7. BATHYMETRY, SEISMIC PROFILES, AND MAGNETIC-ANOMALY PROFILES[1]

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METHODS

Water depth, seismic profiles, and magnetic-anomaly profiles were recorded continuously on Leg 27 while the ship was underway. Water depth was recorded on a Gifft depth recorder calibrated to a sound velocity of 1.463 km/sec (800 fm/sec). The seismic profiling system was as follows:

Sources: two Bolt 600A airguns (a 5-in^3 gun strung 30 m behind the ship and a 30-in^3 gun strung 15 m behind);

Receiver: an eel of 20 MP16-17 hydrophones in series-parallel strung 300 meters behind;

Recorders: two recorders were used. One (Edo 333 B-1) was set with a 10-sec sweep and filters at 80 or 160 to 320 Hz, and the other (Edo 333 C-4) with a 3- or 5-sec sweep and filters at 160 to 320 Hz. The latter sometimes had a delayed trigger.

At the ship's average speed of 17.6 km/h (9.5 knots), the vertical exaggeration of the sea-floor profile was 27:1 on the 10-sec sweep.

The magnetometer was a proton-precession type recording the total geomagnetic-field strength detected by a sensor towed about 200 meters behind the ship. Values from the strip chart were card-punched for computer input. A regional International Geomagnetic Reference Field was removed from the observed values to get the anomaly.

Copies of underway digital data may be obtained at cost by writing directly to the Deep Sea Drilling Project, Scripps Institution of Oceanography, La Jolla, California.

Nomenclature: Physiographic names are from Heezen and Tharp (1966) and Falvey and Veevers (in press). Continental margin reflectors were identified according to the scheme of Veevers et al. (in press, in preparation), and oceanic reflectors according to Veevers et al. (in press). Where these schemes could not be followed, reflectors were simply numbered serially, without implied identifications with reflectors elsewhere along the ship's track.

Illustrations: Figure 1 shows the ship's track in relation to the entire East Indian Ocean (and, incidentally, to part of the tracks of Legs 22, 26, and 28). Figure 2 shows the ship's track in relation to the detailed bathymetry. Figure 3 is a sketch section that summarizes the seismic profiles. Figures 4 to 20 comprise photo copies of the 10-sec-sweep seismic records and charts of the appropriate track, supplemented by the magnetic profiles and line drawings showing the interpretation of the seismic records.

RESULTS AND DISCUSSION

Fremantle to Site 259

The track ran northwestward across the narrow margin of southwest Australia to the continental rise on the eastern side of the Perth Abyssal Plain. Few reflectors were recorded beneath the gently sloping upper slope, steep lower slope (Wallaby-Perth Scarp), and the slope foothills, which are deeply incised with canyons. The obscure basement reflector 3 beneath the rise, identified from Site 259 as oceanic basalt, is overlain by a thick transparent layer, which in turn is overlain by a poorly stratified sequence that includes Reflectors 1 and 2. Site 259 is within a slightly elevated area floored by basalt overlain by a transparent sediment which was shown by drilling to be Lower Cretaceous and upper Paleocene to lower Eocene clay and minor ooze.

Magnetic anomalies over the continental slope foothills and the continental rise as far as Site 259 have not been analyzed. Site 259 itself appears to be in a region of low magnetic anomalies with little spatial coherence. To the immediate southwest of Site 259 anomalies strike southwest-northeast (60° east of north) and thus, this site is on an extrapolation of that trend.

Site 259 to Site 260

The track ran along the foot of the continental rise and slope, across the easternmost part of the Wallaby Plateaus, then across the Cuvier Abyssal Plain, and obliquely across the slope foothills of the Exmouth Plateau and continental rise to the Gascoyne Abyssal Plain.

Continental Rise

Reflector 3, with the character of oceanic basalt, appears near the edge of the continental rise (2000-2300Z hr, 7 Nov), but the rest of the rise almost lacks reflectors.

The low magnetic relief across this section of continental rise is apparently of some regional extent since this low relief was also seen on the adjacent *Glomar Challenger* track 160 km (100 miles) to the northeast (about 1200Z, 7 Dec to 0000Z, 8 Dec). The area that is free of subbottom reflectors coincides with the area of

[1]Woods Hole Oceanographic Institution Contribution No. 3197.

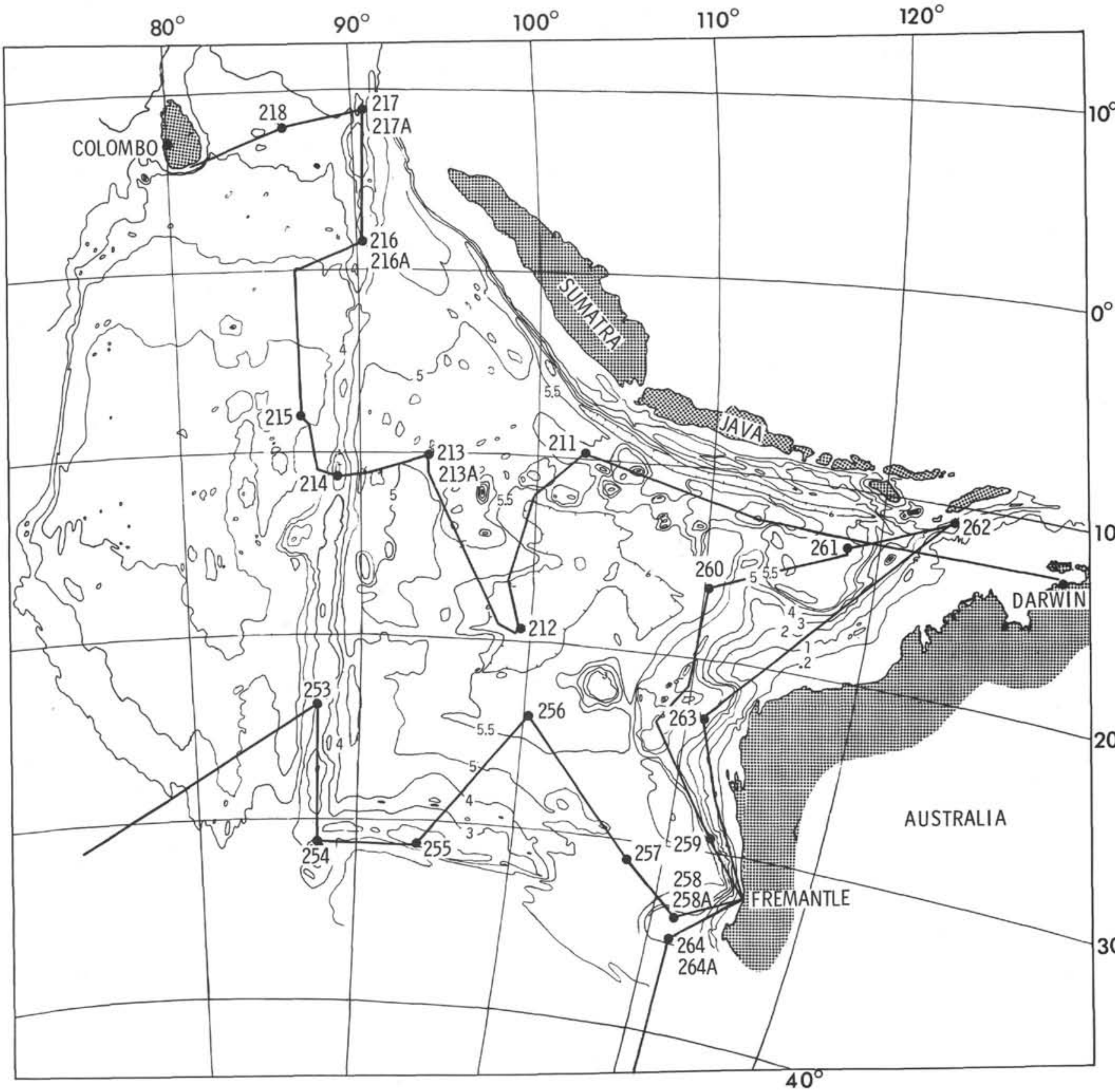

Figure 1. *DSDP Legs 22, 26, 27, and 28 tracks on morphological base traced by John Veevers from Russian map. Depths in km.*

low magnetic relief—both features being characteristic of undisturbed oceanic crust.

The Wallaby-Perth Scarp (see at 2330Z, 7 Nov) marks the boundary between the presumed oceanic continental rise and the lower continental slope and adjacent Wallaby Plateaus. The continuity of relectors of identical character from the lower slope through the Wallaby Plateaus indicates a common development of these provinces during the Cretaceous, when, from comparison with the acoustic stratigraphy of the Exmouth Plateau, the basement Reflector 4 of this region was formed.

Wallaby Plateaus

Heezen and Tharp (1965, 1966) mapped the Wallaby Plateaus (formerly the "West Australian Ridge" of Vening Meinesz [1948]) as three plateaus that lie off Western Australia between latitudes 21°S and 26°S. The Wallaby Plateaus shallow to 2200 meters and are separated from the continental margin by a trough just shallower than 4000 meters (Falvey and Veevers, in press), seen at 1600 to 1700Z, 8 November. Only the easternmost plateau was crossed on this track, and it comprises a summit that rises above flanking terraces. On this plateau and the adjacent slope, acoustic basement (4) lies between 0.2 and 0.6 sec beneath the sea floor, and, as mentioned above, has a similar character to the acoustic basement of the Exmouth Plateau (Reflector 4 [R4] of Veevers et al. [in press]). Besides giving a strong reflection, this reflector is locally cut by numerous faults, seen best between 1700 and 2000Z, 8 November. The overlying sequence is clearly subdivided by four laterally continuous reflectors, among which two reflectors, 2 and 3, have a similar position and character as R2 and R3 of the Exmouth Plateau. The sediments between the reflectors are poorly stratified. The overlying sequence is generally draped over the acoustic basement, but abuts it where the basement has exceptional relief, as seen between 2200 and 2300Z, 8 November, and immediately to the northwest, on the steep southeast flank of the summit. A remarkable feature is the long northern slope of the plateau, which descends, without visible structural change, to within 200 meters of the floor of the Cuvier Abyssal Plain. The low scarp at the edge of the abyssal plain is possibly a fracture zone.

The magnetic field shows few anomalies over the eastern Wallaby Plateau summit when the basement appeared to be without faults. However, from the Wallaby-Perth scarp until the summit (seen from 2300Z, 7 Nov to 2300Z, 8 Nov) and over the north flank and lower terrace (0430-1400Z, 9 Nov) magnetic anomalies suggest basement faulting, again supporting the seismic-profile results. The apparently large negative anomaly seen at 0500Z, 9 November may be mostly an artifact since the ship altered course at that time.

Cuvier Abyssal Plain

The Cuvier Abyssal Plain is underlain by an almost transparent layer, 0.1 - to 0.4-sec thick, bounded by acoustic basement (Reflector 3) and Reflector 2, which marks the base of a finely stratified ponded sequence that extends up to the sea floor. Relief in Reflector 3 is generally paralleled by Reflector 2, and Reflector 2 has, in places, a ragged outline that seems to indicate incipient diapirism. Between 2200Z, 9 November, and 0000Z, 10 November, a wedge of transparent sediment was shown to be overlain by a low mound on the surface of the otherwise flat plain.

The long-wavelength magnetic anomalies found here over the Cuvier Abyssal Plain are characteristic of many relatively undisturbed abyssal plains of old sea floor.

Slope Foothills and Continental Rise

A steep scarp (the Northwest Cape Fracture Zone) separates the slope foothills of the Exmouth Plateau from the Cuvier Abyssal Plain. The slope foothills pass northward into a long continental rise whose acoustic basement (Reflector 4) and an overlying transparent layer continue beneath the Gascoyne Abyssal Plain. At Site 260, acoustic basement (Reflector 4) was found to be basalt (probably a sill), the transparent layer (between Reflectors 2 and 4) was found to be Cretaceous ooze and clay, and a well-stratified surface layer was found to be Cenozoic turbidites. As found elsewhere in the region, the Cretaceous sediment parallels the basalt basement, except in places of high relief, and the turbidites are ponded above the Cretaceous sediments. The apparent thinning of the transparent layer from the top of the rise seen at 0600Z, 10 Nov) to the abyssal plain may indicate the position of ancient lysoclines within this range.

The Exmouth Plateau is characterized by an absence of magnetic anomalies. However, it is seen here, that the slope foothills of the Exmouth Plateau have minor anomalies of less than about 100 gammas. The origin of the distinct 300-gamma negative anomaly, seen at 1300Z, 10 November, over the continental rise cannot yet be explained. Anomalies to the immediate south of Site 260 are likely part of the northeast-southwest trending anomalies of the Argo and Gascoyne Abyssal Plains, identified by Falvey (1972). Site 260 was selected to be on a magnetic anomaly thought to be anomaly 31. The profile shows the ship stopped at the positive peak of that anomaly.

Site 260 to Site 261

After crossing the eastern part of the Gascoyne Abyssal Plain, the track traversed a broad complex of slope foothills with a steep eastern flank and then the Argo Abyssal Plain.

Gascoyne Abyssal Plain

The sequence in the northeast Gascoyne Abyssal Plain is essentially the same as that traversed between Sites 259 and 260. The plain terminates against a ridge at the base of a region of slope foothills.

Slope Foothills

A complex of slope foothills nearly 350 km wide lies off the northwest tip of the Exmouth Plateau. This complex is divisible into three parts: (1) the northwest tip of the Exmouth Plateau (seen from 1800Z, 14 Nov to 0400Z, 15 Nov), with local areas of reflective section to a depth of 0.5 sec, and cut by a probable fracture zone seen at 2230Z, 14 November; (2) a valley at a depth of 5100 meters, (seen at 0400Z to 0700Z, 15 Nov), with pockets of thin transparent sediment and a large negative magnetic anomaly, and bounded on the east by a fracture zone: and (3) a group of ridges that reaches to within 3000 meters of sea level, again with pockets of thin transparent sediment. The eastern flank of these ridges is a probable fracture zone, and it descends with a uniform gradient of 13° through 2700 meters to the Argo Abyssal Plain in a distance of 11 km. Magnetic anomalies over the slope foothills appear to be related to the rugged sea-floor topography.

Figure 2. *D/V* Glomar Challenger *Leg 27 ship track in relation to detailed bathymetry. Date-time in GMT.*

Figure 2. *(Continued).*

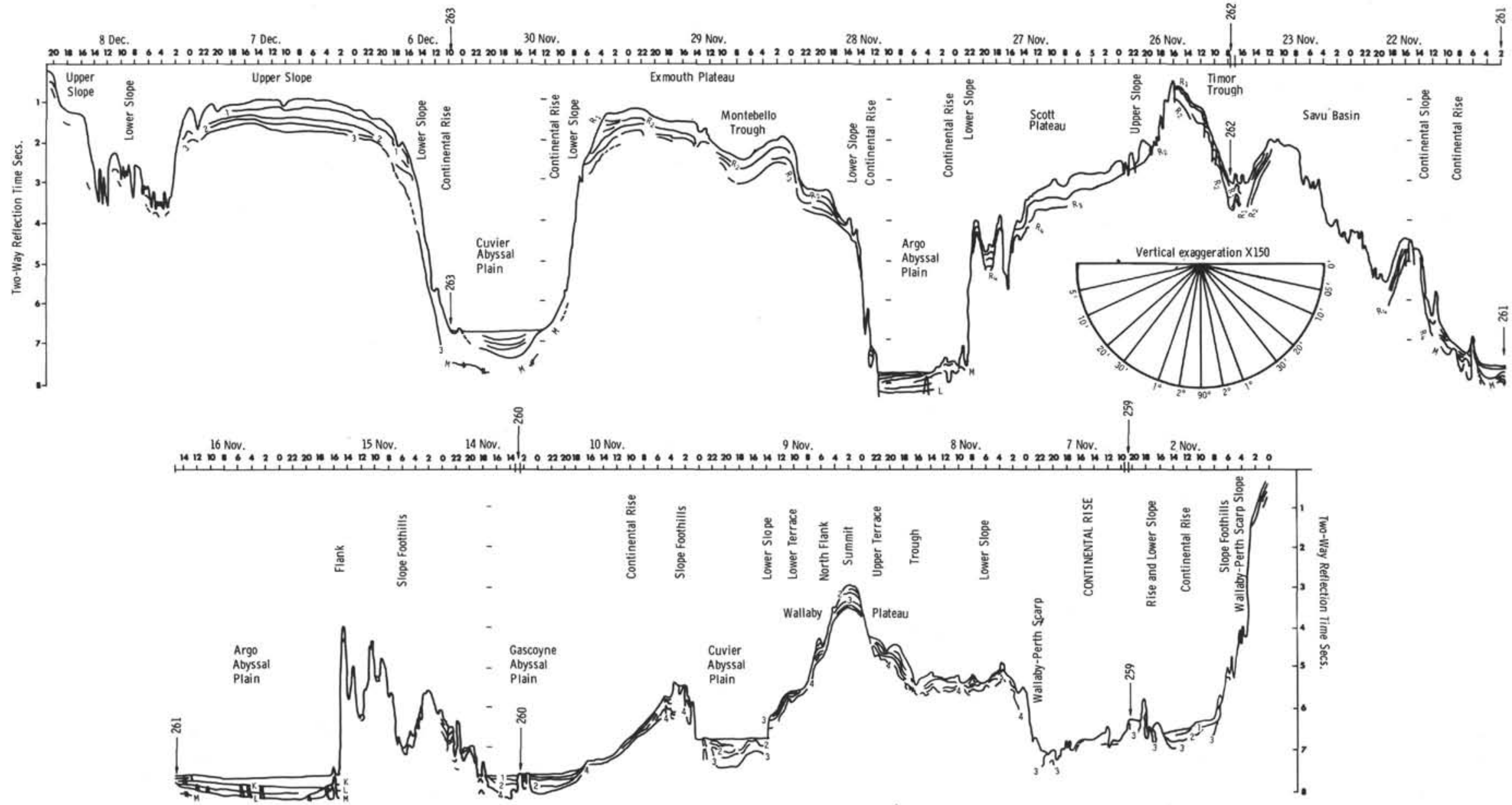

Figure 3. *Sketch section summarizing the subsurface inferred from* Glomar Challenger *profiles. Date-time in GMT.*

Argo Abyssal Plain

Along this traverse, the Argo Abyssal Plain has a central area at a depth of 5700 meters (seen at 0300-1300Z, 16 Nov), and margins 100 meters higher. The only protrusion above the plain is a sediment cap over acoustic basement seen at 1720Z, 15 November. This, and an area seen about 0800Z, 16 November are the only places that show reflector M (Veevers et al., in press) until Site 261 is approached. The interpretation of Lamont-Doherty seismic profiles (Veevers et al., in press) identified three key reflectors, termed K, L, and M, and these are identified here. In the *Glomar Challenger* records, M is acoustic basement and L is the top of an almost transparent layer that is draped over basement. Between L and the sea floor is a well-stratified horizontal layer, within which Reflector K is traceable. The transparent layer is up to 0.5 sec thick, and the well-stratified layer 0.7 sec thick. Protrusions into the well-stratified layer, either cylinders or sheets, are most common in the middle of the plain and seem to originate in the transparent layer. A thin, transparent surface layer, 0.06 sec thick above Reflector I, first appeared at 1330Z, 16 November, and extended past Site 261. Its edge coincides with the 5700-meter contour.

Falvey's (1972) correlation of magnetic anomalies from HMAS *Moresby* profiles can be supported by other profiles in the area, such as those of the *Umitaka Maru* (Tomada and Ozawa, 1966). This correlation shows magnetic lineations that should approximately parallel the track of *Glomar Challenger* over the Argo Abyssal Plain between Sites 260 and 261. Anomalies appear to have a longer wavelength along the track to the northeast than at right angles to that direction. However, anomalies are still of finite amplitude, suggesting that the magnetic grain is not entirely two-dimensional and/or the ship's track did not exactly parallel the strike of the magnetic bodies.

The drilling at Site 261 showed that the surface transparent layer is siliceous ooze, the well-stratified layer is Cenozoic ooze and clay, the deep transparent layer is Cretaceous and Upper Jurassic claystone, and Reflector M is a 10-meter-thick basalt sill that lies between the oldest sediment above and oceanic basalt below. The cylinders or sheets of transparent material in the well-stratified layer are interpreted as piercement structures of claystone squeezed up from the transparent layer, though the possibility remains that some are due to the effect of seismic scattering (Collette and Rutten, 1970). Vague reflectors within the transparent layer are probably due to subtle changes in lithification in the clay.

Site 261 to Site 262

Argo Abyssal Plain

In that part of the Argo Abyssal Plain northeast of Site 261, the surface transparent layer (above Reflector I) thickens, with shallowing sea floor, to 0.1 sec at the edge of the plain. At 0340Z, 22 November the sea floor is seen to be very slightly raised above a presumed piercement structure. The other principal layers continue as before.

Continental Rise

The continental rise extends 130 km along the track to a depth of 4600 meters. Its outline is smooth except for a ridge (presumably a fracture zone) at its lower end and a spur at its upper end. The seismic profile is interpretable in terms of the profile of the Argo Abyssal Plain. The surface transparent layer above Reflector I thickens to 0.2 sec, the layer between I and L becomes less coherent, and the transparent layer between L and M becomes thinner.

The magnetic characteristics are similar to those of the Argo Abyssal Plain. Of the two apparent seamounts crossed at 0530Z and 1100Z on 22 November, the first showed no magnetic effect, but the second (possibly because it is less deep) produces a negative anomaly of approximately 200 gammas.

Continental Slope

Between 1200Z and 1900Z, 22 November, between two probable fracture zones, the track crossed a spur of the Scott Plateau, which has a seismic character quite different from that of the rise and abyssal plain to the southwest and from that of the Savu Basin to the northeast. The southwest flank has a fairly transparent surface layer, up to 0.35 sec thick, overlying an apparently faulted acoustic basement, tentatively identified as R4 of Veevers et al. (in press). The northeast flank has, additionally, a semitransparent layer, up to 0.3 sec thick, between acoustic basement and the surface transparent layer. The near continuity of R4 and Reflector M, seen between 1100Z and 1200Z, 22 November, is a common occurrence along the west Australian margin. The magnetic field has small irregular anomalies seemingly controlled by basement topography.

Savu Basin

The floor of the Savu Basin is ponded at 4100 meters, and rises eastnortheastward to a depth of 1400 meters near the western sill of the Timor Trough. Only a few pockets of sediments are visible outside those of the ponded floor, and the sea floor is characteristically shaped in overlapping rounded hillocks, 2 to 3 km across and 150 meters high, in the style of abyssal hills. Seen between 0800Z and 1200Z, 23 November, the sea floor flattens out at about 1400 meters, just above the western sill of the Timor Trough at 1800 meters. The area is relatively free of magnetic anomalies.

Timor Trough

The track crossed obliquely the lower part of the Australian flank of the Timor Trough, and, in the vicinity of Site 262, the trough axis and foot of the Timor flank. Since the outgoing track from Site 262 covered similar ground, the description of the Timor Trough is covered in the next section.

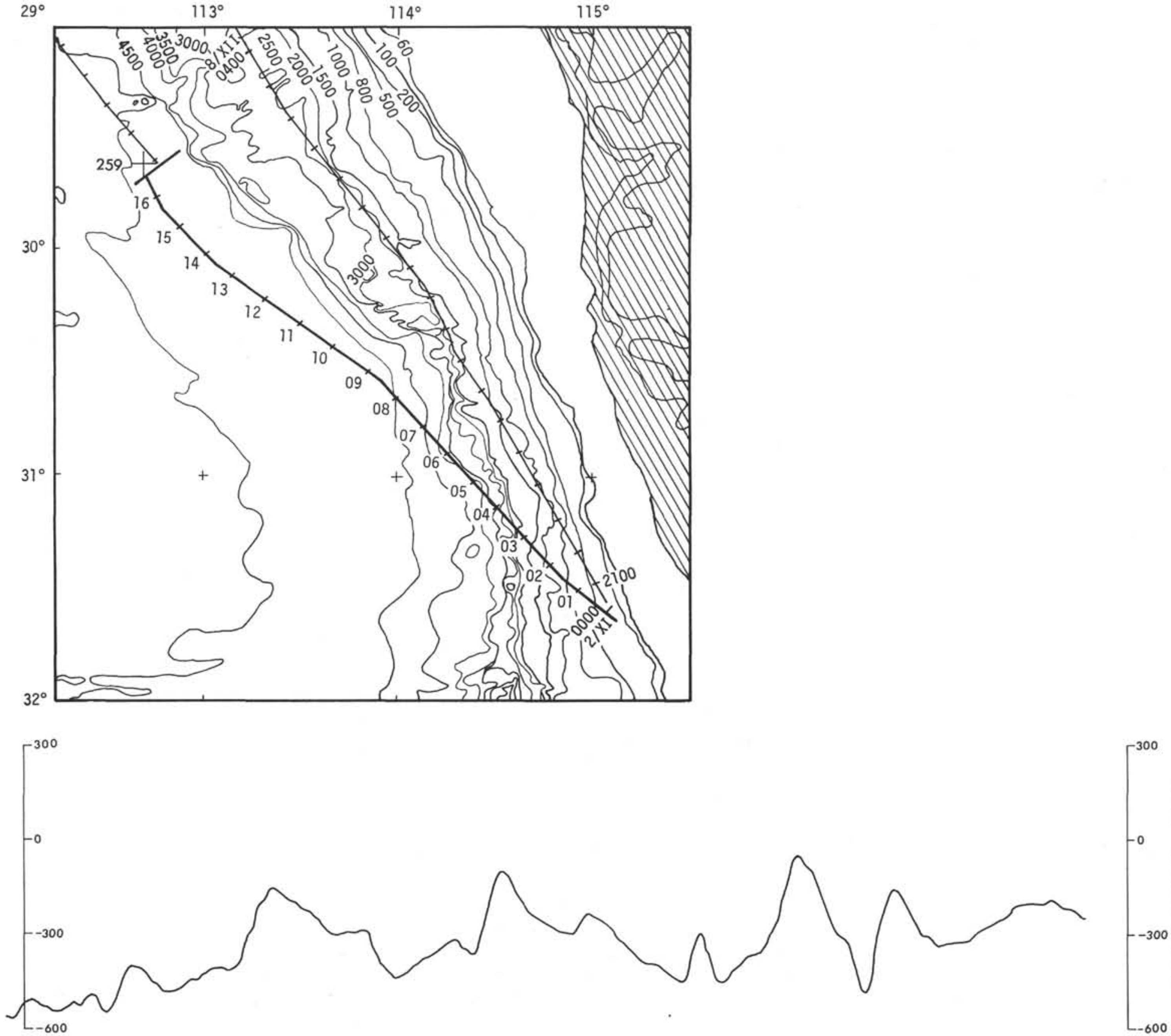

Figure 4. *Underway geophysical data, D/V* Glomar Challenger, *Leg 27. See base maps, Figures 1 and 2.*

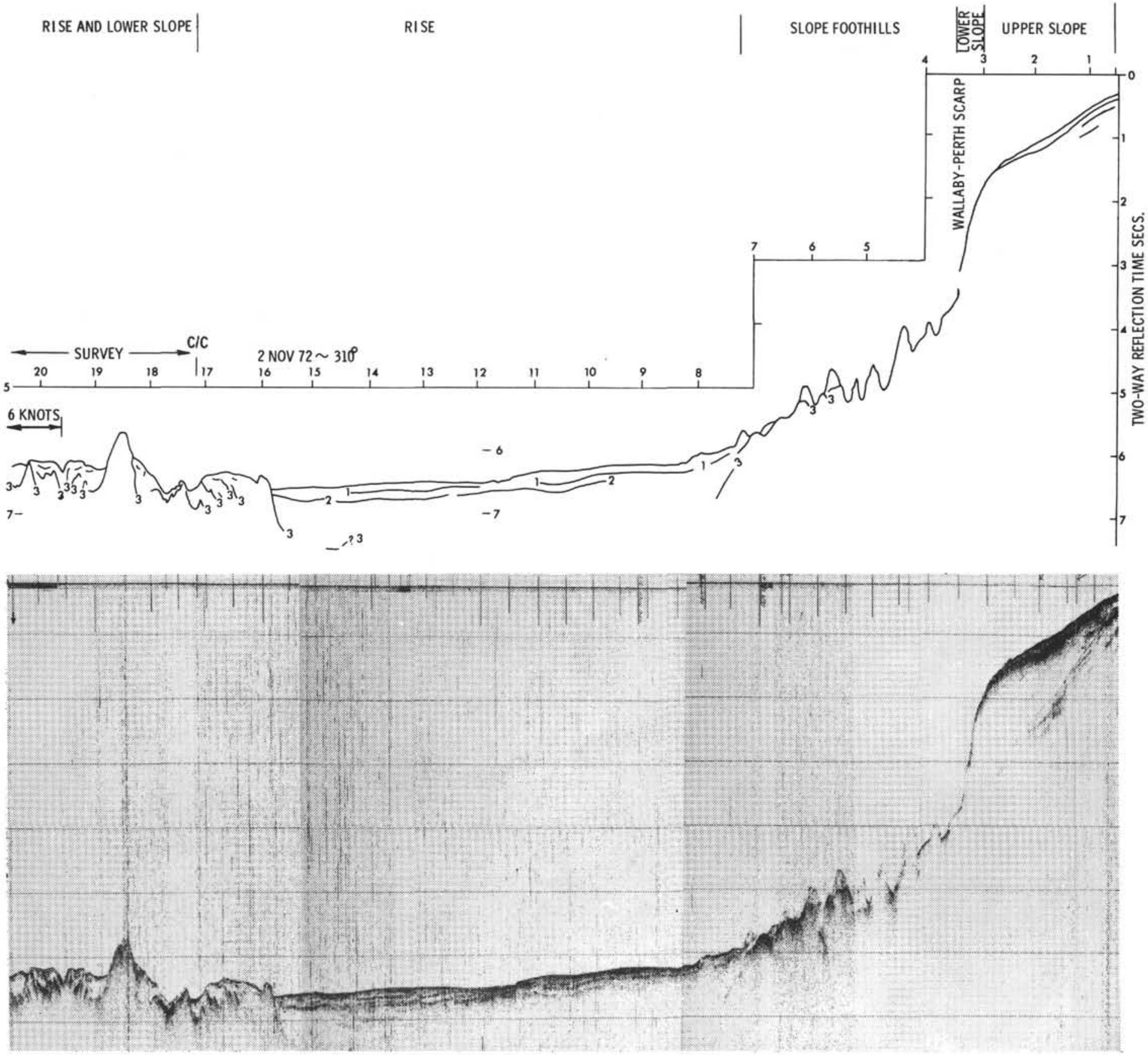

Figure 4. *(Continued)*.

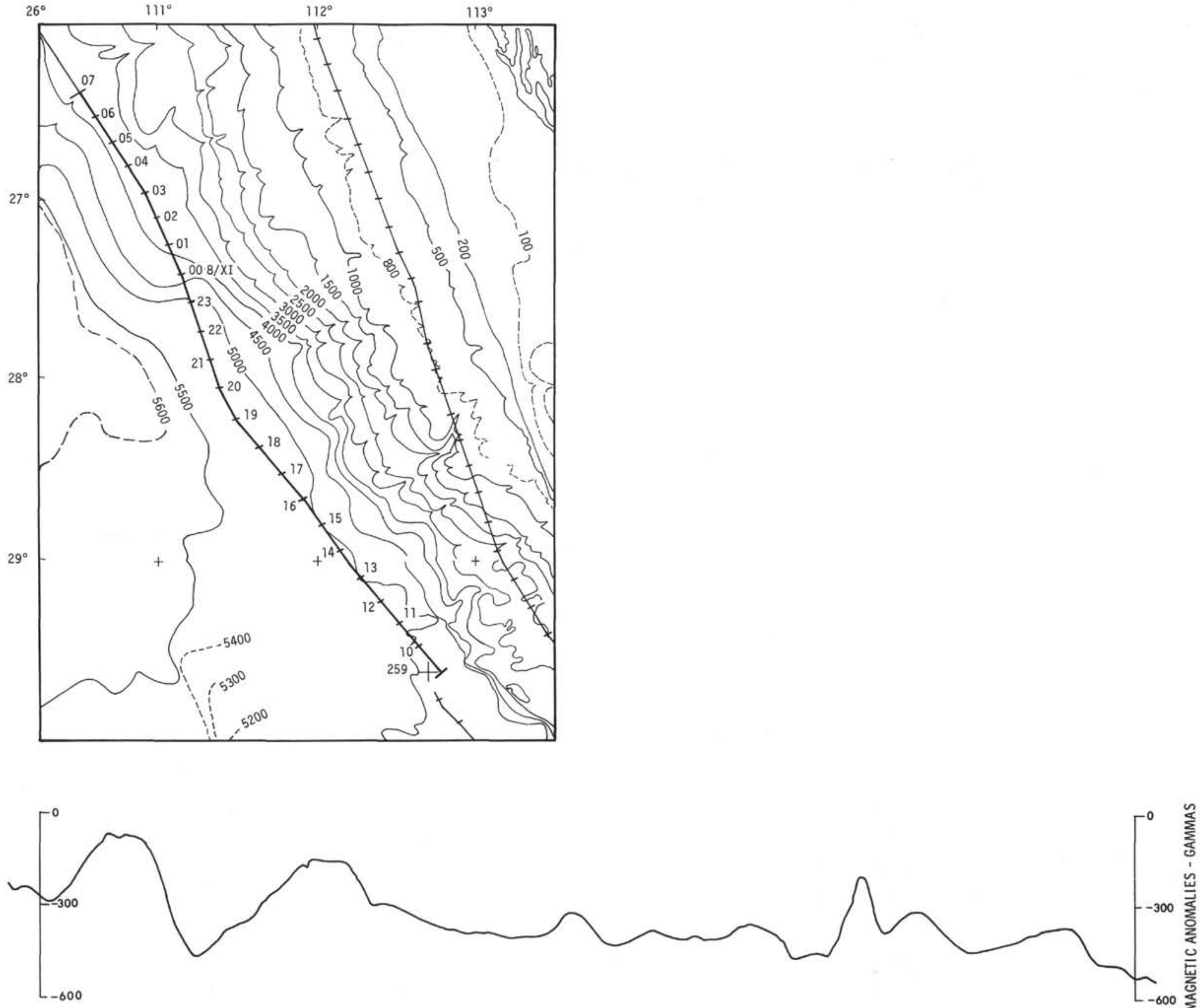

Figure 5. *Underway geophysical data, D/V* Glomar Challenger, *Leg 27. See base maps, Figures 1 and 2.*

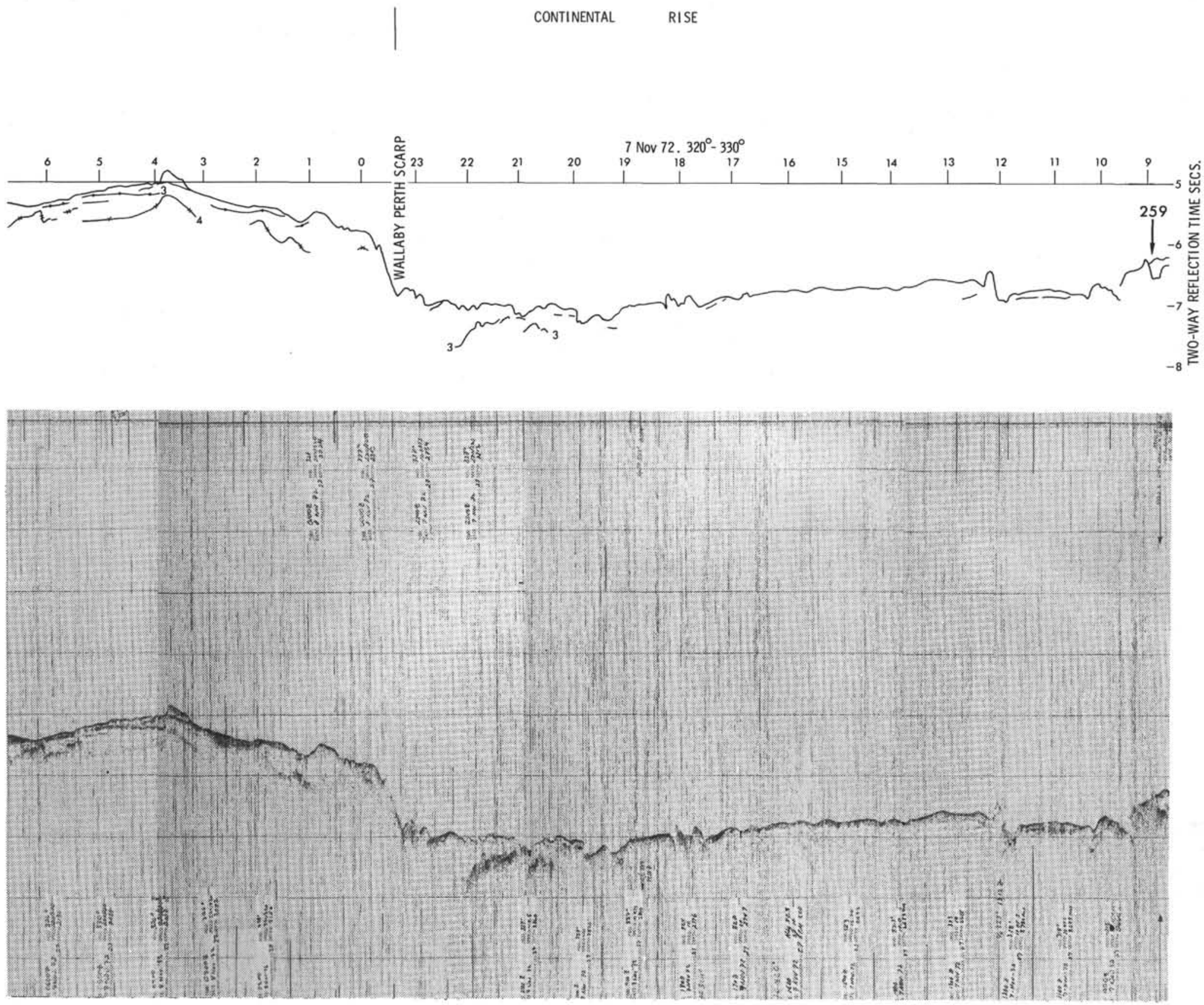

Figure 5. *(Continued).*

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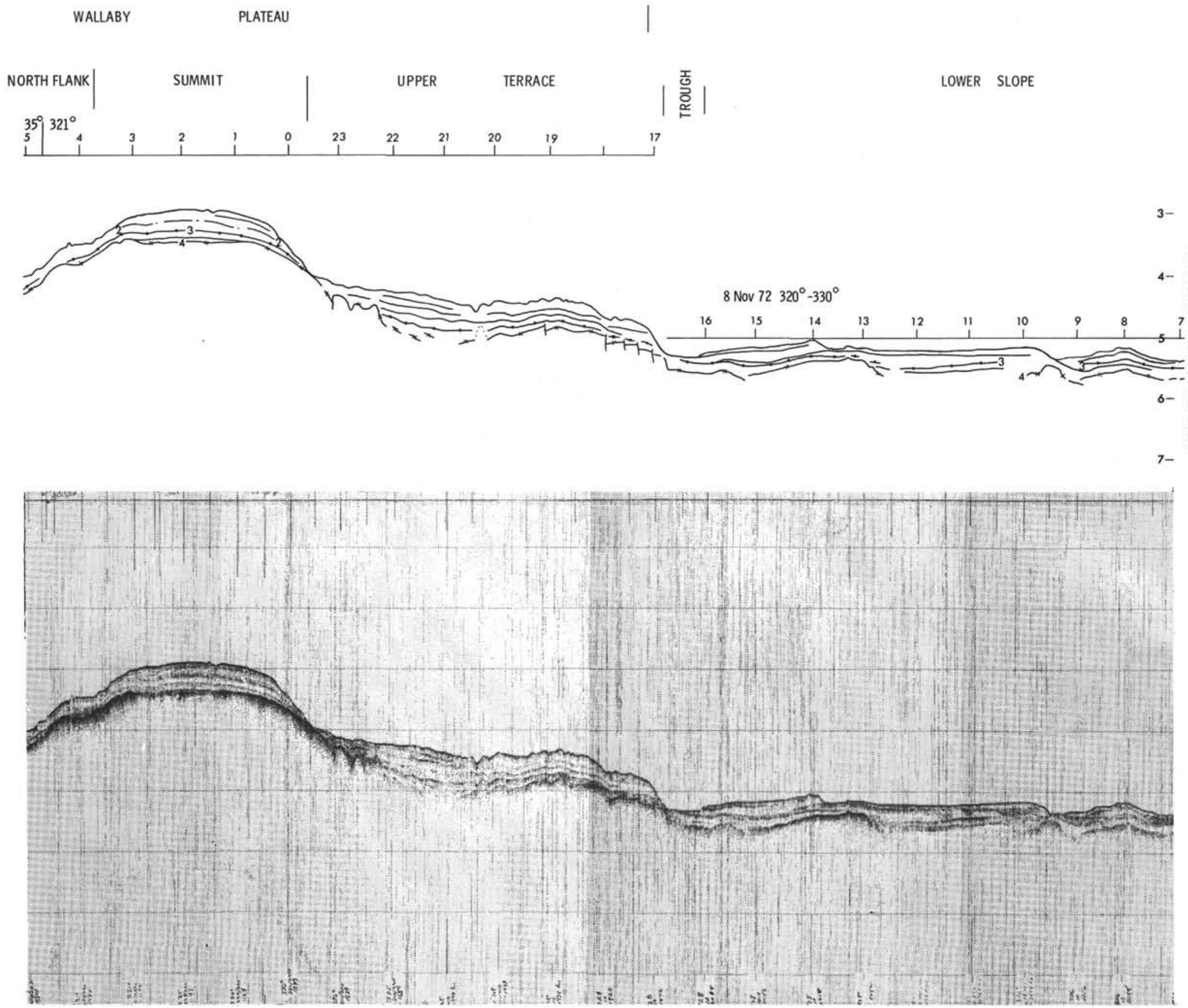

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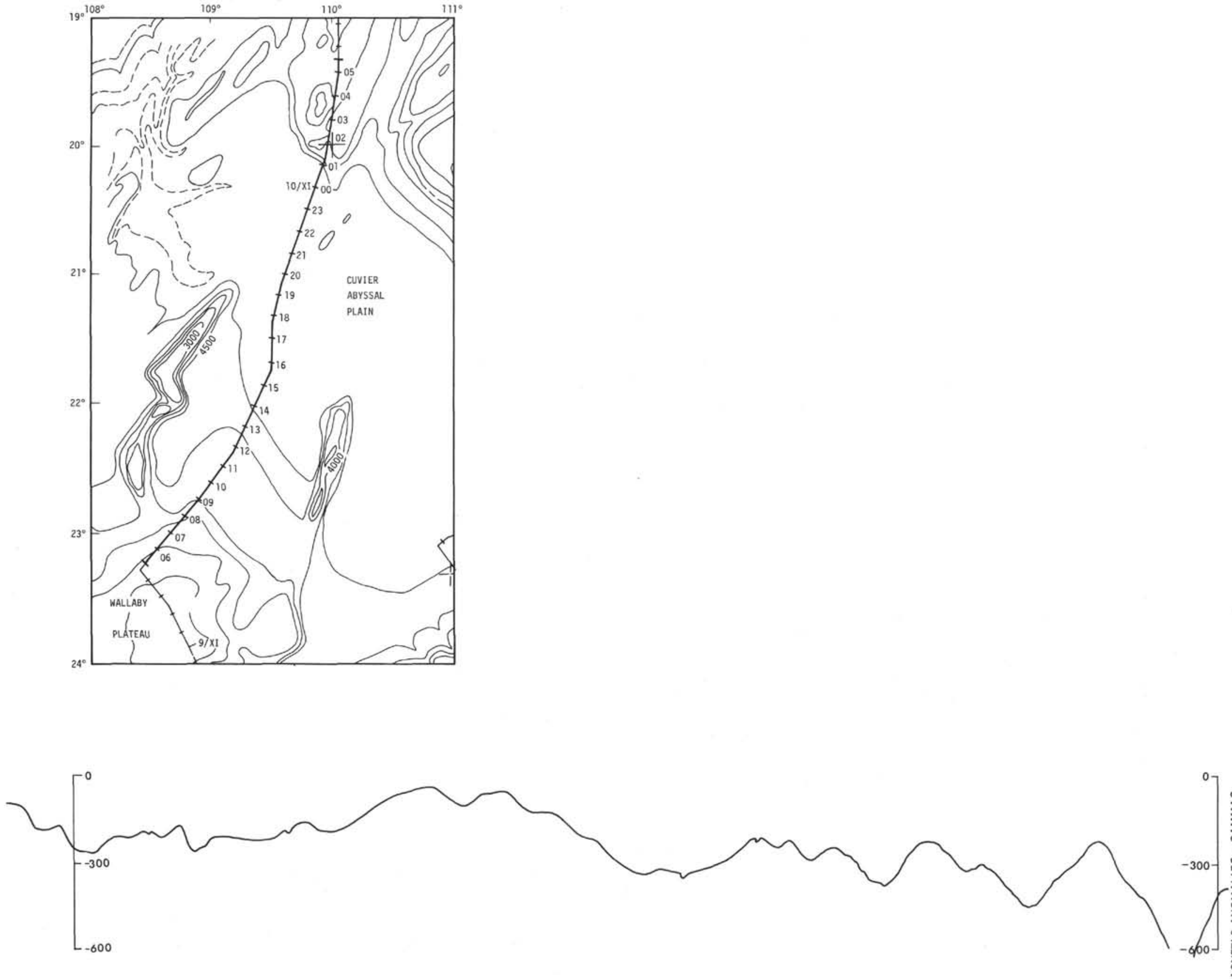

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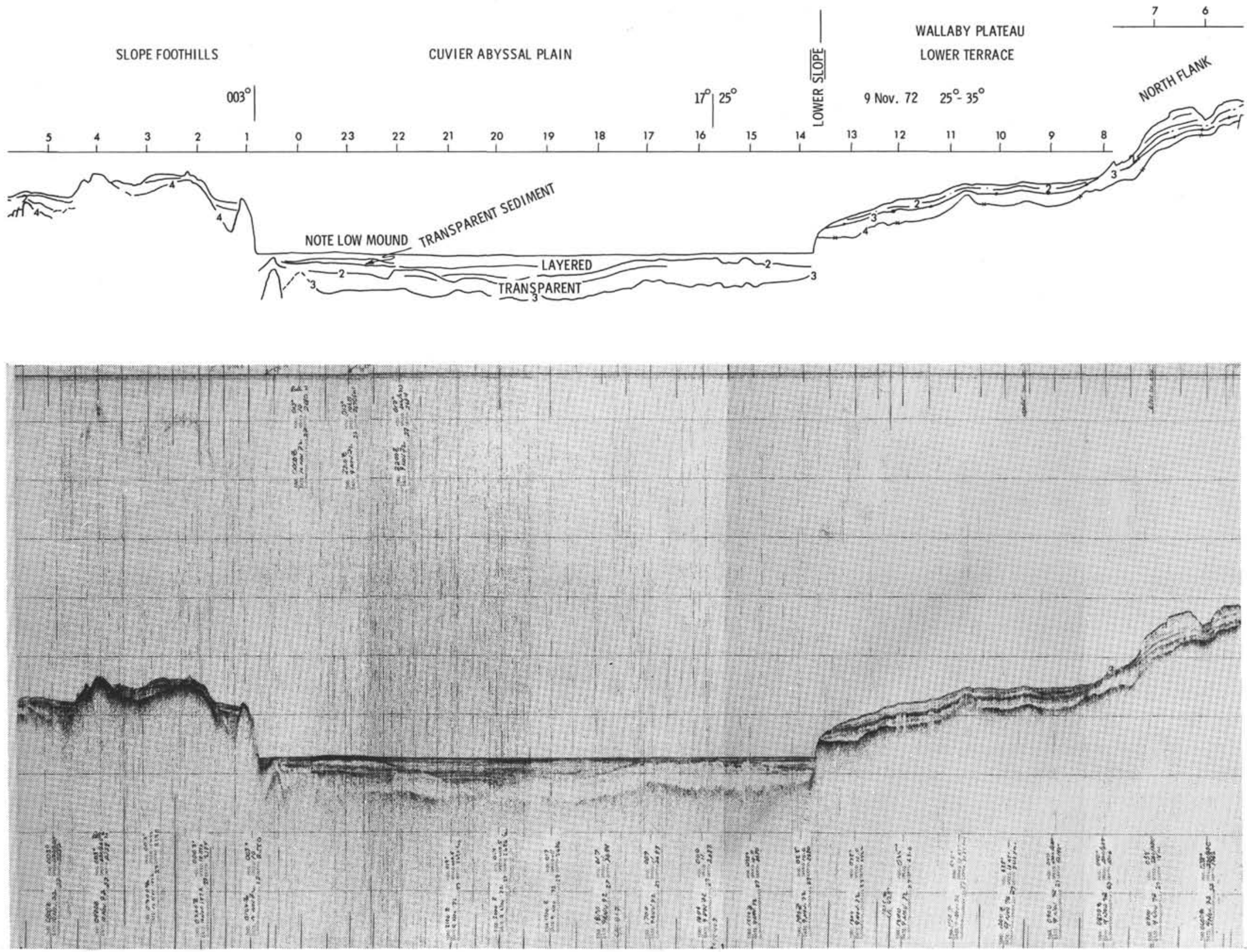

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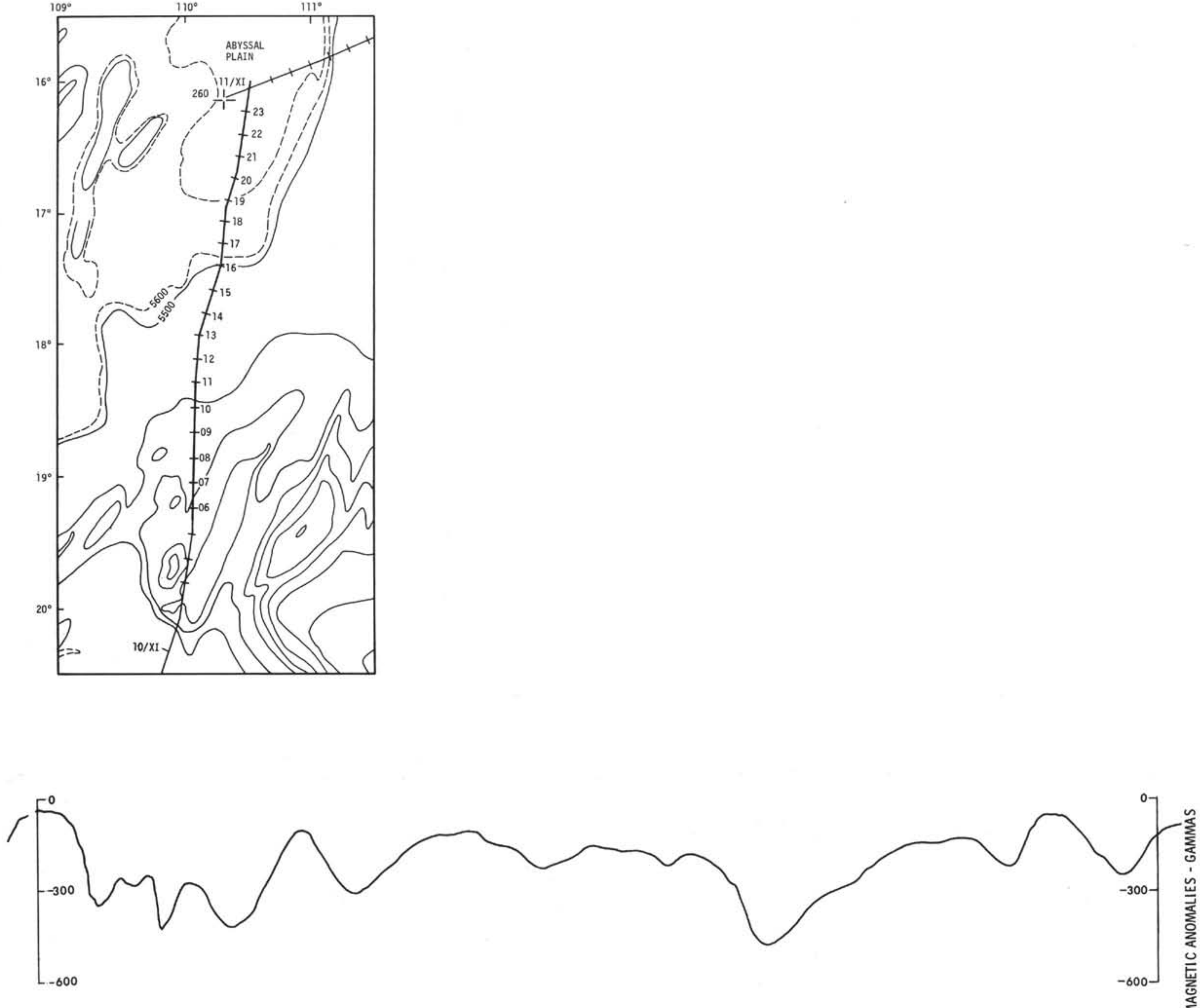

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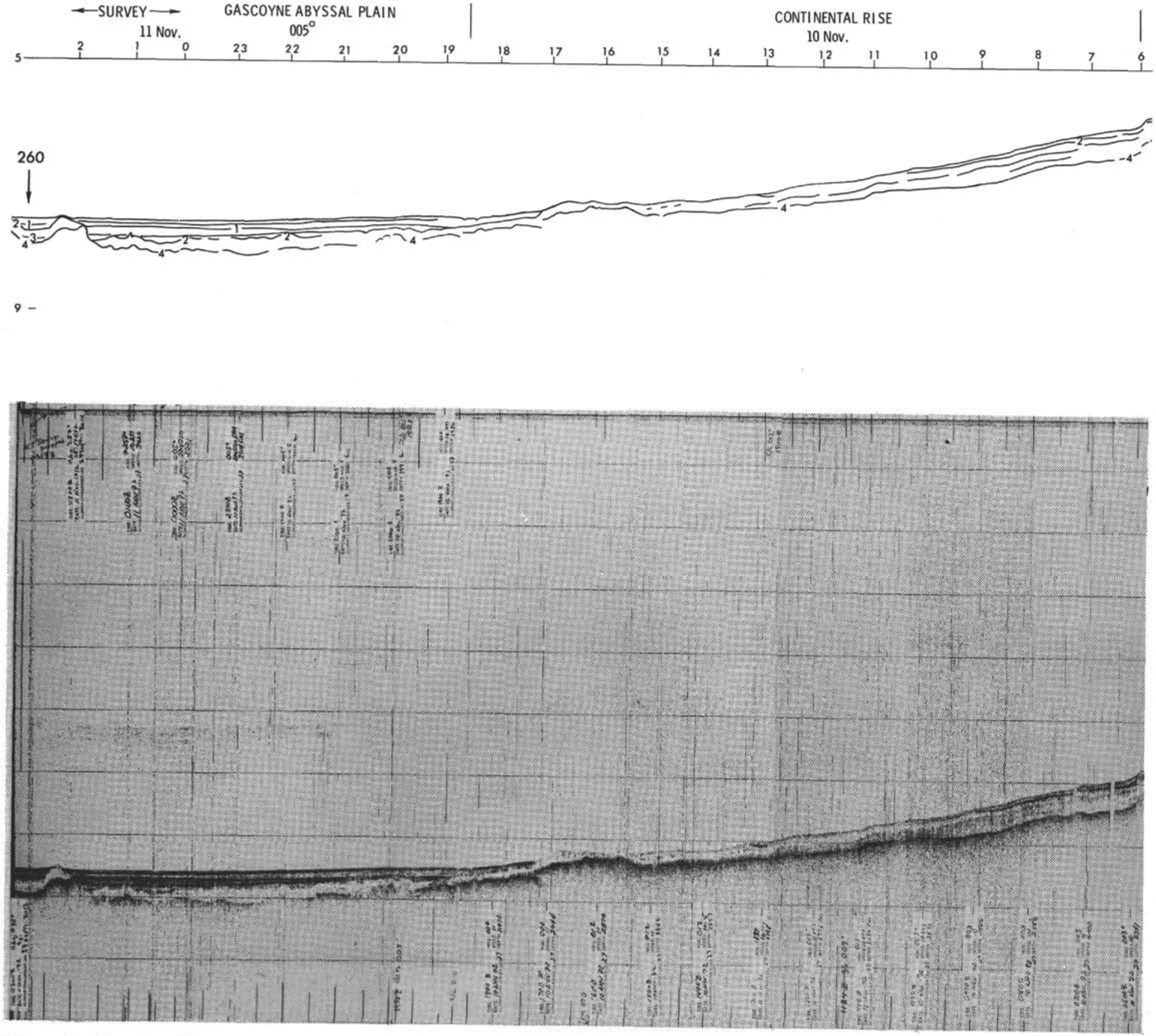

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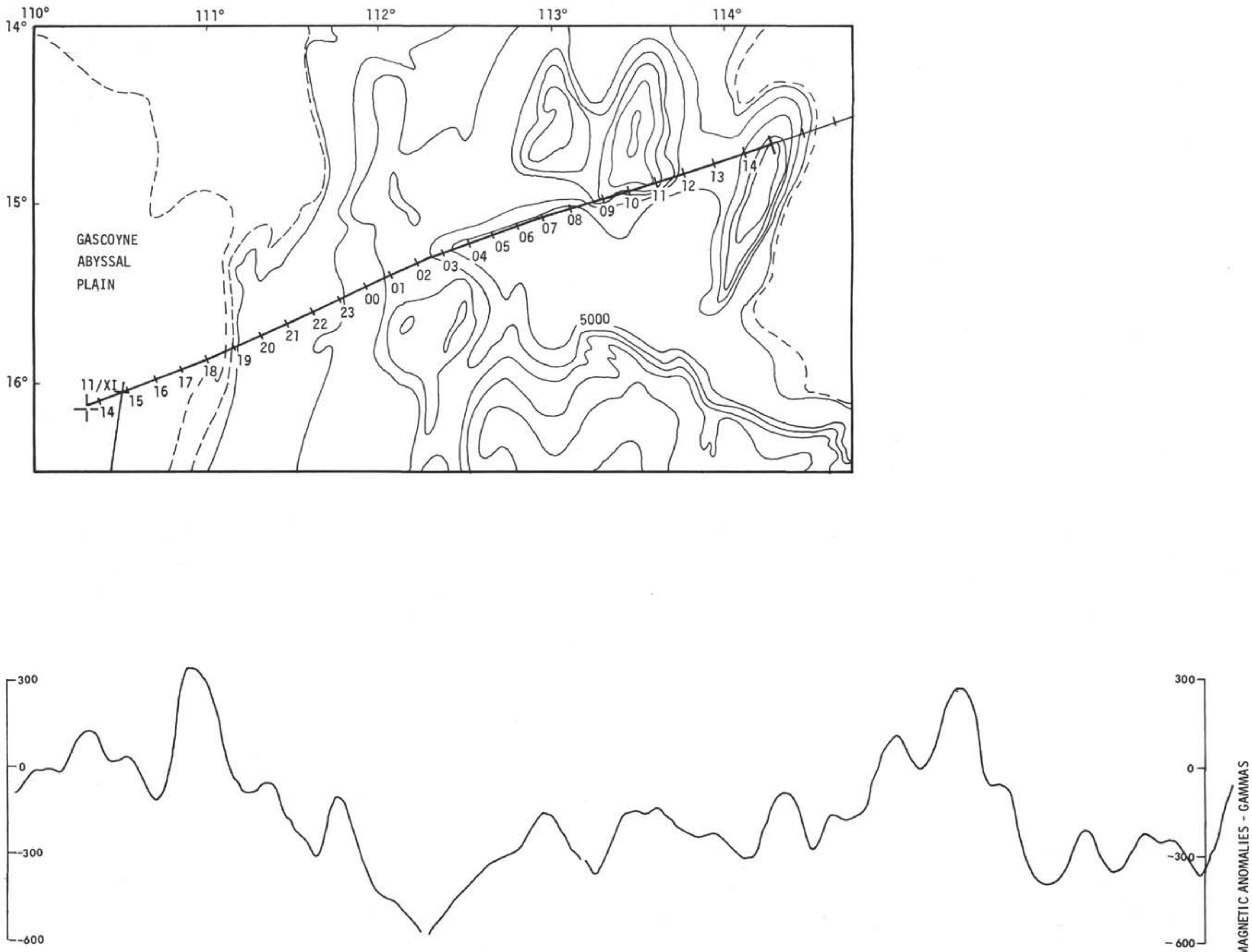

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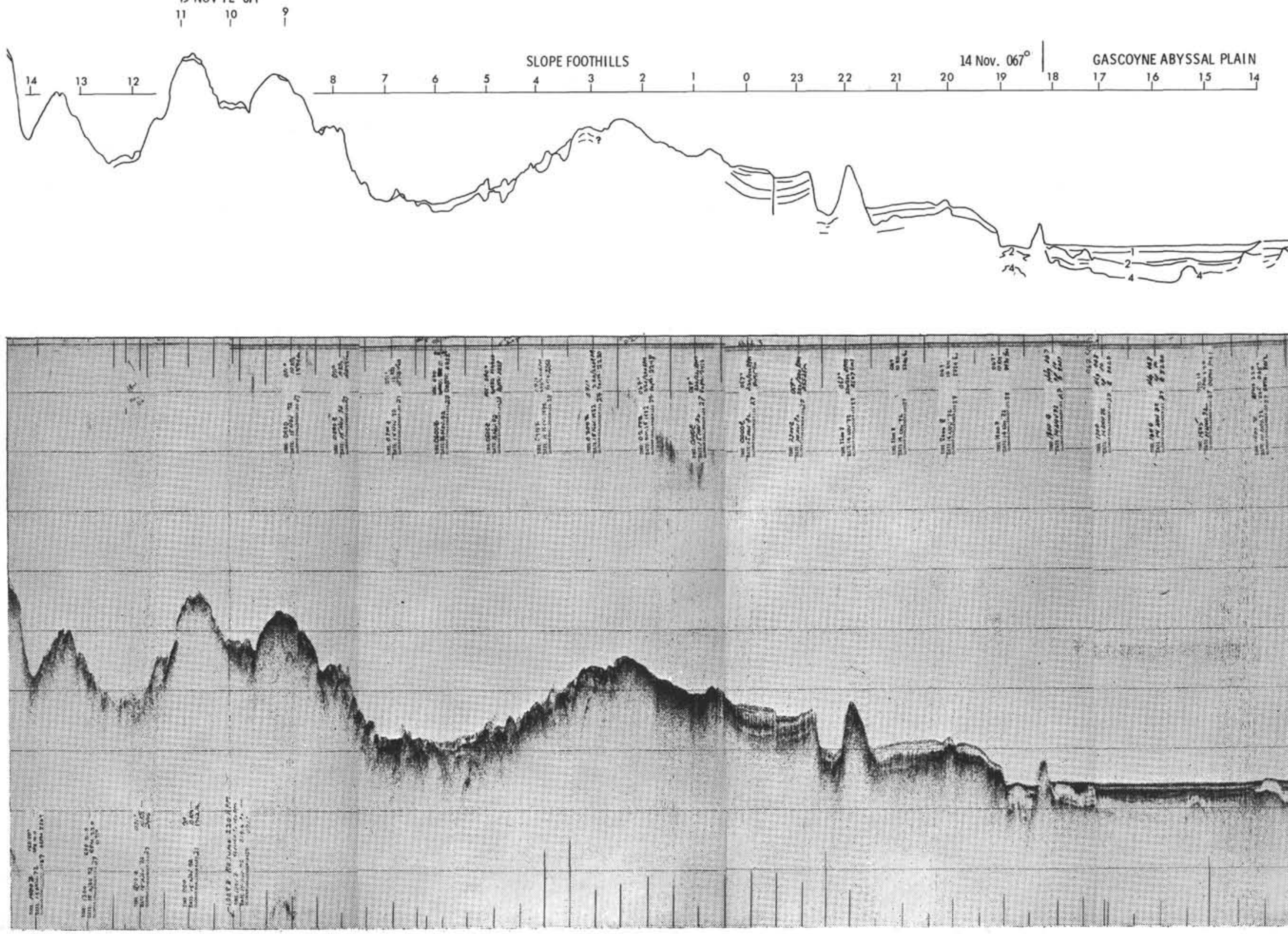

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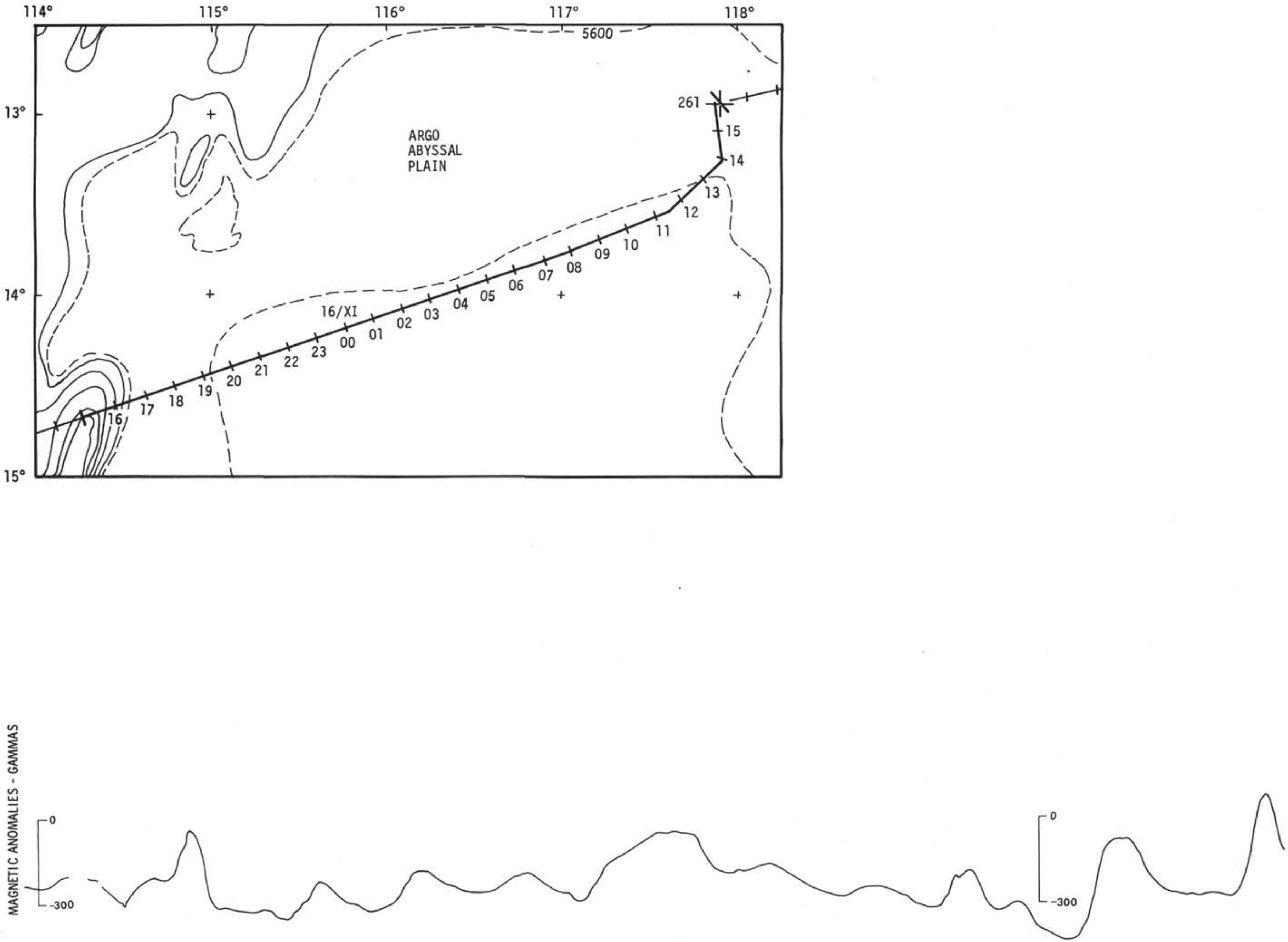
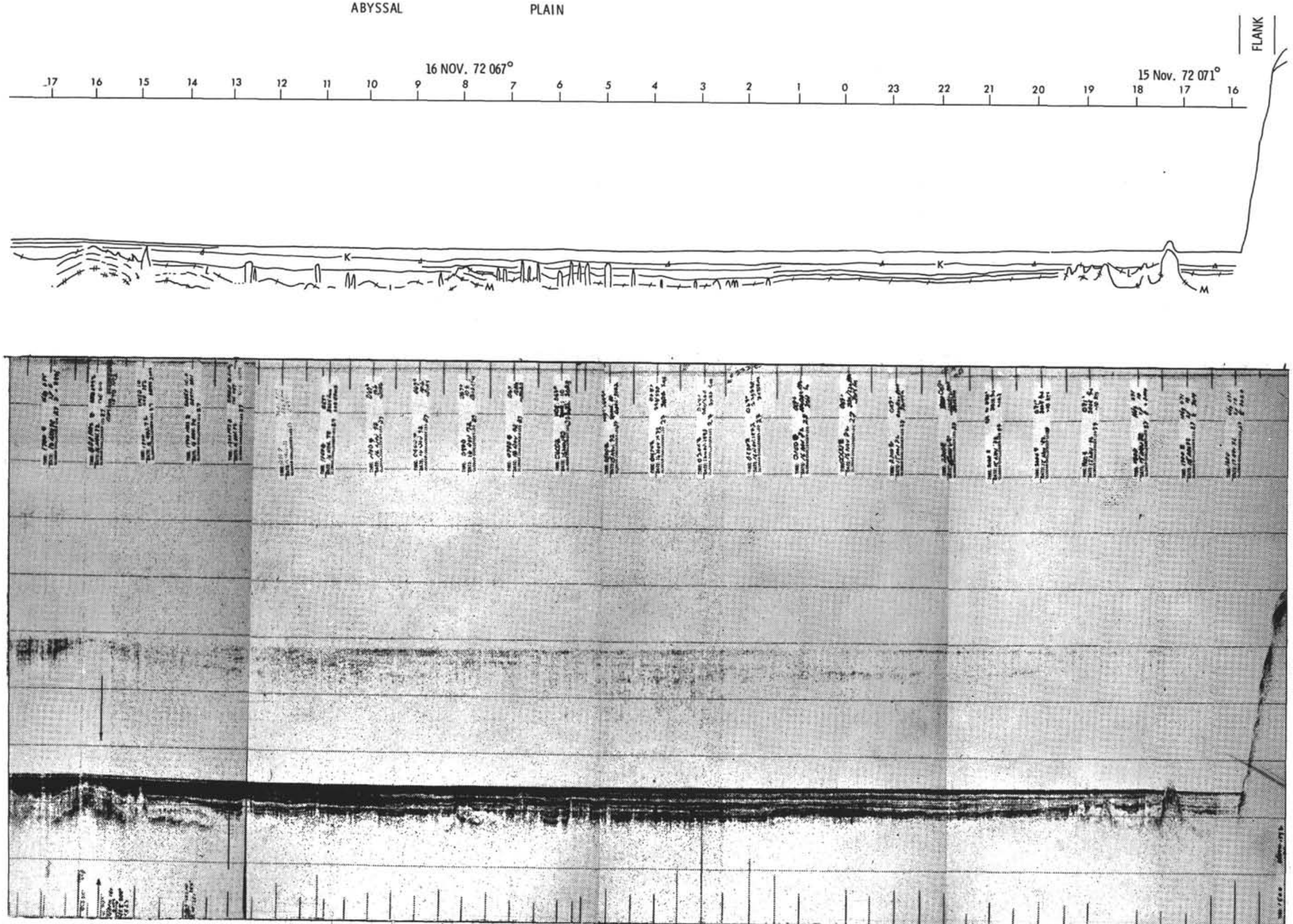


Figure 10. *Underway geophysical data, D/V* Glomar Challenger, *Leg 27. See base maps, Figures 1 and 2.*



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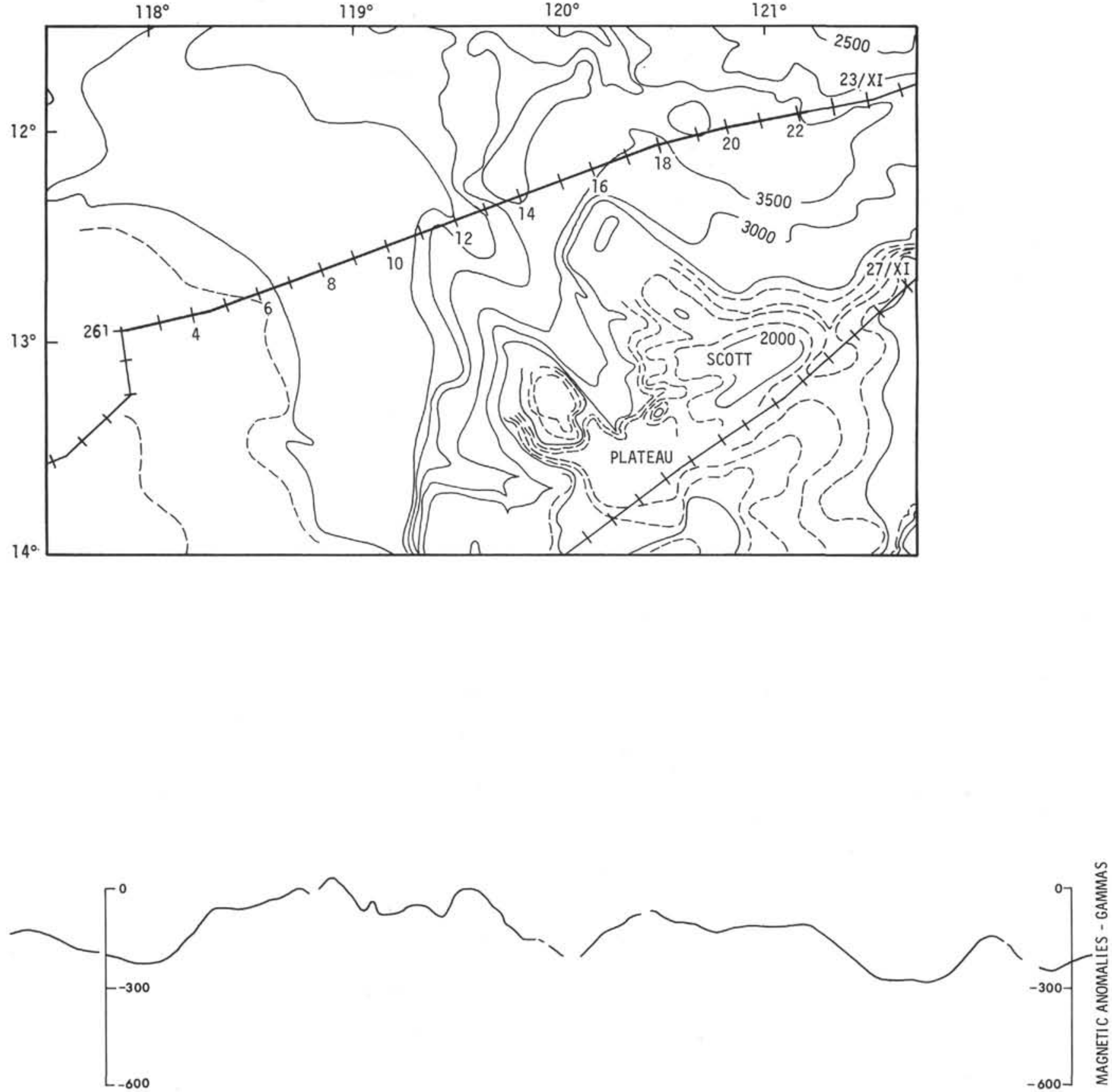

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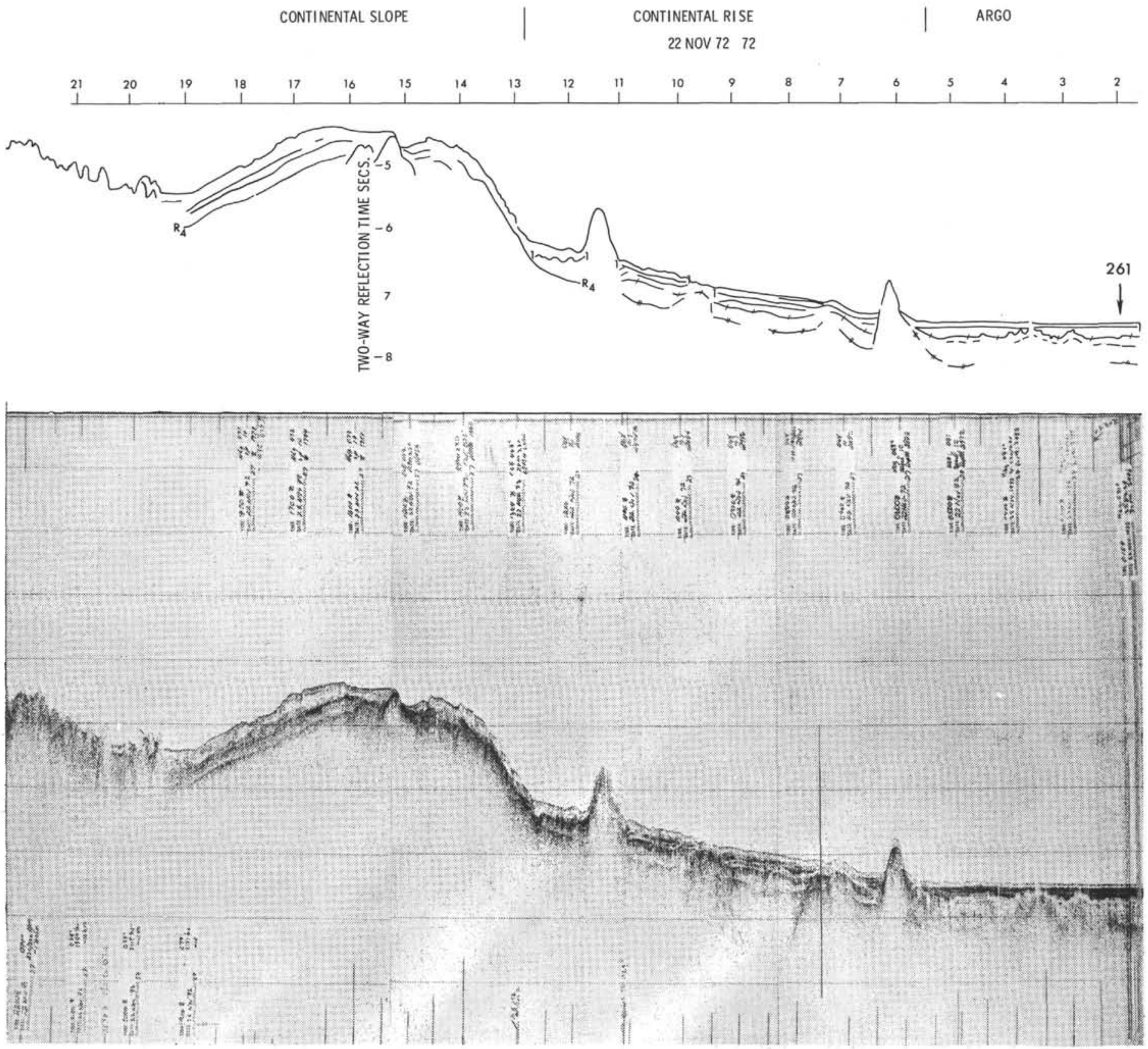

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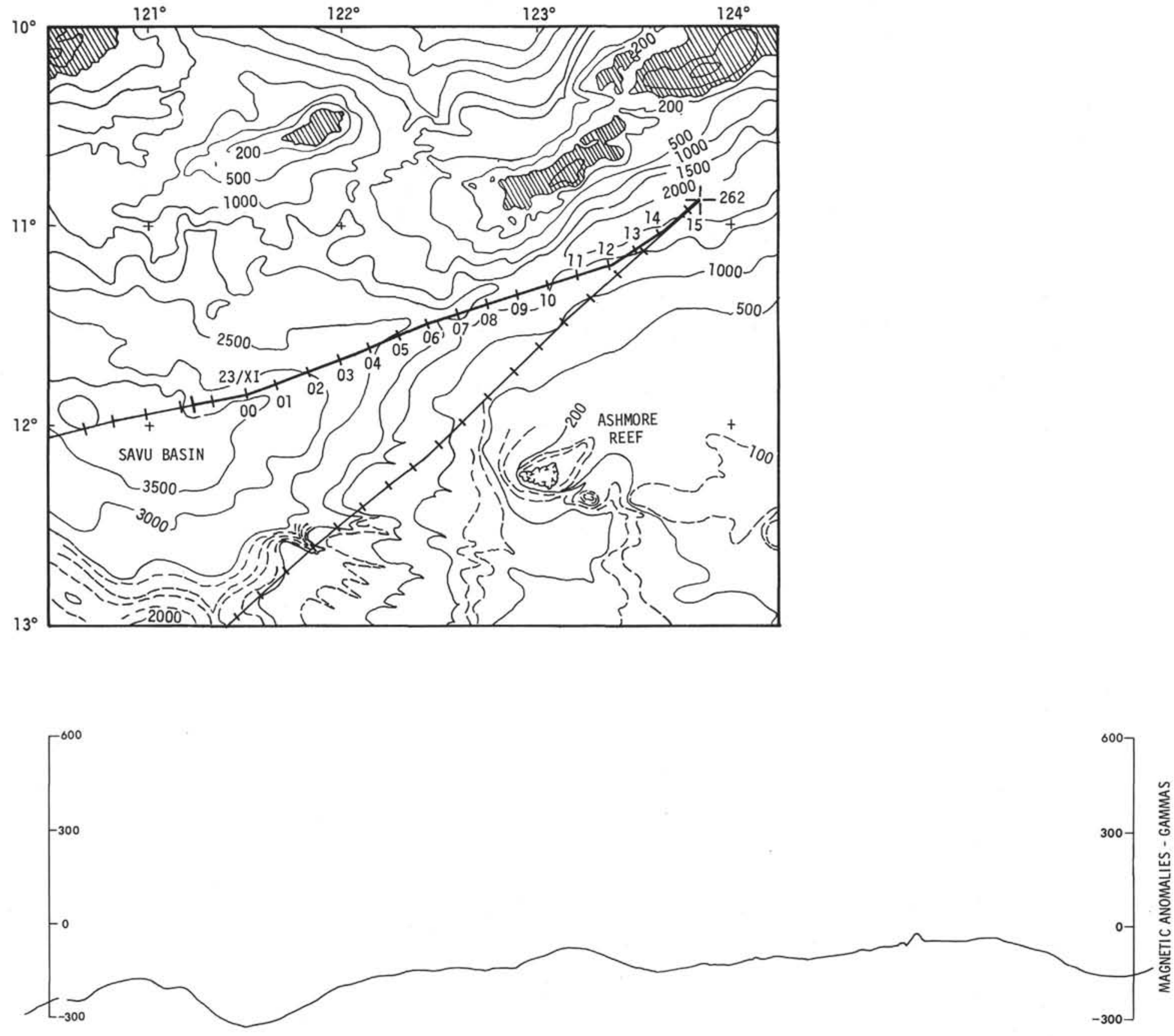

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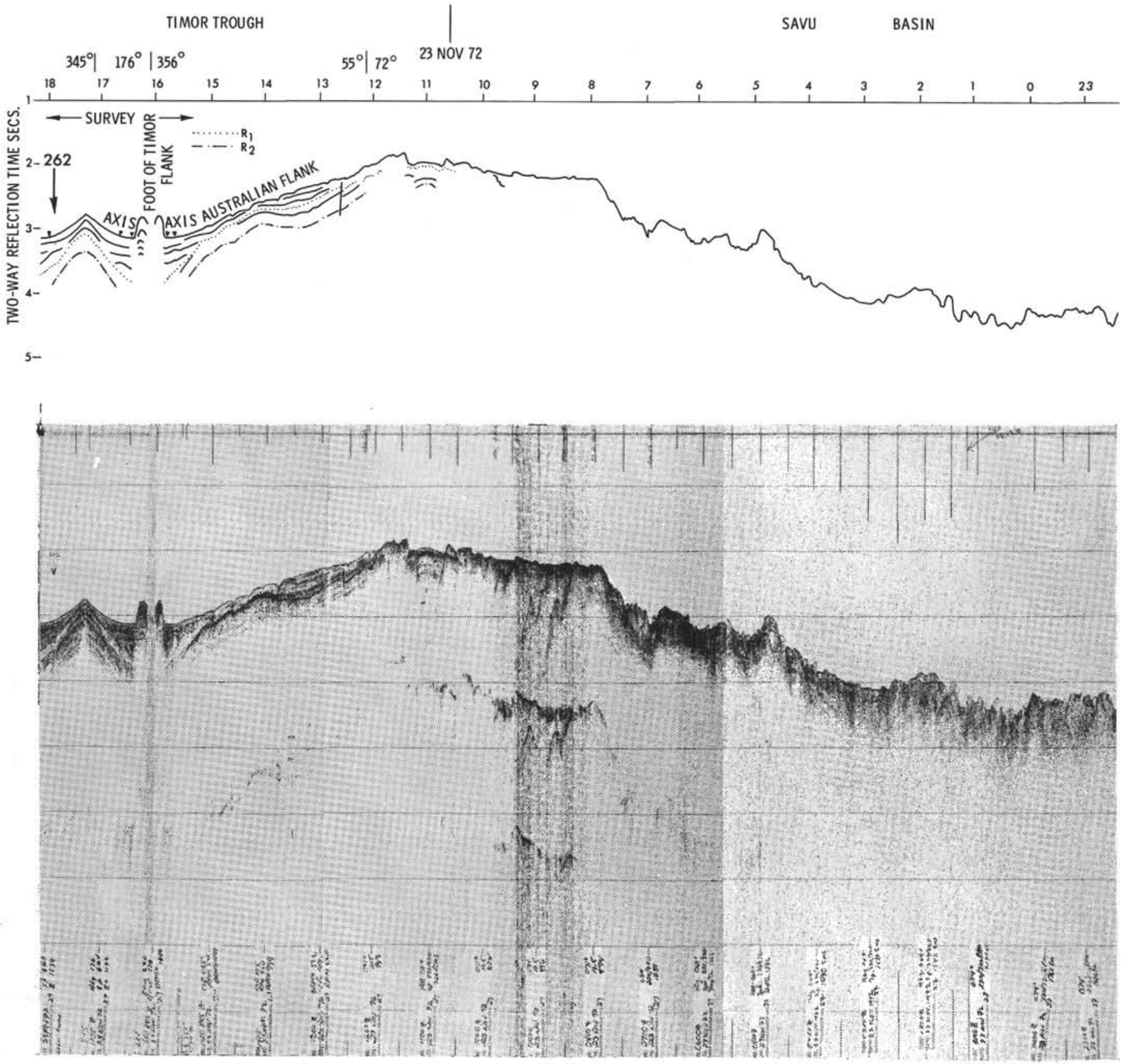

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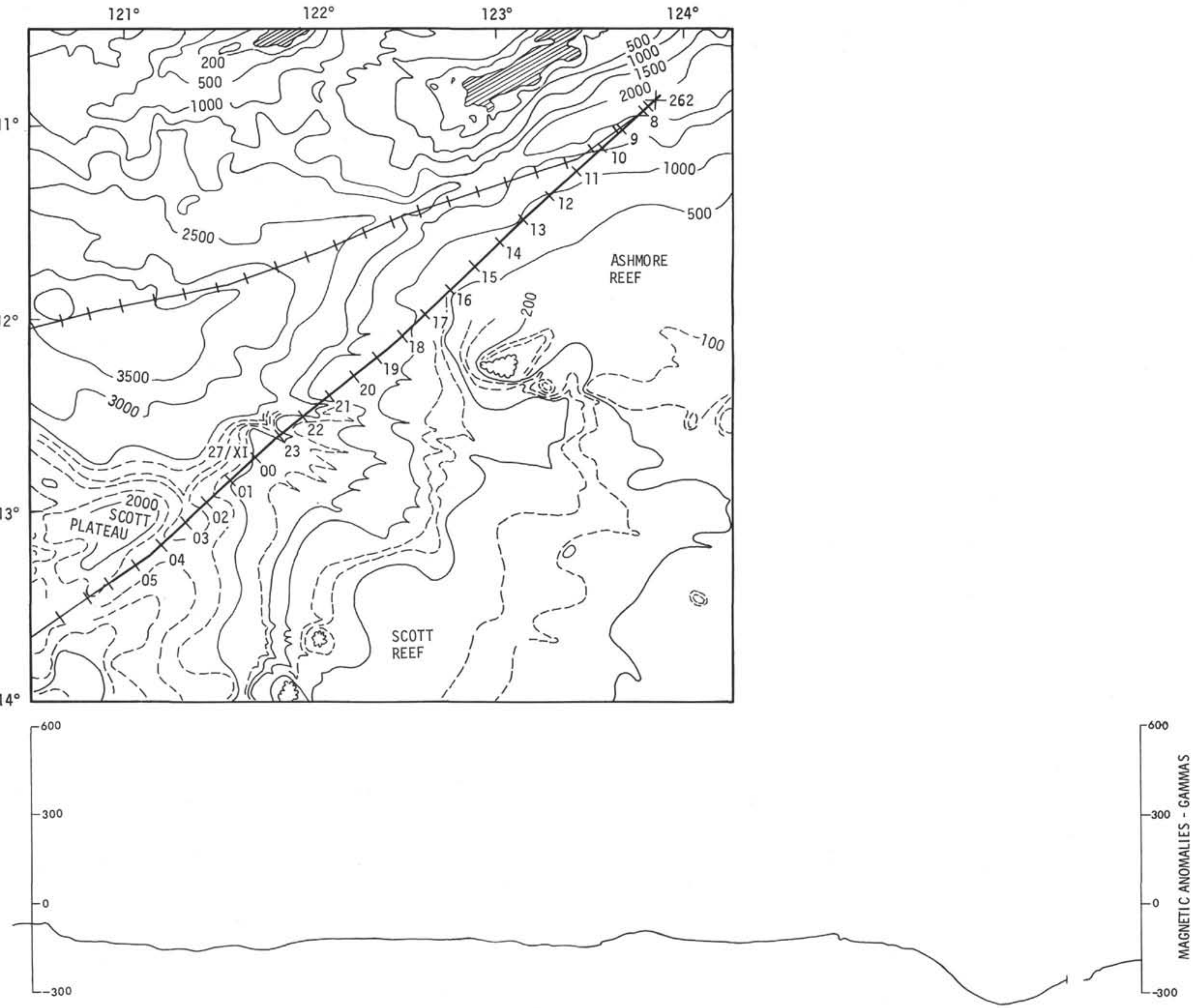


Figure 13. *Underway geophysical data, D/V* Glomar Challenger, *Leg 27. See base maps, Figures 1 and 2.*

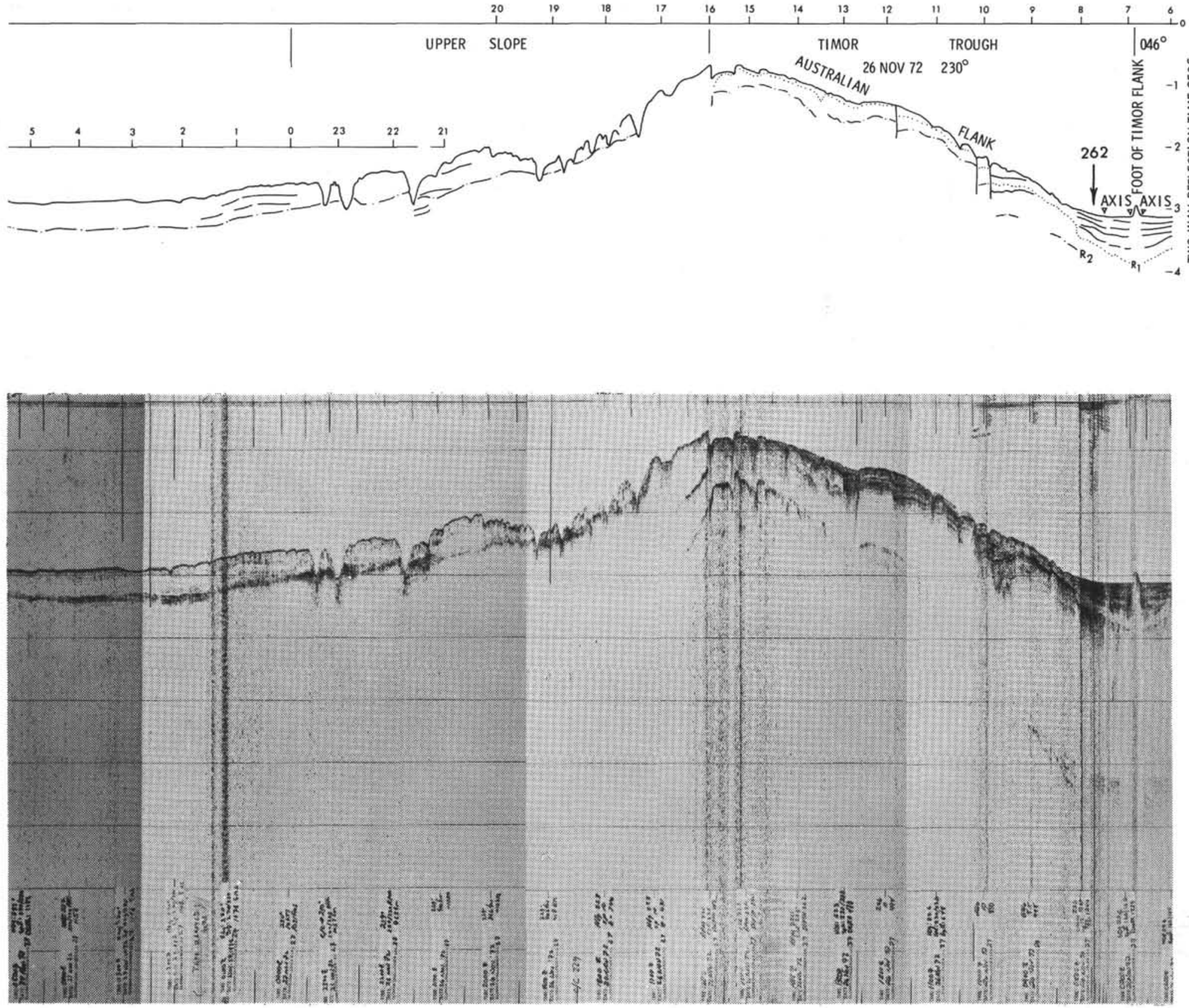


Figure 13. *(Continued).*

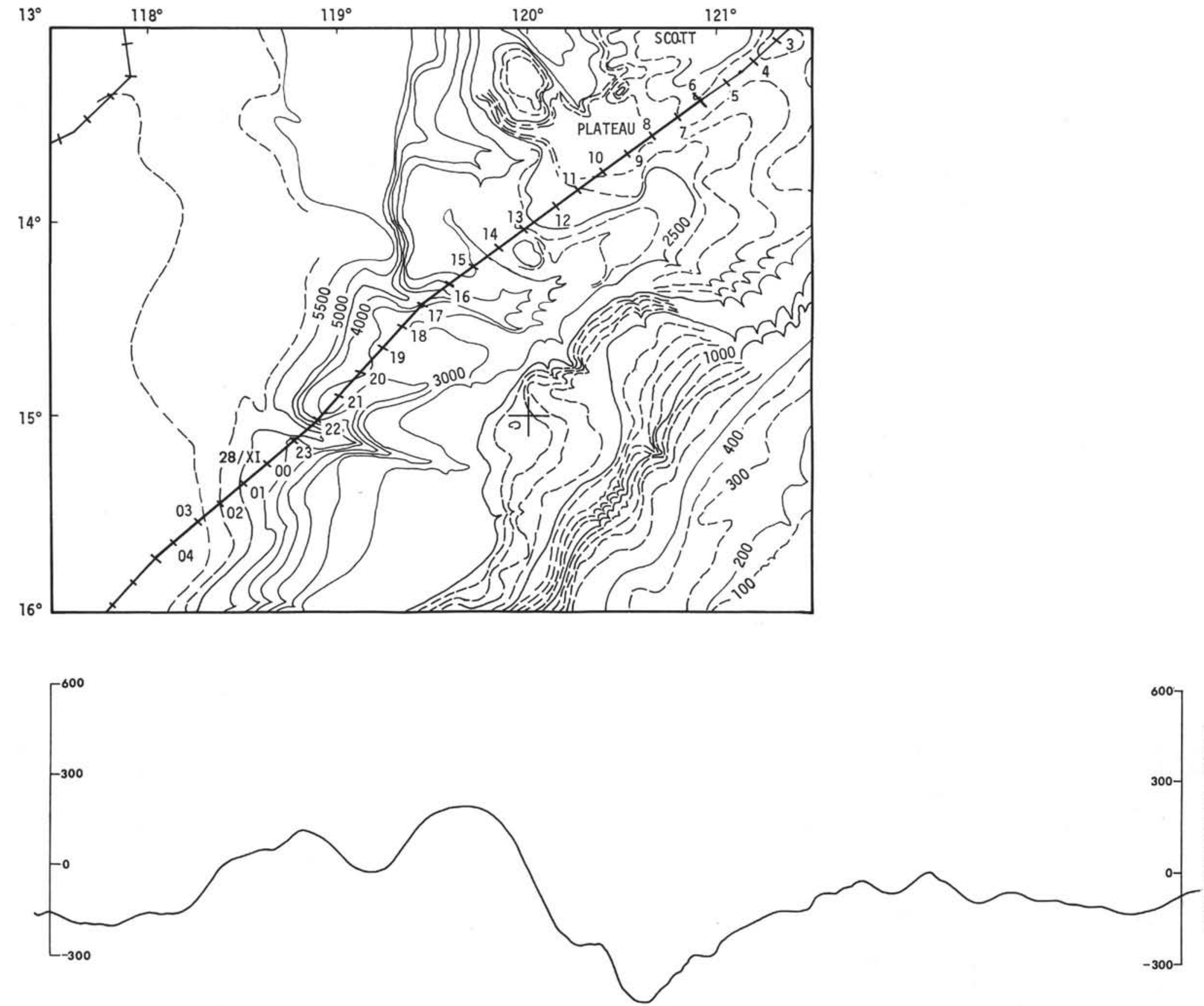
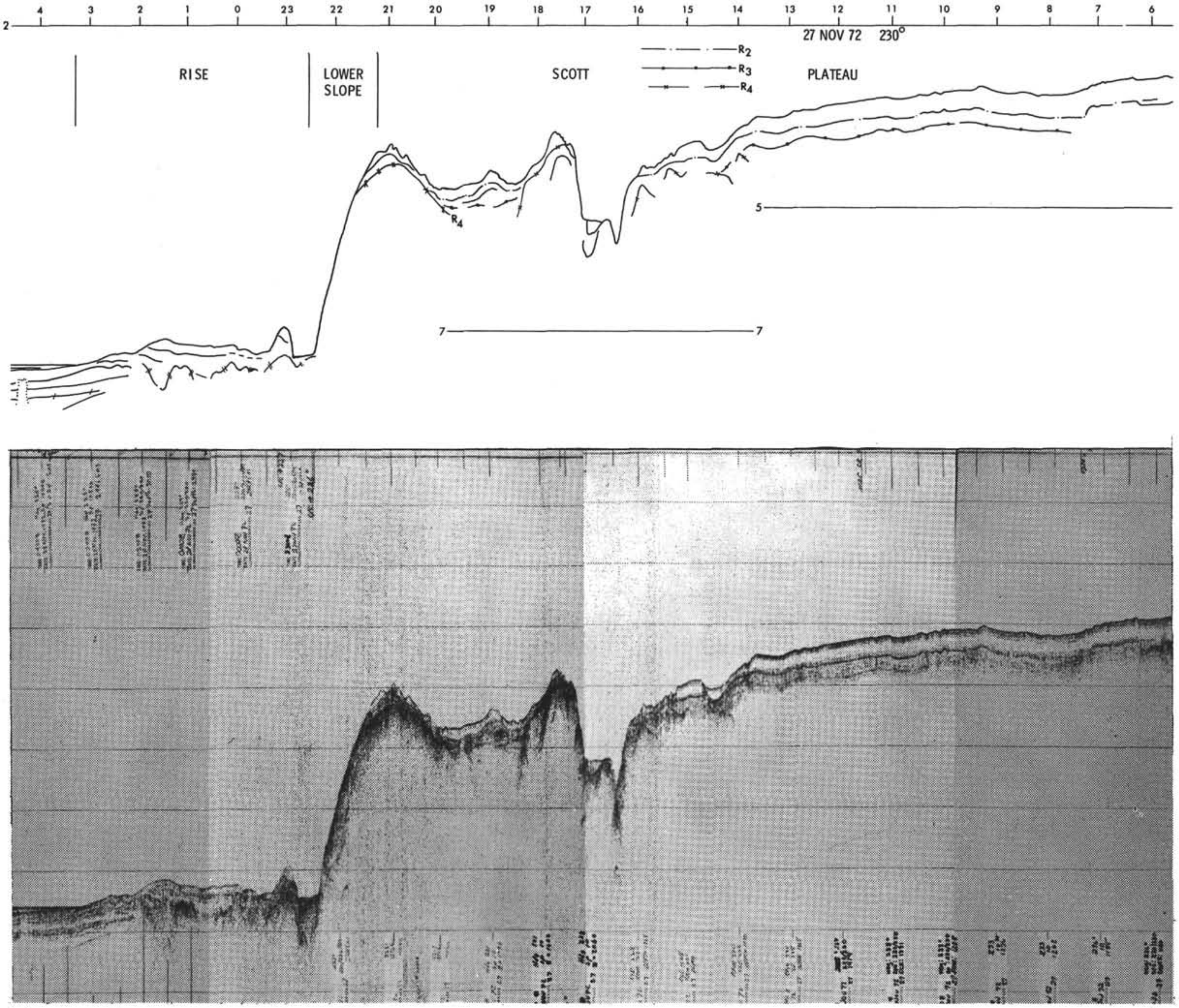


Figure 14. *Underway geophysical data, D/V* Glomar Challenger, *Leg 27. See base maps, Figures 1 and 2.*



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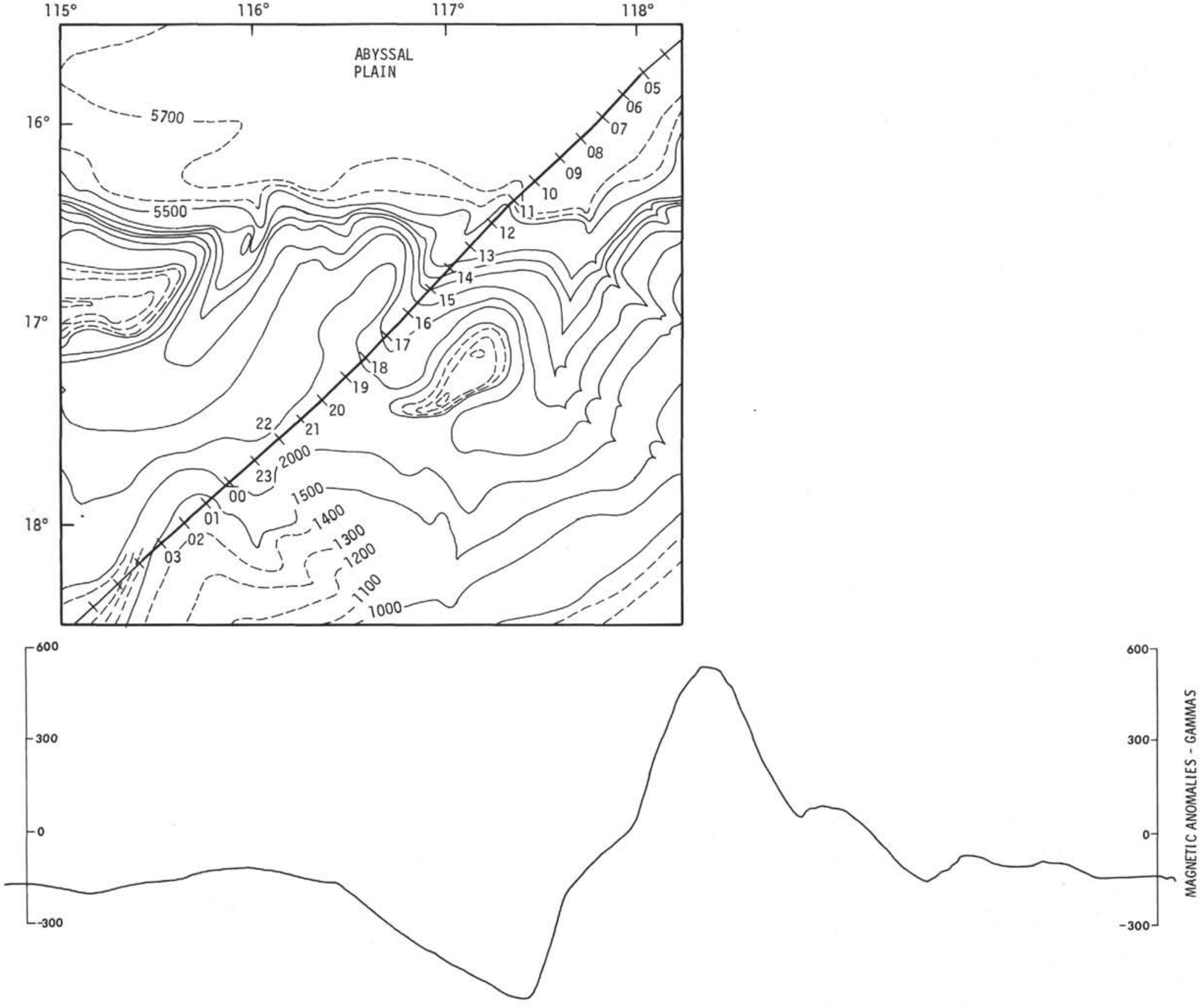
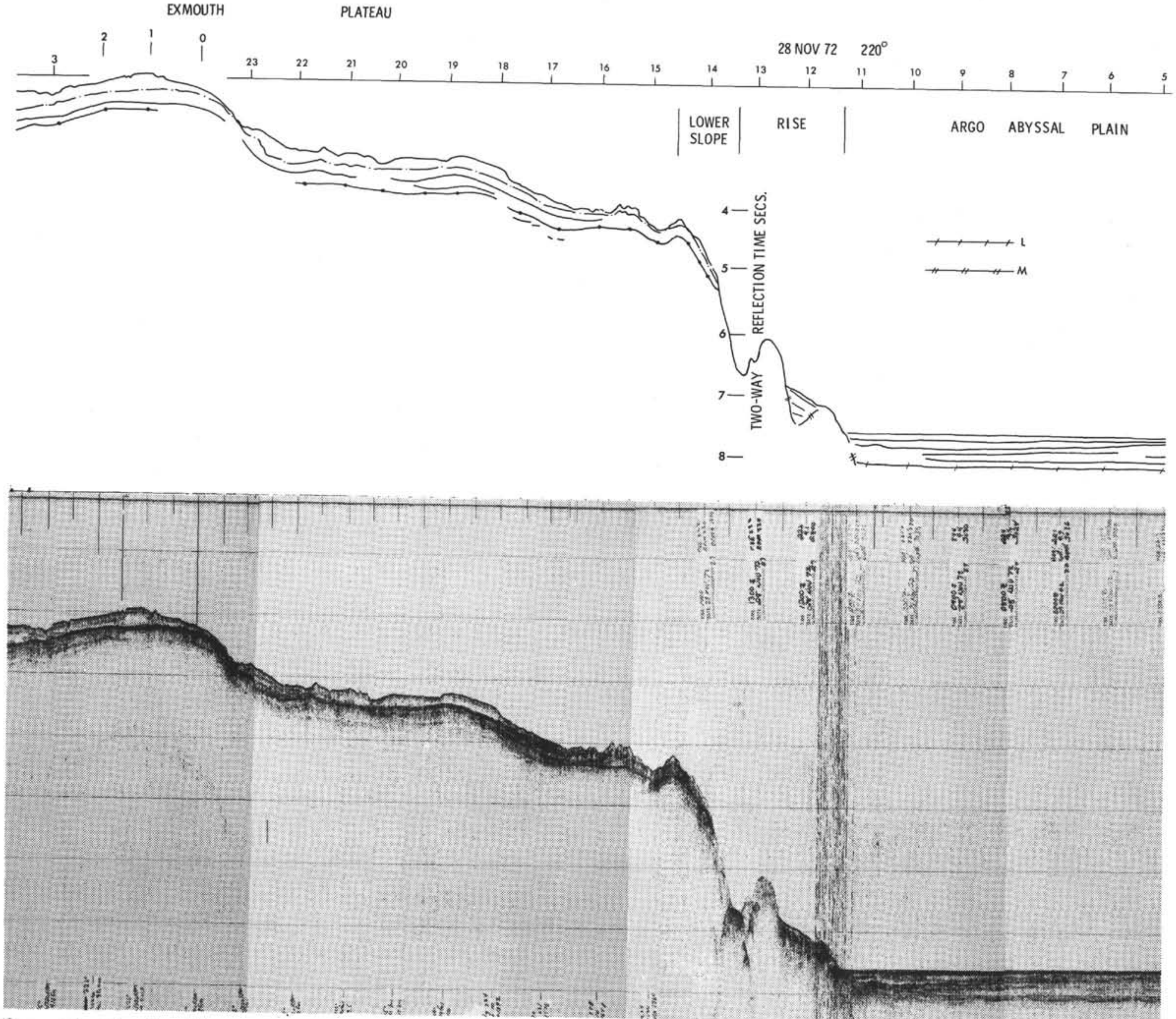


Figure 15. *Underway geophysical data, D/V* Glomar Challenger, *Leg 27. See base maps, Figures 1 and 2.*



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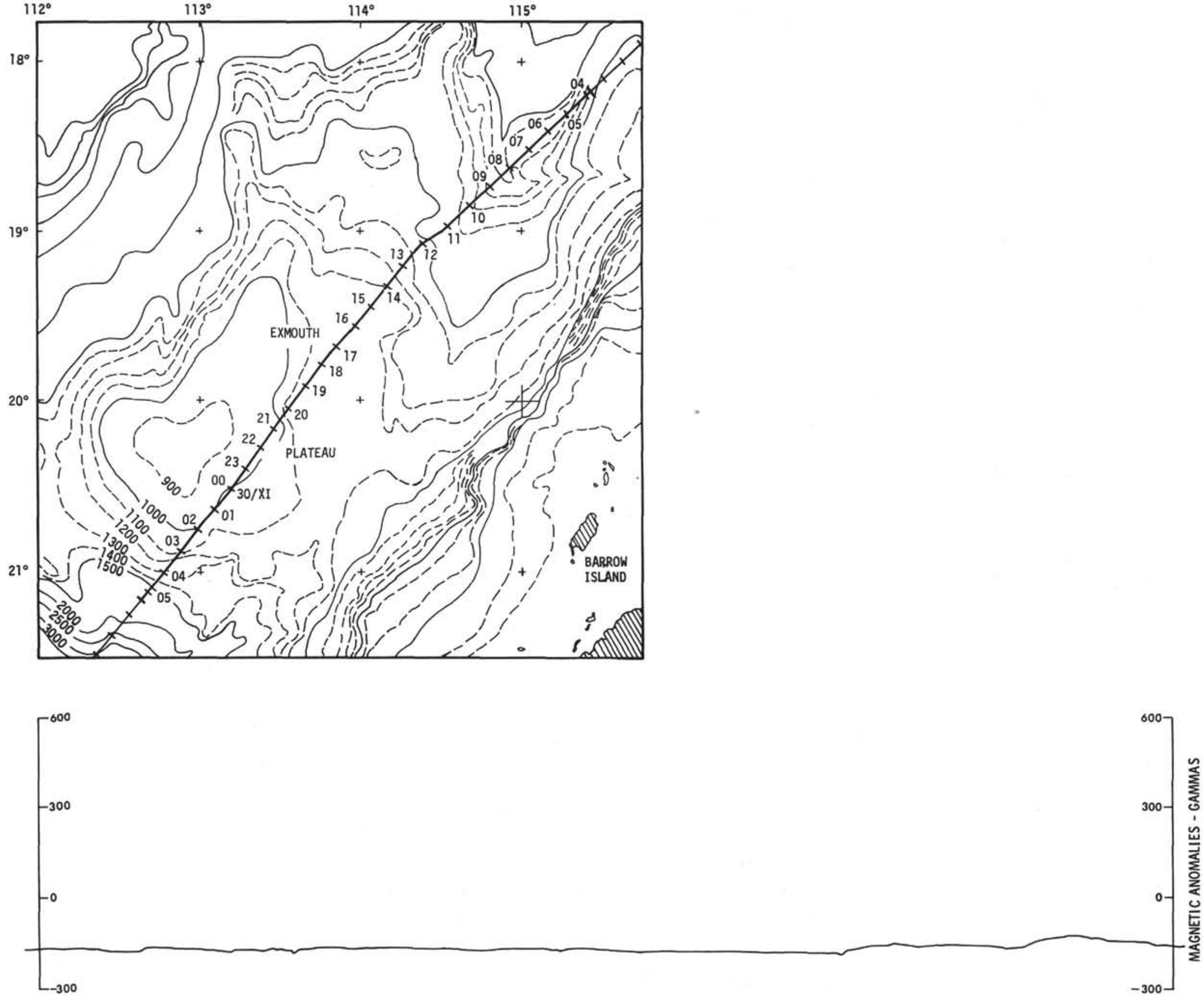
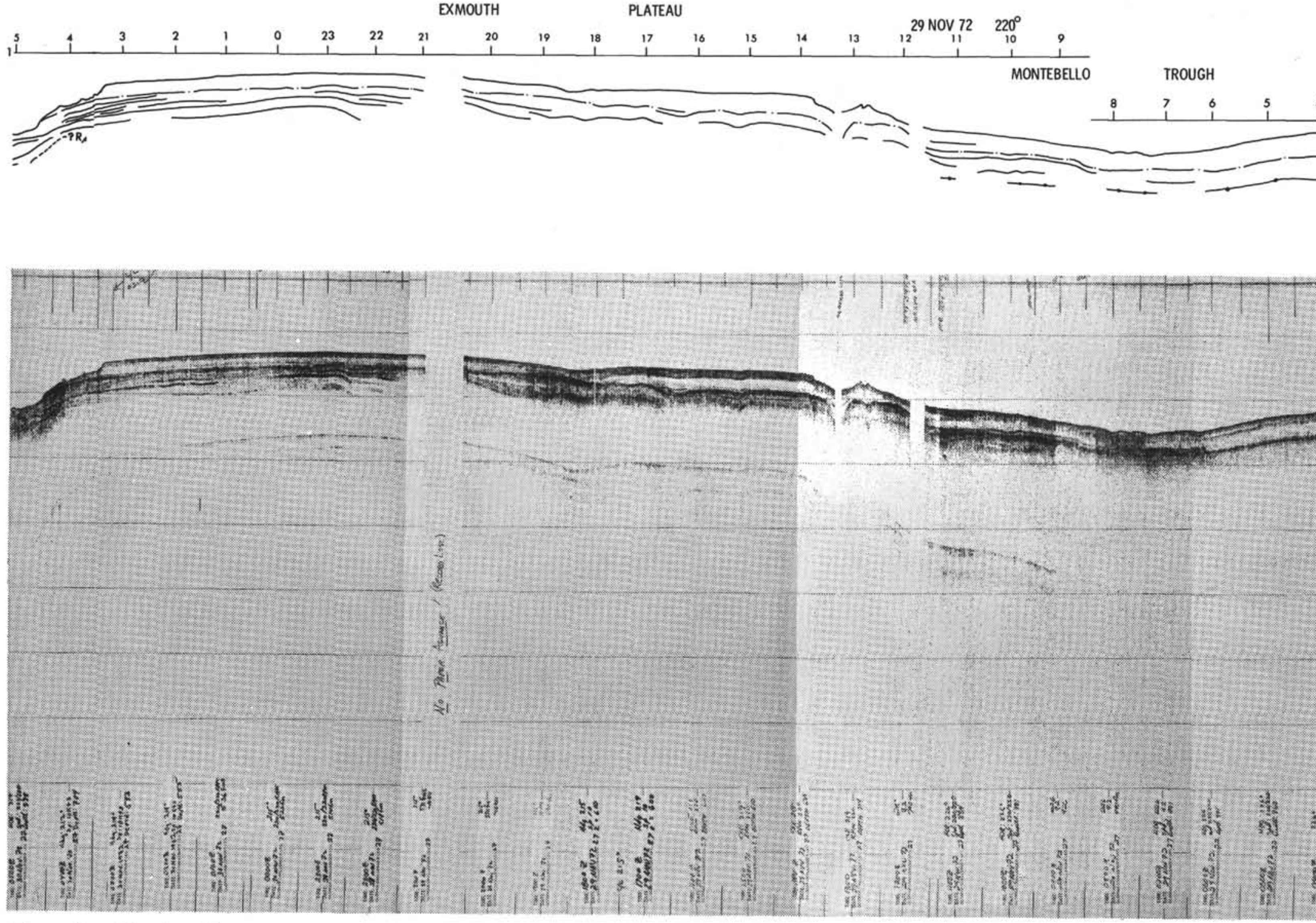


Figure 16. *Underway geophysical data, D/V* Glomar Challenger, *Leg 27. See base maps, Figures 1 and 2.*



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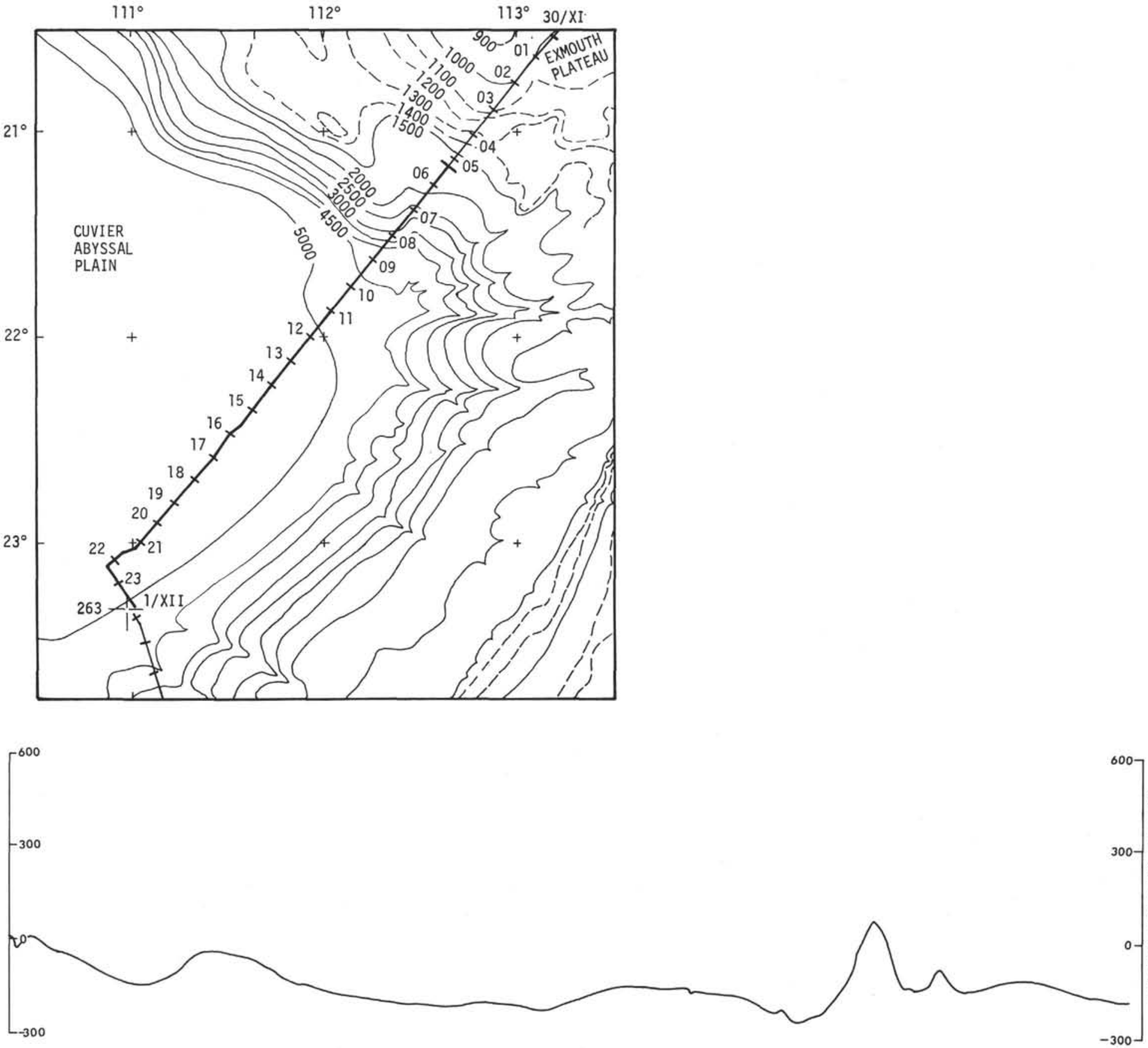

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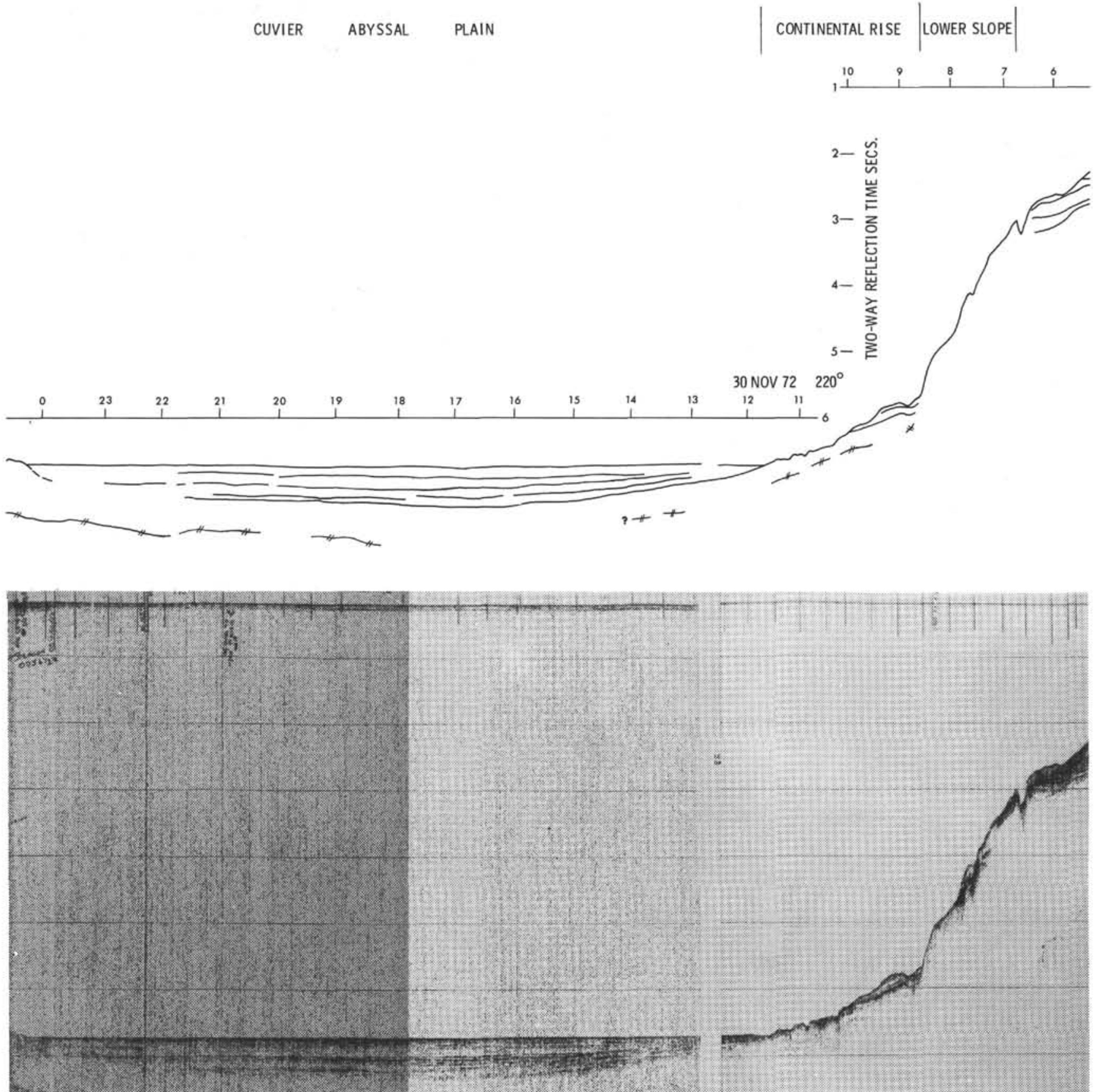

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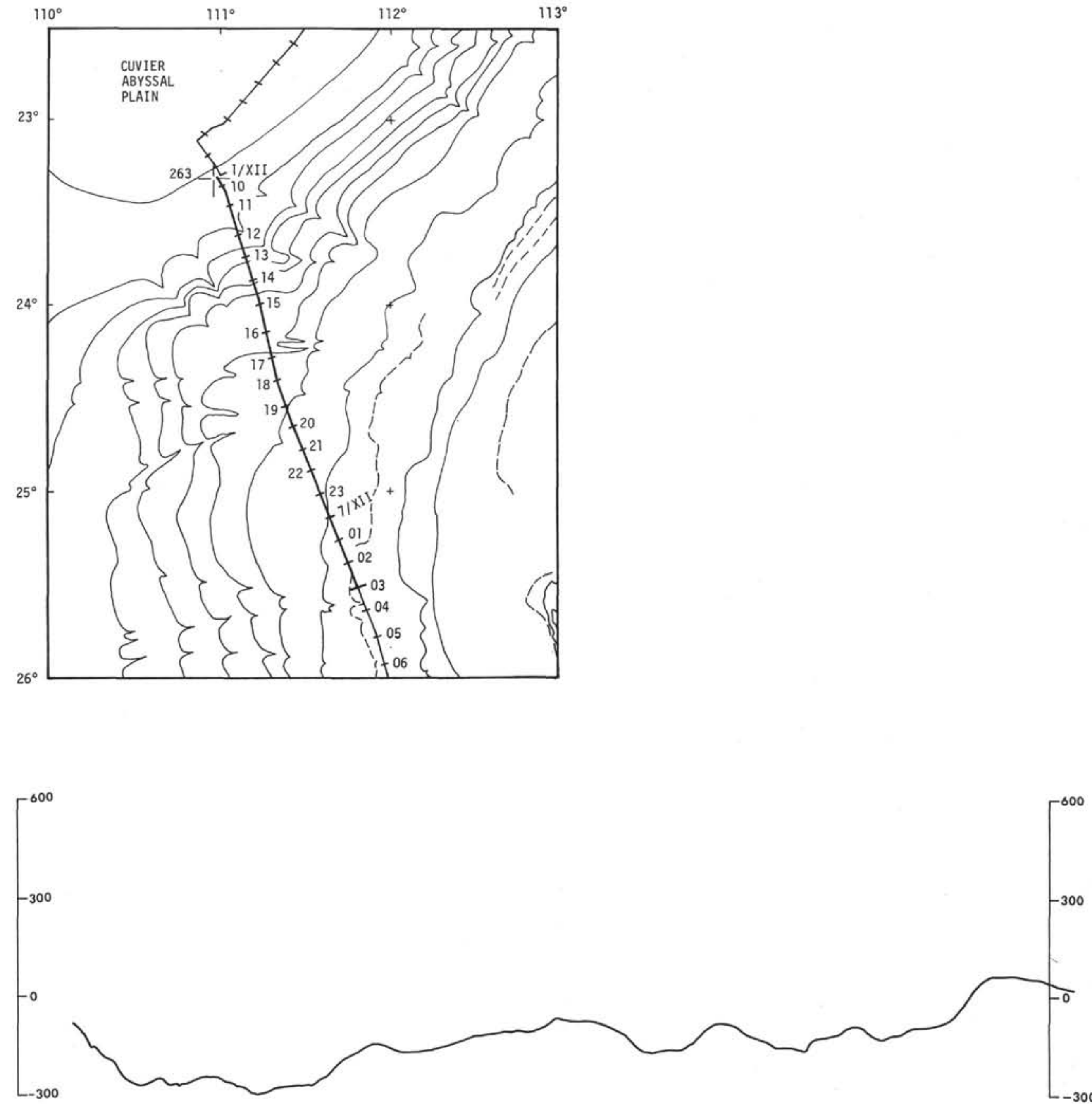

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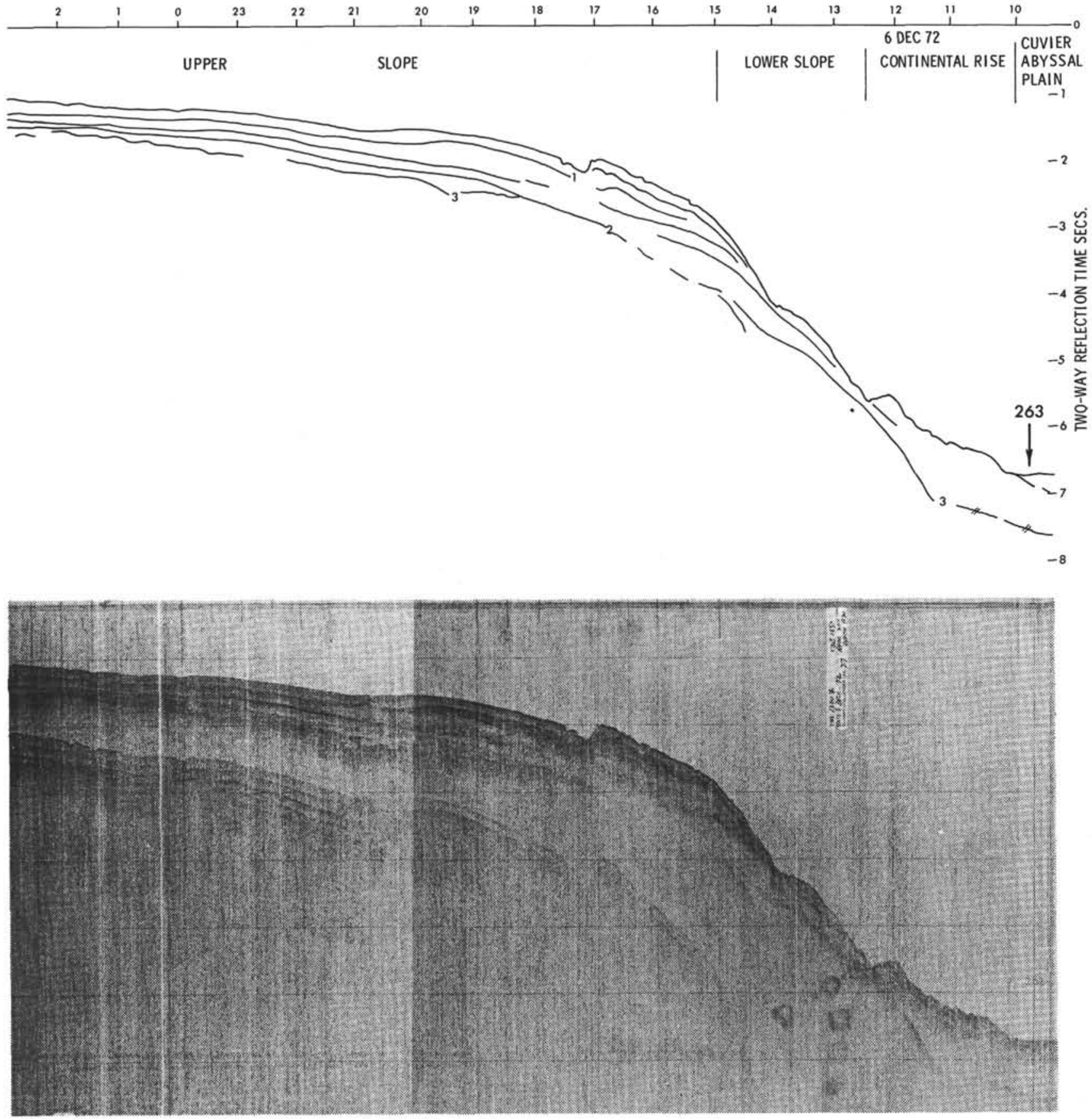

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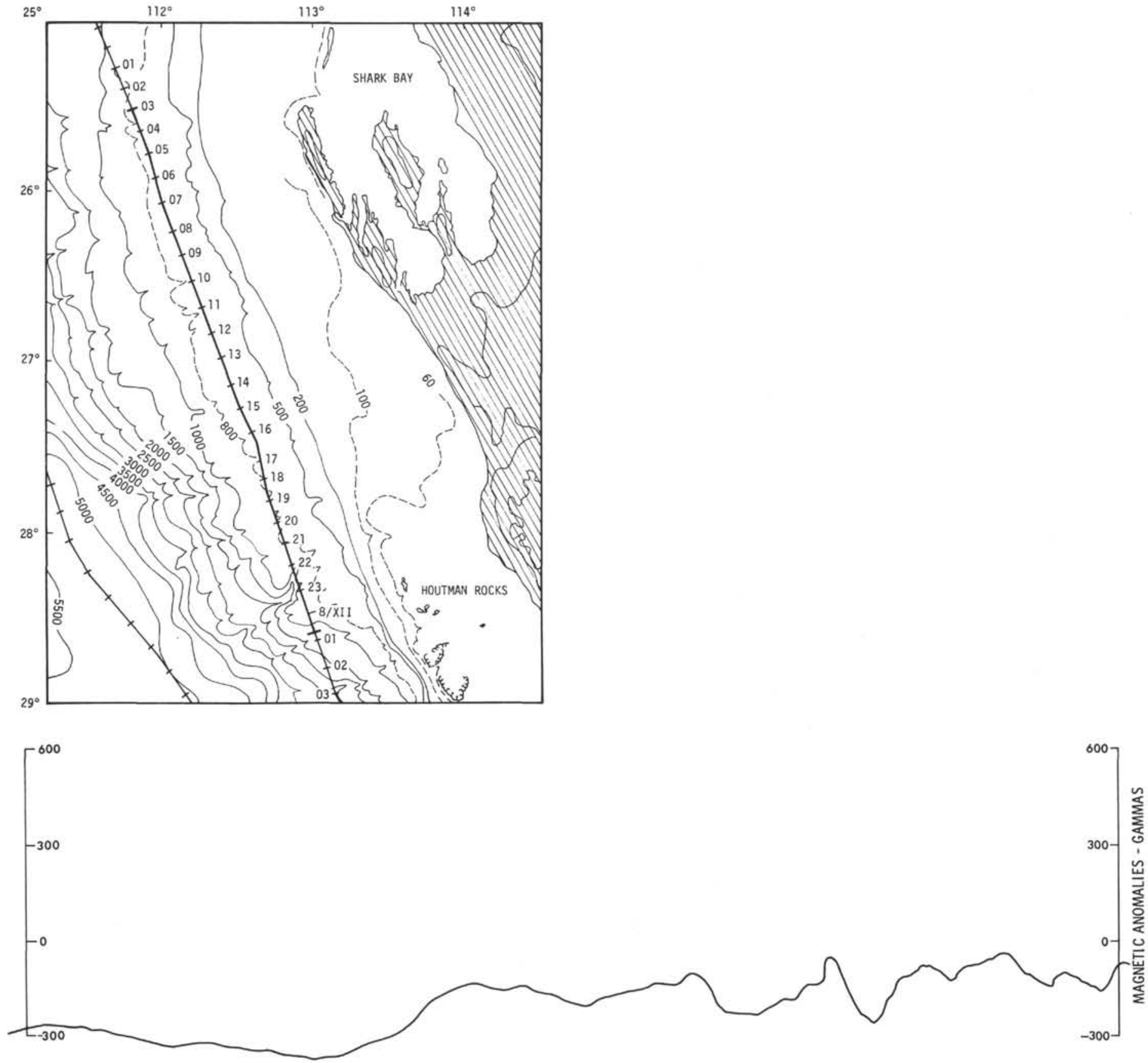

Figure 19. *Underway geophysical data, D/V* Glomar Challenger, *Leg 27. See base maps, Figures 1 and 2.*

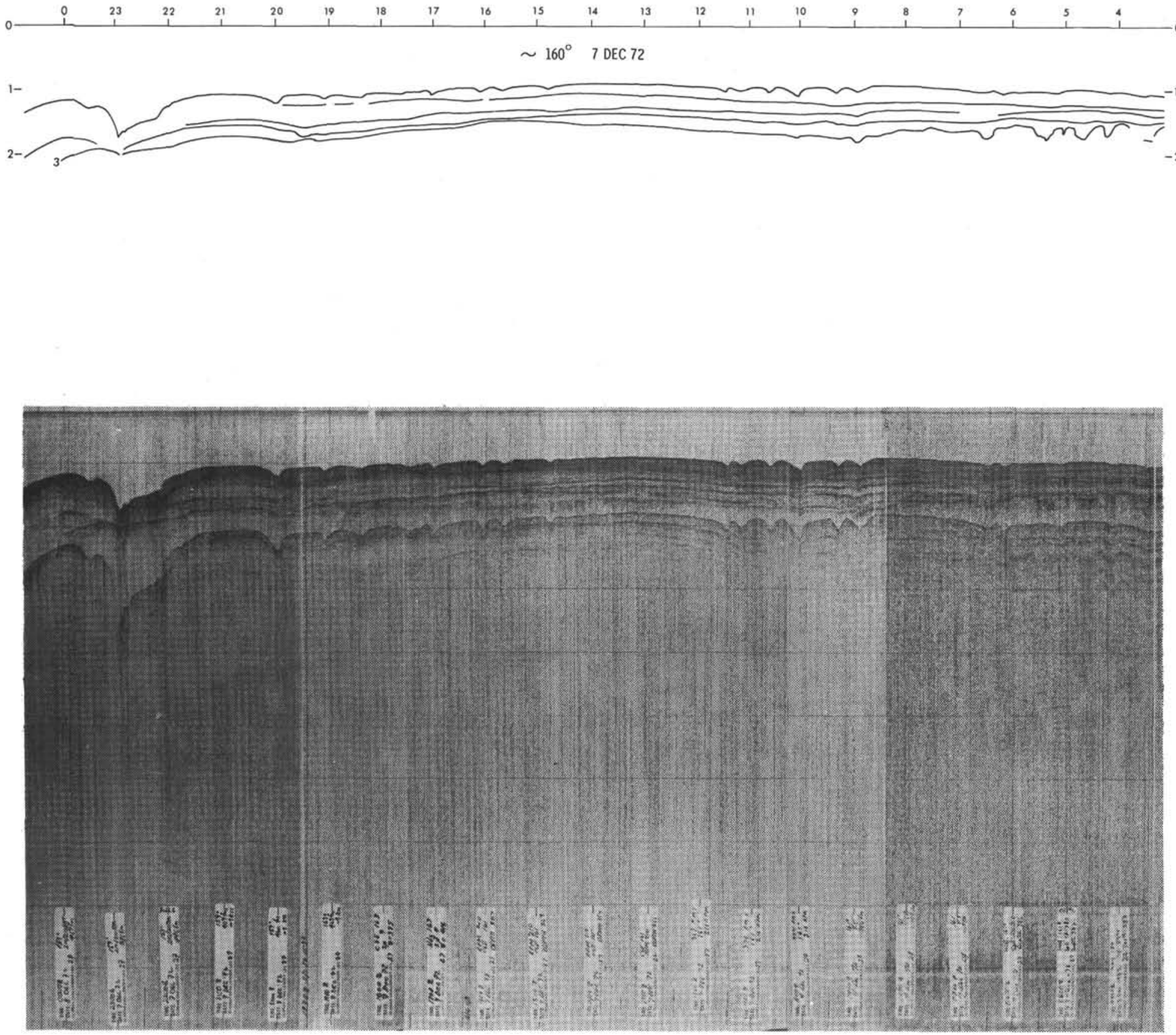

Figure 19. *(Continued).*

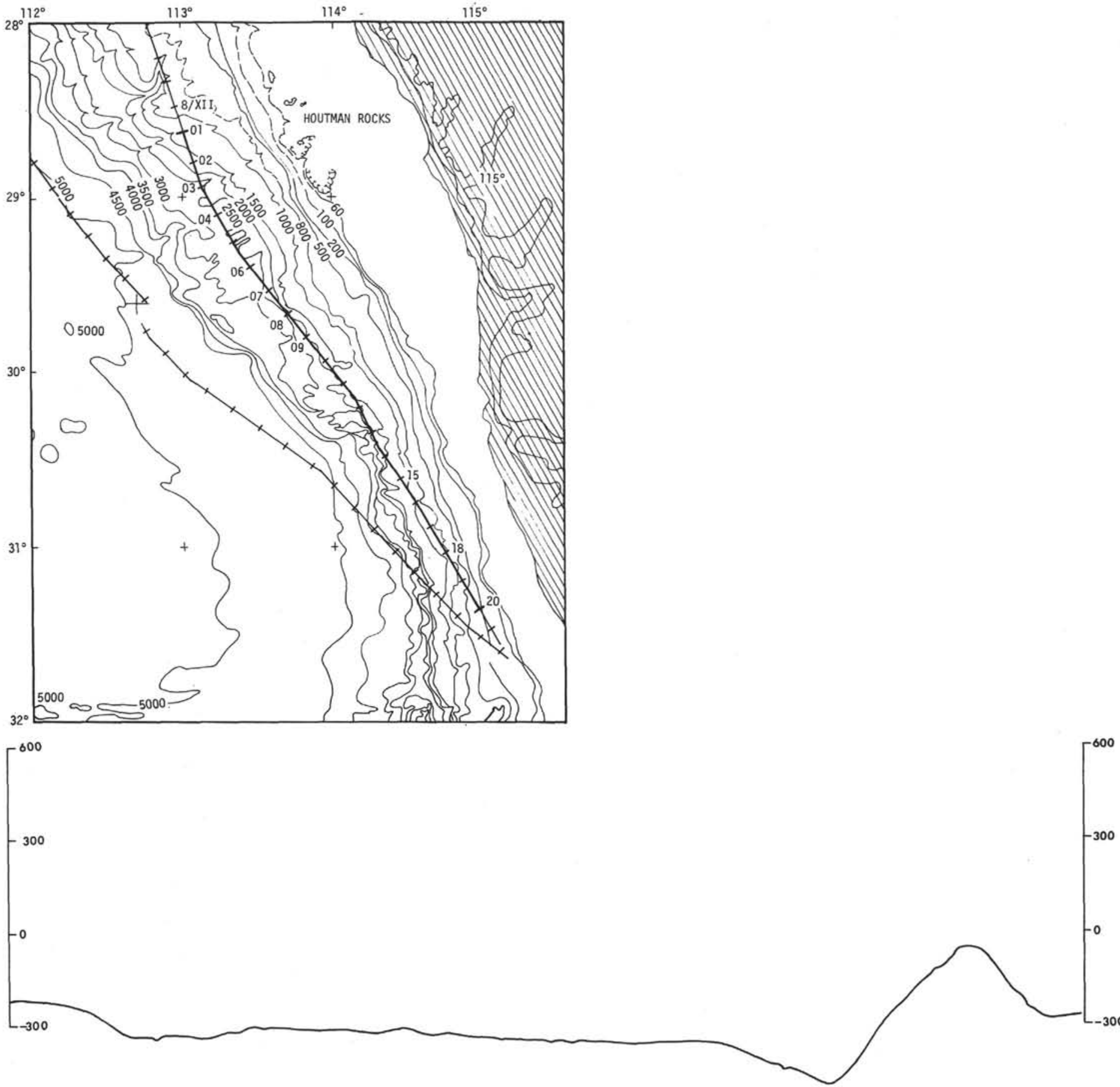

Figure 20. *Underway geophysical data, D/V* Glomar Challenger, *Leg 27. See base maps, Figures 1 and 2.*

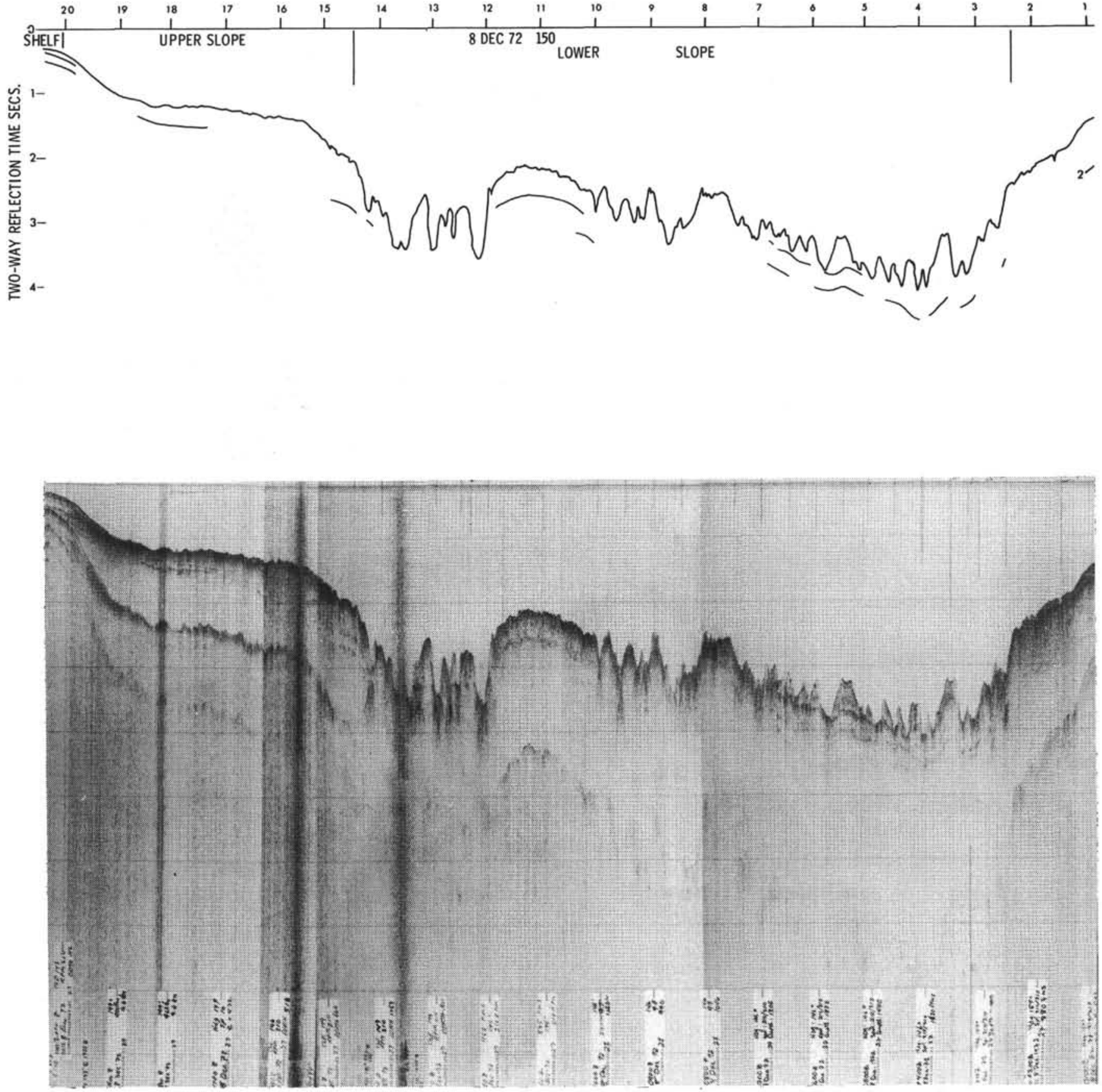

Figure 20. *(Continued).*

Site 262 to Site 263

This is a long track that crossed the Australian flank of the Timor Trough, the Scott Plateau, the southeast part of the Argo Abyssal Plain, the Exmouth Plateau, and the eastern part of the Cuvier Abyssal Plain.

Timor Trough

The Timor Trough can be subdivided into three parts: the deep narrow flat-floored axis, the long Timor flank, and the Australian flanks. Veevers (1971) and Veevers et al. (in preparation) established an acoustic stratigraphy based on two principal reflectors, called R1 and R2, which are traceable beneath the Australian flank and the trough axis. From previous surveys in the area near Site 262, these reflectors were identified in the *Glomar Challenger* profiles. On the track approaching Site 262, R1 and R2 are parallel to each other, and subparallel to the sea floor except at the axis, where they dip more steeply towards Timor. They are overlain, apparently unconformably, by less steeply dipping reflectors. The foot of the Timor flank is a round-crested ridge, identified as Antcline *b* of Veevers et al. (in preparation). As shown by the drilling at Site 262, the lower-dipping sequence above R1 comprises middle Pliocene to Pleistocene infraneritic green nanno ooze, and the top of the steeper-dipping sequence beneath R1 is early Pliocene shallow-water dolomitic calcarenite.

In addition to thickening at the axis, the sediments above R1 also thicken in a syncline as seen between 1200Z and 1400Z, 23 November, which is bounded by Anticline *b* of Veevers et al. (in press b).

This part of the Timor Trough appears to have a singular broad 100-gamma magnetic low roughly parallel to the Australian flank.

In the outgoing track (Sites 262 to 263), the structure appeared the same, except for three down-to-axis faults.

Upper Slope

In the area west and southwest of Ashmore Reef, canyons have incised the upper slope to the level of R2. This reflector, here and beneath the Scott Plateau, is the first continuous reflector below a 0.3- to 0.5-sec-thick surface transparent layer.

Scott Plateau

A second regional reflector (R3) and possibly a third (R4) are seen beneath the Scott Plateau. R3 lies 0.2 sec beneath R2. A discontinuous reflector in the vicinity of the broad canyons, seen between 1400Z and 2200Z, 27 November, is tentatively identified as R4. It has high relief and is draped by R3 and R2.

The Scott Plateau magnetic profile seen before about 1300Z on 27 November is similar to that of the preceding section over the Upper Slope in that there are no magnetic anomalies. A large anomaly, of approximately 600 gammas, occurs on the profile recorded from about 1300Z to 2300Z on 27 November. It was not evident on the *Glomar Challenger* northeastbound track which was approximately 220 km (120 mi.) to the north.

Lower Slope

A lower slope, probably a fracture zone, with apparent gradient of 7°, and without sediment, separates the Scott Plateau from the continental rise.

Continental Rise

The continental rise stands as high as 500 meters above the Argo Abyssal Plain. Acoustic basement, identified as Reflector M, presumably oceanic basalt, has high relief, and is overlain by a subhorizontal layer of weakly reflective sediment.

Argo Abyssal Plain

In this area, the Argo Abyssal Plain is at its maximum depth of 5700 meters. A highly reflective horizontal sequence extends 0.5 sec below the sea floor to Reflector L. Reflector M (basalt) was not seen. A cylindrical or sheet-like transparent body, seen at 0430Z, 28 November, is interpreted as a piercement structure. Again, the magnetic field is undisturbed in this abyssal plain.

Continental Rise and Lower Slope

The slope and rise on the northern face of the Exmouth Plateau are cut across by two broad troughs, the lower of which is filled with sediment. The lower half of the slope is devoid of sediment, and was interpreted as a fracture zone.

One of the largest magnetic anomalies of the entire cruise was seen on the lower slope. It is 900 gammas peak-to-peak amplitude and was crossed from 1300Z to 1900Z on 28 November. Its origin is unknown.

Exmouth Plateau

The regional reflector, R2, is traceable throughout the *Glomar Challenger* profile, R3 was seen in the northern half of the plateau, and R4 was doubtfully recorded near the southern rim. A highly reflective surface layer and a transparent layer overlie R2. Reflector R2's depth ranges generally from 0.2 to 0.4 sec, and it is thicker beneath the Montebello Trough. R2 is a regular, smooth surface except as seen between 1300Z and 1400Z, 29 November, where it (and the sea floor) are depressed into a valley. Where R3 was recorded, it lies a constant 0.3 to 0.4 sec beneath R2, at the base of a fairly transparent layer.

Three interesting features were seen between 0200Z and 0500Z, 30 November, at the southern rim of the Plateau: a steeply dipping acoustic basement, possibly R4; a sequence of prograding layers beneath R2; and a sea floor with a rough profile on a small scale, in contrast with the smooth sea floor over most of the rest of the Plateau. These three features interpreted as indicating the outgrowth of the plateau by the deposition of prograding layers over the rim, and the occasional collapse of bodies of sediments by oversteepening.

The magnetic field over the Exmouth Plateau above the 3000-meter isobath is completely anomaly free. The transition to the fringing, more-anomalous field is quite distinct.

Lower Slope

The sediments above R4 crop out above the lower slope, which has a gradient of 2°. The foot of the slope is interpreted as a fracture zone.

Continental Rise and Cuvier Abyssal Plain

A discontinuous acoustic basement (M, presumably basalt) extends beneath the rise and abyssal plain, and is overlain by a transparent layer, up to 0.6 sec thick, in turn overlain by a well-stratified layer also 0.6 sec thick. The drilling at Site 263 revealed that the feather-edge of the well-stratified layer is Quaternary and upper Pliocene ooze, and the transparent layer is Cretaceous ooze and claystone. Long-wavelength magnetic anomalies were again found as they were on the northbound track to the northwest.

Site 263 to Fremantle

The northern two-thirds of the track crossed the upper slope at a depth of 750 to 1000 meters, and the rest of the track crossed a complex of submarine canyons near Fremantle.

Continental Rise and Lower Slope

The continental rise and lower slope are straight in profile except for three broad terraces.

Upper Slope

The 550-km-long section of the upper slope reveals a history of uniform deposition interrupted by canyon cutting. The present sea floor is smooth except for shallowly incised canyons no deeper than 100 meters. Broader and deeper features indent either end of this section near the edge of the upper slope. In the 1-sec thick band of subbottom reflectors visible above the prominent bottom multiple, an earlier example of a smooth sea floor crossed by shallow canyons was seen (0300-0700Z, 7 Dec). Small magnetic anomalies are present over them.

Lower Slope

A 600-gamma magnetic anomaly was crossed from 000Z to 0500Z, 8 December. This feature, in water depths of 1500 to 3000 meters, appeared to be due to a deeply buried structure but may be a continuation of magnetic trends from the southwest of other origins.

A few subbottom reflections showed that the canyons that cross the slope are cut into sediments whose structure broadly parallels the general level of the sea floor.

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