Cruise Report EW92-07

Research Vessel Maurice Ewing 04 June to 04 July 1992
Bridgetown, Barbados to Charlotte Amalie, St. Thomas

Three-dimensional seismic reflection investigation of fluid flow and structural evolution: Northern Barbados Ridge

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The purpose of this field program was to collect a three dimensional seismic reflection grid and ocean bottom seismometer (OBS) data at the frontal part of the accretionary prism in the Barbados Trench. Our work is designed to provide improvements in imaging the 3-D structure of the prism in the vicinity of the drill sites and to extrapolate the drill data to explain the structural and geochemical patterns at a larger scale. We collected 103 seismic reflection lines spaced 50 m apart creating a 5.1 km swath, 25 km long, for an areal coverage of 127 square kilometers (Figure 1). We also collected one 90 km long reference line. Three OBSs recorded data for four days. The survey area contains eight wells drilled since 1981.

A key part of the field program relied on accurate navigation. We installed a global positioning system (GPS) reference site at the Barbados Bellairs Research Institute of McGill University. A leased telephone line back to the U.S. provided differential navigation corrections to COMSAT for satellite transmission to the ship. It took five days in Barbados to finally get the line established by the afternoon of June 5 even though COMSAT was to have provided this service beginning May 28. Thus the Ewing did not depart until June 6, two days late. The accuracy of the positions are illustrated in a plot of the Ewing location while tied up at the dock in Bridgetown, Barbados. Fixes over a six hour interval clustered within a 3 m radius (Figure 2). Once underway we had intermittent problems with navigation, both with the leased-line and the COMSAT 'decoder' on the ship until the 8th of June. We had a four hour outage on the 11th of June and then no more problems related to the link. The navigation constellation geometry was poor for 30 minutes each day, otherwise at least three satellites with reasonable geometry were usually available. Intermittent DOD testing of individual GPS satellites on a few occasions led to the constellation dropping below the minimum needed for reliable positioning. The display provided to the bridge, along with the high quality navigation was sufficient for the Ewing to maintain line spacings of 50 m. The crew did a fine job of maintaining their concentration and few excursions of more than 5 m off-line resulted. This is quite a feat, given that we were shooting constantly for almost four weeks.

Initial processing of the shot locations and timing information was conducted on board the Ewing. The navigation display and logging put together by Mark Wiederspahn and realtime GPS filters developed by Mike Simpson have been shown to hold up well. The target shot distance was 30 m and about 99% of the time the post-processing distance was found to be within 2 m of the target.

It took almost two full days of streamer work to get the 52 channel (650 m) digital streamer in some semblance of order. This was despite the fact that John Mutter had devoted some of his time on an earlier cruise to do the major job of re-configuration, from 180 to 52 channels. Sometime was lost because there were only two Lamont electronics/streamer technicians. Only Bruce Francis has previous Lamont experience and fully understood the hybrid DSS-Lamont logger set-up, and he was unable to work 72 hours straight during the initial start-up phase of the program. Mike Long has plenty of industry experience and provided solid help with the DSS troubleshooting and air gun firing control system, but the pair were overwhelmed with work at times. The streamer compass sections were quite unreliable and we replaced two of six during initial deployment, after which two were found to give unreliable headings, and one of these finally caused a streamer fault. Since there were no more spares, we removed it from the streamer. The first good line was not shot until the 9th of June.

The seismic source used on this cruise consisted of 10 guns in an array tuned for a 9.6 ratio of primary-to-bubble amplitude in the band 0 to 60 Hz; 32 b-m peak-to-peak. This was achieved by towing the guns from floats at a depth of 5 m. The total volume was 2320 cubic inches (ci), with guns from 80 ci to 465 ci. The gun system was fairly reliable, but we lost many lines because of gun failures aggravated by our using floats. Our analysis prior to the cruise indicated that loss of the 465 ci, 350 ci, 305 ci or 80 ci guns would change the primary-to-bubble ratio by more than 10%, which was deemed unacceptable. Attempts to measure the far-field source function using a commercial sonobuoy failed because of an open circuit in the special one thousand foot Kevlar cable.

The Digicon digital seismic system (DSS) has few quality control capabilities. There were no provisions to display or check the compass information; it was written to trace 0, and not otherwise available. We discovered the unreliable compasses only when we stripped the data ourselves. An additional problem, as yet unresolved, is that the compass information indicate a seven degree north feathering on eastbound lines and a few degree south feathering on westbound lines, after correcting for magnetic variation. This is impossible because it requires a similar magnetic deviation for all compasses or cyclic currents, thus we distrust all the compass data. The most plausible, but still ad hoc explanation, is that there is about a five degree bias in all the compasses, and that the feathering is then about three degrees northward. If this is found to be correct, we will not have to navigate the streamer since three degrees puts the far offset mid-point only about 20 m off-line. The new 3480 tape drives are a great improvement and have removed one of the larger sources of problems with the DSS.

The Lamont data logger is responsible for standard underway geophysical data logging, as well as delivering shot time and other information. It was not up to data logging the Magnavox 4200D GPS data, causing numerous crashes each day until it was decided that this was the cause and then moving the Magnavox logging to another computer. From then on, the logger was much more reliable.

The OBS program consisted of three UT-Austin instruments deployed at ODP Sites 675, 671 and the third two km to the west. Total separation was ~6 km. Dip and strike lines collected over four days were recorded by the the OBSs. The OBS at Site 671 measured three-component data for 60 hours, the others for 6 hours, before reverting to one component for the remainder of the 4 days. The purpose of this work is to try and extract good estimates of the velocity near the OBSs for use in 3D migration and as a method in itself for deriving reliable sediment velocities in deep water.

Using a combination of ProMax, Sioseis and Geoquest, we were able to do simple processing and some interpretation of the data. Most effort was directed at quality control, (including noisy trace editing), and near-channel stacking without trace editing assuming a shot distance of 30 m. These data were f-k migrated at a single velocity and loaded for display into the Geoquest workstation. Overall, the data is of much higher quality than the 10-year-old French line (Mascle et al., 1989). The decollement reflection is a well defined, fairly simple wavelet, with laterally varying amplitudes which seem to correlate with some overlying out-of-sequence faults. The accreted section is distinct, with fewer 'reflections' (coherent noise?) than in the French line, probably because we have much higher signal-to-noise ratio. It looks like the high angle faults, some of which were sampled on the drilling legs, are evident and will be mappable as shown in

Figure 3. Here the decollement is at about 7.1 s and steep dipping faults are observed in the overlying section. The fault zone sampled at ODP Site 675A is well-defined in the seismic data.

The Lamont technical group consisted of:

Bruce Francis, science officer
Michael Long, electronics
S. Budhypramono, computers
John Di Bernado, air guns
Carlos Alvarez, assistant air guns
Ropate Maiwiriwiri, coring bosun

Having a science party including seven students (one in Barbados) and two post-doctorates made the trip more enjoyable and allowed us to get far along in our work. The undergraduates received a new perspective about science which hopefully will motivate them in their future careers. We also had two computer programers along to finish the navigation software developed for this cruise.

The visiting science party consisted of:

Thomas Shipley, Co-chief scientist (UT)
Gregory Moore, Co-chief scientist (UH)
Nathan Bangs, post-doctoral scientist (UT)
Shin'ichi Kuramoto, post-doctoral scientist (U.Tokyo & UH)
Sevin Bilir, graduate student (UT); at navigation station in Barbados
Daniel Barker, graduate student (UT)
Vikamaditya Sen, graduate student (UT)
Gretchen Zwart, graduate student (UC)
Alison Teagen, undergraduate (UT)
Joseph Rank, undergraduate (UT)
Claudia Kawakami, undergraduate (UH)
Mike Simpson, computers (UH)
Mark Wiederspahn, computers (UT)
Yann Hello, ocean bottom seismometers (UT & OSTROM)
Steffen Saustrup, seismic processing (UT)

Specific comments/recommendations for the Ewing science operations:

The following comments are specifically aimed at making the Ewing science operations even better. Several of these items are a question of money, personnel, and compromises; or already in the progress of being remedied.

1. The long-term pre-cruise planning went quite well. We carefully prepared and transmitted a detailed working plan for this cruise well in advance, and over a couple of months it was refined as the capabilities of the Ewing and its personnel were matched to the science needs, equipment and expertise to be supplied by Texas and Hawaii. However, during the last two months things began to fall apart as more detailed and more immediate correspondence was needed. Jim Smith was out of the office for a week at a time with no warning (to us), and with no one as a functional backup. There needs to be someone else in the office who always knows what's going on, or a better communication of Smith's schedule. One example of the impact was the very late arrival of a DPGS receiver we needed before we could prepare some of our software.

2. A second problem was the shift of the science officer about two weeks before the cruise and general level of staffing. When we learned of the change in science officer, we were also told Jim Smith would come out with the replacement science officer, and then we learned that Jim wasn't coming, and that our total science technical group would consist of only six people. We ended up with a smaller complement of science technicians than needed. Lamont should be required to specify the number and type of technicians to be supplied as part of the sub-contract. We attribute at least three days of lost science time to being undermanned relative to the science/equipment demands of the project. At the same time Lamont did respond well to the need for increased helmsmen duties by carrying an extra crew member.

3. The Digicon digital seismic system (DSS) is very unreliable. We had just about every failure imaginable and we had them often. On average we had perhaps eight failures a day during the first ten days. This did seem to decrease as the cruise progressed, but it never was very reliable. DSS failures required much circling and restarting of lines. We highly recommend that at least the lab portion of the field system be updated to a more modern generation; and one with more quality control and trouble shooting features for both the streamer and the lab portions of the system. We estimate we lost about three days to the DSS, plus two during initial configuration and start up; an inordinate amount for a 650 m streamer.

4. The Digicon digital seismic system (DSS) has few quality control capabilities. We could only examine data using a tape drive, computer and software brought by us for this purpose. The addition of the ability to read and plot tapes would be a modest additional investment. An output of realtime information on compass, streamer depth and gun performance statistics would help. Also, the ability to export the shot time and shot point number from the DSS or to import it into the DSS from an external source would be very helpful.

6. The Lamont logger should have an audible alarm to indicate when it stops, it now dies quietly and was often not caught for extended lengths of time.

7. The computer system is rapidly evolving on the Ewing, and it is more capable than on any other ship. Even so, the system is not setup very well with respect to what is expected by incoming scientists. There should be much more auto-mounting of disks; more standard read/write privileges on disks; more devices (all printers, and as many tape drives as possible) available to more machines on a routine basis; not piecemeal to a machine or single science user. If it is truly a network, it should behave as a network with few barriers. Routinely, every scientist should be given an individual login/password. It is not a difficult and would promote better accountability of individual use, particularly if the networking doesn't have other barriers. This would also then enable better management of incoming/outgoing mail (e.g. privacy and no inadvertent deletion by

others). Yellow pages should be implemented so all users can use all (almost all?) machines.

8. There are quite a few smokers on this ship, including in our science party. The result was that the lounge and science office were unpleasant if not unusable to many of the non-smokers. The installation of a smoke air filter in the lounge is a typical solution offered by smokers, but is not effective. We don't know the answer to this problem (a TV in the galley?; no smoking in the office and passage ways?).

9. Wind speed and direction indicator in lab, suitable for logging, should be available.

In summary, we found the Ewing a capable and well-manned ship, with a particularly good atmosphere for doing science. The officers and crew felt they were there to do science, and the more challenging the better. This is in contrast to many ships we have sailed on. The science technical group of six was fine and had a good range of experience and skills. The group was obviously undermanned and one more air gun and one more electronics person would have saved us unnecessary down time.

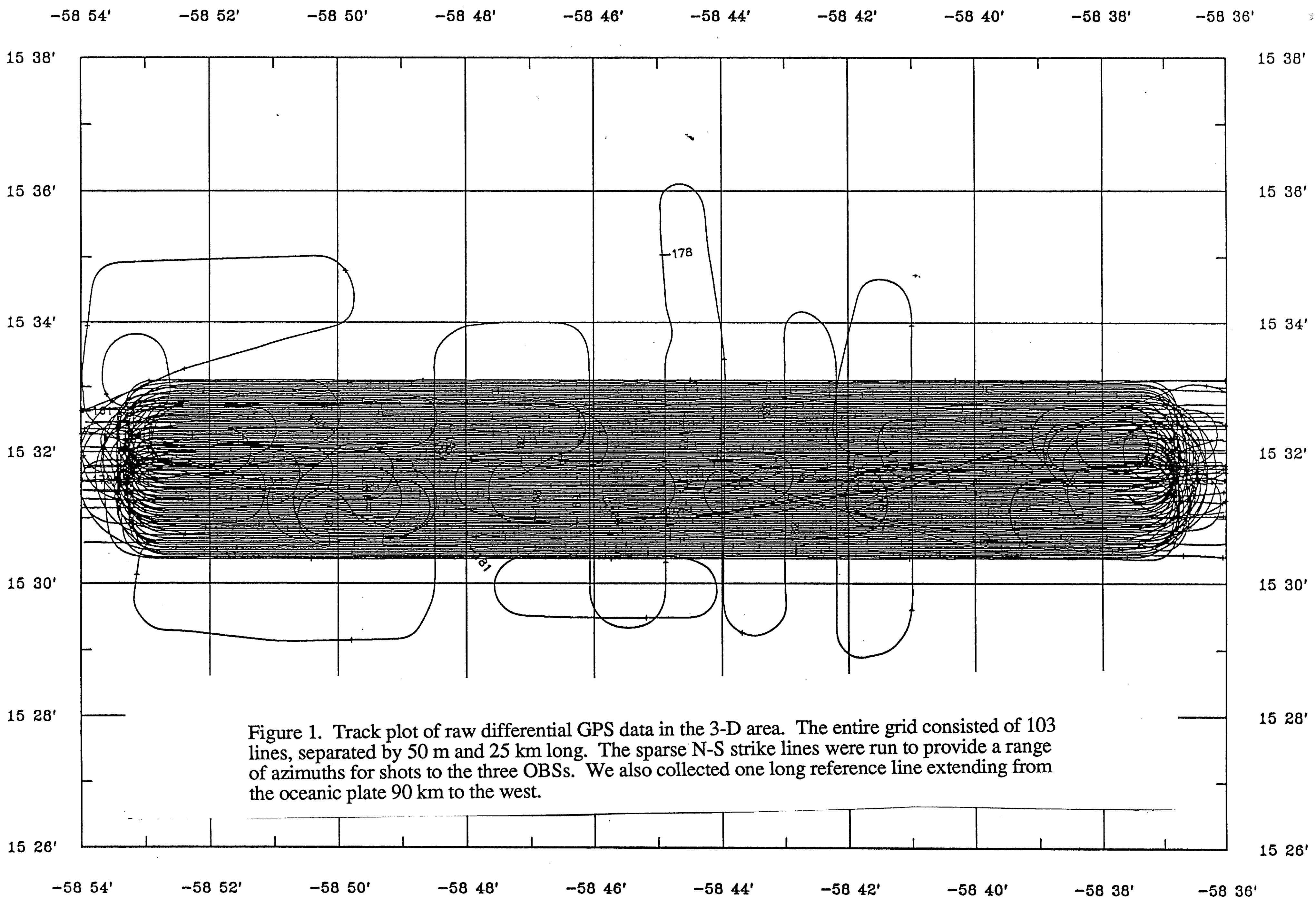

Figure 1. Track plot of raw differential GPS data in the 3-D area. The entire grid consisted of 103 lines, separated by 50 m and 25 km long. The sparse N-S strike lines were run to provide a range of azimuths for shots to the three OBSs. We also collected one long reference line extending from the oceanic plate 90 km to the west.

EW-9207 BARBADOS - PUERTO RICO SURVEY AREA TRACK PLOT ; SCALE = 31 inch/deg

Barbados Dock Fixes

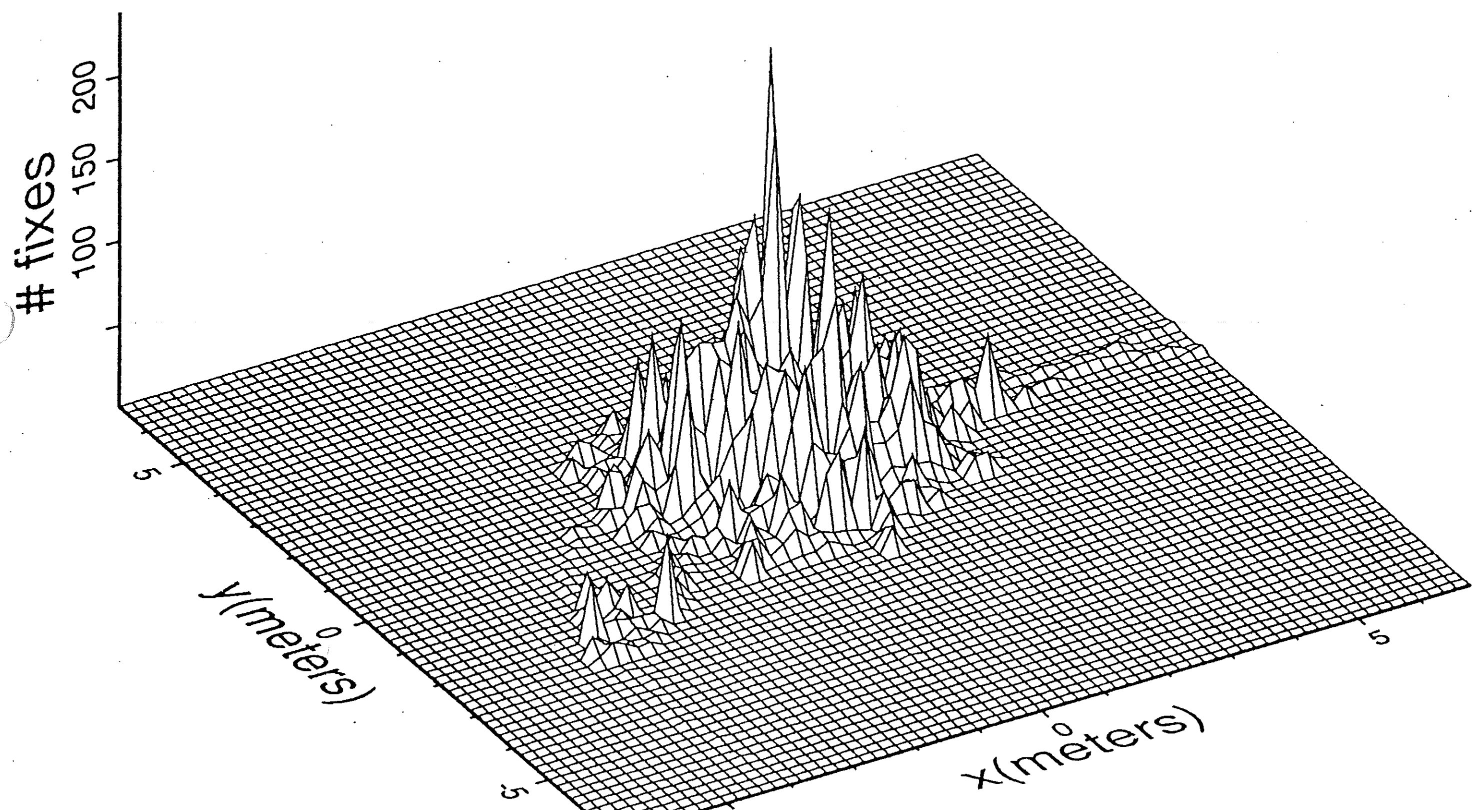

Figure 2. Distribution of differential GPS fixes for six hours while the Ewing was tied up at the dock in Bridgetown Barbados. Note the tight cluster of positions within about a 3 m radius from the center position. Included are about 18,000 positions. Z-axis is number of fixes per 0.2 m x 0.2 m area.

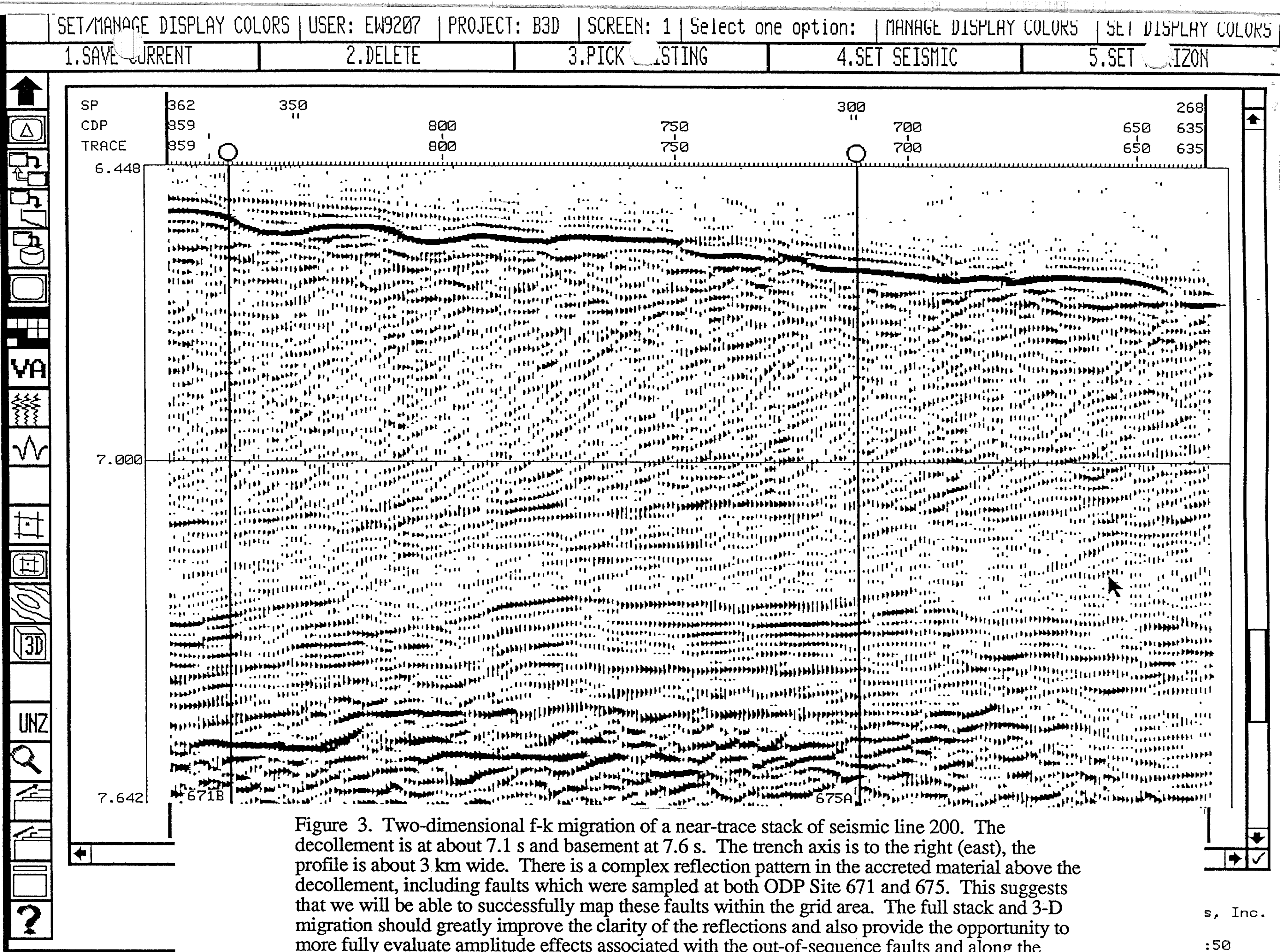

Figure 3. Two-dimensional f-k migration of a near-trace stack of seismic line 200. The decollement is at about 7.1 s and basement at 7.6 s. The trench axis is to the right (east), the profile is about 3 km wide. There is a complex reflection pattern in the accreted material above the decollement, including faults which were sampled at both ODP Site 671 and 675. This suggests that we will be able to successfully map these faults within the grid area. The full stack and 3-D migration should greatly improve the clarity of the reflections and also provide the opportunity to more fully evaluate amplitude effects associated with the out-of-sequence faults and along the decollement.