Erbacher, J., Mosher, D.C., Malone, M.J., et al., 2004
Proceedings of the Ocean Drilling Program, Initial Reports Volume 207

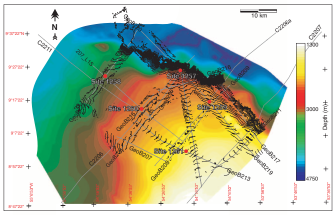
3. SITE SURVEY AND UNDERWAY GEOPHYSICS: DEMERARA RISE, LEG 207[1]

Shipboard Scientific Party[2]

INTRODUCTION

Seismic stratigraphy is critical to understanding the distribution, structure, and thickness of sedimentary formations. These data provide understanding of sedimentary history and critical information for safe and productive drilling. The seismic stratigraphy of the Demerara Rise and Ocean Drilling Program (ODP) Leg 207 drill site locations was established on the basis of existing industry multichannel seismic reflection data, high-resolution multichannel seismic reflection data, and ultra high resolution Parasound echo sounder data. In addition, a short single-channel seismic reflection line was run during ODP Leg 207 by the Underway Geophysics laboratory on the *JOIDES Resolution*. Figure **F1** shows the cruise tracks over the Demerara Rise for data used in this study.

F1. Seismic cruise tracks, p. 5.



METHODS

Seismic reflection data for ODP Leg 207 and the Demerara Rise come from three principal sources.

Industry Multichannel Seismic Reflection

A suite of four industry multichannel seismic reflection lines transects the study area. Shell International acquired these data from the survey vessel *Petrel* (March 1974). Line numbers are C2206, C2207, C2211, and C2212. These data were acquired with a 19.6-L (1200 in^3) air gun array of 14 guns towed at a depth of 7–9 m and a Seismic Engineering Multidyne streamer consisting of 60 channels over 3298 m

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[1] Examples of how to reference the whole or part of this volume.
[2] Shipboard Scientific Party addresses.

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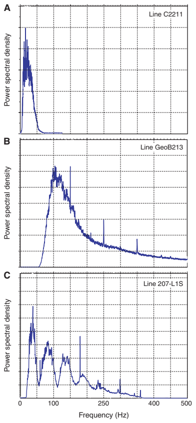
towed at a depth of 15–20 m. The shotpoint interval was 50 m, and data were sampled at 4 ms over a 10-s window length. Original data quality was poor. Reprocessing by the Federal Institute for Geosciences and Natural Resources, Germany, dramatically improved the quality with new semblance analysis, stack, deconvolution, FK-migration, and time-varying bandpass filter. Figure **F2A** shows a typical frequency spectrum for these processed data.

F2. Frequency spectra, p. 6.



Meteor 49-4 Site Survey

In excess of 700 line km of seismic reflection data were acquired during the *Meteor* 49-4 expedition (April–May 2001) on Demerara Rise. All seismic profiling activities during the cruise included simultaneous operation of air gun multichannel seismic reflection and Parasound subbottom sonar profiling. All geophysical data sets were acquired digitally.

High-resolution multichannel seismic reflection data were acquired with the University of Bremen multichannel seismic system. The seismic sound source was a Seismic Systems, Inc. generator-injector (GI) air gun with reduced chamber volume (2 × 0.41 L; 100–500 Hz) fired at a time interval between 9 and 11.5 s and with an air pressure of ~1500 psi. The injector was fired with a 30-ms time delay from the generator shot, which essentially eliminated the bubble pulse. The gun was towed 1.4 m below sea surface. The multichannel seismic streamer (SYNTRON) includes six 100-m-long active sections, each with 16 hydrophone groups. Streamer tow depth was controlled to 3 m below sea level by nine digibirds distributed along its length. Figure **F2B** shows a typical frequency spectrum for these data.

The Parasound system works both as a high-frequency narrow-beam sounder to determine the water depth and as a low-frequency sediment echo sounder. It makes use of the parametric effect, which produces additional frequencies through nonlinear acoustic interaction of finite amplitude waves. If two sound waves of a certain frequency (e.g., 18 and 22 kHz) are emitted simultaneously, a signal of the difference frequency (e.g., 4 kHz) is generated. The new signal component is traveling within the emission cone of the original high-frequency waves, which are limited to an angle of only 4° for the equipment used. Therefore, the footprint size of 7% of the water depth is much smaller than that for conventional systems, and, as a consequence, both vertical and lateral resolution are significantly improved.

Parasound signals were digitally sampled by the PARADIGMA software at a frequency of 40 kHz with a typical window length of 266 ms. The source signal was a band-limited 2- to 6-kHz sinusoidal wavelet with a 4-kHz dominant frequency having a duration of 2 periods (total length = ~500 µs). Data were filtered with a bandpass filter (3.0–5.0 kHz) and amplitude normalized with a time-varying gain.

JOIDES Resolution Underway Geophysics (Leg 207)

One 45-km-long single-channel seismic reflection line was acquired by the *JOIDES Resolution* while coming to location on the Demerara Rise. The intent was to provide a seismic profile crossing Site 1258 orthogonal to an existing line (line GeoB-221) and allowing improved seismic stratigraphic control by tying to opposing lines (lines GeoB-206 and 215) (Fig. **F1**). The seismic source used was a Seismic Systems, Inc. GI gun fired in harmonic mode with 2 × 1.72 L chambers. A 56-ms delay firing between the generator and the injector was employed to dampen the bubble pulse. The gun was towed 2 m below the sea surface and fired every 7 s. The receiving element was a Teledyne model 178 single-channel streamer. It consisted of one group of 60 hydrophones with 1.5-m spacing between phones. Towing depth was ~12 m below the sea surface, which, in retrospect, was too deep and caused severe frequency notching in the bandwidth of interest (Fig. F2C). At the time of acquisition, data were bandpass filtered at 20–750 Hz and digitally sampled at a 0.5-ms interval for a 3-s window length.

RESULTS

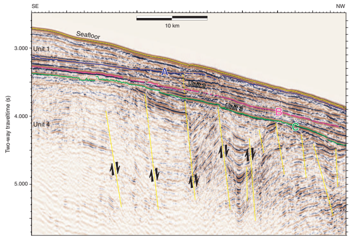
Bathymetry

The Demerara Rise is a north-facing protruberance of the continental margin off Suriname, South America. It lies in water depths ranging from 1200 to 4400 m (Fig. F1). Leg 207 focused on the northern extent of this plateau (water depth = 1800–3400 m). Water depths increase gradually in this region until about the 2600-m isobath. On the north-facing portion, the edge of the Demerara Rise is steep, dipping from 2600 to 4500 m in <10 km distance (10°). On the northwest-facing portion, the seafloor dips gradually at ~1.5°. On the top of the rise, the seafloor appears relatively smooth and featureless on a large scale, with no obvious channels or topographic features of note. On the steep flanks of the rise, the seafloor is dissected by gullies (Fig. F1).

Seismic Stratigraphy

Although industry multichannel seismic data show structure down to 4 or 5 s below seafloor, discussion of the seismic stratigraphy in the context of ODP Leg 207 will be largely restricted to the upper sediment column, within ~600 ms of the seafloor. Five key seismic reflectors, or reflection horizons, separate seismic units and were correlated throughout the seismic data to provide the seismic stratigraphic framework. Seismic profile C2211 demonstrates some of the features characteristic of the industry profiles (Fig. F3). Seismic profiles GeoB219 and 220, transecting the study area from southeast to northwest through Sites 1259 and 1257, provide a good overview of the different seismic stratigraphic units within the target sediments (Fig. F4). These units are presented from oldest to youngest.

F3. Industry seismic profile C2211, p. 7.



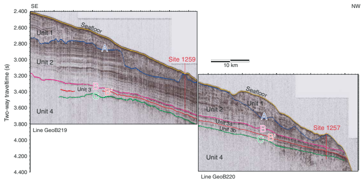
Seismic Unit 4

The lowest seismic unit, just below the section of interest, is represented by contorted and faulted reflections that truncate against a prominent flat-lying reflector termed Reflector "C." This high-amplitude and regionally correlatable horizon reflects the angular unconformity between Cenomanian black shales and underlying synrift sediments, which are mainly clays, siltstones, and sandstones of pre-Cenomanian age.

Seismic Unit 3

Above the angular unconformity is a ~70- to 100-ms-thick sequence of medium-amplitude, parallel, coherent reflections that are largely flat

F4. *Meteor* 49-4 lines GeoB219 and GeoB220, p. 8.



lying. The character of these reflections changes laterally from high amplitude to nearly transparent. The top of the unit is distinguished by a regionally correlatable high-amplitude reflection event termed Reflector "B." In general, Reflector B dips uniformly to the northwest. A single variable-amplitude but coherent reflector within this unit is correlatable across the rise. It is termed Reflector "B′." Unit 3 is broken into two subunits; between Reflectors C and B′ is Subunit 3b and between the Reflectors B′ and B is Subunit 3a. This unit terminates on the steep-walled flanks of the rise.

Seismic Unit 2

Unit 2 lies between Reflector B at its base and Reflector A at its top. Its thickness is highly variable since Reflector A is an erosional surface, possibly channelized in places. The unit tends to be composed of a distinctive sequence of parallel, coherent, flat-lying reflections. On the flank of the Demerara Rise, however, these reflections are incoherent, possibly due to mass failure (slumping and rotation). Unit 2 generally thins toward the north and toward the flanks of the rise.

Seismic Unit 1

The overlying seismic unit is characterized by a sequence of moderate-amplitude near-parallel reflections, although in some cases the unit or sections of the unit appear transparent. In these cases, the sediments have likely failed, disrupting any reflector coherency. This sequence of reflectors shows offlap, onlap, and, in some cases, slight folding. These complexities in form are related to faulting, as correlated with reflector offsets deeper in the succession or mass failure within the section. The sequence is variable in thickness from absent to >500 ms, generally thickening to the south and west (in board). In most cases, the top of this unit is the seafloor, although a thin veneer (<30 ms) with a finely bedded to homogeneous seismic character may overlie it. In these cases, Unit 1 appears unconformable with the overlying sequence and the top contact is called Reflector "O" (Figs. **F3, F4**). This thin veneer is termed Unit Q and is rarely resolved on seismic profiles.

Faulting

Faults within seismic Unit 4 are common. They usually display characteristics of normal extensional faults, forming horst and graben structures with rotated and tilted reflectors between faults. Folding is also common. These characteristics are typical of a synrift margin. In spite of the intensity of faulting in seismic Unit 4, there is only occasional evidence for faulting in the overlying units, although there is abundant evidence of slope mass failures, especially on the steep flanks of Demerara Rise and within Unit 1.

Figure F1. Map of seismic cruise tracks. The bathymetry was derived from the seafloor pick of the seismic data and the Hydrosweep data acquired during the *Meteor* 49-4 expedition.

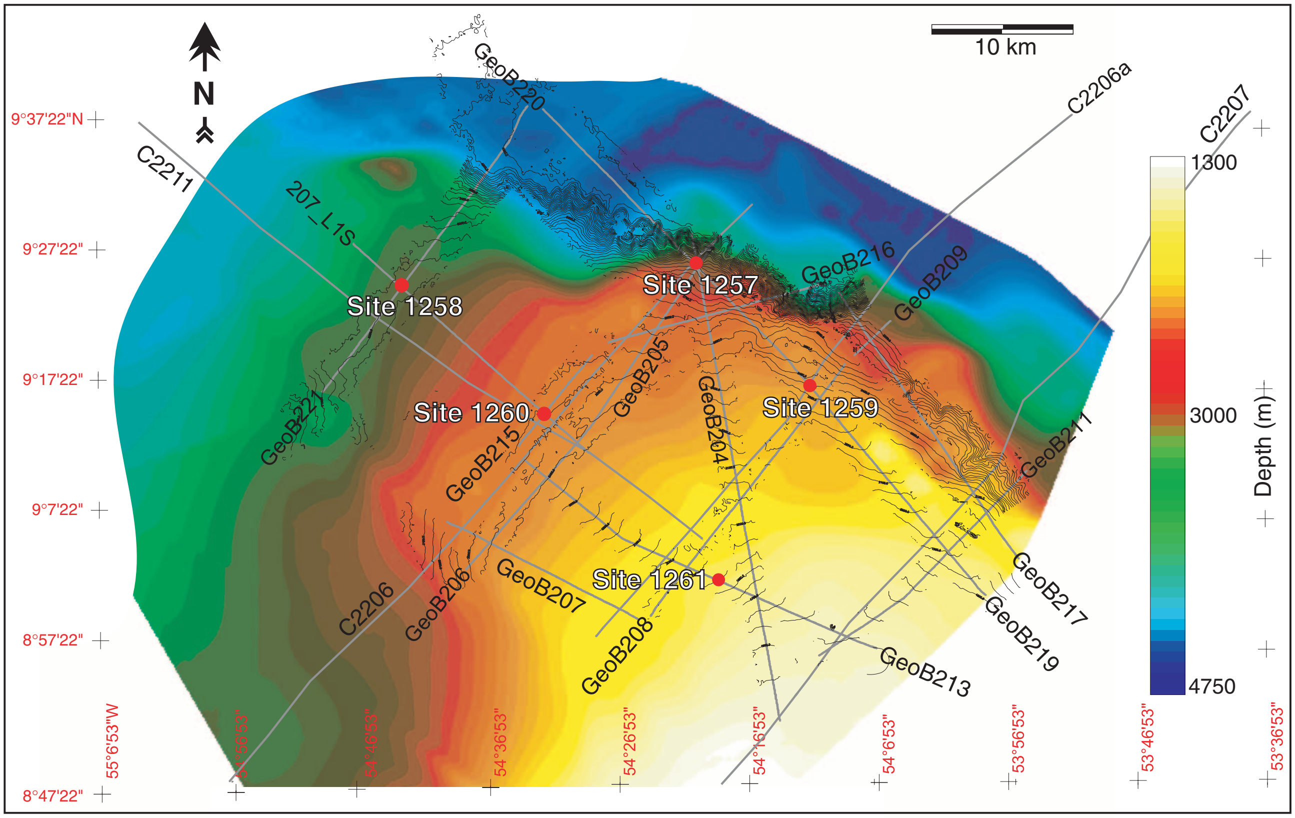


Figure F2. Representative frequency spectra of various seismic data sets. **A.** Industry MCS data. **B.** *Meteor* 49-4 high-resolution MCS data. **C.** Leg 207 underway geophysics data.

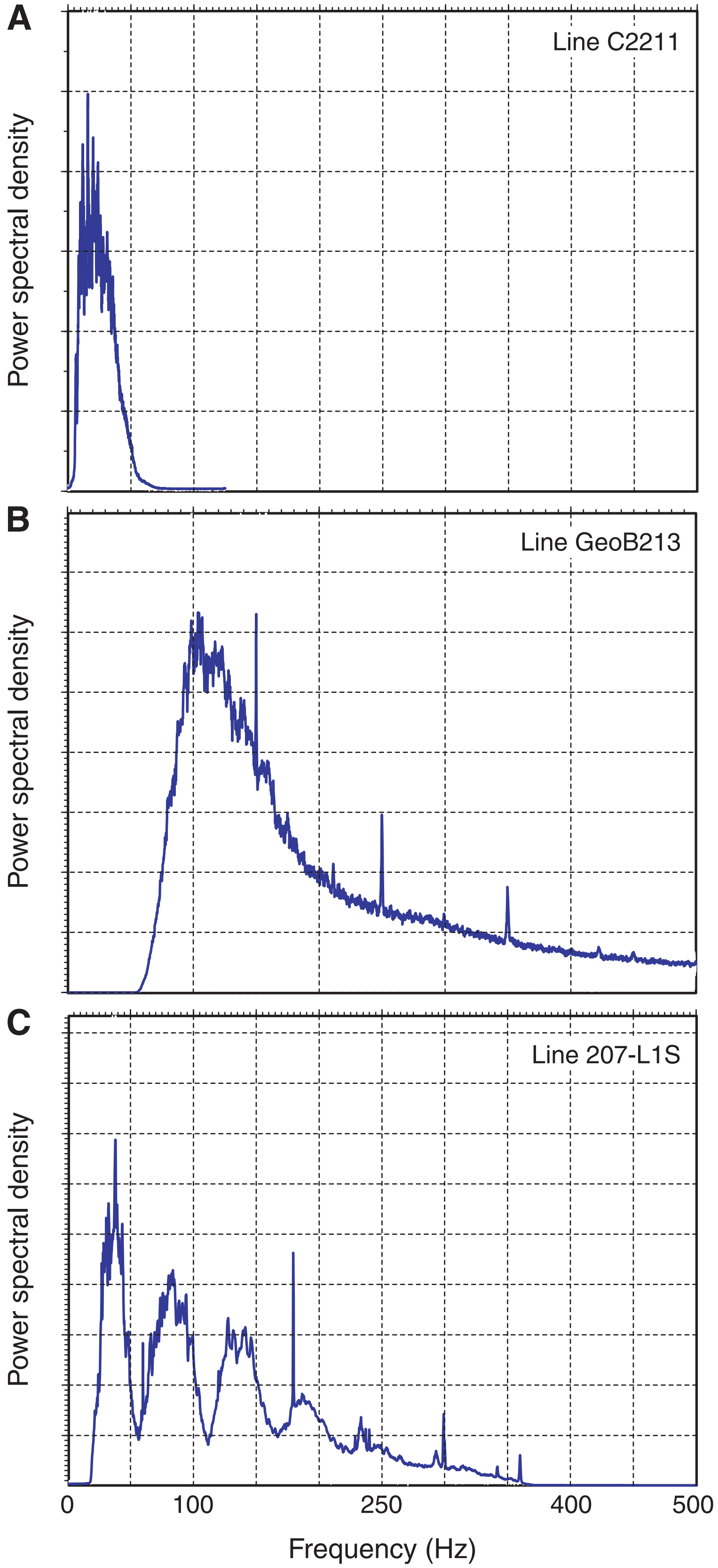


Figure F3. Industry seismic profile C2211, demonstrating the correlated reflection horizons and the various seismic units. The uppermost units are not well defined at the scale of resolution of these data. The large-scale faulting and folding within the synrift sediment package (Unit 4) is well shown by these data.

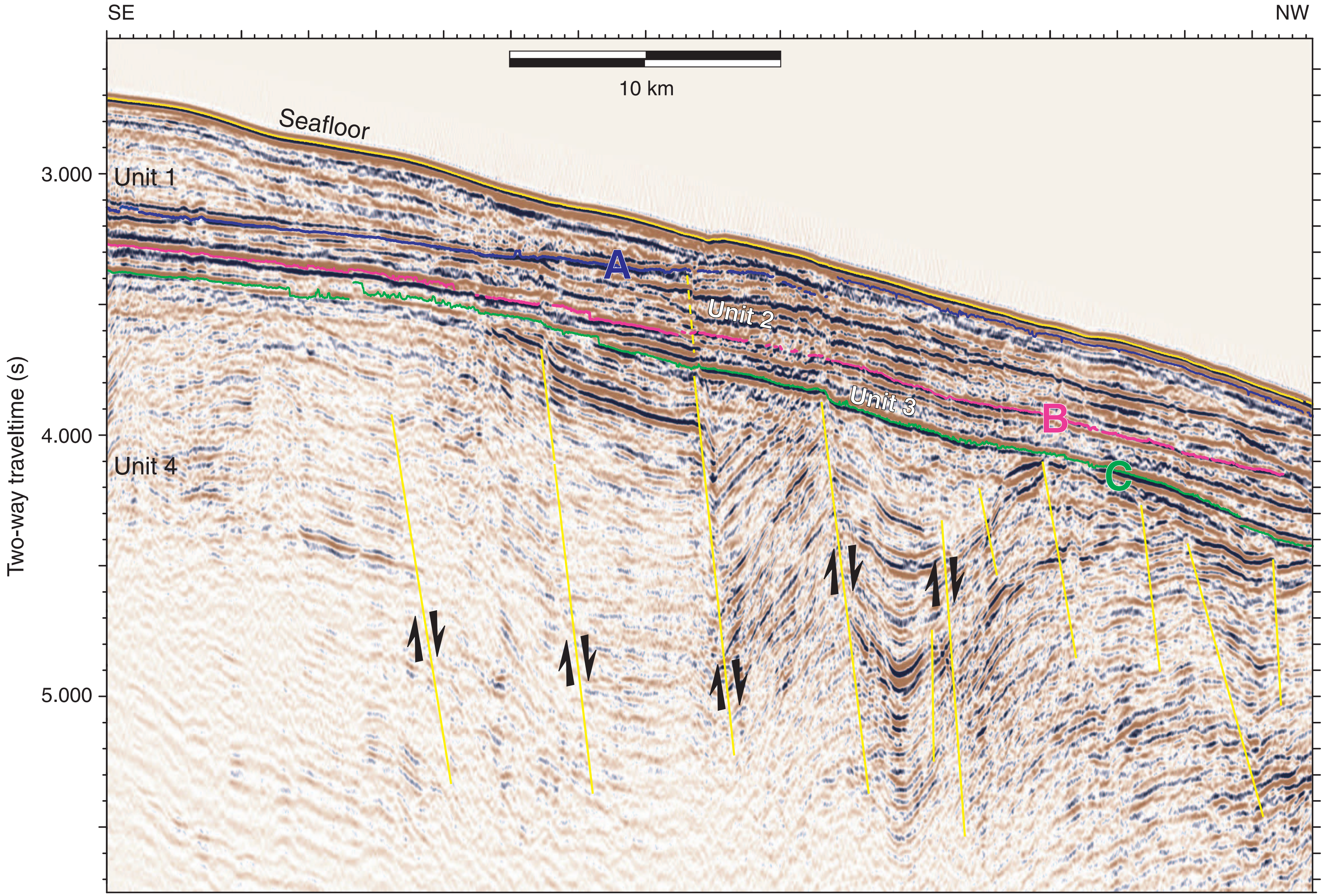


Figure F4. *Meteor* 49-4 lines GeoB219 and GeoB220, which form a single transect across the study area showing the three uppermost seismic units and their typical characteristics.