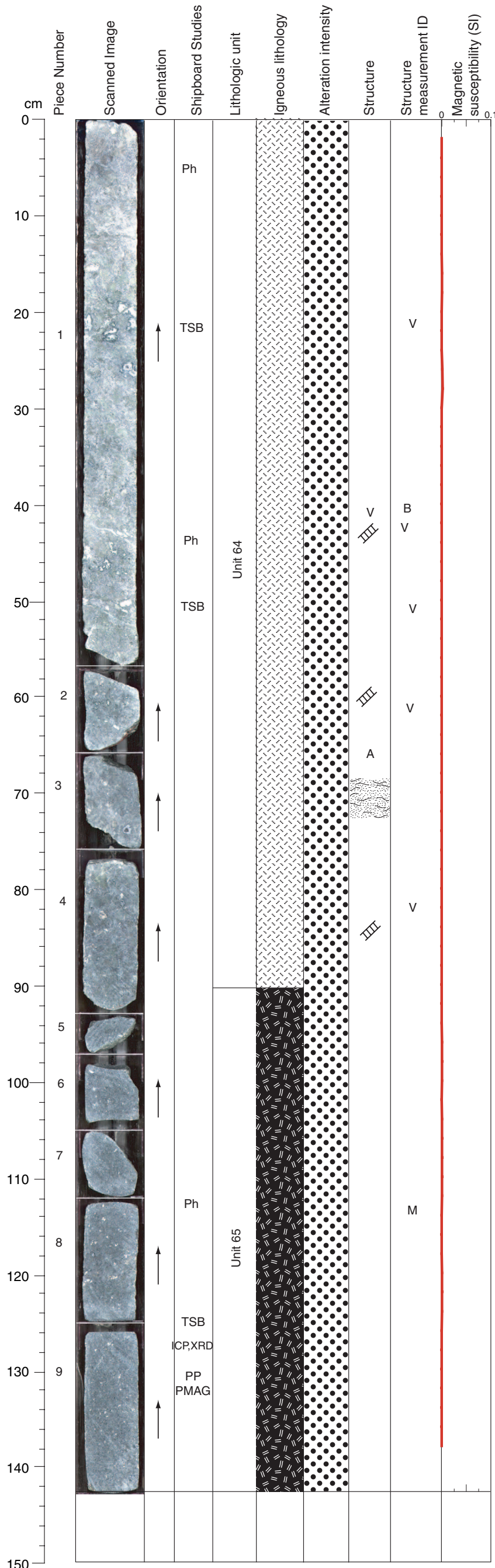
THIN SECTIONS:
304-U1309D- 26R-1, 12.0- 15.0 cm (#150)

STRUCTURE: Portions of the gabbro have a "mottled" appearance with alteration (A) and veining (V2). Most of the veins are either slightly blue or green, although there is a set of dark amphibole (hornblende?) veins (V1) found between 90 and 100 cm.
Relative timing: A>V1>V2

CLOSE UP PHOTOGRAPHS:
1309D_26R_1_28_46.jpg



Core Photo



304-U1309D-26R-2 (Section top: 148.69 mbsf)

UNIT-64: Impregnated Gabbro
Pieces 1-4

PRIMARY MINERALOGY: Determined from Piece 1 (18-40 cm interval)

Olivine	Modal 5% Size 3-5 mm Shape anhedral
Plagioclase	Modal 60% Size 4-10 mm Shape anhedral
Clinopyroxene	Modal 35% Size 5-11 mm Shape anhedral

COMMENTS: The section starts with the continuation of the coarse-grained gabbro from Unit 64 of the previous section where plagioclase has a 'salt and pepper' appearance. Olivine occurs between 19-27 cm and 42-57 cm. An alteration vein crosses at 43 cm.

UNIT-65: Olivine-bearing Gabbro
Pieces 4-9

PRIMARY MINERALOGY: Determined from Piece 9

Olivine	Modal 3% Size 2-3 mm Shape anhedral
Plagioclase	Modal 67% Size 2-4 mm Shape anhedral
Clinopyroxene	Modal 30% Size 2-4 mm Shape anhedral

COMMENTS: This unit consists of medium-grained, olivine-bearing gabbro. The contact to the coarse-grained gabbro of Unit 64 occurs at the bottom of Piece 4 but no sharp boundary is visible.

SECONDARY MINERALOGY: The upper part of this section (0-92 cm) consists of moderately altered olivine gabbro with some large coronitic patches after olivine of tremolite + chlorite +/- talc, rimmed by chlorite (e.g. around 20 cm). Most of the plagioclase and pyroxene seem to be fresh. Some of the olivine cores may have survived within the coronitic patches, but in thin section, olivine is replaced by carbonate. The remainder of this section (92-141 cm) consists of relatively fine-grained olivine-bearing gabbro with a coronitic texture of olivine pseudomorphed by tremolite + chlorite +/- talc, rimmed by chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration, but plagioclase is cut by chlorite veins in the vicinity of olivine.

VEIN ALTERATION: Actinolite-chlorite-talc veins are present in the upper part of the section (e.g. 43, 51 cm), accompanied by minor shear displacement.

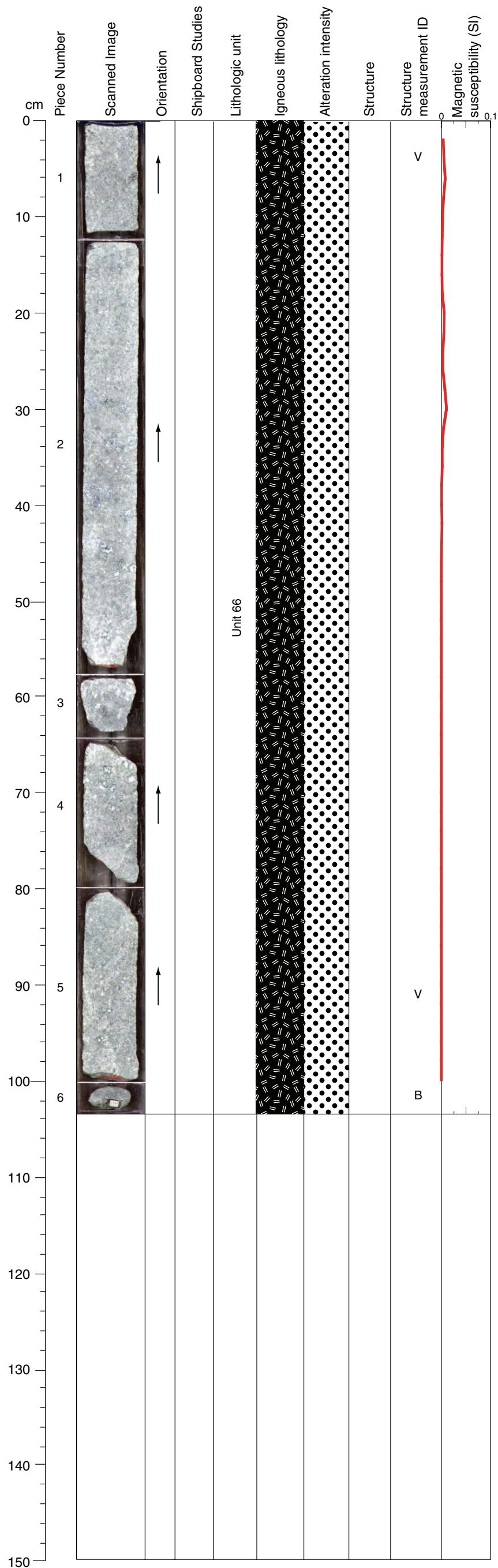
THIN SECTIONS:
[304-U1309D- 26R- 2, 12.0- 14.0 cm \(#151\)](#)
[304-U1309D- 26R- 2, 50.0- 53.0 cm \(#152\)](#)
[304-U1309D- 26R- 2, 125.0- 127.0 cm \(#153\)](#)

STRUCTURE: Top few pieces have very dark and lighter blue veins that either cut or surround grains. There are well-developed alteration rims throughout the section. Below Piece 6 the alteration and veining decreases in intensity.

CLOSE UP PHOTOGRAPHS:
[1309D_26R_2_4_12.jpg](#)
[1309D_26R_2_43_53.jpg](#)
[1309D_26R_2_112_124.jpg](#)



Core Photo



304-U1309D-26R-3 (Section top: 150.11 mbsf)

UNIT-66: Olivine-bearing Gabbro
Pieces 1-6

PRIMARY MINERALOGY: Determined from Piece 2 (15-26 cm interval)

Olivine Modal 3%
 Size 2-4 mm
 Shape anhedral

Plagioclase Modal 63%
 Size 3-6 mm
 Shape anhedral

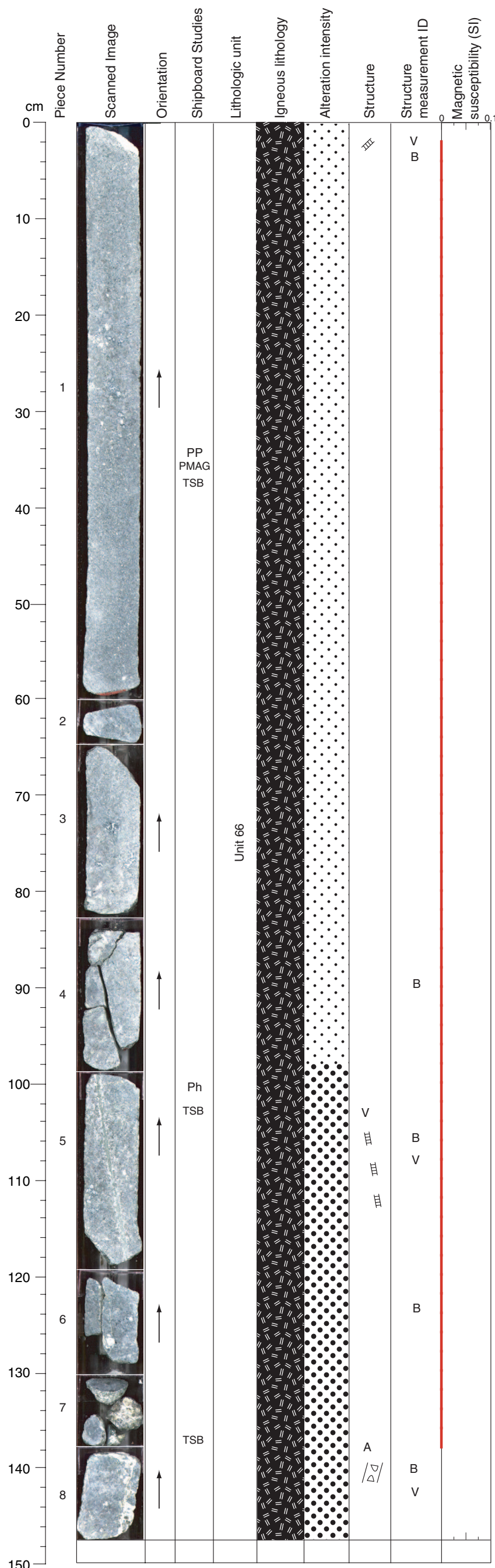
Clinopyroxene Modal 34 %
 Size 3-6 mm
 Shape anhedral

COMMENTS: Unit 66 consists of coarse-grained, olivine-bearing gabbro and represents the coarser continuation of Unit 65.

SECONDARY MINERALOGY: This section consists of moderately altered olivine gabbro with some large coronitic pseudomorphic patches after olivine consisting of tremolite + chlorite +/- talc, rimmed by chlorite. Most of the plagioclase and pyroxenes seem to be fresh.

STRUCTURE: Medium-to-coarse grained olivine gabbro with characteristic alteration and two veins (where marked in the structural measurement column).

Core Photo



304-U1309D-26R-4 (Section top: 151.14 mbsf)

UNIT-66: Olivine-bearing Gabbro
Pieces 1-8

PRIMARY MINERALOGY: Determined from Piece 3

- Olivine Modal 2%
 Size 2-4 mm
 Shape anhedral
- Plagioclase Modal 63%
 Size 3-6 mm
 Shape anhedral
- Clinopyroxene Modal 35%
 Size 3-6 mm average, 14 mm maximum
 Shape anhedral

COMMENTS: This section consists of coarse-grained, olivine-bearing gabbro. Below 31 cm, medium grain sizes occur and the unit shows similarity to Unit 65. Piece 8 is cut by a quartz vein along its length.

SECONDARY MINERALOGY: The upper part of this section (0-98 cm) consists of slightly (ca. 20%) altered olivine gabbro. The lower part of the section is moderately altered olivine gabbro, with large patches of coronitic pseudomorphs after olivine, comprising tremolite + chlorite +/- talc, rimmed by chlorite. Most of the plagioclase and pyroxene appears to be fresh.

VEIN ALTERATION: Quartz (+plagioclase?) veins are present at 1 cm and 98 cm. At 137-145 cm, a vuggy quartz vein has formed within a late magmatic leucocratic dike. In thin section, quartz cuts across chlorite veins related to corona formation, but the chlorite veins cut the albitized margin of the leucocratic dike. A large actinolite vein with a milky plagioclase halo is present at 98-118 cm.

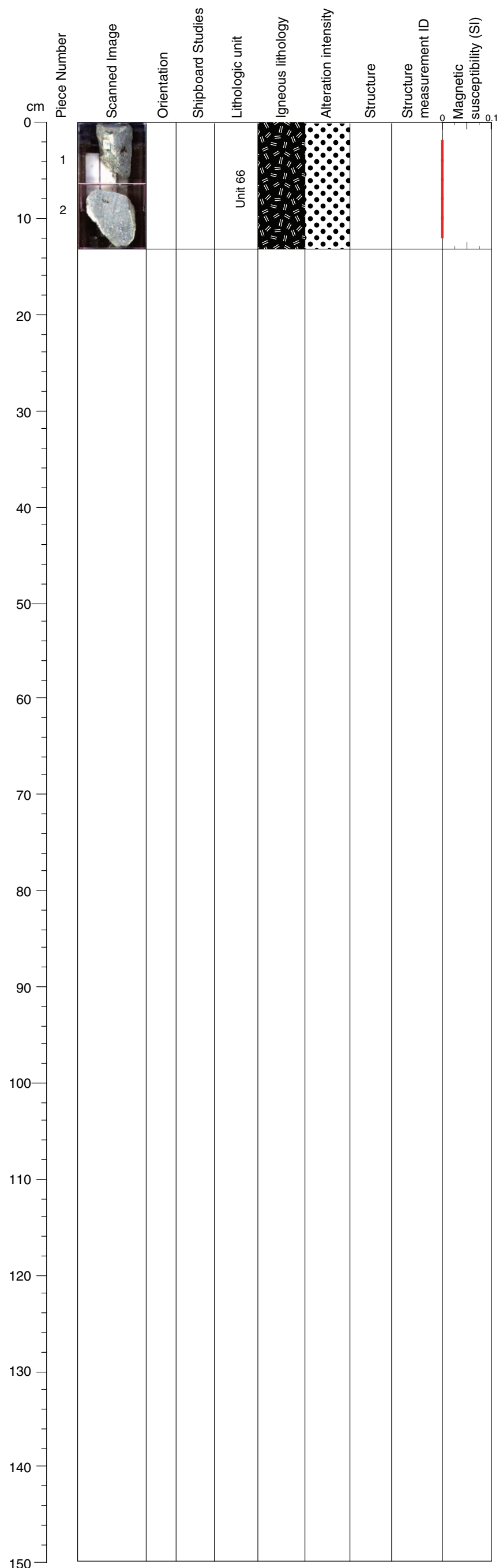
THIN SECTIONS:
[304-U1309D-26R-4, 34.0-36.0 cm \(#154\)](#)
[304-U1309D-26R-4, 102.0-104.0 cm \(#155\)](#)
[304-U1309D-26R-4, 137.0-139.0 cm \(#156\)](#)

STRUCTURE: Relatively unaltered olivine gabbro with alteration rims found mainly in Piece 5 along with a steeply dipping green vein (V). At the base of the section (Piece 8) vuggy alteration (A) contains quartz.

CLOSE UP PHOTOGRAPHS:
[1309d_26r_4_100_105.jpg](#)



Core Photo



UNIT-66: Olivine-bearing Gabbro
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 2

Olivine Modal 1%
 Size 1-4 mm
 Shape anhedral

Plagioclase Modal 64%
 Size 2-3 mm
 Shape anhedral

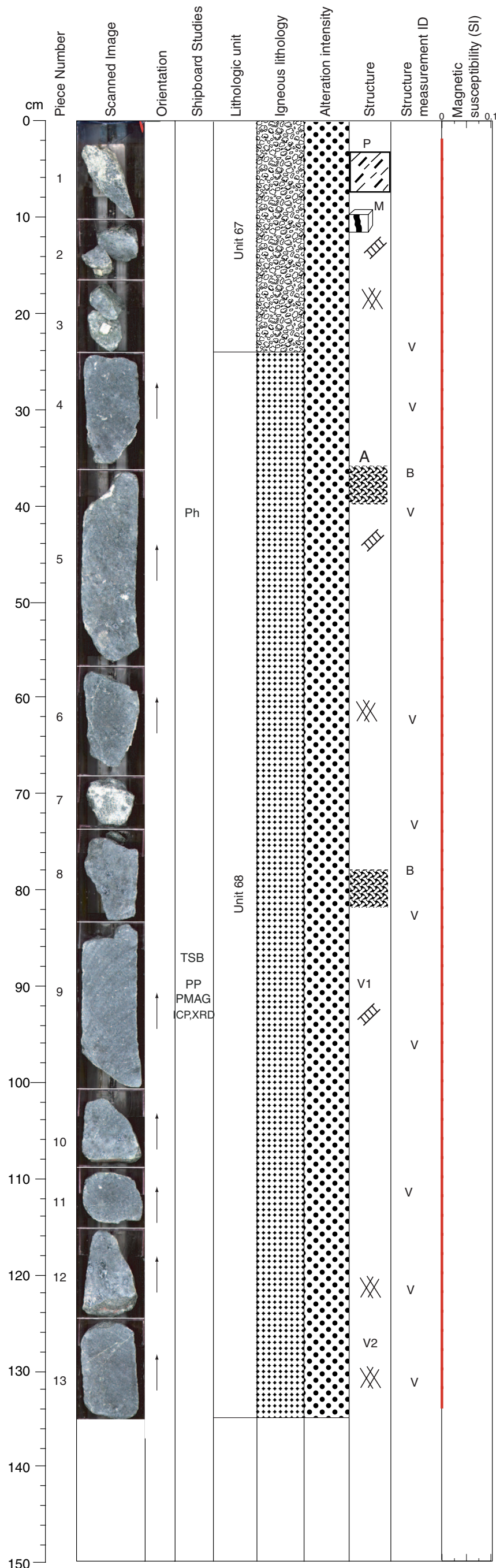
Clinopyroxene Modal 35%
 Size 2-3 mm
 Shape anhedral

COMMENTS: This section consists of coarse-grained olivine-bearing gabbro with a fine-grained area and is the continuation from the previous section.

SECONDARY MINERALOGY: This section consists of moderately altered olivine gabbro with some replacement of ferromagnesian minerals by tremolite + chlorite. Most of the plagioclase and pyroxene seem to be fresh.



Core Photo



304-U1309D-27R-1 (Section top: 152.30 mbsf)

UNIT-67: Mixed Rubble
Pieces 1-3

COMMENTS: Unit 67 consists of several pieces of rubble presumed to be out of place. Piece 1 is a talc-tremolite felsic vein, Piece 2 deformed gabbro, and Piece 3 olivine gabbro.

UNIT-68: Olivine Gabbro
Pieces 4-13

PRIMARY MINERALOGY: Determined from Piece 5

Olivine Modal 5%
Size 2-3 mm
Shape anhedral

Plagioclase Modal 50%
Size 4-6 mm
Shape anhedral

Clinopyroxene Modal 45%
Size 3-6 mm average, 18 mm maximum
Shape anhedral

COMMENTS: Unit 68 consists of olivine gabbro. Coarse grain sizes occur at the top of the unit and grade toward medium size below 56 cm. Quartz veins cut at 34 and 38 cm.

SECONDARY MINERALOGY: The upper part of this section (0-10 cm) consists of altered and brecciated gabbro with indications for high-temperature deformation. The remainder of this section (10-134 cm) consists of moderately altered olivine gabbro with some large coronitic pseudomorphic patches after olivine consisting of tremolite + chlorite +/- talc, rimmed by chlorite. Most of the plagioclase and pyroxenes seem to be fresh.

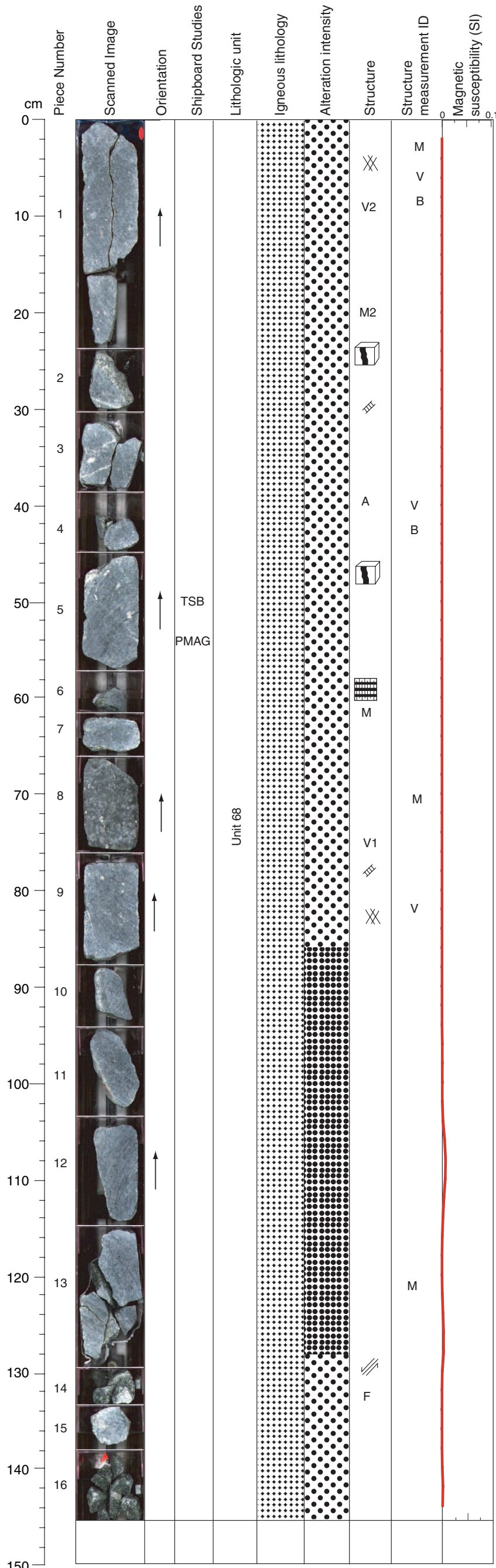
THIN SECTIONS:
304-U1309D-27R-1, 86.0- 88.0 cm (#157)

STRUCTURE: Top of the section has a crystal plastic texture (P) that is cut by a dioritic vein (M) that localizes green alteration (A). Throughout the section the veins include green (steeply dipping) and blue (shallowly dipping and more talc-rich) veins (V1), and thin, white veins (V2) that extend from plagioclase-rich domains (alteration vugs and magmatic veins). Note that in some intervals (mostly in lower part of section) there are carbonate? veins. Relative timing: P>=M>A>V1>V2

CLOSE UP PHOTOGRAPHS:
1309d_27r_1_37_56.jpg



Core Photo



304-U1309D-27R-2 (Section top: 153.64 mbsf)

UNIT-68: Olivine Gabbro
Pieces 1-16

PRIMARY MINERALOGY: Determined from Piece 10

Olivine Modal 5%
Size 2-5 mm
Shape anhedral

Plagioclase Modal 55%
Size 4-7 mm
Shape anhedral

Clinopyroxene Modal 40%
Size 4-7 mm
Shape anhedral

PRIMARY MINERALOGY: Determined from Thin Section (Piece 5)

Olivine Modal 30%
Size 1-3 mm
Shape anhedral

Plagioclase Modal 60%
Size 1-3 mm
Shape subhedral

Clinopyroxene Modal 10%
Size 10 mm
Shape subhedral

COMMENT: This unit consists of medium- to coarse-grained olivine gabbro and is the continuation of the previous section. Olivine occurs sporadically along the length of the section, increasing toward the bottom of the section (Pieces 11-13, 15). Orthopyroxene occurs in the first 3 cm. Quartz veins cross at 46 and 60 cm, an alteration vein at 128 cm.

SECONDARY MINERALOGY: The section consists of alternating layers of gabbro (0-86 cm), troctolite (88-128 cm) and olivine gabbro (128-144 cm). Ferromagnesian minerals are partially altered to actinolite + chlorite +/- talc (in olivine gabbro). The troctolitic part shows the typical coronitic texture with tremolite + chlorite +/- talc, rimmed by chlorite replacing olivine between plagioclase. Most of the pyroxene and plagioclase have survived alteration.

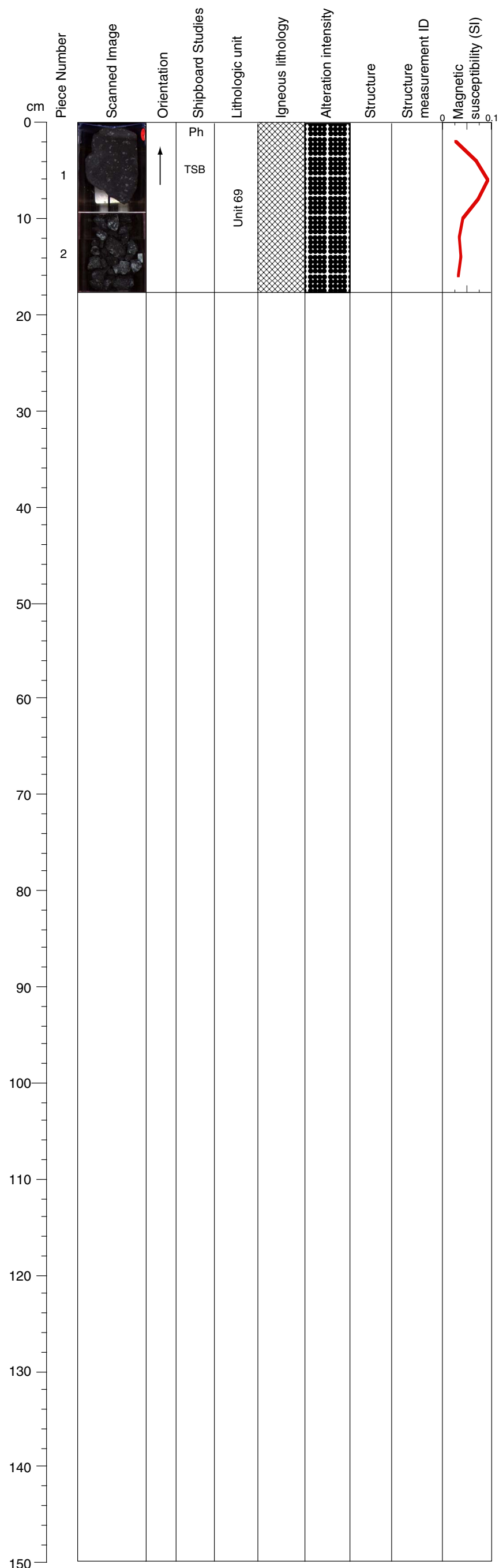
VEIN ALTERATION: Breccia veins of actinolite + plagioclase are present at 25, 33, 53 cm. A quartz + pyrite vein/ open fracture filling is present at 46 cm.

THIN SECTIONS:
304-U1309D- 27R-2, 48.0- 52.0 cm (#158)

STRUCTURE: A weak, magmatic foliation (M) is present throughout the section with discontinuous green and dark-green veins (V1) and intergranular alteration (A) roughly following the steeply dipping magmatic fabric. Layering is parallel to this fabric and includes layering of troctolitic units. White, dioritic veins (M2) with associated white veins (V2) and green alteration cuts earlier intergranular alteration and veins (in piece 2 and 3 for example). Vuggy alteration includes some quartz bearing aggregates. Piece 15 has a fault defined by a lineated mineralized surface. Relative timing: M>A=V1>(?)M2>V2>F



Core Photo



304-U1309D-27R-3 (Section top: 155.08 mbsf)

UNIT-69: Harzburgite
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 1

Olivine Modal 93%
Size too altered
Shape too altered

Pyroxene Modal 7%
Size 1-3 mm
Shape anhedral

COMMENTS: This section consists of serpentinized harzburgite. It contains granular, rounded orthopyroxene, with minor clinopyroxene, as well as altered plagioclase visible in thin section.

SECONDARY MINERALOGY: The section consists of peridotite pervasively altered to mesh-textured serpentinite. Alteration phases are predominantly serpentine and magnetite. A few pyroxene (+/- olivine?) cores seem to have survived alteration.

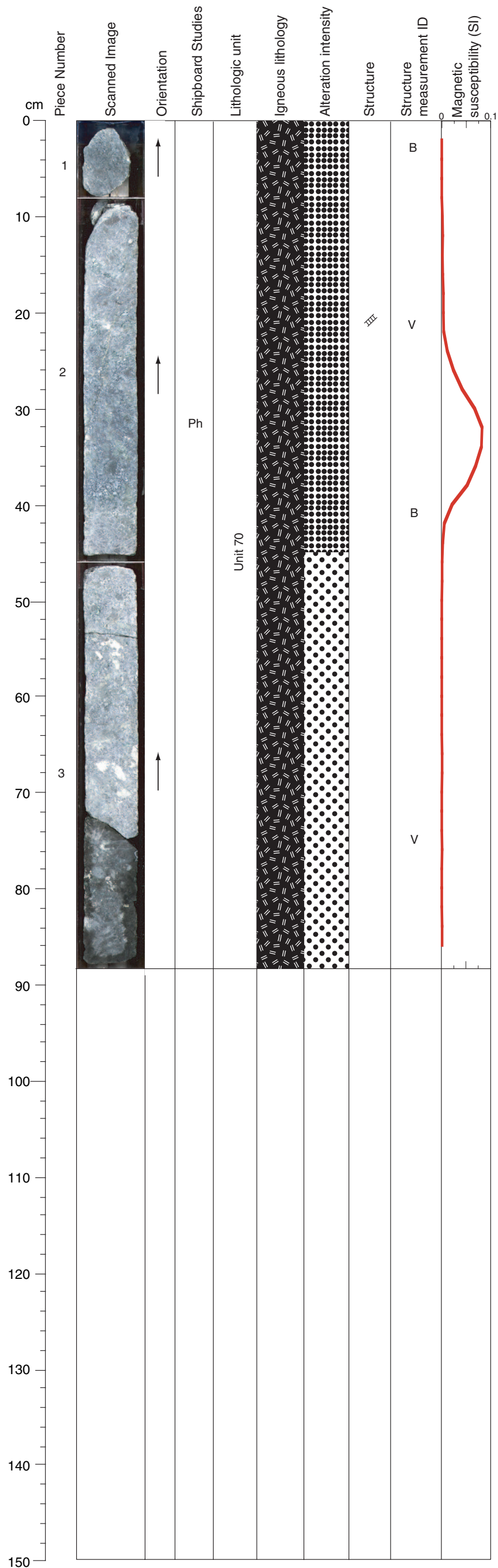
THIN SECTIONS:
304-U1309D-27R-3,4.0- 7.0 cm (#159)

STRUCTURE: See SECONDARY MINERALOGY.

CLOSE UP PHOTOGRAPHS:
1309D_27R_3_0_8.jpg



Core Photo



304-U1309D-28R-1 (Section top: 157.10 mbsf)

UNIT-70: Olivine-bearing Gabbro
Pieces 1-3

PRIMARY MINERALOGY: Determined from Piece 2 (17-29 cm interval)

Olivine	Modal 3% Size 3-5 mm Shape anhedral
Plagioclase	Modal 65% Size 4-6 mm Shape anhedral
Clinopyroxene	Modal 4-6% Size 4-6 mm Shape anhedral

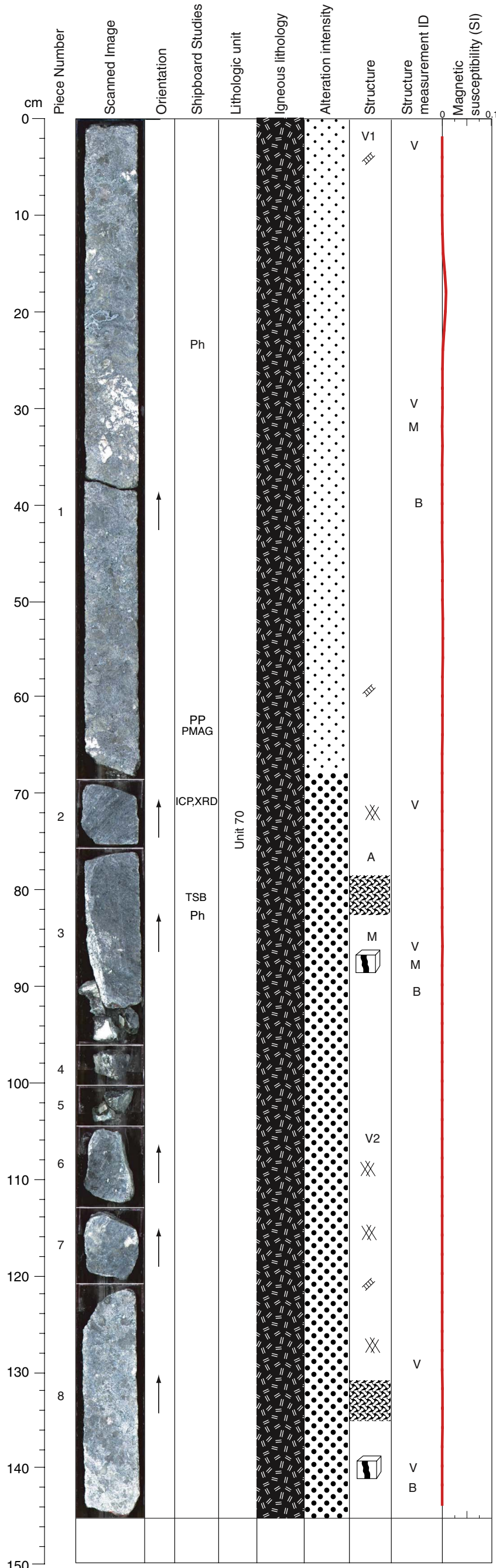
COMMENTS: This section consists of coarse-grained olivine-bearing gabbro. A troctolitic domain occurs at 38 cm. Clinopyroxene oikocrysts are as large as 25 mm across. Isolated orthopyroxene grains occur throughout the section.

SECONDARY MINERALOGY: The upper part of this section (0-45 cm) consists of relatively altered (ca. 40%) olivine gabbro with some large coronitic pseudomorphic patches after olivine (e.g. at 38 cm) consisting of tremolite + chlorite +/- talc, rimmed by chlorite. Most of the plagioclase and pyroxene appear fresh. Even some of the olivine cores may have survived within the coronitic patches. The remainder of this section (45-87 cm) consists of metagabbro in which ferromagnesian minerals are partially altered to actinolite +/- chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration.

STRUCTURE: Olivine-rich layers dominate the section, with 1 thin subhorizontal (blue) vein. The beginning of Piece 3 marks the interval with large pyroxene oikocrysts.

CLOSE UP PHOTOGRAPH:
1309D_28R_1_30_45.jpg

Core Photo



304-U1309D-28R-2 (Section top: 157.98 mbsf)

UNIT-70: Olivine-bearing Gabbro
Pieces 1-8

PRIMARY MINERALOGY: Determined from Piece 1B

Olivine Modal 3%
 Size 2-4 mm
 Shape anhedral

Plagioclase Modal 45%
 Size 5-15 mm
 Shape anhedral

Clinopyroxene Modal 52%
 Size 7-15 mm average,
 Shape anhedral

COMMENTS: This section consists of coarse-grained olivine-bearing gabbro. Isolated orthopyroxene grains occur throughout the section. Piece 3 is very heterogeneous in grain size. A clinopyroxene oikocryst of 67 mm occurs in Piece 1. An altered dioritic dikelet crosses at 141 cm.

SECONDARY MINERALOGY: This section consists of slightly to moderately altered gabbroic rocks. The uppermost part of this section (0-25 cm) and the central part (36-68 cm) consist of slightly altered (ca. 20%) olivine gabbro with some large coronitic pseudomorphic patches after olivine comprising tremolite + chlorite +/- talc, rimmed by chlorite. A spectacular corona patch with a relict fresh olivine core is present at 20 cm. Most of the plagioclase and pyroxene appear fresh. An intersecting pyroxenite interval (25-36 cm) with an even more spectacular orthopyroxene oikocryst shows very minor alteration. The remainder of this section (68-143 cm) consists of metagabbro in which ferromagnesian minerals are partially altered to actinolite +/- chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration. A few minor coronitic patches are present.

VEIN ALTERATION: A large talc-tremolite +/- chlorite vein with secondary plagioclase is present in Piece # 3A,B.

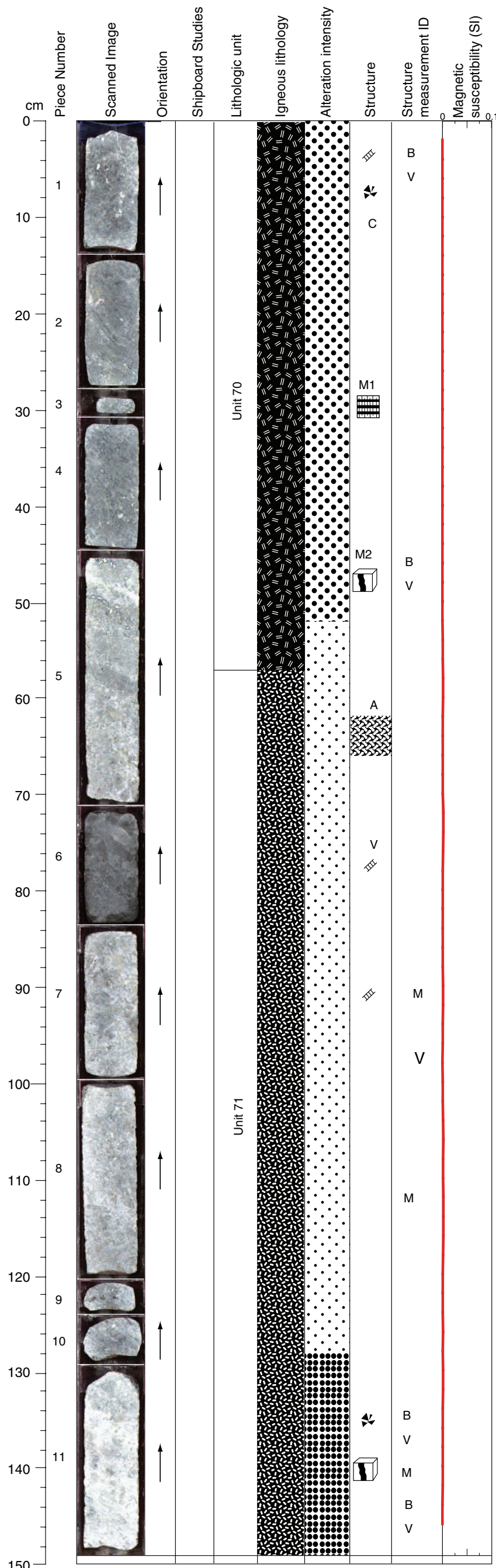
THIN SECTIONS:
304-U1309D-28R-2, 80.0- 83.0 cm (#160)

STRUCTURE: Section is noteworthy for large oikocrysts of pyroxene and diorite veins (M) that have been "reactivated" as green alteration and vein networks (A,V1). In one place (Piece 8) the superposed alteration is essentially a breccia (C). A later set of white veins (V2) is found adjacent to the magmatic veins.
Relative timing: M(?)>A=V1=C>V2

CLOSE UP PHOTOGRAPHS:
1309d_28r_2_22_36.jpg
1309d_28r_2_22_36_2.jpg
1309d_28r_2_80_92.jpg



Core Photo



304-U1309D-28R-3 (Section top: 159.43 mbsf)

UNIT-70: Olivine-bearing Gabbro
Pieces 1-5

PRIMARY MINERALOGY: Determined from Piece 1

Olivine Modal <1%
Size 1-2 mm
Shape anhedral

Plagioclase Modal 60%
Size 5-9 mm
Shape anhedral

Clinopyroxene Modal 40%
Size 6-12 mm
Shape anhedral

COMMENT: This section consists of coarse-grained olivine-bearing gabbro and represents the continuation of the previous two sections. Olivine occurs isolated throughout the section.

UNIT-71: Orthopyroxene-bearing Gabbro
Pieces 5-11

PRIMARY MINERALOGY: Determined from Piece 8

Plagioclase Modal 60%
Size 4-8 mm
Shape anhedral

Clinopyroxene Modal 40%
Size 4-10 mm
Shape anhedral

Orthopyroxene Modal <1 or 1 %
Size 4-5 mm
Shape anhedral

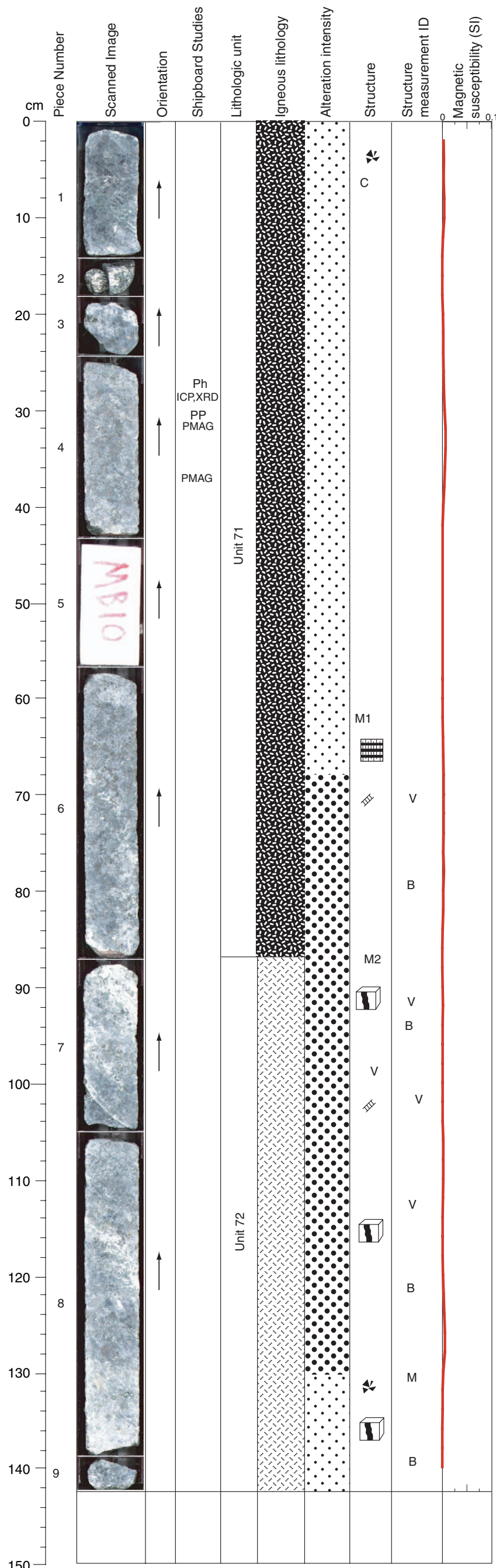
COMMENT: This unit consists of coarse-grained orthopyroxene-bearing gabbro. Modal orthopyroxene increases from the top of the section. Altered dioritic dikelets occur at 135 cm and 142 cm.

SECONDARY MINERALOGY: This section consists of slightly to highly altered gabbro and olivine gabbro. The uppermost part of this section (0-52 cm) consists of moderately altered olivine gabbro with some coronitic pseudomorphic patches after olivine (e.g. at 34 cm) consisting of tremolite + chlorite +/- talc, rimmed by chlorite. Ferromagnesian minerals are partially altered to actinolite + chlorite, but most of the plagioclase and pyroxenes seem to be fresh. The central section (52-129 cm) contains only slightly altered gabbro, whereas the olivine gabbro in the lower section (129-147 cm) is highly altered, showing not only alteration of ferromagnesian minerals to actinolite/ tremolite + chlorite, but also considerable amounts of secondary plagioclase.

VEIN ALTERATION: Actinolite-chlorite veins are present throughout the section. Secondary plagioclase is associated with these veins at 48, 134, 141 cm.

STRUCTURE: Distributed intergranular alteration (A) follows an earlier magmatic fabric (M1). Associated green veins (V) have a cataclastic texture (C) and in places contain sulfides. White, white magmatic veins (M2) are internally brecciated (C) as well. Relative timing: M1>M2>C>=V.

Core Photo



304-U1309D-28R-4 (Section top: 160.93 mbsf)

UNIT-71: Orthopyroxene-bearing Gabbro
Pieces 1-6

PRIMARY MINERALOGY: Determined from Piece 6

Plagioclase Modal 59%
Size 4-7 mm
Shape anhedral

Clinopyroxene Modal 40%
Size 4-7 mm
Shape anhedral

Orthopyroxene Modal 1 %
Size 3-5 mm
Shape anhedral

PRIMARY MINERALOGY: Determined from Thin Section (Piece 4)

Plagioclase Modal 65%
Size 5-9 mm
Shape subhedral-anhedral

Clinopyroxene Modal 25%
Size 5-9 mm
Shape subhedral-anhedral

Orthopyroxene Modal 10 %
Size 5-7 mm
Shape subhedral-anhedral

COMMENT: This unit consists of coarse-grained orthopyroxene-bearing gabbro.

UNIT-72: Gabbro
Pieces 7-9

PRIMARY MINERALOGY: Determined from Piece 1, Section 28R-5

Plagioclase Modal 63%
Size 4-7 mm
Shape anhedral

Clinopyroxene Modal 35%
Size 4-6 mm
Shape anhedral

Orthopyroxene Modal 2 %
Size 5-10 mm
Shape anhedral

COMMENT: This unit consists of coarse-grained gabbro. Altered dioritic dikelets occur at 90 cm and 116 cm.

SECONDARY MINERALOGY: This section consists of slightly to moderately altered olivine gabbro and gabbro. Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxene appear unaltered. Plagioclase is altered to secondary plagioclase along the veins.

VEIN ALTERATION: Yellow-green breccia veins are common in the lower part of the section (68-142 cm). The veins contain actinolite + secondary plagioclase +/- chlorite.

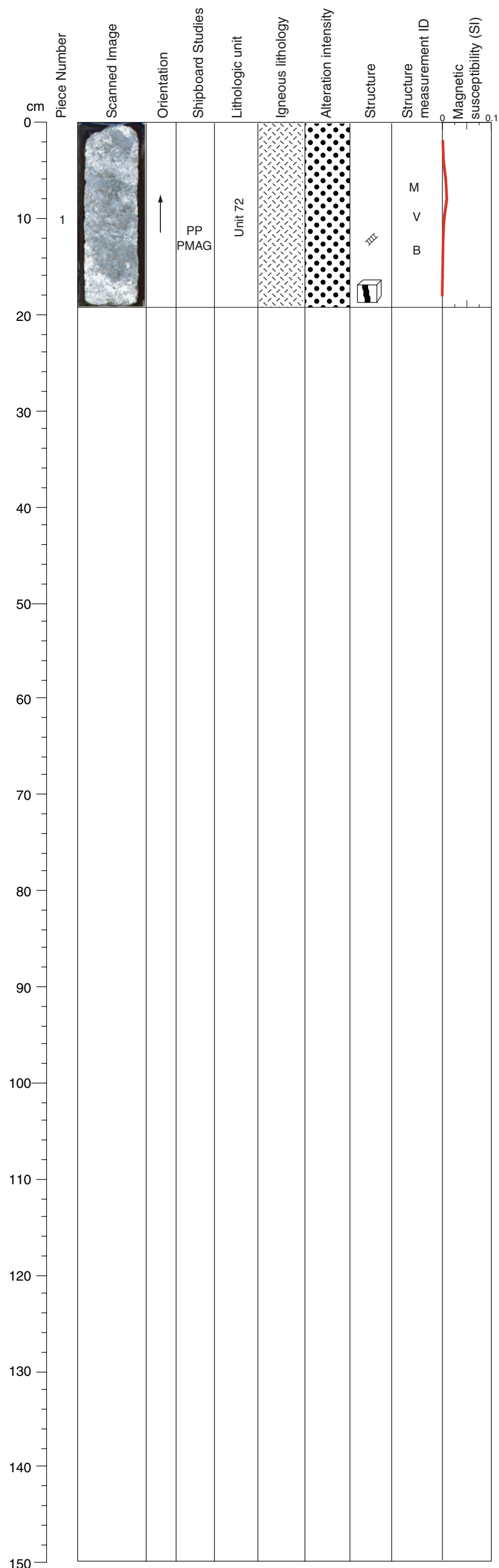
THIN SECTIONS:
304-U1309D-28R-4, 26-29 cm (#161)

STRUCTURE: Veins throughout the section are either blue and shallowly dipping (V) or part of the set of dioritic, magmatic veins (M2). The veins have associated brecciation and microfracture (C). The vein and breccia textures cut an earlier weak magmatic fabric (M1). One interval of the section (from the base of Piece 2 to Piece 6) has no structure, layering, and little alteration. Relative timing: M1>M2=>C>V

CLOSE UP PHOTOGRAPH:
1309D_28R_4_25_43.jpg



Core Photo



304-U1309D-28R-5 (Section top: 162.35 mbsf)

UNIT-72: Gabbro
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1

Plagioclase Modal 63%
 Size 4-7 mm
 Shape anhedral

Clinopyroxene Modal 35%
 Size 4-6 mm
 Shape anhedral

Orthopyroxene Modal 2 %
 Size 5-10 mm
 Shape anhedral

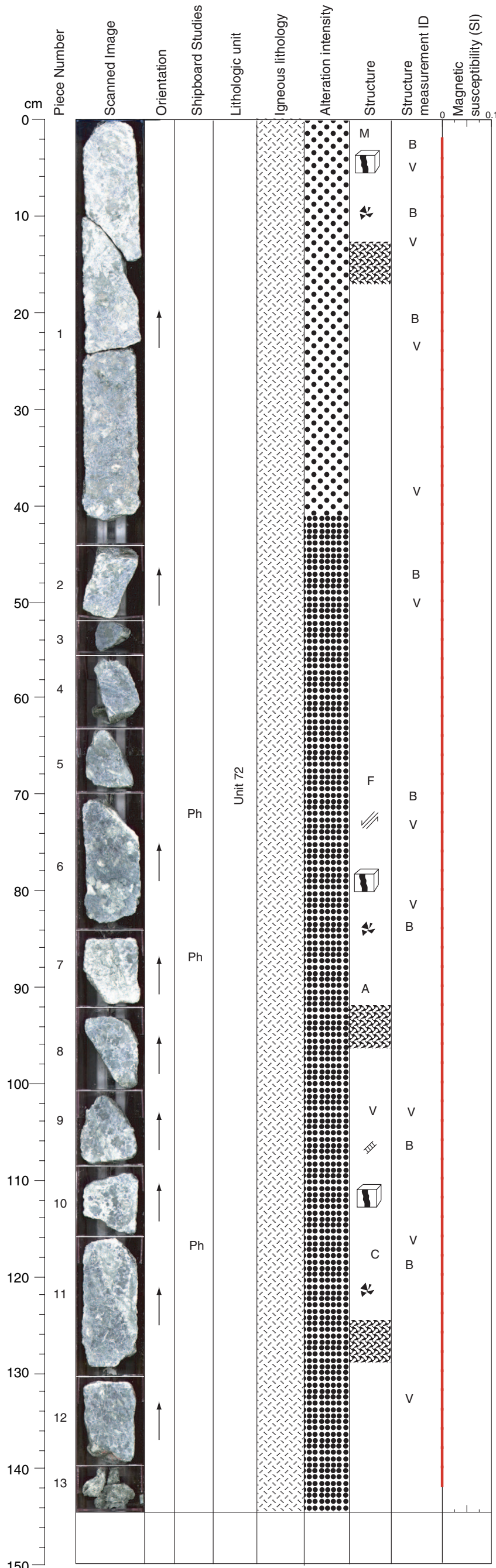
COMMENTS: This section consists of a single piece of coarse-grained gabbro.

SECONDARY MINERALOGY: This section consists of moderately altered gabbro in which ferromagnesian minerals are partially altered to actinolite +/- chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration.

STRUCTURE: Coarse-grained gabbro. A green vein (V) cuts a dioritic vein (M). Relative timing: M>V



Core Photo



304-U1309D-29R-1 (Section top: 161.90 mbsf)

UNIT-72: Gabbro
Pieces 1-13

PRIMARY MINERALOGY: Determined from Piece 1C

Olivine Modal <1 %
Size 2 mm
Shape anhedral

Plagioclase Modal 65%
Size 4-10 mm
Shape anhedral

Clinopyroxene Modal 35%
Size 4-10 mm
Shape anhedral

COMMENT: This section consists of coarse-grained gabbro. Dioritic dikelets occur between 92-95 cm and 115-121 cm.

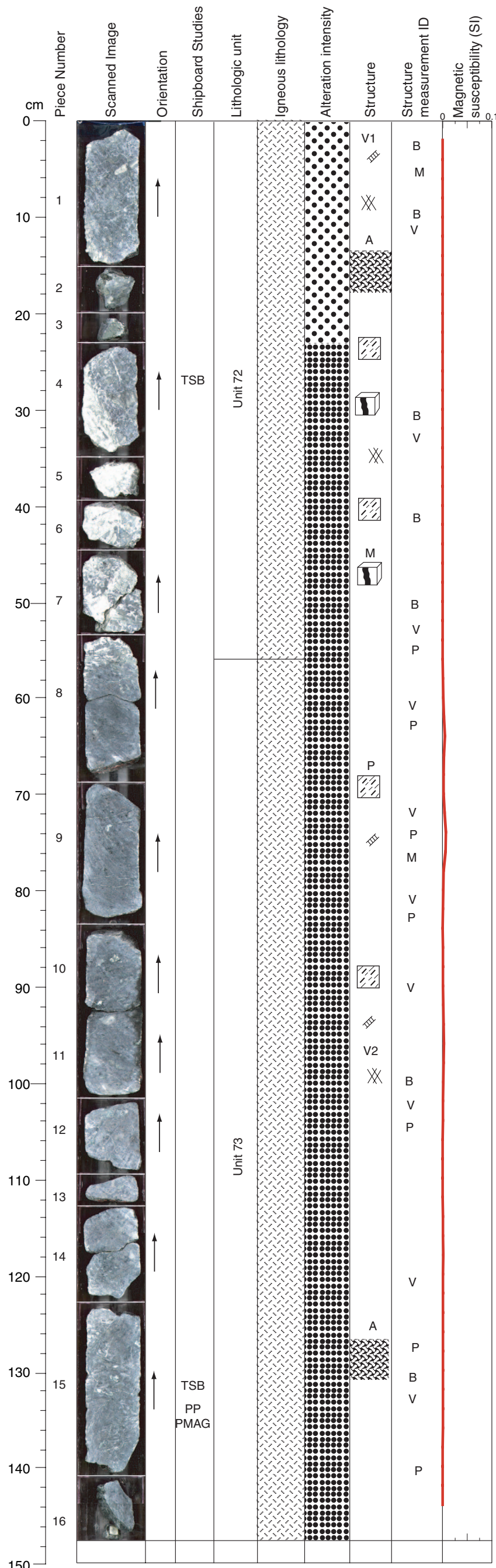
SECONDARY MINERALOGY: This section consists of moderately to highly altered gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration, however less so within the brecciation zone (see below). Brown amphibole seems to be present throughout, but is especially well developed in the lower section.

VEIN ALTERATION: A major brecciation zone is present between 84-123 cm. Yellow-green breccia veins with actinolite + chlorite + secondary plagioclase are also present in Piece 1.

STRUCTURE: Dioritic portions (M) of the section localize brecciation (C) and alteration (A). A talc-rich fault has normal-sense lineations (F) on its surface (Pieces 5 and 6). Intergranular alteration intensifies near Piece 10, and there are some well-defined green veins (V).
M=>C>A>V>F

CLOSE UP PHOTOGRAPHS:
1309D_29R_1_70_75.jpg
1309D_29R_1_85_90.jpg
1309D_29R_1_115_130.jpg

Core Photo



304-U1309D-29R-2 (Section top: 163.40 mbsf)

UNIT-72: Gabbro
Pieces 1-8

PRIMARY MINERALOGY: Determined from Piece 1

Olivine Modal 4%
Size 2 mm
Shape anhedral

Plagioclase Modal 65%
Size 3-10 mm
Shape anhedral

Clinopyroxene Modal 35%
Size 3-10 mm
Shape anhedral

COMMENTS: This unit consists of coarse-grained gabbro. A dioritic dike cuts the unit (Pieces 4 to 8).

UNIT-73: Deformed Gabbro
Pieces 8-15

PRIMARY MINERALOGY: Determined from Piece 14

Olivine Modal <1%
Size 4 mm
Shape anhedral

Plagioclase Modal 60%
Size 4-6 mm
Shape anhedral

Clinopyroxene Modal 40%
Size 4-9 mm
Shape anhedral

COMMENTS: This unit consists of deformed coarse-grained gabbro. A shear zone with elongated pyroxene is at the boundary at 57 cm. Piece 14 is highly deformed and sheared.

SECONDARY MINERALOGY: This section consists of highly altered gabbro in which ferromagnesian minerals are altered to actinolite/ tremolite +/- chlorite. Plagioclase and pyroxenes partially survived the alteration. The gabbro is brecciated in the central part of the section (84-143 cm). Brown amphiboles and foliation zones record a high-temperature alteration event.

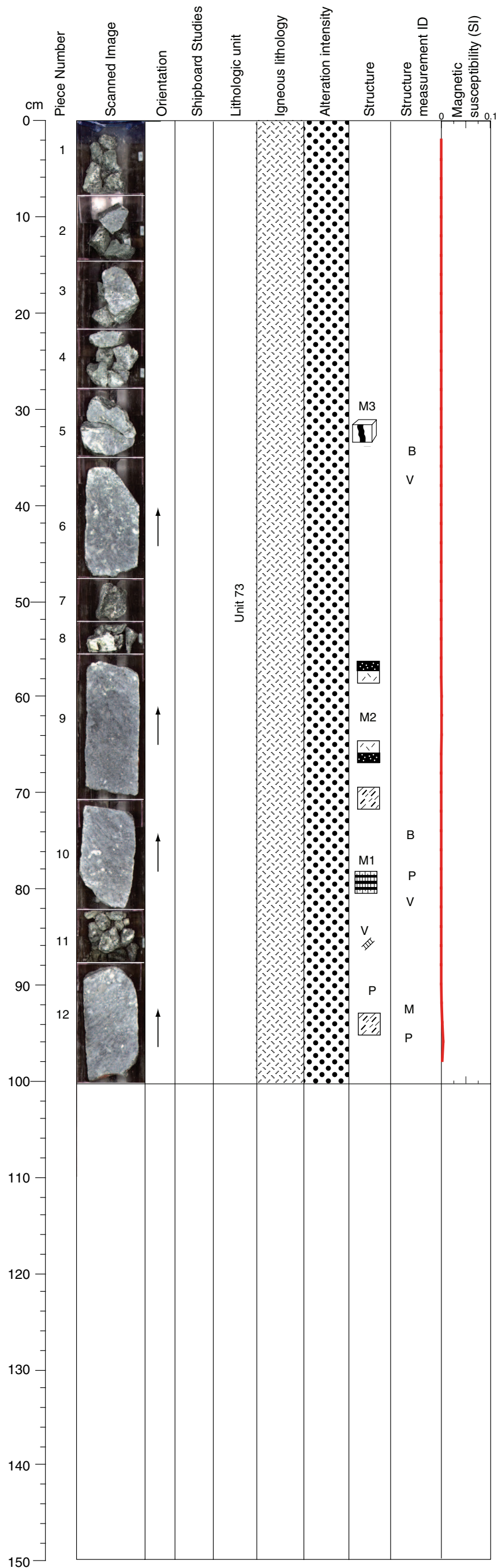
VEIN ALTERATION: Actinolite/ tremolite veins are present as well as veins with brown hornblende.

THIN SECTIONS:
304-U1309D-29R-2, 26.0-28.0 cm (#162)
304-U1309D-29R-2, 131.0- 133.0 cm (#163)

STRUCTURE: Intervals with a strong mylonitic texture (P) interspersed with intervals with more general crystal plastic and semibrittle textures characterize this section. A dark vein set (V1) is both parallel to the crystal plastic fabric and locally cuts it. Feldspar-rich (dioritic) veins (M) cut the crystal plastic textures and localize green alteration (A). Dark green veins (V2) cut both the deformation texture and diffusive alteration. P>M=>V1>A=>V2

CLOSE UP PHOTOGRAPHS:
1309D_29R_2_24_34.jpg
1309D_29R_2_40_44.jpg
1309D_29R_2_45_53.jpg

Core Photo



304-U1309D-29R-3 (Section top: 164.81 mbsf)

UNIT-73: Deformed Gabbro
Pieces 1-12

PRIMARY MINERALOGY: Determined from Piece 6

Olivine Modal <1%
 Size 2 mm
 Shape anhedral

Plagioclase Modal 70%
 Size 3-7 mm
 Shape anhedral

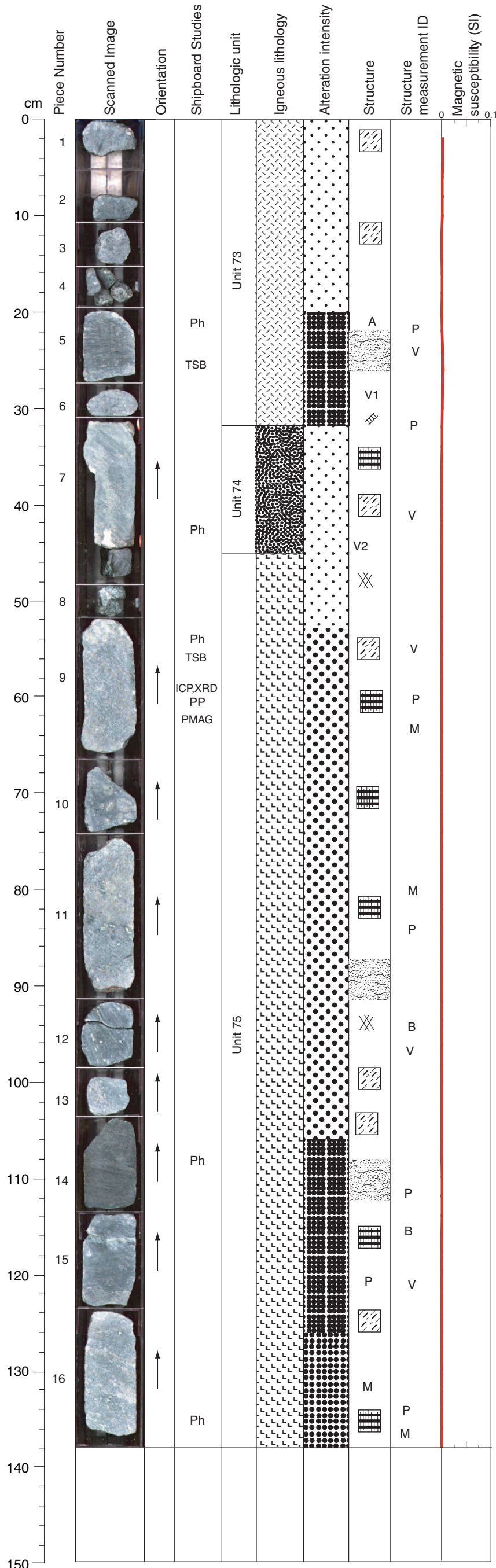
Clinopyroxene Modal 30%
 Size 3-10 mm
 Shape anhedral

COMMENTS: This section consists of coarse-grained deformed gabbro and represents the continuation of the previous section.

SECONDARY MINERALOGY: This section consists of moderately altered and partially foliated gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxene appear fresh. Brown amphibole is present.

STRUCTURE: The structure of this section is largely defined by the magmatic structure of a dioritic intrusion (M3), a coarse-grained gabbroic intrusion (a few cm wide) (M2) and the earliest magmatic foliation (M1). A crystal plastic texture is superposed on the magmatic foliation in Pieces 10 and 11. Green veins (V) cut all of the magmatic structures. Relative timing: M1>P=>M3=>M2>V

Core Photo



304-U1309D-30R-1 (Section top: 166.70 mbsf)

UNIT-73: Deformed Gabbro
Pieces 1-6

PRIMARY MINERALOGY: Determined from thin section (Piece 5)

Plagioclase Modal 40%
 Size 2 mm
 Shape anhedral

Clinopyroxene Modal 60%
 Size 2 mm
 Shape anhedral

COMMENTS: This section starts with the continuation of the deformed gabbro in the previous section. Pieces 5 and 6 show foliation with elongate plagioclase and pyroxene.

UNIT- 74: Microgabbro
Pieces 7A

PRIMARY MINERALOGY: Too fine grained to estimate modal composition.

COMMENTS: In contact to the deformed gabbro occurs a single piece of microgabbro.

UNIT-75: Layered Gabbro
Pieces 7B-16

PRIMARY MINERALOGY: Determined from Piece 16 (Troctolitic Gabbro)

Olivine Modal 20%
 Size 3-4 mm
 Shape anhedral

Plagioclase Modal 73%
 Size 4-6 mm
 Shape anhedral

Clinopyroxene Modal 7%
 Size 3-5 mm
 Shape anhedral

PRIMARY MINERALOGY: Determined from Piece 16 (Olivine Gabbro)

Olivine Modal 10%
 Size 2 mm
 Shape anhedral

Plagioclase Modal 60%
 Size 4-5 mm
 Shape anhedral

Clinopyroxene Modal 30%
 Size 5-7 mm
 Shape anhedral

COMMENTS: This unit consists of deformed layers of troctolitic and olivine gabbro. Layered changes in modal composition are evident in Pieces 9, 11, 15 and 16.

SECONDARY MINERALOGY: This section consists of slightly to moderately altered gabbro (0-20 cm, 32-53 cm, 53-68cm) and moderately to highly altered olivine gabbro (64-106 cm, 126-144 cm) with interlayered mylonitic zones (20-32 cm, 106-126 cm). Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration in the undeformed parts of the section. Brown amphibole and secondary plagioclase is present in the mylonitic zones recording granulite facies alteration conditions.

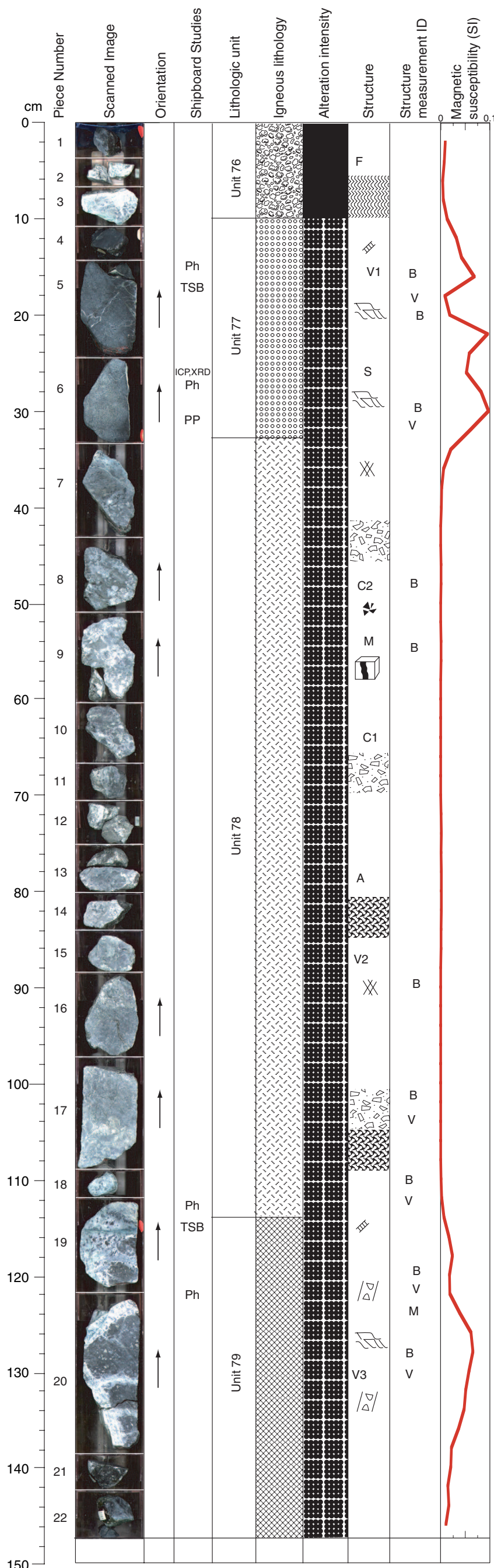
THIN SECTIONS:
[304-U1309D-30R-1, 25.0-28.0 cm \(#165\)](#)
[304-U1309D-30R-1, 55.0-58.0 cm \(#164\)](#)

STRUCTURE: There are two pervasive foliations in this section - a magmatic foliation (M) that in places is parallel to layering of olivine-rich and gabbroic intervals, and a crystal plastic foliation (P) that is very intense in places, but decreases in intensity over short distances. Dark amphibole (A) (high-temperature hornblende?) makes folia parallel to the mylonitic fabric. Veins of the same dark amphibole elsewhere also form a set of veins (V1) at a high angle to, and cutting the mylonitic foliation (Piece 5 for example). Blue and white veins cut all other features (V2). Relative timing: M>P>A>V1>V2

CLOSE UP PHOTOGRAPHS:
[1309D_30R_1_20_27.jpg](#)
[1309D_30R_1_42_46.jpg](#)
[1309D_30R_1_54_66.jpg](#)
[1309D_30R_1_107_115.jpg](#)
[1309D_30R_1_135_140.jpg](#)



Core Photo



304-U1309D-31R-1 (Section top: 171.50 mbsf)

UNIT-76: Mixed Rubble
Pieces 1-3

COMMENTS: Several pieces of talc-tremolite schist occur at the top of the section, and may be out of place.

UNIT-77: Dunite
Pieces 4-6

PRIMARY MINERALOGY: Determined from Piece 5

Olivine Modal 99%
Size too altered
Shape too altered

Spinel Modal 1 %
Size 2-3 mm
Shape equant

COMMENTS: This unit consists of three pieces of dunite that is virtually pyroxene-free. Three small grains occur in a corner of Piece 5 in the archive half. The sample is completely serpentinized and shows the typical mesh-texture. It is cut by a talc-tremolite vein, and by several subordinate carbonate veins.

UNIT-78: Coarse-grained Gabbro
Pieces 7-19

PRIMARY MINERALOGY: Determined from Pieces 9 and 10

Olivine Modal <1%
Size 2-3 mm
Shape anhedral

Plagioclase Modal 70%
Size 5-7 mm
Shape anhedral

Clinopyroxene Modal 30%
Size 4-7 mm average, 20 mm maximum
Shape anhedral

COMMENTS: A coarse-grained gabbro occurs below the dunite; no contact relations were recovered. Zones of cataclasite are found along the unit.

UNIT-79: Plagioclase harzburgite
Pieces 19-22

PRIMARY MINERALOGY: Determined from Piece 20

Olivine Modal 80%
Size (cannot be determined from hand specimen)
Shape anhedral

Plagioclase Modal ? %
Shape anhedral

Pyroxene Modal 20%
Size 2-3 mm
Shape anhedral

COMMENTS: The harzburgite is in direct contact with the intrusive coarse-grained gabbro. Diffuse talc-tremolite veins cross the unit and along the contact.

SECONDARY MINERALOGY: The upper part of this section (0-10 cm) consists of tremolite-talc schist with peridotitic protolith. A dunite from 10-33 cm is highly serpentinized with serpentine as alteration phases and minor chlorite. The central section (33-108 cm) consists of a highly altered gabbro in which ferromagnesian minerals are severely altered to actinolite +/- chlorite. Some fresh pyroxene remains. The lower section (108-146 cm) consists of highly altered peridotite, probably harzburgite. Matrix alteration is >90% serpentine.

VEIN ALTERATION: Carbonate veins are present in the upper serpentinite. The lower serpentinite (Unit 79) is cut by numerous tremolite veins with talc rims.

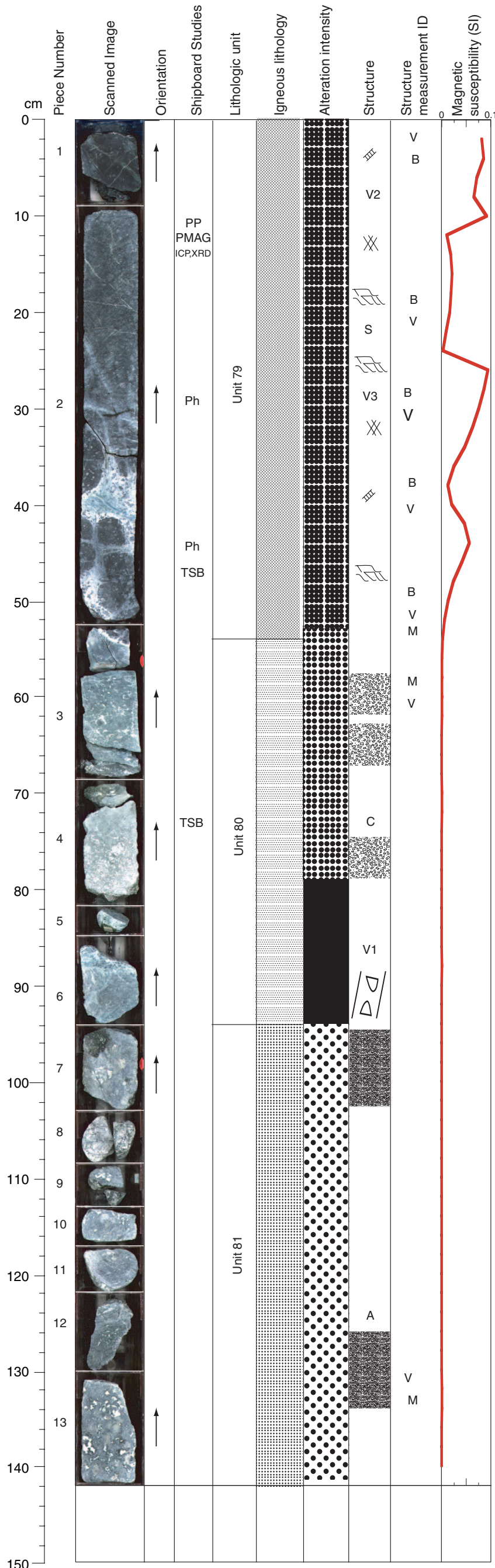
THIN SECTIONS:
304-U1309D-31R-1, 16.0-19.0 cm (#166)
304-U1309D-31R-1, 114.0-118.0 cm (#167)

STRUCTURE: Interleaved gabbro and serpentinized ultramafic rocks - perhaps mixed by brittle faults (?). Fault rocks include schistose rocks (F) among unoriented chips at the top of the section, cataclasite (C2) at the contact between ultramafic and gabbroic rocks in Piece 7, 17, and chips near 70 cm. Ultramafic, serpentinized rocks are noteworthy for the mesh texture (S) and several composite serpentine and carbonate rich veins (V1). These are cut by a dark green (serpentine-bearing?) vein (V2) that is also found within the gabbros. Within the gabbros there is the intergranular alteration (A) associated with green veining, and the dioritic veins (M) associated with more distributed brecciation (C1). Relative timing: M=>C1>A>V1>S>V2>F

CLOSE UP PHOTOGRAPHS:
1309D_31R_1_14_24.jpg
1309D_31R_1_25_33.jpg
1309D_31R_1_112_120.jpg
1309D_31R_1_121_137.jpg



Core Photo



304-U1309D-31R-2 (Section top: 172.96 mbsf)

UNIT-79: Plagioclase harzburgite
 Pieces 1-3A

PRIMARY MINERALOGY: Determined from Piece 2B

Olivine	Modal 74%
	Size too altered
	Shape too altered
Plagioclase	Modal 4%
Pyroxene	Modal 20%
	Size 3-7 mm
	Shape anhedral
Spinel	Modal 2%

COMMENTS: This section starts with the continuation of the impregnated harzburgite. Piece 2B shows preserved olivine cores and maybe fresh pyroxenes. A network of talc-tremolite veins is cutting Piece 2.

UNIT-80: Troctolitic gabbro
 Pieces 3A-6

COMMENTS: In contact with the harzburgite is an unidentified rock. Along the contact occurs a talc band typical of intrusive contact of gabbros into peridotite in Hole 1309B. It is most likely a greenly altered olivine cumulate with plagioclase as an interstitial phase.

UNIT-81: Olivine-bearing and Olivine Gabbro
 Pieces 7-13

PRIMARY MINERALOGY: Determined from Piece 13

Olivine	Modal 15%
	Size 3-5 mm
	Shape anhedral
Plagioclase	Modal 60%
	Size 5-10 mm
	Shape anhedral
Clinopyroxene	Modal 25%
	Size 3-7 mm average, 14 mm maximum
	Shape anhedral

COMMENTS: The lower part of the section consists of coarse-grained olivine gabbro and olivine-bearing gabbro. The modal proportion of olivine increases downhole. Some pieces show deformation.

SECONDARY MINERALOGY: The uppermost part of the section consists of completely serpentinized dunite. The central zone (52-93 cm) contains extremely brecciated gabbro, the lower section (93-140 cm) consists of altered gabbro with coronitic textures of olivine alteration. Secondary minerals within the gabbro are mainly actinolite/ tremolite + chlorite. The patches are made up by tremolite + chlorite +/- talc, rimmed by chlorite.

VEIN ALTERATION: A large talc haloed tremolite vein is present in the serpentine at 40 cm. Some veins within the altered dunite are filled with carbonate, the majority however is made up by tremolite veins.

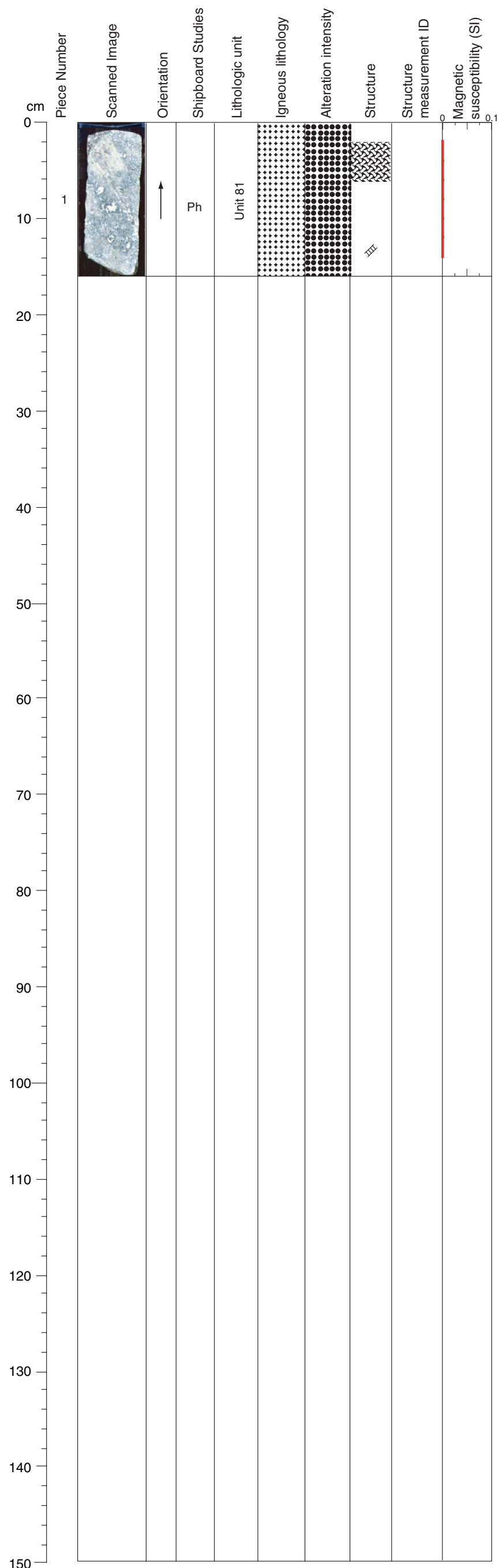
THIN SECTIONS:
[304-U1309D-31R-2, 46.0-48.0 cm \(#184\)](#)
[304-U1309D-31R-2, 73.0-76.0 cm \(#168\)](#)

STRUCTURE: Composite serpentine-rich veins (V2) cut across ultramafic rocks with a mesh texture (S). The veins contain lighter, partly carbonate veins, and internal dark-green median walls. White veins (V3) cut at a high-angle to the serpentine veins. The ultramafic rocks grade into the gabbro (ie. not consistent with a fault contact). However, the gabbro exhibits a range of alteration (A) and cataclastic (C) textures with a breccia just beneath the contact with the ultramafic (piece 5-6). Near the section base, gabbro becomes more troctolitic including high-temperature amphibole veins (V1) that are cut by later feldspar grains. Relative timing: V1>V2>C=A>V3

CLOSE UP PHOTOGRAPHS:
[1309_31R_2_29-49.jpg](#)
[1309D_31R_2_44-64.jpg](#)



Core Photo



304-U1309D-31R-3 (Section top: 174.37 mbsf)

UNIT-81: Olivine Gabbro
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1

Olivine Modal 15%
 Size 3-8mm
 Shape anhedral

Plagioclase Modal 60%
 Size 5-10 mm
 Shape anhedral

Clinopyroxene Modal 25%
 Size 5-10 mm average, 34 mm maximum
 Shape anhedral

COMMENTS: This unit consists of a single piece of coarse-grained olivine gabbro. Pegmatitic pyroxene crystals are sporadic throughout the piece.

SECONDARY MINERALOGY: This section consists of highly altered olivine gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Large coronitic pseudomorphic patches after olivine are common. They consist of tremolite + chlorite +/- talc, rimmed by chlorite. Most of the plagioclase and pyroxene have survived alteration. Brown amphibole seems to be present.

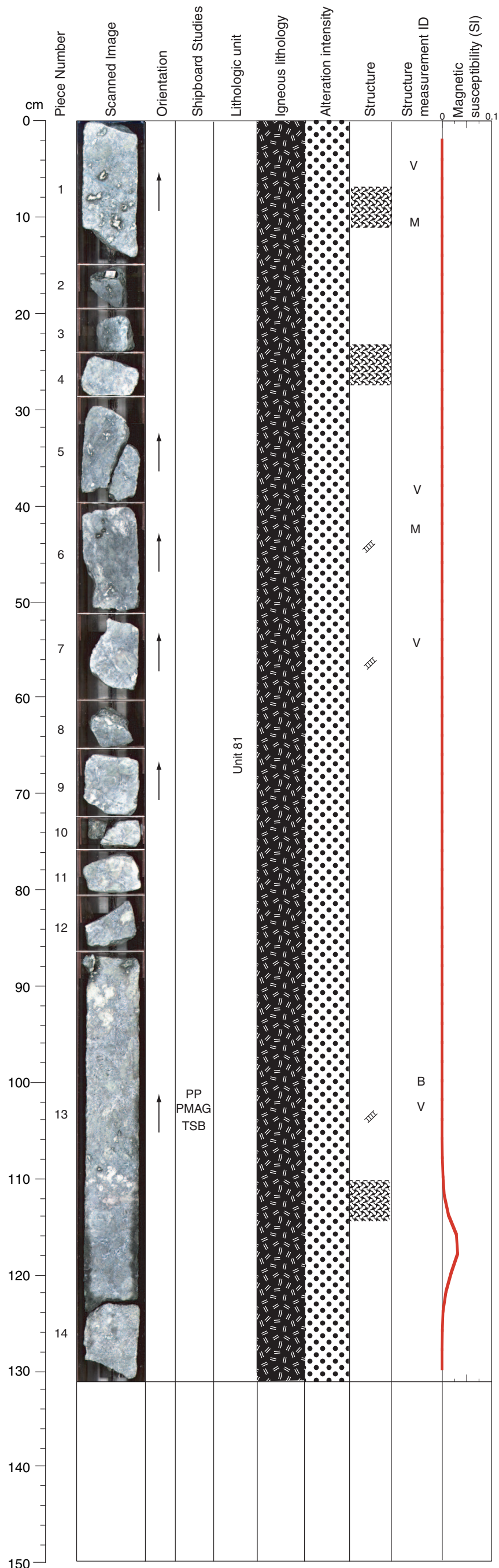
VEIN ALTERATION: Actinolite vein haloed by secondary plagioclase and brown hornblende.

STRUCTURE: In this piece alteration includes a branching vein with internal structure.

CLOSE UP PHOTOGRAPHS:
1309D_31R_3_0-14.jpg



Core Photo



304-U1309D-32R-1 (Section top: 176.30 mbsf)

UNIT-81: Olivine-bearing Gabbro
Pieces 1-13

PRIMARY MINERALOGY: Determined from Piece 13a

- Olivine Modal 2%
 Size 6 mm
 Shape anhedral
- Plagioclase Modal 58%
 Size 10 mm
 Shape anhedral
- Clinopyroxene Modal 40%
 Size 10 mm average, 25 mm maximum
 Shape anhedral

COMMENTS: This section represents the continuation of Section 1309D-30R-2 and consists of coarse-grained olivine-bearing gabbro. The olivine content exceeds 5% in Pieces 1 to 5.

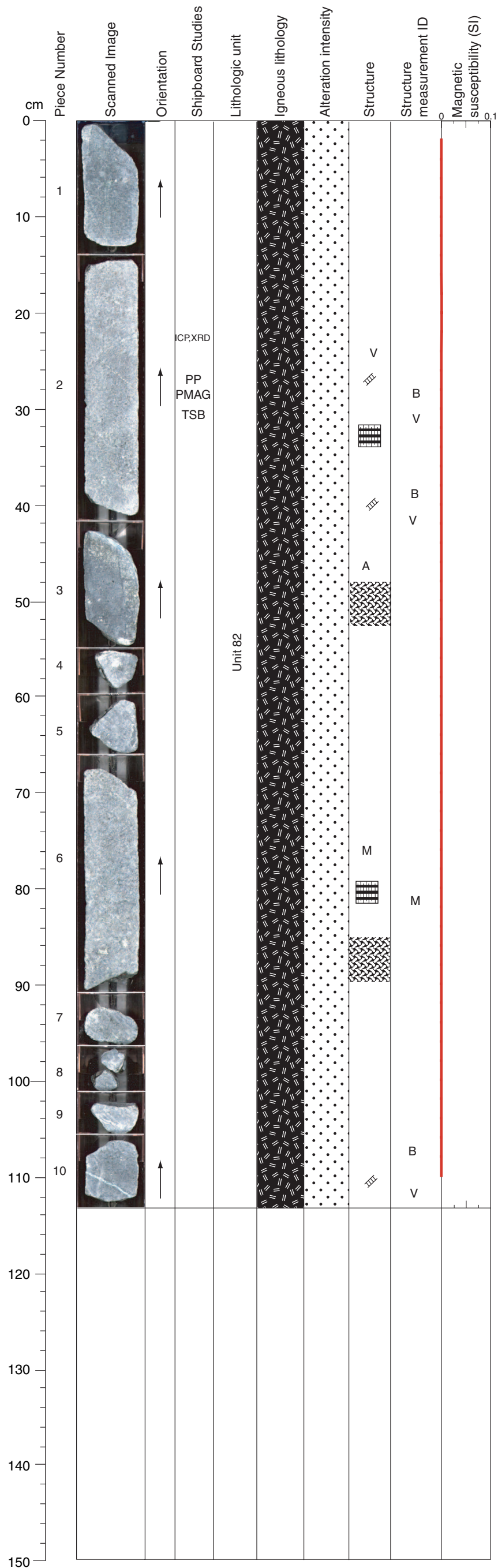
SECONDARY MINERALOGY: This section consists of moderately altered olivine gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxene are not altered. A few large pseudomorphic coronitic patches after olivine are present (e.g. in Piece 1 and at 117 cm), and consist of tremolite + chlorite +/- talc, rimmed by chlorite.

VEIN ALTERATION: A tremolite vein is present at 7 cm.

THIN SECTIONS:
[304-U1309D-32R-1, 103.0-106.0 cm \(#169\)](#)

STRUCTURE: Alteration, particularly chalky-white on plagioclase, dominates the section. Below Piece 7 dark veins cut across all grain boundaries, and in Piece 13 the veins have a shallow dip and a blue color. A>V

Core Photo



304-U1309D-32R-2 (Section top: 177.62 mbsf)

UNIT-82: Olivine-bearing Gabbro
Pieces 1-10

PRIMARY MINERALOGY: Determined from Piece 6

- Olivine Modal <1%
 Size 4-7 mm
 Shape anhedral
- Plagioclase Modal 60%
 Size 4 mm
 Shape subhedral
- Clinopyroxene Modal 40%
 Size 4 mm
 Shape anhedral

COMMENTS: Unit consists of medium-grained, olivine-bearing gabbro. It differs from Unit 81 only by grain size.

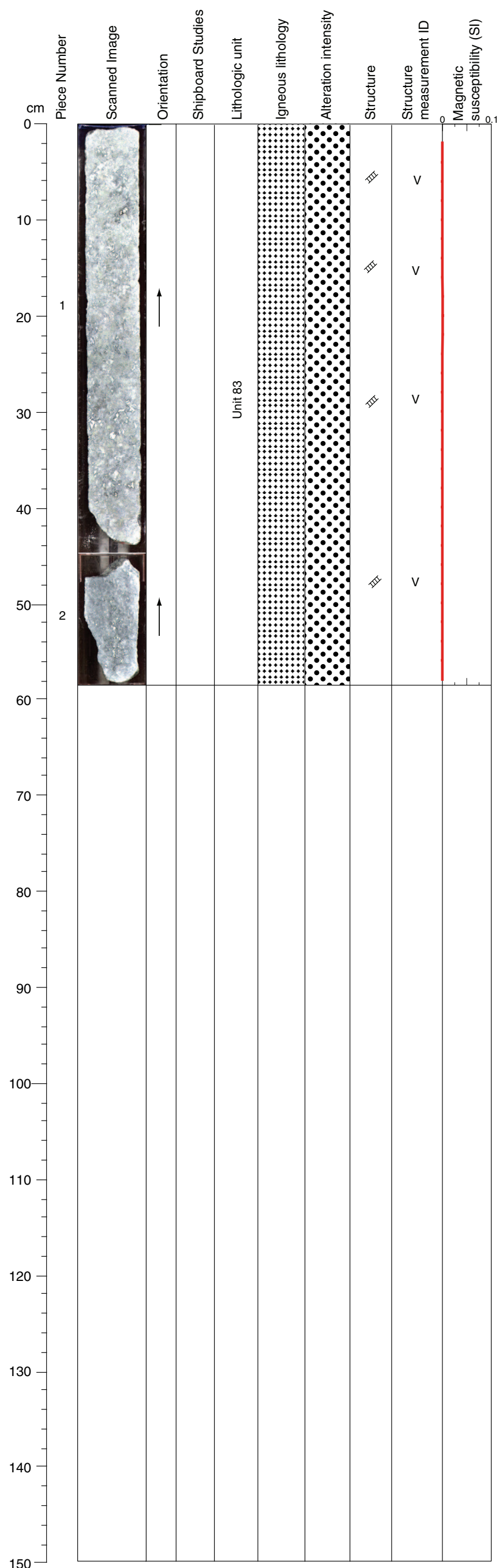
SECONDARY MINERALOGY: This section consists of slightly altered gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxene are unaltered.

VEIN ALTERATION: Talc-tremolite veins are present at 41 cm and at 110 cm.

THIN SECTIONS:
304-U1309D-32R- 2, 30.0- 33.0 cm (#170)

STRUCTURE: Dark alteration (A) in bands and distributed following an earlier magmatic fabric (M) (very weak). A few veins (A) are found throughout the section, including a 5 mm wide blue vein with a shallow dip in Piece 10. M>A>V

Core Photo



304-U1309D-32R-3 (Section top: 178.75 mbsf)

UNIT-83: Coarse-grained Olivine Gabbro
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 1

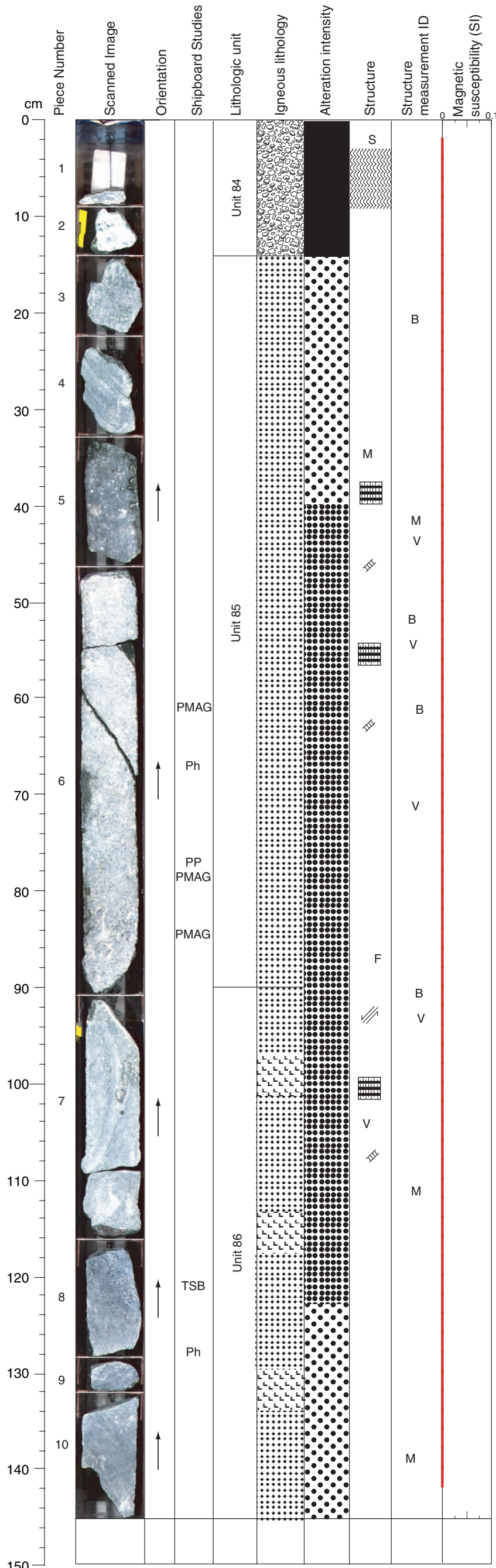
- Olivine Modal 5%
 Size 3-6 mm
 Shape anhedral
- Plagioclase Modal 40%
 Size 5 mm
 Shape subhedral
- Clinopyroxene Modal 55%
 Size 7-15 mm
 Shape anhedral

COMMENTS: Unit 83 consists of coarse-grained olivine gabbro.

SECONDARY MINERALOGY: This section consists of moderately altered gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration.

STRUCTURE: Black amphibole veins and a later set of alteration veins (not differentiated in the structure column).

Core Photo



304-U1309D-33R-1 (Section top: 181.10 mbsf)

UNIT-84: Rubble
Pieces 1-2

COMMENTS: This unit consists of two pieces of fault rock that are presumed to be out of place.

UNIT-85: Coarse-grained Olivine Gabbro
Pieces 3-6

PRIMARY MINERALOGY: Determined from interval 66-71 cm

Olivine Modal 5%
Size 3-5 mm
Shape anhedral

Plagioclase Modal 70%
Size 4-6 mm
Shape anhedral

Clinopyroxene Modal 30%
Size 5-6 mm average, 20 mm maximum
Shape anhedral

COMMENTS: This unit consists of coarse-grained olivine gabbro. Olivine is mostly altered. A fine-grained layer occurs at 79 cm.

UNIT-86: Layered Gabbro
Pieces 7-10

PRIMARY MINERALOGY: Determined from Piece 8 (Troctolitic Gabbro)

Olivine Modal 25%
Size 2-3 mm
Shape anhedral

Plagioclase Modal 63%
Size 3-4 mm
Shape anhedral

Clinopyroxene Modal 12%
Size 12 mm
Shape anhedral

PRIMARY MINERALOGY: Determined from Piece 8 (Olivine Gabbro)

Olivine Modal 35%
Size 2-3 mm
Shape anhedral

Plagioclase Modal 40%
Size 3-4 mm
Shape anhedral

Clinopyroxene Modal 25%
Size 12 mm
Shape anhedral

COMMENTS: Unit 86 consists of domains and layers of medium-grained olivine gabbro and troctolitic gabbro. Increase in modal amount of olivine is accompanied by a decrease in grain size. A coarse-grained clinopyroxene-rich band with grain sizes as large as 11 mm crosses at 135 cm. A fine-grained clinopyroxene-rich band crosscuts at 141 cm (grain size in average 1 mm)

SECONDARY MINERALOGY: The upper part of this section consists of a talc-tremolite schist. The remainder of this section consists of moderately to highly altered olivine-bearing gabbro and troctolite in which ferromagnesian minerals are partially altered to actinolite/tremolite +/- chlorite. Most of the plagioclase and pyroxene have survived alteration. The troctolitic part (90-123 cm) shows coronitic textures replacing olivine with tremolite + chlorite +/- talc, rimmed by chlorite.

VEIN ALTERATION: A quartz vein is present at 93 cm.

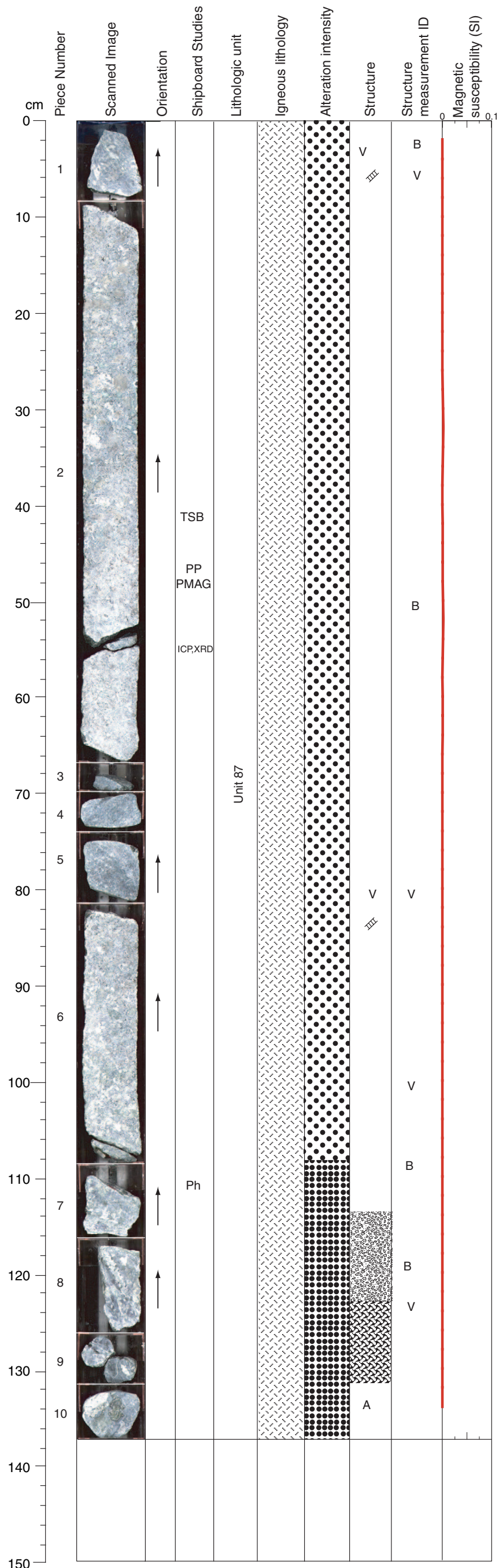
THIN SECTIONS:
304-U1309D-33R-1, 120.0-123.0 cm (#171)

STRUCTURE: The top few chips of the section have well-foliated schistose rocks (S), although the darker grains (pyroxene?) are not stretched. A magmatic foliation (M) is pervasive throughout the underlying gabbro (beginning at Piece 3), and the foliation is cut by dark veins (V). A highly localized talc-rich fault plane (F) is present at 90 cm. Relative timing: M>V>S>F

CLOSE UP PHOTOGRAPHS:
1309D_33R_1_66-76.jpg
1309D_33R_1_66-76.jpg
1309D_33R_1_127_140.jpg



Core Photo



304-U1309D-33R-2 (Section top: 182.55 mbsf)

UNIT-87: Olivine-bearing Gabbro and Gabbro
Pieces 1-10

PRIMARY MINERALOGY: Determined from Piece 2 (30-50 cm interval)

Olivine Modal 3%
Size 4-6 mm
Shape anhedral

Plagioclase Modal 55%
Size 5-7 mm
Shape anhedral

Clinopyroxene Modal 42%
Size 8-25 mm
Shape anhedral

COMMENTS: This unit consists of olivine-bearing gabbro and gabbro. Clinopyroxene has very coarse grain sizes and olivine-rich domains occur. The unit is cut by several alteration veins.

SECONDARY MINERALOGY: This section consists of moderately altered (ca. 30%) olivine bearing gabbro(norite?) in which ferromagnesian minerals are partially altered to actinolite/tremolite +/- chlorite. Most of the plagioclase and pyroxene appear fresh.

VEIN ALTERATION: A tremolite vein with albitized margins is present at 118cm. A tremolite breccia zone is located at 114cm.

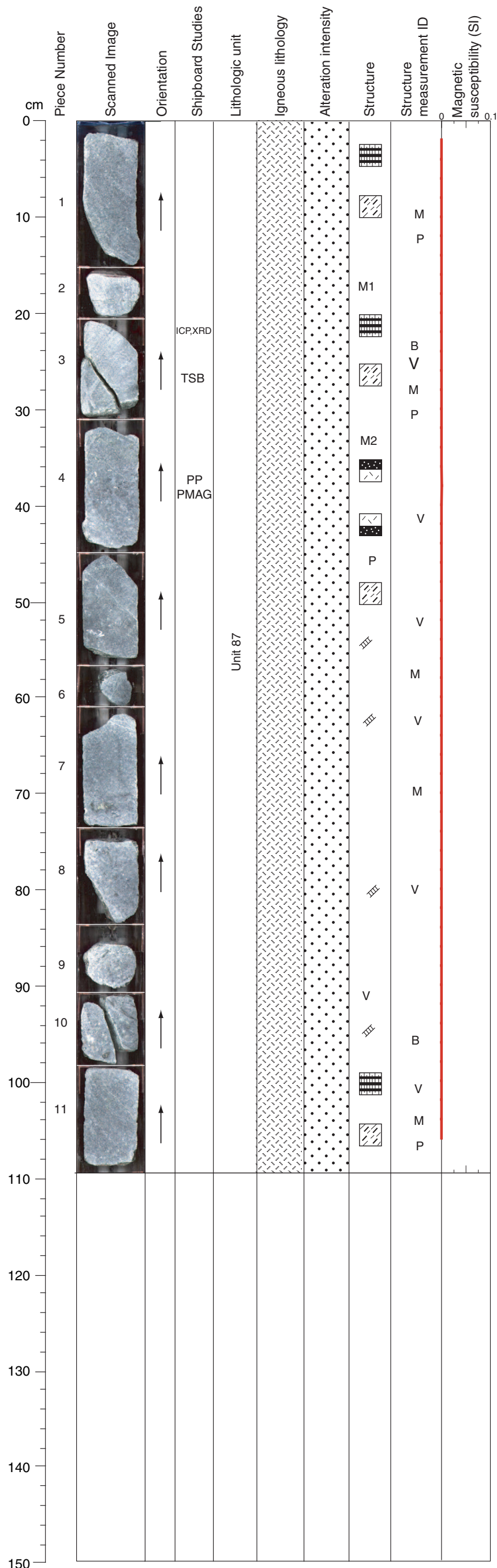
THIN SECTIONS:
304-U1309D-33R-2, 41.0-43.0 cm (#172)

STRUCTURE: Green veins (V) in places cut otherwise undeformed and only moderately altered gabbro. Shear bands (S) cut the gabbroic texture from above 110 cm to below 120. It is unclear whether these shear bands are cataclastic or crystal plastic in nature, or how strongly deformed the sheared material is. Nonetheless, there is highly localized shear strain in this interval, and associated alteration (A).

CLOSE UP PHOTOGRAPHS:
1309D_33R_2_110_127.jpg



Core Photo



304-U1309D-33R-3 (Section top: 183.91 mbsf)

UNIT-87: Olivine-bearing Gabbro and Gabbro
Pieces 1-11

PRIMARY MINERALOGY: Determined from Piece 1

- Olivine Modal <1%
 Size 1 mm
 Shape anhedral
- Plagioclase Modal 60%
 Size 2 mm
 Shape anhedral
- Clinopyroxene Modal 40%
 Size 2 mm
 Shape anhedral

COMMENTS: This section represents the continuation of Unit 87. Magmatic foliation is present throughout the section; changes in modal composition and grain size occur. Piece 4 has slightly coarser grain size as well as narrow clinopyroxene-rich and poor domains.

SECONDARY MINERALOGY: This section consists of slightly altered gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxene seem fresh.

VEIN ALTERATION: Millimeter-sized tremolite veins at 49, 58, and 62 cm

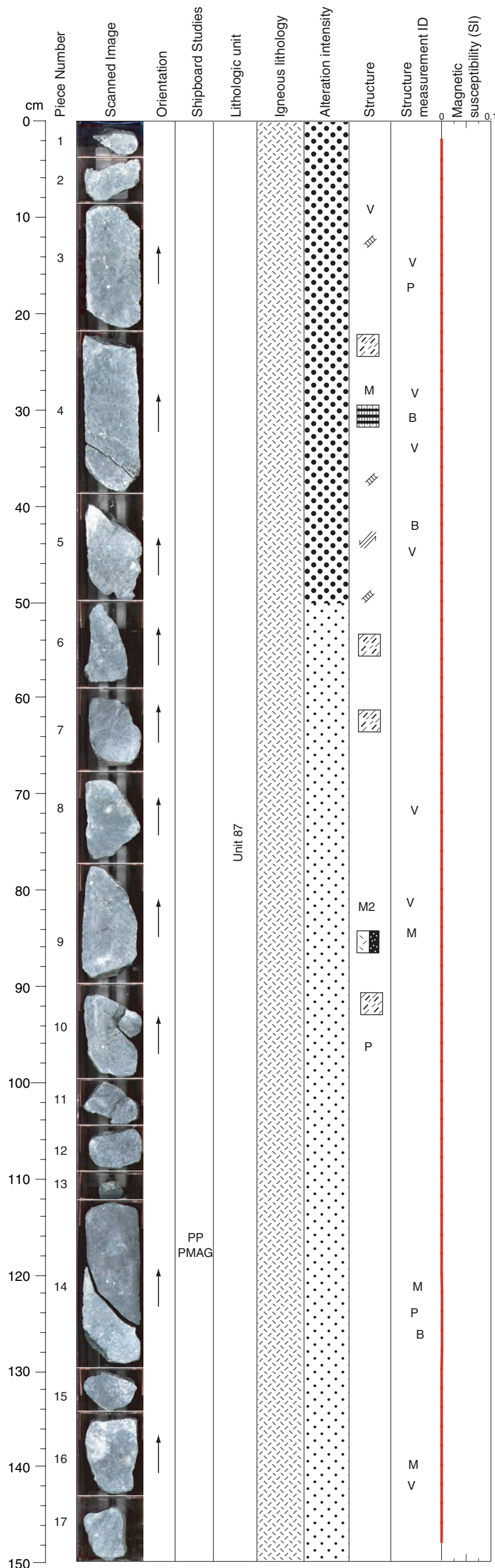
THIN SECTIONS:
304-U1309D-33R-3, 26.0-29.0 cm (#173)

STRUCTURE: Magmatic fabric (M1) with a weak crystal plastic (P) overprint is present throughout the section. At the center of Piece 4, near 38 cm, there is a particularly instructive relationship where a coarse grained gabbro intrudes finer grained gabbro (M2). The deformation appears to post-date the intrusion, although more intense in the finer grained portion of the rock. Two alternative interpretations are that the intrusion accompanied strain (melt-present deformation) or that strain was highly localized in the finer grained rock (strain localization). Blue veins (V) cut all fabrics and are present below 40 cm. Relative timing: M1>P=>M2>V

CLOSE UP PHOTOGRAPHS:
1309D_33R_3_30_45.jpg



Core Photo



304-U1309D-34R-1 (Section top: 186.00 mbsf)

UNIT-87: Olivine-bearing Gabbro and Gabbro
Pieces 1–17

PRIMARY MINERALOGY: Determined from Piece 4A

Olivine	Modal <1% Size 1-2 mm Shape anhedral
Plagioclase	Modal 60% Size 3-4 mm Shape anhedral
Clinopyroxene	Modal 40% Size 2-4 mm Shape anhedral

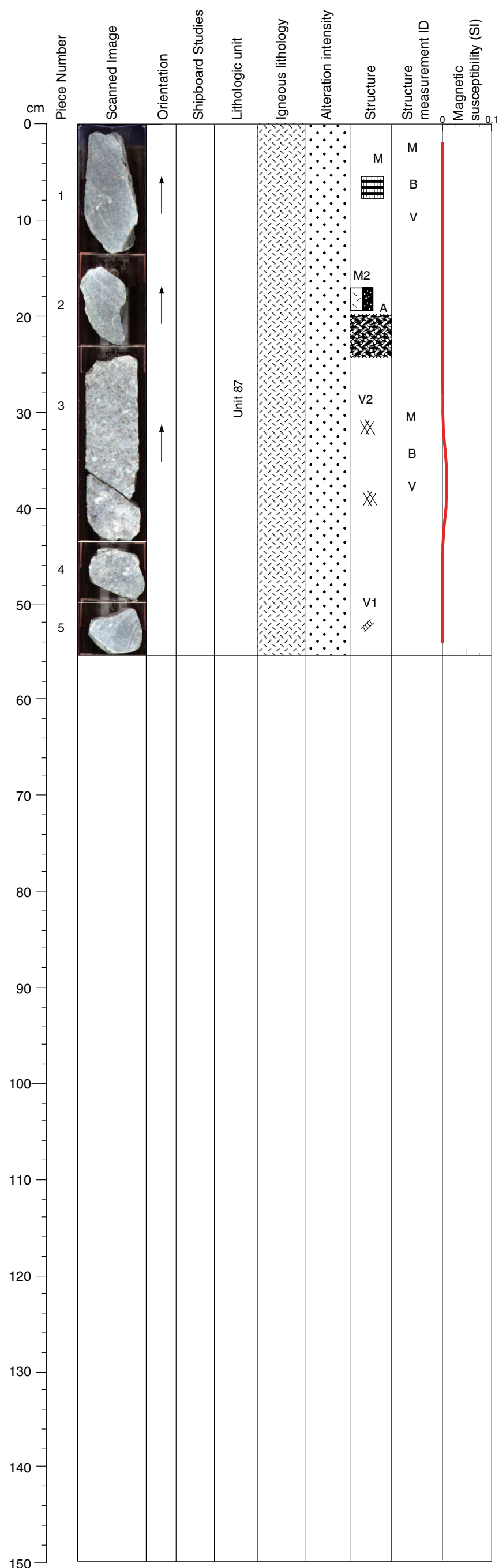
COMMENTS: This section represents the continuation of Unit 87. Magmatic foliation is still present. Grain sizes as large as 15 mm occur sporadically in Pieces 8 to 15. Piece 4B shows slicken sides.

SECONDARY MINERALOGY: This section consists of slightly to moderately altered microgabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration.

VEIN ALTERATION: Millimeter-sized tremolite/ actinolite veins at 33, 46, 73 cm.

STRUCTURE: The magmatic foliation (M) with the crystal plastic (P) overprint is present in this section, albeit weak, and absent from the top few pieces. In Piece 9 a plagioclase-rich domain (M2) cuts the fabric. Elsewhere, green veins (V) cut the fabric, in one places creating a microfault (F) with normal offset. Relative timing: M>P>M2>V>F

Core Photo



304-U1309D-34R-2 (Section top: 187.50 mbsf)

UNIT-87: Olivine-bearing Gabbro and Gabbro
Pieces 1-5

PRIMARY MINERALOGY: Determined from Piece 3a

Olivine Modal 1%
 Size 6-8 mm
 Shape anhedral

Plagioclase Modal 60%
 Size 5 mm
 Shape anhedral

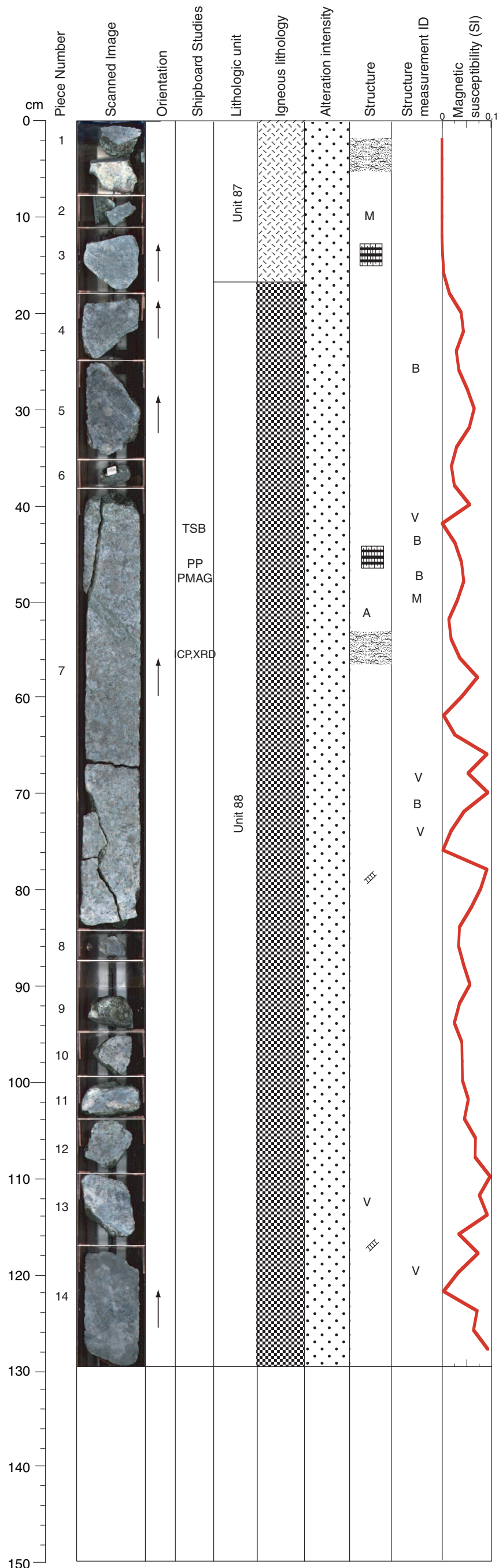
Clinopyroxene Modal 40%
 Size 7-10 mm
 Shape anhedral

COMMENTS: This section represents the continuation of Unit 87. A band of larger grain sizes (as large as 11 mm) occurs in Piece 4.

SECONDARY MINERALOGY: This section consists of slightly altered microgabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxene are unaltered. A few coronitic patches replacing olivine present in Piece 3A.

STRUCTURE: A pyroxene-defined magmatic foliation (M1) is present in this section, locally cut by a higher angle intrusive contact (M2). The later intrusion is a more highly altered medium-grained gabbro. There are two veins in the section - a green vein (V2) in Piece 1 and a darker, possibly higher temperature dark vein (V1) in Piece 4. Relative timing: M1>M2>V1>V2.

Core Photo



304-U1309D-35R-1 (Section top: 190.80 mbsf)

UNIT-87: Olivine-bearing Gabbro and Gabbro
Pieces 1–3

PRIMARY MINERALOGY: Determined from Piece 3

Plagioclase Modal 60%
 Size 2 mm
 Shape anhedral

Clinopyroxene Modal 40%
 Size 2-3 mm
 Shape anhedral

COMMENTS: This represents the continuation of Unit 87 and shows a weak magmatic foliation.

UNIT-88: Oxide Gabbro
Pieces 4–14

PRIMARY MINERALOGY: Determined from Piece 7A

Plagioclase Modal 58%
 Size 6-8 mm
 Shape anhedral

Clinopyroxene Modal 35%
 Size 5-7 mm average, 45 mm maximum
 Shape anhedral

Oxides Modal 7%
 Size 7 mm
 Shape anhedral

COMMENTS: This unit consists of coarse-grained oxide gabbro.

SECONDARY MINERALOGY: This section consists of only slightly altered gabbro (0-25 cm) and oxide-gabbro (25-129 cm) in which ferromagnesian minerals are partially altered to actinolite/ tremolite. Most of the plagioclase and pyroxene are fresh.

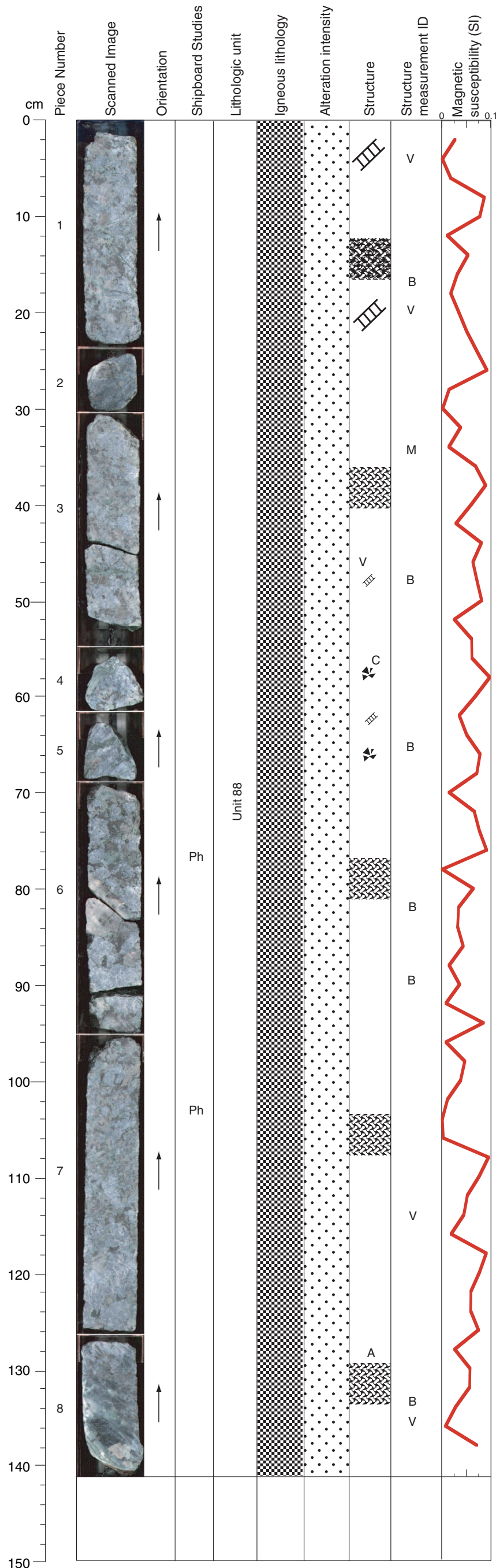
VEIN ALTERATION: Centimeter-scale actinolite vein at 53 cm, millimeter-scale actinolite vein at 102 cm.

THIN SECTIONS:
304-U1309D- 35R- 1, 43.0- 45.0 cm (#174)

STRUCTURE: The gabbroic rocks have a weak magmatic fabric (M) toward the top of the section (Piece 4 for example), and have dense intergranular alteration (A) throughout the section, localizing in vein-like green bands of alteration. White and green veins cut all of the other texture (V). The alteration decreases into the oxide gabbros in the lower half of the section. The transition from gabbro into oxide gabbro is gradational in this section. M>A>V



Core Photo



304-U1309D-35R-2 (Section top: 192.10 mbsf)

UNIT-88: Oxide Gabbro
Pieces 1-8

PRIMARY MINERALOGY: Determined from Piece 6 (Pegmatitic to nearly pegmatitic coarse-grained oxide gabbro)

Plagioclase Modal 55%
Size 18 mm average, 30 mm maximum
Shape anhedral

Clinopyroxene Modal 35%
Size 12-15 mm average, 60 mm maximum
Shape anhedral

Oxides Modal 10%
Size fine-grained to 14 mm
Shape subhedral to anhedral

PRIMARY MINERALOGY: Determined from Piece 7 (Coarse-grained oxide gabbro)

Plagioclase Modal 55%
Size 12-15 mm
Shape anhedral

Clinopyroxene Modal 35%
Size 10 mm
Shape anhedral

Oxides Modal 10%
Size fine-grained to 14 mm
Shape subhedral to anhedral

COMMENTS: This section represents the continuation of Unit 88. It consists of very coarse oxide-gabbro and pegmatitic domains occur with grain sizes as large as 60 mm. Oxides occur mostly interstitial and only rarely within silicates.

SECONDARY MINERALOGY: This section consists of only slightly altered oxide gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite. Most of the plagioclase and pyroxene are unaltered.

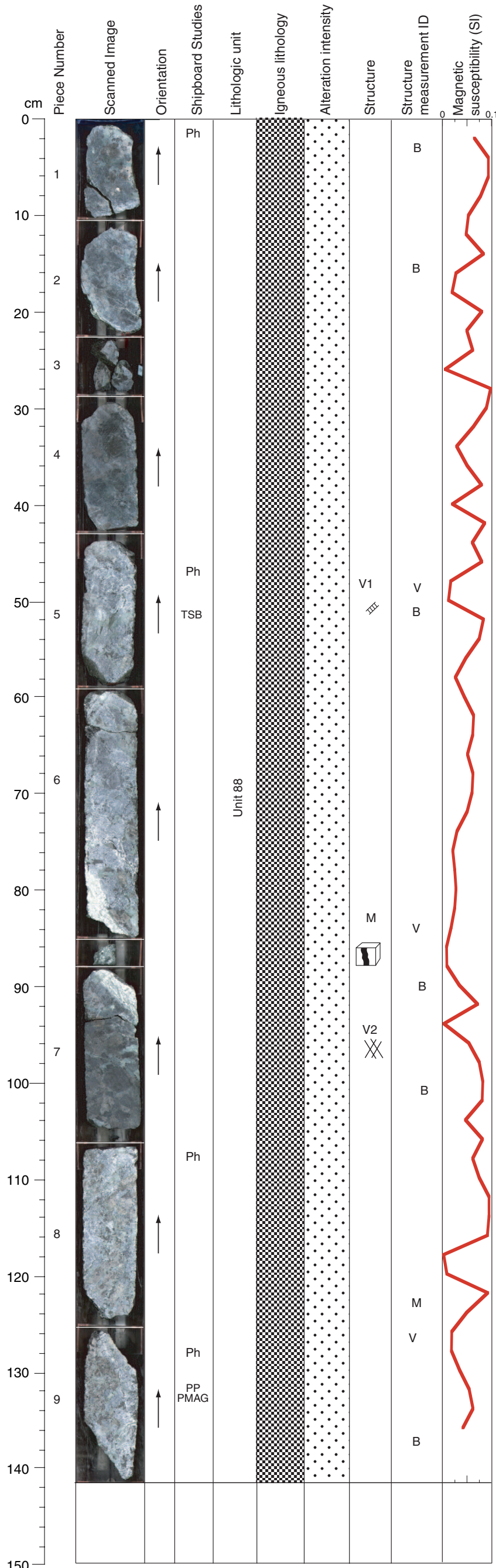
VEIN ALTERATION: Millimeter-scale vein at 17 cm, 0.5 cm-vein at 51 and 64 cm.

STRUCTURE: Oxide gabbros continue from previous section; green veins (V) cut the oxides and other grains, and localize alteration (A) along the grain boundaries. In Piece 5 the veins have a slight cataclastic (C) texture. V=A=C

CLOSE UP PHOTOGRAPHS:
1309D_35R_2_75_94.jpg
1309D_35R_2_100_115.jpg



Core Photo



304-U1309D-35R-3 (Section top: 193.50 mbsf)

UNIT-88: Oxide Gabbro

Pieces 1-10

PRIMARY MINERALOGY: Determined from Piece 4 (Pegmatitic to nearly pegmatitic coarse-grained oxide gabbro)

Plagioclase Modal 55%
Size 12 mm average, 36 mm maximum
Shape anhedral

Clinopyroxene Modal 35%
Size 10 mm average
Shape anhedral

Oxides Modal 10%
Size fine-grained to 12 mm
Shape subhedral to anhedral

PRIMARY MINERALOGY: Determined from Piece 9 (Coarse-grained oxide gabbro)

Plagioclase Modal 55%
Size 11 mm
Shape anhedral

Clinopyroxene Modal 35%
Size 7 mm
Shape anhedral

Oxides Modal 10%
Size fine-grained to 7 mm
Shape subhedral to anhedral

COMMENTS: This section represents the continuation of Unit 88. Oxides are heterogeneously distributed and occur in bands (Piece 9) and domains (Piece 10). Pegmatitic grain sizes occur in Piece 4, and a cataclastic zone between 78 and 93 cm.

SECONDARY MINERALOGY: This section consists of only slightly altered oxide gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite. Most of the plagioclase and pyroxene are unaltered.

VEIN ALTERATION: Centimeter-scale vein at 53 and 98 cm. Centimeter scale felsic dikelet with intense actinolite and chlorite alteration at 86 cm.

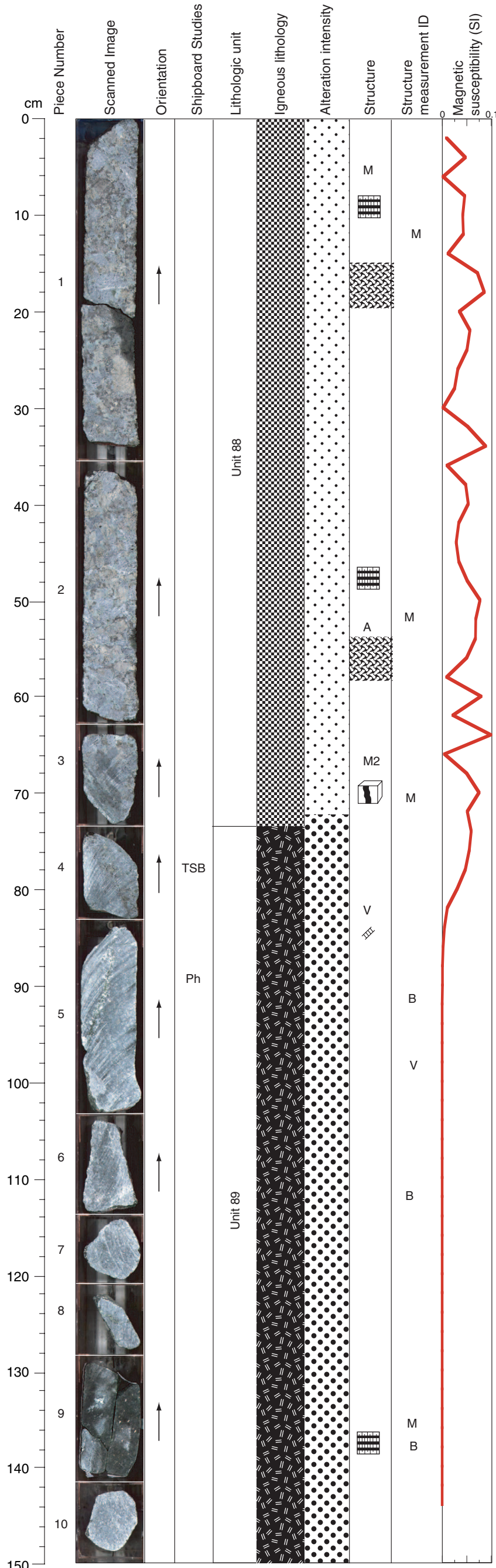
THIN SECTIONS:
304-U1309D- 35R- 3, 50.0- 53.0 cm (# 185)

STRUCTURE: Oxide gabbro with plagioclase alteration around amphibole grains. Plagioclase-amphibole veins form a set of (almost sigmoidal) en echelon veins (V1) in Piece 5. From piece 6 through 8 a feldspar rich vein (M) with superposed green alteration (V2) dips toward 270. It is unclear if the vein took up any shear strain. M=>V1>V2

CLOSE UP PHOTOGRAPHS:
1309D_35R_3_1-17.jpg
1309D_35R_3_45_60.jpg
1309D_35R_3_106-124.jpg
1309D_35R_3_125-140.jpg



Core Photo



304-U1309D-36R-1 (Section top: 195.60 mbsf)

UNIT-88: Oxide Gabbro
Pieces 1-3

PRIMARY MINERALOGY: Determined from Piece 1

- Plagioclase Modal 50%
Size 10-15 mm average, 25 mm maximum
Shape anhedral
- Clinopyroxene Modal 30%
Size 10-15 mm average, 35 mm maximum
Shape anhedral
- Oxides Modal 20%
Size 9 mm
Shape anhedral

COMMENTS: The upper part of this section is a continuation of the coarse-grained oxide gabbro from the previous sections. This section contains the highest amount of oxides of Unit 88.

Unit 89: Olivine-bearing Gabbro and Gabbro
Pieces 4-10

PRIMARY MINERALOGY: Determined from Piece 5

- Olivine Modal 7%
Size 1-2 mm
Shape anhedral
- Plagioclase Modal 63%
Size 4-5 mm
Shape anhedral
- Clinopyroxene Modal 30 %
Size 3-6 mm
Shape anhedral

COMMENTS: This unit consists of medium-grained olivine to olivine-bearing gabbro with a steep magmatic foliation. Pieces 9 and 10 have troctolitic domains.

SECONDARY MINERALOGY: This section consists of slightly altered oxide gabbro and moderately altered gabbro. Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxene are fresh. Some large coronitic patches after olivine consisting of tremolite + chlorite +/- talc, rimmed by chlorite are present in the gabbro section at 133 cm.

VEIN ALTERATION: Brecciated, actinolite- and albite-bearing dioritic veins are present in the metagabbroic section Pieces 5, 6.

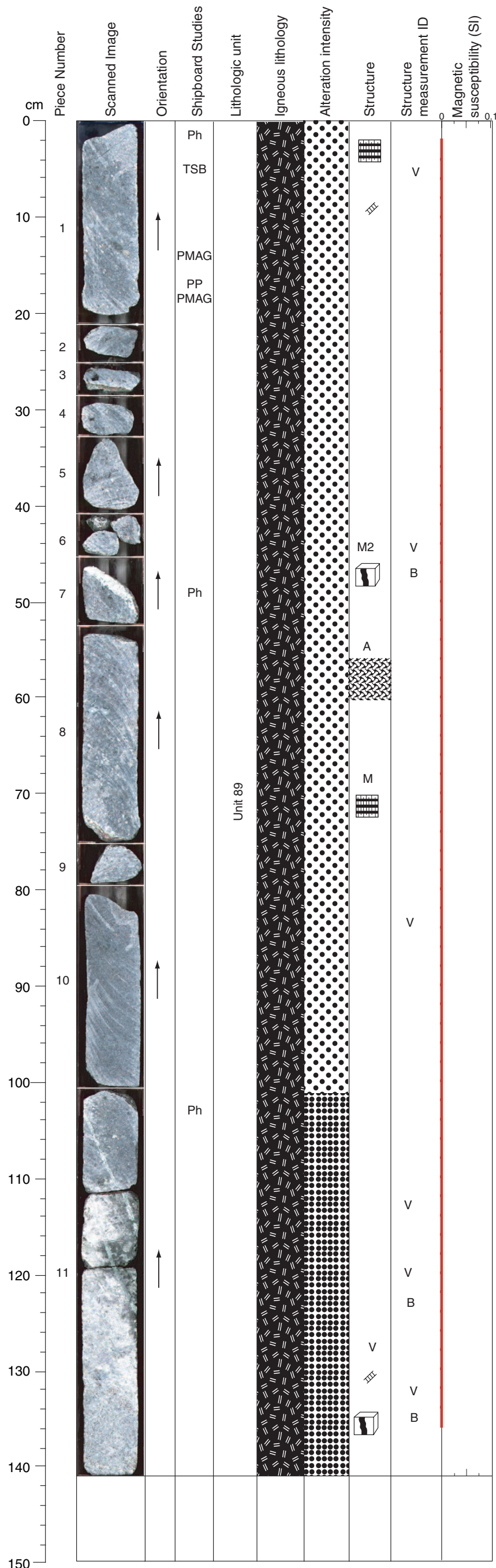
THIN SECTIONS:
304-U1309D-36R- 1, 76.0-78.0 cm (#175)

STRUCTURE: The interval to 60 cm (Pieces 1 and 2) contains brown pyroxene that defines a magmatic foliation (M) with green alteration (A) of some feldspar imparting an alteration texture that parallels the magmatic fabric. Within oxide-rich portions, the alteration is continuous up to the oxide grain boundaries. Pieces 3-5 have a dioritic component (M2) that is interstitial to the pyroxene grains, and there is localized alteration against a sharp contact at the base of Piece 3. The localization of alteration continues through Piece 5 as a vein with green alteration on the amphibole-portions (V). Around the dioritic intrusion there is a strong magmatic fabric defined by fine pyroxene grains, in places creating a magmatic lineation. The olivine-rich components in Piece 8 also follow the magmatic fabric with coronitic textures.

CLOSE UP PHOTOGRAPHS:
1309D_36R_1_87_95.jpg



Core Photo



304-U1309D-36R-2 (Section top: 197.09 mbsf)

UNIT-89: Olivine-bearing Gabbro and Gabbro
Pieces 1-11

PRIMARY MINERALOGY: Determined from Piece 8

- Olivine Modal 1%
 Size 1 mm average, 7 mm maximum
 Shape anhedral
- Plagioclase Modal 65%
 Size 5-6 mm
 Shape anhedral
- Clinopyroxene Modal 35%
 Size 3-7 mm
 Shape anhedral

COMMENTS: This section consists of medium-grained, olivine-bearing gabbro and is the continuation of the previous section. Olivine content is decreasing downsection and Piece 11 contains orthopyroxene. Magmatic foliation is present throughout the section. A dioritic dike cuts Piece 7 along its length. Piece 11 is cut at 119 cm and 123 cm and overall infiltrated by a dioritic dike. A quartz vein occurs at 80 cm.

SECONDARY MINERALOGY: This section consists of moderately altered gabbro. Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Some large coronitic pseudomorphic patches after olivine consisting of tremolite + chlorite +/- talc, rimmed by chlorite are present at 22 and 60 cm. Most of the plagioclase and pyroxenes seem to have survived alteration.

VEIN ALTERATION: Brecciated, dioritic veins with actinolite and albite are present at 45-51 cm and 116-145 cm

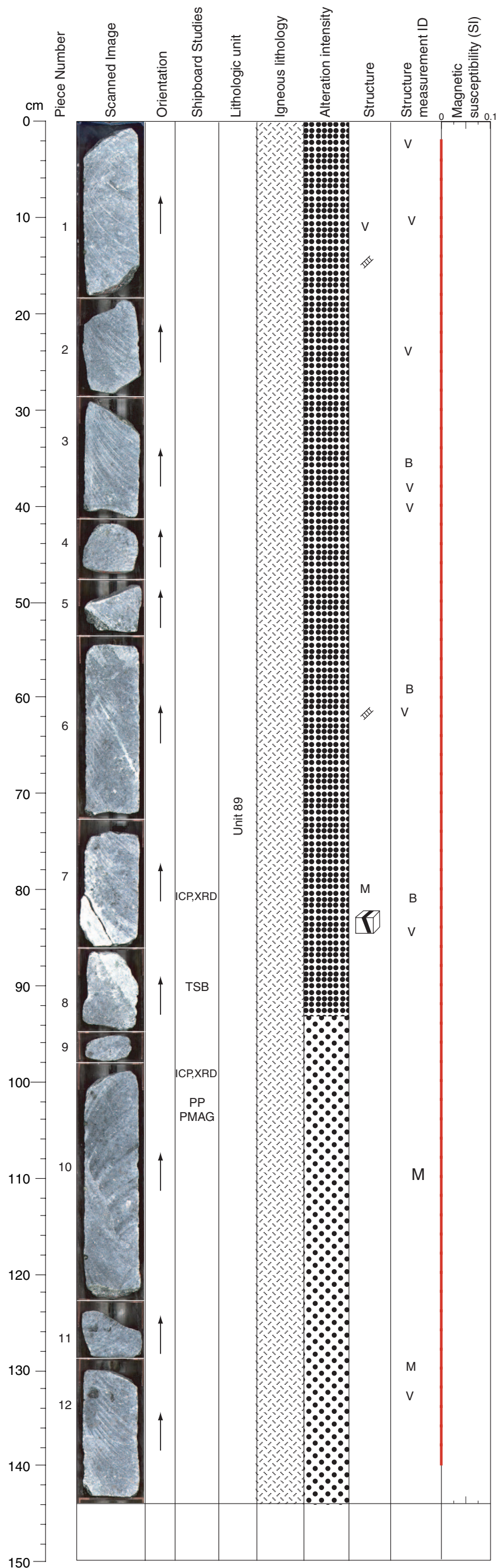
THIN SECTIONS:
[304-U1309D-36R- 2, 4.0-6.0cm \(#176\)](#)

STRUCTURE: Pyroxene-defined magmatic fabric (M) in a microgabbro (in places, medium-grained). Subhorizontal green veins (V) cut the microfabric. The fabric has strongly variable intensity throughout section, with most intense interval in Piece 5. The microgabbro has a gradational contact with the coarser grained gabbro in Piece 11. In Pieces 7 and 11 there are later feldspar-rich veins with superposed alteration (M2). The veins cut the gabbroic fabric, and in places have poorly defined vein-boundaries. Well-defined green and white veins are adjacent to, and cut these magmatic intrusions. M>M2>V

CLOSE UP PHOTOGRAPHS:
[1309D_36R_2_0_20.jpg](#)
[1309D_36R_2_45_50.jpg](#)
[1309D_36R_2_100_120.jpg](#)
[1309D_36R_2_120_140.jpg](#)



Core Photo



304-U1309D-36R-3 (Section top: 198.49 mbsf)

UNIT-89: Olivine-bearing Gabbro and Gabbro
Pieces 1-12

PRIMARY MINERALOGY: Determined from Piece 1

Plagioclase Modal 60%
 Size 4 mm
 Shape anhedral

Clinopyroxene Modal 40%
 Size 2-4 mm
 Shape anhedral

COMMENTS: This section consists of medium-grained gabbro and is the continuation of the previous sections. Magmatic foliation is visible between 19 cm and 47 cm. Olivine content decreases downsection. Pieces 10 and 12 contain orthopyroxene. Isolated coarse clinopyroxene grains occur in Pieces 6-9, 10 and 12. Dioritic dikes cross between 79-85 cm and 86-92 cm. Alteration veins occur at 8 cm, 38 cm and 63 cm.

SECONDARY MINERALOGY: This section consists of moderately altered olivine-bearing gabbro. Olivine is altered to tremolite + chlorite + talc + carbonate and rimmed by chlorite forming pseudomorphic coronas (e.g. at 22 and 60 cm). Most of the plagioclase and pyroxenes seem to have survived alteration. A few brown hornblende relics are present around pyroxene.

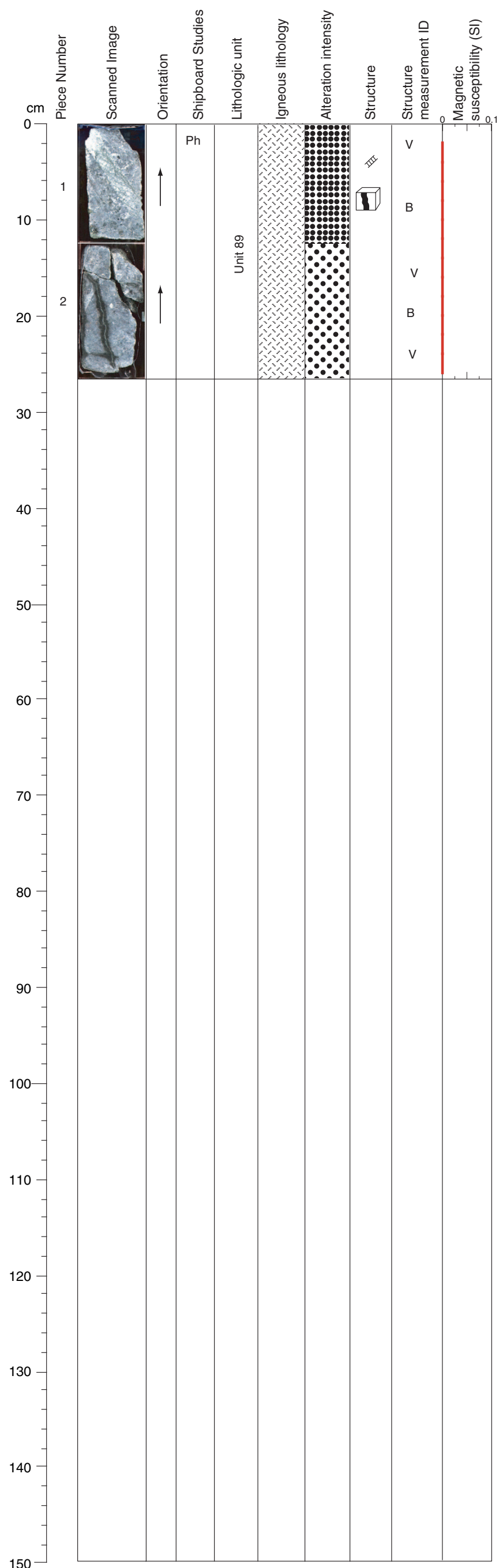
VEIN ALTERATION: Brecciated, late leucocratic magmatic dikelets with actinolite and albite are present at 45-51 cm and 116-145 cm.

THIN SECTIONS:
304-U1309D-36R-3, 89.0-92.0 cm (#177)

STRUCTURE: Single blue vein (V) with a shallow dip at the base of Piece 1 cuts otherwise relatively coarse-grained gabbro. Into the middle of the section a fine-grained dioritic component is largely interstitial to the coarser grained gabbro, and develops veins around 85 cm (M). Elsewhere, a combination of green and white minerals fill well-defined veins (V).M>V



Core Photo



304-U1309D-36R-4 (Section top: 199.91 mbsf)

UNIT-89: Olivine-bearing Gabbro and Gabbro
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 2

- Plagioclase Modal 59%
 Size 3-4 mm
 Shape anhedral
- Clinopyroxene Modal 40%
 Size 3 mm
 Shape anhedral
- Orthopyroxene Modal 1 %
 Size 3 mm
 Shape anhedral

COMMENTS: This section consists of medium-grained gabbro and is the continuation of the previous sections. Piece 2 contains orthopyroxene. A dioritic dike of 10 to 15 mm crosses at 6 cm and an alteration vein occurs nearly vertical at 20 cm.

SECONDARY MINERALOGY: This section consists of moderately to highly altered gabbro. Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration. Some brown hornblende seems to be present.

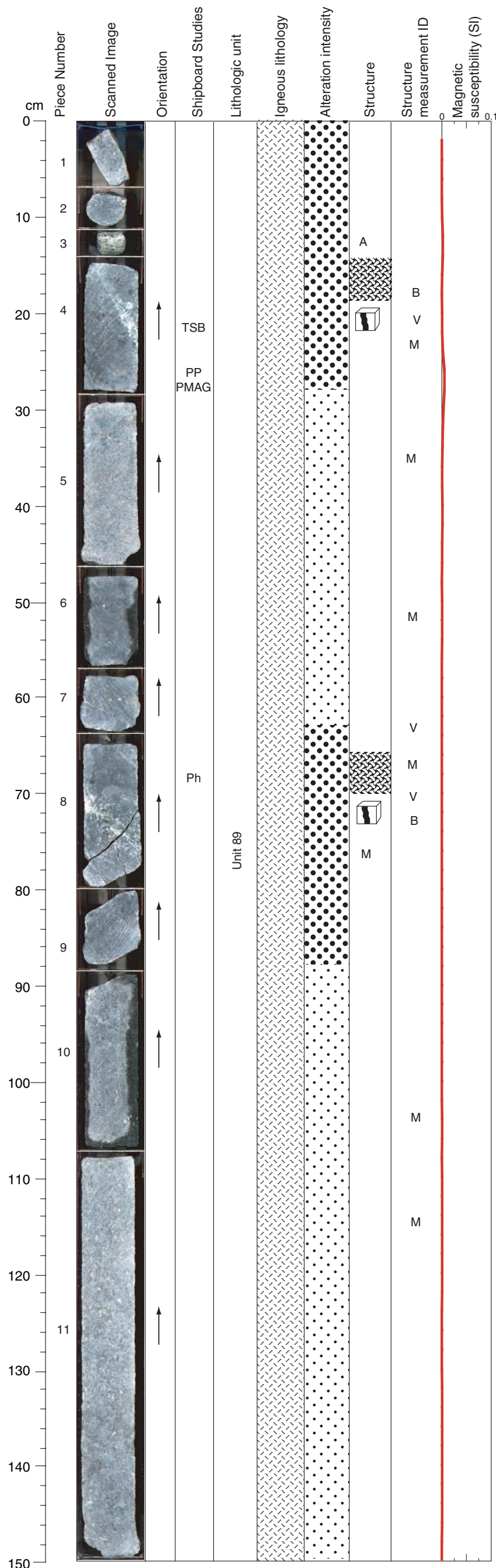
VEIN ALTERATION: A cm-sized brecciated dioritic vein with actinolite + talc and albite is present within Piece 1. Small actinolite + talc veins are present in Piece 2.

STRUCTURE: Dioritic vein with green alteration overprint.

CLOSE UP PHOTOGRAPHS:
1309D_36R_4_0_15.jpg



Core Photo



304-U1309D-37R-1 (Section top: 200.40 mbsf)

UNIT-89: Olivine-bearing Gabbro and Gabbro
Pieces 1-11

PRIMARY MINERALOGY: Determined from Piece 10

Olivine	Modal <1% Size 2-4 mm Shape anhedral
Plagioclase	Modal 70% Size 2-3 mm Shape anhedral
Clinopyroxene	Modal 30% Size 4-8 mm Shape anhedral
Orthopyroxene	Modal <1% Size 4-8 mm Shape anhedral

COMMENTS: This section consists of medium-grained gabbro and is the continuation of the previous sections. Isolated coarse clinopyroxenes occur below 69 cm. Pieces 4 to 6 and 9 are orthopyroxene-bearing gabbro. Alteration veins cross at 19 cm and 72 cm.

SECONDARY MINERALOGY: This section consists of slightly to moderately altered gabbro. There are a few large coronitic patches after olivine consisting of tremolite + chlorite +/- talc, rimmed by chlorite within the olivine-bearing gabbro. Most of the plagioclase and pyroxenes seem to have survived alteration. Some brown hornblendes are present around the dike with secondary plagioclase.

VEIN ALTERATION: A breccia vein with actinolite, secondary plagioclase and brown hornblende is present at 70-78 cm.

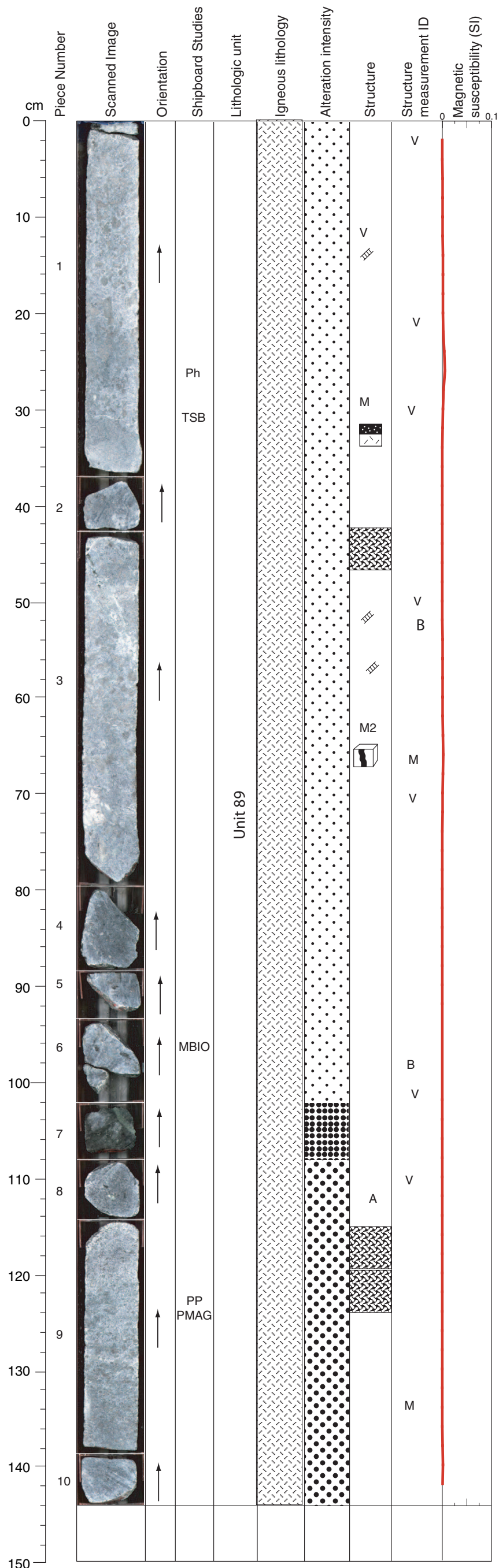
THIN SECTIONS:
[304-U1309D-37R-1, 20.0-22.0 cm \(#178\)](#)

STRUCTURE: Pieces 4 and 8 preserve type examples of diorite (M) veins that are overprinted by later green alteration (A). In Piece 8 the diorite vein has poorly defined vein walls, and dioritic material is interstitial to the immediately adjacent gabbro. M>A

CLOSE UP PHOTOGRAPHS:
[1309D_37R_1_67_77.jpg](#)



Core Photo



304-U1309D-37R-2 (Section top: 201.90 mbsf)

UNIT-89: Olivine-bearing Gabbro and Gabbro
Pieces 1-10

PRIMARY MINERALOGY: Determined from Piece 3

Plagioclase Modal 70%
 Size 5-10 mm
 Shape anhedral

Clinopyroxene Modal 30%
 Size 5-10 mm average, 20 mm maximum
 Shape anhedral

COMMENTS: This section consists of medium-grained gabbro and is the continuation of the previous sections. Grain sizes change throughout the section. Microgabbro occurs between 42 cm and 55 cm with a sharp contact. Medium grain sizes dominate below 108 cm. The remainder of the section is generally coarse-grained. A dioritic dike crosses at 52 cm. A pyroxene band with fine to medium grain size occurs between 63 cm and 64 cm.

SECONDARY MINERALOGY: This section consists of slightly to highly altered gabbro. Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration. Some brown hornblende seems to be present. Pyrite is found in Pieces 6 and 7.

VEIN ALTERATION: Breccia veins with actinolite and albite are present around 47-57 cm and 93-107 cm.

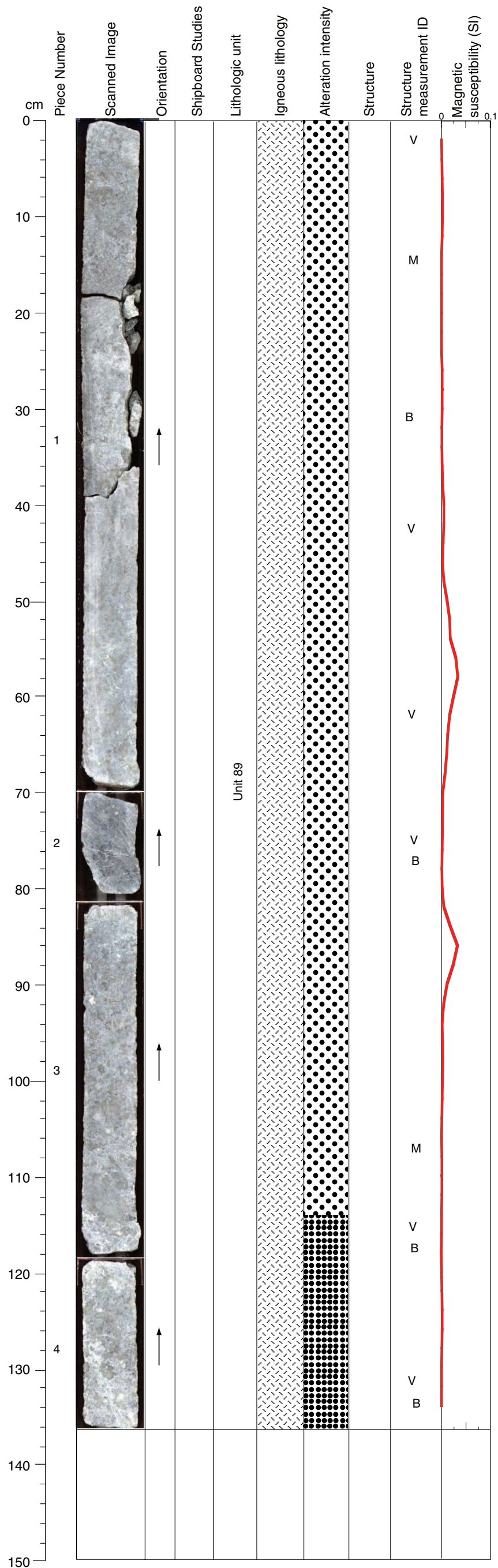
THIN SECTIONS:
304-U1309D-37R- 2, 30.0- 33.0 cm (#179)

STRUCTURE: The base of Piece 1 preserves a sharp contact (M1) between coarser and very fine grained gabbro. Interstitial feldspar appears to be continuous with adjacent felsic veins (M2) in Piece 3 (possibly an impregnation feature-thin section suggests later recrystallization of initially cotectic feldspar). Below 110 cm the dioritic component of the gabbro creates a composite magmatic/alteration texture, given the tendency of the plagioclase to localize alteration (A). Above 60 cm the alteration includes well-defined green (steeply dipping) and blue (shallowly dipping) veins (V). M1>M2>A>V

CLOSE UP PHOTOGRAPHS:
1309D_37R_2_25_35.jpg



Core Photo



304-U1309D-37R-3 (Section top: 203.33 mbsf)

UNIT-89: Olivine-bearing Gabbro and Gabbro
Pieces 1-4

PRIMARY MINERALOGY: Determined from Piece 3

Plagioclase Modal 70%
 Size 5-7 mm
 Shape anhedral

Clinopyroxene Modal 30%
 Size 4-7 mm average, 20 mm maximum
 Shape anhedral

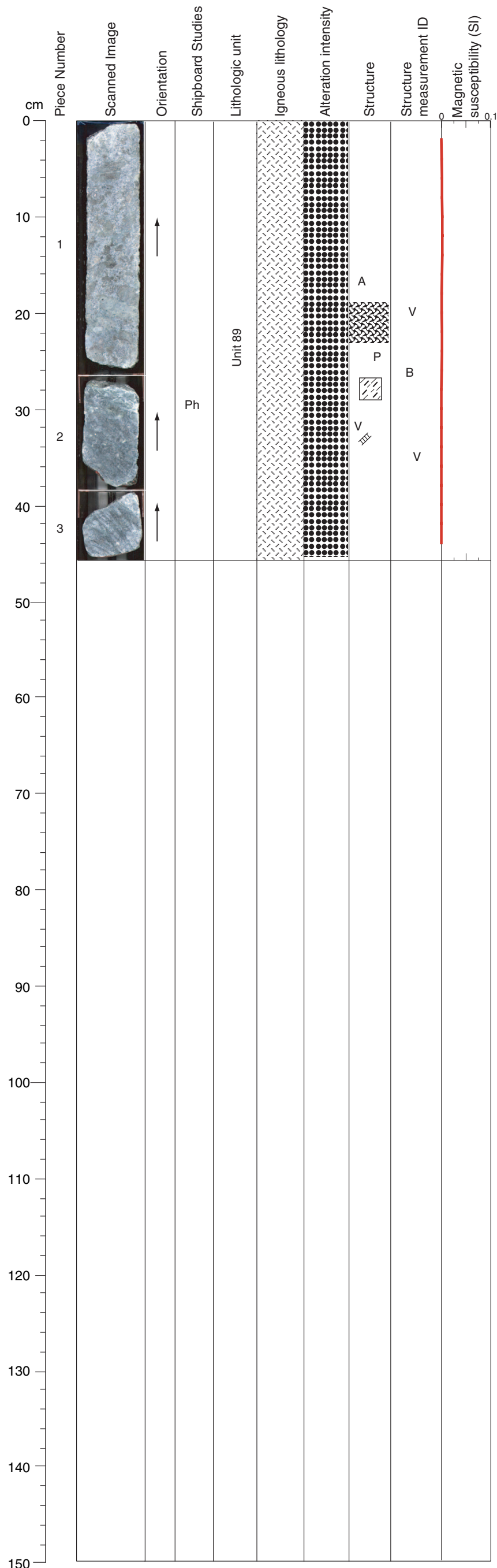
COMMENTS: This section consists of coarse-grained gabbro and is the continuation of the previous sections. Olivine-bearing gabbro occurs between 50-69 cm and 81-100 cm. Coarse clinopyroxene grains are present in the section.

SECONDARY MINERALOGY: This section consists of moderately altered olivine gabbro (0-114 cm) and highly altered gabbro (144-135 cm). Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most plagioclase and pyroxene remain fresh. Secondary plagioclase is present in higher amounts within the gabbroic section. Some brown hornblende may be present in the olivine gabbro.

VEIN ALTERATION: An actinolite vein is present at 52-62 cm.

STRUCTURE: Throughout the section coarse pyroxene is in contact with medium-grained pyroxene, surrounded by very fine grained plagioclase (interstitial dioritic material). Alteration is localized along the plagioclase-rich portions, although veins are subordinate to more diffusive alteration (and diorite-distribution). See Structural Measurement ID for location of structures.

Core Photo



304-U1309D-37R-4 (Section top: 204.69 mbsf)

UNIT-89: Olivine-bearing Gabbro and Gabbro
Pieces 1-3

PRIMARY MINERALOGY: Determined from Piece 1

Plagioclase Modal 65%
 Size 7 mm
 Shape anhedral

Clinopyroxene Modal 35%
 Size 5-9 mm average, 22 mm maximum
 Shape anhedral

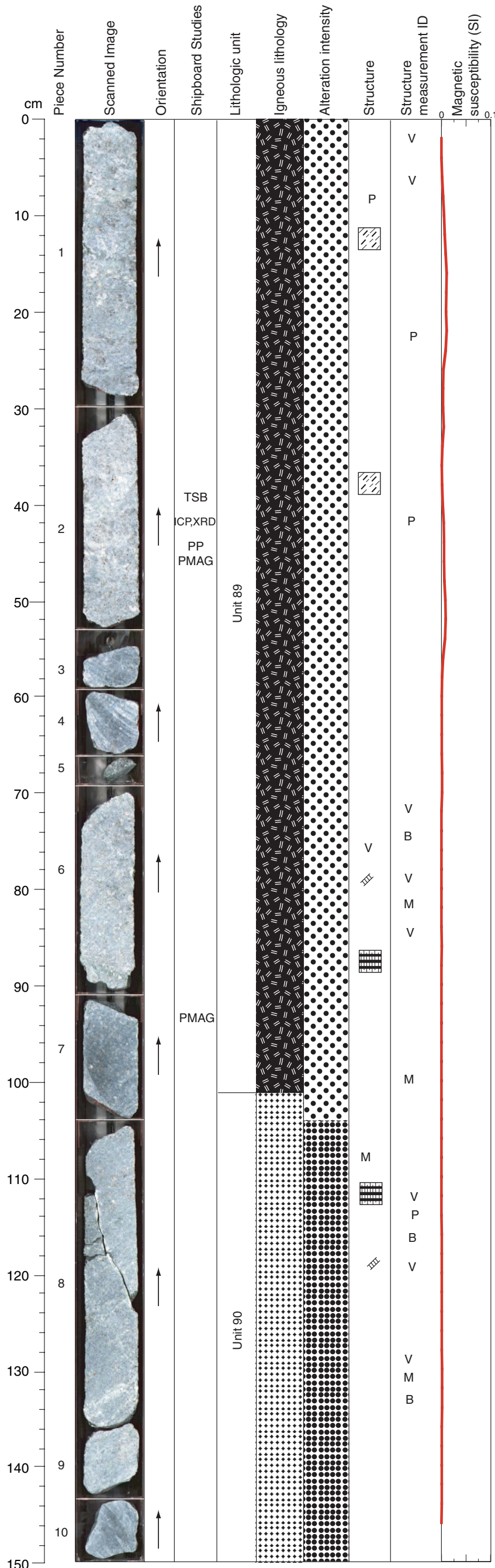
COMMENTS: This section consists of coarse-grained gabbro and is the continuation of the previous sections. Clinopyroxene grains reach sizes of 50 mm in Piece 1. Weak magmatic foliation is present in Piece 1.

SECONDARY MINERALOGY: This section consists of highly altered gabbro. Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration. Secondary plagioclase is present.

STRUCTURE: Similar coarse-grained gabbro to previous sections (with interstitial plagioclase and associated later alteration). At the top of Piece 2 is a semibrittle shear zone (P), overprinted by greenschist grade alteration (A), although the amount of strain is small. Below that are several subhorizontal veins (V). P>A>V

CLOSE UP PHOTOGRAPHS:
1309D_37R_4_27_32.jpg

Core Photo



304-U1309D-38R-1 (Section top: 205.20 mbsf)

UNIT-89: Olivine-bearing Gabbro
Pieces 1-7

PRIMARY MINERALOGY: Determined from Piece 2

Plagioclase Modal 65%
 Size 7 mm
 Shape anhedral

Clinopyroxene Modal 35%
 Size 3-6 mm average, 17 mm maximum
 Shape anhedral

COMMENTS: This unit consists of medium- and coarse grained gabbro. The modal content of orthopyroxene is low and grain size varies throughout the unit. Pieces 1 to 3 are coarse grained; Pieces 4 to 7 are medium grained. Piece 7 has a magmatic foliation.

UNIT-90: Olivine Gabbro with troctolitic domains
Pieces 7-9

PRIMARY MINERALOGY: Determined from Piece 8A (Troctolite)

Olivine Modal 10%
 Size 2-3 mm
 Shape anhedral

Plagioclase Modal 87%
 Size 3-5 mm
 Shape anhedral

Clinopyroxene Modal 3%
 Size 2 mm
 Shape anhedral

PRIMARY MINERALOGY: Determined from Piece 8A (Olivine gabbro)

Olivine Modal 12%
 Size 2-3 mm
 Shape anhedral

Plagioclase Modal 63%
 Size 3-5 mm
 Shape anhedral

Clinopyroxene Modal 25%
 Size 3-4 mm
 Shape anhedral

COMMENTS: This unit marks the first occurrence of very steeply dipping troctolitic bands (boundary can be best seen on the back side of the core). Coarse-grained clinopyroxene-rich domains appear at 108-113 and 136-139 cm until it grades into troctolitic areas.

SECONDARY MINERALOGY: This section consists of moderately altered gabbro and highly altered olivine gabbro and troctolite. Olivine has reacted to coronas of chlorite + tremolite + talc +/- carbonate. Pyroxenes have been partially altered to actinolite. Most of the plagioclase is fresh. Some secondary plagioclase and brown hornblende are present in the upper part of the section.

VEIN ALTERATION: A talc-tremolite-chlorite vein is present at 110-124 cm.

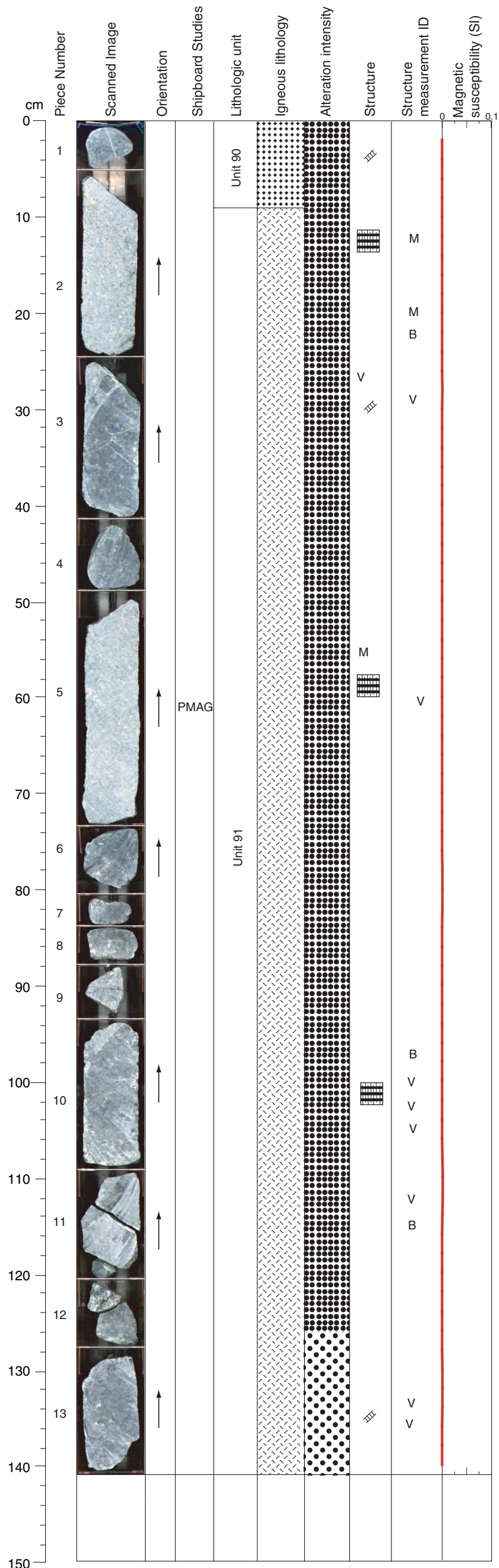
THIN SECTIONS:
304-U1309D-38R- 1, 38.0-41.0 cm (#180)

STRUCTURE: Top of the section is characterized by a medium grained pyroxene-feldspar (modal proportion varies throughout) gabbro with "salt-and-pepper" appearance. There is a weak crystal plastic fabric throughout this interval as well (P). In Piece 6 thin, dark veins (V) appear and are present below that piece. Well-defined magmatic layering (M) begins in Piece 7 and continues throughout with troctolitic portions beginning in Piece 8

CLOSE UP PHOTOGRAPHS:
1309D_38R_1_30_50.jpg



Core Photo



304-U1309D-38R-2 (Section top: 206.70 mbsf)

UNIT-90: Olivine Gabbro with Troctolitic Domains
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 1

- Olivine Modal 10%
Size 2-3 mm
Shape anhedral
- Plagioclase Modal 87%
Size 3-5mm
Shape anhedral
- Clinopyroxene Modal 3%
Size 2 mm
Shape anhedral

COMMENTS: The section begins with two pieces of medium-grained troctolite.

UNIT-91: Gabbro
Pieces 2-13

PRIMARY MINERALOGY: Determined from Piece 3

- Plagioclase Modal 75%
Size 7 mm
Shape anhedral
- Clinopyroxene Modal 25%
Size 2-3 mm average, 11 mm maximum
Shape anhedral

COMMENTS: This coarse-grained gabbro is in contact at 9 cm with Unit 90 by a sharp boundary with a wavy outline. It contains a low olivine content that varies sporadically. An olivine-rich, pyroxene-poor band occurs between 70 and 77 cm. Style of alteration changes at 80 cm.

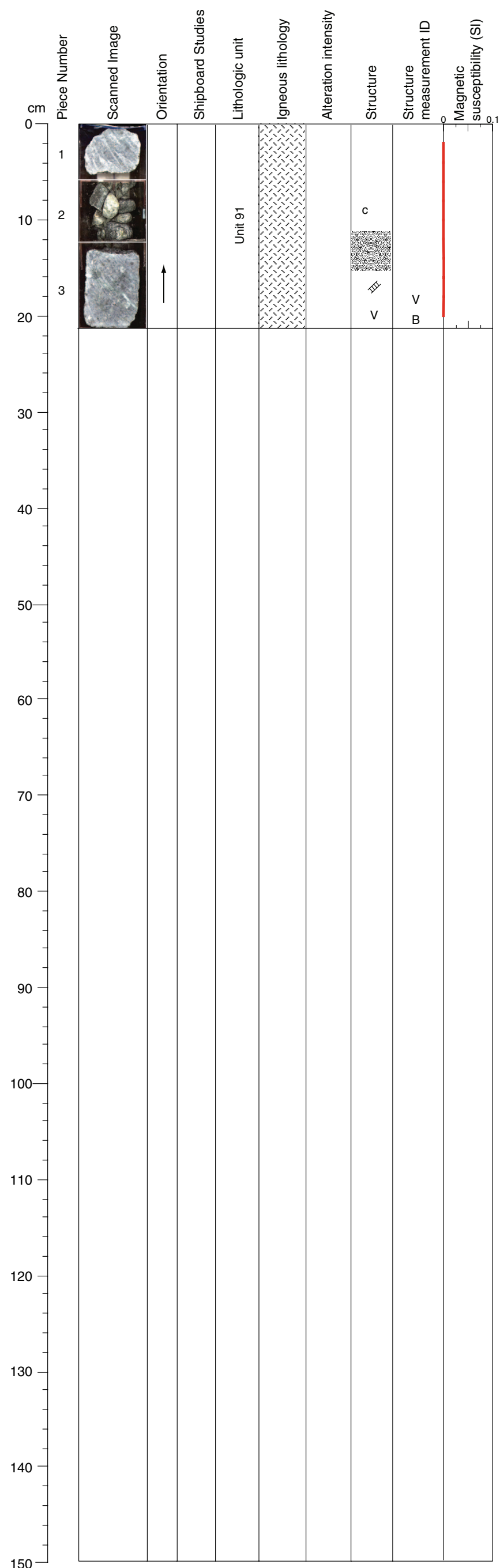
SECONDARY MINERALOGY: This section consists of moderately to highly altered ol-gabbro (83-126 cm) and gabbro (0-83, 126-139 cm). Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration. Secondary plagioclase is present in greater proportion in the gabbro.

VEIN ALTERATION: A talc-tremolite vein is present at 112-115 cm, small actinolite veins are present throughout the section.

STRUCTURE: This section is noteworthy for fine-grained, granular feldspar (M) interstitial to the gabbro, but not well-defined dioritic veins. Green veins (V) are localized in the more dioritic zones. The magmatic foliation intensifies below Piece 5, and there are several modestly dipping blue veins in Pieces 10, 11, and 12. M>V



Core Photo



304-U1309D-38R-3 (Section top: 208.10 mbsf)

UNIT-91: Gabbro
Pieces 1-3

PRIMARY MINERALOGY: Determined from Piece 3 in Section 38R-002

Plagioclase Modal 75%
 Size 7 mm
 Shape anhedral

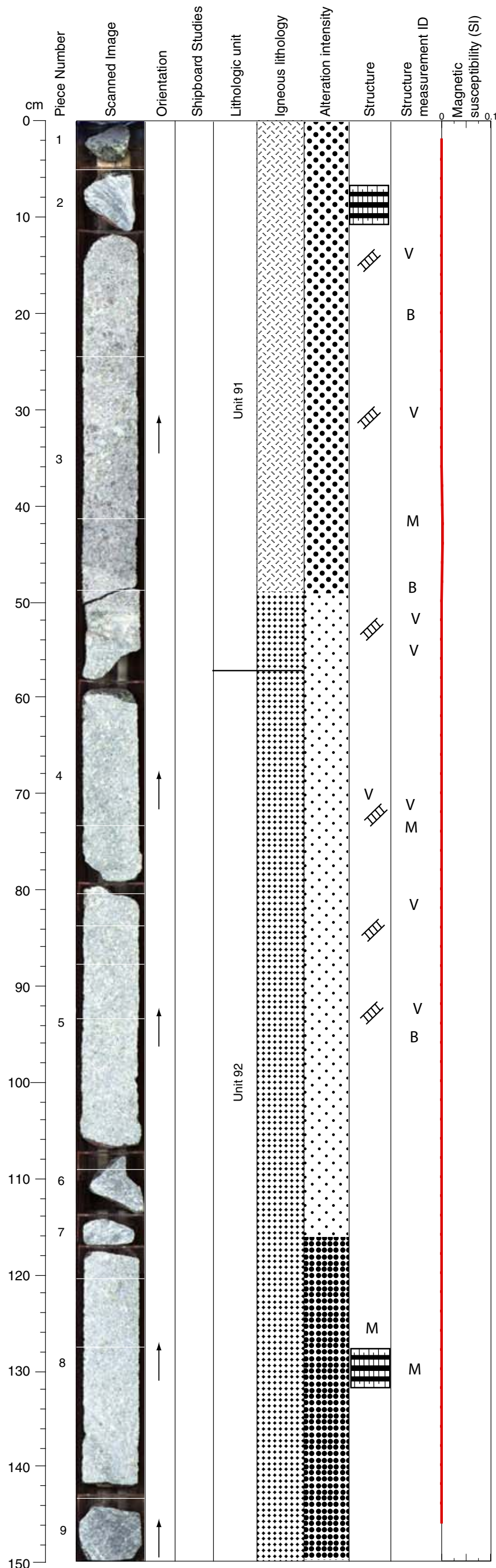
Clinopyroxene Modal 25%
 Size 2-3 mm average, 11 mm maximum
 Shape anhedral

SECONDARY MINERALOGY: This section consists of highly altered gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxenes seem to be fairly fresh.

VEIN ALTERATION: A talc-tremolite vein is present in Piece 3.

STRUCTURE: Single green vein (V) with some microcracking (C) in plagioclase rich portions. V=C

Core Photo



304-U1309D-39R-1 (Section top: 210.00 mbsf)

UNIT-91: Gabbro
Pieces 1-3

PRIMARY MINERALOGY: Determined from Piece 3 (36-47 cm interval)

Plagioclase Modal 60%
Size 4-6 mm
Shape anhedral
Clinopyroxene Modal 40%
Size 3-11mm
Shape anhedral

COMMENTS: This unit consists of coarse-grained gabbro and is the continuation of the previous Section U1309D-38R-3. Piece 2 shows magmatic foliation.

UNIT-92: Olivine Gabbro
Pieces 3-9

PRIMARY MINERALOGY: Determined from Piece 4

Olivine Modal 20%
Size 1-2 mm
Shape anhedral
Plagioclase Modal 55%
Size 5 mm
Shape anhedral
Clinopyroxene Modal 25%
Size 4-7 mm
Shape anhedral

COMMENTS: Unit 92 consists of medium-grained olivine gabbro and shows increasing olivine downsection. Magmatic foliation is visible from 107 cm (Piece 5) onward.

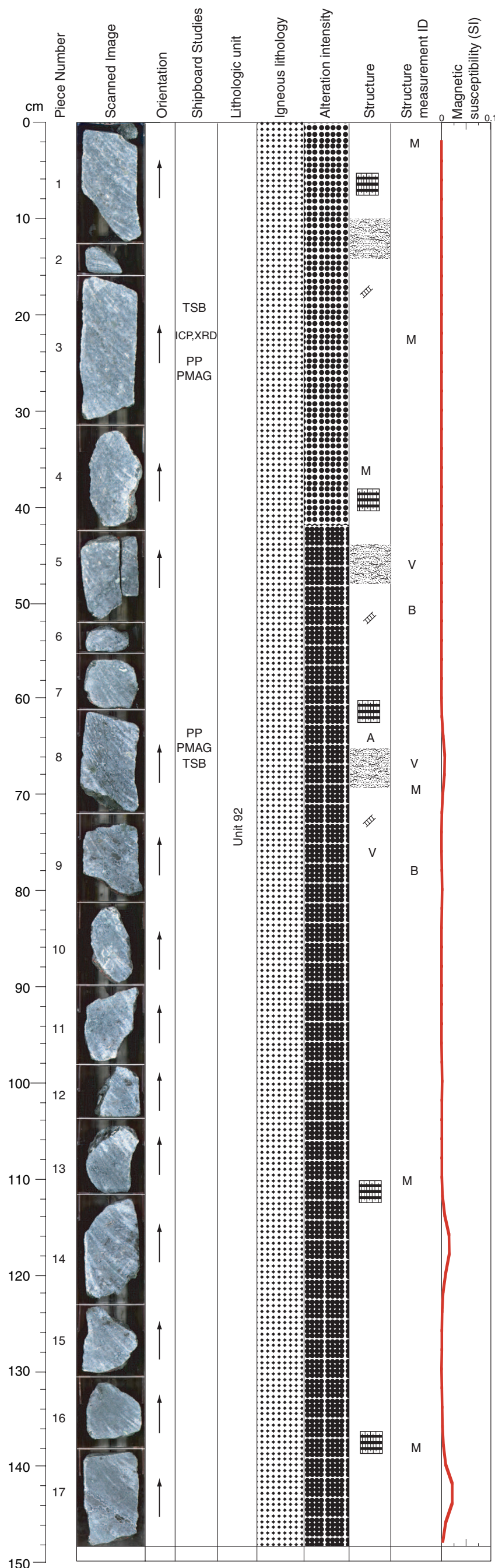
SECONDARY MINERALOGY: This section consists of slightly to moderately altered gabbro and highly altered olivine gabbro. Ferromagnesian minerals are partially altered to actinolite/tremolite +/- chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration. Some brown hornblende may be present in the olivine gabbro. Coronitic textures with tremolite + chlorite +/- talc, rimmed by chlorite after olivine are present in the lower part of the section.

VEIN ALTERATION: Small actinolite veins are present in Pieces 3, 4, 5, 7.

STRUCTURE: Coarse-grained gabbro with a strong magmatic (possibly crystal plastic) fabric (M) in Piece 2 and Piece 6 (where it is steeply dipping). A few veins (V) are present in the section, and the coarse grained gabbro grades into a olivine gabbro toward its base. M>V



Core Photo



304-U1309D-39R-2 (Section top: 211.50 mbsf)

UNIT-92: Olivine Gabbro
Pieces 1-17

PRIMARY MINERALOGY: Determined from Piece 3 (Olivine gabbro)

Olivine Modal 20%
Size <1-3 mm
Shape anhedral

Plagioclase Modal 55%
Size 3-5 mm
Shape anhedral

Clinopyroxene Modal 25%
Size 4-5 mm average, 9 mm maximum
Shape anhedral

PRIMARY MINERALOGY: Determined from Piece 8 (Troctolitic gabbro)

Olivine Modal 12%
Size <1-3 mm
Shape anhedral

Plagioclase Modal 76%
Size 3-5 mm
Shape anhedral

Clinopyroxene Modal 12%
Size 4-6 mm average, 9 mm maximum
Shape anhedral

COMMENTS: This section consists of coarse-grained olivine gabbro from Unit 92. Troctolitic areas occur between 34-40 cm and 61-74 cm. Olivine content decreases again from 110 cm toward the bottom of the section. Magmatic foliation is visible throughout the section.

SECONDARY MINERALOGY: This section consists of slightly to moderately altered gabbro and highly altered olivine gabbro. Most of the plagioclase is fresh. Pyroxene is partially altered to actinolite. Some brown hornblende may be present in the olivine gabbro. Coronitic textures produced by the reaction of olivine with plagioclase to produce tremolite + chlorite +/- talc, rimmed by chlorite are present in the central and lower part of the section. Locally relict olivine may be present (e.g. 141-146 cm). In thin section, olivine grains are replaced by serpentine in addition to talc, tremolite and chlorite. Pyrite is found in the lower part of the section (e.g. Pieces 10, 13, 15).

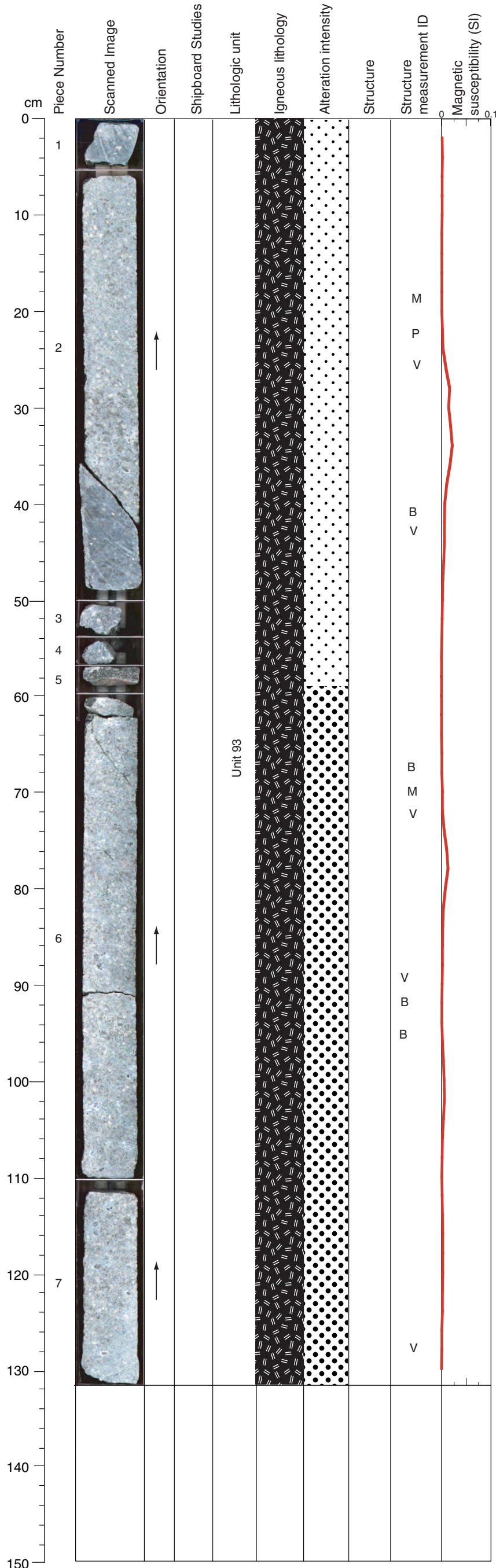
VEIN ALTERATION: A chlorite-tremolite-talc vein is present between 22-30 cm (X-ray data).

THIN SECTIONS:
304-U1309D-39R-2, 19.0- 22.0 cm (#181)
304-U1309D-39R-2, 65.0- 68.0 cm (#182)

STRUCTURE: Feldspar-rich and olivine-rich sections control the alteration (A). Dark veins (V) crosscut the alteration.



Core Photo



304-U1309D-39R-3 (Section top: 213.00 mbsf)

UNIT-93: Olivine-bearing Gabbro
Pieces 1-7

PRIMARY MINERALOGY: Determined from Piece 2

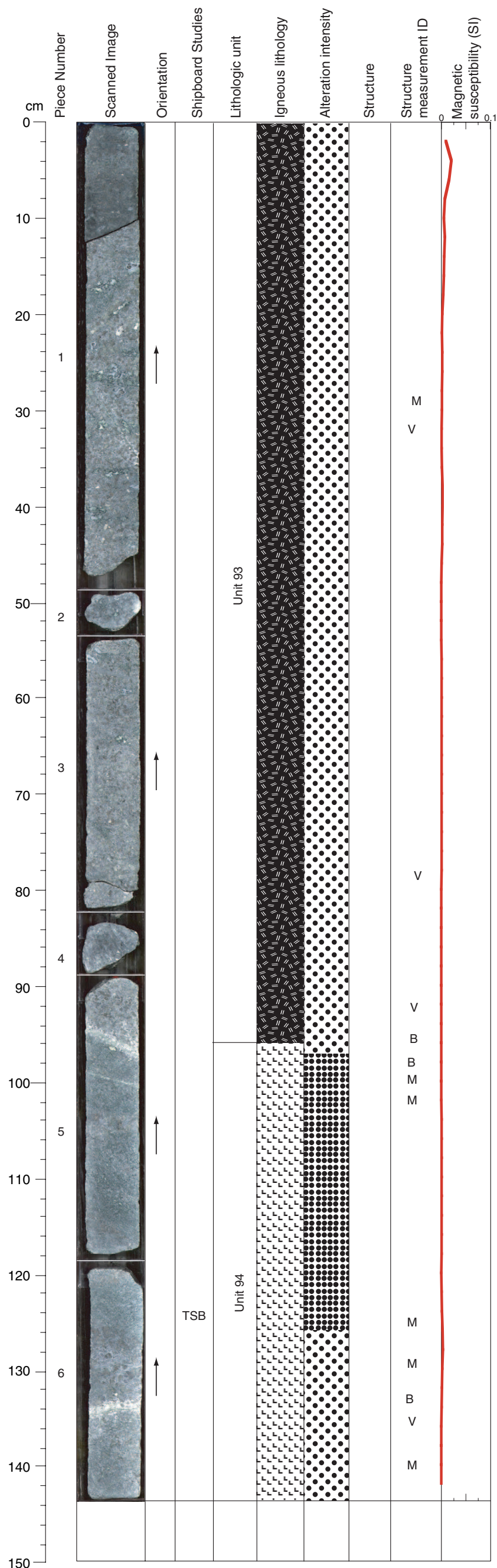
- Olivine Modal 2%
 Size 3-4mm
 Shape anhedral
- Plagioclase Modal 68%
 Size 5-10 mm
 Shape anhedral
- Clinopyroxene Modal 30%
 Size 5-10 mm
 Shape anhedral

COMMENTS: This unit consists of coarse-grained olivine-bearing gabbro, contains less olivine compared to Unit 92. Grain size increases to 60 cm where medium sizes occur again. Clinopyroxene-contents decrease at 127 cm. Magmatic foliation is visible throughout the section.

SECONDARY MINERALOGY: This section consists of slightly altered gabbro and moderately altered olivine gabbro. Ferromagnesian minerals are partially altered to actinolite/tremolite +/- chlorite. Some large coronitic patches (pseudomorphs after olivine) consisting of tremolite + chlorite +/- talc, rimmed by chlorite are present within the olivine gabbro (e.g. at 67, 82, 127 cm). In some patches relict olivine survived alteration. Most of the plagioclase and pyroxene are unaltered.

STRUCTURE: Interstitial microcracked/recrystallized feldspar, in otherwise coarse-grained gabbro. Grades into a feldspar-rich domain without well-developed feldspar-rich veins. Steeply dipping dark green veins cut troctolitic portions toward the base of the section. See Structure Measurement ID column for structure locations.

Core Photo



304-U1309D-39R-4 (Section top: 214.31 mbsf)

UNIT-93: Olivine-bearing Gabbro
Pieces 1-5

PRIMARY MINERALOGY: Determined from Piece 3A

- Olivine Modal 2%
 Size 3 mm
 Shape anhedral
- Plagioclase Modal 63%
 Size 3-5 mm
 Shape anhedral
- Clinopyroxene Modal 35 %
 Size 3-10 mm
 Shape anhedral

COMMENTS: This section represents the continuation of the olivine-bearing gabbro from Section U1309D-39R-003. Coarse grain sizes persist and magmatic foliation is visible throughout the section. Subparallel olivine-rich layers occur at 16 cm, 19 cm, 26 cm, 32 cm, 36 cm, 41 cm, and 56 cm. Further down section they occur in patches rather as layers.

UNIT-94: Troctolitic Gabbro
Pieces 5-6

PRIMARY MINERALOGY: Determined from Piece 5

- Olivine Modal 15%
 Size 2-3 mm
 Shape anhedral
- Plagioclase Modal 55%
 Size 3-4 mm
 Shape anhedral
- Clinopyroxene Modal 30%
 Size 3-5 mm
 Shape anhedral
- Orthopyroxene Modal <1%
 Size 3 mm
 Shape anhedral

COMMENTS: Unit 94 consists of medium-grained troctolitic gabbro with gabbroic domains. Orthopyroxene is present at 103 cm, and between 126 cm and the end of the section at 143 cm an orthopyroxene-rich domain occurs. A troctolitic area occurs between 120 and 125 cm.

SECONDARY MINERALOGY: This core section consists of moderately to highly altered ol-gabbros and moderately altered gabbro. Most of the plagioclase is fresh. Pyroxenes are partially altered to actinolite/ tremolite. Some brown hornblende may be present in the olivine gabbro. Coronitic textures with tremolite + chlorite +/- talc, rimmed by chlorite after olivine are present in the upper and central part of the section. Some of the large coronitic patches still contain relict olivine (e.g. at 27, 29 cm)

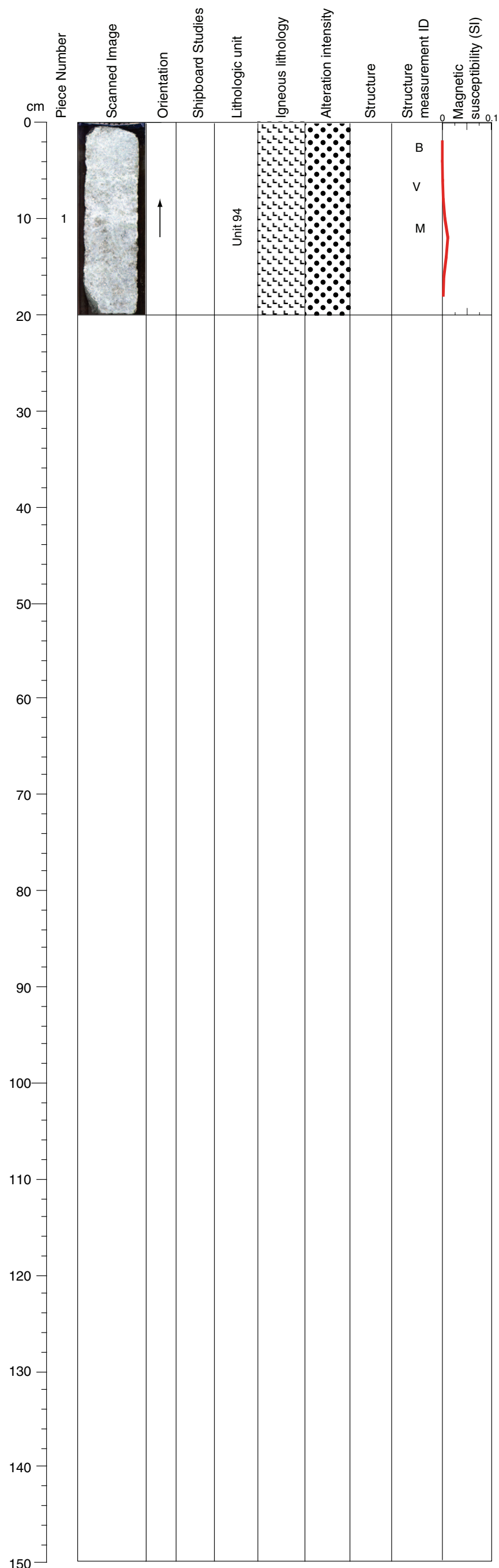
VEIN ALTERATION: Felsic dikes with albite and actinolite are present at ca. 95 cm and 133 cm.

THIN SECTIONS:
304-U1309D-39R- 4,124.0- 127.0 cm (#183)

STRUCTURE: Troctolitic intervals grade in and out of coarse-grained gabbro. Pieces 5 and 6 preserve an interval remarkable for grain size variation in gabbros with the layering cut by dioritic intrusions. See Structure Measurement ID column for structure locations.



Core Photo



304-U1309D-39R-5 (Section top: 215.74 mbsf)

UNIT-94: Troctolitic gabbro
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1

Olivine Modal <1%
 Size 3 mm
 Shape anhedral

Plagioclase Modal 70%
 Size 5 mm
 Shape anhedral

Clinopyroxene Modal 30%
 Size 5-15 mm
 Shape anhedral

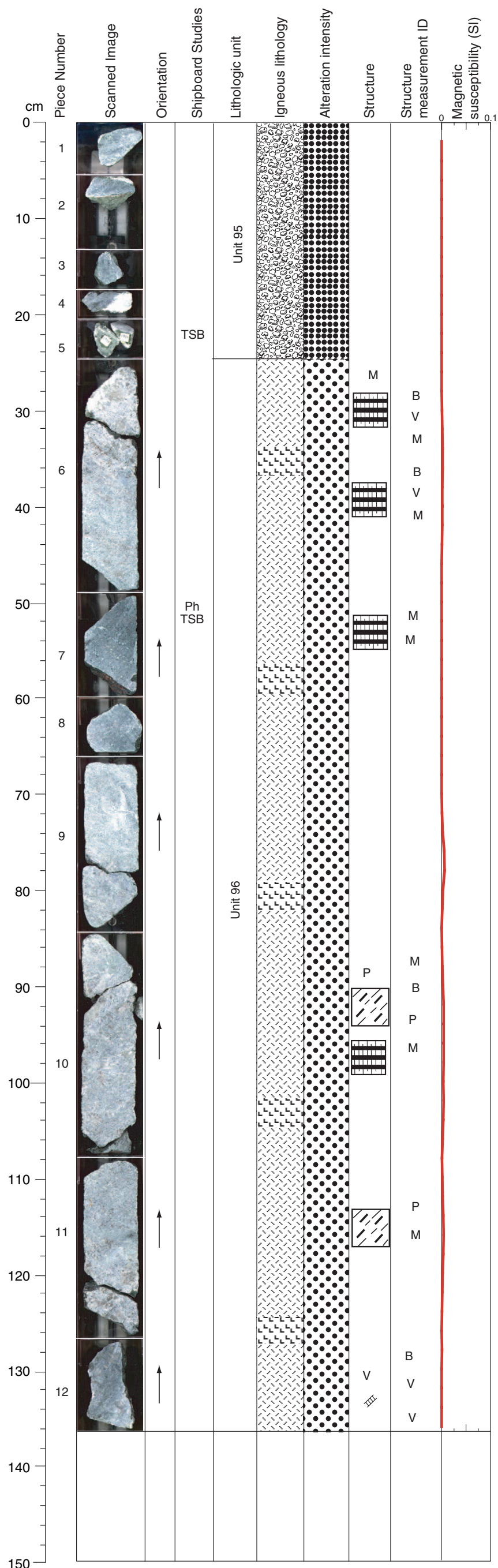
COMMENTS: This section consists of a single piece of medium-grained troctolitic gabbro.

SECONDARY MINERALOGY: This section consists of highly altered olivine gabbro. Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxenes seem to have survived alteration. Some brown hornblende and albite seems to be present.

VEIN ALTERATION: A cm-scale felsic dike with albite, actinolite and brown hornblende is present.

STRUCTURE: Coarse-grained gabbro with a feldspar-rich domain (not a vein) near 10 cm. No structure symbols inserted.

Core Photo



304-U1309D-40R-1 (Section top: 214.80 mbsf)

UNIT-95: Mixed Rubble
Pieces 1-5

COMMENTS: This unit consists of several pieces of troctolite that are presumed to be out of place. Pieces 2 to 5 have quartz growing on the margins.

UNIT-96: Alternating Gabbro and Troctolitic Gabbro
Pieces 6-12

PRIMARY MINERALOGY: Determined from Piece 9A

Olivine Modal 30%
Size 1-3 mm
Shape anhedral

Plagioclase Modal 58%
Size 1-3 mm
Shape anhedral

Clinopyroxene Modal 12%
Size 1-3 mm
Shape anhedral

COMMENTS: This unit consists of medium-grained gabbro and troctolitic gabbro, and is very similar to Unit 94. A 7 mm thick microgabbro dike cuts the magmatic foliation at 52 cm. Coarse-grained gabbro dikes occur between 25-34 cm, 76-78 cm and 116-129 cm. Orthopyroxene grains commonly occur close to the dike margins in the host rock.

SECONDARY MINERALOGY: This section consists of highly altered troctolite and moderately altered gabbro. Ferromagnesian minerals are partially altered to actinolite/tremolite +/- chlorite. Some brown hornblende may be present in the gabbro. Coronitic textures with tremolite + chlorite +/- talc, rimmed by chlorite (pseudomorphs after olivine) characterize the troctolite.

VEIN ALTERATION: A cm-scale felsic dike with albite, quartz, actinolite and pyrite is present at 18-24 cm. A similar mineral assemblage on the surface of Piece 2.

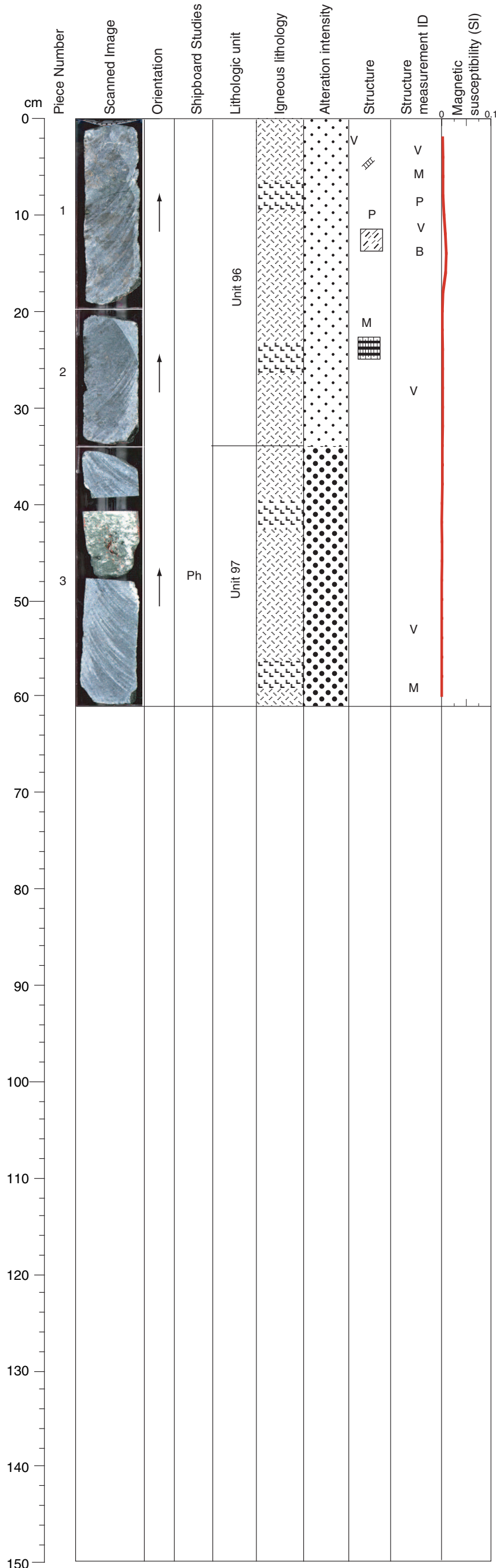
THIN SECTIONS:
304-U1309D-40R-1, 21.0-24.0cm (#186)
304-U1309D-40R-1, 52.0-55.0cm (#187)

STRUCTURE: Olivine-bearing gabbro with a weakly defined magmatic fabric (M) (moderate dip to 270 in the core reference frame). Minor alteration and bands of pyroxene enrichment follow the fabric (near 50 cm). Coarse-grained intrusions have well-defined contacts (see Primary Mineralogy Comments) although the contacts are not particularly sharp. In Piece 9 there is a concentration in diorite, although it does not define a vein. A very weak crystal plastic fabric (P) is present in Pieces 10 and 11. A blue vein (V) cuts all fabrics in Piece 12, and is subhorizontal. M>P>V

CLOSE UP PHOTOGRAPHS:
1309D_40R_1_50-56.jpg



Core Photo



304-U1309D-40R-2 (Section top: 216.17 mbsf)

UNIT-96: Alternating Gabbro and Troctolitic Gabbro
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 1

Plagioclase Modal 55%
Size 5-10 mm average, 25 maximum
Shape anhedral

Clinopyroxene Modal 45%
Size 5-15 mm average, 30 mm maximum
Shape anhedral

COMMENTS: Piece shows very coarse grain sizes and a high modal concentration of orthopyroxene (4%). Piece 2 does not contain orthopyroxene.

UNIT-97: Alternating Gabbro and Troctolitic Gabbro
Piece 3

PRIMARY MINERALOGY: Determined from Piece 3C

Olivine Modal 20%
Size 1-2 mm
Shape anhedral

Plagioclase Modal 66%
Size 2-3 mm
Shape anhedral

Clinopyroxene Modal 14%
Size 1-2 mm
Shape anhedral

COMMENTS: Unit 97 consists of a single piece of medium-grained gabbro with troctolitic gabbro domains. This unit differs in grain size but is otherwise similar to Unit 96. Magmatic foliation is visible in the piece. Amphibole can be seen at the surface where the core broke along a talc-tremolite vein.

SECONDARY MINERALOGY: This section consists of slightly altered gabbro and moderately altered troctolitic gabbro. Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxene seem to be fresh. Brown hornblende is present in the gabbro. Coronitic textures with tremolite + chlorite +/- talc, rimmed by chlorite (alteration of olivine) characterize the troctolitic gabbro.

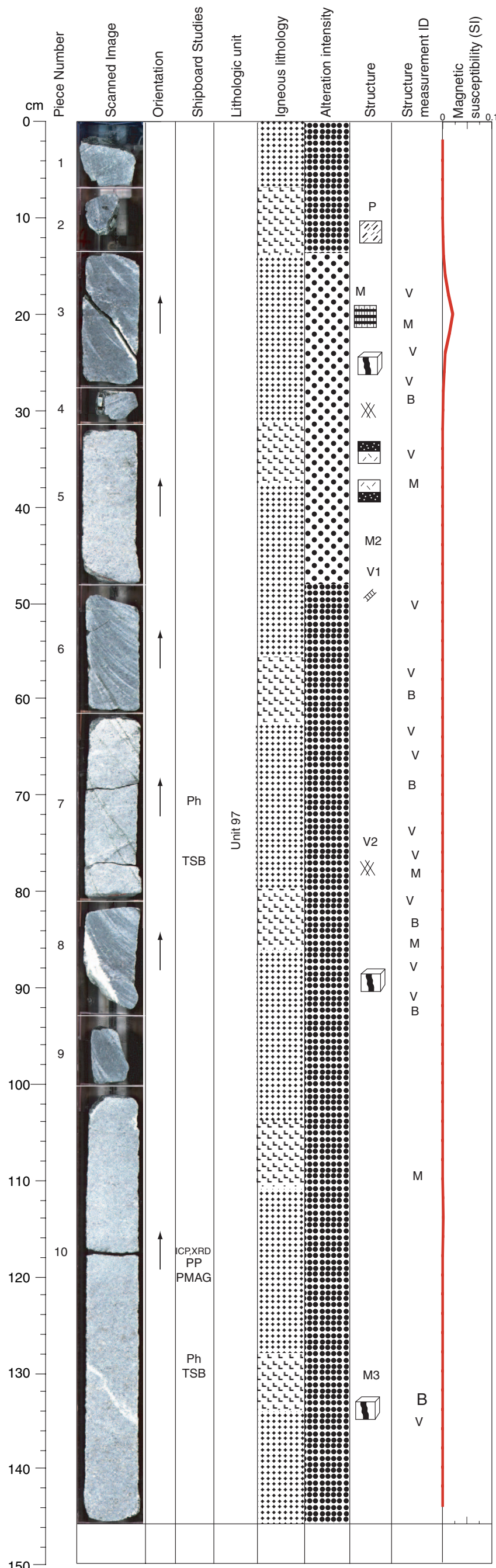
VEIN ALTERATION: Several small ?actinolite veins are present in Piece 1.

STRUCTURE: A weak crystal plastic texture (P) superposed on the magmatic fabric (M) produces an interesting granularity to the gabbro. The fabric is inclined out of the plane of the saw cut. Piece 3, in particular, is cut to afford a view of a mineral lineation defined by pyroxene. Dark and light veins (V) cut across the fabric.

CLOSE UP PHOTOGRAPHS:
1309D_40R_2_40_46.jpg



Core Photo



304-U1309D-41R-1 (Section top: 219.50 mbsf)

UNIT-97: Alternating Troctolitic and Olivine Gabbro
Pieces 1-10

PRIMARY MINERALOGY: Determined from Piece 10 (Troctolitic Gabbro)

Olivine	Modal 20% Size 1-2 mm Shape anhedral
Plagioclase	Modal 68% Size 2-3 mm Shape anhedral
Clinopyroxene	Modal 12% Size 2-4 mm Shape anhedral

PRIMARY MINERALOGY: Determined from Piece 10B (Olivine Gabbro)

Olivine	Modal 15% Size 1-2 mm Shape anhedral
Plagioclase	Modal 70 % Size 2-3 mm Shape anhedral
Clinopyroxene	Modal 15% Size 2-4 mm Shape anhedral

COMMENTS: Unit 97 consists of alternating medium-grained troctolitic and olivine gabbro. The section is heterogeneous in terms of grain size and distribution of clinopyroxene. Various alteration veins cross the section at 22 cm, 35 cm, 61 cm, 67 cm, 72 cm and 132 cm.

SECONDARY MINERALOGY: This section consists of highly altered troctolitic gabbro (0-11 cm, 48-145 cm) and moderately altered olivine gabbro (14-48 cm). Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxene are fresh. Some brown hornblende may be present in the olivine gabbro. Coronitic textures with tremolite + chlorite +/- talc, rimmed by chlorite after olivine are present in the troctolitic part of the section (e.g. in Piece 10a).

VEIN ALTERATION: A 0.5-cm vein with secondary plagioclase and actinolite/ tremolite is present between 20-25 cm. A cm-scale felsic dike with albite + actinolite/ tremolite is present in Piece 8.

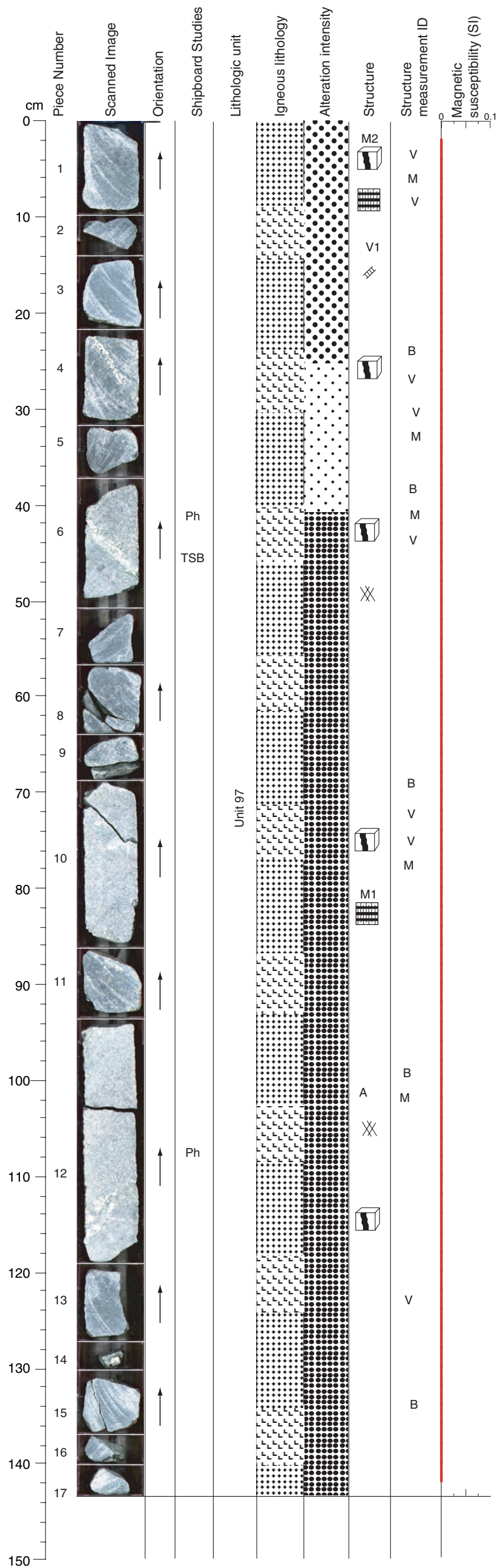
THIN SECTIONS:
[304-U1309D-40R-1, 21.0-24.0 cm \(#186\)](#)
[304-U1309D-40R-1, 52.0-55.0 cm \(#187\)](#)

STRUCTURE: Foliated troctolite with a slight crystal plastic (P) texture superposed on the magmatic fabric (M1). Piece 8 preserves an intrusion of gabbro into the troctolite (M2). Early high-temperature amphibole veins (V1) are found within the troctolite, but not the gabbro(?). Near the gabbroic intrusion, and in Pieces 9 and 10, feldspar-rich veins (M3) cut all other layering and fabric. Thinner white veins and thicker green veins (V2) extend from these magmatic intrusions, and are found throughout the section. M>P>V1>(?)M2>M3>V2

CLOSE UP PHOTOGRAPHS:
[1309D_41R_1_70_92.jpg](#)
[1309D_41R_1_128_138.jpg](#)



Core Photo



304-U1309D-41R-2 (Section top: 220.95 mbsf)

UNIT-97: Alternating Troctolitic and Olivine Gabbro
Pieces 1-17

PRIMARY MINERALOGY: Determined from Piece 10

- Olivine Modal 15%
Size 2-3 mm
Shape anhedral
- Plagioclase Modal 65%
Size 3 mm
Shape anhedral
- Clinopyroxene Modal 20%
Size 3-6 mm
Shape anhedral

COMMENTS: This unit consists of olivine and troctolitic gabbro with mostly medium grain sizes. Changes in pyroxene content occur throughout the section and Piece 3 is a troctolite. Grain sizes are grading within the section but are also very heterogeneous within pieces. Between 107 and 113 cm, a coarser interval occurs. Magmatic layering is strongly developed. Alteration vein occurs at 27 and 46 cm.

SECONDARY MINERALOGY: This section consists of moderately to highly altered olivine gabbro with some troctolitic layers. Olivine is completely replaced by tremolite + chlorite + talc + carbonate + magnetite and rimmed by chlorite in the troctolitic parts of the section (e.g. in Piece 3). Few brown hornblende relics are present.

VEIN ALTERATION: Centimeter-scale late magmatic leucocratic dikes with albite, actinolite and brown hornblende are present in Pieces 4 and 6.

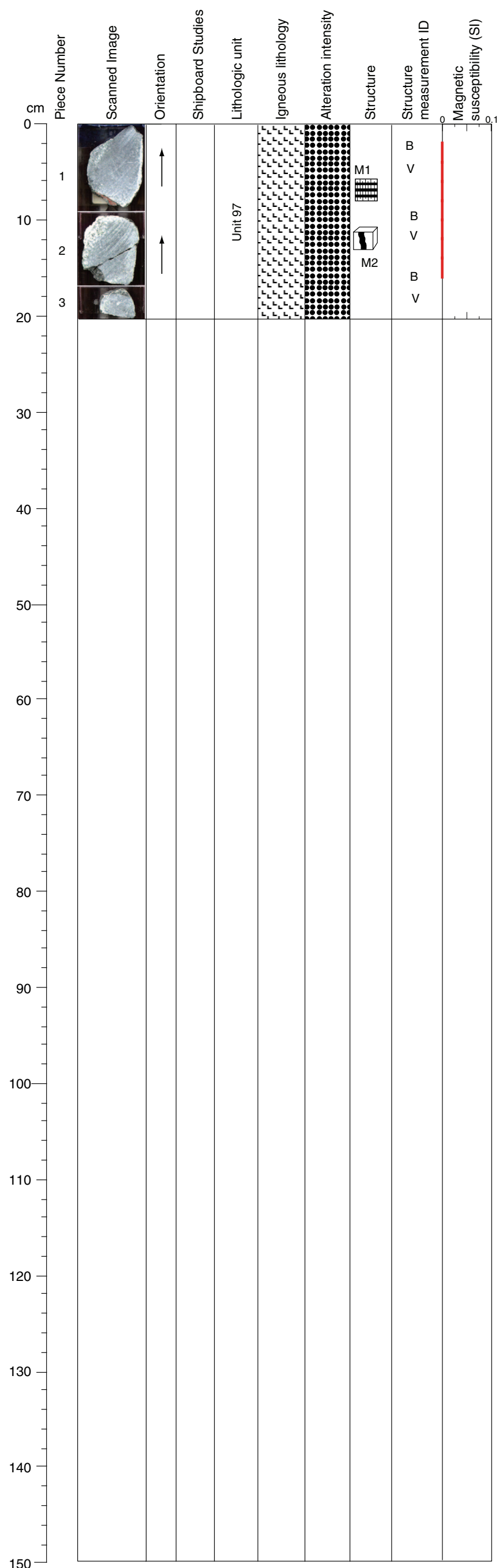
THIN SECTIONS:
[304-U1309D-41R-2, 45.0-47.0 cm \(#190\)](#)

STRUCTURE: Magmatic layering (M) throughout the section, but best developed in Pieces 1 and 11; the latter is the more coarse grained. Dark amphibole (high-temperature) veins (V1) are found locally. Veins of diorite (M2) cut all other magmatic features, but are parallel to the magmatic foliation in Pieces 5 and 6. The dioritic veins apparently localize later alteration (A). Away from the dioritic veins, the fine-grained, granular feldspar is interstitial to the gabbro. M>V1>M2>A

CLOSE UP PHOTOGRAPHS:
[1309D_41R_2_40_50.jpg](#)
[1309D_41R_2_107-119.jpg](#)



Core Photo



304-U1309D-41R-3 (Section top: 222.38 mbsf)

UNIT-97: Alternating Troctolitic and Olivine Gabbro
Pieces 1-3

PRIMARY MINERALOGY: Determined from Piece 1

Olivine Modal 20%
 Size 1-2 mm
 Shape anhedral

Plagioclase Modal 73%
 Size 3-6 mm
 Shape anhedral

Clinopyroxene Modal 7%
 Size 1 mm
 Shape anhedral

COMMENTS: This section consists of medium-grained troctolitic gabbro. An alteration vein cuts Piece 2 at the edge.

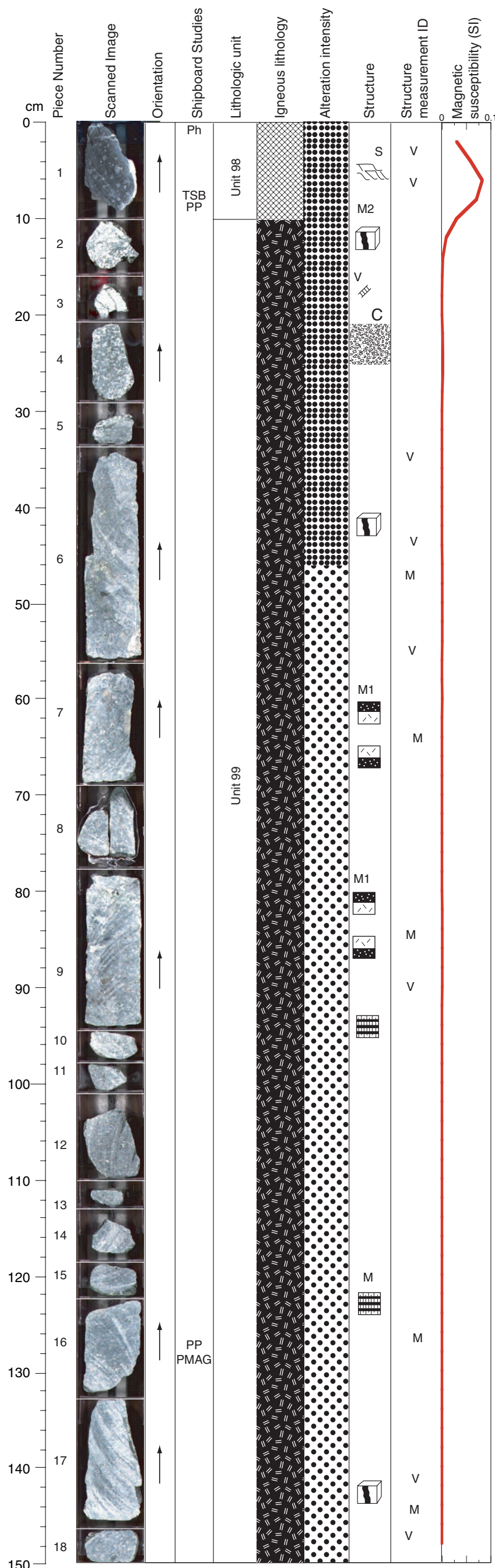
SECONDARY MINERALOGY: This section consists of highly altered troctolitic gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Coronitic textures of olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite are characteristic.

VEIN ALTERATION: A cm-scale breccia vein with albite, actinolite and few brown hornblende is present at 10-15 cm.

STRUCTURE: Troctolitic gabbro cut by diorite vein (M2). A magmatic (possible crystal plastic) texture (M1) mixes some diorite with the troctolite; the diorite largely cuts the troctolitic gabbro. M1>M2



Core Photo



304-U1309D-42R-1 (Section top: 224.30 mbsf)

UNIT-98: Harzburgite
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1

- Olivine Modal 85-90%
Size too altered
Shape too altered
- Pyroxene Modal 10-15%
Size 3-5 mm
Shape anhedral

COMMENTS: Unit 98 consists of a single piece of peridotite. It shows heterogeneous distribution of pyroxenes (one cutting surface contains 10%, the other 15% pyroxenes. Pyroxenes show olivine inclusions and corroded textures in the binocular suggesting an impregnation event. Olivine cores are preserved in some parts. Several carbonate veins occur and a talc-tremolite vein is cut at the upper edge of the piece.

UNIT-99: Olivine-bearing Gabbro
Pieces 2-18

PRIMARY MINERALOGY: Determined from Piece 7 (Coarse-grained Gabbro)

- Olivine Modal <1 %
Size 3 mm average, 12 mm maximum
Shape anhedral
- Plagioclase Modal 60%
Size 5-7 mm average, 11 mm maximum
Shape anhedral
- Clinopyroxene Modal 40%
Size 3-7 mm average, 30 mm maximum
Shape anhedral

PRIMARY MINERALOGY: Determined from Piece 6 (Medium-grained olivine-bearing Gabbro)

- Olivine Modal 1-2 %
Size 1-2 mm
Shape anhedral
- Plagioclase Modal 49%
Size 3-4 mm
Shape anhedral
- Clinopyroxene Modal 49%
Size 2-4 mm
Shape anhedral

COMMENTS: Unit 99 consists of medium-grained olivine-bearing gabbro. Between 46 to 87 cm and 77 to 87 cm coarse-grained gabbro dikes occur. A dioritic dike occurs at 80 cm. Magmatic foliation is visible in Pieces 10 to 18.

SECONDARY MINERALOGY: The uppermost part of this section consists of highly serpentinized peridotite in which olivine is partly altered to serpentine and magnetite; pyroxene is altered to tremolite along its margins. The remainder of this section consists of moderately to highly altered gabbro and olivine gabbro. Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Some brown hornblende may be present, especially in association with the felsic veins (see below). Coronitic textures with tremolite + chlorite +/- talc, rimmed by chlorite (alteration of olivine) are present in the olivine gabbro (e.g. Piece 16).

VEIN ALTERATION: A talc-tremolite + pyrite vein is present in the serpentinite (Piece 1). A felsic dike with albite, brown hornblende and actinolite is present at 14-19 cm.

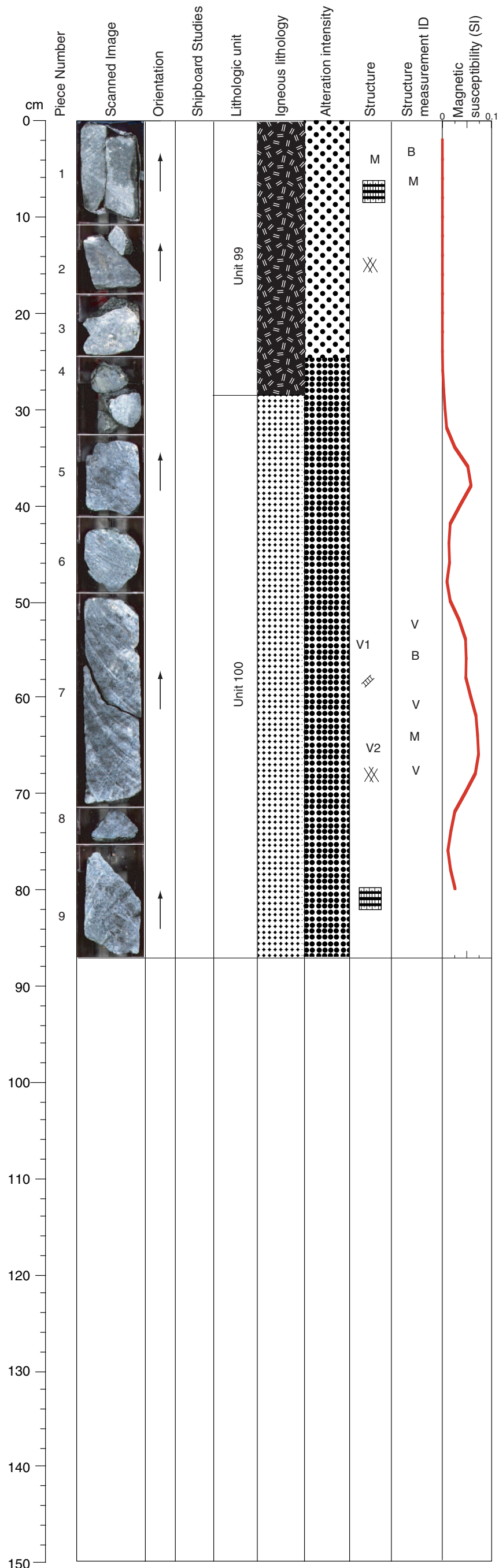
THIN SECTIONS:
304-U1309D-42R-1, 7.0-9.0 cm (#191)

STRUCTURE: The top of the section is an ultramafic rock with a serpentine-rich vein (S) on the corner of the piece. The two pieces below the serpentinite are diorites (M2) with internal textures (a weak subhorizontal fabric (C) defined by plagioclase and hornblende) and an alteration overprint. Although partly cataclastic, the brittle texture may be related to the diorite (i.e. not necessarily a fault contact between gabbro and peridotite). The gabbro below the dioritic vein has a well-defined layering (M), and is relatively coarse-grained (grain size coarsens in the middle of the section). Intrusive contacts are preserved between a coarse grained gabbro and finer grained dioritic rocks present throughout the section. Dark amphibole (hornblende?) veins (V) cut both units, and green alteration and veining is localized along the contact. Troctolitic gabbros occur in Pieces 8 and 9, and the coarse-grained gabbros intrude these (and the dioritic gabbros intrude the coarse-grained gabbros) (M1). M>M1>M2>C>V

CLOSE UP PHOTOGRAPHS:
1309D_42R_1_0_10.jpg
1309D_42R_1_0_10_2.jpg



Core Photo



304-U1309D-42R-2 (Section top: 225.80 mbsf)

UNIT-99: Olivine-bearing Gabbro
Pieces 1-4

PRIMARY MINERALOGY: Determined from Piece 1

- Olivine Modal 2%
 Size 2-3 mm
 Shape anhedral
- Plagioclase Modal 68%
 Size 3 mm
 Shape anhedral
- Clinopyroxene Modal 30%
 Size 3-4 mm
 Shape anhedral

COMMENTS: This section starts with medium-grained olivine-bearing gabbro. Magmatic foliation is well developed in Piece 1. Pieces 2 to 4 show coarser grain sizes as large as 25 mm and represent a dike.

UNIT-100: Olivine Gabbro
Pieces 4-9

PRIMARY MINERALOGY: Determined from Piece 7

- Olivine Modal 40%
 Size 4-7 mm average, 11 mm maximum
 Shape anhedral
- Plagioclase Modal 40%
 Size 5 mm average, 12 mm maximum
 Shape anhedral
- Clinopyroxene Modal 20%
 Size 3-7 mm
 Shape anhedral

COMMENTS: This unit starts with troctolitic gabbro in Pieces 5 and 6 and grades to olivine gabbro. They show medium grain sizes and magmatic foliation.

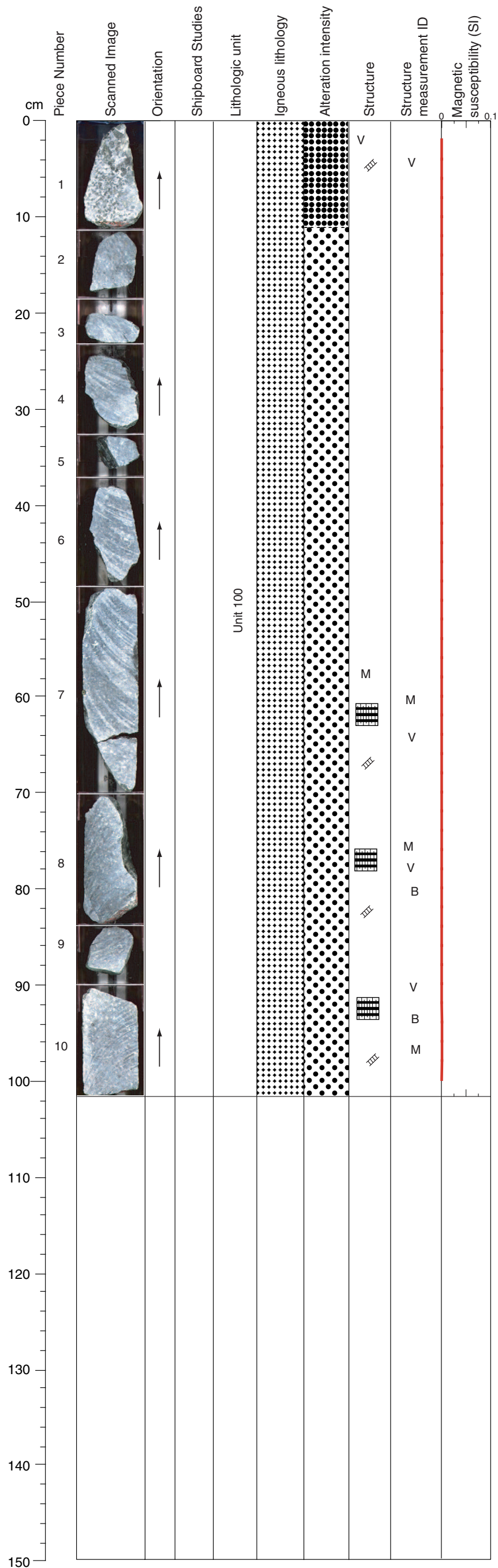
SECONDARY MINERALOGY: This section consists of moderately altered gabbro in the upper part (0-25 cm) and highly altered troctolite in the lower part (25-75 cm). Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxene are fresh. Some brown hornblende may be present in the gabbro. Coronitic textures with tremolite + chlorite +/- talc, rimmed by chlorite are caused by olivine alteration and characterize the troctolitic part of the section.

VEIN ALTERATION: A tremolite vein at 68 cm.

STRUCTURE: Weak, steeply dipping troctolitic fabric (M) is variable throughout the section (see Piece 9). Dark, >1 mm-wide veins (V) cut the troctolite. Thin, milky-white veins (V2) also cut the troctolite (see Pieces 6-7). M>V>V2



Core Photo



304-U1309D-43R-1 (Section top: 228.80 mbsf)

UNIT-100: Olivine Gabbro
Pieces 1-10

PRIMARY MINERALOGY: Determined from Piece 6

Olivine Modal 7%
Size 3-4 mm
Shape anhedral

Plagioclase Modal 63%
Size 4 mm
Shape anhedral

Clinopyroxene Modal 30%
Size 3-5 mm
Shape anhedral

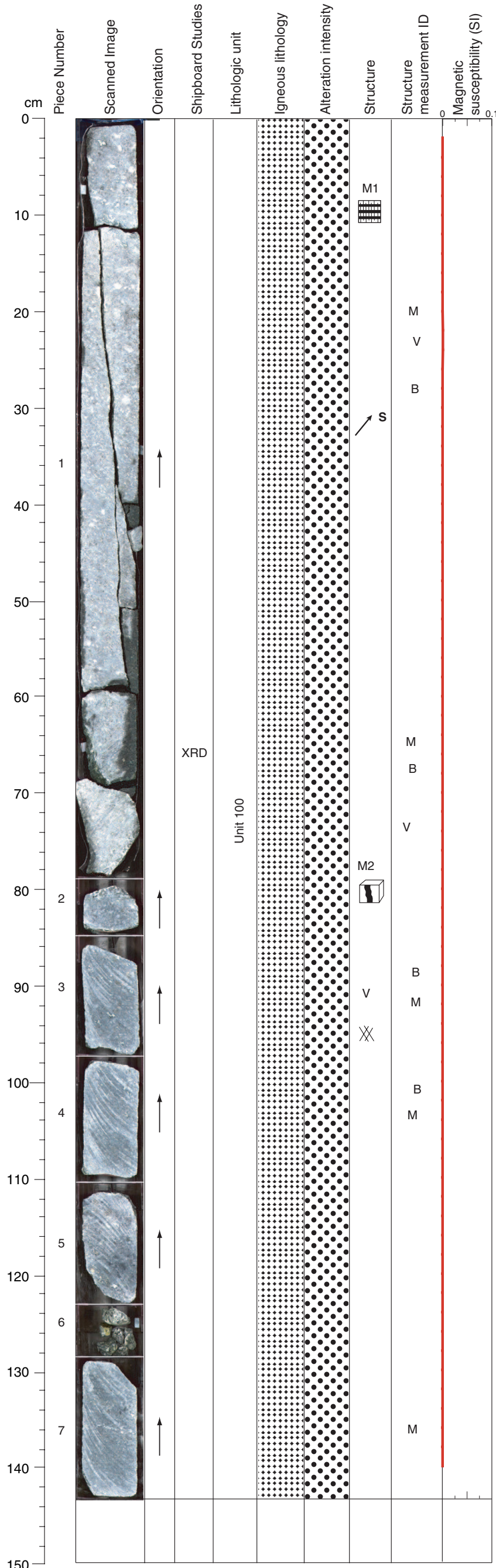
COMMENTS: Section U1309D-43R-1 consists of medium-grained olivine gabbro with pyroxene-rich and -poor layers. Magmatic foliation is present throughout the section. Toward the end of the section (Piece 10), spacing of gabbroic areas is wider and olivine occurs in patches.

SECONDARY MINERALOGY: This section consists of highly altered gabbro in the upper part (0-12 cm), with moderately altered olivine gabbro below. Ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxene have survived alteration. Substantial brown hornblende is present in the gabbro Piece 1. Coronitic textures with tremolite + chlorite +/- talc, rimmed by chlorite are caused by olivine alteration and characterize some layers within the olivine gabbro (e.g. at 50-55 cm).

VEIN ALTERATION: Tremolite-talc veins in top of Piece 10 and on right side of Piece 8.

STRUCTURE: Coarse-grained gabbro with diorite, cut by dark amphibole (hornblende?) veins (V). Layers of troctolite although no foliation overall, up to Piece 10 where a magmatic (M) fabric intensifies. M>V

Core Photo



304-U1309D-43R-2 (Section top: 229.92 mbsf)

UNIT-100: Olivine Gabbro
Pieces 1-7

PRIMARY MINERALOGY: Determined from Piece 4

Olivine	Modal 12% Size 2-3 mm Shape anhedral
Plagioclase	Modal 58% Size 4-5 mm Shape anhedral
Clinopyroxene	Modal 30% Size 3-5 mm Shape anhedral

COMMENTS: This unit consists of medium-grained olivine gabbro with olivine-rich areas between 5-14 cm and 81-101 cm. A coarse-grained interval occurs between 118-121 cm and represents a dike. Magmatic foliation is visible throughout the section.

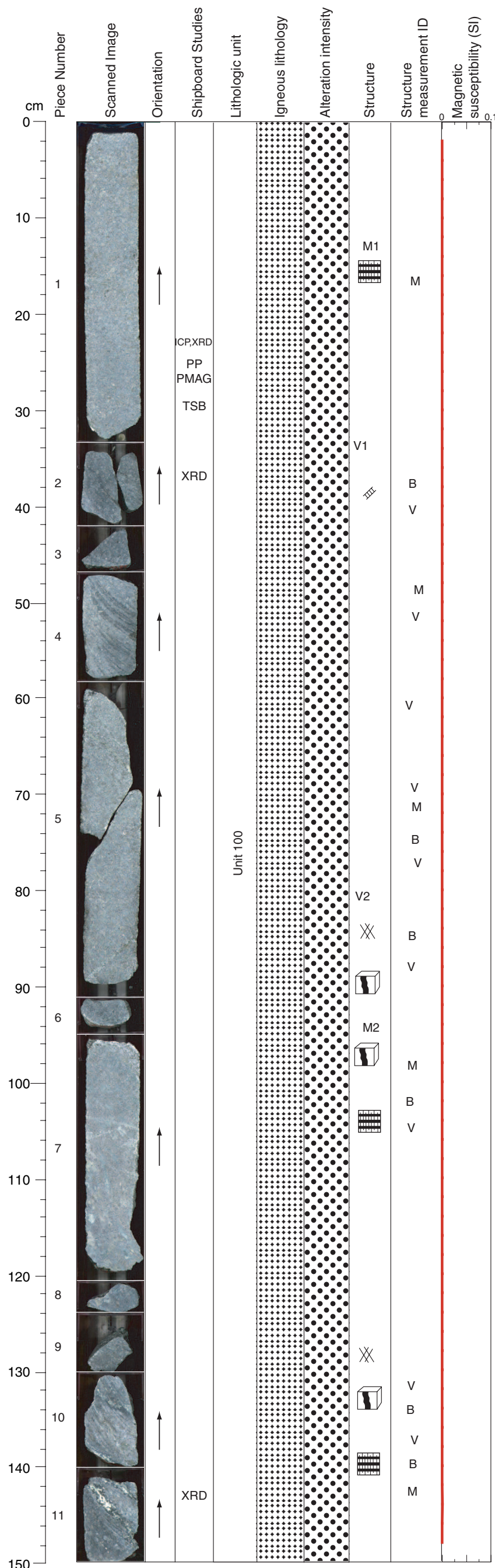
SECONDARY MINERALOGY: This section consists of moderately altered olivine gabbro in which ferromagnesian minerals are partially altered to actinolite/tremolite +/- chlorite. Most of the plagioclase and pyroxene have survived alteration. Coronitic patches with tremolite + chlorite +/- talc, rimmed by chlorite (caused by olivine alteration) are present (e.g at 8-11 cm). Sulfides are found in Pieces 4 and 5.

VEIN ALTERATION: A tremolite vein runs vertically throughout Piece 2. Between 65-66 cm, a vein with calcite, clays (saponite?) and pale amphibole is present.

STRUCTURE: Alteration rims on pyroxene, plagioclase, and olivine follow a weak magmatic fabric (M). One face, now a drilling fracture, has an oblique lineation. A diorite vein (M2) cuts the fabric in Piece 2. Below this piece there is little to no diorite in the section. Green veins (V) cuts the fabric in Pieces 3 through 7. M>M2>V



Core Photo



304-U1309D-44R-1 (Section top: 233.20 mbsf)

UNIT-100: Olivine Gabbro
Pieces 1-11

PRIMARY MINERALOGY: Determined from Piece 5B

Olivine	Modal 12% Size 1-2 mm Shape anhedral
Plagioclase	Modal 58% Size 3-5 mm Shape anhedral
Clinopyroxene	Modal 30% Size 2-5 mm Shape anhedral

COMMENTS: This section consists of medium-grained olivine gabbro and represents the continuation of the previous Section U1309D-43R-2. Magmatic foliation is visible throughout the section and has been overprinted by deformation in Piece 7. Fine-grained pyroxene-rich areas formed with 'schlieren' of olivine. Alteration veins cross the section at 35 cm, 49 cm, 64 cm, 86 cm, 104 cm, 140 cm and 144 cm.

SECONDARY MINERALOGY: This section consists of moderately altered gabbro and olivine gabbro in which pyroxenes are slightly altered to actinolite/tremolite. Most of the plagioclase appears fresh. Olivine is completely altered to tremolite + chlorite +/- talc forming coronitic textures with a rim of chlorite. In places a local late alteration of olivine to an interstratified chlorite-clay (possibly to sudite after XRD) mineral is observed (e.g. yellow-white patches between 142-147 cm).

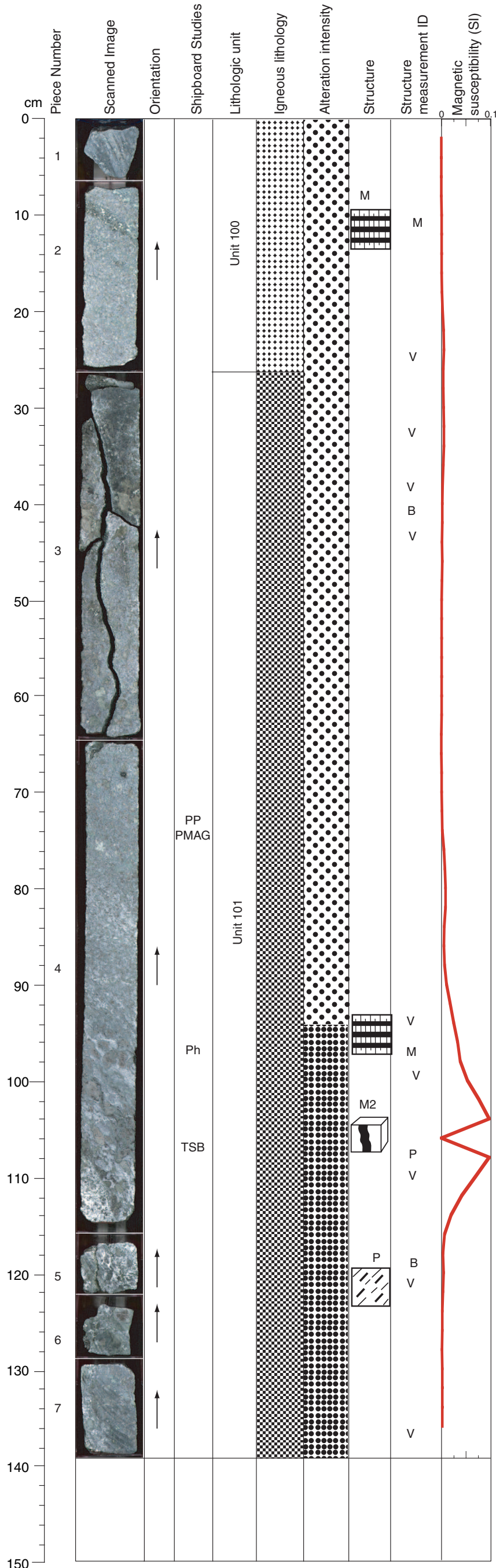
VEIN ALTERATION: Actinolite/tremolite veins with halos of altered plagioclase are observed (e.g. at 104 cm). Between 36-37 cm, a vein with amphibole and clays (saponite?) is observed (X-ray data).

THIN SECTIONS:
304-U1309D-44R-1, 29.0-32.0 cm (#192)

STRUCTURE: Coarse-grained gabbro with a weak foliation (M1), with a possible small concentration of interstitial diorite. Foliation intensifies toward Piece 7 where there are small diorite veins (M2) that localize alteration. Dark (high-temperature) amphibole veins (V1) are parallel to the magmatic foliation. In Piece 5, a talc(?) -rich vein (V2) forms the center of a dioritic intrusion (the dioritic intrusion does not have well-defined vein walls). Note that this section, like many others above and below, does not have pronounced microcracking or cataclasis. This section is a good example of how the talc-rich veins might take up some shear strain (and therefore is the expression of brittle deformation). M1>V1(?)>M2>V2



Core Photo



304-1309D-44R-2 (Section top: 234.70 mbsf)

UNIT-100: Olivine Gabbro
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 1

- Olivine Modal 12%
Size 2 mm
Shape anhedral
- Plagioclase Modal 58%
Size 4 mm
Shape anhedral
- Clinopyroxene Modal 30%
Size 3-4 mm
Shape anhedral

COMMENTS: The section starts with medium-grained olivine gabbro that represents the continuation from the previous section.

UNIT-101: Disseminated Oxide Gabbro
Pieces 3-7

PRIMARY MINERALOGY: Determined from Piece 3 (Oxide Gabbro)

- Olivine Modal <1 %
Size 2-3 mm
Shape anhedral
- Plagioclase Modal 68%
Size 3-7 mm
Shape anhedral
- Clinopyroxene Modal 30%
Size 3-6 mm average, 20 mm maximum
Shape anhedral
- Oxide Modal 2%
Size fine-grained to 2 mm
Shape anhedral

PRIMARY MINERALOGY: Determined from Piece 4 (94-138 cm interval) (Coarser-grained Oxide Gabbro)

- Plagioclase Modal 60%
Size 5-11 mm
Shape anhedral
- Clinopyroxene Modal 35%
Size 7 mm average, 20 mm maximum
Shape anhedral
- Oxide Modal 5%
Size fine-grained to 6 mm
Shape anhedral

COMMENTS: Unit 101 consists of gabbro with about 2% of oxides disseminated in the matrix. Olivine is not present until Piece 7. An interval of oxide gabbro (with as much as 5% oxide) shows deformation between 95 and 114 cm. A diorite dike cuts the core between 107 and 125 cm.

SECONDARY MINERALOGY: The alteration of the first 20 cm of this section is related to the alteration of olivine to chlorite (in rims) and tremolite + chlorite +/- talc in the center. The rest of the green color may be due to a slight alteration of pyroxene to actinolite. Pyroxene within the foliated gabbro between 94 and 110 cm show alteration rims of actinolite/tremolite with possibly some brown hornblende. The felsic dike that cuts the section at 110 to 121 cm is essentially altered in the greenschist facies with some possible relics of brown hornblende.

VEIN ALTERATION: A blue-white subvertical vein, made of a talc/tremolite?? assemblage cut the Piece 3.

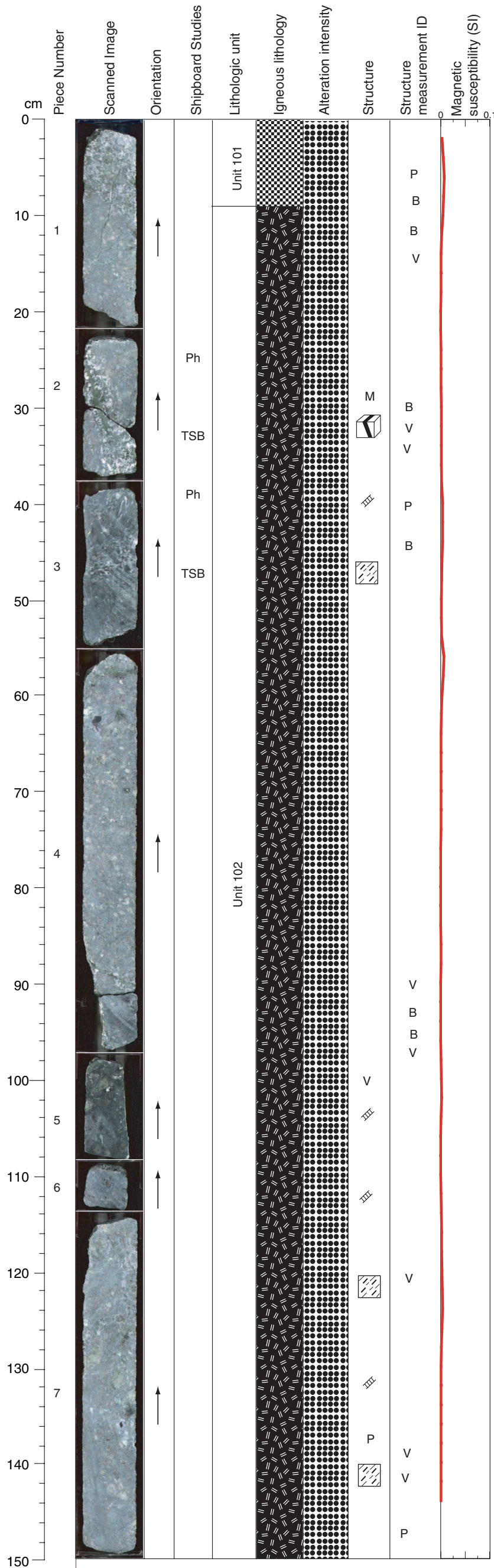
THIN SECTIONS:
304-U1309D-44R-2, 106.0-109.0 cm (#193)

STRUCTURE: Coarse-grained olivine gabbro with a magmatic fabric (M). Base of Pieces 3 through 5 are diorite (M2) (with a steeply dipping fabric) with localized green alteration. A mylonite (P) in the gabbro-diorite is well developed at the base of Piece 4 and continues through Piece 5. M>M2>P

CLOSE UP PHOTOGRAPHS:
1309D_44R_2_95-114.jpg
1309D_44R_2_95-114_2.jpg



Core Photo



304-1309D-44R-3 (Section top: 236.08 mbsf)

UNIT-101: Oxide Gabbro
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1

Plagioclase	Modal 59%
	Size 4-8 mm
	Shape anhedral
Clinopyroxene	Modal 40%
	Size 3-6 mm
	Shape anhedral
Oxide	Modal 1%
	Size <1 mm
	Shape anhedral

COMMENTS: The section begins with the continuation of the coarse-grained oxide gabbro of the previous section. This section is similar to the bottom piece of Section U1309D-44R-2 and shows the same pervasive alteration. Olivine is very rare.

UNIT-102: Olivine-bearing Gabbro
Pieces 1-7

PRIMARY MINERALOGY: Determined from Piece 4A

Olivine	Modal 3%
	Size 3 mm average, 15 mm maximum
	Shape anhedral
Plagioclase	Modal 62%
	Size 4-8 mm
	Shape anhedral
Clinopyroxene	Modal 35%
	Size 4-6 mm average, 13 mm maximum
	Shape anhedral

COMMENTS: Coarse grain sizes of about 7 mm occur throughout the section except in Piece 5 that shows larger grain sizes of as much as 20 mm. Clinopyroxene grains of as large as 26 mm occur sporadically in the section. Oxides occur in patches at 33 cm and 127 cm as well as between 51-59 cm. A finer-grained interval with brittle deformation occurs between 23-59 cm. Steeply dipping magmatic foliation is present at the bottom in Piece 7.

SECONDARY MINERALOGY: This section consists of highly altered gabbro and olivine gabbro. Substantial brown hornblende and albite are present, related to a felsic dike intrusion (Piece 2,) as well as in a high-temperature deformed part of the section (Piece 3). Large coronitic patches of olivine alteration with tremolite + chlorite +/- talc filling and rims of chlorite are present in the lower part of the section (e.g. around 63 cm).

VEIN ALTERATION: A late leucocratic magmatic dike in Piece 2 containing albite and brown hornblende shows a massive filling of actinolite/ tremolite + chlorite. Between 29-34 cm, a vein with amphibole and calcite +/- clays (saponite?) is observed (identified by XRD).

THIN SECTIONS:

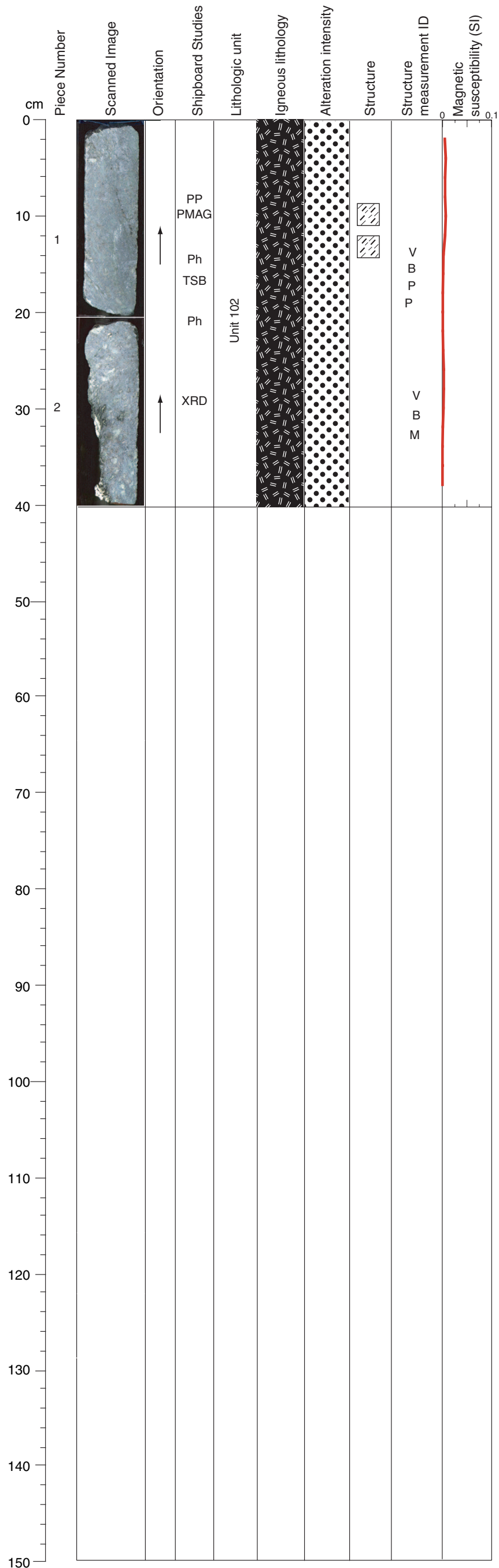
- [304-U1309D-44R-3, 32.0-34.0 cm \(#194\)](#)
- [304-U1309D-44R-3, 47.0-49.0 cm \(#195\)](#)

STRUCTURE: Contact between diorite and gabbro (M) is preserved in Piece 2 with the diorite having a brecciated texture. Black amphibole veins (V) are present throughout the section, but particularly noteworthy in Pieces 5 through 7 where they are parallel to the foliation (P) (a composite magmatic and crystal plastic fabric). M>V>P

CLOSE UP PHOTOGRAPHS:

- [1309D_44R_3_24_38.jpg](#)
- [1309D_44R_3_38_54.jpg](#)

Core Photo



304-U1309D-44R-4 (Section top: 242.14 mbsf)

UNIT-102: Olivine-bearing Gabbro
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 2

Olivine	Modal 2% Size 3-5 mm Shape anhedral
Plagioclase	Modal 63% Size 3-5 mm Shape anhedral
Clinopyroxene	Modal 35% Size 5-7 mm average, 11 mm maximum Shape anhedral

COMMENTS: This unit consists of coarse-grained olivine-bearing gabbro and shows the same near vertical magmatic foliation as seen at the bottom of the previous section. It is most intense in the interval between 13 and 30 cm. An oxide seam occurs at 10 cm.

SECONDARY MINERALOGY: Olivine is altered to tremolite + chlorite +/- talc with rims of chlorite against plagioclase. Pyroxene in the foliation shows alteration rims of actinolite, locally with earlier brown hornblende.

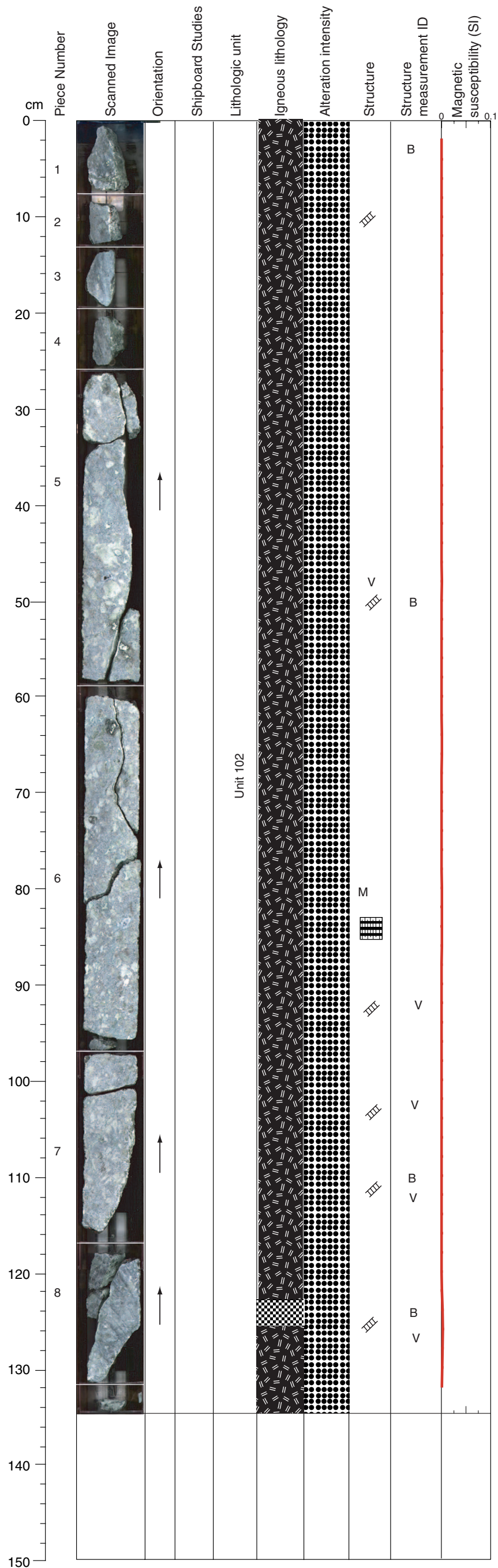
VEIN ALTERATION: A mm-scale vein of brown hornblende runs roughly parallel to the mylonitic foliation at 20 cm. Between 29-34 cm, a vein with amphibole and calcite +/- clays (saponite?) is observed (identified by XRD).

THIN SECTIONS:
[304-U1309D-44R-4, 16.0-18.0 cm \(#196\)](#)

STRUCTURE: Well-defined steeply dipping foliation, that decreases at the base of Piece 2.

CLOSE UP PHOTOGRAPHS:
[1309D_44R_4_14_20.jpg](#)
[1309D_44R_4_20_30.jpg](#)

Core Photo



304-U1309D-45R-1 (Section top: 238.00 mbsf)

UNIT-102: Olivine-bearing / Oxide Gabbro
Pieces 1-9

PRIMARY MINERALOGY: Determined from Piece 6B

- Olivine Modal 4%
Size 4-8 mm
Shape anhedral
- Plagioclase Modal 56%
Size 6-9mm
Shape anhedral
- Clinopyroxene Modal 40%
Size 6-9 mm average, 15 mm maximum
Shape anhedral

COMMENTS: Unit 102 consists of coarse-grained gabbro with olivine- and oxide-rich domains. Olivine and oxides never occur at the same place. Olivine is common between 13 and 96 cm and at 107 cm, whereas oxides occur at 125 cm. Pyroxene shows very coarse grain sizes to as large as 35 mm, with the average size of 15 mm.

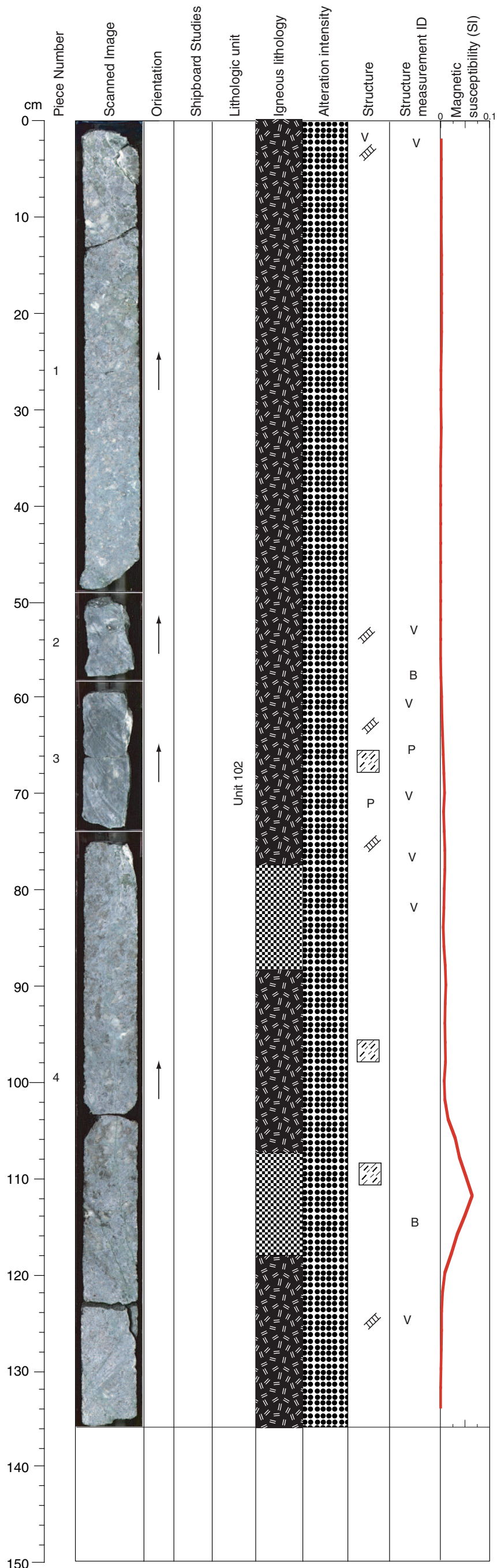
SECONDARY MINERALOGY: This section consists of highly altered olivine gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. The actinolite alteration rim around large pyroxene crystals can be seen with the naked eye. Substantial brown hornblende is present in Piece 8. Large coronitic patches of olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite are present throughout the section (e.g. 45, 62 cm).

VEIN ALTERATION: Subvertical mm-sized talc-tremolite veins cut throughout the entire section.

STRUCTURE: Green veins (V) are superposed on feldspar rich areas; feldspar rich areas grade into coarse-grained gabbro throughout section. Magmatic fabric (M) well developed in Piece 8. M>V



Core Photo



304-U1309D-45R-2 (Section top: 239.34 mbsf)

UNIT-102: Olivine-bearing / Oxide Gabbro
Pieces 1-4

PRIMARY MINERALOGY: Determined from Piece 4A (Coarse-grained Gabbro)

Plagioclase Modal 60%
Size 5-6 mm
Shape anhedral

Clinopyroxene Modal 40%
Size 6-9 mm average, 25 mm maximum
Shape anhedral

PRIMARY MINERALOGY: Determined from Piece 4C (Medium-grained Gabbro)

Plagioclase Modal 65%
Size 2-3 mm
Shape anhedral

Clinopyroxene Modal 35%
Size 1-3 mm average, 9 mm maximum
Shape anhedral

COMMENTS: This section represents the continuation of the previous section of olivine-bearing gabbro with sporadic oxide. Coarse grain sizes persist throughout the section. An olivine gabbro interval occurs between 35 and 46 cm. Oxides occur between 78-88 cm and 108-119 cm. An overall fine-grained interval with a wide range in grain sizes occurs between 123-134 cm. This might represent an area where mingling of crystal mushes occurred.

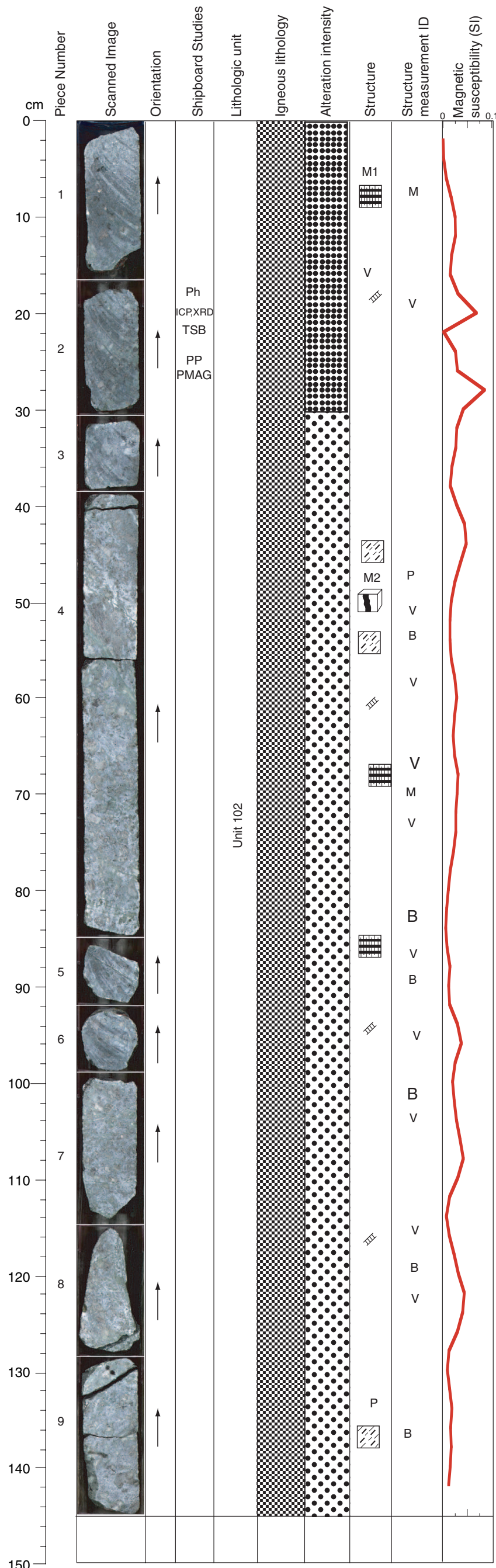
SECONDARY MINERALOGY: This section consists of highly altered gabbro, essentially in the greenschist facies. Pyroxenes are partially altered to actinolite/ tremolite with some possible relicts of brown hornblende. Most of the plagioclase seems to be fresh.

VEIN ALTERATION: A talc/tremolite vein cuts the lower half part of the section.

STRUCTURE: Coarse grained gabbro mixed with (possible) diorite. Weak crystal plastic (P) overprint on magmatic fabric imparts an almost cataclastic (semi-brittle) texture (e.g. angular grains of pyroxene). Green, thin continuous and steeply dipping veins (V) through Piece 5. P>V



Core Photo



304-U1309D-45R-3 (Section top: 240.70 mbsf)

UNIT-102: Olivine-bearing / Oxide Gabbro
Pieces 1-9

PRIMARY MINERALOGY: Determined from Piece 4C

Plagioclase Modal 60%
Size 5-7 mm
Shape subhedral to anhedral

Clinopyroxene Modal 40%
Size 3-10 mm average, 15 mm maximum
Shape subhedral to anhedral

COMMENTS: This unit consists of coarse-grained gabbro with olivine-bearing and oxide-rich areas. An oxide seam is crossing the core between 17 and 29 cm and a clot occurs at 40-45 cm. Furthermore, they occur between 115 and 142 cm. A shear zone is deforming them at 115-120 cm. Crystal mush mingling of two different grain sizes occurs at the top of the section.

SECONDARY MINERALOGY: This section consists of highly altered gabbro in the upper part (0-30 cm) and moderately altered gabbro in the lower part. Pyroxenes show an alteration rim formed by actinolite/tremolite, with some possible relicts of brown hornblende. Most of the plagioclase seems to be fresh.

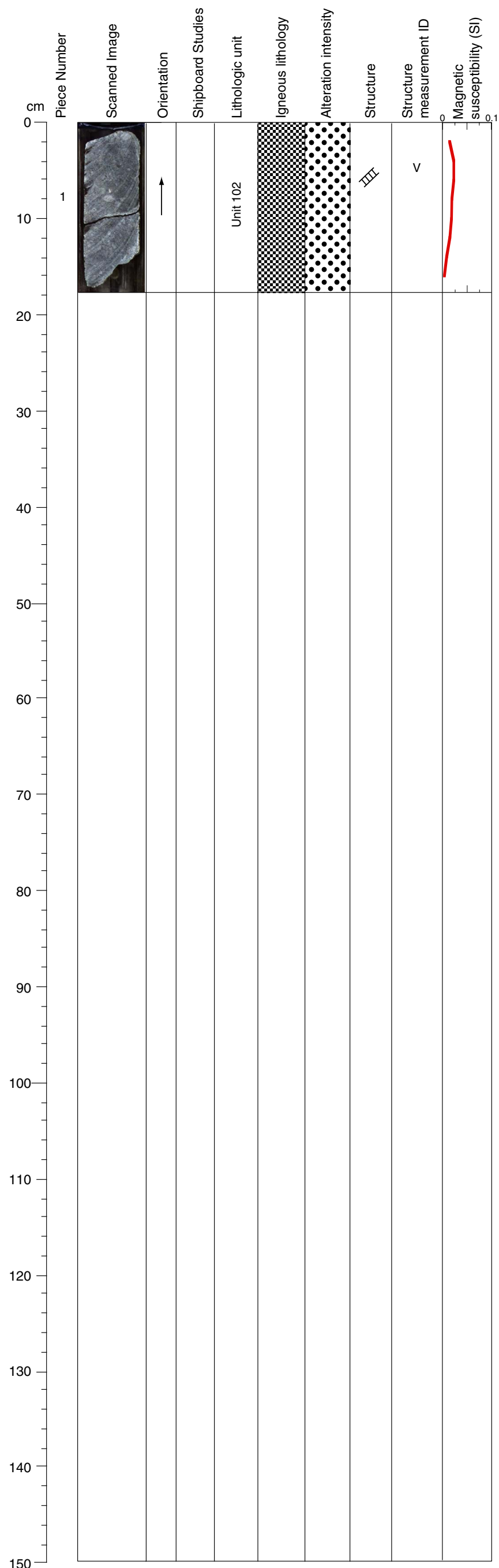
VEIN ALTERATION: Several actinolite veins in this section (e.g. at 52-60 cm).

THIN SECTIONS:
304-U1309D-45R-3, 20.0-22.0 cm (#197)

STRUCTURE: Gradation into coarse-grained gabbro throughout Piece 1 culminating in an oxide-rich gabbro in Piece 2. Diorite veins (M2), some lensoidal, are inclined toward 270 in a band, paralleling a crystal plastic foliation (P) (in Piece 4). Throughout the lower part of the section there is banding of dark and light gabbro (M1) - best viewed on the drilled face of the section. In Piece 8 the grains take on an angular shape, similar to the crystal plastic (i.e. semibrittle) fabric in the previous section. Green thin veins cut the diorite (V).
M1>P=>(?)M2>V

CLOSE UP PHOTOGRAPHS:
1309D_45R_3_16_30.jpg

Core Photo



304-U1309D-45R-4 (Section top: 242.14 mbsf)

UNIT-102: Olivine-bearing / Oxide Gabbro
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1

Plagioclase Modal 65%
Size 4-7 mm average, 15 mm maximum
Shape anhedral

Clinopyroxene Modal 35%
Size 5-10 mm average, 30mm maximum
Shape anhedral

Oxide Modal <1%
Size finely disseminated
Shape anhedral

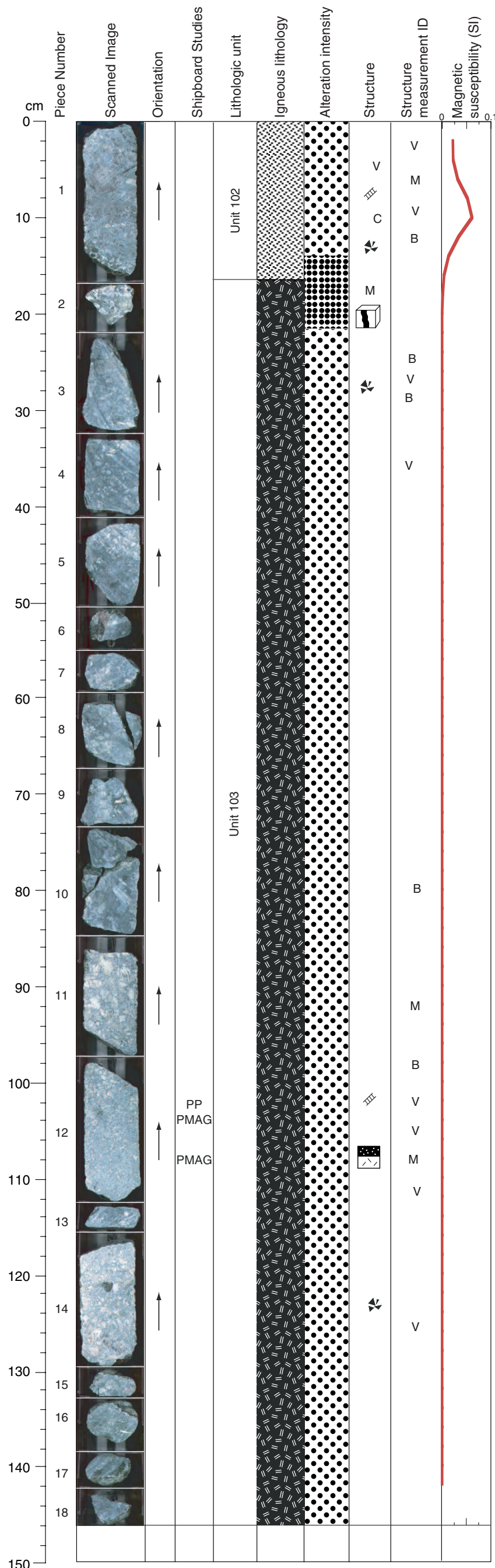
COMMENTS: This section consists of coarse-grained gabbro with disseminated oxides. The piece shows very seriate texture (grain sizes can vary between 1 and 15 mm) and may represent a mingling of crystal mushes.

SECONDARY MINERALOGY: This section consists of moderately altered gabbro in greenschist facies. Pyroxenes are slightly altered to actinolite/tremolite with possibly some relics of brown hornblende. Most of the plagioclase seems to be fresh. Sulfides are present.

STRUCTURE: Gradational contact from fine to coarser grained gabbro. One green vein.



Core Photo



304-U1309D-46R-1 (Section top: 242.80 mbsf)

Unit 102: Olivine-bearing / Oxide Gabbro
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1

Plagioclase Modal 70%
Size 5-10 mm
Shape subhedral to anhedral

Clinopyroxene Modal 30%
Size 5-7 mm average, 10 mm maximum
Shape subhedral to anhedral

COMMENTS: This section consists of a single piece of gabbro with oxides and is the continuation of the previous Section U1309D-45R-4. It is very heterogeneous in grain sizes and pyroxenes vary between 2 and 30 mm.

Unit 103: Olivine-bearing Gabbro
Pieces 2-18

PRIMARY MINERALOGY: Determined from Piece 4 and 5

Olivine Modal <1%
Size 2 mm
Shape anhedral

Plagioclase Modal 65%
Size 5-6 mm average, 10 mm maximum
Shape subhedral to anhedral

Clinopyroxene Modal 35%
Size 5-7 mm average, 10 mm maximum
Shape subhedral to anhedral

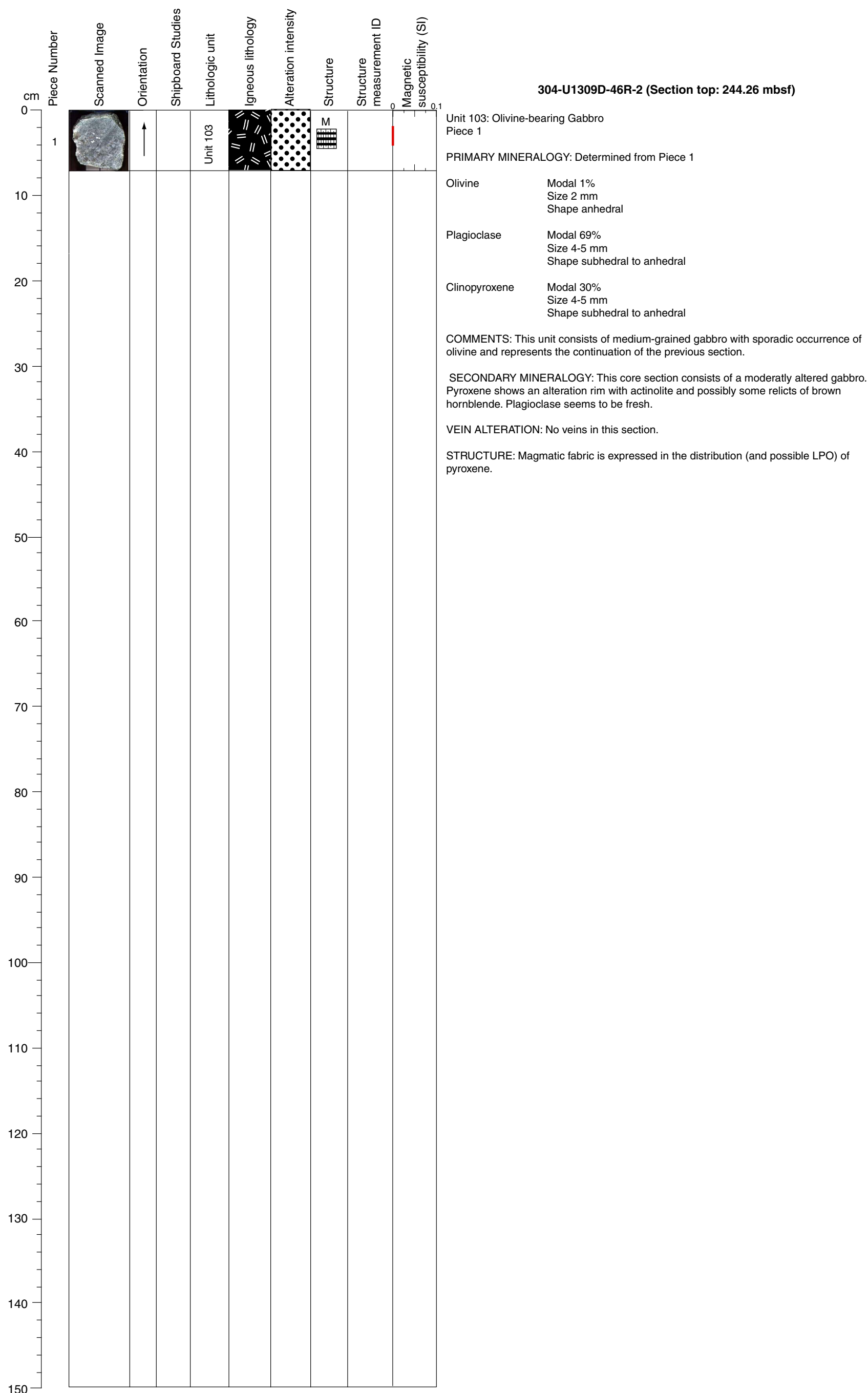
COMMENTS: Unit 103 is very heterogeneous in terms of grain size (pyroxenes varying between 3 and 23 mm and very seriate) and sporadic presence of olivine. Olivine occurs between 68 and 84 cm and 99 to 103 cm. Starting from 96 cm, a medium-grained interval occurs with pyroxene grains as large as 1-5 mm which continues until 123 cm where grain sizes increase to as much as 3-18 mm again.

SECONDARY MINERALOGY: This section consists of a moderately altered gabbro in the greenschist facies cuts by a highly altered felsic dike (at 14-21 cm). In the metagabbro, pyroxenes are partially altered to actinolite/tremolite and plagioclase seems to be fresh. Sulfides are present in Piece 1. The felsic dike shows an alteration in the greenschist facies with pyroxene altered to actinolite and some secondary plagioclase. Brown hornblende are present at the edges of pieces.

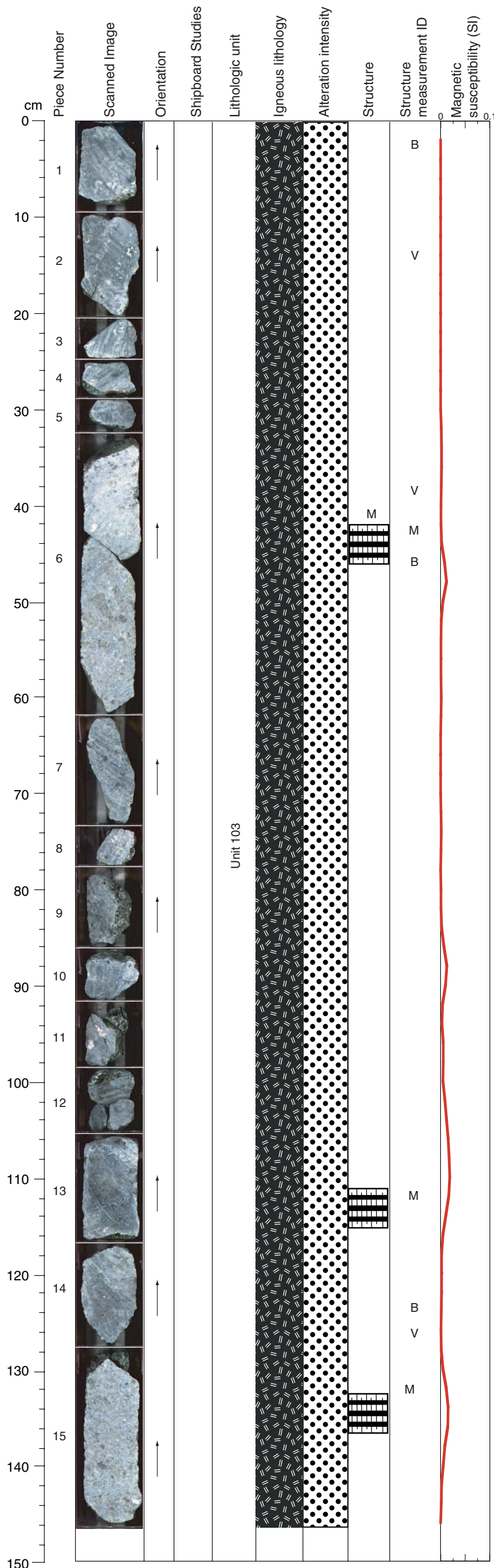
STRUCTURE: Large pyroxene grains cut by dark, branching veins (V). Internally altered, with gently dipping diorite veins (M2) surrounded by intense microcracking (C), and dark amphibole mineralization. Grain size decreases toward the base of the section, and well-defined contact between fine and coarse grained portions (M1). The section is somewhat brecciated in this (more feldspar-rich) portion. M1>M2=C=V



Core Photo



Core Photo



304-1309D-47R-1 (Section top: 247.60 mbsf)

Unit 103: Olivine-bearing Gabbro
Pieces 1-15

PRIMARY MINERALOGY: Determined from Piece 6

Olivine Modal 7%
 Size 2-4 mm
 Shape anhedral

Plagioclase Modal 68%
 Size 4-7 mm
 Shape subhedral to anhedral

Clinopyroxene Modal 25%
 Size 5-10 mm average, 18 mm maximum
 Shape subhedral to anhedral

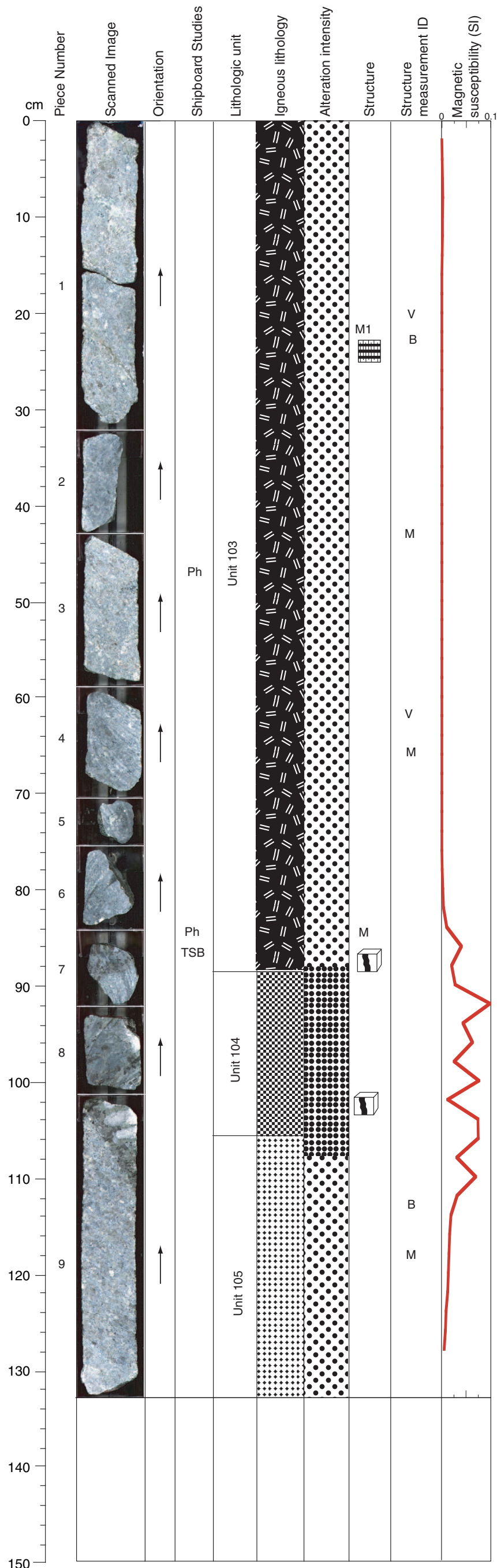
COMMENTS: This section consists of olivine-bearing gabbro. Grain size varies between medium- and coarse-grained, with slight changes in pyroxene-content noted. Olivine-rich bands occur at 106 cm, 112 cm and 119 cm.

SECONDARY MINERALOGY: This section consists of moderately altered olivine gabbro in the greenschist facies. Pyroxene is partially altered to actinolite/ tremolite. Some large coronitic pseudomorphic patches after olivine consisting of tremolite + chlorite + talc +/- carbonate, rimmed by chlorite are present. Most of the plagioclase seems to be fresh.

VEIN ALTERATION: A brown green actinolite vein is present in Piece 14.

STRUCTURE: Layering throughout the section is steeply dipping and defined by the alteration pattern of olivine and plagioclase grains.

Core Photo



304-U1309D-47R-2 (Section top: 249.09 mbsf)

Unit 103: Olivine-bearing Gabbro
Pieces 1-7

PRIMARY MINERALOGY: Determined from Piece 3

Olivine	Modal 7% Size 3-4 mm Shape anhedral
Plagioclase	Modal 68% Size 4-10 mm Shape anhedral
Clinopyroxene	Modal 25% Size 3-5 mm average, 12 mm maximum Shape anhedral

COMMENTS: This section begins with the olivine-bearing gabbro seen in the previous section. Olivine contents increase toward the end of the section whereas grain sizes decrease slightly. Seriate grain sizes persist.

Unit 104: Oxide Gabbro
Pieces 7-9

PRIMARY MINERALOGY: Determined from Piece 8

Plagioclase	Modal 66% Size 5-9 mm average, 25 maximum Shape anhedral
Clinopyroxene	Modal 28% Size 5-7 mm average, 10 mm maximum Shape anhedral
Oxide	Modal 7% Size <1 to 6 mm Shape anhedral

COMMENTS: Unit 104 consists of very coarse-grained oxide gabbro that is cutting the olivine-bearing gabbro. Toward its margins, grain sizes decrease and oxide content increases. Sulfides are present as well.

Unit 105: Olivine Gabbro
Piece 9

PRIMARY MINERALOGY: Determined from Piece 9

Olivine	Modal 7% Size 3-4 mm Shape anhedral
Plagioclase	Modal 68% Size 4-10 mm Shape anhedral
Clinopyroxene	Modal 25% Size 3-5 mm average, 12 mm maximum Shape anhedral

COMMENTS: The bottom of the section is made of coarse-grained olivine gabbro. Grain sizes range between 3 and 13 mm in the sample (very seriate). It represents the continuation of Unit 103.

SECONDARY MINERALOGY: This section is characterized by a moderate greenschist facies alteration. Pyroxene is partially altered to actinolite/ tremolite. Olivine is altered to tremolite + chlorite + talc and shows coronitic pseudomorphic patches rimmed by chlorite. Most of the plagioclase seems to be fresh. An inclusion of oxide gabbro between 88-107 cm seems more altered than olivine gabbro. This high alteration consists of some secondary plagioclase and actinolite after pyroxene.

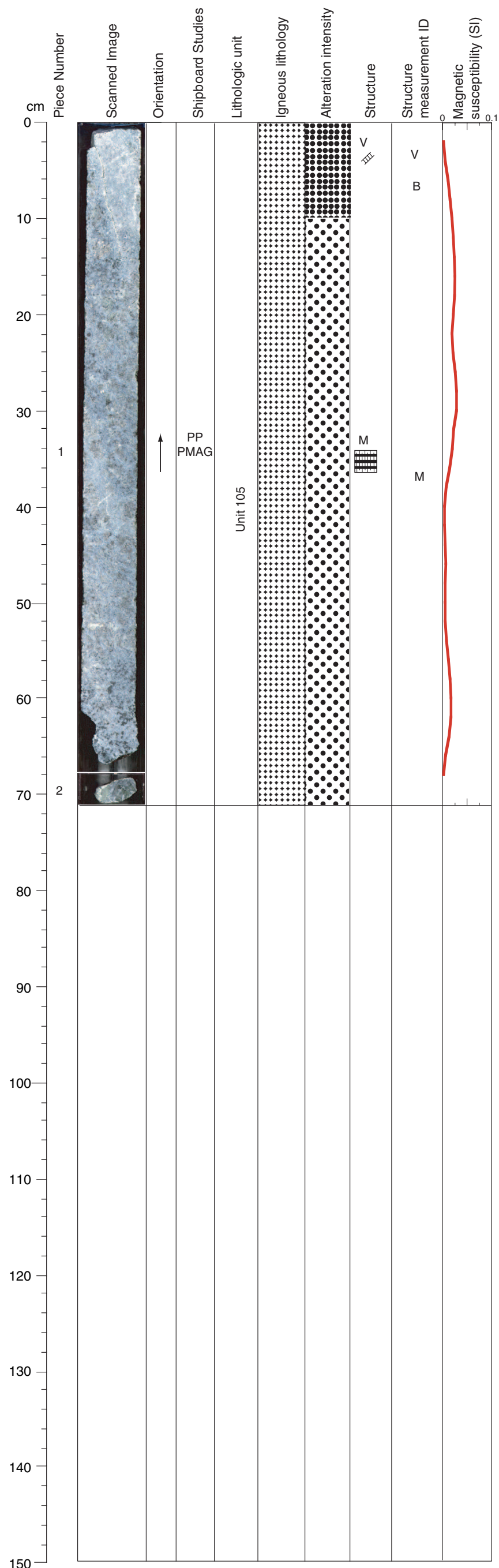
VEIN ALTERATION: No veins in this section.

THIN SECTIONS:
[304-U1309D-47R-2 86-89 cm \(#198\)](#)

STRUCTURE: Altered olivine and plagioclase grains outline the magmatic fabric. There is a contact between coarser and finer grained gabbros in Piece 7, and a moderately dipping coarse grained intrusion in Pieces 8 and 9.

CLOSE UP PHOTOGRAPHS:
1309D_47R_2_46_66.jpg
1309D_47R_2_84_112.jpg
1309D_47R_2_84_112_2.jpg

Core Photo



304-U1309D-47R-3 (Section top: 250.42 mbsf)

Unit 105: Olivine Gabbro
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 1 (20-35 cm interval)

- Olivine Modal 10%
 Size 3-5 mm
 Shape anhedral
- Plagioclase Modal 65%
 Size 4-7 mm average, 12 mm maximum
 Shape anhedral
- Clinopyroxene Modal 25%
 Size 4-7 mm average, 20 mm maximum
 Shape anhedral

COMMENTS: This section consists of coarse-grained olivine gabbro. Olivine-rich and pyroxene-rich domains occur.

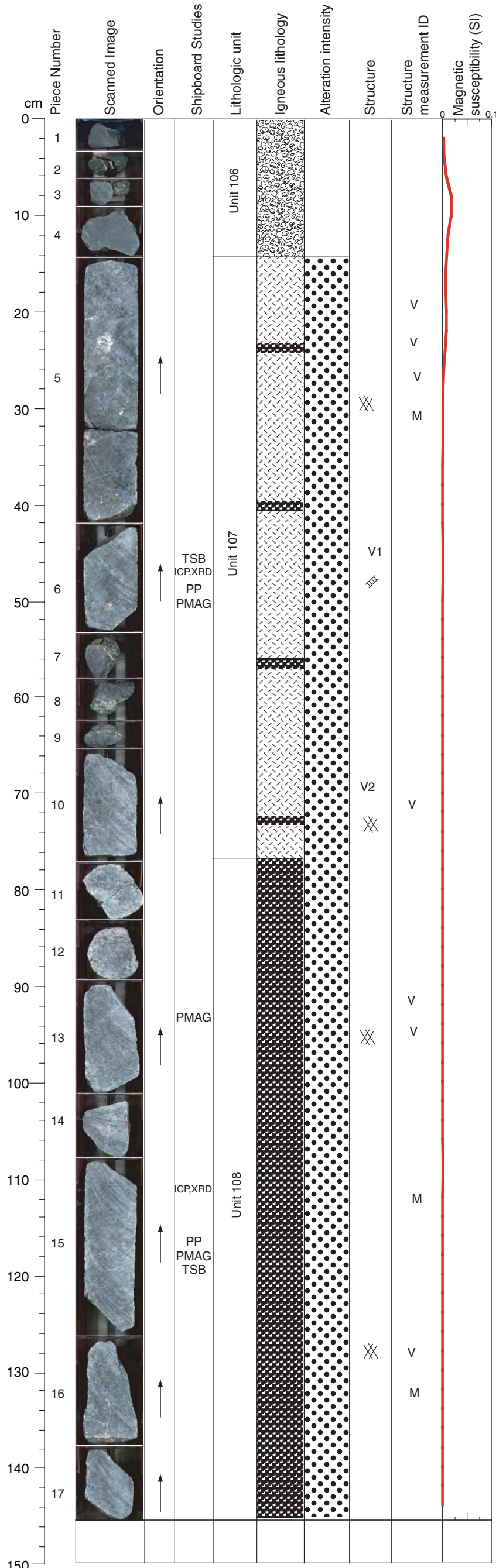
SECONDARY MINERALOGY: This section consists of moderately altered gabbro in the greenschist facies. Pyroxenes are partially altered to actinolite/tremolite. Few olivine are present and completely replace by tremolite + chlorite as pseudomorphs patches. The upper ten centimeters are more altered, secondary plagioclase are present. The lower part of the section is oxide gabbro. Secondary plagioclase is present and pyroxene is slightly altered to actinolite.

VEIN ALTERATION: A green actinolite vein is present in the upper part of the section, with altered plagioclase around.

STRUCTURE: Diorite (M) follows earlier layering (with green alteration and one vein) (V).



Core Photo



304-U1309D-48R-1 (Section top: 252.40 mbsf)

Unit 106: Mixed rubble
Pieces 1-4

COMMENTS: This unit consists of basalt (Piece 1) and microgabbro (Pieces 2 to 4) that are presumed to be out of place.

Unit 107: Gabbro with Troctolitic Bands
Pieces 5-10

PRIMARY MINERALOGY: Determined from Piece 5

Plagioclase Modal 65 %
Size 4 to 6 mm
Shape anhedral

Clinopyroxene Modal 35%
Size 4 to 10 mm
Shape anhedral

COMMENTS: This unit consists predominantly of medium-grained gabbro. A troctolitic band with wavy outline and coronitic texture crosses along the core. Two kinds of pyroxenes occur, large crystals and oikocrystic pyroxenes enclosing plagioclase in the matrix.

Unit 108: Troctolite
Pieces 11-17

PRIMARY MINERALOGY: Determined from Piece 15

Olivine Modal 15%
Size 1 to 3 mm
Shape anhedral

Plagioclase Modal 82 %
Size 6 to 9 mm
Shape anhedral

Clinopyroxene Modal 3%
Size 1 to 3 mm
Shape anhedral

COMMENTS: From 77 cm down, the core is invaded along grain boundaries by an anorthositic melt and the pyroxene-plagioclase ratio decreases. Pyroxene contents are generally decreasing downcore. Accordingly, between 77 and 101 cm olivine gabbro occurs, between 101 and 114 cm troctolitic gabbro and between 114 and 145 cm troctolite.

SECONDARY MINERALOGY: This core consists of moderately altered olivine gabbro. Plagioclase appears fresh and pyroxene is slightly altered to actinolite. Olivine is completely altered to tremolite + chlorite +/- talc +/- carbonate +/- magnetite +/- sulfide +/- serpentine forming coronitic textures. A few brown hornblendes are present.

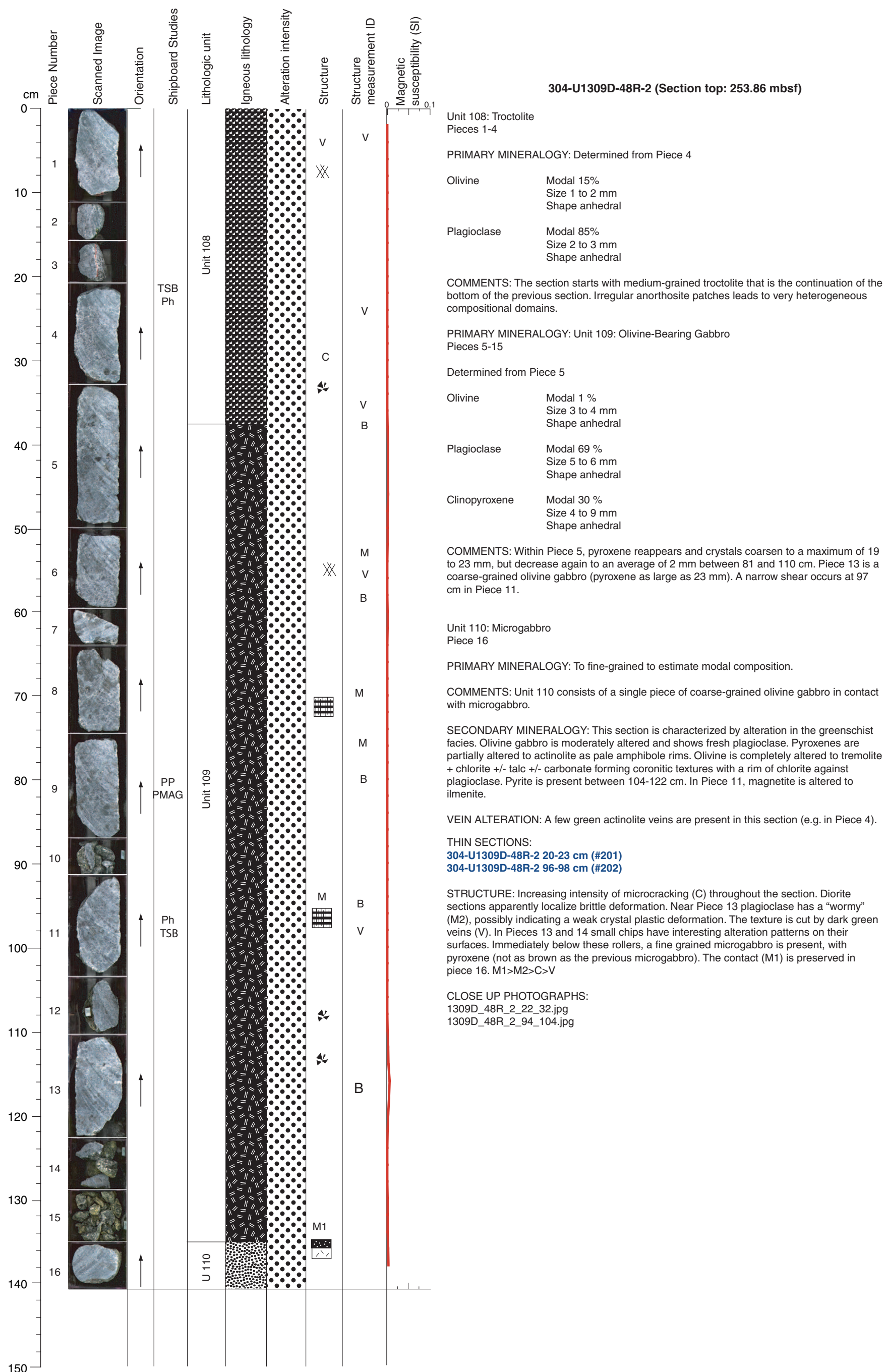
VEIN ALTERATION: Some green actinolite veins are present in this section (e.g. at 36-38 cm).

THIN SECTIONS:

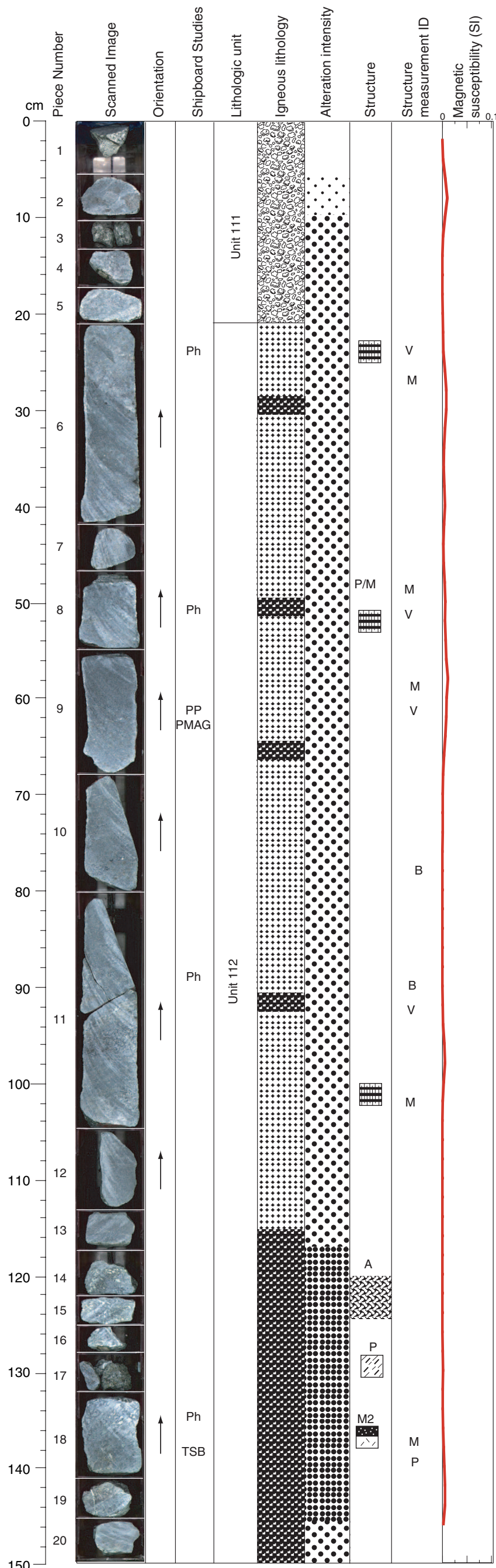
304-U1309D-48R-1 44-46 cm (#199)
304-U1309D-48R-1 119-122 cm (#200)

STRUCTURE: Rubble at the top of the section (assumed to be out of place) includes diabase. In the gabbro, white veins (V2), patchy zone of higher plagioclase content, and large oikocrysts typify the section. A single dark (high-temperature?) amphibole vein (V1) cuts the diorite portions. Plagioclase-rich zones in Pieces 10 through 17 impart a "mottled" texture, although there are no distinctive alteration rims. V1>V2

Core Photo



Core Photo



304-U1309D-49R-1 (Section top: 257.20 mbsf)

Unit 111: Mixed Rubble
Pieces 1-5

COMMENTS: Unit 111 consists of medium-grained olivine gabbro except for Piece 2 which is coarse-grained. The pieces are presumed to be out of place.

Unit 112: Olivine Gabbro with Troctolitic Bands
Pieces 6-20

PRIMARY MINERALOGY: Determined from Piece 6

Olivine	Modal 5 % Size 1 to 2 mm Shape anhedral
Plagioclase	Modal 60% Size 4 to 5 mm Shape anhedral
Clinopyroxene	Modal 35% Size 3 to 6 mm Shape anhedral

COMMENTS: Unit 112 consists predominantly of olivine gabbro cut by several narrow troctolite bands at 30, 51, 66 and 92 cm. Troctolite occurs from 117 cm to the bottom of the section. Magmatic foliation is present throughout the section. The unit starts with coarse grain sizes (as large as 25 mm) that grade after the first troctolitic band to medium grain sizes (4 mm in average) until 56 cm where a fine-grained interval with grain sizes of 1 mm persist until 61 cm. Below, grain sizes alternate between fine and medium grain sizes until 87 cm where a plagioclase-rich and a pyroxene-rich domain interfinger. Pieces 18 to 20 show strong deformation. A shear zone cut by a small intrusion of oxide gabbro is present in Piece 18. Piece 19 shows another contact between oxide gabbro and troctolite. Piece 20 is a mylonite with big pyroxene grains.

SECONDARY MINERALOGY:

The section is moderately altered, due to olivine alteration in the main part of the section. The alteration varies with the local abundance of olivine. Olivine reacts with plagioclase to form a dark rim of chlorite with actinolite +/- talc in the center. Pyroxene edges seem slightly altered to actinolite. Plagioclase is mostly fresh. Coarse pyroxene in Piece 2 are slightly altered to actinolite/tremolite. From 118 to 145 cm olivine are more altered. Talc is less abundant in the olivine alteration and show a white-brown patches in the center of the green corona.

VEIN ALTERATION: Tremolite-talc(?) veins are observed in the last pieces of the section. Few actinolite veins are recorded in the moderately altered part (e.g. 52 and 62 cm)

THIN SECTIONS:

304-U1309D-49R-1 137-139 cm (#203)

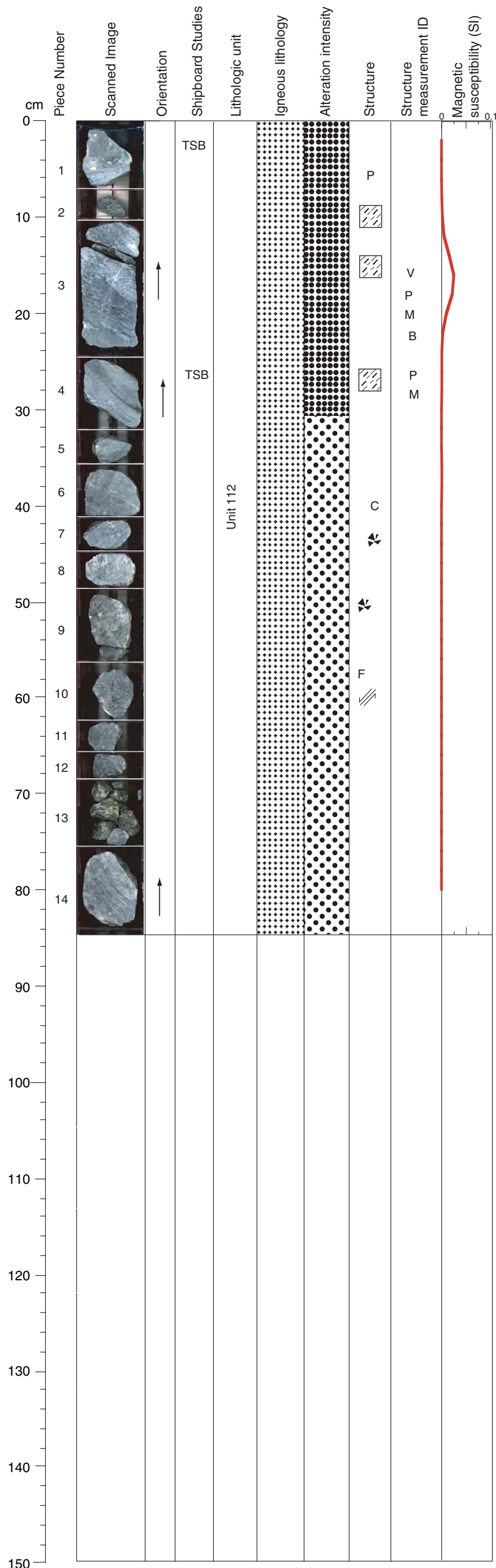
STRUCTURE: Several pieces have a crystal plastic (P) texture superposed on a magmatic (M1) fabric. Diorite, layers of coarse-grained, olivine-rich (troctolitic) gabbro, and gradational contacts between coarser and finer grained gabbros, all parallel the magmatic/deformation fabric. Piece 16 is cut by soft, white (not carbonate) alteration minerals (A) above a mylonitic shear zone. The shear zone is a contact (M2) between oxide gabbro and the overlying gabbro - however, it is unclear exactly what the timing relationship is; i.e. the oxide gabbros may partly cut the mylonite. M1>P>=?M2>A

CLOSE UP PHOTOGRAPHS:

- 1309D_49R_1_22_40.jpg
- 1309D_49R_1_48_67.jpg
- 1309D_49R_1_86_104.jpg
- 1309D_49R_1_133_144.jpg



Core Photo



304-U1309D-49R-2 (Section top: 258.70 mbsf)

Unit 112: Olivine Gabbro with Troctolitic Bands
Pieces 1-14

PRIMARY MINERALOGY: Determined from Piece 14

Plagioclase Modal 65%
Size 4 to 6 mm
Shape anhedral

Clinopyroxene Modal 35%
Size 3 to 6 mm
Shape anhedral

COMMENTS: Unit 112 consists of olivine gabbro. Magmatic foliation is visible but overprinted by deformation with elongate pyroxene. The section grades to less deformed, coarse-grained gabbro below 45 cm. Olivine is only present in Pieces 1 to 8.

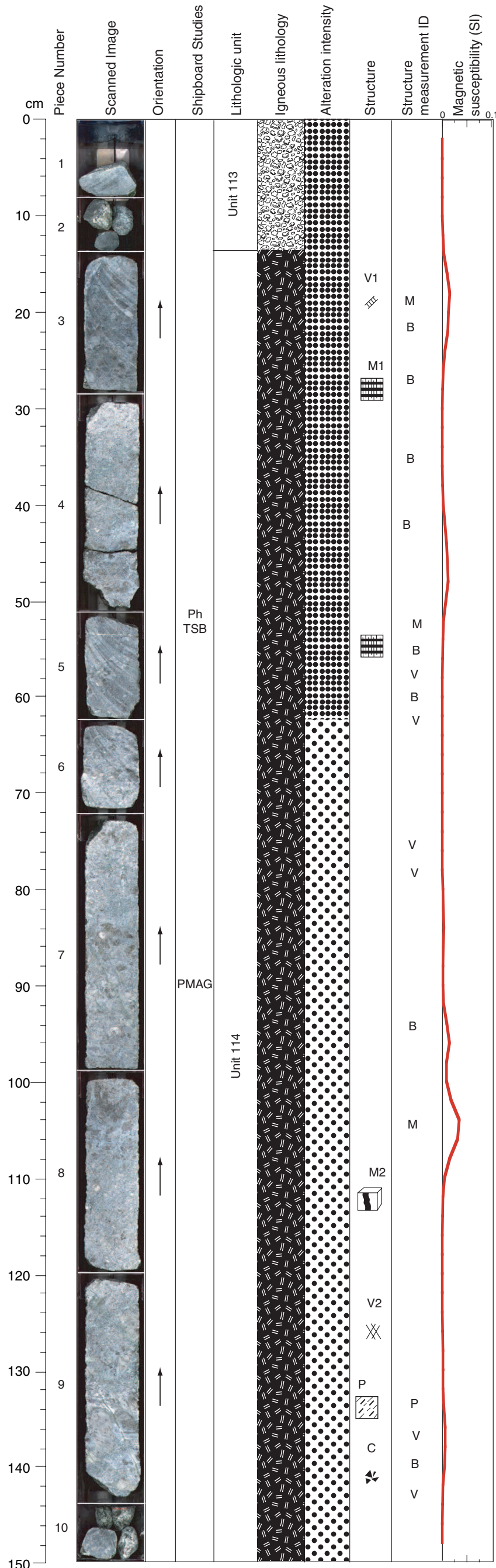
SECONDARY MINERALOGY: This section consists of highly to moderately altered olivine gabbro. The first 30 cm are foliated olivine gabbro in which plagioclase and pyroxene show high temperature recrystallization. Olivine is completely altered to tremolite + chlorite + talc +/- carbonate and shows coronitic pseudomorphic patches rimmed by chlorite. In the rest of the core, pyroxene is slightly altered to actinolite; plagioclase appears fresh. Olivine is replaced by tremolite + chlorite + talc. Oxide gabbro is present between 44 and 75 cm and shows the same alteration as olivine gabbro (for pyroxene) with few secondary plagioclase.

VEIN ALTERATION: Few green actinolite veins are present in this section (e.g. in Piece 1).

THIN SECTIONS:
304-U1309D-49R-2 2-5 cm (#204)
304-U1309D-49R-2 26-29 cm (#205)

STRUCTURE: Mylonitic texture (P) continues with altered olivine and plagioclase defining the texture. Mylonite possibly preserves sense of shear indicators, particularly near orthopyroxene. Toward the base of the section the crystal plastic texture becomes weaker, and microcracking (C) intensifies. A talc-lined surface (F) occurs in Piece 10, below which crystal plastic texture is poorly developed, with large, round orthopyroxene grains mostly undeformed. P>C>F

Core Photo



304-U1309D-50R-1 (Section top: 262.00 mbsf)

Unit 113: Rubble
Pieces 1-2

COMMENTS: This unit consists of several cobbles of fine-grained olivine gabbro. They are very similar to the top of Section U1309D-49R-2 and it is not clear if they are in place.

Unit 114: Olivine-bearing Gabbro
Pieces 3-10

PRIMARY MINERALOGY: Determined from Piece 7

Olivine Modal 3%
 Size 3 to 5 mm
 Shape anhedral

Plagioclase Modal 57%
 Size 3 to 5 mm
 Shape anhedral

Clinopyroxene Modal 40%
 Size 7 to 10 mm
 Shape anhedral

COMMENTS: Unit 114 consists of coarse-grained olivine-bearing gabbro. The cores are very heterogeneous in grain size and less in modal composition. Piece 5 shows oikocrystic pyroxene and again at 93 and 128 cm. Piece 6 shows irregular anorthositic patches. A pyroxene megacryst as much as 48 mm occurs at 148 cm at Piece 9.

SECONDARY MINERALOGY: This section consists of highly to moderately altered olivine gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxene appear fresh. Some large corona patches of olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite are present.

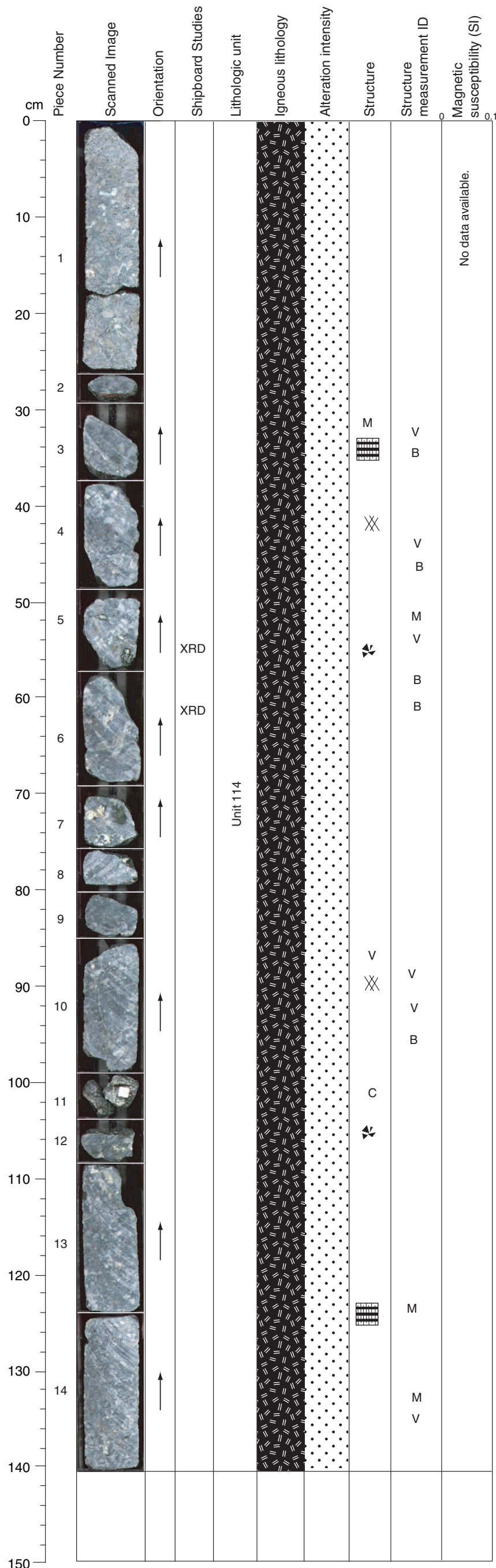
VEIN ALTERATION: An actinolite/ tremolite vein with albite halo is present at 130-135 cm.

THIN SECTIONS:
[304-U1309D-50R-1 52-55 cm \(#206\)](#)

STRUCTURE: Coarse-grained, mixed olivine and feldspar rich gabbros with weak layering (M1); microcracking (C) localized in the feldspar-rich portions. Dark amphibole veins (V1) are inclined toward 90 degrees (in the core reference frame). From Pieces 8 into 9 interstitial fine-grained plagioclase is concentrated into veins (M2) that localize minor crystal plastic texture (P), green alteration and later veining (V2). M1>V1=M2>P>C>V1>V2

CLOSE UP PHOTOGRAPHS:
1309D_50R_1_52_61.jpg

Core Photo



304-U1309D-50R-2 (Section top: 263.50 mbsf)

Unit 114: Olivine-bearing Gabbro
Pieces 1-14

PRIMARY MINERALOGY: Determined from Piece 1A

- Olivine: Modal 3%, Size 4 to 7 mm, Shape anhedral
- Plagioclase: Modal 62%, Size 7 to 10 mm, Shape anhedral
- Clinopyroxene: Modal 35%, Size 10 mm, maximum 21 mm, Shape anhedral

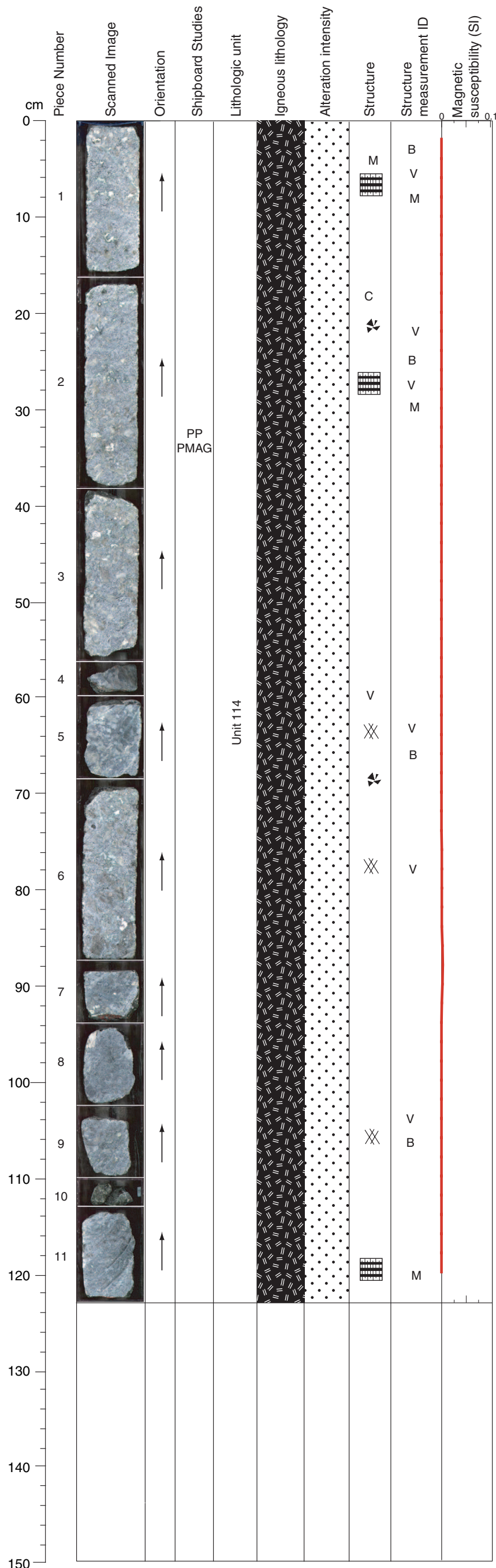
COMMENTS: This section consists of very coarse-grained olivine-bearing gabbro. Grain sizes decrease slightly below 76 cm.

SECONDARY MINERALOGY: This section consists of only slightly altered olivine gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Secondary minerals are mostly chlorite and pale amphibole grown along grain boundaries. Most of the plagioclase and pyroxenes seem to have survived alteration. A few coronitic patches of olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite are present.

STRUCTURE: Feldspar-rich (M) areas (note, hornblende is absent from many "dioritic" intervals due to subsequent alteration), localize microcracking (C) and green alteration and veins (V). Away from the regions of high feldspar concentrations, there is disseminated feldspar interstitial to the gabbro. 1-2 blue veins cut the section in Pieces 1 through 8. M>C>V



Core Photo



304-U1309D-50R-3 (Section top: 264.72 mbsf)

Unit 114: Olivine-bearing Gabbro
Pieces 1-11

PRIMARY MINERALOGY: Determined from Piece 3

Olivine Modal 3%
Size 2 to 5 mm
Shape anhedral

Plagioclase Modal 57%
Size 4 to 6 mm
Shape anhedral

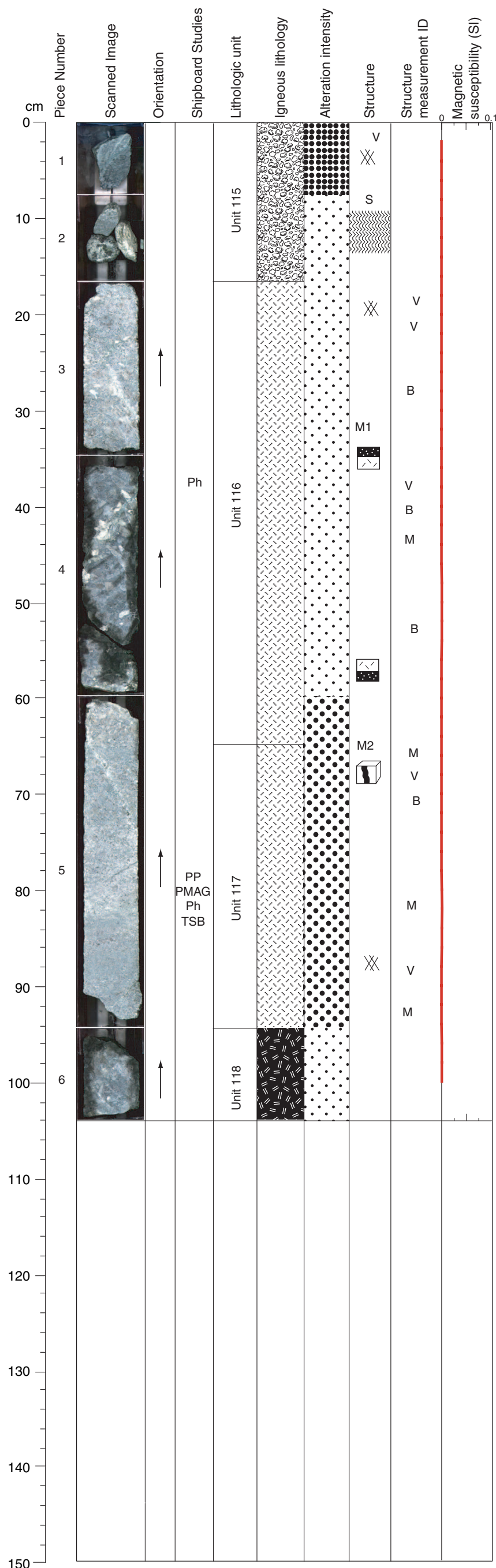
Clinopyroxene Modal 40%
Size 5 to 10 mm
Shape anhedral

COMMENTS: This section consists of very coarse-grained olivine-bearing gabbro and represents the continuation of the previous two sections. Piece 8 is fractured.

SECONDARY MINERALOGY: This section consists of only slightly altered olivine gabbro in which the ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Secondary minerals are mostly chlorite and pale amphibole grown along grain boundaries. Most of the plagioclase and pyroxene are fresh. Some corona patches of olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite are present (e.g. at 6-8, 76-78 cm).

STRUCTURE: Feldspar-rich (M) areas (note, hornblende is absent from many "dioritic" intervals due to subsequent alteration). localize microcracking (C), green alteration and veins (V). Away from high concentrations of feldspar-rich material, there is disseminated feldspar interstitial to the gabbro. Blue veins are present in several pieces as well. M>C>V

Core Photo



304-U1309D-51R-1 (Section top: 266.80 mbsf)

Unit 115: Mixed Rubble
Pieces 1-2

COMMENTS: Unit 115 consists of two pieces of deformed olivine gabbro and very similar to the bottom part of Section U1309D-49R-1. These pieces are presumed to be out of place.

Unit 116: Gabbro
Pieces 3-5

PRIMARY MINERALOGY: Determined from Piece 2 and 3

Olivine Modal < 1%
Size 2 mm
Shape anhedral

Plagioclase Modal 45%
Size 5 to 6 mm
Shape anhedral

Clinopyroxene Modal 55%
Size 4 to 10 mm
Shape anhedral

COMMENTS: This unit consists of seriate gabbro that typically shows two types of pyroxene, coarse and small grains in a finer grained matrix.

Unit 117: Gabbro
Piece 5

PRIMARY MINERALOGY: Determined from Piece 5

Plagioclase Modal 45%
Size 4 mm
Shape anhedral

Clinopyroxene Modal 55%
Size 2 to 3 mm
Shape anhedral

COMMENTS: This unit represents the fine-grained foliated variety of Unit 116 with two types of pyroxenes.

Unit 118: Olivine-bearing Gabbro
Piece 6

PRIMARY MINERALOGY: Determined from Piece 6

Olivine Modal < 1%
Size 1 mm
Shape anhedral

Plagioclase Modal 50%
Size 5 to 6 mm
Shape anhedral

Clinopyroxene Modal 50%
Size 4 to 10 mm
Shape anhedral

COMMENTS: This unit consists of coarse-grained gabbro that contains low amounts of olivine but is otherwise very similar to Unit 116. Coarse-grained pyroxenes show some resorbed outlines at the grain scale.

SECONDARY MINERALOGY: This section consists of slightly to highly altered olivine gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Most of the plagioclase and pyroxene seem to have survived alteration. However, secondary plagioclase seems to be present between 0-7 and 60-04 cm. Coronitic textures of olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite characterize Piece 1. A few coronitic patches of olivine alteration are present in Piece 3.

VEIN ALTERATION: Some actinolite/ tremolite veins with albite halo are present at 22-30, 38-48, 62-74 cm.

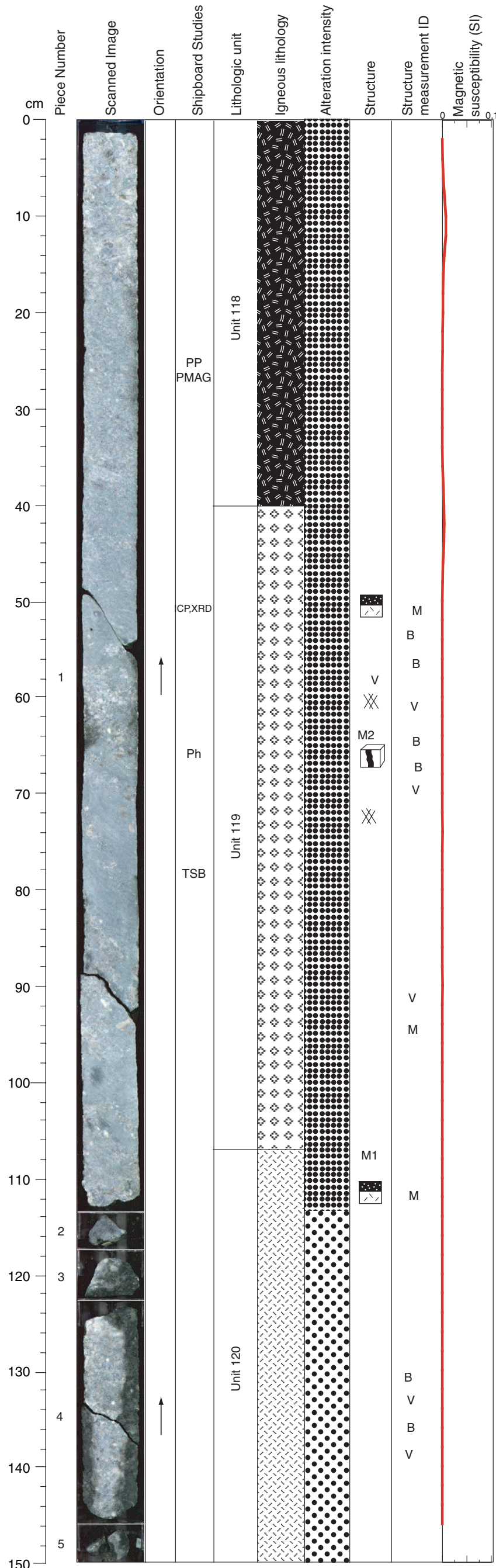
THIN SECTIONS:
304-U1309D-51R-1 82-85 cm (#207)

STRUCTURE: Stretched "troctolitic" fabric with composite green veins (V) are above rollers that include talc-tremolite schists (S). Below the gabbro is medium grained with feldspar-rich veins (M2) (fine-grained feldspar interstitial to gabbro), later blue veins, and, in Piece 5, an intrusive feldspar-rich unit in the center of the piece that includes elongate amphibole grains. A remarkably coarse-grained gabbro (M1) with a seriate texture cuts the medium grained gabbro. M1=?M2>S=>(?)V

CLOSE UP PHOTOGRAPHS:
1309D_51R_1_36_52.jpg
1309D_51R_1_80_93.jpg



Core Photo



304-U1309D-51R-2 (Section top: 267.83 mbsf)

Unit 118: Olivine-bearing Gabbro
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1 (Interval 0-30 cm)

- Olivine Modal 2%
 Size 2 mm
 Shape anhedral
- Plagioclase Modal 63%
 Size 3 to 5 mm
 Shape anhedral
- Clinopyroxene Modal 35%
 Size 3 to 9 mm
 Shape anhedral

COMMENTS: This section starts with coarse-grained gabbro that represents the continuation of the previous section.

Unit 119: Olivine-bearing Microgabbro
Piece 1

COMMENTS: With a gradational contact to Unit 118, 5-10 mm pyroxene 'swim' as clusters of single grains in a microgabbroic matrix. A troctolitic domain is visible as well. This unit probably represents an infiltrated crystal mush

Unit 120: Gabbro
Pieces 1-5

PRIMARY MINERALOGY: Determined from Piece 4

- Plagioclase Modal 60%
 Size 5 to 7 mm
 Shape anhedral
- Clinopyroxene Modal 40%
 Size 4 to 6 mm
 Shape anhedral

COMMENTS: This unit consists of a coarse-grained gabbro and is very similar in texture to Unit 118 but with less olivine.

SECONDARY MINERALOGY: This section consists of moderately to highly altered gabbro and olivine gabbro in which ferromagnesian minerals are partially altered to actinolite/tremolite +/- chlorite. Some secondary plagioclase and brown hornblende seems to be present. A few large corona patches of olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite are present (e.g., around 6 cm).

VEIN ALTERATION: Small blue-green veins with pale amphibole and brown hornblende are present around 59 and 63 cm.

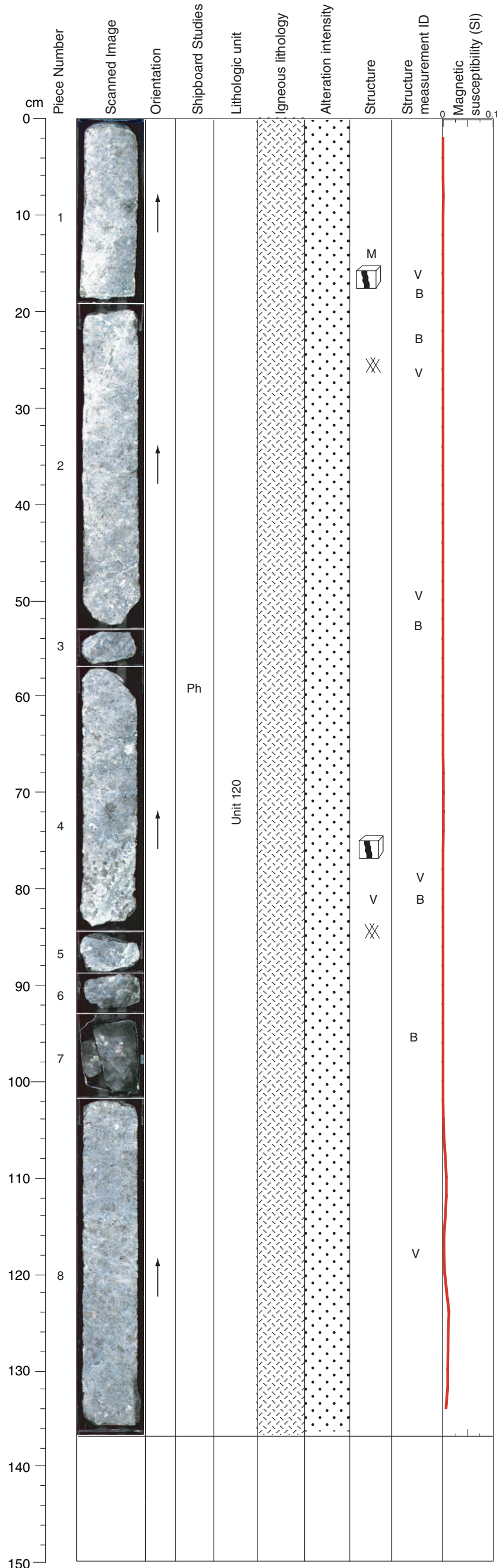
THIN SECTIONS:
304-U1309D-51R-2 77-80 cm (#208)

STRUCTURE: Section preserves a gradational contact between coarse and fine grained gabbro. The coarse-grained phase has interstitial microcracked, fine-grained feldspar that grades into plagioclase-rich layers in finest grained pyroxene-rich gabbro. In summary: the coarse-grained orthopyroxene bearing gabbro is cut by both a microgabbro (M1) and by dioritic gabbro-dioritic veins (M2). Green veins are superposed on feldspar rich portions (V).

CLOSE UP PHOTOGRAPHS:
1309D_51R_2_65_85.jpg



Core Photo



304-U1309D-51R-3 (Section top: 269.33 mbsf)

Unit 120: Gabbro
Pieces 1-8

PRIMARY MINERALOGY: Determined from Piece 2

- Olivine Modal < 1%
 Shape anhedral
- Plagioclase Modal 60%
 Size 4 to 7 mm
 Shape anhedral
- Clinopyroxene Modal 40%
 Size 7 to 10 mm
 Shape anhedral

COMMENTS: This section consists of coarse-grained gabbro with fine grained pyroxene in a coarse matrix. A dioritic vein cuts the core at 79 cm. Alteration veins cross at 13 and 25 cm.

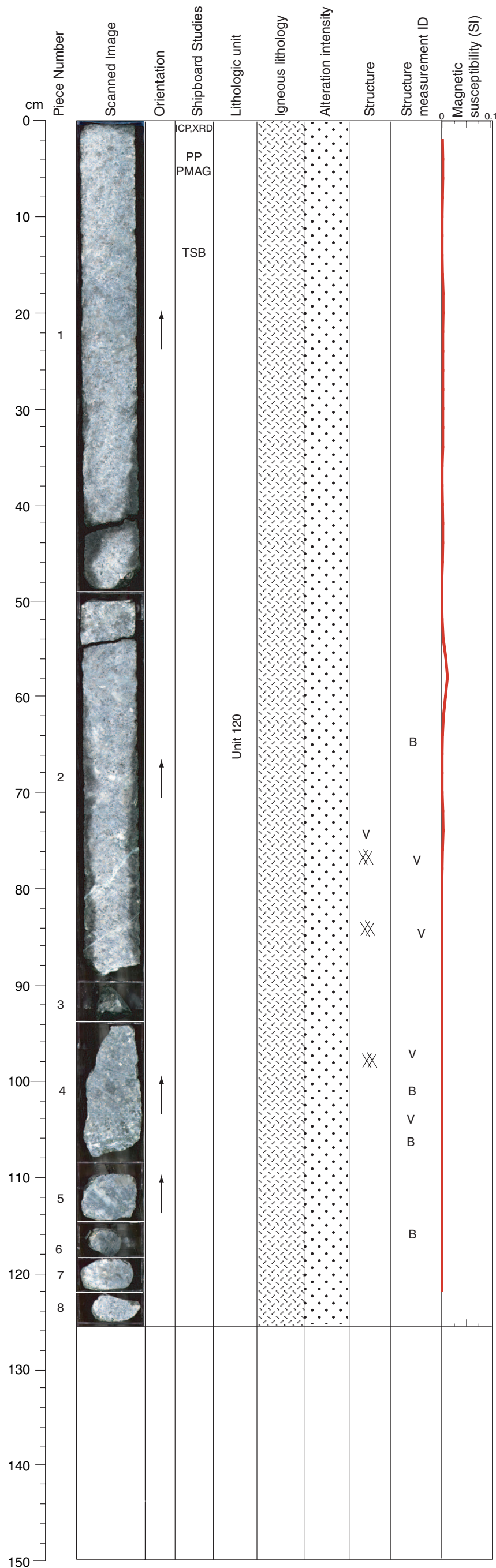
SECONDARY MINERALOGY: This section consists of only slightly altered gabbro in which ferromagnesian minerals are partially altered to actinolite/ tremolite +/- chlorite. Alteration is confined to grain boundaries; pyroxene and plagioclase are fresh.

VEIN ALTERATION: A cm-scale felsic albite-actinolite/ tremolite dike with brown hornblende on the margins is present at 76-88 cm. A similar but thinner vein is present at 9-18 cm.

STRUCTURE: Feldspar-rich matrix to gabbro that grades into leucocratic veins (M). Superposed green veins (V) and alteration localized in plagioclase rich intervals. M>V.

CLOSE UP PHOTOGRAPHS:
1309D_51R_3_58_84.jpg

Core Photo



304-U1309D-51R-4 (Section top: 270.68 mbsf)

UNIT-120: Gabbro
Pieces 1-8

PRIMARY MINERALOGY: Determined from Piece 2B

Olivine Modal < 1%
 Size < 1 mm
 Shape anhedral

Plagioclase Modal 60%
 Size 5 to 10 mm
 Shape anhedral

Clinopyroxene Modal 40%
 Size 4 to 7 mm
 Shape anhedral

COMMENTS: This section consists of coarse-grained gabbro. Medium grain sizes occur between 94 and 108 cm.

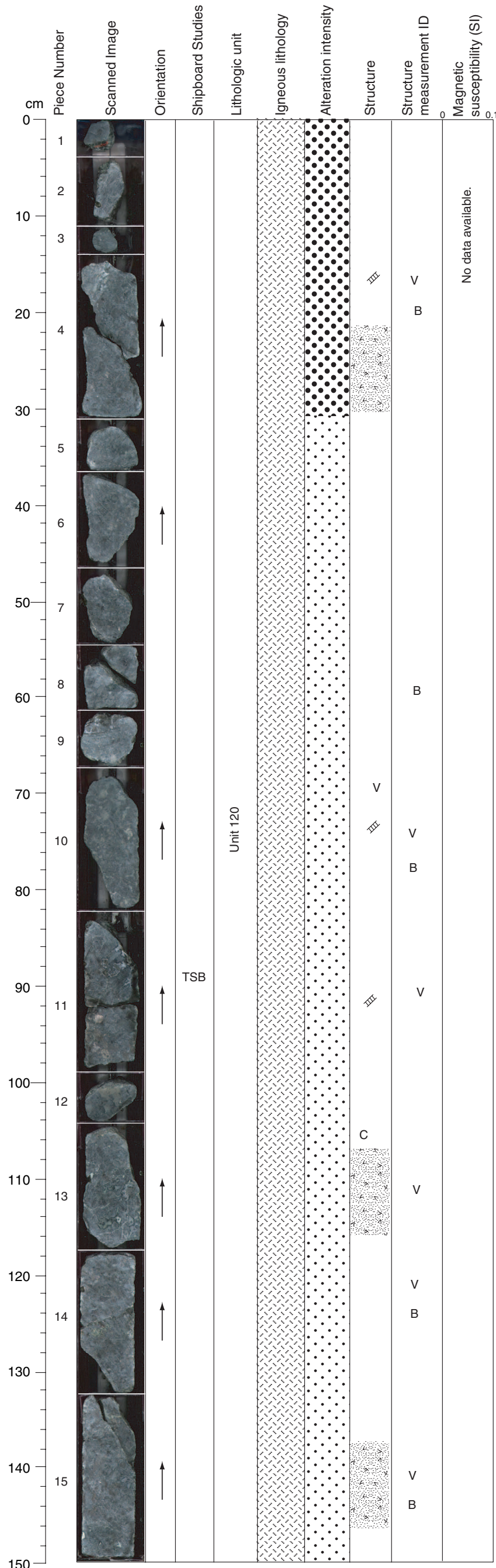
SECONDARY MINERALOGY: The section consists of gabbro showing a distinctly low degree of alteration. Alteration phases are mostly chlorite along grain boundaries of plagioclase. Minor amounts of albite and brown hornblende are present locally (see vein alteration).

VEIN ALTERATION: Some talc-tremolite veins are present (in Pieces 2 and 4 as well as at 75-81 cm). Breccia vein/ felsic dike in top part of Piece 4 contains albite and brown hornblende.

THIN SECTIONS:
[304-U1309D-51R-4 13-16 cm \(#209\)](#)

STRUCTURE: Coarse-grained gabbro (with dioritic matrix) cut by blue vein (near 65 cm).

Core Photo



304-U1309D-52R-1 (Section top: 271.60 mbsf)

Unit 120: Gabbro
Pieces 1-15

PRIMARY MINERALOGY: Determined from Piece 10

Olivine	Modal < 1% Shape anhedral
Plagioclase	Modal 65% Size 7 mm Shape anhedral
Clinopyroxene	Modal 35% Size 4 to 8 mm Shape anhedral

COMMENTS: This section consists of coarse-grained gabbro. Sporadic olivine grains occur between 88-90 cm, 107-116 cm and 146-148 cm. Pieces 5-7 and 13 show mostly medium grain sizes.

SECONDARY MINERALOGY: The upper part of the section (0-31 cm) is moderately altered, the lower part only slightly altered gabbro. Secondary minerals are mostly chlorite +/- pale amphibole along grain boundaries. This gives the rock a green color when looking through transparent plagioclase on the cut core surface. Large corona patches of olivine alteration are present in the lower part of the section (e.g. at 86-88 cm). A few spots of disseminated sulfides are found within the section (e.g. on lower side of piece 13). Alteration is slightly higher in distinct zones.

VEIN ALTERATION: A felsic vein with albite and brown hornblende is present at 14-19 cm.

THIN SECTIONS:
[304-U1309D-52R-1 88-90 cm \(#211\)](#)

STRUCTURE: Steeply dipping plagioclase-amphibole (green) vein (V) cutting coarse, clean pyroxenes (with a metallic luster). The surrounding plagioclase has dense microfractures (C), with limited alteration (some grain boundary alteration. C>V

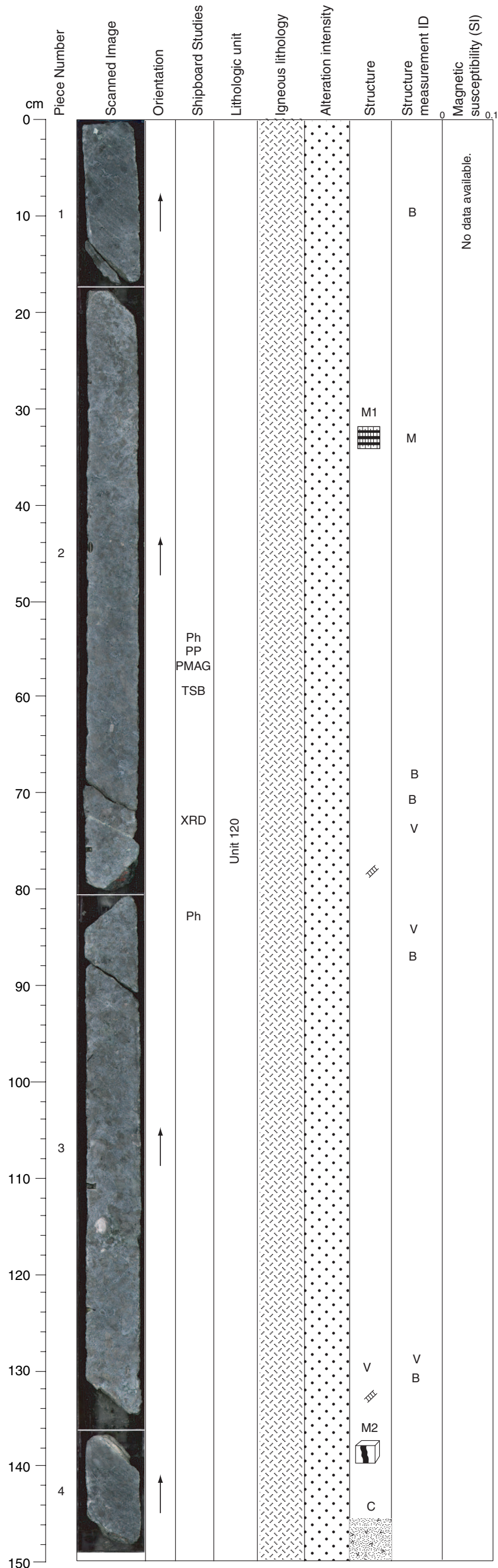
No data available.

TSB

Unit 120



Core Photo



304-U1309D-52R-2 (Section top: 273.10 mbsf)

Unit 120: Gabbro
Pieces 1-4

PRIMARY MINERALOGY: Determined from Piece 3B

Olivine Modal < 1%
Shape anhedral

Plagioclase Modal 65 %
Size 4 to 6 mm
Shape anhedral

Clinopyroxene Modal 35%
Size 4 to 9 mm
Shape anhedral

COMMENTS: This section consists of coarse-grained gabbro. Olivine occurs sporadically but more commonly than in the previous section (between 0-9 cm, 37-69 and 119-126 cm). Very coarse pyroxene crystals occur in Piece 4 (as large as 40 mm but cut by the edge of the core).

SECONDARY MINERALOGY: The section is characterized by a low degree of alteration. Secondary minerals are mostly chlorite and pale amphibole grown along grain boundaries. A few coronitic patches of olivine alteration with fresh olivine cores are present (e.g. at 5 cm). Rare sulfide minerals are present throughout the section.

VEIN ALTERATION: Some mm-sized calcite-tremolite-clays (saponite?) veins are present (e.g. at 72-75 and at top of Piece 4, identified by XRD).

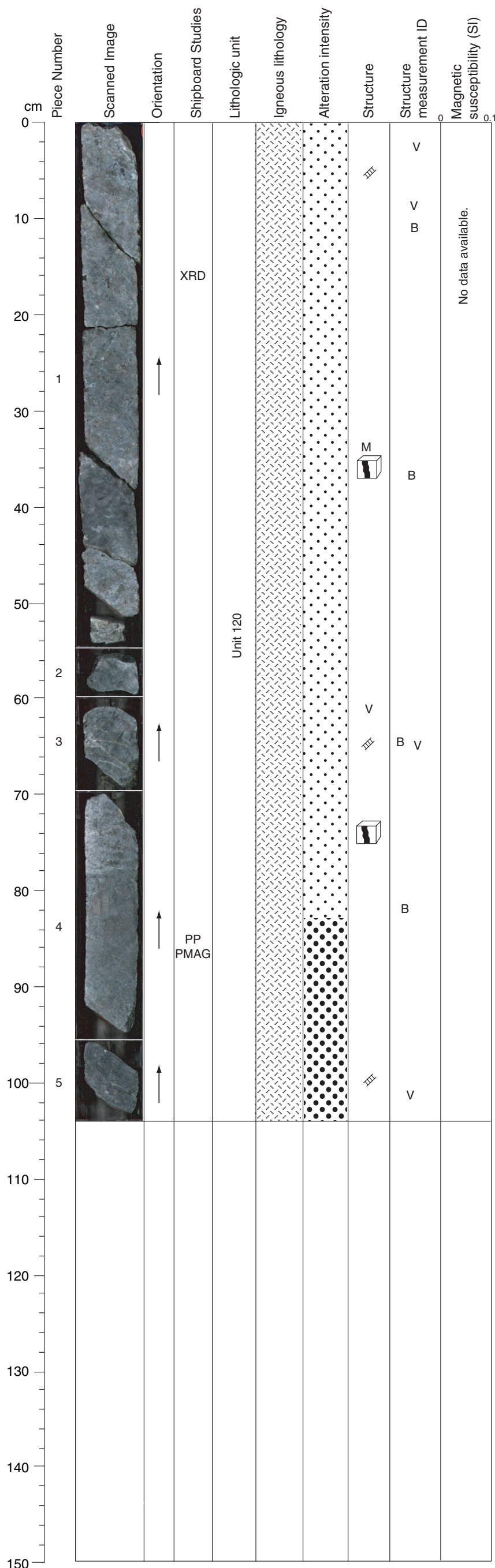
THIN SECTIONS:
304U-1309D-52R-2, 59.0-62.0 cm (#210)

STRUCTURE: Feldspar-rich domains are not clearly dioritic but are relatively clean. Distribution of feldspar and coarse-grained pyroxene define a magmatic layering (relatively gently dipping) (M1). Microcracking (C) decreases in intensity from Section U1309D-52R-1. Talc veins (V) are present in Pieces 3 and 4. A sharply bounded pyroxene-rich intrusion (M2), and some microfracture occur in these pieces as well. M1>M2>C>V

CLOSE UP PHOTOGRAPHS:
1309D_52R_2_55_71.jpg
1309D_52R_2_82_92.jpg

Core Photo

304-U1309D-52R-3 (Section top: 274.60 mbsf)



Unit 120: Gabbro
Pieces 1-5

PRIMARY MINERALOGY: Determined from Piece 1B

Plagioclase Modal 65%
 Size 5 to 7 mm
 Shape anhedral

Clinopyroxene Modal 35%
 Size 3 to 7 mm
 Shape anhedral

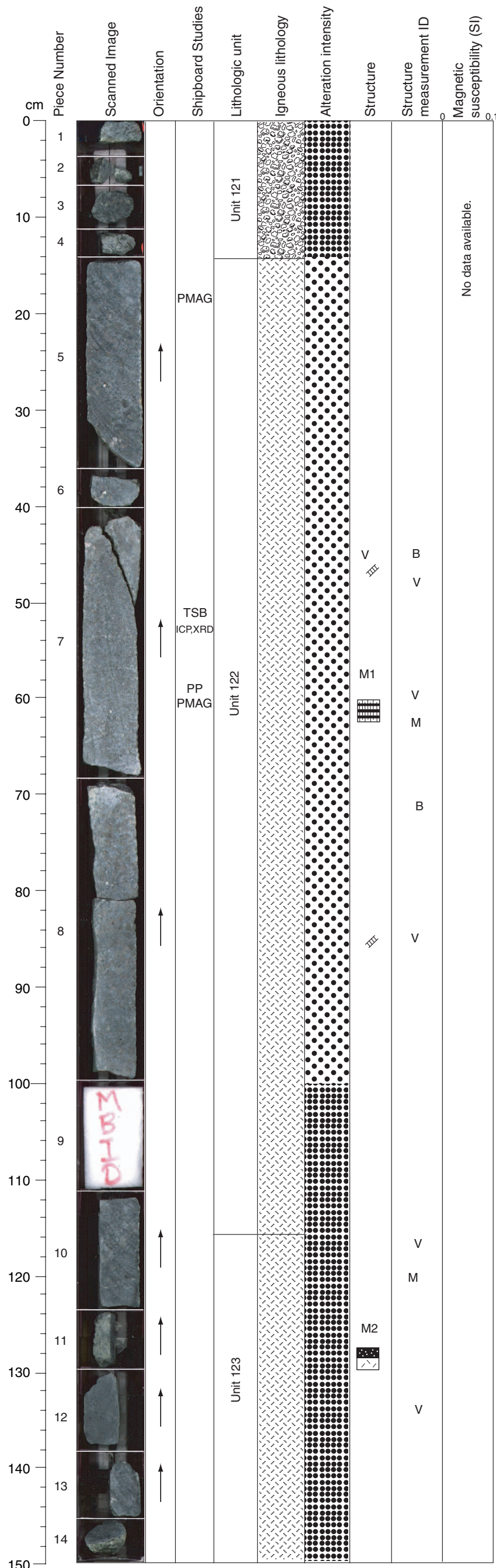
COMMENTS: This section consists of coarse-grained gabbro. Olivine occurs at 6 cm, 21-23 cm and 41-43 cm. Piece 3 is fractured. An anorthositic vein has intruded the section between 70 and 78 cm. Grain sizes grade toward medium with averages around 5 mm below 85 cm.

SECONDARY MINERALOGY: The section consists of slightly altered gabbro and moderately altered microgabbro. Secondary minerals are mostly chlorite +/- pale amphibole along grain boundaries. Very few coronitic patches of olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite are present (e.g. at 23, 28 cm). Rare sulfides are present throughout the section. The rock is mostly fresh and shows only minor greenschist facies alteration.

VEIN ALTERATION: Millimeter-scale talc-tremolite veins are present at 8-14, 62-67, 78, 100 cm.

STRUCTURE: Coarse-grained gabbro with dark amphibole veins (V). Several intrusive contacts (M) are present: Piece 1 contains a very coarse grained gabbro; Pieces 3 and 4 grade into a feldspar rich body. The feldspar rich domains coincide with later green veins. The contact with the feldspar-rich area dips out of the cut plane. M>V

Core Photo



304-U1309D-53R-1 (Section top: 276.40 mbsf)

Unit 121: Mixed Rubble
Pieces 1-4

COMMENTS: The section starts with several pieces of coarse-grained gabbro that are very similar to the bottom of Section U1309D-52R-003. They are presumed to be out of place.

Unit 122: Gabbro
Pieces 5-10

PRIMARY MINERALOGY: Determined from Piece 8A

Plagioclase Modal 70%
Size 4 to 5 mm
Shape anhedral

Clinopyroxene Modal 30%
Size 4 to 6 mm, maximum 15 mm (Piece 7)
Shape anhedral

COMMENTS: This unit consists of medium to coarse-grained gabbro and is essentially the same as in Unit 120. The unit starts with coarse grain sizes with a medium-grained interval between 46 and 68 cm where coarse grain sizes reappear.

Unit 123: Gabbro
Pieces 10-14

PRIMARY MINERALOGY: Determined from Piece 2A (Coarse part)

Plagioclase Modal 59%
Size 7 to 10 mm
Shape anhedral

Clinopyroxene Modal 40%
Size 7 to 10 mm
Shape anhedral

COMMENTS: Coarse pyroxenes coexist with fine matrix pyroxene below 116 cm, and probably represents mingling of crystal mushes. Piece 12 is a microgabbro.

SECONDARY MINERALOGY: The section contains moderately to highly altered gabbros in which pyroxenes are fairly unaltered. Plagioclase shows substantial alteration along its grain boundaries with dark green chlorite but is still fresh in the interior. Some disseminated sulfide is present.

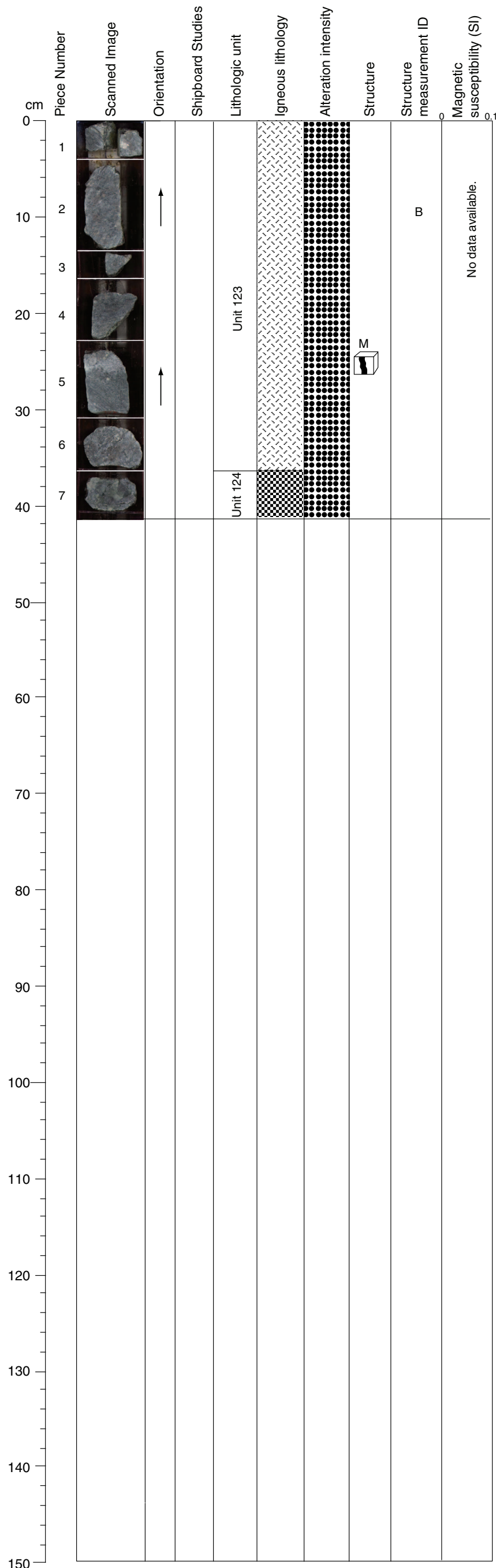
VEIN ALTERATION: A vertical pale amphibole +/- chlorite vein is present on surface of the core from Pieces 8 to 13 and within Piece 7.

THIN SECTIONS:
304-U1309D-53R-1 50-52 cm (#212)

STRUCTURE: Top few pieces are rubble that include some gabbroic fault rock. Within the section coarse-grained pyroxene grains in the gabbro are surrounded by feldspar - possibly dioritic - matrix. Amphibole veins are steeply dipping (V), and at a high-angle to traces of magmatic layering (M2). Into Piece 12 the gabbro becomes very fine grained (M1).
M1>M2>V

CLOSE UP PHOTOGRAPHS:
1309D_53R_1_42_68.jpg

Core Photo



304-U1309D-53R-2 (Section top: 277.90 mbsf)

UNIT-123: Gabbro
Pieces 1-6

PRIMARY MINERALOGY: Determined from Piece 2A

Plagioclase Modal 80%
 Size 5 to 6 mm
 Shape anhedral

Clinopyroxene Modal 20%
 Size 6 to 10 mm
 Shape anhedral

COMMENTS: This section represents the continuation of the gabbro from the previous section. A small feldspathic intrusion is in Piece 5.

UNIT-124: Oxide Gabbro
Piece 7

PRIMARY MINERALOGY: Determined from Piece 7

Plagioclase Modal 59%
 Size 7 to 10 mm
 Shape anhedral

Clinopyroxene Modal 40%
 Size 1 to 10 mm
 Shape anhedral

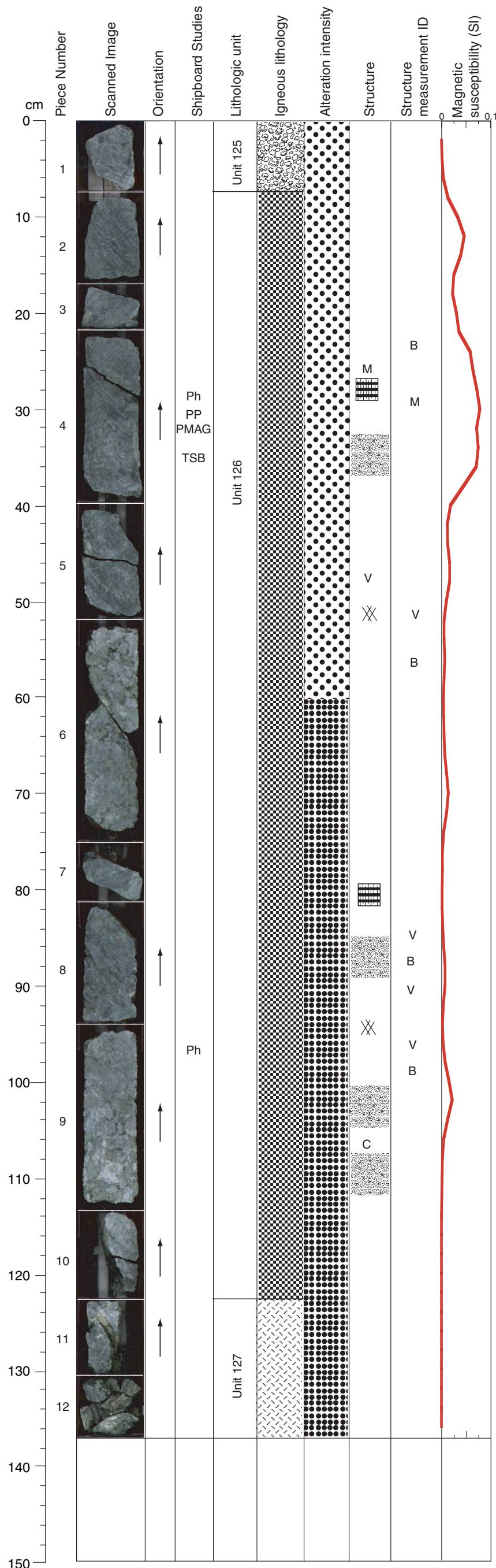
Oxides Modal 1-2%
 Shape anhedral

COMMENTS: A single piece of coarse-grained oxide gabbro occurs at the bottom of the section.

SECONDARY MINERALOGY: The core consists of highly altered gabbro in which the pyroxenes are still pretty fresh. Some disseminated sulfides are present.

STRUCTURE: Noteworthy for yellow-brown alteration (A - not shown in symbol column) on the drilled faces of several pieces, and a feldspar-rich zone (M) adjacent to coarse pyroxene grains (Piece 5). M>A

Core Photo



304-U1309D-54R-1 (Section top: 281.20 mbsf)

UNIT-125: Rubble
Piece 1

COMMENTS: Unit 125 consists of a single piece of coarse-grained gabbro. It is presumed to be out of place.

UNIT-126: Oxide Gabbro
Pieces 2-10

PRIMARY MINERALOGY: Determined from Piece 6

Plagioclase Modal 68%
Size 10-15 mm average, 30 mm maximum
Shape anhedral

Clinopyroxene Modal 30%
Size 10-15 mm average, 25 mm maximum
Shape anhedral

Oxide Modal 2%
Size 3-5 mm
Shape anhedral

COMMENTS: Unit 126 consists of coarse-grained oxide gabbro. The modal content of oxides decreases downsection and true oxide gabbros occur between 8 and 75 cm. Below 75 cm the gabbro contains less than 2% oxides. Nevertheless, the plagioclase/pyroxene ratio stays constant as well as grain sizes and shapes. Piece 4 has a fine-grained and a coarse-grained part both very oxide-rich with a subhorizontal boundary.

UNIT-127: Gabbro
Pieces 11-12

PRIMARY MINERALOGY: Determined from Piece 11

Olivine Modal 1%
Size 7 mm
Shape anhedral

Plagioclase Modal 70%
Size 5-7mm average, 20 mm maximum
Shape anhedral

Clinopyroxene Modal 30%
Size 5-9 mm
Shape anhedral

COMMENTS: Unit 127 consists of coarse-grained gabbro. Modal olivine does not exceed 1%.

SECONDARY MINERALOGY: The section consists of moderately altered gabbro in the upper part and highly altered brecciated, melt infiltrated(?) gabbro in the lower part. A few disseminated sulfides are in the upper gabbro. Secondary plagioclase is present in the lower gabbro. Pyroxenes show broad alteration rims, and are quite altered. Severely altered plagioclase has white rims. A zone of melt infiltration with sulfide-rich melt is severely altered (hydrothermally?) to dark green amphibole(?).

VEIN ALTERATION: Many sub-mm amphibole veins are present in the lower part of the section (below 45 cm).

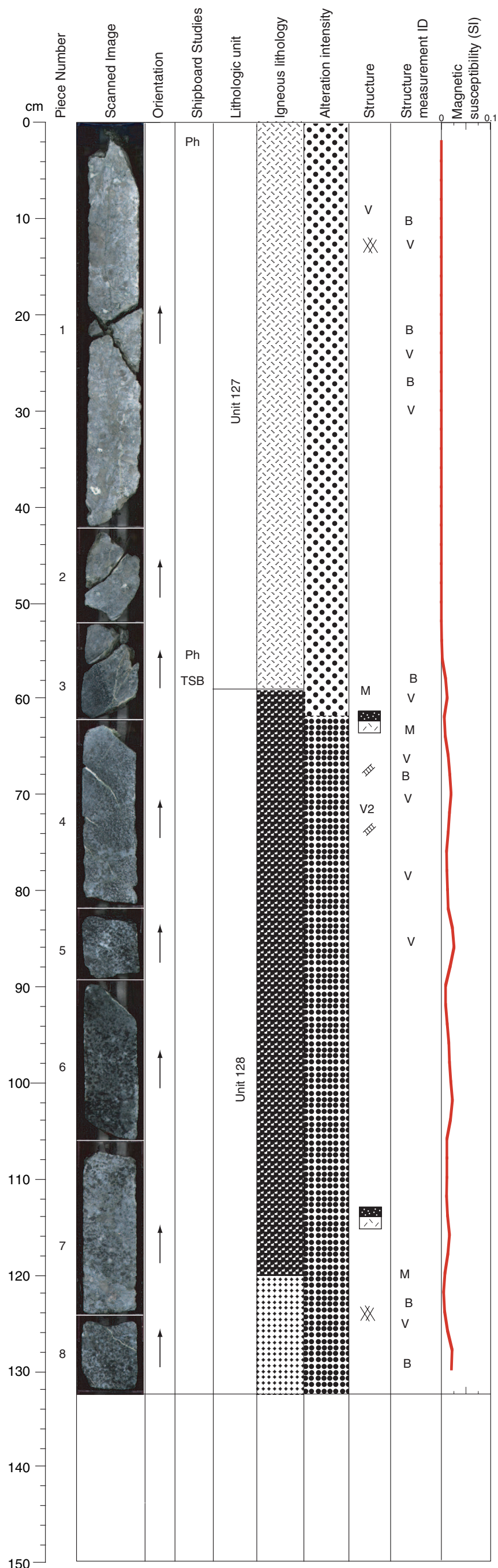
THIN SECTIONS:
304U-1309D-54R-1, 34.0-36.0 cm (#213)
304U-1309D-54R-1, 106.0-109.0 cm (#214)

STRUCTURE: A magmatic fabric (M), defined by pyroxene (in places has a metallic luster, in places is green from alteration) dips steeply toward 270 degrees (in the core reference frame). Intense microcracking (C) is localized in the plagioclase-rich section. Microcracks intersect pyroxene grains, and have allowed alteration along cleavage planes and cracks, rather than brecciation. (V). M>C>V

CLOSE UP PHOTOGRAPHS:
1309D_54R_1_26_40.jpg
1309D_54R_1_94_112.jpg



Core Photo



304-U1309D-54R-2 (Section top: 282.57 mbsf)

UNIT-127: Gabbro
Pieces 1-3

PRIMARY MINERALOGY: Determined from Piece 1D

- Olivine Modal <1%
 Size 7 mm maximum
 Shape anhedral
- Plagioclase Modal 60%
 Size 6-9 mm
 Shape anhedral
- Clinopyroxene Modal 40%
 Size 6-10 mm average, 26 mm maximum
 Shape anhedral

COMMENTS: Coarse-grained gabbro from the previous section continues at the top of the section. Overall modal content of olivine remains below 1%. A clinopyroxene oikocryst as large as 4 cm occurs in Piece 1.

UNIT-128: Troctolite and Olivine Gabbro
Pieces 3-8

PRIMARY MINERALOGY: Determined from Piece 6

- Olivine Modal 40%
 Size 4-6 mm
 Shape anhedral
- Plagioclase Modal 35%
 Size 3-4 mm
 Shape anhedral to subhedral
- Clinopyroxene Modal 25%
 Size 4-5 mm
 Shape anhedral

COMMENTS: Medium-grained troctolite and olivine gabbro are in direct contact with the coarse-grained gabbro. Grain size decreases in both units toward the contact and may form apparent 'chilled' margins. Pyroxene content in the upper part of the unit is very low; locally they are troctolite in composition. Pyroxene occurs at 72 and 109 cm and a small pyroxene-band crosses between 75-77 cm. Clinopyroxene increases modally downward to subequal proportions below 120 cm forming olivine gabbro. Coarse pyroxene grain sizes occur between 118 cm and 123 and may represent a coarse dike.

SECONDARY MINERALOGY: The section consists of moderately altered gabbro in the upper part and highly altered troctolite in the lower part. The metagabbro shows a few large corona patches due to olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite (e.g. at 38 cm). Most pyroxene and plagioclase are fresh. In the troctolitic part of the section plagioclase is partly altered to secondary plagioclase or prehnite with green rims of chlorite surrounding it. Olivine is mostly altered to black serpentine +/- talc. Some olivine relics are preserved. Rare fresh pyroxene are present. Disseminated sulfides are noted.

VEIN ALTERATION: Subvertical mm-sized pale amphibole +/- talc veins are present in the upper part of the section. Millimeter-scale (45°) talc-tremolite or serpentine veins are present in the lower section.

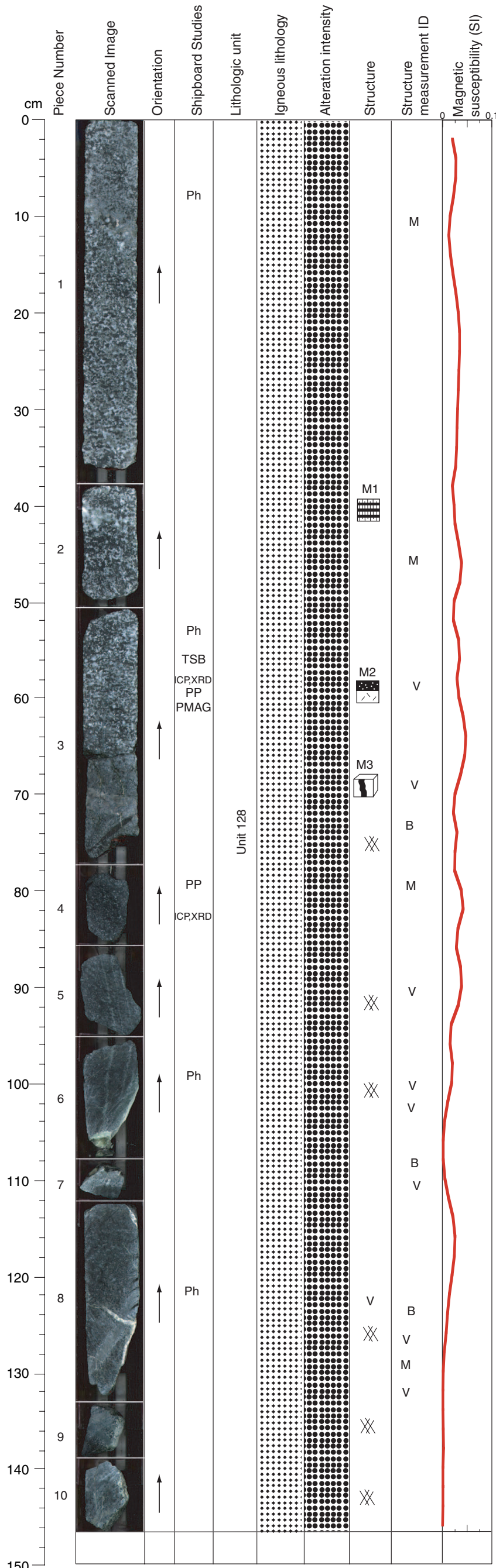
THIN SECTIONS:
304U-1309D-54R-2, 57.0- 59.0 cm (#215)

STRUCTURE: Similar to Section U1309D-54R-001, this section is cut by steeply dipping green veins (V) and plagioclase-olivine alteration. In Piece 3b there is a steeply dipping contact (M) between coarse grained gabbro and troctolite; the contact is cut by the green veins. In Piece 7, the coarse-grained gabbro intrudes the troctolite in a narrow band. Carbonate veins (V2) cut across the section, changing in their composition along their vein length. M>V=>V2

CLOSE UP PHOTOGRAPHS:
1309D_54R_2_54_62.jpg
1309D_54R_2_70.jpg



Core Photo



304-U1309D-54R-3 (Section top: 283.89 mbsf)

UNIT-128: Troctolite and Olivine Gabbro
Pieces 1-10

PRIMARY MINERALOGY: Determined from Piece 1

- Olivine Modal 40%
Size 3-6 mm average, 9 mm maximum
Shape anhedral
- Plagioclase Modal 35%
Size 3-6 mm average, 9 mm maximum
Shape anhedral
- Clinopyroxene Modal 25%
Size 4-5 mm
Shape anhedral

COMMENTS: This section consists mostly of coarse-grained olivine gabbro. Olivine, plagioclase and clinopyroxene occur in subequal proportions. Pyroxene occurs as large oikocrysts and is not evenly distributed in the section. A coarse-grained, 30 mm wide pyroxene-band occurs at 12 cm. Pyroxene-content decreases between 40 and 57 cm to troctolitic composition, and increases again towards a coarse-grained, 20 mm wide gabbro dike with pyroxene as large as 18 mm at 71 cm. Pieces 5 to 7 are troctolites. Piece 8 contains pyroxene and is cut by a microgabbro dike at 124 cm. Coarse pyroxene at the edge of Piece 9 might represent a dike as well.

SECONDARY MINERALOGY: The upper part of the section (0-66 cm) consists of highly altered troctolite with considerable serpentine and less coronitic pale amphibole+chlorite as alteration after olivine. Plagioclase is partially altered to prehnite and chlorite. Dissiminated magnetite and sulfides are present. The intermediate part of the section (66-132 cm) consisting of highly serpentinized peridotite contains serpentine, talc, chlorite, magnetite after olivine and pale amphibole after pyroxene and olivine. The highly altered troctolite in the lowermost part of the section (132-146 cm) shows the typical coronitic pattern because of olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite. Some relict olivine is still present. Secondary plagioclase may be present. Dissiminated sulfides are found throughout the section.

VEIN ALTERATION: A 3 mm talc-tremolite vein haloed by a 1.5 cm zone of pale amphibole and/ or chlorite + albite is present in the peridotite at 98-106 cm. Small vertical mm-scale veins of pale amphibole and/ or talc in troctolite at 66-74 cm are cut by a 2 cm-dikelet of plagioclase and pyroxene at 70-72 cm. A quartz-pyrite vein is present at 122-130 cm. Between 77-146 cm several mm thin veins of calcite are observed.

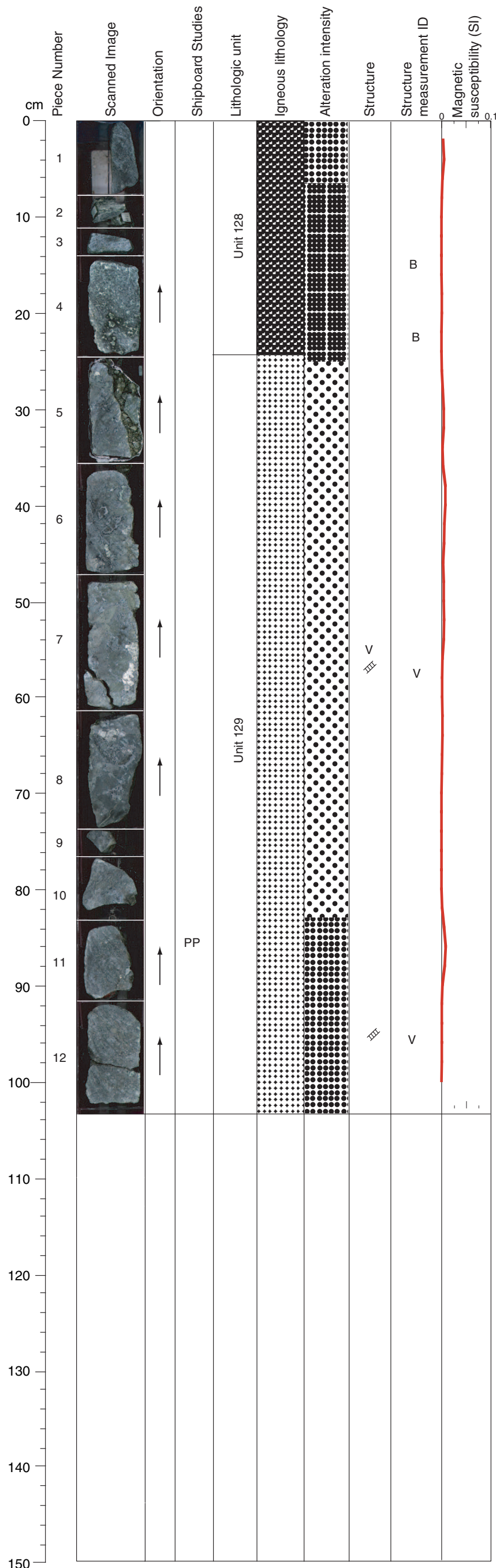
THIN SECTIONS:
304U-1309D-54R-3, 55.0-58.0 cm (#216)

STRUCTURE: Serpentinized olivine in troctolite; toward Piece 4 the troctolite grades into dunite (M1). Shallowly dipping plagioclase-rich domains (M2) have diffuse boundaries (e.g. Piece 2). A steeply dipping coarse grained gabbroic intrusion (M3) cuts the troctolite in Piece 3. Veins (V) crosscut all of these intrusions, but change their character in the gabbroic phases obscuring the crosscutting relationship. Most veins have some carbonate.
M>M2>M3>V

CLOSE UP PHOTOGRAPHS:
1309D_54R_3_7_27.jpg
1309D_54R_3_52_78.jpg
1309D_54R_3_98_106.jpg
1309D_54R_3_121_131.jpg



Core Photo



304-U1309D-54R-4 (Section top: 285.35 mbsf)

Unit 128: Troctolite and Olivine Gabbro
Pieces 1-4

PRIMARY MINERALOGY: Determined from Piece 4

- Olivine Modal 40%
 Size 2-6mm
 Shape anhedral
- Plagioclase Modal 60%
 Size 2-3 mm average, 6 mm maximum
 Shape anhedral
- Clinopyroxene Modal 3%
 Size 2 mm
 Shape anhedral

COMMENTS: At the top of the section occurs coarse-grained troctolite. Below 18 cm, pyroxene occurs again but mostly confined to bands. Olivines are filled by sulfides from alteration (?).

Unit 129: Olivine Gabbro
Pieces 5-12

PRIMARY MINERALOGY: Determined from Piece 5 and 6

- Olivine Modal 5%
 Size 15 mm maximum
 Shape anhedral
- Plagioclase Modal 65%
 Size 7-10 mm average, 15 mm maximum
 Shape anhedral
- Clinopyroxene Modal 40%
 Size 7-12 mm average, 30 mm maximum
 Shape anhedral

COMMENTS: Unit 129 consists of very coarse-grained olivine gabbro. Pyroxene grain sizes decrease downsection from 20-25 mm in Piece 5 to 15 mm in Piece 8 toward 6 mm in Piece 12. Large clinopyroxene oikocryst occur in Piece 7 (50 mm) and Piece 8 (30 mm).

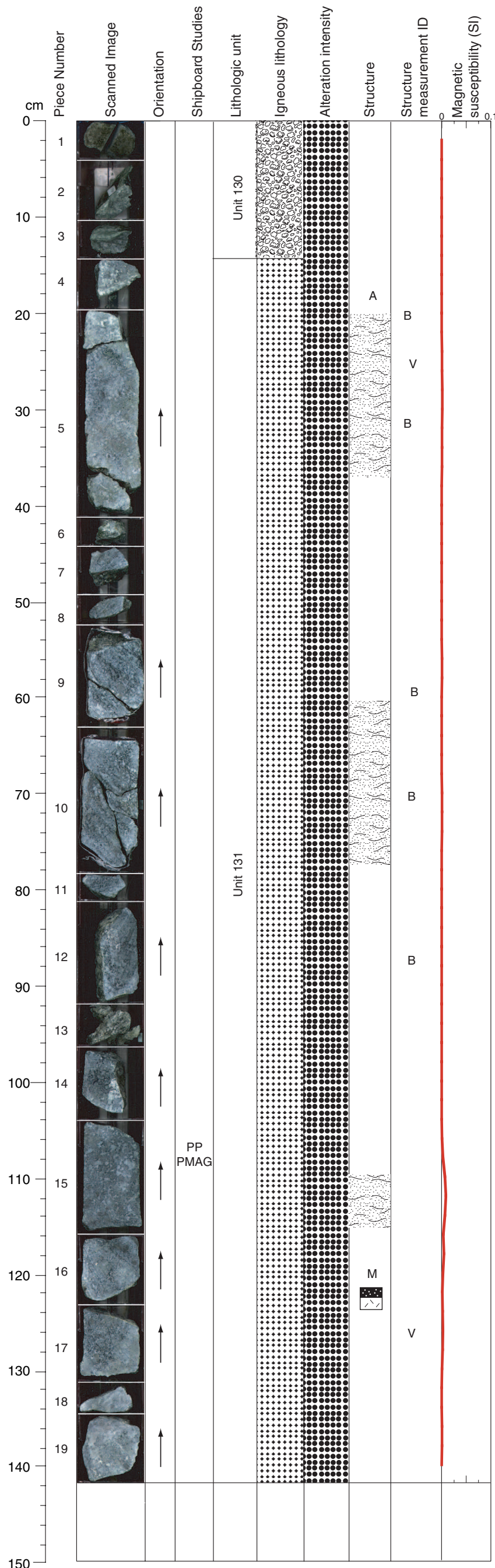
SECONDARY MINERALOGY: The upper part of the section consists of highly to very highly altered troctolite. Coronitic textures due to olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite are present with some severely altered large corona patches after olivine. The central part of the section contains moderately altered olivine gabbro with several corona patches due to olivine alteration in which some large relict olivine is left. The lower part of the section consists of highly altered microgabbro in which ferromagnesian minerals are partially altered to pale amphibole and chlorite.

VEIN ALTERATION: No veins in this section.

STRUCTURE: Well-developed igneous textures with beautiful pyroxene grain boundaries. About two plagioclase rich veins (V).



Core Photo



304-U1309D-55R-1 (Section top: 286.00 mbsf)

UNIT-130: Rubble
Pieces 1-3

COMMENTS: Unit 130 consists of medium-grained olivine gabbro presumed to be out of place. Piece 3 has a shear zone at the edge.

UNIT-131: Olivine Gabbro
Pieces 4-19

PRIMARY MINERALOGY: Determined from Piece 10

Olivine Modal 20%
 Size 3-5 mm
 Shape anhedral

Plagioclase Modal 50%
 Size 3-4 mm average, 6 mm maximum
 Shape anhedral

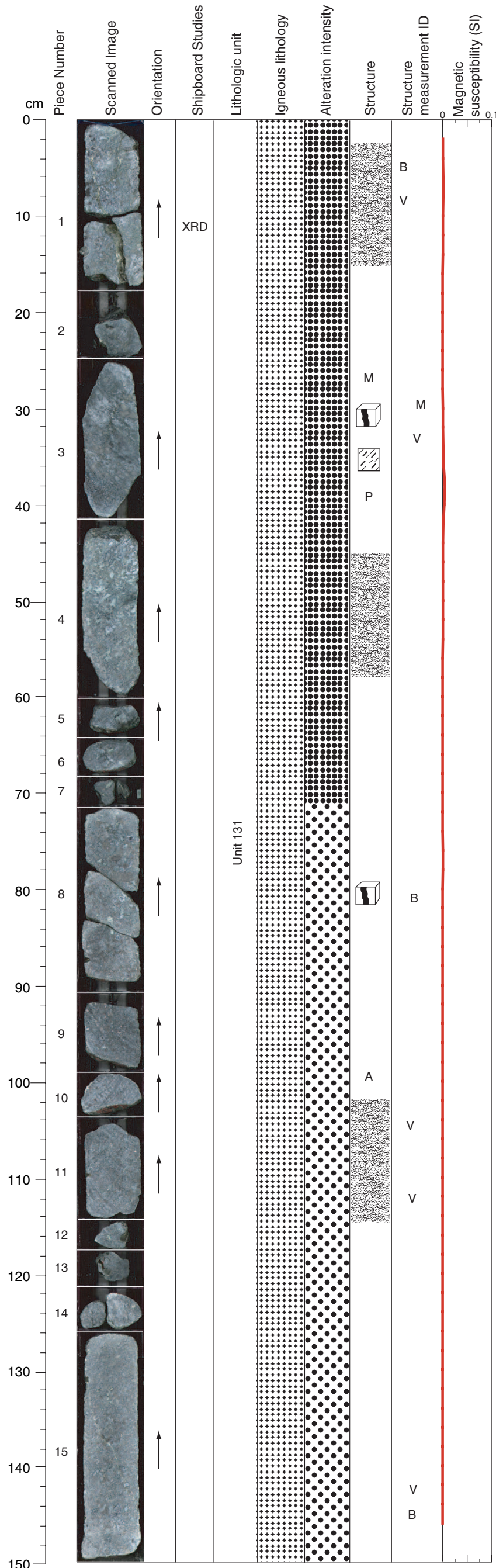
Clinopyroxene Modal 30%
 Size 3-5 mm average, 25 mm maximum
 Shape anhedral

COMMENTS: Unit 131 consists of coarse-grained olivine gabbro with large clinopyroxene oikocrysts. A steeply dipping coarse-grained gabbro dike crosscuts the section between 127 cm and 138 cm. The contact is diffuse and no change in grain size is observed. Olivine concentration decreases downsection.

SECONDARY MINERALOGY: The section consists of highly altered gabbro with partially altered ferromagnesian minerals. Corona textures are due to olivine alteration to tremolite + chlorite +/- talc, rimmed by chlorite. Most of the pyroxene and plagioclase are fresh.

STRUCTURE: "Coronitic" alteration (A) expressed as reaction rims on plagioclase and olivine. Surrounding matrix is a very fine-grained feldspar. Little evidence for microfracture. Last 3 pieces (Pieces 16-19) include a transition into a very coarse grained gabbroic intrusion (M).
M>A

Core Photo



304-U1309D-55R-2 (Section top: 287.42 mbsf)

UNIT-131: Olivine Gabbro
Pieces 1-15

PRIMARY MINERALOGY: Determined from Piece 4

Olivine Modal 30%
 Size 5-9 mm
 Shape anhedral

Plagioclase Modal 40%
 Size 5-6 mm average
 Shape anhedral

Clinopyroxene Modal 30%
 Size 15 mm maximum
 Shape anhedral

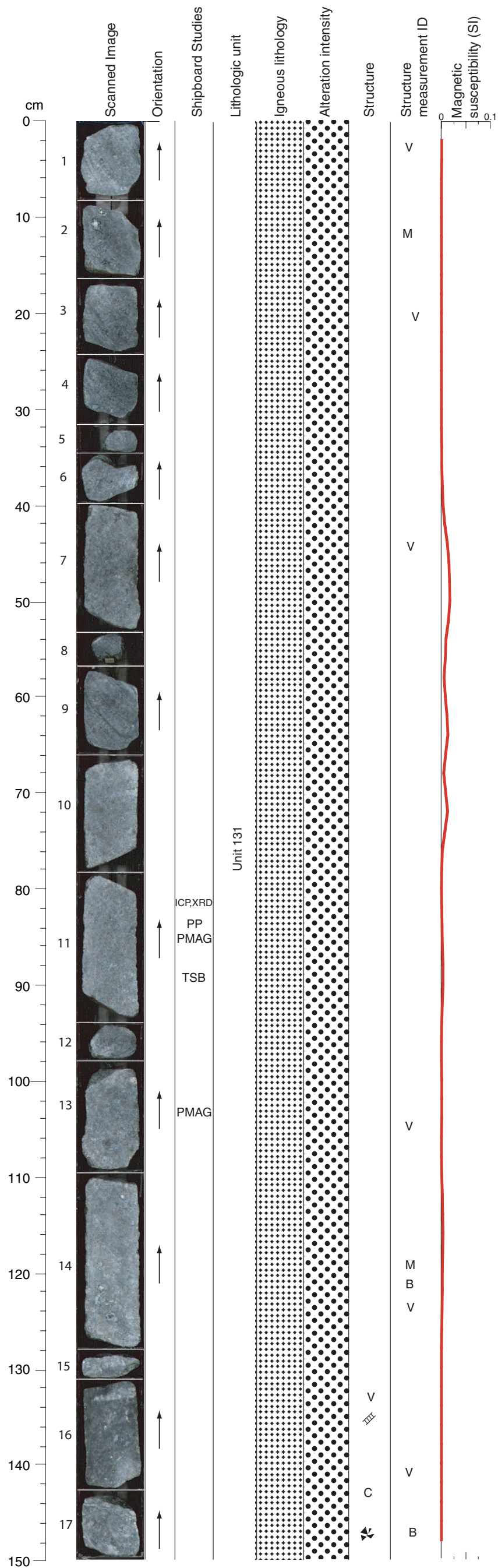
COMMENTS: This section consists of coarse-grained olivine gabbro. The modal content of pyroxene increases downhole with fewer clinopyroxene oikocrysts with decreasing olivine. Piece 4 shows magmatic foliation. Alteration veins occur at 3 cm, 10 cm, 78 cm, and 85 cm.

SECONDARY MINERALOGY: This section consists of highly to moderately altered olivine gabbro in which pyroxene are mostly fresh. Corona textures are due to olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite. Relics of olivine have survived within some of the larger corona patches. Plagioclase is quite altered with extensive rims of dark green chlorite.

VEIN ALTERATION: Thin pale amphibole veins are present in the first and last piece.

STRUCTURE: Green, intergranular (with respect to pyroxene) alteration (A) with some veining. Pyroxene defines a magmatic foliation (M) in Piece 4. Pieces 3 and 8 have intrusions of coarse grained gabbro, increasingly "mixed" with olivine. Note that the intrusion in Piece 3 has a weak crystal plastic texture (P). M>A>P

Core Photo



304-U1309D-55R-3 (Section top: 288.92 mbsf)

UNIT-131: Olivine Gabbro
Pieces 1-17

PRIMARY MINERALOGY: Determined from Piece 13

Olivine Modal 5%
 Size 3-5 mm
 Shape anhedral

Plagioclase Modal 60%
 Size 3-7 mm
 Shape subhedral to anhedral

Clinopyroxene Modal 35%
 Size 3-7 mm average, 12 mm maximum
 Shape subhedral to anhedral

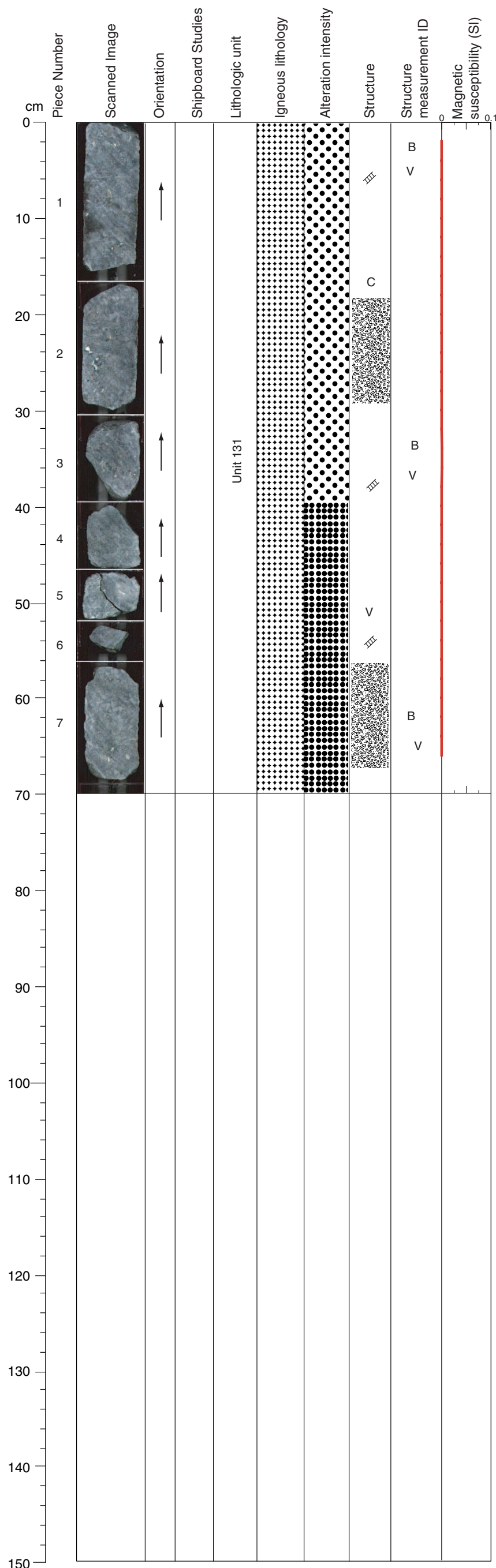
COMMENTS: This section consists of coarse-grained olivine to olivine-bearing gabbro. A medium-grained interval occurs between 9 and 100 cm. Oxides occur as small interstitial grains between 41 and 79 cm.

SECONDARY MINERALOGY: This section contains moderately altered olivine gabbro with mostly fresh pyroxene. Plagioclase is quite altered along the grain boundaries, showing a rim of dark green chlorite. Corona textures because of olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite are common. Some of the larger corona patches contain relics of fresh olivine.

THIN SECTIONS:
[304-U1309D-55R-3, 88.0-90.0 cm \(#217\)](#)

STRUCTURE: Fine-grained olivine gabbro with variable amounts of pyroxene at the base of the section (Piece 17). Piece 17 has a slightly brecciated (C) texture with dark amphibole veins (V). C>V

Core Photo



304-U1309D-55R-4 (Section top: 290.42 mbsf)

UNIT-131: Olivine Gabbro
Pieces 1-7

PRIMARY MINERALOGY: Determined from Piece 2

Olivine Modal 1%
Size 2-3 mm, 6 mm maximum
Shape anhedral

Plagioclase Modal 64%
Size 5-10 mm average, 12 mm maximum
Shape anhedral

Clinopyroxene Modal 35%
Size 4-7 mm
Shape anhedral

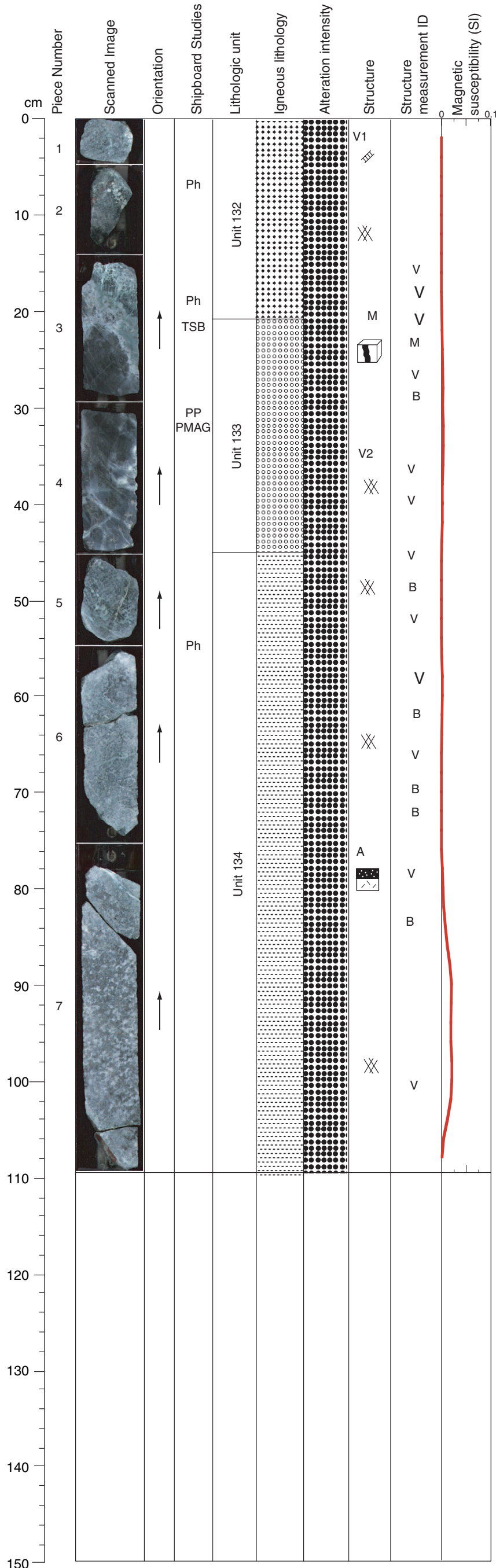
COMMENTS: This section consists of coarse-grained olivine-bearing gabbro with plagioclase-rich and pyroxene-rich domains. Piece 7 is very pyroxene-rich.

SECONDARY MINERALOGY: The section consists of moderately altered olivine gabbro in the upper part and highly altered gabbro in the lower part. Olivine in the olivine gabbro is altered to coronitic patches with tremolite in the center and a rim of chlorite surrounding it where it is in contact with plagioclase. Pyroxene is partly altered to actinolite, plagioclase is altered to chlorite on its grain boundaries.

VEIN ALTERATION: Millimeter-scale vein of tremolite at 10 cm, 45 cm. Vein intensity is higher in the lower part of the section.

STRUCTURE: Unaltered and unfractured pyroxene dominate the section. Intense microfracture (C) is present in the feldspar-rich domains, imparting almost a cataclastic fabric to Piece 4. Steeply dipping, dark amphibole veins (V) (hornblende?) cut other fabrics (e.g. the cataclasite). Toward the base of the section the cataclasite becomes slightly green although dark amphibole fill the intergranular spaces. C>V

Core Photo



304-U1309D-56R-1 (Section top: 290.80 mbsf)

UNIT-132: Olivine Gabbro
Pieces 1-3

PRIMARY MINERALOGY: Determined from Piece 1

- Olivine: Modal 20%, Size 1-2 mm, Shape anhedral
- Plagioclase: Modal 60%, Size 2-4 mm average, 6 mm maximum, Shape anhedral
- Clinopyroxene: Modal 20%, Size 2-6 mm, Shape anhedral

COMMENTS: This unit consists of medium-grained olivine gabbro with magmatic foliation. An olivine-band occurs at 11 cm. At the edge of Piece 3 occurs an altered dioritic dike.

UNIT-133: Serpentinized Dunite
Pieces 3-4

PRIMARY MINERALOGY: Determined from Piece 3 and 4

- Olivine: Modal 94 %, Size too altered, Shape too altered
- Plagioclase: Modal 1%, Size 1-2 mm, Shape anhedral
- Clinopyroxene: Modal 4%, Size 2-3 mm, Shape anhedral
- Spinel: Modal 1%, Size 2-3 mm, Shape anhedral

COMMENTS: The olivine gabbro grades with a diffuse talc-tremolite-rich contact into a totally serpentinized dunite. Pyroxene and to a lesser extent altered plagioclase occur as intercumulus phase. A high amount of sulfides is observed.

UNIT-134: Serpentinized Troctolitic Gabbro
Pieces 5-7

PRIMARY MINERALOGY: Determined from Piece 7

- Olivine: Modal 50%, Size 3-7 mm, Shape anhedral
- Plagioclase: Modal 40%, Size 4-6 mm, Shape subhedral to anhedral
- Clinopyroxene: Modal 10%, Size 2 mm average, 4 mm maximum, Shape anhedral

COMMENTS: A coarse-grained troctolitic gabbro occurs in the lower part of the section without direct contact with the dunite. It contains clinopyroxene oikocrysts.

SECONDARY MINERALOGY: This section consists of highly altered troctolite in the upper and lower parts of the section and highly altered serpentinite in the central part. The troctolite shows a typical coronitic texture where olivine is altered to tremolite and rimmed by chlorite along the contact with plagioclase. Pyroxene is partly altered to actinolite, plagioclase is altered to chlorite on its grain boundaries.

VEIN ALTERATION: Centimeter-scale vein with 5 cm halo at 7 cm. At 15-39 cm complex vein system with tremolite and talc. Millimeter-scale tremolite veins at 54, 67, 78 cm. The latter with cm-scale halo.

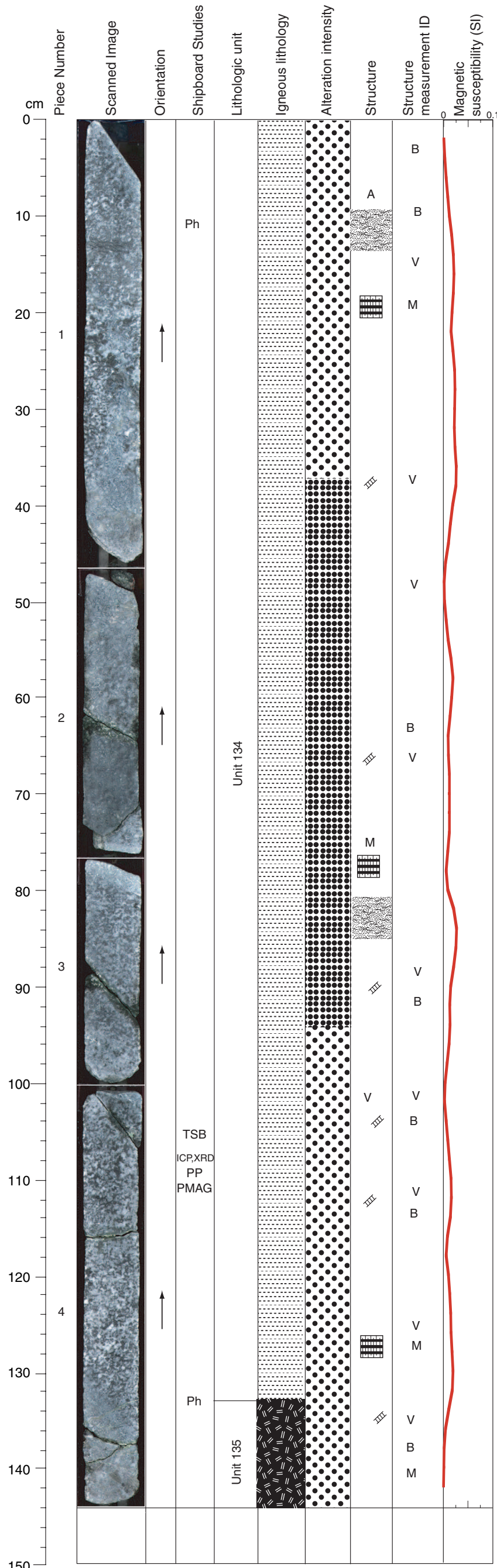
THIN SECTIONS:
304-U1309D-56R-1, 20.0-23.0 cm (#233)

STRUCTURE: The section is noteworthy for dark gabbroic rock grading into troctolite and into a serpentinized ultramafic and back into troctolite (from top to bottom). The gabbro contains abundant dark amphibole grains (hornblende?) (V1), and composite green veins (V2). The troctolite is noteworthy for an altered plagioclase layer (M), and "open" veins with talc-rich surfaces with mineral lineations. At the base of the section (Piece 7) the troctolite contains a very sharp contact between green and gray troctolite (an alteration boundary) (A). These lower pieces of troctolite (Pieces 5-7) are cut by several veins, internally brecciated and serpentine rich. The serpentinized ultramafic has a green talc-rich zone that forms a dipping band of alteration (in Piece 3), and a network of alteration bands (in Piece 4). Green talc-serpentine veins cut across the alteration band and trace into the serpentinite. M>V1>A>V2

CLOSE UP PHOTOGRAPHS:
1309D_56R_1_6_26.jpg
1309D_56R_1_18_46.jpg
1309D_56R_1_55_74.jpg



Core Photo



304-U1309D-56R-2 (Section top: 291.90 mbsf)

UNIT-134: Serpentinized Troctolitic Gabbro
Pieces 1-4

PRIMARY MINERALOGY: Determined from Piece 1 (Troctolitic Gabbro)

Olivine	Modal 40%
	Size 5-10 mm
	Shape anhedral
Plagioclase	Modal 53%
	Size 3-5 mm average, 8 mm maximum
	Shape anhedral
Clinopyroxene	Modal 7%
	Size 4-6 mm
	Shape anhedral

PRIMARY MINERALOGY: Determined from Piece 4 (Troctolite)

Olivine	Modal 40%
	Size 5-10 mm
	Shape anhedral
Plagioclase	Modal 60%
	Size 3-5 mm average, 8 mm maximum
	Shape anhedral
Clinopyroxene	Modal 1%
	Size 4-6 mm
	Shape anhedral

COMMENTS: The upper section is coarse-grained troctolitic gabbro with a weak magmatic foliation. A very coarse-grained pyroxene-rich dike cuts the unit between 39 and 46 cm and a coarse pyroxene-band occurs at 52 cm. Pyroxene content is decreasing downsection and troctolites occur below 77 cm. Serpentine veins occur at 14 cm.

UNIT-135: Olivine-bearing Gabbro
Pieces 4

PRIMARY MINERALOGY: Determined from Piece 4D

Olivine	Modal 2%
	Size 4-6 mm
	Shape anhedral
Plagioclase	Modal 45%
	Size 4-6 mm
	Shape anhedral
Clinopyroxene	Modal 53%
	Size 4-7 mm average, 35 mm maximum
	Shape anhedral

COMMENTS: A very coarse-grained, olivine-bearing gabbro dike with a diffuse contact occurs at the bottom of the section.

SECONDARY MINERALOGY: The section consists of moderately to highly altered troctolite (with gabbroic inclusions at 40-46, 137-144 cm). Plagioclase is rimmed by dark green chlorite and may be altered partially to prehnite or secondary plagioclase. Olivine is severely altered to black ?serpentine + talc.

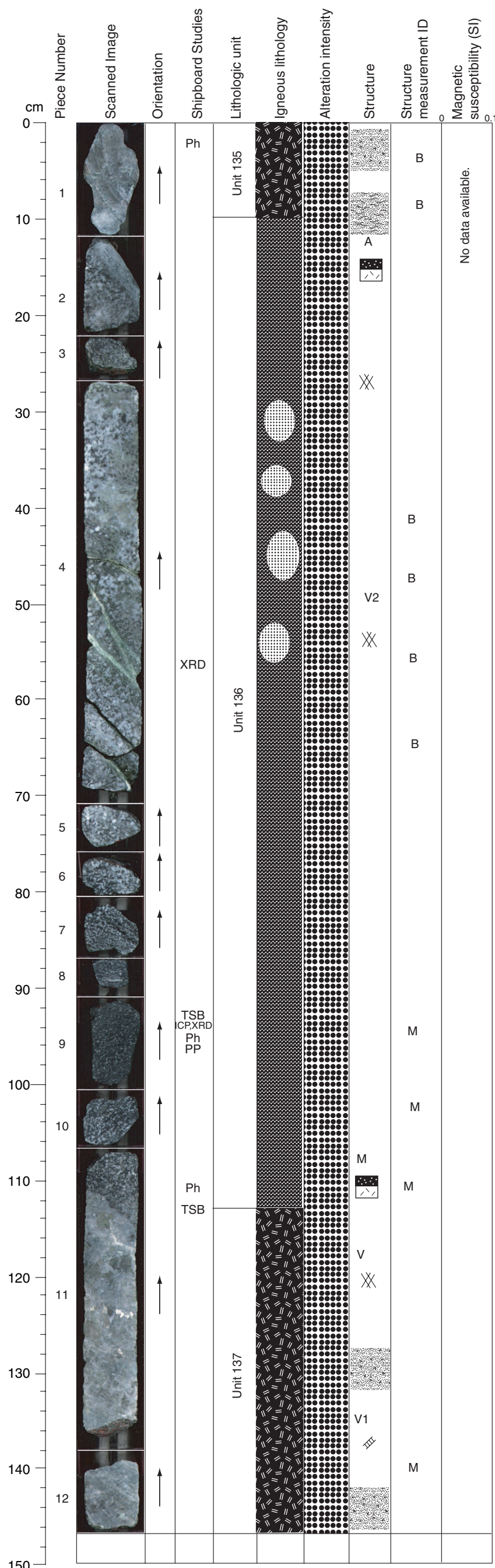
VEIN ALTERATION: Millimeter-scale vein with cm-scale alteration halo at 64, 91, 116, 134 cm.

THIN SECTIONS:
[304-U1309D-56R-2, 104.0-106.0 cm \(#218\)](#)

STRUCTURE: Dark troctolitic and olivine-bearing gabbro. Piece 1 has dark oxide seams (A). Within Piece 2 feldspar-rich and altered olivine bands (M) are present. Each piece in this section is cut by gently dipping serpentine-rich veins (V). M>A>V

CLOSE UP PHOTOGRAPHS:
[1309D_56R_2_8_28.jpg](#)
[1309D_56R_2_130_144.jpg](#)

Core Photo



304-U1309D-56R-3 (Section top: 293.34 mbsf)

UNIT-135: Olivine-bearing Gabbro
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1A

- Olivine Modal 2%
Size 5-7 mm
Shape anhedral
- Plagioclase Modal 45%
Size 5-10 mm average, 25 mm maximum
Shape anhedral
- Clinopyroxene Modal 53%
Size 4-7 mm average, 25 mm maximum
Shape anhedral

COMMENTS: A very coarse-grained olivine-bearing gabbro occurs at the top of the section. Pyroxene can reach grain sizes as large as 30 mm.

UNIT-136: Troctolite with pyroxene-rich domains
Pieces 1-11

PRIMARY MINERALOGY: Determined from Piece 6A

- Olivine Modal 45%
Size 5-6 mm
Shape anhedral
- Plagioclase Modal 55%
Size 5-6 mm
Shape anhedral

COMMENTS: Unit 136 consists of coarse-grained troctolite. A 25 mm wide reaction zone at the contact leads to the formation of corona textures in the troctolite. Pyroxene-rich domains occur in the upper part of the unit between 20 and 60 cm and might represent large (~40 mm) clinopyroxene oikocrysts. Further downward, pyroxene disappears and troctolites persists. Below 80 cm, medium grain sizes occur and magmatic foliation is visible. Piece 9 is very rich in olivine crystals.

UNIT-137: Olivine-bearing Gabbro
Pieces 11-12

PRIMARY MINERALOGY: Determined from Piece 11

- Olivine Modal 1%
Size 4-6 mm
Shape anhedral
- Plagioclase Modal 64%
Size 7-12 mm average, 22 mm maximum
Shape anhedral
- Clinopyroxene Modal 35%
Size 4-12 mm average, 20 mm maximum
Shape anhedral

COMMENTS: A very coarse-grained, olivine-bearing gabbro occurs in sharp contact with the troctolite. Pyroxene has grains as large as 25 mm. Parallel bands of plagioclase- and olivine-rich layers occur with a sharp change to pyroxene-rich composition at the bottom of the section. It is not clear if this represents layering or a dike. Piece 11 and 12 fit perfectly together.

SECONDARY MINERALOGY: This section consists of highly altered troctolite and olivine-bearing gabbro. At the top and bottom of the the section troctolite units show a high alteration in the greenschist facies because of olivine alteration. Olivine are replaced by tremolite + chlorite +/- talc and rimed by chlorite. This typical coronitic texture is present almost in all the section. In the central part of the section (from 78 to 110 cm, and especially in Piece 9) the darker color of the rock is due to the high serpentinization of the olivine to form a mesh texture with magnetite. Plagioclase is also more altered to prehnite and chlorite.

VEIN ALTERATION: 0.5-cm wide tremolite-talc veins at 46, 53, 56, 66 cm.

THIN SECTIONS:

- 304-U1309D-56R-3, 92.0-94.0 cm (#219)
- 304-U1309D-56R-3, 112.0-115.0 cm (#220)

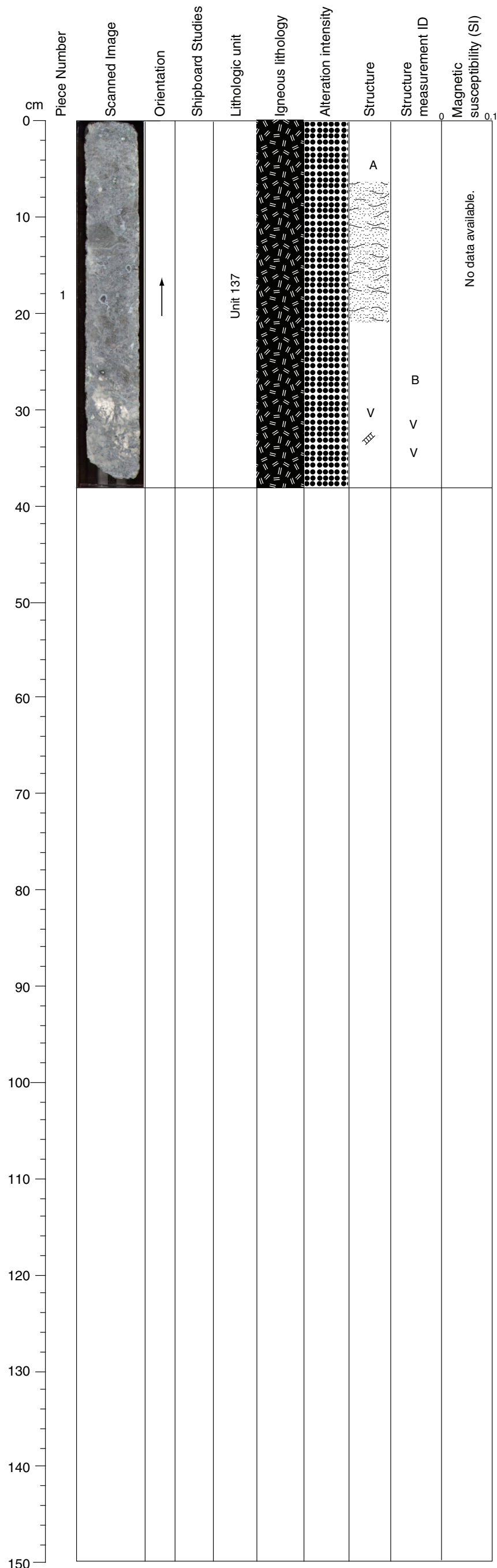
STRUCTURE: Coarse-grained gabbro with intense microfracturing in the plagioclase-rich zone. The plagioclase in these zones is fairly translucent. Sharp contact with the olivine gabbro at the base of piece 1 begins an interval wherein altered plagioclase and olivine forms a continuous network (A). In Piece 2, the contact between fresh and intensely altered troctolite (M) is very sharp. In Piece 4, composite branching green veins (V2) with white, crystalline centers form a interconnected branching set. Local pyroxene has a metallic luster. The contact between troctolite and coarse grained gabbro at 110 cm is sharp. The gabbro beneath this contact is intensely fractured (microfractures) (C) and contains dark amphibole veins (V1). M>A>V1>C>V2

CLOSE UP PHOTOGRAPHS:

- 1309D_56R_3_0_21.jpg
- 1309D_56R_3_91_100.jpg
- 1309D_56R_3_109_125.jpg



Core Photo



304-U1309D-56R-4 (Section top: 294.80 mbsf)

UNIT-137: Olivine-bearing Gabbro
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1

Olivine	Modal 2% Size 3-5 mm average, 10 mm maximum Shape anhedral
Plagioclase	Modal 63% Size 7-10 mm Shape anhedral
Clinopyroxene	Modal 35% Size 7-11 mm average, 63 mm maximum Shape anhedral

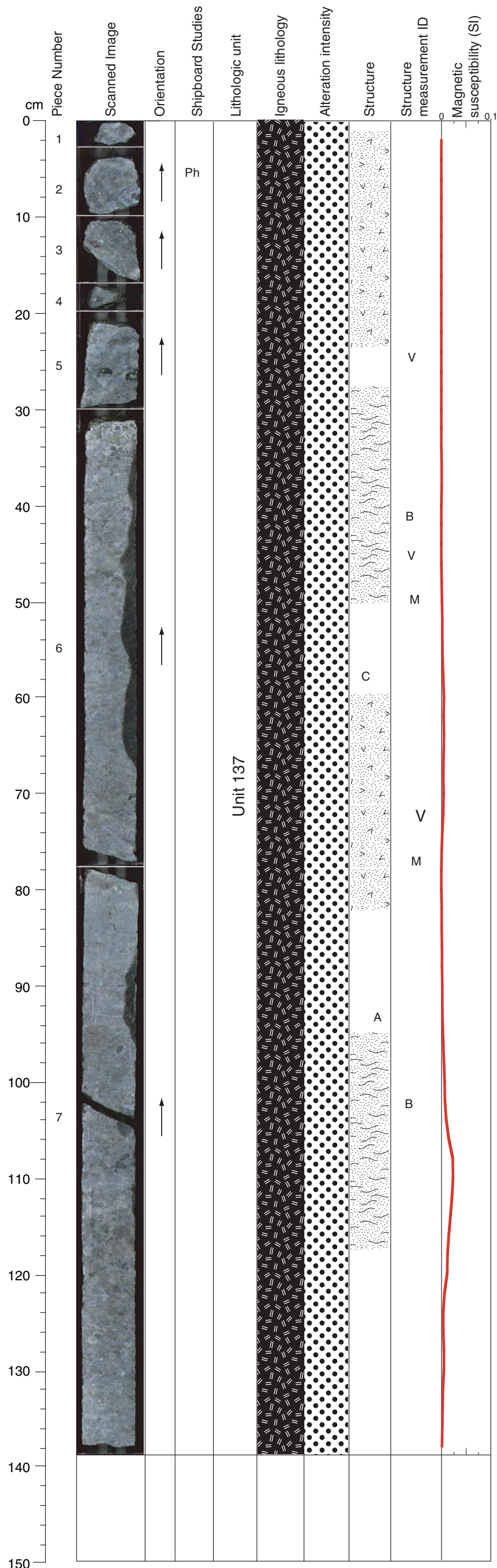
COMMENTS: This section consists of very coarse-grained, olivine-bearing gabbro and is the continuation of the previous section. Clinopyroxene oikocryst as large as 8 cm occur between 27 cm and 36 cm.

SECONDARY MINERALOGY: The section contains highly altered olivine -bearing gabbro. Large corona patches due to olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite, in parts with olivine relics, are present. Most pyroxene is preserved. Plagioclase shows alteration with dark green chlorite rims. Low abundance of brown hornblende seems to be present.

VEIN ALTERATION: Millimeter-scale blue-green tremolite vein at 29 cm.

STRUCTURE: A continuation of Section U1309D-56R-3 texturally with the one exception that there is a pronounced corona texture (A) on olivine and plagioclase grains. A gently dipping blue vein (V) is present. A>V

Core Photo



304-U1309D-57R-1 (Section top: 295.60 mbsf)

UNIT-137: Olivine-bearing Gabbro
Pieces 1-7

PRIMARY MINERALOGY: Determined from Piece 6

- Olivine Modal 2%
 Size 2-5 mm average, 10 mm maximum
 Shape anhedral
- Plagioclase Modal 63 %
 Size 7-10 mm average, 22 mm maximum
 Shape anhedral
- Clinopyroxene Modal 35%
 Size 5-11 mm average, 33 mm maximum
 Shape anhedral

COMMENTS: This section consists of very coarse-grained, olivine-bearing gabbro with sporadic occurrence of olivine. A fine-grained foliated interval occurs between 80 and 86 cm.

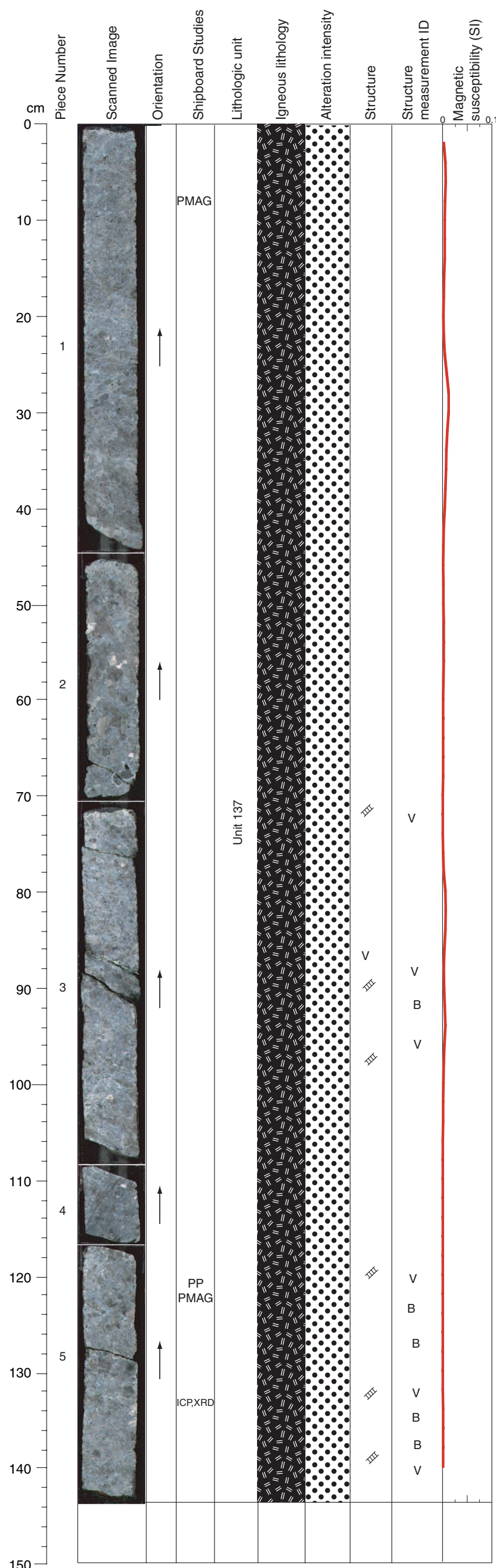
SECONDARY MINERALOGY: This section consists of moderately altered olivine-bearing gabbro, in the greenschist facies. Plagioclase are mostly fresh and pyroxene is slightly altered to actinolite. Olivine are replaced by tremolite + chlorite +/- talc and rimmed by chlorite. This alteration is characterized by a corona texture. Some sulfides are present.

VEIN ALTERATION: Few thin green actinolite veins are present in this section (e.g. between 44-47 cm).

STRUCTURE: Alteration rims on olivine and plagioclase (A). Microcracking in plagioclase-rich portions of the section are locally radial from the corona textured olivine (e.g. Piece 2). Microcracking (C) is pervasive away from these corona textures as well. A>=(?)C

CLOSE UP PHOTOGRAPHS:
1309D_57R_1_4_10.jpg
1309D_57R_1_4_10_2.jpg

Core Photo



304-U1309D-57R-2 (Section top: 296.98 mbsf)

UNIT-137: Olivine-bearing Gabbro
Pieces 1-5

PRIMARY MINERALOGY: Determined from Piece 3D

- Olivine Modal 2%
 Size 3-5 mm average, 10 mm maximum
 Shape anhedral
- Plagioclase Modal 58%
 Size 7-10 mm average, 20 mm maximum
 Shape anhedral
- Clinopyroxene Modal 40%
 Size 5-11 mm average, 35 mm maximum
 Shape anhedral

COMMENTS: This section consists of coarse-grained olivine-bearing gabbro and is the continuation from the previous sections. Olivine is rare.

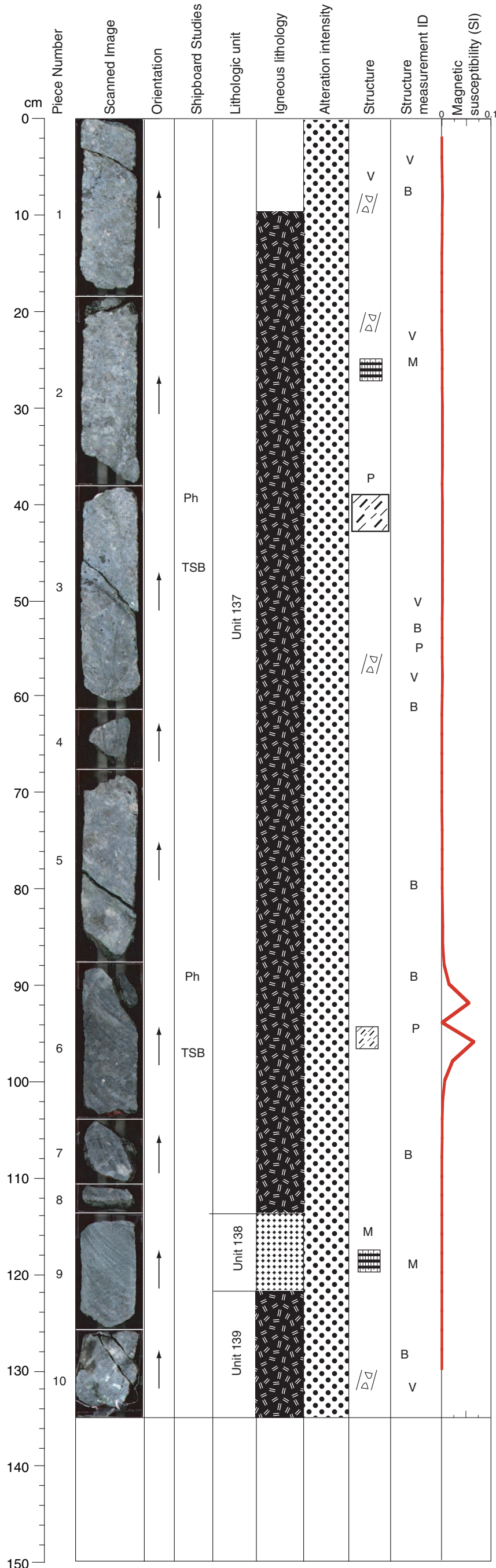
SECONDARY MINERALOGY: This section is characterized by a moderate alteration in the greenschist facies. Plagioclase is fresh and pyroxene edges seem slightly altered to actinolite. Olivine is fresh, but locally rimmed by chlorite + tremolite +/- talc, showing a corona texture.

VEIN ALTERATION: No veins are present in this section.

STRUCTURE: Green veins (V), shallowly dipping, cut across otherwise coarse grained (feldspar-poor) gabbro.



Core Photo



304-U1309D-57R-3 (Section top: 298.41 mbsf)

UNIT-137: Olivine-bearing Gabbro
Pieces 1-8

PRIMARY MINERALOGY: Determined from Piece 5

Olivine Modal 2%
 Size 3-5 mm average, 7 mm maximum
 Shape anhedral

Plagioclase Modal 58%
 Size 7-10 mm average, 20 mm maximum
 Shape anhedral

Clinopyroxene Modal 40%
 Size 5-11 mm average, 35 mm maximum
 Shape anhedral

COMMENTS: This section consists of very coarse-grained gabbro and is the continuation of the previous sections. Olivine occurs in rare patches in the section. A green alteration vein with oxides along and around it cuts vertically across the unit between 30 cm and 60 cm. Small clinopyroxene oikocryst as large as 12-15 mm occurs. An interval with interstitial oxide occurs at 95 cm. Piece 6 shows deformation.

UNIT-138: Olivine Gabbro
Piece 9

PRIMARY MINERALOGY: Determined from Piece 9

Olivine Modal ~20%
 Size 1-2 mm
 Shape anhedral

Plagioclase Modal ~50%
 Size 1-2 mm
 Shape anhedral

Clinopyroxene Modal ~30%
 Size 1-2 mm
 Shape anhedral

COMMENTS: A fine-grained olivine gabbro dike cuts the olivine-bearing gabbro. It is 7 cm wide and shows magmatic foliation in contrast to the surrounding units.

UNIT-139: Olivine-bearing Gabbro
Pieces 9-10

PRIMARY MINERALOGY: Determined from Piece 1

Olivine Modal 5%
 Size 3-7 mm
 Shape anhedral

Plagioclase Modal 65%
 Size 6-7 mm
 Shape anhedral

Clinopyroxene Modal 30%
 Size 7-11 mm average, 25 mm maximum
 Shape anhedral

COMMENTS: Unit 139 consists of the very coarse-grained olivine-bearing gabbro from Unit 137. Olivine occurs in patches.

SECONDARY MINERALOGY: This section consists of moderately altered olivine gabbro because of olivine alteration. Alteration varies along with the local abundance of olivine. In the main part of the section olivine seems to be fresh and rimmed by chlorite + tremolite +/- talc. Pyroxene edges are slightly altered to actinolite; plagioclase is mostly fresh. At the bottom (Piece 10) olivine are completely altered and replaced by tremolite + chlorite + talc as pseudomorphic patches. The reaction between olivine and plagioclase forms a rim of chlorite around patches.

VEIN ALTERATION: Thin green actinolite veins are present in this section (e.g. in Pieces 1,2, 3).

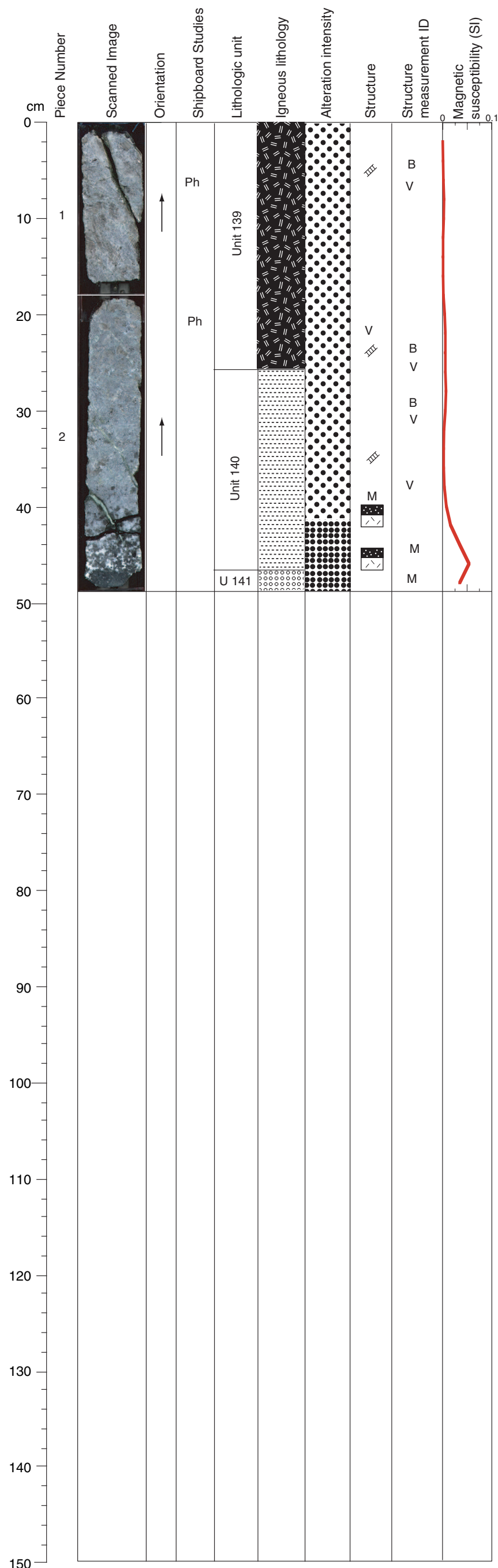
THIN SECTIONS:
[304-U1309D-57R-3, 45.0-47.0 cm \(#221\)](#)
[304-U1309D-57R-3, 96.0-99.0 cm \(#222\)](#)

STRUCTURE: This section has a gabbroic texture, with very fine-grained interstitial diorite (note that secondary alteration alters primary hornblende leaving a plagioclase-rich material rather than a diorite). The section is cut by dark green, cataclastic veins (V). In Pieces 3-4 the veins are shear bands. The base of Piece 4 has a gently dipping talc-rich vein with a polished surface (i.e. a slip plane). A magmatic foliation (M) with a superposed crystal plastic texture (P) is strong below Piece 4 with disseminated oxides. Toward the base of the section there is a fine grained intrusive with a very weak crystal plastic texture, below which is more gabbro with a coronitic texture. M>P>V

CLOSE UP PHOTOGRAPHS:
1309D_57R_3_38_60.jpg
1309D_57R_3_88_104.jpg
1309D_57R_3_88_104_2.jpg



Core Photo



304-U1309D-57R-4 (Section top: 299.74 mbsf)

UNIT-139: Olivine-bearing Gabbro
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 1 (Olivine-bearing Gabbro)

Olivine Modal 3%
Size 2-4 mm average, 7 mm maximum
Shape anhedral

Plagioclase Modal 45%
Size 5-7 mm
Shape anhedral

Clinopyroxene Modal 52%
Size 5-10 mm average, 23 mm maximum
Shape anhedral

Determined from Piece 2A (Troctolitic Gabbro)

Olivine Modal 30%
Size 2-5 mm
Shape anhedral

Plagioclase Modal 60%
Size 4-7 mm
Shape anhedral

Clinopyroxene Modal 10%
Size 7-10 mm average, 40 mm maximum
Shape anhedral

COMMENTS: This section consists of the very coarse-grained olivine-bearing gabbro and is the continuation from the previous section.

UNIT-140: Reaction Zone
Piece 2

PRIMARY MINERALOGY: Too heterogeneous

COMMENTS: This unit represents a very heterogeneous reaction zone between the coarse-grained, olivine-bearing gabbro and lower dunite. A pyroxene oikocryst with a straight upper edge marks a change in crystallization style. Pyroxene content gradually decreases downsection and olivine content increases, therefore grading toward troctolite composition.

UNIT-141: Serpentinized Dunite
Piece 2

PRIMARY MINERALOGY: Determined from Piece 2B (Dunite)

Olivine Modal ~100 %
Size too altered
Shape too altered

COMMENTS: Plagioclase disappears with a relative sharp boundary at 47 cm; only small amounts occur as an intercumulus phase in the dunite.

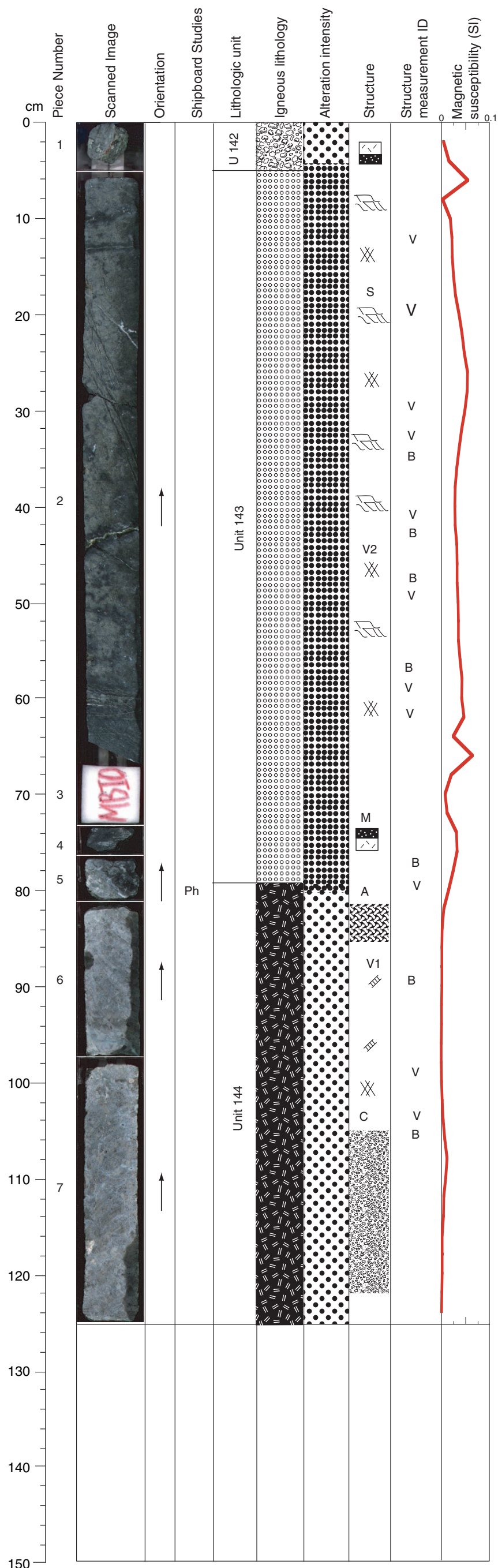
SECONDARY MINERALOGY: This section consists of moderately altered olivine gabbro in the upper part with highly altered troctolite below. Plagioclase seems to be fresh and pyroxenes are slightly altered to actinolite in the upper section. Olivines show corona texture (chlorite rim) and are altered to tremolite + chlorite +/- talc. Olivines, in troctolite, seem to be fresh and rimmed by chlorite +/- tremolite due to reaction with plagioclase. A mesh texture is present formed by magnetite and maybe serpentine. Plagioclase could be altered to prehnite.

VEIN ALTERATION: Green-blue tremolite veins are present between 32-38 cm and 38-45 cm.

STRUCTURE: Gabbroic textures with an interstitial dioritic component grades into more troctolitic rock across several subhorizontal contacts (M). Steeply dipping veins are coated with serpentine-rich minerals (V). The veins may have taken up some slip. M>V

CLOSE UP PHOTOGRAPHS:
1309D_57R_4_6_26.jpg
1309D_57R_4_20_48.jpg

Core Photo



304-U1309D-58R-1 (Section top: 300.40 mbsf)

UNIT-142: Rubble
Piece 1

COMMENTS: Unit 142 consists of a single piece of coarse-grained olivine gabbro presumed to be out of place.

UNIT-143: Serpentinized Dunite
Pieces 2-5

PRIMARY MINERALOGY: Determined from Piece 2

Olivine Modal 94%
Size ~10 mm
Shape anhedral

Plagioclase Modal 1%
Size 2-3
Shape anhedral

Clinopyroxene Modal 5%
Size 3-4 mm average, 11 mm maximum
Shape anhedral

COMMENTS: This unit consists of nearly completely serpentinized dunite with plagioclase and clinopyroxene as intercumulus phases. The degree of alteration changes around pyroxene oikocrysts leaving them stand out as dark areas within greenish-white mesh texture. Many small spinel grains occur in the upper part and decrease downsection. Piece 3 seems to be relatively fresh. The modal proportion of intercumulus clinopyroxene and plagioclase is higher at the bottom. The lower contact is a talc-tremolite rich area with pyroxene pseudomorphs.

UNIT-144: Olivine-bearing Gabbro
Pieces 5-6

PRIMARY MINERALOGY: Determined from Piece 6

Olivine Modal 1%
Size 4-5 mm
Shape anhedral

Plagioclase Modal 59%
Size 5-9 mm average, 13 mm maximum
Shape anhedral

Clinopyroxene Modal 40%
Size 5-9 mm average, 15 mm maximum
Shape anhedral

COMMENTS: Following the dunite, the coarse-grained olivine-bearing gabbro from the previous sections occurs again (see Unit 137 and 139). Piece 4 shows an alteration front.

SECONDARY MINERALOGY: The moderate alteration of the first piece is due to the total alteration of the olivine grains to form a dark chlorite rim with a core of actinolite/tremolite + chlorite +/- talc. The ultramafic unit is highly altered to mesh textured serpentine + magnetite; some relics of olivine are present in mesh cores. The few grains of plagioclase look almost totally altered to chlorite. Dark red spots with dark green halo may be altered chromite (?). Sulfides are observed. The remainder of the section is less altered, due to a reaction of olivine with plagioclase forming dark chlorite rims. In the center, talc forms a gray halo around some fresh olivine relics. Most of the pyroxene are only slightly altered to actinolite.

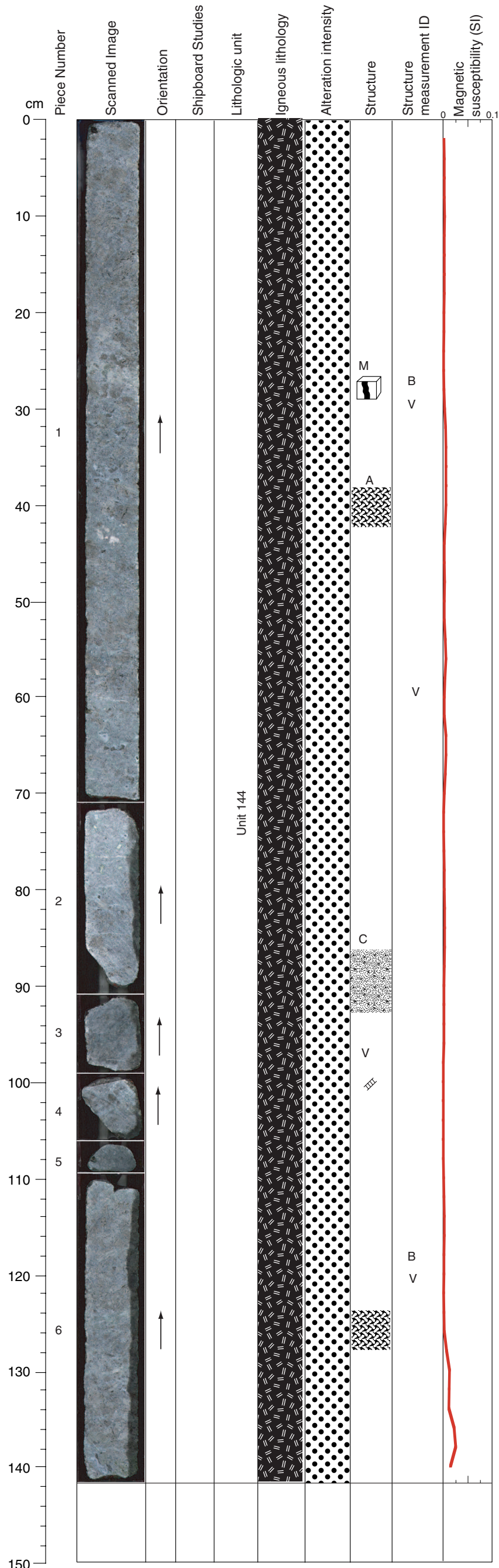
VEIN ALTERATION: Several magnetite veins and parallel white, lens-shaped chrysotile veins, cut the central part of the serpentinite unit from 20 to 40 cm. White carbonate veins are observed at 22 and 43 cm. Green serpentine (?) veins observed in this unit (e.g. at 13 cm) show a dark alteration halo of (?)recrystallized serpentine + magnetite. The mafic unit shows less veins. A blue-green tremolite vein is observed at 98 cm.

STRUCTURE: Piece 1 (a roller) contains a contact between olivine gabbro and serpentinite (M). In the serpentinite, steeply dipping veins (V2) (carbonate-rich) cut the mesh texture (S). Gently dipping cross-hatched white veins (V2) within dark serpentinite form a gently dipping band. The lower contact between the serpentinite and gabbro (M) is sharp, although there is intense alteration and modest stretch (A) of gabbroic grains close to the contact. White and green veins cut the contact (V2). Within the gabbro, microcracks (C) in feldspar and associated dark hornblende (?) veins (V1) are in turn cut by subhorizontal blue veins (V2). The base of the section contains olivine gabbro with characteristic corona texture. M>C=>V1=>A>V2

CLOSE UP PHOTOGRAPHS:
1309D_58R_1_73_81.jpg



Core Photo



304-U1309D-58R-2 (Section top: 301.65 mbsf)

UNIT-144: Olivine-bearing Gabbro
Pieces 1-6

PRIMARY MINERALOGY: Determined from Piece 1

- Olivine Modal 3%
 Size 4-7 mm average, 9 mm maximum
 Shape anhedral
- Plagioclase Modal 62%
 Size 7-9mm average, mm maximum
 Shape anhedral
- Clinopyroxene Modal 35%
 Size 7-12 mm average, 40 mm maximum
 Shape anhedral

COMMENTS: This section consists of very coarse-grained olivine-bearing gabbro and is the continuation of the previous section. Infiltration of a feldspathic intrusion occurs between 62 cm and 140 cm. Piece 3 has a very high plagioclase-pyroxene ratio. Piece 4 contains a relatively high amount of sulfides in the plagioclase.

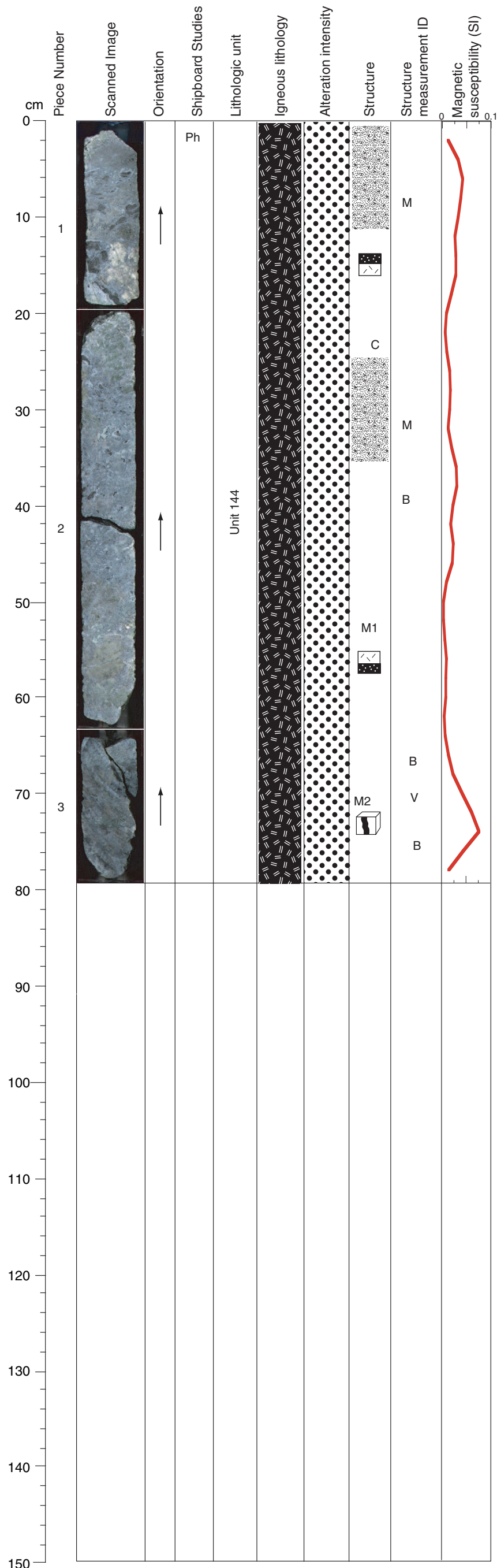
SECONDARY MINERALOGY: The moderate alteration in this unit is because of olivine alteration that reacts with plagioclase to form dark chlorite rims. In the center of the rim, olivine shows varying degree of alteration. Either some relics can be observed in the center of gray talc coronas, or the olivine is totally altered to tremolite/chlorite +/- talc. Most of the pyroxenes are only slightly altered to actinolite.

VEIN ALTERATION: Few thin actinolite veins are observed (25 and 125 cm).

STRUCTURE: Gabbro with interstitial feldspar (and amphibole) with a coarse-grained olivine gabbro. Plagioclase-olivine alteration rims (A) and subhorizontal bands of feldspar-rich material (M) also are the manifestation of late magma infiltration and alteration. Microcracking (C) intensifies in Piece 3 along with dark amphibole veins (hornblende?) (V).
M>V>A>C



Core Photo



304-U1309D-58R-3 (Section top: 303.06 mbsf)

UNIT-144: Olivine-bearing Gabbro
Pieces 1-3

PRIMARY MINERALOGY: Determined from Piece 2A

- Olivine Modal 12%
Size 4-13 mm
Shape anhedral
- Plagioclase Modal 58%
Size 7-10 mm average, 15 mm maximum
Shape anhedral
- Clinopyroxene Modal 30%
Size 7-15 mm average, 80 mm maximum
Shape anhedral

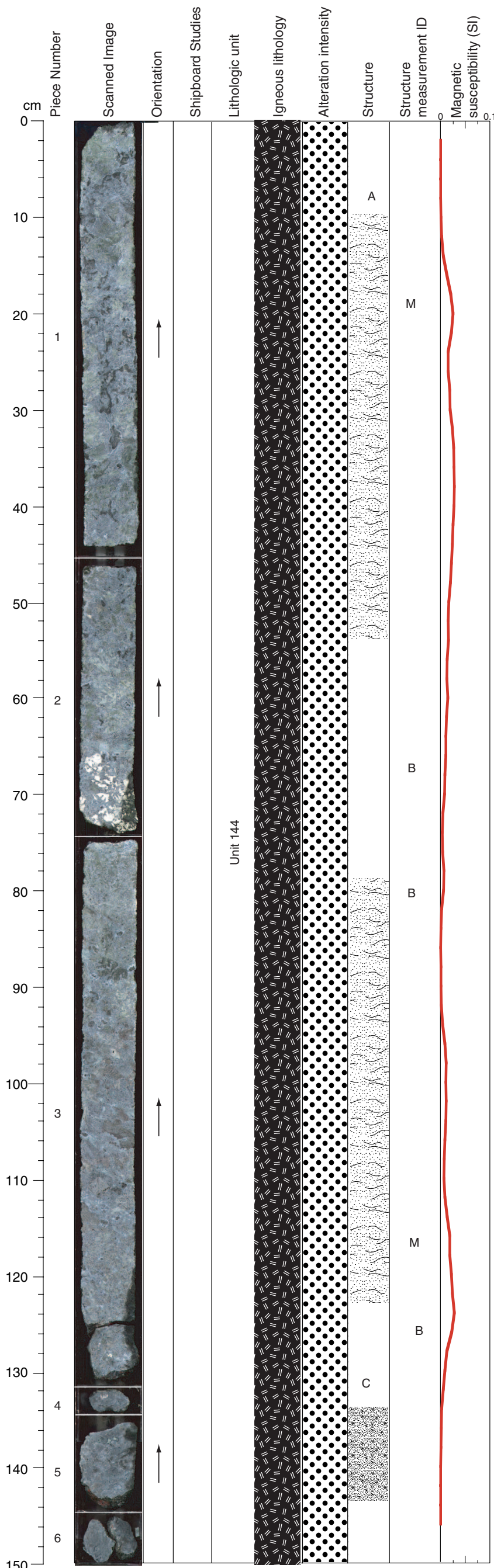
COMMENTS: This section consists of very coarse-grained, olivine gabbro and is the continuation of the previous section. A microgabbro dike cuts the section between 2 cm and 5 cm. It has an irregular outline and contains minor plagioclase clasts. Large clinopyroxene oikocrysts occur between 12-19 cm, 20-29 cm, 47-52 cm, 54-59 cm and 59-62 cm. Oxides occur at 72 cm.

SECONDARY MINERALOGY: The moderate alteration in this unit is due to a reaction between olivine and plagioclase to form a dark chlorite rim. In the center of the rim, olivine show various degree of alteration. Either some relics can be observed in the center of gray talc coronas, or the olivine is totally altered to tremolite/chlorite +/- talc. Most of the pyroxene are only slightly altered to actinolite.

STRUCTURE: Relationships between intrusive units (M1) are associated with an almost cataclastic texture (C). Near 10 cm olivine gabbro has an internal clast-in-matrix texture with somewhat stretched and altered olivine grains with plagioclase rims. The texture continues through the section except where the gabbro is coarse grained and contains pyroxene oikocrysts. Near the base of the section, plagioclase-rich, subhorizontal intrusions (M2) are internally brecciated. M1=>C>M2

CLOSE UP PHOTOGRAPHS:
1309D_58R_3_0_20.jpg

Core Photo



304-U1309D-59R-1 (Section top: 305.20 mbsf)

UNIT-144: Olivine-bearing Gabbro
Pieces 1-6

PRIMARY MINERALOGY: Determined from Piece 3A

Olivine	Modal 7% Size 4-10 mm Shape anhedral
Plagioclase	Modal 53% Size 7-10 mm Shape anhedral
Clinopyroxene	Modal 40% Size 7-12 mm average, 90 mm maximum Shape anhedral

COMMENTS: This section consists of very coarse-grained olivine gabbro and is the continuation of the previous section. Piece 1 shows vertical alignment of olivine. Large clinopyroxene oikocryst occur between 1-7 cm, 33-41 cm, 47-51 cm, 66-74 cm, 77-82 cm, 88-91 cm and 99-102 cm. Oxide spots occur at 73 cm and between 95-96 cm and 123-124 cm.

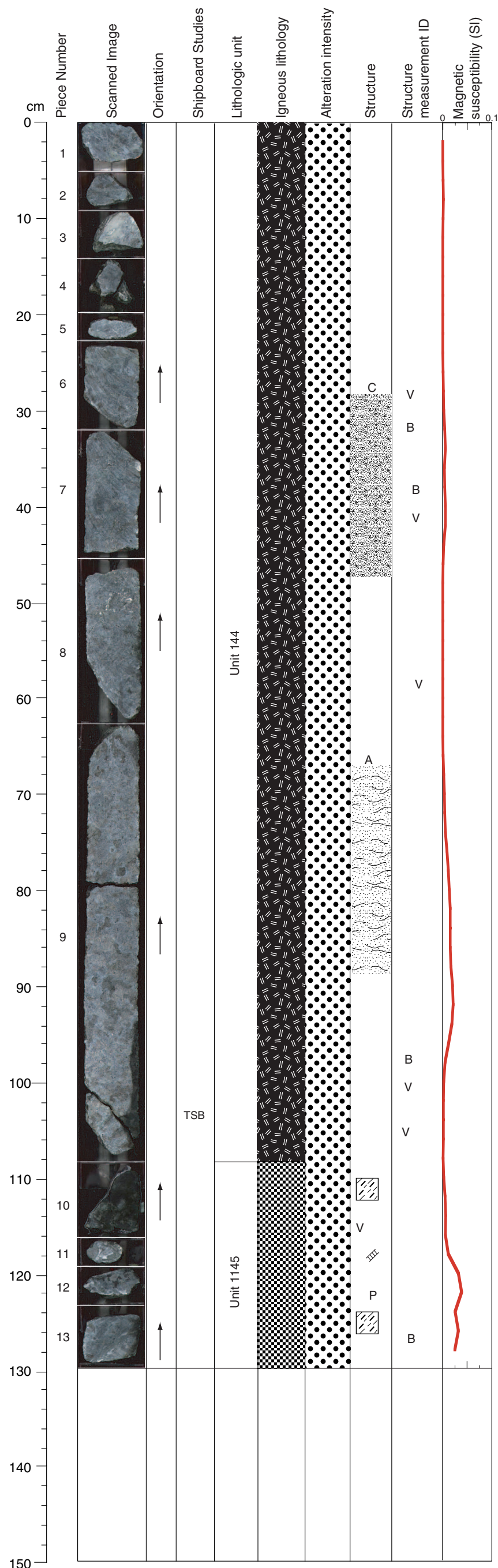
SECONDARY MINERALOGY: This section consists of moderately altered olivine gabbro in greenschist facies. Plagioclase seems to be fresh and thin actinolite rims are present around pyroxene. Olivine are altered to tremolite + chlorite + talc +/- carbonate as pseudomorphic patches. These patches are rimmed by chlorite due to reaction between plagioclase and olivine.

VEIN ALTERATION: No veins are present in this section.

STRUCTURE: Oikocryst-bearing olivine-bearing gabbro with "stretched" coronitic textures (A) and other "wormy" igneous textures. A very fine-grained intrusion (M) is present in Piece 3, and microcracking intensifies in Piece 5. There is enrichment of feldspar around the corona textures. M>A



Core Photo



304-U1309D-59R-2 (Section top: 306.70 mbsf)

UNIT-144: Olivine-bearing Gabbro
Pieces 1-9

PRIMARY MINERALOGY: Determined from Piece 9A

- Olivine Modal 1%
 Size 4-6 mm, 11 mm maximum
 Shape anhedral
- Plagioclase Modal 69%
 Size 4-10 mm
 Shape anhedral
- Clinopyroxene Modal 30%
 Size 6-10 mm average, 30 mm maximum
 Shape anhedral

COMMENTS: This section consists of very coarse-grained olivine gabbro and is the continuation of the previous section. Large clinopyroxene oikocrysts occur in Pieces 3 and 8.

UNIT-145: Oxide Gabbro
Pieces 10-13

PRIMARY MINERALOGY: Determined from Piece 13

- Plagioclase Modal 68%
 Size 5-15 mm
 Shape anhedral
- Clinopyroxene Modal 30%
 Size 6-10 mm
 Shape anhedral
- Oxide Modal 2%
 Size 2-3 mm
 Shape anhedral

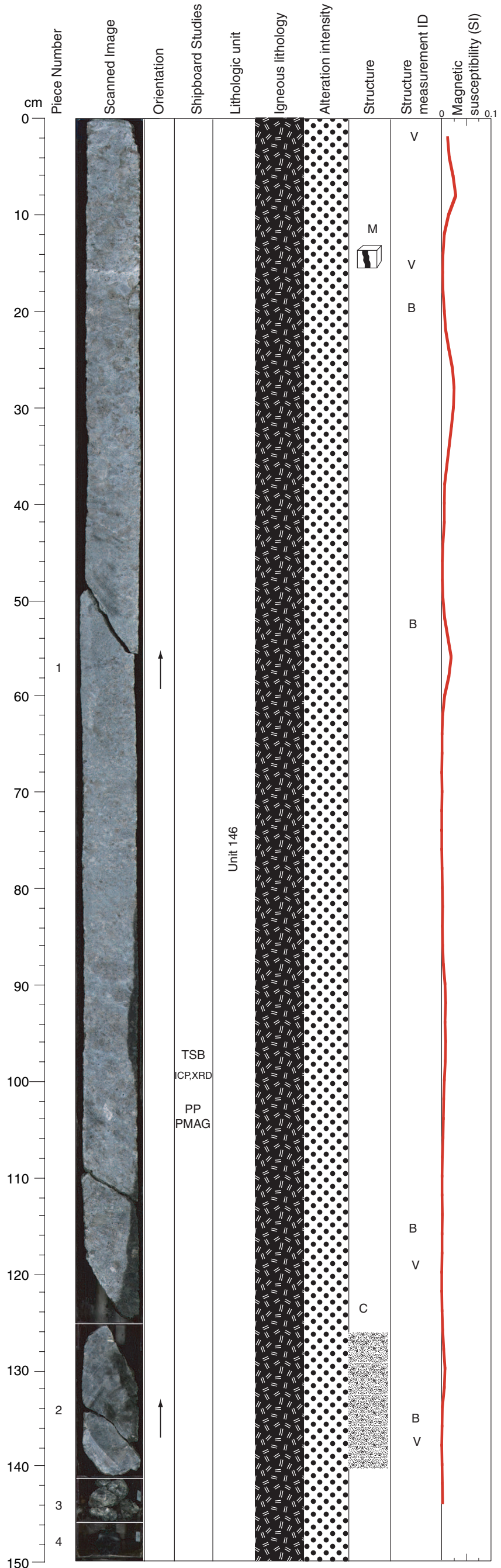
COMMENTS: This unit consists of coarse-grained oxide gabbro. It shows plastic deformation and later high-temperature brecciation.

SECONDARY MINERALOGY: This section is characterized by a moderate alteration in greenschist facies. The main part of the section is olivine gabbro in which pyroxenes are slightly altered to actinolite and plagioclase seem to be fresh. A few olivine crystals are present in Piece 7 and 9 and show alteration rims. These rims are formed by chlorite +/- talc. Olivine can be completely replaced by tremolite + chlorite +/- carbonate as pseudomorphic patches (e.g. in Piece 7). At the bottom of the section oxide gabbro seems to be more altered. Pyroxene are partially replaced by actinolite and olivine show the same alteration as olivine in olivine gabbro.

VEIN ALTERATION: No veins are present in this section.

STRUCTURE: Intense microcracking (C) in plagioclase-rich areas and corona textures (A) in the plagioclase-olivine rich portions. The coronas are irregularly shaped, but not obviously stretched. Very large pyroxene with green alteration along cleavage planes and a pyroxene oikocryst are also present. Below 60 cm (into Piece 8) microfractures are absent, and the "matrix" is a very fine grained plagioclase with very small grains of amphibole. The base of the section (Pieces 10-13) are from a (possibly) mylonitic shear zone (P). The shear zone has continuous milky white plagioclase with an irregular fabric (possibly melt-present deformation). Fabric in Piece 13 is cut by a green vein (V). P>A=>C>V

Core Photo



304-U1309D-59R-3 (Section top: 308.00 mbsf)

UNIT-146: Olivine-bearing Gabbro
Pieces 1-4

PRIMARY MINERALOGY: Determined from Piece 1A (0-30 cm interval) (Coarse-grained Gabbro)

Olivine Modal 2%
Size 4-5mm average, 6 mm maximum
Shape anhedral

Plagioclase Modal 63%
Size 6-9 mm average, 16 mm maximum
Shape anhedral

Clinopyroxene Modal 35%
Size 5-7 mm average, 15 mm maximum
Shape anhedral

PRIMARY MINERALOGY: Determined from Piece 1 (50-53 cm interval)

Olivine Modal 2%
Size 1-2 mm
Shape anhedral

Plagioclase Modal 63%
Size 2-3 mm
Shape anhedral

Clinopyroxene Modal 35%
Size <1-2 mm average, 3 mm maximum
Shape anhedral

COMMENTS: This section consists of coarse-grained, olivine-bearing gabbro. Variations in grain size occur throughout the section, with a medium-grained interval between 49 cm and 57 cm.

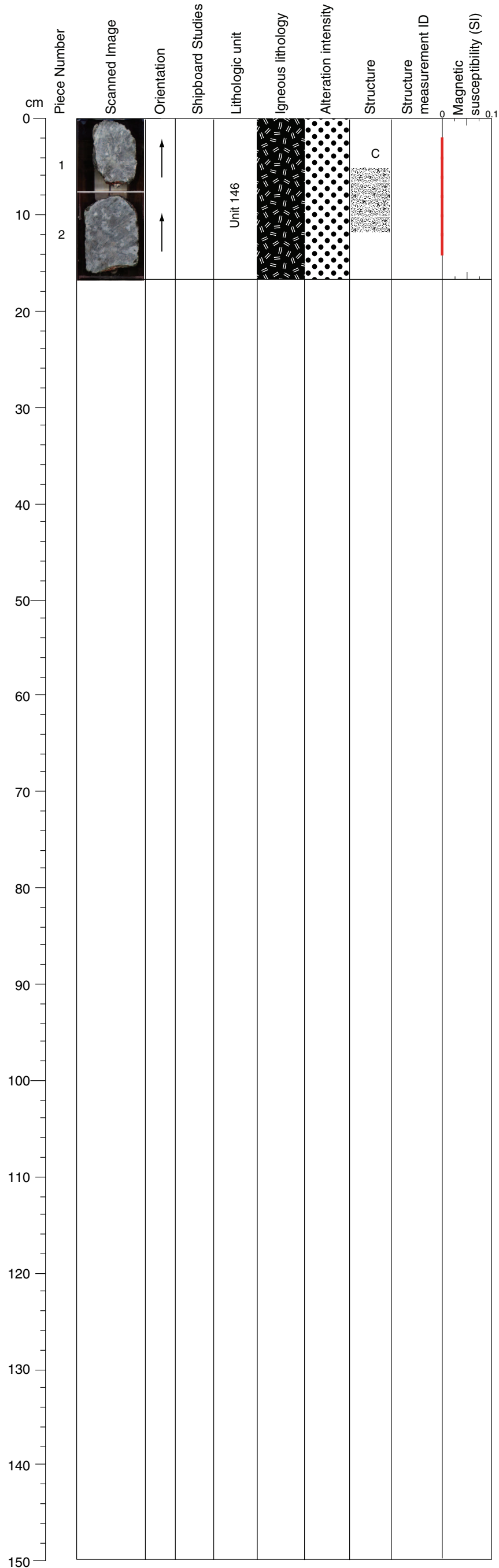
SECONDARY MINERALOGY: This section is characterized by moderate alteration; the degree of alteration varies with the local abundance of olivine. Olivine is altered to tremolite + chlorite + talc as pseudomorphic patches. A reaction with plagioclase forms a corona texture (chlorite rim). Pyroxene edges are slightly altered to actinolite, plagioclase are mostly fresh.

VEIN ALTERATION: No veins are present in this section.

STRUCTURE: Coarse-grained gabbro with a feldspar rich magmatic "vein" (M) at ~15 cm. The base of the section has intense microcracking (C) (Piece 2) in feldspar-rich domains (note that there is no corona texture; rather, the texture has coarse pyroxene and plagioclase). M>C



Core Photo



304-U1309D-59R-4 (Section top: 309.45 mbsf)

UNIT-146: Olivine-bearing Gabbro
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 2

Olivine Modal <1%
Size 2 mm
Shape anhedral

Plagioclase Modal 55%
Size 5-7 mm average, 13 mm maximum
Shape anhedral

Clinopyroxene Modal 45%
Size 5-12 mm
Shape anhedral

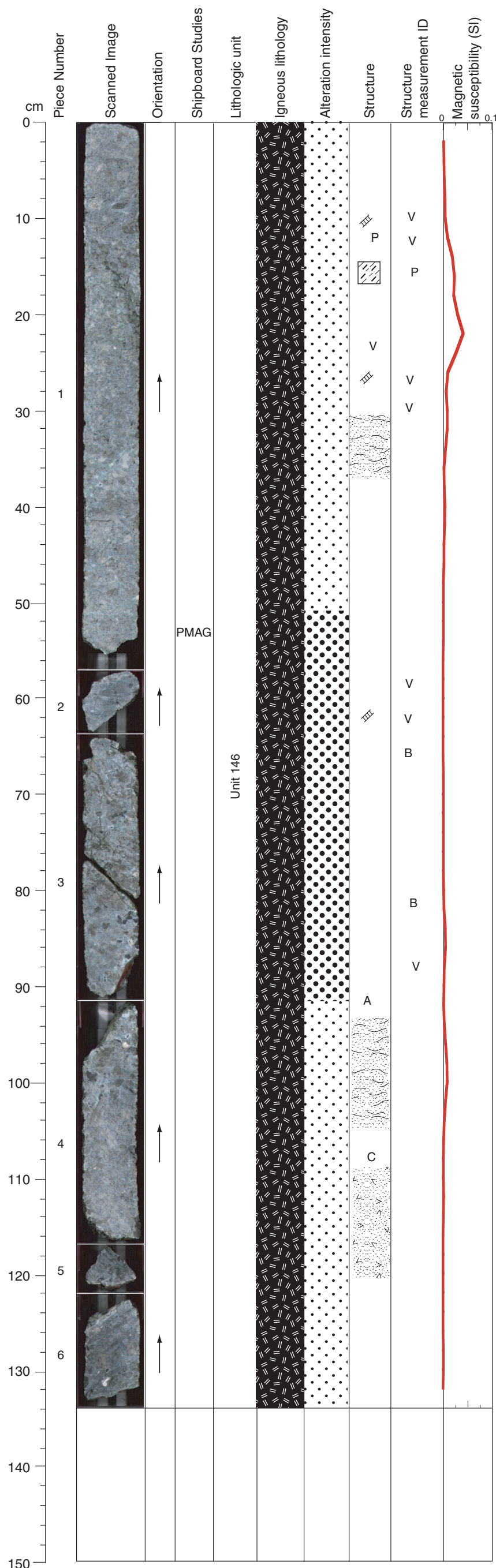
COMMENTS: This section consists of coarse-grained, olivine-bearing gabbro and is the continuation of the previous section.

SECONDARY MINERALOGY: This section consists of moderately altered gabbro in the greenschist facies. Plagioclase appears fresh and pyroxene is only slightly altered to actinolite. Few olivine are present and altered to tremolite + chlorite +/- talc, and rimmed by chlorite.

VEIN ALTERATION: No veins are present in this section.

STRUCTURE: A continuation of the texture in Section U1309D-59R-3 with intense microcracking (C) in a pyroxene-feldspar rich rock (with no corona texture).

Core Photo



304-U1309D-60R-1 (Section top: 310.00 mbsf)

UNIT-146: Olivine-bearing Gabbro
Pieces 1-6

PRIMARY MINERALOGY: Determined from Piece 1

Olivine Modal 1%
Size 3-5 mm average, 15 mm maximum
Shape anhedral

Plagioclase Modal 54%
Size 5-10 mm
Shape anhedral

Clinopyroxene Modal 45%
Size 4-11 mm average, 25 mm maximum
Shape subhedral to anhedral

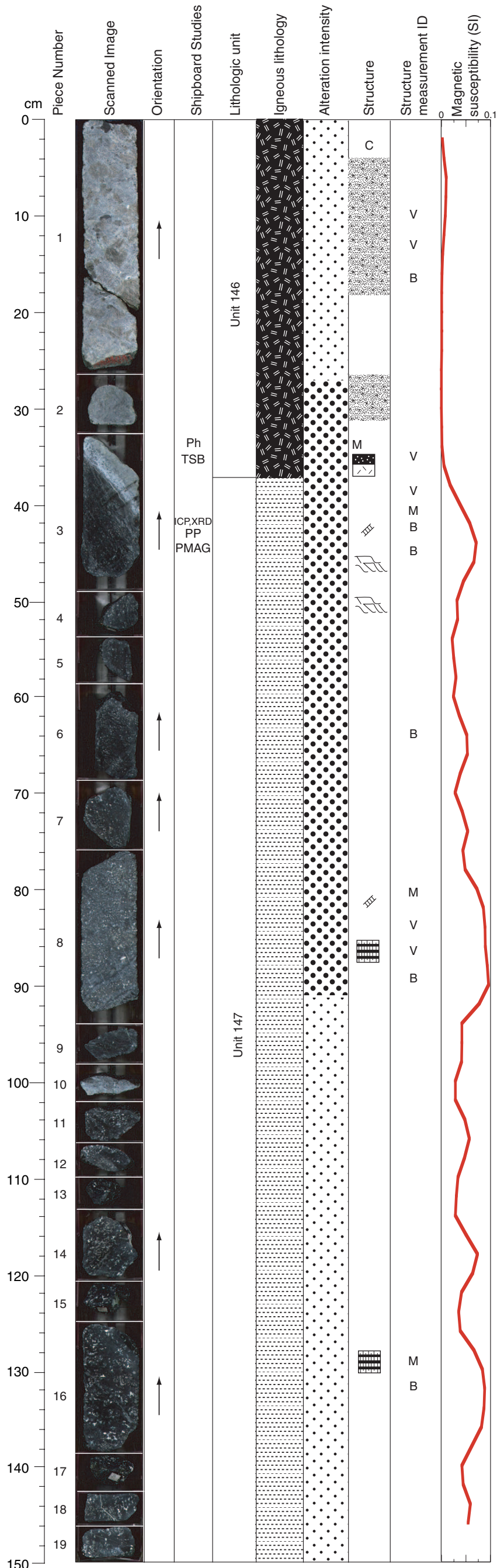
COMMENTS: This section consists of coarse-grained, olivine-bearing gabbro and is the continuation from the previous section. Olivine occurs irregularly through the section. Oxides occur along a vein 15-20 cm.

SECONDARY MINERALOGY: The section consists of slightly to moderately altered oxide-bearing gabbro with chlorite rims around plagioclase. Large pyroxene crystals are mostly fresh. Some large coronitic olivine alteration patches with tremolite + chlorite +/- talc, rimmed by chlorite are present in which some olivine is still fresh (e.g. around 9 cm, and in Piece 3b).

VEIN ALTERATION: No veins in this section.

STRUCTURE: The upper portion of the section contains coarse-grained gabbro with interstitial plagioclase; relict olivine has corona textures (A). Near a dipping, diffuse green vein (V) there is a very weak crystal plastic (P) fabric in the plagioclase. In Piece 3, near 80 cm, there is a gently dipping green serpeninitic vein below which (M) the gabbroic texture is much more crystalline (i.e. the interstitial fine-grained plagioclase is largely absent; equigranular plagioclase and pyroxene are common). Corona grain boundary alteration is present in the lower interval of the section. The base of the section (Piece 4 and below) has more intense microcracking (C) than above.
M>P=>A=>V=>C

Core Photo



304-U1309D-60R-2 (Section top: 311.33 mbsf)

UNIT-146: Olivine-bearing Gabbro
Pieces 1-3

PRIMARY MINERALOGY: Determined from Piece 1

- Olivine Modal 1%
 Size 4-9 mm
 Shape anhedral
- Plagioclase Modal 54%
 Size 5-9 mm
 Shape anhedral
- Clinopyroxene Modal 45%
 Size 5-15 mm average, 30 mm maximum
 Shape subhedral to anhedral

COMMENTS: A coarse-grained, olivine-bearing gabbro at the top of the section is a continuation of the previous section. A green alteration vein crosses at 15 cm. A chilled margin, defined by decreasing grain size from 22-28 cm, marks the lower boundary of this unit.

UNIT-147: Olivine-rich troctolite
Pieces 3-19

PRIMARY MINERALOGY: Determined from Piece 8

- Olivine Modal 86%
 Size 5-6 mm
 Shape anhedral
- Plagioclase Modal 7%
 Size 2-6 mm
 Shape anhedral
- Clinopyroxene Modal 7%
 Size 10-20 mm average, 22 mm maximum
 Shape anhedral

COMMENT: Near the upper edge of Piece 3, an intrusive contact between the olivine-bearing gabbro and a serpentinitized dunite cumulate displays fine-scale interfingering. An 8-9 mm wide talc-carbonate alteration zone parallels the boundary and extends into the cumulate. The top of the unit is a dunite with a small proportion of plagioclase and clinopyroxene as intercumulus phases, and the overall composition alternates downhole on a centimeter scale from dunite to troctolitic gabbro, both as magmatic layers and as patches. Pyroxene occurs as prismatic oikocrysts and shows a preferred orientation which is not seen in the plagioclase.

SECONDARY MINERALOGY: The upper part of this section consists of slightly to moderately altered olivine-bearing gabbro in which pyroxene is rimmed by actinolite and plagioclase by chlorite. A few corona patches of olivine alteration with tremolite + chlorite +/- talc, rimmed by chlorite are present in Piece 1. The lower part of the section consists of serpentinite in which olivine is severely altered to serpentine, magnetite, chlorite. In the darkest pieces, plagioclase is highly altered to chlorite. Elsewhere, it may be also be partially altered to prehnite. At the contact with gabbro the serpentinite is overprinted by intense talc-carbonate (calcite or aragonite)-tremolite alteration, including veins (some sulfide-bearing) parallel to the contact.

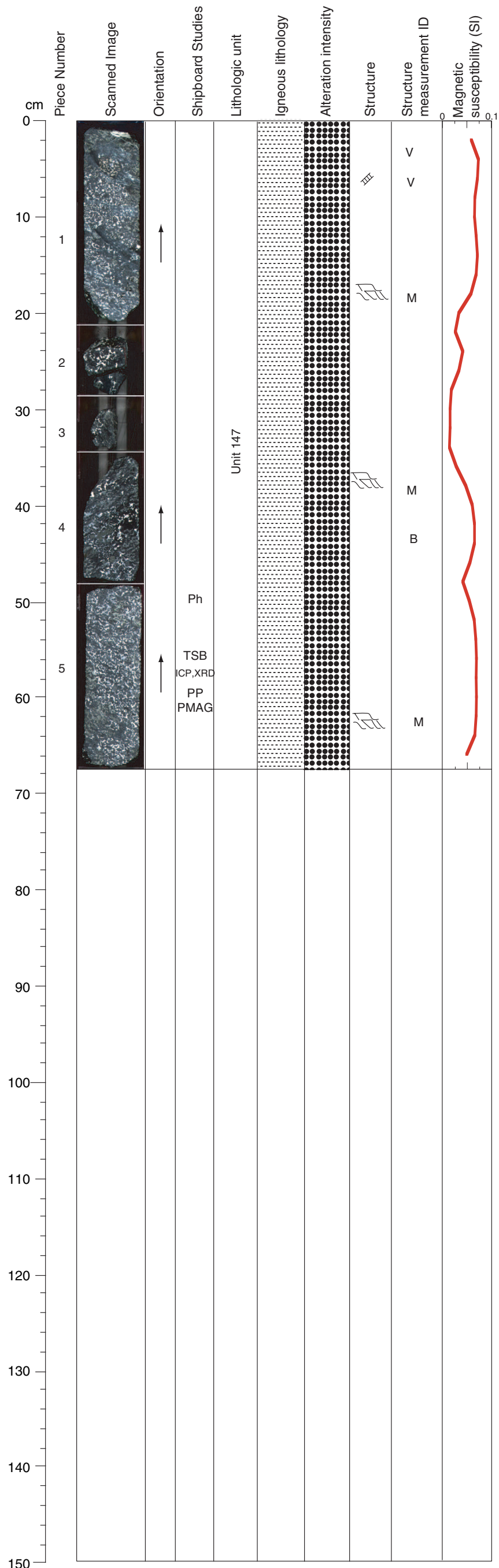
VEIN ALTERATION: A talc-tremolite vein is present at 12-20 cm within the gabbro and several smaller talc-tremolite veins are present within the serpentinite. Carbonate veins, in places sulfide bearing, are present at the contact between serpentinite and gabbro.

THIN SECTIONS:
304-U1309D-60R-2, 34.0-37.0 cm (#223)

STRUCTURE: Uppermost pieces (e.g. Piece 1 and 2) are coarse-grained gabbro with interstitial plagioclase and intense microcracks (C). An unoriented piece (Piece 2) is a fine-grained cataclasite, potentially with a flow texture. Below the weak cataclasite is a contact with an ultramafic rock (M2). The contact is intensely altered (plagioclase-amphibole), that cuts the pervasive serpentinite mesh texture (S) at a low angle. The remainder of the section is dark serpentinite with thin, discontinuous white veins (V) at a high angle to the serpentinitized bands. The serpentinitization textures follow an earlier (olivine-defined?) foliation M1>M2>C>V=S

CLOSE UP PHOTOGRAPHS:
1309D_60R_2_33_49.jpg

Core Photo



304-U1309D-60R-3 (Section top: 312.83 mbsf)

UNIT-147: Olivine-rich troctolite
Pieces 1-5

PRIMARY MINERALOGY: Determined from Piece 5 (Troctolitic Gabbro)

Olivine Modal 48%
Size 2-6 mm
Shape anhedral

Plagioclase Modal 40%
Size 2-3 mm
Shape anhedral

Clinopyroxene Modal 12%
Size 15 mm average, 25 mm maximum
Shape anhedral

COMMENTS: This section continues the olivine-rich cumulate from the previous section. It seems that either plagioclase or clinopyroxene occurs as intercumulus phase but rarely together in the same place. The cores are dominantly troctolitic gabbro.

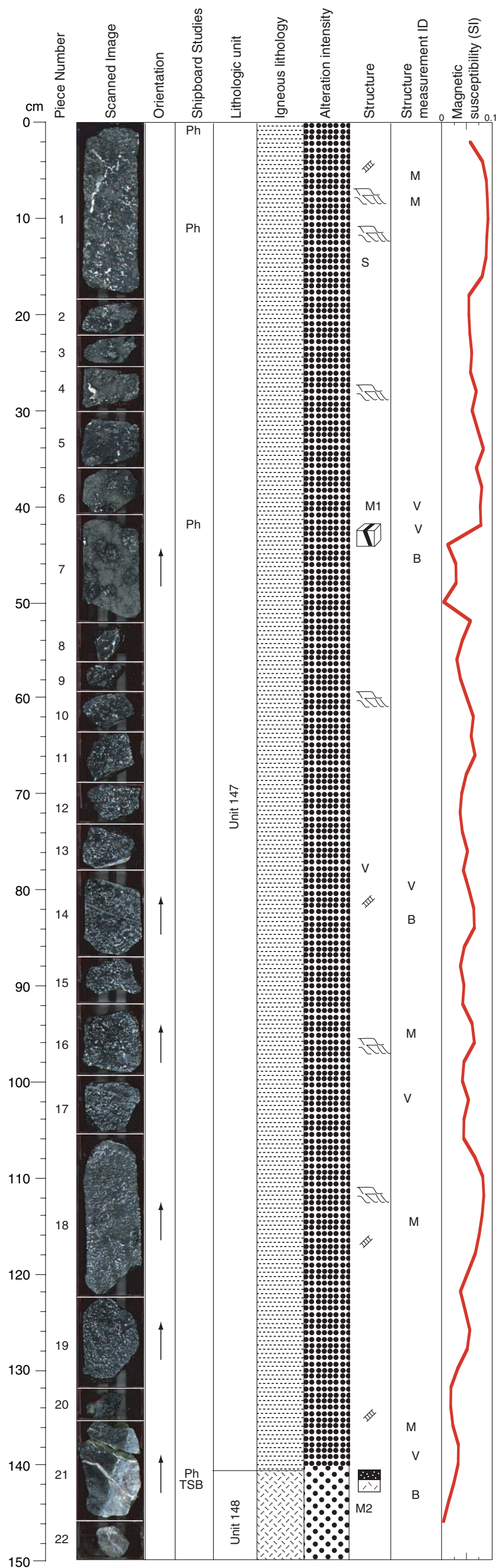
SECONDARY MINERALOGY: The section consists of highly altered mafic troctolite in which olivine is mostly altered to serpentine, chlorite and magnetite. Plagioclase shows a chlorite rim and is altered to prehnite and perhaps clay. Augite seems to be unaltered.

VEIN ALTERATION: A carbonate vein with thin talc-tremolite halo is present in Piece 1.

STRUCTURE: Patchy alteration (A) throughout serpentinized (S) mafic troctolite (to dunite). S>A

CLOSE UP PHOTOGRAPHS:
1309D_60R_3_48_68.jpg

Core Photo



304-U1309D-61R-1 (Section top: 314.80 mbsf)

UNIT-147: Olivine-rich trictikute

Pieces 1–21

PRIMARY MINERALOGY: Determined from Piece 18 (Olivine Gabbro)

Olivine Modal 50%
Size 2-6 mm
Shape anhedral

Plagioclase Modal 35%
Size 2-3 mm
Shape anhedral

Clinopyroxene Modal 15%
Size 15 mm average, 36 mm maximum
Shape anhedral

COMMENTS: This unit continues from the previous section. Olivine gabbro dominates. Piece 1 shows a high percentage of intercumulus phases and a higher pyroxene/plagioclase-ratio than the previous section. It is an olivine gabbro. Abundant and larger interstitial plagioclase occurrences suggest melt segregation. Pieces 2 to 8 are dunites with relatively coarse plagioclase. Piece 7 has the fewest intercumulus phases in the section and contains isolated clinopyroxene-oikocrysts in an almost plagioclase-free, serpentinized olivine matrix. Pieces 9 to 10 are troctolitic gabbro. A prehnite vein crosscuts at 82 cm and there are diffuse talc-tremolite veins at 100 and 104 cm. Magmatic foliation is visible in Piece 16. Piece 19 has a very low pyroxene-plagioclase-ratio.

UNIT-148: Gabbro

Pieces 21–22

PRIMARY MINERALOGY: Determined from Piece 21B

Plagioclase Modal 70%
Size 5-11 mm
Shape anhedral

Clinopyroxene Modal 30%
Size 6-11 mm average, 20 mm maximum
Shape anhedral

COMMENTS: A very coarse-grained gabbro dike cuts the olivine gabbro with an interfingering contact. Patchy plagioclase along the margins of the gabbro obscures the contact and no chilled margin is recognized. A 2-3 mm wide reaction zone containing talc forms along the contact.

SECONDARY MINERALOGY: The section consists predominantly of highly altered olivine-rich gabbro in which olivine is mostly altered to serpentine, chlorite, and magnetite. Plagioclase within the gabbro-troctolite section shows a rim of chlorite and seems to be altered to prehnite. The gabbro in the lowermost part of the section is moderately altered with chlorite +/- pale amphibole along the grain boundaries.

VEIN ALTERATION: Carbonate vein present at 140 cm.

THIN SECTIONS:

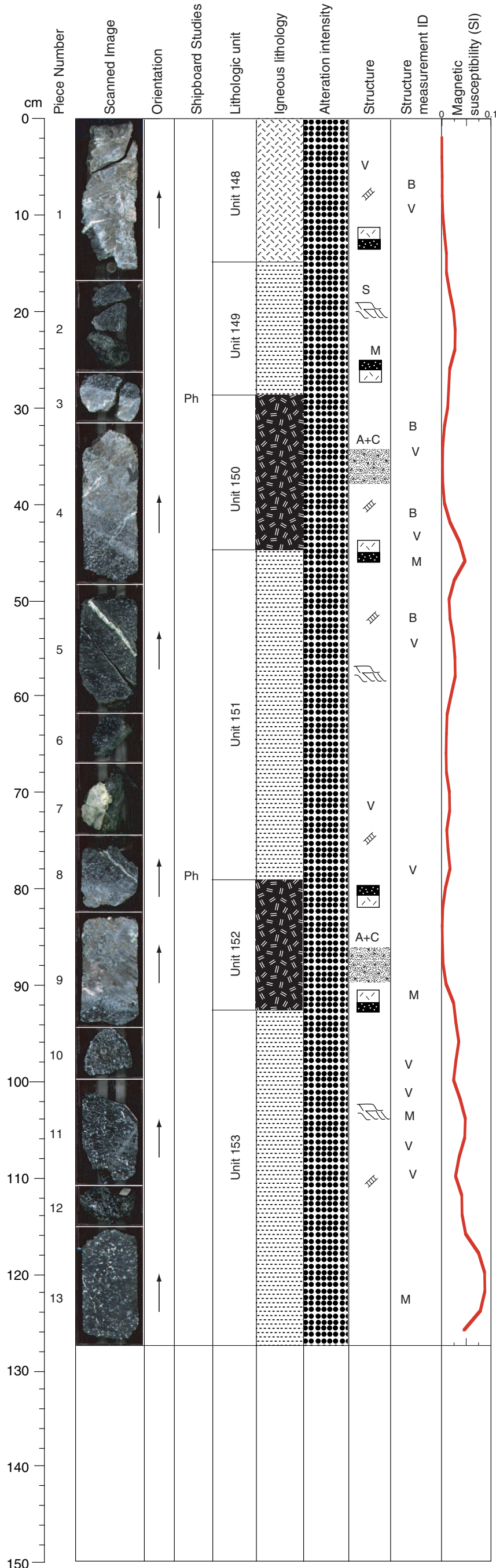
[304-U1309D-61R-1, 140.0-142.0 cm \(#225\)](#)

STRUCTURE: Serpentinized olivine-rich gabbro with discontinuous and intergranular veins (not carbonate) (V) that cut the serpentinite texture (S). Rounded pyroxene-bearing gabbroic inclusions ("impregnation" texture) (M1). Late veins and patchy alteration in Piece 18 cut the serpentinite textures. In Piece 21, near the base of the section, there is a steeply dipping, intensely altered contact (M2), between the ultramafics and an underlying gabbroic intrusion, cut by a carbonate vein. M1=M2>S>V

CLOSE UP PHOTOGRAPHS:

- 1309D_61R_1_0_17.jpg
- 1309D_61R_1_41_51.jpg
- 1309D_61R_1_140_147.jpg

Core Photo



304-U1309D-61R-2 (Section top: 316.30 mbsf)

UNIT-148: Gabbro
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1B

Plagioclase Modal 45%
 Size 9-20mm
 Shape anhedral

Clinopyroxene Modal 55%
 Size 10-32 mm average, mm maximum
 Shape anhedral

COMMENTS: At the top of the section, the very coarse-grained gabbro dike of the previous section continues. The reaction zone along the contact is less well developed.

UNIT-149: Olivine-rich troctolite
Pieces 1-3

PRIMARY MINERALOGY: Determined from Piece 2 to 3

Olivine Modal 88%
 Size 2-6 mm
 Shape anhedral

Plagioclase Modal 7%
 Size 2-5 mm
 Shape anhedral

Clinopyroxene Modal 5%
 Size 6-12 mm average, 20 mm maximum
 Shape anhedral

COMMENTS: This unit is actually continuation of Unit 147. Contacts to the overlying gabbro dike occur in Pieces 1 and 2.

UNIT-150: Olivine-bearing Gabbro
Pieces 3-4

PRIMARY MINERALOGY: Determined from Piece 4

Olivine Modal 1%
 Size 3-4 mm average, 15 mm maximum
 Shape anhedral

Plagioclase Modal 60%
 Size 6-12 mm
 Shape anhedral

Clinopyroxene Modal 40%
 Size 4-18 mm
 Shape anhedral

COMMENTS: This unit consists of a very coarse-grained gabbro dike that cuts the ultramafic cumulates. A small branch from the lower contact extends into the cumulates.

UNIT-151: Olivine-rich troctolite
Pieces 4-8

PRIMARY MINERALOGY: Determined from Piece 5

Olivine Modal 88%
 Size 2-6 mm
 Shape anhedral

Plagioclase Modal 7%
 Size 2-5 mm
 Shape anhedral

Clinopyroxene Modal 5%
 Size 6-12 mm average, 20 mm maximum
 Shape anhedral

COMMENTS: This unit consists of varied gabbroic cumulates that have an overall troctolitic gabbro composition. Veins cut the unit at 52 cm, 56 cm, 57 cm and 77 cm containing sulfides.

UNIT-152: Olivine-bearing Gabbro
Pieces 8-9

PRIMARY MINERALOGY: Determined from Piece 9

Olivine Modal 3%
 Size 4-12 mm average
 Shape anhedral

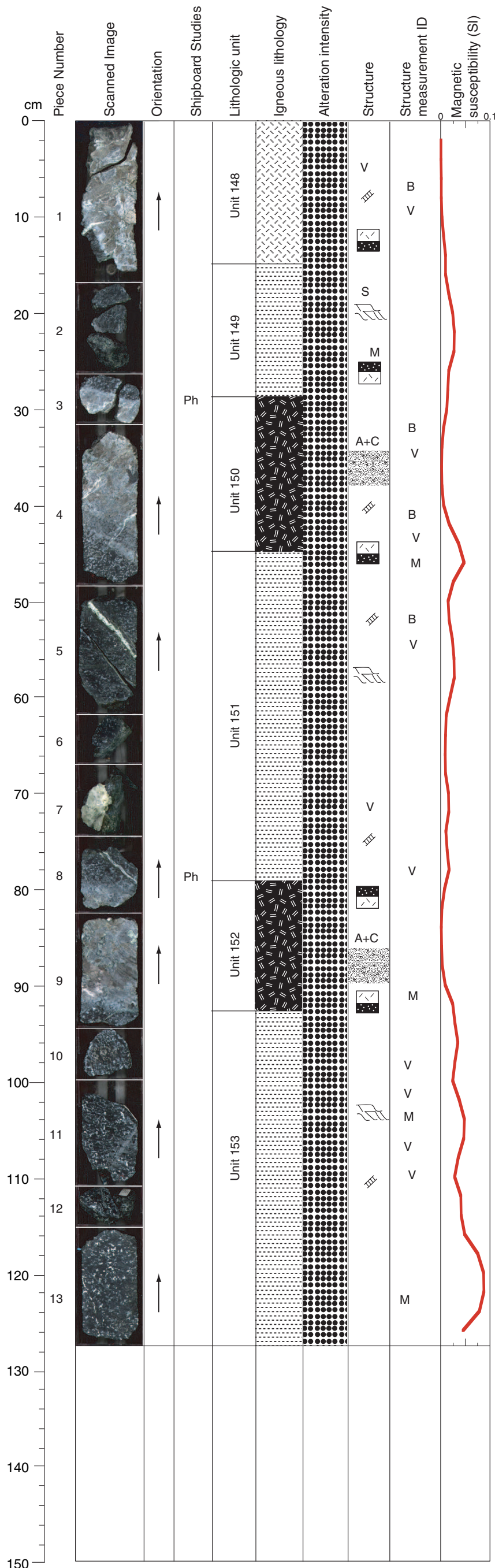
Plagioclase Modal 57%
 Size 7-16 mm average, 30 mm maximum
 Shape anhedral

Clinopyroxene Modal 40%
 Size 10-35 mm average, 50 mm maximum
 Shape anhedral

COMMENTS: The unit consists of a coarse-grained olivine-bearing gabbro dike. The upper contact is gradational and a well developed reaction zone forms a corona texture in the ultramafic cumulate below the lower contact.



Core Photo



304-U1309D-61R-2 (continued) (Section top: 316.30 mbsf)

UNIT-153: Olivine-rich troctolite
Pieces 9-13

PRIMARY MINERALOGY: Determined from Piece 13 (Olivine-rich troctolite)

Olivine Modal 88%
 Size 2-6 mm average, 9 mm maximum
 Shape anhedral

Plagioclase Modal 7%
 Size 2-4 mm
 Shape anhedral

Clinopyroxene Modal 5%
 Size 17-30 mm
 Shape anhedral

COMMENTS: This unit consists of varied mafic/ultramafic cumulates, with olivine-rich troctolite as the dominant rock type. Piece 13 is very plagioclase-rich. A 4 mm wide microgabbro dike cuts at 105 cm.

SECONDARY MINERALOGY: The section consists of alternating layers of highly altered gabbro and highly altered mafic troctolite. Ferromagnesian minerals in the fractured gabbro are strongly altered to actinolite + chlorite +/- talc. Large pyroxene crystals clearly show talc on their cleavage surfaces. Very few coronitic alteration patches after olivine consisting of tremolite +/- chlorite +/- talc with a rim of chlorite are found (e.g. in Piece 9). In the troctolite olivine is mostly altered to form serpentine, chlorite, tremolite and magnetite. Plagioclase is partly altered to chlorite along the grain boundaries.

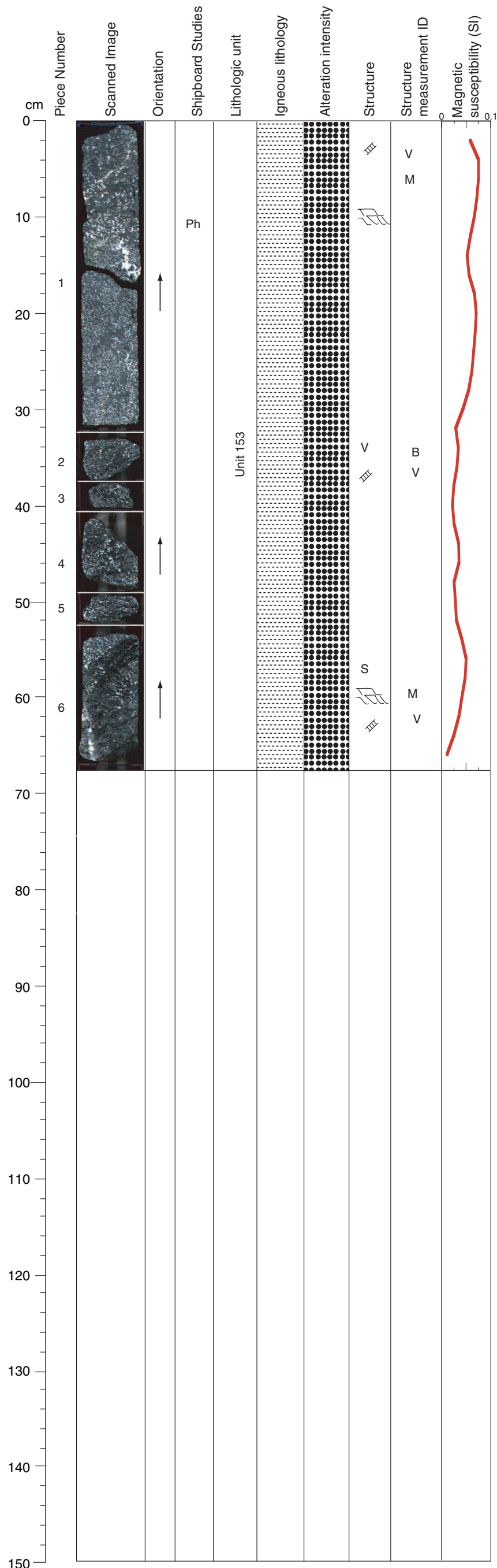
VEIN ALTERATION: Carbonate-tremolite veins are present in the troctolite at 12 cm and 49-54 cm. Small actinolite veins are present at 36 cm and 44 cm.

STRUCTURE: The coarse-grained intrusion at the base of Section U1309D-61R-1 continues with coarse-grained pyroxene and plagioclase. The contact with the mafic rocks (M) at 10 cm (making this a narrow gabbroic intrusion) is cut by carbonate veins (V). In Piece 3, 4, and 9, another gabbroic intrusion contains coronitic alteration (A) textures and intense microcracking (C). Veins cut the serpentinitized (S) mafic units, although dark serpentine "seams" cut the veins, in places. M>A=>C>V>S

CLOSE UP PHOTOGRAPHS:

- 1309D_61R_2_27_48.jpg
- 1309D_61R_2_75_95.jpg

Core Photo



304-U1309D-61R-3 (Section top: 317.58 mbsf)

UNIT-153: Olivine-rich troctolite
Pieces 1-6

PRIMARY MINERALOGY: Determined from Piece 1 (Olivine-rich troctolite)

- Olivine Modal 85%
 Size 4-11 mm
 Shape anhedral
- Plagioclase Modal 10%
 Size 2-5 mm
 Shape anhedral
- Clinopyroxene Modal 5%
 Size 17 mm average, 30 mm maximum
 Shape anhedral

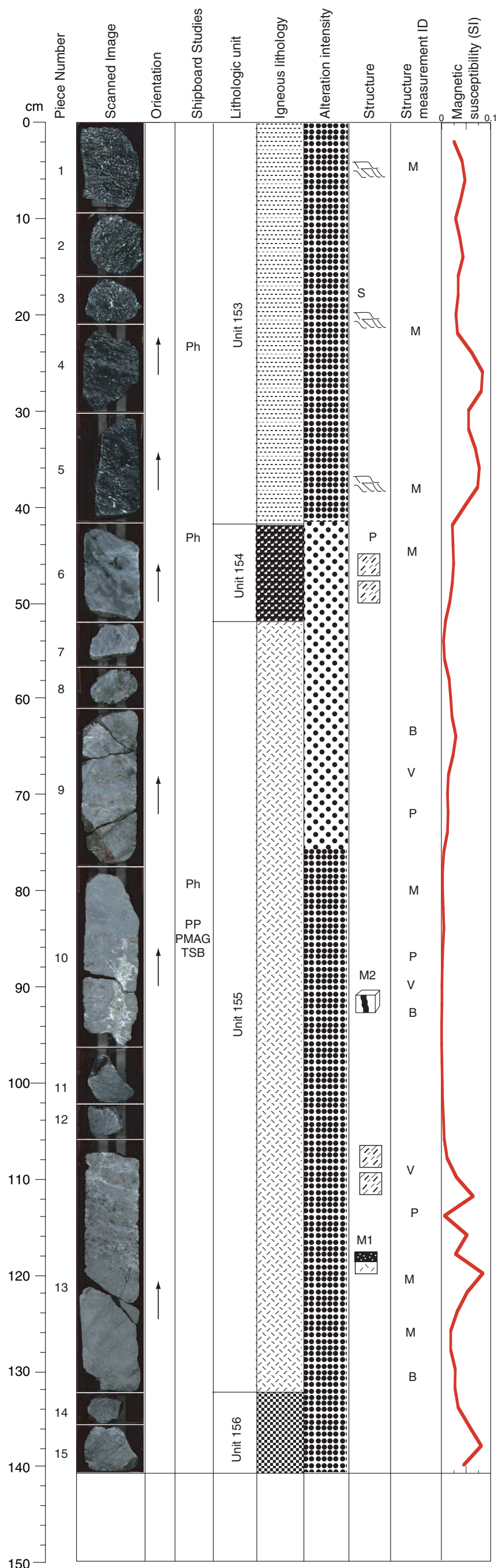
COMMENTS: This section is a continuation of the previous section. Intercumulus phases are more abundant, and more variable, than in the previous section; olivine-rich troctolite is the dominant rock type. In Piece 1B, plagioclase is the sole intercumulus phase. Pyroxene-rich areas with less plagioclase occur toward the end of the section. Piece 5 and 6 show preferred orientation of the intercumulus phases. A 1 mm wide gabbroic dike occurs at 30 cm and an 8 mm wide gabbroic dike crosses between 59 cm and 65 cm. An alteration vein occurs at 26 cm.

SECONDARY MINERALOGY: This section consists of highly altered mafic troctolite. Olivine is severely altered to serpentine, magnetite, and chlorite. Plagioclase may be partially gone to prehnite. In Piece 1, between 3-10 cm, pyroxenes seem to be still fresh.

STRUCTURE: Carbonate veins (V) (and some other compositions) crosscut dark serpentinized (S) troctolitic gabbro. S>V

CLOSE UP PHOTOGRAPHS:
1309D_61R_3_10_30.jpg

Core Photo



304-U1309D-62R-1 (Section top: 319.60 mbsf)

UNIT-153: Olivine-rich troctolite and Dunite
 Pieces 1-5
 PRIMARY MINERALOGY: Determined from Piece 1 (Olivine-rich troctolite)

Olivine Modal 83%
 Size 2-7 mm
 Shape anhedral

Plagioclase Modal 10%
 Size 2-3 mm
 Shape anhedral

Clinopyroxene Modal 7%
 Size 15-17 mm
 Shape anhedral

COMMENTS: This unit continues the mafic/ultramafic cumulate of the previous section. Magmatic foliation is visible. Pieces 4 and 5 show a very heterogeneous distribution of intercumulus phases with dunitic areas in between.

UNIT-154: Troctolite
 Pieces 6
 PRIMARY MINERALOGY: Determined from Piece 6

Olivine Modal 30%
 Size 7-20 mm
 Shape anhedral

Plagioclase Modal 70%
 Size 7-24 mm
 Shape anhedral

COMMENTS: A single piece of troctolite with pegmatitic grain sizes and corona texture occurs. It shows deformation.

UNIT-155: Gabbro
 Pieces 7-13
 PRIMARY MINERALOGY: Determined from Piece 13

Plagioclase Modal 65%
 Size 7-10 mm
 Shape anhedral

Clinopyroxene Modal 35%
 Size 4-11 mm average, 20 mm maximum
 Shape anhedral

COMMENTS: This unit consists of strongly deformed gabbro that has been intruded by an undeformed microgabbro. The microgabbro shows magmatic foliation in Piece 13A.

UNIT-156: Oxide Gabbro
 Pieces 14-15
 PRIMARY MINERALOGY: Determined from Piece 15 (Oxide Gabbro)

Plagioclase Modal 50%
 Size <1 - 1 mm
 Shape anhedral

Clinopyroxene Modal 40%
 Size <1-1 mm
 Shape anhedral

Oxide Modal 10%
 Size finely disseminated
 Shape anhedral

COMMENTS: Two pieces of oxide gabbro occur at the bottom of the section. Both show contacts to the microgabbro from the previous unit.

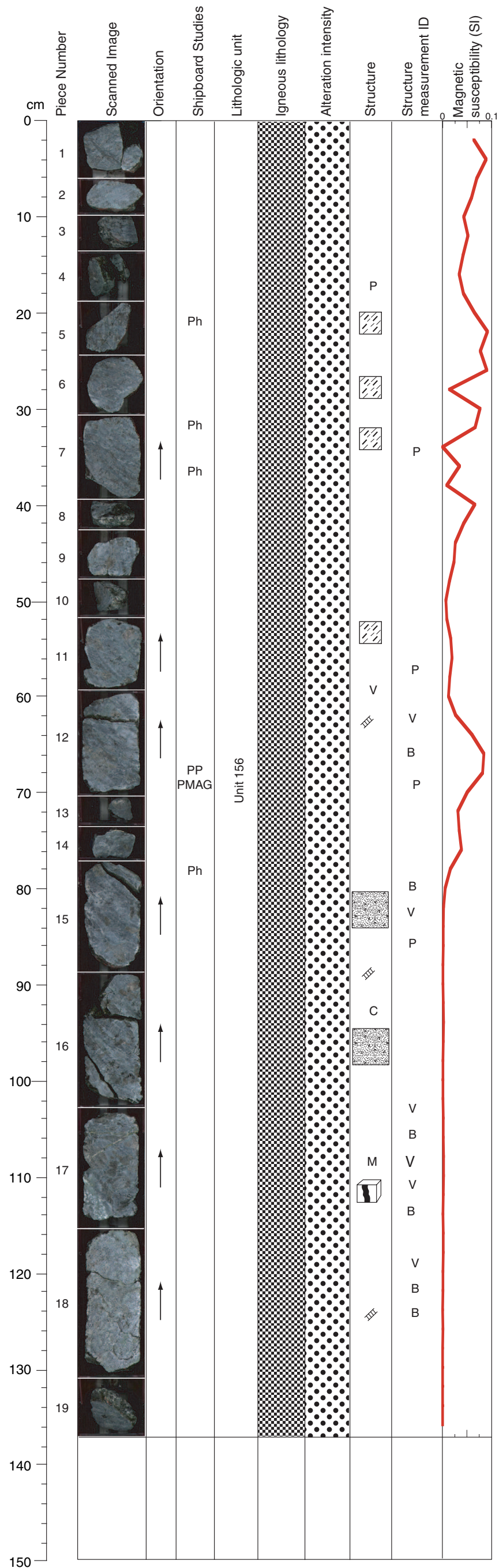
SECONDARY MINERALOGY: This section consists of highly altered mafic troctolite at the top, moderately altered olivine gabbro in the central part and highly altered olivine-bearing gabbro at the bottom. In the upper part, olivine is severely altered to serpentine, magnetite, and chlorite. Plagioclase in this part may be partially altered to prehnite. Pyroxene is mostly fresh. In the central part of the section, Piece 6 shows some large coronitic olivine alteration patches with tremolite + chlorite + talc, rimmed by chlorite in which some olivine is still fresh. Pyroxene is slightly altered to actinolite on the edges. Plagioclase seems to be fresh. In the lower part of the section, few olivine crystals were obviously present and are now completely replaced by tremolite + chlorite +/- talc and rimmed by chlorite. A felsic dike is present between 85-95 cm and shows altered plagioclase.

THIN SECTIONS:
 304-U1309D-62R-1, 85.0-88.0 cm (#226)

STRUCTURE: Mafic troctolite with serpentinized texture (S) continues from previous section, with a gently dipping fabric. The contact is not preserved, but Piece 6 marks the beginning of a new gabbro unit. The gabbro is recrystallized (P) plagioclase pyroxene gabbro with relict (altered) olivine grains with igneous grain boundaries. Pieces 7 and 8 have intense microcracking (C), brown pyroxene, and continuous milky white plagioclase. In Piece 11 this texture is cut by a feldspar rich vein (M2) with superposed green alteration. Below this, through Piece 13, is a mylonite with a semibrittle texture (e.g. pyroxenes have relict igneous grain shapes). The base of this mylonite is an intrusion (M1) of a fine grained, dark gabbro; the crystal plastic strain may be attributed to the intrusion of the "microgabbro".
 M1=>P>M2>S=>C

CLOSE UP PHOTOGRAPHS:
 1309D_62R_1_22_41.jpg
 1309D_62R_1_42_50.jpg
 1309D_62R_1_78_95.jpg

Core Photo



304-U1309D-62R-2 (Section top: 321.01 mbsf)

UNIT-156: Oxide Gabbro
Pieces 1-19

PRIMARY MINERALOGY: Determined from Piece 12

- Plagioclase Modal 68%
Size 7-10 mm
Shape anhedral
- Clinopyroxene Modal 30%
Size 7-15 mm average, 35 mm maximum
Shape anhedral
- Oxide Modal 2%
Size finely disseminated
Shape anhedral

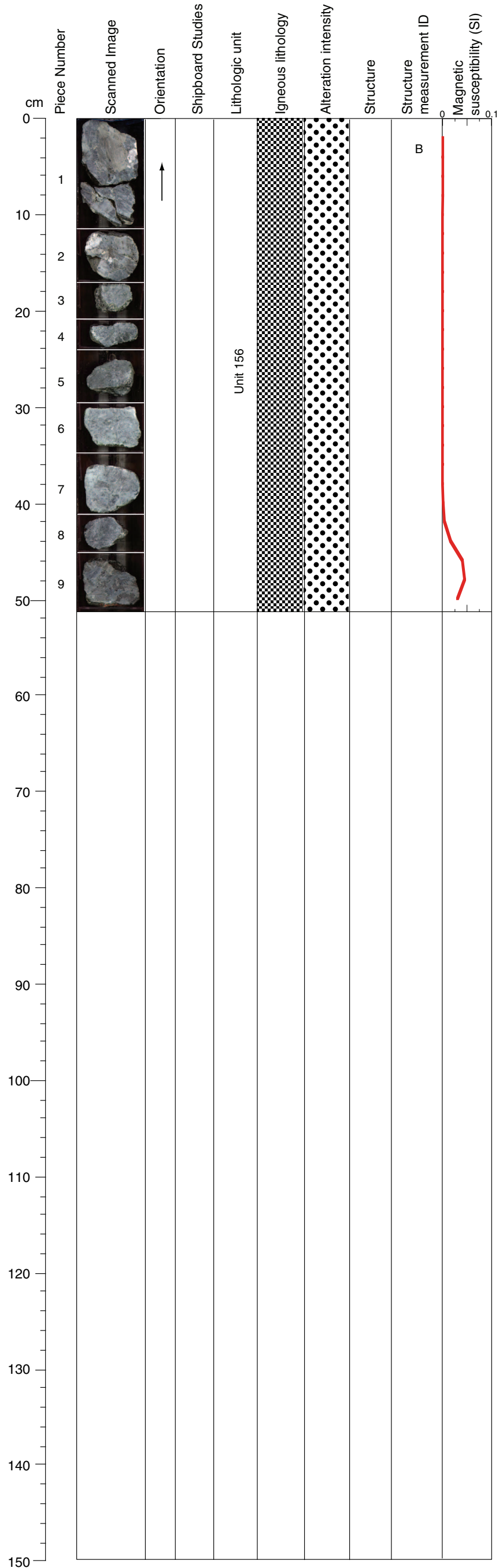
COMMENTS: This unit consists of coarse-grained oxide gabbro. Piece 15 shows an extremely low pyroxene-plagioclase ratio that suggests the infiltration of a feldspathic melt. There is a general grain size coarsening toward the center of the section.

SECONDARY MINERALOGY: This section consists of moderately altered gabbro. Pyroxene is slightly altered to actinolite; most orthopyroxene is rimmed by chlorite +/- talc. Plagioclase is mostly fresh. Some sulfides are present. A felsic dike is present between 109-113 cm and shows an alteration in the greenschist facies with altered plagioclase and actinolite veins.

STRUCTURE: Semibrittle, "granular" texture (P) is continuous through Pieces 5-7, making this interval (starting in section 62R2) a relatively wide, semibrittle shear zone. Microcracking (C) intensifies in the feldspar below this, with virtually no crystal plastic deformation. In Piece 17, the gabbro is cut by green veins (V) and a relatively wide, steeply dipping, feldspar-rich intrusion (M) with a green alteration overprint. P=>(?)M>C>V

CLOSE UP PHOTOGRAPHS:
1309D_62R_2_20_40.jpg
1309D_62R_2_31_39.jpg
1309D_62R_2_35_55.jpg
1309D_62R_2_77_87.jpg

Core Photo



304-U1309D-62R-3 (Section top: 322.38 mbsf)

UNIT-156: Oxide Gabbro
Pieces 1-9

PRIMARY MINERALOGY: Determined from Piece 1 and 9

Plagioclase Modal 50%
 Size 7-17 mm average
 Shape anhedral

Clinopyroxene Modal 45%
 Size 7-16 mm average, 37 mm maximum
 Shape anhedral

Oxide Modal 5%
 Size 3-6 mm
 Shape anhedral

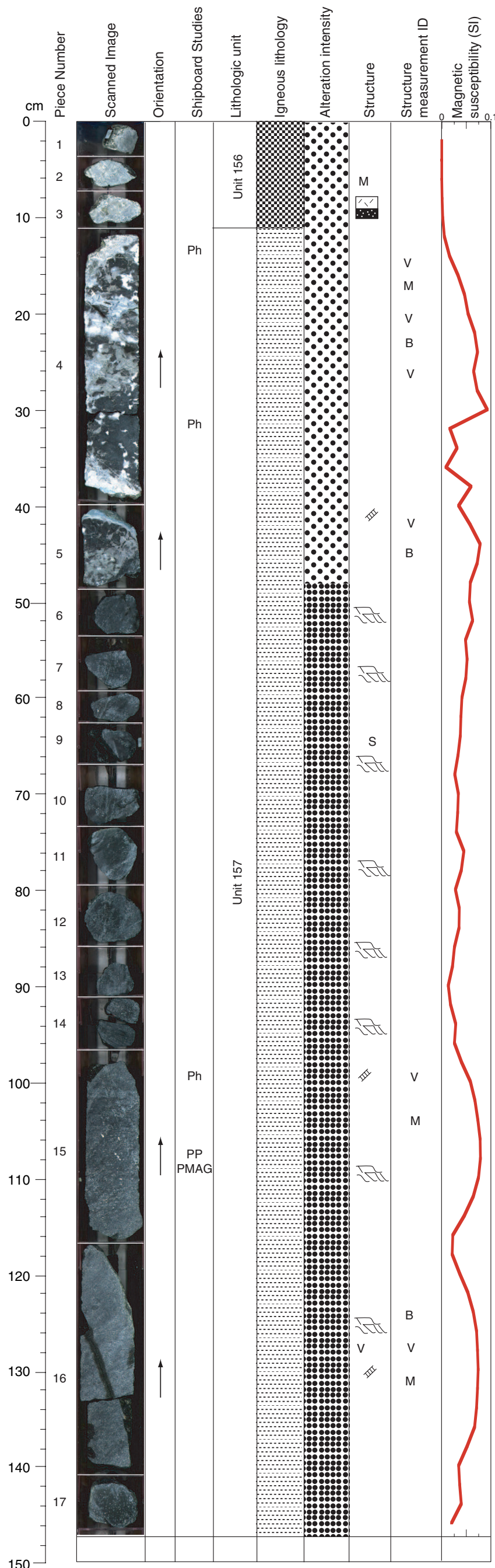
COMMENTS: This section starts with a pegmatitic oxide gabbro in the first two pieces. Pieces 3 to 8 have a very low pyroxene/plagioclase ratio suggesting that they have been infiltrated by a feldspathic melt. They show medium to coarse grain sizes and a low amount of olivine. Piece 9 looks similar to Pieces 1 and 2.

SECONDARY MINERALOGY: This section consists of gabbro which is moderately altered within the greenschist facies. Pyroxene edges seem slightly altered to actinolite. Plagioclase is generally fresh.

VEIN ALTERATION: No veins in this section.

STRUCTURE: Gradation back into oxide-rich gabbros; no noteworthy structure.

Core Photo



304-U1309D-63R-1 (Section top: 324.40 mbsf)

UNIT-156: Oxide Gabbro
Pieces 1-3

PRIMARY MINERALOGY: Determined from Piece 3 (Gabbro)

- Olivine Modal <1%
 Size 1-2 mm
 Shape anhedral
- Plagioclase Modal 60%
 Size 3-5 mm
 Shape anhedral
- Clinopyroxene Modal 40%
 Size 7-14 mm
 Shape anhedral

COMMENTS: Pieces 1 and 3 are oxide gabbro similar to the middle part of the previous unit. They show a very low pyroxene/plagioclase-ratio and minor olivine. Piece 2 is a very small piece of fine-grained ultramafic rock. It is not clear if these pieces are in place or fallen down the hole.

UNIT-157: Olivine-rich troctolite
Pieces 4-17

PRIMARY MINERALOGY: Determined from Piece 15 (Olivine-rich troctolite)

- Olivine Modal 90%
 Size 1-2 mm
 Shape anhedral
- Plagioclase Modal 5%
 Size 1-2 mm
 Shape anhedral
- Clinopyroxene Modal 5%
 Size 2-4 mm
 Shape anhedral
- Spinel Modal <1%
 Size <1-1 mm
 Shape anhedral

COMMENTS: This unit consists of ultramafic cumulates with intercumulus plagioclase and pyroxene. The first two pieces are olivine gabbro, and the remainder of the section is dunite. At the top of Piece 4 is a contact with oxide gabbro from the previous unit, and intercumulus phases are exceptionally coarse adjacent to the contact (Pieces 4 and 5). Clinopyroxene oikocrysts are as large as 40 mm and interstitial plagioclase as large as 25 mm. Intercumulus phases are heterogeneously distributed and completely absent in some barren, dunitic areas. Grain sizes are the smallest so far. The contrast between coarse grain sizes near the top of the unit and the smaller grain sizes near the bottom, might suggest melt segregation and crystal growth in the vicinity of an upper gabbro intrusion.

SECONDARY MINERALOGY: This section consists of moderately altered coarse-grained plagioclase-bearing peridotite to highly altered plagioclase-bearing peridotite. Olivine is severely altered to serpentine, magnetite, chlorite. Plagioclase is partially altered to prehnite. Pyroxene seems fresh.

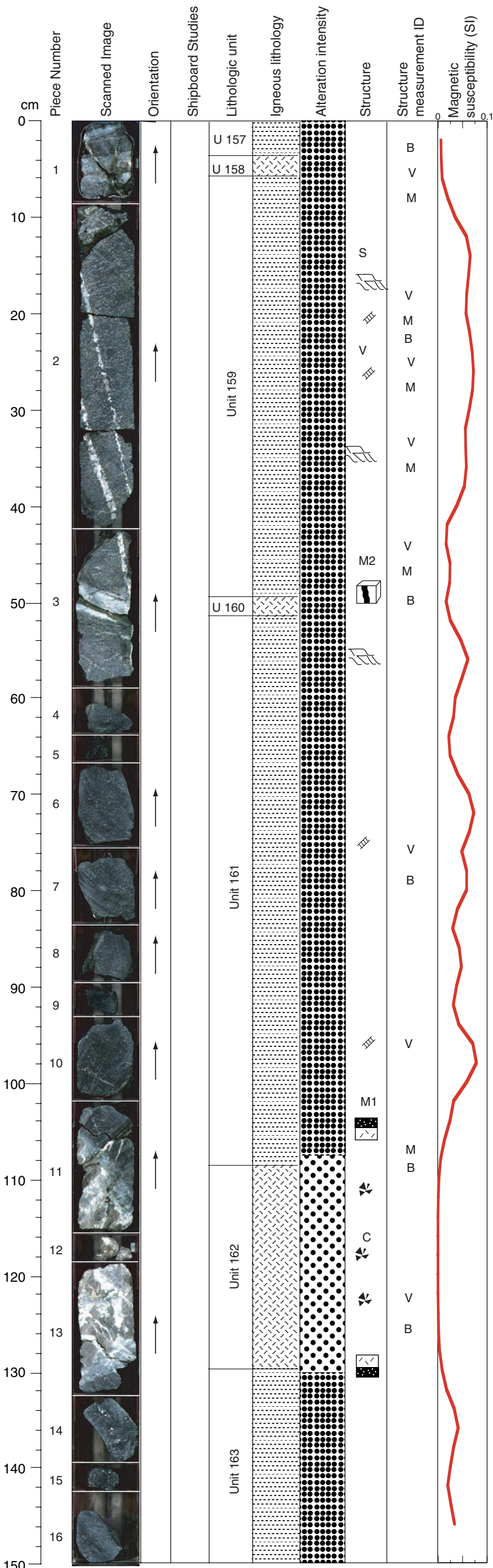
VEIN ALTERATION: A tremolite-talc vein is present between 36-41 cm.

STRUCTURE: Inclined margin in Piece 3 marks the end of the gabbroic intrusion (M), above which are granular plagioclase, and pyroxene with microcracks. Below the contact, large patches of serpentinite (S) (with a mesh texture) and patches of continuous feldspar and pyroxene. Oikocrysts of pyroxene surround both the feldspar and serpentinite. Below a blue vein (V) at the top of Piece 5 is continuous serpentinite with a dipping mesh texture. M>S>V

CLOSE UP PHOTOGRAPHS:

- 1309D_63R_1_12_30.jpg
- 1309D_63R_1_31_48.jpg
- 1309D_63R_1_99_114.jpg

Core Photo



304-U1309D-63R-2 (Section top: 325.86 mbsf)

UNIT-157: Olivine-rich troctolite
 Piece 1
PRIMARY MINERALOGY: Determined from Piece 1
 Olivine Modal 90%
 Size 1-2 mm
 Shape anhedral
 Plagioclase Modal 5%
 Size 1-2 mm
 Shape anhedral
 Clinopyroxene Modal 5%
 Size 2-4 mm
 Shape anhedral
 Spinel Modal <1 %
 Size <1-1 mm
 Shape anhedral
COMMENTS: This unit consists of olivine-rich troctolite with a crosscutting talc-tremolite vein.

UNIT-158: Gabbro dike
 Piece 1
PRIMARY MINERALOGY: Determined from Piece 1 (Gabbro)
 Plagioclase Modal 70%
 Size 5-13 mm
 Shape anhedral
 Clinopyroxene Modal 30%
 Size 3-6 mm
 Shape anhedral
COMMENTS: A small gabbro dike is cutting through the olivine-rich troctolite.

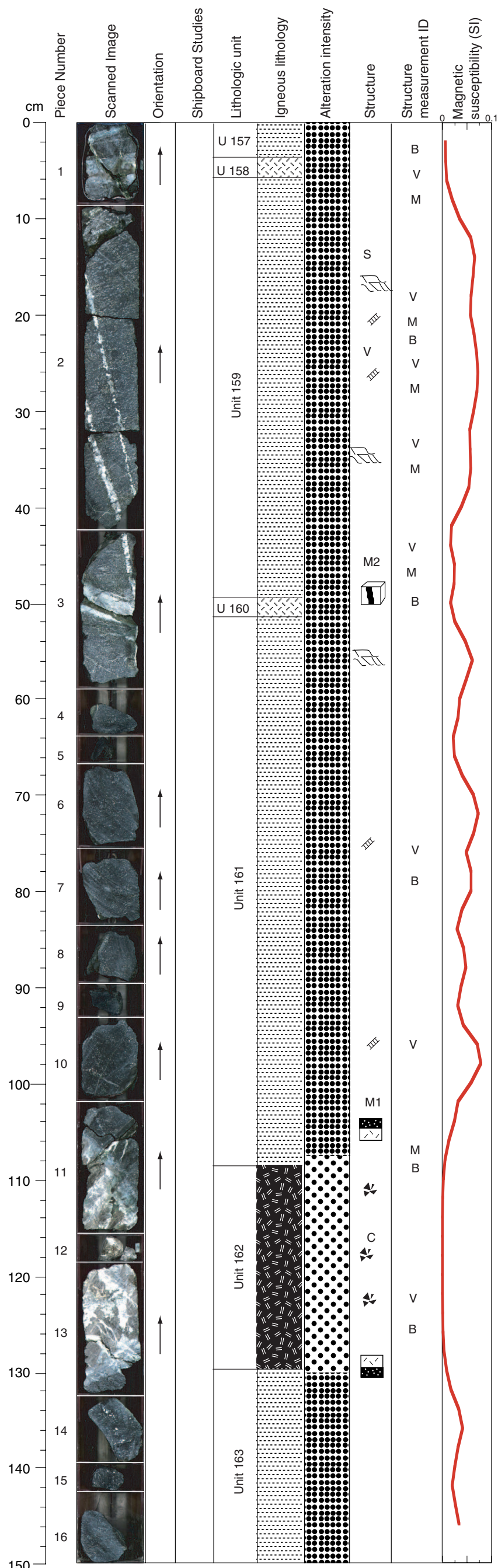
UNIT-159: Olivine-rich troctolite
 Pieces 1-3
PRIMARY MINERALOGY: Determined from Piece 2B
 Olivine Modal 86%
 Size 2-5 mm
 Shape anhedral
 Plagioclase Modal 7%
 Size 1-2 mm
 Shape anhedral
 Clinopyroxene Modal 7%
 Size 7-10 mm
 Shape anhedral
COMMENTS: This unit is very similar to Unit 157. Only few and fine grained intercumulus plagioclases and clinopyroxenes occur. Two gabbroic dikes (8 mm and 4 mm wide) cut almost perpendicular the preferred orientation of the intercumulus phases.

UNIT-160: Gabbro
 Piece 3
PRIMARY MINERALOGY: Determined from Piece 23 (A and B) (Gabbro)
 Olivine Modal <1%
 Size 1-2 mm
 Shape anhedral
 Plagioclase Modal 80%
 Size 3-4mm
 Shape anhedral
 Clinopyroxene Modal 20%
 Size 2-7 mm average, 40 mm maximum
 Shape anhedral
COMMENTS: This unit consists of a medium-grained gabbro dike cutting subhorizontally the core. A yellow, greenish reaction zone formed at the lower contact but not at the upper in the ultramafic cumulates.

UNIT-161: Dunite
 Pieces 3-11
PRIMARY MINERALOGY: Determined from Piece 6
 Olivine Modal 92%
 Size 3-5 mm
 Shape anhedral
 Plagioclase Modal 3%
 Size <1-2 mm
 Shape anhedral
 Clinopyroxene Modal 5%
 Size 4 mm
 Shape anhedral
COMMENTS: This unit consists of dunite with very small intercumulus plagioclase and clinopyroxene that are homogeneously distributed. A narrow dike of less than 1 mm crosscuts the section at 99 cm.



Core Photo



304-U1309D-63R-2 (continued) (Section top: 325.86 mbsf)

UNIT-162: Olivine-bearing Gabbro
Pieces 11–13

PRIMARY MINERALOGY: Determined from Piece 13

Olivine Modal <1%
 Size 3-5 mm
 Shape anhedral

Plagioclase Modal 70%
 Size 15-21 mm average, 45 mm maximum
 Shape anhedral

Clinopyroxene Modal 30%
 Size 7-16 mm average, 65 mm maximum
 Shape anhedral

COMMENTS: This unit consists of a very coarse-grained olivine-bearing gabbro dike. Contacts are preserved on both sides with a 8 mm wide zone of talc penetrating into them

UNIT-163: Olivine-rich troctolite
Pieces 14–16

PRIMARY MINERALOGY: Determined from Piece 14

Olivine Modal 88%
 Size 3-5 mm
 Shape anhedral

Plagioclase Modal 5%
 Size 1-2 mm
 Shape anhedral

Clinopyroxene Modal 3%
 Size 3-7 mm
 Shape anhedral

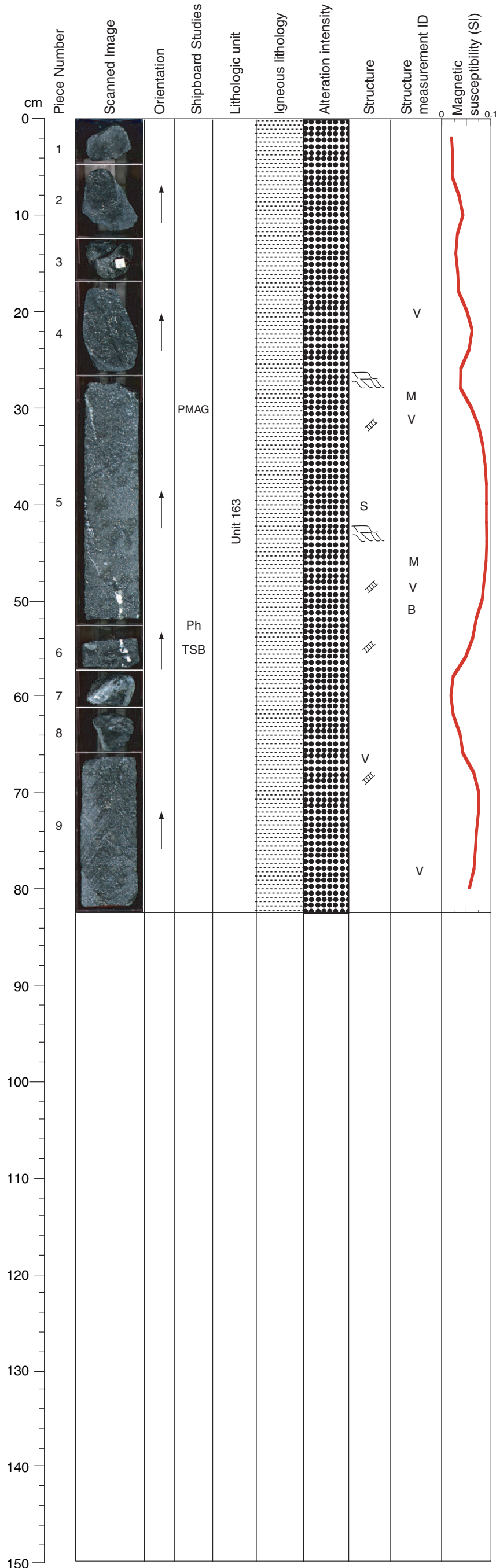
COMMENTS: It is the continuation of the previous section but contains a slightly higher amount of coarser intercumulus plagioclase and clinopyroxene.

SECONDARY MINERALOGY: This core section consists of a highly altered plagioclase-bearing peridotite cut by gabbroic intrusions that are moderately altered (107-130 cm). In the peridotite, olivine is severely altered to serpentine, magnetite and chlorite. Plagioclase may be partially altered to prehnite. Pyroxene seems to be fresh. A transversal dike with plagioclase and pyroxene is present in Pieces 2 and 3. The gabbro layers show alteration in the greenschist facies in which plagioclases are rimmed by chlorite. Pyroxene seem to be fresh.

VEIN ALTERATION: A lot of actinolite veins are present in the gabbro layers. Few green actinolite veins are present in the peridotite (e.g. between 94-102 cm) and a blue/green tremolite +/- talc? vein is present between 0-1 cm.

STRUCTURE: Serpentinite with well-developed mesh texture (S) cut by steeply dipping veins (V) and shallowly dipping feldspar and alteration mineral-rich band (M2). In Piece 11, intensely internally brecciated (C) gabbro (M1) sealed by feldspar. The boundary between the gabbroic intrusion and the overlying troctolite/peridotite is discordant. S>M1>M2>C>V (Note the serpentinite texture follows an earlier magmatic foliation.

Core Photo



304-U1309D-63R-3 (Section top: 327.36 mbsf)

UNIT-163: Olivine-rich troctolite
Pieces 1-9

PRIMARY MINERALOGY: Determined from Piece 9

Olivine Modal 88%
Size 10 mm
Shape anhedral

Plagioclase Modal 7%
Size <1-2 mm
Shape anhedral

Clinopyroxene Modal 5%
Size 10 mm
Shape anhedral

COMMENTS: This section consists of fine-grained olivine-rich troctolite with a very homogeneous distribution of intercumulus phases. This section is characterized by several crosscutting gabbro dikes. A 7 mm wide, medium-grained gabbro dike occurs in Piece 5 and 6 and a 12 mm wide one with sharp outlines in Piece 7. Another dike might be represented by a reaction zone that occurs along the edges of Pieces 7 and 8. Piece 8 is crosscut by a fine dike of 1-4 mm width.

SECONDARY MINERALOGY: This section consists of highly altered plagioclase-bearing peridotite. Olivine is extensively altered to serpentine and magnetite forming a mesh texture and more or less chlorite that forms a rim at the contact with plagioclase. Plagioclase are partially altered to white-pale green prehnite. In the plagioclase-pyroxene dike between Pieces 5 and 6, plagioclase is altered to prehnite and pyroxene seems partially altered to tremolite.

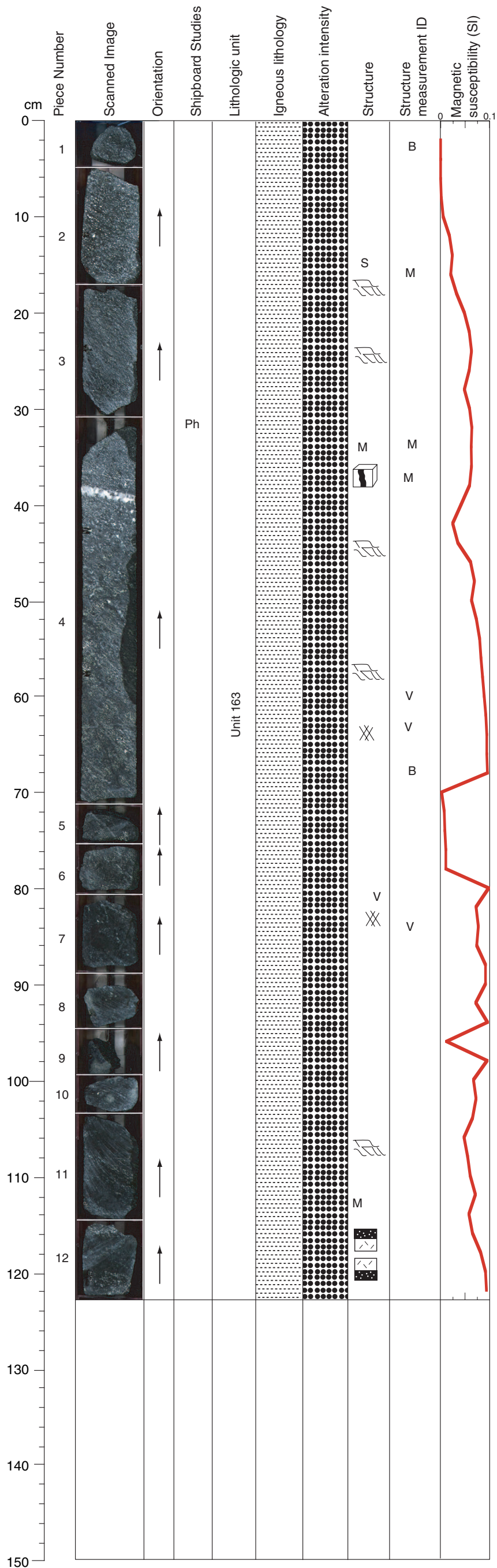
THIN SECTIONS:
304U-U1309D-63R-3, 54.0-57.0 cm (#227)

STRUCTURE: Serpentinite (S) cut by discontinuous carbonate-serpentine composite veins (V), with compositional variation along the vein length

CLOSE UP PHOTOGRAPHS:
1309D_63R_3_52_56.jpg



Core Photo



304-U1309D-64R-1 (Section top: 329.20 mbsf)

UNIT-163: Olivine-rich troctolite
Pieces 1-12

PRIMARY MINERALOGY: Determined from Piece 4

- Olivine Modal 83%
 Size 10-16 mm
 Shape anhedral
- Plagioclase Modal 7%
 Size 2-5 mm
 Shape anhedral
- Clinopyroxene Modal 10%
 Size 10-23 mm
 Shape anhedral

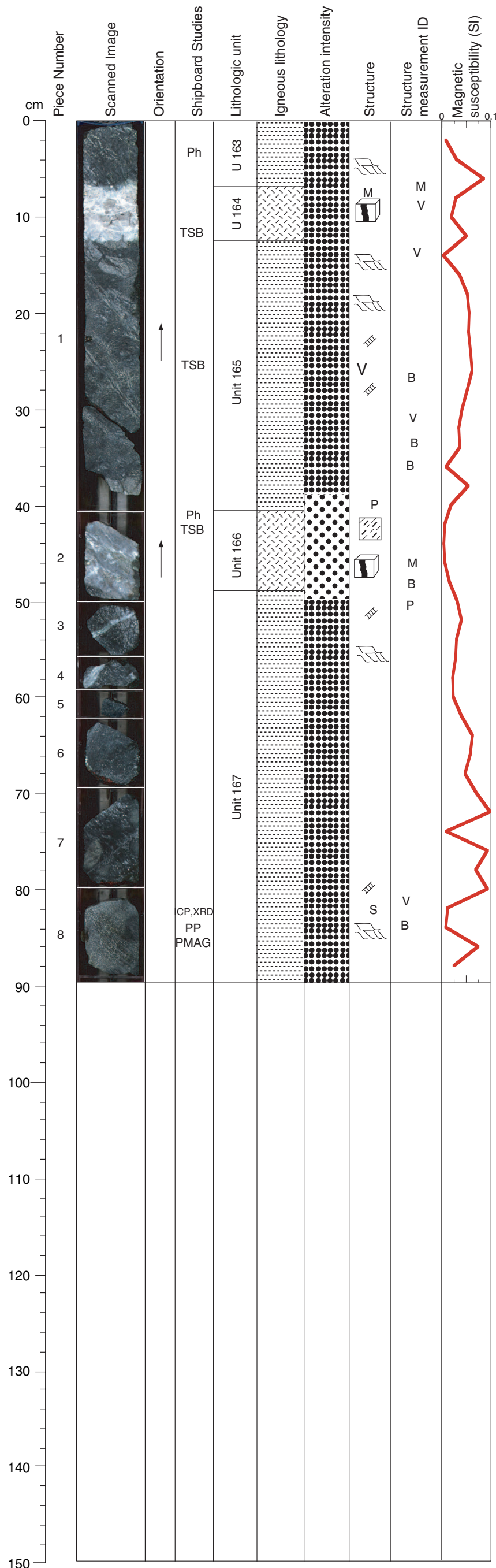
COMMENTS: This section continues the previous section. A preferred orientation of intercumulus plagioclase and clinopyroxene in Piece 1 and 2 is emphasized by the orientation of serpentine veins. Plagioclase-content decreases, and clinopyroxene becomes dominant, from 42-82 cm. Wehrlite occurs between 50 cm and 80 cm. Below 82 cm, intercumulus phases have low abundance, and dunites prevail. There is a 10 mm wide, subhorizontal, medium-grained gabbro dike at 38 cm. A very narrow, 1 mm wide dike occurs parallel to it at 36 cm.

SECONDARY MINERALOGY: This section consists of highly altered plagioclase-bearing peridotite. Olivine is severely altered to serpentine, magnetite, chlorite. Plagioclase may be partially altered to prehnite. Pyroxene seems to be fresh. A felsic dike is present at 38 cm.

STRUCTURE: Well-defined fabric (S) in serpentinite (following an original olivine-defined fabric) (see Piece 3), cut by coarse-grained vein in Piece 4. In some places there are pyroxene oikocrysts. Late, very thin (<<1mm) white veins (V) in serpentine-rich domains. Piece 12 is noteworthy for a >90% serpentine "band" (M) in otherwise plagioclase-bearing serpentine (e.g. dunitic horizon in mafic troctolite-to-dunite). M>S>V

CLOSE UP PHOTOGRAPHS:
1309D_64R_1_30_70.jpg

Core Photo



304-U1309D-64R-2 (Section top: 330.43 mbsf)

UNIT-163: Olivine-rich troctolite
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1

Olivine Modal 83%
 Size 10-16 mm
 Shape anhedral

Plagioclase Modal 7%
 Size 2-5 mm
 Shape anhedral

Clinopyroxene Modal 10%
 Size 10-23 mm
 Shape anhedral

COMMENTS: This unit consists of olivine-rich troctolite with heterogeneously distributed intercumulus plagioclase and clinopyroxene showing a strong preferred orientation. Modal compositions range between troctolitic gabbro and dunite.

UNIT-164: Gabbro Dike
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1 (Gabbro)

Plagioclase Modal 45%
 Size 7-15 mm
 Shape anhedral

Clinopyroxene Modal 55%
 Size 6-30 mm
 Shape anhedral

COMMENTS: The steep preferred orientation seen in the unit above is cut by a subhorizontal gabbro dike. It is 55 mm wide and very coarse-grained with clinopyroxene grains as large as 30 mm. There is a weak reaction zone in the overlying cumulates at the upper contact.

UNIT-165: Dunite
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1 (Dunite)

Olivine Modal 96%
 Size too altered
 Shape too altered

Plagioclase Modal ~2%
 Size 1-2 mm
 Shape anhedral

Clinopyroxene Modal ~2%
 Size 3-12 mm
 Shape anhedral

COMMENTS: This unit consists of very highly altered dunite. The high degree of alteration makes it difficult to identify intercumulus phases. Secondary serpentinization follows the same preferred orientation as in Unit 163. It cuts an older, subhorizontal, set of serpentine veins.

UNIT-166: Gabbro
Piece 2

PRIMARY MINERALOGY: Determined from Piece 2 (Gabbro)

Plagioclase Modal 75%
 Size 4-11 mm
 Shape anhedral

Clinopyroxene Modal 25%
 Size 4-10mm
 Shape anhedral

COMMENTS: A coarse-grained gabbro dike cuts the dunites but only the lower contact is recovered. The main part of the unit shows a strong mylonitic deformation, with a 25 mm-wide undeformed, coarse-grained gabbro along the contact.

UNIT-167: Olivine-rich troctolite
Pieces 2-8

PRIMARY MINERALOGY: Determined from Piece 7A (Dunite)

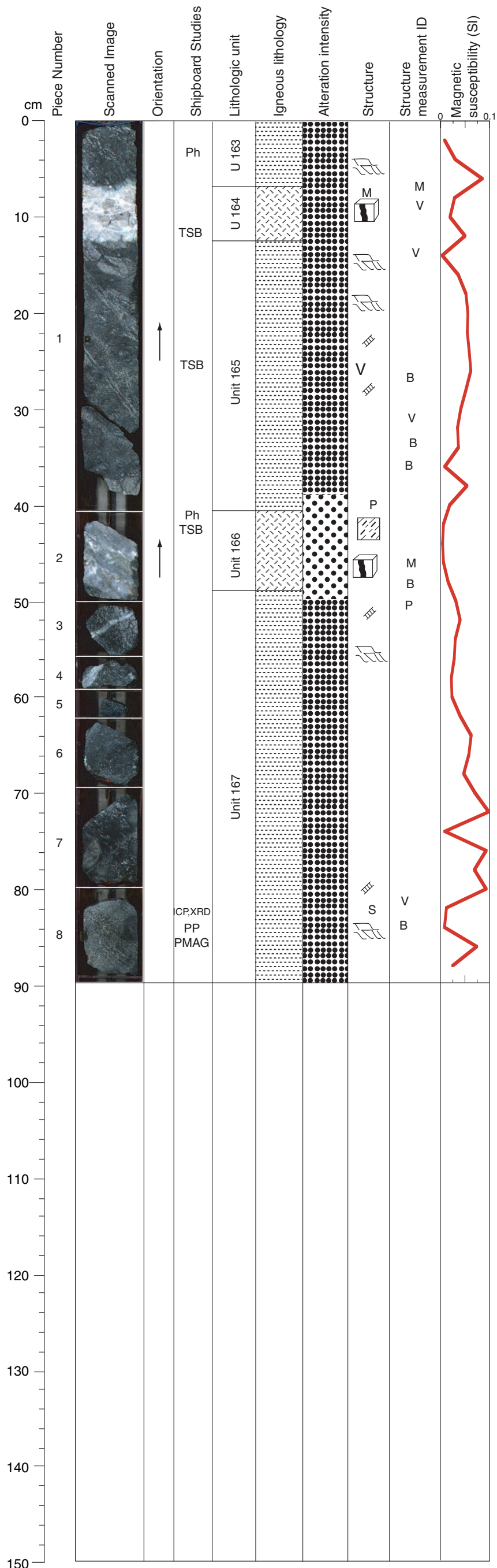
Olivine Modal 96%
 Size 1-2 mm
 Shape anhedral

Plagioclase Modal 2%
 Size mm average, mm maximum
 Shape 1-3 anhedral

Clinopyroxene Modal 2%
 Size 1-3 mm
 Shape anhedral



Core Photo



304-U1309D-64R-2 (continued) (Section top: 330.43 mbsf)

COMMENTS: This unit consists of dominantly dunites. A 4 mm wide gabbro dike cuts through Piece 3 and 4 forming a whitish-greenish reaction zone around it.

SECONDARY MINERALOGY: This core section consists of highly altered dunite. In the upper part, olivine seems to be fresh. A layer of moderately altered gabbro is present between 7-13 cm. In the lower part, olivine is severely altered to serpentine, magnetite, carbonate, and chlorite. Plagioclase is partially altered to prehnite. Pyroxene seems to be fresh. A foliated gabbro within the dunite (central part of the section) has abundant recrystallized plagioclase and pyroxene, but shows only moderate alteration in the greenschist facies. The greenschist facies alteration corresponds here to a slight alteration of pyroxene to actinolite and plagioclase to chlorite along their rims.

VEIN ALTERATION: Abundant talc-tremolite veins are present in the serpentinite.

THIN SECTIONS:

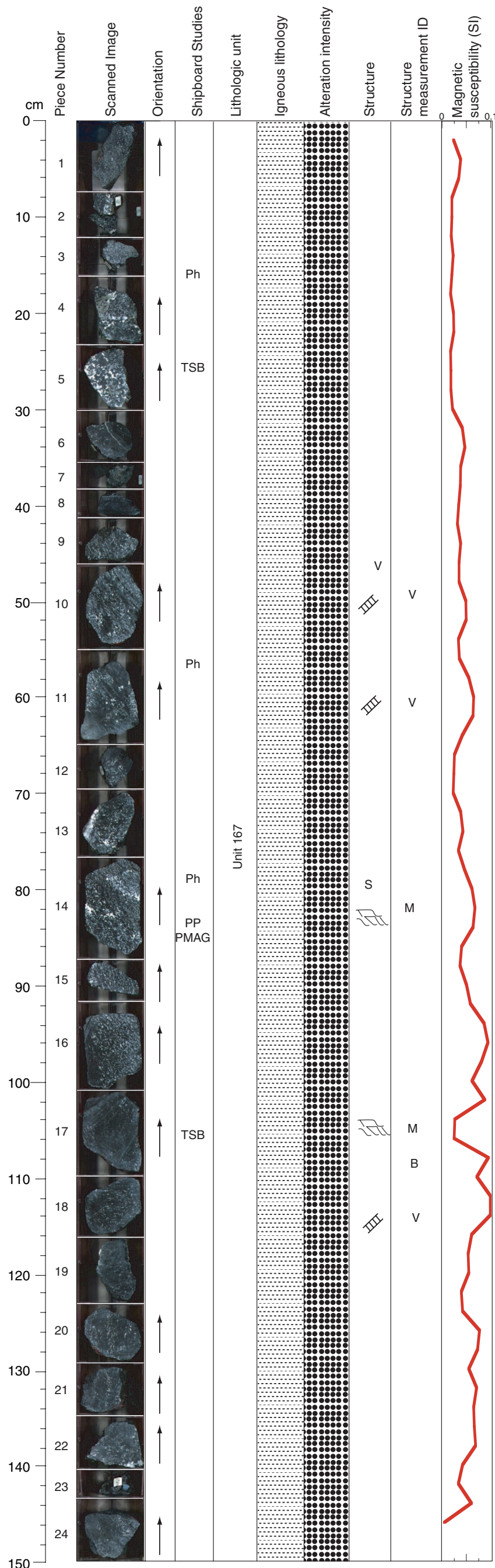
- 304-U1309D-64R-2, 11.0-14.0 cm (#228)
- 304-U1309D-64R-2, 24.0-27.0 cm (#229)
- 304-U1309D-64R-2, 42.0- 45.0 cm (#230)

STRUCTURE: Well-defined mesh-texture (S) inclined to 90 degrees in the core reference frame. In places takes on the appearance of a semibrittle flow texture (although most likely a static replacement of an earlier magmatic texture defined by olivine). Serpentine veins (V1) cut the mesh texture, and the suite is cut by a coarse-grained gabbroic intrusion (M). The gabbro has large plagioclase domains (grains) surrounding slightly rounded (magmatically?) pyroxene. Another intrusive body, in Piece 2, has a mylonitic (P) texture. The mylonite contains bands of olivine (altered) mixed with bands of pyroxene and recrystallized plagioclase. The shear zone may have sense of shear indicators and a candidate for melt-present strain history. The base of the section contains more mesh-textured serpentinized peridotite. M=>P>S (note S follows an earlier - earliest - magmatic (mantle?) foliation).

CLOSE UP PHOTOGRAPHS:

- 1309D_64R_2_3_23.jpg
- 1309D_64R_2_41_49.jpg

Core Photo



304-U1309D-65R-1 (Section top: 334.00 mbsf)

UNIT-167: Serpentinized Troctolitic Gabbro and Olivine-rich troctolite
Pieces 1–24

PRIMARY MINERALOGY: Determined from Piece 14 (Troctolitic Gabbro)

Olivine Modal 30%
 Size 1-4 mm
 Shape anhedral

Plagioclase Modal 60%
 Size 1-4 mm
 Shape anhedral

Clinopyroxene Modal 10%
 Size 1-2 mm average, 30 mm maximum
 Shape anhedral

COMMENTS: This section consists of olivine-rich cumulates and is a continuation of the previous section. Amount, size and distribution of intercumulus plagioclase and clinopyroxene change throughout the section and samples grade from troctolitic gabbro (Pieces 1 to 17) to dunite (Pieces 18 to 24), accordingly. Dunitic domains also occur in Pieces 5 to 8, 10 to 12 and 16 to 17. This section is dominantly medium-grained but coarse grain sizes appear in Pieces 2, 4 to 5, and 13 to 14. Areas of dunite and coarser grain sizes are commonly associated. Gabbroic dikes crosscut the section at several intervals. Piece 2 contains one that is 6 mm wide. Piece 13 contains a 4 mm wide dike and Piece 23 has a 6 mm wide gabbro dike. The dikes are all generally medium-grained but Piece 23 has a finer grain size than Piece 2 and Piece 13. Magmatic foliation is visible in Pieces 10-16 and high sulfide contents occur in Pieces 11 to 18.

SECONDARY MINERALOGY: This section consists of highly altered plagioclase-bearing peridotite. Olivine is severely altered to serpentine, magnetite, chlorite. Milky white alteration of plagioclase are partially altered to prehnite. Pyroxene crystals seem to be fresh.

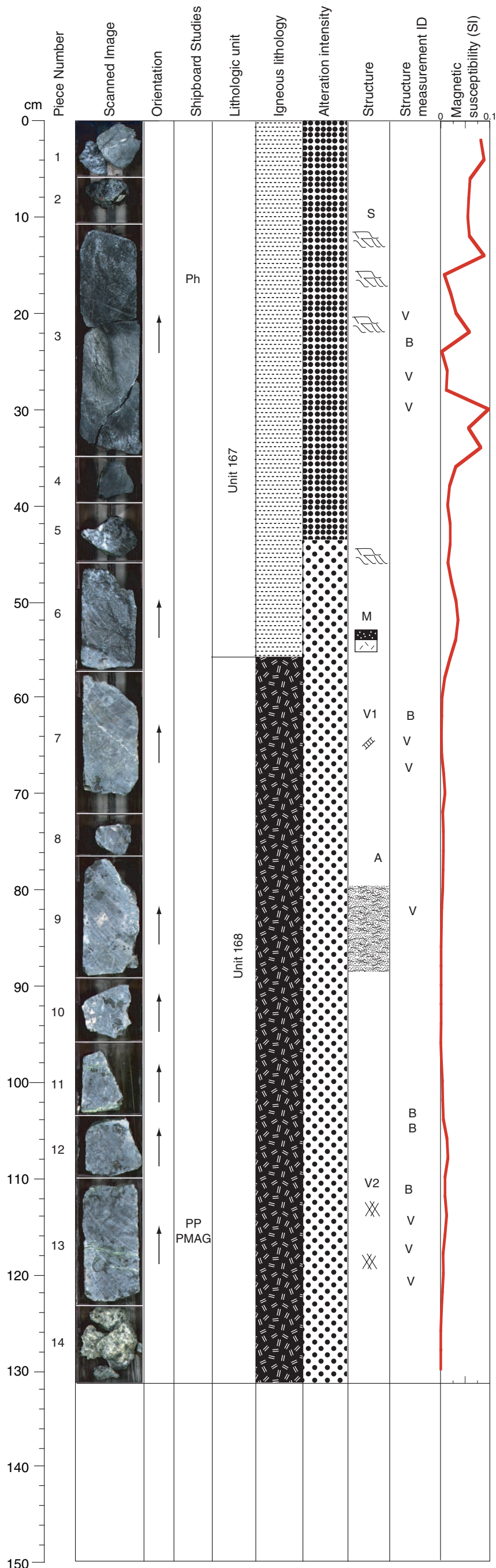
VEIN ALTERATION: A carbonate vein is observed at 33 cm. Few white thin veins, possibly filled with plagioclase and actinolite are observed through the section (e.g. at 62 cm)

THIN SECTIONS:
[304-U1309D-65R-1, 25.0-28.0 cm \(#231\)](#)
[304-U1309D-65R-1, 104.0-106.0 cm \(#232\)](#)

STRUCTURE: Patchy serpentinization (S) on an early olivine-defined texture. Some later veins (V). S > V

CLOSE UP PHOTOGRAPHS:
[1309D_65R_1_16_30.jpg](#)
[1309D_65R_1_55_63.jpg](#)
[1309D_65R_1_77_86.jpg](#)

Core Photo



304-U1309D-65R-2 (Section top: 335.50 mbsf)

UNIT-167: Serpentinized Troctolitic Gabbro and Olivine-rich troctolite
Pieces 1-6

PRIMARY MINERALOGY: Determined from Piece 3A (Dunite)

Olivine Modal 93%
 Size 2-3 mm
 Shape anhedral

Plagioclase Modal 7%
 Size 1-2 mm
 Shape anhedral

COMMENTS: This section is dominated by dunite interrupted by olivine-rich troctolitic layers. Piece 2 shows coarse intercumulus plagioclase, with fine clinopyroxene oikocrysts. Piece 3 has a small proportion of intercumulus phases. Between 40 cm and 51 cm, a 6 cm wide zone occurs consisting of olivine-rich troctolite with almost no clinopyroxene.

UNIT-168: Olivine-bearing Gabbro
Pieces 6-14

PRIMARY MINERALOGY: Determined from Piece 9 (Olivine Gabbro)

Olivine Modal 7%
 Size 5-92 mm
 Shape anhedral

Plagioclase Modal 68%
 Size 7-21 mm
 Shape anhedral

Clinopyroxene Modal 25%
 Size 7-20 mm
 Shape anhedral

COMMENTS: This unit consists of very coarse-grained olivine gabbro that cuts olivine-rich troctolite. Olivine is unevenly distributed. Both intrusive contacts are preserved but no distinct reaction zone can be observed at the upper contact.

SECONDARY MINERALOGY: This section consists of highly altered plagioclase-bearing peridotite at the top and moderately altered gabbro at the bottom. In the upper part, olivine is severely altered to serpentine, magnetite, and chlorite. Plagioclase may be partially altered to prehnite. Pyroxene seems to be fresh. In the lower part, pyroxene is slightly altered to actinolite whereas plagioclase is generally fresh. Little olivine is present and it is completely altered to tremolite + chlorite +/- talc and rimmed by chlorite (e.g. at 74 cm).

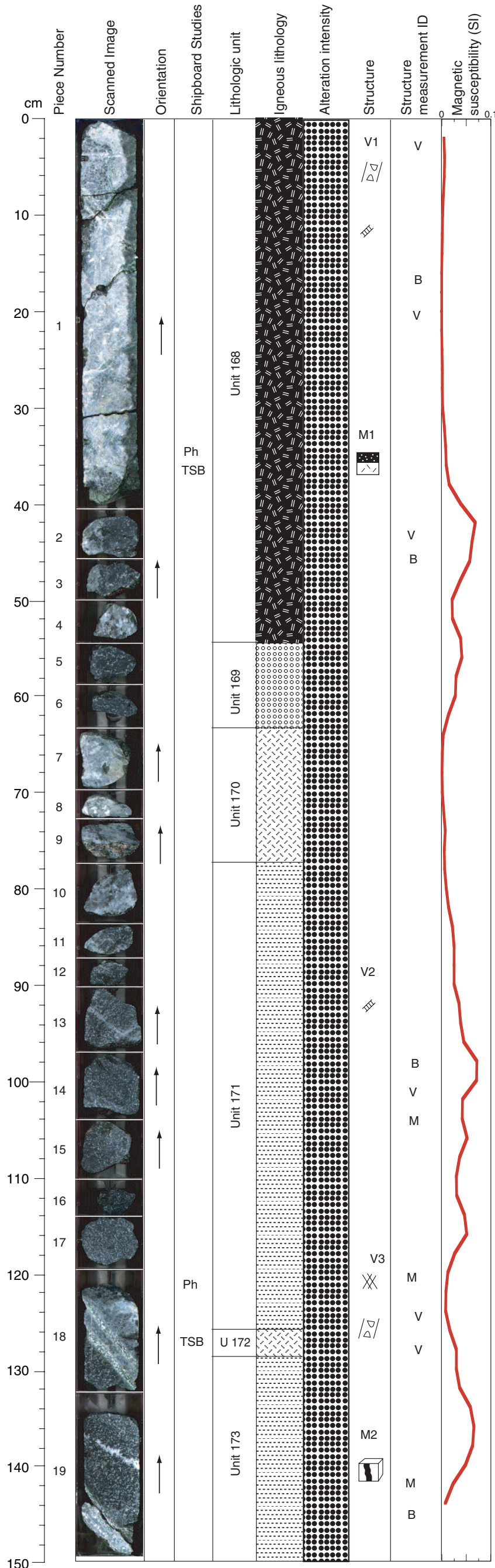
VEIN ALTERATION: Talc-tremolite veins are present in the upper part of the section. In the lower part, green actinolite veins are present (e.g. between 116-118 cm).

STRUCTURE: Inclined mesh texture serpentinite (S) with variable amounts of green and black serpentine alteration. Inclined green veins cut the fabric. The ultramafic rock grades into gabbro across an intrusive contact (M) at the base of Piece 6. The gabbro has interstitial milky white plagioclase along a vein (V1) and surrounding coarse grained pyroxene. Some coronitic texture (A). Toward Piece 13 gently dipping green veins (V2) cut intergrown plagioclase and pyroxene. M>S>V1>V2.

CLOSE UP PHOTOGRAPHS:
1309D_65R_2_15_35.jpg



Core Photo



304-U1309D-66R-1 (Section top: 338.80 mbsf)

UNIT-168: Olivine-bearing Gabbro
 Pieces 1-4
 PRIMARY MINERALOGY: Determined from Piece 1
 Plagioclase Modal 70%
 Size 4-6 mm
 Shape anhedral
 Clinopyroxene Modal 30%
 Size 4-7 mm
 Shape anhedral
 COMMENTS: This section begins with the continuation of the very coarse-grained, olivine-bearing gabbro. Olivine occurs very rarely. A subvertical contact with Unit 169 extends throughout. Strong interaction between the two units is observed. Either a dike or an intrusive finger occurs at 9 cm.

UNIT-169: Dunite
 Pieces 5-6
 PRIMARY MINERALOGY: Determined from Piece 5
 Olivine Modal 93%
 Size 2-10 mm
 Shape anhedral
 Plagioclase Modal 7%
 Size 1-10 mm
 Shape anhedral
 COMMENTS: This unit consists of medium-grained dunite. A small volume of intercumulus phases consist almost entirely of plagioclase.

UNIT-170: Gabbro
 Pieces 7-9
 PRIMARY MINERALOGY: Determined from Piece 7
 Plagioclase Modal 75%
 Size 4-10 mm
 Shape anhedral
 Clinopyroxene Modal 25%
 Size 12-27 mm
 Shape anhedral
 COMMENTS: This unit consists of two pieces of gabbro that are similar to Unit 168.

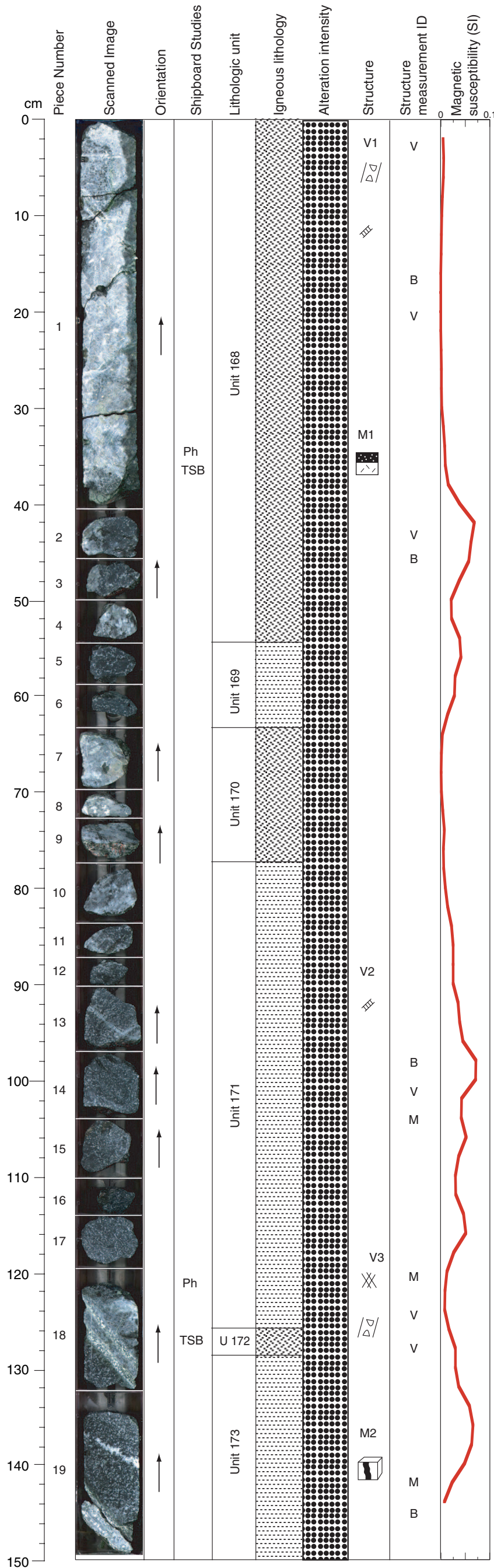
UNIT-171: Troctolitic Gabbro
 Pieces 10-18
 PRIMARY MINERALOGY: Determined from Pieces 14-15
 Olivine Modal 80%
 Size 2-10 mm
 Shape anhedral
 Plagioclase Modal 15%
 Size 1-2 mm
 Shape anhedral
 Clinopyroxene Modal 5%
 Size 4-11 mm
 Shape anhedral
 COMMENTS: This unit consists dominantly of troctolitic gabbro with a homogeneous distribution of intercumulus plagioclase and clinopyroxene. Several gabbro dikes occur in this unit commonly branching. Two dikes intersect at a low angle in Piece 18. The older one shows a more diffuse outline and corona texture.

UNIT-172: Gabbro
 Piece 18
 PRIMARY MINERALOGY: Determined from Piece 18
 Plagioclase Modal 75%
 Size 2-3 mm
 Shape anhedral
 Clinopyroxene Modal 25%
 Size 1-2 mm
 Shape anhedral
 COMMENTS: This unit consists of a 12 mm wide, medium-grained gabbro dike that intrudes olivine-rich troctolite. A 7 mm wide, whitish-greenish reaction zone with corona texture occurs within the ultramafic cumulates at the contacts with adjacent units.

UNIT-173: Olivine-rich troctolite
 Pieces 18-19
 PRIMARY MINERALOGY: Determined from Piece 19
 Olivine Modal 75%
 Size 2-5 mm
 Shape 2-5 anhedral
 Plagioclase Modal 20%
 Size 1-4 mm
 Shape anhedral
 Clinopyroxene Modal 5%
 Size 2-3 mm
 Shape anhedral



Core Photo



304-U1309D-66R-1 (continued) (Section top: 338.80 mbsf)

COMMENTS: The section ends in a medium-grained troctolitic gabbro with a coarse plagioclase-band at 136 cm. A whitish-greenish reaction zone at the edge of Piece 19 might indicate another dike that was not recovered.

SECONDARY MINERALOGY: This section consists of highly altered layered troctolite and olivine-bearing gabbro. In the troctolite, olivine is severely altered to serpentine, magnetite, talc, tremolite, and chlorite. Plagioclase is partially altered to prehnite. Pyroxene appears fresh. In the metagabbro, alteration is confined to olivine alteration. Olivines are completely replaced by tremolite+ chlorite + talc + serpentine and rimmed by chlorite. Plagioclase is rimmed by chlorite; pyroxene is slightly altered to actinolite. In thin section, secondary plagioclase and recrystallized pyroxene are present in Piece 1D.

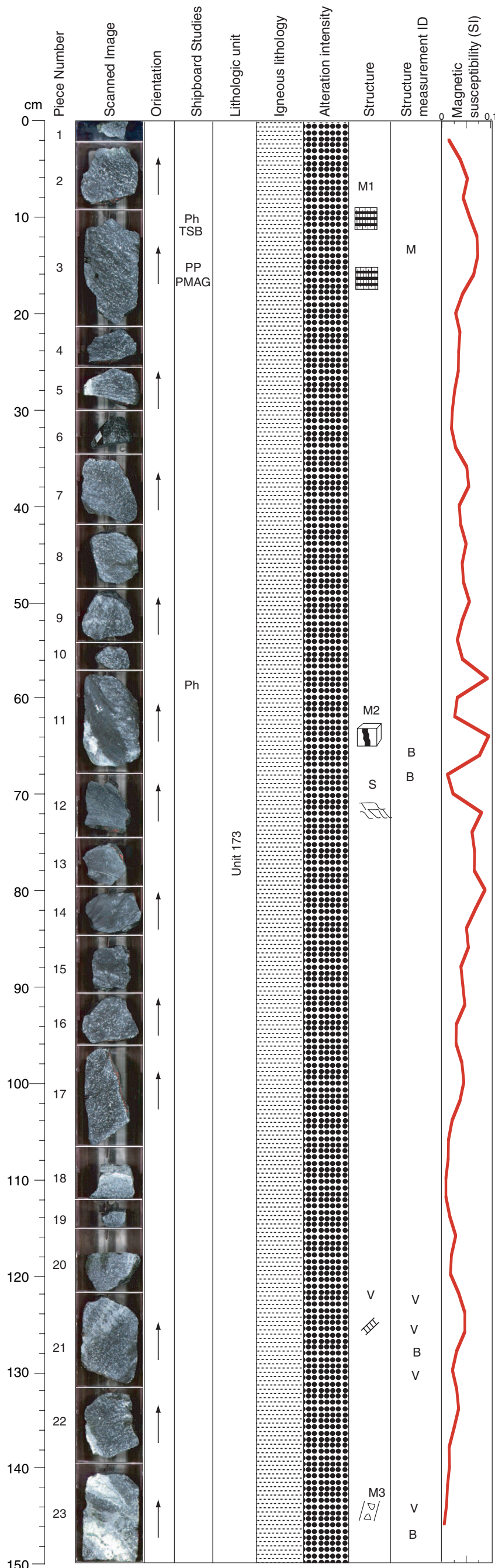
VEIN ALTERATION: Green actinolite vein are present in this section (e.g. between 4-12 cm).

THIN SECTIONS:
 304-U1309D-66R-1, 35.0-38.0 cm (#234)
 304-U1309D-66R-1, 126.0-128.0 cm (#235)

STRUCTURE: A plagioclase-bearing, hornblende-rich vein (with grains oriented normal to the vein walls) (V1) cuts the gabbro and is in turn cut by one of a set of serpentine-rich veins (V2) (that localize drilling-induced fractures) in Piece 1. The base of Piece 1 grades into a mafic troctolite/dunite (M) that is serpentinized, although there is no serpentine fabric. Veins (V2) (both serpentine and composite plagioclase-serpentine veins) cut the troctolite, and locally (e.g. Piece 18) are cut by white veins (V3). The white veins are not perpendicular to the serpentine veins. A plagioclase-only vein (M2) intrudes the troctolitic gabbro in Piece 19 (no vein walls). M>M2>V1>V2>V3.

CLOSE UP PHOTOGRAPHS:
 1309D_66R_1_34_40.jpg
 1309D_66R_1_120_130.jpg

Core Photo



304-U1309D-66R-2 (Section top: 340.30 mbsf)

UNIT-173: Troctolite and Olivine-rich troctolite
Pieces 1–23

PRIMARY MINERALOGY: Determined from Piece 17 (Troctolite)

Olivine	Modal 75% Size 1-5 mm Shape anhedral
Plagioclase	Modal 25% Size 1-2 mm Shape anhedral
Clinopyroxene	Modal <1% Size 2 mm Shape anhedral

COMMENTS: This unit consists of medium-grained ultramafic rocks and is a continuation of the previous section. Plagioclase and clinopyroxene occur as intercumulus phases and are unevenly distributed. The section consists mostly of olivine-rich troctolite but Pieces 12 to 15 are dunite. Several gabbro dikes cut the section and whitish-greenish reaction zones in Pieces 2, 5, 18 and 22 indicates that others dikes occur but were not recovered. Piece 11 contains a 12 mm wide, medium-grained olivine gabbro dike and very narrow dikes also occur in Pieces 4 and 17. Piece 23 contains an 'en echelon', medium-grained gabbro dike with a maximum width of 15 mm.

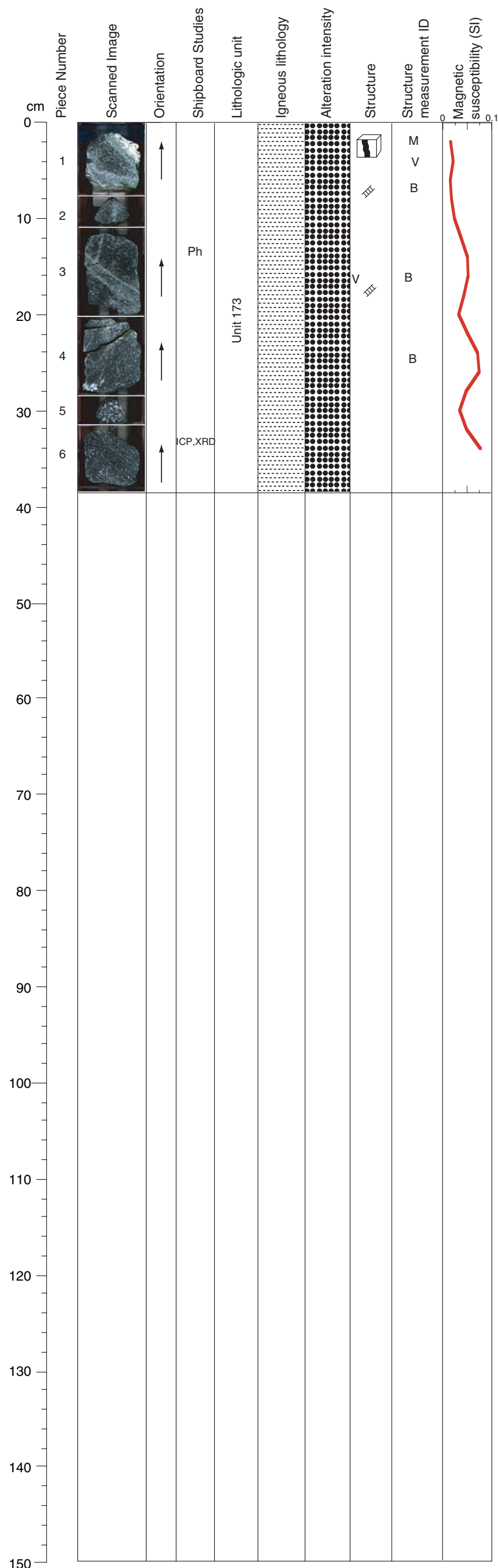
SECONDARY MINERALOGY: This section consists of highly altered troctolite and dunite. Piece 11 shows the contact between troctolite and dunite and a contact with a gabbroic intrusion in which some olivine is completely altered, pyroxenes are generally fresh and plagioclase altered to prehnite. In troctolite, olivine is altered to serpentine, magnetite and chlorite. Plagioclase is altered to prehnite. Pyroxene appears fresh. A felsic dike is present in Piece 23.

THIN SECTIONS:
[304-U1309D-66R-2, 10.0-13.0 cm \(#236\)](#)

STRUCTURE: Serpentinized mafic and ultramafic rocks with an inclined foliation (M1) (not a mesh texture - primary, defined by plagioclase-serpentine folia). In Piece 11 a steeply dipping serpentine vein (M2) with irregular vein walls cuts coarser grained serpentinite with recognizable olivine grains. A second steeply dipping vein cut by cross veins of serpentine is present in Piece 21. Mesh-texture serpentinite (S) is present in Piece 12 and grades into more homogeneous serpentinite. The base of the section contains angular, feldspar-rich composite veins (M3), one of which may tip out within the piece. M1>M2>M3>V

CLOSE UP PHOTOGRAPHS:
[1309D_66R_2_10_20.jpg](#)
[1309D_66R_2_57_68.jpg](#)

Core Photo



304-U1309D-66R-3 (Section top: 341.80 mbsf)

UNIT-173: Troctolite and Olivine-rich troctolite
Pieces 1-6

PRIMARY MINERALOGY: Determined from Piece 4 (Troctolite)

Olivine Modal 88%
 Size 3-7 mm
 Shape anhedral

Plagioclase Modal 10%
 Size 1-3 mm
 Shape anhedral

Clinopyroxene Modal 2%
 Size 9-13 mm
 Shape anhedral

COMMENTS: This section consists of medium-grained olivine-rich troctolite; plagioclase represents the dominant intercumulus phase. Piece 1 fits directly to the bottom of the previous section with two dike margin reaction zones at the edges. An early dike is cut by a 9 mm wide, medium-grained gabbro dike at a 90° angle in Piece 3.

SECONDARY MINERALOGY: This section consists of highly altered plagioclase-bearing peridotite. Olivine is severely altered to serpentine, magnetite and chlorite. Plagioclase may be partially altered to prehnite. Pyroxene seems to be fresh. A felsic dike is present in Piece 1.

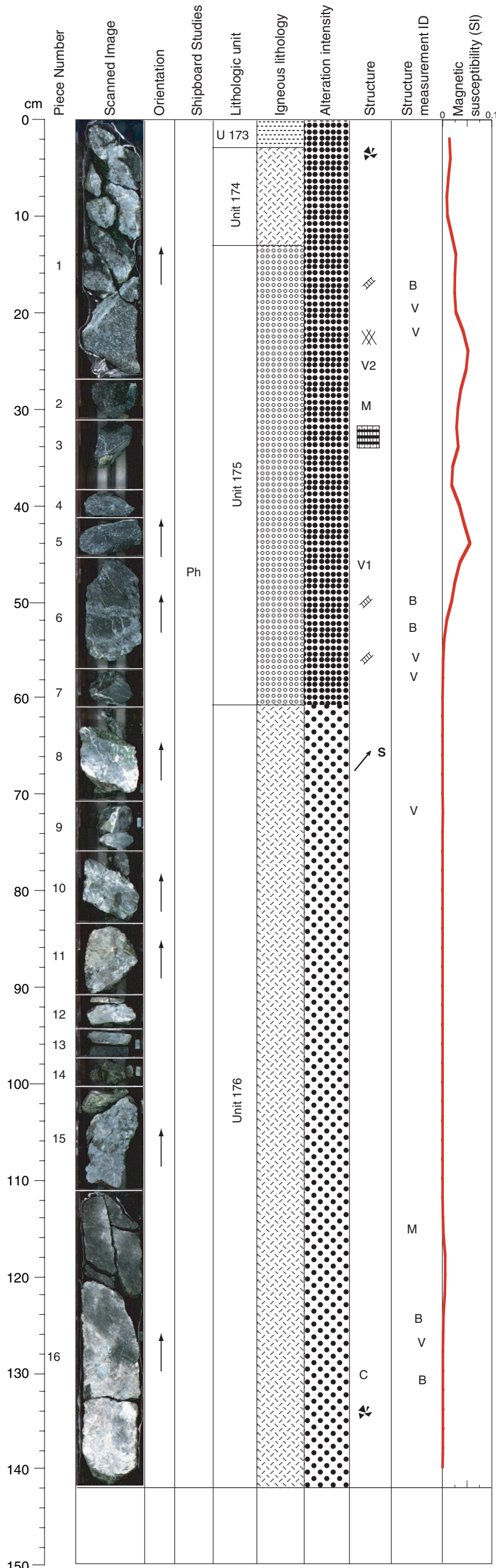
VEIN ALTERATION: Few green actinolite veins are present in this section (e.g. between 24-26 cm).

STRUCTURE: Continuation of the intrusive texture (feldspar veins) from Section U1309D-66R-2, and gradation back into serpentinized mafic/ultramafic rocks. Gently dipping veins (V) cut the serpentinite with splays extending off the vein into the serpentinite. Local enrichment of cloudy feldspar is present as well.

CLOSE UP PHOTOGRAPHS:
1309D_66R_3_12_20.jpg



Core Photo



304-U1309D-67R-1 (Section top: 343.60 mbsf)

UNIT-173: Olivine-rich troctolite
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1

Olivine Modal 88%
 Size 3-7 mm
 Shape anhedral

Plagioclase Modal 10%
 Size 1-3 mm
 Shape anhedral

Clinopyroxene Modal 2%
 Size 9-13 mm
 Shape anhedral

COMMENTS: This unit consists of a small interval of olivine-rich troctolite in Piece 1. Crosscutting dikes typical in the last section are present as well. A narrow dike crosses with a dip of 40 degrees and is cut by another dike.

UNIT-174: Gabbro
Piece 1

COMMENTS: A 20 mm wide gabbro dike.

UNIT-175: Dunite
Pieces 1-7

PRIMARY MINERALOGY: Determined from Pieces 4, 5 and 6

Olivine Modal 92%
 Size 2-4 mm
 Shape anhedral

Plagioclase Modal 5%
 Size 2-3 mm
 Shape anhedral

Clinopyroxene Modal 3%
 Size 3-5 mm
 Shape anhedral

COMMENTS: This unit consists of dunite with intercumulus plagioclase. The unit is cut several times by irregular, branching gabbroic dikes. A 7 mm wide, fine-grained dike occurs at the top of the unit at 19 cm and has a broad alteration zone. Piece 3 contains a 2 mm wide, medium-grained gabbro dike. Piece 6 contains two intersecting, medium-grained gabbro dikes. Both show reaction zones in the mafic cumulate along the contacts in contrast to the second dike.

UNIT-176: Gabbro
Pieces 8-16

PRIMARY MINERALOGY: Determined from Piece 16

Olivine Modal <1%
 Size 4-7 mm
 Shape anhedral

Plagioclase Modal 60 %
 Size 7-30 mm
 Shape anhedral

Clinopyroxene Modal 40 %
 Size 9-35 mm average, 43 mm maximum
 Shape anhedral

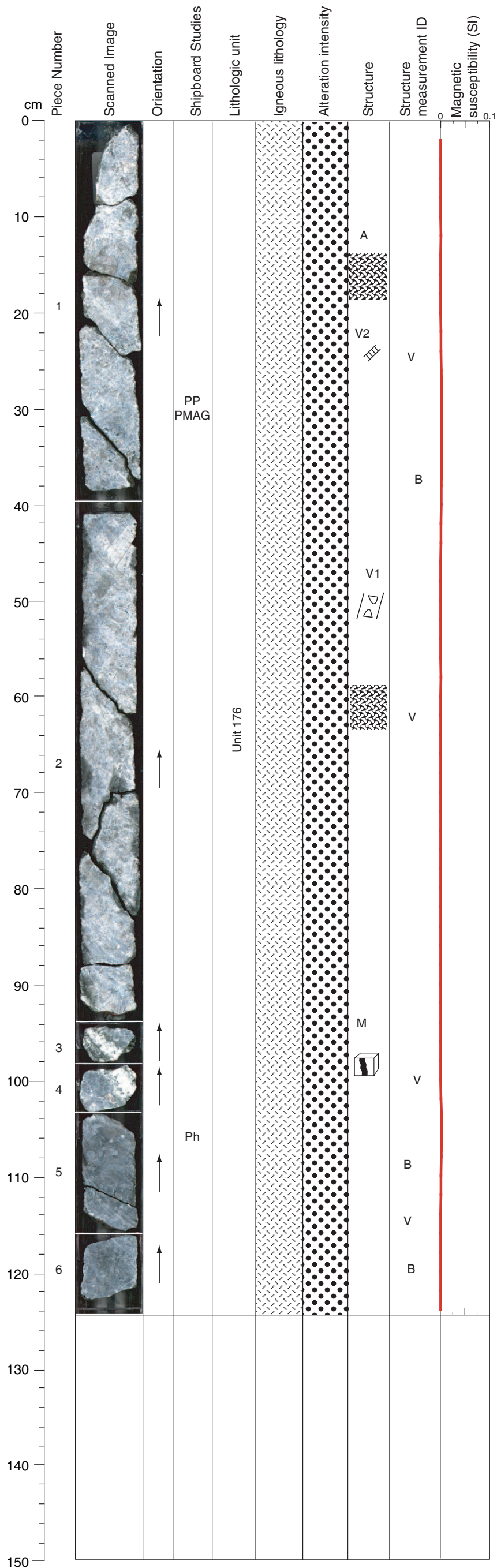
COMMENTS: This unit consists of very-coarse grained to pegmatitic gabbro with sporadic olivine. Piece 15 is an olivine gabbro with clinopyroxene oikocrysts.

SECONDARY MINERALOGY: This section consists of highly altered plagioclase bearing peridotite in the upper part of the section (0-61 cm) and moderately altered gabbro in the lower part of the section (61-142 cm). Olivine is severely altered to serpentine, magnetite, and chlorite within the upper part of the section. Plagioclase shows a rim of chlorite and may be partially altered to prehnite in the interior. Ferromagnesian minerals in the gabbro are partially altered to actinolite + chlorite +/- talc.

STRUCTURE: Intensely brecciated (C) (along green serpentinized joints) dark and plagioclase-bearing serpentinite. A weak foliation (M) is defined by the black serpentine (in Pieces 2 through 6). Shallowly, dipping veins (V1) are in turn cut by irregular carbonate-serpentine veins (V2). The green serpentine defines obliquely plunging mineral lineation on the surface of Piece 8. M>C>V1>V2

CLOSE UP PHOTOGRAPHS:
1309D_67R_1_46_56.jpg

Core Photo



304-U1309D-67R-2 (Section top: 345.02 mbsf)

UNIT-176: Gabbro
Pieces 1-6

PRIMARY MINERALOGY: Determined from Piece 2

- Olivine Modal <1%
 Size 2-5 mm
 Shape anhedral
- Plagioclase Modal 65%
 Size 5-10 mm average, 25 mm maximum
 Shape anhedral
- Clinopyroxene Modal 35%
 Size 4-20 mm average, 45 mm maximum
 Shape anhedral

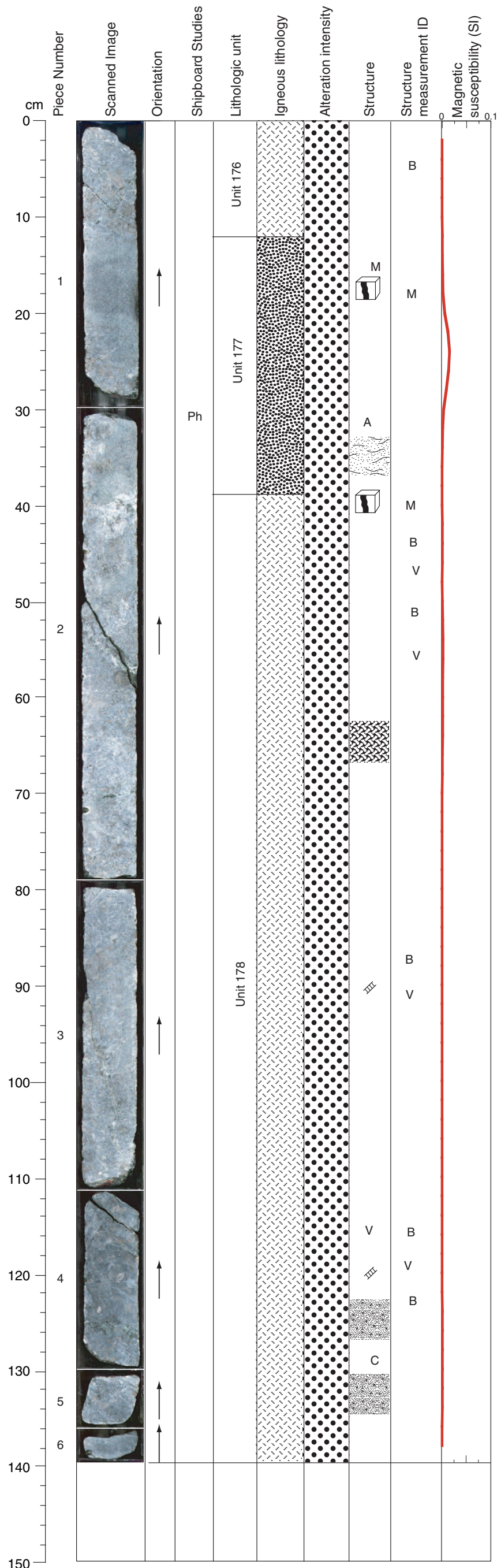
COMMENTS: This section consists of very coarse-grained gabbro. An olivine-rich region occurs between 81 cm and 94 cm. A late magmatic, leucocratic dike cuts the section between 90 cm and 123 cm. Piece 6 has a very high plagioclase/pyroxene ratio.

SECONDARY MINERALOGY: This section consists of moderately altered olivine-bearing gabbro essentially because of olivine alteration. It varies along with the local abundance of olivine. Olivine is pseudomorphed by tremolite + chlorite + talc. The reaction of olivine with surrounding plagioclase forms corona textures with a chlorite rim. Pyroxene edges seem slightly altered to actinolite whereas plagioclase is mostly fresh.

STRUCTURE: Coarse grained gabbro with dark grains (hornblende?) surrounding pyroxene (A). In places (e.g. Piece 2) there are dark veins (V1), possibly hornblende, cutting the gabbroic texture. The gabbroic texture has evenly crystallized textures of plagioclase and pyroxene - although the plagioclase is internally granular from minor recrystallization and alteration associated with green amphibole (minor alteration) (V2). Magmatic veins (M) that are feldspar rich, and there are excellent examples of the intersection of these late feldspar aggregates with "primary" feldspar. M>A>V1>V2

CLOSE UP PHOTOGRAPH(S):
1309D_67R_2_104_115.jpg

Core Photo



304-U1309D-67R-3 (Section top: 346.26 mbsf)

UNIT-176: Gabbro
Piece 1

PRIMARY MINERALOGY:

Plagioclase Modal 65%
 Size 5-14 mm average, 20 mm maximum
 Shape anhedral

Clinopyroxene Modal 35%
 Size 5-14 mm average, 20 mm maximum
 Shape anhedral

COMMENTS: At the top of the section the coarse-grained gabbro continues from the previous section. Piece 1 shows the same high plagioclase/pyroxene-ratio seen in Piece 6 in Section U1309D-67R-2.

UNIT-177: Microgabbro
Pieces 1-2

PRIMARY MINERALOGY: Too fine-grained to determine modal composition in hand sample.

COMMENTS: This unit consists of microgabbro that intrudes the coarse-grained gabbro. A gabbroic domain occurs between 24 cm and 38 cm.

UNIT-178: Gabbro
Pieces 2-6

PRIMARY MINERALOGY: Determined from Piece 4B

Plagioclase Modal 70 %
 Size 4-10 mm
 Shape anhedral

Clinopyroxene Modal 30%
 Size 4-13 mm average, 22 mm maximum
 Shape anhedral

COMMENTS: This unit consists of the same coarse-grained gabbro as Unit 176. Infiltration by the microgabbro is visible in the remainder of the section but decreases downsection. Piece 6 is microgabbro and a troctolitic band occurs at 125 cm.

SECONDARY MINERALOGY: This section consists of moderately greenschist facies altered gabbro. Pyroxene margins seem slightly altered to actinolite, whereas plagioclases are generally fresh.

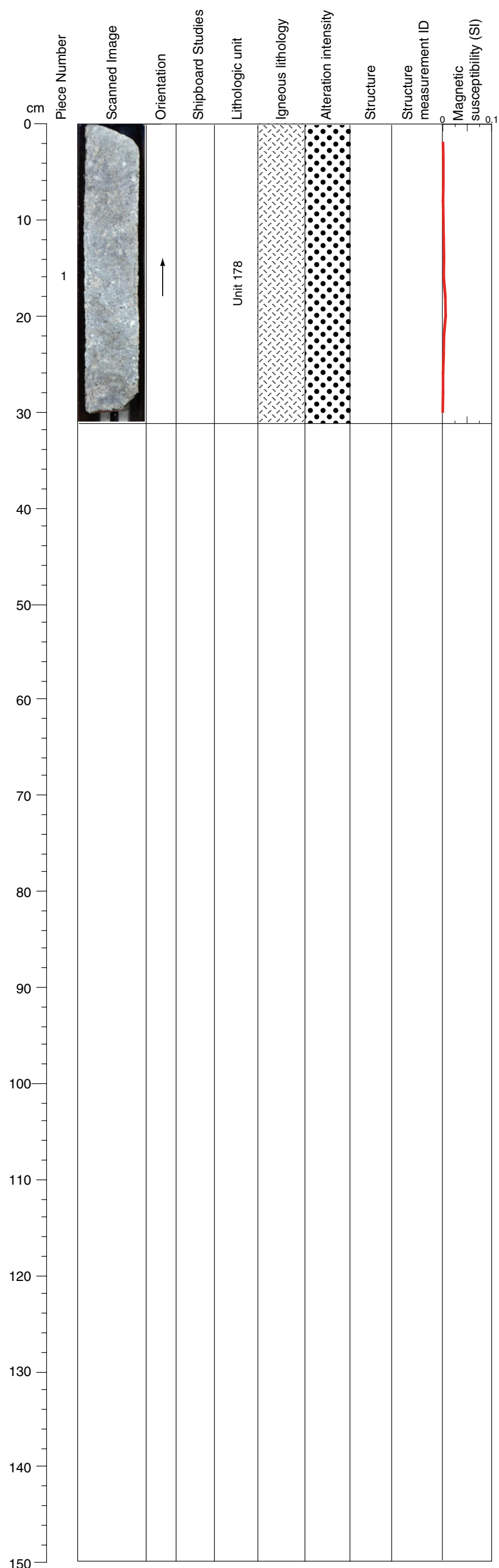
VEIN ALTERATION: A green actinolite vein is present between 93-110 cm.

STRUCTURE: Intrusive contacts (M) between a dark "microgabbro" (relative timing is unclear, but judging from Piece 2 and mixing of microgabbro domains with coarse grained pyroxene, it could be the coarse grained intruding the fine). Otherwise, microcracking (C) of the feldspar domains of the gabbro, alteration rims around pyroxenes (A), and potentially minor brecciation in Piece 5 typify the gabbro. There are some late green veins (V); M>A=>C=V.

CLOSE UP PHOTOGRAPHS:
1309D_67R_3_30_50.jpg



Core Photo



304-U1309D-67R-4 (Section top: 347.65 mbsf)

UNIT-178: Gabbro
Piece 1

PRIMARY MINERALOGY: Determined from Piece 1 (Gabbro)

Olivine Modal <1%
 Size 2-4 mm
 Shape anhedral

Plagioclase Modal 55%
 Size 4-10 mm
 Shape anhedral

Clinopyroxene Modal 45%
 Size 3-24 mm average, 35 mm maximum
 Shape anhedral

COMMENTS: This section consists of a single piece of coarse-grained gabbro and is the continuation of the previous section. A microgabbro domain occurs at the top of the piece. A troctolite band crosses at 18 cm.

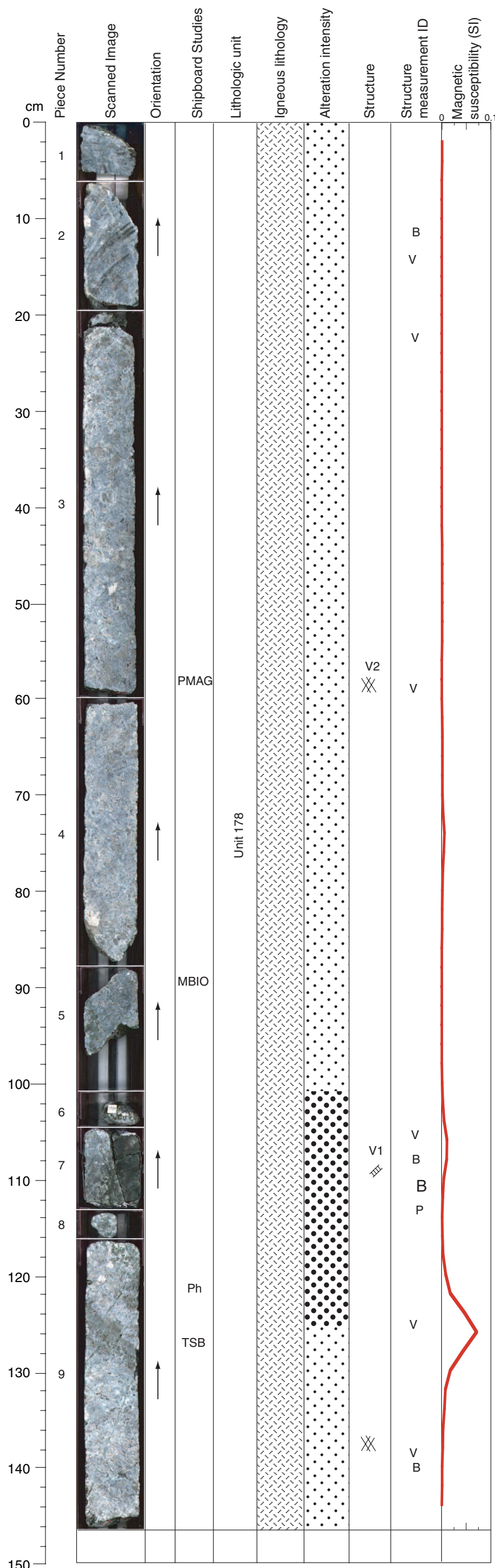
SECONDARY MINERALOGY: This section consists of olivine-gabbro, moderately altered under greenschist facies conditions. Pyroxene margins seem to be slightly altered to actinolite whereas plagioclase is generally fresh. Olivine is completely altered to tremolite + chlorite +/- talc and rimmed by chlorite.

VEIN ALTERATION: No veins in this section.

STRUCTURE: Some alteration rims around olivine (relict); coarse-grained gabbro. No structure symbols or measurements.



Core Photo



304-U1309D-68R-1 (Section top: 348.40 mbsf)

UNIT-178: Gabbro
Pieces 1-9

PRIMARY MINERALOGY: Determined from Piece 4

- Olivine Modal <1%
 Size 2-4 mm
 Shape anhedral
- Plagioclase Modal 65%
 Size 4-9 mm average, 14 mm maximum
 Shape anhedral
- Clinopyroxene Modal 35%
 Size 3-10 mm average, 27 mm maximum
 Shape anhedral

COMMENTS: This section consists of very coarse-grained gabbro. Olivine occurs between 48-54 cm and 72-79 cm. A late magmatic, leucocratic dike cuts the core between 110 cm and 120 cm. A 20 mm wide, medium-grained oxide gabbro dike occurs at 128 cm.

SECONDARY MINERALOGY: The upper portion of the section (0 - 100 cm) consists of virtually unaltered gabbro. From 100 - 124 cm it consists of moderately altered gabbro in which plagioclase and pyroxene are partially altered to actinolite and chlorite. The section from 124 - 146 cm consists of slightly altered gabbro that contains minor amounts of actinolite and chlorite.

VEIN ALTERATION: Mm-scale actinolite veins at 122 and 134 cm.

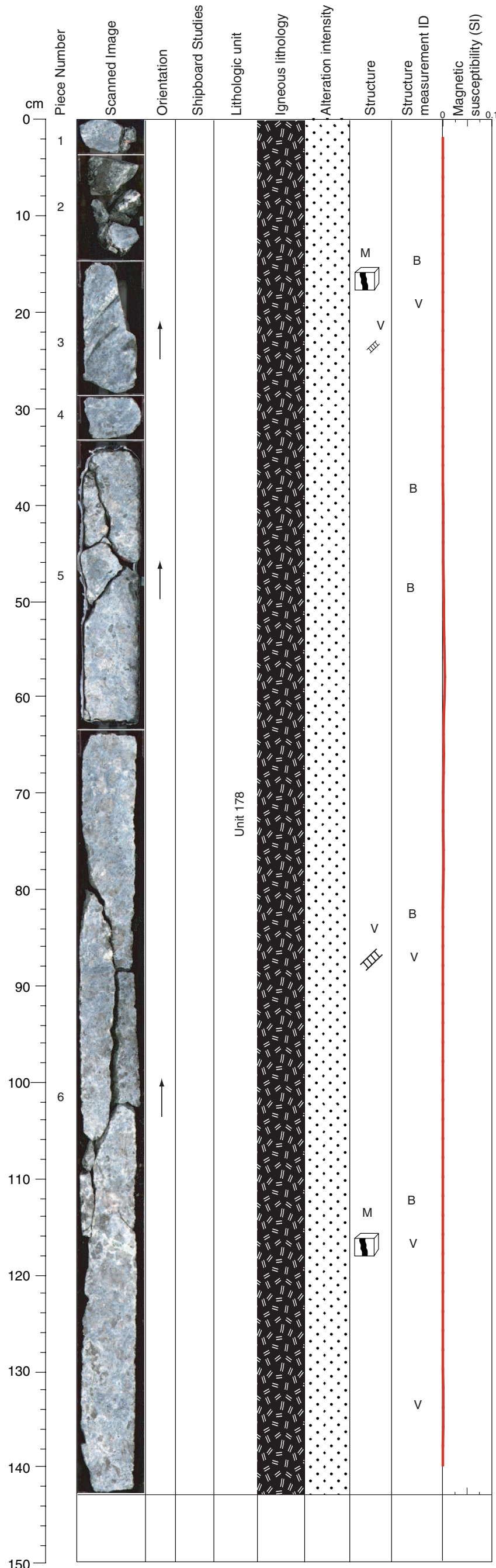
THIN SECTIONS:

304-U1309D-68R-1, 126.0-128.0 cm (#237)

STRUCTURE: Some microcracking (C) - not indicated in structure symbol column - continuous plagioclase texture in an otherwise coarse-grained gabbro. Steeply dipping dark amphibole (hornblende?)-plagioclase vein in Piece 7 with some possible crystal plastic deformation (V1). Green (low-temperature) amphibole veins parallel to one another (V). C>V

CLOSE UP PHOTOGRAPHS:
1309D_68R_1_120_134.jpg

Core Photo



304-U1309D-68R-2 (Section top: 349.46 mbsf)

UNIT-178: Olivine-bearing Gabbro
Pieces 1-2

PRIMARY MINERALOGY: Determined from Piece 6A

Olivine Modal 2%
 Size 2-5 mm average, 10 mm maximum
 Shape anhedral

Plagioclase Modal 68%
 Size 9-12 mm average, 27 mm maximum
 Shape anhedral

Clinopyroxene Modal 30%
 Size 9-30 mm average, 36 mm maximum
 Shape anhedral

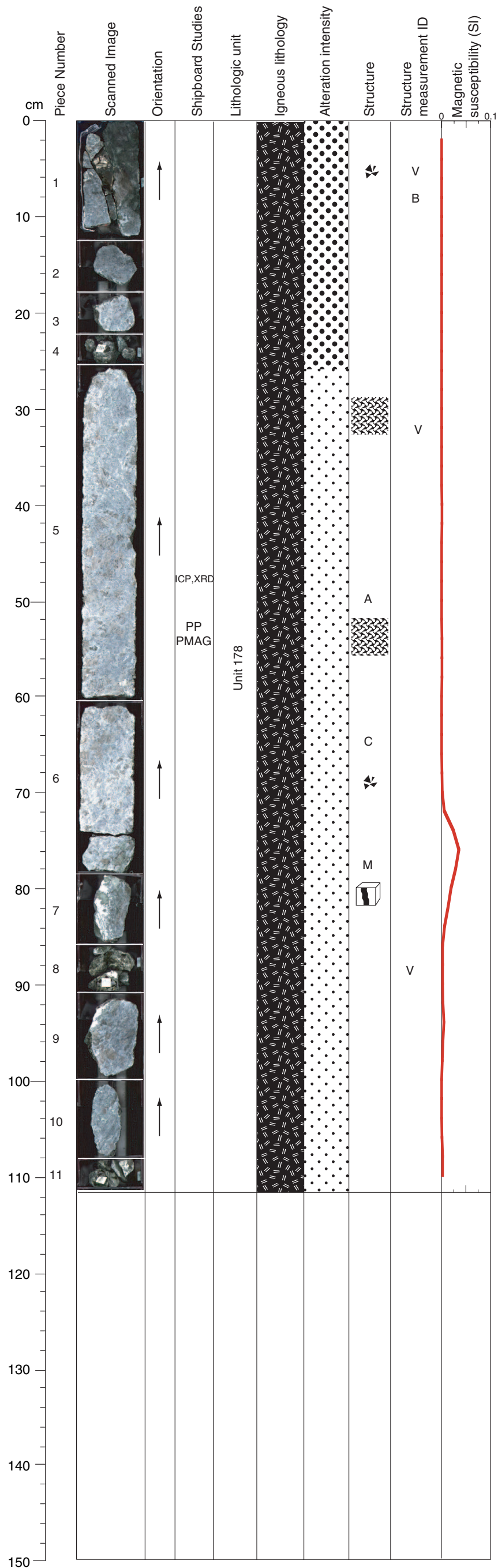
COMMENTS: This section consists of coarse-grained, olivine-bearing gabbro. Olivine content is increasing downsection. Late magmatic, leucocratic dikes crosscut at 20 cm and 117 cm. Piece 6 has a heterogenous distribution of minerals. In Piece 6D, the gabbro becomes pegmatitic with clinopyroxene grain size as large as 36 mm.

SECONDARY MINERALOGY: The section consists of slightly altered gabbro in which plagioclase and pyroxene are partly altered to chlorite and actinolite.

VEIN ALTERATION: Breccia vein with actinolite and albite at 116 cm. :

STRUCTURE: Steeply dipping feldspar-rich vein (M) cuts coarse-grained gabbro with a mild coronitic (plagioclase-olivine) texture. Other gently dipping green veins have feldspar rims (V). M>V

Core Photo



304-U1309D-68R-3 (Section top: 351.28 mbsf)

UNIT-178: Olivine-bearing Gabbro
Pieces 1-11

PRIMARY MINERALOGY: Determined from Piece 5

Olivine Modal 2%
Size 3-5 mm average, 9 mm maximum
Shape anhedral

Plagioclase Modal 63%
Size 5-16 mm average, 23 mm maximum
Shape subhedral to anhedral

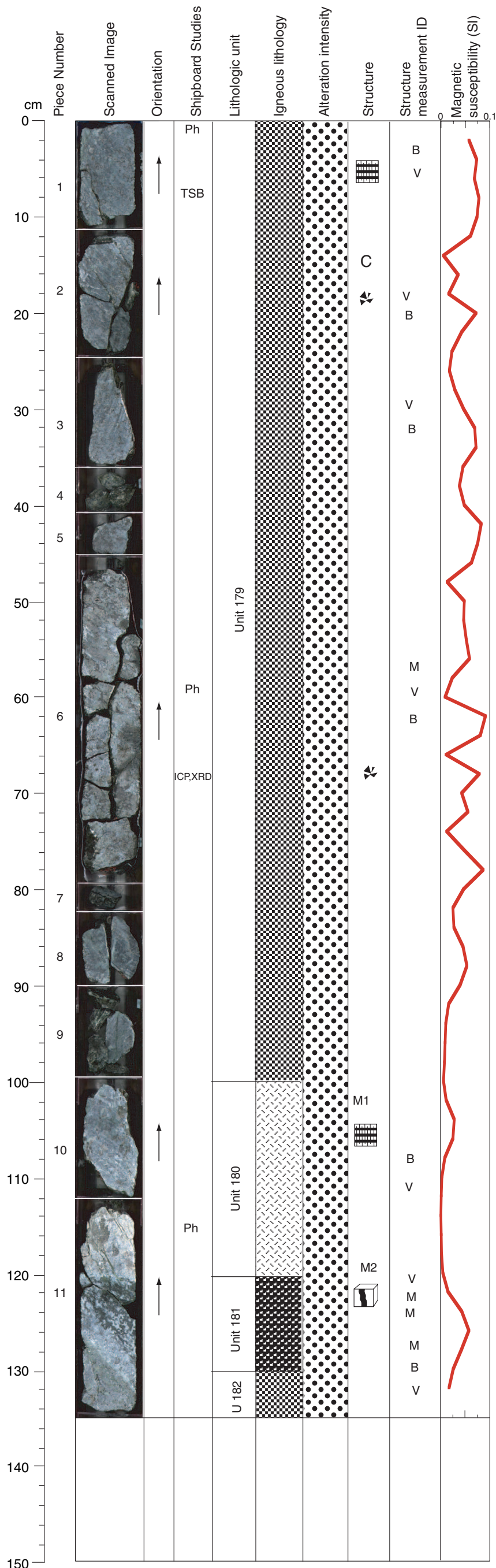
Clinopyroxene Modal 35%
Size 3-18 mm average, 36 mm maximum
Shape anhedral

COMMENTS: This section consists of coarse-grained, olivine-bearing gabbro. The olivine-content increases downsection. A late magmatic, leucocratic dike occurs in Pieces 8 and 9.

SECONDARY MINERALOGY: The section consists of moderately to slightly altered gabbro in which plagioclase and pyroxene are partly altered to chlorite and actinolite.

STRUCTURE: Coarse-grained gabbro with intervals of microcracking (C) in relatively continuous plagioclase. There is a feldspar-rich magmatic vein (M) in Piece 7; olivine-plagioclase grain-boundaries are altered, whereas pyroxene is altered along cleavage planes (A) throughout the section. M>?C>A

Core Photo



304-U1309D-69R-1 (Section top: 353.20 mbsf)

UNIT-179: Oxide Gabbro
Pieces 1-10

PRIMARY MINERALOGY: Determined from Piece 6

Plagioclase Modal 47%
Size 5-12 mm
Shape anhedral

Clinopyroxene Modal 50%
Size 3-21 mm average, 38 mm maximum
Shape anhedral

Oxide Modal 12%
Size 1-5 mm
Shape anhedral

COMMENTS: This section begins with coarse-grained oxide gabbro that contains a very high modal amount of oxides. Oxide-content decreases downsection below 82 cm.

UNIT-180: Gabbro
Piece 11

PRIMARY MINERALOGY: Determined from Piece 11A

Olivine Modal <1%
Size 3 mm
Shape anhedral

Plagioclase Modal 65%
Size 4-9 mm
Shape anhedral

Clinopyroxene Modal 45%
Size 3-10 mm average, 40 mm maximum
Shape anhedral

COMMENTS: This unit consists of coarse-grained gabbro that is very similar to Unit 178. No oxides could be observed.

UNIT-181: Troctolite
Piece 11

PRIMARY MINERALOGY: Determined from Piece 11B

Olivine Modal 50%
Size 3-6 mm
Shape anhedral

Plagioclase Modal 45%
Size 3-6 mm
Shape anhedral

Clinopyroxene Modal 3-4%
Size 5 mm
Shape anhedral

COMMENTS: This troctolite is in contact with the adjacent coarse-grained gabbro and has a 5 mm wide reaction zone along the contact. At the bottom of the unit, the contact with an oxide gabbro has a much wider reaction zone (25-30 mm).

UNIT-182: Oxide Gabbro
Piece 11

PRIMARY MINERALOGY: Determined from Piece 11B

Plagioclase Modal 67%
Size 2-6 mm average, 10 mm maximum
Shape anhedral

Clinopyroxene Modal 30%
Shape anhedral

Oxide Modal 3%
Size 1-3 mm average
Shape anhedral

COMMENTS: At the bottom of Piece 11 is a medium- to coarse-grained oxide gabbro with a relatively small amount of oxides.

SECONDARY MINERALOGY: The section consists of moderately altered oxide gabbro with plagioclase and pyroxene somewhat altered to chlorite and actinolite.

VEIN ALTERATION: A carbonate vein is located on the right edge of Piece 3 between 25 - 36 cm.

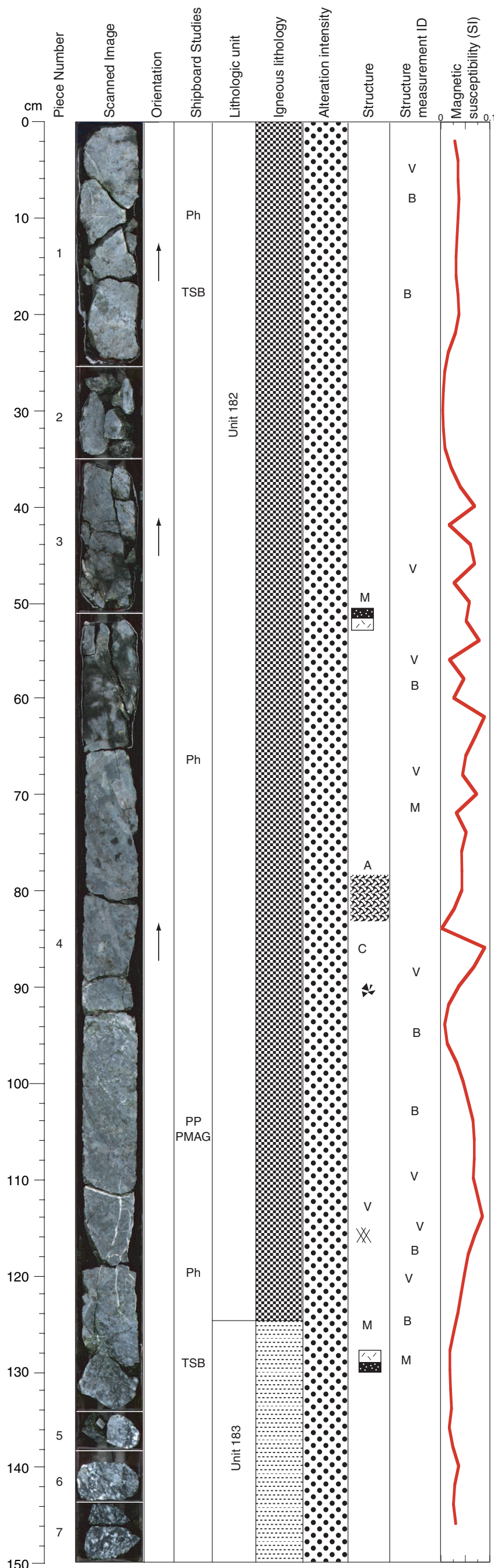
THIN SECTIONS:
304-U1309D-69R-1, 6.0- 8.0 cm (#238)

STRUCTURE: Oxide gabbro with a weak pyroxene-defined fabric (M1) is altered in places, and internally brecciated (C). Pyroxene grains are cracked along cleavage planes, and locally filled with oxides. Piece 11 hosts a moderately dipping (ultramafic?) inclusion (M2) with altered boundaries cutting the coarse grained gabbro. M1>M2>C

CLOSE UP PHOTOGRAPHS:
1309D_69R_1_0_10.jpg
1309D_69R_1_57_77.jpg
1309D_69R_1_113_133.jpg



Core Photo



304-U1309D-69R-2 (Section top: 354.55 mbsf)

UNIT-182: Oxide Gabbro

Pieces 1-4

PRIMARY MINERALOGY: Determined from Piece 4

- Plagioclase Modal 50%
Size 9-21 mm
Shape anhedral
- Clinopyroxene Modal 40%
Size 9-22 mm average, 55 mm maximum
Shape anhedral
- Oxide Modal 10%
Size 3-10 mm
Shape anhedral

COMMENTS: This unit consists of coarse-grained gabbro with very coarse oxide grains. A clinopyroxene oikocryst with olivine chadacrysts occurs between 18 and 20 cm and might represent a digested part of a wehrlitic rocks. Below 37 cm, orthocumulate textures persist with sulfides. The long axes of clinopyroxene dip relatively steeply. Impregnation by a late magmatic, leucocratic dike occurs between 89 cm and 103 cm.

UNIT-183: Olivine Gabbro and Troctolite

Pieces 4-7

PRIMARY MINERALOGY: Determined from Pieces 6 and 7B

- Olivine Modal 65%
Size 2-6 mm
Shape anhedral
- Plagioclase Modal 20%
Size 3-5 mm
Shape anhedral
- Clinopyroxene Modal 15%
Size 3-8 mm average, 20 mm maximum
Shape anhedral

COMMENTS: This unit consists of olivine gabbro that grades to troctolite. A wide reaction zone with corona texture forms along the contact between the oxide gabbro and the ultramafic cumulates. Clinopyroxene encloses plagioclase that shows a wide range of grain sizes (0.5 - 6 mm). Sulfides occur.

SECONDARY MINERALOGY: The upper part of the section (0 - 138 cm) consists of moderately altered oxide gabbro with partially altered pyroxenes and plagioclase to chlorite and actinolite. The lower portion of the section (138 - 149 cm) consists of mafic troctolite or feldspathic peridotite that is moderately altered because of a reaction between olivine and plagioclase to form chlorite, tremolite and talc and by hydration of olivine to serpentine + magnetite.

VEIN ALTERATION: A cluster of carbonate veins is present at 110 - 124 cm.

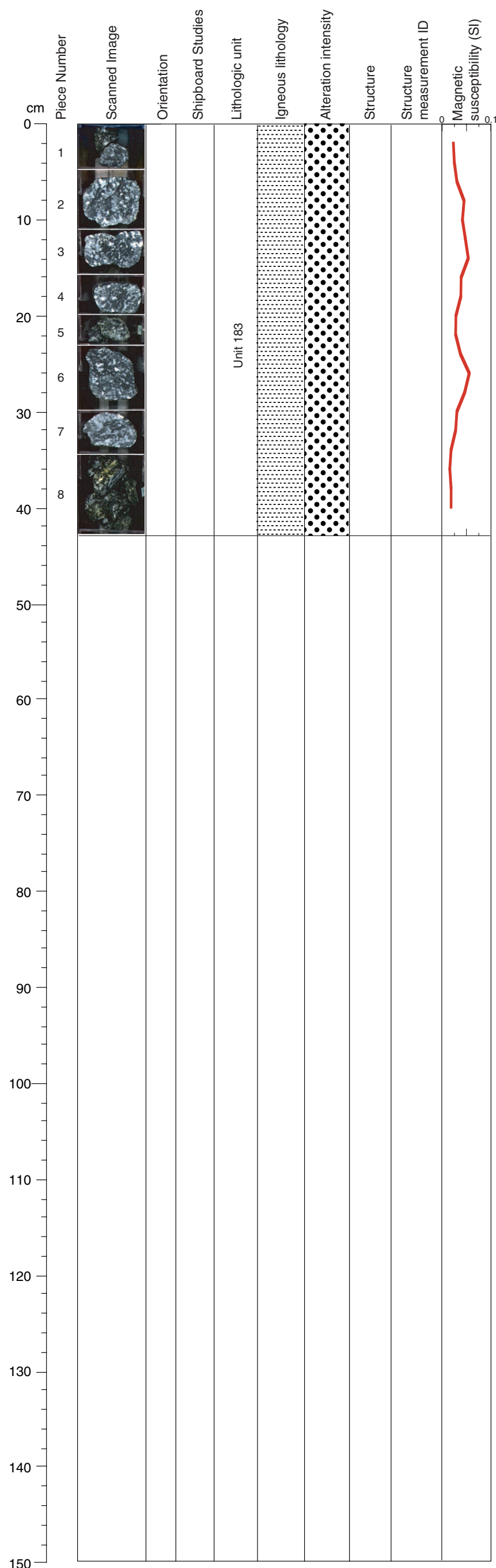
THIN SECTIONS:
304-U1309D-69R-2, 16.0-18.0 cm (# 239)
304-U1309D-69R-2, 128.0-131.0 cm (#240)

STRUCTURE: Grain size coarsens toward the center of the section with amphibole (green) alteration (A) along tabular, blocky pyroxene grains. Surrounding the grains the gabbro is internally brecciated (C), with irregular carbonate rich veins (V) cutting all other textures. At the base of the section (Piece 6) there is plagioclase-bearing, serpentinized ultramafic rock with a weak magmatic/serpentine foliation. C=A>V

CLOSE UP PHOTOGRAPHS:
1309D_69R_2_9_26.jpg
1309D_69R_2_65_80.jpg
1309D_69R_2_118_133.jpg



Core Photo



304-U1309D-69R-3 (Section top: 356.05 mbsf)

UNIT-183: Troctolitic Gabbro
Pieces 1-8

PRIMARY MINERALOGY: Determined from Piece 2

Olivine Modal 73%
 Size 3-6 mm
 Shape anhedral

Plagioclase Modal 15%
 Size 3-7 mm
 Shape anhedral

Clinopyroxene Modal 12%
 Size 4-12 mm
 Shape anhedral

COMMENTS: This section consists of coarse-grained troctolitic gabbro. The amount and distribution of intercumulus plagioclase and clinopyroxene changes throughout the section, but has a relatively high plagioclase/pyroxene ratio.

SECONDARY MINERALOGY: The section consists of troctolitic gabbro that is moderately altered because of a reaction between olivine and plagioclase to make chlorite and tremolite, and by hydration of olivine to serpentine + magnetite.

VEIN ALTERATION: No veins in this section.

STRUCTURE: No structure of note.

