Wecoma 9605B
STRATAFORM High-Resolution Multichannel Seismic Survey, Eel River Basin

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Introduction

High-resolution, multichannel seismic (MCS) reflection data were collected from the outer shelf to slope, offshore Eel River Basin jointly by Lamont-Doherty Earth Observatory (L-DEO) and the University of Texas Institute for Geophysics (UTIG). The survey was designed to image stratal geometries at a scale intermediate between those of very-high-resolution (500-3500 Hz) Huntec deep-towed seismic profiles and commercial MCS (JEBCO) data already available from this region. The design of the survey was formulated at a meeting held at Lamont-Doherty Earth Observatory (L-DEO) on 20 October 1995, attended by a subset of STRATAFORM participants and modified by input received at the 15-17 February 1996 STRATAFORM Annual meeting in San Diego. Siting of the grid was based on an evaluation of existing data and an effort to cover as much as possible of the high-priority swath-mapping area stipulated at the Eureka workshop in January 1995. The survey fulfills the STRATAFORM goals of providing "nested" seismic coverage (several Huntec and JEBCO lines were duplicated with the high-resolution MCS system) and linking shelf and slope environments. It will also permit tracking the history of northward sediment dispersal from the Eel River and study of the Humbolt Slide.

We overcame several equipment failures, and benefitting from good weather, we achieved nearly all of our objectives. The Captain, officers, and crew of R/V *Wecoma* were highly competent and cooperative. Their professionalism contributed greatly to the success of this cruise.

MCS Acquisition and Recording

Source

45/45 cu. in. GI gun @ 2000 psi
Towing depth: 2.5 m

Gun firing was timed to yield a distance between shots equal to the streamer group interval at a nominal ship speed of 4.86 kt. For the ITI streamer (12.5 m group interval), the interval between shots was 5 s, while for the Geco streamer (15 m group interval), the interval was 6 s.

Recording

Data were digitized,, demultiplexed and recorded throughout the cruise with an OYO DAS-1. Early in the survey, occasional interference, in the form of high-ampliude, low-frequency bursts, was present on profiles processed aboard ship. This problem was corrected by grounding the negative side of the streamer power supply.

We began recording with a solid-state, 48-channel streamer manufactured by Innovative Technologies, Inc. (ITI) and owned by L-DEO. This streamer was recently reconditioned to repair problems encountered during its first deployment aboard the R/V *Gyre* in September, 1995. As a back-up for this *Wecoma* cruise, we leased a second, oil-filled, 48-channel streamer from Mitcham Industries, manufactured by Geco. This proved to be a very worthwhile precaution: 10 of the 48 channels of the ITI streamer became unusable in the first several days of use. After 5.5 days of recording, we switched to the Geco streamer and it worked very well for 5.1 days until there was an electrical failure in the leased power supply and signal conditioner. These problems were insurmountable, and we switched back to the ITI streamer for the last 2.0 days of recording.

ITI Streamer

48 x 12.5 m group length (600 m total).
7 birds programmed to maintain a depth of 2.5 m.
0.5 msec sampling with OYO DAS-1 digital recording system writing to 3480 tape cartridges (180 shots/tape).
3 second records.
42 m near-trace offset, 629.5 m far-trace offset - first 4 lines shot.
22 m near-trace offset, 609.5 m far-trace offset - 5th - 24th lines shot.
21 m near-trace offset, 608.5 m far-trace offset - 25th - 41st lines shot and 79th to end of cruise.

Geco DSS V Streamer

48 x 15 m group length (720 m total).
7 birds programmed to maintain a depth of 8 ft (2.4 m).
0.5 msec sampling with OYO DAS-1 digital recording system writing to 3480 tape cartridges (180 shots/tape).
3 second records.
57 m near-trace offset, 762 m far-trace offset (one line only).
31.5 m near-trace offset, 736.5 m far-trace offset (remaining Geco streamer lines).

Navigation

Navigation was by DGPS. The ship followed lines defined by waypoints selected prior to the cruise. The differential correction transmitted by the Cape Mendocino Coast Guard station was used by the STRATAFORM MX200 GPS unit. Time and position were fed via cable to the shipboard ECDIS system and its CRT display on the bridge. This provided un-dithered GPS ship's position to be monitored by the helmsman and enabled him to hold the ship to within 10m of the desired track. Deviations greater than 10m were rare or were required to avoid crab pots or fishing vessels. A VGA monitor duplicating the bridge display in the main lab enabled the scientific party to monitor our progress.

3.5 kHz Profiles

Good quality 3.5 kHz profiles at 1-sec sweep were collected continuously on the shipboard EPC recorder (including all turns and other seismic down time).

Seismic Survey

Cruise W9605B departed Eureka at 1320 on 15 July 1996 and ended at 1000 on 1 August in Eureka. The seismic grid surveyed consists of 84 lines (~2200 km) extending ~45 km from north to south along the coast from roughly Trinidad Head to Eel River, and from the 40m isobath out to a maximum water depth of 950 m (Figure 1). Weather conditions were generally good and did not cause any disruption of seismic acquisition.

The principal characteristics of the survey lay-out were as follows (Figure 1):

- Most shore-parallel "strike lines" (even-numbered lines) were 800 m apart; line spacing increased for the most seaward strike lines. Spacing also increased within the gas "wipeout area" that runs in a broad swath along the upper slope from north to south through the center of the grid. All strike lines were parallel.
- Two strike lines were extended south of the planned grid to near the head of Eel Canyon to check for evidence (e.g., buried channels) of discharge of Eel River sediment directly into Eel Canyon during lowstands. This was in response to a suggestion by M.E. Field, Co-Chief Scientist of the STRATAFORM 1996 Huntec survey, who had just collected data in that area.
- Two additional lines were extended to the north wall of Eel River canyon to collect MCS and 3.5 kHz data that could aid future attempts at sampling outcrops of strata traced to our grid.
- Dip lines (odd-numbered lines) in the northern part of the grid paralleled the northern lines of the STRATAFORM 1995 Huntec survey. Similarly, the central group of dip lines paralleled the southern Huntec lines, and the southernmost dip lines paralleled JEBCO line 205. Within these three areas, all dip lines were parallel and spaced roughly 800 m apart. Between these areas, changes in orientation were accomplished by varying dip line orientations in fan-like patterns. Line spacings there are commonly >800 m and spread to slightly more than 1 km. Most dip lines ended near the 500 m isobath. In one area at the southern edge of the upper Humboldt slide zone we collected a grid with as little as 200m between dip lines that will allow investigation of the optimum line spacing for interpretation of stratigraphic features.
- Dip lines were run through the "wipeout area" where gas-charged strata absorb or scatter acoustic energy at as little as 20 msec below the seafloor. It is hoped that our high-resolution MCS data will image stratigraphy through the gas better than did the JEBCO data, though limited shipboard processing was inconclusive on this point.
- Several lines from the 1995 Huntec survey and JEBCO lines 205 and 201 were duplicated. Such duplication, in keeping with the STRATAFORM goal of providing nested coverage.
- Lines were shot across both the 450 m mooring and 60 m tripod sites.

We brought three 3480 tape cartridge drives, intending to use two for recording and the third for off-line playback and processing. Unfortuantely, one of the recording drives failed at sea after it had written ~250 tapes, forcing us to replace it with the playback unit. As a result, only nine seismic lines were processed and interpreted at sea; two of those were also migrated. These nine lines provided proof that we have achieved our goal of ~5m vertical resolution and roughly a second of 2-way traveltime penetration (~900 m). We recorded a total of 1018 200-mbyte field tapes. These have been divided evenly between L-DEO and UTIG for complete shorebased processing.

Floats attached to crab pots were encountered between the 40 and 60 m isobaths. Rather than risk entangling and seriously damaging our towed gear, we stayed seaward of most that we found. The main problem areas were in the northeastern part of the grid and in the far southeast. Consequently, many dip profiles in these areas did not extend as far landward as had been planned, and some of the most landward of the planned strike lines were omitted. Floating logs of various sizes were an additional hazard.

Data recorded by the 48-channel ITI streamer deteriorated early in the cruise. We began with 3 unsuitably noisey channels on the second day of recording, and this streadily increased to at least 10 unusable channels by day 5. We replaced it on day 7 with the leased, back-up streamer.

We found a minor amount of damage to bird 4 when the ITI streamer was hauled in for replacement. Bird 4 had been indicating anomalously large depths (8-10 m) for a period preceding retrieval, and we guess that it may have snagged and dragged an object that subsequently fell free.

The Geco streamer leased from Mitcham Industries provided 48 channels of data with excellent signal-to-noise ratios. Unfortunately, an insurmountable electrical failure in the signal conditioner supplied with this streamer ended recording after 5.1 days; we completed the last 2 days with the original ITI streamer.

Results

The loss of shipboard processing capability limited the amount of interpretation that could be carried out. Nevertheless, some initial results are outlined below.

Shelf

As reported in previous studies, the shelf offshore Eureka is especially smooth and relatively featureless on the scale of MCS profiling. Shallow (~10's of msec) sub-bottom reflectors are imaged on most of the lines we have processed, and vertical resolution is 5m or less (Figure 2). The few lines we have seen thus far show the mid-shelf occassionally contains the thickest depositional units in the upper several tens of meters sub-seafloor, with clear thinning to truncation/bypass on the upper slope. Unconformable surfaces bounding prograding units can be seen above the seafloor multiple; complete shorebased processing will be required to diminish the multiple and investigate stratal patterns at greater depth.

As was already known from the existing JEBCO and Huntec data, gas occurs in sediments in a band up to 5 km wide and oriented approximately north-south beneath the outer shelf and upper slope in water depths from 70 to 250 m. It commonly obscures the stratigraphy in these areas, and is accompanied by apparent amplitude anomalies along adjacent regions (Figure 2). Gas plumes rising 10's of meters from the seafloor are thought to have been detected on our 3.5 kHz records.

A large, buried channel occurs near the landward end of line 25 (Figure 1). The channel is ~0.15 s. (~100 m) deep, 1 km wide, and incises surface that is ~0.3 s. (~70 m) below the seafloor. A smaller, shallower channel incises the same horizon seaward of the main channel. Interpretation of adjacent lines will reveal whether both of these features represent crossings of a single, meandering channel and whether they are related to Eel River drainage. The low-resolution JEBCO data suggest a more northerly source for this channel system. At shelf depths (<200 m) multiples add to the difficulty of seismic interpretation of the shallow subsurface.

Slope

Slope channels are of at least two distinctive types. Line 66, across the lower slope, displays both kinds in the northwestern part of the grid (Figure 3).

1) Shallowly buried (~0.05 s or ~40 m, assuming 1600 m/s sonic velocity) aggradating gullies (Figure 3) are spaced at 300 - 600 m intervals. They occupied the same locations throughout their existence, their signature extending up to 0.3 s (~240 m) below seafloor. The gullies were ~0.025 s (~20 m) deep. They have become inactive and are now partially infilled, having a reduced surface expression on line 66 (Figure 3). Migration will be a particularly important step in processing images of these features.

2) Northward of the aggrading gullies we observed larger buried channels, up to 0.15 s (~120 m) deep and 1 km wide (Figure 3). These channels are erosional and exhibit lateral migration and erosion of fill by subsequent channelling.

No dip lines across the Humboldt Slide have yet been processed, but seismic coverage of this feature is excellent. The data should constrain the style and relative timing of slope failure(s).

Tectonic Features

The large plunging anticline in the central part of the study area is well imaged, as is a similar feature to the south. Onlap of sediments against these features and the development of unconformities within the adjacent sedimentary section document the history of uplift.

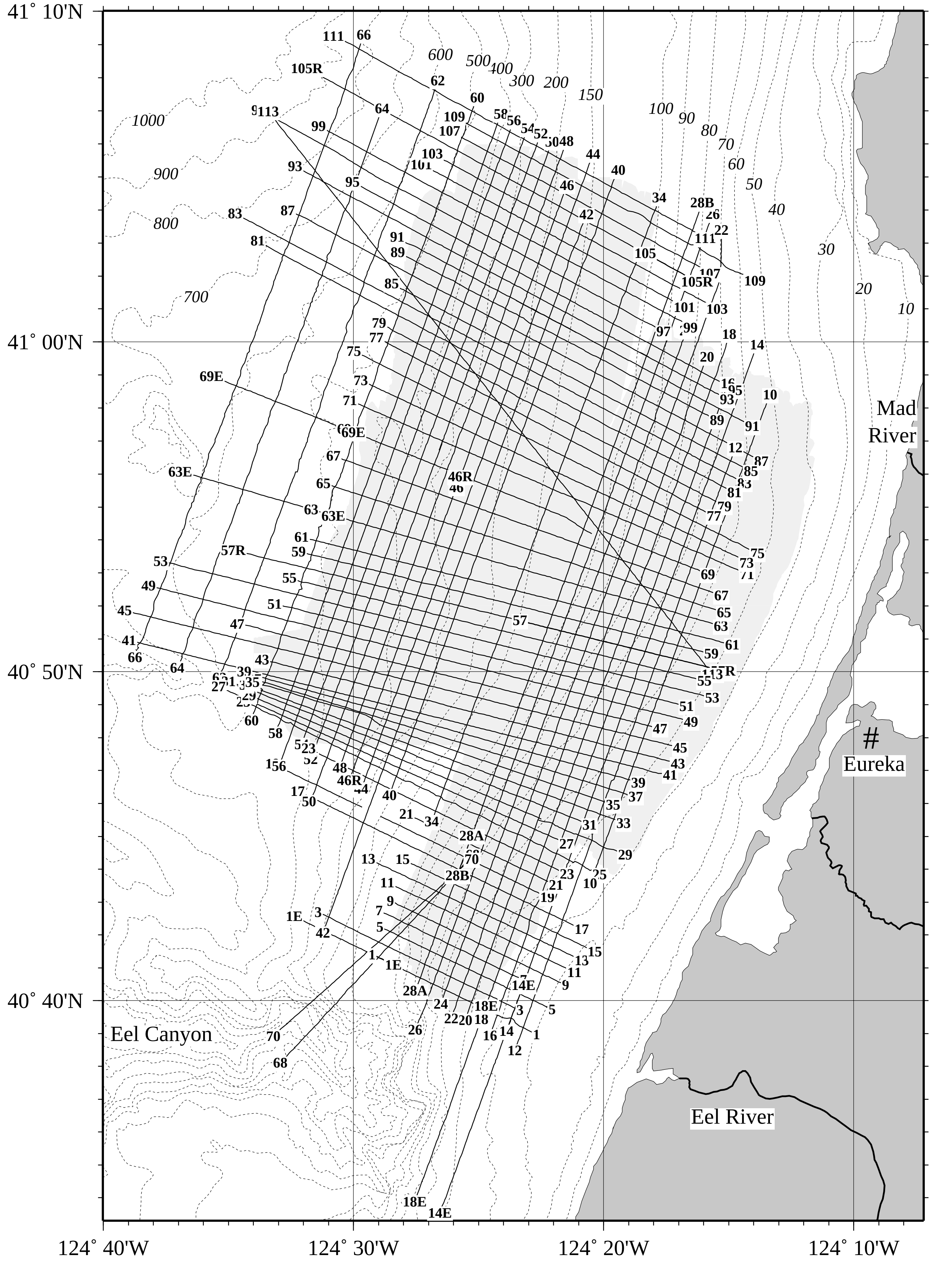
Figure Captions

Figure 1. Survey track showing numbered MCS lines collected by the R/V *Wecoma* during our STRATAFORM high-resolution MCS operations. The shaded pattern notes the region of STRATAFORM swath bathymetry/backscatter data acquired by L. Mayer and J. Goff during summer 1995.

Figure 2. Part of dip line 63 across the outer shelf/upper slope. At the assumed sound velocity of 1600 m/sec, this image reveals 5 m of vertical resolution in the upper 100 m of section. Prograding units bounded by erosional unconformities can be seen; slumped sediments are suggested by disrupted reflectors beneath the slope. Highly reflective surfaces ("amplitude anomalies") suggest stratigraphically trapped gas at the western edge of this portion of line 63. In a several km-wide zone trending N-S along the outer slope, gas is assumed to be responsible for the nearly total loss of reflected energy beneath a few 10's of msecs below seafloor. Only the inner 12 channels have been stacked; the full 48 channels will be incorporated in shorebased processing that will diminsh the seafloor multiple and reveal stratal geometry to roughly 1 sec of two-way traveltime.

Figure 3. Section of strike line 66 (migrated) showing both aggradational gullies and erosional channels on the lower slope.

Figure 1: W9605B Line Navigation (Seismic Reflection Coverage)



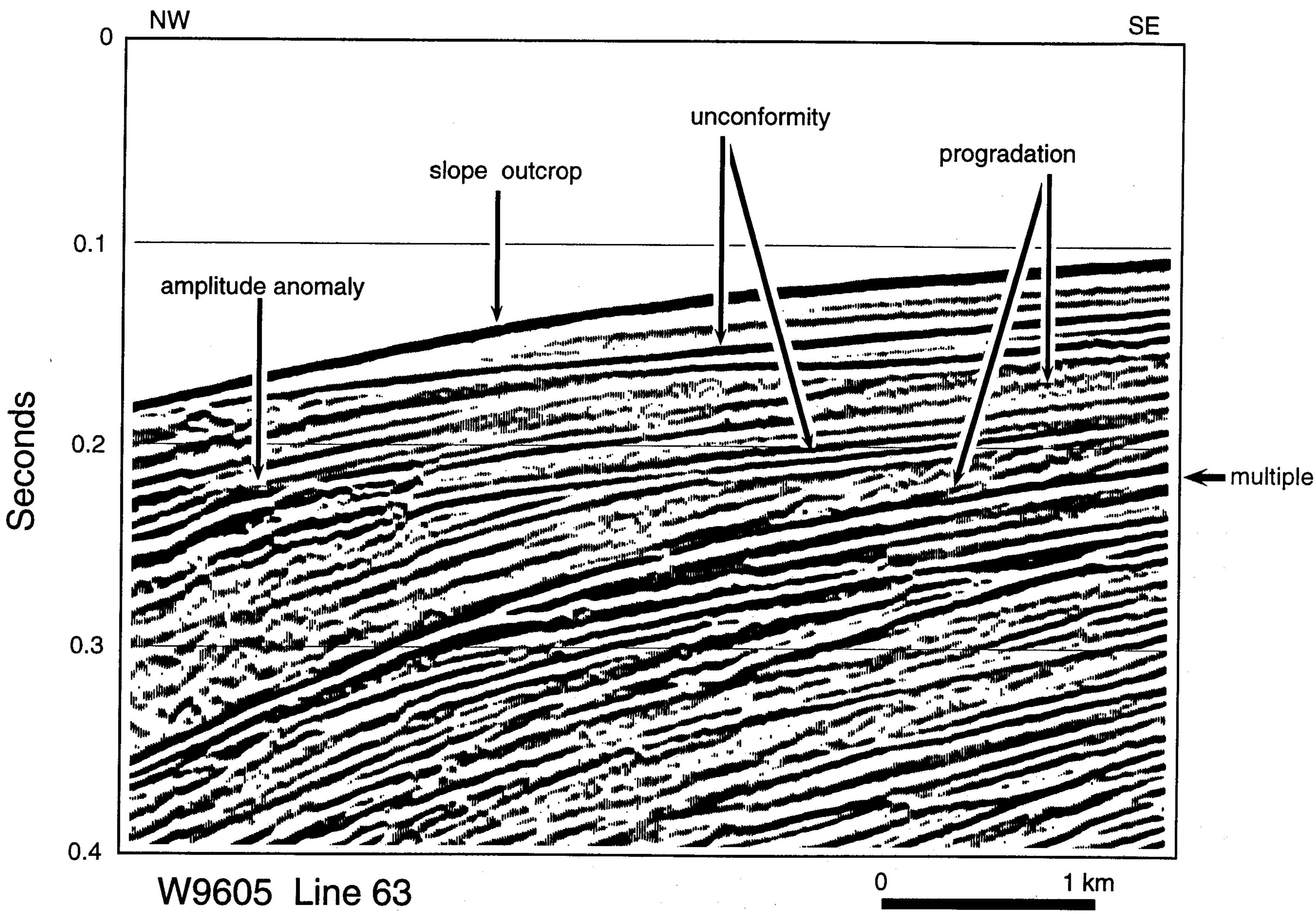

NW
SE
0
0.1
0.2
0.3
0.4
Seconds
amplitude anomaly
slope outcrop
unconformity
progradation
multiple
W9605 Line 63
0
1 km

Figure 2

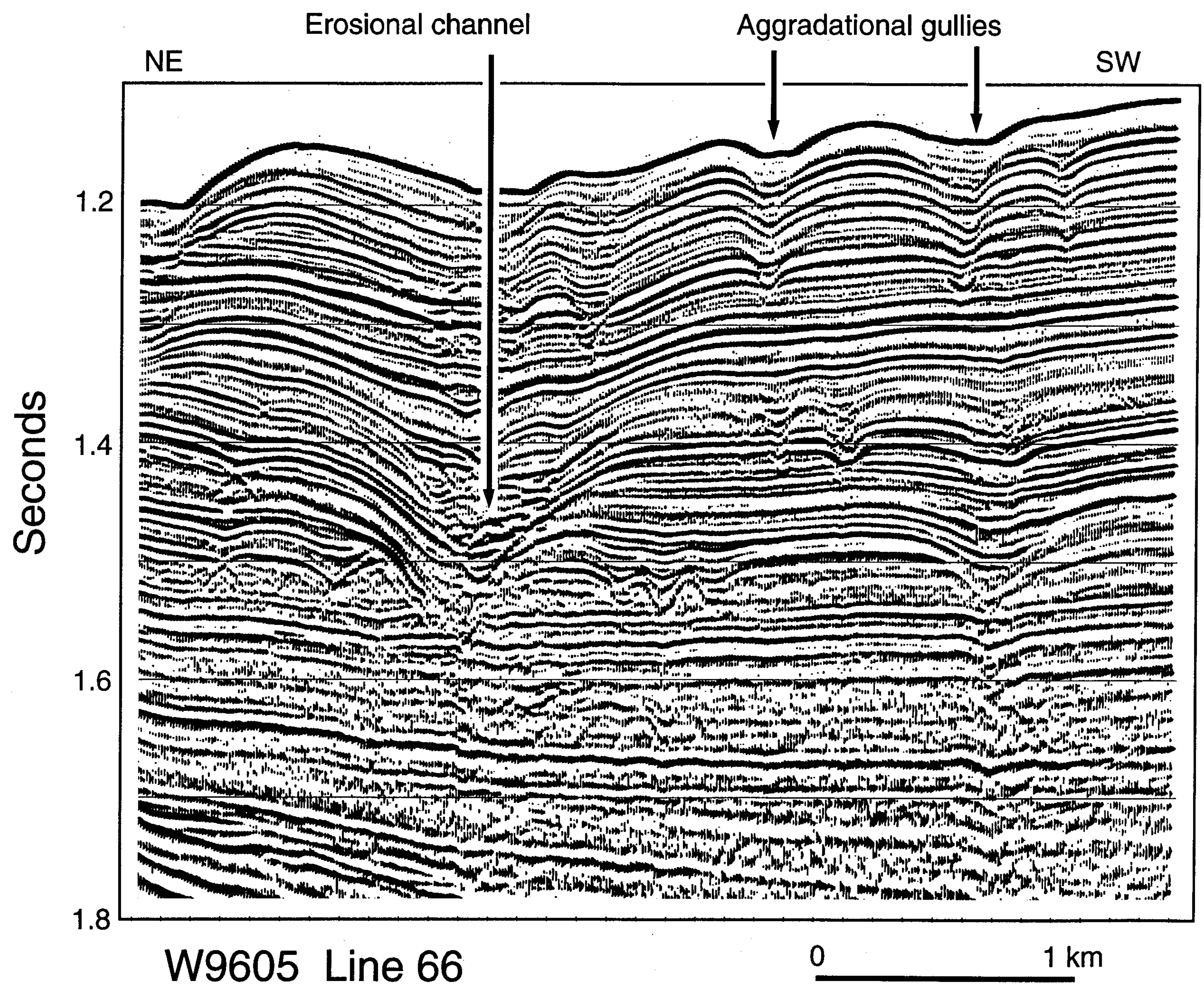

Erosional channel
Aggradational gullies
NE
SW
Seconds
1.2
1.4
1.6
1.8
W9605 Line 66
0
1 km

Figure 3