Site BA2[1]

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Chapter contents

Introduction

Site BA2 (22.92446°N, 58.66628°E) is situated in the headwaters of Wadi Mehlah (Fig. F1), along the Batin-Dima road (Fig. F2 in the **Introduction to Science Theme 3** chapter), and hosted in partially serpentinized dunite of the mantle section of the Samail ophiolite (Fig. F1 in the **Introduction to Science Theme 1A** chapter). A 400 m rotary borehole was sited here. The resulting data will address active weathering (hydration, oxidation, and carbonation) of mainly serpentinized dunite.

Rotary Hole BA2A (drilled in January 2017) is located 6 km northwest of Sites BA1, BA3, and BA4, in a large dunite body. Here we summarize the onsite lithology of Hole BA2A drill cuttings, a series of X-ray diffraction (XRD) measurements on powdered cuttings, and 3 X-ray fluorescence (XRF) measurements on powdered cuttings.

Geological setting

Hole BA2A was sited ~75 m southwest of the road where it passes through the wadi, within the largest dunite body in the Samail ophiolite. The surface outcrop of the dunite body is lens shaped, trends northwest–southeast, and is ~7.5 km long by ~2.5 km wide at its widest part. Site BA2 site is located ~300 m from the northeast edge, about midway along the length of the lens. The dunite is cut by minor harzburgite layers and pyroxenite and gabbronorrite dikes. This is the same dunite body that is sampled by Hole BA4A.

Operations

Minor drill pad preparation was necessary at this site in order to level the alluvium. A small track from the road was required for access.

All times are reported as local time in Oman (UTC + 4 h).

Hole BA2A drilling summary

- Spud in: 04 March 2017, 12:47 h
- Surface casing (SW) installed: 04 March 2017, 15:30 h
- Surface casing type/diameter: MS; 9-5/8 inch
- Depth of surface casing: 0.30–5 meters below ground level (mbgl)
- Hole diameter: 6 inches (5.00–400 mbgl)
- Total depth (TD): 400.00 mbgl
- Completion type: open hole
- Discharge by air lift: dry
- Static water level: NA

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Geology summary

Serpentinized dunite.

Technical issues

The borehole was dry. In order to clean the borehole, water from the nearby wadi was injected into the borehole and pumped out again. This process was repeated twice; at the end of the second cleaning step, wadi water was left in the borehole at standing water level (SWL) 5.1 mbgl.

Operations summary

- 3 March 2017: mobilize drill rig, equipment, and drilling crew from Site BA1 to Site BA2.
- 4 March 2017: prepare 12-1/4 inch diameter bottom-hole assembly (BHA) and start drilling from ground level to 5.0 mbgl. Install 9-5/8 inch diameter MS surface casing 0.3–5.0 mbgl. Cement grouted annulus (SG = 1.74) and leave to dry and settle.
- 5 March 2017: prepared 6 inch diameter BHA and drill 5–58 mbgl. Collect and describe drill cuttings every meter; collect subsamples for later analysis. Observe seepage at 22 mbgl but not able to measure flow and fill a bottle to analyze electrical conductivity (EC), pH, and temperature (T).
- 6 March 2017: no water in borehole. Continue drilling 58–150 mbgl. Collect and describe drill cuttings every meter; collect subsamples for later analysis. Foam drilling mud: EC = 1504 mS/cm, pH = 10.8, T = 31.7°C.
- 7 March 2017: no water in borehole. Continue drilling 150–241 mbgl. Collect and describe drill cuttings every meter; collect subsamples for later analysis. Foam drilling mud: EC = 1116 mS/cm, pH = 9.9, T = 30.4°C.
- 8 March 2017: no water in borehole. Continue drilling 24–342 mbgl. Collect and describe drill cuttings every meter; collect subsamples for later analysis. Foam drilling mud: EC = 1084 mS/cm, pH = 10.0, T = 27.1°C.
- 9 March 2017: no water in borehole; sounder indicates water at 201.32 mbgl, but was most likely the foam drilling mud. Continue drilling 342–400 mbgl. Collect and describe drill cuttings every meter; collect subsamples for later analysis. Foam drilling mud: EC = 2130 mS/cm, pH = 9.78, T = 29.6°C. Foam mud was collected in a bucket; after 5 hours, water separated was measured: EC = 9410 mS/cm, pH = 10.99, T = 28.4°C. After reaching TD (400 mbgl), well cleaning operation was conducted for 1 h. Water from the nearby wadi was injected with air 2 times and blown out. Poured water in again at 300 mbgl and tried to blow it out but no water come out.
- 10 March 2017: Friday, no work.
- 11 March 2017: conduct falling head test by pouring water into the well (see **Supplementary material** > **N_Drill site reports**). After falling head test, wellhead was constructed.
- 12 March 2017: finalize wellhead, clean site, and demobilize drill rig, equipment, and drilling crew. SWL = 7.22 mbgl.

Petrology from drill cuttings log and XRD

The cuttings log indicates that dunite is present throughout the 400 m of Hole BA2A (see Fig. F2; Table T1). XRF samples at 159, 199, and 299 m have molar (Mg + Fe)/Si ratios of 1.97–2.00 and molar Mg/(Mg + Fe) ratios (Mg#s) of 0.909–0.910; these 3 intervals are composed of serpentinized dunite (Table T2 in the **Introduction to Science Theme 3** chapter). However, XRD data for samples from 229, 339, and 399 m were interpreted to indicate the presence of "orthopyroxene" or "enstatite," so minor harzburgite lenses might be present in the hole (Table T1 in the **Introduction to Science Theme 3** chapter).

Hydrothermal alteration/veins

Serpentine is particularly noted in the cuttings log in intervals 9–10, 14–36, 37–46, and 52–54 m depth (Table T1). XRD data indicate that serpentine is the major phase in all analyzed samples (Table T1 in the **Introduction to Science Theme 3** chapter). It is likely that all of the cuttings from Hole BA2A are dominated by serpentine ± brucite alteration assemblages.

XRD samples were gathered for powders from drill cuttings at 10 m intervals in Hole BA2A. The resulting spectra were qualitatively analyzed by James Bird at University of Southampton. All intervals contained serpentine, interpreted as lizardite, and most also contained brucite. "Amphibole" was detected at 239 m, and "eckermannite" was interpreted to be present at 229 m. If these identifications are approximately correct, the amphiboles may be part of alteration assemblages in gabbroic or pyroxenite dikes. Similarly, diopside identified from XRD data at 189 m could be a rodingite assemblage mineral from included gabbroic or pyroxenite dikes in that interval. XRD peaks at low 2ϕ angles at depths of 59, 169, 189, 219, 239, 339, 349, 359, 369, and 399 m in Hole BA2A were interpreted to indicate the presence of "clinochlore," "chlorite," and/or "eastonite." We think this indicates the presence of low-Al, high-Mg sheet silicates in the alteration assemblage. It is likely that all incorporate Cr in their octahedral sites. This is useful because such phases were not well characterized during core description of Holes BA1B, BA3A, and BA4A onboard *Chikyu*.

Identification of "bementite" based on XRD data for the sample at 149 m is probably an error.

Geochemistry

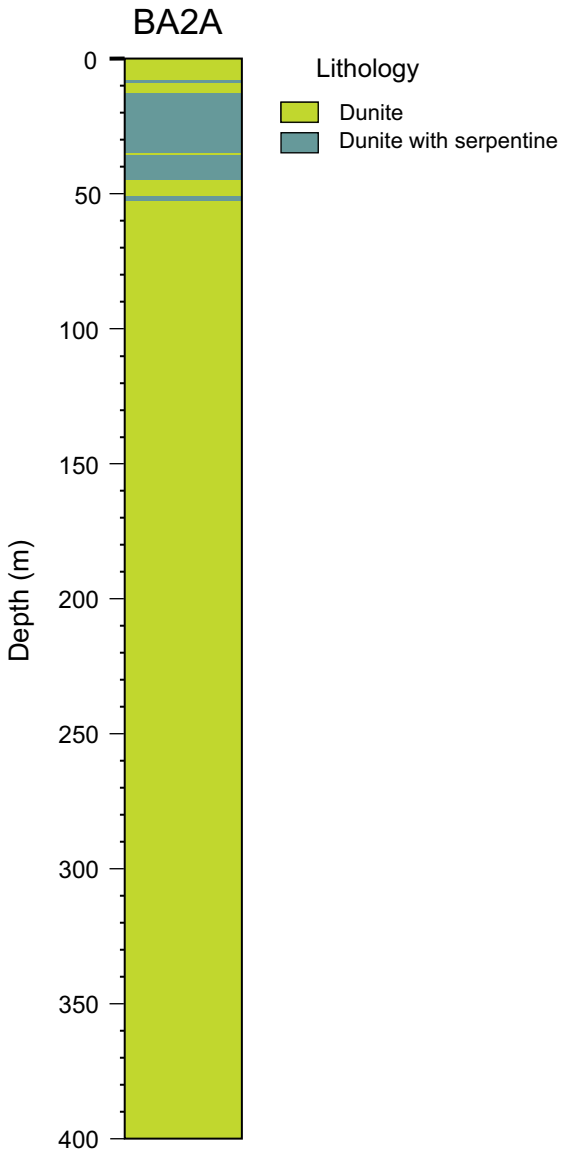
XRF analyses of cuttings from three, 1 m intervals indicate that all are dunites (Table T4 in the **Introduction to Science Theme 3** chapter): Mg# = 0.905–0.910, Ni = 2090–2850 ppm, and Cr = 2330–2400 ppm.

Downhole measurements

No significant groundwater was encountered during drilling. Tiny seepages occurred at 240, 257, 279, and 341 m. The hole was filled twice with water from a nearby stream in order to flush and clean the dry hole. At the end of this process, stream water was left in the hole, and a limited set of wireline logs were recorded by the University of Montpellier Group using a slimline logging system in May 2017 (Tables T56, T57 in the **Methods** chapter).The logging tool set includes dual laterolog resistivity, magnetic susceptibility, spectral gamma, acoustic and optical borehole televiewer, and the fluid property probe (pH, Eh, temperature, dissolved oxygen, electrical conductivity). Because of a blockage in the borehole, logs could only be recorded to a depth of 133 m. Logs are available in **Supplementary material** > **L_Wireline logging**. Please note that the fluid logs are not representative because the dry hole was filled with stream water. The only remarkable observation in the fluid logs was the change in pH from pH 8 (injected oxidized stream water) to a highly reduced (–828 mV) pH 10.6 water 1 month after filling the hole with nearby stream water.

Figure F1. Photograph of Site BA2 during rotary drilling operations, looking southwest. Image credit: Nicolas Bompard.

Figure F2. Lithologic section, Hole BA2A.



Table

Table T1. Lithology log, Hole BA2A. **This table is available in Microsoft Excel format.**