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A LEFT-LATERAL STRIKE-SLIP FAULT SEAWARD OF THE OREGON CONVERGENT MARGIN

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Abstract. We have mapped a recently active left-lateral strike-slip fault (the Wecoma fault) on the floor of Cascadia Basin west of the Oregon convergent margin, using SeaMARC I sidescan sonar, Seabeam bathymetry and multichannel seismic and magnetic data. The fault intersects the base of the continental slope at 45°10'N and extends northwest (293°) for at least 18.5 km. The fault's western terminus was not identified, and the eastern end of the fault splays apart and disrupts the lower continental slope. The fault extends to the base of the 3.5-km-thick sedimentary section and overlies a basement discontinuity that may be related to movement along the Wecoma fault. Prominent seafloor features crosscut by the fault individually display between 120 and 2500 m of left-lateral separation, allowing the general history of fault motion to be evaluated. The fault's average slip rate since 10-24 ka is inferred to be 5-12 mm/yr, based on the age of an offset submarine channel. Surficial structural relationships, in conjunction with the maximum inferred slip rate, indicate that fault movement initiated at least 210 ka and that the fault has been active during the Holocene.

INTRODUCTION

An unexpected result of recent Seabeam and SeaMARC I sonar surveys of the Oregon convergent margin was the discovery of two groups of faults oriented oblique to the base of the continental slope. A NE-SW trending group consists of shallow tear faults that separate structural provinces within the accretionary prism [MacKay et al., 1992]. A second group, oriented NW-SE, is more enigmatic because it involves faults that extend seaward across the abyssal plain along azimuths oblique to both the base of slope and the relative convergence direction [Appelgate et al., 1989; Goldfinger et al., 1989]. These faults are significant because they may influence the structural development of the accretionary complex, as well as provide pathways for fluids escaping the dewatering prism. The origin and driving mechanism for these faults are not clear, and an understanding of their structure and history may reveal new insight into tectonic processes along this and other convergent margins.

This paper describes one such NW-SE trending fault, the Wecoma fault, based on observations from SeaMARC I sidescan sonar, Seabeam bathymetry and multichannel seismic and magnetic data. We use seismic and magnetic data to show that the fault extends to the base of the sedimentary section and may offset basement. Surficial features crosscut by the fault display varying amounts of left-lateral separation, which we use to infer the relative age and displacement history of these features. Finally, we estimate the average slip rate of the fault on the basis of the age of an offset submarine channel, which provides a constraint for the minimum age of initial fault motion.

GEOLOGIC SETTING

At the Oregon convergent margin (Figure 1), the Juan de Fuca plate is subducting beneath the North American continent at a rate of ~ 40 mm/yr, directed ~ 069° [DeMets et al., 1990]. Juan de Fuca crust entering the subduction zone here is 9 Ma [Connard et al., 1984] and is overlain by ~ 3.5 km of sediment [MacKay et al., 1992]. The sedimentary section consists of a lower sequence of continentally derived turbidites interbedded with hemipelagic muds, capped by late Pleistocene to Holocene sediments of the Astoria Fan [Kulm et al., 1973]. Offscraped sediments from the downgoing oceanic plate form an accretionary prism that has grown 30 km wider in the last 2 m.y. as a result of the westward migration of the deformation front [Silver, 1972; Carson et al., 1974; Barnard, 1978]. The compaction and dewatering of sediments near the toe liberates fluids that are driven out of the accretionary prism along faults and permeable stratigraphic horizons. Recent studies emphasize the role of faults as fluid pathways and suggest that flow velocities along faults may be 2 to 3 orders of magnitude greater than for diffuse intergranular flow [Moore et al., 1990]. Graphic evidence for focused flow out of the prism is provided by stratigraphically and structurally controlled vent sites, which host authigenic carbonate deposits and chemosynthetic animals [Kulm et al., 1986; Lewis and Cochrane, 1990; Kulm and Suess, 1990; Moore et al., 1990].

THE WECOMA FAULT

The plan view morphology of the Wecoma fault is shown by the Seabeam bathymetry (Figure 2) and by a corresponding mosaic of four 5-km-wide SeaMARC I sidescan sonar swaths (Figure 3). In the sidescan image, the western two thirds of the fault appears as a linear, low-backscatter feature oriented 293°. Near its eastern end, the fault splays into several subsidiary faults that intercept the base of the accretionary prism near 45°10'N. Several prominent seafloor features are crosscut by the Wecoma fault, and structural relationships at each site enable the nature and style of movement along the fault to be evaluated. The following section presents descriptions of specific locations along the fault that reveal aspects of the fault's structure and recent history.

Eastern Plateau and Embayment

The diverging splays near the fault's eastern end bound a flat-topped, triangular plateau (Figure 3). The plateau is a

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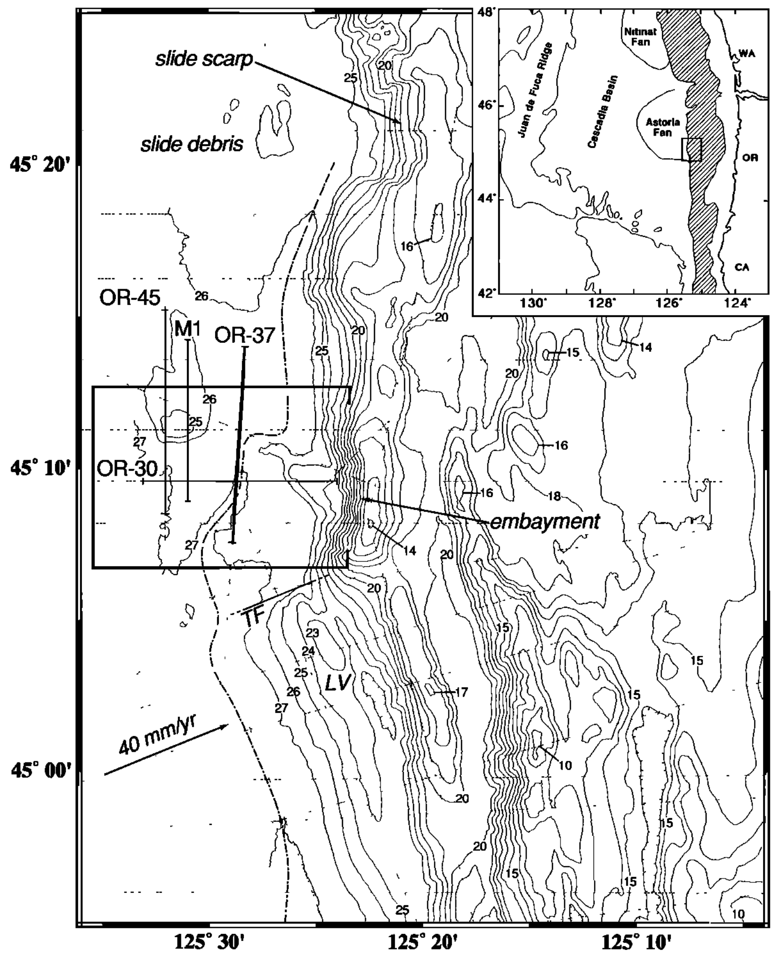

Fig. 1. Seabeam bathymetry of the abyssal plain and lower continental slope off Oregon. Contour interval is 100 m, annotated in hundreds of meters. Enclosed basins contain tick marks that point downhill; closed contours without ticks are topographic highs. The outlined area contains the Wecoma fault and corresponds to the location of Figures 2 and 3. Multichannel seismic reflection track lines are represented by light dashed lines, and the profiles shown in Figure 4 are labeled. A magnetic profile (Figure 10) is labeled M1. The axis of the slope base channel discussed in the text is indicated by a dot-dashed line. The arrow shows the ~ 40 mm/yr relative convergence vector between the Juan de Fuca and North American plates. LV is landward-vergent thrust ridge; TF is tear fault. Inset shows location of survey area within the northeast Pacific Ocean, with line pattern indicating the continental slope.

pop-up structure (C. Goldfinger et al., Active strike-slip faulting and folding of the Cascadia plate boundary and forearc in central and northern Oregon, submitted for inclusion in U.S. Geological Survey Professional Paper 1560, 1991) (hereinafter referred to as Goldfinger et al., submitted manuscript, 1991) composed of coherent subsurface horizons uplifted between upward diverging splays of the main Wecoma fault (Figure 4a). A series of concave-up fault surfaces project upward to the seafloor where a pair of surficial scarps outcrop along the western tip of the plateau (Figure 3). The plateau's southern flank contains two poorly defined surficial fault scarps, which are crosscut by a pair of small valleys that have eroded headward into the plateau. In contrast, the northern edge of the plateau is defined by a steep fault scarp, which is incised by a single sharply defined landslide scarp. The surface of the plateau displays homogeneous low backscatter relative to the surrounding seafloor, which may indicate that the plateau has been elevated above the level of deposition of coarse-grained Astoria fan sediments long enough to accumulate a draping veneer of lower-backscatter hemipelagic mud.

East of the plateau, a steep, semicircular embayment in the seaward flank of the marginal ridge is inferred to result from the disruption of the lower slope by the Wecoma fault (Figure 1). The width of the embayment roughly corresponds to that of the plateau, and the embayment's northern and southern boundaries are defined by narrow, linear gullies that extend upslope from the points where the plateau-bounding faults abut the base of slope. These gullies may be the surface expression of extensions of the plateau-bounding faults. If they do represent faults, however, their displacement history is not clear. The marginal ridge here formed as a landward verging thrust sheet [MacKay et al., 1992], and the presence of

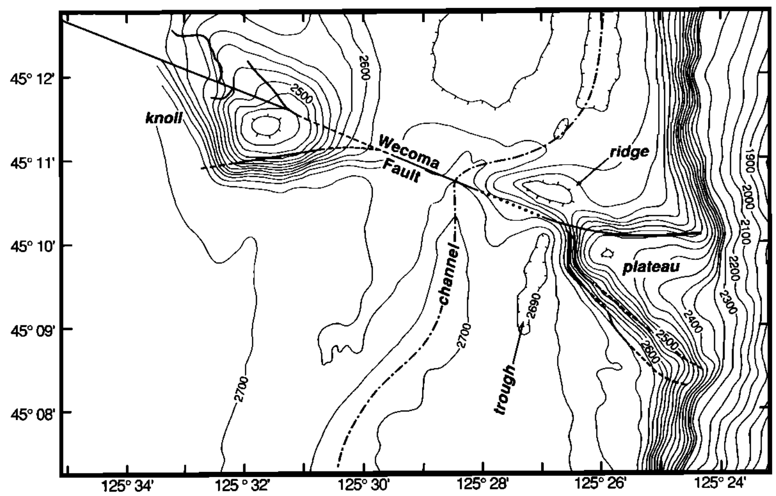

Fig. 2. Detailed bathymetry of the Wecoma fault, based on Seabeam soundings and SeaMARC I imagery. Contour interval is 20 m except on the lower continental slope, where contours are spaced 100 m apart. Ticks on closed contours point downhill. The Wecoma fault and its major subsidiaries are marked by bold lines (dashed where inferred, dotted where covered), and the slope base channel is shown by a dot-dashed line. Labeled features are discussed in the text.

faults on the seaward flank of the marginal ridge may simply be a consequence of the Wecoma fault being incorporated into the marginal ridge along with the rest of the upper sedimentary section. An alternate possibility is that the faults are actively disrupting the marginal ridge, which could account for the left step in the base of slope at the north side of the embayment (Figure 3). However, there is no left-lateral separation of the lower slope across the embayment as a whole. The Wecoma fault may also funnel escaping fluids to the base of the marginal ridge, where high fluid flux could have contributed to shape the embayment via spring sapping and other processes similar to those described for headless canyons farther south along the Oregon margin [Moore et al., 1990; Orange and Breen, 1990] and elsewhere [Robb, 1984].

Fault-Parallel Ridge

Immediately west of the plateau, a 2.5-km-long ridge parallels the north side of the Wecoma fault (Figure 2). The fault trace is evident west of the ridge tip as a linear, south facing scarp (Figure 5), but adjacent to the ridge the fault is buried beneath slump blocks and debris derived from the ridge's southern flank. The slump blocks are backtilted, as indicated by the acoustic shadows within the northern part of each block. South facing, coalesced arcuate scarps bound these blocks to the north. Similar slumps and debris fields extend along the length of the ridge's southern flank, beyond the right edge of Figure 5. The ridge's northern side displays a shallower slope and does not contain recent slump or fault scarps (Figure 3), suggesting that the ridge's recent history has involved oversteepening and slumping of the southern flank without similarly affecting the northern flank.

Although various patterns of faulting can be envisioned to have constructed the ridge, the observed morphology is best explained by left-lateral movement of the Wecoma fault. According to this model, the ridge was originally uplifted as part of the plateau, from which it was subsequently cleaved and displaced left laterally by the Wecoma fault. A sliver of the plateau thus translated westward would be predicted to exhibit the sort of morphology displayed by the ridge, with a steep scarp along its young fault-bounded southern side and shallower slopes over its older western and northern sides, which have had a longer period to establish equilibrium slopes through mass wasting. The north side of the ridge is predicted to be bounded by south dipping faults associated with the original uplift of the plateau, although our seismic data do not adequately image this part of the ridge. The morphology of the northern flank of the plateau, which exhibits steep slopes incised by a sharply defined landslide scar, is consistent with this model. The present position of the ridge relative to the plateau indicates that at least 2.5 km of left-lateral motion has occurred along the Wecoma fault.

Fault-Channel Intersection and Slip Rate

An important feature crosscut by the fault is a submarine channel located seaward of the base of the continental slope (Figure 1). This is one of two primary channels on the Astoria Fan [Nelson et al., 1970] that were scoured in the late Pleistocene by frequent southward flowing turbidity currents [Nelson, 1976]. The course of the channel appears to have been influenced by motion associated with the Wecoma fault. The channel bends westward around the previously described ridge before it crosses the fault (Figure 2), and a trough located south of the fault and ~ 2.5 km east of the present channel may represent an abandoned channel bed, offset left laterally from the present channel axis.

At the fault/channel intersection (Figure 6), the present channel axis approaches the fault from the northeast and crosscuts the eastern side of an older erosional feature. The channel's west bank is offset ~ 120 m left laterally across the Wecoma fault, causing the bank south of the fault to completely block the channel. South of the Wecoma fault, the channel's west bank is offset by several minor faults, which

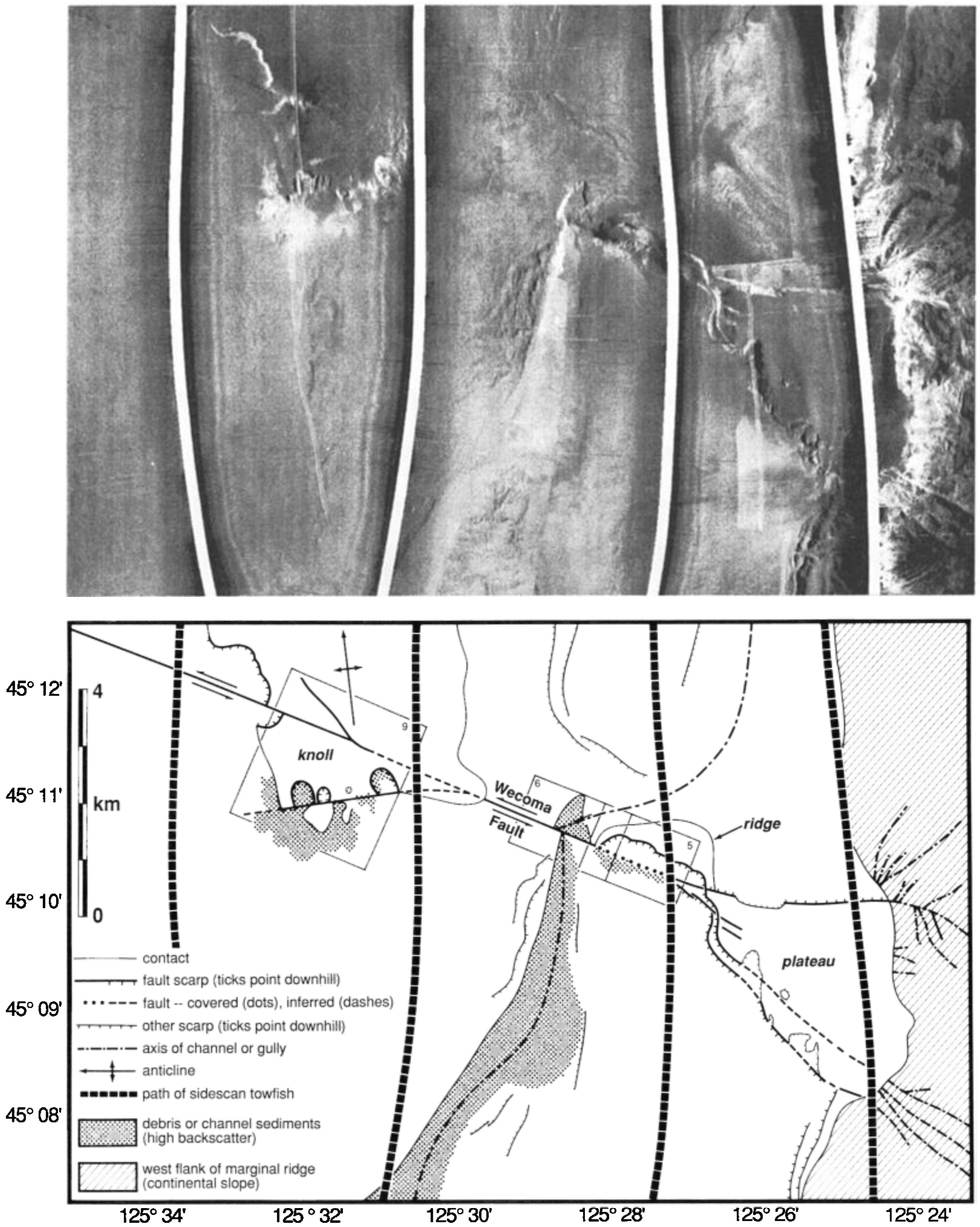

Fig. 3. Mosaic and geological interpretation of SeaMARC I sidescan sonar swaths of 5 km width over the Wecoma fault, showing the same area as Figure 2. The linear Wecoma fault extends southeast from the upper left corner. On this and subsequent sidescan images, high backscatter is indicated by white and acoustic shadow by black. The locations of Figures 5, 6, and 9 are outlined.

individually display 25 to 50 m of right-lateral separation. The resolution of these features is a function of the sonar beam geometry and along-track sampling rate, which for this 2-km SeaMARC I swath yield a resolution of ~ 1 m across track and 10 to 15 m along track at the location of these faults [Malinverno et al., 1990]. The minor faults do not extend northward across the Wecoma fault, and they are not evident on seismic profiles. We infer that they are shallow features with dips that flatten with depth and join the main Wecoma fault at a high level.

The slip rate of the Wecoma fault can be evaluated by (1) assuming that the channel's west bank was originally a continuous feature that formed during the last erosive pulse of sediment through the channel and (2) estimating the age of the west bank. A reconstruction of the fault/channel intersection (Figure 7), created by subtracting strike-slip motion along each

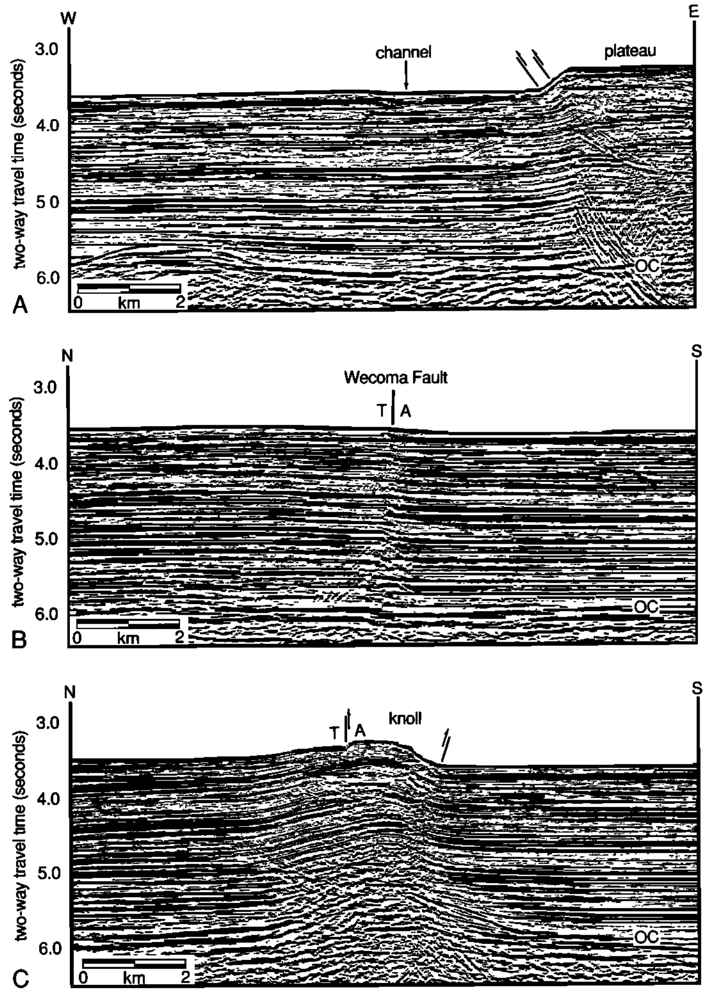

Fig. 4. Migrated multichannel seismic time sections, displayed with automatic gain control (AGC), of (a) line OR-30, (b) line OR-37, and (c) line OR-45. The location of each profile is shown on Figure 1. The sense of strike-slip separation (inferred from sidescan data) is given by A (away) and T (toward), and vertical separation is shown by arrows. Vertical exaggeration at the seafloor is ~ 2:1. OC is oceanic crust; channel is slope base channel.

of the faults, illustrates the initial continuity of the channel's west bank prior to its offset. Alternate reconstructions are possible; however, Figure 7 is representative of the initial channel morphology indicated by each. Although age data are not available for channel sediments near the fault, previous sediment studies [Nelson et al., 1970; Nelson, 1976] have shown that Astoria Fan channels were eroded during a period of high turbidity current activity in the late Pleistocene. The frequency of turbidity currents decreased in the early Holocene, and the last erosional episode recognized within Astoria Fan channels occurred following the eruption of Mount Mazama (to form Crater Lake, Oregon) 6600 years B.P. However, Nelson (1976) observed that Mazama ash was absent from cores taken from the slope base channel south of 45°25'N, and he suggested that the channel was blocked prior to 6600 years B.P., diverting Mazama-ash turbidity currents to the west. Seabeam bathymetry (Figure 1) shows that the slope base channel is blocked at 45°21'N by debris from a major lower-slope submarine slide. Goldfinger et al. (submitted manuscript, 1991) estimate a minimum age of 10,300 years B.P. for the slide on the basis of ^{14}C dating of post slump hemipelagic sediments cored on one of the slide blocks, and a maximum age of 24,000 years B.P. inferred from sedimentation rates and the lack of onlapping or ponding of post slump turbidites evident in seismic reflection profiles across the debris field. Assuming that the slide prevented subsequent turbidity currents from reaching the fault and that the final erosive pulse occurred just before or as a consequence of the slide, then the 120 m separation of the channel's west bank indicates an average slip rate of ~ 5-12 mm/yr. These rates would be lower if the final channel erosion occurred before the slide; they would be higher if recent, locally derived turbidity currents have caused channel erosion.

The morphology of the Wecoma fault in Figure 6 provides an additional constraint for the minimum total offset along the fault. The fault east of the channel appears as a steep, south

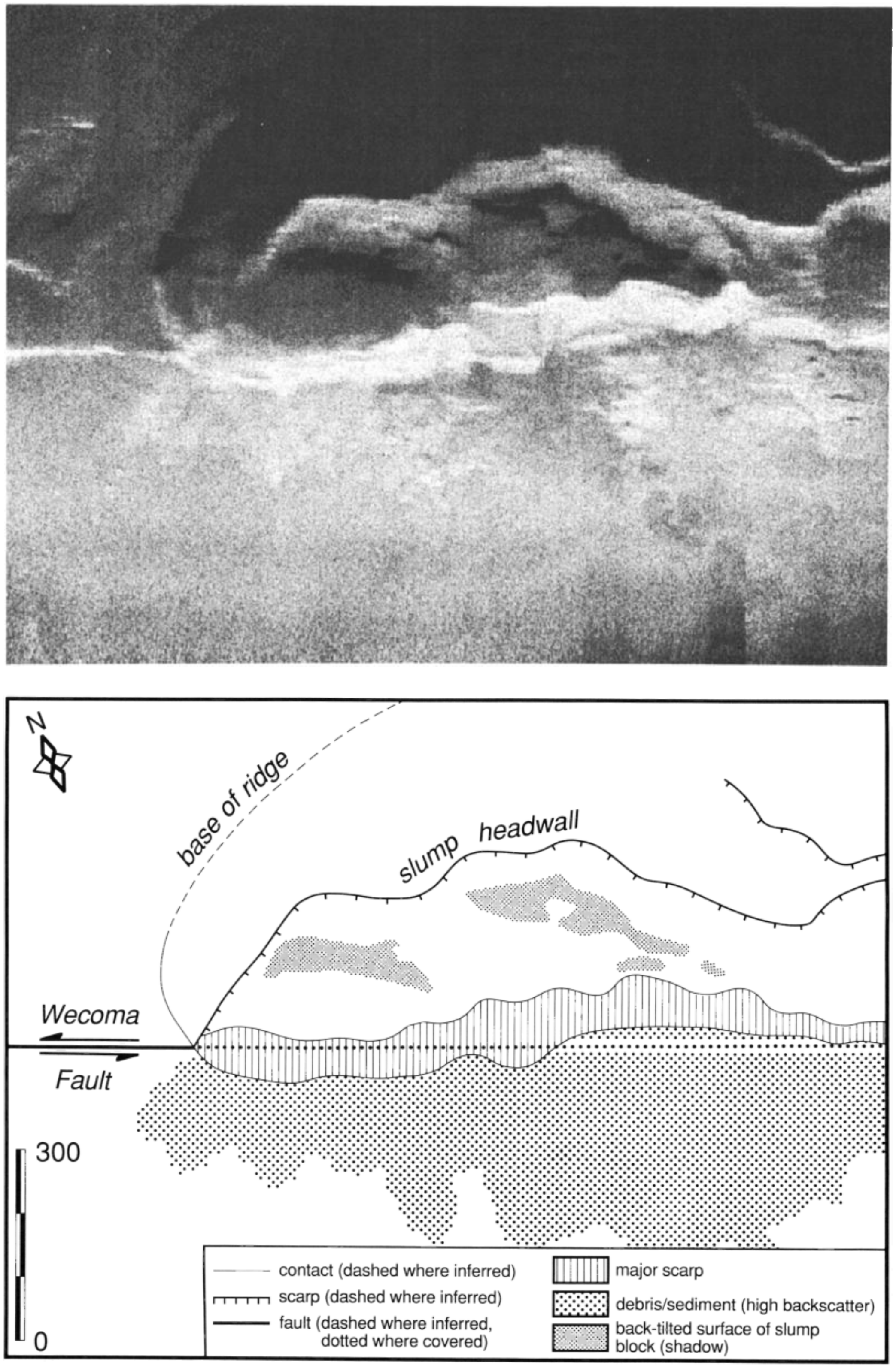

Fig. 5. Part of a SeaMARC I image (2 km swath width) and geological interpretation of the western tip of the linear ridge on the north side of the Wecoma fault. Pertinent features are marked and discussed in text. Nadir is along bottom of image, insonification is toward the top. See Figure 3 for location.

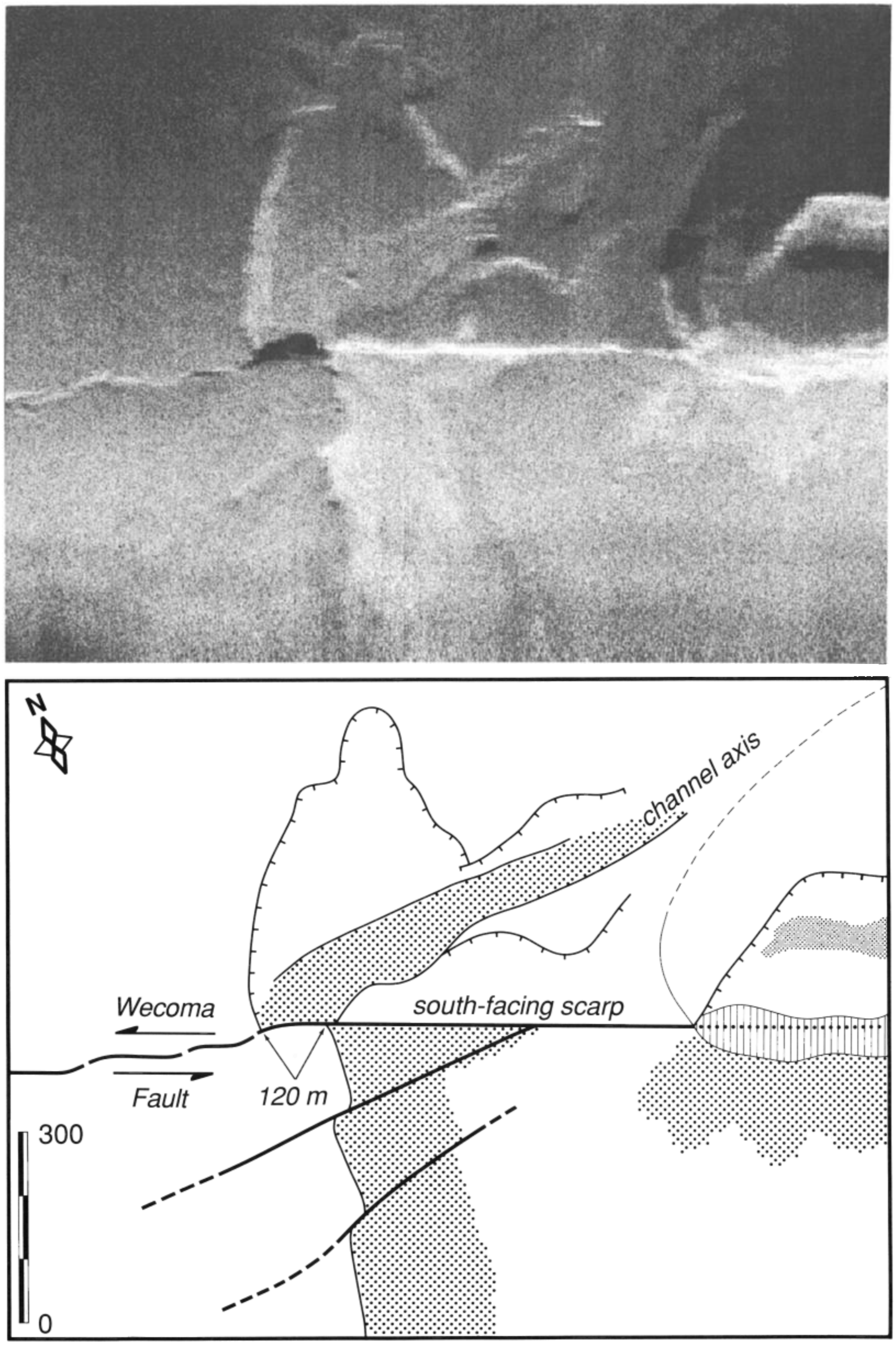

Fig. 6. Part of a SeaMARC I image (2 km swath width) and geological interpretation of the intersection between the Wecoma fault and slope base channel. The channel's west bank has been left laterally offset 120 m along the fault, blocking the channel. Structures discussed in text are indicated. Nadir is along the bottom of the image; insonification is toward the top. See Figure 3 for location. Symbols are as in Figure 5.

Fig. 7. Reconstruction of the fault/channel intersection. Motion along each of the recognized faults has been subtracted to restore the channel's west bank to its inferred original configuration.

facing scarp, as indicated by its high backscatter. This could be due to uplift of the northern block; however, a similar scarp is not present west of the channel, indicating this sort of uplift has not occurred there. An alternate explanation that takes left-lateral fault motion and channel erosion into account is depicted in Figure 8. This series of diagrams shows the southern block being eroded as it passes the channel axis, forming a plain ~ 15 m below the basin depth to the west and north. According to this model, the south facing scarp along the fault results from erosion of the southern block rather than from uplift of the northern block, and the south facing scarp records 500 m of left-lateral motion. This is a minimum value, because the fault trace is buried beneath slump debris along the ridge to the east.

Multichannel seismic reflection profiles across this part of the Wecoma fault indicate that the fault extends to the base of the sedimentary section and overlies a basement structural discontinuity. The fault surface is planar and nearly vertical,

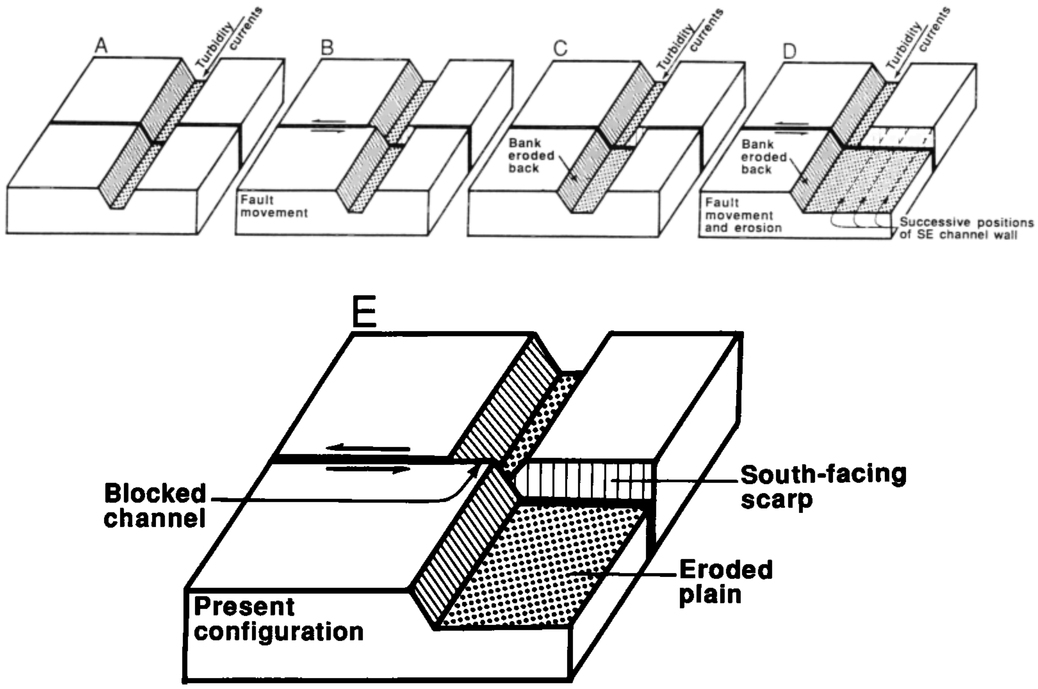

Fig. 8. Schematic diagrams showing a simple model for the evolution of the Wecoma fault's intersection with the slope base channel. The model involves left-lateral movement of the fault and channel erosion due to turbidity currents. The original channel (A) is displaced along the Wecoma fault (B), causing the southwest bank to partially block the channel. Subsequent channel activity erodes the southwest bank back so that it is continuous with the northwest bank (C). Continued fault movement (D) progressively translates the southeast bank farther east, while channel erosion keeps the position of the southwest bank in check. Thus as the south block moves past the channel it is planed down to the level of the thalweg, exposing a south facing scarp along the fault east of the channel. Recent fault motion has moved the west bank across the channel, blocking it (E).

and reflections offset across the fault display down-to-the-south vertical separation (Figure 4b). The basement reflection exhibits a similar sense of separation, suggesting that movement of the Wecoma fault may involve basement as well as the overlying sediments. The detailed history of Wecoma fault is difficult to discern from seismic data because the strike-slip nature of the fault as well as inhomogeneities in the pattern of fan deposition through time introduce uncertainty in the correlation of individual horizons across the fault.

Knoll and Western Wecoma Fault

Farther west, the Wecoma fault crosses the summit of a 250-m-high knoll (Figure 2). The knoll marks the southern end of a north plunging anticline [Cochrane and Lewis, 1988; Goldfinger et al., 1992], which appears in the regional bathymetry (Figure 1) as a low topographic ridge that diminishes in relief to the north. The anticline abuts the Wecoma fault and rapidly diminishes in relief to the south (Figure 4c). A 2-km-swath sidescan image (Figure 9) suggests that the south side of the knoll is bounded by a SW trending fault splay that is not well imaged in the regional sidescan mosaic. A pair of upward diverging faults beneath the knoll (Figure 4c) intersect the surface at approximately the same positions as the faults shown in Figure 9. The knoll has been uplifted between these faults in a manner similar to positive flower structures (Goldfinger et al., submitted manuscript, 1991) observed on other strike-slip faults [Roberts, 1983; Harding et al., 1983]. Together, the geometries of the faults and plunging anticline are compatible with the pattern expected to result from transpression [Sanderson and Marchini, 1984], or across a restraining bend in the fault.

Multichannel seismic and magnetic data indicate the presence of a structural basement high beneath the knoll. The structural high extends south of the knoll (Figures 4a and 4c) and is overlain by sedimentary horizons that pinch out toward its crest, indicating that basement relief existed here prior to the deposition of the first sediments. A magnetic profile across the eastern part of the knoll (Figure 10) shows a distinct boundary over the fault zone, with magnetization increasing on the northern block. Forward modeling of this magnetic line suggests that this profile could be generated by a 100- to 200-m uplift of the northern block, with a zone of nonsusceptible basement rock along the fault zone, possibly indicating crushed material or nonmagnetic, hydrothermally altered rock. Alternatively, strike-slip movement along a basement fault may have juxtaposed rock of differing magnetization here. These data cannot constrain the age of the basement offset, however, and the inferred basement offset may be independent of Wecoma fault motion.

Several lines of evidence suggest that fluids are being expelled from the sediments at numerous sites on the knoll. A

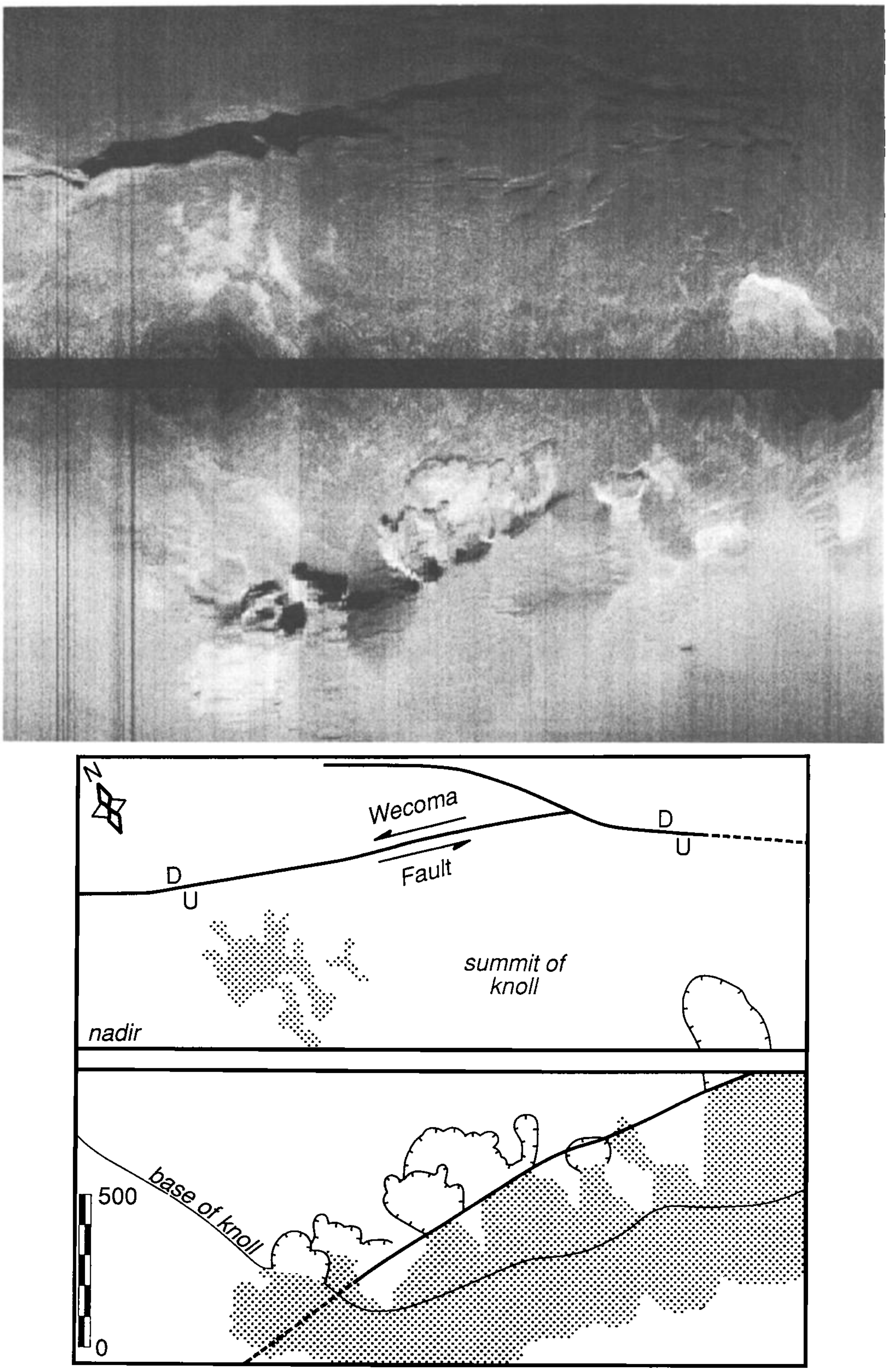

Fig. 9. SeaMARC I image (2 km swath width) and geological interpretation of the Wecoma fault where it crosses the knoll. The main trace of the Wecoma fault forms a north facing scarp that casts an acoustic shadow. The southern flank of the knoll is bounded by a fault that also casts a linear acoustic shadow. High backscatter at the knoll's summit is inferred to indicate the presence of carbonates that precipitate at fluid expulsion zones (discussed in text). Insonification is directed outward from nadir. See Figure 3 for location. Symbols are as in Figure 5.

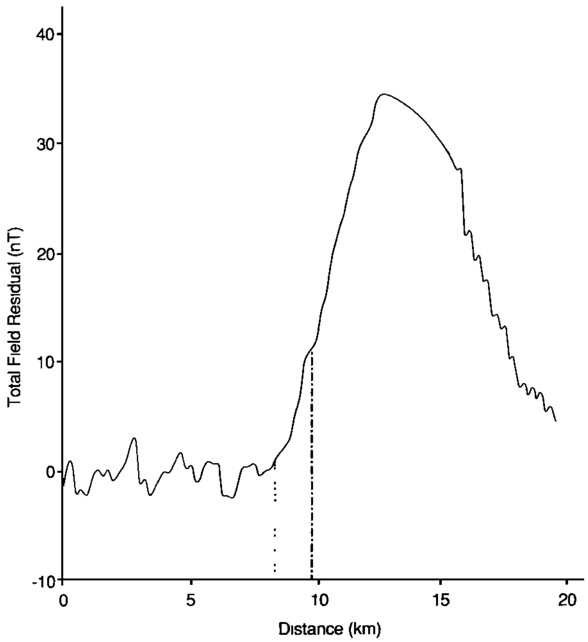

Fig. 10. Magnetic profile over the knoll (M1 on Figure 1). The profile represents the observed total field minus the 1985 International Geomagnetic Reference Field minus a best fit linear regional trend. The x axis represents distance from the southern end of the line. The dotted and dot-dashed lines indicate the approximate positions of the southern splay fault and the main Wecoma fault, respectively.

submersible study of the southern slope of the knoll documented disarticulated *Calyptogena* sp. and *Solemya* sp. clam shells dispersed over a depth range of 2625 m to 2504 m, and deep-tow camera surveys photographed apparently live *Calyptogena* sp. and *Solemya* sp. clams along faults on the knoll's western flank. Similar clams recovered from the Oregon margin were found in association with fluid vent sites [Kulm et al., 1986; Lewis and Cochrane, 1990] and are thought to metabolize hydrogen sulfide from the vent fluids as an energy source (A. DeBevoise, personal communication, 1990). The presence of clams on the knoll suggests that fluids are (or recently were) being vented in concentrations sufficient to support chemosynthetic animals in some locations, and fluids sampled south of the knoll's summit were found to contain small quantities of both hydrogen sulfide and methane (L. D. Kulm, unpublished data, 1988). A field of high-backscatter material at the knoll's summit closely resembles the backscatter pattern associated with documented carbonate fields elsewhere along the Oregon margin [Kulm et al., 1989]. Carbonates precipitate at (or just below) the seafloor in regions where methane-rich fluids are being expelled from the accretionary prism [Kulm et al., 1986; Ritger et al., 1987; Kulm and Suess, 1990]. We infer that the high-backscatter field here represents a similar carbonate deposit associated with active (or recently active) expulsion of methane-rich fluids.

The westernmost surficial feature crosscut by the Wecoma fault is the headwall of a slump on the west flank of the knoll, which is offset left laterally 350 m (Figure 11). The fault trace can be followed 4 km farther northwest, where the vertical relief across the fault diminishes to the point where it is no longer resolvable in the sidescan imagery. A distinct terminus to the fault was not observed.

DISCUSSION

History of the Wecoma Fault

The varying degree of separation displayed by the features offset by the Wecoma fault allow us to infer the fault's history. The relative ages of offset structures are determined by assuming that slip rate is constant along the fault: the west bank of the slope base channel is youngest, the slump scarp

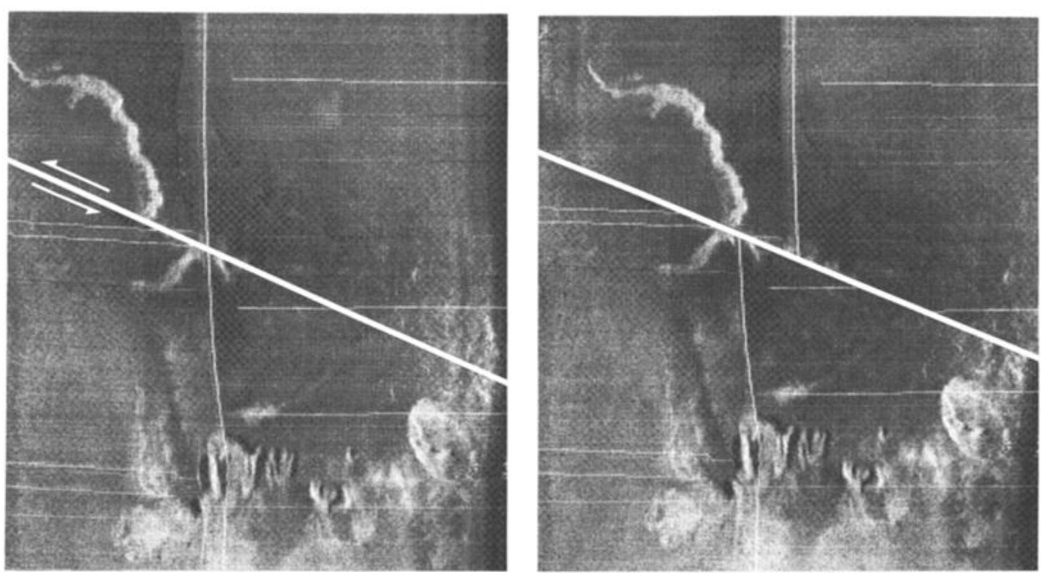

Fig. 11. Close-up of Figure 3 showing the knoll in its present configuration (left) and after subtracting 350 m of fault motion (right), illustrating the inferred original continuity of the arcuate slump headwall.

on the west side of the knoll is intermediate in age, and the translated ridge northwest of the triangular plateau is oldest. Applying the range of slip rates calculated from the offset channel, the age of the slump scarp is ~ 30-70 ka, and the translated ridge is ~ 210-500 ka, indicating that the Wecoma fault has been active since at least 210 ka.

The foregoing observations suggest the following general history for the fault and structures near it, in chronological order.

1. Basement relief developed. By analogy with the modern Juan de Fuca ridge crest, the basement high presently under the knoll may represent either volcano/tectonic fabric generated at the ridge axis, relief created along a transform or other ridge offset, or off-axis volcanism.
2. Sediments over the basement high were deposited, creating the basal sequence of sediments that thin towards the crest of the high.
3. The triangular plateau was uplifted; this was accommodated by movement along the fault splays imaged in the seismic lines.
4. The present trace of the Wecoma fault was established. After the plateau formed, the northern strand of the Wecoma fault crosscut the northern part of the plateau and subsequently translated it westward to form the linear ridge. The left-lateral displacement juxtaposed the elevated remnants of the plateau against deeper seafloor, thus creating steep slopes on the northern plateau and southern ridge, which became the sites of slumps and landslides evident in the sidescan images.
5. Slumping, perhaps triggered by seismic shaking, occurred on the west side of the knoll. Although the timing of this slump event indicates that the knoll had attained some degree of relief by this time, our data do not constrain the age of the knoll's initial uplift.
6. The present slope base channel developed. The evolution of the fault-channel intersection probably involved numerous erosional episodes as turbidity currents scoured the channel throughout the Pleistocene, separated by intervals during which the channel was offset by the Wecoma fault. Subsequent erosive pulses reestablished the continuity of the channel across the fault.
7. Submarine slide debris blocked the channel north of the Wecoma fault, and further motion of the fault was recorded at the fault/channel intersection without modification by channel erosion.

Driving Mechanism

What mechanism is responsible for driving the Wecoma fault? The fault's overall morphology as well as its obliquity to the local convergence direction suggest that it is not a simple tear fault. For comparison, a well-developed tear fault is located along the north end of the landward vergent thrust ridge that is presently forming at the base of slope between 44°55'N and 45°05'N (Figure 1). Seismic profiles show that this tear fault extends to about the middle of the sedimentary section, does not offset basement, and does not extend seaward of the base of slope [MacKay et al., 1992]. The orientations of the tear fault and the thrust ridge (~ 070° and 339°, respectively) suggest that these features formed in response to the ~ 069° relative convergence direction between the Juan de Fuca plate and the North American plate. If the Wecoma fault is driven by stresses generated at the trench, the obliquity of the fault to the convergence direction could account for transpression sufficient to produce the pattern of faulting observed around the knoll and the slope base channel, although the mechanism responsible for driving strike-slip motion far from the main deformation front is not obvious.

The seismic and magnetic data suggest that basement is offset across the Wecoma fault, implying that deformation of the Juan de Fuca plate itself may be involved. It is possible that the Wecoma fault marks an older zone of weakness in the underlying crust, reactivated in response to subduction-related stresses. The surface trace of the Wecoma fault (293°) is nearly orthogonal to the present spreading axis of the Juan de Fuca ridge (020°) and may thus reflect the trace of a fracture zone. Interestingly, if the trend of the Wecoma fault is projected westward, it intersects the Juan de Fuca Ridge at a structurally complex ridge offset that separates the Cobb and Axial Volcano spreading segments. However, the history of this part of the Juan de Fuca plate is complicated. Seafloor magnetic anomaly patterns at the convergent margin show that the azimuth of the Juan de Fuca ridge was nearly north-south at the time this crust formed [Elvers et al., 1973; Wilson et al., 1984], therefore any fracture zone here should be oriented east-west. Magnetic anomalies also show that the inner pseudofault of a southward directed propagating rift, active on the Juan de Fuca ridge between 17.0 and 4.5 Ma, is entering the subduction zone near the same latitude as the Wecoma fault [Wilson et al., 1984]. According to the model of Wilson et al. [1984] for the tectonic evolution of the Juan de Fuca ridge, the crust now being subducted at 45°10'N was originally part of the Pacific plate and was transferred onto the Juan de Fuca plate by the passage of the propagator. For these reasons, it is difficult to assess whether the basement structure beneath the Wecoma fault is inherited from spreading center processes.

Segmentation of the subducted Juan de Fuca plate has been inferred beneath the North American continent [Michaelson and Weaver, 1986], and perhaps the Wecoma fault represents the early segmentation of the downgoing slab as it approaches the trench [Goldfinger et al., 1990]. Goldfinger et al. [1992] suggest that WNW trending strike-slip faults evident on the downgoing plate also crosscut the accretionary prism on the continental slope. Continuity of these faults across the plate boundary would have profound implications for the structural development and present tectonic setting of the Cascadia accretionary prism. Further detailed studies of Cascadia Basin and the Cascadia accretionary prism are necessary to clarify the regional significance of the Wecoma fault.

CONCLUSIONS

1. The Wecoma fault is a left-lateral strike-slip fault that extends at least 18.5 km seaward from the base of the Oregon accretionary prism. The fault is oriented 293°, oblique to both the trend of the subduction zone's deformation front and the relative convergence direction between the Juan de Fuca and North American plates. This orientation is nearly perpendicular to the axial strike of the modern Juan de Fuca ridge but ~ 20° oblique to the azimuth of local magnetic anomalies.
2. The Wecoma fault extends through the entire sedimentary section and may offset basement on the Juan de Fuca plate. The morphology of the embayment at the fault/marginal ridge intersection suggests that the fault has influenced the structural development of the lower slope.

3. Various surficial structures display between 120 m and 2500 m of left-lateral horizontal separation across the Wecoma fault. The varying amounts of offset exhibited by these features allow their relative ages to be determined.

4. The fault's late Pleistocene-Holocene average slip rate ranges from 5 to 12 mm/yr. Applying the maximum slip rate to the greatest observed offset yields a minimum age for the fault of 210 ka.

5. Methane-rich fluids have vented from the summit and flanks of the knoll, where local zones of fluid expulsion support communities of chemosynthetic clams.

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