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GEOLOGICAL SURVEY

MORPHOLOGIC SETTING FOR CORE SITES ON THE SLOPE IN THE BALTIMORE CANYON TROUGH

by

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INTRODUCTION

Twenty shallow-penetration 3.5-kHz profiles 2 to 4 km in length were collected over 36 core sites (34 piston cores and 2 gravity cores) (fig. 1). The seismic-reflection data were collected in order to characterize the morphology of each core site and to show the general stratification and possible reflectors that might be expected within the cored interval. Because the objective of the sampling program was to evaluate the sea-floor stability in the Baltimore Canyon trough area, establishing the morphological setting and internal stratification was considered important. Initially the core sites were selected by the USGS (U.S. Geological Survey) on the basis of geophysical data collected in preparation for Lease Sale 49 and believed to represent slumps, slides, scarps, and undisturbed sediment. On the basis of seismic-reflection profiles and general bathymetry for the area of Lease Sale 49, 3.5-kHz profiles shown here, and published bathymetric data from detailed surveys, the morphologic setting of each of the core sites was interpreted. The purpose for establishing the morphologic setting was to aid in the analysis of the geotechnical data. In a detailed study of the slope south of Baltimore Canyon, McGregor and others (1979) found a correlation between morphology of the core site and the geotechnical and physical properties of the cores.

The physiographic province of the Continental Slope in this area is topographically extremely complex and requires detailed bathymetric data, especially along strike lines, to define it adequately. The slope is highly dissected by downslope-trending canyons and valleys. The available data were integrated to determine the morphologic setting of each site as to whether located on a valley wall, valley axis, or ridge separating the valleys (table 1). Discussion of subbottom horizons is limited to those seen on the 3.5-kHz profiles over the core sites, since the resolution is sufficient to allow correlation between the uppermost horizons and the cored interval.

The geotechnical properties of this suite of 10 m cores as well as an evaluation of sea-floor stability are discussed by Keer and Cardinell (1981), Olsen and others (1981), and Olsen and Rice (1982).

METHODS

A 3.5-kHz system with a hull-mounted transducer and a signal correlator was used on R/V ENDEAVOR on cruise 42, August 29-September 23, 1979 to survey each of the core sites. Core site locations are listed in table 2. A trackline passing through and extending approximately 1.5 km on either side of the core site was oriented generally in a dip direction, perpendicular to the trend of the Continental Slope. Profiles were collected in water depths ranging from 250 to 1,400 m over core sites ranging from 320 m to 1,324 m (corrected for sound velocity with Matthews Tables, 1939). Navigation was based on Loran-C.

Photographs of the original 3.5-kHz profiler records show the intended target of each coring operation. The designation CD refers to the station number and PC refers to the sample number. Throughout this text the PC or core number is used to identify the sites. Sea-floor gradient for each core site (table 1) was determined from each profile by measuring the elevation change for the horizontal distance and using the tangent function, except for

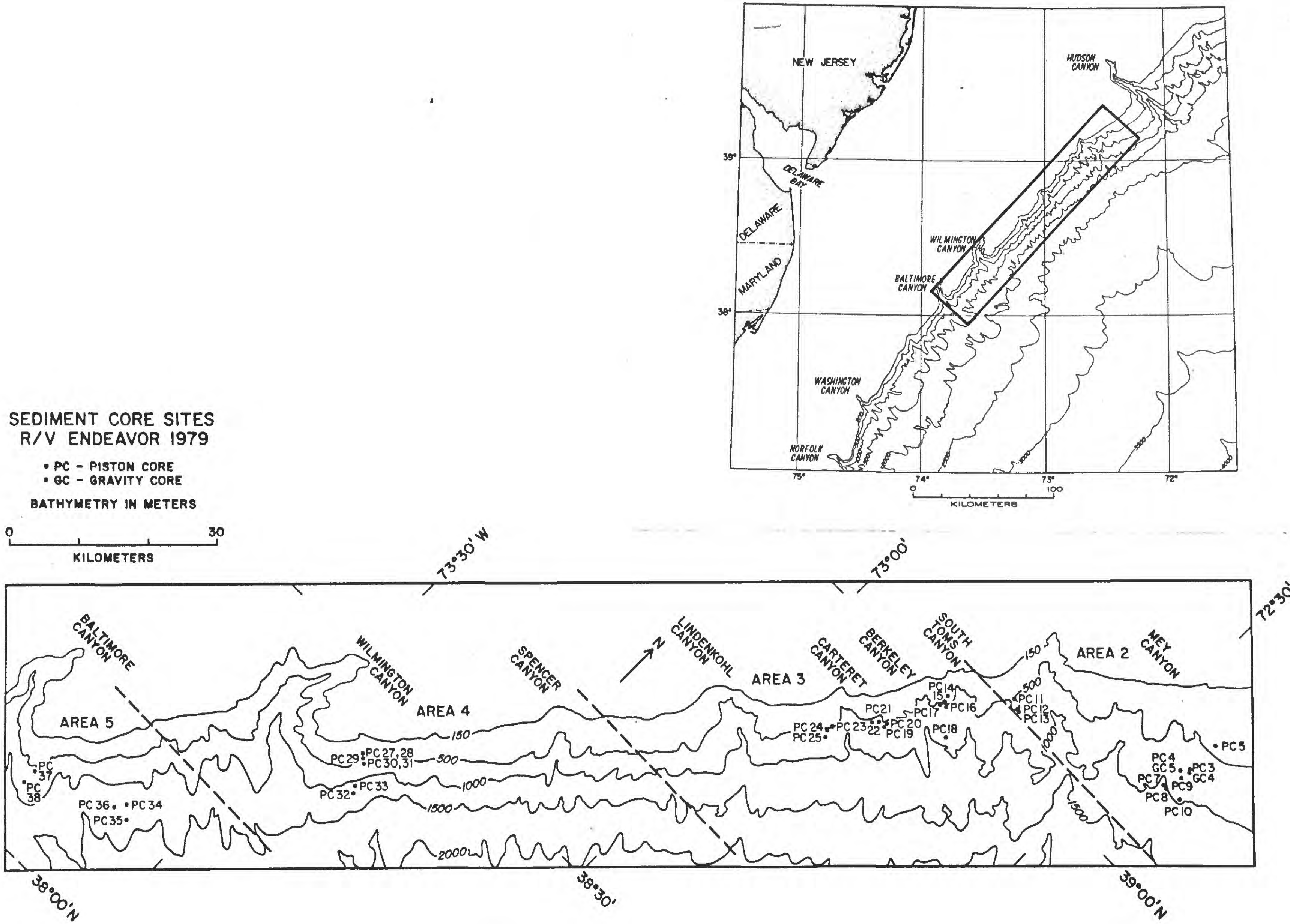

Figure 1. Index map showing location of study area and stations where cores were taken. Position of each station and cores is listed in table 2.

Table 1. Compilation of morphologic setting of core sites

Core no.[1]	C.D. stat. no.	Lease block no.	Valley headwall or axis	Valley wall	Inter-valley ridge	Possible slump material	Possible slump scar	U=Upper M=Middle Slope	Water depth (m)	Sea-floor gradient (°)	Subbottom reflectors in cored interval (m)	Correlation[2] of core with reflectors
Area 5 - Baltimore Canyon area												
PC37	CD37	884		X				U	573	22		
PC38	CD38	884		X				M	877	10		
PC34	CD34	843			X		X	M	1,221	7	5	At 3 m soft zone
PC35	CD35	843			X	X		M	1,342	5	4	No evidence
PC36	CD36	843	X			X		M	1,300	8	5	3-4 m weak layer
Area 4 - Wilmington Canyon area												
PC27	CD24	583			X			U	324	10		
PC28	CD24	583			X			U	328	10		
PC29	CD25	583		X				U	392	6		
PC30	CD26	583		X				U	520	19		
PC31	CD27	583		X				U	553	8	4	Consolidation change
PC32	CD32	627			X	X		M	1,098	8	1, 5	No evidence
PC33	CD32A	583		X		X		M	1,040	16	6	Soft zone (possible gas)
Area 3 - Carteret to Berkeley Canyons												
PC23	CD21	108		X				U	505	8		
PC24	CD22	108		X				U	637	15		
PC25	CD22	108		X				U	607	15		
PC22	CD20	65		X				U	525	9	1, 3	1 m not sampled, 3 m consolidation change
PC21	CD19	21	X					U	595	8		
PC20	CD18	21		X				U	598	10		
PC19	CD17	21		X				U	592	10		
PC14	CD12	990	X					U	403	11		
PC15	CD13	990	X					U	471	6		
PC16	CD14	990		X				U	543	9	4	Consolidation change
PC17	CD16	990			X			U	475	6		
PC18	CD15	23			X			M	810	14	3, 6	Soft zone (possible gas)
Area 2 - South Toms to Mey Canyons												
PC11	CD10	903			X			U	435	7		
PC12	CD11	903		X				U	566	5	7	
PC13	CD11	903		X				U	556	5		
PC 7	CD 9	864	X					M	1,148	7	3	Stiff clay layer
PC 8	CD 9	864	X					M	1,180	7	3	Change in strength
PC 9	CD 6	820			X			M	784	5		
PC10	CD 7	865			X		X	M	979	5	1, 2	Not sampled
GC 4	CD 4	820			X			M	712	9	2	Not sampled
PC 3	CD 4	820			X			M	708	9	1	Not sampled.
GC 5	CD 5	820			X			M	738	4		
PC 4	CD 5	820			X			M	840	4		
PC 5	CD 1	776			X			U	412	15		

1/PC=Piston core; GC=Gravity core.
2/Olsen and Rice, 1982; Keer and Cardinell, 1981.

Table 2. Piston core site location, collected on R/V ENDEAVOR 1979, on the Mid-Atlantic Continental Slope.

Core no.	Station no.	Latitude N.	Longitude W.
PC03	CD04	39°09.12′	72°24.30′
PC04	CD05	39°08.90′	72°24.09′
PC05	CD01	39°12.23′	72°24.30′
PC07	CD09	39°07.23′	72°24.94′
PC08	CD09	39°07.21′	72°24.82′
PC09	CD06	39°08.53′	72°24.32′
PC10	CD07	39°07.27′	72°23.25′
PC11	CD10	39°03.69′	72°41.32′
PC12	CD11	39°03.30′	72°40.58′
PC13	CD11	39°03.32′	72°40.83′
PC14	CD12	39°00.16′	72°46.43′
PC15	CD13	38°59.98′	72°46.07′
PC16	CD14	38°59.66′	72°45.80′
PC17	CD16	38°59.40′	72°46.16′
PC18	CD15	38°57.98′	72°43.52′
PC19	CD17	38°55.36′	72°48.90′
PC20	CD18	38°55.32′	72°48.80′
PC21	CD19	38°55.23′	72°49.49′
PC22	CD20	38°04.71′	72°49.59′
PC23	CD21	38°52.15′	72°52.74′
PC24	CD22	38°51.87′	72°52.27′
PC25	CD22	38°51.86′	72°52.30′
PC28	CD24	38°24.91′	73°23.54′
PC29	CD25	38°24.74′	73°23.24′
PC30	CD26	38°24.51′	73°22.92′
PC31	CD27	38°24.38′	73°22.80′
PC32	CD32	38°22.05′	73°21.50′
PC33	CD32A	38°22.49′	73°21.98′
PC34	CD34	38°08.72′	73°36.42′
PC35	CD35	38°08.01′	73°35.57′
PC36	CD36	38°08.12′	73°37.25′
PC37	CD37	38°05.71′	73°45.02′
PC38	CD38	38°04.54′	73°45.04′

those sites where detailed bathymetry was available (Bennett and others, 1978; Robb and others, 1981). Because the sea-floor gradient was based on a single crossing of the core site, it does not necessarily represent a maximum value.

DISCUSSION OF PROFILES

The profiles are discussed in a regional grouping starting at the south near Baltimore Canyon (area 5) and proceeding north to Mey Canyon (area 2). The area number designation (2-5) is used from Hall and Ensminger (1979) to facilitate comparison of geophysical data. No cores were collected in the area they designated as 1. Maximum penetration recorded on the seismic profiles was approximately 100 m. Bathymetry for the core sites and morphologic setting were determined from lease block bathymetry in Hall and Ensminger (1979) and Outer Continental Shelf Resource Management maps NOS NJ 18-3 (OCS) and NOS NJ 18-6 (OCS), scale 1:250,000. At some core sites, subbottom horizons were indicated within the range of the cored interval. These are noted in table 1. Observations of changes in physical properties of the cores possibly correlating with these reflectors are also indicated in table 1.

Area 5 - Baltimore Canyon area

Area 5 includes the Continental Slope from Baltimore Canyon to south of Wilmington Canyon (fig. 1). Five cores (34 through 38) were collected in two lease blocks (884 and 843). Cores 37 and 38 were collected from the northeast wall of Baltimore Canyon (figs. 2, 3). The 3.5-kHz profiles for both sites show well stratified continuous horizons. Thinning of sediments appears to have occurred upslope from core site 38. Two cores (34 and 35) were collected on an intervalley ridge transverse to the slope, midway between Baltimore and Wilmington Canyons (figs. 4, 5). Core 36 was collected in the headwall of a valley adjacent to the ridge (fig. 6). The marked increase in contour spacing between 1,300 and 1,400-m contours on the ridge (NOS NJ 18-6 (OCS)) is a characteristic often associated wth sediment failure (Bennett and others, 1978). Shallow subbottom horizons are relatively smooth, continuous, and seaward-dipping at site 34. A 75-m high scarp is present upslope from this site. Downslope from site 34, at core site 35, the surface topography is irregular and the subbottom horizons are irregular and discontinuous. Core 34 is interpreted to be in a possible scar resulting from mass movement and core 35 in redeposited material. Core 36 is located in the axis of a headwall of a slope valley. The topography and subbottom horizons are irregular with apparent truncation of subbottom horizons at the sea floor.

Area 4 - Wilmington Canyon area

The slope between Wilmington and Spencer Canyons is included in area 4. Seven cores (27 through 33) were collected in lease blocks 583 and 627 on the slope northeast of Wilmington Canyon. Detailed bathymetry and sea-floor gradients for portions of blocks 583 and 627 are given by Bennett and others (1978). Core sites 27 and 28 are on the upper slope above the head of a slope valley (fig. 7). The 3.5-kHz penetration was poor, suggesting the presence of sand. Sites 29, 30, and 31 are on the upper slope in the wall of a slope valley. Continuous subbottom horizons are present at all 3 sites (fig. 7). Side echoes suggest that the 3.5-kHz profile through the core sites is along a valley wall. Core sites 32 and 33 are on an intervalley ridge and valley wall, respectively. These sites were located on a suggested slump block

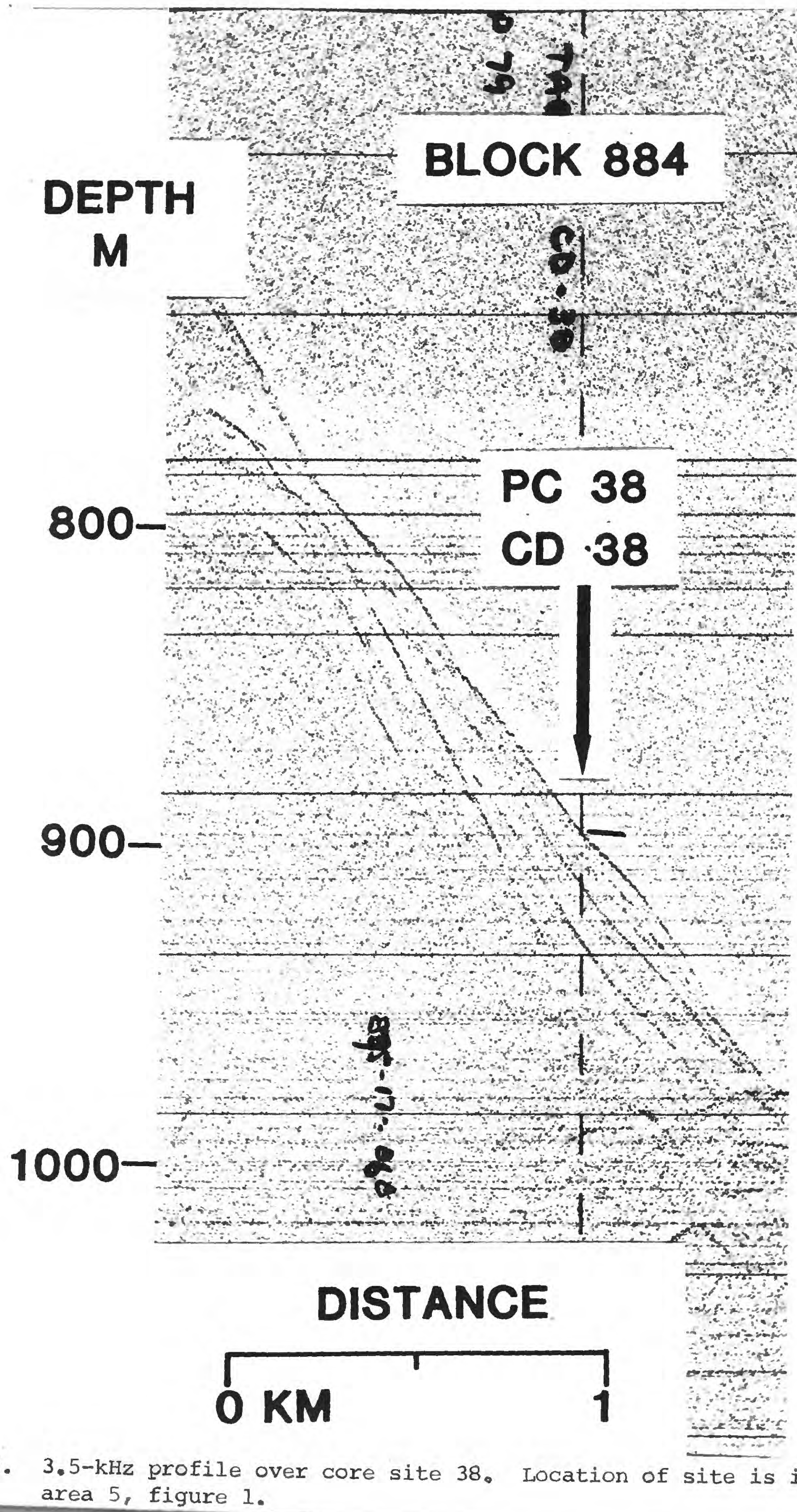

Figure 2. 3.5-kHz profile over core site 38. Location of site is in area 5, figure 1.

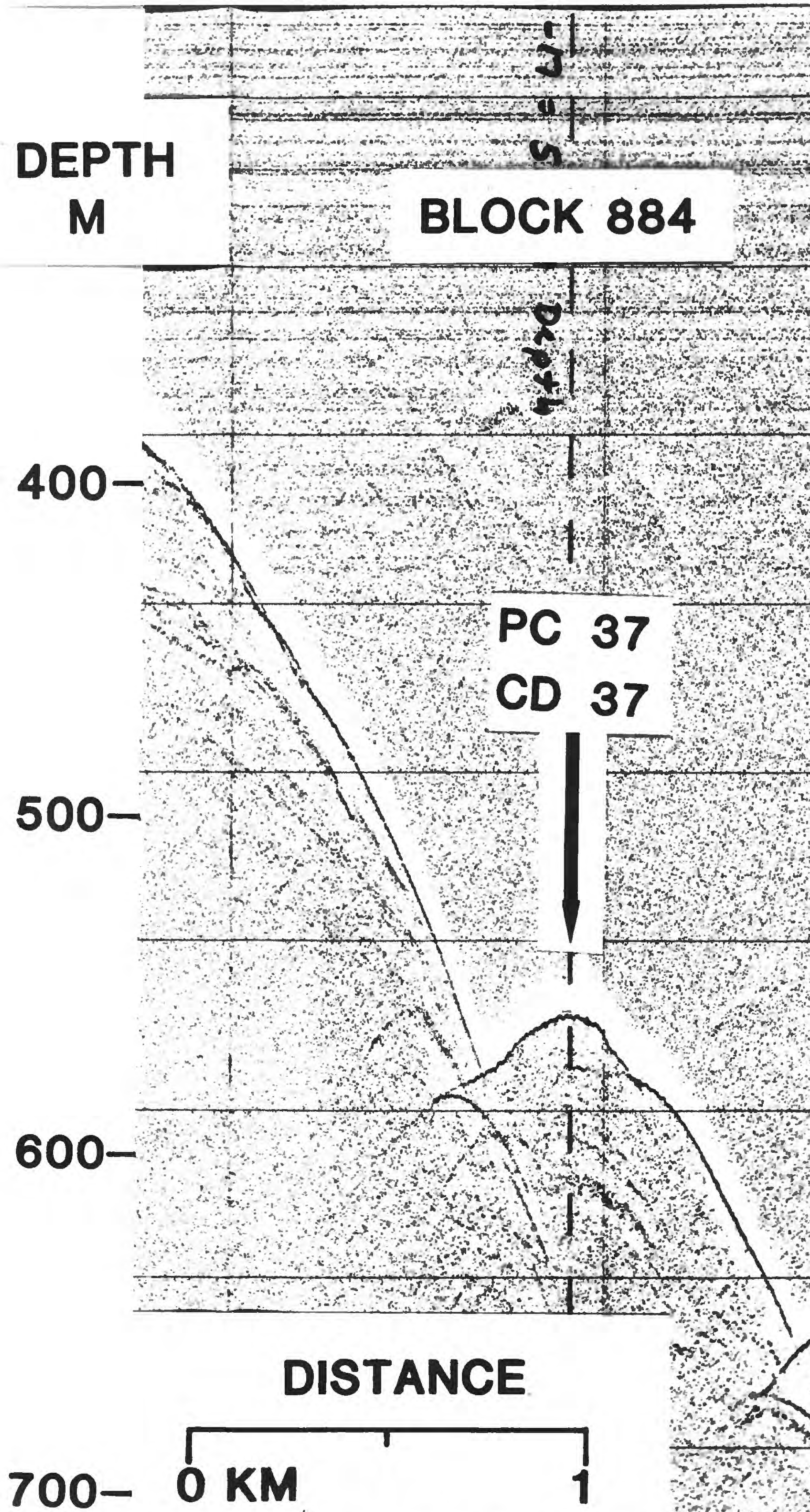

Figure 3. 3.5-kHz profile over core site 37. Location of site is in area 5, figure 1.

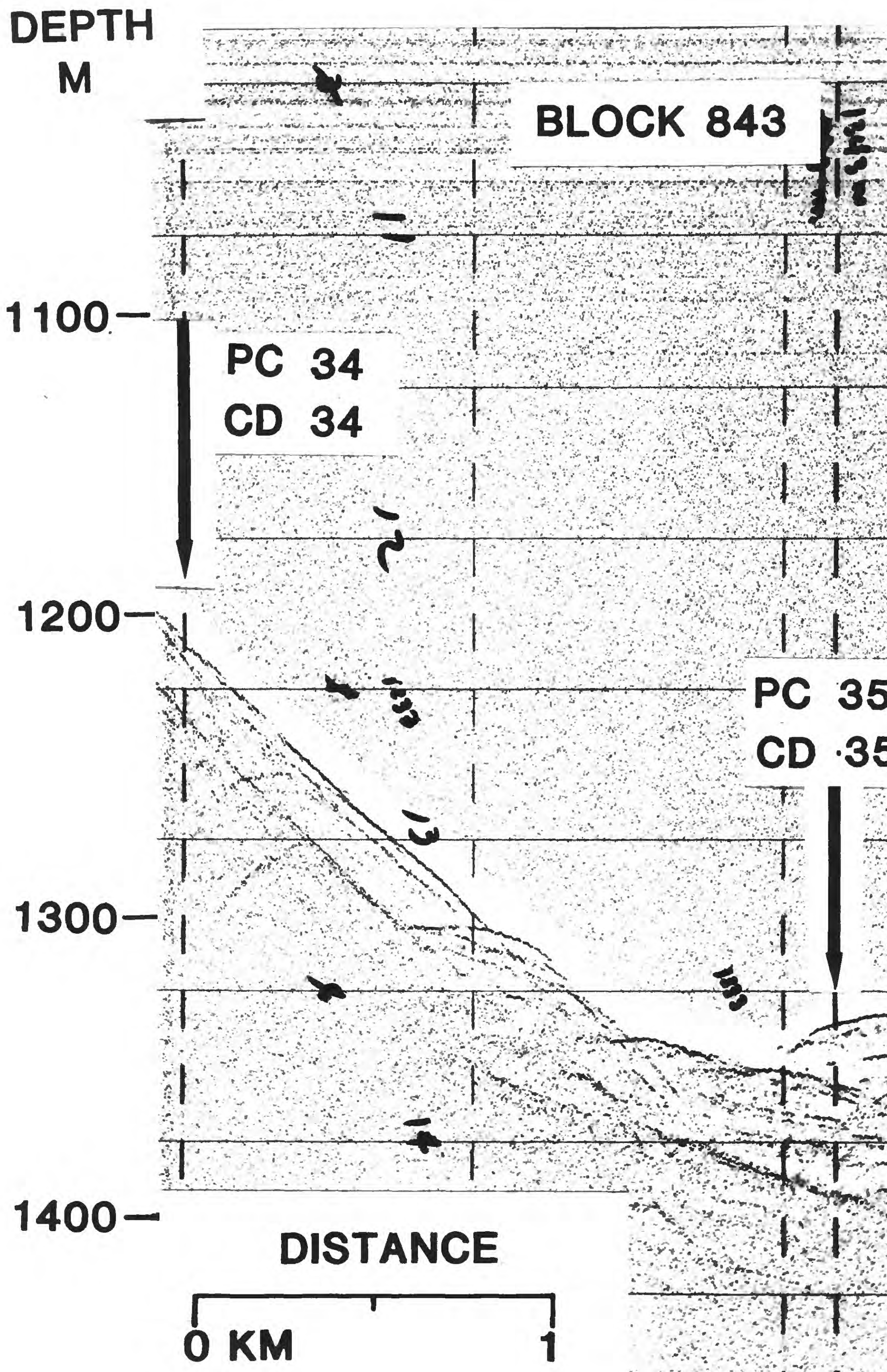

Figure 4. 3.5-kHz profile over core sites 34 and 35. Location of sites is in area 5, figure 1.

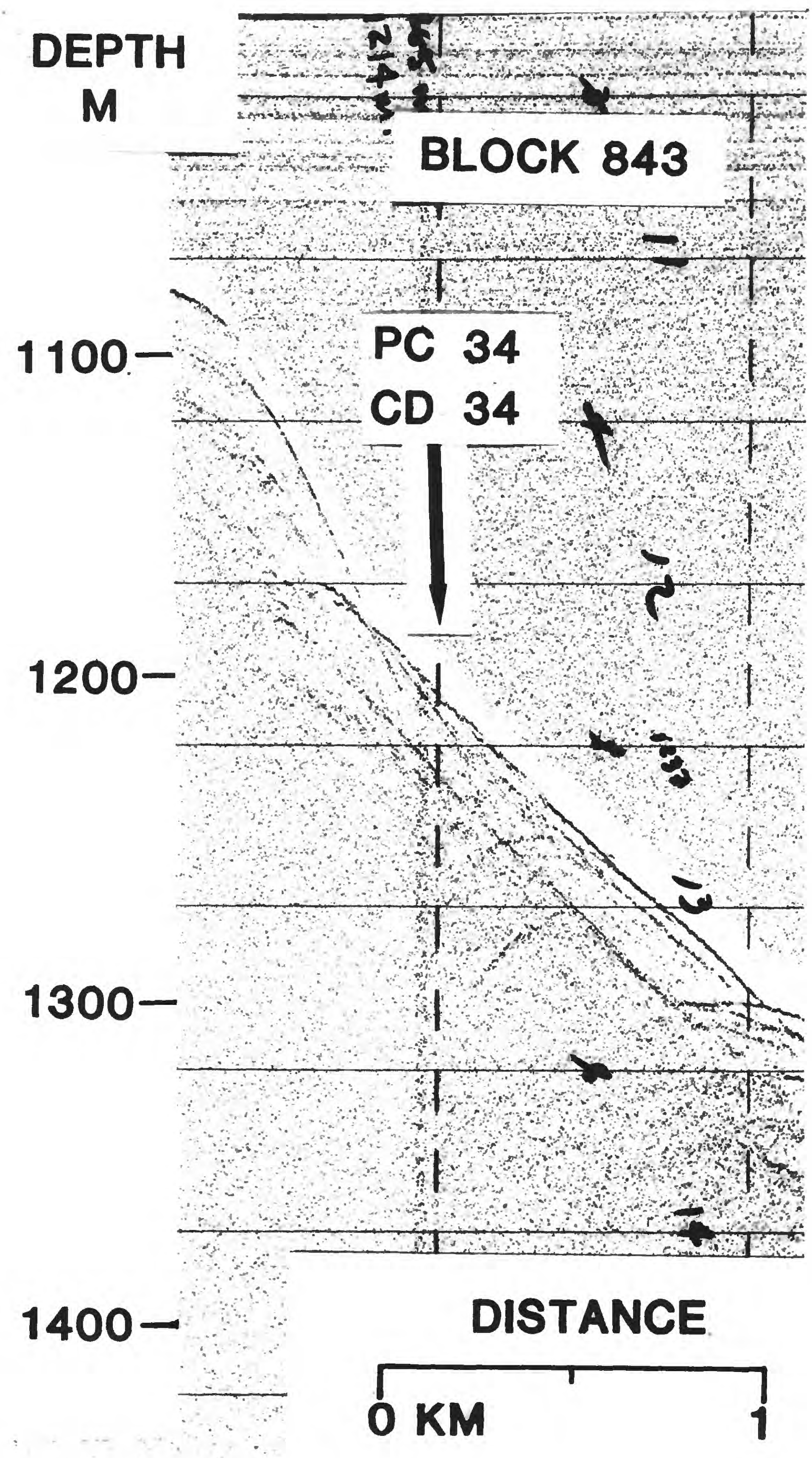

Figure 5. 3.5-kHz profile over core site 34. Location of site is in area 5, figure 1.

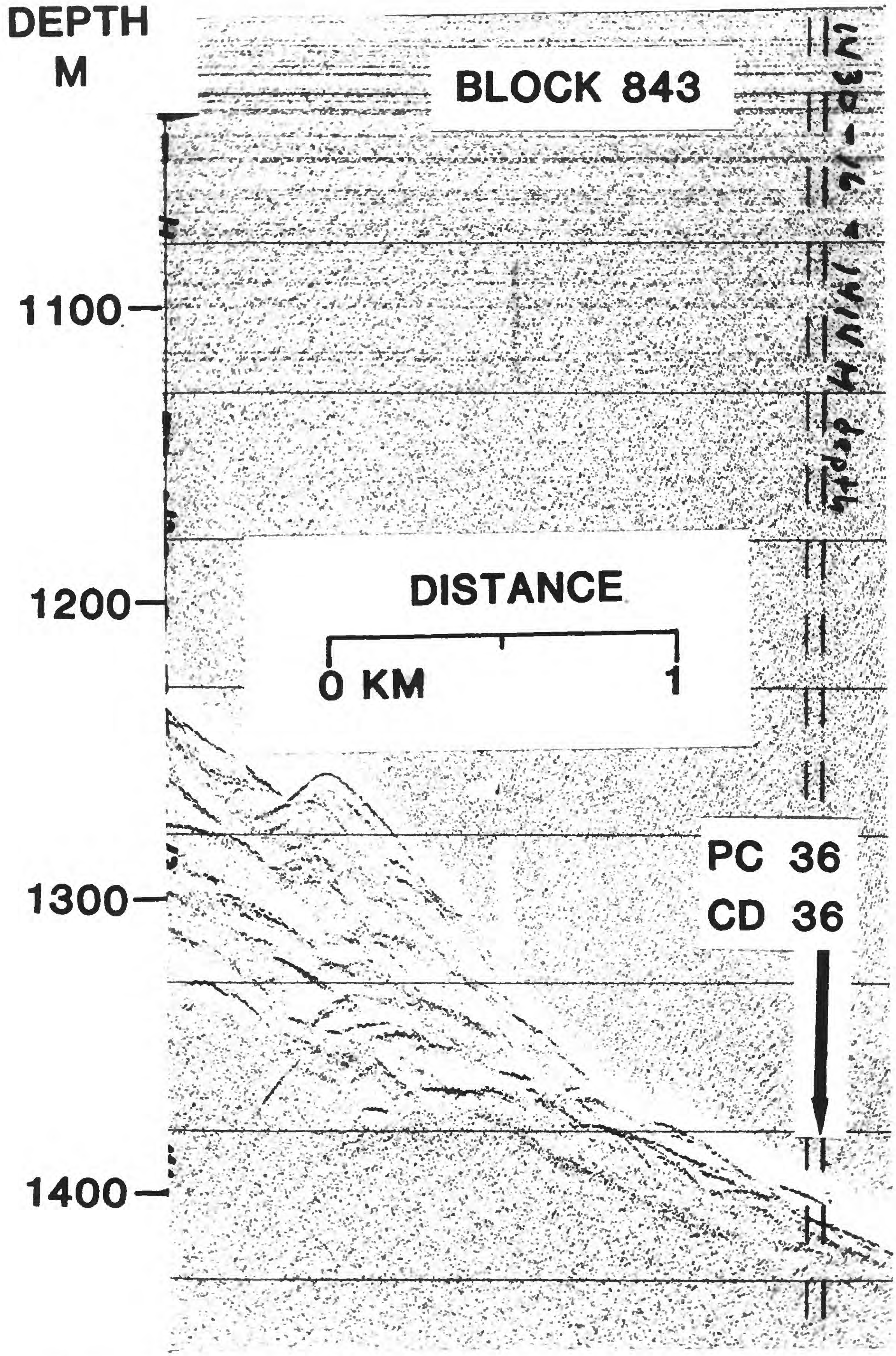

Figure 6. 3.5-kHz profile over core site 36. Location of site is in area 5, figure 1.

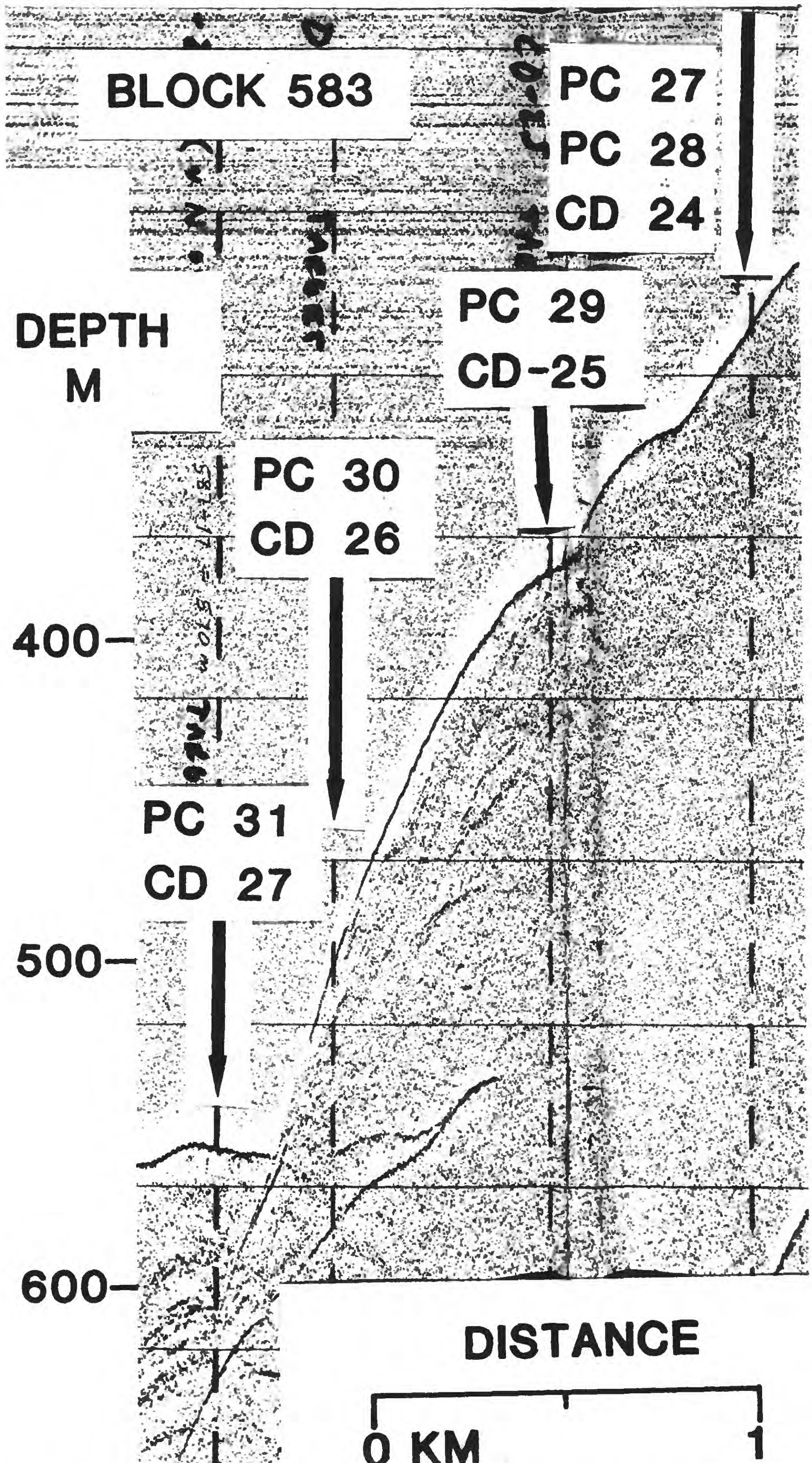

Figure 7. 3.5-kHz profile over core sites 27, 28, 29, 30, and 31. Location of sites is in area 4, figure 1.

(McGregor and Bennett, 1977). The upper horizons at site 32 are irregular and discontinuous, and overlie smooth continuous horizons at depth. This suggests that the upper zone may be slumped material (fig. 8). Horizons at site 33, however, are continuous with some thinning of material on the valley wall (fig. 9). Valley erosion or mass wasting may have removed much of the sediment at site 33.

Area 3 - Carteret Canyon to Berkeley Canyon

The slope from the vicinity of Carteret Canyon to northeast of Berkeley Canyon is included in area 3. Twelve cores were collected in five lease blocks (108, 65, 21, 990, and 23). Core sites 23, 24, and 25 are in the wall of a valley just south of Carteret Canyon. A well stratified sequence is present and the horizons are continuous through the three core sites (fig. 10). All three sites have a 10-15 m thick, acoustically transparent, surface-sediment layer.

Midway between Carteret and Berkeley Canyons core sites 19 and 20 are in the northeast wall of a slope valley (fig. 11); site 22, in the southwest wall (fig. 12); and site 21, in the headwall of the same valley (fig. 13). The three sites in the valley walls (19, 20, 22) have continuous seaward-dipping horizons. The surface topography along the profiles over the core sites is irregular due to dissection in the valley walls. This dissection of the valley walls is seen on GLORIA data in this area (Twichell and Roberts, in press). The profile down the valley axis over core site 21 has very irregular surface topography and side echoes (fig. 13). Subbottom horizons dip seaward, and are very patchy and diffuse partially due to interference from side echoes. Some horizons appear to be truncated by the sea floor. Material at site 21 could have accumulated at the base of the valley walls, with an increased deposition rate from some contribution by mass wasting.

Northeast of Berkeley Canyon, three cores were collected near the head of a slope valley. Core sites 14 and 15 are believed to be near the head of the valley and core 16 was taken from the valley wall (fig. 14). Subbottom horizons are continuous with some thinning of layers near site 15. Surface topography is slightly irregular. Core sites 17 and 18 are on an adjacent intervalley ridge (figs. 15, 16). A well stratified sequence of continuous horizons dipping in a seaward direction is present at site 17.

Area 2 - South Toms Canyon to Mey Canyon

Area 2 includes the Continental Slope from South Toms to Mey Canyons. Twelve cores (10 piston and 2 gravity cores) were collected in five lease blocks (903, 865, 864, 820, and 776). Core site 11 is on the upper slope near the head of a valley (fig. 17); downslope from site 11, sites 12 and 13 are on the upper part of the valley wall (fig. 17). Reflecting horizons at site 11 are continuous but diffuse, suggesting attenuation of the sound by the presence of surface sand layers. Horizons at depth can be traced downslope to sites 12 and 13. The irregular surface topography in the vicinity of sites 12 and 13 is believed associated with dissection of the valley wall. Site 13 might be in one of these side valleys, because the hyperbolic echo pattern at core "hit" resembled that observed over valleys.

Core sites 7 and 8 are in the axis of Mey Canyon (fig. 18), possibly in a

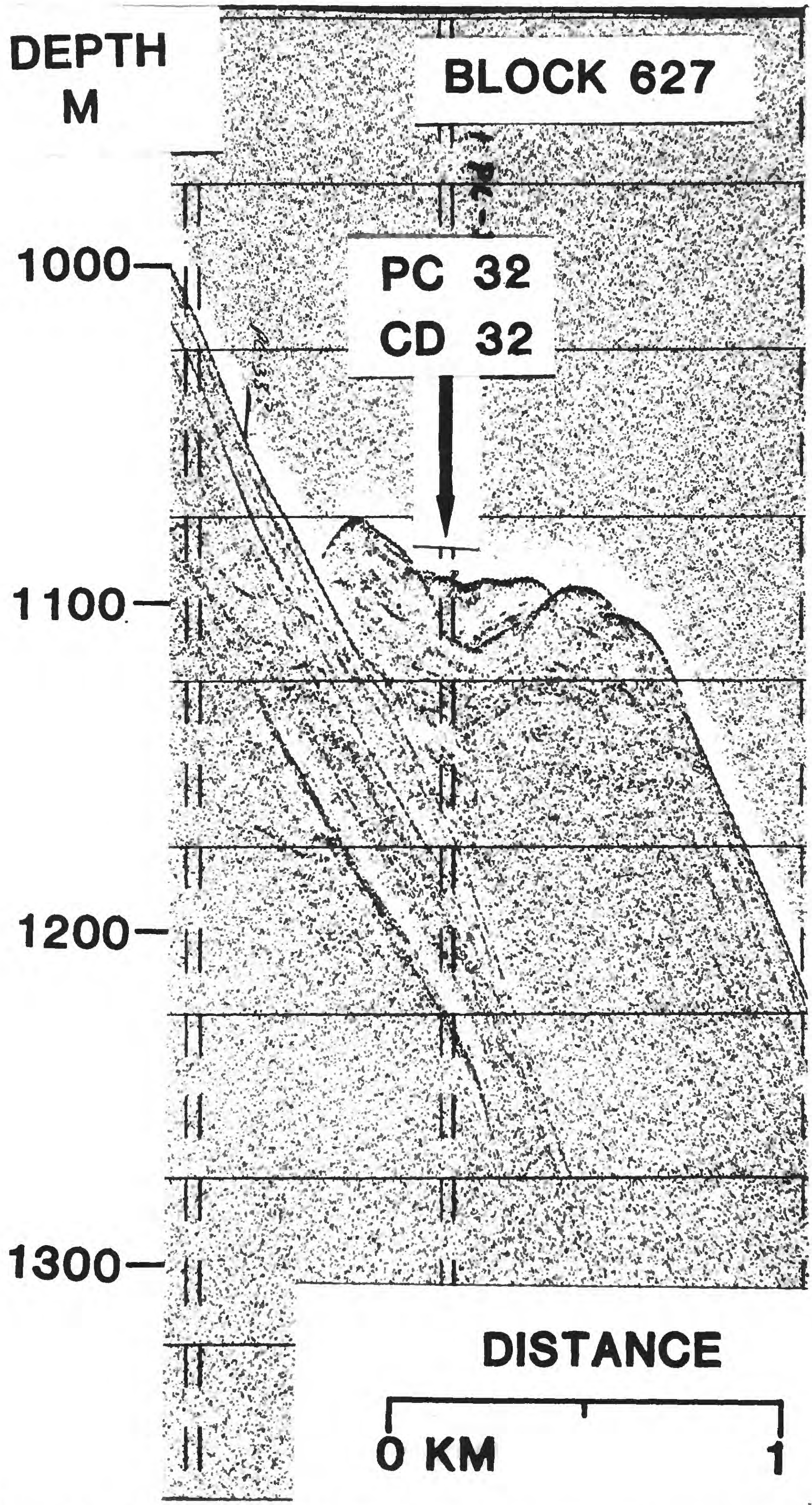

Figure 8. 3.5-kHz profile over core site 32. Location of site is in area 4, figure 1.

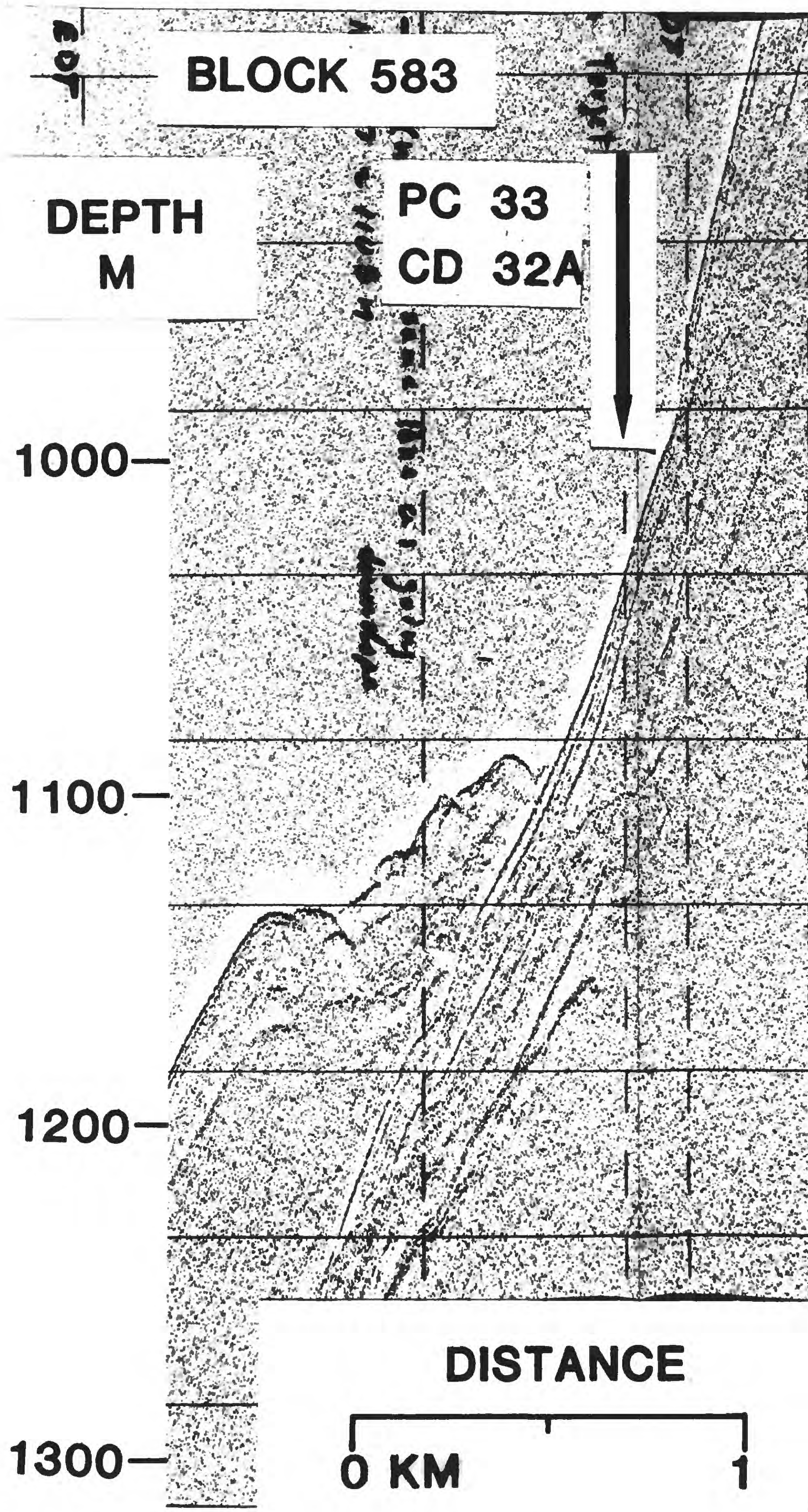

Figure 9. 3.5-kHz profile over core site 33. Location of site is in area 4, figure 5.

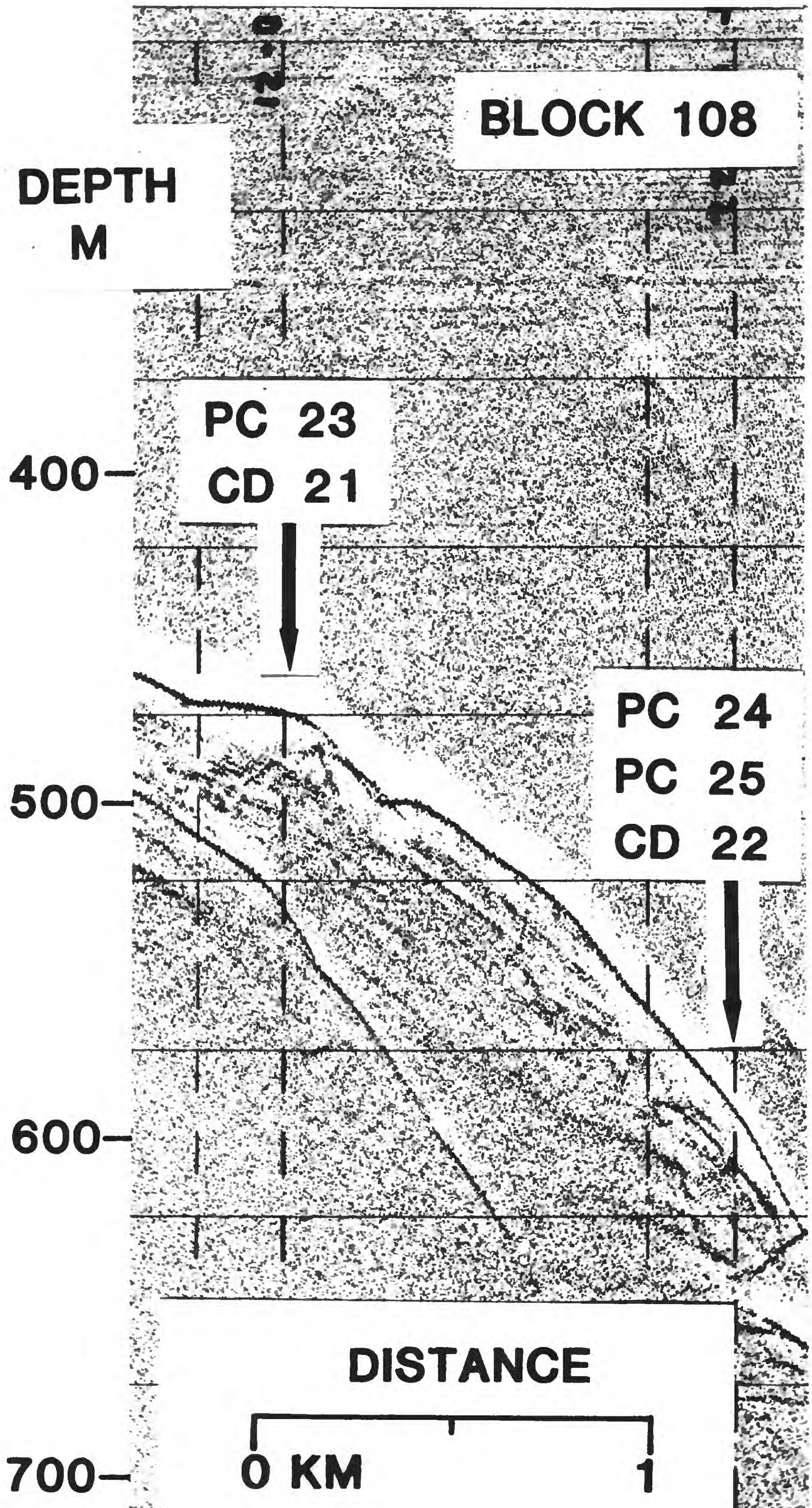

Figure 10. 3.5-kHz profile over core sites 23, 24, and 25. Location of sites is in area 3, figure 1.

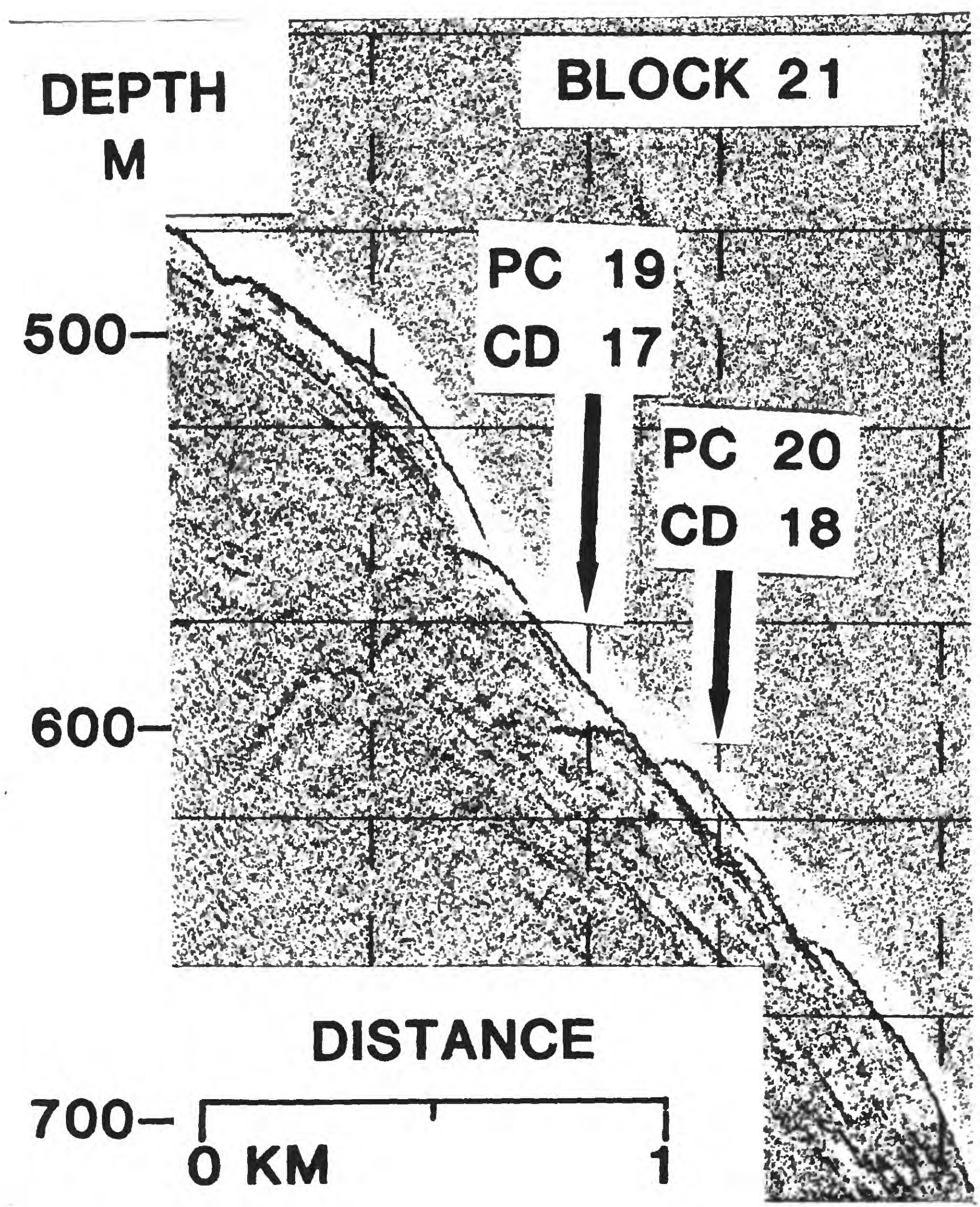

Figure 11. 3.5-kHz profile over sites 19 and 20. Location of sites is in area 3, figure 1.

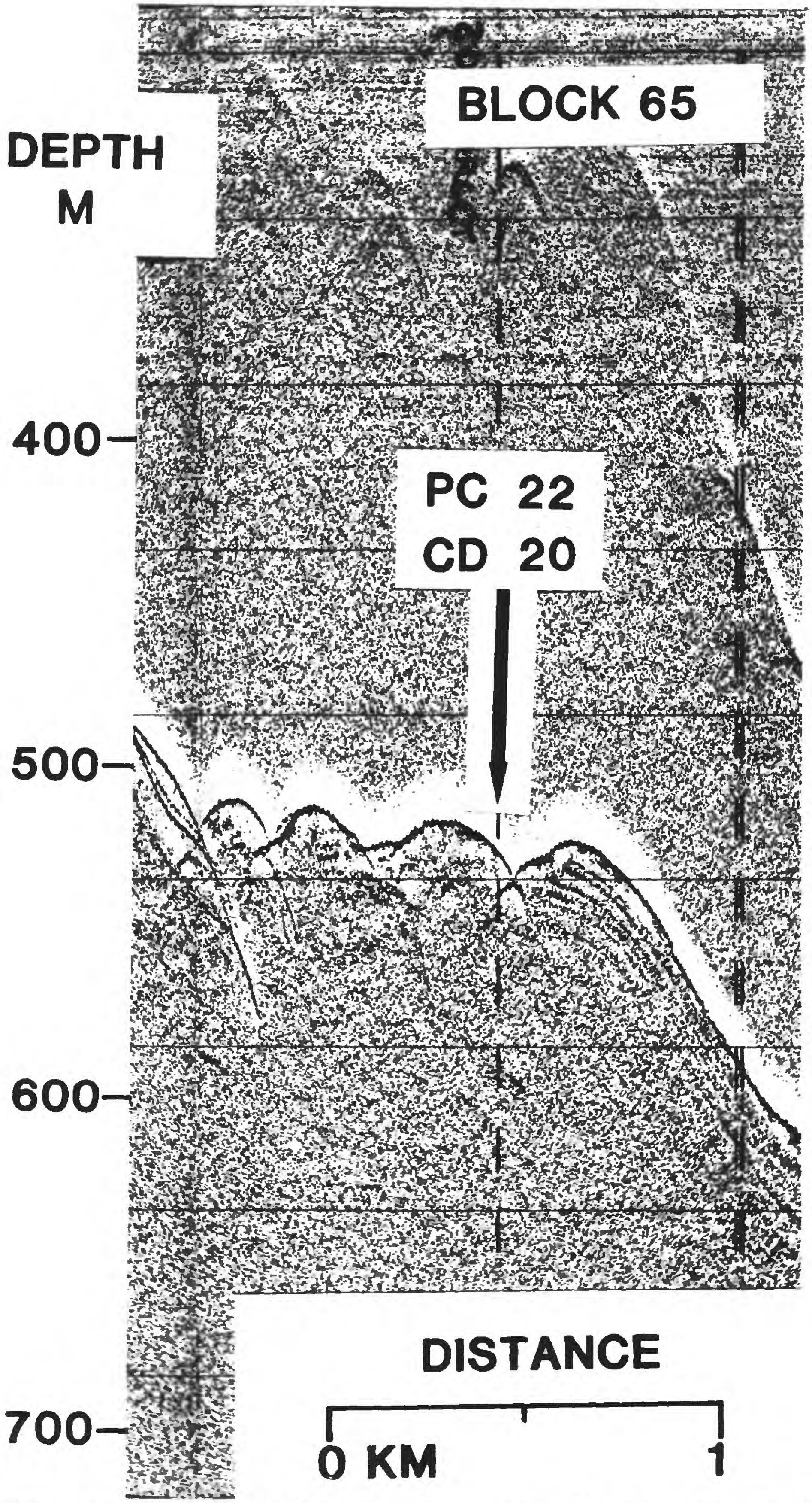

Figure 12. 3.5-kHz profile over core site 22. Location of site is in area 3, figure 1.

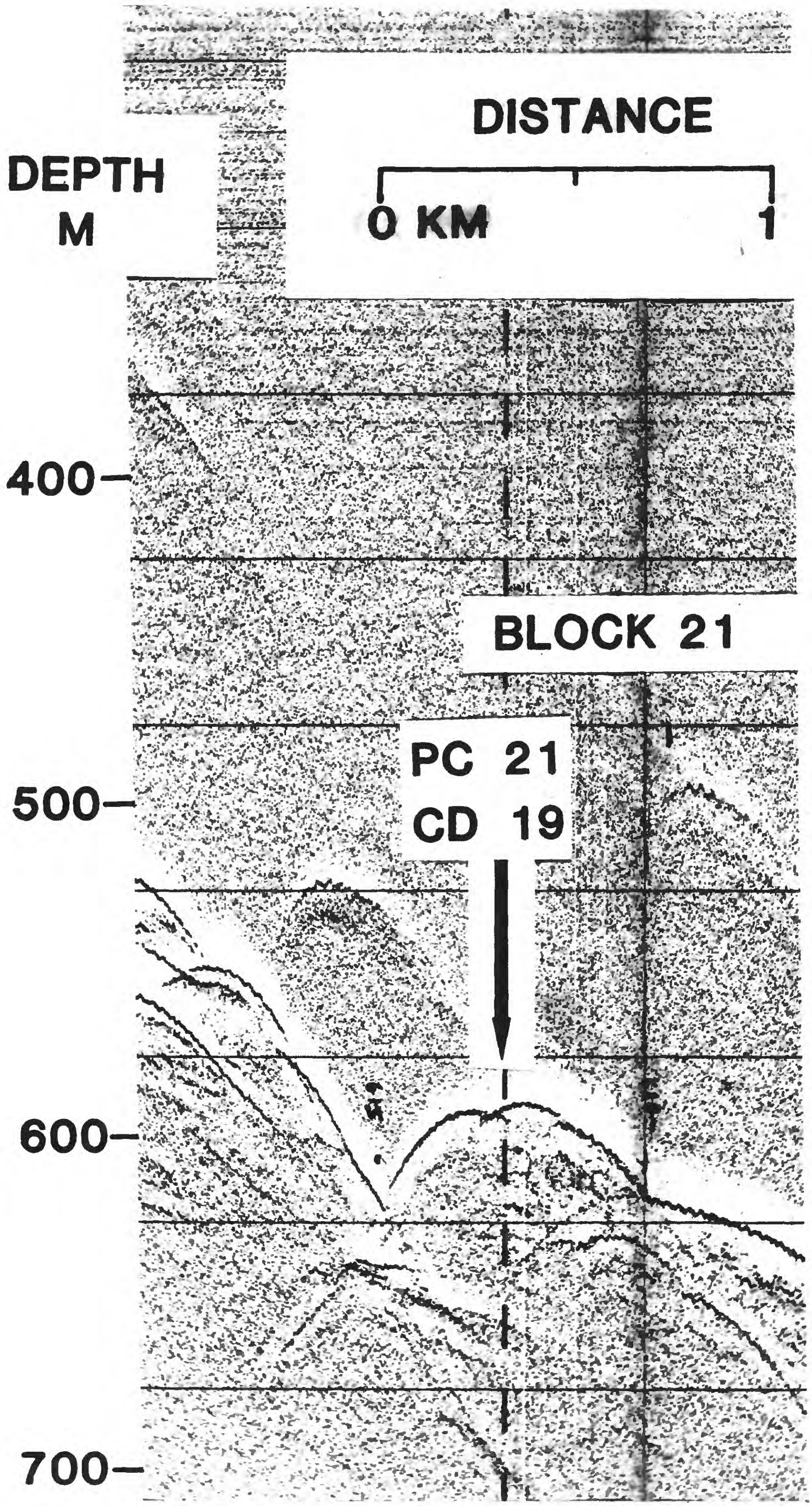

Figure 13. 3.5-kHz profile over core site 21. Location of site is in area 3, figure 1.

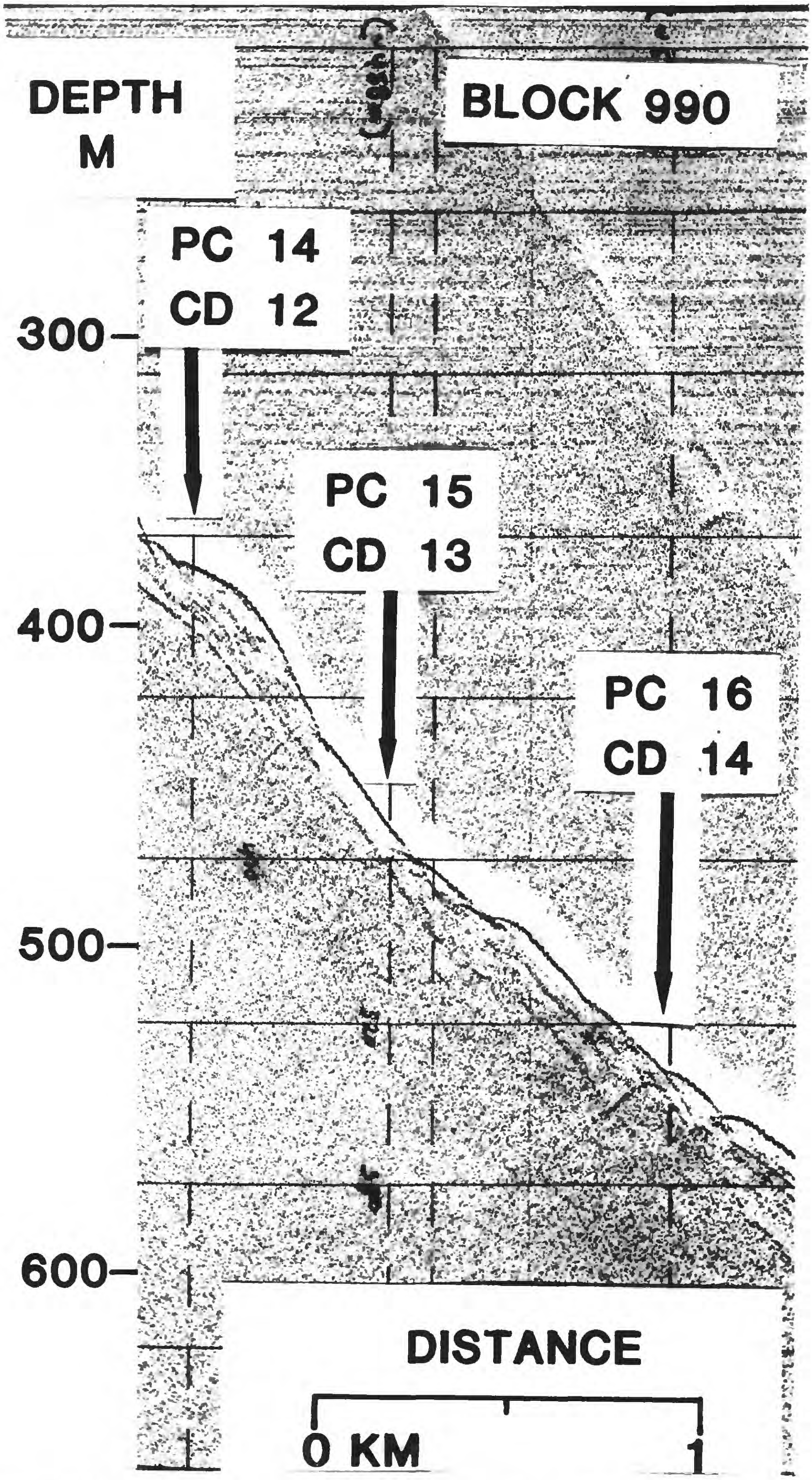

Figure 14. 3.5-kHz profile over core sites 14, 15, and 16. Location of sites is in area 3, figure 1.

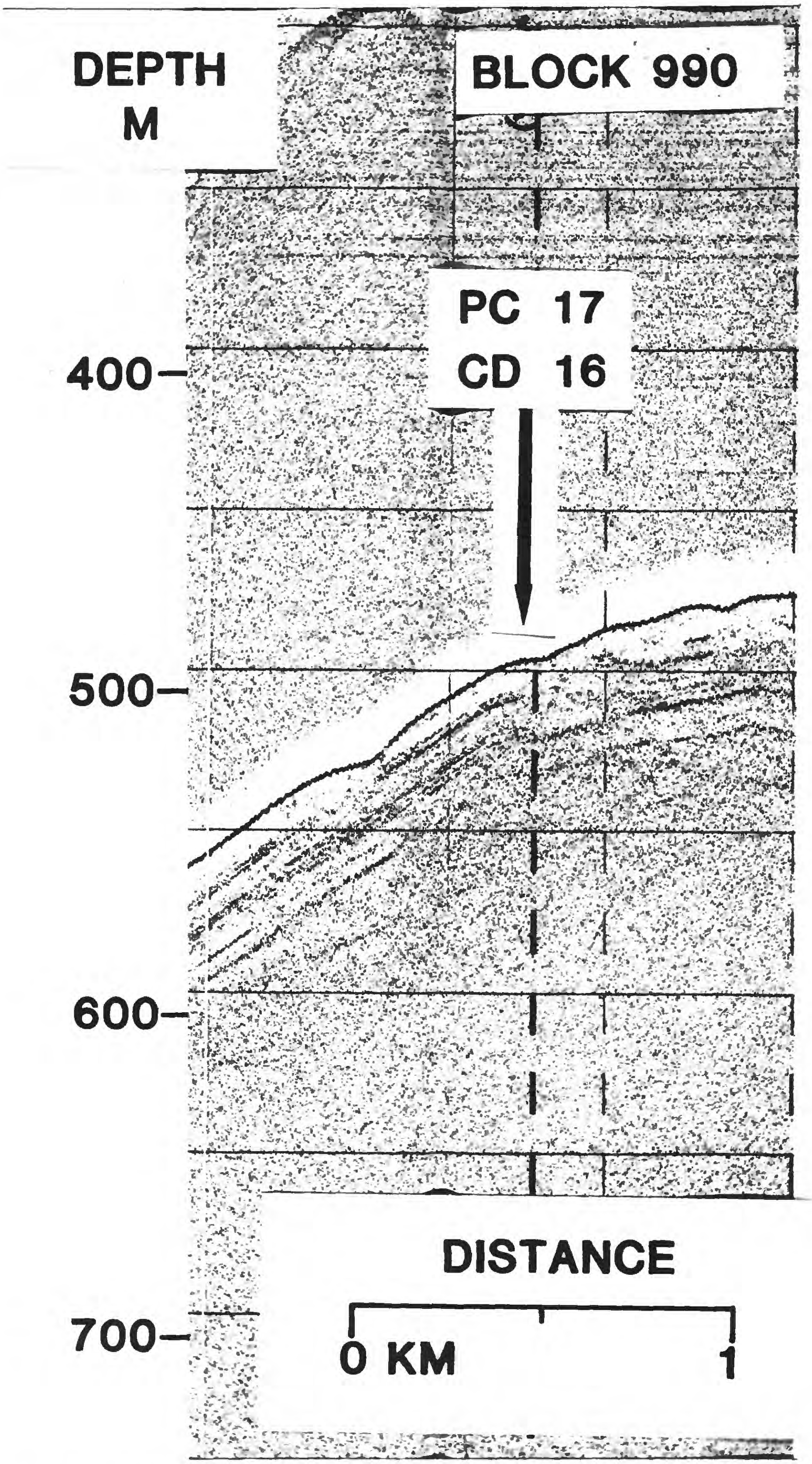

Figure 15. 3.5-kHz profile over core site 17. Location of site is in area 3, figure 1.

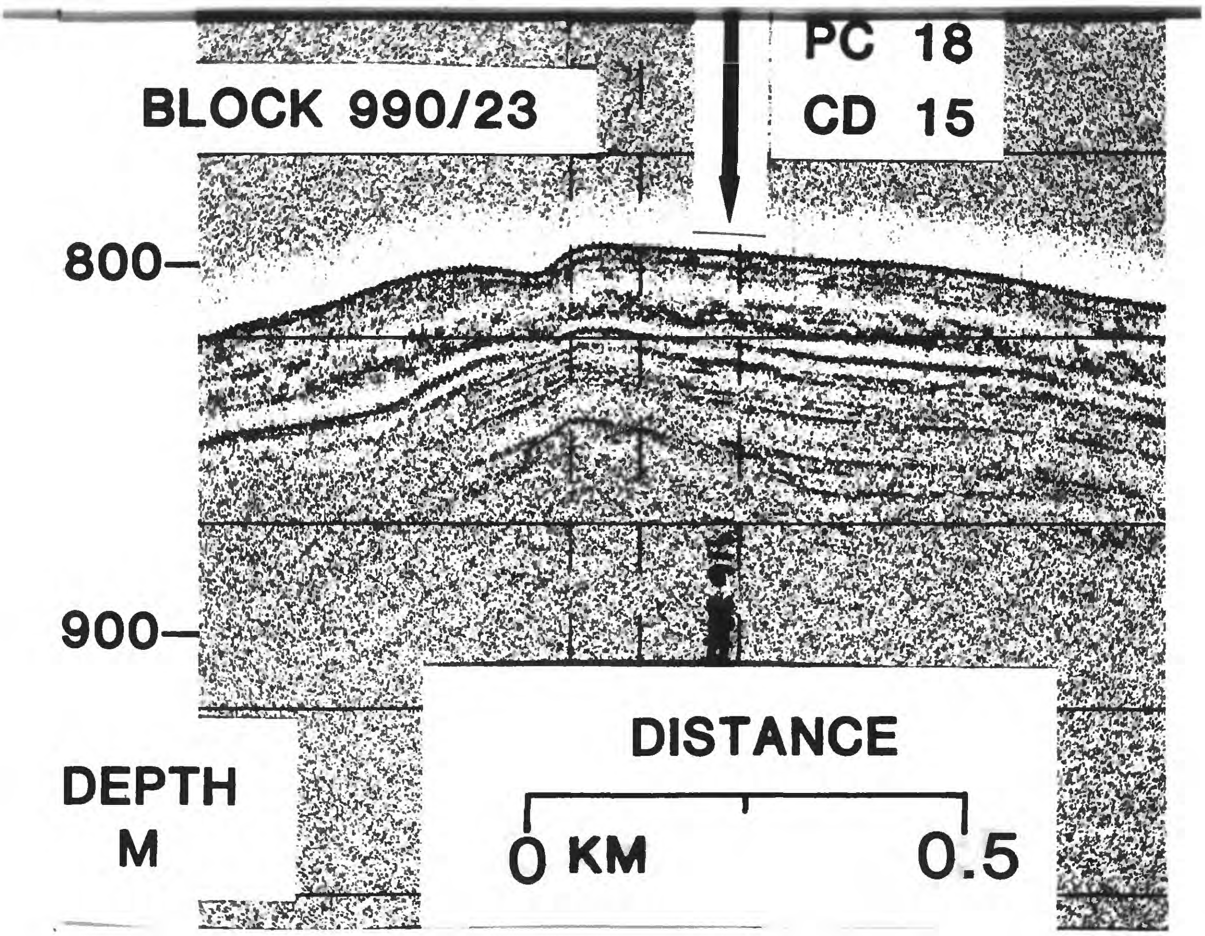

Figure 16. 3.5-kHz record of core site 18 as core was being taken. Location of site is in area 3, figure 1. Because of a malfunction in the 3.4-kHz system, this record is during the coring operation while the ship was on station.

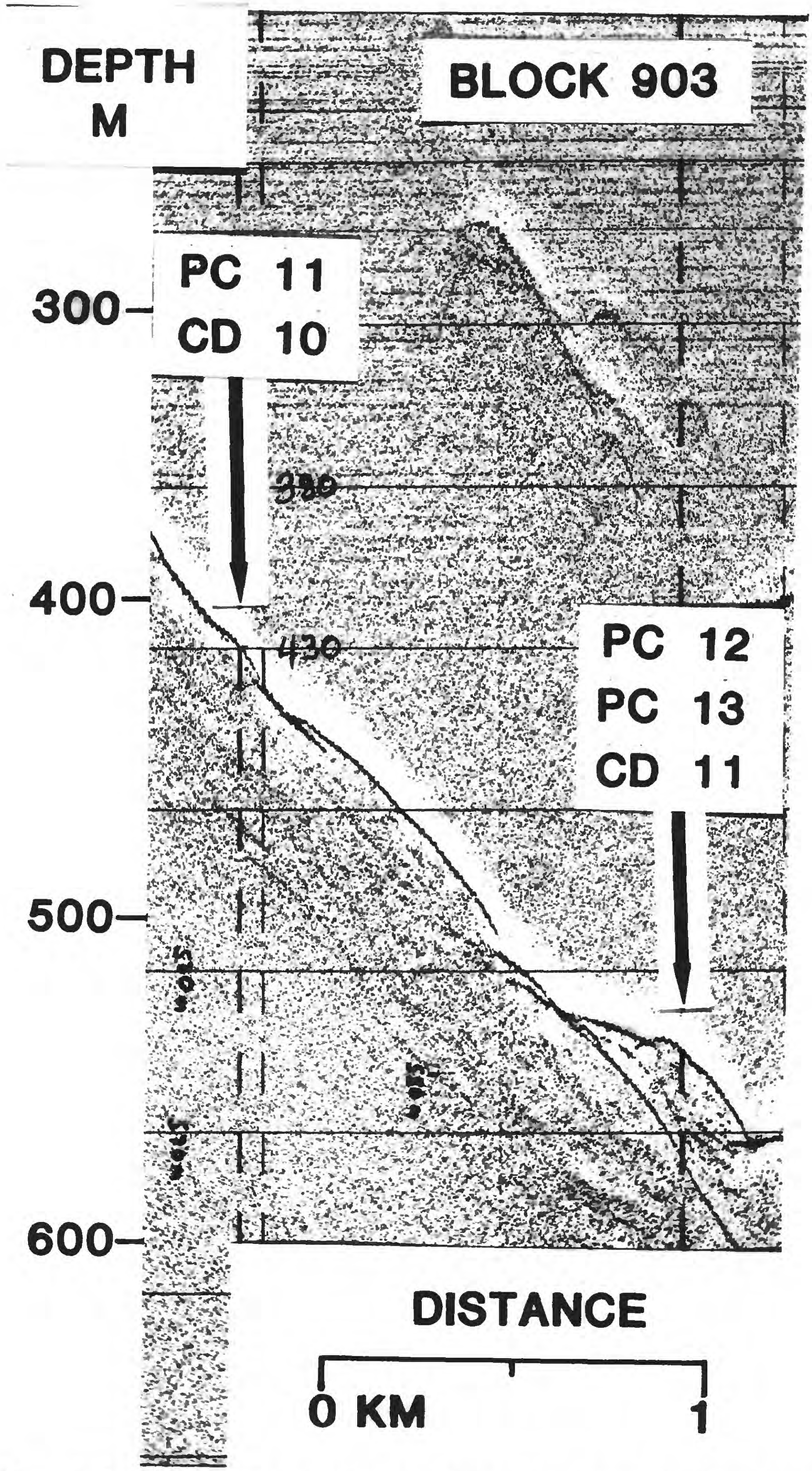

Figure 17. 3.5-kHz profile over core sites 11, 12, and 13. Location of sites is in area 2, figure 1.

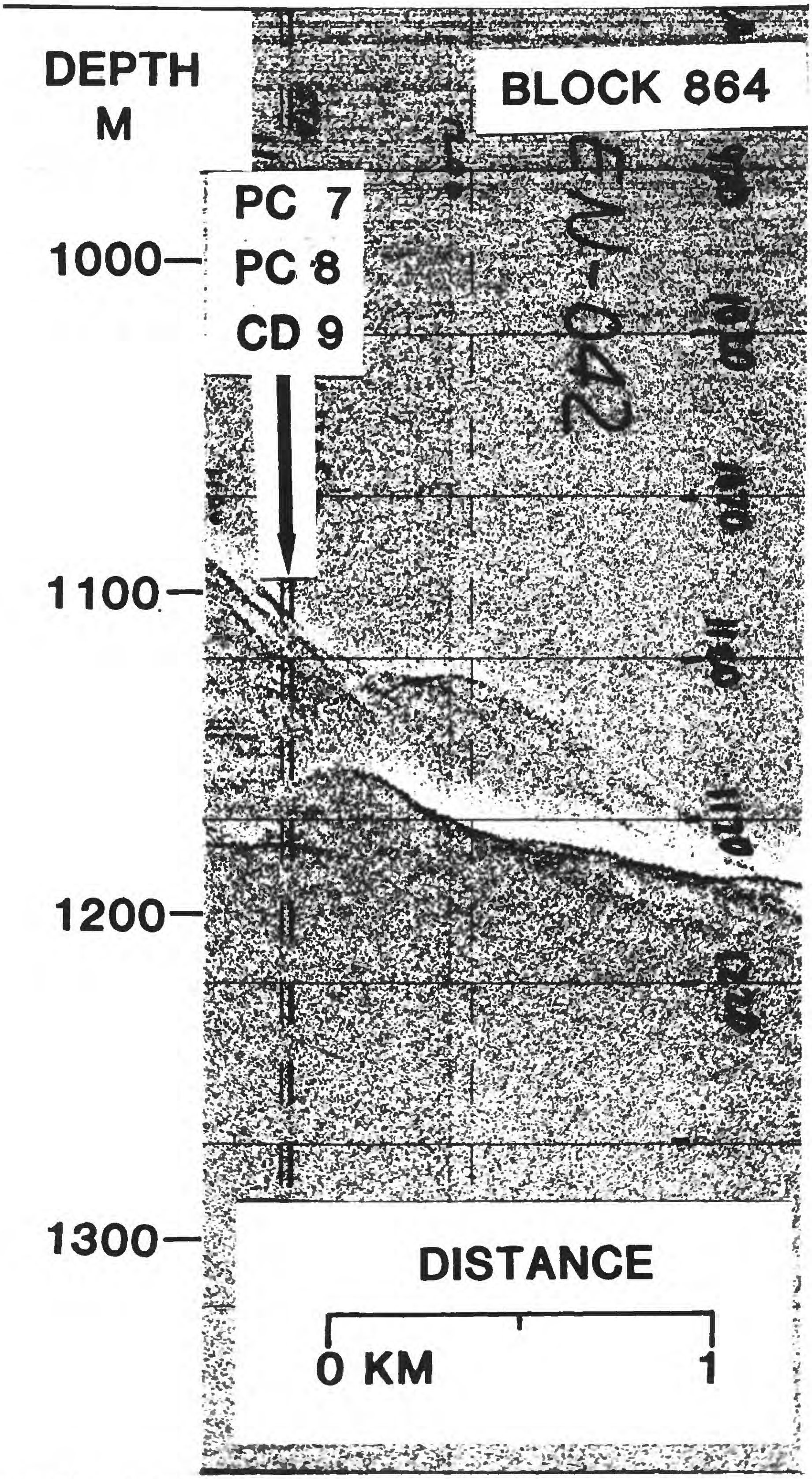

Figure 18. 3.5-kHz profile over core sites 7 and 8. Location of sites is in area 2, figure 1.

closed basin within the axis (based on limited bathymetric data, see Hall and Ensminger, 1979). Poor subbottom penetration suggests the presence of sand. Side echoes are very pronounced, implying that the sites, especially 7, are in close proximity to the base of the canyon wall.

Two cores sites, 9 and 10, are on the ridge flanking Mey Canyon to the northeast (fig. 19). Well-stratified smooth seaward-dipping horizons can be traced between the core sites. A 70-m erosional scarp is present between the core sites. It appears that 70 m of sediment has been removed at site 10, resulting in a small-scale irregular surface (less than 5 m of relief). Piston core sites 3 and 4 and gravity core sites 4 and 5 are located upslope from site 9, on the axis of the ridge (fig. 20). The 3.5-kHz profile shows numerous smooth horizons, although the sea-floor return itself was very weak and poorly defined.

Core site 5 on the upper slope has an irregular surface topography underlain by numerous smooth seaward-dipping subbottom horizons (fig. 21). Approximately 20 m of unstratified material overlies the well-stratified sequence. Because of the smooth subbottom reflectors, the topography is not caused by draping. However, due to the lack of surface stratification, the origin of the irregular topography cannot be determined. Either erosion by bottom currents or surface deformation due to mass wasting are possible mechanisms, with the former being the more likely.

INTERPRETATION OF SEA-FLOOR STABILITY

The morphologic setting of each core site is indicated (headwall of valley, axis of valley, valley wall, intervalley ridge, possible slump scar, and possible slump deposit) (table 1). Two erosional scarps were identified and both had a similar relief of 70-75 m (figs. 5, 19). The character of the subbottom horizons on the 3.5-kHz profiles over the cores sites are discussed, because lack of reflector continuity can often be related to bottom processes such as mass wasting. Criteria used to indicate material that might have undergone mass wasting included bathymetric change in contour spacing, irregular surface topography, presence of erosional scars, change in character of subbottom horizons, and their lack of continuity. Those core sites in valley walls that might have shown some of the above characteristics were generally not considered slump sites, because morphologic control by dissected topography could cause similar characteristics on single profiles. Stability analysis of each core site indicated that only one site had a factor of safety less than 1 (Keer and Cardinell, 1981; Olsen and Rice, 1982). This core was in a possible slump block which was interpreted on the basis of geophysical data (McGregor and Bennett, 1977).

CONCLUSION

The data indicate a generalized relationship between the morphologic settings for the cores (valley axis, valley wall, and intervalley ridge) and their geotechnical properties (Olsen and Rice, 1982), although considerable variability exists. The geotechnical data are generally consistent with the interpreted processes that are believed to be occurring in each of the geomorphic areas. On the intervalley ridges well-stratified sediments are accumulating so that high water contents and normal to underconsolidation could be expected. The valley walls are undergoing mass wasting of material

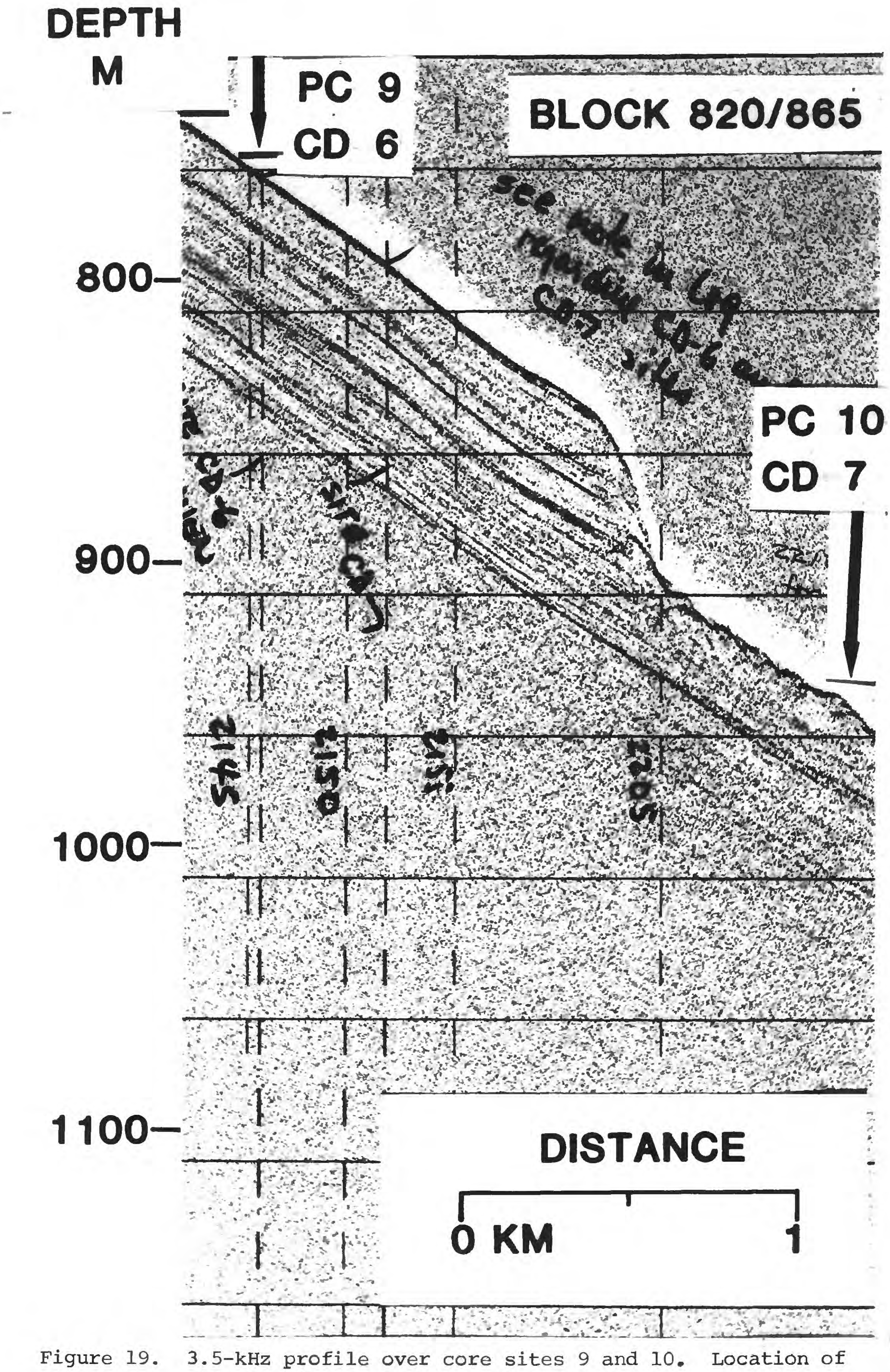

Figure 19. 3.5-kHz profile over core sites 9 and 10. Location of sites is in are 2, figure 1.

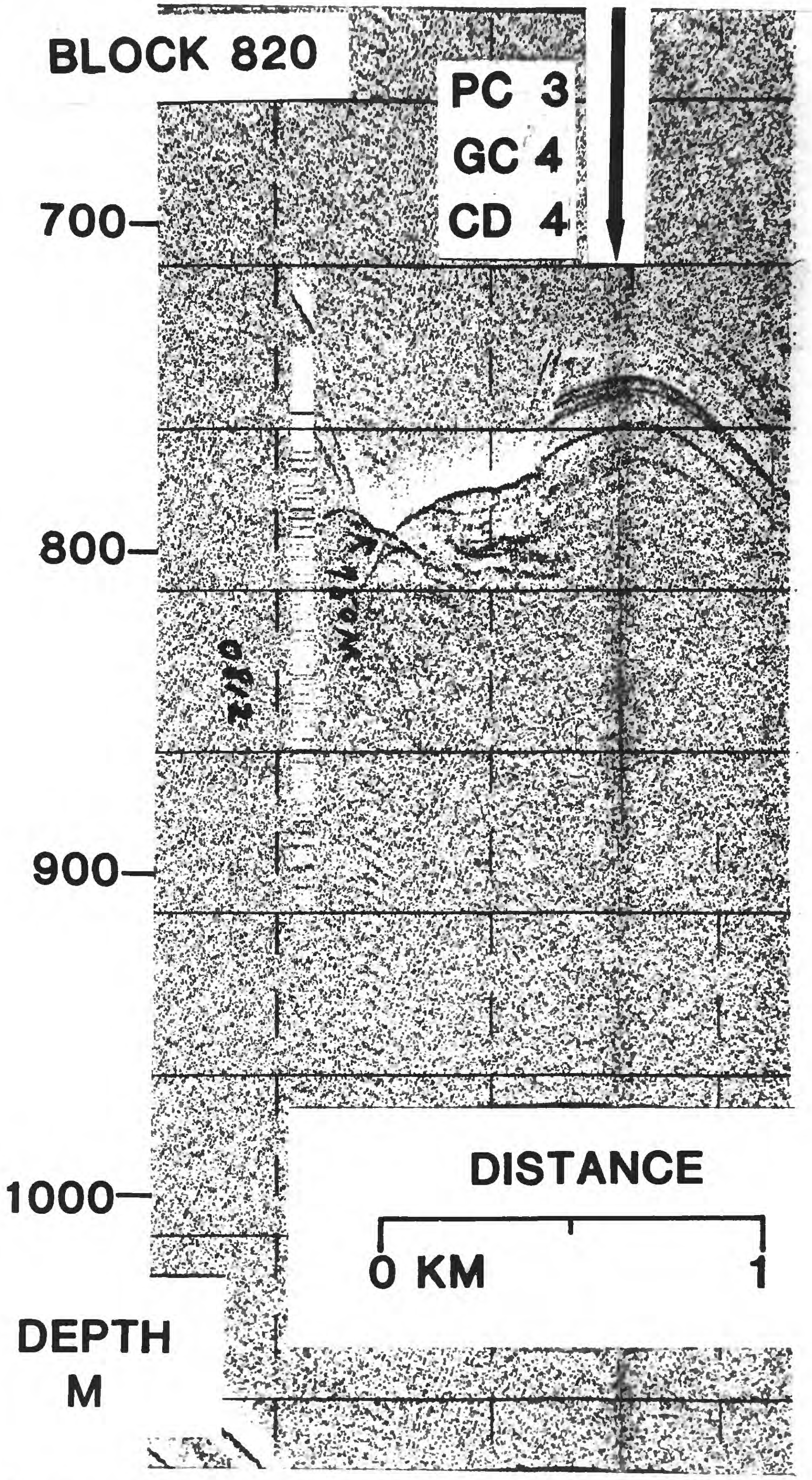

Figure 20. 3.5-kHz profile over core sites 3 and 4. Location of sites is in area 2, figure 1.

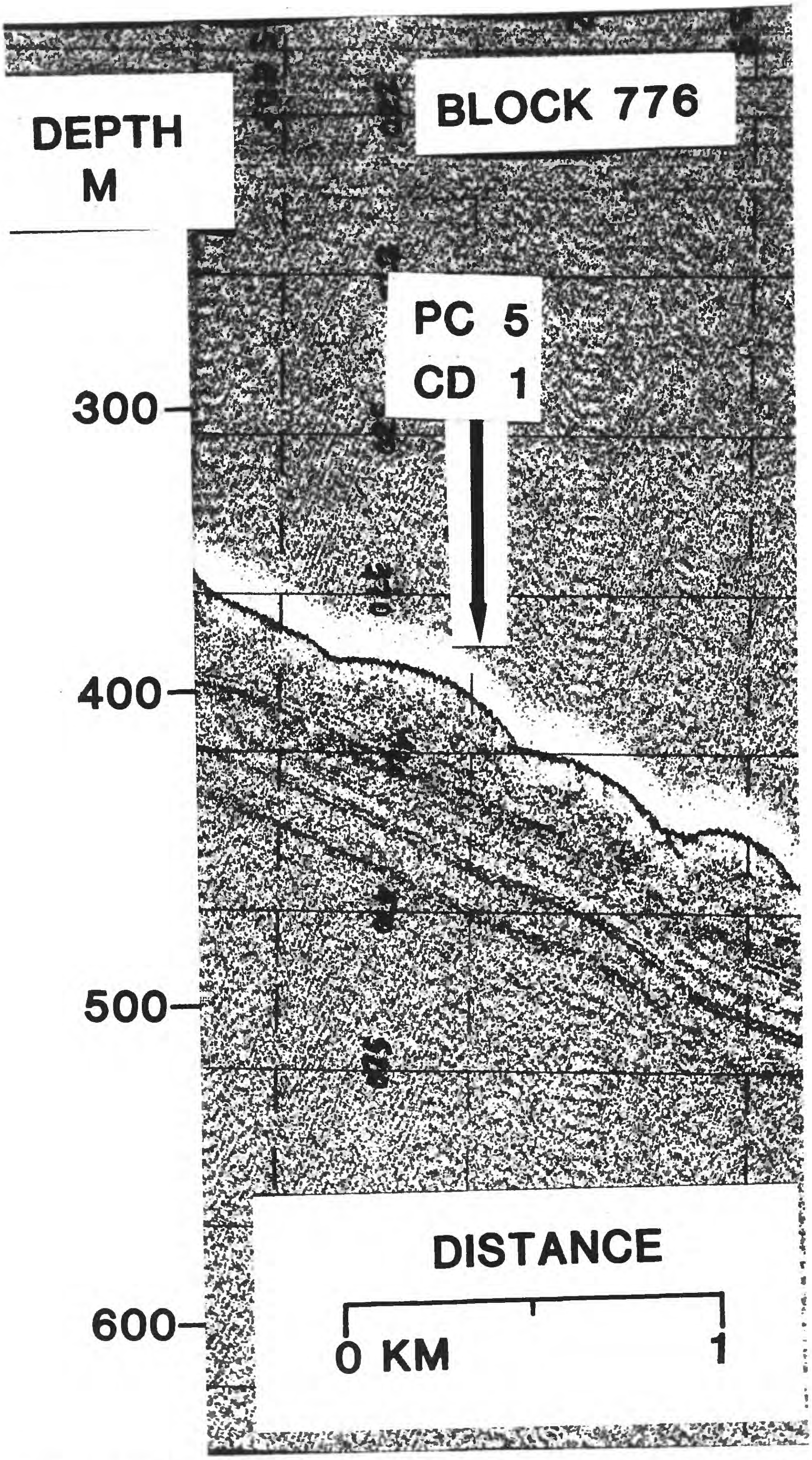

Figure 21. 3.5-kHz profile over core site 5. Location of site is in area 2, figure 1.

on the steep slopes (McGregor and others, 1981; Twichell and Roberts, in press) as well as thinning of layers shown on the profiles so that overconsolidation of sediments is more likely to be found especially in the dendritic gully system. The variability observed on valley walls is to be expected considering the gullied topography (fig. 12). Those sediments removed from the valley walls by mass wasting are deposited in the valley axes, which based on geophysical interpretation must be periodically flushed (e.g., truncation of reflectors at the sea floor). Depending on the recency of sediment movement in the axis and many other factors, the sediments cored could appear to have variable water contents as well as consolidation states.

The morphology is an integral part of interpreting and understanding sea-floor processes and the geotechnical and physical properties of the sea-floor sediments.

ACKNOWLEDGEMENTS

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