Attachment B

INNER-SHELF GEOLOGY OF THE CHUKCHI SEA FROM POINT LAY TO WAINWRIGHT

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INTRODUCTION

Reconnaissance surveys have been made of the part of Chukchi Sea from near Point Lay to Wainwright during two cruises of the R/V KARLUK, one in 1975 on which Barnes was chief scientist and one in 1981 on which Hunter was chief scientist (Fig. 1). The tracklines referred to in this report are numbered separately for the two cruises. The inner shelf to the south, from Point Hope to Point Lay, has not yet been studied. The area north of Wainwright has been studied by Phillips (Attachment C of this report).

POINT LAY AREA

In 1975 we ran one trackline (Line 6) off Kukpowruk Pass, near Point Lay. The line comprised a shore-normal leg out to a depth of 14 m (6.5 km offshore) and a shore-parallel leg extending northward from the seaward end of the shore-normal leg. The quality of the monographs was somewhat degraded, especially on the shore-normal leg, by the presence of a pycnocline and probable internal waves (Fig. 2a), but many features are visible on the sonograph from the shore-parallel leg. Monographs from the shore-parallel leg show sparse ice gouges of widely varying orientation. Only one gouge was deep enough (1.0 m) to be certainly identified on the fathograms (Fig. 3a). The most prominent type of feature on the monographs from the shore-parallel leg was a patchwork of light and dark areas; many of the dark areas contain symmetrical wave ripples spaced about 1.5 m apart and trending at a small angle to the shoreline (Fig. 3b). An interpretation of the dark rippled patches as relatively coarse sediment was confirmed by a sample that contained pebbles as much as 2 cm in diameter. Some of the unrippled dark patches may be outcrops of bedrock. Depth profiles across the patches show a vertical relief of as much as 1 m. Most of the patches are irregular in shape, but some have boundaries that tend to be aligned in a southwest-northeast direction, suggesting control by storm waves (Hunter and others, in press).

Uniboom seismic records from offshore parts of the Point Lay area show gently dipping reflectors that extend up to the seafloor (Fig. 4a). The sediment cover is apparently very thin, (no more than 1 or 2 m) and the gravel was probably derived largely from local bedrock. Very close to shore, the uniboom records suggest that the top of the bedrock extends subhorizontally beneath shoreface deposits, which must be of Pleistocene or Holocene age.

AREA SOUTHWEST AND WEST OF ICY CAPE PASS

We ran two tracklines (Line 7 and leg e of Line 9) west and southwest of Icy Cape Pass in 1975, reaching a water depth of 22 m at a point 14 km offshore. The seafloor in this area is relatively steep and irregular out to a depth of 13 m and is nearly flat and smooth farther seaward. Monographs from this area show sparse ice gouges, most of which trend northeast-southwest (at small angles to the shoreline) and at least one of which can be demonstrated to have formed by an ice mass moving to the northeast. None of the gouges are deep enough (0.5 m) to be certainly identified on the depth records. Apart from the few ice gouges and locally a few pockmarks (depressions a few meters wide, of unknown origin), the monographs taken from water depths of more than 14 m (4 km offshore) show a characterless seafloor. Monographs are not available from a zone ranging from 9 to 14 m in water depth. Those taken closer to shore (leg e of Line 9) show some dark patches, some of which contain symmetrical wave ripples that are spaced 1.5-2.0 m apart and that trend at small angles to shore. Depth profiles across the patches show a vertical relief of as much as 1 m.

Uniboom seismic records from the offshore part of line 7 show a subhorizontal reflector at a depth of about 7 m below the seafloor (Fig.4b). This reflector truncates gently dipping deeper reflectors and is interpreted to represent the top of Cretaceus bedrock. A break in the records makes it impossible to trace this reflector into more shallow water.

BLOSSOM SHOALS

Blossom Shoals, an area of seaward-convex arcuate ridges and troughs located northwest of Icy Cape, was traversed by four legs of one of our tracklines (Line 9) in 1975; one of those legs extended 5 km offshore. The vertical relief of these shoals is as much as 8 m. Monographs show that much of this area is covered by sand waves (Figs. 5-7), all of which have their steep sides facing to the northeast and were presumably formed by the northeastward flow of the Alaskan Coastal Water Current, perhaps aided by tidal and storm-generated currents. The sand waves are as high as 2 m in parts of the area, and these large sand waves are spaced 25-50 m apart. Sand waves do not appear as well developed on the crests of some ridges as on their flanks. The troughs between some of the ridges appear relatively dark in the monographs, especially in the troughs between individual sand waves (Fig.7). These dark areas are interpreted to be formed either by relatively coarse material or by cohesive fine-grained sediment.

Ice gouges are sparse in the Blossom Shoals area. The few ice gouges occur mostly on the ridge crests and tend to be very short. Some of the gouges “bounce” from the crest of one sand wave to the next (Fig. 6b).

Uniboom seismic records from Blossom Shoals show a subhorizontal reflector that lies at or near the level of the troughs and extends beneath the adjacent ridges (Fig. 8). This trough-level reflector is interpreted to represent the base of Holocene deposits. A deeper reflector of unknown age (perhaps the top of Cretaceus bedrock) can also be identified locally in this area.

NORTHERN KASEGALUK LAGOON

The part of Kasegaluk Lagoon east of Icy Cape was studied in 1975 (Line 10) and in 1981 (Line 3). The parts of the lagoon studied have a nearly flat, smooth, muddy bottom at a depth of 2 to 3 m. Monographs from this area show a few ice gouges (Fig. 9a), none of which have detectable vertical relief on the fathograms, from the vicinity of Akoliakatat Pass but no gouges from more enclosed parts of the lagoon. Pockmarks (depressions of unknown origin 1 to 2 m in diameter and no visible relief on the depth records) appear locally on the monographs (Fig. 9b). Parts of the monographs show features that resemble sand waves but that are not associated with any visible relief on the Fathograms (Fig. 2b); these features may represent internal waves similar to those off Point Lay (Fig.2a).

AKOLIAKATAT PASS TO PINGORAROK PASS

In 1981 we ran a single zigzag trackline (Line 2) reaching a water depth of 12 m (as far offshore as 3.5 km) along the shoreface from Akoliakatat Pass to Pingorarok Pass. Monographs from this area resemble those from the areas off Point Lay and southwest of Icy Cape. Ice gouges are sparse and oriented in various directions. None of the gouges are deep enough to be definitely identified on the depth profiles. The most common type of feature on the monographs is a patchwork of light and dark areas, Many of the dark areas contain symmetrical ripples that trend at small angles to the shoreline and are spaced 0.8-1.0 m apart. Depth profiles show that the patches are associated with a vertical relief of as much as 1 m or locally even 2 m. The dark patches are interpreted to be coarse sand or gravel, and the ripples are interpreted to be wave ripples generated by storm waves. Uniboom seismic records were not obtained on this line because of relatively high waves, but records from northeast of Pingorarok Pass, where the seafloor appears similar to this area on monographs, indicated that bedrock extends up to or very near to the seafloor.

PINGORAROK PASS TO WAINWRIGHT

The stretch of coast between Pingorarok Pass and Wainwright was traversed by two roughly shore-normal lines that extend to a water depth of 19 m, 8 km offshore (Legs b and c of Line 11 in 1975), and by roughly shore-parallel zigzag lines on the shoreface at water depths of 5-16 m (Leg a of Line 11 in 1975 and Line 1 in 1981). Ice gouges are sparse in most of this area, but a zone of dense though shallow (no more than 0.5 m) shore-parallel gouging occurs at water depths of 16 to 18 m (Fig.10). At least one gouge can be shown to have been formed by an ice mass moving to the northeast. As in the area to the southwest, the most common type of feature on the monographs is a patchwork of light and dark areas (Fig. 11). The patches range in shape from irregular to elongated at high angles to shore. Depth profiles show the patches to be associated with a vertical relief of as much as 1 m or locally even 2 m. Some of the patches contain symmetrical ripples that trend at small angles to the shoreline and are spaced 1.0-1.5 m apart. As in the area to the southwest, the dark rippled patches are interpreted to be coarse sand or gravel, and the ripples in these coarse sediments are interpreted to have been generated by storm waves. Some of the dark patches without wave ripples may be outcrops of bedrock.

Uniboom seismic records from most of this area show gently dipping reflectors that extend up to very near the seafloor (Fig. 12). These reflectors are interpreted to be beds of Cretaceus age, and the sediment cover is apparently very thin, no thicker than 1 or 2 m. Off Wainwright, however, a channel was cut about 17 m into the bedrock and filled with sediment of pressumed Quaternary age (Fig. 13).

CONCLUSIONS

(1) Ice gouging was found to be dense only locally in the area surveyed, and no gouges deeper than 1 m were found. However, the intense current activity on Blossom Shoals would probable erase ice gouges quickly, even if gouging was intense there.

(2) Sand waves as much as 2 m high are abundant on Blossom Shoals, off Icy Cape. All of the sand waves have steep sides facing northeastward and were evidently formed by the Alaska Coastal Water Current. The rates of migration of the sand waves have not been measured, but it may be possible to measure the rates in the future or to estimate the rates from current measurements.

(3) Patches of material that appears dark on monographs and is commonly ripple-marked are common. The ripple-marked patches must be coarse sand or gravel. Patches that are not ripple-marked may be gravel that is too coarse or too poorly sorted to be ripple-marked, coarse sand or gravel in which ripple marks have been destroyed by the activity of animals or by ice action, fine-grained cohesive sediment, or bedrock outcrops. The ripples in the coarse sediment patches are of symmetrical, wave-generated type and are spaced about a meter apart. Their size and occurrence only in coarse material indicate that they were generated by storm waves. When the sediment grain size is known, it will be possible to estimate the sizes of the waves that produced the ripples.

(4) Pockmarks (relatively small depressions) of unknown origin occur locally. Some pockmarks in other areas have been attributed to the escape of gas from the sediment, but origins by current scour, ice action, or the activity of animals are also possible.

(5) High-resolution seismic data suggest that the thickness of unconsolidated sediment of Holocene and/or Pleistocene age is thin (less than 10 m) on much of the inner shelf. Blossom Shoals, however, is a major depositional area offshore from Icy Cape.

(6) These reconnaissance surveys indicate that the nearshore conditions of the Chukchi Sea are different that those observed in the Beaufort Sea. As in the nearshore Beaufort Sea, the covering of Holocene sediments in the Chukchi Sea inner shelf is apparently very thin or lacking. Ice is an important geologic agent affecting the seafloor along the Chukchi coast, but hydraulic processes are clearly dominant. In the Beaufort Sea, in contrast, ice-related processes are dominant in most nearshore areas. This suggest that hydraulic processes may become the determining design criterion for nearshore bottom-founded structures, although ice processes will have to be considered as well.

(7) All of the above conclusions are based only on reconnaissance surveys and need to be tested by additional data.

REFERENCES

Hunter, R. E., Thor, D. R., and Swisher, M. L., in press, Depositional and erosional features of the inner shelf, northeastern Bering Sea: Geologie en Mijnbouw, v. 61.

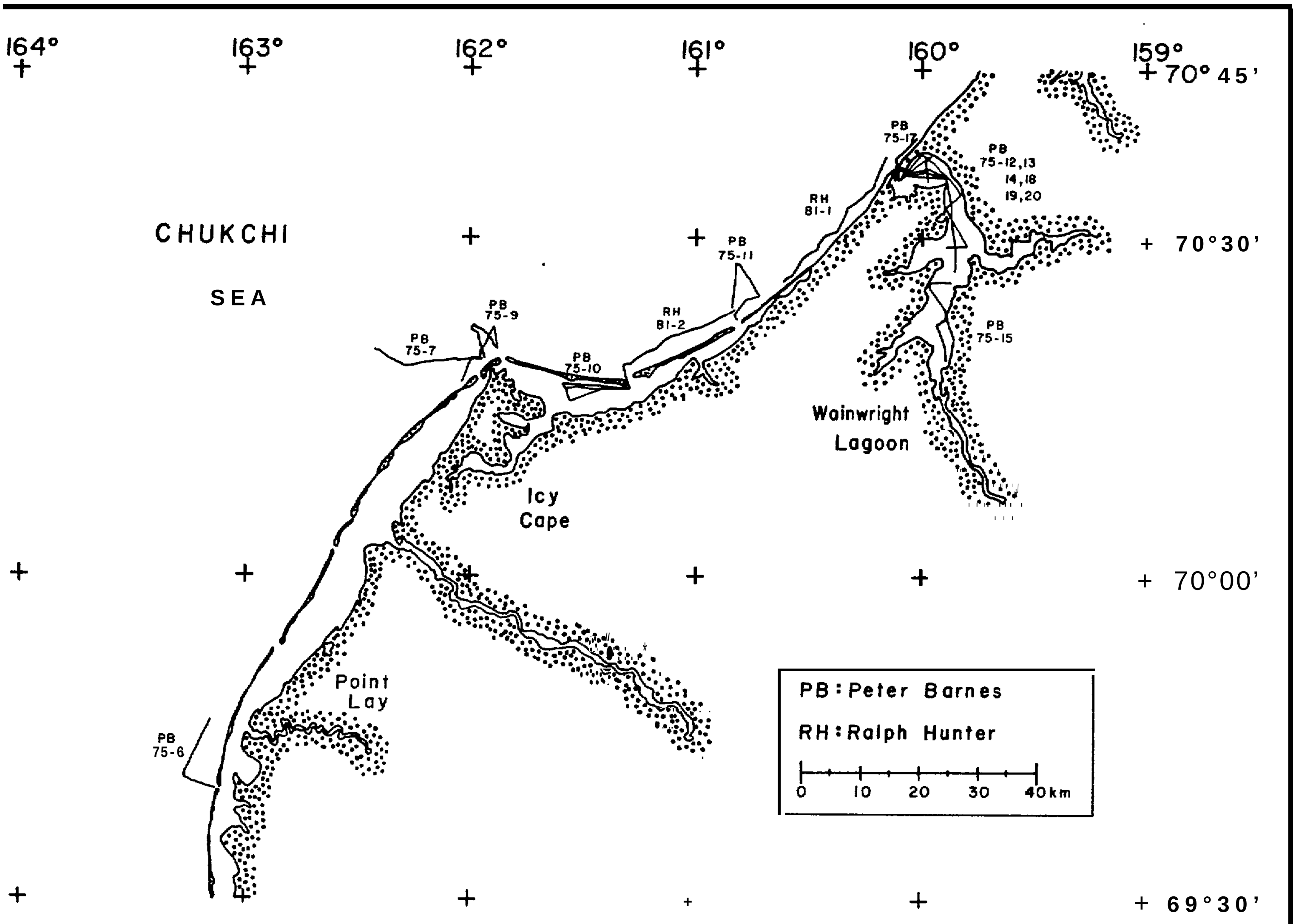


Fig. 1 Index map showing **tracklines** in the inner shelf of the **Chukchi** Sea between Point Lay and **Wainwright.**

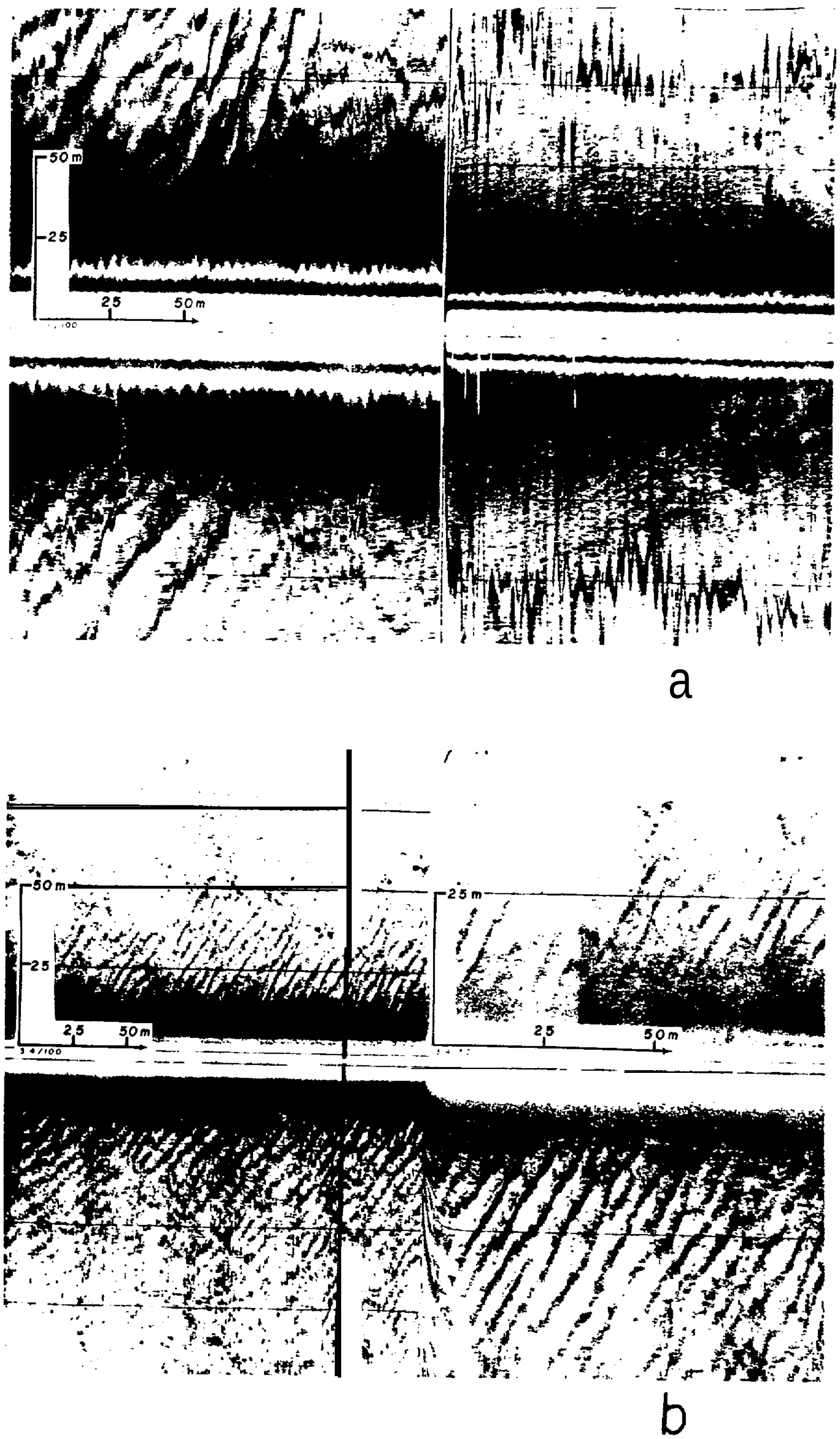


Fig. 2 Monographs showing features interpreted to orginate within the water column rather than on the seafloor. a. Probable pycnocline and internal waves; Note that seafloor features became visible when side-scan fish was lowered (right side of monograph). Off Point Lay (1975, line 6a, 1150-1153 hrs, water depth 13 m). b. Probable internal waves at two different side-range scales in Kasegaluk Lagoon (1975, line 10, 1358-1402 hrs, water depth 2.4 m).

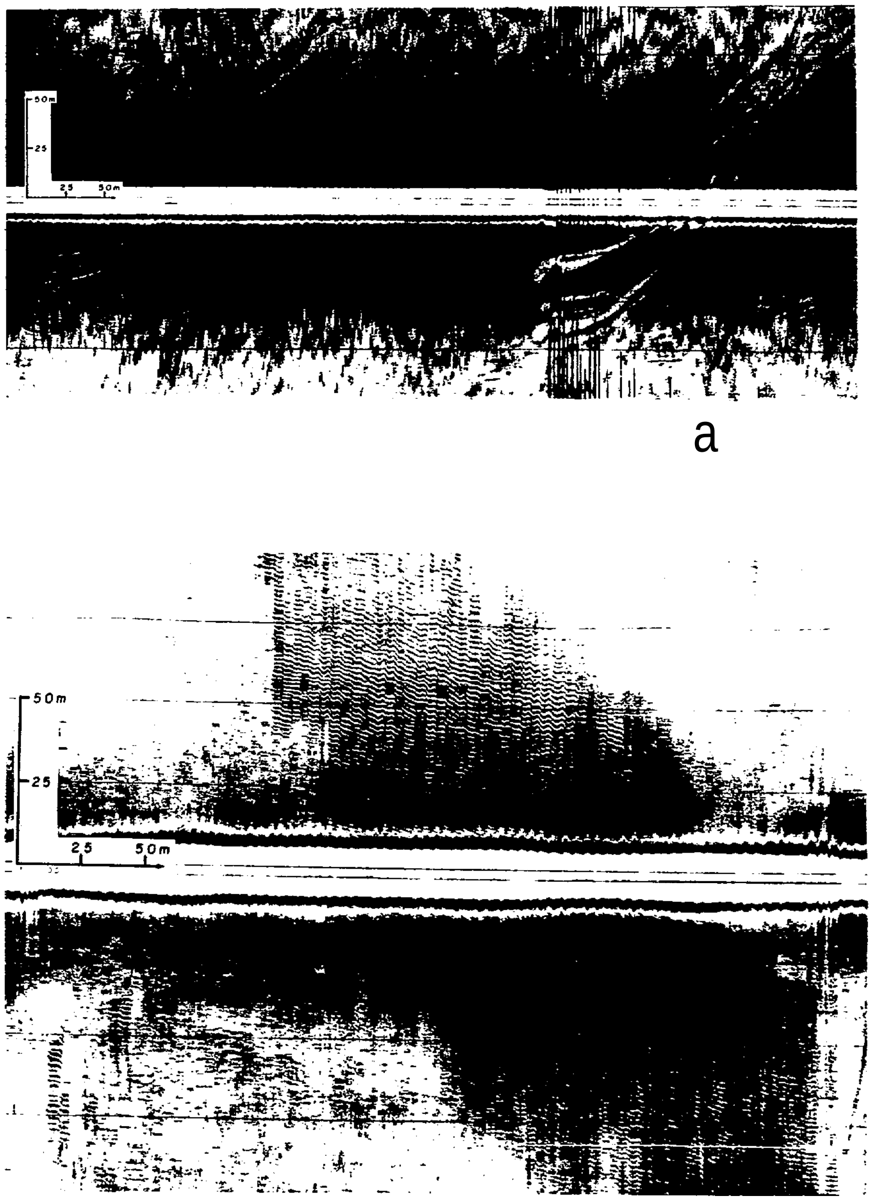


Fig. 3. Monographs showing seafloor features off Point Lay. a. Two ice gouges whose similar trends and terminations suggest that they were formed by **two** gouging tools of a single rigid mass of ice. The gouge on the right is 1 m deep (1975, line 6a, 1200-1207 hrs, water depth 14 m). b. Dark- and light-toned patches; the dark patches consist of coarse sand or gravel with ripples spaced about 1.5 m apart (1975, line 6b, 1338-1341 hrs, water depth 15 m).

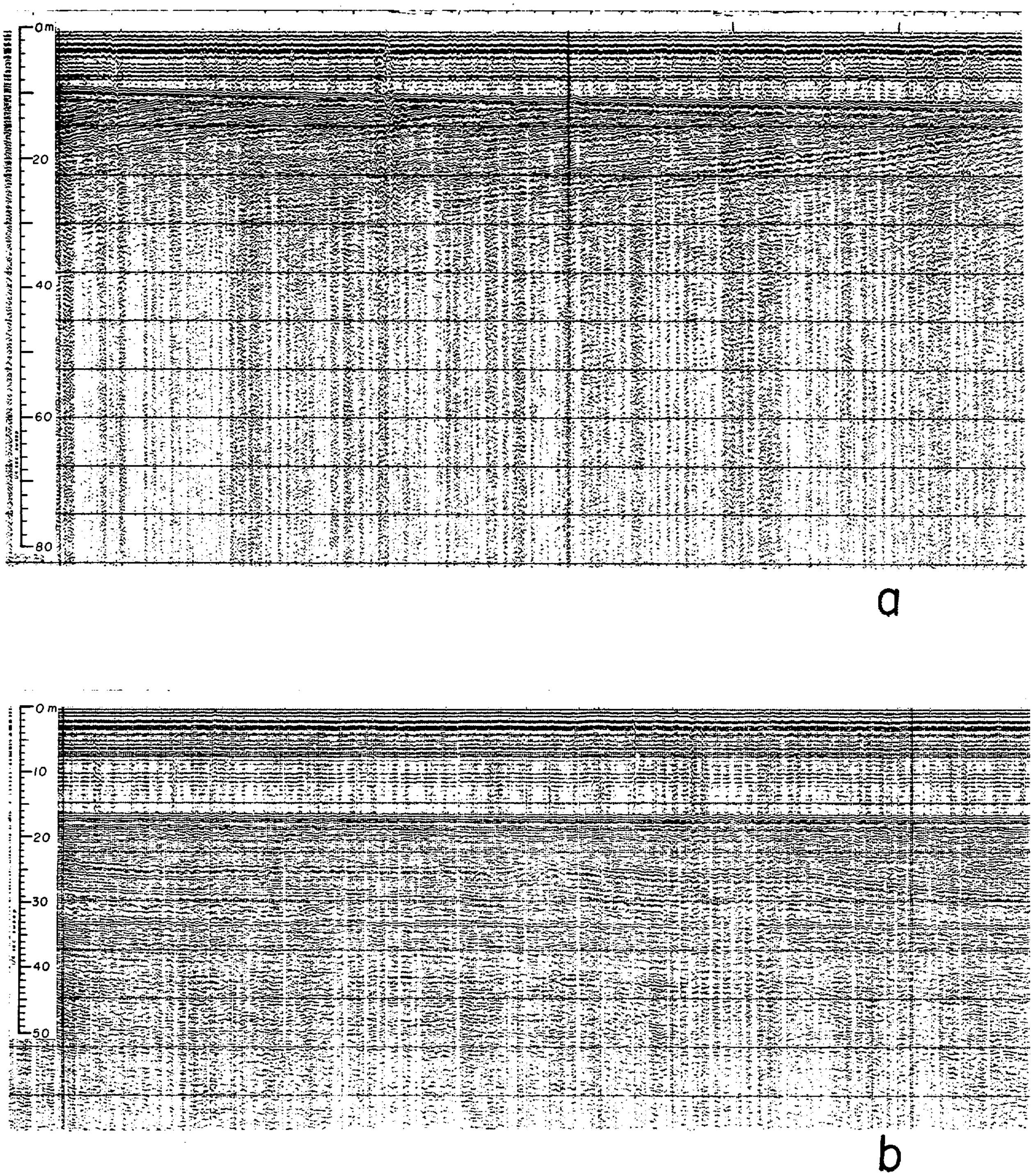
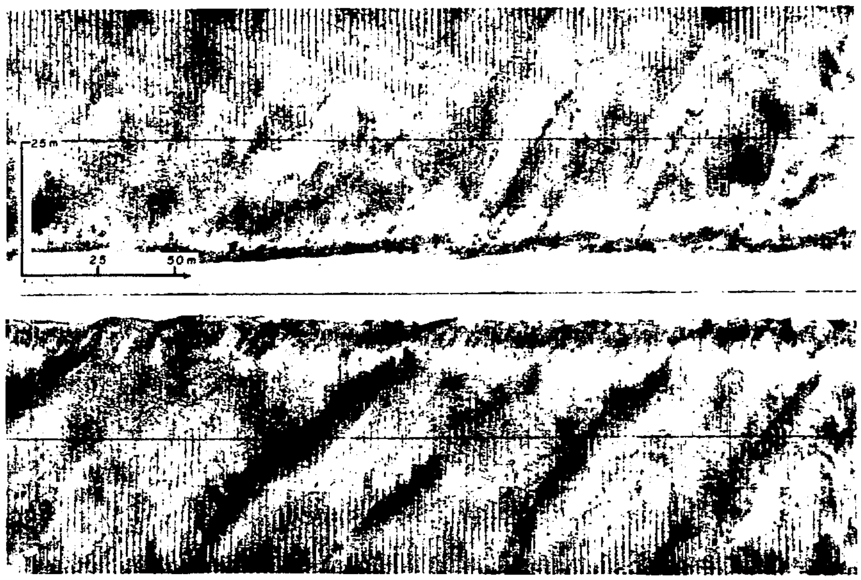


Fig. 4. **Uniboom** seismic profiles showing gently dipping stratified bedrock of presumed Cretaceus age. a. Bedrock with no detectable sediment **cover,** off Point Lay (1975, line 6a, 1122-1130 **hrs).** b. Bedrock overlain by about 7 m of sediment of presumed Quaternary age (1975, line 7, 1425-1430 hrs).



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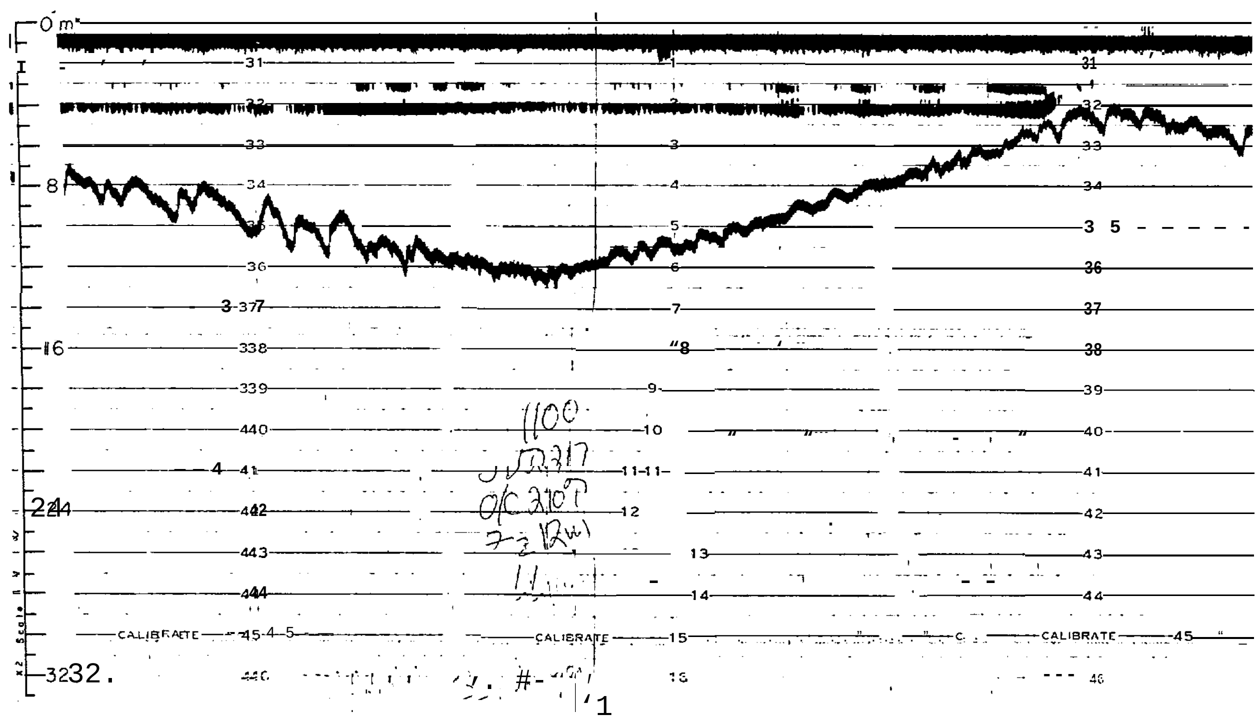


b

Fig. 5. Sandwaves on Blossom Shoals. These 2-m-high sand waves are the largest found in the area. a. **Sonograph** (1975, line 9d, 1055-1105 hrs, water depth 8-11 m). b. Fathogram of same sandwaves.

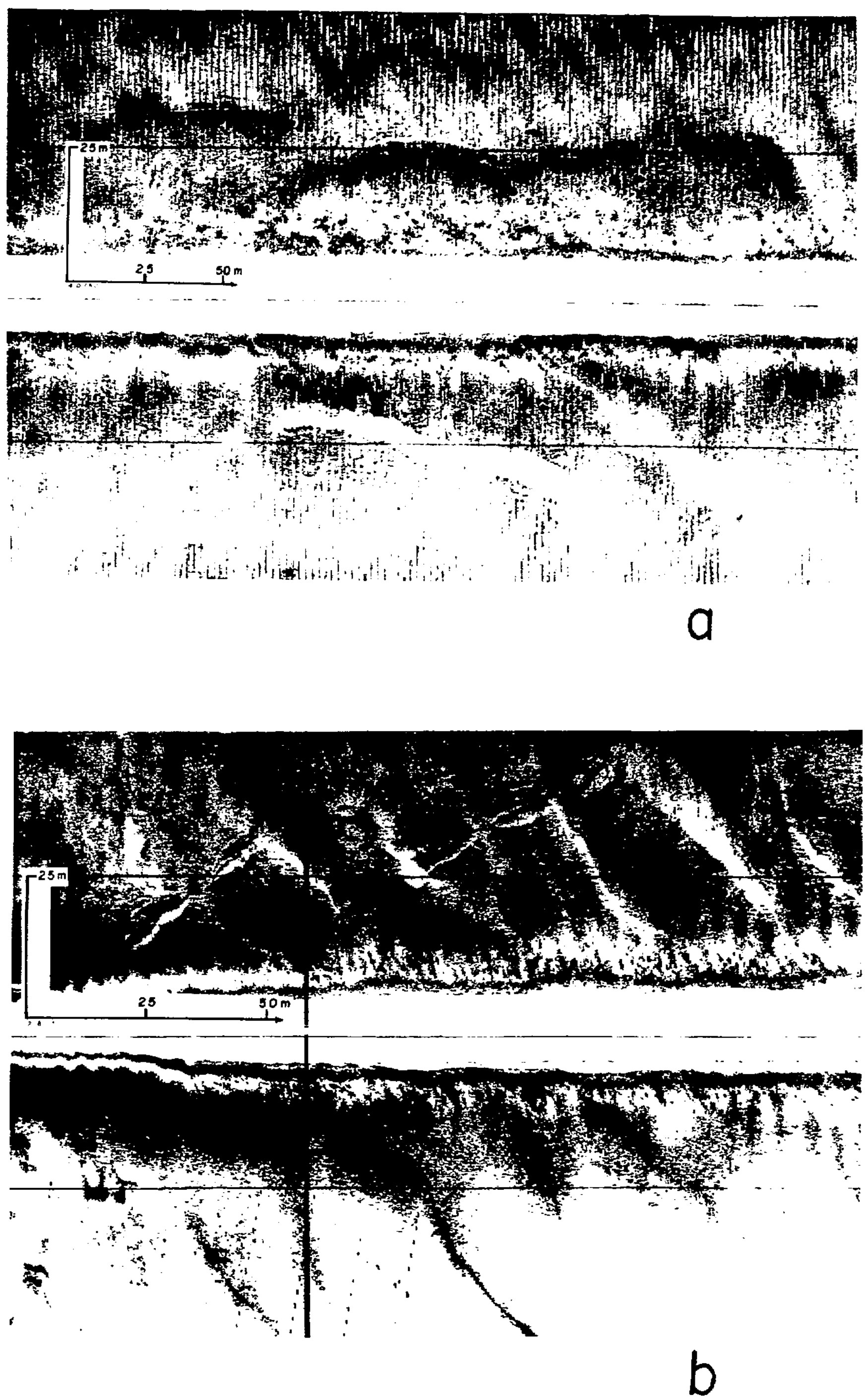


Fig. 6. Monographs showing sandwaves on Blossom Shoals. a. Sa ndwaves 1 m high (1975, line 9 a, 0900.5-0902.5 hrs, water depth 11 m). b. Sandwaves with ice gouges "bouncing from crest to crest (1975, line 9, 0910.5-0912.5 hrs, water depth 10-11 m).

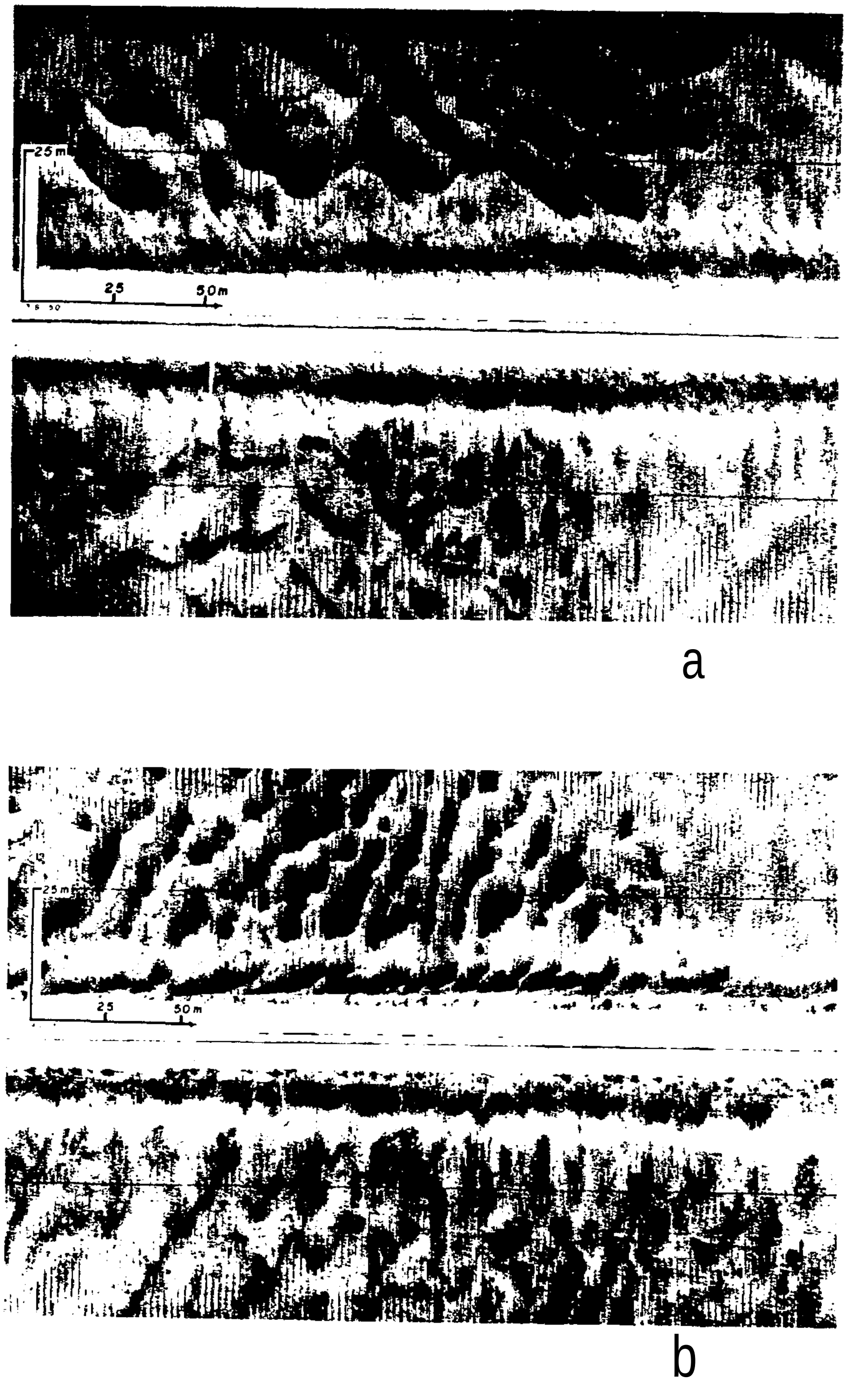
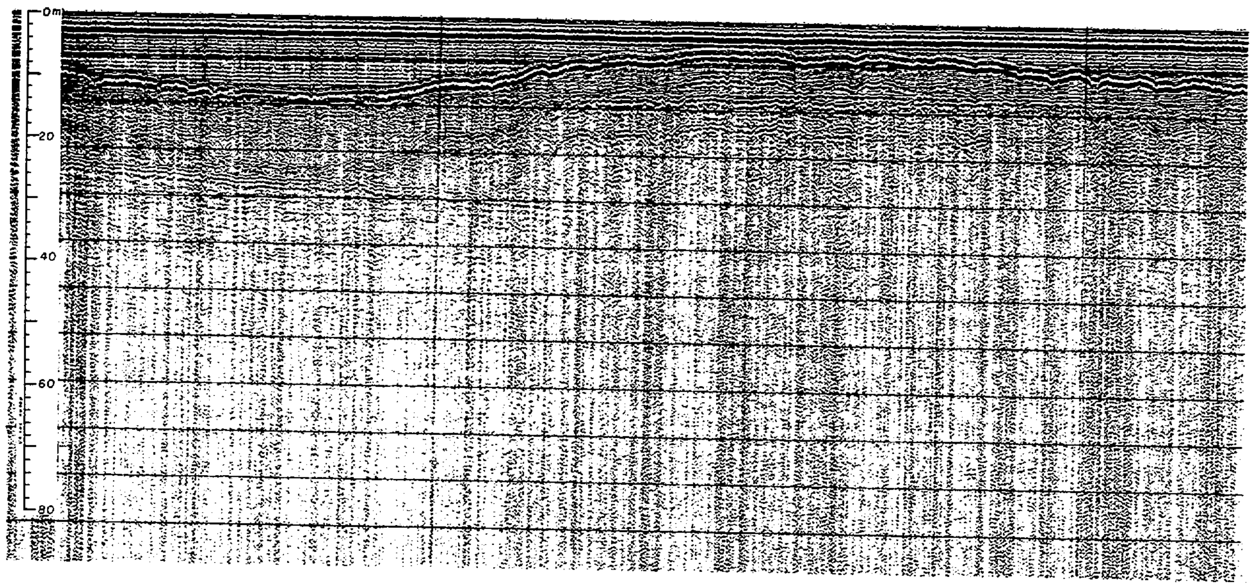


Fig. 7. Monographs showing sandwaves in troughs between sand ridges, Blossom Shoals. Note dark patches in troughs between individual sandwaves. a. Sandwaves less than 0.5 m high (1975, line 9b, 0939.5-0941 hrs, water depth 12 m). b. Sandwaves 0.5-1 m high (1975, line 9d, 1058-1100 hrs, water depth 12 m).



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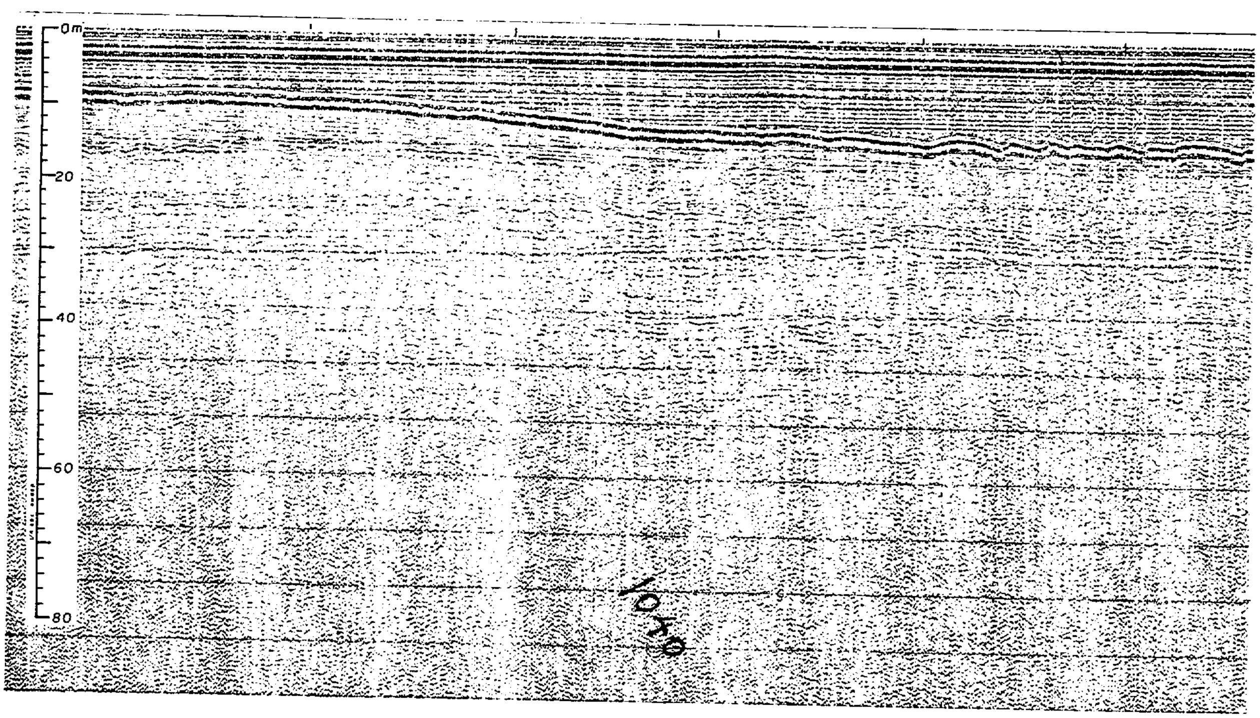
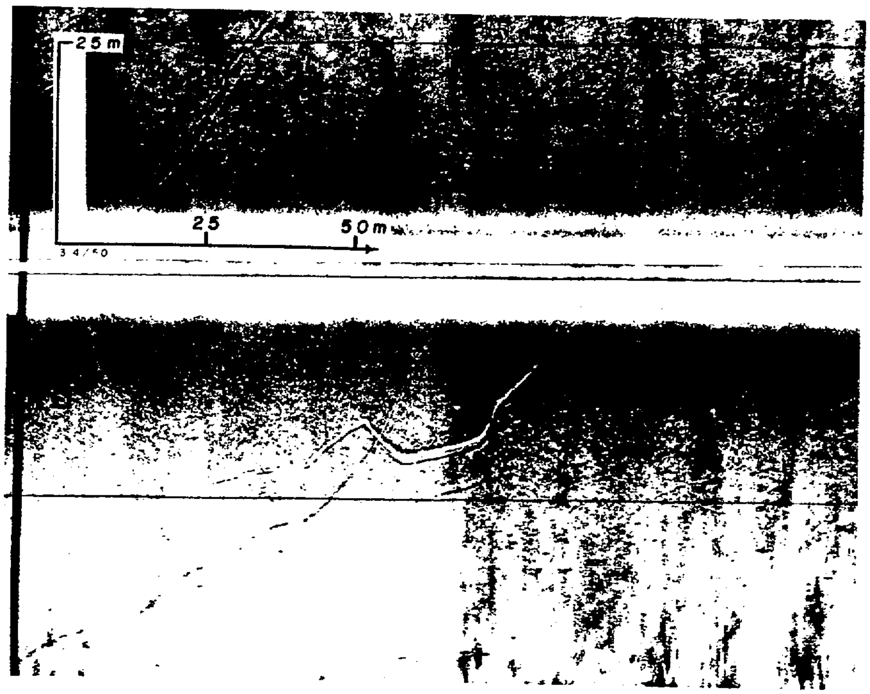


b

Fig. 8. **Uniboom** seismic profiles showing subhorizontal reflector at level of troughs between sand ridges, Blossom Shoals. a. 1975, line 9b, 0937-0943 hrs. b. **1975,** line 9c, 1037-1042 hrs.



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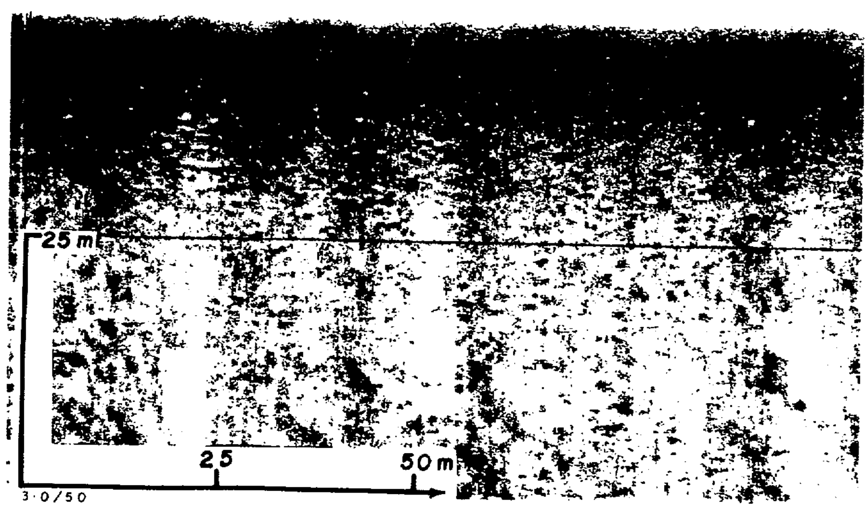
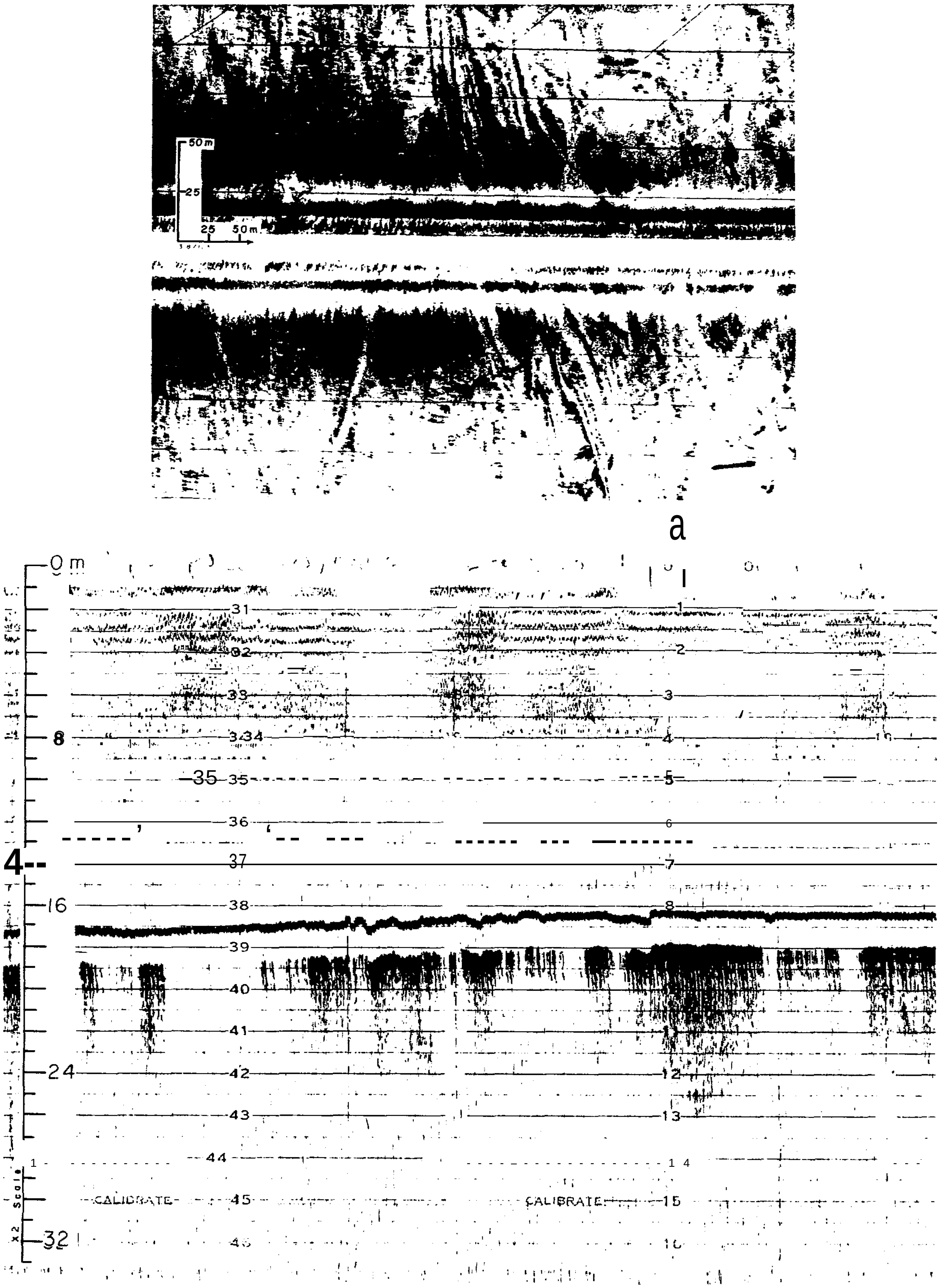


b

Fig. 9. Monographs showing features in Kasegaluk Lagoon. a. Ice gouges near Akoliakatat Pass (1975, line 10, 1345-1346.5 hrs, water depth 2.8 m). b. Pockmarks (small depressions) of unknown origin (1975, line 10, 1413.5-1415 hrs, water depth 2.4 m).



b

Fig. 10. Intense ice gouging between Pingorarok Pass and **Wainwright.**
a. **Sonograph (1975,** line he, 1420-1424 **hrs,** water depth 16-17 m) .
b. **Fathogram** from same area as sonograph.

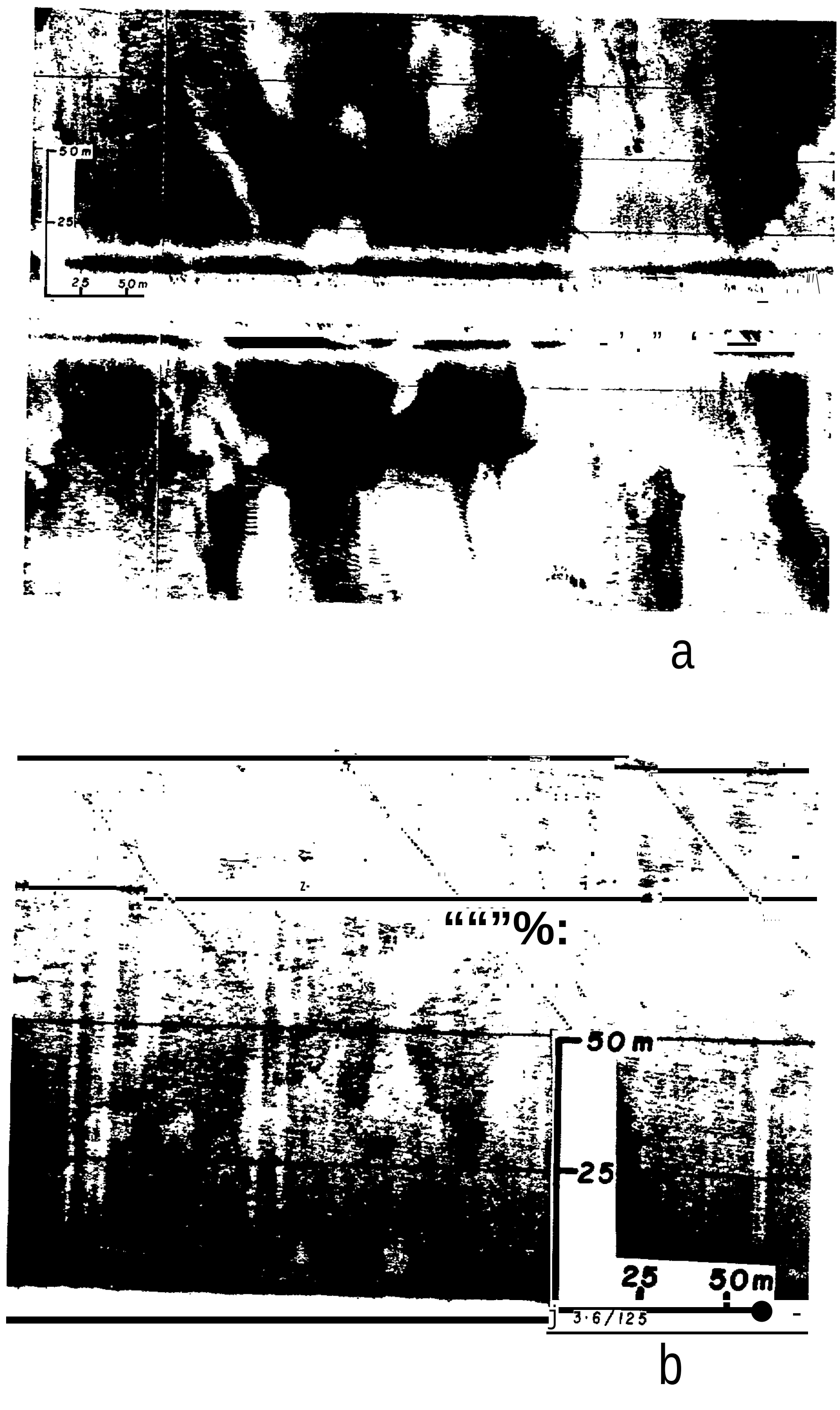
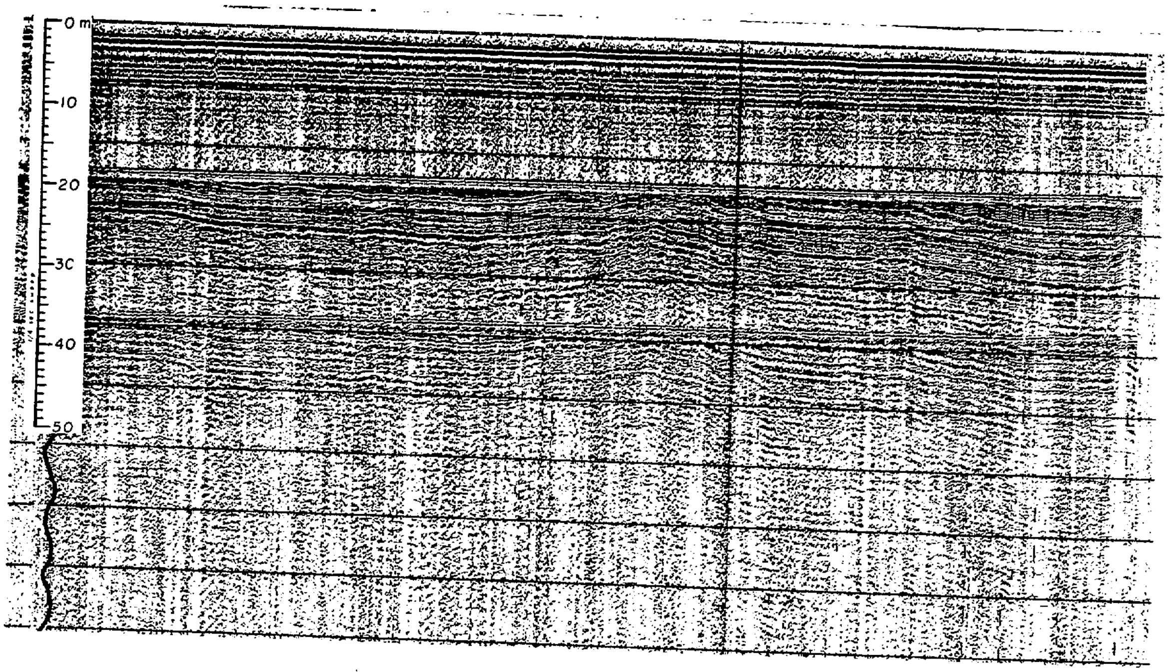


Fig. 11. Monographs showing patterns of light and dark patches between Pingorarok Pass and Wainwright. a. Dark patches with wave ripples (1975, line 11 a, 1207-1211 hrs, water depth 11-12 m). b. Dark patches without visible wave ripples (1981, line 1, 1602.5-1604.5 hrs, water depth of 6 m).



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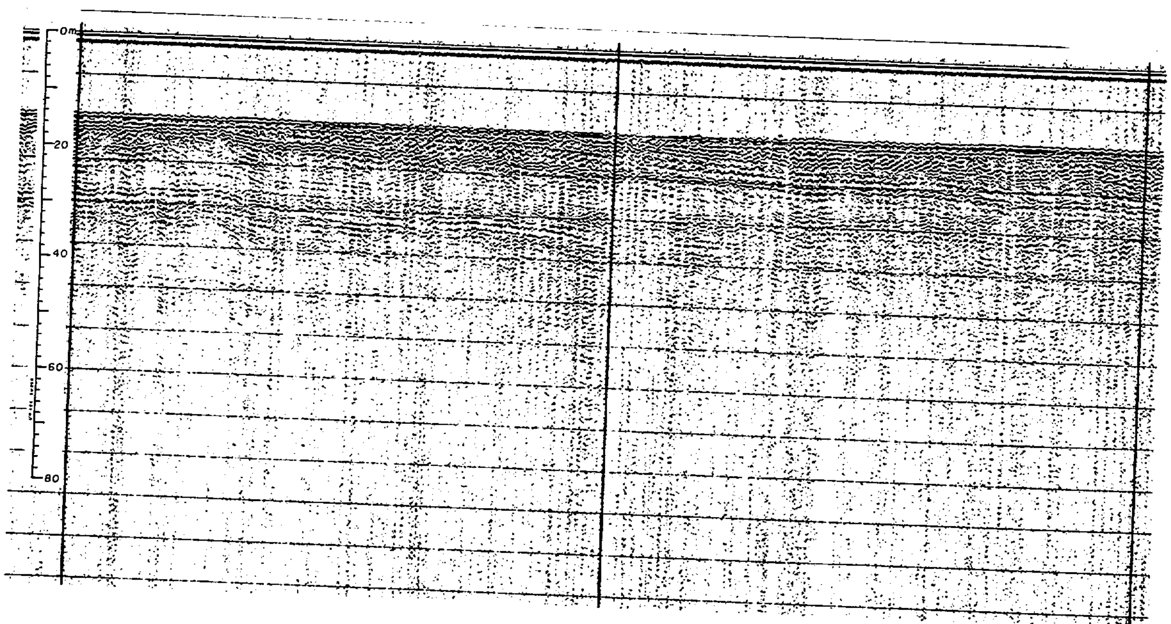

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Fig. 12. **Uniboom** seismic profiles showing gently dipping bedrock of presumed Cretaceus age with very little **if** any sediment cover, from area **between Pingorarok** Pass and **Wainwright.** a. Bedrock **gently** and **irregularly** folded (1975, line he, 1402-1407 **hrs).** b. Bedrock dipping uniformly (1981, line 1, 1740-1750 **hrs).**

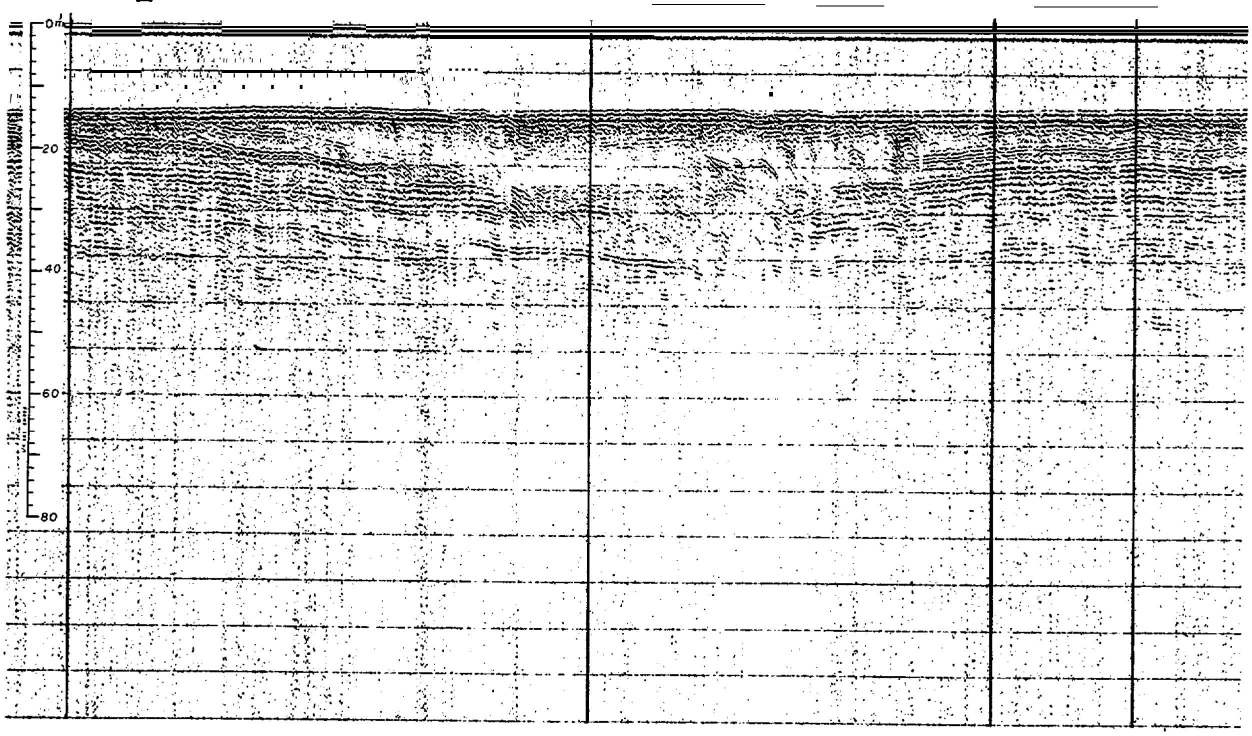

Fig. 13. **Uniboom** seismic profile directly off **Wainwright,** showing channel cut into Cretaceus bedrock and filed by sediment of presumed Quaternary age (1981, line 1, 1540-1550 **hrs).**