Integrated Ocean Drilling Program Expedition 317 Scientific Prospectus

Global and Local Controls on Continental Margin Stratigraphy: Canterbury Basin, Eastern South Island, New Zealand

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Abstract

Integrated Ocean Drilling Program (IODP) Expedition 317 focuses on understanding the relative importance of global sea level (eustasy) versus local tectonic and sedimentary processes in controlling continental margin depositional cyclicity. The emphasis is on the Oligocene–Holocene period when global sea level change was dominated by glacioeustasy. Drilling the Canterbury Basin on the eastern margin of the South Island of New Zealand takes advantage of high rates of Neogene sediment supply, which preserved a high-frequency (0.5–1 m.y. periods) record of depositional cyclicity. The Canterbury Basin offers the opportunity for expanded study of the complex interactions between processes responsible for the preserved stratigraphic record of sequences and provides information on the early history of the Alpine Fault plate boundary. The deepest target of this expedition is the early Oligocene Marshall Paraconformity hypothesized to mark the initiation of thermohaline circulation and the proto-Antarctic Circumpolar Current.

Currents have strongly influenced deposition in parts of the basin by locally building large sediment drifts, which aggraded to shelf depths, within the prograding Neogene section. Understanding the depositional history, paleoceanographic record, and sequence stratigraphic significance of these drifts are secondary drilling objectives.

The sequences to be drilled are correlative with those drilled on the New Jersey margin (Legs 150, 150X, 174A, and 174AX), Bahamas (Leg 166), and Marion Plateau (Leg 194) during the Ocean Drilling Program. Completion of at least one transect across a far-field siliciclastic margin, which has been subject to entirely different local forcing, is a necessary next step in deciphering continental margin stratigraphy. The Canterbury Basin, where both sequence stratigraphic geometries and seismic databases are of qualities comparable to those of New Jersey, is an ideal setting for such a drilling program.

Schedule for Expedition 317 (Canterbury Basin)

Expedition 317 to the Canterbury Basin on the eastern margin of the South Island of New Zealand is derived from the original Integrated Ocean Drilling Program (IODP) drilling Proposal 600, including addendums 600-I and 600-II (available at **iodp.tamu.edu/scienceops/expeditions/canterbury_basin.html**). Following ranking by the IODP Scientific Advisory Structure, the expedition was scheduled for the research vessel R/V *JOIDES Resolution,* operating under contract with the U.S. Implementing Organization (USIO). At the time of publication of this *Scientific Prospectus,* the expedition is scheduled to start in Townsville, Australia on 4 November 2009 and end in Wellington, New Zealand on 4 January 2010. A total of 45.2 days will be available for the drilling, coring, and downhole measurements described in this report (for the current detailed schedule, see **iodp.tamu.edu/scienceops/**). The supporting site survey data for Expedition 317 are archived at the **IODP Site Survey Data Bank.** Further details about the facilities aboard the *JOIDES Resolution* and the USIO can be found at **www.iodp-usio.org/**.

Introduction

Defining the relative importance of global sea level (eustasy) versus local tectonic, sedimentary, and oceanographic processes in controlling continental margin depositional cyclicity is a fundamental problem in sedimentary geology. Understanding how these processes interact to form preserved stratigraphy would greatly enhance our ability to read the record, covering many tens of millions of years, of Earth history contained within the thick sedimentary deposits beneath the world's continental shelves. Proposal 600 addresses this question by drilling the Canterbury Basin on the eastern margin of the South Island of New Zealand (Figs. **F1, F2, F3**).

High rates of Neogene sediment supply preserved a high-frequency (0.5–1 m.y. periods) seismically resolvable record of depositional cyclicity in the offshore basin (Fulthorpe and Carter, 1989; Browne and Naish, 2003; Lu and Fulthorpe, 2004). Exploration wells indicate the presence of middle Miocene–Holocene sedimentary sequences, generally correlative with those drilled on the New Jersey margin during the Ocean Drilling Program (ODP). However, the Canterbury Basin differs in ways that allow expanded study of the complex processes of sequence formation in line with the global approach to sea level change advocated by previous planning groups:

1. The stratigraphy records the development of the Antarctic Circumpolar Current and oceanographic fronts. Currents have strongly influenced deposition by locally modifying sequence architecture and leading to the deposition of large sediment drifts, which aggraded to near shelf depths, within the prograding Neogene section.
2. Rifting is younger (Cretaceous) than the New Jersey margin (Jurassic), and sediment is supplied from a rapidly uplifting mountain range (the Southern Alps). Regional tectonic and geological histories have been intensively studied, allow-

ing evaluation of the influence of sediment supply on sequence formation and of the tectonic evolution of the Alpine Fault plate boundary.

The Canterbury Basin is part of the Eastern New Zealand Oceanic Sedimentary System (ENZOSS) (Carter et al., 1996). The distal (≤4460 m water depth) component of ENZOSS was targeted by ODP Leg 181, which focused on drift development in the Southwest Pacific Gateway, principally under the influence of the evolving Antarctic Circumpolar Current and the Deep Western Boundary Current (Shipboard Scientific Party, 1999a). Proposal 600 complements Leg 181 drilling by focusing on the landward part of ENZOSS.

Background

Drilling transect strategy for sea level studies

The geologic record provides an opportunity to quantify the timing, rate, amplitude, mechanisms/controls, and effects (stratigraphic response) of eustatic change which, in turn, provide a baseline for predicting future relative sea level changes and assessing anthropogenic influences. However, eustatic effects are complexly intertwined with processes of basin subsidence and sediment supply (e.g., Cloetingh et al., 1985; Karner, 1986; Posamentier et al., 1988; Christie-Blick et al., 1990; Reynolds et al., 1991; Christie-Blick and Driscoll, 1995; Kominz et al., 1998; Kominz and Pekar, 2001). Controversy arises from the application of the sequence stratigraphic model (SSM) (Mitchum et al., 1977; Van Wagoner et al., 1988; Posamentier et al., 1988; Posamentier and Vail, 1988; Vail et al., 1991) to sea level studies. Sequence stratigraphy highlighted the cyclic nature of the continental margin stratigraphic record and led to the theory of eustatic control of sequences and the resultant eustatic cycle chart (Haq et al., 1987). This global sea level model (GSM) (Carter et al., 1991) remains contentious (e.g., Cloetingh et al., 1985; Carter, 1985; Karner, 1986; Christie-Blick et al., 1990; Christie-Blick, 1991; Carter et al., 1991; Karner et al., 1993; Christie-Blick and Driscoll, 1995; Dewey and Pitman, 1988; Miall and Miall, 2001).

To understand the history of eustasy versus subsidence/sediment supply changes, borehole transects across passive continental margins are required (COSOD II, 1987). The long-term strategy developed by ODP-related planning groups (Watkins and Mountain, 1990; Loutit, 1992) involves drilling margins worldwide to evaluate global synchroneity, by correlation among multiple basins and with the oxygen isotopic record, and to document stratigraphic responses in diverse tectonic and depositional settings, including carbonate, siliciclastic, and mixed siliciclastic-carbonate sedimentary systems on both continental and oceanic crust. Initial investigation was to focus on the Neogene "Icehouse" period (Miller et al., 1991) when high-resolution chronological control is available and glacial cycles provide a well-understood mechanism for eustatic change, calibrated by the deep-ocean oxygen isotope record. This approach has guided ODP efforts off New Jersey (Leg 150: Mountain, Miller, Blum, et al., 1994; Miller and Mountain, 1994; Leg 174A: Austin, Christie-Blick, Malone, et al., 1998; Legs 150X and 174AX: Miller et al., 1994; Miller, Sugarman, Browning, et al., 1998), and the Bahamas (Leg 166: Eberli, Swart, and Malone, 1996) and continues to influence IODP planning (e.g., Canterbury Basin IODP Expedition 317).

The passive margin approach integrates seismic profiles and a drilling transect to calibrate the SSM and test the GSM, including investigation of local controls on sequence formation. Seismic profiles provide sequence architecture, seismic facies, and morphologic constraints on depositional processes and tectonism. A drilling transect is required to document (1) ages of sequence stratigraphic surfaces, including sequence-bounding unconformities, or their correlative conformities, and maximum flooding surfaces; (2) facies and lithologies comprising each sequence (stratigraphic response to sea level oscillations); (3) porosity, cementation, and diagenesis; and (4) paleowater depths from benthic biofacies. Two-dimensional (2-D) modeling of these data within the sequence stratigraphic framework allows estimation of eustatic amplitudes because the form of the tectonic component of subsidence is known for passive margins (Kominz and Pekar, 2001).

The ideal approach involves drilling target sequences in at least two locations:

1. Drilling immediately landward of clinoform breakpoints, presumed to represent the paleoshelf edge, provides information on facies and paleodepths at the breakpoint. Such paleowater depth estimates are essential for determination of eustatic amplitudes (Moore et al., 1987; Kominz and Pekar, 2001; Pekar and Kominz, 2001). In practice, distances of sites from individual breakpoints will necessarily vary. Two-dimensional backstripping will enable use of data from sites farther landward to constrain water depths at the breakpoint.
2. Drilling on the slope for paleoenvironment and facies of the lowstand systems tract. This is also essential for eustatic amplitude estimation in the event that sea level fell below the preceding clinoform breakpoint. Increased abundance of pelagic microfossils in such settings provides sequence boundary ages.

The ideal location for dating is near the clinoform toe to minimize the hiatus at the sequence boundary (Christie-Blick et al., 1998), but locations higher on the slope are necessary to reduce drilling depths (e.g., location of Leg 174A New Jersey margin Site 1072 relative to sequence boundary m1[s], Austin, Christie-Blick, Malone, et al., 1998). In addition, locations on the slope will provide better constrained paleowater depths, which are likely to be poorly constrained at clinoform toes (as is the case at the Clipper well). A further reason for drilling higher on the slope is that seismic correlation from clinoform toes landward to the clinoform front and shelf is difficult on all margins because the section basinward of clinoform toes is condensed and landward divergence of reflections contributes to mis-ties.

Geological setting

Regional geology

The eastern margin of the South Island of New Zealand is part of a continental fragment, the New Zealand Plateau, that rifted from Antarctica beginning at ~80 Ma (Anomaly 33). Rifting between the New Zealand Plateau and Antarctica-Australia was active along a mid-ocean-ridge system passing through the southern Tasman Sea and Pacific basins until ~55 Ma (Anomaly 24). Linking of the Indian Ocean and Pacific spreading centers truncated the spreading ridge in the southern Tasman Sea in the late Eocene. Spreading on the Indian and Pacific segments of this now-continuous Southern Ocean ridge system resulted in the formation of the modern boundary between the Australian and Pacific plates, comprising the Macquarie Ridge, Alpine Fault, and Tonga-Kermadec subduction zone (Molnar et al., 1975).

The Canterbury Basin lies at the landward edge of the rifted continental fragment and underlies the present-day onshore Canterbury Plains and offshore continental shelf. Banks and Otago peninsulas (Fig. **F2**) are middle–late Miocene volcanic centers. Basin sediments thin toward these features and also westward, where they onlap basement rocks onshore that are involved in uplift and faulting linked to the latest Miocene (8–5 Ma) initiation of the current period of mountain building along the Southern Alps (Adams, 1979; Tippett and Kamp, 1993a; Batt et al., 2000).

The plate tectonic history of the New Zealand Plateau is recorded in the stratigraphy of South Island. The postrift Cretaceous–Holocene sedimentary history of the Canterbury Basin comprises a first-order (80 m.y.) tectonically controlled transgressive–regressive cycle. The basin formed part of a simple passive margin from the Late Cretaceous to some time in the late Eocene when convergence between the Australasian and Pacific plates began to influence the region, eventually leading to formation of the Alpine Fault at ~23 Ma (King, 2000). The marine sedimentary section can be divided into three principal intervals, the Onekakara, Kekenodon, and Otakou groups (Carter, 1988), during which contrasting large-scale sedimentary processes operated (Fig. **F4**).

Cretaceous–Paleogene transgression and Oligocene highstand

The postrift transgressive phase (Onekakara Group) produced ramplike seismic geometries and terminated during the late Eocene when flooding of the land mass was at a maximum (Fleming, 1962). Reduced terrigenous influx during the postrift phase of subsidence and transgression resulted in deposition of regionally widespread siliceous or calcareous biopelagites (Amuri Formation), which range in age up to early Oligocene (~33 Ma). The sequence is then interrupted by a current-induced unconformity, the Marshall Paraconformity (Carter and Landis, 1972), which occurs at the base of mid–late Oligocene cross-bedded glauconitic sand (Concord Formation) and calcarenite limestone (Weka Pass Formation), together comprising the Kekenodon Group (Fig. **F4**) (Carter, 1985, 1988). Exploration wells reveal that the paraconformity and probable equivalents of the Amuri and Weka Pass formations exist offshore (Wilding and Sweetman, 1971; Milne et al., 1975; Hawkes and Mound, 1984; Wilson, 1985). The paraconformity, which is the deepest target of the proposed drilling, is also recognized at drill sites throughout the region east of the Tasmanian Gateway and is hypothesized to represent the initiation of thermohaline circulation (Deep Western Boundary Current) and the proto-Antarctic Circumpolar Current upon opening of the seaway between Antarctica and Australia (~33.7 Ma), prior to opening of the Drake Passage (Carter et al., 2004c). New Zealand lay directly in the path of the developing current system. The paraconformity has been dated onshore using strontium isotopes as representing a hiatus lasting from 32.4 to 29 Ma (Fulthorpe et al., 1996). Its deepwater representation may have formed 1–2 m.y. earlier (Carter et al., 2004c).

Miocene–Holocene regression

Regression commenced in the late Oligocene or early Miocene in response to an increase in sediment supply provided by the initiation of Alpine Fault movement (Carter and Norris, 1976; Kamp, 1987). The Alpine Fault formed as a dextral strike-slip zone with 500 km displacement since the earliest Miocene (23 Ma) (Kamp, 1987). On eastern South Island, this resulted in the deposition of a widespread shelf siltstone (Bluecliffs Formation), starting in the latest Oligocene. At abyssal depths, in the path of the Deep Western Boundary Current, fine-grained terrigenous–carbonate rhythms at 41 k.y. Milankovitch frequency commenced at almost the same time (~24–23 Ma) (Carter et al., 2004c). This early uplift is distinct from the 5–10 Ma pulse of uplift that has culminated in the present-day Southern Alps because the early uplift is not recognized by fission track dating (e.g., Batt et al., 2000). Uplift of the Southern Alps accelerated at ~8–5 Ma (Tippett and Kamp, 1993a; Batt et al., 2000) or ~10–8 Ma (Carter and Norris, 1976; Norris et al., 1978; Adams, 1979; Tippett and Kamp, 1993b), indicating an increased component of convergence along the fault. Transpression led to an increase in the rate of sediment supply to the offshore Canterbury Basin (Lu et al., 2005). As in New Jersey, this sediment influx was deposited as prograding clinoforms (Otakou Group) (Fig. **F4**). Currents continued to influence deposition. At present, the core of the northward-flowing Southland Current, inboard of the Southland Front (part of the Subtropical Front [STF]) is over the ~300 m isobath (Chiswell, 1996). In deeper water, to at least 900 m, a local gyre of the Antarctic Circumpolar Current circulates clockwise within the head of Bounty Trough parallel to the Southland Current (Fig. **F2**) (Morris et al., 2001). Large sediment drifts within the prograding section (Fig. **F4**) show that similar currents, probably strengthened during glacial periods, existed throughout much of the Neogene (Fulthorpe and Carter, 1991; Lu et al., 2003; Carter et al., 2004c).

Subsidence history

Backstripping suggests little tectonic subsidence in the central part of the offshore basin between ~30 and ~8 Ma (Figs. **F5, F6**) (Browne and Field, 1988), though an increase in subsidence rate beginning at ~8 Ma may be a response to increasing convergence at the Alpine Fault. This could be an in-plane force effect since deformation is locally absent. Figures **F5** and **F6** show evidence for uplift at ~50–35 Ma, which could reflect the late Eocene reorganization of plate boundaries.

Site survey data and interpretation

Data acquisition

A large amount of multichannel seismic (MCS) data collected in 1982 for a petroleum exploration consortium (B.P. Shell Todd) is available from the offshore Canterbury Basin, most significantly the CB-82 profiles (e.g., Fulthorpe and Carter, 1989). Although covering an extensive area, the data exhibit relatively low vertical resolution (20 m). Therefore, this survey was augmented in 2000 by 2-D high-resolution MCS profiles collected during a 21-day cruise (*R/V Maurice Ewing* cruise EW00-01) (Figs. **F3, F7, F8, F9**). The survey grid lies approximately midway between the Banks and Otago peninsulas on the present-day middle to outer shelf and slope, above the late Miocene–Holocene depocenter, and over the area where the largest sediment drifts developed (Fig. F3). The seismic source consisted of two generator-injector (GI) air guns (both 45/45 in^3), and the streamer was deployed with 12.5 m groups in 96- and 120-channel configurations. A total of 57 profiles (~3750 km) were collected, covering ~4840 km^2. Line spacings are 0.7–3.0 km in the dip direction and 2.0–5.5 km in the strike direction. Penetration, 1.7–2.0 s below seafloor, is sufficient to image the entire Oligocene–Holocene section. Data were processed using Focus software and then loaded into the GeoQuest interpretation system. High resolution was achieved by using reliable high-frequency sources (maximum frequency = 500 Hz), a small sample interval (1 ms), and high fold (48–60). Vertical resolution (~5m for two-way traveltimes [TWT] <1 s) is up to 4–5 times better than that of existing commercial MCS data (Fig. F10). However, seafloor and peg leg multiples are pronounced beneath the shelf. In order to deal with this problem, prestack deconvolution and FK-filtering were applied to some critical sections, yielding some improvements in quality.

The commercial low-resolution MCS grid data, however, were used to extend interpretations beyond the EW00-01 grid. The CB-82 data were particularly useful for ties to exploration wells, determining sediment drift distribution, and locating clinoform breakpoints, onlap, and canyons associated with the oldest sequences. The grid consists of 81 profiles, representing ~6000 km (Fig. F3). Record length is 5 s; sample rate is 4 ms. Digital copies of all stacked profiles were loaded into the GeoQuest system. Paper copies of migrated profiles were also available and 20 of the digital profiles were migrated as part of this project.

Seismic stratigraphy

The high-resolution EW00-01 MCS data have been interpreted to provide a high-frequency sequence stratigraphic framework for the offshore Canterbury Basin (e.g., Fig. F7). Nineteen regional sequence-bounding unconformities (Unconformities U1–U19) are identified in the middle Miocene–Holocene shelf-slope sediment prism of the offshore Canterbury Basin (Lu and Fulthorpe, 2004). Three larger seismic units are defined based on seismic architecture and facies (Fig. F7):

1. Unconformities U1–U4 mostly lack distinct clinoform breakpoints within the seismic coverage.
2. Unconformities U5–U8 feature breakpoints; internal reflection geometries are predominantly sigmoid and paleoshelves are smooth and defined by onlap and truncation. Sequences comprise predominantly highstand deposits.

3. Unconformities U9–U19 are downlapped on paleoshelves and truncate underlying reflections near paleoshelf edges; internal reflection geometries are oblique and U- and V-shaped channels incising paleoshelves indicate exposure during sea level lowstands. Forced regressive systems tracts are interpreted to occur and may indicate asymmetric sea level cycles.

Ages of Unconformities U3–U10 are based on ties to the Clipper exploration well (Hawkes and Mound, 1984), and the ages of Unconformities U11–U19 are based on ties to ODP Site 1119 (Fig. **F11**) (Shipboard Scientific Party, 1999b; R.M. Carter, pers. comm., 2002). Endeavour (Wilding and Sweetman, 1971) and Resolution (Milne et al., 1975) exploration wells were tied to the EW00-01 survey using the commercial CB-82 MCS profiles to calibrate the lowermost Unconformities U1, U2, and U3 (Fig. **F7**). Ages of upper Pliocene–Holocene Unconformities U11–U19 are most reliable since they derive from continuously cored Site 1119. The Site 1119 section is virtually complete; only one downlap unconformity (Unconformity U18 at ~87 meters below seafloor [mbsf], representing the Stage 7/8 boundary, ~252–277 k.y.) has a significant hiatus (~25 k.y.). Unconformity U19 (~48 mbsf) corresponds to the Stage 5/6 boundary (~113 ka), and the age of the deepest sediment recovered is ~3.9 Ma (Carter et al., 2004a). Ages of lower Pliocene and Miocene unconformities are less well constrained.

Correlation with oxygen isotopic records suggests a eustatic origin for the sequence boundaries. The number of seismic sequences is similar to that of coeval cycles on the Miocene–Holocene $\delta^{18}O_{sw}$ record of Billups and Schrag (2002) when cycles of comparable frequency are compared (Fig. **F11**). However, local processes have exerted fundamental control on sequence architecture. Along-strike currents strongly influence sequence development and large sediment drifts dominate parts of the Neogene section.

Sediment drifts and paleoflow

The presence of long-lived drifts beneath the modern shelf confirms that currents swept the New Zealand Plateau as early as 15 Ma (Fig. **F12**) (Lu and Fulthorpe, 2004). The STF, Subantarctic Front (SAF), and associated currents may have existed close to their present positions relative to New Zealand by the middle or latest Miocene (Carter et al., 2004c). The STF is represented by the Southland Front along the eastern South Island (Fig. **F2**). The $\delta^{13}C$ record at Site 1119 is interpreted as reflecting glacial–interglacial alternations of subtropical and subantarctic water caused by movement of the STF across the site (Carter et al., 2004a, 2004b). Falling sea level deflects the front basinward during glacial periods, with the counterintuitive result that the site experiences a warmer water mass during glacials; intervals of interbedded sand and mud mark the passage of the front basinward and landward across the site (Carter et al., 2004b). Sand beds occurring near the peak of glaciation are interpreted to represent proximity of STF and SAF, which may coalesce near the site, intensifying current strength (Carter et al., 2004b).

Currents have formed at least 11 large elongate drifts within the lower Miocene–Holocene section (e.g., Fig. **F12**) (Lu et al., 2003). The drifts were initiated near the slope toe and aggraded to (or nearly to) shelf water depths. Drift deposits can be ≤1000 m thick and have mounded morphologies with channel-like moats along their landward flanks. Internal geometries define two end-members of elongate drift: simple and complex. Early (middle Miocene) simple drifts are small and concentrated in the southern part of the survey area (Figs. **F3, F7**). Drift thickness and longevity both increased as the shelf aggraded, increasing accommodation space, while the locus of drift development migrated northeastward through time. Late (late Miocene–Holocene) simple drifts are therefore larger and occur in the northeastern part of the survey area (Figs. **F3, F8**). Late simple drifts are divided into three parts (base, core, and crest) based on seismic facies. These facies form in response to progressive confinement of current flow within the moat. Complex drifts (multicrested and multistage; Fig. **F3**) may form as current pathways migrate in response to sea level change, modulated by paleoslope inclination, and as a result of fluctuations in the rate of sediment supply.

Current erosion in drift moats forms diachrononous unconformities, which cut across sequence boundaries. Several sequence boundaries pass through some of the larger drifts, indicating that they existed throughout several cycles of relative sea level change (Figs. **F7, F12**). Drift deposition controls sequence thickness distributions: sequences are thickest at drift mounds and thin within moats. In addition, currents focus deposition on the slope, reducing the rate of basinward movement of the shelf edge but increasing that of the slope toe. As a result, slope inclination is minimized (cf. Figs. **F8** and **F9**). Cessation of drift development and replacement of along-strike by downslope processes result in increased rates of shelf-edge progradation and slope steepening as the accommodation space over the expanded slope is filled. Termination of large elongate drift development (~3.25 Ma at Site 1119) (Carter et al., 2004a) may have been caused by the initiation of late Pliocene–Pleistocene high-amplitude sea level change, which enhanced downslope processes by exposing the shelf edge. Slope platforms can form above extinct drifts, reducing accommodation and locally accelerating shelf-edge progradation. Along strike from some large elongate drifts, seismic evidence for current activity is lacking and coeval strata are clinoformal (Fig. F9) in spite of the demonstrable presence of a current. Therefore, elongate drift formation is the product of multiple controls, including current intensity, seafloor morphology, and sediment input.

Scientific objectives

Primary objective

1. *Date clinoform seismic sequence boundaries and sample associated facies to provide information for estimation of eustatic amplitudes*

The facies, paleoenvironments, and depositional processes associated with the sequence stratigraphic model on prograding continental margins, where sequences are best resolved seismically, have yet to be adequately constrained by scientific ocean drilling. Prediction of the distribution of sediments within sequences is highly model dependent (e.g., systems tract models of Posamentier et al., 1988; Vail et al., 1991). These models offer great potential for understanding oil and gas resources and ground water/pollution remediation issues. However, the fundamental assumptions and predictive capabilities of these models can only be tested by drilling on shallow continental shelves; drilling will contrast upper Miocene–lower Pliocene sequences with smooth, onlapped paleoshelves and rounded breakpoints (below Unconformity U9; principally Sites CB-01A to CB-04B) and upper Pliocene–Pleistocene sequences with eroded and incised downlapped paleoshelves and more pronounced breakpoints (above Unconformity U9; all sites) (Fig. F7). This will test the hypothesis that paleoshelves below Unconformity U9 were not subaerially exposed at sequence boundaries, whereas those above Unconformity U9 were exposed.

Secondary objectives

1. *Drill the Marshall Paraconformity in the offshore basin*

Drilling the Marshall Paraconformity offshore will provide information on its regional distribution, age, and origin (Fig. F4). Based on ties to exploration wells, the EW00-01 data resolve, for the first time, a seismic surface potentially correlative with the onshore Marshall Paraconformity (Figs. F7, F8, F9). The paraconformity has been dated at its onshore type section using strontium isotopes as representing a hiatus lasting from 32.4 to 29 Ma (Fulthorpe et al., 1996). It is therefore correlative with the postulated mid-Oligocene eustatic lowstand (Haq et al., 1987). However, a eustatic lowstand is unlikely to have been the direct cause of the paraconformity because correlative features have been inferred to form in water depths as deep as 4000–5000 m throughout the southwest Pacific (Carter, 1985; Carter et al., 2004c). The limited paleoenvironmental data available suggest that, even at locations now located onshore, the Marshall Paraconformity could not have been widely subaerially exposed, though such exposure may have occurred on localized highs (Lewis, 1992).

Instead, the paraconformity probably records intensified current erosion, or nondeposition, at all water depths, which accompanied the development of a partial Antarctic Circumpolar Current system following the opening of the seaway south of Tasmania (Carter, 1985; Fulthorpe et al., 1996; Carter et al., 2004c). Seismic interpretation supports a current-related origin by indicating that the paraconformity forms the base of the interval of sediment drift deposition. Indeed, immediately post-Marshall Paraconformity sedimentation involved sediment drift deposition in shallow- (Ward and Lewis, 1975), intermediate- (Fulthorpe and Carter, 1991; Lu et al., 2003), and deepwater settings (Shipboard Scientific Party, 1999a; Carter et al., 2004c). There are indications from Leg 181 drilling that the paraconformity developed in deep (bathyal) water ~1–2 m.y. earlier than in shallow water (McGonigal and Di Stefano, 2002). Dating the paraconformity in the offshore Canterbury Basin at Site CB-04B or at deepwater contingency Site CB-06B will test this hypothesis by sampling it where paleowater depths were intermediate.

2. *Constrain the erosion history of the Southern Alps*

The late Oligocene–early Miocene increase in sediment supply to the offshore basin apparently predates the modern transpressional uplift of the Southern Alps, whose main pulse began at ~8–5 Ma (Tippett and Kamp, 1993a; Batt et al., 2000) or ~10–8 Ma (Carter and Norris, 1976; Norris et al., 1978; Adams, 1979; Tippett and Kamp, 1993b). Such onshore results correlate with increases in subsidence rate and sediment supply in the offshore basin (Figs. **F5, F6, F11**) but may underestimate earlier, but significant, convergence and uplift (Walcott, 1998). The offshore sedimentary prism is the only record of erosion that preceded the current uplift phase; it constitutes a record of age, volume, and facies of erosion products from the Oligocene to the Holocene.

Sediment volumes within mapped seismic sequences provide a measure of onshore paleoerosion rates. Calculating such volumes involves integration of both the commercial and EW00-01 MCS data since the commercial data have broader areal coverage (Fig. **F3**). Sequence volumes have been used to calculate sedimentation rates (Fig. **F11**) (Lu et al., 2005). The limited available age control precludes estimation of meaningful sedimentation rates for individual sequences since such rates are strongly influenced by sequence duration. Therefore, sedimentation rates averaged over groups of sequences are presented instead. The resulting rates correlate well with estimates of the perpendicular component (convergence) of relative plate motion at the Alpine Fault: both increase during the last 5–8 m.y. (Fig. **F11**). In contrast, high sedimentation rates during deposition of S2–S4 occur during a period of low convergence rate at the fault (Lu et al., 2005). However, these high rates correlate with similar peaks in sedimentation rates off New Jersey and West Africa (Steckler et al., 1999; Lavier et al., 2000, 2001) and occur during a period of falling global sea level (Fig. **F11**). They are probably, therefore, a response to global climatic trends. Drilling will verify ages of the progradational units for integration with sediment volume results to provide an enhanced, sequence-by-sequence record of sedimentation rates for correlation with tectonic and climatic events. Provenance studies will further add to our understanding of the early history of the plate boundary. Mineralogical and isotopic analyses of sand grains, with Ar-Ar dating of those grains, will allow matching of outcrop ages and source areas to sequences offshore. Ideally, we would like to calibrate sequences through the entire Neogene section, but penetration through the entire section at shelf water depths will be technically difficult and time consuming. As a compromise, Sites CB-01A and CB-3B penetrate to Unconformity U4 (~12.4 Ma).

3. *Determine sediment drift depositional histories and paleoceanographic record*

The shelf-edge-parallel elongate drifts are unusual features in such an inboard continental margin setting; their facies are largely unknown. They were probably deposited adjacent to a current flowing northward along the prograding clinoform slope; progradation in parts of the basin was by the accretion of successive sediment drifts (Fulthorpe and Carter, 1991; Lu et al., 2003). Drifts can encompass several seismic sequences, and the erosional unconformities in moats are diachronous (Figs. **F7, F8, F12**) (Lu et al., 2003). Drift formation is not, therefore, linked directly to individual sea level cycles. Site 1119 (Leg 181) confirmed the drift origin of these features; interglacial silty sand and glacial silty clay cycles were recognized in current-deposited sediments (Shipboard Scientific Party, 1999b). However, Site 1119 only penetrated to 494.8 mbsf in sediments of 3.9 Ma, insufficient to sample more than the upper few meters of the underlying large elongate drift (Drift D10 of Lu et al., 2003; Carter et al., 2004a). The earlier history of the frontal systems is therefore poorly constrained. In addition, the climatic record of Site 1119 correlates well with that from the Vostok ice core (Carter et al., 2004b) and drilling deeper could provide an extended proxy for Antarctic continental air temperatures. Furthermore, Drift D11 can be considered the type example of a late simple elongate drift, and displays all of the component seismic facies (base, core, and crest) (Lu et al., 2003). It is estimated to be of late Miocene (~11 Ma) to Pliocene (~3.6–3.25 Ma) age (Fig. **F12**) (Lu and Fulthorpe, 2004; Carter et al., 2004a) and may be the longest-lived sedimentary bedform on Earth. Drilling into Drift D11 would therefore be essential to determine the lithologies that make up the large volumes of sediment within the elongate drifts and recover the paleoceanographic record contained within the drift deposit.

Because of time constraints, imposed in part by the 10 day transit from Townsville, drilling into Drift D11 is no longer a primary objective of this expedition. Therefore, all sites originally proposed for drilling into Drift D11 (Sites CB-05B, CB-05C, CB-05D, and CB-05E) are henceforth considered as contingency sites and to be drilled only if drilling at shallower slope and shelf sites is not possible (see **"Risk and contingency strategy"**). However, it is still possible that insights into sediment drift deposition and paleoceanography may be obtained from drilling at primary slope Site CB-04B. Drift geometries become gradually less pronounced along strike toward the southwest (from CB-05 sites to Site CB-04B) and pronounced mounded drift geometries are absent at Site CB-04B (Lu and Fulthorpe, 2004). However, generation of mounded drifts requires specific conditions, which are not well understood; a slope contour current alone is insufficient, as is indicated by the fact that such drifts are not being formed under the present current regime. It is therefore possible that currents have reworked the sediments at Site CB-04B and left a paleoceanographic record of glacial–interglacial cycles, as at Site 1119 (Carter et al., 2004c), without producing distinctive geometries.

Coring and drilling strategy

General operations plan

Leg 174A drilling on the New Jersey shelf illustrated the difficulty of shelf drilling with a dynamically positioned drilling vessel (Austin, Christie-Blick, Malone, et al., 1998). The main problem was the collapse of loose sands trapping the drill string, although stationkeeping in shallow water was also occasionally difficult. Therefore, the proposed drilling strategy for Expedition 317 has been heavily influenced by Leg 174A experience. The choice of site locations is partly a compromise between the need to sample as many of the interpreted sequence boundaries as possible and to avoid deep penetrations in shallow water on the shelf. In particular, we have tried to minimize penetration depth at the shallowest water shelf sites (Sites CB-01A and CB-02A).

The overall operations plan and time estimates are summarized in Table **T1.** Time estimates are based on formation lithologies and depths inferred from seismic and regional geological interpretations including prior drilling in this area (Site 1119). After departing from Townsville, Australia, we will transit for ~10 days to Canterbury Basin and prepare for drilling operations.

In order to determine the impact of global sea level change on deposition cyclicity, it is important to drill the same sedimentary sequences at critical locations (e.g., landward of clinoform breakpoints where paleoenvironmental data are critical for eustatic amplitude estimates and on paleoslopes where increased microfossil abundance provides optimal age control). For example, Leg 174A drilling recovered valuable paleoenvironmental information diagnostic of a shallow-water, lagoonal environment landward of a breakpoint. Therefore, it is essential to conduct operations on the modern shelf (Sites CB-03, CB-01, and CB-02) to reach sequence paleoshelves landward of their breakpoints, as well as upper paleoslopes of the oldest sequences. In addition, paleoslopes of many sequences can be penetrated at moderately shallow slope Site CB-04.

The proposed drilling strategy is to begin by drilling at shelf Site CB-03B at the deep-water end (121 m) of the shelf transect (Fig. **F7;** Table **T1**) if weather conditions allow (see below). This will provide experience in shelf sediment drilling before moving to sites in even shallower water. Actual penetration depths may vary from (but will not exceed) the proposed target depth (1249 mbsf), depending on drilling progress (time consumption) and bit wear out.

We will then move to the primary slope Site CB-04B, which should provide good age control for sequences drilled on the shelf (at Site CB-03B). An additional target at this site is penetration and recovery of the Marshall Paraconformity, estimated to lie at ~1600 mbsf (Fig. **F9**). If hole conditions and/or time constraints do not allow for such deep penetration at this site, actual penetration depth need not exceed the depth of the lowermost unconformity recovered at shelf Site CB-03B.

On completion of slope drilling, we will move back to the shelf and drill the two additional shelf Sites CB-01A and CB-02A (Fig. **F7;** Table **T1**) to provide spatial control of facies within sequences and to recover the lowermost unconformities landward of their clinoform breakpoints.

Drilling operations in shallow water require special operational precautions to ensure safety for crew and equipment. Weather conditions (particularly sea state and resulting heave behavior of the vessel) are critical and will therefore greatly influence this drilling plan (see **"Risk and contingency strategy"**).

Coring strategy

The first hole at each site (Hole A) will be cored with advanced piston corer (APC)/ extended core barrel (XCB) to refusal depth (estimated to be ~250–350 mbsf). The second hole (Hole B) at each site will be drilled without coring to a depth slightly above the refusal depth of Hole A (e.g., ~300 mbsf), and rotary core barrel (RCB) coring will extend from this depth to the target depth.

After coring is completed in the B holes, holes will be conditioned, loaded with mud, and the bit released in the hole. We will then run a series of wireline logs, including a check shot vertical seismic profile (VSP) in open hole (see **"Logging/downhole measurements strategy"**). It is assumed that borehole walls in the B holes will increasingly deteriorate during the course the drilling operations. Therefore, we plan to log the two deep-penetration Sites CB-03B and CB-04B in two stages (upper and lower parts of the holes) to maximize the quality of the logging results (see **"Logging/ downhole measurements strategy"**). This includes drilling a dedicated logging Hole C at Site CB-04B to a depth of ~800 mbsf (covering the upper deteriorated section of Hole B at this site).

During Leg 174A, it was found that RCB drilling was the most effective approach at shelf sites with a high proportion of unconsolidated sand. If APC/XCB coring results prove to be unsatisfying at Canterbury shelf sites (e.g., during operations at the first shelf Site CB-03B), subsequent shelf sites (Sites CB-01A and CB02A) could be approached by RCB drilling alone.

We assume single penetrations at all sites. Double penetrations would be valuable; however, it is essential to obtain information from multiple sites in order to calibrate the sequence stratigraphy. Given the time limitations, therefore, double penetrations are not feasible.

Primary sites

Shelf sites

Site CB-03B

This site (~121 m water depth) is located at the deeper (outer) end of the shelf transect (Fig. F7). It was chosen as primary site in response to an Environmental Protection and Safety Panel (EPSP) request (December 2005 meeting) to avoid high seismic amplitudes observed at Site CB-03A. Site CB-03B is located updip from Site CB-03A where there is no EW00-01 crossing strike profile. Site CB-03B is, however, located on commercial crossing strike profile CB-82-25. If cored to the anticipated target depth (1249 mbsf), it will penetrate sequence boundaries of Unconformities U19–U4. Because of anticipated deterioration of the upper part of the hole during drilling of this deep-penetration site, it is also planned to log the "A" hole (after completion of APC/XCB coring).

Sites CB-01A and CB-02A

These two sites are located at the landward end of the shelf transect at ultra-shallow water depths (85 and 111 m). Target penetration depths are 780 and 800 mbsf (penetrating Unconformities U19–U4 and U19–U6, respectively, at different palaeodepth locations). The location of Site CB-01A enables us to reach Unconformity U4 with minimum penetration, and this is the only site that can sample shelf facies near paleoshelf edges of Unconformities U4 and U5. Likewise, Site CB-02A samples shelf facies near paleoshelf edges of Unconformities U7 and U8. If time is limited at the end of the expedition, reduced penetration or, alternatively, merging of these two sites into one intermediate site, alternate Site CB-01B (located between Sites CB-01A and CB-02A), may be considered (see **"Risk and contingency strategy"**). Sites CB-03B and CB-04B are designed to sample the corresponding clinoform fronts.

Slope site

Site CB-04B

This site (~346 m water depth) serves as primary site for drilling the slope of the Canterbury Basin (Fig. F9). Drilling would penetrate Unconformities U6–U9, U11, and U13–U19. Drilling time estimates presume reaching the Marshall Paraconformity, estimated to lie above the target depth of 1700 mbsf. If reaching the Marshall Paraconformity is abandoned as an objective for this site, the penetration depth need not exceed the depth of the lowermost unconformity recovered at the shelf sites. To maximize logging quality, the upper part (~800 m) of the hole will be logged in a dedicated logging hole "C."

Logging/downhole measurements strategy

One of the primary objectives of the logging program will be to provide precise seismic/well correlations to constrain the seismic stratigraphy of the Canterbury Basin. Identifying the natures and depths of the main seismic reflectors and unconformities will be key to understanding the respective influences of local tectonics and eustasy on the depositional history.

Logging operations will consist of three runs in the deepest hole of each site. In addition, because of the unstable nature of the formation expected in these sediments and of the need for accurate logs in the shallower sequences, the upper sections of the sites with the deepest penetration (>1000 mbsf) will also be logged after completion of APC/XCB operations (Site CB-03B) or with a dedicated logging hole (Site CB-04B).

In each hole logged, the first run will be the triple combination (triple combo) tool string, which will record resistivity, neutron porosity, bulk density, and spectral natural gamma ray. The caliper log provided by the density tool will allow assessment of hole condition, log quality, and the potential for success of the following runs. The second run, with the Formation MicroScanner (FMS)-sonic tool string, will record gamma ray, sonic velocity (for compressional and shear waves), and high-resolution electrical images. The compressional velocity logs will be combined with the density logs to generate synthetic seismograms for detailed seismic-log correlations. To calibrate the integration of well and seismic data, the final run in each hole will be a VSP, recorded with the Versatile Seismic Imager (VSI). The seismic source for the VSP will be a 105 in^3 GI air gun, positioned ~2 m below sea level, and offset by ~50 m from the side of the ship. The expected vertical spacing between stations will be 20 m over the entire open interval of each hole logged. Spacing could be reduced for specific targets such as prominent unconformities.

For more information on specific logging tools, please refer to **iodp.ldeo.columbia.edu/TOOLS_LABS**.

Risk and contingency strategy

General contingency plan

Four principal factors could affect the implementation of the drilling plan:

1. Adverse hole conditions at shelf sites (e.g., encountering thick intervals of loose sand that can collapse into the hole),
2. Weather conditions that can limit the ability to drill in shallow water by exceeding the water depth–dependent restrictions on allowable heave,
3. Time delays (e.g., arising from measures taken to respond to hole conditions and changing weather), and
4. Shallow hazards.

Hole conditions

Loose sand at shelf sites will be dealt with in the first instance by using heavy mud to condition the holes. We may also move from primary to alternate shelf sites (e.g., Sites CB-01B, CB-01C, CB-02B, and CB-03A) if it is judged that better conditions may be encountered at such an alternate site, for example, if the lateral extent of problem intervals can be estimated using the seismic profiles.

Ideally, unconsolidated sand would be cased off and a limited amount of casing (up to 600 m) might be available if it is not used during one of the previous expeditions. However, casing, which also requires the installation of a reentry cone, will be employed only as a last resort because it will involve a significant time penalty that would almost certainly lead to the loss of one or more sites from the planned drilling program. The advantages and disadvantages of casing use will have to be evaluated at sea should the need arise.

Weather conditions

Drilling in shallow water on the shelf is more challenging than drilling in deep water. In part, this is because the ship must maintain position to within 3%–8% of water depth (depending on water depth range). Stationkeeping turned out not to be a significant problem when shelf drilling was conducted on the New Jersey margin (Leg 174A). However, drilling in shallow water also involves restrictions on the amount of heave that can be tolerated by the heave compensator. The amount of allowable heave increases with water depth within three depth ranges: 76–300 m, 301–650 m, and >651 m. Therefore, we must be prepared to modify the drilling strategy in response to changing weather conditions.

For example, if weather conditions when the drilling vessel arrives on site are such as to exceed the allowable heave at shelf Site CB-03B (121 m water depth), we will instead begin drilling at slope Site CB-04B (346 m water depth), where greater heave is permissible. If conditions improve sufficiently, we may decide to leave Site CB-04B at a convenient point (e.g., end of XCB drilling or RCB bit replacement) to return to Site CB-03B, dropping a free-fall funnel (FFF) at Site CB-04B if necessary to allow reentry.

Similarly, if the sea state increases beyond acceptable limits while drilling at a shelf site and seems likely to remain high for some time, we may decide to move to Site CB-04B, rather than pull out of the shelf hole and wait for an improvement in the weather. We would deploy a FFF at the shelf hole if reentry is deemed necessary on our return.

In the event that sea conditions are too extreme to operate even at Site CB-04B, which is in the 301–650 m water depth window, we will move to either Site CB-04C (713 m water depth), Site CB-05F (682 m water depth), or Site CB-06B (1158 m water depth). Once again, we would return to Site CB-04B or the shelf when weather conditions allowed, making use of a FFF at Site CB-06B if necessary.

Because all primary and alternate sites are distributed over a small area, transit times between sites are negligible (most sites are within 10–15 km of one another, and the maximum distance between sites is 50 km).

Timing

If significant time is used up responding to shelf hole conditions and poor weather, one option might be to consider drilling Site CB-01B instead of Sites CB-01A and CB-02A. Site CB-01B lies between Sites CB-01A and CB-02A and achieves some of the objectives of each of those sites. Such a decision would only be made following a meeting of the science party.

Shallow hazards

We have addressed these risks by conducting an independent shallow hazard evaluation, applying our standard shipboard operating procedures, and staffing shipboard personnel dedicated to monitoring for signs of potentially hazardous accumulation of hydrocarbons.

The independent shallow hazard evaluation was completed for all proposed sites. The results of the evaluation were reviewed by the IODP EPSP, who forwarded recommendations to the Science Operator. The stratigraphic sections to be penetrated in the proposed boreholes correspond to sequences that do not show hydrocarbons in commercial wells in the study area. Analysis of seismic reflection data indicates that although shallow gas does occur in some regions of the study area, it is not present at any of the planned drill sites. Shallow gas is not seen as a significant issue at the planned sites, but sites were relocated to further mitigate any potential risks.

During the expedition, operations will be guided by our routine safety monitoring procedures (described in Pimmel and Claypool, 2001) to ensure that the sediments being drilled do not contain greater than expected amounts of hydrocarbons. The objective of hydrocarbon monitoring from a safety standpoint is to distinguish potentially hazardous accumulations of hydrocarbons from the background of the normal increase in biogenic hydrocarbon content with depth. Identification of chemical composition and physical properties of any gas or solid petroleum substance is critically important for recognition of the presence or possibility of dangerous accumulations. The composition of gases may enable distinction between biogenic gas and thermogenic gas that has leaked upward from an underlying oil and gas accumulation. The prevailing guideline is that drilling should be stopped if hydrocarbons (or hydrocarbon indications) suggesting the presence of substantial accumulations of gas and oil are encountered.

All recovered cores will be routinely monitored for signs of a potentially hazardous accumulation of hydrocarbons described in Pimmel and Claypool (2001). Immediately after the core is recovered on deck, sediment headspace samples will be taken from the cores to conduct gas analyses by gas chromatography (GC). If the core shows signs of free gas accumulation visible through the clear plastic core liners (e.g., bubbling, gas pockets, expansion, etc.), a liner penetration tool will be used to collect gases that will also be analyzed by GC. Facilities are also available on board the ship to determine the type, amount, and thermal maturity of organic matter using a pyrolysis Source Rock Analyzer should this assist in the interpretation of potential risk.

We sail shipboard personnel dedicated to the safety monitoring program. Two full-time chemistry technicians' primary responsibility is to provide 24/7 collection and analyses of the safety monitoring samples. In addition, we will sail an organic geochemist to provide the Operations Superintendent (responsible shipboard science operator representative) and Co-Chief Scientists with advice concerning interpretation of these analyses and potential risks.

Alternate sites

Seismic profiles of all proposed sites discussed below (and of all primary sites discussed above) are included in the site sheets of this prospectus.

Shelf sites

Sites CB-01B, CB-01C, and CB-02B

These sites (101, 97, and 116 m water depths, respectively) serve as alternate sites for primary Sites CB-01A and CB-02A. During the review process of Proposal 600, the value of penetrating sequence boundaries on their clinoforms was stressed. We have therefore included Sites CB-01B and CB-02B, which also have the benefit of being in slightly deeper water than Sites CB-01A and CB-02A, respectively, though at the expense of greater penetration depths. On balance, we prefer Sites CB-01A and CB-02A over the respective "B" sites both for scientific reasons and to minimize penetrations in shallow water.

Because of an underlying mounded drift deposit at Site CB-01B, it was suggested (EPSP December 2005 meeting) that an additional alternate site be selected. Therefore, Site CB-01C is included as an alternate to Site CB-01B. It was necessary to locate Site CB-01C on a different dip profile (EW00-01-70) in order to avoid the drift (Fig. **AF1**).

Site CB-03A

Site CB-03A (125 m water depth) was not chosen as a primary site because of high amplitudes observed in the seismic data at ~1.05 s.

Slope sites

Site CB-04A

This site (340 m water depth) is located in the immediate vicinity of Site CB-04B. Because of high amplitudes at 1.6–1.7 s in the seismic profiles at Site CB-04A, EPSP approved penetration only to 1270 mbsf. However, this is insufficient to reach the Marshall Paraconformity at this site, and therefore Site CB-04B was chosen as a primary slope site. Both Sites CB-04A and CB-04B are close to a seafloor depression on EW00-01 Profile 23 (Fig. **AF9**), raising concern that the depression might represent a large pockmark. No precise bathymetric data exist for the area, but the feature also appears on the next basinward strike profile, indicating that it is an incised slope canyon.

Sites CB-05B, CB-05C, CB-05D, and CB-05E

These sites (389–402 m water depths) target sediment Drift D11. Site CB-05C, which drills into the crest of the drift, is considered the primary site for drilling Drift D11. The crest of Drift D11 is less deeply buried at Site CB-05C than the crest of Drift D10 at Site 1119 (Leg 181). Although drilling sediment drifts is no longer a primary objective of Expedition 317, a CB-05 site could yet be drilled as a contingency site if shallow shelf drilling turns out to be impossible, either because of hole conditions or poor weather, and sufficient time remains available. It is preferable to drill the thickest part of Drift D11, just basinward of profile EW00-01-23 (Fig. AF12), at Site CB-05C. Site CB-05D was added, slightly downdip from Site CB-05B, to avoid a high-amplitude reflection at 1.8–1.9 s. Site CB-05D is on commercial crossing strike profile CB-82-47 (see site sheets). Finally, Site CB-05E on EW00-01 profile 23 was added as an additional alternative site to avoid some high amplitudes near the seafloor at Site CB-05B. Site CB-05E is not at a line crossing but is ~200 m away.

All CB-05 sites are assessed as having a "low," as opposed to "negligible" or "zero," risk of shallow gas. This is because of a widespread interval of high amplitudes that occurs at all of Sites CB-05B to CB-05E at ~850–950 ms (Figs. AF13, AF14, AF15, AF16). This high-amplitude interval is ubiquitous in this area and cannot be avoided. However, a similar facies occurs at a similar depth at Site 1119 and was penetrated safely there. The high amplitudes may result from higher carbonate content and higher frequency of occurrence of silty sand beds than in overlying sediments. Note that Site 1119 is over a different drift (Drift D10) from that to be penetrated at the CB-05 sites (Drift D11). However, the high amplitudes at Site 1119 occupy the same stratigraphic interval as those at Sites CB-05B to CB-05E (part of the interval between Unconformities U11 and U14), suggesting a similar origin.

Site CB-04C, Site CB-05F, and Site CB-06B

These sites (713, 682, and 1158 m water depths, respectively) are the only sites within the water depth range with the least restricted heave limits (>651 m). Therefore, they serve as global alternate sites in case the sea state does not allow operations at any primary sites in <650 m water depth. Furthermore, basinward of the toe of the modern slope, as at Site CB-06B, the Marshall Paraconformity can be reached with greatly reduced penetration (<1100 mbsf). Sites CB-04C and CB-05F have the same scientific objectives as Sites CB-04B and CB-05C, respectively, with the deepest target being the Marshall Paraconformity. However, Sites CB-04B and CB-05C remain the preferred drilling locations for these objectives because of the reduced number of sequences penetrated at the deeper sites.

Sampling and data-sharing strategy

Shipboard and shore-based researchers should refer to the IODP Sample, Data, and Obligations policy (**www.iodp.org/program-policies/**). This document outlines the policy for distributing IODP samples and data. It also defines the obligations incurred by sample and data recipients. All requests for data and core samples must be approved by the Sample Allocation Committee (SAC). The SAC is composed of Co-Chief Scientists, Staff Scientist, and IODP Curator on shore and curatorial representative in place of the Curator on board the ship.

Scientists must submit their research plans using the Sample/Data Request form (**smcs.iodp.org/**) no later than 3 months before the expedition. This planning process is necessary to coordinate the research to be conducted and to ensure that the scientific objectives are achieved. Based on the sample requests (shore based and shipboard), the SAC and Shipboard Scientific Party will formulate an expedition-specific sampling and data-sharing plan for shipboard and postexpedition activities. This plan will be subject to modification depending upon the actual material recovered and collaborations that may evolve between scientists during the expedition. Modifications to the sampling plan during the expedition require the approval of the SAC.

All sample frequencies and sizes must be justified scientifically and will depend on core recovery, the full spectrum of other sample requests, and the cruise objectives. Some redundancy of measurement is unavoidable, but minimizing the duplication of measurements among the shipboard party and identified shore-based collaborators will be a factor in evaluating sample requests. All shipboard scientists will be expected to collaborate and cooperate within the framework of this plan. Sampling for individual scientist's postcruise research may be conducted during the expedition or may be deferred to postcruise.

If critical intervals are recovered (e.g., prominent unconformities, ash layers), there may be considerable demand for samples from a limited amount of cored material.

These intervals may require modifications to the sampling plan (e.g., special handling, reduced sample size, or deferring of sampling to postcruise).

Following Expedition 317, cores will be delivered to the IODP Core Repository at Texas A&M University, College Station, USA. All collected data and samples will be protected by a 1 year postcruise moratorium, during which time data and samples are available only to the Expedition 317 science party and approved shore-based participants. This moratorium will extend either 1 year from the end of the expedition, or, if a postcruise sampling party is required, 1 year following the completion of the sampling party.

References

Adams, C.J.D., 1979. Age and origin of the Southern Alps. *In* Walcott, R.I., and Cresswell, M.M. (Eds.), *The Origin of the Southern Alps*. Bull.—Roy. Soc. N. Z., 18:73–78.

Austin, J.A., Jr., Christie-Blick, N., Malone, M.J., et al., 1998. *Proc. ODP, Init. Repts.,* 174A: College Station, TX (Ocean Drilling Program). **doi:10.2973/odp.proc.ir.174a.1998**

Batt, G.E., Braun, J., Kohn, B.P., and McDougall, I., 2000. Thermochronological analysis of the dynamics of the Southern Alps, New Zealand. *Geol. Soc. Am. Bull.,* 112(2):250–266. **doi:10.1130/0016-7606(2000)112<0250:TAOTDO>2.3.CO;2**

Berggren, W.A., Kent, D.V., Swisher, C.C., III, and Aubry, M.-P., 1995. A revised Cenozoic geochronology and chronostratigraphy. *In* Berggren, W.A., Kent, D.V., Aubry, M.-P., and Hardenbol, J. (Eds.), *Geochronology, Time Scales and Global Stratigraphic Correlation*. Spec. Publ.—SEPM (Soc. Sediment. Geol.), 54:129–212.

Billups, K., and Schrag, D.P., 2002. Paleotemperatures and ice volume of the past 27 Myr revisited with paired Mg/Ca and $^{18}O/^{16}O$ measurements on benthic foraminifera. *Paleoceanography,* 17(1):1003. **doi:10.1029/2000PA000567**

Browne, G.H., and Field, B.D., 1988. A review of Cretaceous–Cenozoic sedimentation and tectonics, east coast, South Island, New Zealand. *In* James, D.P., and Leckie, D.A. (Eds.), *Sequences, Stratigraphy, Sedimentology: Surface and Subsurface*. Mem.—Can. Soc. Pet. Geol., 15:37–48.

Browne, G.H., and Naish, T.R., 2003. Facies development and sequence architecture of a late Quaternary fluvial-marine transition, Canterbury Plains and shelf, New Zealand: implications for forced regressive deposits. *Sediment. Geol.,* 158(1–2):57–86. **doi:10.1016/S0037-0738(02)00258-0**

Cande, S.C., and Kent, D.V., 1995. Revised calibration of the geomagnetic polarity timescale for the Late Cretaceous and Cenozoic. *J. Geophys. Res.,* 100(B4):6093–6096. **doi:10.1029/94JB03098**

Cande, S.C., and Stock, J.M., 2004. Pacific–Antarctic–Australia motion and the formation of the Macquarie plate. *Geophys. J. Int.,* 157(1):399–414. **doi:10.1111/j.1365-246X.2004.02224.x**

Carter, L., Carter, R.M., McCave, I.N., and Gamble, J., 1996. Regional sediment recycling in the abyssal southwest Pacific Ocean. *Geology,* 24(8):735–738. **doi:10.1130/0091-7613(1996)024<0735:RSRITA>2.3.CO;2**

Carter, R.M., 1985. The mid-Oligocene Marshall Paraconformity, New Zealand: coincidence with global eustatic sea-level fall or rise? *J. Geol.,* 93:359–371.

Carter, R.M., 1988. Post-breakup stratigraphy of the Kaikoura Synthem (Cretaceous–Cenozoic), continental margin, southeastern New Zealand. *N. Z. J. Geol. Geophys.,* 31:405–429.

Carter, R.M., Abbott, S.T., Fulthorpe, C.S., Haywick, D.W., and Henderson, R.A., 1991. Application of global sea-level and sequence-stratigraphic models in Southern Hemisphere Neogene strata from New Zealand. *In* Macdonald, D.I.M. (Ed.), *Sedimentation, Tectonics, and Eustasy: Sea-level Changes at Active Margins*. Spec. Publ. Int. Assoc. Sedimentol., 12:41–65.

Carter, R.M., Fulthorpe, C.S., and Lu, H., 2004a. Canterbury drifts at Ocean Drilling Program Site 1119, New Zealand: climatic modulation of southwest Pacific intermediate water flows since 3.9 Ma. *Geology,* 32(11):1005–1008. **doi:10.1130/G20783.1**

Carter, R.M., Gammon, P.R., and Millwood, L., 2004b. Glacial–interglacial (MIS 1–10) migrations of the Subtropical Front across ODP Site 1119, Canterbury Bight, southwest Pacific Ocean. *Mar. Geol.,* 205(1–4):29–58. **doi:10.1016/S0025-3227(04)00017-9**

Carter, R.M., and Landis, C.A., 1972. Correlative Oligocene unconformities in southern Australasia. *Nature (London), Phys. Sci.,* 237:12–13.

Carter, R.M., McCave, I.N., and Carter, L., 2004c. Leg 181 synthesis: fronts, flows, drifts, volcanoes, and the evolution of the southwestern gateway to the Pacific Ocean, eastern New Zealand. *In* Richter, C. (Ed.), *Proc. ODP, Sci. Results,* 181: College Station, TX (Ocean Drilling Program), 1–111. **doi:10.2973/odp.proc.sr.181.210.2004**

Carter, R.M., and Norris, R.J., 1976. Cainozoic history of southern New Zealand: an accord between geological observations and plate-tectonic predictions. *Earth Planet. Sci. Lett.,* 31(1):85–94. **doi:10.1016/0012-821X(76)90099-6**

Chiswell, S.M., 1996. Variability in the Southland Current, New Zealand. *N. Z. J. Mar. Freshwater Res.,* 30:1–17.

Christie-Blick, N., 1991. Onlap, offlap, and the origin of unconformity-bounded depositional sequences. *Mar. Geol.,* 97(1–2):35–56. **doi:10.1016/0025-3227(91)90018-Y**

Christie-Blick, N., Austin, J.A., Jr., and Shipboard Scientific Party, 1998. Introduction: Oligocene to Pleistocene eustatic change at the New Jersey continental margin—a test of sequence stratigraphy. *In* Austin, J.A., Jr., Christie-Blick, N., Malone, M.J., et al., *Proc. ODP, Init. Repts.,* 174A: College Station, TX (Ocean Drilling Program), 5–16. **doi:10.2973/odp.proc.ir.174A.101.1998**

Christie-Blick, N., and Driscoll, N.W., 1995. Sequence stratigraphy. *Annu. Rev. Earth Planet. Sci.,* 23(1):451–478. **doi:10.1146/annurev.ea.23.050195.002315**

Christie-Blick, N., Mountain, G.S., and Miller, K.G., 1990. Seismic stratigraphic record of sea-level change. *In* National Research Council (Ed.), *Sea-level Change:* Washington, DC (National Academy Press), 116–140.

Cloetingh, S., McQueen, H., and Lambeck, K., 1985. On a tectonic mechanism for regional sealevel variations. *Earth Planet. Sci. Lett.,* 75(2–3):157–166. **doi:10.1016/0012-821X(85)90098-6**

Coombs, D.S., Cas, R.A., Kawachi, Y., Landis, C.A., McDonough, W.F., and Reay, A., 1986. Cenozoic volcanism in north, east, and central Otago. *In* Smith, I.E.M. (Ed.), *Late Cenozoic Volcanism in New Zealand.* Bull.—R. Soc. N. Z., 23:278–312.

COSOD II, 1987. *Report of the 2nd Conference on Scientific Ocean Drilling:* Washington/Strasbourg (JOIDES/European Sci. Found.).

Dewey, J.F., and Pitman, W.C., 1998. Sea level changes: mechansims, magnitudes and rates. *In* Pindell, J.L., and Drake, C.L. (Eds.), *Paleogeographic Evolution and Nonglacial Eustasy, Northern South America.* Spec. Publ.—SEPM (Soc. Sediment. Geol.), 58:1–16

Eberli, G., Swart, P., and Malone, M., 1996. *ODP Prelim. Rpt.,* 166. **doi:10.2973/odp.pr.166.1996**

Fleming, C.A., 1962. New Zealand biogeography: a paleontologist's approach. *Tuatara,* 10:53–108.

Fulthorpe, C.S., and Carter, R.M., 1989. Test of seismic sequence methodology on a Southern Hemisphere passive margin: the Canterbury Basin, New Zealand. *Mar. Pet. Geol.,* 6(4):348–359. **doi:10.1016/0264-8172(89)90031-7**

Fulthorpe, C.S., and Carter, R.M., 1991. Continental-shelf progradation by sediment-drift accretion. *Geol. Soc. Am. Bull.,* 103(2):300–309. **doi:10.1130/0016-7606(1991)103<0300:CSPBSD>2.3.CO;2**

Fulthorpe, C.S., Carter, R.M., Miller, K.G., and Wilson, J., 1996. Marshall Paraconformity: a mid-Oligocene record of inception of the Antarctic Circumpolar Current and coeval glacio-eustatic lowstand? *Mar. Pet. Geol.,* 13(1):61–77. **doi:10.1016/0264-8172(95)00033-X**

Haq, B.U., Hardenbol, J., and Vail, P.R., 1987. Chronology of fluctuating sea levels since the Triassic. *Science,* 235(4793):1156–1167. **doi:10.1126/science.235.4793.1156**

Hawkes, P.W., and Mound, D.G., 1984. Clipper-1 geological completion report. *N. Z. Geol. Surv. Open-File Rep.,* 1036.

Hoernle, K., White, J.D.L., van den Bogaard, P., Hauff, F., Coombs, D.S., Werner, R., Timm, C., Garbe-Schönberg, D., Reay, A., and Cooper, A.F., 2006. Cenozoic intraplate volcanism on New Zealand: upwelling induced by lithospheric removal. *Earth Planet. Sci. Lett.,* 248(1–2):350–367. **doi:10.1016/j.epsl.2006.06.001**

Kamp, P.J.J., 1987. Age and origin of the New Zealand orocline in relation to Alpine Fault movement. *J. Geol. Soc. (London, U. K.),* 144(4):641–652. **doi:10.1144/gsjgs.144.4.0641**

Karner, G.D., 1986. Effects of lithospheric in-plane stress on sedimentary basin stratigraphy. *Tectonics,* 5:573–588.

Karner, G.D., Driscoll, N.W., and Weissel, J.K., 1993. Response of the lithosphere to in-plane force variations. *Earth Planet. Sci. Lett.,* 114(4):397–416. **doi:10.1016/0012-821X(93)90072-H**

Kennett, J.P., and von der Borch, C.C., 1986. Southwest Pacific Cenozoic paleoceanography. *In* Kennett, J.P., von der Borch, C.C., et al., *Init. Repts. DSDP,* 90: Washington, DC (U.S. Govt. Printing Office), 1493–1517. **doi:10.2973/dsdp.proc.90.148.1986**

King, P.R., 2000. Tectonic reconstructions of New Zealand: 40 Ma to the present. *N. Z. J. Geol. Geophys.,* 43:611–638.

Kominz, M.A., 1984. Oceanic ridge volumes and sea-level change: an error analysis. *In* Schlee, J.S. (Ed.), *Interregional Unconformities and Hydrocarbon Accumulation.* AAPG Mem., 36:109–127.

Kominz, M.A., Miller, K.G., and Browning, J.V., 1998. Long-term and short-term global Cenozoic sea-level estimates. *Geology,* 26(4):311–314. **doi:10.1130/0091-7613(1998)026<0311:LTASTG>2.3.CO;2**

Kominz, M.A., and Pekar, S.F., 2001. Oligocene eustasy from two-dimensional sequence stratigraphic backstripping. *Geol. Soc. Am. Bull.,* 113(3):291–304. **doi:10.1130/0016-7606(2001)113<0291:OEFTDS>2.0.CO;2**

Lavier, L.L., Steckler, M.S., and Brigaud, F., 2000. An improved method for reconstructing the stratigraphy and bathymetry of continental margins: application to the Cenozoic tectonic and sedimentary history of Congo margin. *AAPG Bull.,* 78:923–939.

Lavier, L.L., Steckler, M.S., and Brigaud, F., 2001. Climatic and tectonic control on the Cenozoic evolution of the West African margin. *Mar. Geol.,* 178(1–4):63–80. **doi:10.1016/S0025-3227(01)00175-X**

Lewis, D.W., 1992. Anatomy of an unconformity on mid-Oligocene Amuri Limestone, Canterbury, New Zealand. *N. Z. J. Geol. Geophys.,* 35(4):463–475.

Loutit, T.S. (Ed.), 1992. *JOIDES Sea Level Working Group (SLWG) Report:* Woods Hole, MA (Woods Hole Oceanographic Institute).

Lu, H., and Fulthorpe, C.S., 2004. Controls on sequence stratigraphy of a middle Miocene–Holocene, current-swept, passive margin: offshore Canterbury Basin, New Zealand. *Geol. Soc. Am. Bull.,* 116(11):1345–1366. **doi:10.1130/B2525401.1**

Lu, H., Fulthorpe, C.S., and Mann, P., 2003. Three-dimensional architecture of shelf-building sediment drifts in the offshore Canterbury Basin, New Zealand. *Mar. Geol.,* 193(1–2):19–47. **doi:10.1016/S0025-3227(02)00612-6**

Lu, H., Fulthorpe, C.S., Mann, P., and Kominz, M., 2005. Miocene–Recent tectonic and climate controls on sediment supply and sequence stratigraphy: Canterbury Basin, New Zealand. *Basin Res.,* 17(2):311–328.

McGonigal, K., and Di Stefano, A., 2002. Calcareous nannofossil biostratigraphy of the Eocene–Oligocene Transition, ODP Sites 1123 and 1124. *In* Richter, C. (Ed.), *Proc. ODP, Sci. Results,* 181: College Station, TX (Ocean Drilling Program), 1–22. **doi:10.2973/odp.proc.sr.181.207.2002**

Miall, A.D, and Miall, C.E., 2001. Sequence stratigraphy as a scientific enterprise: the evolution and persistence of conflicting paradigms. *Earth Sci. Rev.,* 54(4):321–348. **doi:10.1016/S0012-8252(00)00041-6**

Miller, K.G., et al., 1994. *Proc. ODP, Init. Repts.,* 150X: College Station, TX (Ocean Drilling Program). **doi:10.2973/odp.proc.ir.150X.1994**

Miller, K.G., and Mountain, G.S., 1994. Global sea-level change and the New Jersey margin. *In* Mountain, G.S., Miller, K.G., Blum, P., et al., *Proc. ODP, Init. Repts.,* 150: College Station, TX (Ocean Drilling Program), 11–20. **doi:10.2973/odp.proc.ir.150.102.1994**

Miller, K.G., Mountain, G.S., the Leg 150 Shipboard Party, and Members of the New Jersey Coastal Plain Drilling Project, 1996. Drilling and dating New Jersey Oligocene–Miocene sequences: ice volume, global sea level, and Exxon records. *Science,* 271(5252):1092–1995. **doi:10.1126/science.271.5252.1092**

Miller, K.G., Sugarman, P.J., Browning, J.V., et al., 1998. *Proc. ODP, Init. Repts.,* 174AX: College Station, TX (Ocean Drilling Program). **doi:10.2973/odp.proc.ir.174AX.1998**

Miller, K.G., Wright, J.D., and Fairbanks, R.G., 1991. Unlocking the ice house: Oligocene–Miocene oxygen isotopes, eustasy, and margin erosion. *J. Geophys. Res.,* 96(B4):6829–6848.

Milne, A.D., Simpson, C., and Threadgold, P., 1975. Resolution-1 well completion report. *N. Z. Geol. Surv. Open-File Rep.,* 648.

Mitchum, R.M., Vail, P.R., and Thompson, S., 1977. Seismic stratigraphy and global changes of sea level, part 2: the depositional sequence as a basic unit for stratigraphic analysis. *In* Payton, C.E. (Ed.), *Seismic Stratigraphy: Applications to Hydrocarbon Exploration.* AAPG Mem., 26:53–62.

Molnar, P., Atwater, T., Mammerickx, J., and Smith, S., 1975. Magnetic anomalies, bathymetry and the tectonic evolution of the South Pacific since the Late Cretaceous. *Geophys. J. R. Astron. Soc.,* 40:383–420.

Moore, T.C., Loutit, T.S., and Greenlee, S.M., 1987. Estimating short-term changes in eustatic sea level. *Paleoceanography,* 2:625–637.

Morris, M., Stanton, B., and Neil, H., 2001. Subantarctic oceanography around New Zealand: preliminary results from an ongoing survey. *N. Z. J. Mar. Freshwater Res.,* 35:499–519.

Mountain, G.S., Miller, K.G., Blum, P., et al., 1994. *Proc. ODP, Init. Repts.,* 150: College Station, TX (Ocean Drilling Program). **doi:10.2973/odp.proc.ir.150.1994**

Norris, R.J., Carter, R.M., and Turnbull, I.M., 1978. Cainozoic sedimentation in basins adjacent to a major continental transform boundary in southern New Zealand. *J. Geol. Soc. (London, U. K.),* 135(2):191–205. **doi:10.1144/gsjgs.135.2.0191**

Pekar, S.F., and Kominz, M.A., 2001. Two-dimensional paleoslope modeling: a new method for estimating water depths of benthic foraminiferal biofacies and paleoshelf margins. *J. Sediment. Res.,* 71(4):608–620. **doi:10.1306/100600710608**

Pimmel, A., and Claypool, G., 2001. Introduction to shipboard organic geochemistry on the *JOIDES Resolution. ODP Tech. Note,* 30. **doi:10.2973/odp.tn.30.2001**

Posamentier, H.W., Jervey, M.T., and Vail, P.R., 1988. Eustatic controls on clastic deposition, I. Conceptual framework. *In* Wilgus, C.K., Hastings, B.S., Ross, C.A., Posamentier, H.W., Van Wagoner, J., and Kendall, C.G.St.C. (Eds.), *Sea-Level Changes: An Integrated Approach.* Spec. Publ.—Soc. Econ. Paleontol. Mineral., 42:109–124.

Posamentier, H.W., and Vail, P.R., 1988. Eustatic controls on clastic deposition, II. Sequence and systems tract models. *In* Wilgus, C.K., Hastings, B.S., Ross, C.A., Posamentier, H.W., Van Wagoner, J., and Kendall, C.G.St.C. (Eds.), *Sea-Level Changes: An Integrated Approach.* Spec. Publ.—Soc. Econ. Paleontol. Mineral., 42:124–154.

Reynolds, D.J., Steckler, M.S., and Coakley, B.J., 1991. The role of the sediment load in sequence stratigraphy: the influence of flexural isostasy and compaction. *J. Geophys. Res.,* 96:6931–6949.

Shipboard Scientific Party, 1999a. Leg 181 summary: southwest Pacific paleoceanography. *In* Carter, R.M., McCave, I.N., Richter, C., Carter, L., et al., *Proc. ODP, Init. Repts.,* 181: College Station, TX (Ocean Drilling Program), 1–80. **doi:10.2973/odp.proc.ir.181.101.2000**

Shipboard Scientific Party, 1999b. Site 1119: drift accretion on Canterbury Slope. *In* Carter, R.M., McCave, I.N., Richter, C., Carter, L., et al., *Proc. ODP, Init. Repts.,* 181: College Station, TX (Ocean Drilling Program), 1–112. **doi:10.2973/odp.proc.ir.181.103.2000**

Steckler, M.S., Mountain, G.S., Miller, K.G., and Christie-Blick, N., 1999. Reconstruction of Tertiary progradation and clinoform development on the New Jersey passive margin by 2-D backstripping. *Mar. Geol.,* 154(1–4):399–420. **doi:10.1016/S0025-3227(98)00126-1**

Tippett, J.M., and Kamp, P.J.J., 1993a. Fission track analysis of the late Cenozoic vertical kinematics of continental Pacific crust, South Island, New Zealand. *J. Geophys. Res., [Solid Earth Planets],* 98(9):16119–16148.

Tippett, J.M., and Kamp, P.J.J., 1993b. The role of faulting in rock uplift in the Southern Alps, New Zealand. *N. Z. J. Geol. Geophys.,* 36(4):497–504.

Vail, P.R., Audemard, F., Bowman, S.A., Eisner, P.N., and Perez-Cruz, G., 1991. The stratigraphic signatures of tectonics, eustasy, and sedimentology—an overview. *In* Einsele, G., Ricken, W., and Seilacher, A. (Eds.), *Cycles and Events in Stratigraphy:* Berlin (Springer), 617–659.

Van Wagoner, J.C., Posamentier, H.W., Mitchum, R.M., Jr., Vail, P.R., Sarg, J.F., Loutit, T.S., and Hardenbol, J., 1988. An overview of the fundamentals of sequence stratigraphy and key definitions. *In* Wilgus, C.K., Hastings, B.S., Ross, C.A., Posamentier, H.W., Van Wagoner, J., and Kendall, C.G.St.C. (Eds.), *Sea-Level Changes: An Integrated Approach.* Spec. Publ.—Soc. Econ. Paleontol. Mineral., 42:39–45.

Walcott, R.I., 1998. Modes of oblique compression: late Cenozoic tectonics of the South Island of New Zealand. *Rev. Geophys.,* 36(1):1–26. **doi:10.1029/97RG03084**

Ward, D.M., and Lewis, D.W., 1975. Paleoenvironmental implications of storm-scoured ichnofossiliferous mid-Tertiary limestones, Waihao district, South Canterbury, New Zealand. *N. Z. J. Geol. Geophys.,* 18:881–908.

Watkins, J.S., and Mountain, G.S. (Eds.), 1990. *Role of ODP Drilling in the Investigation of Global Changes in Sea Level.* Rep. JOI/USSAC Workshop, El Paso, Texas, 24–26 October 1988.

Watters, W.A., 1978. Tertiary volcanism–Miocene. *In* Suggate, P.R., and Stevens, G.R. (Eds.), *The Geology of New Zealand:* Wellington (New Zealand Govt. Printer), 2:637–644.

Wilding, A., and Sweetman, I.A.D., 1971. Endeavour-1 petroleum report. *N. Z. Geol. Surv. Open-File Rep.,* 303.

Wilson, I.R., 1985. Galleon-1 geological completion report. *N. Z. Geol. Surv. Open-File Rep.,* 1146.

Table T1. Operations summary.

Expedition 317 - Canterbury Basin

Operations Plan & Time Estimate

(Pollard / Storms / Grout / Midgley, 22 May 2009)

Site No.	Location (Latitude Longitude)	Sea Floor Depth (mbrf)	Operations Description	Transit (days)	Drilling Coring (days)	LWD/MWD Log (days)
Townsville			**Begin Expedition** 5 port call days			
			Transit ~2172 nmi to **Waypoint 1** @ 10.5	8.6		
			Transit ~210 nmi to **CB-03B** @ 10.5	0.8		
CB-03B	44° 53.0308' S	132	Hole A: APC to ~ 250 mbsf. XCB to ~ 350 mbsf. Log w/ FMS-Sonic, Triple Combo, VSI		1.7	1
EPSP	171° 50.4059' E		Hole B: Drill to 300 mbsf. RCB to ~ 1249 mbsf. Log w/ Triple Combo, FMS-Sonic, VSI		6.7	2
approved						
to 1249 mbsf						
			Sub-Total Days On-Site: 11			
			Transit ~8 nmi to **CB-04B** @ 6	0.1		
CB-04B	44° 56.2443' S	357	Hole A: APC/XCB to ~ 350 mbsf.		1.5	0
EPSP	172° 1.3629' E		Hole B: RCB ~ 350-1700 Log - triple combo, FMS - Sonic and VSI 750-1700 mt.		14.3	1.9
approved			Hole C: Drill 800 mt. Log - Triple combo, FMS - Sonic and VSI 80-800 mt.		0	4.1
to 1913 mbsf						
			Sub-Total Days On-Site: 21.2			
			Transit ~18 nmi to **CB-01A** @ 8	0.1		
CB-01A	44° 46.1085' S	96	Hole A: APC/XCB to ~ 350 mbsf.		1.4	0
EPSP	171° 40.4393' E		Hole B: RCB ~ 300-780 Log - triple combo, FMS - Sonic and VSI 80-780 mt.		2.8	1.6
approved						
to 780 mbsf						
			Sub-Total Days On-Site: 5.7			
			Transit ~7 nmi to **CB-02A** @ 2	0.1		
CB-02A	44° 50.8274' S	122	Hole A: APC to ~ 250 mbsf. XCB to ~ 350 mbsf.		1.3	0
EPSP	171° 47.2079' E		Hole B: RCB ~ 300-800 Log - triple combo, FMS - Sonic and VSI 80-800 mt.		2.9	1.8
approved						
to 800 mbsf						
			Sub-Total Days On-Site: 5.9			
			Transit ~89 nmi to **Waypoint to Wellington** @ 10.5	0.4		
			Transit ~179 nmi to **Wellington, NZ** @ 10.5	0.7		
Wellington, NZ			**End Expedition**	**10.8**	**32.7**	**12.5**

Port Call:	**5**	**Total Operating Days:**	**56**
Sub-Total On-Site:	**45.2**	**Total Expedition:**	**61**

Note(s):

Figure F1. Canterbury Basin on eastern margin of the South Island of New Zealand. Inset map shows Ocean Drilling Program (ODP) Site 1119 and proposed Expedition 317 site locations with primary and alternate sites marked in red and yellow, respectively (also see Fig. **F3**).

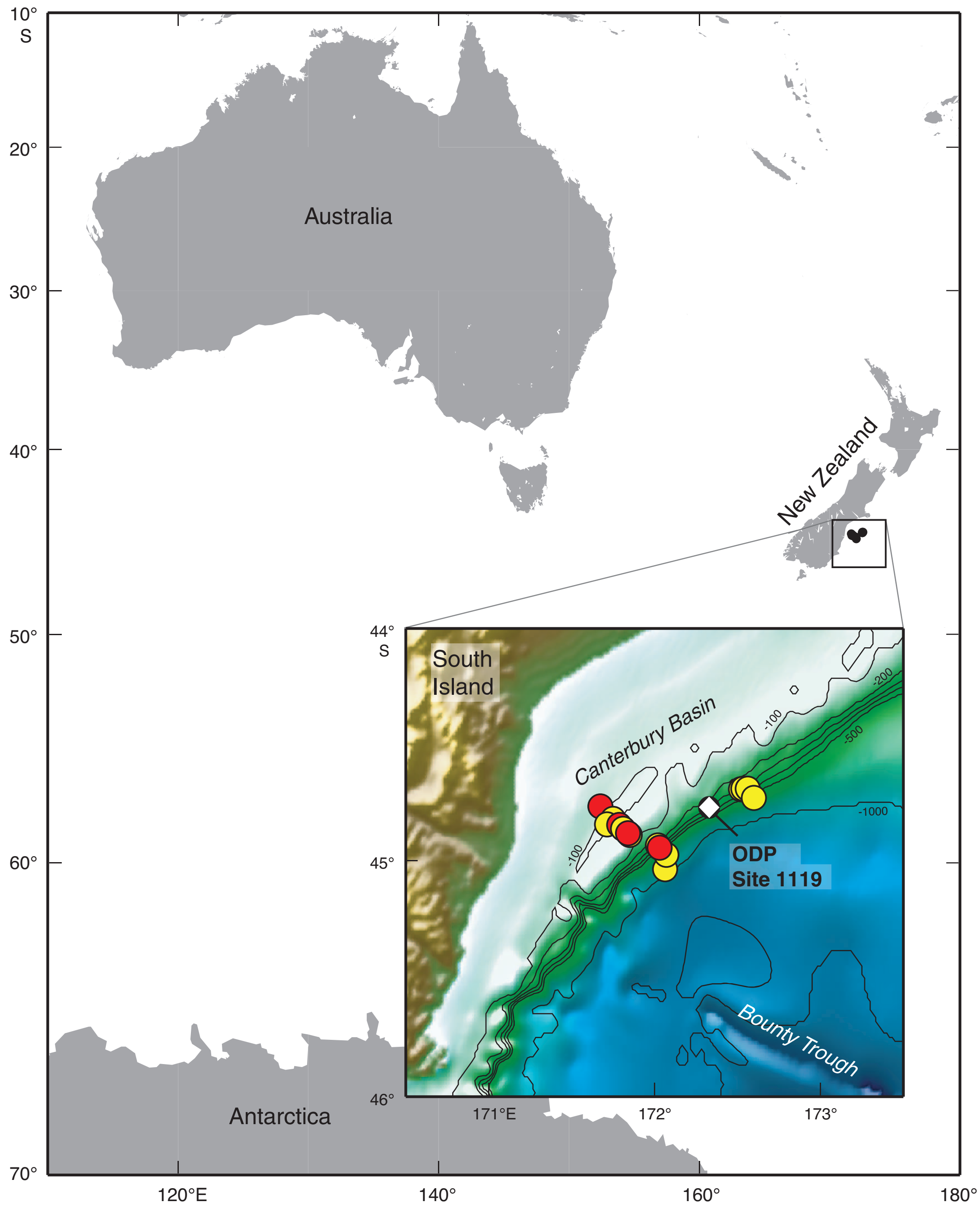


Figure F2. Canterbury Basin underlies the present-day onshore Canterbury Plains and offshore continental shelf. It is bounded by the Miocene volcanic centers of the Banks Peninsula (BP; 5.8–12 Ma, Watters, 1978) to the northeast and the Otago Peninsula (OP; 9.6–16.0 Ma, Coombs et al., 1986; Hoernle et al., 2006) to the southwest and faces the Bounty Trough to the southeast. The Alpine Fault is the boundary between the Australasian and Pacific plates. Locations of the modern Southland Front and Subantarctic Front, together with local gyre within the Bounty Trough, are shown (Chiswell, 1996; Shipboard Scientific Party, 1999a; Morris et al., 2001). Also shown are the four exploration wells in the offshore basin (R = Resolution, C = Clipper, E = Endeavour, and G = Galleon) as well as Ocean Drilling Program (ODP) Site 1119. A fifth well, Cutter, was drilled in 2006; information concerning Cutter-1, however, is sparse. Bathymetric contours are in meters.

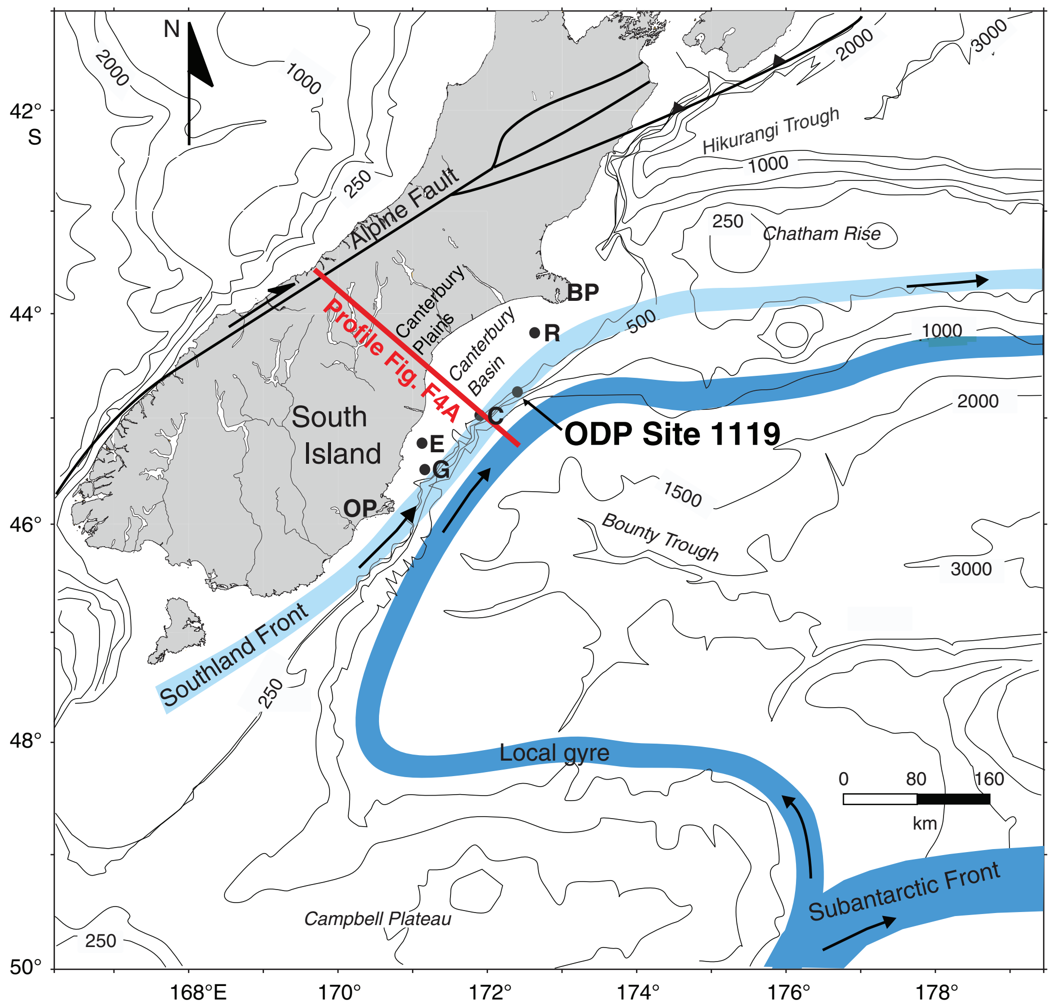


Figure F3. Proposed drill Sites CB-01A to CB-06B (primary and alternate sites marked in red and yellow, respectively) together with EW00-01 high-resolution (frequencies up to 300 Hz) MCS grid (thick straight lines), low-resolution CB-82 commercial MCS grid (thin straight lines), exploration wells Clipper and Resolution, and Ocean Drilling Program (ODP) Site 1119. The EW00-01 survey provided improved vertical resolution (~5 m in the upper 1 s) for defining high-frequency sedimentary sequences. Also shown is the distribution of seismically resolvable sediment drifts (Drifts D1–D11; blue curved lines mark crests of the drift mounds). Drifts D1–D6 and D10–D11 are simple elongate drifts. Drifts D7–D9 are complex drifts. Drift D8 has three subcrests (D8-1, D8-2, and D8-3) and is a multicrested complex drift. Drift D9 is multistage drift with superimposed Subdrifts D9-1, D9-2, and D9-3. Dashed blue lines = drifts identified on CB-82 profiles. Thick black lines = locations of dip profiles on which sites are located (12, 14, 60, and 66). Bathymetric contours are in meters.

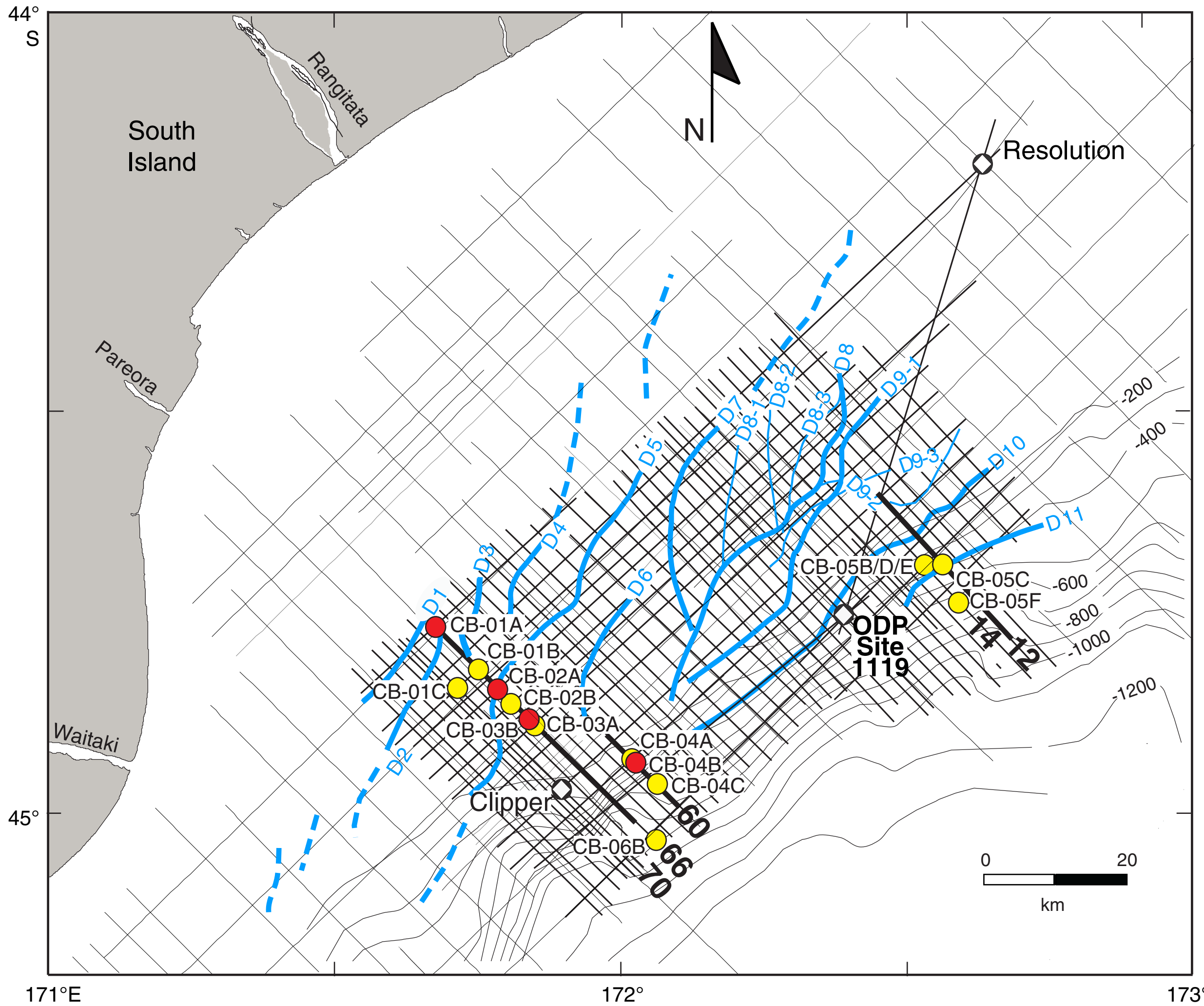


Figure F4. Schematic stratigraphy of the Canterbury Basin at three different scales. **A.** Large-scale postrift stratigraphy (see profile location in Fig. F2). Onekakara, Kekenodon, and Otakou groups were deposited during regional transgressive, highstand, and regressive phases, respectively. **B.** Seismic-scale stratigraphy. The sediment drifts occur within the Otakou Group. The limestones are shown as distal facies of the uppermost transgressive Onekakara Group and lowermost regressive Otakou Group. **C.** Outcrop-scale stratigraphy across the Marshall Paraconformity. Modified from Fulthorpe et al. (1996).

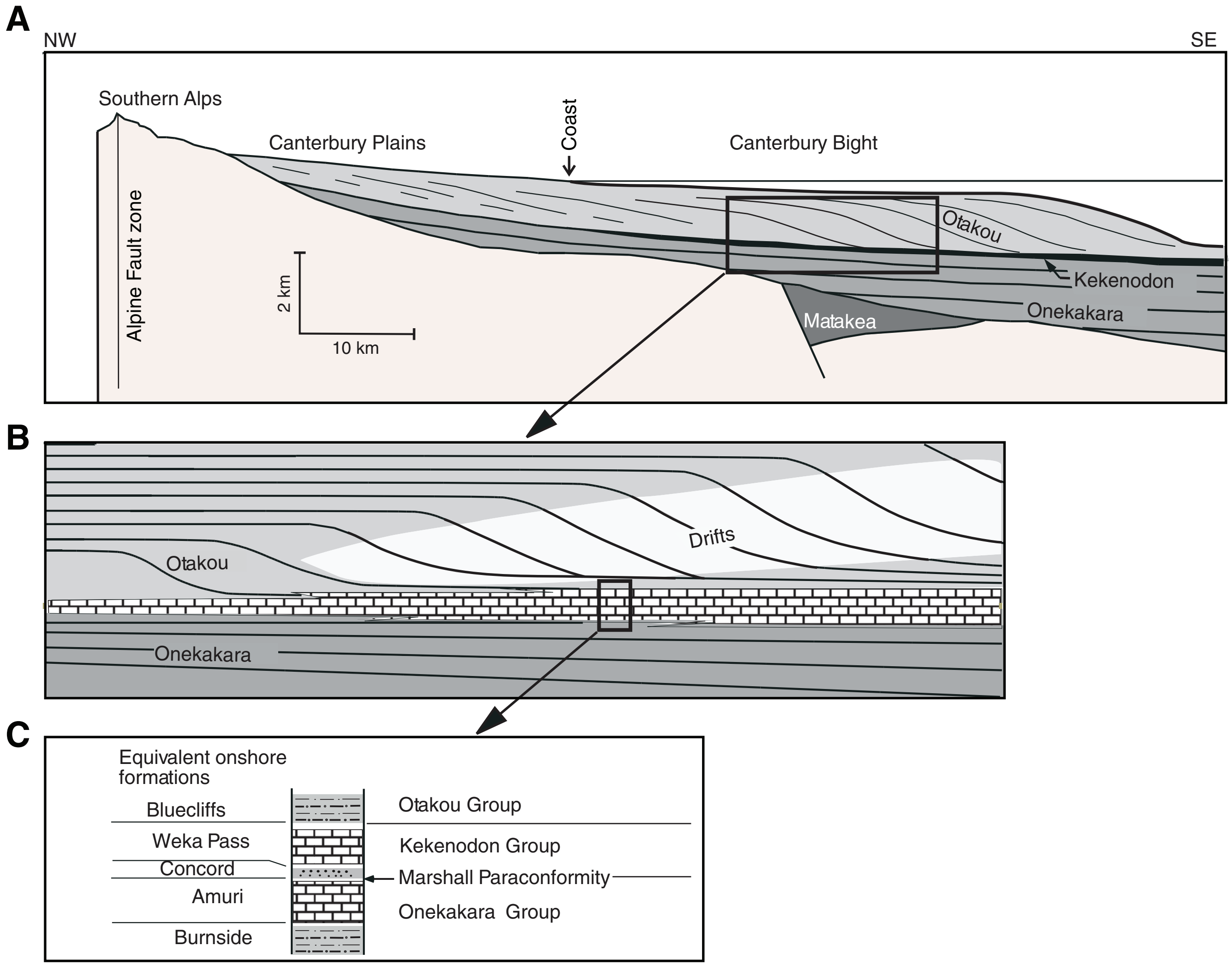


Figure F5. Total and tectonic subsidence curves for the Clipper exploration well (Fig. F2) with and without paleowater depth estimates. The tectonic subsidence curve with paleowater depths shows that most tectonic subsidence occurred during the early Late Cretaceous with mild uplift during the latest Cretaceous. Little tectonic subsidence has occurred during the last 30 m.y. The increase in tectonic subsidence rate beginning at ~8 Ma may be a response to increasing convergence at the Alpine Fault. Curves provided by G. Browne, R. Wood, and R. Funnell, New Zealand Institute of Geological and Nuclear Sciences.

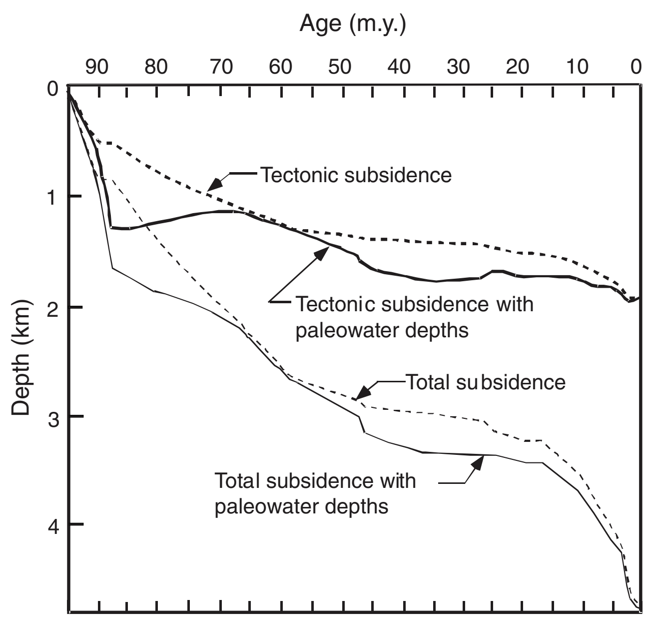


Figure F6. Revised subsidence analysis for the Clipper exploration well with eustatic estimates. **A.** Water depth (WD) (blue), tectonic subsidence (red), and theoretical thermal curves (minimum and maximum) for the Clipper Exploration well (Figs. F2, F3). As also shown in Figure F5, most tectonic subsidence occurred during the early Late Cretaceous with mild uplift during the latest Cretaceous. This analysis also shows the low rates of tectonic subsidence between 30 Ma and ~8 Ma and the increase in total subsidence beginning at ~8 Ma, which may be associated with increasing convergence at the Alpine Fault. **B.** R2, an estimate of eustasy, has large uncertainties because of poorly constrained paleowater depths of much of the sediment preserved in the Clipper well (M. Kominz, unpubl. data). NJ = New Jersey.

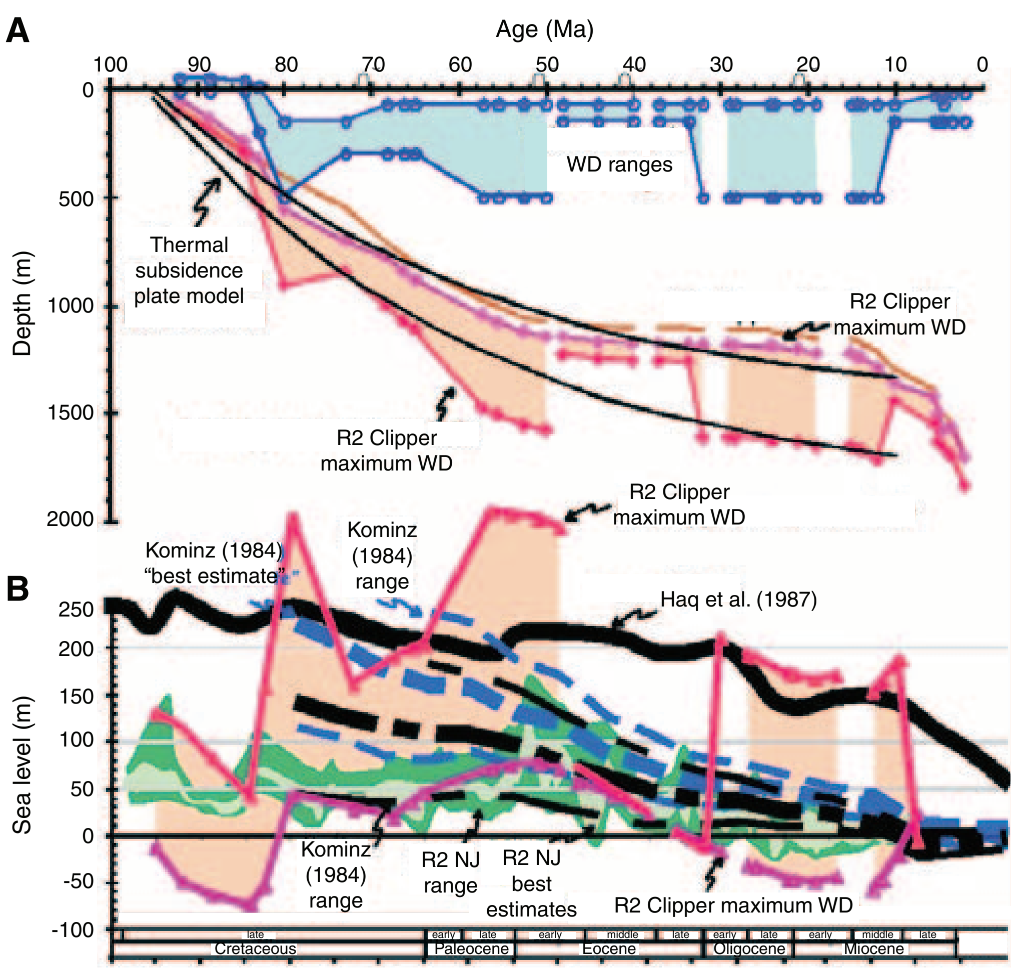


Figure F7. A. Uninterpreted MCS dip profile EW00-01-66 from the southern part of the survey grid showing locations of primary and alternate drill sites (see Fig. **F3** for location). **B.** Interpretation showing sequence boundaries and selected locations of onlap, truncation, and downlap (arrows). Circles = clinoform breakpoints, representing paleoshelf edges. Paleoshelf edges from Unconformities U4–U8 prograde steadily. The amount of progradation decreases from Unconformities U8 to U12, increasing again from Unconformities U13 to U19. Unconformities U4–U8 are onlapped and truncate underlying reflections; internal reflection geometries from Unconformities U4–U9 are mainly sigmoid. Sites CB-01A and CB-02A sample these sequence boundaries landward of their breakpoints. Site CB-02A also samples the paleoslope of Unconformity U6, and Site CB-03B samples paleoslopes of Unconformities U4–U7. In contrast, Unconformities U10–U19 are downlapped on paleoshelves, but also truncate underlying reflections, and internal reflection geometries from Unconformity U9–seafloor are oblique. Site CB-03B samples these sequence boundaries landward of their breakpoints. Sediment drift development in this area had largely ceased by Unconformity U4. Only Drift D5 is present; it is capped by a postdrift slope platform at Unconformity U4. Prograding clinoforms dominate later sequences and the slope steepens (to 3°–5°). Drifts migrate northwestward (landward) on dip profiles. Erosional unconformities at the landward edges of drift moats are diachronous and intersected by multiple sequence boundaries. MP = Marshall Paraconformity. (**Figure shown on next page.**)

Figure F7 (continued). (Caption shown on previous page.)

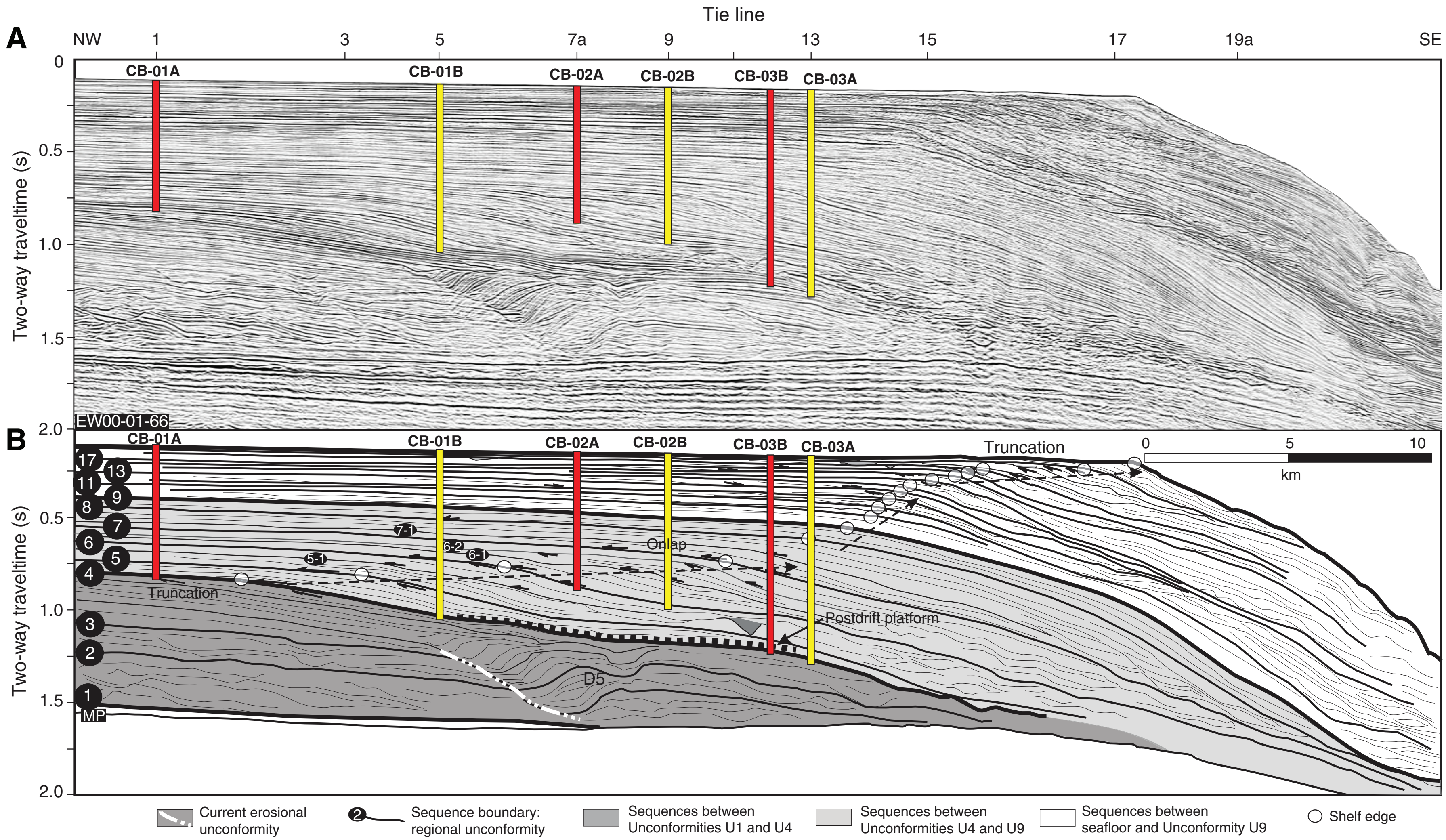


Figure F8. A. Uninterpreted dip profile EW00-01-12 across the slope in the northern part of the survey grid (see Fig. F3 for location). **B.** Interpretation showing sequence boundaries and selected locations of reflection truncation (arrows). Contingency Site CB-05C samples Drift D11, the last of the large elongate drifts of the Canterbury Basin, and the underlying Marshall Paraconformity (MP) (see Fig. F4).

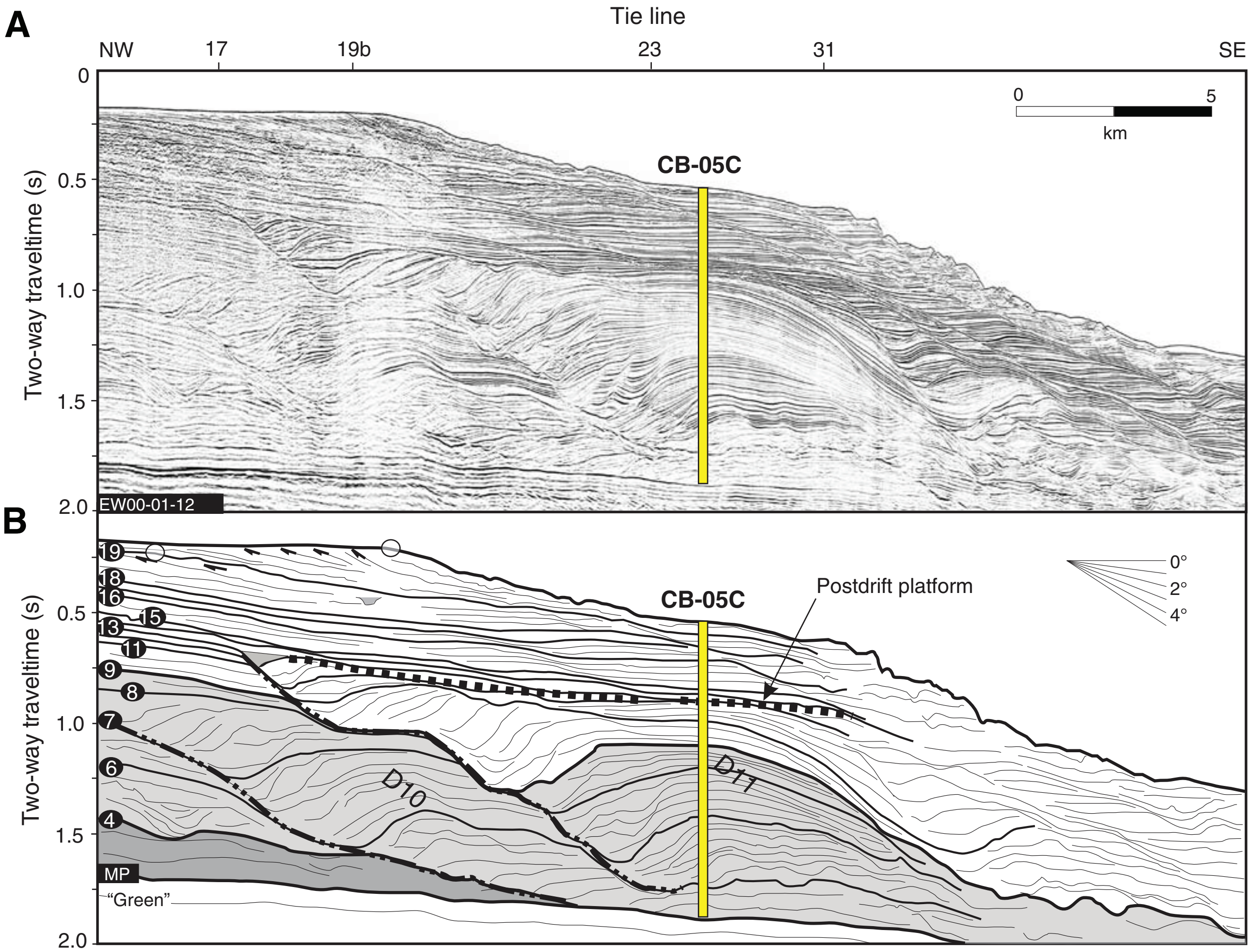


Figure F9. A. Uninterpreted dip profile EW00-01-60 across the slope in the southern part of the survey grid (see Fig. **F3** for location). **B.** Interpretation showing sequence boundaries and selected locations of reflection truncation (arrows). Primary Site CB-04B and alternate Site CB-04A sample slope facies of sequences, particularly important for age control (see Fig. **F11**), as well as the underlying Marshall Paraconformity (MP) (Site CB-04B).

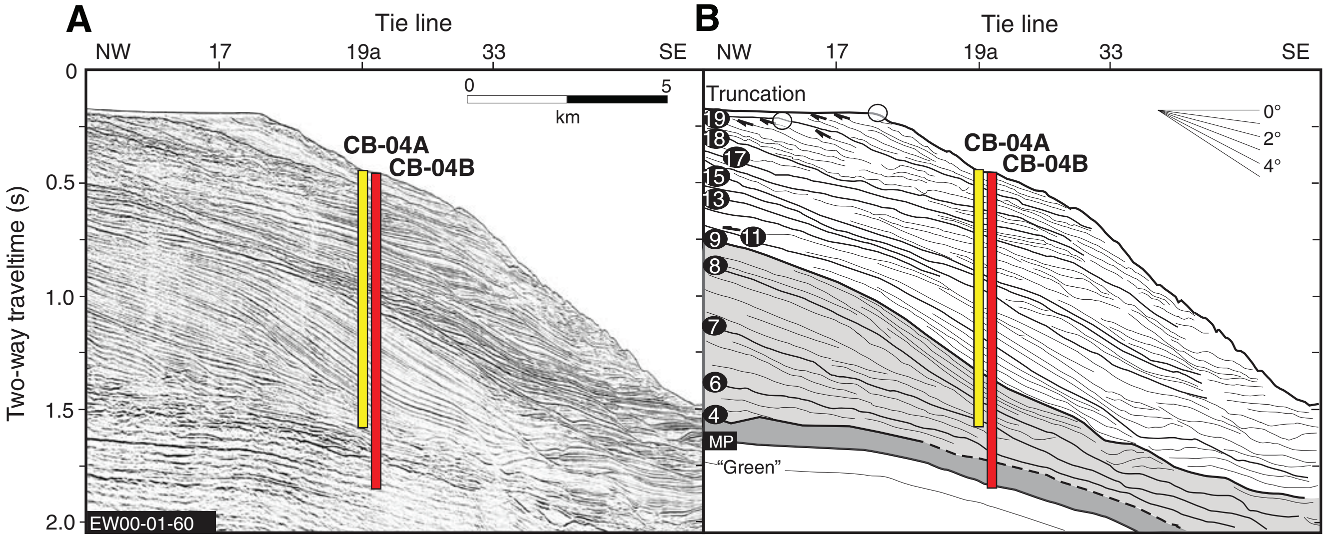


Figure F10. Comparison of colocated commercial multichannel seismic (MCS) profile (**A**) and the high-resolution MCS profile (**B**) across a large sediment drift in the offshore Canterbury Basin, New Zealand, showing the improved imaging provided by the high-resolution survey. The commercial profile has a vertical resolution of ~20 m, whereas that of the high-resolution profile is ~5 m in the upper second.

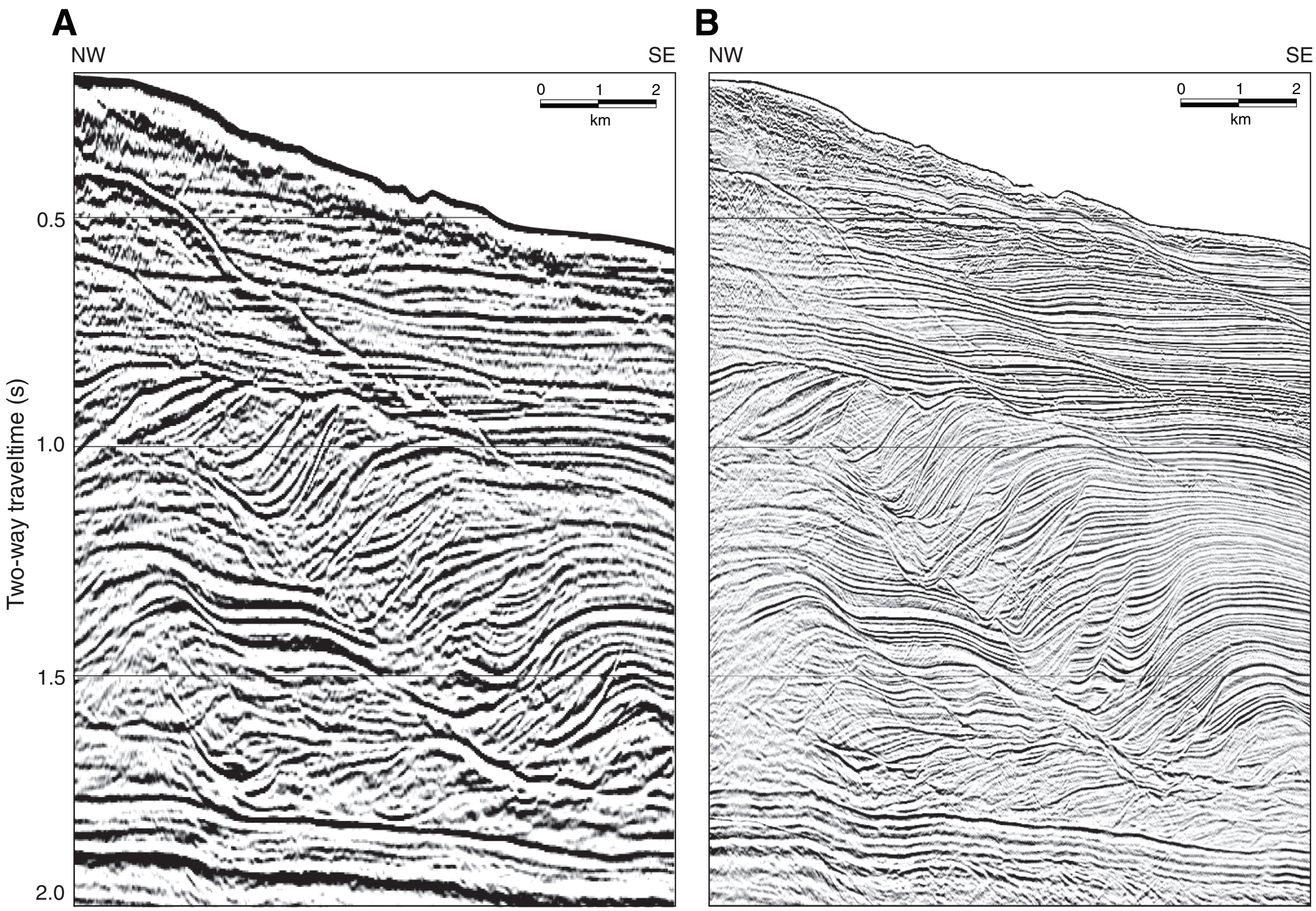


Figure F11. Ages of seismic sequence boundaries and correlation with the oxygen isotopic record, sedimentation rates, and Alpine Fault convergence rates. Two isotopic records are shown, both from Billups and Schrag (2002): (1) unmodified benthic foraminiferal $\delta^{18}O$ record from ODP Site 747 and (2) the same record corrected using Mg/Ca thermometry to remove the temperature effect and yield the $\delta^{18}O$ of seawater ($^{18}O_{sw}$), predominantly a response to ice volume and therefore an enhanced proxy for global sea level. The $\delta^{18}O_{sw}$ record correlates better both with individual seismic sequences and longer term progradational and aggradational trends, as well as with the Haq et al. (1987) eustatic curve (also shown, recalibrated to the timescale of Berggren et al., 1995). This suggests eustatic control of sequence timing. Cooling events Mi2, Mi3a, Mi3b, Mi4, and Mi5, derived from the oxygen isotope records from DSDP Site 608 and ODP Sites 703 and 704 (Miller et al., 1996), are shown. Average sedimentation rates are calculated from estimated sequence volumes. The perpendicular component of motion at the Alpine Fault plate boundary was calculated using the method of Cande and Stock (2004). Finite rotations for Australia-Pacific motion were determined for four chrons (2A, 2.58 Ma; 3A, 6.04 Ma; 5, 11.53 Ma; 6, 20.13 Ma; ages are those of Cande and Kent, 1995). The increase in both sedimentation and convergence rates over the last 5–8 m.y. correlate well. The early phase of high sedimentation rates (S2–S4) may reflect global processes. See **"2. Constrain the erosion history of the Southern Alps"** in "Secondary Objectives" for further discussion. A summary of South Island tectonic and volcanic events is also shown. (**Figure shown on next page.**).

Figure F11 (continued). (Caption shown on previous page.)

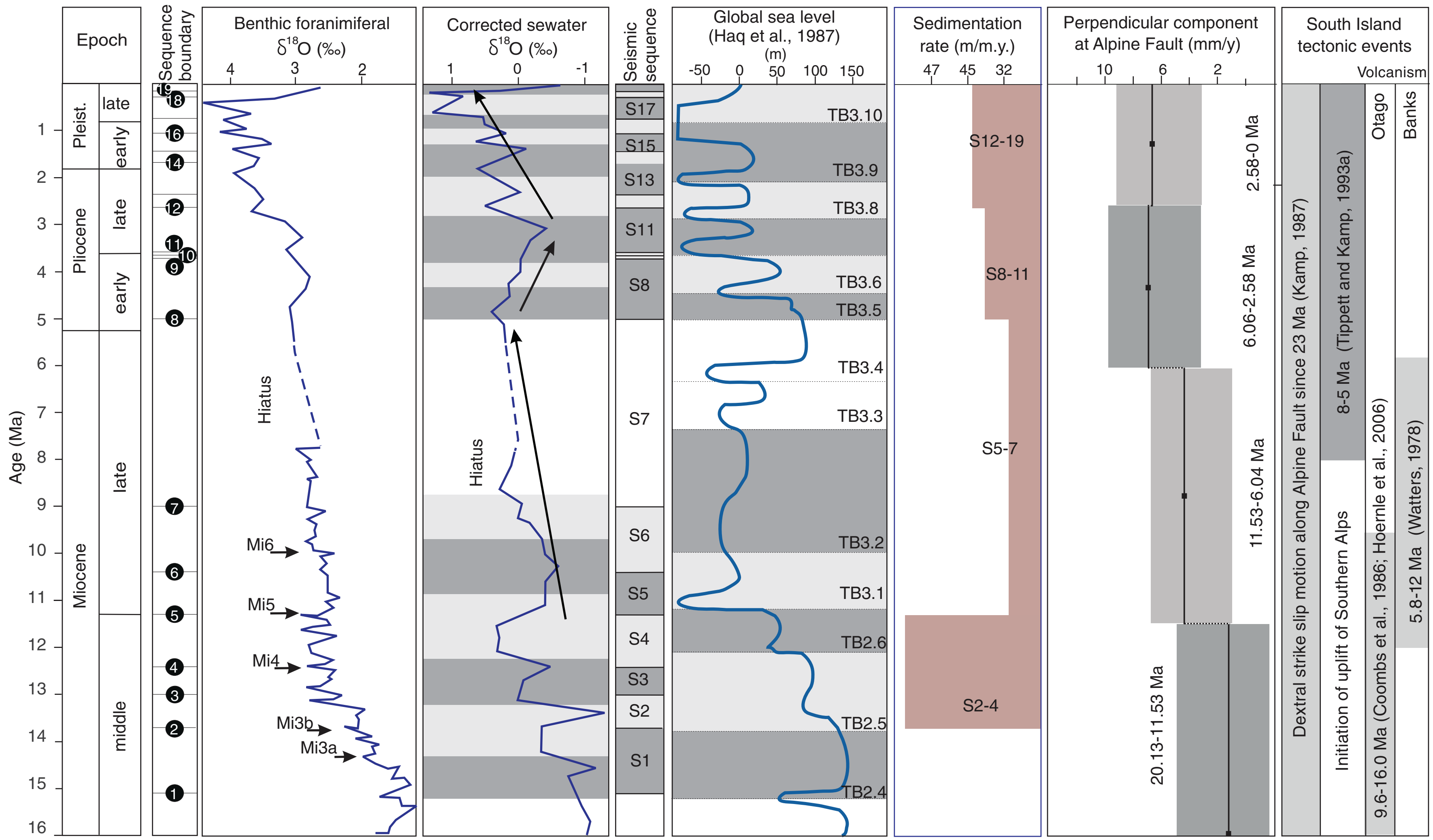
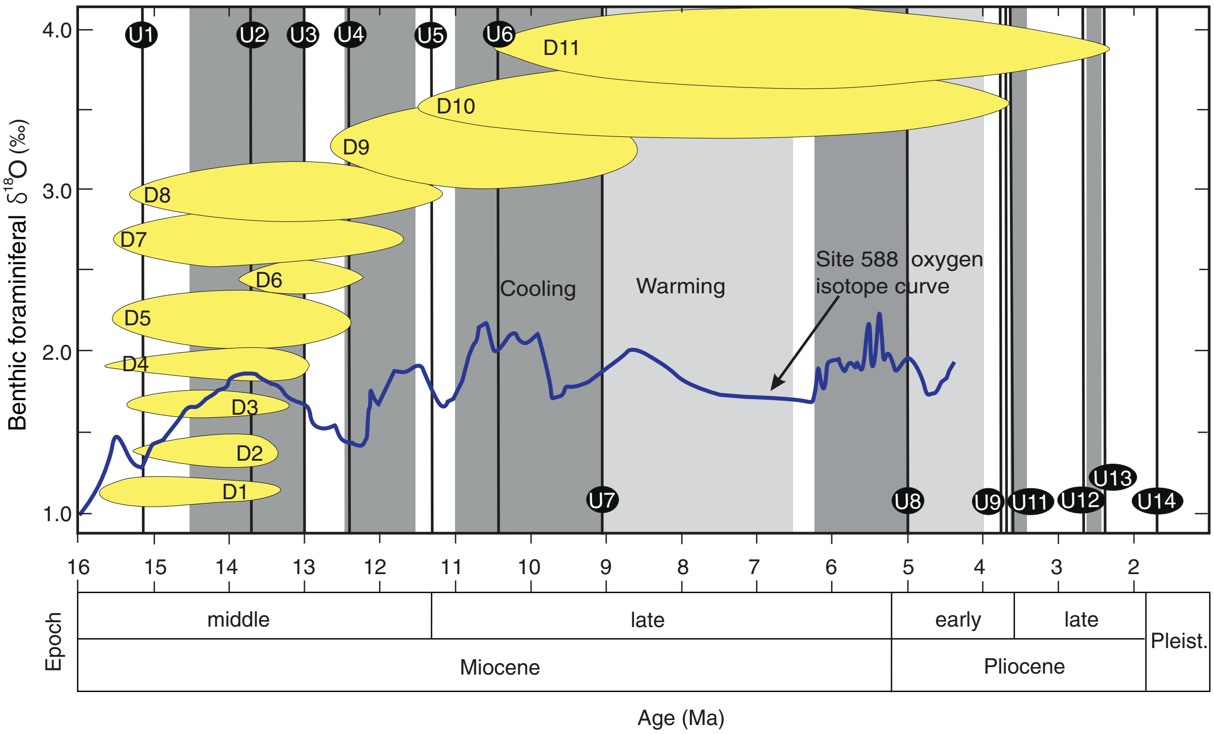


Figure F12. Correlation of Unconformities U1–U14 with periods of activity of sediment drifts and oxygen isotopic record from DSDP Site 588 in the southwest Pacific (Kennett and von der Borch, 1986). The relative size of the ellipse representing each drift is an approximate measure of drift volume. Drifts D1–D4 are of short duration (~3 m.y.), whereas Drifts D10–D11 are both larger and longer lived (~7 m.y.). Dark and light shading represent cool and warm periods, respectively, as defined by Kennett and von der Borch (1986).



Site summaries

Proposed Site CB-01A

Priority:	Primary
Position:	44°46.1085′S, 171°40.4393′E
Water depth (m):	85
Target drilling depth (mbsf):	780
Approved maximum penetration (mbsf):	780
Survey coverage:	EW00-01-66 (CDP 7250), EW00-01-01 (CDP 2456) • Track map (Fig. **AF1**) • Seismic profile (Fig. **AF2**) • Location map (Fig. **F3**) • MCS profile EW00-01-66 (Fig. **F7**)
Objective (see text for details):	Sample facies landward of clinoform breakpoints of progradational sequence boundaries, particularly Unconformities U4–U9 (middle Miocene to Pliocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) Hole B • Drill without coring to APC refusal depth • RCB coring to 780 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI Alternative: Hole A • RCB to 780 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–780 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud

Site summaries (continued)

Proposed Site CB-01B

Priority:	Alternate for CB-01A
Position:	44°49.2774′S, 171°44.9968′E
Water depth (m):	101
Target drilling depth (mbsf):	1023
Approved maximum penetration (mbsf):	1023
Survey coverage:	EW00-01-66 (CDP 5906), EW00-01-05 (CDP 10749) • Track map (Fig. **AF1**) • Seismic profile (Fig. **AF3**) • Location map (Fig. **F3**) • MCS profile EW00-01-66 (Fig. **F7**)
Objective (see text for details):	Sample facies landward of clinoform breakpoints of progradational sequence boundaries, particularly Unconformities U6–U9 and slopes of Unconformities U4–U5 (middle Miocene to Pliocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) Hole B • Drill without coring to APC refusal depth • RCB coring to 1023 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI Alternative: Hole A • RCB to 1023 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–1023 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud

Site summaries (continued)

Proposed Site CB-01C

Priority:	Alternate for CB-01A
Position:	44°50.7113′S, 171°42.7941′E
Water depth (m):	97
Target drilling depth (mbsf):	976
Approved maximum penetration (mbsf):	976
Survey coverage:	EW00-01-70 (CDP 1836), EW00-01-05 (CDP 11378) • Track map (Fig. **AF1**) • Seismic profile (Fig. **AF4**) • Location map (Fig. **F3**)
Objective (see text for details):	Sample facies landward of clinoform breakpoints of progradational sequence boundaries, particularly Unconformities U6–U19 and slopes of Unconformities U4–U5 (middle Miocene to Pliocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) Hole B • Drill without coring to APC refusal depth • RCB coring to 976 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI Alternative: Hole A • RCB to 976 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–976 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud

Site summaries (continued)

Proposed Site CB-02A

Priority:	Primary
Position:	44°50.8274′S, 171°47.2079′E
Water depth (m):	111
Target drilling depth (mbsf):	800
Approved maximum penetration (mbsf):	800
Survey coverage:	EW00-01-66 (CDP 5250), EW00-01-07A (CDP 2591) • Track map (Fig. **AF1**) • Seismic profile (Fig. **AF5**) • Location map (Fig. **F3**) • MCS profile EW00-01-66 (Fig. **F7**)
Objective (see text for details):	Sample facies landward of clinoform breakpoints of progradational sequence boundaries, particularly near breakpoints of Unconformities U7–U9 and Unconformity U6 slope (late Miocene to Pliocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) Hole B • Drill without coring to APC refusal depth • RCB coring to 800 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI Alternative: Hole A • RCB to 800 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–800 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud

Site summaries (continued)

Proposed Site CB-02B

Priority:	Alternate for CB-02A
Position:	44°51.8507′S, 171°48.6836′E
Water depth (m):	116
Target drilling depth (mbsf):	918
Approved maximum penetration (mbsf):	918
Survey coverage:	EW00-01-66 (CDP 4816), EW00-01-09 (CDP 14229) • Track map (Fig. **AF1**) • Seismic profile (Fig. **AF6**) • Location map (Fig. **F3**) • MCS profile EW00-01-66 (Fig. **F7**)
Objective (see text for details):	Sample facies landward of clinoform breakpoints of progradational sequence boundaries, particularly near breakpoints of Unconformities U7–U9 and Unconformity U6 slope (late Miocene to Pliocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) Hole B • Drill without coring to APC refusal depth • RCB coring to 918 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI Alternative: Hole A • RCB to 918 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–918 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud

Site summaries (continued)

Proposed Site CB-03A

Priority:	Alternate for CB-03B
Position:	44°53.4453′S, 171°50.9851′E
Water depth (m):	125
Target drilling depth (mbsf):	1318
Approved maximum penetration (mbsf):	1318
Survey coverage:	EW00-01-66 (CDP 4139), EW00-01-13 (CDP 12117) • Track map (Fig. **AF1**) • Seismic profile (Fig. **AF7**) • Location map (Fig. **F3**) • MCS profile EW00-01-66 (Fig. **F7**)
Objective (see text for details):	Sample facies landward of, but close to, clinoform breakpoints of progradational sequence boundaries, particularly Unconformities U8–U19 and slope facies of Unconformities U4–U7 (middle Miocene to Holocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) • Wireline log (triple combo, FMS-sonic) • VSP with VSI Hole B • Drill without coring to APC refusal depth • RCB coring to 1318 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI Alternative: Hole A • RCB to 1318 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–1318 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud

Site summaries (continued)

Proposed Site CB-03B

Priority:	Primary
Position:	44°53.0308′S, 171°50.4059′E
Water depth (m):	121
Target drilling depth (mbsf):	1249
Approved maximum penetration (mbsf):	1249
Survey coverage:	EW00-01-66 (CDP 4313), CB-82-25 (CDP 17882) • Track map (Fig. **AF1**) • Seismic profile (Fig. **AF8**) • Location map (Fig. **F3**) • MCS profile EW00-01-66 (Fig. **F7**)
Objective (see text for details):	Sample facies landward of, but close to, clinoform breakpoints of progradational sequence boundaries, particularly Unconformities U8–U19 and slope facies of Unconformities U4–U7 (middle Miocene to Holocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) • Wireline log (triple combo, FMS-sonic) • VSP with VSI Hole B • Drill without coring to APC refusal depth • RCB coring to 1249 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI Alternative: Hole A • RCB to 1249 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–1249 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud

Site summaries (continued)

Proposed Site CB-04A

Priority:	Alternate for CB-04B
Position:	44°56.0933′S, 172°01.1532′E
Water depth (m):	340
Target drilling depth (mbsf):	1270
Approved maximum penetration (mbsf):	1270
Survey coverage:	EW00-01-60 (CDP 2072), EW00-01-19a (CDP 3147) • Track map (Fig. **AF1**) • Seismic profile (Fig. **AF9**) • Location map (Fig. **F3**) • Dip profile EW00-01-60 (Fig. **F9**)
Objective (see text for details):	Sample slope facies of progradational sequence boundaries, particularly Unconformities U7–U9 (middle/late Miocene to early Pliocene), U11, and U13–U19 (Pliocene to Holocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) • Wireline log (triple combo, FMS-sonic) • VSP with VSI Hole B • Drill without coring to APC refusal depth • RCB coring to 1270 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–1270 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud

Site summaries (continued)

Proposed Site CB-04B

Priority:	Primary
Position:	44°56.2443′S, 172°01.3629′E
Water depth (m):	346
Target drilling depth (mbsf):	1700
Approved maximum penetration (mbsf):	1913
Survey coverage:	EW00-01-60 (CDP 2010), no crossing line (close to EW00-01-19a) • Track map (Fig. **AF1**) • Seismic profile (Fig. **AF10**) • Location map (Fig. **F3**) • Dip profile EW00-01-60 (Fig. **F9**)
Objective (see text for details):	Sample slope facies of progradational sequence boundaries, particularly Unconformities U4, U6–U9 (middle Miocene to early Pliocene), U11, and U13–U19 (Pliocene to Holocene) plus Marshall Paraconformity (if located above 1700 mbsf) (Oligocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) Hole B • Drill without coring to APC refusal depth • RCB coring to 1700 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI Hole C • Drill without coring (tricone bit) to 800 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–1647 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud 1647 mbsf (or slightly shallower)–1913 mbsf: Limestone

Site summaries (continued)

Proposed Site CB-04C

Priority:	Alternate for CB-04B
Position:	44°57.8052′S, 172°03.6799′E
Water depth (m):	713
Target drilling depth (mbsf):	1500
Approved maximum penetration (mbsf):	Pending approval
Survey coverage:	EW00-01-60 (CDP 1338), no crossing line • Track map (Fig **AF1**) • Seismic profile (Fig **AF11**) • Location map (Fig. **F3**)
Objective (see text for details):	Sample slope facies of progradational sequence boundaries, particularly Unconformities U6–U9, U11, and U13–16 (Late Miocene to early Pliocene) Sample Marshall Paraconformity (Oligocene) and top of Amuri Limestone (late Eocene)
Drilling, coring, and downhole measurement program:	Hole A: • APC/XCB to refusal (APC core orientation) • Wireline log (triple combo, FMS-sonic) • VSP with VSI Hole B: • Drill without coring to APC refusal depths • RCB coring to 1500 mbsf • wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–1282 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud 1282 mbsf (or slightly shallower)–1500 mbsf: Limestone

Site summaries (continued)

Proposed Site CB-05B

Priority:	Global alternate
Position:	44°41.6069′S, 172°32.1071′E
Water depth (m):	390
Target drilling depth (mbsf):	1783
Approved maximum penetration (mbsf):	1783
Survey coverage:	EW00-01-14 (CDP 6667), EW00-01-23 (CDP 3020) • Track map (Fig. **AF12**) • Seismic profile (Fig. **AF13**) • Location map (Fig. **F3**)
Objective (see text for details):	Sample current-deposited sediments on the slope, particularly large sediment Drift D11 (late Miocene to early Pliocene) Sample Marshall Paraconformity and top of Amuri Limestone (late Eocene to early Oligocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) • Wireline log (triple combo, FMS-sonic) • VSP with VSI Hole B • Drill without coring to APC refusal depth • RCB coring to 1783 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–1598 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud 1598 mbsf (or slightly shallower)–1783 mbsf: Limestone

Site summaries (continued)

Proposed Site CB-05C

Priority:	Global alternate
Position:	44°41.5230′S, 172°33.9178′E
Water depth (m):	402
Target drilling depth (mbsf):	1625
Approved maximum penetration (mbsf):	1625
Survey coverage:	EW00-01-12 (CDP 3190), no crossing line • Track map (Fig. **AF12**) • Seismic profile (Fig. **AF14**) • Location map (Fig. **F3**) • Dip profile EW00-01-12 (Fig. **F8**)
Objective (see text for details):	Sample current-deposited sediments on the slope, particularly large sediment Drift D11 (late Miocene to early Pliocene) Sample Marshall Paraconformity and top of Amuri Limestone (late Eocene to early Oligocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) • Wireline log (triple combo, FMS-sonic) • VSP with VSI Hole B • Drill without coring to APC refusal depth • RCB coring to 1625 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–1593 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud 1593 mbsf (or slightly shallower)–1625 mbsf: Limestone

Site summaries (continued)

Proposed Site CB-05D

Priority:	Global alternate
Position:	44°41.6521′S, 172°32.1686′E
Water depth (m):	390
Target drilling depth (mbsf):	1783
Approved maximum penetration (mbsf):	1783
Survey coverage:	EW00-01-14 (CDP 6687), CB-82-47 (CDP 14540) • Track map (Fig. **AF12**) • Seismic profile (Fig. **AF15**) • Location map (Fig. **F3**)
Objective (see text for details):	Sample current-deposited sediments on the slope, particularly large sediment Drift D11 (late Miocene to early Pliocene) Sample Marshall Paraconformity and top of Amuri Limestone (late Eocene to early Oligocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) • Wireline log (triple combo, FMS-sonic) • VSP with VSI Hole B • Drill without coring to APC refusal depth • RCB coring to 1783 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–1595 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud 1595 mbsf (or slightly shallower)–1783 mbsf: Limestone

Site summaries (continued)

Proposed Site CB-05E

Priority:	Global alternate
Position:	44°41.5377′S, 172°32.2100′E
Water depth (m):	389
Target drilling depth (mbsf):	1789
Approved maximum penetration (mbsf):	1789
Survey coverage:	EW00-01-23 (CDP 2988), no crossing line (near EW00-01-14) • Track map (Fig. **AF12**) • Seismic profile (Fig. **AF16**) • Location map (Fig. **F3**)
Objective (see text for details):	Sample current-deposited sediments on the slope, particularly large sediment Drift D11 (late Miocene to early Pliocene) Sample Marshall Paraconformity and top of Amuri Limestone (late Eocene to early Oligocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) • Wireline log (triple combo, FMS-sonic) • VSP with VSI Hole B • Drill without coring to APC refusal depth • RCB coring to 1789 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–1605 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud 1605 mbsf (or slightly shallower)–1789 mbsf: Limestone

Site summaries (continued)

Proposed Site CB-05F

Priority:	Global alternate
Position:	44°44.4039′S, 172°35.8192′E
Water depth (m):	682
Target drilling depth (mbsf):	1320
Approved maximum penetration (mbsf):	Pending approval
Survey coverage:	EW00-01-14 (CDP 7810), no crossing line • Track map (Fig. AF12) • Seismic profile (Fig. AF17) • Location map (Fig. F3)
Objective (see text for details):	Sample current-deposited sediments on the slope, particularly large sediment Drift D11 (late Miocene to early Pliocene) Sample Marshall Paraconformity and top of Amuri Limestone (late Eocene to early Oligocene)
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) • Wireline log (triple combo, FMS-sonic) • VSP with VSI Hole B • Drill without coring to APC refusal depths • RCB coring to 1320 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–1199 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud 1199 mbsf (or slightly shallower)–1320 mbsf: Limestone

Site summaries (continued)

Proposed Site CB-06B

Priority:	Global alternate
Position:	45°02.2126′S, 172°03.7098′E
Water depth (m):	1158
Target drilling depth (mbsf):	1106
Approved maximum penetration (mbsf):	1106
Survey coverage:	EW00-01-66 (CDP 408), no crossing line • Track map (Fig. **AF1**) • Seismic profile (Fig. **AF18**) • Location map (Fig. **F3**)
Objective (see text for details):	Sample Marshall Paraconformity and top of Amuri Limestone (late Eocene to early Oligocene) Sample distal facies of sequences. Identified at this site are Unconformities U13, U11, U9, and U7 (late Miocene to late Pliocene).
Drilling, coring, and downhole measurement program:	Hole A • APC/XCB to refusal (APC core orientation) Hole B • Drill without coring to APC refusal depth • RCB coring to 1106 mbsf • Wireline log (triple combo, FMS-sonic) • VSP with VSI
Anticipated lithology:	0–871 mbsf: Terrigenous siltstone and silty mudstone with intervals of fine-grained sand and mud 871 mbsf (or slightly shallower)–1106 mbsf: Limestone

Figure AF1. Track map for proposed Sites CB-01A, CB-01B, CB-01C, CB-02A, CB-02B, CB-03A, CB-03B, CB-04A, CB-04B, CB-04C, and CB-06B. Track lines are all EW00-01 profiles, except for CB-82-25. Only profiles crossing sites are shown for clarity. Common depth points (CDPs) are at 1000 CDP intervals.

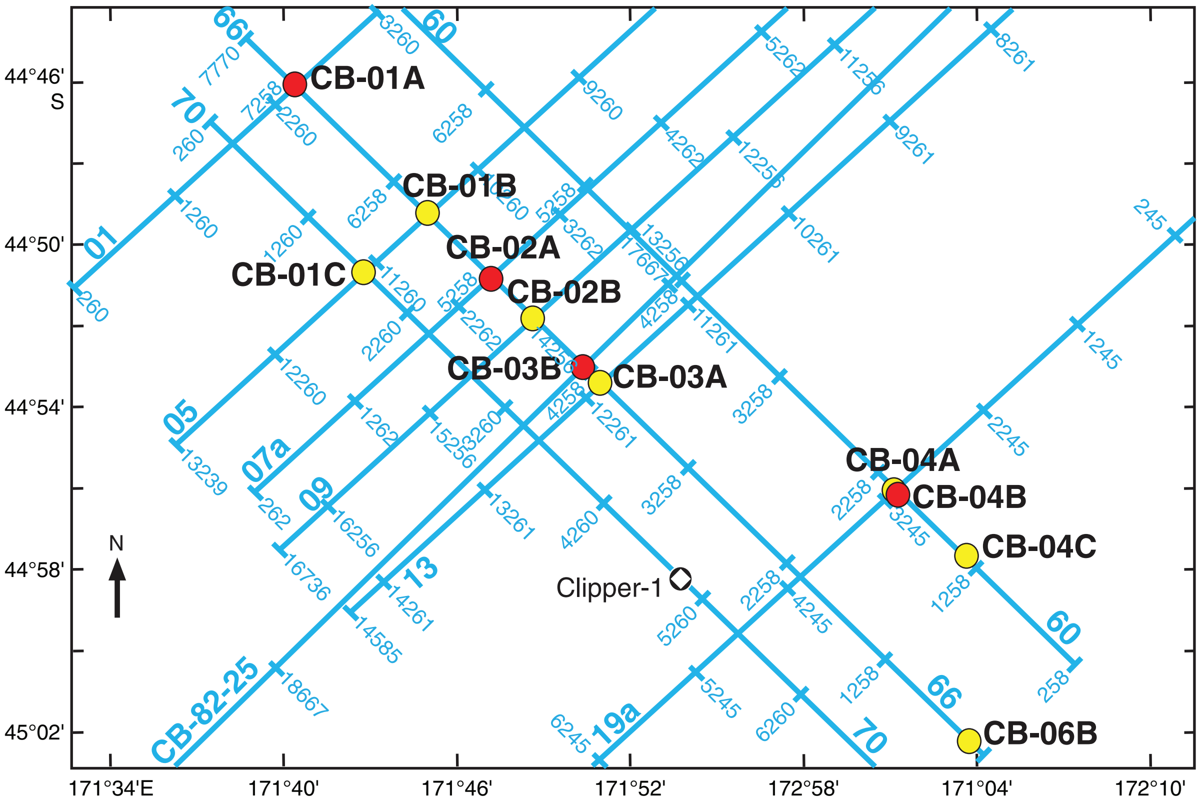


Figure AF2. Proposed Site CB-01A. CDP = common depth point, MP = Marshall Paraconformity.

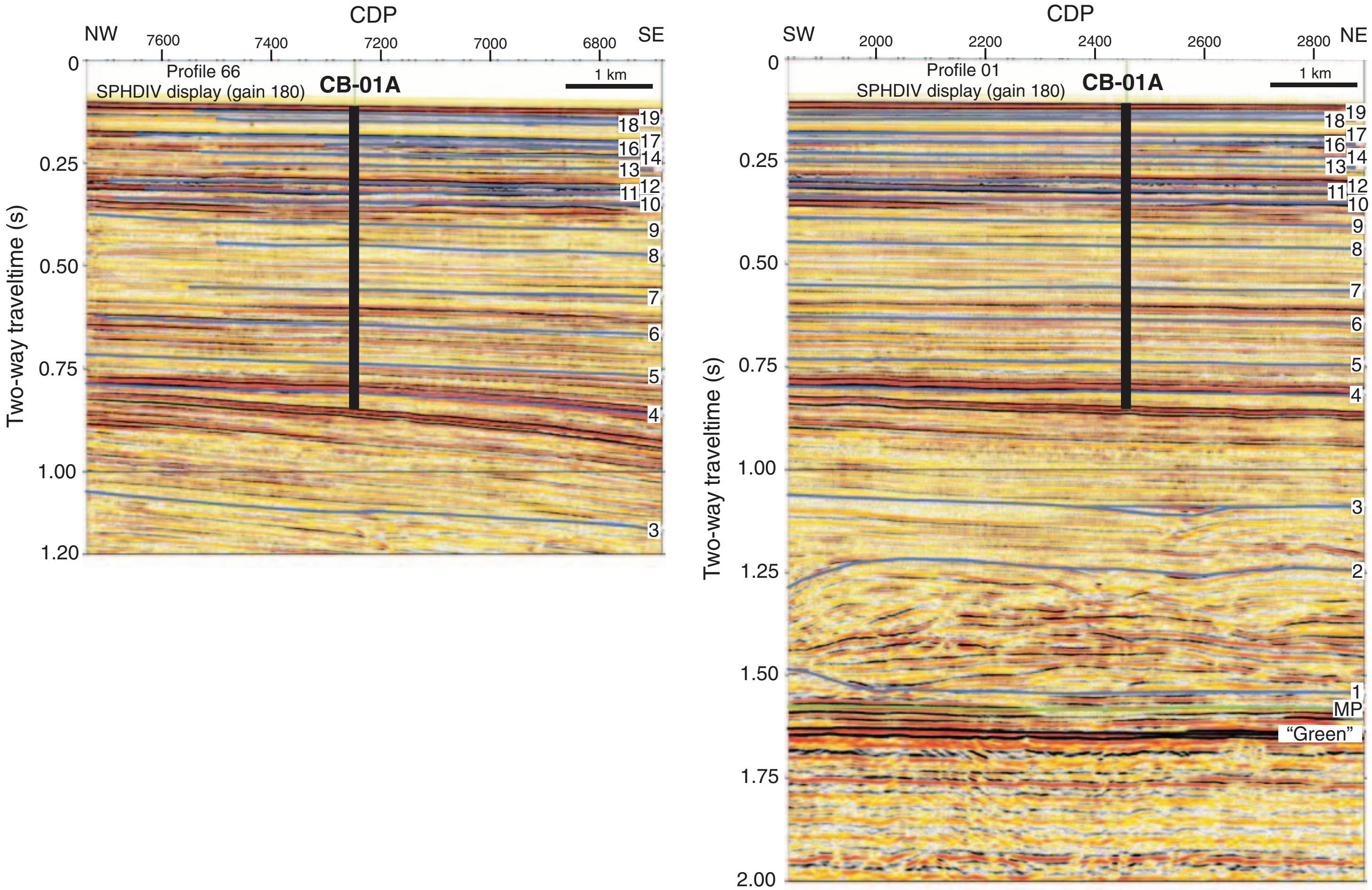


Figure AF3. Proposed Site CB-01B. CDP = common depth point, MP = Marshall Paraconformity.

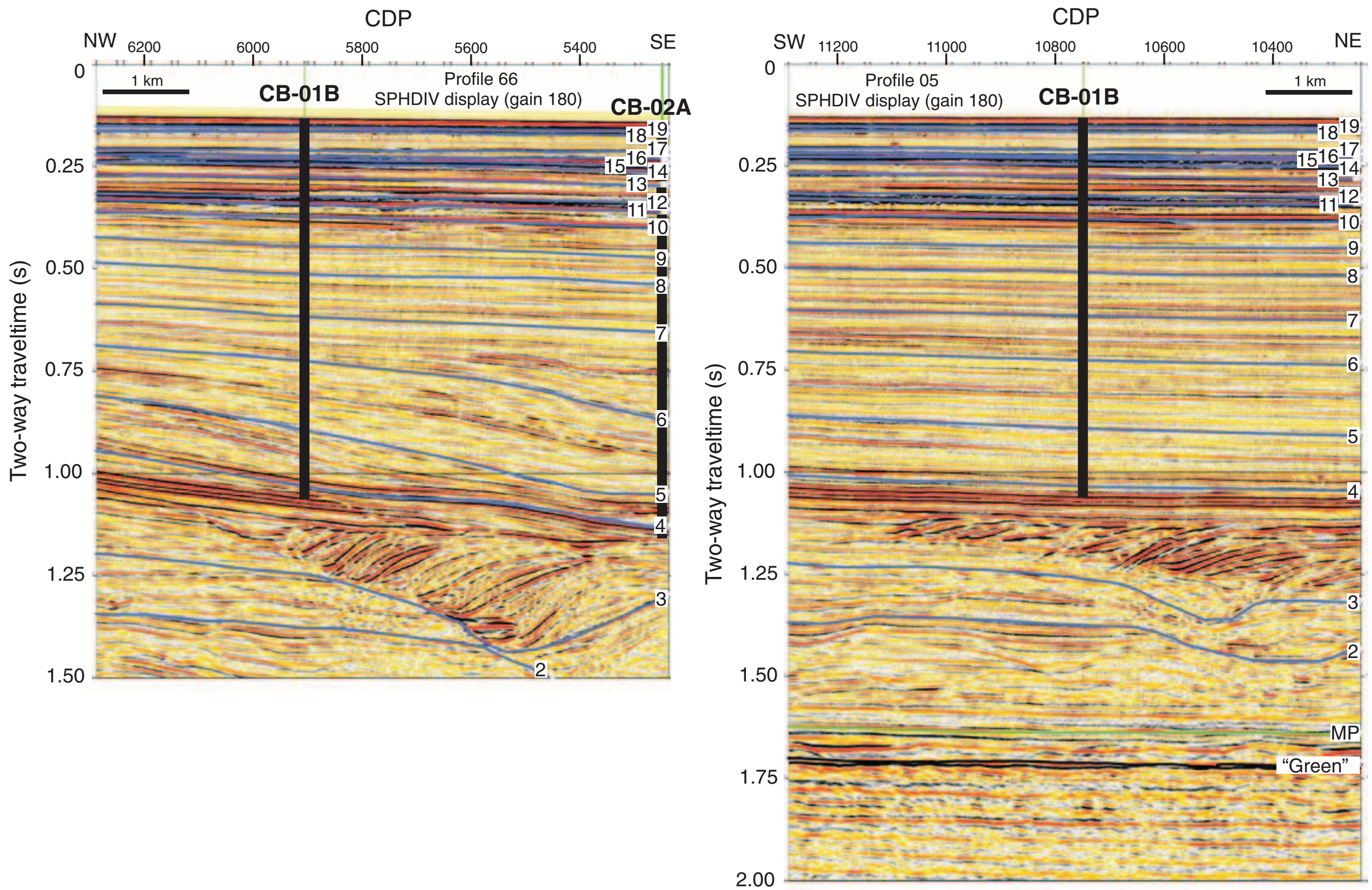


Figure AF4. Proposed Site CB-01C. CDP = common depth point, MP = Marshall Paraconformity.

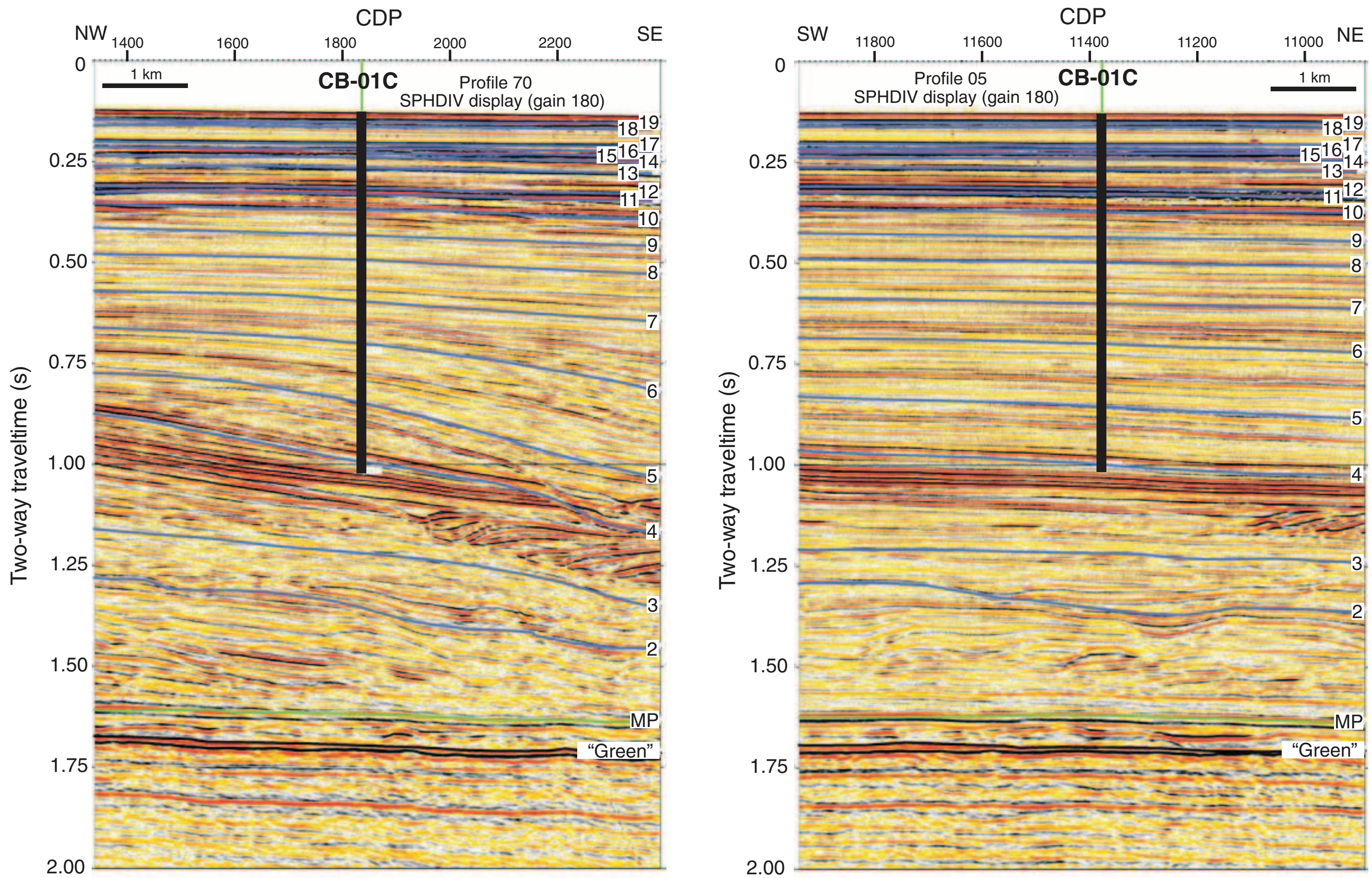


Figure AF5. Proposed Site CB-02A. CDP = common depth point, MP = Marshall Paraconformity.

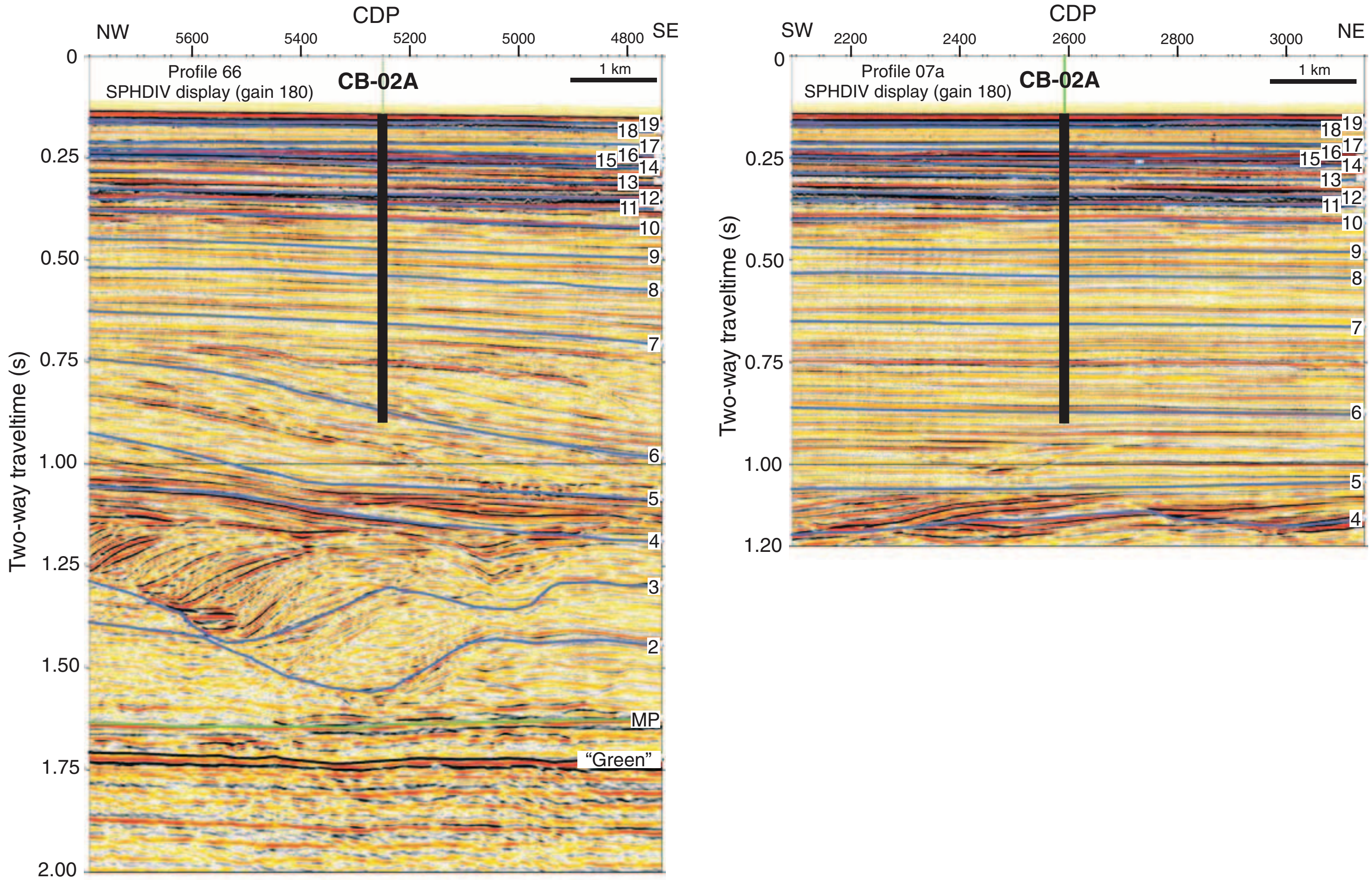


Figure AF6. Proposed Site CB-02B. CDP = common depth point, MP = Marshall Paraconformity.

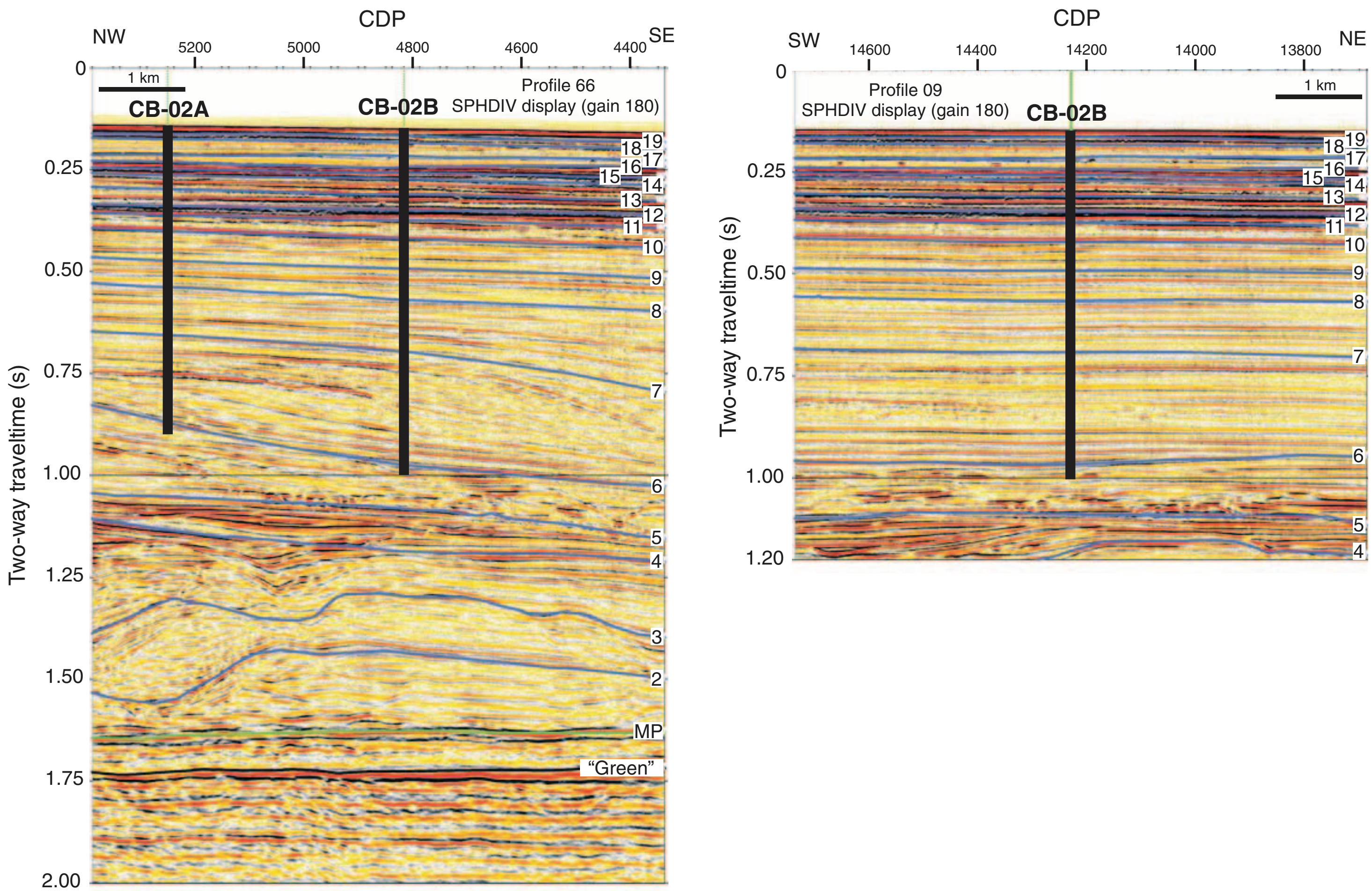


Figure AF7. Proposed Site CB-03A. CDP = common depth point, MP = Marshall Paraconformity.

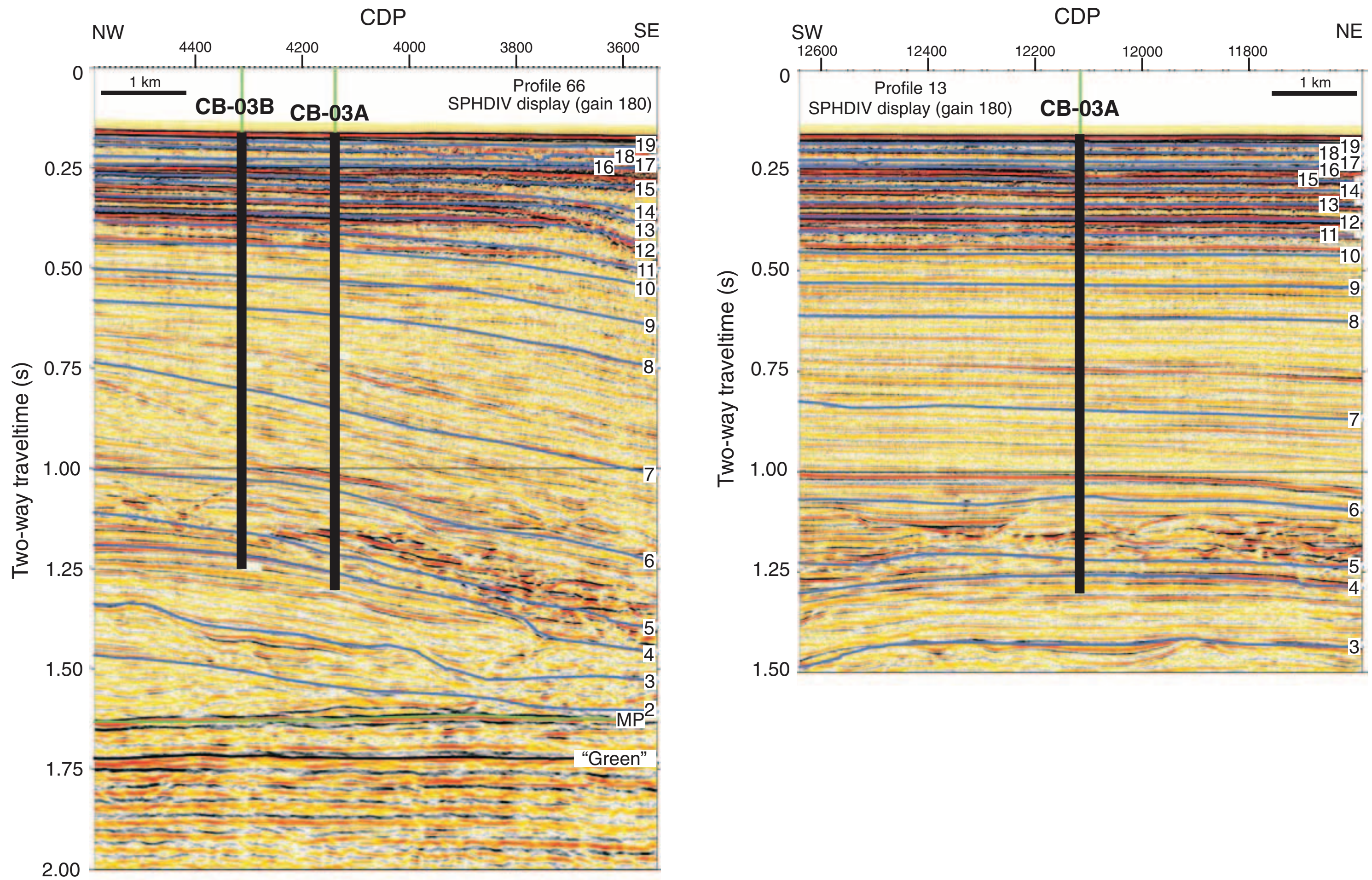


Figure AF8. Proposed Site CB-03B. CDP = common depth point, MP = Marshall Paraconformity.

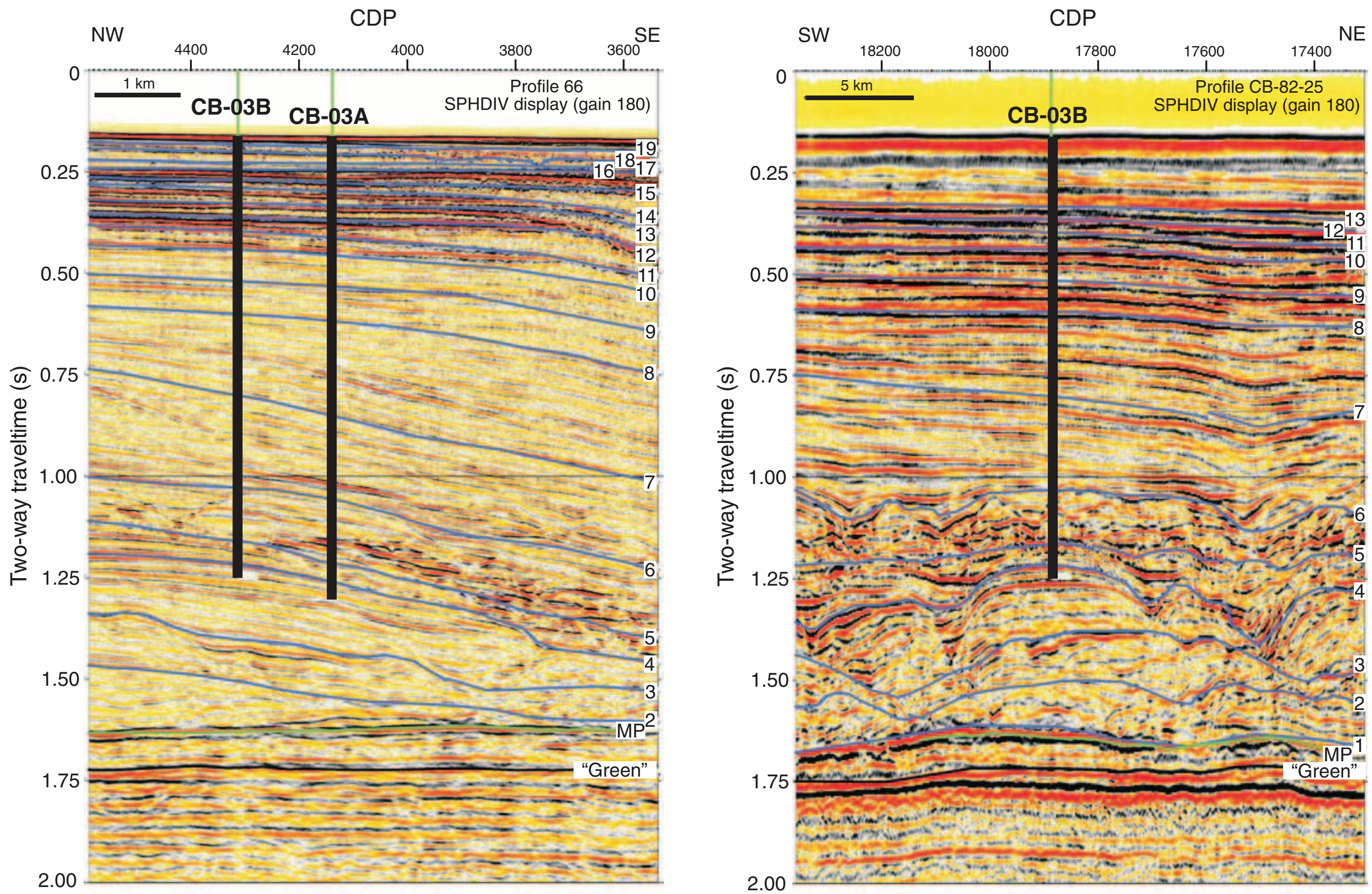


Figure AF9. Proposed Site CB-04A. CDP = common depth point, MP = Marshall Paraconformity.

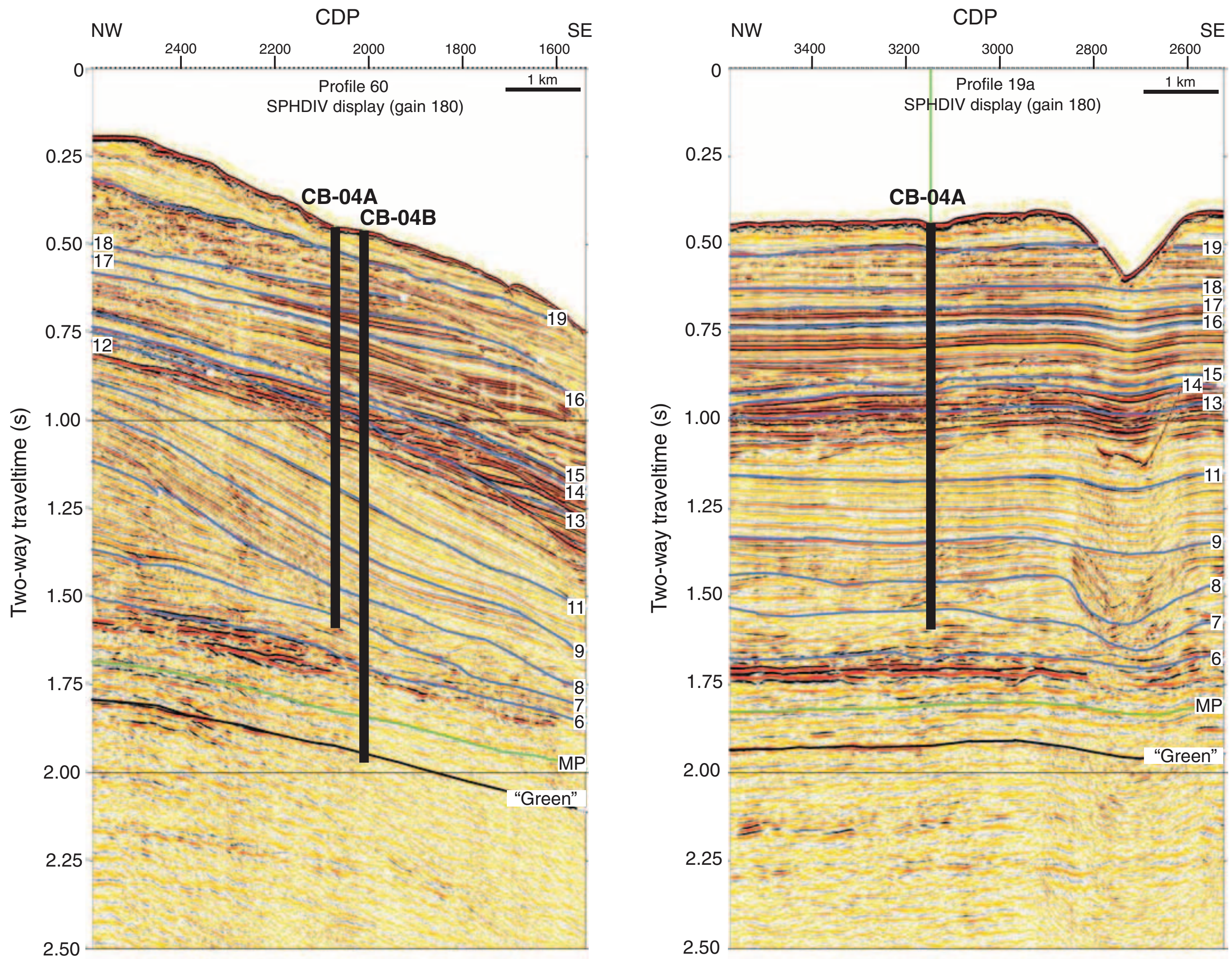


Figure AF10. Proposed Site CB-04B. There is no crossing profile. CDP = common depth point, MP = Marshall Paraconformity.

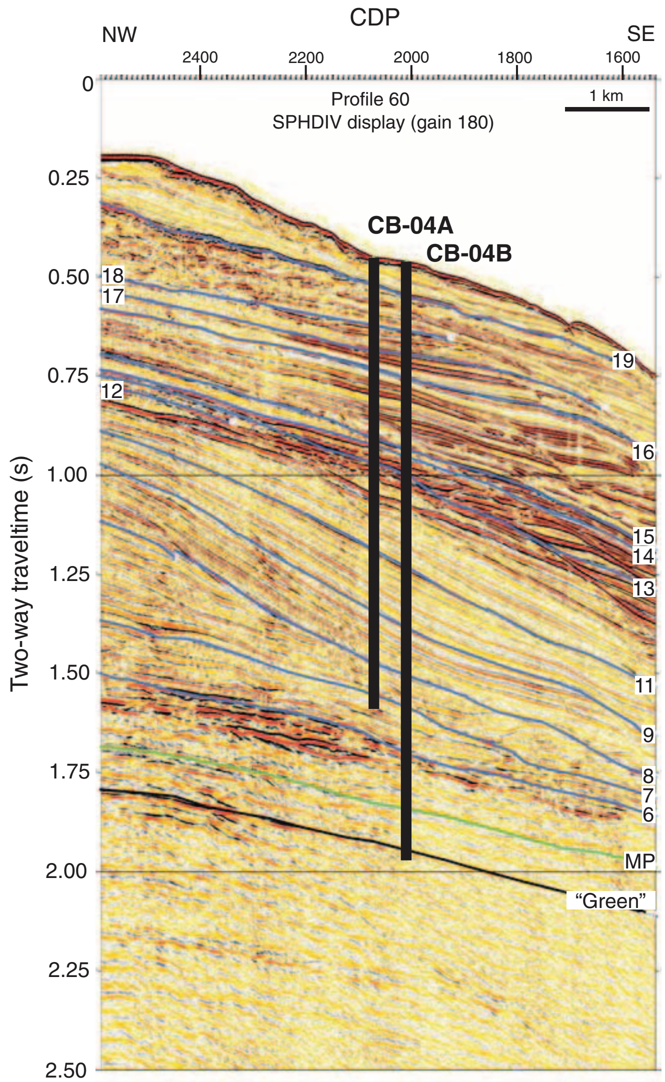


Figure AF11. Proposed Site CB-04C. There is no crossing profile. CDP = common depth point, MP = Marshall Paraconformity.

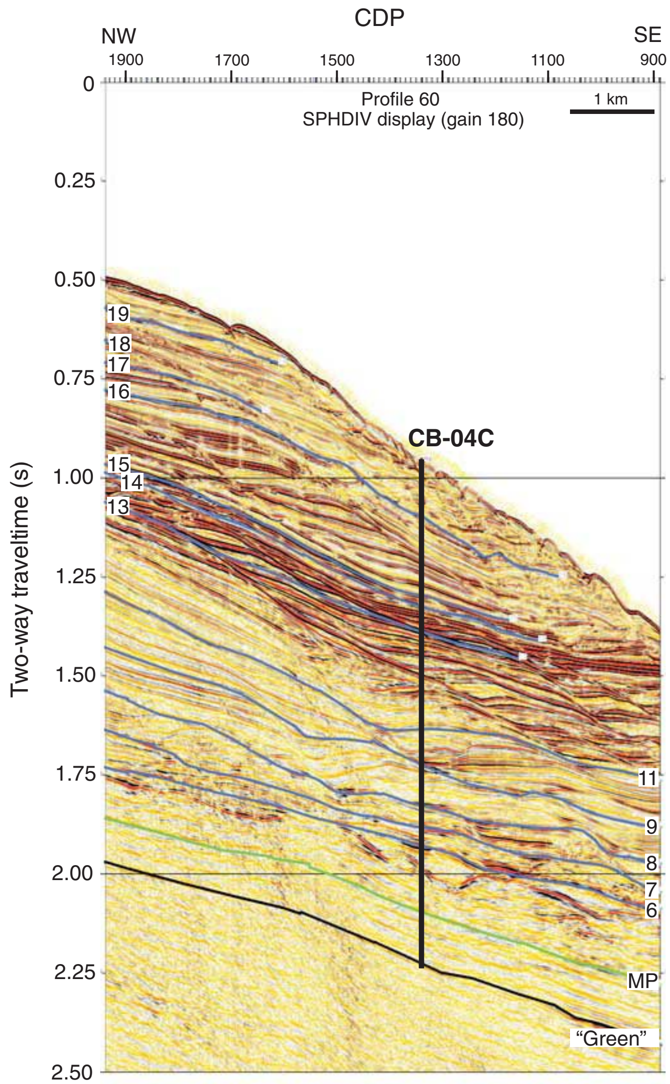


Figure AF12. Track map for proposed Sites CB-05B, CB-05C, CB-05D, CB-05E, and CB-05F. Ocean Drilling Program (ODP) Site 1119 is also shown. Blue track lines = EW00-01 profiles, red = CB-82-47. Only profiles crossing sites are shown for clarity. Common depth points (CDPs) are at 1000 CDP intervals.

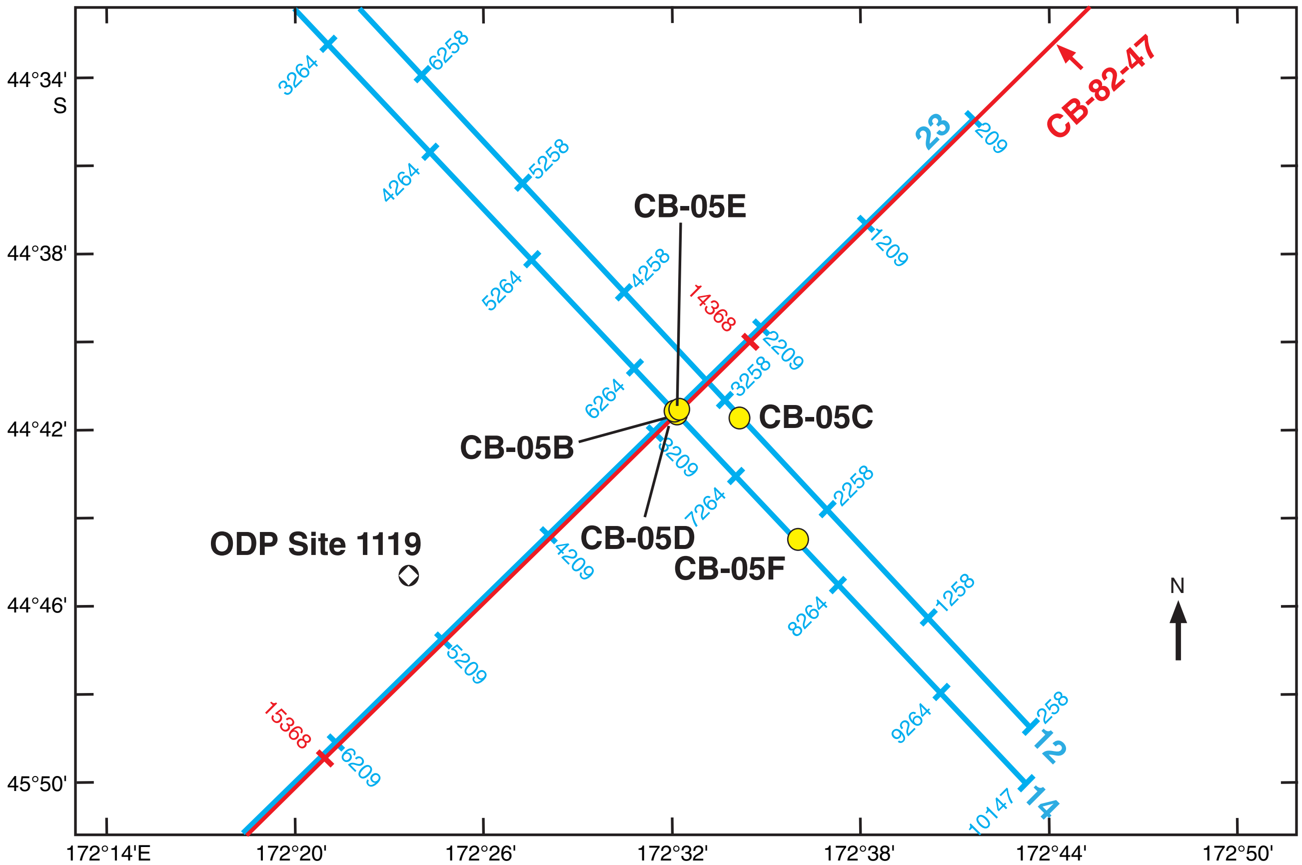


Figure AF13. Proposed Site CB-05B. CDP = common depth point, MP = Marshall Paraconformity.

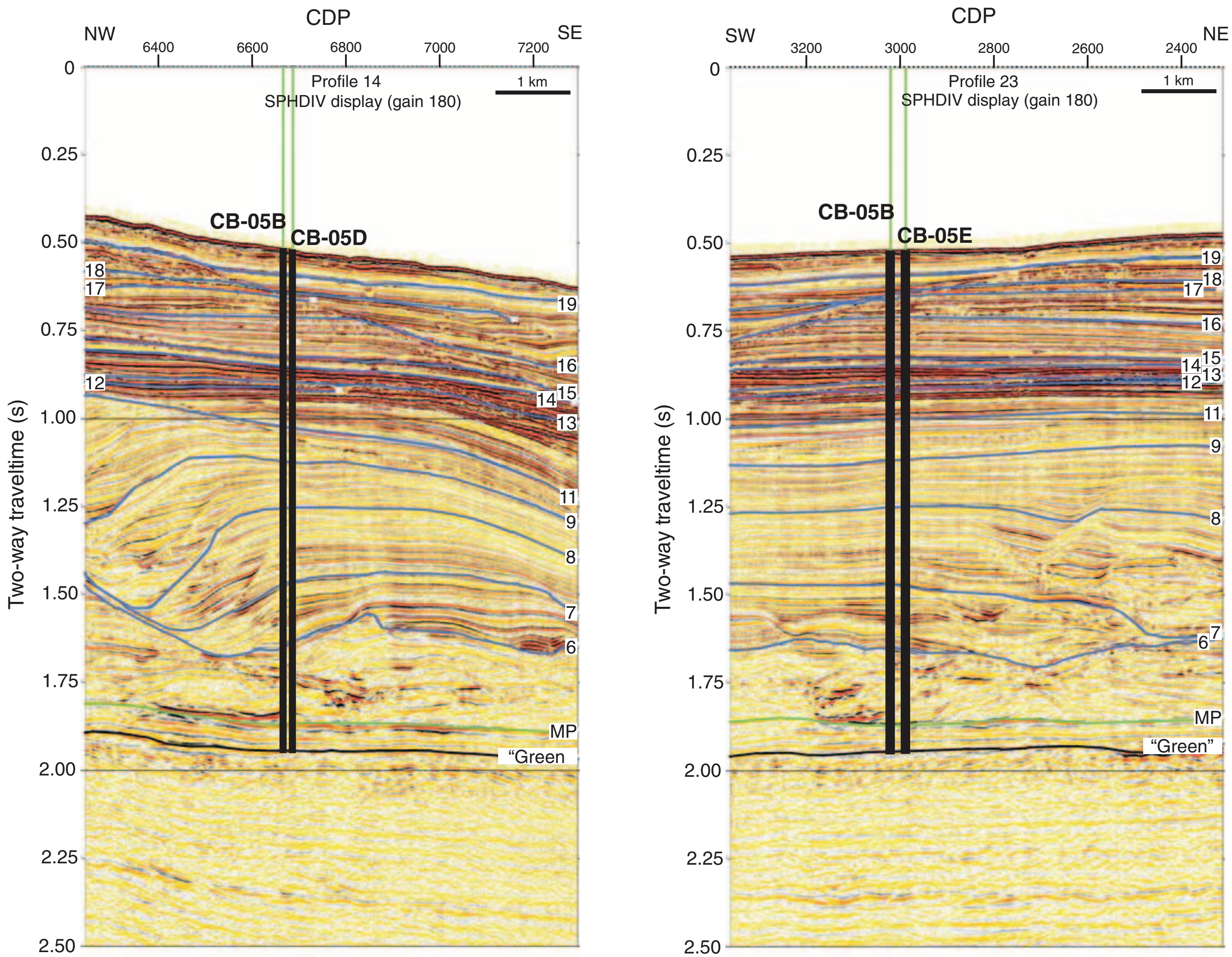


Figure AF14. Proposed Site CB-05C. There is no crossing profile. CDP = common depth point, MP = Marshall Paraconformity.

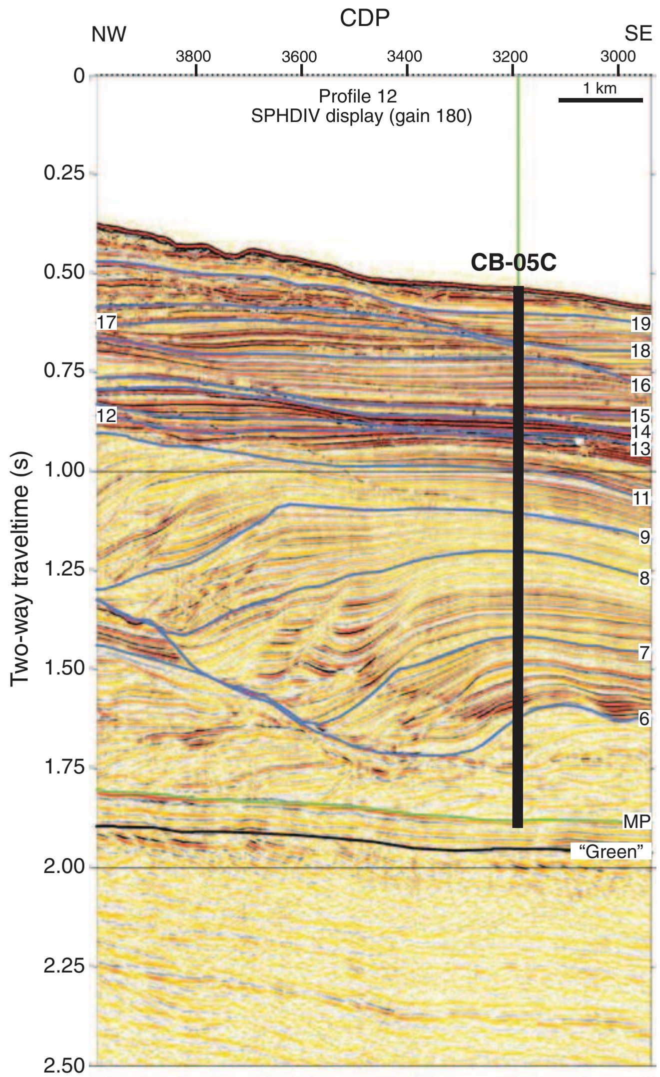


Figure AF15. Proposed Site CB-05D. CDP = common depth point, MP = Marshall Paraconformity.

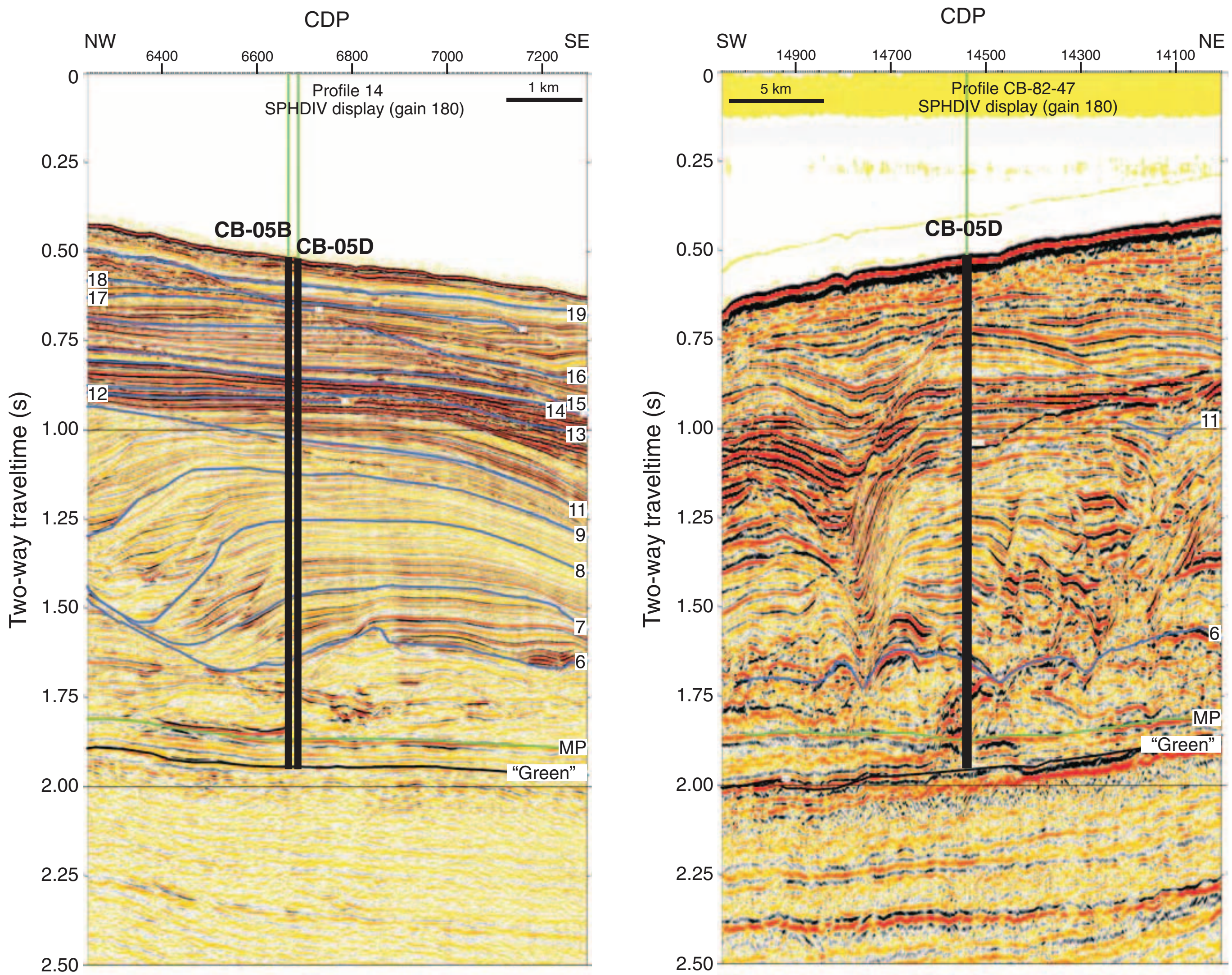


Figure AF16. Proposed Site CB-05E. There is no crossing profile. CDP = common depth point, MP = Marshall Paraconformity.

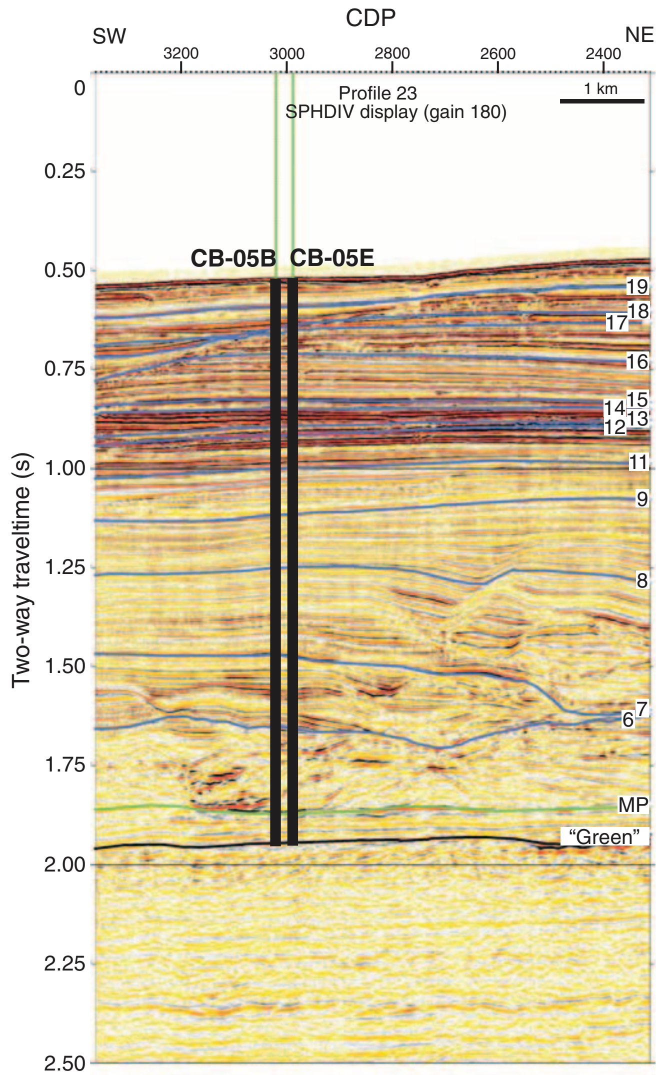


Figure AF17. Proposed Site CB-05F. There is no crossing profile. CDP = common depth point, MP = Marshall Paraconformity.

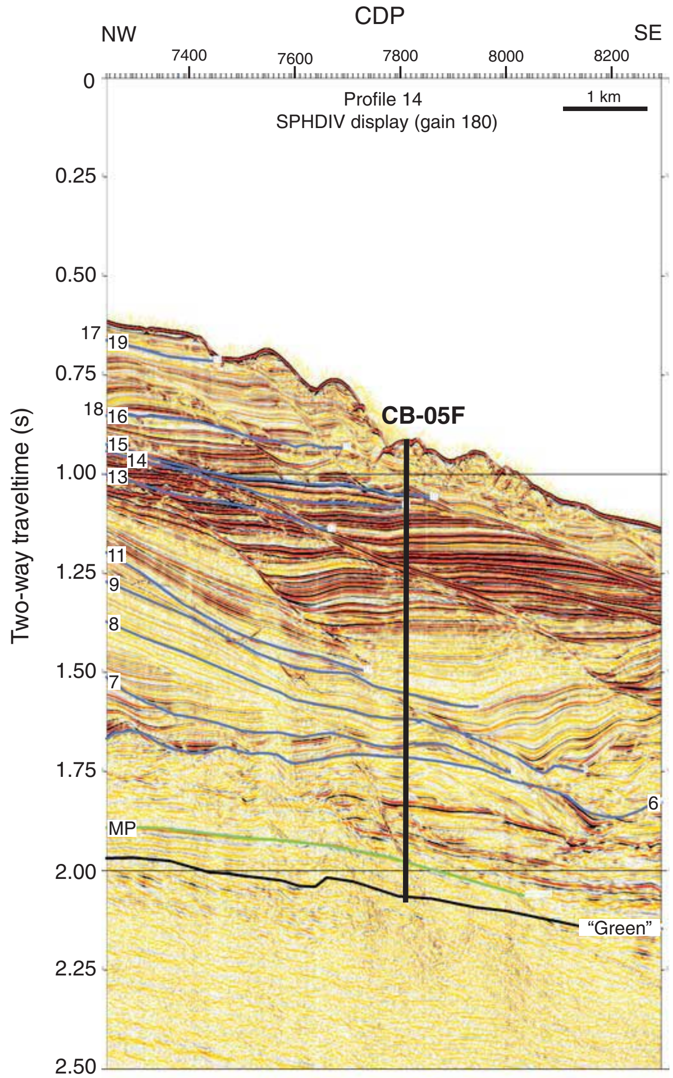
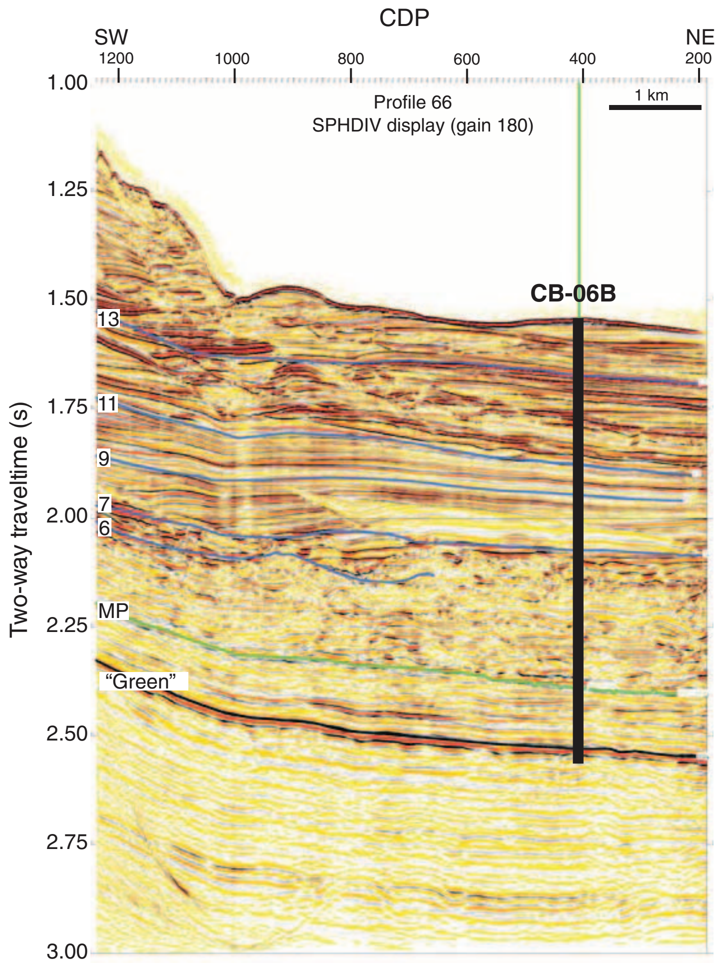


Figure AF18. Proposed Site CB-06B. There is no crossing profile. CDP = common depth point, MP = Marshall Paraconformity.



Expedition scientists and scientific participants

The current list of participants for Expedition 317 can be found at **iodp.tamu.edu/scienceops/precruise/canterbury/participants.html.**