DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
THE BUREAU OF LAND MANAGEMENT

MISCELLANEOUS FIELD STUDIES
MAP MF-1193
AARON AND OTHERS—ENVIRONMENTAL CONDITIONS RELATING TO POTENTIAL GEOLOGIC HAZARDS,
U. S. NORTHEASTERN ATLANTIC CONTINENTAL MARGIN
SHEET 2 OF 3

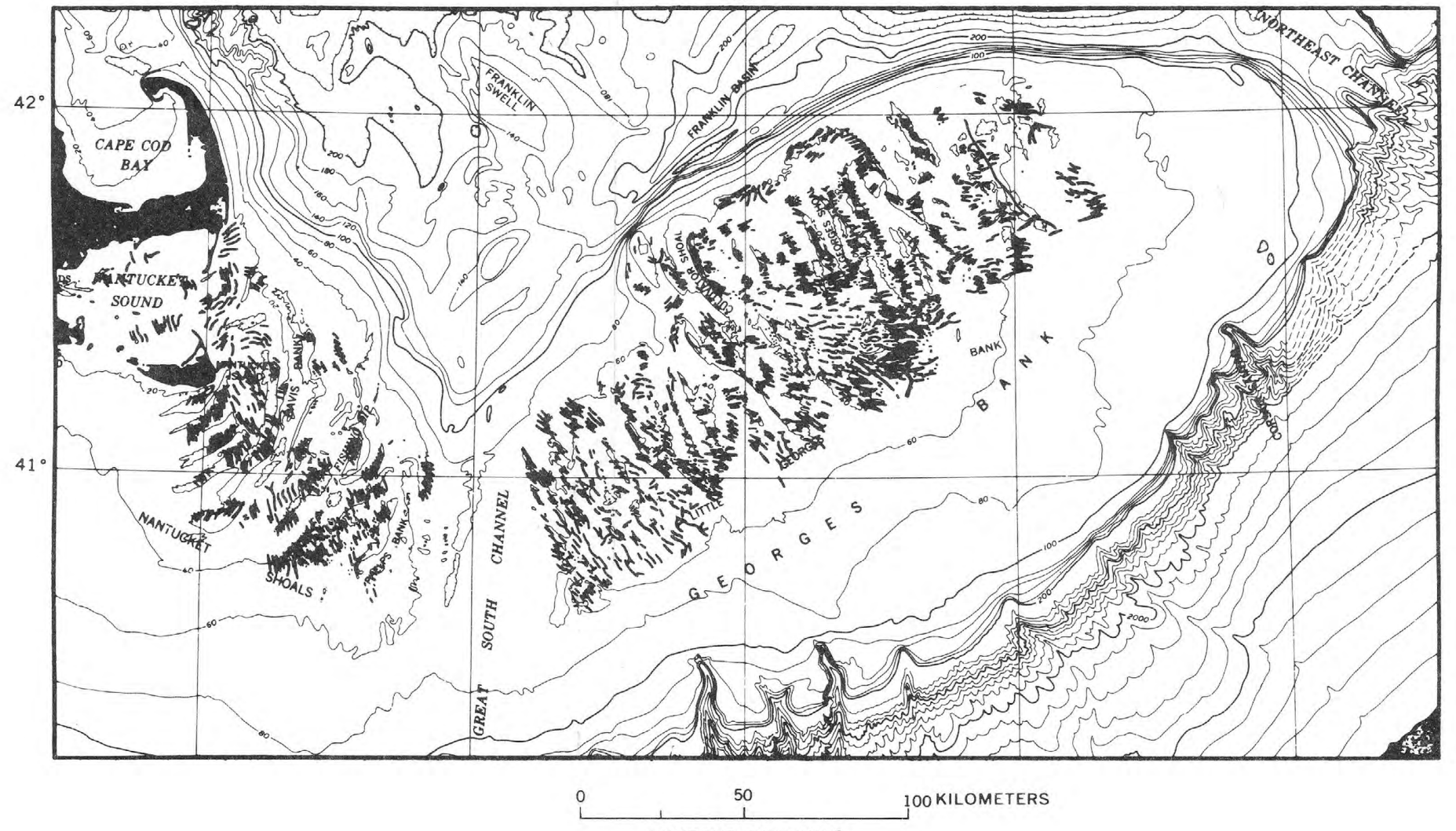

Figure 8.—Distribution of sand waves on Georges Bank and Nantucket Shoals. Heavy lines represent crests of sand waves. From Uchupi (1970).

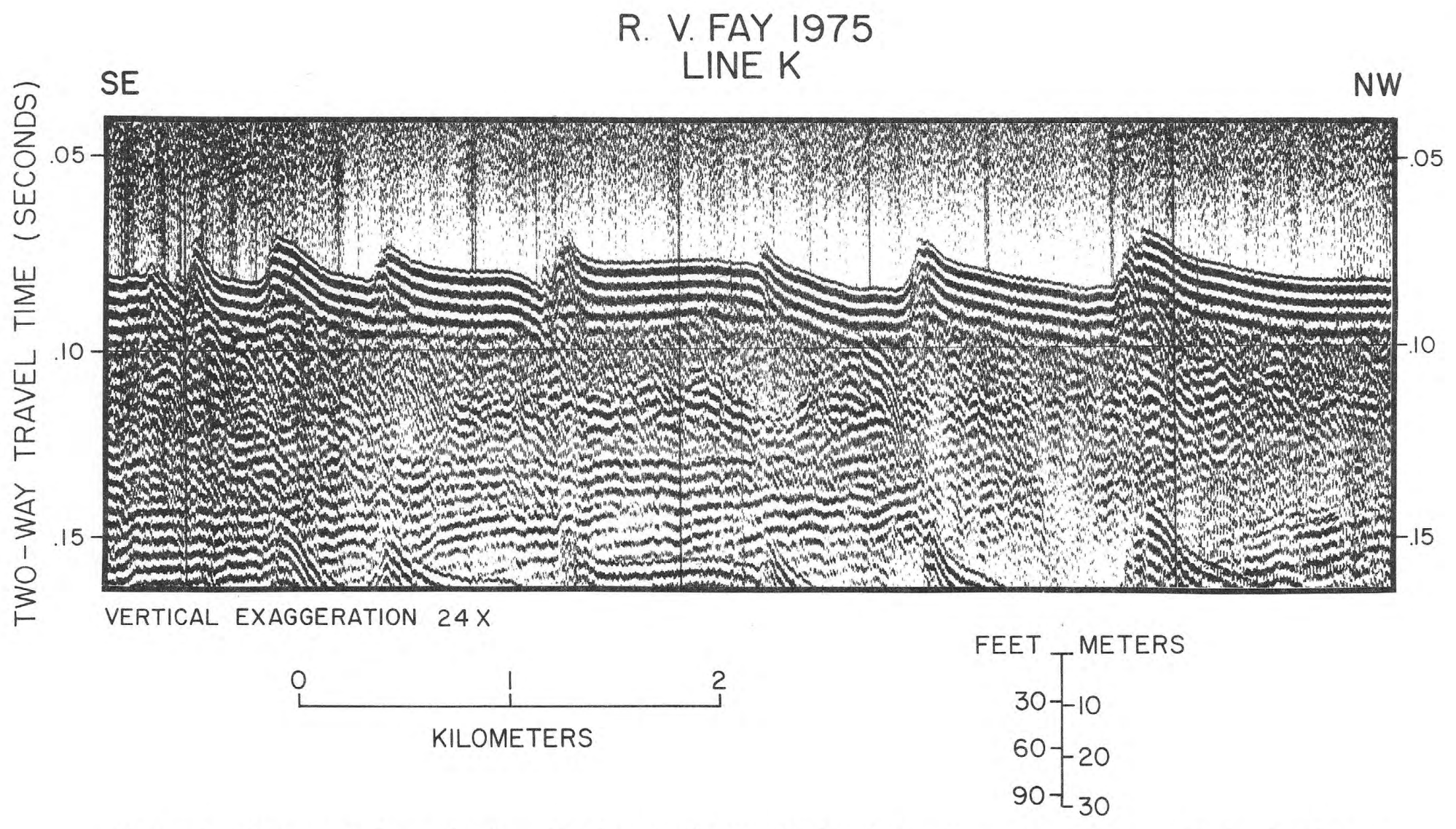

Figure 9.—High-resolution seismic-reflection profile line K showing sand waves on Georges Bank. See figure 12 for location of line K.

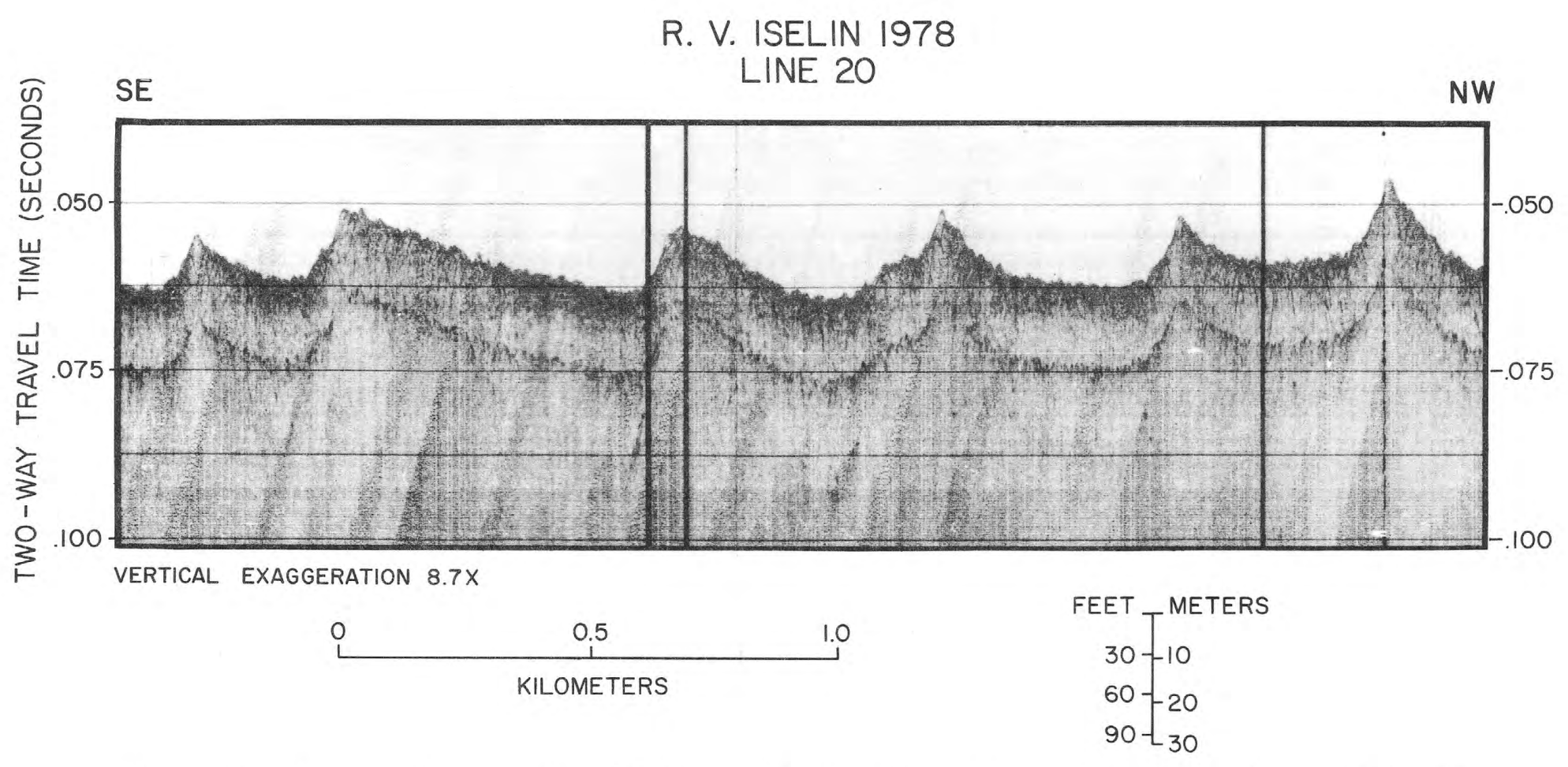

Figure 10.—High-resolution seismic-reflection profile line 20 showing sand waves on Georges Bank. See figure 12 for location of line 20.

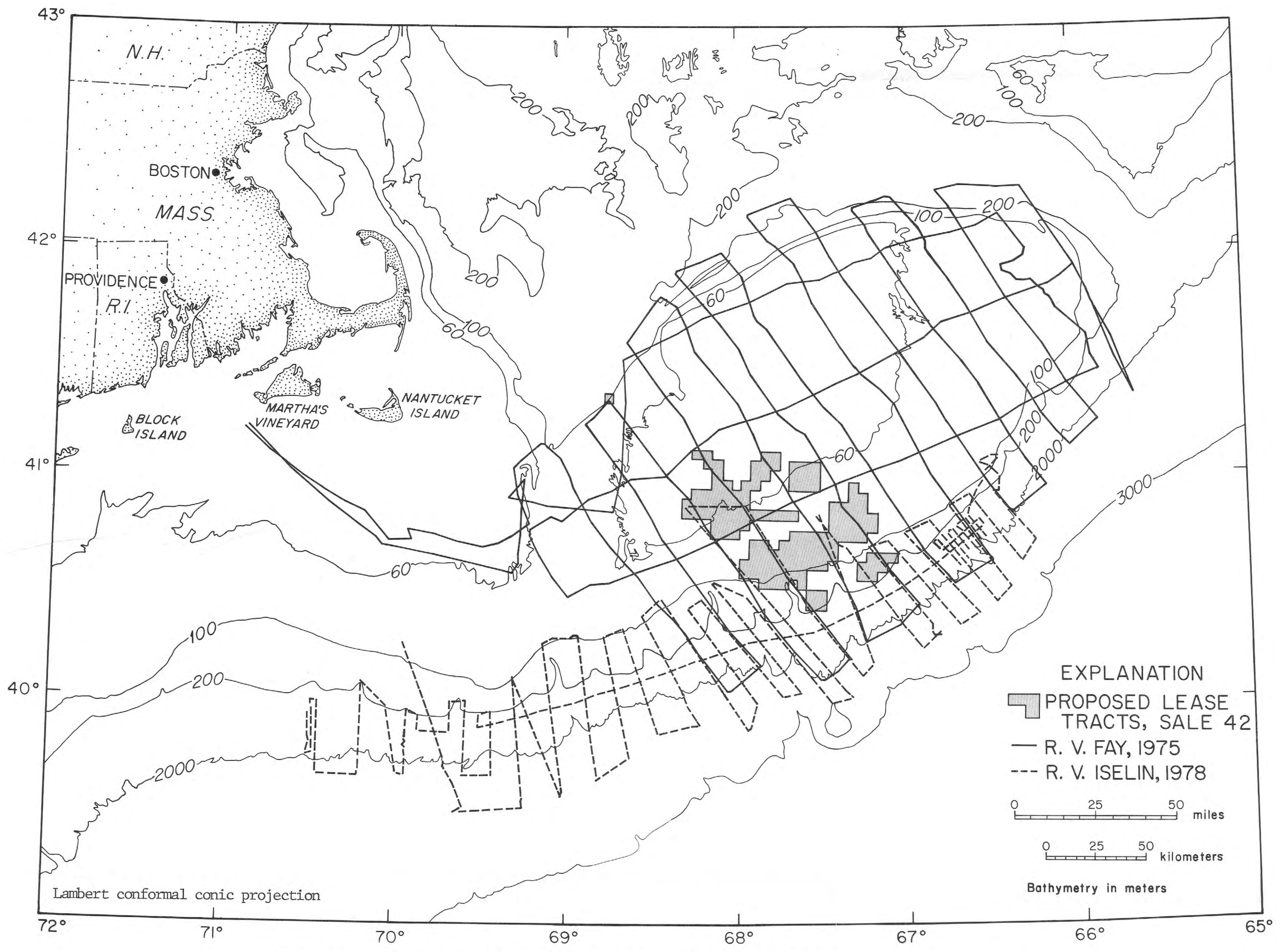

Figure 11.—Trackline locations of high-resolution seismic-reflection data on Georges Bank and adjacent areas.

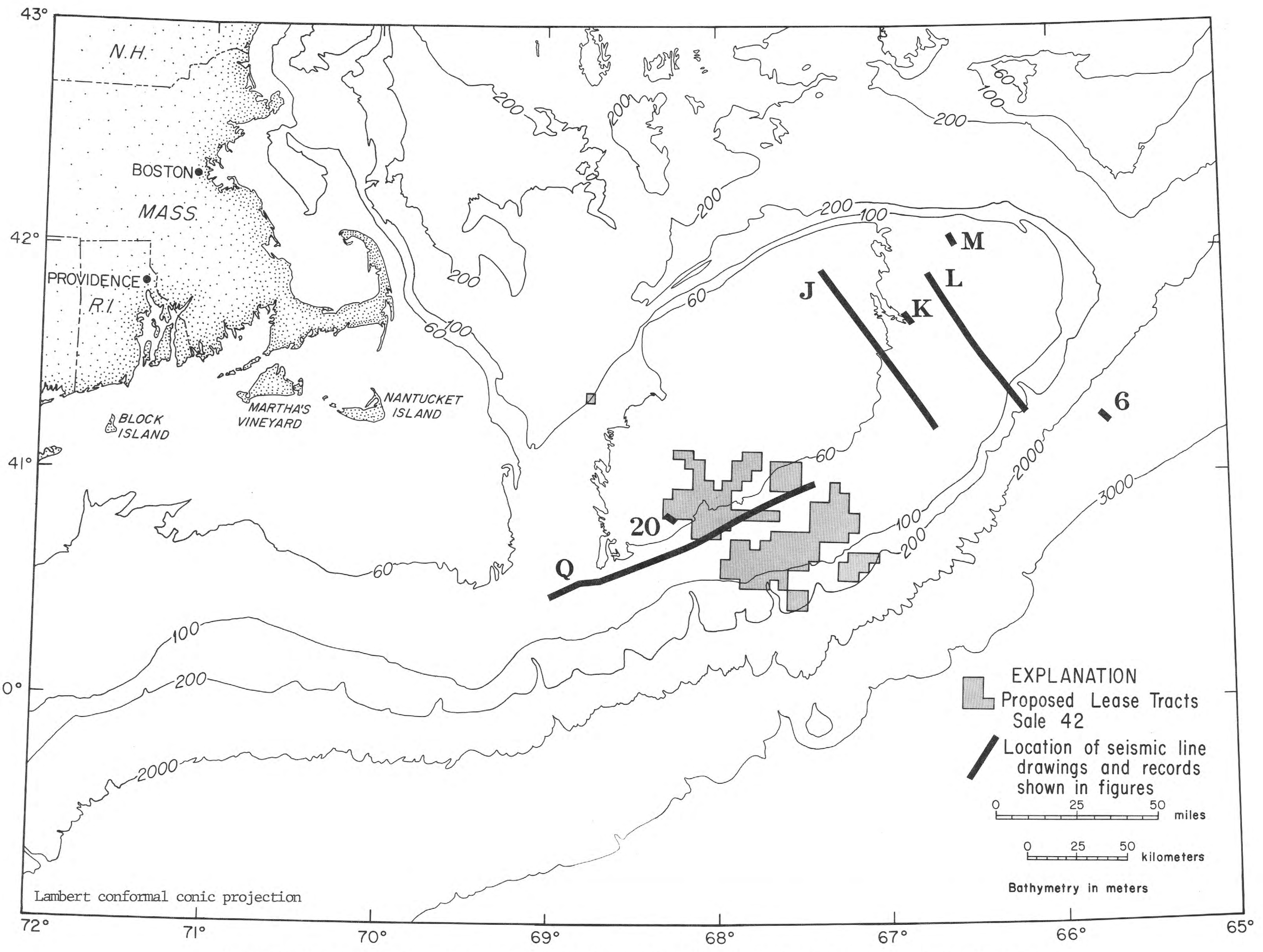

Figure 12.—Location of high-resolution seismic-reflection profiles J, K, L, M, Q, 6, and 20 on Georges Bank and vicinity.

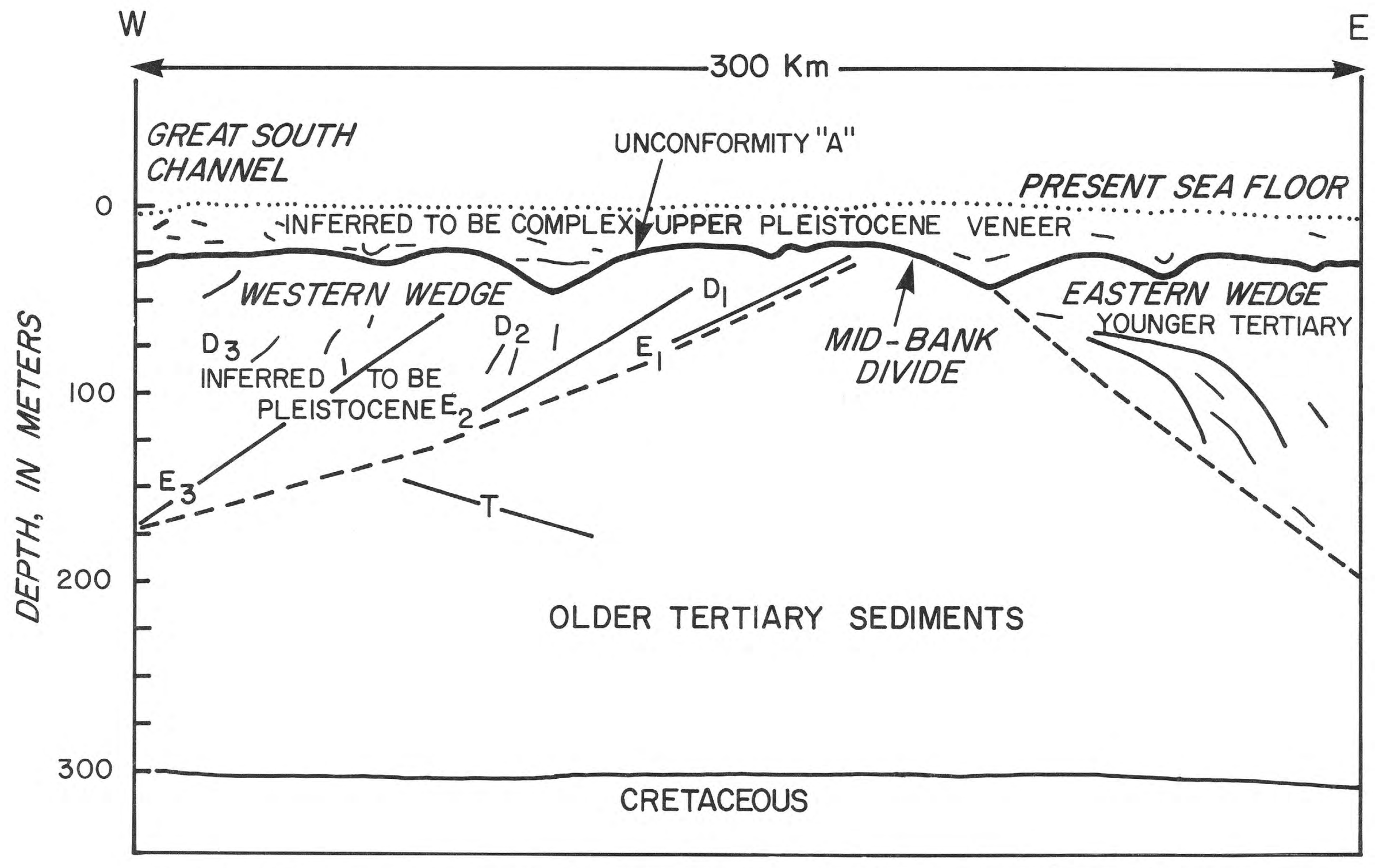

Figure 13.—Idealized east-west cross-section of Georges Bank, showing principal stratigraphic relationships inferred from seismic-reflection data. Not to scale. Lines E_1, E_2, and E_3 designate erosional events (unconformities); intervals D_1, D_2, and D_3 represent periods of deposition and contain irregular, discontinuous seismic reflectors. Dashed lines bounding older Tertiary sediments are major unconformities. Relative attitude of older Tertiary strata is shown by the letter T. Adapted from Lewis and Sylwester (1976).

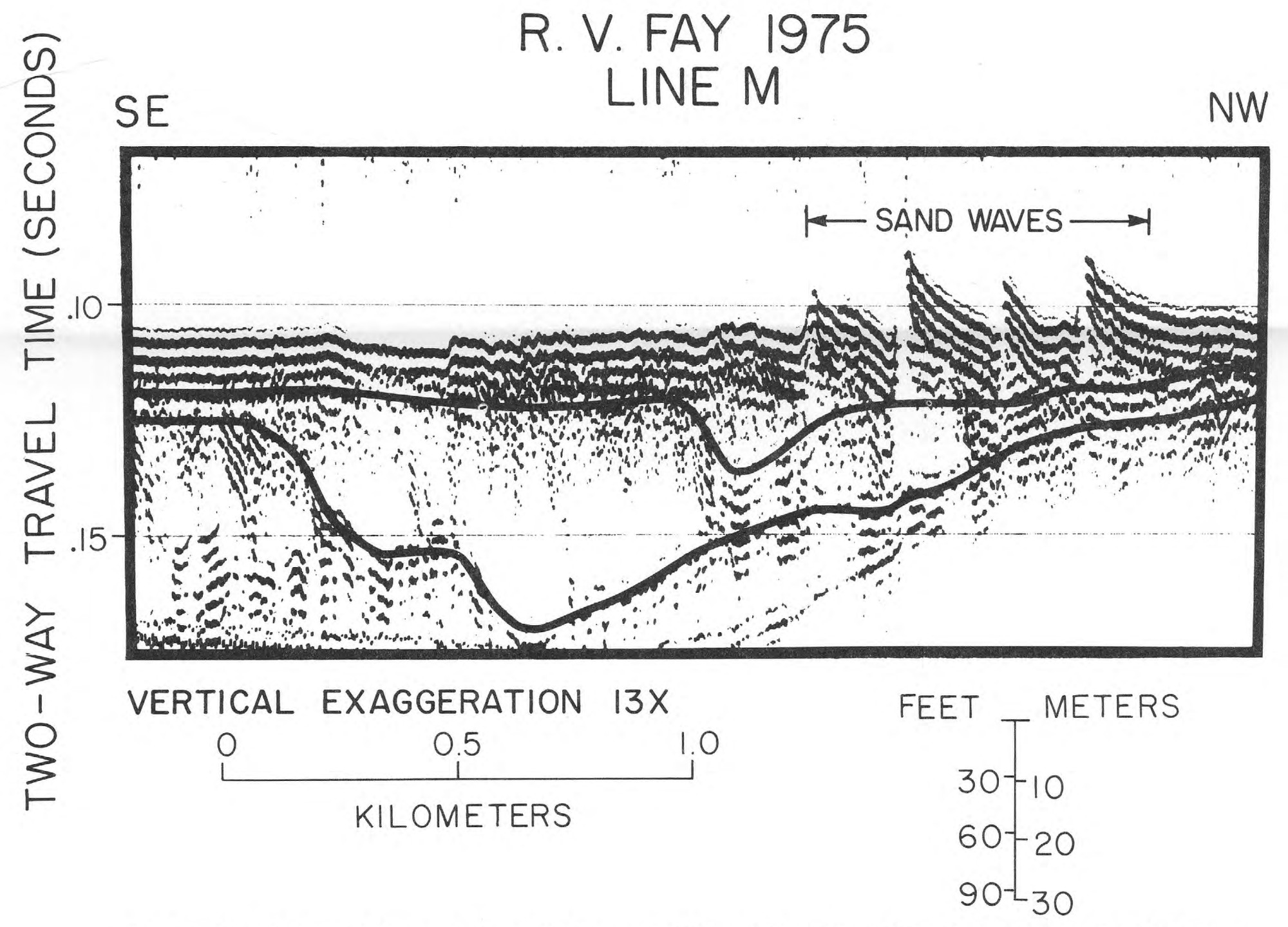

Figure 14.—High-resolution seismic-reflection profile line M (see fig. 12 for location) showing Pleistocene sediments overlying Georges Bank. The heavy lines depict episodes of channel cutting and filling.

SCOUR AND MOBILE BED FORMS

Bottom-moored instrument systems and direct observations on Georges Bank provide abundant evidence that normal tidal and wave-driven currents are competent to resuspend and transport surficial bottom sediment. Two potential hazards result from such strong currents and vigorous sediment motion on the Continental Shelf.

Scour

Scouring is a process of erosion by the action of flowing water. A potential hazard could result if scouring removed sediment from the base of support structures (platform legs, footings, pipelines, etc.) causing weakening or differential settlement of the structures. The structure itself is an obstruction that tends to increase local current speeds and shear stress at the bottom, resulting in increased erosion (scour). Other factors governing the magnitude of erosion include current velocity, water depth, the size, shape, and composition of grains composing sea floor sediments, and the size and shape of manmade structures interacting with currents.

An example of the destructive effect of scour is documented by Wilson and Abel (1973), who described the installation and ultimate abandonment of a drill rig on the Nova Scotian Shelf. Rig emplacement included protection from scour, which was expected in the normal tidal currents of 1.5 kn (77 cm/s), in the form of a mesh laid as a mat around the rig pontoons. In a major storm the protective matting was badly damaged, and the rig rotated. In a second storm about three weeks later, the protective matting was damaged beyond repair, the pontoons were undermined, and the rig settled 0.7 m.

Mobile Bed Forms

A morphologic result of sediment transport is a wave-like geometric configuration of the water-sediment interface. These wave-like forms, termed bed forms, are migratory features; their size, geometry, speed, and direction of movement are related to the grain size of the sediments in the bed and to flow conditions such as water depth and current velocity.

Sand waves, which are large potentially-mobile bed forms, abound on parts of the New England Continental Shelf where strong tidal currents, augmented by wave-driven currents, act on loose surficial sand. They are located mainly on Georges Bank and Nantucket Shoals (fig. 8) in water depths of 60 m or less. Figures 9 and 10 illustrate sand waves in high-resolution seismic-reflection profiles acquired by the USGS (see figs. 11 and 12 for tracklines and location of profiles, respectively). The distribution of sand waves in USGS seismic-reflection profiles is shown in figure 15. Sand waves on Georges Bank typically range in height from 5 to 15 m and in wave length from approximately 150 to 750 m (Jordan, 1962). The highest sand wave reported was over 27 m high (Jordan, 1962). Sand waves typically are asymmetrical (figs. 9 and 10). The steeper, lee slope is inclined 20° or more and is oriented facing down-current, perpendicular to the maximum current direction.

The sharp asymmetry of many sand waves on Georges Bank suggests that they are active, although little is known about their migration rate. Stewart and Jordan (1964) showed that sand waves more than 8 m high on Georges Shoal migrated a maximum net distance of 300 m westward in a 25-to-28-year period. This migration rate, about 12 m/year, was in an area where tidal currents of up to 2 kn were measured. Further study of sand wave migration rates on Georges Bank was initiated by the USGS during 1979. The presence and stability of large bed forms on the Continental Shelf is an important aspect of assessing geologic hazards related to offshore development. Sand piled against a support structure by large mobile bed forms could, in the extreme case, weaken the structure either by changing its resonant frequency (Garrison and Bea, 1977), or by placing an excessive lateral stress on it. Such was the fate of Texas Tower radar stations erected on Georges Bank during the late 1950's. Sand levels around the legs of the towers deepened enough to weaken the structures, leading eventually to their abandonment and salvage in 1964 (Emery and Uchupi, 1972).

SHALLOW STRUCTURE

Various aspects of the structure of the Continental Shelf and Slope of the Georges Bank area were summarized by Emery and Uchupi (1965), Knott and Hoskins (1968), Uchupi (1970), Schultz and Grover (1974), and Lewis and Sylwester (1976). Whereas the deep structure and early geologic history of Georges Bank is the major consideration in studying hydrocarbon resource potential, the very shallow structure and late history, especially of the Pleistocene, is of particular interest to environmental assessment. Sediments deposited during the Pleistocene Epoch form the substrate that supports important benthic faunal communities, including many commercial fish (cod, haddock, and flounder), crustaceans (lobsters, crabs, and shrimp), and bivalve molluscs (clams and scallops). These sediments also may provide foundation support for hydrocarbon production and transportation facilities. The physiography of Georges Bank, in large part a product of Pleistocene history, strongly influences the circulation pattern and strength of tidal and wave-driven currents that traverse the bank.

In 1975 the USGS collected 2,900 km of high-resolution seismic-reflection data on Georges Bank (Fig. 11, R. V. *Fay*) in order to systematically study the shallow sedimentary structure of the region. The data show that Georges Bank is underlain by southeast-dipping coastal plain strata, inferred to be of Tertiary age, that have been erosionally truncated on the eastern and western sides of the bank. Younger Tertiary sediments were deposited on the eroded eastern flank, whereas the eroded western flank was covered by an extensive prograded wedge of Pleistocene sediments. Figure 13 illustrates these relationships. Figures 16, 17, and 18, adapted from Lewis and Sylwester (1976), are interpretative drawings, based on reflectors observed in the seismic records, that illustrate the shallow structure. Following an interglacial period of marine planation, the truncated bank surface (unconformity "A") was blanketed by up to 80 m of upper Pleistocene glacial drift, mostly outwash, that masks underlying features. This surficial sedimentary veneer was reworked during the sea-level rise that accompanied the termination of the last glacial stage, and reworking by waves and currents continues to the present time.

The Pleistocene sediments overlying Georges Bank are acoustically complex; several episodes of channel cutting and filling (fig. 14) are inferred. The distribution of buried channels in USGS seismic-reflection data is shown in figure 15. Some deep channels are cut completely through Pleistocene sediments into the underlying Tertiary strata. Sediments that are acoustically transparent, possibly representing organic, reworked, or disturbed materials, are common in the Pleistocene veneer. In general, seismic-reflecton data suggest that the properties of sediments on Georges Bank are quite variable and that they change dramatically over short distances. When loaded, sediments with such variability, especially in strata of organic material, soft clays, and silts that could contain shallow gas, could settle differentially and threaten the stability of platform structures erected on them. These variable conditions must be considered in the design of the structures and adequately explored in site surveys.

There is no evidence of shallow faulting on Georges Bank. However, minor faulting in the upper 20 to 80 m of Pleistocene sediment might be difficult to detect because of the inherent resolution of the seismic system (about 5 m) and the lack of continuous stratigraphic reflecting horizons.

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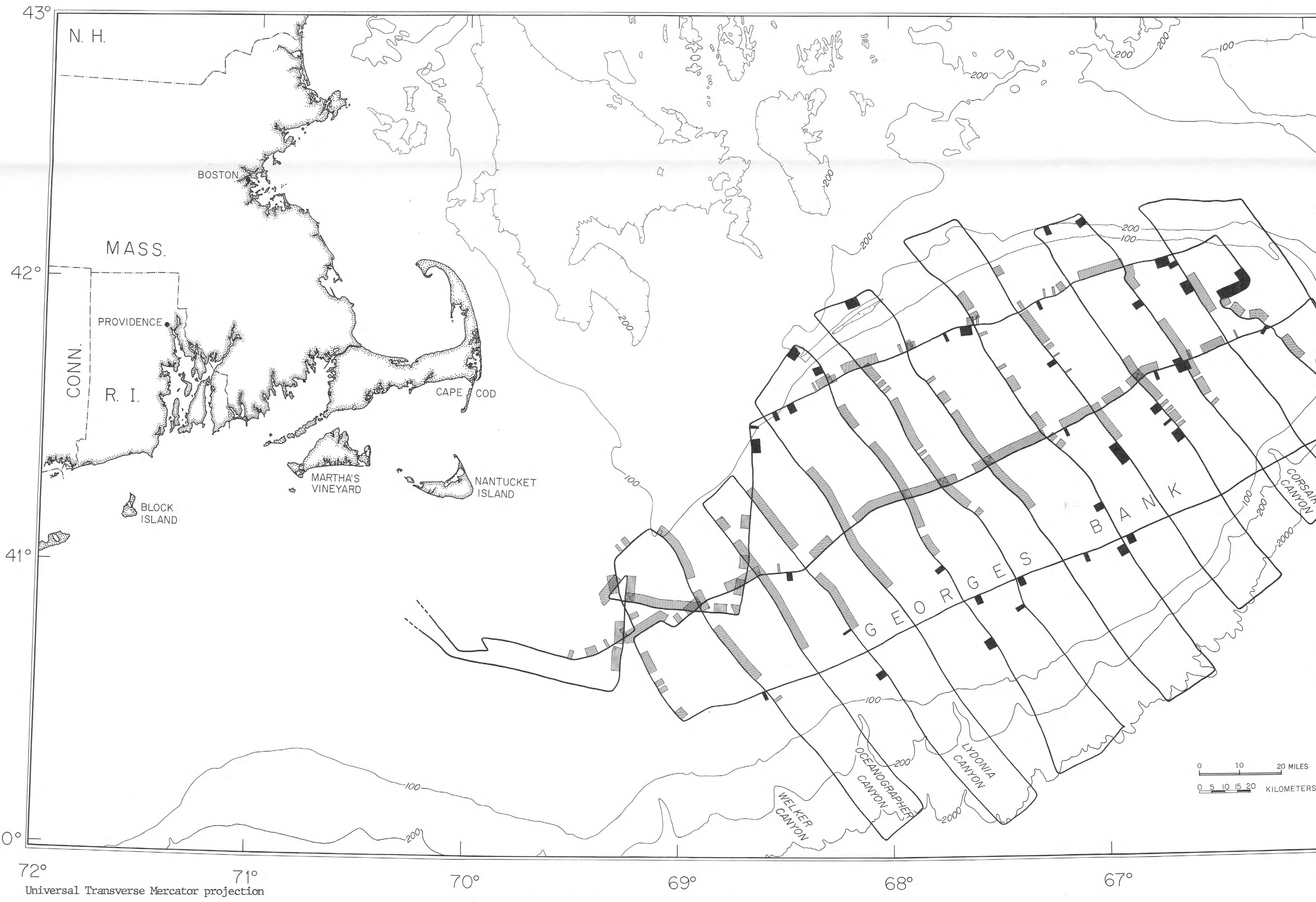
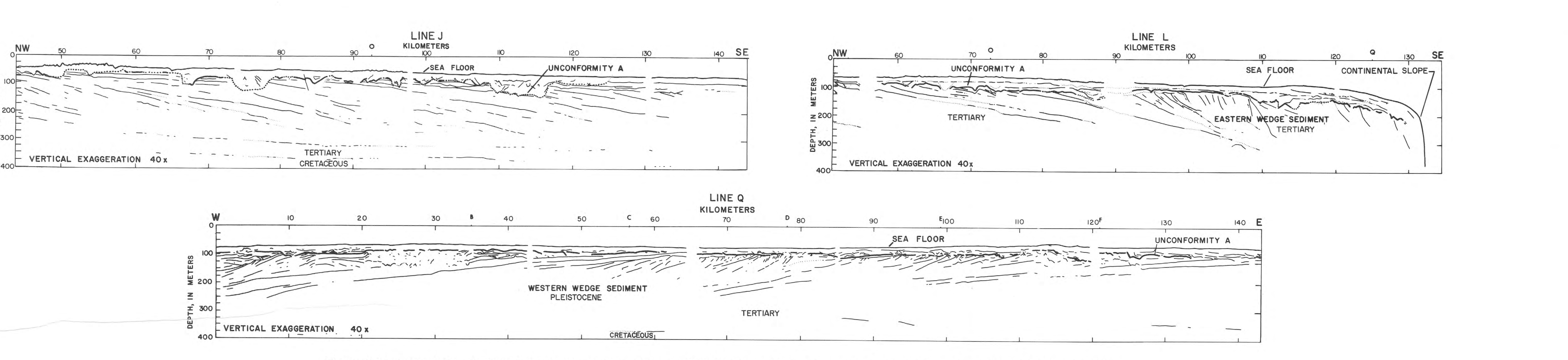


Figure 15.—Distribution of sand waves and buried channels on Georges Bank, from seismic-reflection data.



Figures 16-18.—Interpretative drawings of the shallow structure of Georges Bank, based on reflectors observed in seismic profiles J, L, and Q (see fig. 12 for location). Unconformity "A" (idealized in fig. 13) is dotted where inferred. The letter or letters (O, Q, B, C, D, E, F) appearing above the kilometer-scale line in each drawing show where other seismic tracklines intersect lines J, L, and Q. Breaks in the drawings indicate intervals where seismic-reflection data were not collected. Drawings are adapted from Lewis and Sylwester (1976).

MAPS SHOWING ENVIRONMENTAL CONDITIONS RELATING TO POTENTIAL GEOLOGIC HAZARDS ON THE UNITED STATES NORTHEASTERN ATLANTIC CONTINENTAL MARGIN

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