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A preliminary Mid-Cretaceous to Late Pleistocene seismic stratigraphy for the deep eastern Gulf of Mexico adjacent the Florida Escarpment

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ABSTRACT

An investigation of predominantly USGS single-channel seismic reflection data in the deep eastern Gulf of Mexico has identified six prominent and regionally extensive unconformity and correlative conformity surfaces which bound six seismic units. The deepest unconformity mapped, the Mid-Cretaceous Unconformity (MCU), underlies all six seismic units and is exposed along the Florida Escarpment. North of approximately 27°N the gradient of both the exposed MCU and the subbottom MCU are less steep than the MCU gradients south of 27°N. South of 27°N, the large canyons which incise the Florida Escarpment extend westward into the subbottom for at least 15 km. The similarity between the exposed and buried parts of the MCU implies that the erosional and depositional processes controlling the morphology of the Florida Escarpment have operated for a considerable, but still unknown length of time. Initial canyon cutting began before the deposition of canyon floor sediment fill, interpreted to be Middle Tertiary in age.

The majority of seismic units above the MCU have an onlap geometry on the underlying discontinuity surface and a concordant geometry on the overlying surface. Sediment source areas were north and west of the study area, and the concordant upper surfaces of these deposits imply generally non-erosional conditions. In general there appears to be predominantly pelagic/hemipelagic deposition during the Middle Cretaceous to Late Miocene, hemipelagic and distal siliciclastic deposition during the Late Miocene to Middle Pleistocene, and proximal fan siliciclastic deposition during the Middle to Late Pleistocene. This change in depositional style is related to the general migration of depocenters from the western Gulf to the eastern Gulf from the Middle Cretaceous to the present. Depocenters of the two youngest seismic units correlate with the DeSoto channel and Mississippi Fan main channel systems respectively. These youngest seismic units fill in lows on the underlying structural surfaces. The general position of channel/levee systems appears to be strongly controlled by pre-existing topography.

Sediment contributions from the west Florida platform to the Mississippi Fan since the Mid-Cretaceous appear to be relatively minor because wedge-shaped seismic units with seismic reflectors downlapping away from the escarpment are rare. Some minor sets of downlapping reflectors, however, were found within a Middle Pleistocene unit and are considered to be carbonate turbidites or debris flows that travelled down the Florida Escarpment.

INTRODUCTION

The deep eastern Gulf of Mexico contains a portion of both the Mississippi Fan and the Florida Abyssal Plain and is bounded to the east and southwest by the steep Florida and Campeche carbonate escarpments, respectively (Fig. 1). The seismic stratigraphy and lithostratigraphy along the eastern edge of this region is poorly known because of inadequate coverage of seismic data adjacent the Florida Escarpment (e.g. Angstadt and others, 1985; Bouma and others, 1983/1984; Bouma and others, 1986; Corso and others, 1989; Feeley and others 1984; Feeley and others, 1990; Ibrahim and others, 1981; Ladd and others, 1976; Rosenthal, 1987; Shaub and others, 1984; Walters 1985; Weimer, 1989; and Wu and others, 1990) (Fig. 2) and because of a complete lack of deep sea bore holes within 100 km of the carbonate escarpment (DSDP leg 96, Bouma and others, 1986). Consequently, there is insufficient data as yet to make detailed comparisons between the stratigraphy of this eastern area and the relatively well known stratigraphy of the Mississippi Fan to the west (Feeley and others, 1990; Walters 1985; Weimer, 1989; and Wu and others, 1990). It is plausible that a significant contribution of West Florida platform carbonate sediments to the fan may make this area unique. The lack of adequate seismic and borehole coverage has also prevented the extension of Florida Escarpment morphology studies (Twichell and others, 1990) into the subsurface for this area and prevented the construction of regional structure maps on the escarpment subbottom surface. Some of these problems can now be addressed using the single-channel seismic data collected by the USGS during sidescan sonar (GLORIA II) cruises in 1982 and 1985 (EEZ-Scan 85 Scientific Staff, 1987) (Fig. 3).

The purpose of this report, which is based primarily on the USGS seismic data, is to investigate the seismic stratigraphy of the deep Eastern Gulf of Mexico adjacent the Florida escarpment by (1) identifying prominent and regionally extensive acoustic unconformities or correlative conformities, (2) describing the seismic units bounded by these surfaces of discontinuity, (3) constructing depth-to-structure and isopach maps, and (4) discussing acoustic discontinuity surfaces and seismic units in a local and regional seismic stratigraphic context, including an assessment of the contribution of Florida platform carbonate sediments to the Mississippi Fan.

PREVIOUS STUDIES OF THE GULF OF MEXICO

Large-scale crustal studies of the Gulf of Mexico using multi-channel and refraction seismic data have revealed the structure upon which the sediments were deposited, and have provided seismic velocity values for the sediments (Ibrahim and others, 1981; Ibrahim and Uchupi, 1982; Rosenthal, 1987). Trehu and others (1989) and Wu and others (1990) provide useful overviews of the sedimentation history of the Gulf of Mexico continental margin.

The study area, bordered by latitudes 24°N to 28°N and longitudes 84°W to 87°W (Fig. 1), contains a thick sequence of predominantly mid-Cretaceous to Holocene sediments. These sediments were derived from a number of sources and include two major types: terrigenous siliciclastic sediments associated with the Mississippi Fan, and its predecessors (may be mixed with pelagic sediments), and carbonate clastic sediments derived from the surrounding steep carbonate escarpments and shallow carbonate platforms.

The Mississippi Fan and terrigenous siliciclastic sediments

The Mississippi Fan contains mostly terrigenous siliciclastic sediment and is located in water depths from 1200 to 3600 m. It is part of a large depositional center, primarily of Pliocene-Pleistocene age, which also includes shelf and slope sediments (Weimer, 1990). The fan covers approximately 300,000 km^2 and includes 290,000 km^3 of sediment (Barnes and Normark, 1985).

The bulk of the seismic studies fo the Mississippi Fan have concentrated only on portions of the fan and on its youngest sediments (Bouma and others, 1986; Stelting and others, 1986; Walters, 1985; Weimer, 1989 and 1990; Weimer and Buffler, 1988; and Wu and others, 1990). Weimer (1990) concentrated on the upper fan and used a combination of University of Texas, Institute of Geophysics (UTIG) and commercial multi-channel seismic reflection data sets to identify 17 seismic sequences, each characterized by channel, levee, overbank, and mass transport deposits. Walters (1985), and Wu and others (1990) both focussed on the continental slope and upper

Mississippi Fan. Walters (1985) divided the Plio-Pleistocene section into five regional seismic stratigraphic sequences and discussed the important role of salt movement (before and after clastic sedimentation) on sediment distribution. Wu and others (1990) fit a general stratigraphy of the northeastern Gulf of Mexico into a seismic sequence framework and discussed sediment accumulation patterns. Studies on the middle and lower portions of the fan using seismic-reflection, sidescan-sonar, and drilling data collected during Deep Sea Drilling Project (DSDP) leg 96 (Bouma and others, 1986) showed the evolution of the youngest fan channel and correlated lithologies to seismic facies (Kastens and Shor, 1985; Stelting and others, 1986). Bouma and others (1983/1984) used high-resolution seismics to study the younger Mississippi Fan sediments on the upper, middle, and lower fan. There is a lack of seismic studies of the lower fan sediments and their association with sediments derived from the Florida Platform.

Regional studies of the entire Mississippi Fan include studies of Pleistocene and older sediments. Feeley and others (1984) identified eight seismic sequences, and isopach maps of these sequences suggest that the axis of maximum accumulation has migrated eastward with time. Important controls on fan sediment deposition and distribution include: sea level changes, amount and location of unstable sediment on the outer shelf, the positions of sediment sources and submarine canyons, salt tectonics, and the position of pre-existing fan units (Feeley and others, 1984). Studies by Feeley and others (1984) and Shaub and others (1984) place the base of the Mississippi Fan at the base of the oldest identifiable channel-levee system (age Late Miocene, Bouma and others, 1986), a boundary where seismic facies change from parallel reflections to subparallel reflections. This change in facies in the Gulf of Mexico basin is thought to show a depositional change from more mixed biogenic and terrigenous sediments to predominantly terrigenous, siliciclastic, submarine fan sediments (Weimer, 1990).

Minor volumes of pelagic sediments are interpreted to occur within the Mississippi Fan at intervals when terrigenous sediment is trapped on continental shelves due to relatively high sea levels (Weimer, 1990). Because the Holocene is one such interval, pelagic foraminiferal oozes up to 1.5 m thick (Bouma and ohters, 1986), cover the surface of the Mississippi Fan as well as on the nearby carbonate escarpments and platforms. The Holocene and older pelagic oozes are characterized by laterally continuous seismic reflections and are considered "condensed sections" because they represent substantial amounts of timc (Weimer, 1990).

Carbonate Escarpments and Carbonate Sediments

The Campeche and West Florida carbonate escarpments (Fig. 1) are steep cliffs with up to 1,500 m relief that were formed by reef growth on subsiding crust (Antoine and others, 1967; Bryant and others, 1969; Wilhelm and Ewing, 1972). Parts of the escarpments have eroded as much as 8 km (Corso and others, 1986) at least in part by dissolution by acids created from brines seeping out along the base of the escarpment (Paull and Neuman, 1987).

A regional study of the Florida Escarpment (Twichell and others, 1990) revealed that the escarpment differs in erosional style and surface sediment type along its length. North of 27° the escarpment is less steep than the southern section and is characterized by a Cenozoic carbonate mud cover, numerous small canyons, and thin coalescing sheets of fine-grained carbonate debris that interfinger with gravity flows of Mississippi Fan along its base. The southern section is steeper, is deeply incised by box canyons, and both talus and fine-grained carbonate debris interfinger with fan sediments along its base. The base of the escarpment marks the transition from platform carbonate to deep sea fan siliciclastic deposition. A 500 - 2,000 m thick sequence of predominantly Mississippi Fan sediments laps up against the base of the escarpment (Twichell and others, 1990) in the study area. Because sediment accumulation rates on the fan have been very high (6 - 11 m /1,000 yrs) during certain time periods including 80,000 - 15,000 yrs b.p. (Kohl, 1985), carbonate deposits would be rapidly buried during those intervals.

The subsurface portion of the Florida Escarpment correlates with a set of closely spaced deep regional unconformities found in many seismic studies of the Gulf of Mexico (e.g., Addy and Buffler, 1984; Angstadt and others, 1985; Buffler, 1983; Rosenthal, 1987; Shaub and others, 1984; Schlager and others, 1984) (Fig. 4). One deep unconformity was identified in over 95% of the deep Gulf basin by Shaub and others (1984) and its widespread extent and strong signature enabled it to be correlated to wells on the northeast Gulf margin by Addy and Buffler (1984). This latter correlation assigned a Middle Cretaceous age to this prominent unconformity which was later commonly called the "Mid-Cretaceous Unconformity". This unconformity is part of a set of closely spaced unconformities of similar age (91.5 to 94 my) in the Gulf of Mexico that can be difficult to distinguish and, consequently, have many names in the literature. These unconformities include the "Mid-Cretaceous Sequence Boundary" of Schlager (1989); the "Mid-Cretaceous flooding Surface" of Wu and others (1990); the "Mid-Cenomanian Unconformity" of Buffler and others (1980), Buffler, (1983), and Addy and Buffler (1984). In addition, this Mid-Cenomanian unconformity correlates to the Middle Cretaceous shelf reflector or "Top Lower Cretaceous" of Haq and others (1987). The similarities and differences between these surfaces are discussed by Wu and others. (1990). For the purposes of this paper the general term Mid-Cretaceous Unconformity (MCU) will be used and is considered to have formed between 91.5 and 94 my (range of dates from Wu and others, 1990).

In summary, the sediments of the deep eastern Gulf of Mexico adjacent the Florida Escarpment consist of a combination of Mississippi Fan proximal and distal siliciclastics, pelagic oozes, and carbonate debris from the Florida Escarpment. Each of these basic sediment types should be distinguishible on single-channel seismic reflection records because of its unique fill patterns and internal seismic characteristics (seismic facies).

SEISMIC INTERPRETATION METHODS AND SEISMIC DATA BASE

The preliminary seismostratigraphic interpretation methods used in this study are similar to those outlined in Mitchum and Vail (1977). Regionally extensive unconformity and correlative conformity surfaces were first identified on all travel-time seismic profiles and then converted to depth data. Basic seismic facies characteristics were noted, and isopach and depth-to-structure maps were constructed. The geological significance of the seismic characteristics shown by the strata of this report were inferred by using the general principles of Mitchum and Vail (1977), i.e. (a) reflection terminations and continuity were used to infer depositional mechanisms; (b) reflection configurations were used to deduce bedding and depositional mechanisms; (c) reflection amplitude was used to infer velocity-density contrast and bed spacing; and (d) external forms and facies patterns were used to infer sediment source areas and depositional environments.

Single-channel seismic reflection data were collected in the Gulf of Mexico by the U.S. Geological Survey (USGS) in cooperation with the Institute of Oceanographic Sciences of the United Kingdom aboard the R/V FARNELLA in 1982 and 1985 (EEZ-Scan 85 Scientific Staff, 1987; Twichell and others, 1989), and these data were interpreted and digitized for this study (Fig. 3).

The single airgun seismic source varied from 40 in^3 to 160 in^3 and was recorded by a two-channel hydrophone with the two channels summed together and an analog paper recorder for display. Most records were recorded at a 5 second sweep rate (giving a vertical exaggeration of approximately 20), and were filtered to omit frequencies below 20 Hz and above 200 Hz. Subbottom penetration exceeded 2 seconds in the deep Gulf of Mexico but was considerably less on the Florida Carbonate Platform (Twichell and others, 1989). Vertical resolution probably varies from approximately 10 meters to almost 50 m, depending on subbottom velocity and dominant input wavelet frequency (Sylwester, 1983).

UTIG collected approximately 5,600 km of 12-fold seismic reflection data (four airguns, 1,500 in^3) on the fan (Feeley and others,1984). Approximately 500 line km of this data set were interpreted (lines IG77-gt2-10a and IG77-gt2-10bc, Fig. 3). These data were used to correlate acoustic unconformities or correlative conformities at the line crossings of the UTIG lines and the single-channel data.

Conversion of two-way traveltime to subbottom depth was accomplished by combining two velocity calculation methods: (1) calculation of a Common Depth Point (CDP) velocity analysis equation for the Mississippi Fan (Feeley and others, 1984) and (2) averaging the internal velocities reported from Ocean Bottom Seismometer (OBS) refraction data (Ibrahim and others, 1981) from the eastern Gulf of Mexico. The CDP velocity equation is as follows:

$$V=99.19T^2 + 287.08T + 1552.27$$

where "V" is velocity in meters/sec (m/s), "T" is the 2-way travel time in seconds, and "1552.27" (m/s) is the sea water velocity constant (Feeley and others, 1984). The CDP equation was applied to the average 2-way travel times of all acoustic unconformities/correlative conformities identified on the single-channel profiles. The results from the CDP equation were in agreement with average OBS velocities for the upper four of the six seismic units identified in this report. The CDP velocities of the lower two seismic units yielded values of 2.4 km/s and 2.9 km/s respectively, which were considerably lower than the 3.0 km/s value predicted for both by the OBS data of Ibrahim and others (1981). Because the CDP equation of Feeley and others (1984) was intended for use with travel times less than those of the lower two seismic units of this report, the OBS velocity of 3.0 km/s was assigned to both deeper units. The following are the velocities used in this report: sea water (1.552 km/s), unit 20 (1.7 km/s), unit 30 (1.7 km/s), unit 40 (1.8 km/s), unit 50 (2.0 km/s), unit 60 (3.0 km/s), and unit 70 (3.0 km/s). It should be emphasized here that these values are only estimates and are not meant to be definitive. The average velocity for the sediments described in this report is 2.3 km/s.

The travel-time seismic profile interpretations were digitized and converted to depth and thickness using the velocity values listed above. The resulting data were plotted and hand-contoured. Comparison of the depth-to-structure values of this report to the depth-to-structure values of previously published reports are shown in Figure 4.

SEISMIC STRATIGRAPHY

Six prominent and regionally extensive unconformities or correlative conformity surfaces that bound 6 seismic units have been identified in the USGS seismic profiles. In order of increasing age and depth surfaces are identified as S-20, S-30, S-40, S-50, S-60, and S-70. The term "seismic units" is used to describe the depositional sequences of strata bounded by these surfaces to distinguish them from seismic "sequences" as defined by Mitchum and Vail (1977). Each seismic unit overlies the surface with the corresponding number (i.e. unit 30 overlies S-30). Although seismic sequences are similar to the seismic units of this report, they differ by containing genetically related concordant strata between surfaces of discontinuity. Because this study presents only a preliminary analysis of the profiles, only the regional discontinuities have been mapped. There are local discontinuities between these seismic surfaces that have not been addressed in this study, and thus the strata between these seismic surfaces are not necessarily all genetically related. Instead, a description of unconformities, correlative conformities, structural surfaces, and fill patterns will be used to infer sediment source as well as erosional and depositional processes.

Descriptions and illustrations of the seismic units

Descriptions of all six of the seismic units of this report and their bounding surfaces based on seismic profiles, depth-to-structure maps, and isopach maps are given in the below sections. A summary of the seismic characteristics used in this report can be found in Table 1. Because the lateral extent of all 6 seismic units extend beyond the study area, only a portion of their external shape is known. Consequently, descriptions of their external form are limited to where these units onlap the Florida Escarpment.

Figure 4 provides a stratigraphic comparison between the seismic units described in this study with seismic units and seismic sequences delineated in previous studies (e.g. Bouma and others, 1986; Feeley and others, 1984; Ibrahim and others, 1981; Rosenthal, 1987; Shaub and others, 1984; Walters 1985; and Weimer, 1989). Figures 5-12 give examples of the single-channel seismic data. Other seismic lines will be referenced but not are illustrated in this report (Appendix A provides line drawings of these seismic lines). Reduced profiles of nearly all USGS single-channel seismic data used in this report have been published (EEZ Scan 85, Scientific Staff, 1987) or can be obtained from the National Geophysical Data Center (Twichell and others, 1989).

Surface 70

Surface 70 (S-70) is a prominent regionally extensive unconformity upon which each of the 6 seismic units onlap along the base of the Florida Escarpment (Figs. 5,11). This surface dips generally westward (Fig. 13), and is characterized by a predominantly continuous, high-amplitude reflection (Figs. 6, 7, 10). In some areas near the Florida Escarpment, however, this reflector can be semicontinuous (Figs. 5, 9). Surface 70 is commonly the deepest high-amplitude reflection in the single channel seismic data, but along the base of the Florida Escarpment some deeper reflectors are present (Fig. 11). This unconformity intersects the sea floor along the Florida Escarpment (i.e., Fig. 5). Because S-70 exists both exposed on the seafloor along the escarpment and in the subbottom west of the escarpment, the unconformity is considered to be time-transgressive.

The dip of S-70 generally decreases westward away from the escarpment (Fig. 13). North of approximately 26.8°N and south of approximately 25°N the slope of S-70 is approximately 2.5° between 5 and 20 km seaward of the base of the escarpment, and is steeper between those two latitudes where it is approximately 4°. Local relief on this surface is provided by canyons and gullies along the escarpment (Figs. 8, 9, 14) and by a steep mound in the southwest portion of the study area (87.76°W, 24.65°N). The local structural high is approximately 20 km wide at its base along the seismic line 3-22 (Appendix A), and thins to a peaked summit. The relief on this structural high is about 2,800 m. The slope of S-70 on this mound is comparable to that seen adjacent to the Florida Escarpment. The cross-profile dimension of this structural high does not exceed 50 km because it is absent on adjacent lines.

Canyons which cut into the Florida Escarpment predominantly occur south of 27°N (Twichell and others, 1990). Where seismic data density is relatively high, these canyons can be seen to extend at least 15 km into the subsurface to the west of the present escarpment base (Fig. 14). The seismic coverage, however, is not of sufficient density at any locality to conclusively define the maximum westward extent of the canyons.

Unit 70

Unit 70 (Fig. 15), the oldest unit, is interpreted to be convergent onlap fill (Figs. 5, 11; Table 1). This wedge-shaped unit thickens westward reaching a thickness greater than 1,200 m at the western edge of the data. Basal internal reflectors of unit 70 onlap updip onto the lower boundary of the unit (S-70). Unit 70 thins eastward by internal convergence and onlap and pinches out approximately 20 km west of the base of the Florida Escarpment between 26.5°N and 25°N. North and south of this section of the escarpment, Unit 70 pinches out before reaching the base of the escarpment. The canyon floors on the seismic profiles do not appear to be filled by unit 70 (Figs. 9, 10). Unit 70 also thins by internal convergence and onlap near a local structural high in the southwest portion of the data area. Surface 60 (S-60), the top of Unit 70, generally mimics the shape of the bottom surface, but is not as steeply dipping (Fig. 16). S-60 has an average slope of approximately 0.3° at distances greater than 20 km from the contact with S-70. This slope can be compared to the average slope of approximately 1.0° for S-70 at distances greater than 20 km from the base of the Florida Escarpment.

Internal reflector characteristics within Unit 70 are generally convergent toward the edge of the deposit or subparallel-wavy in shape, semicontinuous, and of low to medium amplitude. These characteristics are fairly uniform throughout the unit. The upper boundary of the unit is characterized by concordance or very low angle erosional truncation (Figs. 5, 11).

Surfacce 70 is correlative with the MCU of Shaub and others (1984) (Fig. 4), and is considered to have formed between 91.5 and 94 my (range of dates provided by Wu and others 1990). Unit 70 is assumed to correlate with the Campeche and Lower Mexican Ridges units identified by Shaub and others (1984) based on depth (two-way travel time), thickness, and similar internal reflection configuration. Correlations by Shaub and others (1984) to previously dated holes yielded age estimates of Mid-Cretaceous at the base of the Campeche unit and Mid-Tertiary at the top of the Lower Mexican Ridges Unit.

Unit 60

Unit 60, like unit 70, is inferred to be convergent onlap fill (reflections converge towards the edge of the deposit, Table 1) and this unit thickens westward reaching a thickness in excess of 1,200 m at the western edge of the data (Fig. 17). Basal internal reflectors onlap updip onto the lower boundary of the unit, surfaces S-60 and S-70 (Figs. 5, 11). Surface 60 predominantly slopes toward the west and has a total relief of 1800 m (Fig. 16). Local relief and morphologic variation include onlap onto the local structural high beneath S-70 in the southwestern portion of the data area and a broad NE-SW trending depression in the northern section of the area. In map view, the contact of S-60 and S-70 runs subparallel to the Florida Escarpment between 26.5°N and 25°N. Here it occurs approximately 20 km west of the present base of the escarpment (Figs. 5, 11). North and south of 26.5°N and 25°N respectively, the S-60/S-70 contact diverges from the current base of the escarpment. The top of unit 60, surface 50 (S-50) (Fig. 18), dips westward in a manner similar to the base of the unit but at a lower angle (approximately 0.1° at a distance greater than 20 km from the S-50/S-70 contact).

Reflections within unit 60 are generally convergent towards the edge of the deposit and subparallel-wavy, continuous, and variable in amplitude (Table 1). There are a number of high amplitude reflections near the top of unit 60 well seaward of the Florida Escarpment (Figs. 11, 12) as well as within the canyons of the escarpment (Figs. 5, 10). Not all reflections within the unit are concordant (i.e. no terminations) and there are both local areas of downlap and toplap/erosional truncation. The upper boundary of unit 60, however, appears to be concordant.

Unit 60 may correlate with the combination of the Upper Mexican Ridges and Cinco de Mayo units of Shaub and others (1984) because these combined seismic units lie at similar two-way travel time depths and have similar isopach trends to Unit 60 (Fig. 4). Shaub and others (1984) assigned an age of Middle Tertiary to Late Miocene for the Upper Mexican Ridges unit by correlation of seismic horizons to DSDP holes (Worzel and others, 1973). An age of Late Miocene to Pliocene was also assigned to the Cinco de Mayo unit. Unit 60 of this study is assumed to be Middle Tertiary to Pliocene in age.

Unit 50

Unit 50 (Fig. 19) thickens rapidly adjacent to the Florida Escarpment, but then remains a fairly constant thickness to the western edge of the study area. This unit is inferred to be sheet drape onlap fill (Table 1). The unit is thickest (greater than 1,000 m) in the northwest and thins to the southeast. Sheet drape onlap fill characterizes the unit along the Florida Escarpment (Figs. 5, 6, 7, 10, 11). Basal internal reflections onlap both S-50 and S-70. S-50, like surfaces S-60 and S-70, dips westward decreasing in dip away from the escarpment (Fig. 18). The total relief of this surface is approximately 900 m, about half the relief of S-60. Surface morphologic variations on S-50 include the local structural high beneath S-70 in the southwest portion of the data area and several east-west trending broad troughs in the northern portion of the data area. In map view, the contact of S-50 and S-70 parallels the base of the Florida Escarpment between 26.5°N and 25°N. Here the contact runs approximately 2-10 km to the west of the escarpment base. To the north and south of this area the contact diverges away from the base of the escarpment and gets no closer than about 30 km from the escarpment base. The top boundary of unit 50, surface 40 (S-40), is generally concordant and flatter than the bottom boundary (S-50). The top surface (S-40, Fig. 20) dips toward the south which is different from the westward dipping base (S-50).

Internal reflections are parallel to subparallel, continuous, and mostly low in amplitude. There are some variations including minor downlaps (e.g. line 3-22) and high amplitude areas in some portions of the canyons near the Florida Escarpment (Figs. 9, 10). A set of unusual east dipping internal reflectors can be seen in the upper portion of unit 50 in Figure 5. There is also a strong possibility of a local unconformity/correlative conformity within unit 50 that is not mapped in this study (Fig. 12 and lines 2-18, 2-19, 2-20, gt2-10 of Appendix A).

Surface 50 correlates with the base of unit 1 of Feeley and others (1984), and is assumed to be of the same age as the base of unit 1 of Weimer (1989) and the base of the Sigsbee unit of Shaub and others (1984) (Fig. 4). Age estimates of this surface can be found in Feeley and others (1990) (6.6 my) and Feng and Buffler (1991) (5.5 my). Correlations to Feeley and others (1984) and subsequent comparisons with Weimer (1989) and Weimer (1991) date the top of Unit 50 at approximately 0.6 my.

Unit 40

Unit 40 is interpreted to be sheet drape onlap fill (Table 1) and, like all of the previously described units, thickens in a westward direction (Fig. 21). It is, however, thinner (less than 300 m thick) and does not extend as far north as the older units. The base of unit 40, S-40 and S-70, is flatter than the older units (approximately 300 m relief) and it dips to the south instead of to the west (Fig. 20). Morphologic variations on this slope include two broad, subdued, north-south trending depressions; one hear the base of the escarpment and the other near the western edge of the study area. Unit 40 does not lap against S-70 in the northern part of the data area. Instead, it pinches out on the top of unit 50 10-100 km west of the Florida Escarpment (S-70). South of 26.5° N, the base of unit 40 contacts S-70 within 0.5 to 5 km of the present base of the escarpment. The top boundary of unit 40, surface 30 (S-30, Fig. 22), contains no obvious reflector terminations and is considered to be concordant. This top surface dips toward the southeast and has many large closed structural depressions.

Internal reflectors are parallel to subparallel, moderately continuous, and moderate in amplitude (Table 1; Figs. 5, 6, 10, 11, 12). The internal reflector configurations exhibit more variability than those of underlying units.

The base of unit 40 was correlated to the base of unit 5 of Feeley and others (1984). The top surface of unit 40 is probably of similar age to the top of unit 5 of Feeley and others (1984) because both lie at similar two-way travel times. In addition, the age of unit 40 is most likely similar to units 11 and 12 of Weimer (1989) (Fig. 4). These correlations suggest an age of unit 40 between approximately 0.47 and 0.6 my.

Unit 30

Unit 30 (Fig. 23) is interpreted to be a combination of mounded and sheet drape onlpap fill (Table 1; Figs. 5, 7, 11), and differs from the underlying units by thickening in a northward direction. The maximum thickness is greater than 700 m along the north central boundary of the study area, and a zone of thick sediments parallels the Florida Escarpment approximately 20 to 50 km to the west of the escarpment base. The base of this unit, formed by surfaces S-30 and S-70, contains both onlapping and downlapping reflectors although onlap dominates. Surface 30 (Fig. 22) is relatively flat (total relief of 400 m and broad areas of extremely low gradients) with many broad closed depressions and a wide shallow north-south trending depression adjacent the Florida Escarpment. In map view, the contact of S-30 and S-70 at the base of this unit occurs within 2 km of the base of the Florida Escarpment between 26.5°N and 24.5°N and it occurs approximately 10 km from the base outside of that area. The top of unit 30,surface 20 (S-20, Fig. 24), has a dip to the southwest in contrast to the southeast dip of the bottom of unit 30 (Fig. 22). This top surface contains a broad northwest-southeast trending depression in the northwest portion of the data area.

Internal reflection characteristics are highly variable with parallel to subparallel (Figs. 9, 10,), semicontinuous to continuous (Fig. 7), and low to high amplitude reflectors (Fig. 11). Within unit 30, most reflectors are parallel and onlap the unit 30 base, but there is more internal toplap, onlap, and downlap than in the older units (Figs. 5, 6, 12). A set of unusual east dipping internal reflectors can be seen in the lower portion of unit 30 in Figure 5.

The top surface of unit 30 (S-20) has been correlated to the top of unit 6 of Feeley and others (1984), and it is likely that both unit 6 of Feeley and others (1984) and unit 30 of this study are of similar age (Fig. 4). Correlations with Feeley and others (1984) and subsequent comparisons with Weimer (1989) and Weimer (1991) place the age of unit 30 between approximately 0.18 my and 0.47 my.

Unit 20

Unit 20, the youngest seismic unit, is thickest (greater than 500 m) near the main channel of the Mississippi Fan (Fig. 25), and is interpreted to be mounded onlap fill (Figs. 5, 12). Basal reflectors onlap both S-20 and S-70. The base dips south to southwest and contains a broad northwest-southeast trending depression underlying the main channel that exists on the sea floor at the top of unit 20 (Fig. 24). Sediments are thickest over this depression (Fig. 25). In map view, the contact of S-20 and S-70 at the base of unit 20 is within several kilometers of the base of the Florida Escarpment throughout the study area. Diffractions and sideswipe in the seismic profiles prohibit placing this S-20/S-70 contact with a high degree of certainty. The upper surface of unit 20 is the seafloor (Fig. 1) which slopes gently to the east in the northern portion of this area and gently to the south/southwest in the southern portion. The relief on the seafloor west of the escarpment is approximately 400 m (similar to the 550 m of relief on the base of unit 20).

Internal reflectors are subparallel, discontinuous, locally chaotic, and high in amplitude (Figs. 11, 12). These characteristics are slightly masked or distorted near the seafloor surface on some seismic lines by the strong bubble pulse created by the airgun seismic source. Most internal reflectors are concordant but there is some internal downlap in the upper portion of this unit. The variety of internal reflector geometries and seismic facies suggest that future study of unit 20 will reveal one or several regional unconformities/correlative conformities within it.

The base of unit 20 (S-20, Fig. 24) has been correlated to the base of unit 7 of Feeley and others (1984) (Fig. 4) on UTIG seismic reflection line gt2-10 (Appendix A). Consequently, unit 20 of the present study appears to be composed of both sequence 7 and 8 of Feeley and others (1984). Comparisons with Weimer (1989) and Weimer (1991) place the base of unit 20 at approximately 0.18 my.

Seismic facies

An investigation of the internal reflector characteristics of the six seismic units of this report indicates three different seismic facies. The facies categories and their inferred origins are as follows:

(1) parallel and continuous reflectors are indicative of pelagic/hemipelagic drape.

(2) parallel, variable amplitude, and variable continuity reflectors are indicative of distal fan siliciclastic gravity controlled flows (debris flows and turbidity currents).

(3) divergent to chaotic, variable amplitude, and variable continuity reflectors are indicative of proximal fan siliciclastic and carbonate gravity controlled flows (debris flows and turbidity currents) and mass movements (slumps and slides).

Certain combinations of these three facies types are likely to occur with each of the five basin edge fill patterns discussed earlier (i.e. divergent onlap, sheet drape onlap, sheet onlap, mounded onlap, and slope front downlap fills; Fig. 4, Table 1). The three facies types and five fill patterns were combined to produce five basin edge depositional models unique to the deep eastern Gulf of Mexico (Table 1). The seismic units of this report were then interpreted within the framework provided by these five models. These basic depositional models are generally in agreement with the more detailed facies studies of Feeley and others (1984), Walters (1985), and Weimer (1989).

DISCUSSION

In general, seismic interpretations appear to show mixed pelagic and siliciclastic deposition on top of the MCU during Middle Cretaceous to Late Miocene time (units 70 and 60) and siliciclastic deposition from Late Miocene to Holocene time (units 50 - 20). Seismic characteristics imply a general change from distal to proximal fan siliciclastic deposition during this latter interval (units 50 - 20). The progression through time from pelagic to distal fan to proximal fan deposition is related to the pattern of deposition both within and outside of the study area. Shaub and others (1984), Feeley and others (1984), and Walters (1985) show a general migration of depocenters from the western to the eastern Gulf during the time represented by the seismic units of this study.

MCU morphology and Florida Escarpment canyon development

The morphology of S-70 (MCU) in the subbottom is similar to the morphology that is exposed on the seafloor along the Florida Escarpment. Like the escarpment, S-70 has a distinct change in slope near 27°N (Fig. 13). At locations where seismic coverage is sufficient, large canyons can be traced at least 15 km into the subsurface west of the escarpment (Figs. 9, 10, 14). The similarity between the seafloor and S-70 implies that the erosional and depositional processes controlling the morphology of the Florida Escarpment have operated for a considerable, but still unknown, length of time. The age of canyon initiation began before the deposition of unit 60 (Middle Tertiary, ~30 my) because unit 60 is deposited on some of the canyon floors (Fig. 9). Additional seismic lines further basinward, parallel to the escarpment, are needed to determine whether canyon cutting preceded deposition of unit 70.

unit 70 and unit 60 - pelagic/hemipelagic deposition

Unit 70 is interpreted to contain a combination of pelagic/hemipelagic sediments (represented by draped reflections that have high continuity) and mass movement deposits represented by reflections that have high continuity and a divergent pattern; Table 1). The high reflector continuity within unit 70 probably rules out the presence of large mass movement deposits, but small gravity flow deposits and turbidites probably exist. The divergent onlap fill pattern is thought to reflect lateral variations in the rate of deposition caused by rainout and subsequent downslope remobilization from the surrounding steep slopes. A second, but less likely, reason for the divergent fill pattern would be the progressive tilting or subsidence of the MCU depositional surface. The area of maximum thickness for unit 70 in the study area is on the west central boundary and the isopach map (Fig. 15) implies a depocenter lying some distance to the west. Regional mapping by Shaub and others (1984) revealed a Middle Cretaceous to Middle Tertiary depocenter in the southwestern Gulf of Mexico.

Unit 60 is interpreted to consist of predominantly pelagic/hemipelagic drape (divergent and continuous reflectors) but also distal fan siliciclastic gravity controlled flows that were derived from the west (variable amplitude reflectors) (Table 3). The area of maximum thickness is, like unit 70, on the western boundary of the data area (Fig. 17) and implies a depocenter to the west. Shaub and others (1984) show two depocenters that correlate with this unit (Table 1); one in the southwestern Gulf and one in the central Gulf. Deposition in the central Gulf during this time (Middle Tertiary, ~30 my, Shaub and others, 1984 to Late Miocene, ~ 5.5 my, Feng and Buffler, 1991) is likely responsible for the distal siliciclastics of unit 60.

unit 50 and unit 40 - hemipelagic and distal Mississippi fan siliciclastic deposition

The sheet drape onlap fill pattern and generally parallel to subparallel, continuous, and variable amplitude reflectors of unit 50 and unit 40 are interpreted to reflect both hemipelagic and distal fan siliciclastic deposition (Table 1). This combination of sediment types was probably created by rainout and gravity flow depositional processes. If unit 50 or unit 40 contained solely distal fan sediments, they would be expected to have a sheet onlap fill pattern, without draped deposits, formed only by gravity controlled flows.

The isopach map of unit 50 (Fig. 19) shows the thickest part of this deposit in the northwest corner of the study area rather than to the west. This shift suggests a northerly source rather than a westerly source. Mississippi Fan units 1 through 4 of Feeley and others (1984) approximately correlate to unit 50 of this report (Fig. 4), and are linked to four depocenters in the north central Gulf. These four depocenters illustrate a generally eastward migration of sedimentation, and unit 50 is thought to shift generally eastward during its deposition (Late Miocene, 5.5 my Feng and Buffler, 1991 to Middle Pleistocene, 0.6 my, Weimer, 1991)

Unit 50 contains some unusual eastward dipping reflectors on several dip lines across the Florida Escarpment (Fig. 5). The origin of these unusual reflectors is still unknown but might be due to a combination of sediment drape and current erosion which prevent sediment deposition immediately adjacent the escarpment. Alternatively, these depressions could result from high-energy sediment gravity flows scouring "plunge pools".

Unit 40 differs from unit 50 by being thinner (Fig. 21), having a gentler gradient of the upper surface which dips southeast instead of south, and by roughly filling in a large structural low (Fig. 22). Unit 40 is characterized by subparallel, moderate continuity, and moderate amplitude reflections that are interpreted to be indicative of predominantly proximal fan siliciclastic deposition. Unit 40 also differs from unit 50 by its absence in the northeastern portion of the study area adjacent to the Florida Escarpment (Figs. 7, 21). Seismic lines in this area were interpreted to indicate non-depositional conditions.

Unit 40 thickens toward the west central portion of the data area. Unit 40 approximately correlates with unit 5 of Feeley and others (1984). Unit 40 has a depositional axis on the central Mississippi Fan. The age of unit 40 (approximately 0.47 to 0.6 my) has been determined by correlation with Feeley and others (1984) and subsequent comparisons with Weimer (1989) and Weimer (1991).

unit 30 and unit 20 - proximal Mississippi Fan siliciclastic deposition

Units 30 and 20 are interpreted to contain proximal fan siliciclastic sediments deposited via gravity flows (including channelized flows) and mass movements because of a mounded onlap fill pattern and significant variability of reflection configuration, continuity, and amplitude (Table 1). The mounded onlap fill pattern is probably caused by the building of channel-levee systems. The variability of seismic characteristics of units 30 and 20 is likely due to the combination of channel levee, and mass transport deposits.

The depositional axis of unit 30 lies near the broad depression that runs parallel to the Florida Escarpment (Fig. 23). This depositional axis correlates with the DeSoto channel (mapped with GLORIA data). The pre-existing topography seems to have controlled the position of channel-levee system which was also noted by Feeley and others (1984), Bouma and others (1983/1984), and Weimer (1989). Unit 30 approximately correlates in extent to unit 6 of Feeley and others (1984) and has an age of approximately 0.085 to 0.5 my (Walters, 1985).

Unit 30, like unit 50, contains some unusual eastward dipping reflectors adjacent to the Florida Escarpment (Fig. 5). These reflectors do not appear to be associated with any of the common eastward dipping sediments of channel/levee systems. The origin of the unusual reflectors is still unknown but might be due to a combination of sediment drape and current erosion or winnowing processes.

The depositional axis of unit 20, like the axis of unit 30, lies near a northwest-southeast trending structural trough in surface S-20 (Fig. 24). This depression in S-20 lies approximately 150 km southwest of the one filled by unit 30. The depositional axis of unit 20 correlates with the main Mississippi Fan channel (mapped from GLORIA data) and lies approximately 25-50 km westward of the S-20 structural depression in the northwest portion of the data area. If unit 20 started by filling the depression in S-20, then this offset implies a westward migration of the depositional axis during the deposition of unit 20. South of approximately 25.5°N and approximately where the main Mississippi Fan channel becomes unresolved on GLORIA data, the depositional axis of unit 20 widens significantly (Fig. 25). This widening is interpreted to show a divergence of the main channel into smaller channels or a change to unchannelized gravity flow deposition. Unit 20 corresponds with the combination of units 7 and 8 of Feeley and others (1984). The age of unit 20 is estimated by comparison to Weimer (1989) and Weimer (1991) to be from approximately 0.18 my to the Late Pleistocene.

Carbonate sediment contribution to the deep eastern Gulf

Assessment of carbonate sediment contributions to the eastern Gulf basin fill were made by studying the westward dipping downlapping reflectors adjacent to the Florida Escarpment on northeast - southwest trending seismic profiles (isopach and structural maps were of little use for assessment because no definitive carbonate signals could be detected). No seismic units that consisted predominantly of carbonate sediments were found on the seismic profiles . Consequently, a large contribution of carbonate sediments to the eastern Gulf is unlikely. Some minor sets of downlapping reflectors, however, were found within unit 30. Because unit 30 has a channel-levee system adjacent to the Florida Escarpment (Fig. 23), some of these westward dipping reflectors are part of the western flank of siliciclastic levee sediments. The remaining reflectors have downlap downdip and onlap updip and appear to indicate carbonate mass movements derived from the west Florida platform and slope (Fig. 7).

The lower portions of the DSDP borehole (~ 3772 to 3801 meters below sea level, see Fig. 4) at site 615 (125 km from the Florida Escarpment) are correlative with unit 30 of this study, and lithologic data show a 29 m thick carbonate gravity-flow deposit (Brooks and others, 1986). This unit apparently is below the resolution of our seismic data, and thus we were unable to resolve the source and pathway of this flow.

Twichell and others (1990) found interfingering carbonate and fan terrigenous surficial deposits along the base of the Florida Escarpment throughout the study area of this report. With the exception of unit 30, no conclusive carbonate deposits were found in our seismic data. This lack of obvious carbonate deposits may be due to the inability of the single-channel seismic data to resolve thin carbonate deposits and the masking of carbonate talus immediately adjacent to the Florida Escarpment by sideswipe and diffraction noise.

SUMMARY

Based on this preliminary seismic stratigraphic study of predominantly USGS single-channel seismic data in the eastern Gulf of Mexico, the following conclusions were made:

(1) Six seismic units comprise the Middle Cretaceous to Holocene section of the deep eastern Gulf. These units are bounded by regionally extensive unconformity and correlative conformity surfaces.

(2) The oldest surface, the Mid-Cretaceous Unconformity (MCU), has similar gradient changes and canyon features in the subbottom as the seafloor along the Florida Escarpment. This similarity implies that the erosional and depositional processes controlling the morphology of the Florida Escarpment have operated for a considerable, but still unknown, length of time. The age of canyon initiation is unknown but began before the deposition of unit 60 (i.e. before the Middle Tertiary).

(3) The predominantly onlap geometry on the lower unit boundaries and concordant geometry on the upper unit boundaries implies sediment source areas to the north and west and generally non-erosional conditions. The unconformities and correlative conformities appear to represent times of nondeposition rather than erosion.

(4) The main seismic facies classifications and basin edge fill stratal patterns were used to infer depositional mechanisms and sediment types. The seismic facies types, mechanisms, and sediment types are as follows:

(a) parallel and continuous reflectors (pelagic/hemipelagic drape)

(b) parallel, variable amplitude, and variable continuity reflectors (distal siliciclastic gravity controlled flows)

(c) divergent to chaotic, variable amplitude, and variable continuity reflectors (proximal fan siliciclastic and carbonate gravity controlled flows and mass movements.

(5) Units 70 and 60 (Middle Cretaceous to Late Miocene) were created primarily by pelagic/hemipelagic drape and some mass transport deposits derived from a western source. Units 50 and 40 (Late Miocene to Middle Pleistocene) were created by roughly equal amounts of hemipelagic drape and distal siliciclastic gravity-controlled flow deposition. Units 30 and 20 (Middle to Late Pleistocene) were created primarily by proximal fan siliciclastic gravity controlled flow and mass movement deposition. The temporal sequence of pelagic to distal clastic to proximal clastic deposition is related to the general migration of depocenters from the western Gulf to the eastern Gulf during the time represented by the seismic units of this report.

(6) Depocenters of units 30 and 20 (Middle Pleistocene to present) correlate with the present DeSoto channel and Mississippe channel systems, respectively. These seismic units initially fill in lows on structural surfaces but migrate laterally approximately 25 to 50 km during development.

(7) Sediment contribution from the West Florida platform to the Mississippi Fan dsince the Mid-Cretaceous are thought to be relatively minor because no wedge shaped seismic units with predominately downlapping seismic reflectors were found along the base of the escarpment. Some minor sets of downlapping reflectors, however, were found within unit 30 and are considered here to be carbonate turbidite or debris flows that travelled down the Florida Escarpment.

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FIGURE CAPTIONS

Figure 1. Bathymetric map of the eastern Gulf of Mexico. Thick lines represent the extent of the DeSoto Channel and the main Mississippi fan channel. Both channels were mapped from GLORIA sidescan imagery. The bathymetry was digitized from the National Oceanic and Atmospheric Administration's (NOAA) National Ocean Service (NOS) Bathymetric Map Series of 1: 125,000 and 1: 1,000,000 scale.

Figure 2. Location map showing the approximate boundaries of eight seismic investigations discussed in this report with coverage in the eastern Gulf of Mexico. The area bounded by thick lines (area F) is the study area of this report. A = Shaub and others, 1984; B = Ibrahim and others, 1981; C = Feeley and others, 1984; D = Walters, 1985; E = Bouma and others, 1986; F= this report; G = Weimer, 1990; and H = Angstadt and others, 1985).

Figure 3. Map of the study area showing selected tracklines of R/V FARNELLA cruises FRNL82-7, FRNL85-2, and FRNL85-3A and R/V IDA GREEN cruise 23. Solid lines represent the ships track along which seismic data were collected, interpreted, and digitized. Thick lines indicate seismic profiles in the corresponding figures. Dotted lines represent the base of the Florida and Campeche Escarpments. Also shown are the locations of DSDP boreholes at sites 614, 615, 616, 623, and 624 and the outline of Fig. 14.

Figure 4. Schematic comparison of selected seismic sequence and seismic unit studies in the vicinity of DSDP site 615 (see Fig. 3 for location). Data for this figure was taken from depth-to-structure maps published in these seismic studies.

Figure 5. Seismic line 3-20 (see Fig. 3 for profile location) with the seismic surfaces identified marked by dots and numbers. The seismic units are identified as unit 70 etc. This dip profile adjacent to the Florida Escarpment shows how the units onlap the escarpment. Also note the internal convergence in unit 60 and unit 70, the eastward dipping reflectors in the lower portions of unit 50 and unit 30 immediately adjacent the Florida Escarpment, and the westward downlapping reflectors in the upper portions of unit 30.

Figure 6. Seismic line 3-12 (see Fig. 3 for location) runs parallel with the Florida Escarpment, and the lowermost surface S-70 is is a subsurface continuation of the escarpment. Note that unit 70 is missing and that unit 60 is the basal unit on this profile.

Figure 7. Seismic line 2-20 (see Fig. 3 for location) intersects the Florida Escarpment near 26° N. This profile intersects line 3-1 (Fig. 8), and surface 70 is not easily defined along the base of the escarpment because of the diffractions associated with this steep slope. Unit 40 pinches out west of the profile, and thus is absent here as are units 60 and 70.

Figure 8. Seismic line 3-1 (see Fig. 3 for location) which runs parallel to the Florida Escarpment and about 5 km seaward of its base. This profile intersects line 2-20 (Fig. 7), and the lowermost surface, S-70, is not easily defined in places because of the numerous small canyons cut into it.

Figure 9. Seismic line 3-12 (see Fig. 3 for location) parallels the escarpment near 25° N where it is deeply incised by large canyons.

Figure 10. Seismic line FS-1 (see Fig. 3 for location) parallels line 3-12 (Fig. 9), but is seaward of it. This profile also intersects line 3-24 (Fig. 11). The canyons cut in S-70 are more subdued than in Figure 9.

Figure 11. Seismic line 3-24 (see Fig. 3 for location) is a dip profile that intersects lines 3-12 (Fig. 9) and FS-1 (Fig. 10). Note the possible erosion of unit 70 adjacent to the escarpment.

Figure 12. Seismic line 2-20 (see Fig. 3 for location) shows unit 40 which is absent closer to the escarpment (Fig. 7). Note the upper boundary of unit 40 (S-30) is mostly concordant and dips eastward in places. The internal reflections of unit 40 are onlapping and prograding eastward. Unit 30 onlaps updip and progrades westward on this seismic line.

Figure 13. Depth-to-structure map of the subsurface portion of surface 70. Surface 70 is exposed along the Florida Escarpment, but this protion is not shown on this map. Contours are in meters below sea level drawn , and the contour interval is 200 m.

Figure 14. Depth to surface 70 in a small area along the Florida Escarpment where seismic coverage was relatively dense (see Fig. 3 for location). Depth contours at 1500 m, 2000 m, 2500 m and 3000 m have been constructed from SeaBeam data and are shown as dashed lines while contours below 3000 m have been generated from single-channel seismic data discussed in this report. Bold portions of these lines reference figures used in this report.

Figure 15. Isopach map for unit 70. Contours are in meters , and the contour interval is 100 m. This unit thickens systematically to the west/southwest.

Figure 16. Depth-to-structure map for surface 60. Contours are in meters drawn on the base of unit 60 seaward of surface 70. Contour interval is 50 m.

Figure 17. Isopach map for unit 60. Contours are in meters, and the contour interval is 100 m. This unit thickens westward; rapidly within 25 km of the escarpment and more gradually seaward of here.

Figure 18. Depth-to-structure map for surface 50. Contours are in meters and are drawn on the base of unit 50 seaward of surface 70. Contour interval is 50 m.

Figure 19. Isopach map for unit 50. Contours are in meters, and the contour interval is 100 m. This unit thickens towards the northwest rather than the west.

Figure 20. Depth-to-structure map for surface 40. Contours are in meters and are drawn on the base of unit 40 seaward of surface 70. Contour interval is 50 m.

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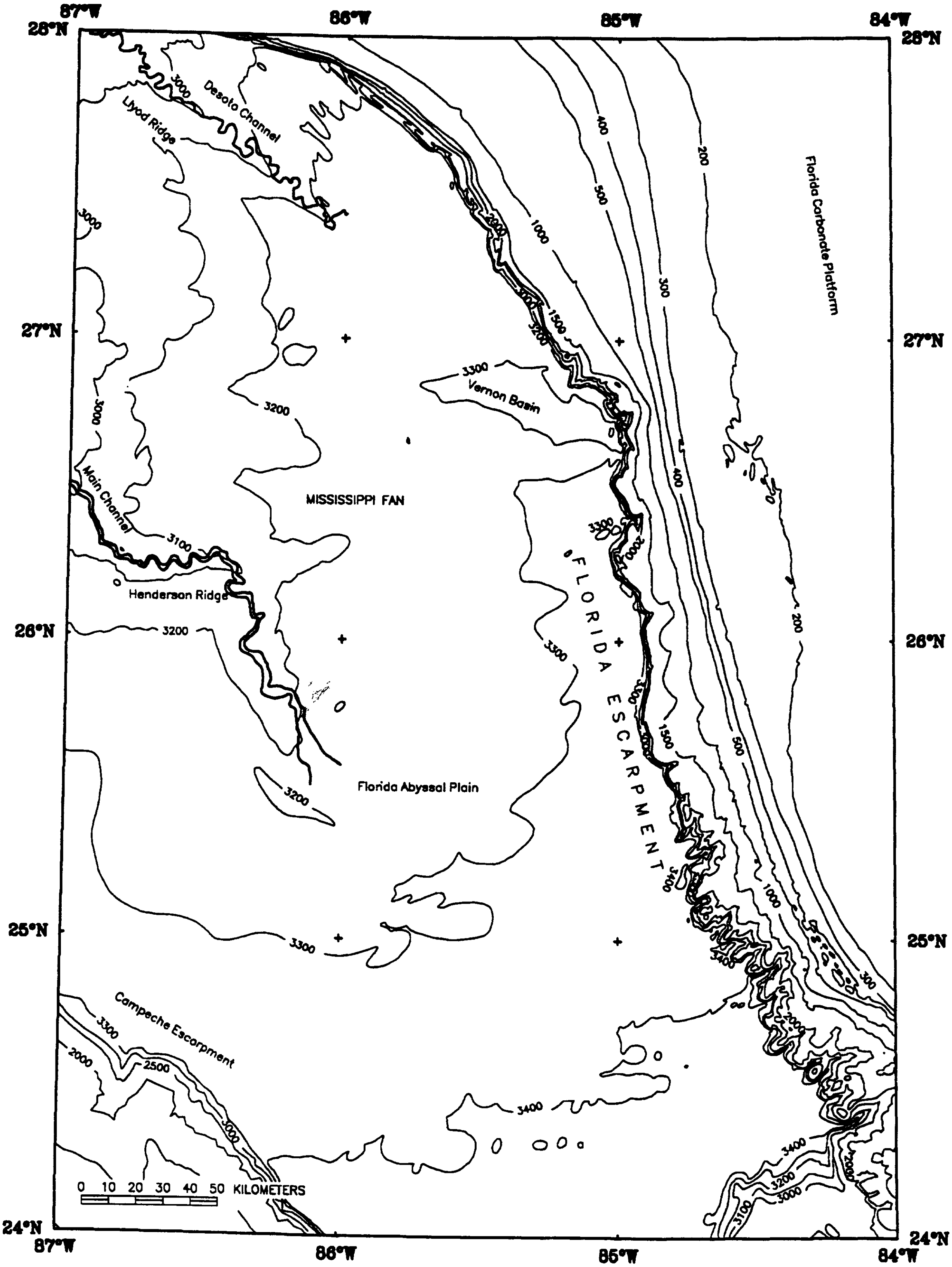


Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5

Figure 1

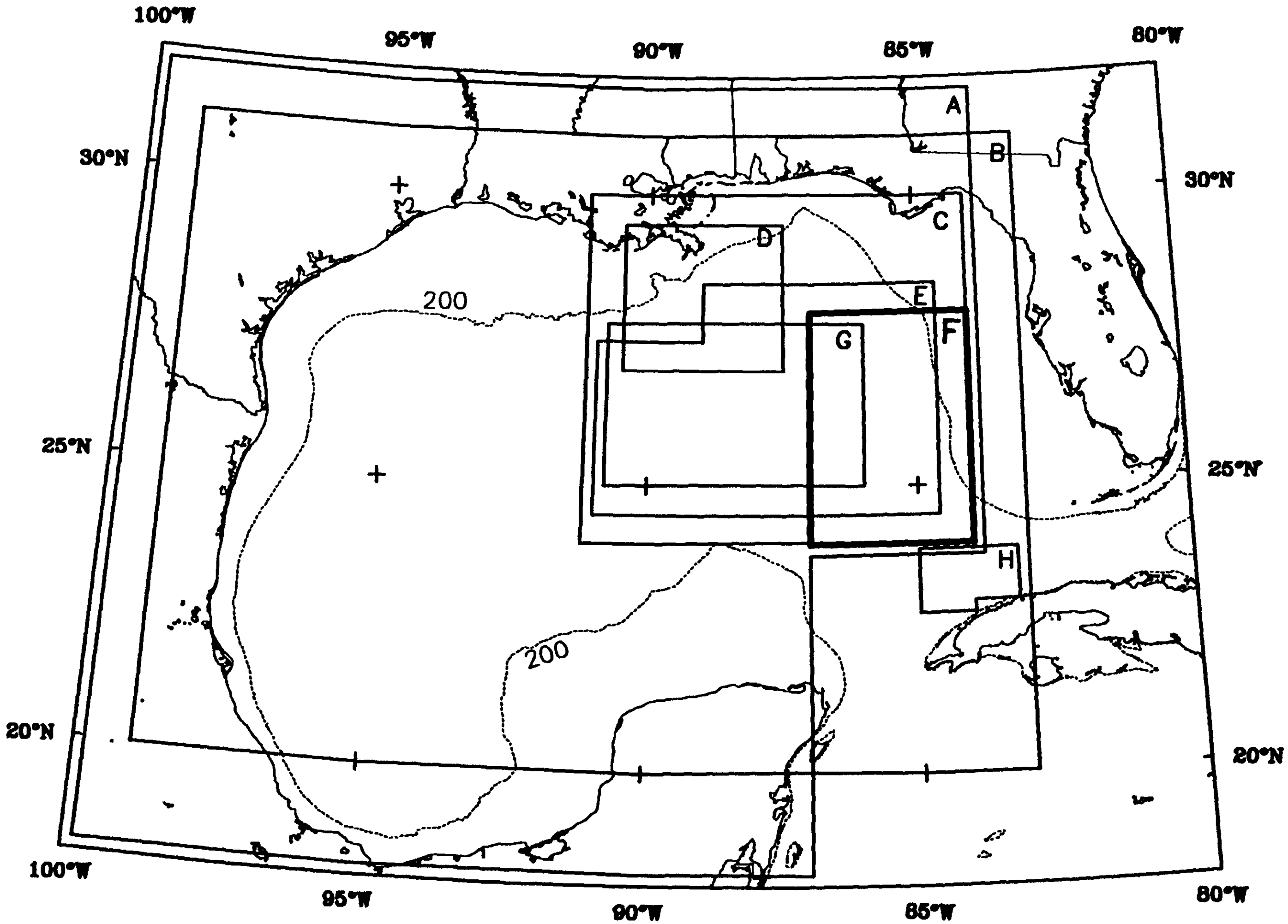


Figure 2

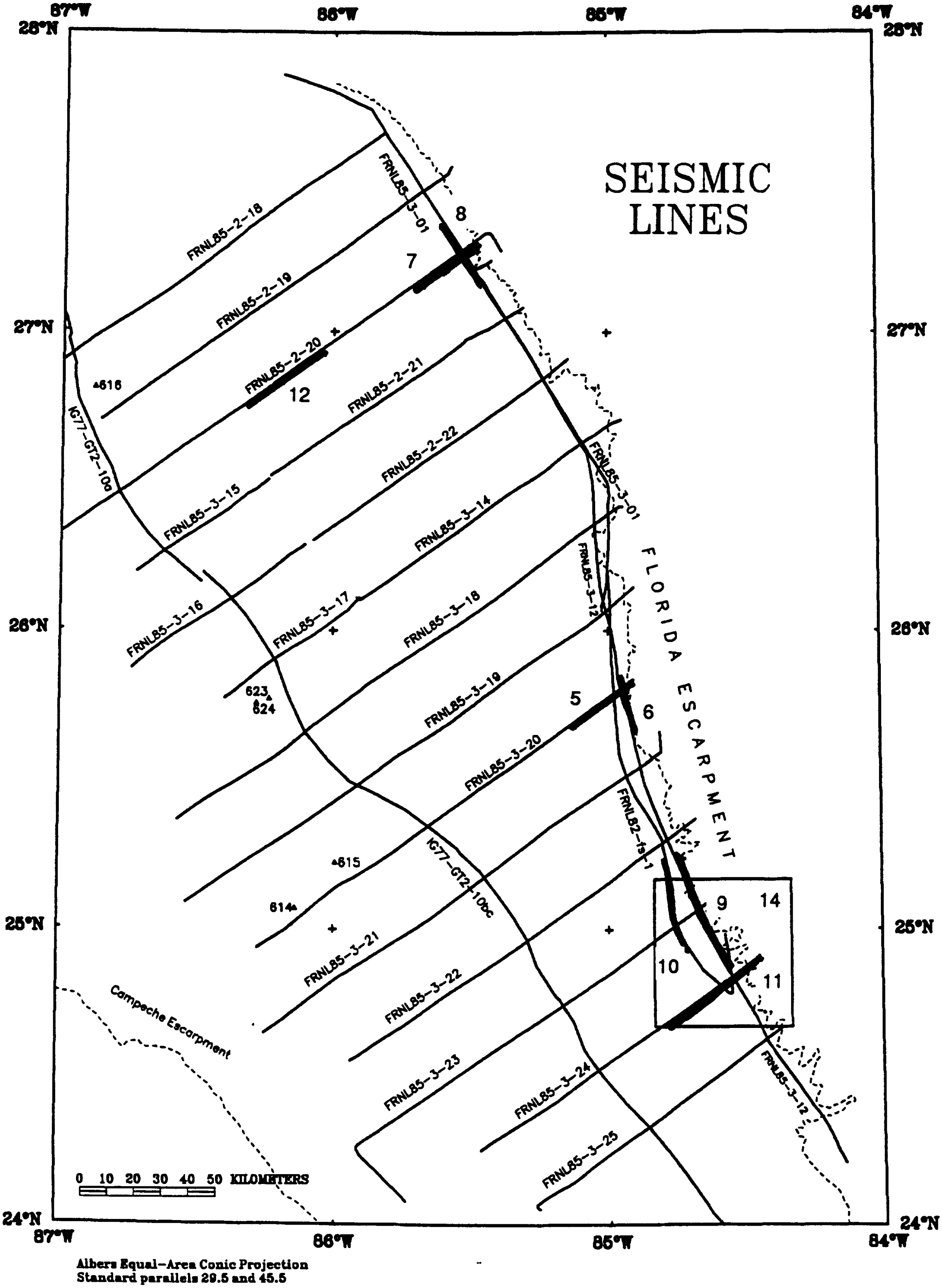
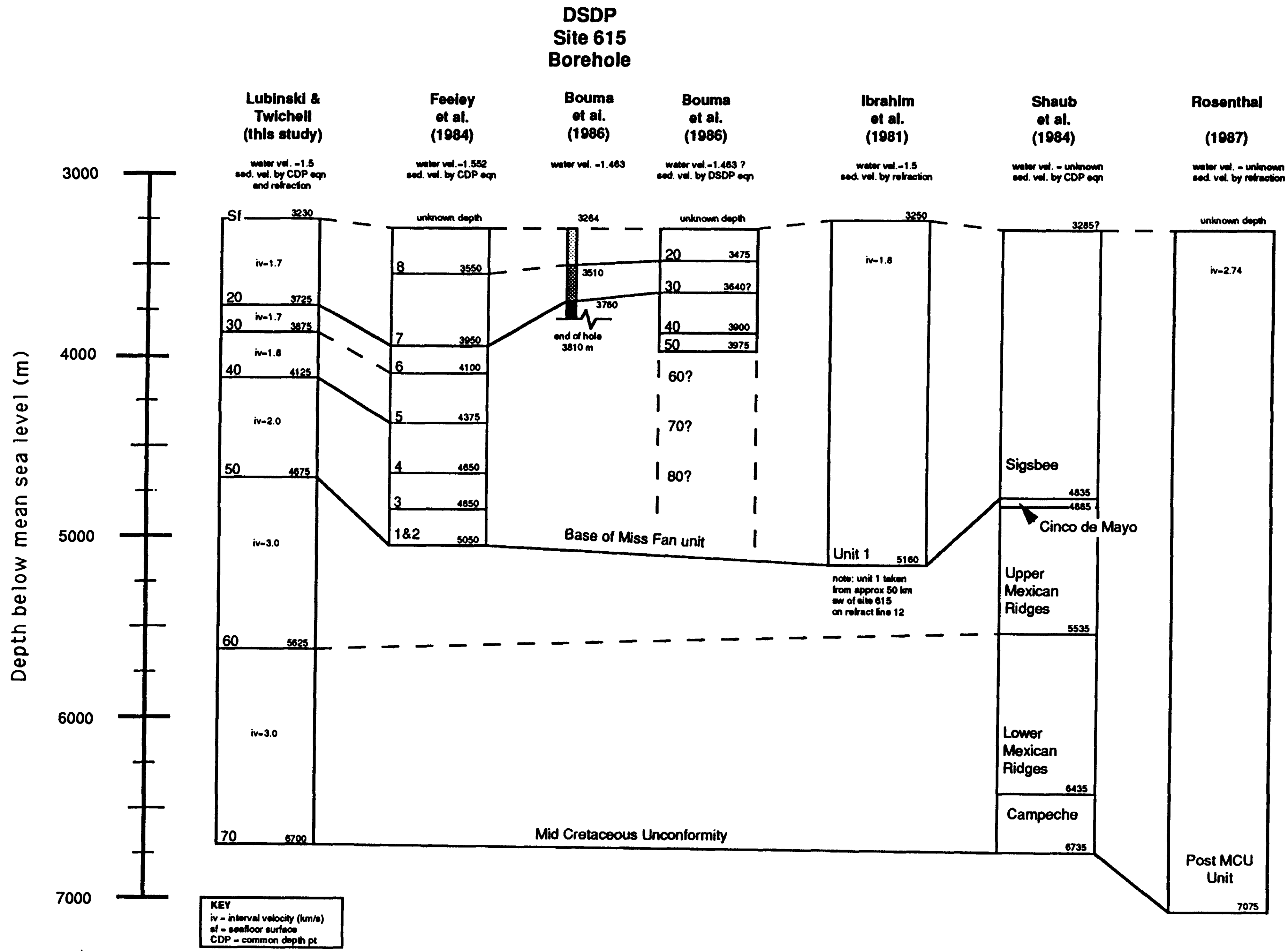

87°W
86°W
85°W
84°W
28°N
27°N
26°N
25°N
24°N
SEISMIC LINES
FLORIDA ESCARPMENT
Campeche Escarpment
FRNL85-2-18
FRNL85-2-19
FRNL85-2-20
FRNL85-2-21
FRNL85-2-22
FRNL85-3-01
FRNL85-3-12
FRNL85-3-14
FRNL85-3-15
FRNL85-3-16
FRNL85-3-17
FRNL85-3-18
FRNL85-3-19
FRNL85-3-20
FRNL85-3-21
FRNL85-3-22
FRNL85-3-23
FRNL85-3-24
FRNL85-3-25
FRNL82-fs-1
IG77-GT2-10a
IG77-GT2-10bc
616
615
614
623
624
5
6
7
8
9
10
11
12
14
0 10 20 30 40 50 KILOMETERS
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5

Figure 3



DSDP
Site 615
Borehole
Depth below mean sea level (m)
3000
4000
5000
6000
7000
Lubinski & Twichell (this study)
water vel. =1.5
sed. vel. by CDP eqn and refraction
Sf
3230
iv=1.7
20
3725
iv=1.7
30
3875
iv=1.8
40
4125
iv=2.0
50
4675
iv=3.0
60
5625
iv=3.0
70
6700
Feeley et al. (1984)
water vel.=1.552
sed. vel. by CDP eqn
unknown depth
8
3550
7
3950
6
4100
5
4375
4
4650
3
4850
1&2
5050
Bouma et al. (1986)
water vel. =1.463
3264
3510
3760
end of hole 3810 m
Bouma et al. (1986)
water vel.=1.463 ?
sed. vel. by DSDP eqn
unknown depth
20
3475
30
3640?
40
3900
50
3975
60?
70?
80?
Base of Miss Fan unit
Ibrahim et al. (1981)
water vel.=1.5
sed. vel. by refraction
3250
iv=1.8
Unit 1
5160
note: unit 1 taken from approx 50 km sw of site 615 on refract line 12
Shaub et al. (1984)
water vel. = unknown
sed. vel. by CDP eqn
3285?
Sigsbee
4835
4885
Cinco de Mayo
Upper Mexican Ridges
5535
Lower Mexican Ridges
6435
Campeche
6735
Rosenthal (1987)
water vel. = unknown
sed. vel. by refraction
unknown depth
iv=2.74
Post MCU Unit
7075
Mid Cretaceous Unconformity
KEY
iv = interval velocity (km/s)
sf = seafloor surface
CDP = common depth pt

Figure 4

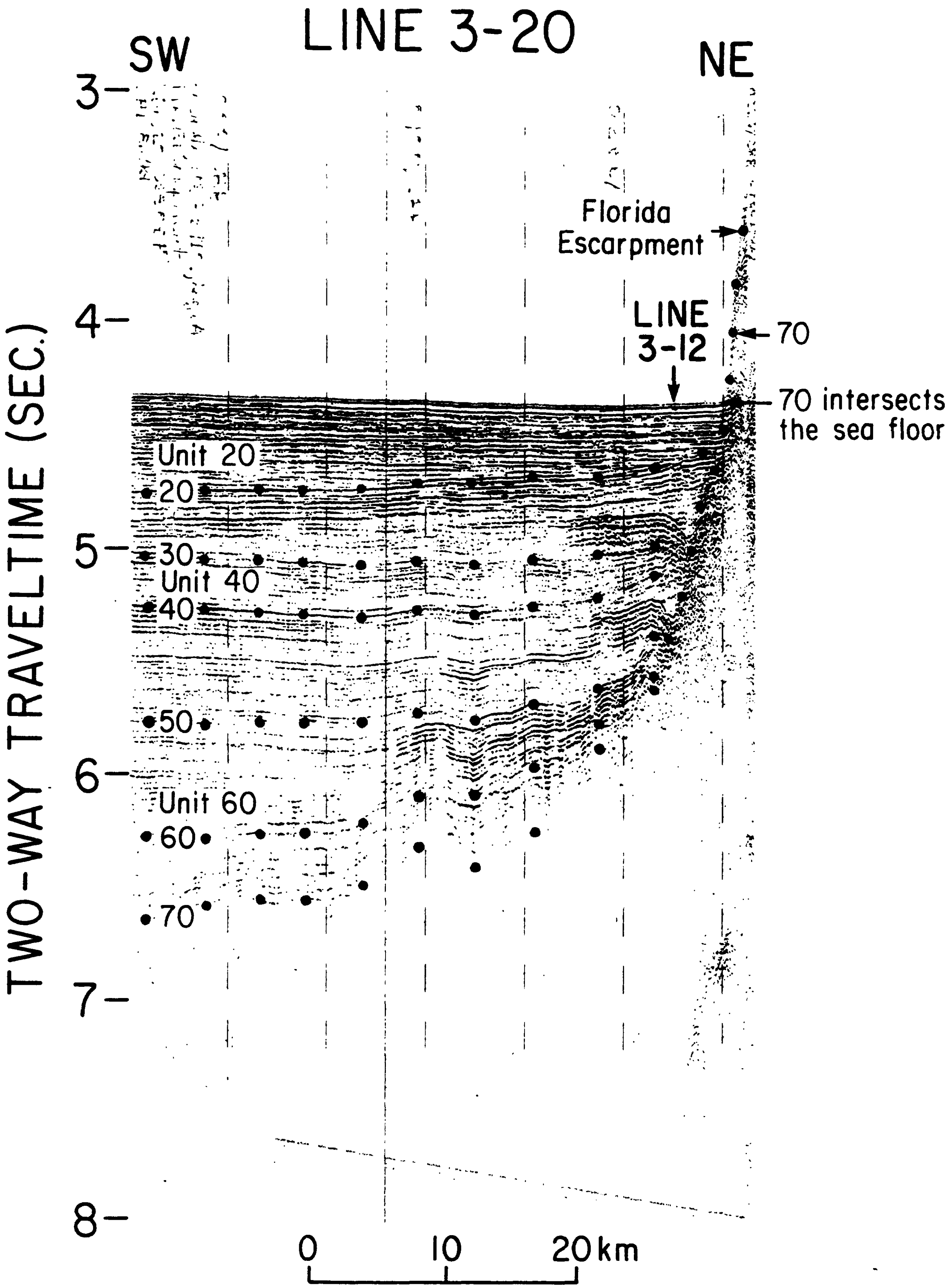

LINE 3-20
SW
NE
TWO-WAY TRAVELTIME (SEC.)
3
4
5
6
7
8
Florida Escarpment
LINE 3-12
70
70 intersects the sea floor
Unit 20
20
30
Unit 40
40
50
Unit 60
60
70
0
10
20 km

Figure 5

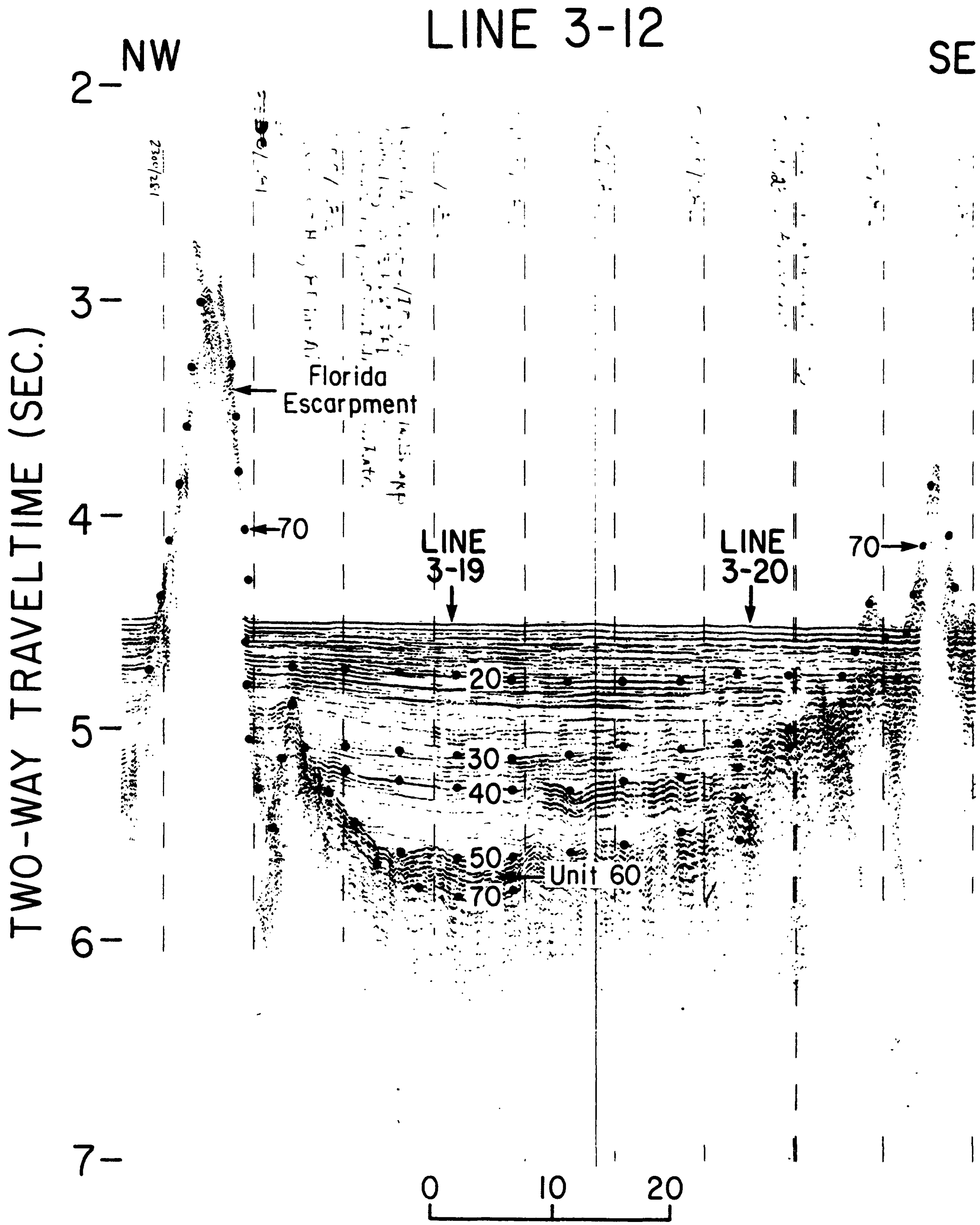

LINE 3-12
NW
SE
TWO-WAY TRAVELTIME (SEC.)
2
3
4
5
6
7
Florida Escarpment
70
LINE 3-19
LINE 3-20
70
20
30
40
50
Unit 60
70
0
10
20

Figure 6

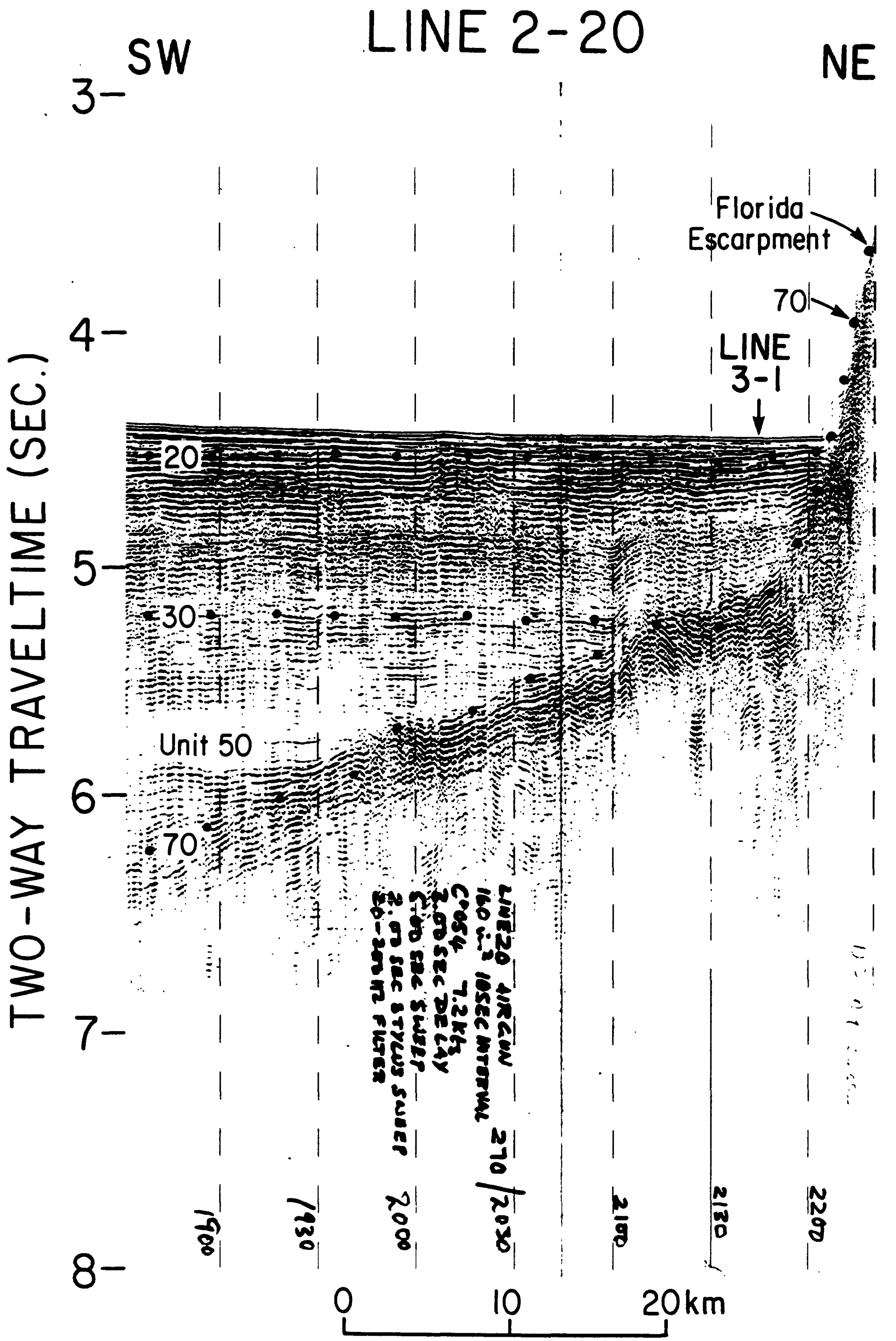

LINE 2-20
SW
NE
TWO-WAY TRAVELTIME (SEC.)
3
4
5
6
7
8
Florida Escarpment
70
LINE 3-1
20
30
Unit 50
70
1900
1930
2000
2030
2100
2130
2200
0
10
20km

Figure 7

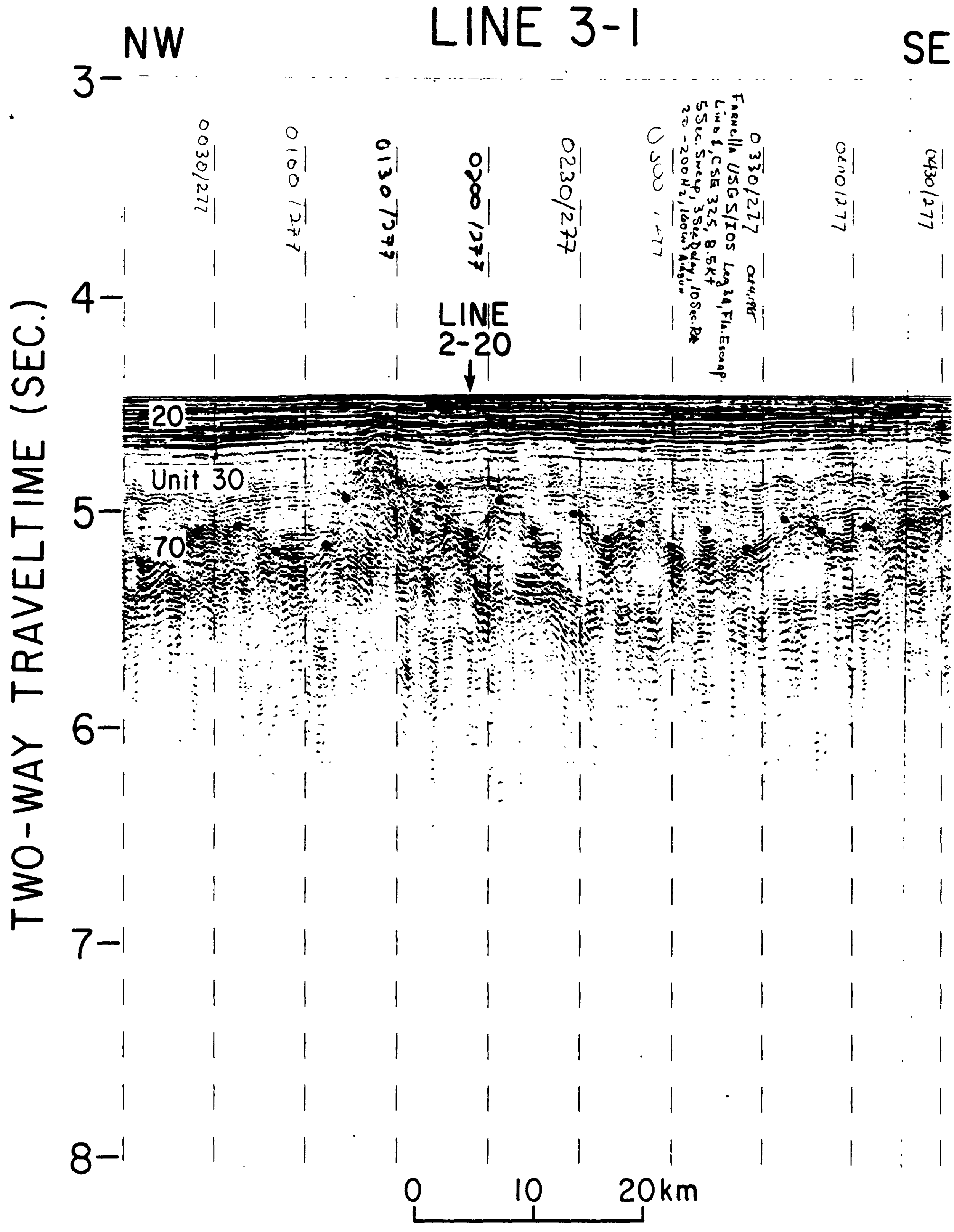

LINE 3-1
NW
SE
TWO-WAY TRAVELTIME (SEC.)
3
4
5
6
7
8
LINE
2-20
20
Unit 30
70
0
10
20km

Figure 8

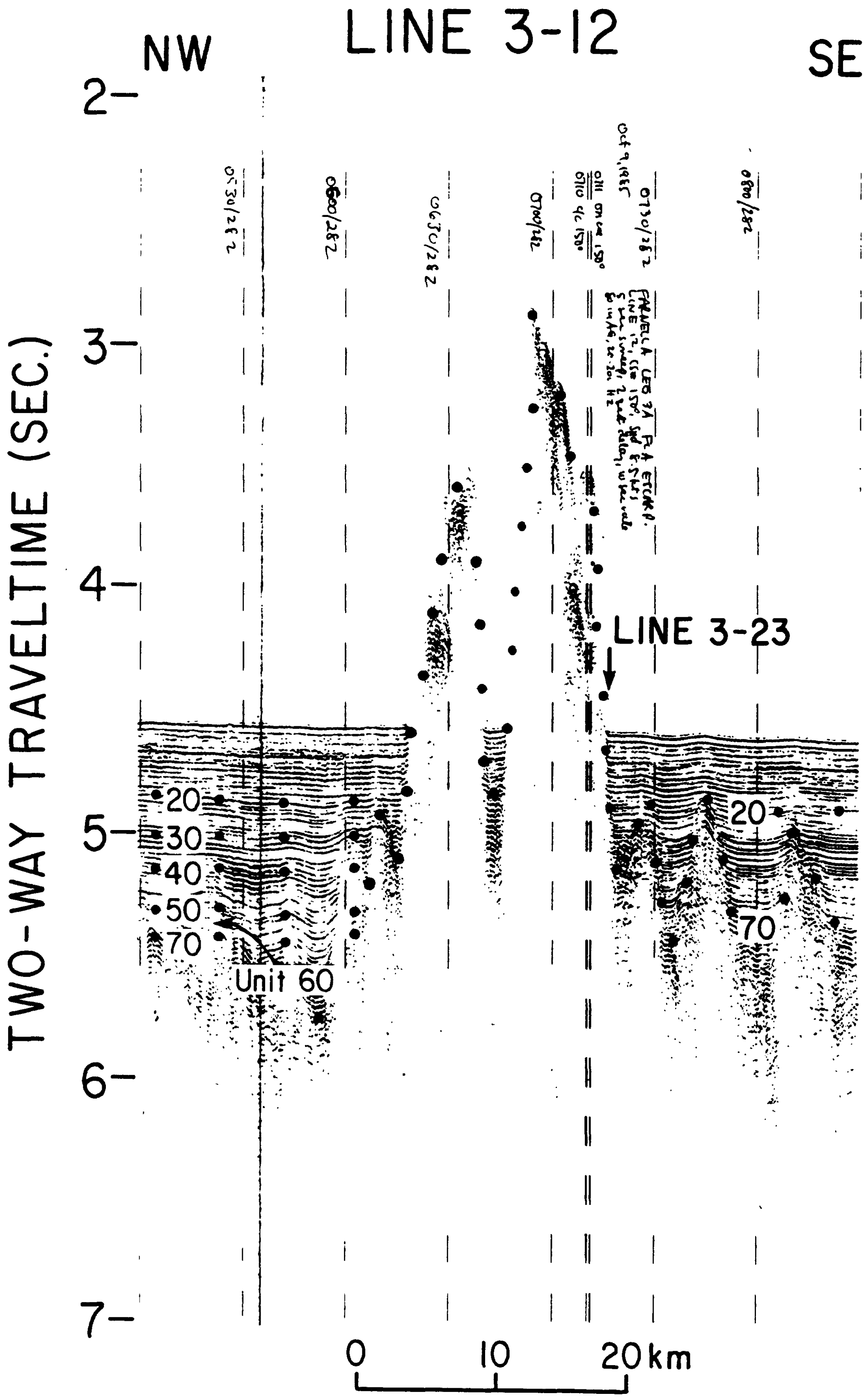

LINE 3-12
NW
SE
TWO-WAY TRAVELTIME (SEC.)
2
3
4
5
6
7
LINE 3-23
20
30
40
50
70
Unit 60
20
70
0
10
20km

Figure 9

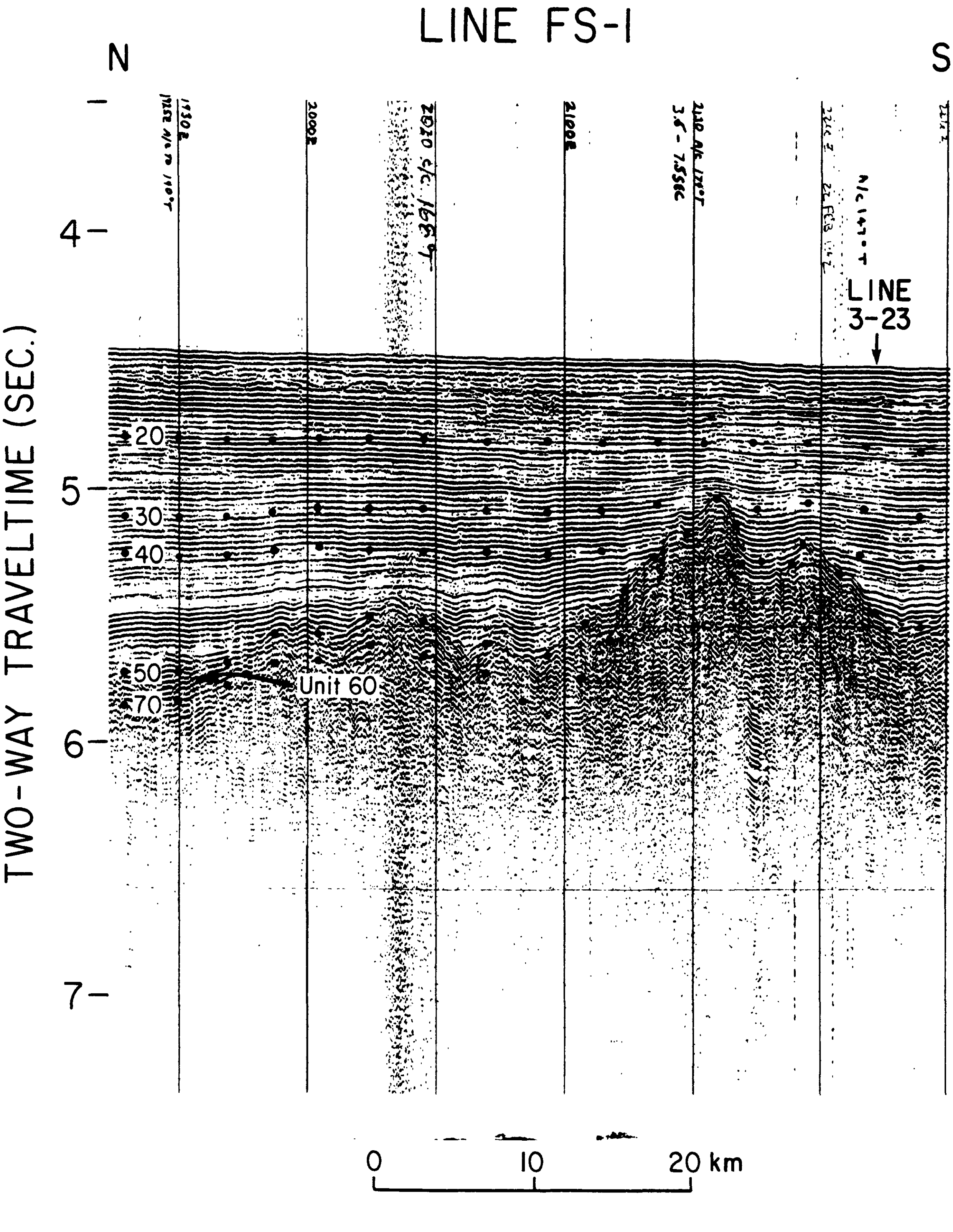

LINE FS-1
N
S
TWO-WAY TRAVELTIME (SEC.)
4
5
6
7
LINE
3-23
20
30
40
50
70
Unit 60
0
10
20 km

Figure 10

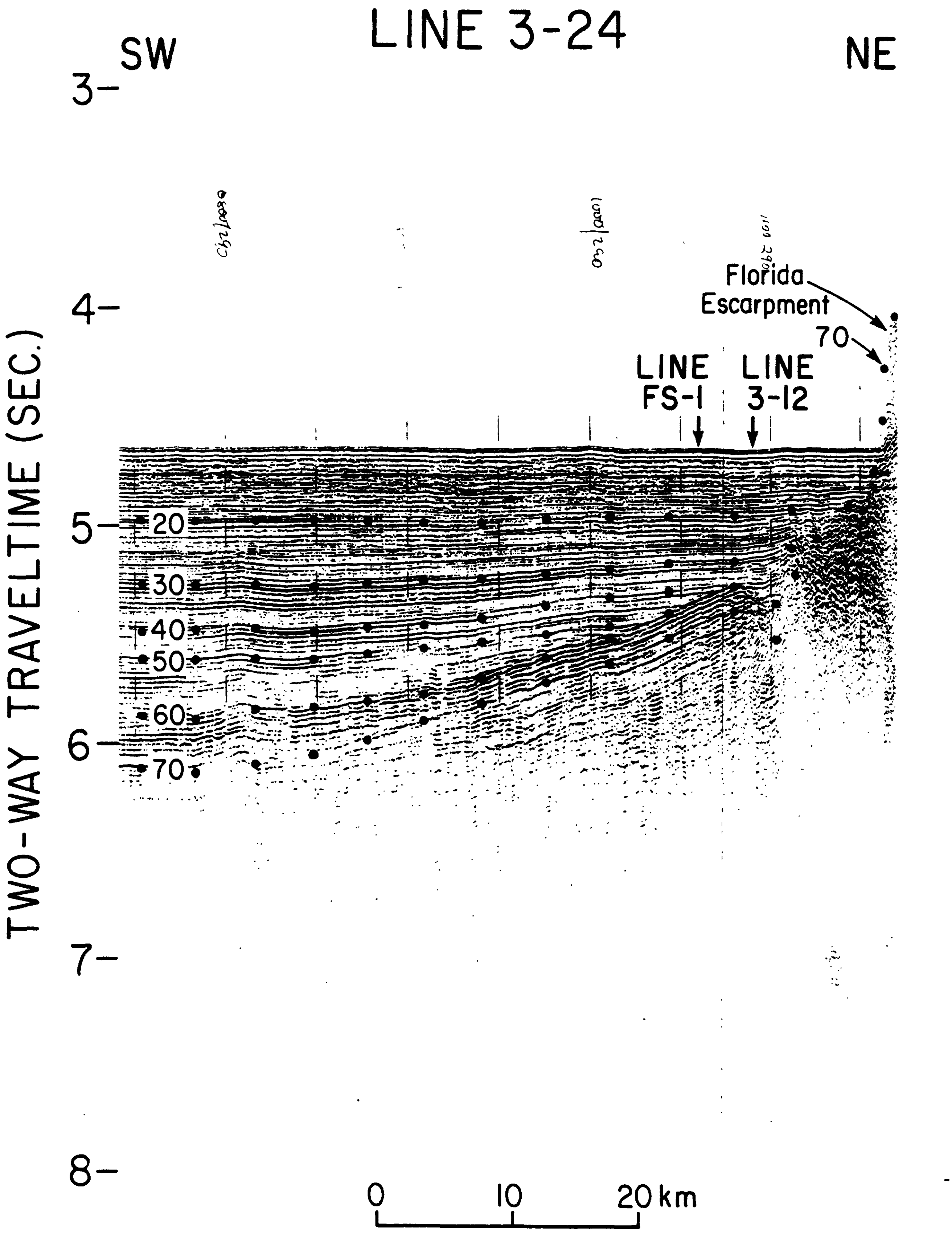
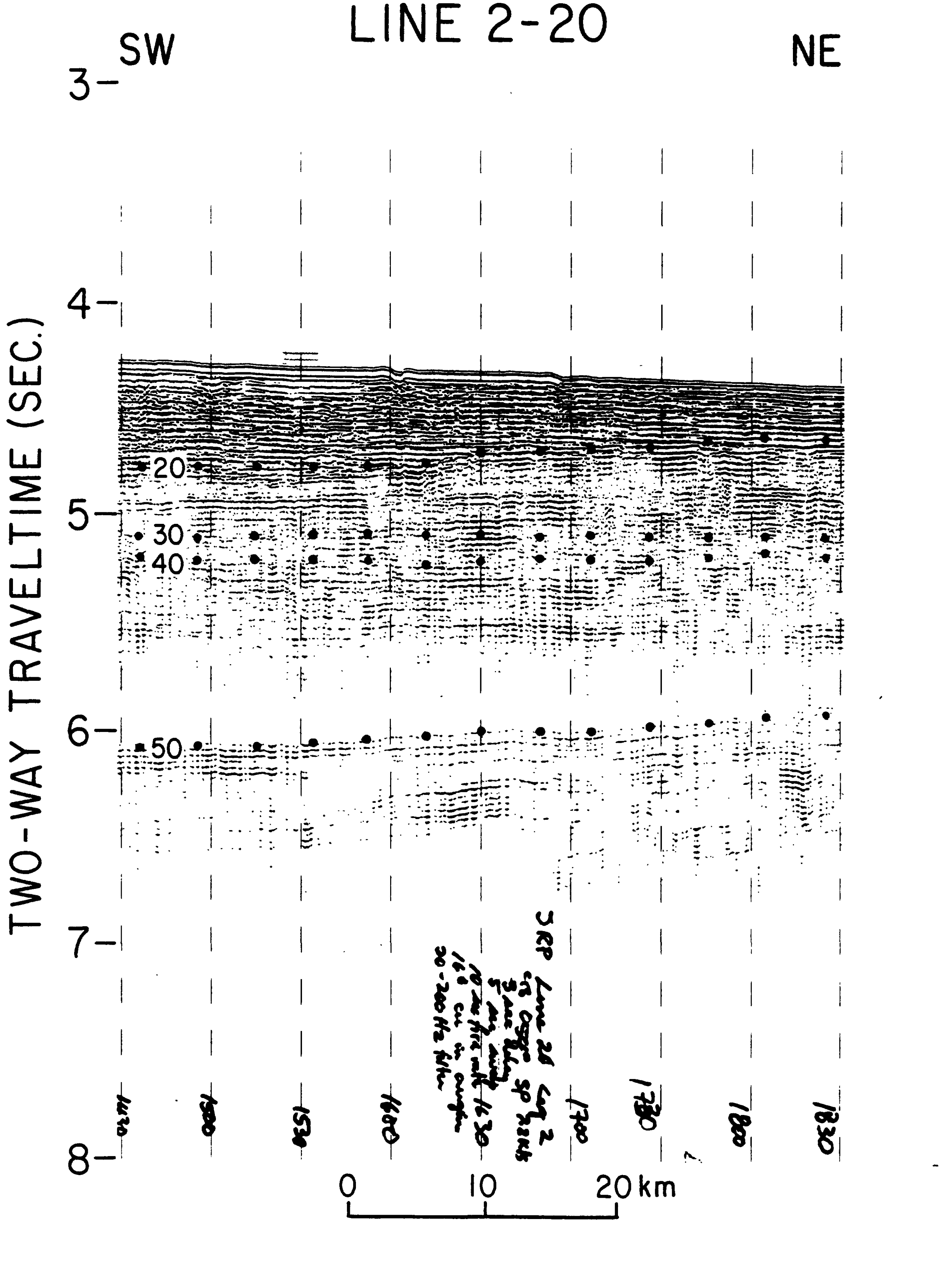

LINE 3-24
SW
NE
3-
4-
5-
6-
7-
8-
TWO-WAY TRAVELTIME (SEC.)
Florida
Escarpment
70
LINE
FS-1
LINE
3-12
20
30
40
50
60
70
0
10
20 km

Figure 11



LINE 2-20
SW
NE
TWO-WAY TRAVELTIME (SEC.)
3
4
5
6
7
8
20
30
40
50
0
10
20 km

Figure 12

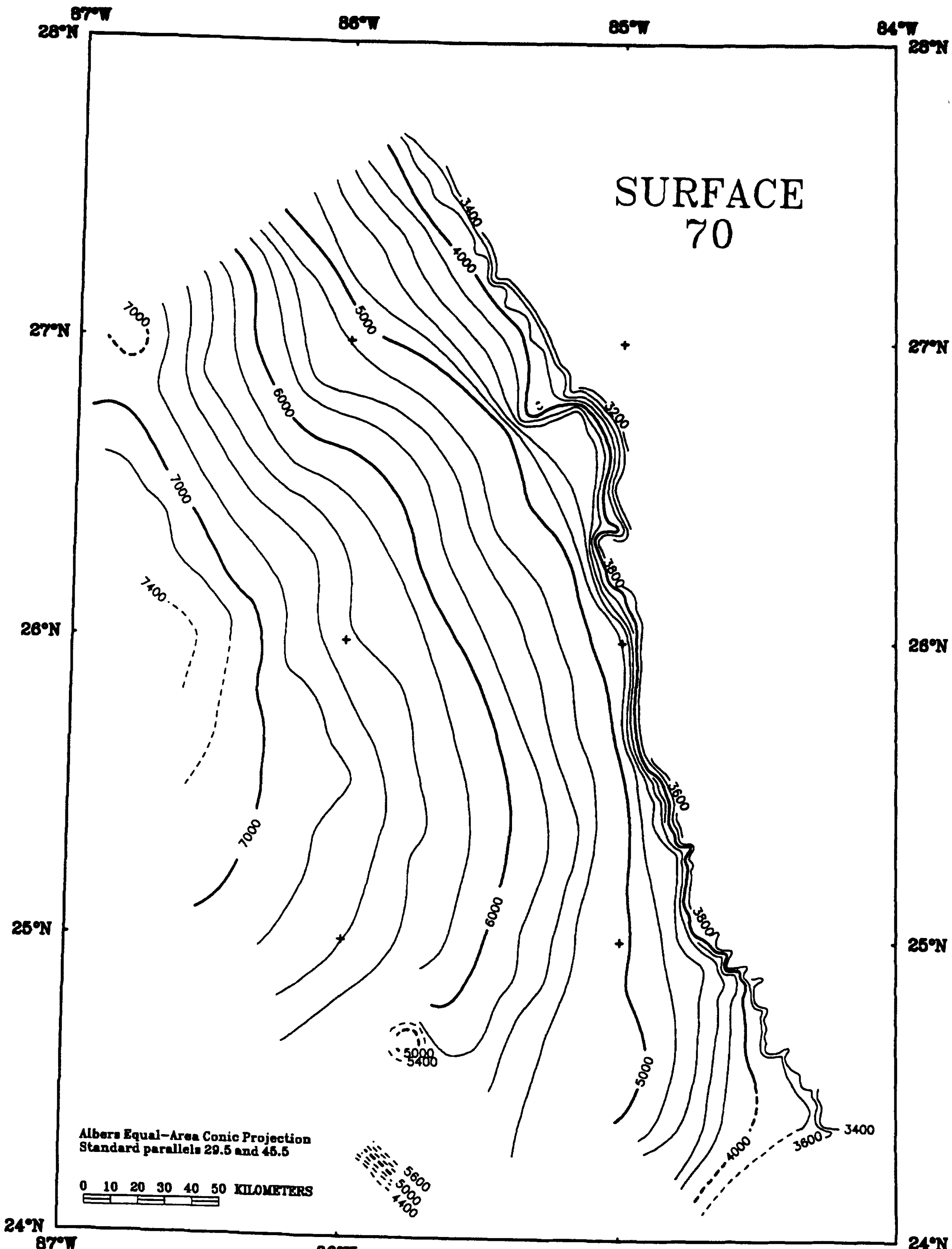

SURFACE
70
87°W
86°W
85°W
84°W
28°N
27°N
26°N
25°N
24°N
3400
4000
5000
6000
7000
7400
3200
3800
3600
5400
5600
4400
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5
0 10 20 30 40 50 KILOMETERS

Figure 13

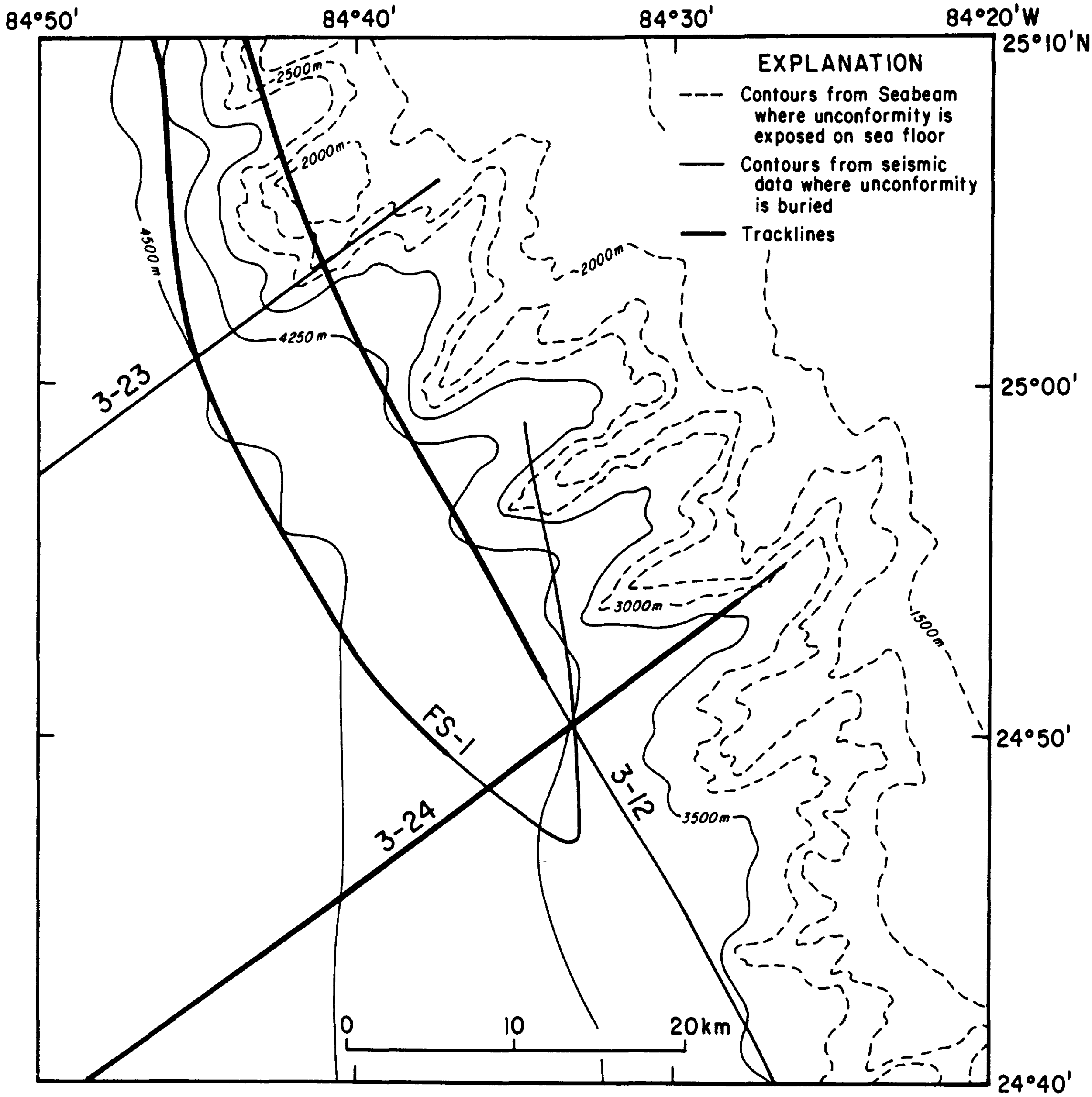

84°50'
84°40'
84°30'
84°20'W
25°10'N
25°00'
24°50'
24°40'
EXPLANATION
Contours from Seabeam where unconformity is exposed on sea floor
Contours from seismic data where unconformity is buried
Tracklines
2500m
2000m
2000m
4500m
4250m
3000m
3500m
1500m
3-23
3-24
FS-1
3-12
0
10
20km

Figure 14

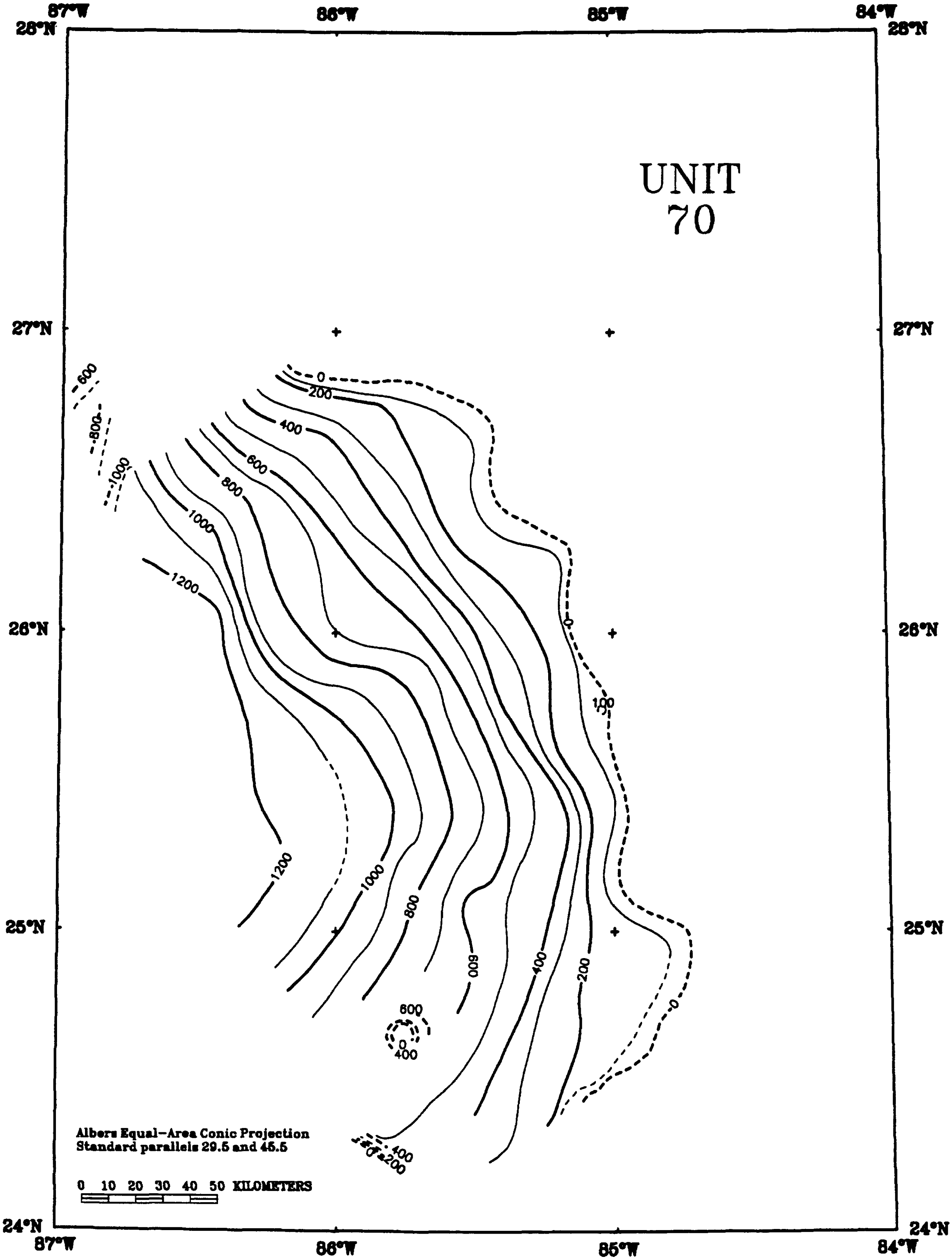

87°W
86°W
85°W
84°W
28°N
27°N
26°N
25°N
24°N
UNIT
70
0
200
400
600
800
1000
1200
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5
0 10 20 30 40 50 KILOMETERS

Figure 15

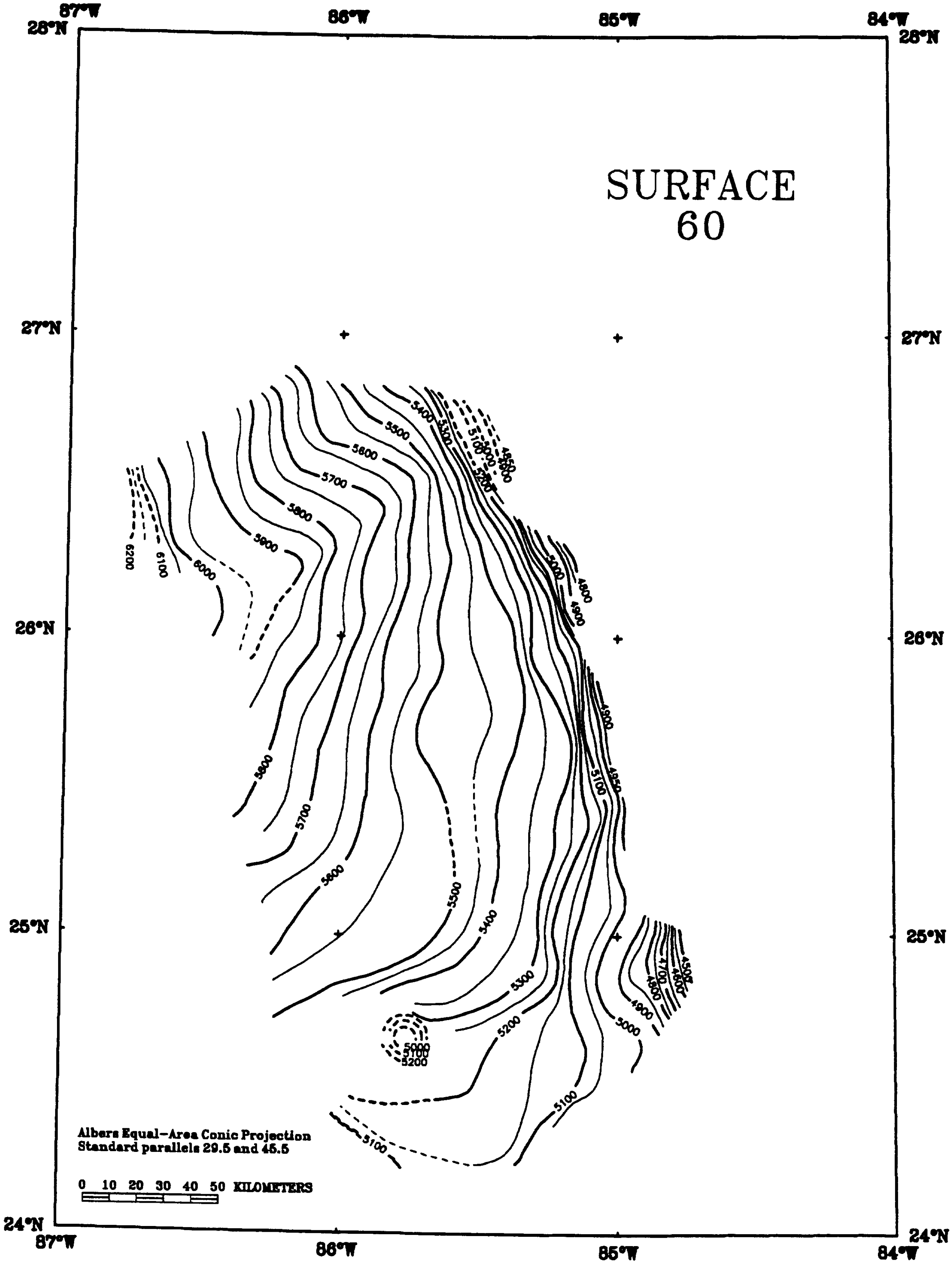

87°W
86°W
85°W
84°W
28°N
27°N
26°N
25°N
24°N
SURFACE
60
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5
0 10 20 30 40 50 KILOMETERS

Figure 16

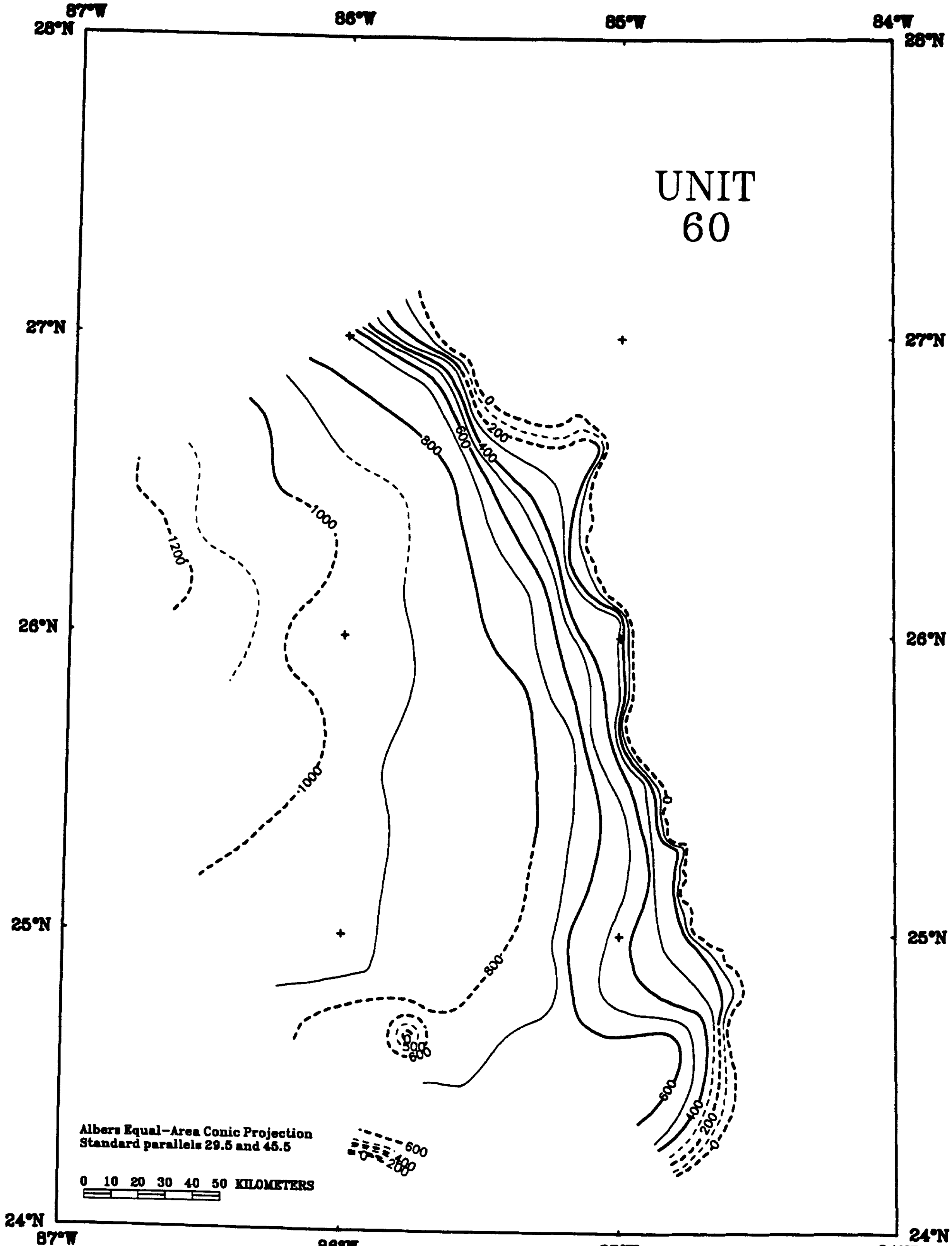

87°W
86°W
85°W
84°W
28°N
27°N
26°N
25°N
24°N
UNIT
60
0
200
400
600
800
1000
1200
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5
0 10 20 30 40 50 KILOMETERS

Figure 17

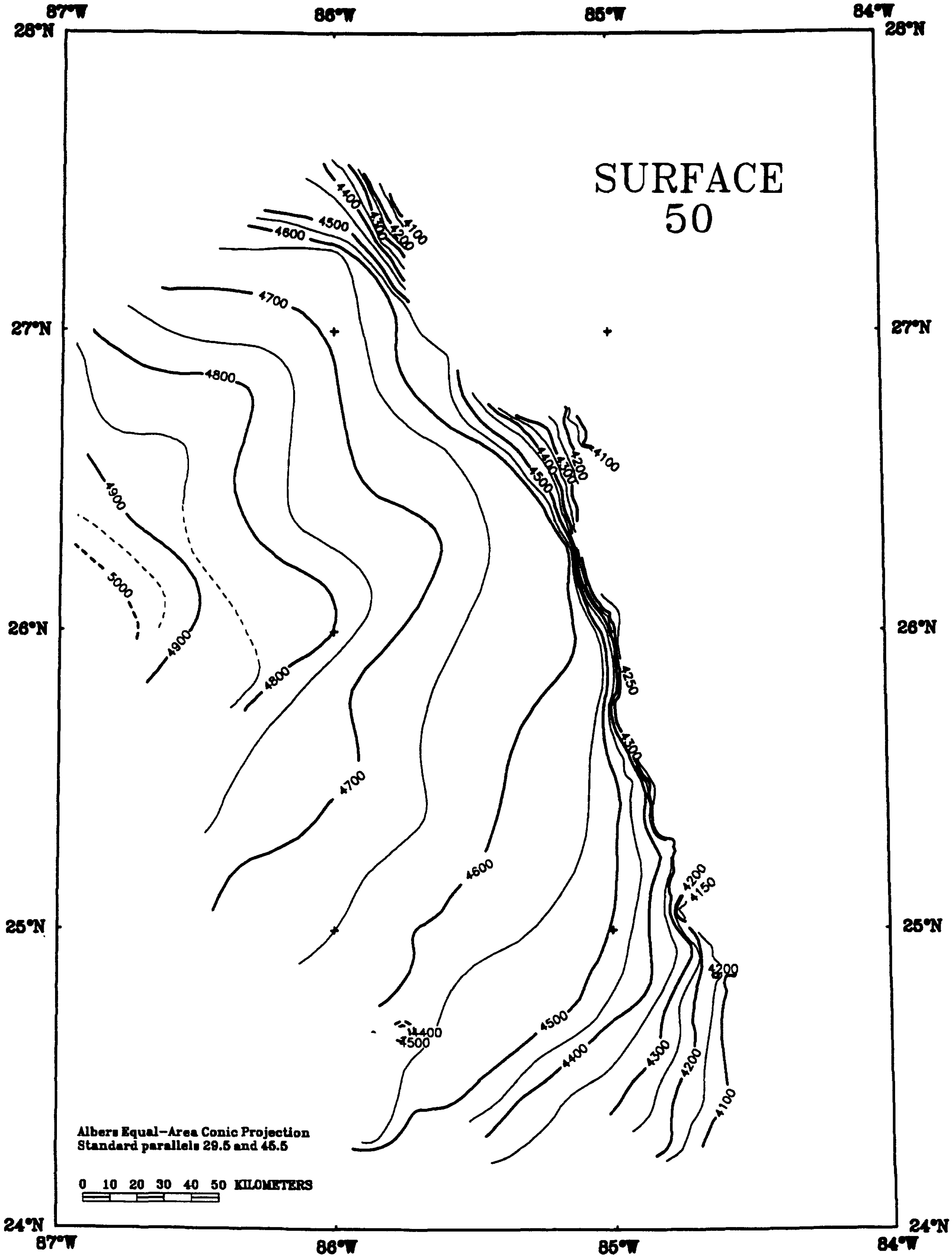

SURFACE
50
87°W
86°W
85°W
84°W
28°N
27°N
26°N
25°N
24°N
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5
0 10 20 30 40 50 KILOMETERS

Figure 18

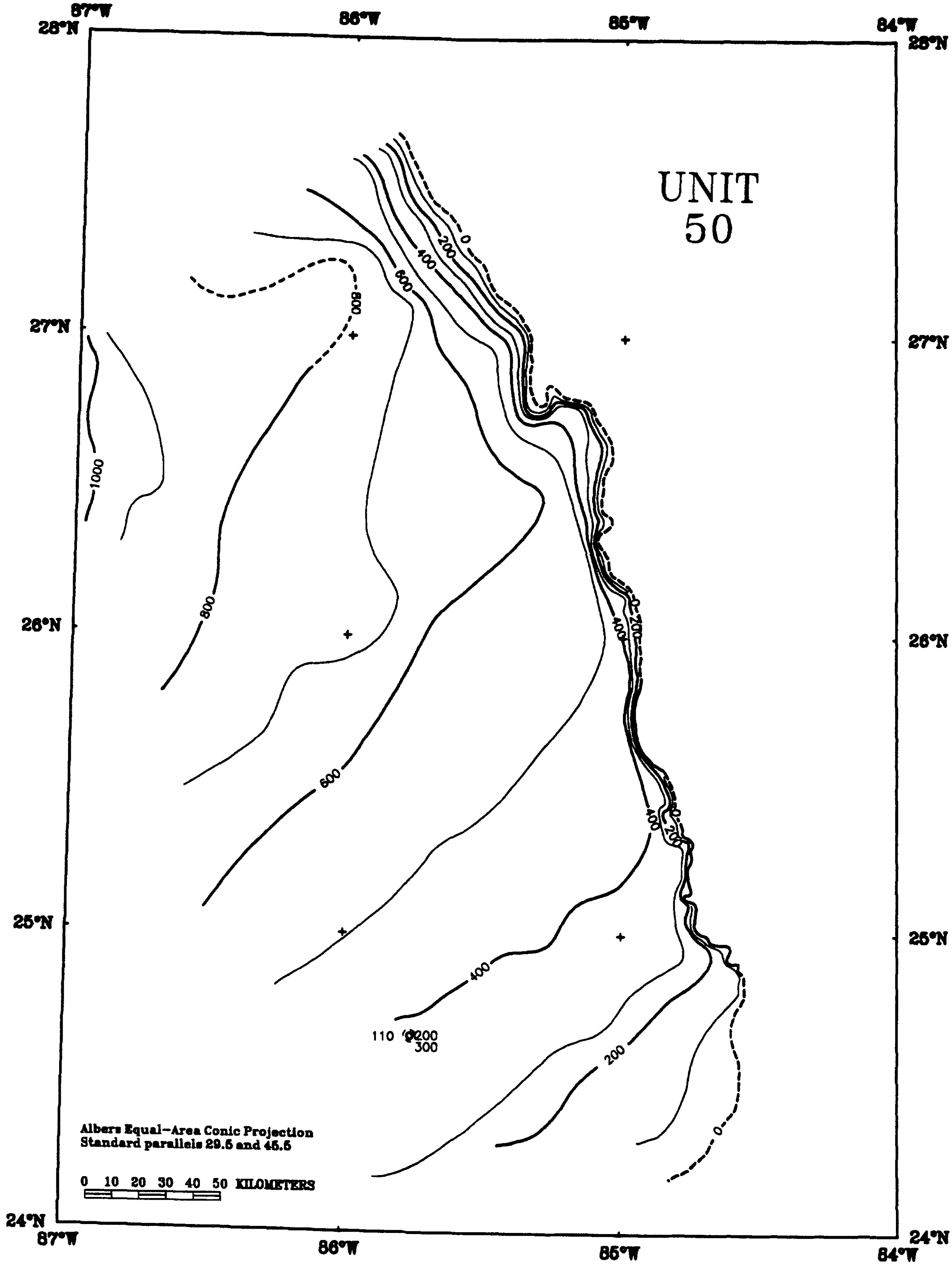

87°W
86°W
85°W
84°W
28°N
27°N
26°N
25°N
24°N
UNIT
50
0
200
400
600
800
1000
110
300
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5
0 10 20 30 40 50 KILOMETERS

Figure 19

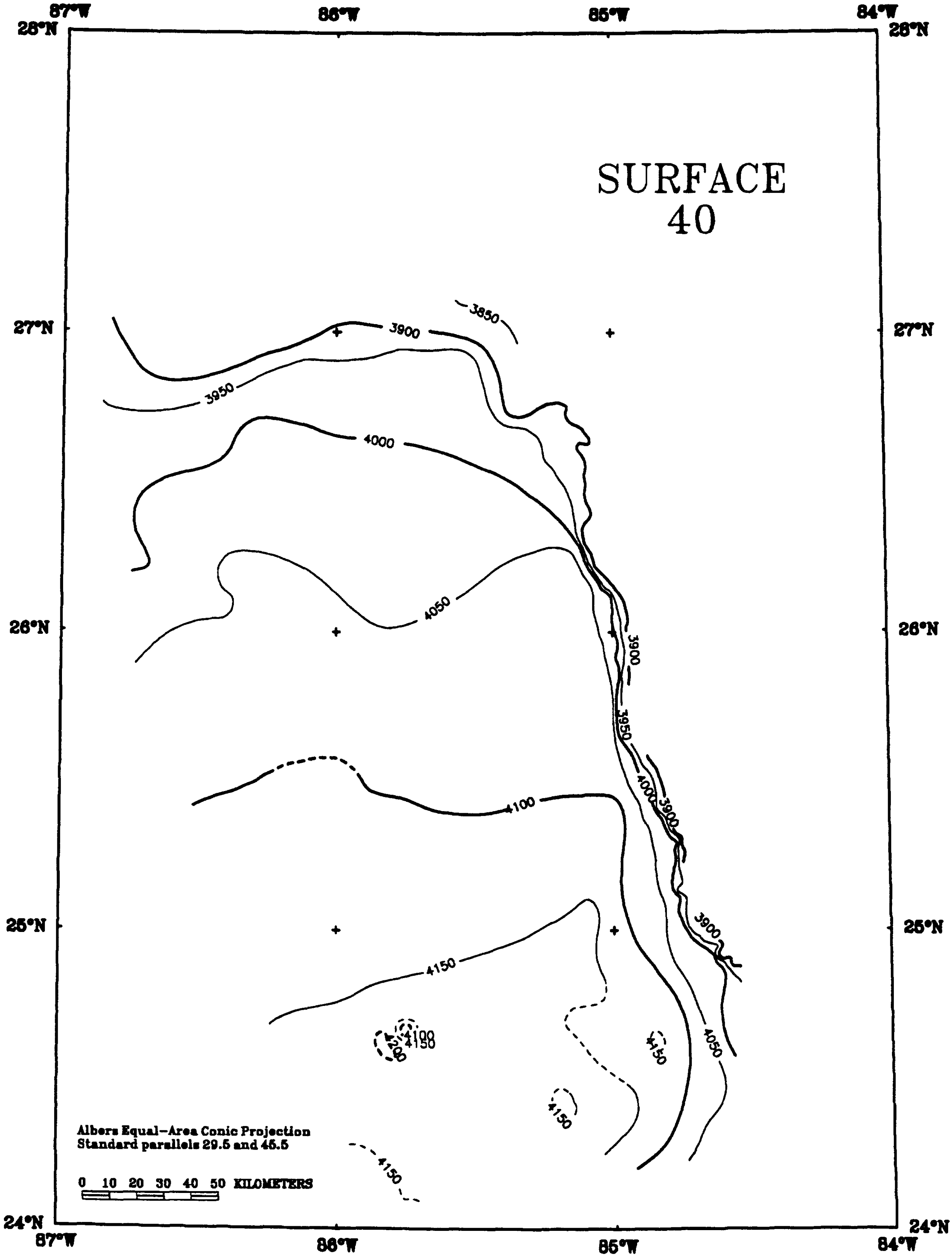

87°W
86°W
85°W
84°W
28°N
27°N
26°N
25°N
24°N
SURFACE
40
3850
3900
3950
4000
4050
4100
4150
4200
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5
0 10 20 30 40 50 KILOMETERS

Figure 20

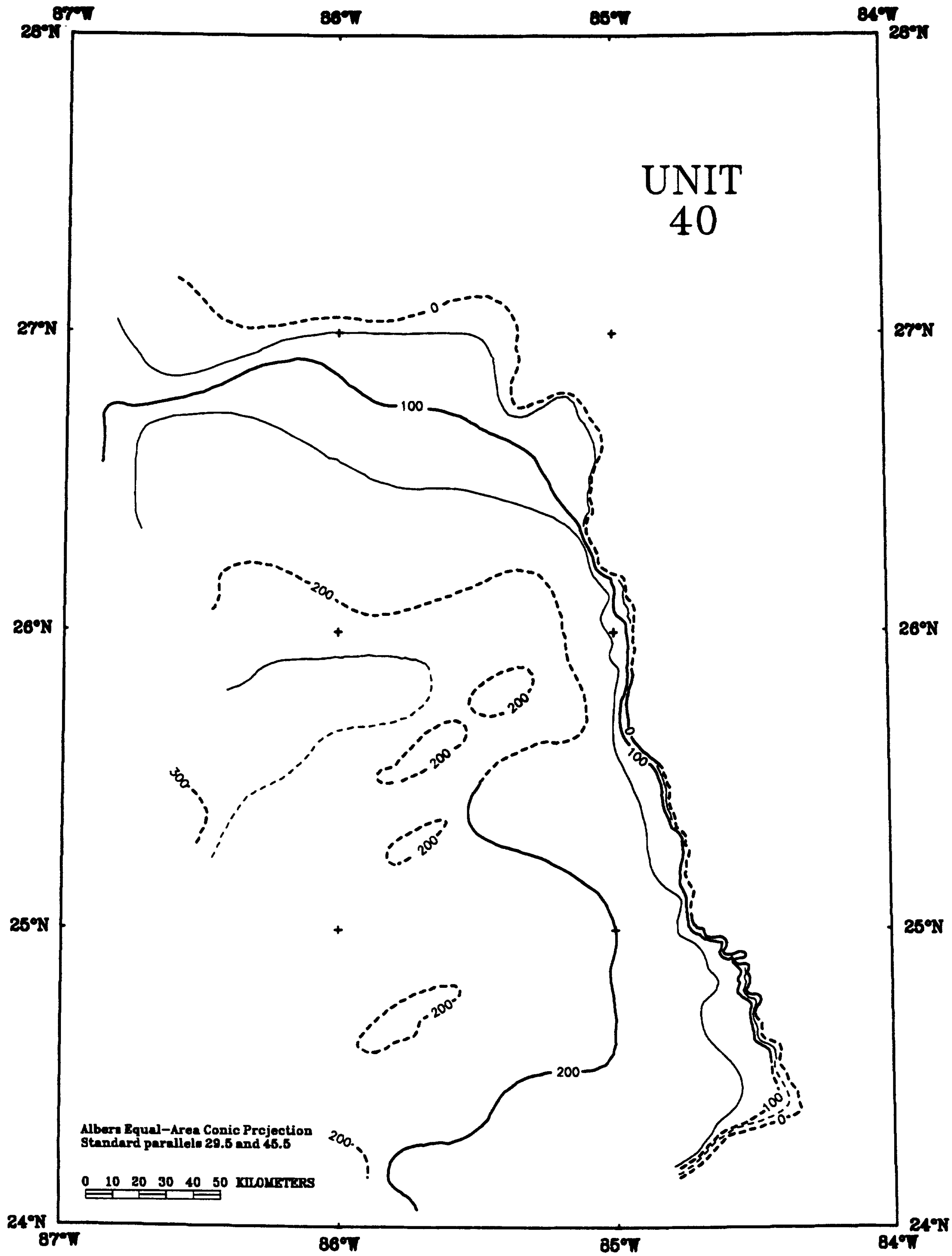

87°W
86°W
85°W
84°W
28°N
27°N
26°N
25°N
24°N
UNIT
40
0
100
200
300
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5
0 10 20 30 40 50 KILOMETERS

Figure 21

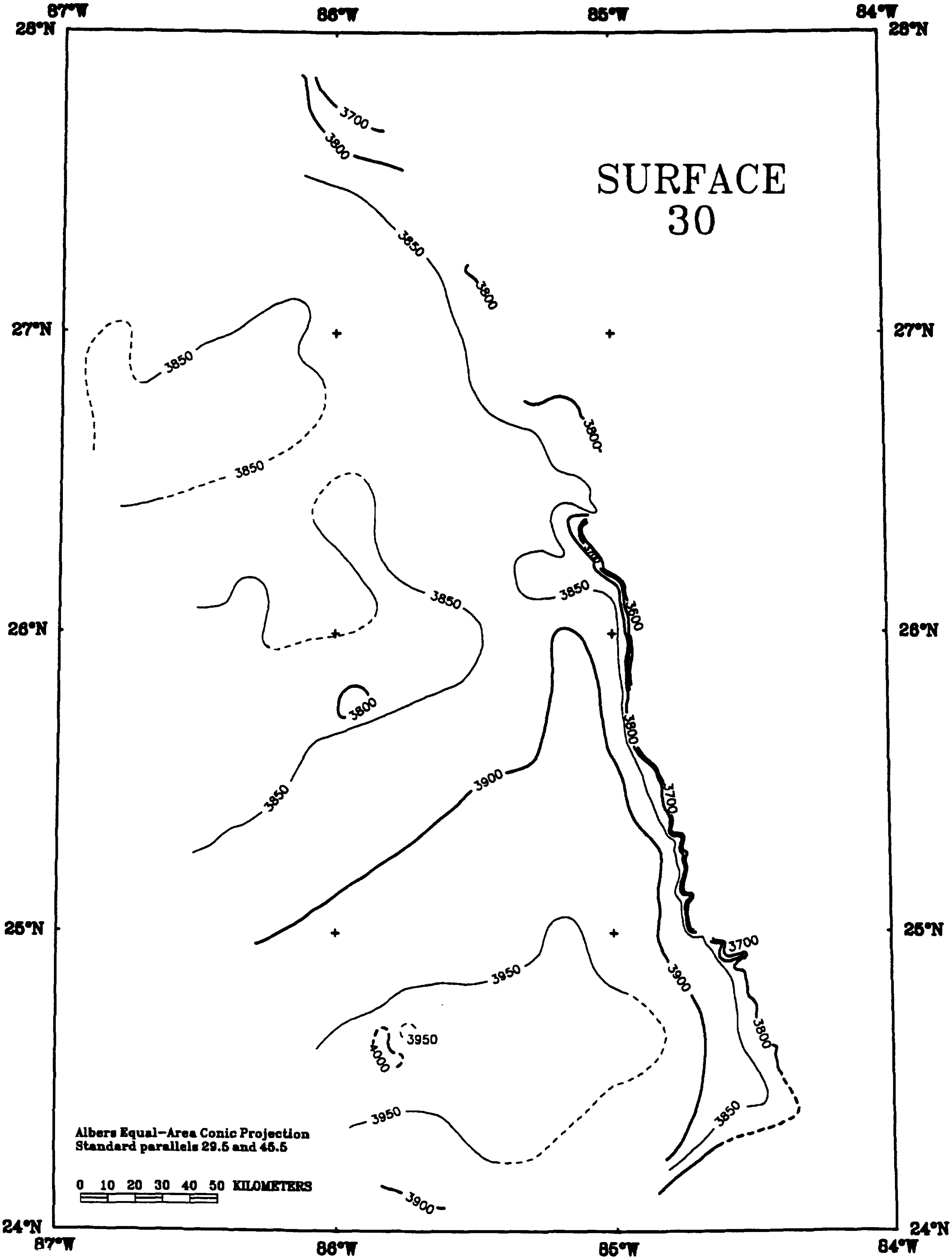

87°W
86°W
85°W
84°W
28°N
27°N
26°N
25°N
24°N
SURFACE
30
3700
3800
3850
3900
3950
4000
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5
0 10 20 30 40 50 KILOMETERS

Figure 22

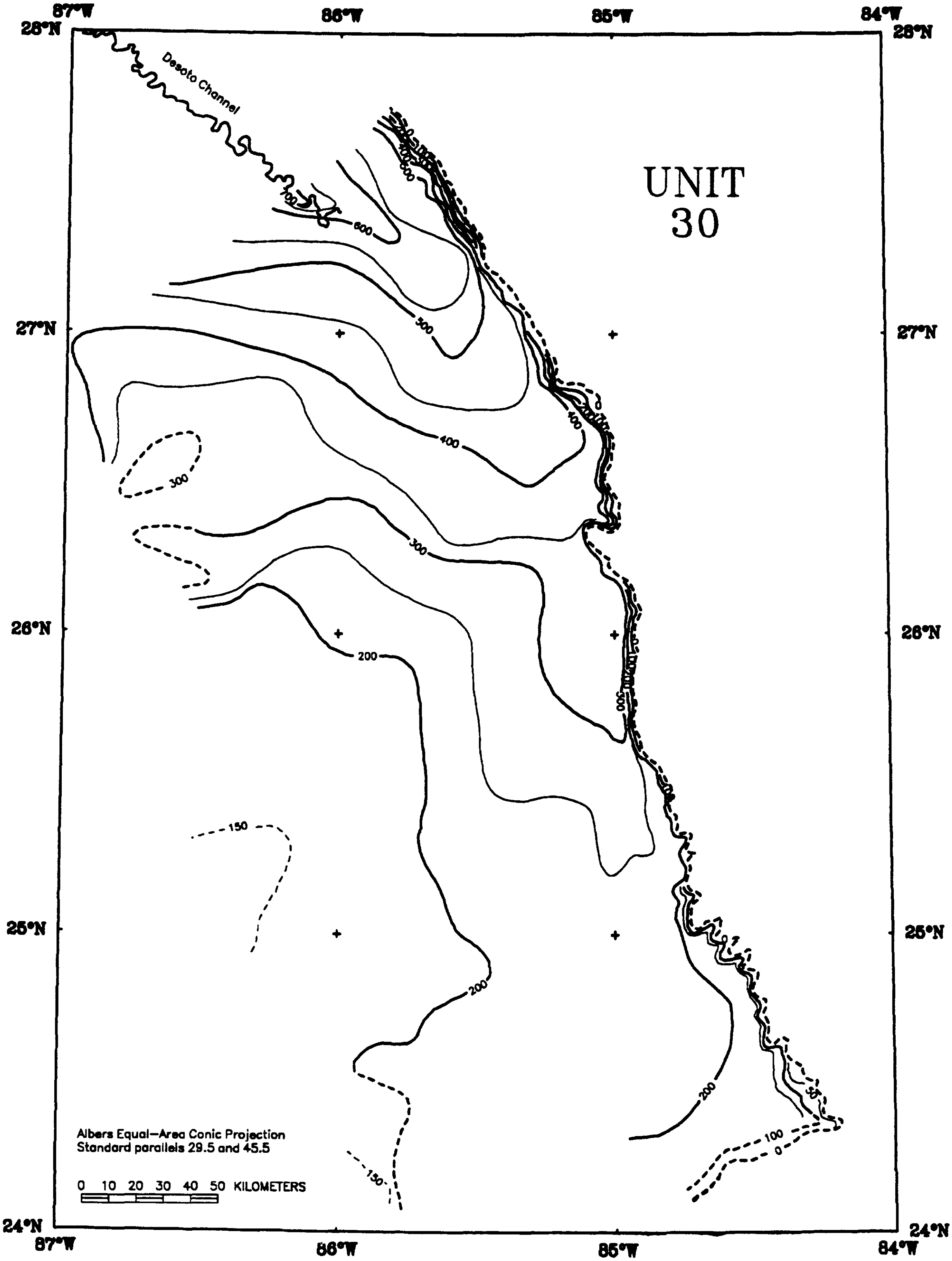

87°W
86°W
85°W
84°W
28°N
27°N
26°N
25°N
24°N
Desoto Channel
UNIT
30
700
600
500
400
300
200
150
100
50
0
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5
0 10 20 30 40 50 KILOMETERS

Figure 23

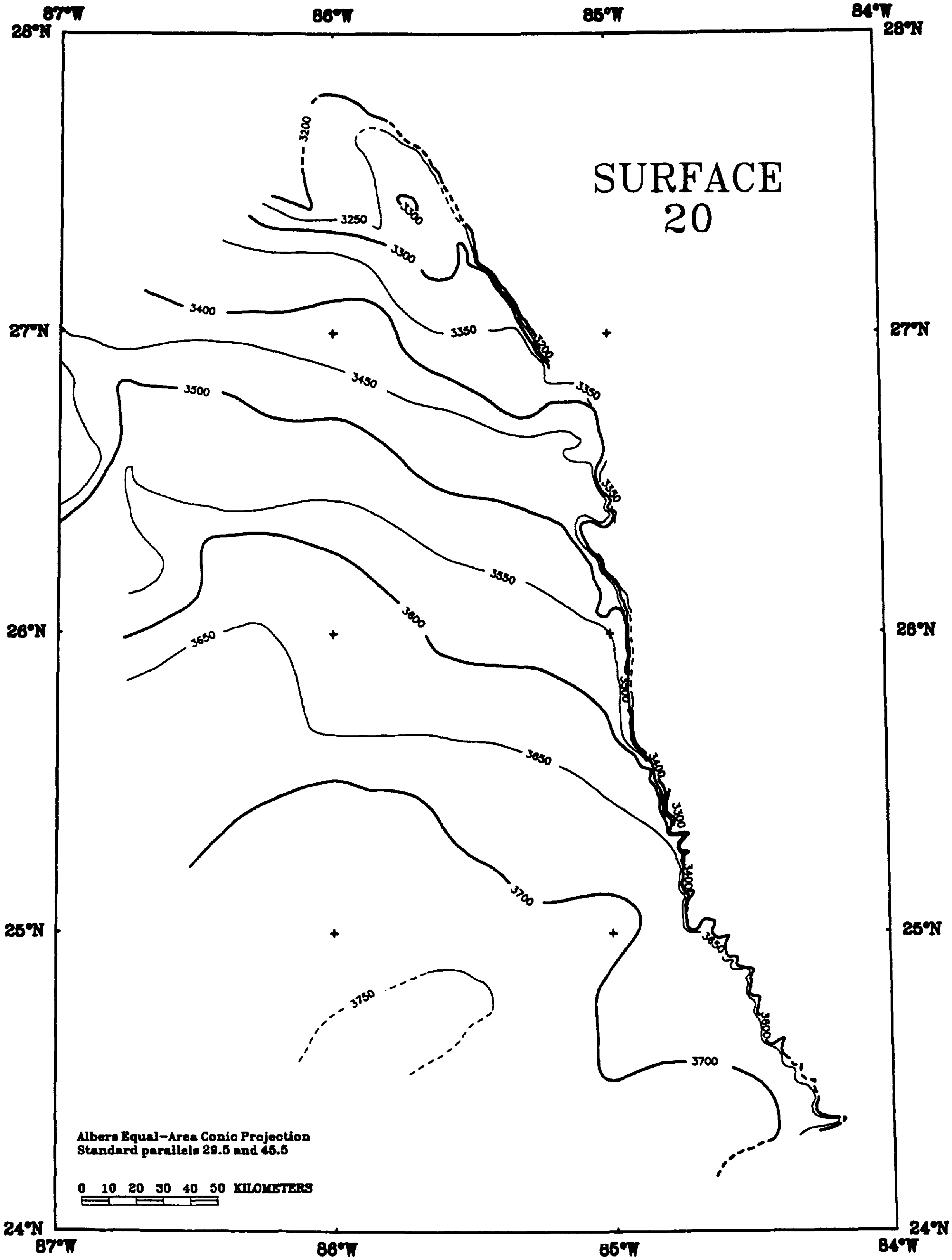

87°W
86°W
85°W
84°W
28°N
27°N
26°N
25°N
24°N
SURFACE
20
3200
3250
3300
3300
3400
3350
3450
3500
3550
3600
3650
3650
3700
3750
3700
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5
0 10 20 30 40 50 KILOMETERS

Figure 24

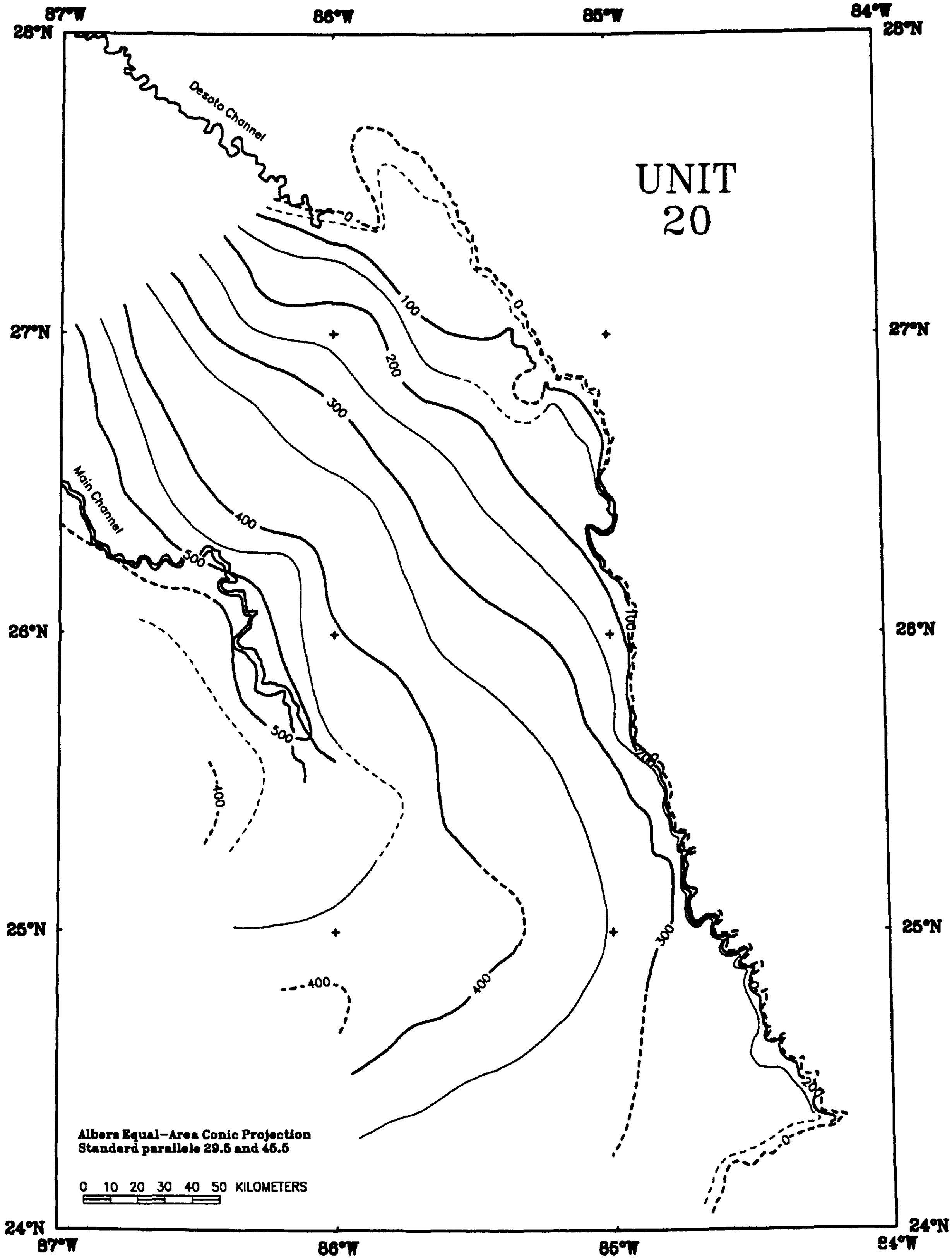
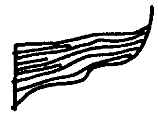
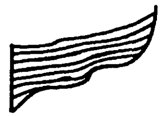
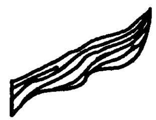

87°W
86°W
85°W
84°W
28°N
27°N
26°N
25°N
24°N
UNIT
20
Desoto Channel
Main Channel
0
100
200
300
400
500
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5
0 10 20 30 40 50 KILOMETERS

Figure 25

Table 1

REFLECTION TERMINATIONS	REFLECTION CONFIGURATIONS	REFLECTION CONTINUITY	REFLECTION AMPLITUDE	EXTERNAL FORMS& FACIES PATTERNS	SCHEMATIC SEISMIC FIGURE	INFERRED SEDIMENT TYPE(S)& DEPOSITIONAL MECHANISM(S)	SEISMIC UNITS OF THIS REPORT
Top concordant Bottom onlap	divergent near steep slopes and parallel elsewehere	continuous	low to medium	convergent onlap fill		pelagic/ hemipelagic rainout and remobilization mass movement on steep slopes	unit 70 unit 60
Top concordant Bottom onlap	parallel to subparallel wavy	continuous	variable	sheet drape onlap fill		hemipelagic and distal siliciclastic rainout and gravity controlled flows	unit 60 unit 50 unit 40 unit 30
Top concordant Bottom onlap	parallel even	semicontinuous to variable	variable	sheet onlap fill		distal siliciclastic gravity controlled flows	no units predominately with this sediment type and depositional mechanism although portions of unit 40 fit this category
Top concordant or erosional Bottom onlap	subparallel to chaotic	semicontinuous to variable	variable	mounded onlap fill		proximal fan siliciclastic gravity controlled flows including channelized flows and mass movements	unit 30 unit 20
Top concordant or erosional Bottom updip onlap downdip downlap	divergent, subparallel, or chaotic	semicontinuous	variable	slope front dowlap fill		carbonate fine grained debris and/or talus blocks gravity controlled flows and mass movements	no units predominately with this sediment type and depositional mechanism although portions of unit 30 fit this category

APPENDIX A

Distance versus depth line drawings for all 22 seismic profiles used in this report

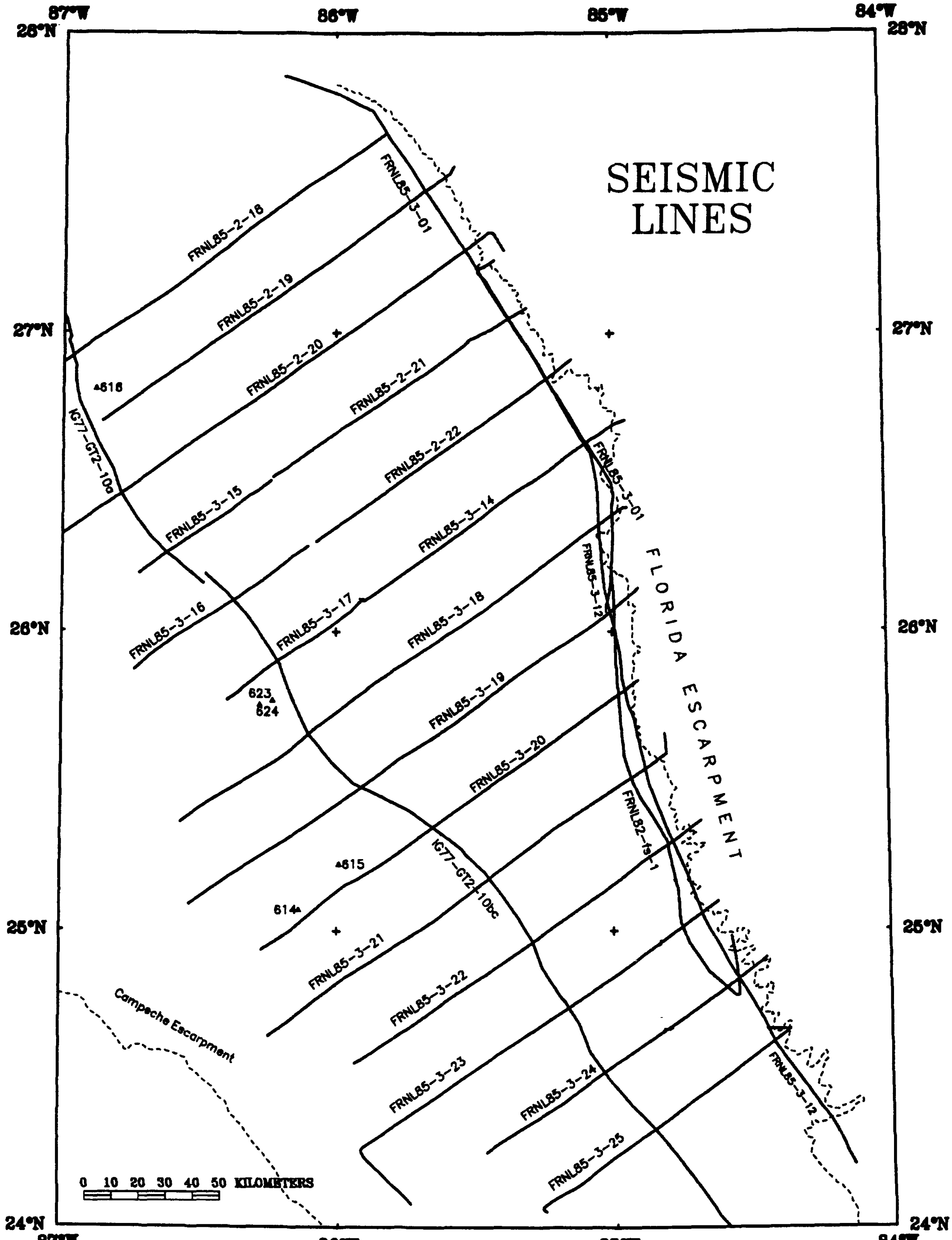
Track map shows locations of the seismic lines in Appendix A

vertical exaggeration is approximately 25 X

seafloor is thin line numbered 1

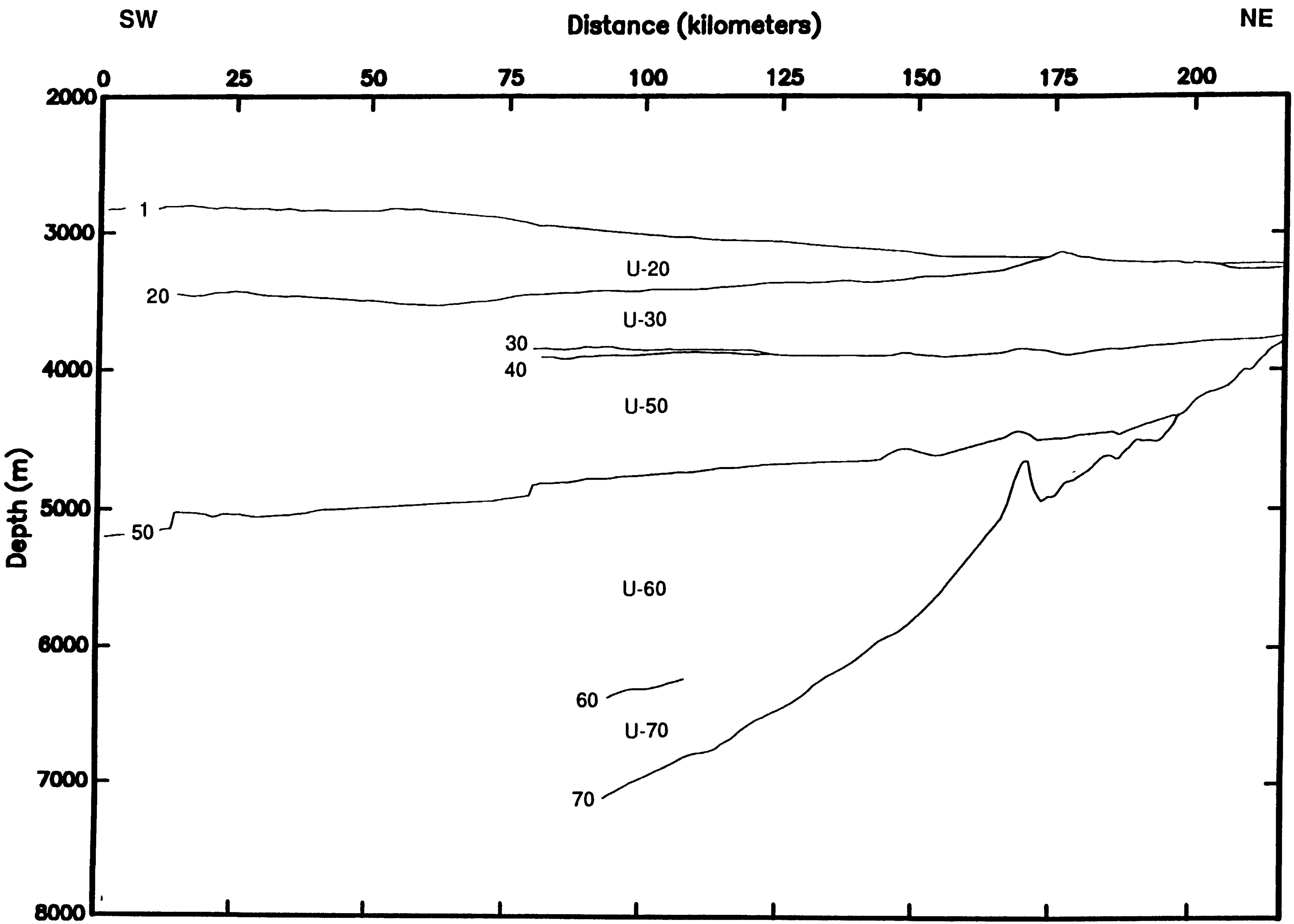
unconformity and correlative conformity surfaces are represented by thin lines and numbers (20, 30, 40, 50, 60, and 70)

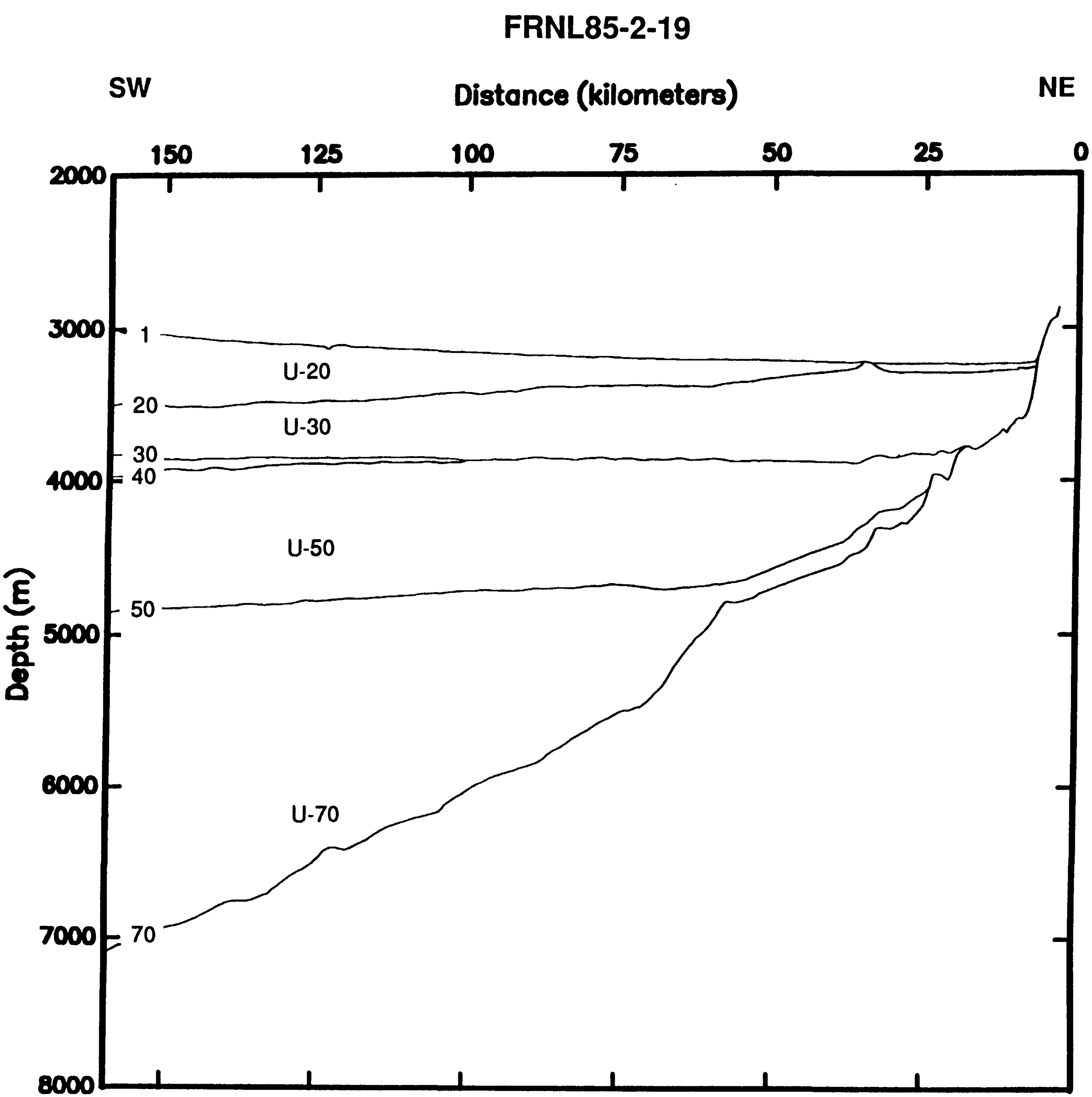
seismic units are labelled with alphanumerics U-20, U-30, U-40, U-50, U-60, and U-70



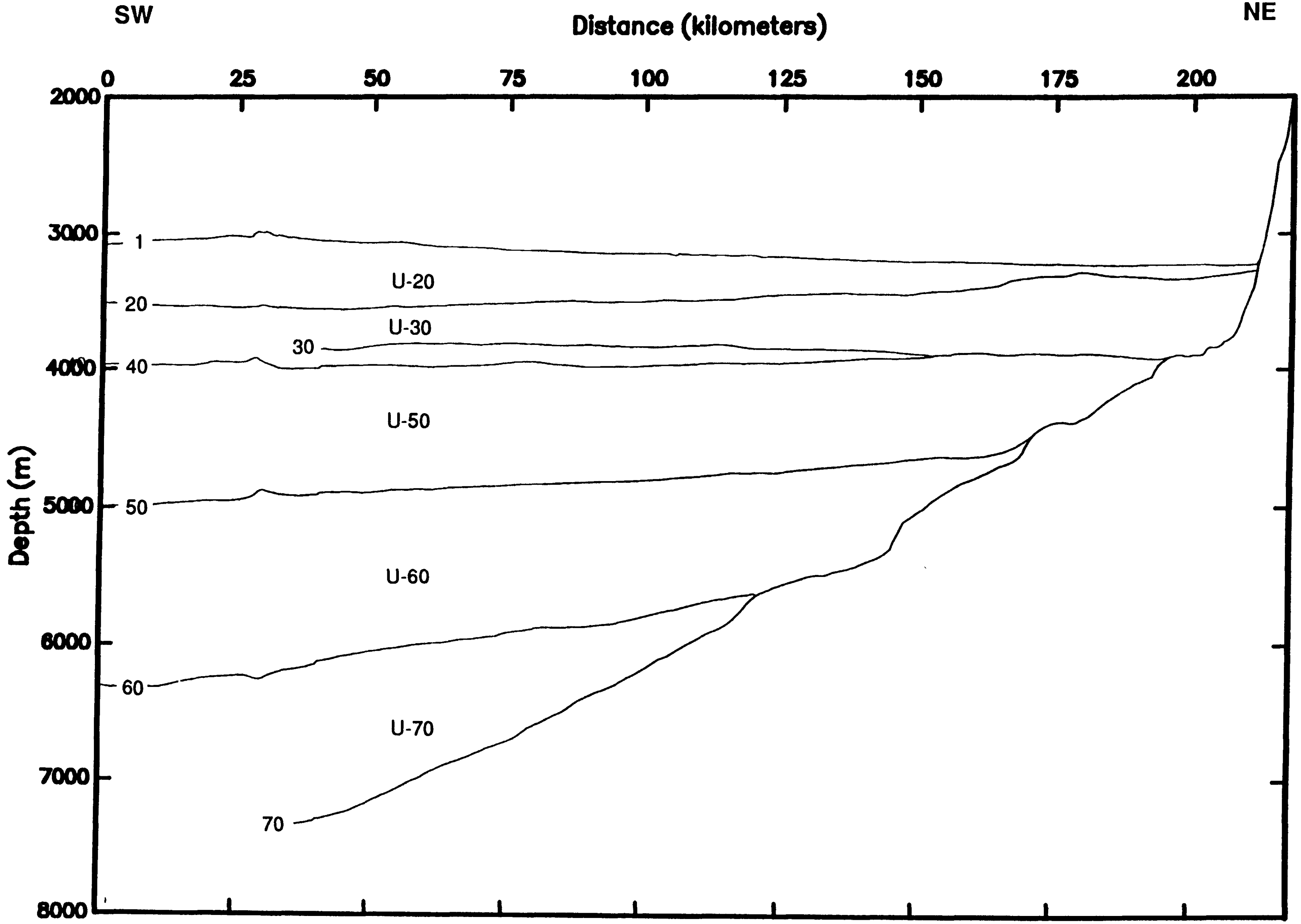
Albers Equal-Area Conic Projection
Standard parallels 29.5 and 45.5

FRNL85-2-18

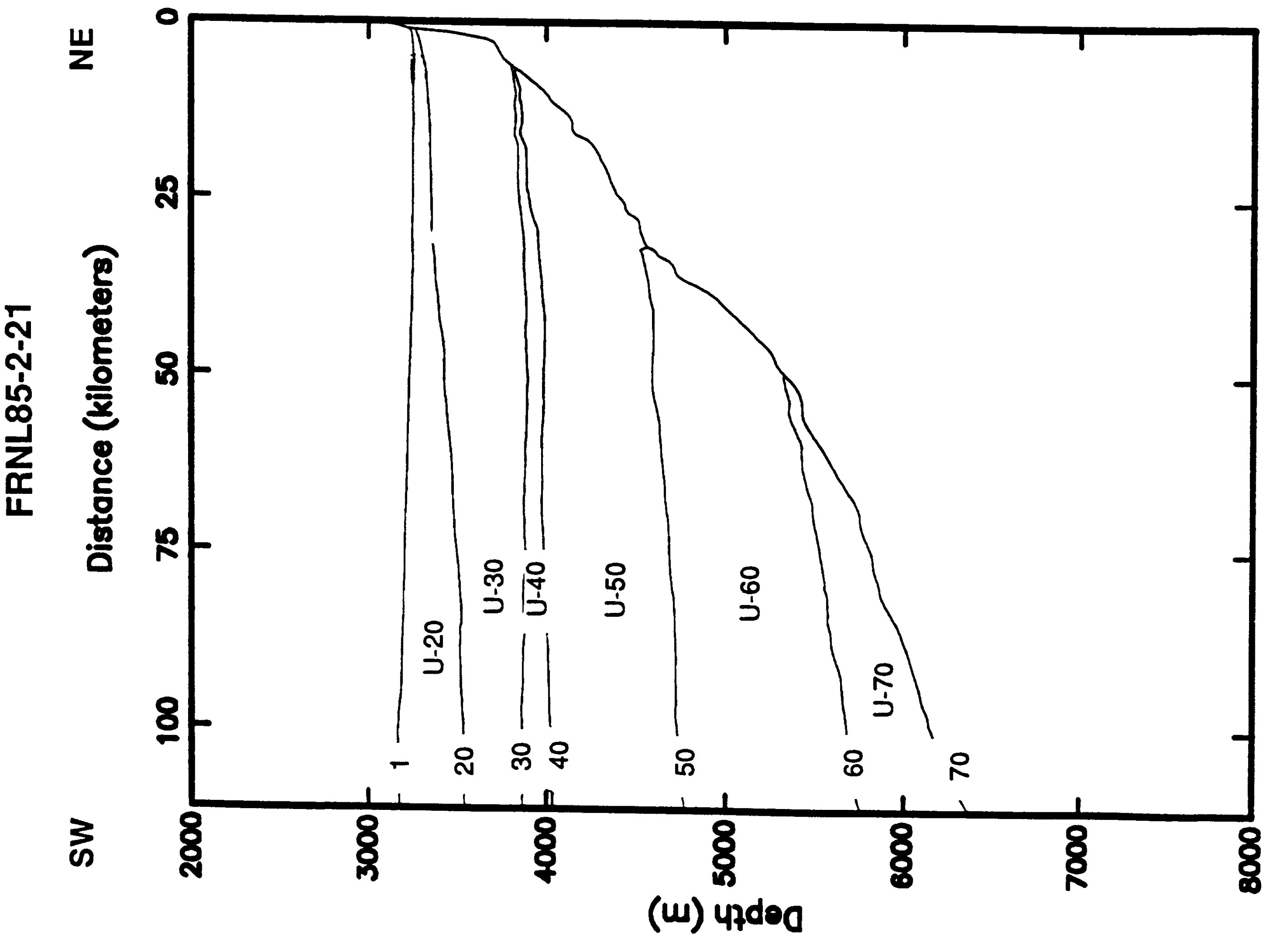

SW
Distance (kilometers)
NE
0
25
50
75
100
125
150
175
200
2000
3000
4000
5000
6000
7000
8000
Depth (m)
1
20
U-20
U-30
30
40
U-50
50
U-60
60
U-70
70

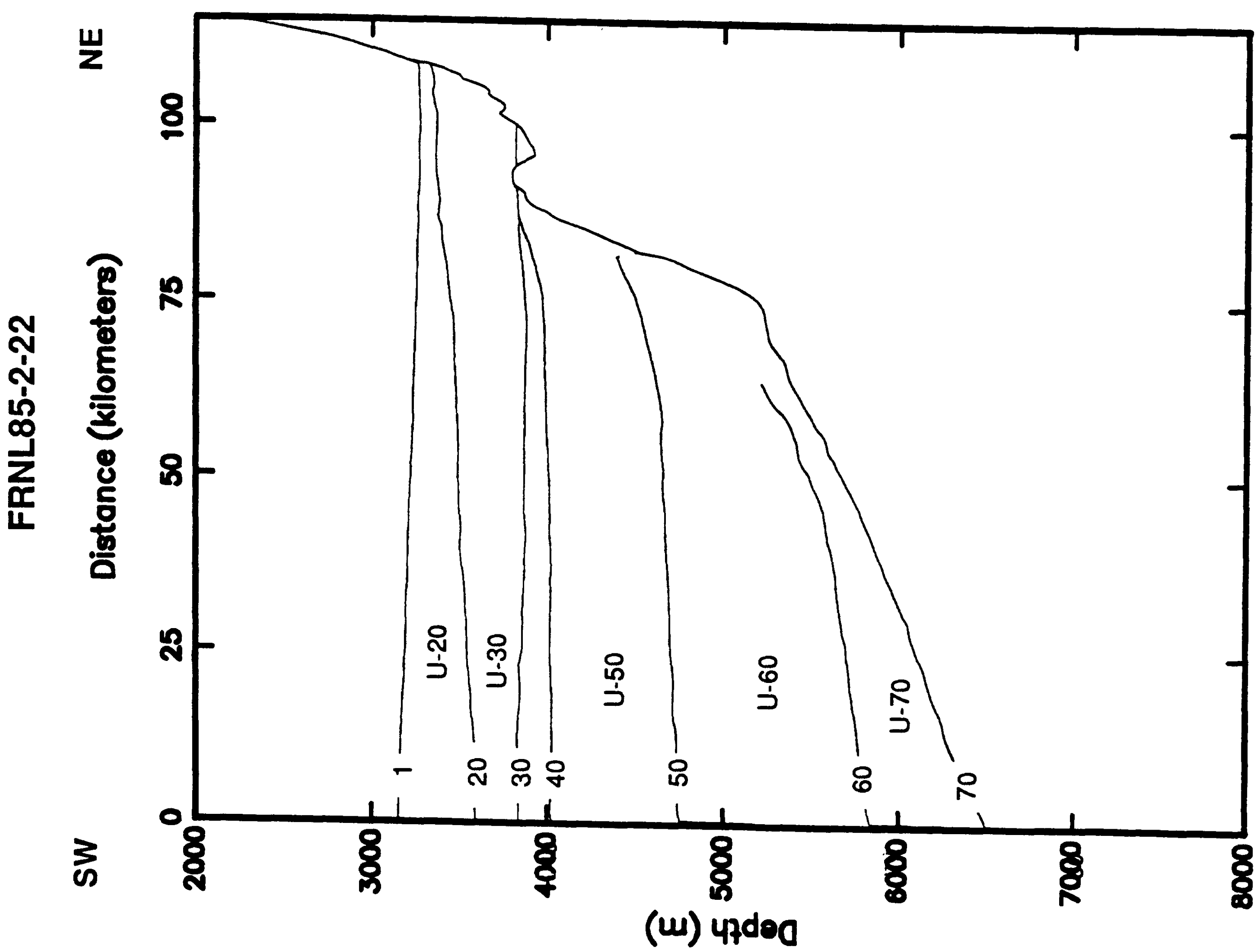

FRNL85-2-19
SW
Distance (kilometers)
NE
150
125
100
75
50
25
0
2000
3000
4000
5000
6000
7000
8000
Depth (m)
1
U-20
20
U-30
30
40
U-50
50
U-70
70

FRNL85-2-20

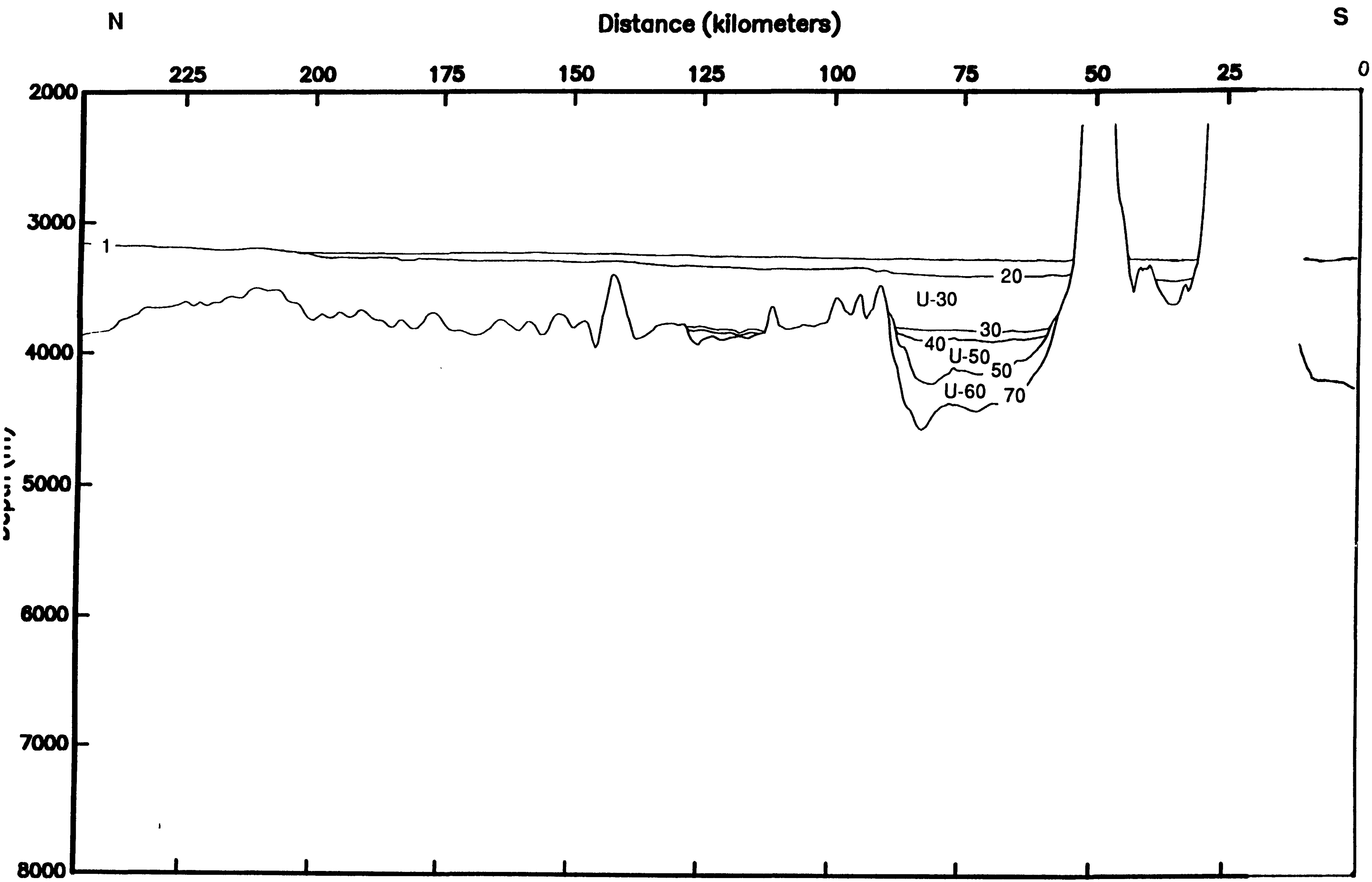


SW
NE
Distance (kilometers)
0
25
50
75
100
125
150
175
200
2000
3000
4000
5000
6000
7000
8000
Depth (m)
1
20
30
40
50
60
70
U-20
U-30
U-50
U-60
U-70


FRNL85-2-21
Distance (kilometers)
SW
NE
0
25
50
75
100
Depth (m)
2000
3000
4000
5000
6000
7000
8000
U-20
U-30
U-40
U-50
U-60
U-70
1
20
30
40
50
60
70

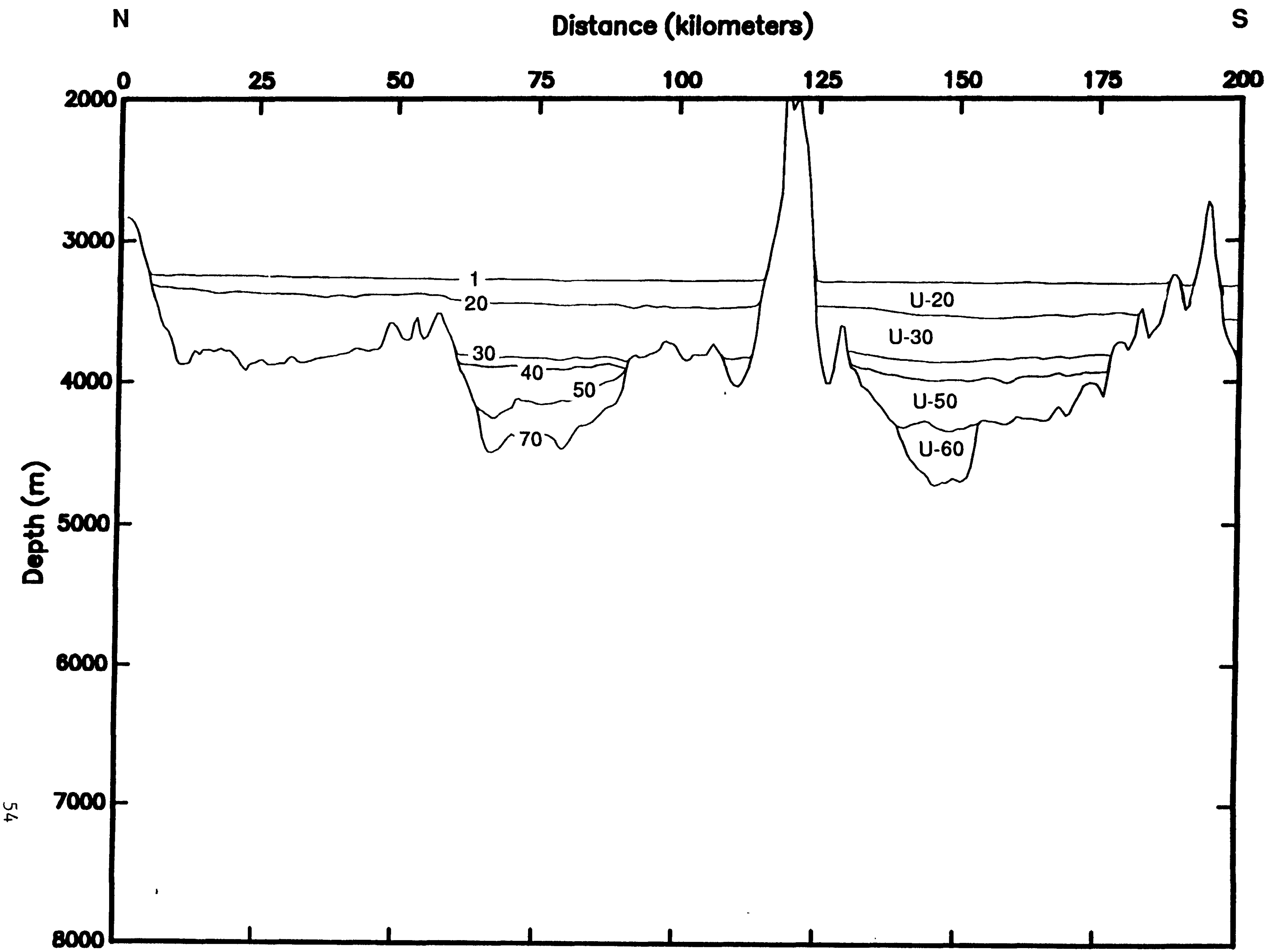

FRNL85-2-22
Distance (kilometers)
SW
NE
0
25
50
75
100
Depth (m)
2000
3000
4000
5000
6000
7000
8000
1
20
30
40
50
60
70
U-20
U-30
U-50
U-60
U-70

FRNL85-3-01

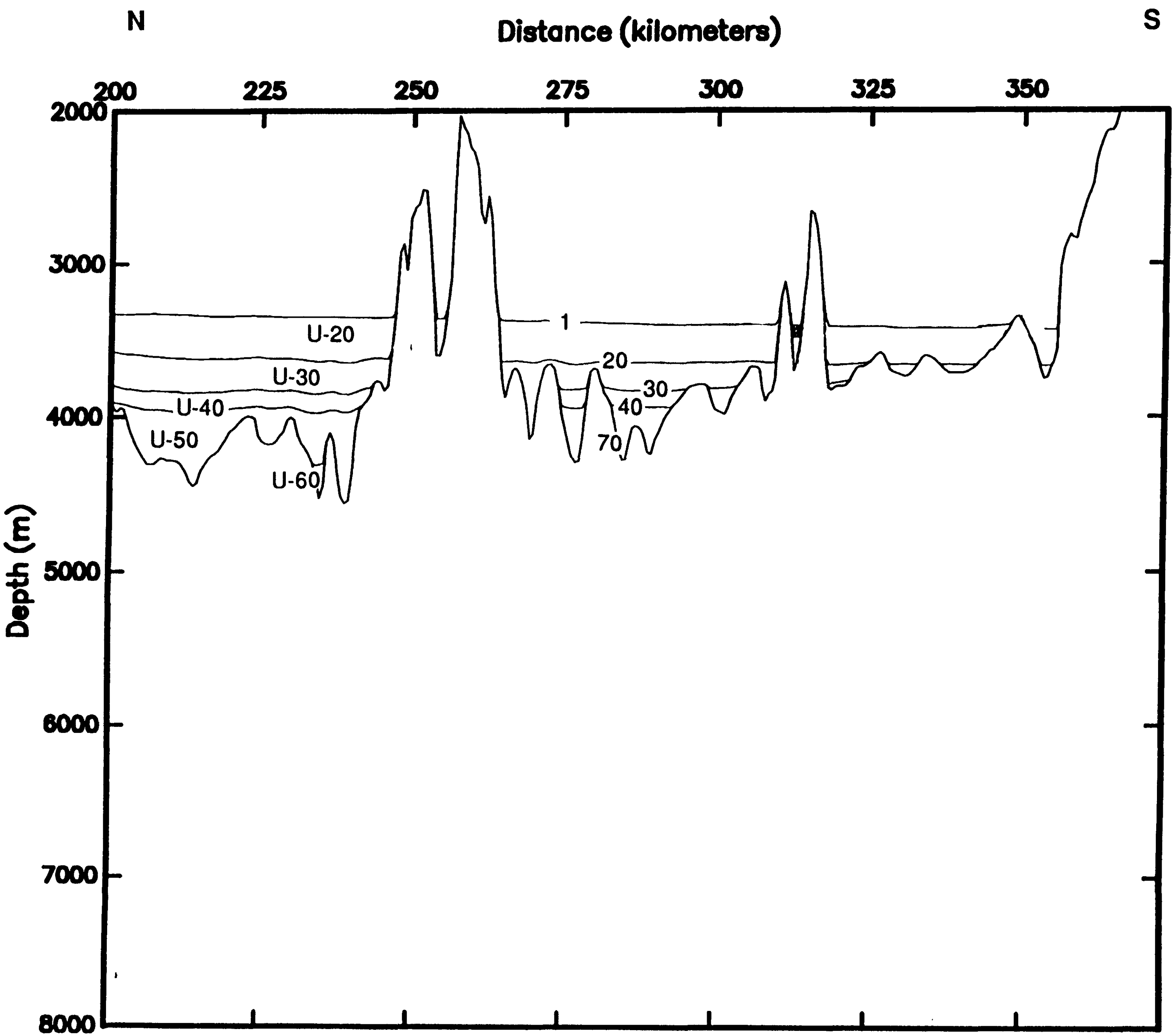


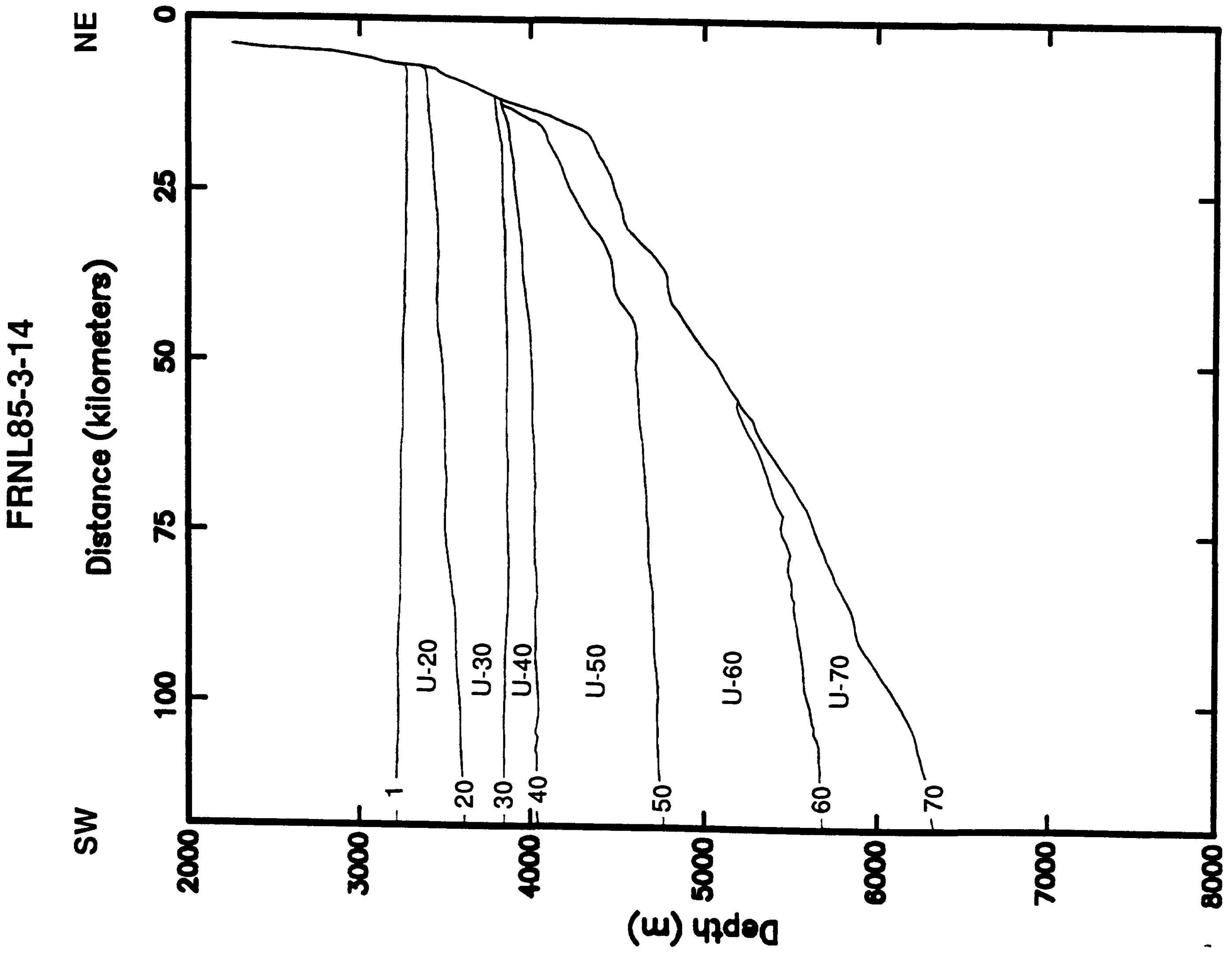
N
Distance (kilometers)
S
225
200
175
150
125
100
75
50
25
0
2000
3000
4000
5000
6000
7000
8000
1
20
U-30
30
40
U-50
50
U-60
70

FRNL85-3-12 - piece 1 of 2



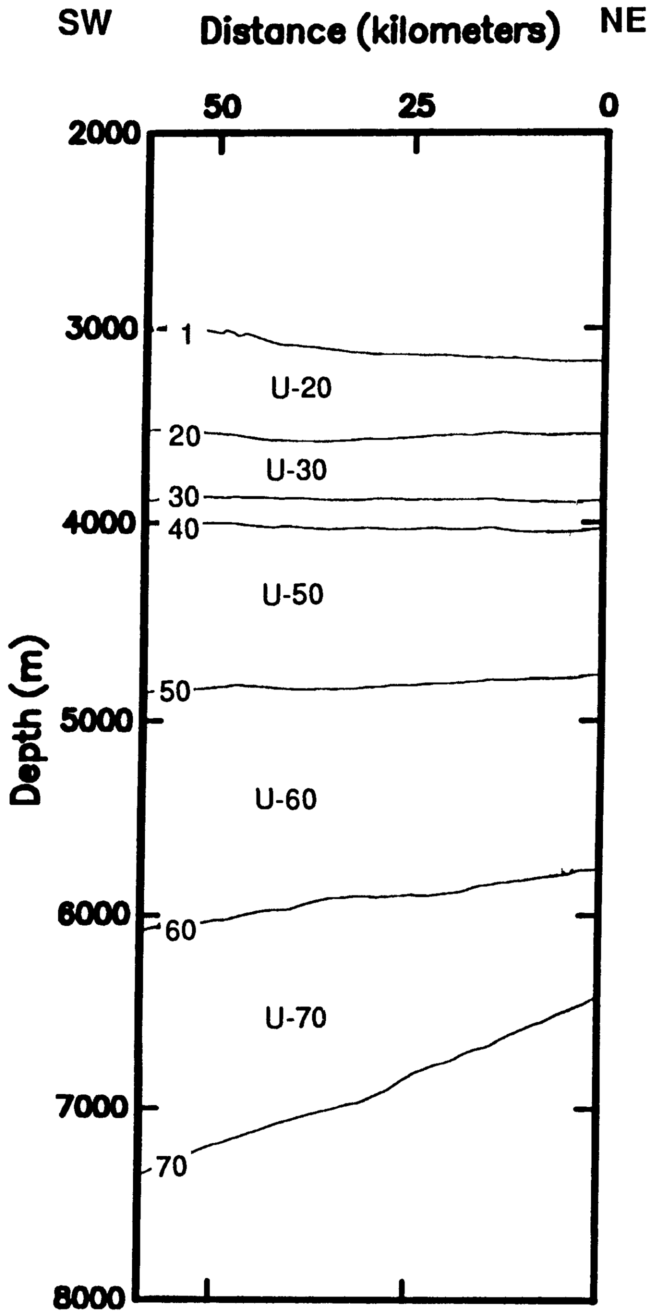
FRNL85-3-12 - piece 2 of 2





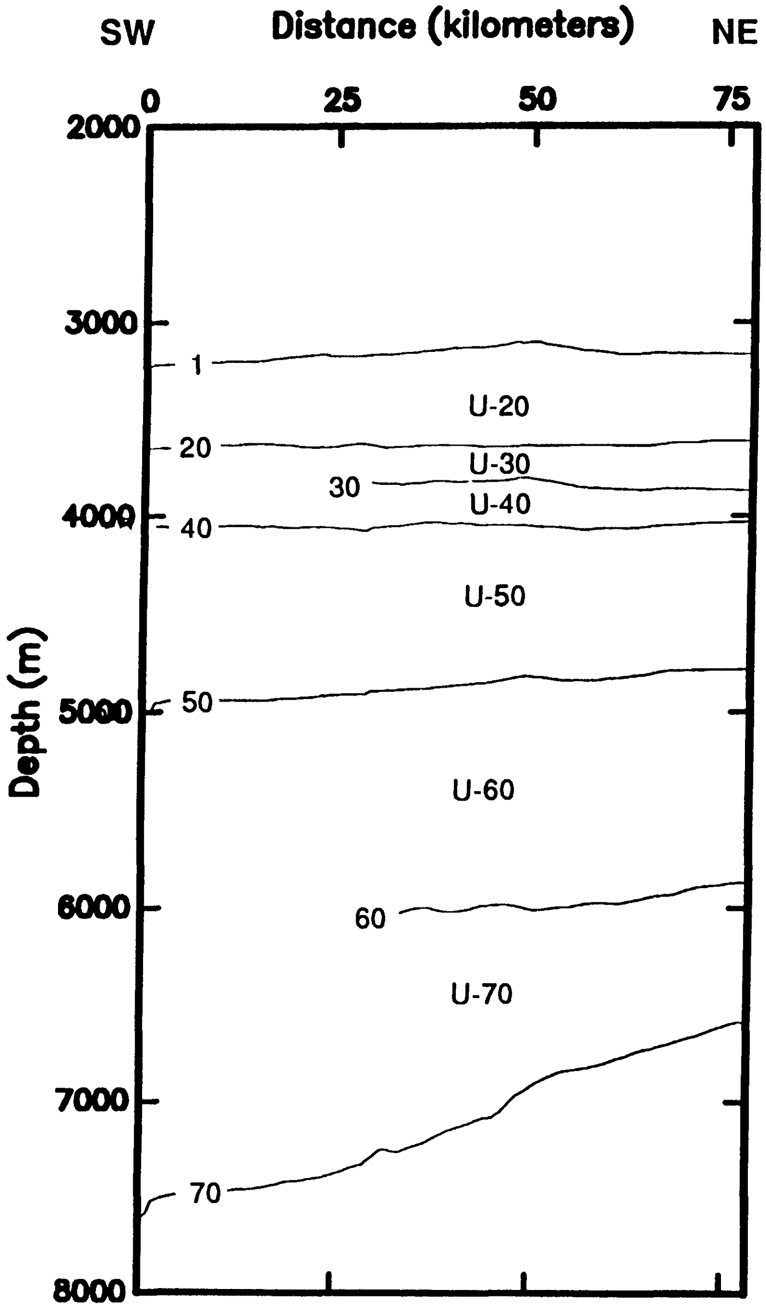
FRNL85-3-14
Distance (kilometers)
SW
NE
0
25
50
75
100
Depth (m)
2000
3000
4000
5000
6000
7000
8000
1
20
30
40
50
60
70
U-20
U-30
U-40
U-50
U-60
U-70

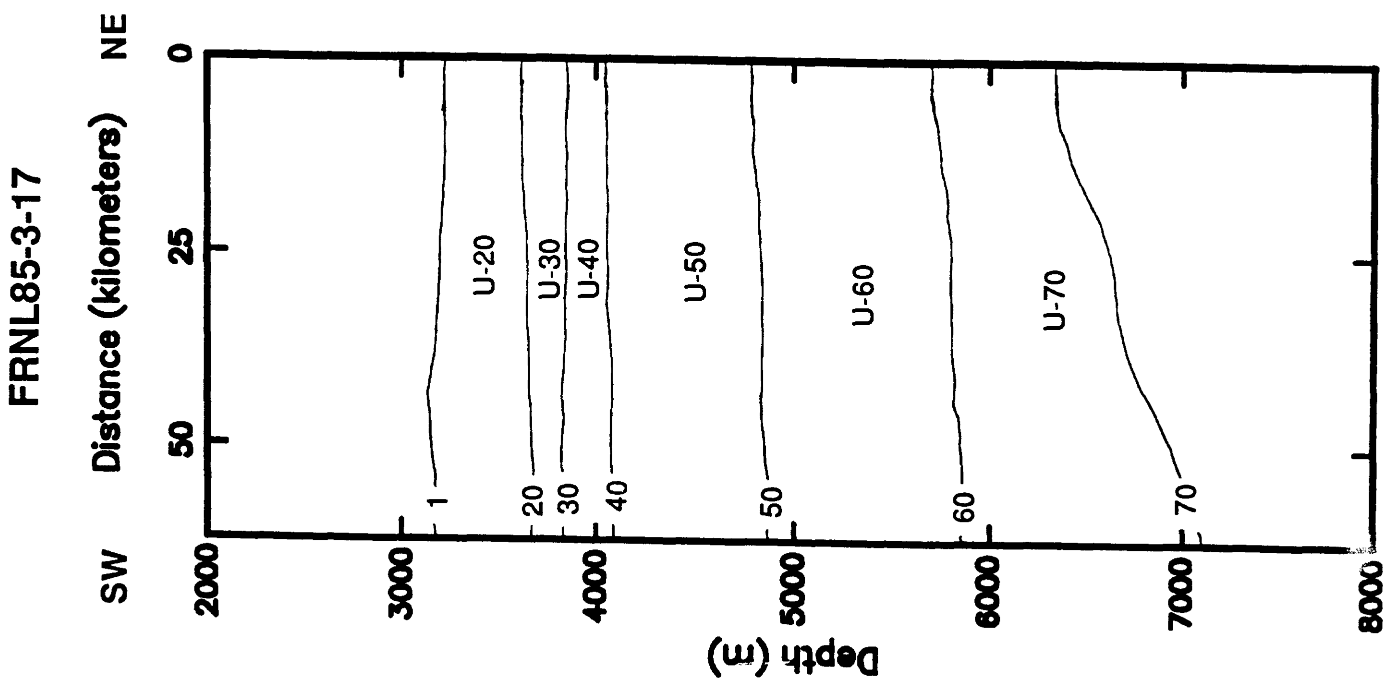
FRNL85-3-15

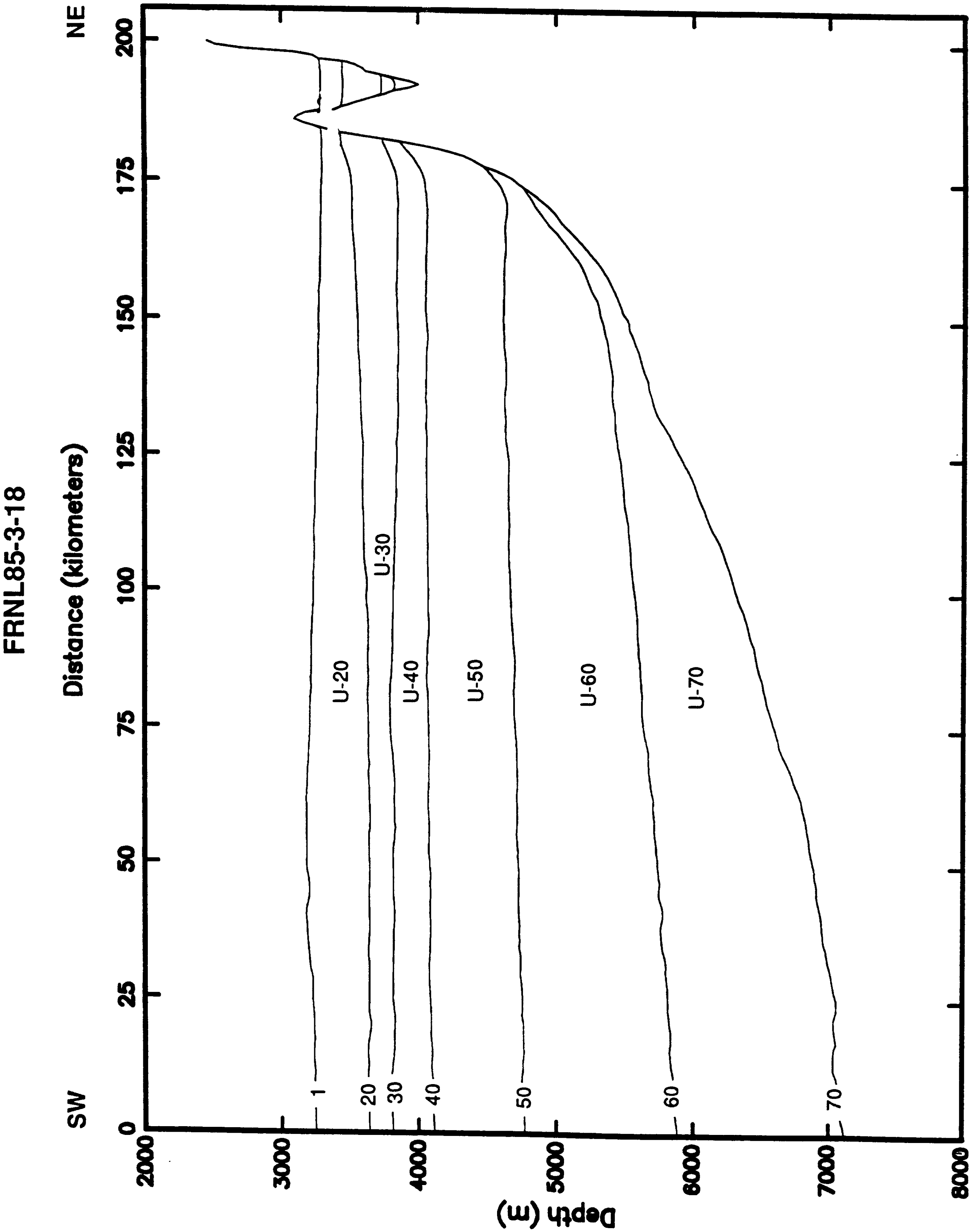


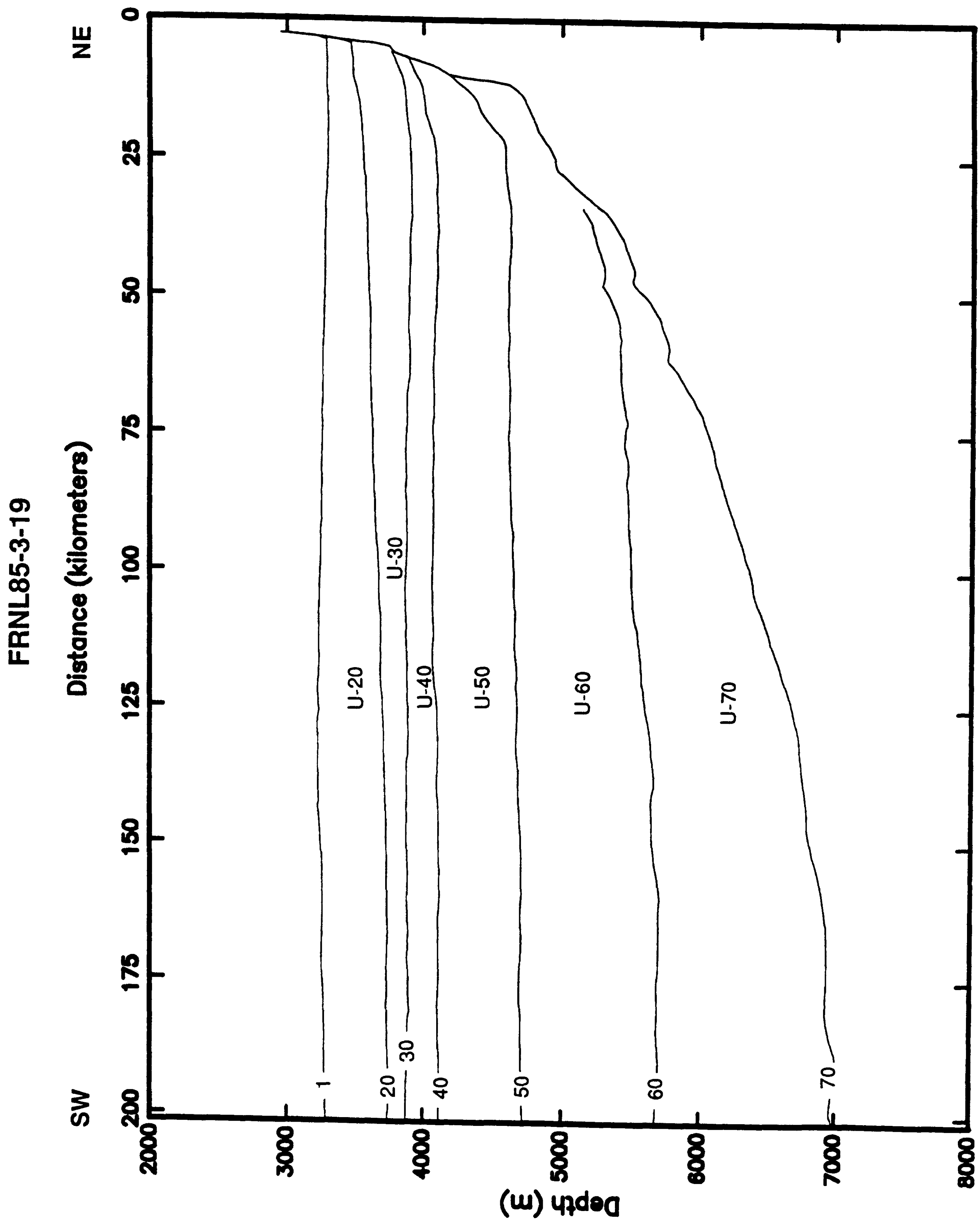
SW
Distance (kilometers)
NE
50
25
0
Depth (m)
2000
3000
4000
5000
6000
7000
8000
1
U-20
20
U-30
30
40
U-50
50
U-60
60
U-70
70

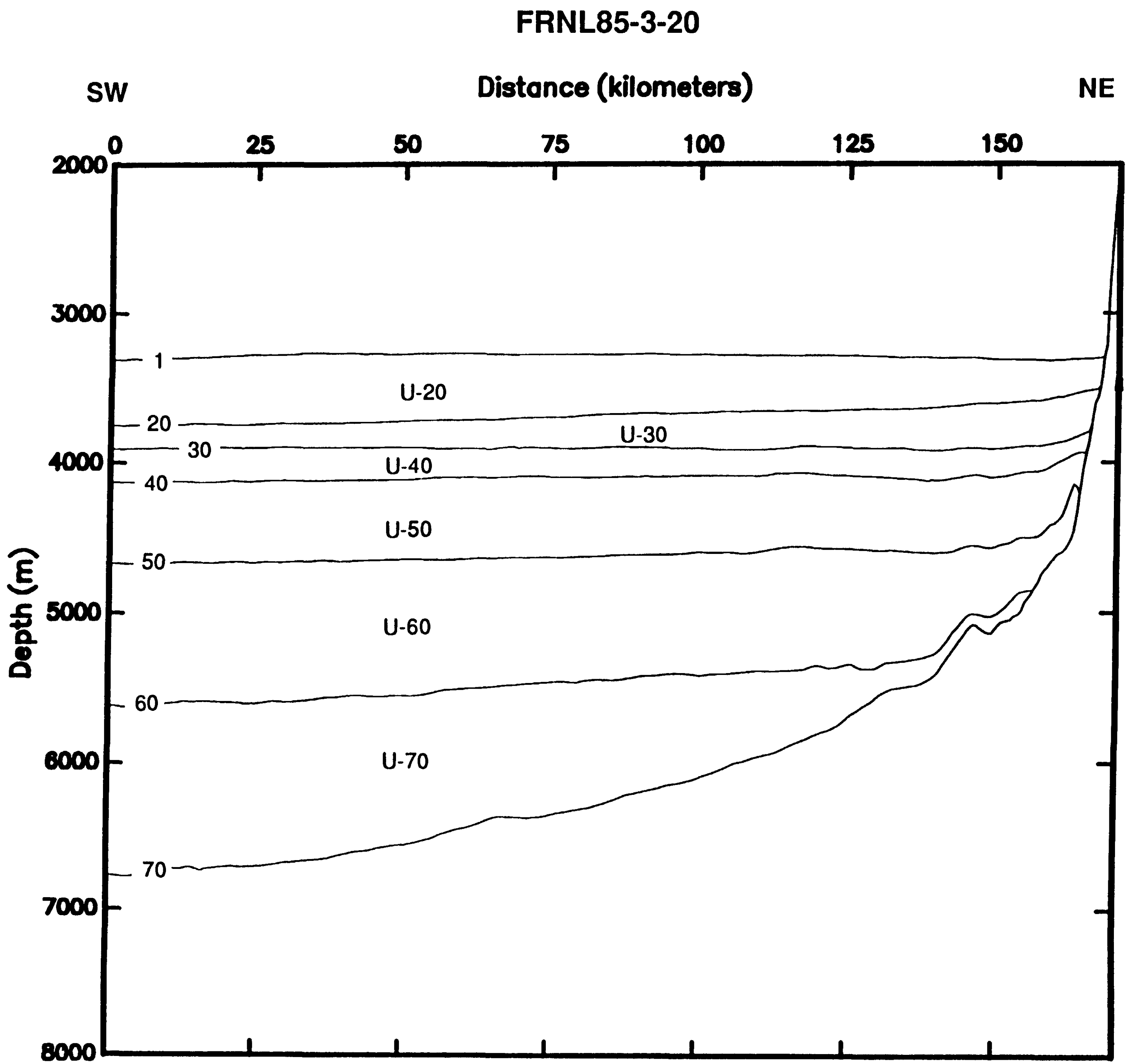
FRNL85-3-16

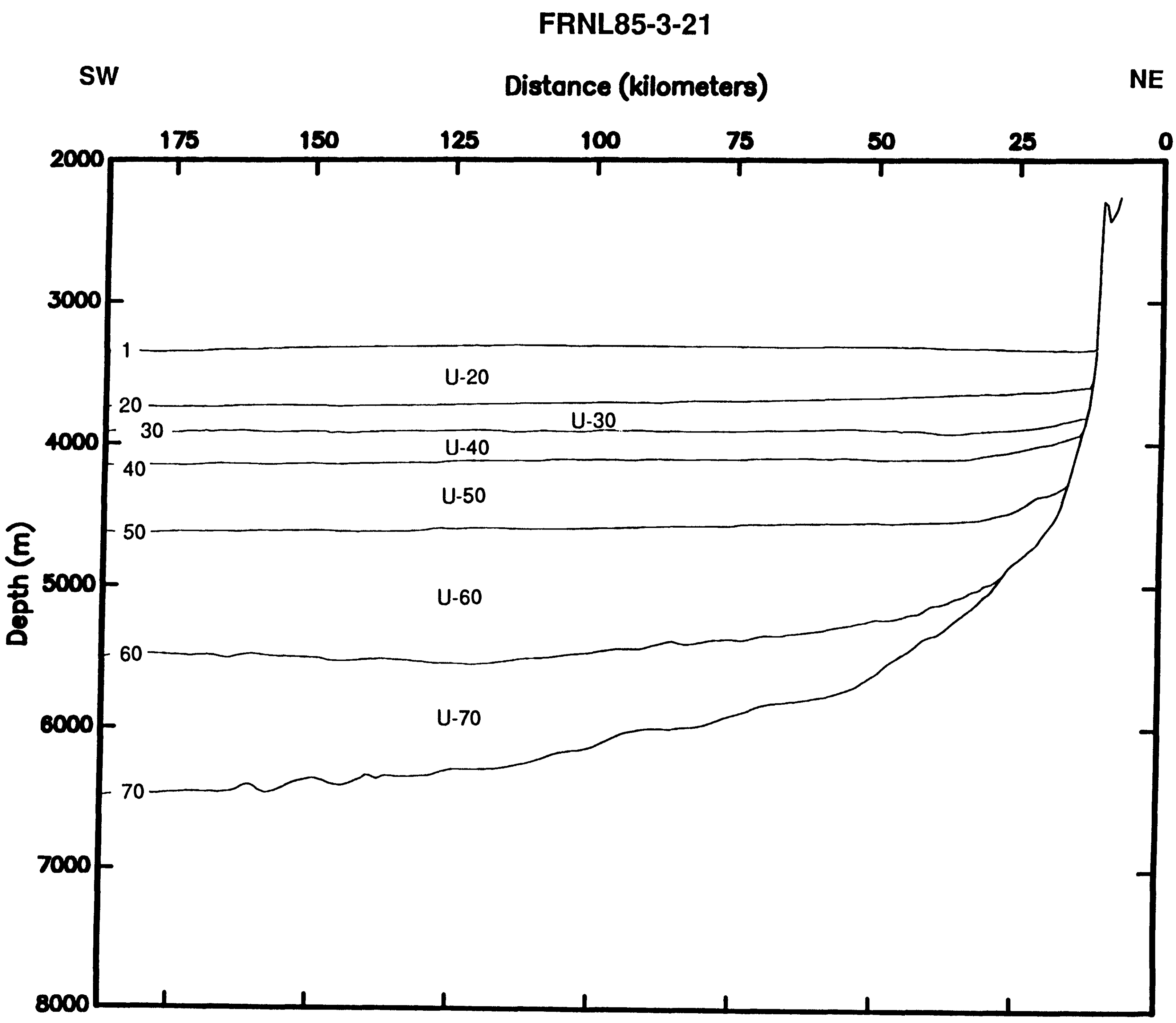

SW
Distance (kilometers)
NE
0
25
50
75
2000
3000
4000
5000
6000
7000
8000
Depth (m)
1
20
30
40
50
60
70
U-20
U-30
U-40
U-50
U-60
U-70

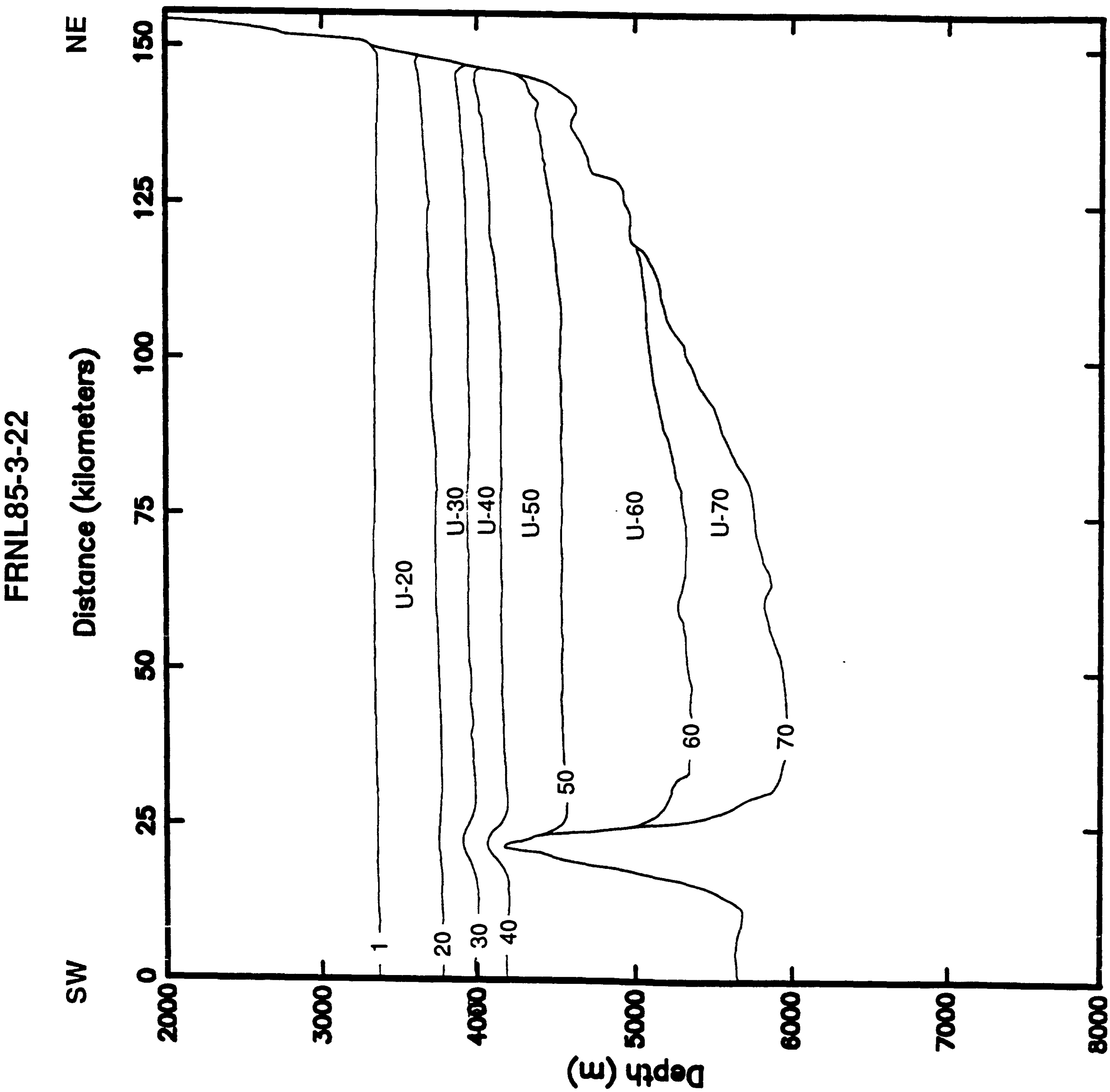

FRNL85-3-17
Distance (kilometers)
NE
SW
0
25
50
Depth (m)
2000
3000
4000
5000
6000
7000
8000
U-20
U-30
U-40
U-50
U-60
U-70
1
20
30
40
50
60
70


FRNL85-3-18
Distance (kilometers)
SW
NE
0
25
50
75
100
125
150
175
200
Depth (m)
2000
3000
4000
5000
6000
7000
8000
1
20
30
40
50
60
70
U-20
U-30
U-40
U-50
U-60
U-70


FRNL85-3-19
Distance (kilometers)
Depth (m)
NE
SW
0
25
50
75
100
125
150
175
200
2000
3000
4000
5000
6000
7000
8000
U-20
U-30
U-40
U-50
U-60
U-70
1
20
30
40
50
60
70


FRNL85-3-20
SW
Distance (kilometers)
NE
0
25
50
75
100
125
150
2000
3000
4000
5000
6000
7000
8000
Depth (m)
1
20
30
40
50
60
70
U-20
U-30
U-40
U-50
U-60
U-70


FRNL85-3-21
SW
Distance (kilometers)
NE
175
150
125
100
75
50
25
0
2000
3000
4000
5000
6000
7000
8000
Depth (m)
1
20
30
40
50
60
70
U-20
U-30
U-40
U-50
U-60
U-70


FRNL85-3-22
Distance (kilometers)
SW
NE
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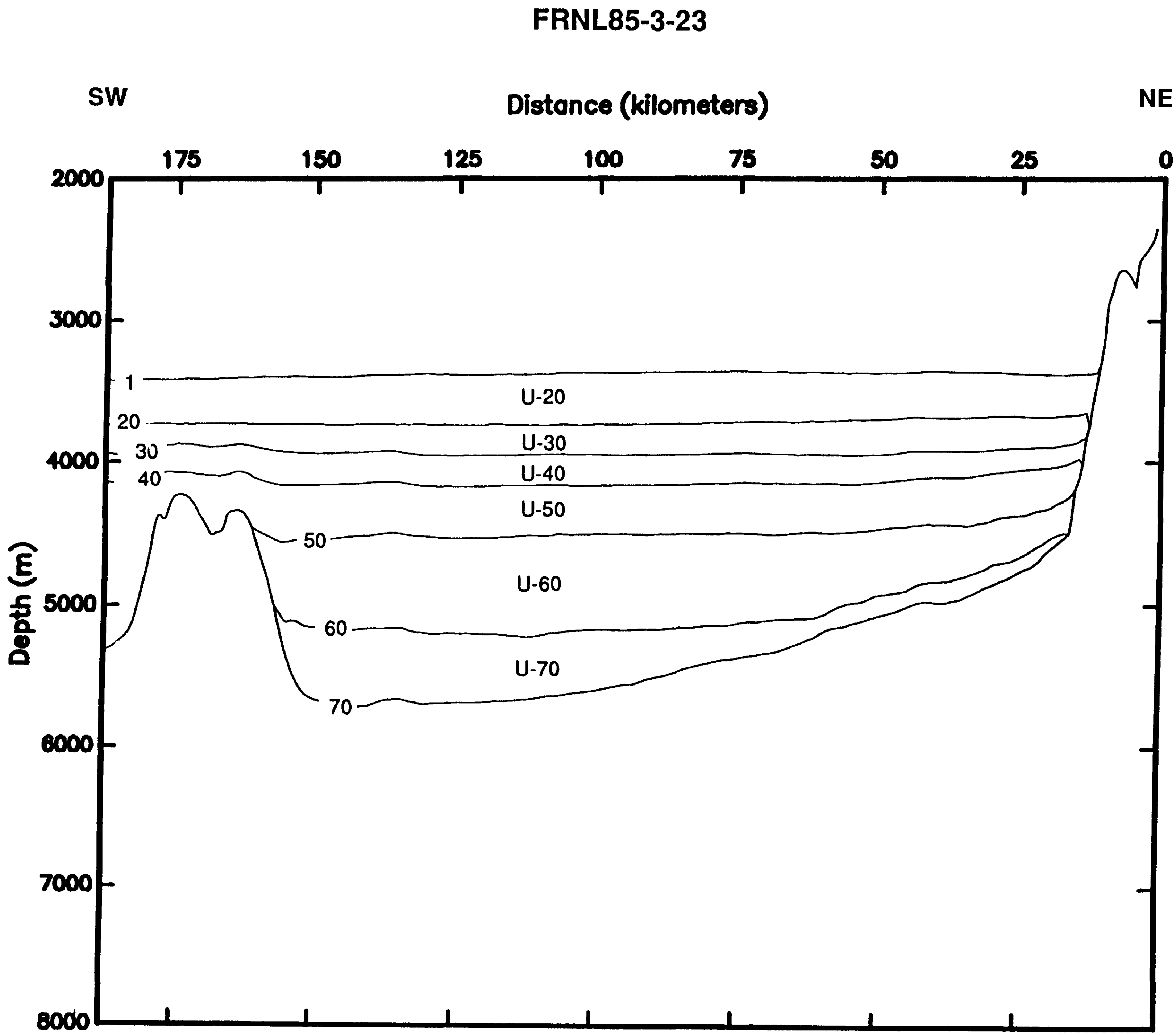
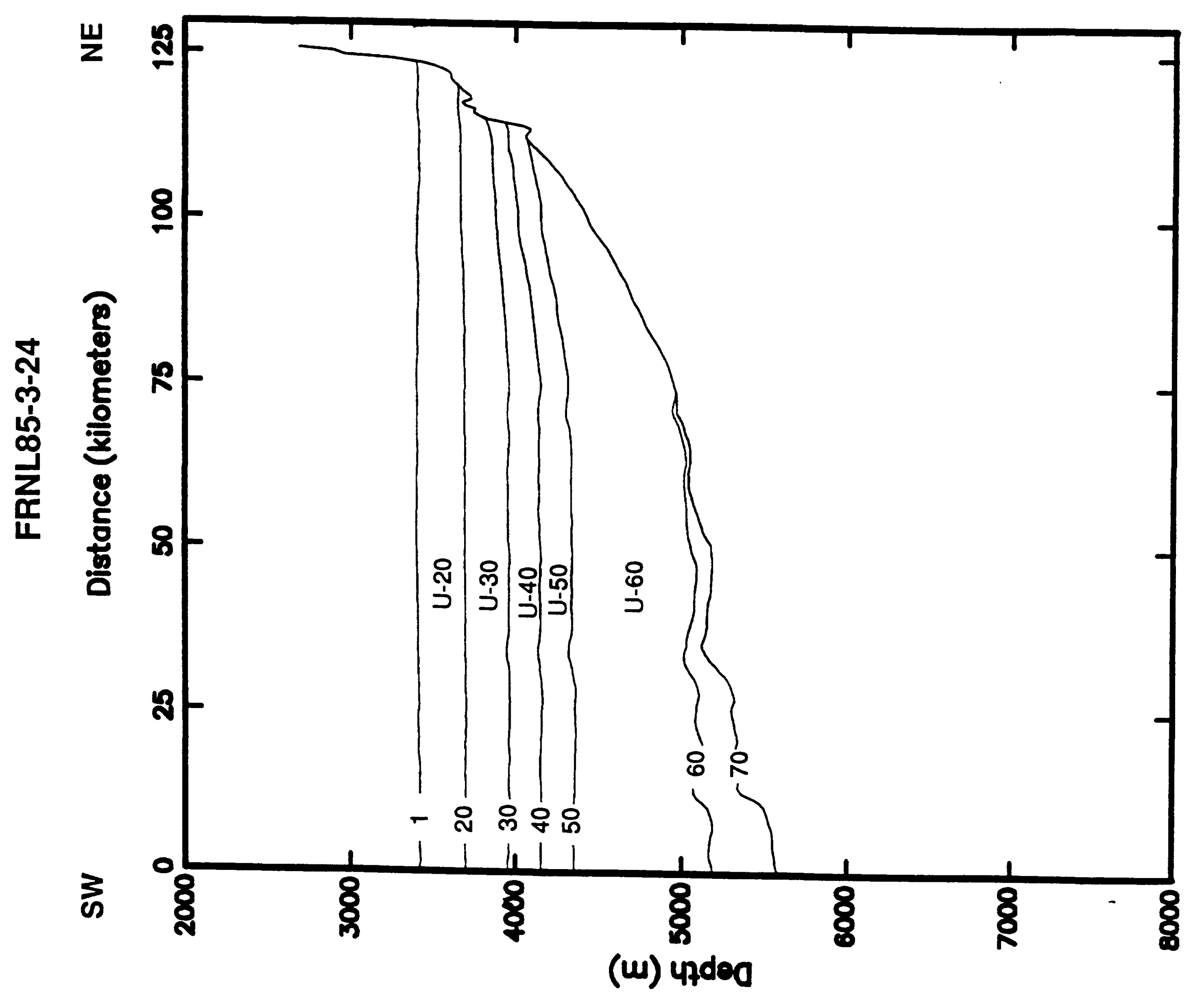
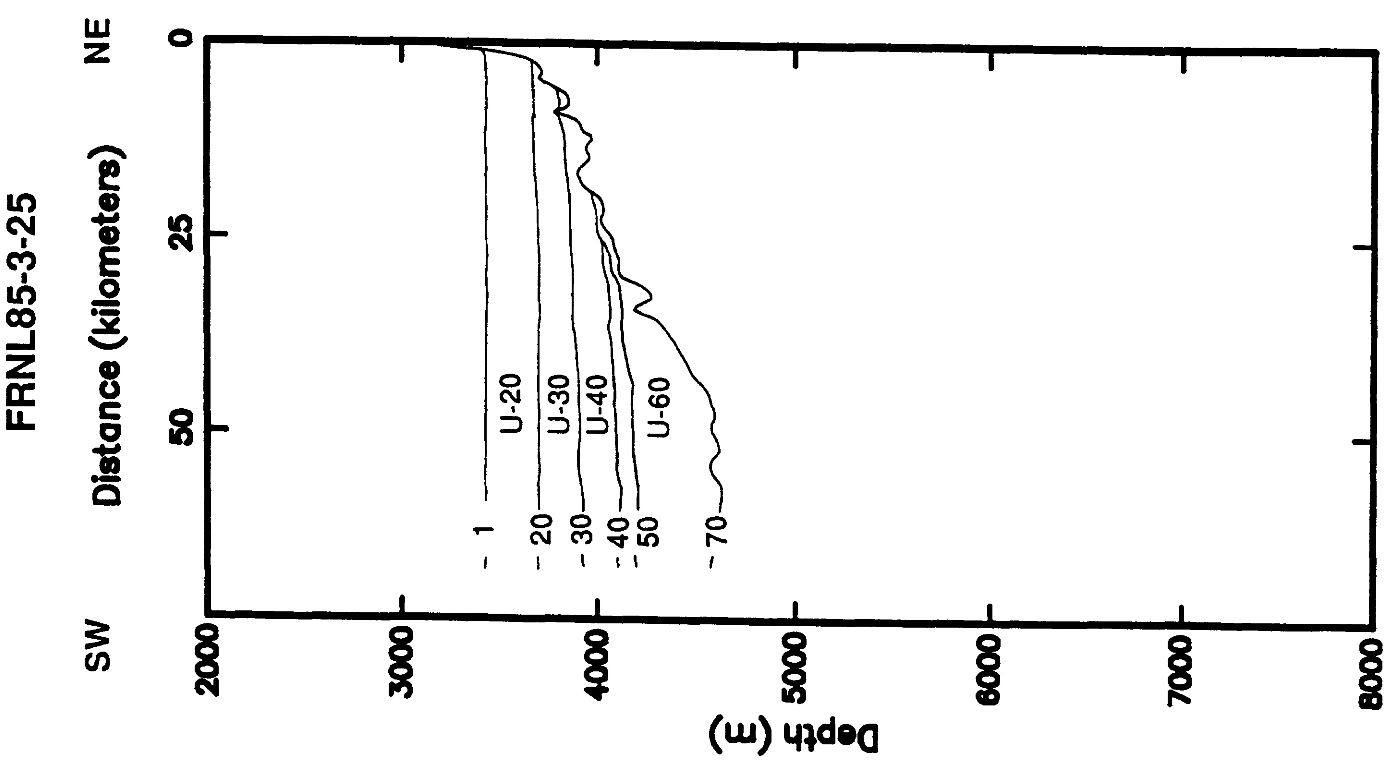
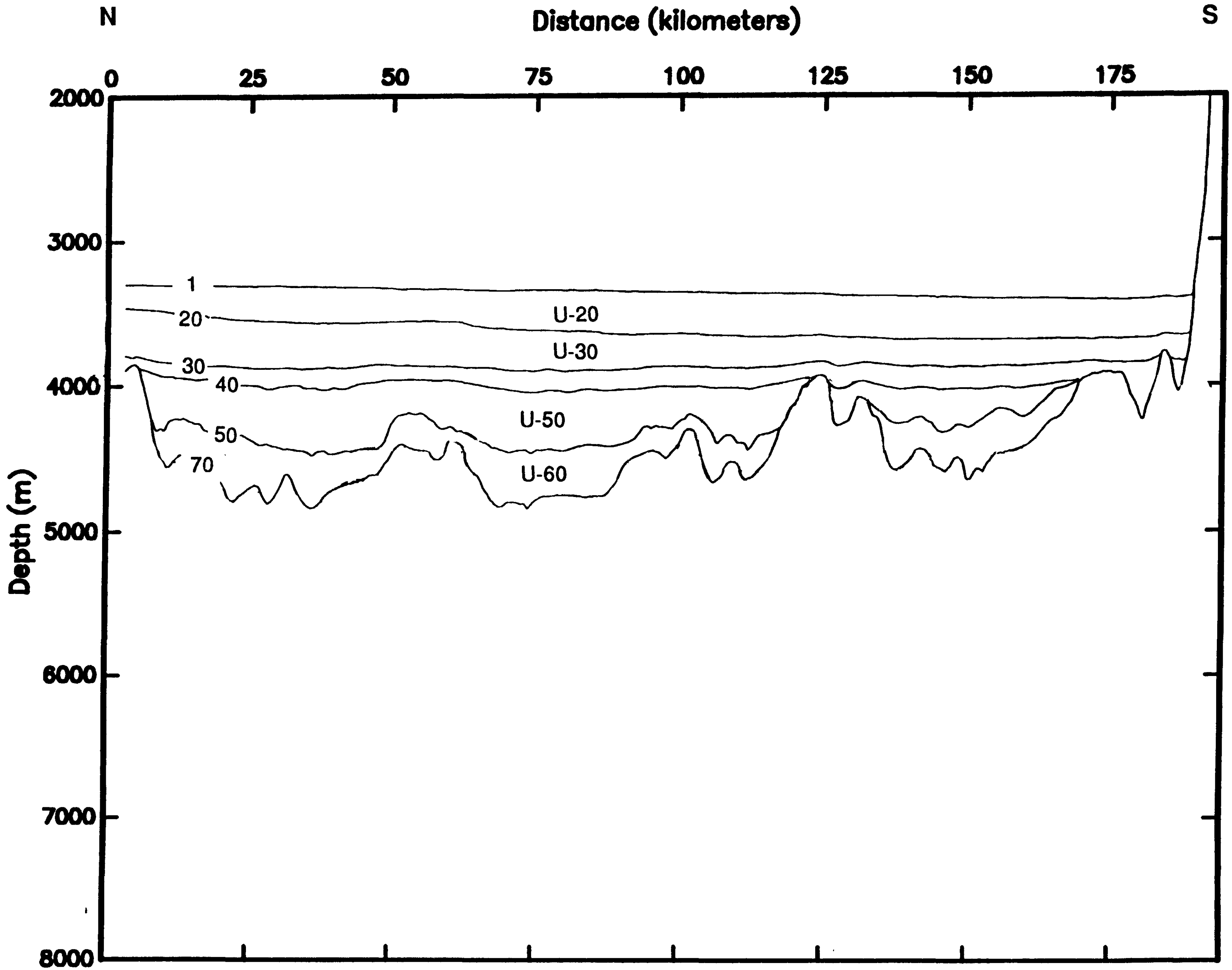
25
50
75
100
125
150
Depth (m)
2000
3000
4000
5000
6000
7000
8000
1
20
30
40
50
60
70
U-20
U-30
U-40
U-50
U-60
U-70


FRNL85-3-23
SW
Distance (kilometers)
NE
175
150
125
100
75
50
25
0
2000
3000
4000
5000
6000
7000
8000
Depth (m)
1
20
30
40
50
60
70
U-20
U-30
U-40
U-50
U-60
U-70


FRNL85-3-24
Distance (kilometers)
SW
NE
0
25
50
75
100
125
Depth (m)
2000
3000
4000
5000
6000
7000
8000
U-20
U-30
U-40
U-50
U-60
1
20
30
40
50
60
70


FRNL85-3-25
Distance (kilometers)
SW
NE
0
25
50
Depth (m)
2000
3000
4000
5000
6000
7000
8000
U-20
U-30
U-40
U-60
1
20
30
40
50
70

FRNL82-fs-1


N
S
Distance (kilometers)
0
25
50
75
100
125
150
175
2000
3000
4000
5000
6000
7000
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Depth (m)
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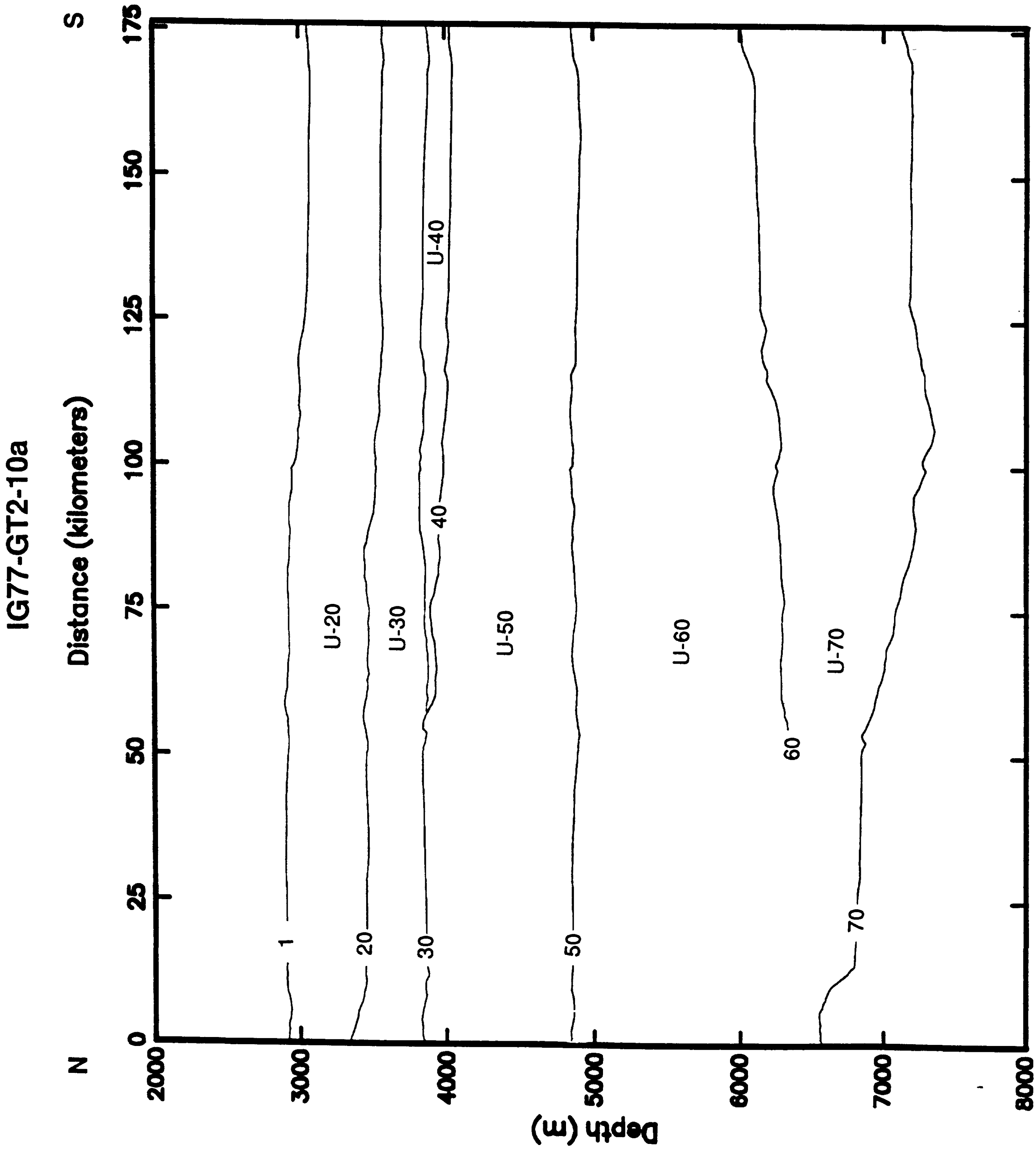
U-30
U-50
U-60



IG77-GT2-10a
Distance (kilometers)
Depth (m)
N
S
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25
50
75
100
125
150
175
2000
3000
4000
5000
6000
7000
8000
1
20
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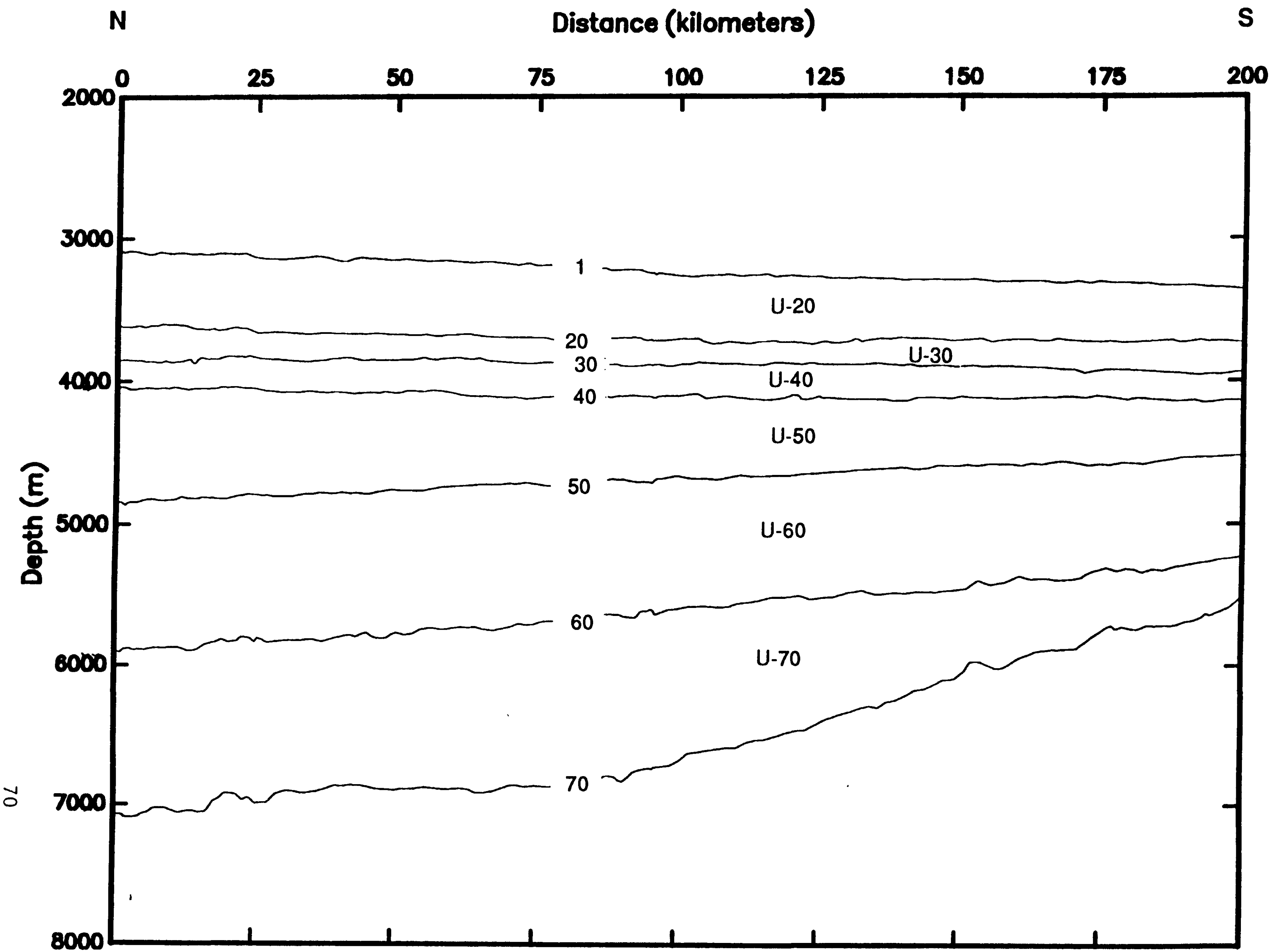
40
50
60
70
U-20
U-30
U-40
U-50
U-60
U-70

IG77-GT2-10bc - piece 1 of 2



IG77-GT2-10bc - piece 2 of 2