3.3 IMPORTANT TYPES OF ECHO CHARACTER IN SEDIMENTS OF THE SOUTH CHINA SEA (SONNE-95 CRUISE)

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Introduction

In total the PARASOUND echo-sound records of the SONNE cruise 95 comprise profiles extending over more than 2500 nautical miles. The profiles were especially useful for the ad-hoc selection of appropriate coring sites in undisturbed hemipelagic sediments (see section on Coring Sites, Core Logs, and Initial Core Descriptions; Pflaumann et al., this volume). Moreover, the records form a base for both the stratigraphic correlations between cores and future mapping and balancing of sediment accumulation and erosion. PARASOUND echo records, i.e., the micromorphology and reflectivity characteristics of sediments in PARASOUND sub-bottom profiles can be classified and interpreted largely analogous to 3.5 kHz records, following the classification schemes proposed by Damuth (1975), Jacobi and Hayes (1982), and Mienert (1986). In general, however, the echo-character classification system of PARASOUND records appears more simple than that of conventional 3.5 kHz records, mainly because of the reduced occurrence of hyperbolae in the PARASOUND records.

PARASOUND Echo Types

(A) Draping sediment echo types are the most promising evidence of undisturbed hemipelagic deposition (Fig. 1), especially the echo type of *standing and migrating sediment waves* (Fig. 2 and record at GIK site 17936). Based on the fact that the highly focussed PARASOUND echo beam is largely devoid of hyperbolic echos, the record of Fig. 2 provides rare and partly new insights into the mechanisms of sediment-wave migration: (1) The waves generally move obliquely upslope and in particular, upstream, i.e. against the contour current of upper Pacific Deepwater which debouches from the Philippine Basin across the Bashi Strait and along the lower South Chinese continental margin to the west (Wang L.J., 1992). (2) The migration of wave ridges (about 60 m/1-2 M.y.) is linked to thin-rhomboidal sediment wedges that occur in the sediment pile at the lower end of the leeward slope of the waves at frequent and possibly regular intervals. Clearly the sediment wedges record discontinuous rates of deposition and current action.

(B) Fig. 3 depicts a *thick sediment drape* covering the southern Dangerous Grounds carbonate platform in front of the synglacial Sunda river. Based on the preliminary shipboard stratigraphy (see section on

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Preliminary Sedimentation Rates; Sarnthein et al., this volume) the first outstanding reflector near 15 m below sea floor may correspond to stage 5.5 (Eemian). Further below, various prominent reflectors may be linked to antecedent extreme sealevel highstands such as during stages 7.7, 9.3, and 11.3, when the Sunda shelf was flooded and the Sunda River did not exist as today. Many delicate reflectors that occured in between the major reflectors on the color image of the PARASOUND monitor, were not preserved on the paper copy of Fig. 3. The first major reflector can be traced over more than 200 km all over the deltaic hemipelagic sediment pile in front of the Sunda shelf up to GIK station 17965.

(C) *Sediment slumps* are clearly recognized in PARASOUND echograms as thick transparent layers that may cut across underlying sediment beds and carry acoustic reverberations and a rough morphology near the surface (Fig. 4 and parts of echogram at GIK station 17953).

(D) Slight *current erosion of hemipelagic sediments* is obviously a widespread feature on the margins of the South China Sea as documented by extensive fields of solitary or bundled hyperbolae that 'cut' into the sea floor in the PARASOUND records from the continental slope of South China (Fig. 5a and b). Because of the narrow PARASOUND beam we surmise that these hyperbolae result from small-scale (0.1->1.0 m) and steep shaped erosional furrows. In some cases these furrows are linked to turbidite currents, where they are clearly confined to the inner ('*gleithang*') slope of curved turbidite channels. In most cases, however, the erosional marks probably originate from large-scale contour currents as deduced from the widespread and continuous distribution of the hyperbola marks reaching from the lower to the upper continental slope (e.g., southeast of Pratas Atoll, about 117°E) .

(E) *Intensive erosion on the upper slope* resulted in a widespread dentate relief up to ten meters high and partly burried by subsequent (Holocene?) sedimentation (Figure 6). Here the erosional activity is further supported by pinch outs of layered Tertiary sediments (compare Wong et al., this volume).

(F) *Turbidites* are marked in PARASOUND records by coarse acoustic layering, mostly separated by thin transparent layers with characteristic small-scale discontinuities and unconformities as a result of braided turbidite channels. In contrast to hemipelagic sediments, turbidites generally do not drape but fill the pre-existing sea-floor morphology and thus can be easily distinguished in PARASOUND records, except for rare cases of very distal turbidites (echograms at GIK stations 17952 and 17953).

There are various PARASOUND echo types not depicted in this section: those associated with sediment waves on the shelf, these with hemipelagic sediments on the upper continental slope (at about 600-1000 m depth), sediments which carry signs of weak downslope winnowing, and cases of extreme sediment transport resulting in slight unconformities.

REFERENCES

Damuth, J.E. (1975): Echo character of the western equatorial Atlantic floor and its relationship to the dispersal and distribution of terrigenous sediments. - Marine Geology, 18, 17-45.

Jacobi, R.D. and D.E. Hayes (1982): Bathymetry, microphysiography, and reflectivity characteristics of the West African margin between Sierra Leone and Mauritania. - In: U. von Rad et al. (eds.) Geology of the Northwest African continental margin (Springer Verlag, Berlin), 545-604.

Mienert, J. (1986): Akustostratigraphie im äquatorialen Ostatlantik: Zur Entwicklung der Tiefenzirkulation der letzten 3,5 Millionen Jahre. - "Meteor" Forschungserg., C 40, 19-86.

Wang, L.-J. (1992): The late Quaternary oxygen isotope record and its implications for the ventilation state of the South China Sea.-, In: Ye, Z. and P.X. Wang, P. (eds), Contributions to late Quaternary Paleoceanography of the South China Sea (Qingdao Ocean Press, Qingdao), 195-205.

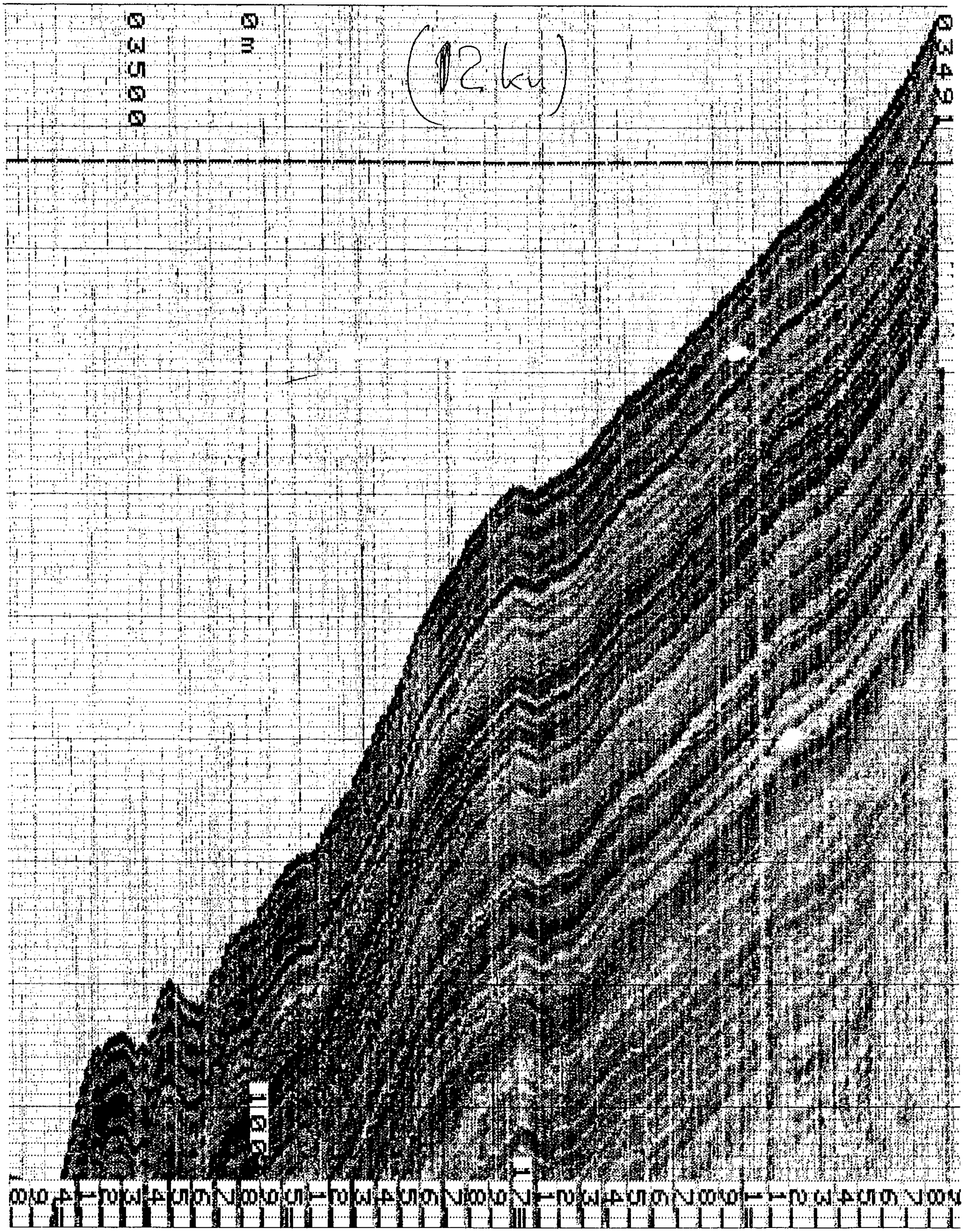

Figure 1. Sediment drape upslope of a field of sediment waves (near GIK site 17936)

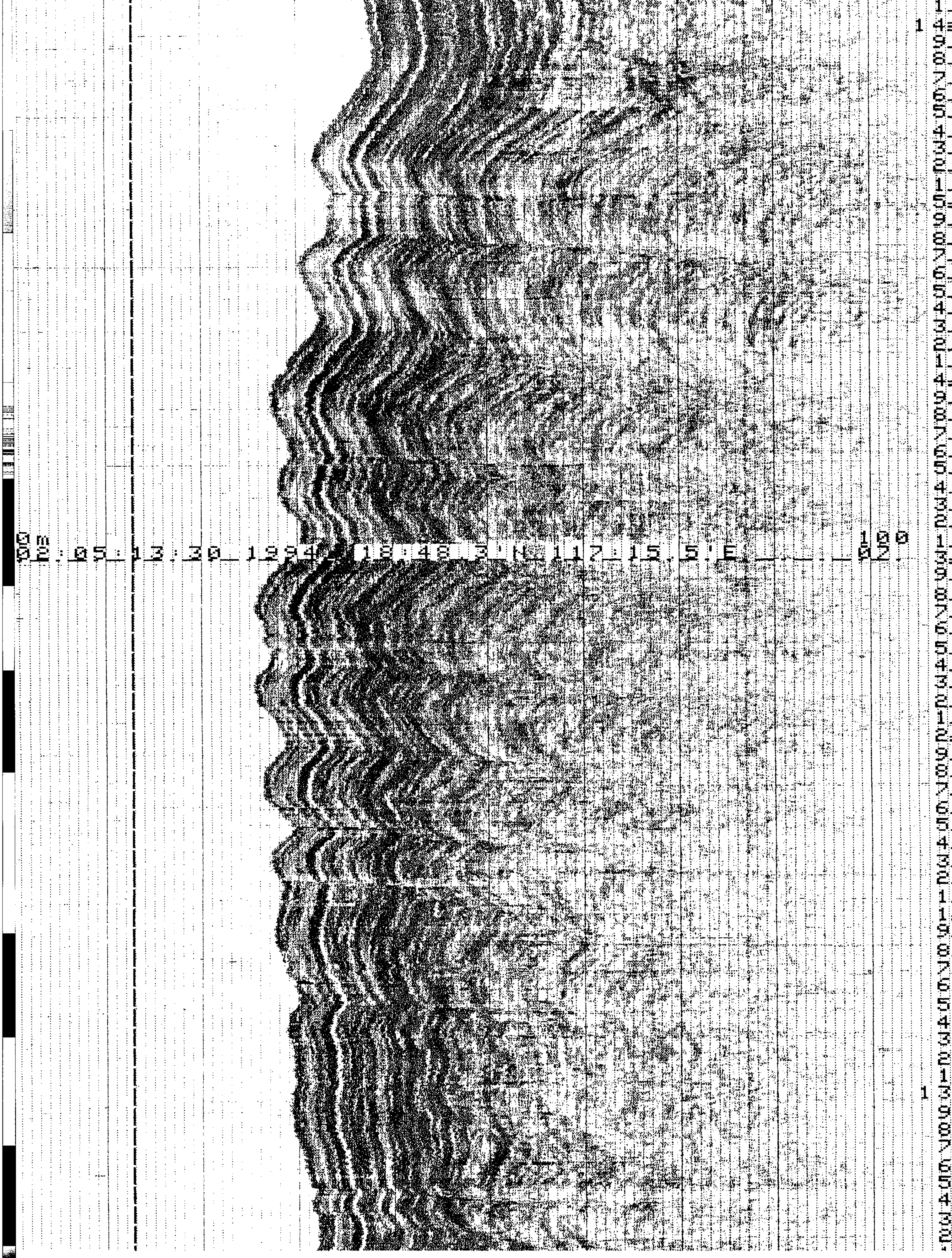

Figure 2. Migrating sediment waves near GIK station 17936

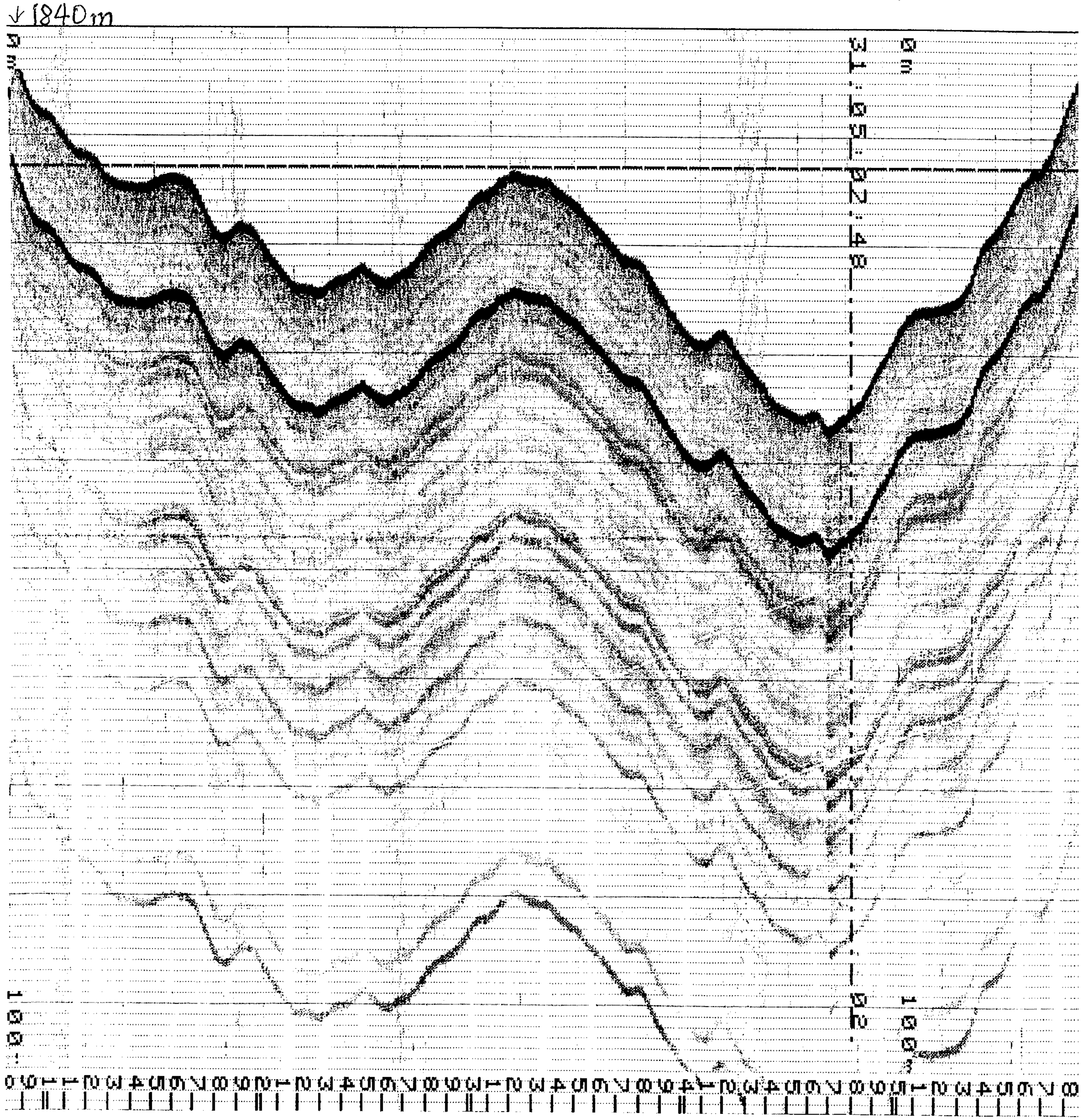

Figure 3. Sediment drape on top of the southern Dangerous Grounds carbonate platform, in front of the glacial Sunda river, near GIK stations 17961-17962.

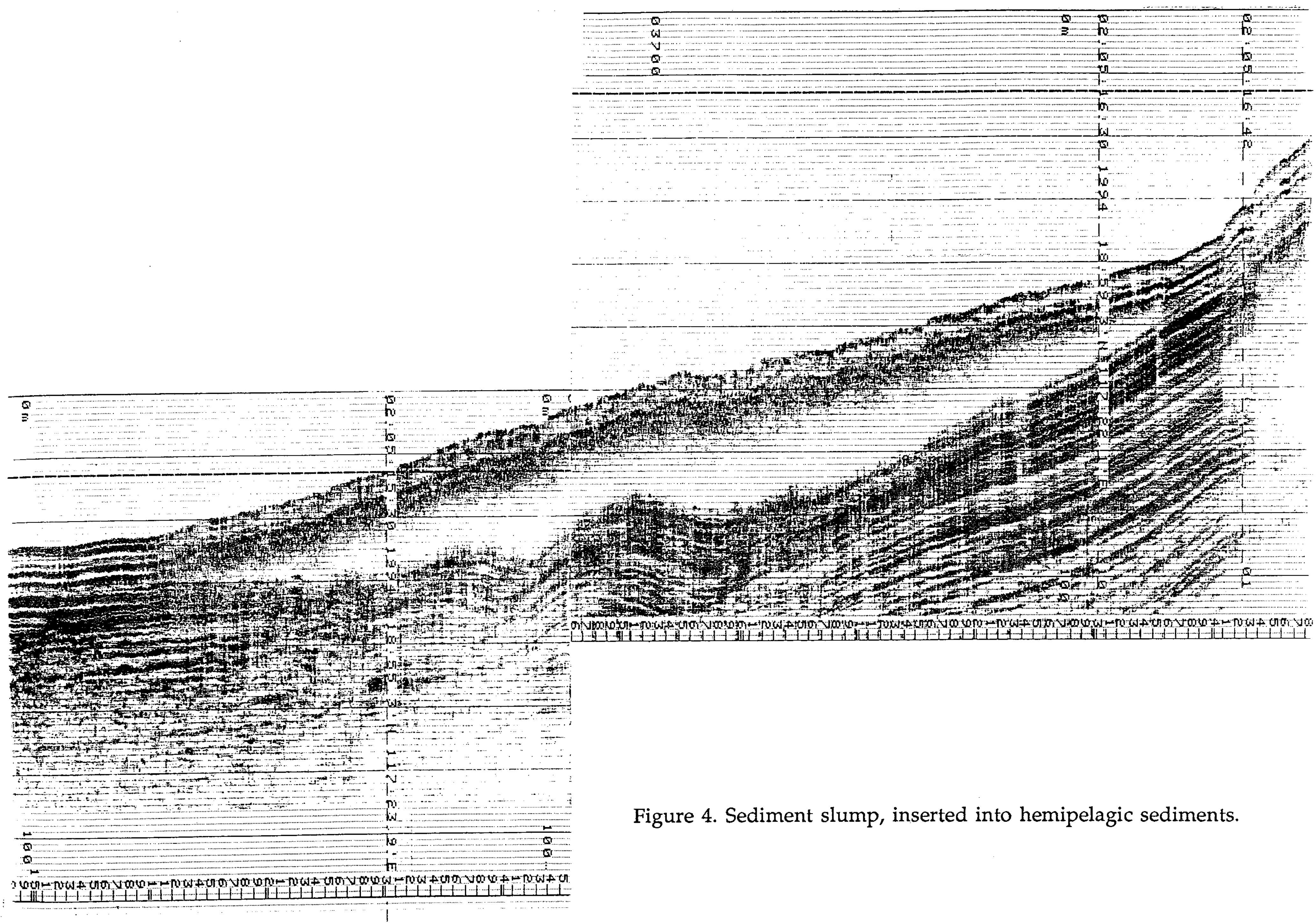

Figure 4. Sediment slump, inserted into hemipelagic sediments.

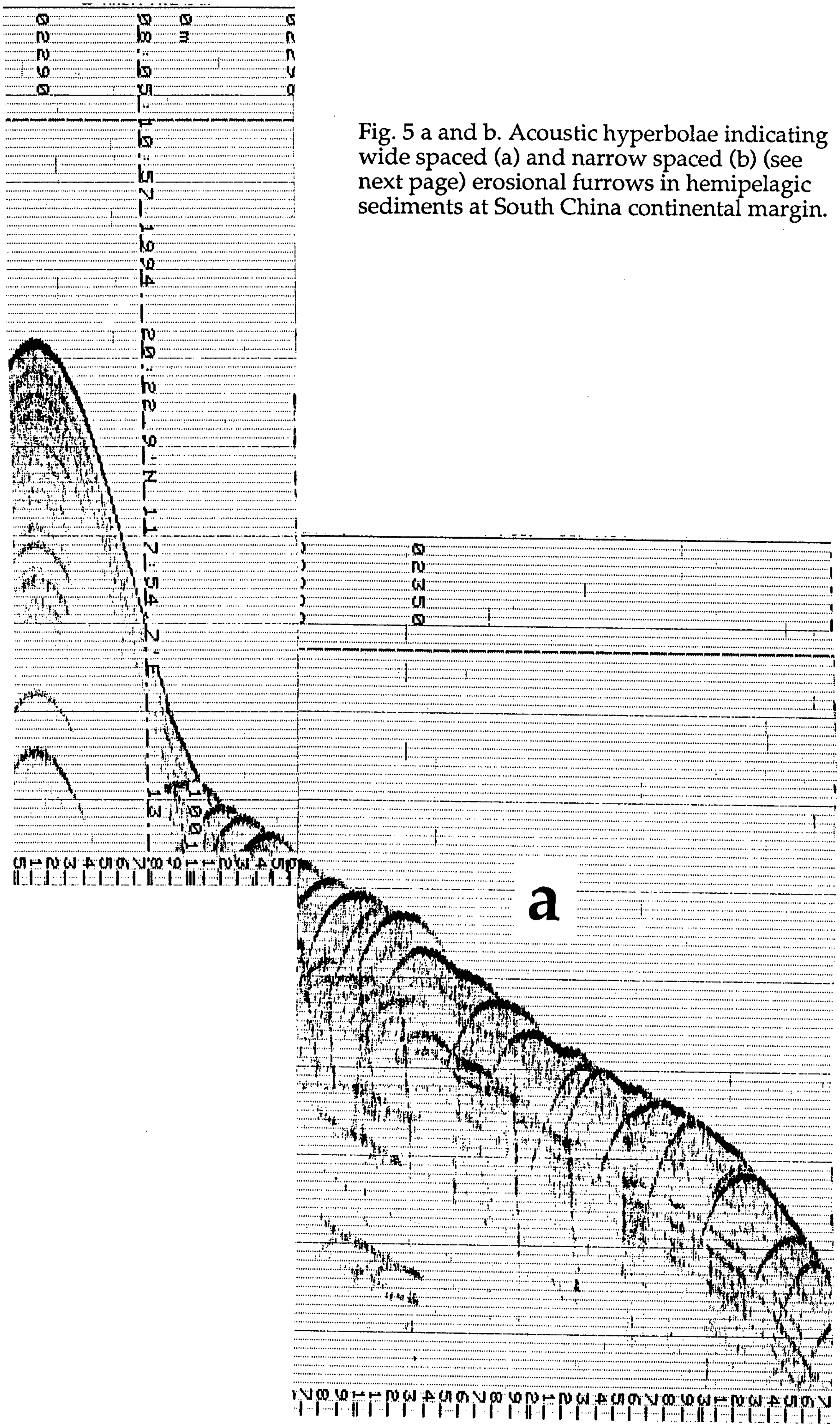

Fig. 5 a and b. Acoustic hyperbolae indicating wide spaced (a) and narrow spaced (b) (see next page) erosional furrows in hemipelagic sediments at South China continental margin.

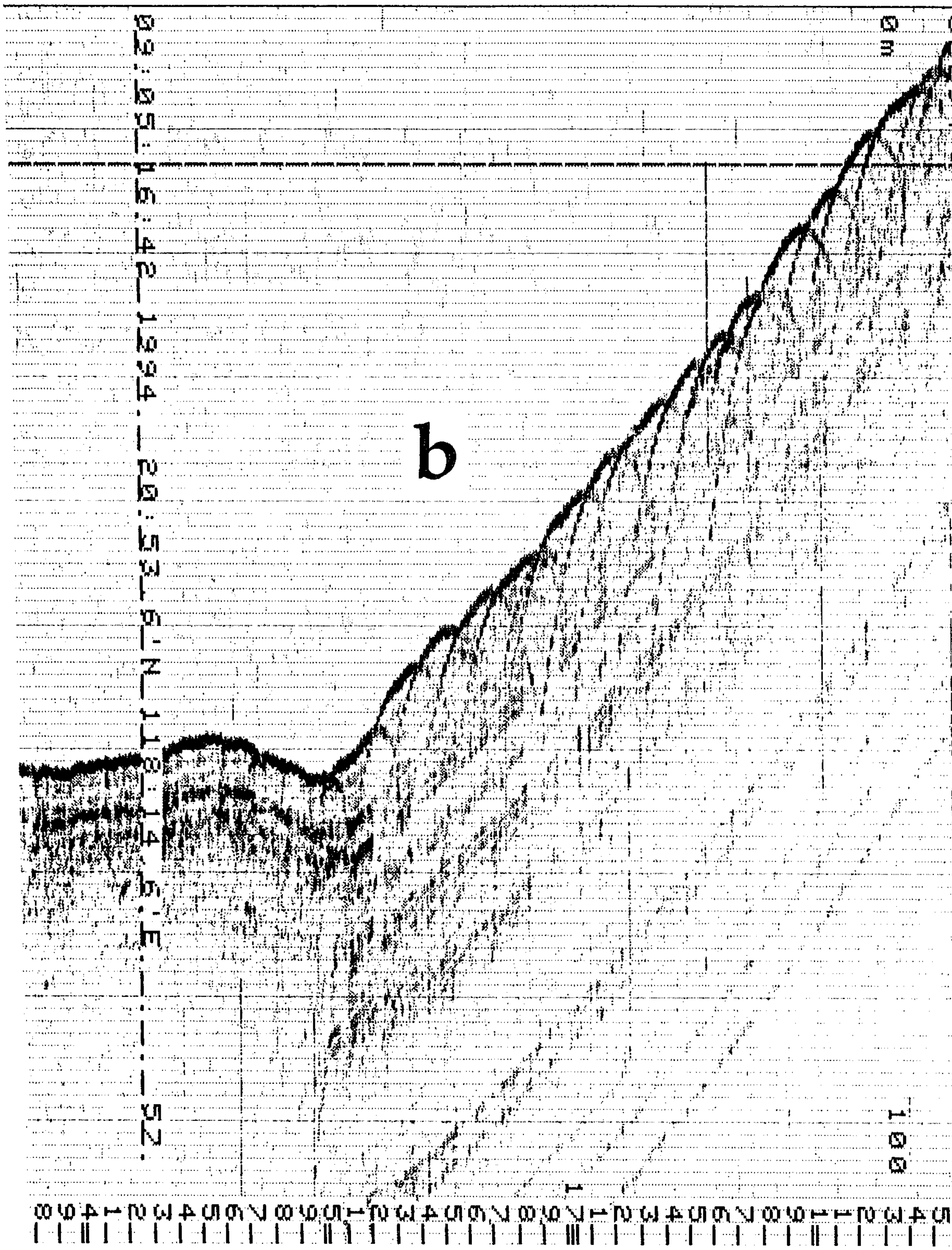

Fig. 5 (continued)

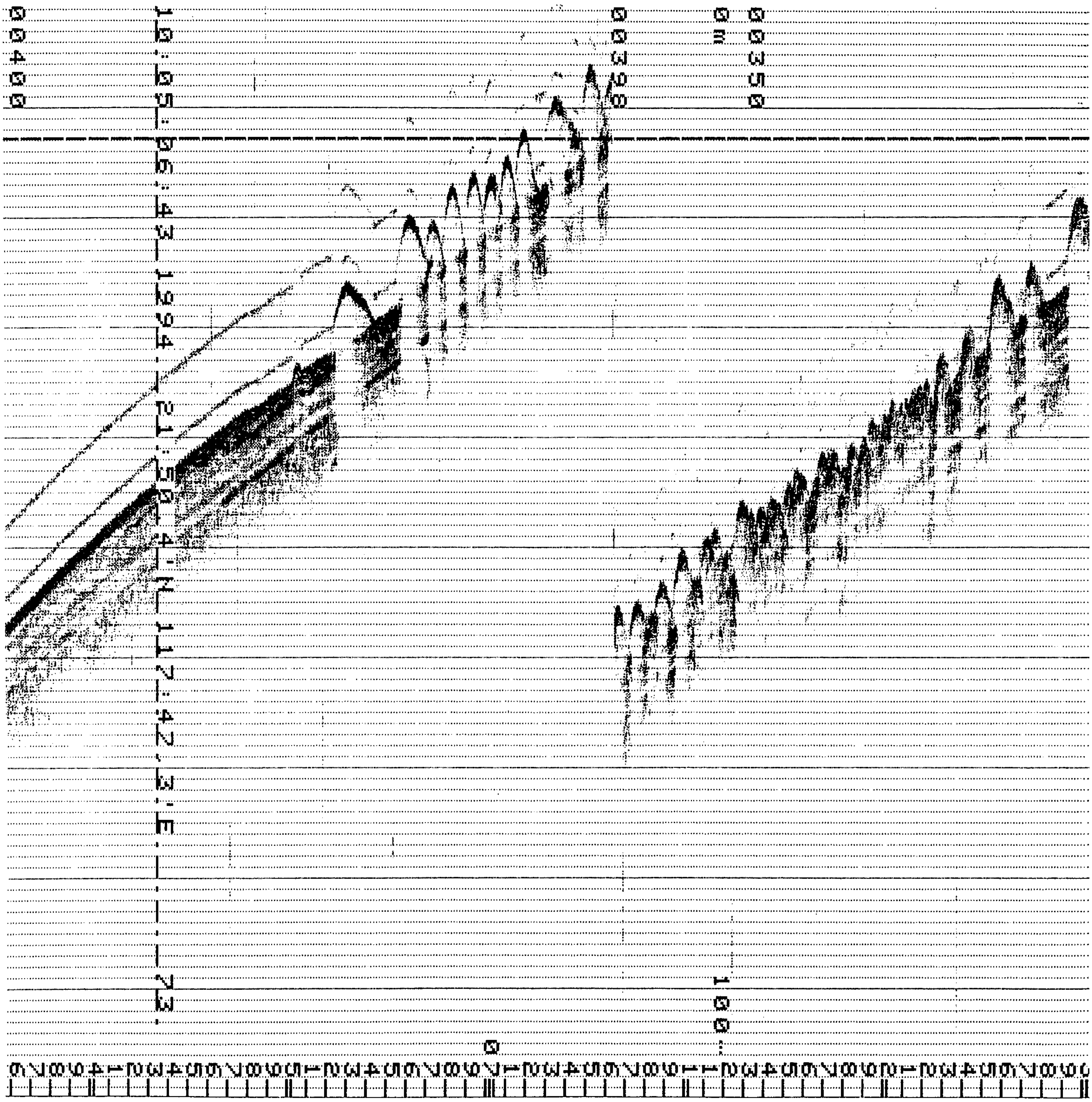

Figure 6. Erosion marks in sediments on the uppermost slope (about 350-450 m water depth), partly burried by subsequent sedimentation.

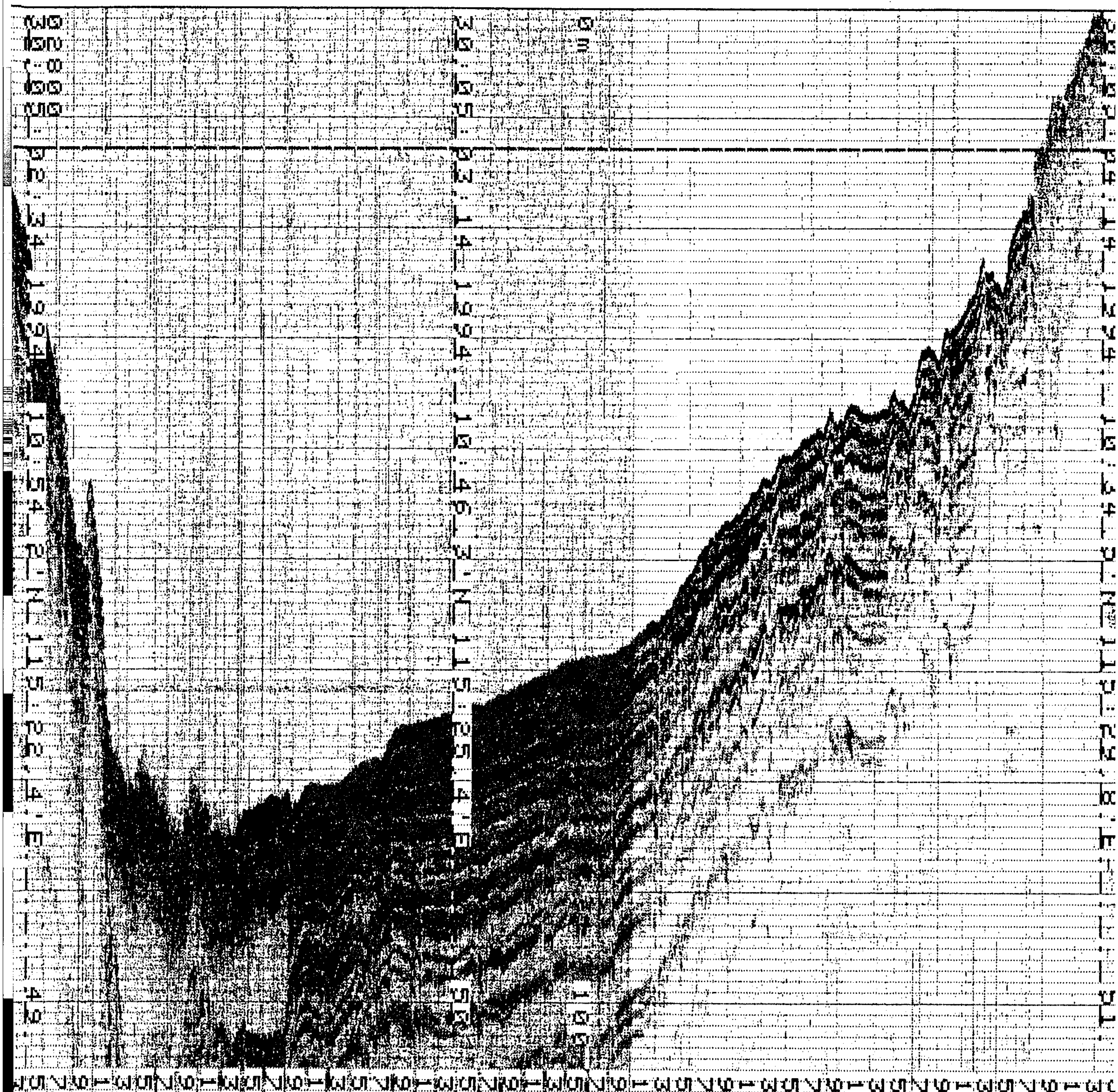

Figure 7. High-speed (12-kn) record of turbidite layers and marginal slumps in the deep-water channel cutting across the Dangerous Grounds carbonate platform similar to the 'Tongue of the Ocean' (for bathymetry see Fig. 2 in section Hydrosweep Bathymetric Records, this volume).