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A TRENCH FAN IN THE IZU–OGASAWARA TRENCH ON THE BOSO TRENCH TRIPLE JUNCTION, JAPAN

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Abstract

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The Mogi Trench Fan, 18 km in diameter, is located in the 9.1 km deep Izu–Ogasawara Trench. Analysis of the morphology and internal structure of the Mogi Fan was based on 3.5 kHz records, seismic reflection profiles and Seabeam bathymetry. The Mogi Fan was fed from a point source, and displays an even-shaped partial cone morphology which can be divided into upper, middle and lower fans. The upper fan is defined as an apparent topographic mound, having a large-scale single channel with well-defined levees that appear to be composed mainly of coarse-grained turbidites. The middle fan is characterized by divergent channels and lobes. The lower fan is a smooth mound with no channel features. It is postulated that the lower fan is constructed chiefly by turbidity currents that reflected back from the higher outer slope. Seismic reflection records across the fan show deformation resulting from plate subduction in the upper fan; this deformation can be traced laterally to the lower bulge of the inner slope neighbouring the Mogi Fan. Several characteristics of the morphology of the Mogi Fan indicate that it is presently inactive. The fan development is interpreted to have formed and prograded in the trench during a period of lowering sea level. During rising sea level, the sediment supply to the trench abruptly decreased, and the tectonic deformation of the fan morphology was correspondingly enhanced.

Introduction

The Mogi Trench Fan, a sedimentary cone-shaped deposit, developed in a trench undergoing active subduction, is a unique feature because of its short residence time in the trench. Potentially, it can be an indicator of sediment supply versus tectonic deformation in a trench environment. An understanding of the behaviour of a trench fan, its construction, development and destruction, allows us to make estimates concerning the sediment yield as well as the sediment subduction and accretion processes in the trench. Trench fans are documented from several localities (the Aleutian Trench, Piper et al., 1973; the Nankai Trough, Le Pichon et al., 1987; Nakamura et al., 1987; the Chile Trench, Thornburg and Kulm, 1987) and generally they were constructed at the mouth of a submarine canyon that crossed the inner slope and prograded to the trench floor. However, the interaction between sedimentation and deformation of a trench fan is still poorly understood.

In this paper, we describe the morphology of a trench fan, 18 km in diameter in a water depth of 9.1 km, located on the northern part of the Izu–Ogasawara Trench near the trench triple junction off the Boso Peninsula (Fig.1). The recognition of the fan is based on morphological data obtained on 3.5 kHz subbottom profiles and seismic reflection profiles. We discuss the construction and deformation of

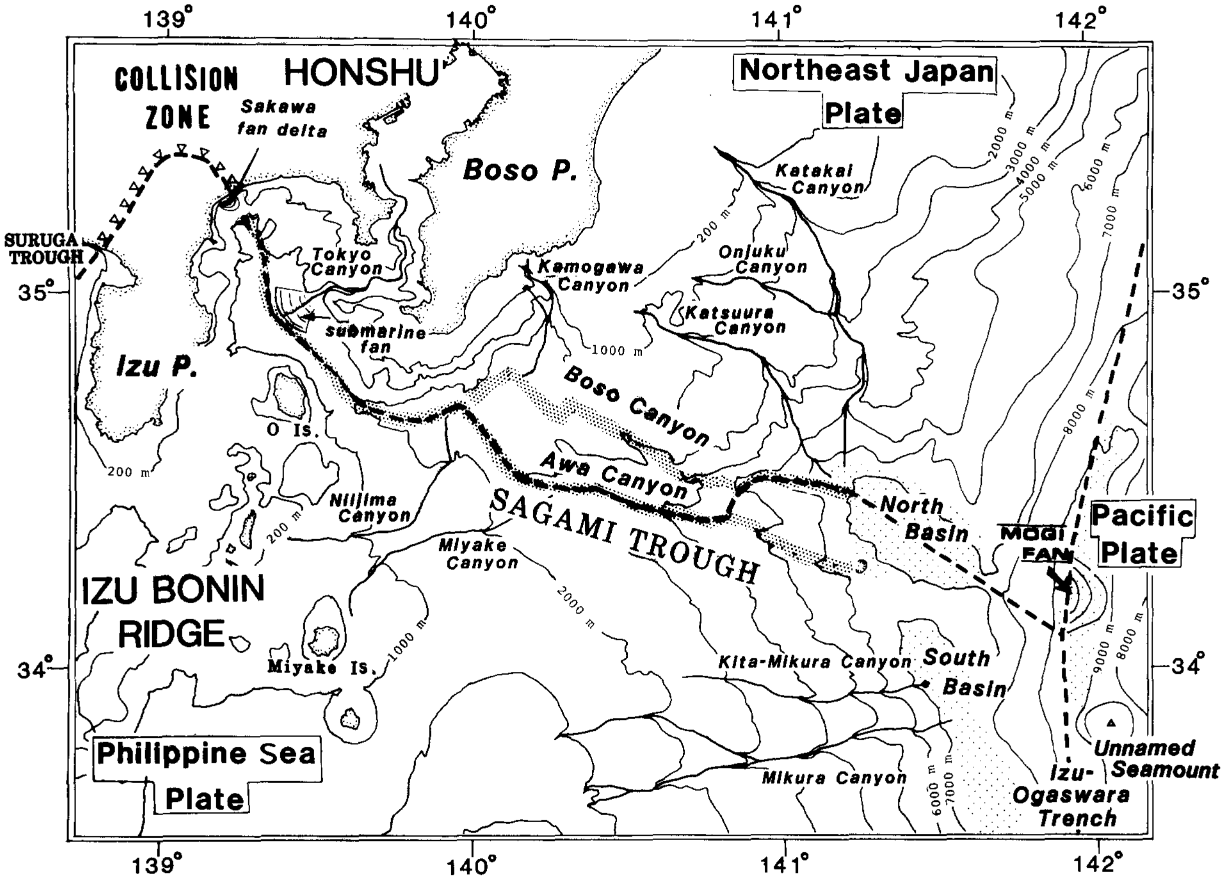

Fig.1. Generalized topographic map of the Sagami Trough and the trench triple junction area off Boso Peninsula. The Sagami Trough provided a pathway for transport of clastic detritus from the Izu collision zone, and many submarine canyons drain into the Izu–Ogasawara Trench via Awa and Boso canyons. The Sagami Trough axis is the Philippine Sea–Northeast Japan Plate boundary. Heavy dashed lines indicate plate boundaries.

the trench fan as it relates to sea-level changes and subduction tectonics.

Data collection

The 3.5 kHz subbottom profiles and multichannel airgun seismic reflection profiles which constitute the data base for this paper, were collected during cruise KH-86-5 of the R.V. *Hakuho-maru* of the Ocean Research Institute, University of Tokyo, in 1986. During this cruise, about 200 line km of 3.5 kHz subbottom profiles and 20 line km of multichannel seismic profiles were collected across the Mogi Fan. The tracklines are shown in Fig.2. We also utilized 3.5 kHz subbottom profiles and single-channel watergun records from a study area of the KAIKO Project (phase 1, leg 2 cruise, 1985) (KAIKO 1 Research Group, 1986). The data on the morphological characteristics and the bathymetric map (Fig.3) were prepared from the compilation by the KAIKO 1 Research Group (1986) and from Kato et al. (1985).

Geotectonic setting

The triple junction off Boso Peninsula connects the Izu–Ogasawara Trench, the Japan Trench and the Sagami Trough (Fig.1). It is a trench–trench–trench triple junction as defined by McKenzie and Morgan (1969). The

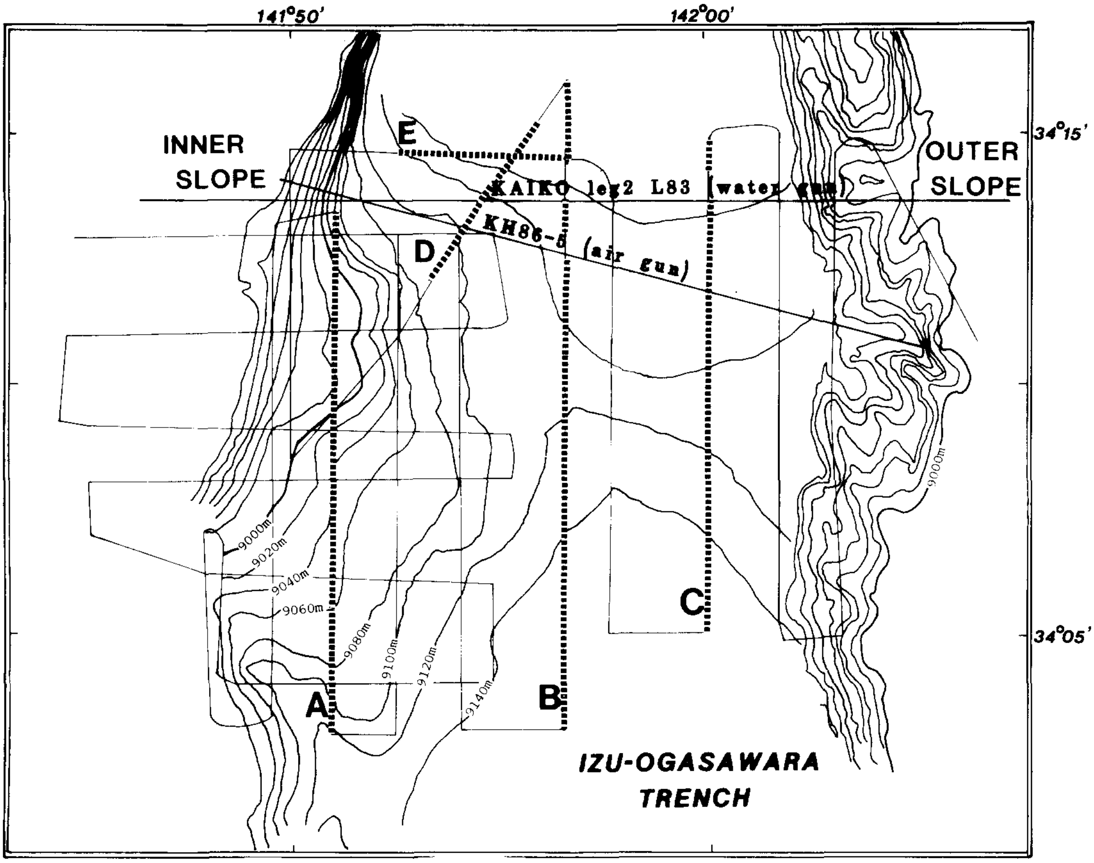

Fig.2. Trackline plot of 3.5 kHz acoustic profiles from the KH86-5 cruise over the Mogi Fan and near the trench triple junction off Boso Peninsula. Lettered dashed lines show position of profiles in Figs.5 and 6.

study area is located near this junction and is part of a very complex and unique tectonic setting because of the convergence of three different plates.

As shown in Fig.1, the subducting Philippine Sea Plate in this region consists of a volcanic ridge, the Izu–Bonin Ridge. The plate boundary between this ridge and the Honshu part of the Northeast Japan Plate bends acutely to the north, and is delimited by the Sagami Trough. This is because the Izu–Bonin Ridge has collided with Honshu at the northern margin of the Izu Peninsula (Sugimura, 1972; Kaizuka, 1975; Matsuda, 1978; Nakamura and Shimazaki, 1981; Renard et al., 1987). According to onshore data around the Honshu near the Izu Peninsula, tremendous amounts of coarse clastic sediments indicating alluvial to deep-sea environments are deposited. The Ashigara Group located on the north of the Izu Peninsula, for example, is composed of trough-fill to fan-delta sediments up to 3 km thick, ranging from 1.7 to 0.5 Ma old (Huchon and Kitazato, 1984; Ito, 1985; Amano et al., 1986). Most of these sediments are thick-bedded, coarse-grained sandstones and conglomerates supplied from the uplifted Honshu region resulting from the collision of the Honshu and the Izu–Bonin Ridge.

Figure 1 illustrates the Pacific Plate subducting below the Philippine Sea Plate and Northeast Japan Plate along the Izu–Ogasawara Trench. The bottom of the Izu–Ogasawara Trench exceeds 9 km (water depth), and is one of the deepest trenches in the world. Seno et al. (in prep.) estimate that the Pacific Plate moves west-northwest at a rate of approximately 6.3 cm/yr and 9.8 cm/yr with

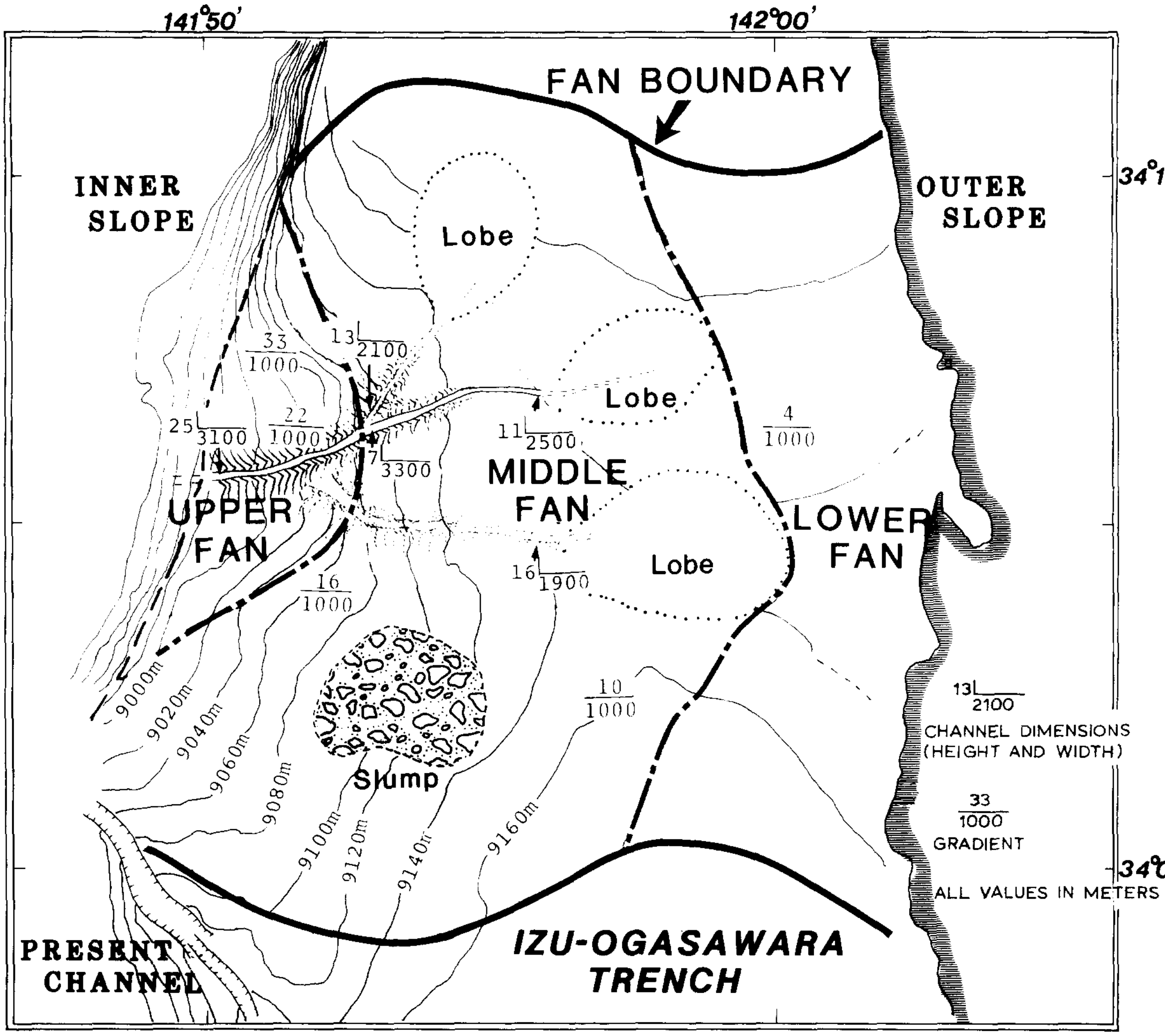

Fig.3. Morphological map of the Mogi Fan showing fan divisions, gradients, channel pattern and dimensions.

respect to the Izu–Bonin Ridge and Northeast Japan Plate, respectively. Many seismic records demonstrate that extensive accretionary prisms cannot be recognized in the northern part of the Izu–Ogasawara Trench, i.e., tectonic erosion of the inner slope on the overriding plate seems to dominate in the trench (Matsubara and Seno, 1980; Renard et al., 1987).

Submarine geomorphology

The Sagami Trough is a major topographic low extending NW–SE between the collision zone of the Izu–Bonin Ridge and Honshu, and the trench triple junction (Fig.1). Up-dip of the Sagami Trough, the Sakawa fan-delta has formed. This fan-delta, approximately 5 km in width, is likely to be active. Indeed, on the lowest slope, a remarkable sedimentary tongue of coarse clastic sediments and gravels with abundant glass and wood fragments was deposited after the Sakawa River flood in July, 1972 (Otsuka et al., 1974).

Within the Sagami Trough, two submarine channels, the Awa Canyon and Boso Canyon, are defined as longitudinal axial channels. The Awa Canyon, traced along the axis of the

Sagami Trough, is interpreted to be the present axial channel of the trough. The Boso Canyon, located along the Boso Escarpment north of the Awa Canyon, is a meandering submarine channel downcutting through the basement of Mio-Pliocene sedimentary rocks (Nakamura et al., 1987). Many submarine channels, such as the Tokyo Canyon, Katsura Canyon, and Katakai Canyon, drain into the Sagami Trough as tributary channels. The Sagami Trough thus acts as the major conduit for clastic materials eroded from the collision zone between the Izu–Bonin Ridge and Honshu as well as the Kanto region. The region includes several active volcanoes and a rapidly uplifting hinterland.

The Izu–Ogasawara Trench in the study area extends N–S, and is approximately 10 km wide. The bottom of the Izu–Ogasawara Trench gradually elevates and narrows to the north of the Mogi Fan. The trench-fill sediments tend to thin to the north of the study area, and nearly disappear north of 34°40′N. On the other hand, a small-sized seamount is situated on the trench floor at 33°50′N (Fig.1), and the trench-fill sediments are likely to be trapped by the seamount. Consequently, a restricted trench basin has formed between 34°40′ and 33°50′N inside the Izu–Ogasawara Trench. Based on acoustic data, thick trench-fill sediments (about 1 km thick), can be recognized above the acoustic basement. The trench floor within the restricted basin seems to be flat and smooth with no channel recognizable in the trench.

The inner slope basins in the study area are located in a water depth of 7 km. They can be divided into two basins, the North and South basins, which are separated by the WNW–ESE trending Central High (Fig.4). The North Basin is rhombic in shape, and approximately 700 km^2 in area. The Awa, Boso and Katakai canyons feed directly into the northwestern margin of the North Basin. The clastic sediments are likely to have been supplied mainly from the collision zone. The sediments can then be transported from North Basin to the floor of the Izu–Ogasawara Trench. The North and South noses extend north and south and act as a barrier between the two inner slope basins and the Izu–Ogasawara Trench floor. The spines of these noses curve in a zigzag fashion. On the turning points of the spine curvature, steep steps with high slope angles are recognized. Several seismic reflection profiles show that these steps correspond to the sites of possible low angle, W-dipping thrusts. These possible thrust terminations tend to undulate N–S, and constitute a macroscopic-scale thrust-pile structure. They are well developed on the eastern slope of the higher main bulge. The morphological characteristics of the North and South noses are quite similar to the inner slope of the southern Suruga Trough, which is generally believed to have been constructed as an accretionary prism composed of imbricated thrust piles. From this, we interpret that the North and South noses have also been constructed as accretionary prisms.

Focusing on the North Nose, the bathymetric map (Fig.4) suggests two topographic components: a higher main bulge and a lower, smaller bulge separated by an elongate N–S depression. The submarine channel from the North Basin to the Izu–Ogasawara Trench shifts its course abruptly to the east–southeast. The lower bulge, 2.5 km wide and 40 km long, is located at the eastern extremity of the North Nose, in a water depth of less than 8700 m. The distribution of the lower bulge is limited, being adjacent to the Mogi Fan. The lower bulge is the deepest bulge in the inner slope, and it is a small topographic feature with a lean and straight spine.

Fan morphology

The existence of a fan was first described by Renard et al. (1987), but the morphology was poorly understood. As shown in Fig.3, the Mogi Fan is an even-shaped partial cone extending W–E. Although many characteristic features change gradually in a downfan direction, the combined morphological and acoustic properties based on 3.5 kHz data allow the

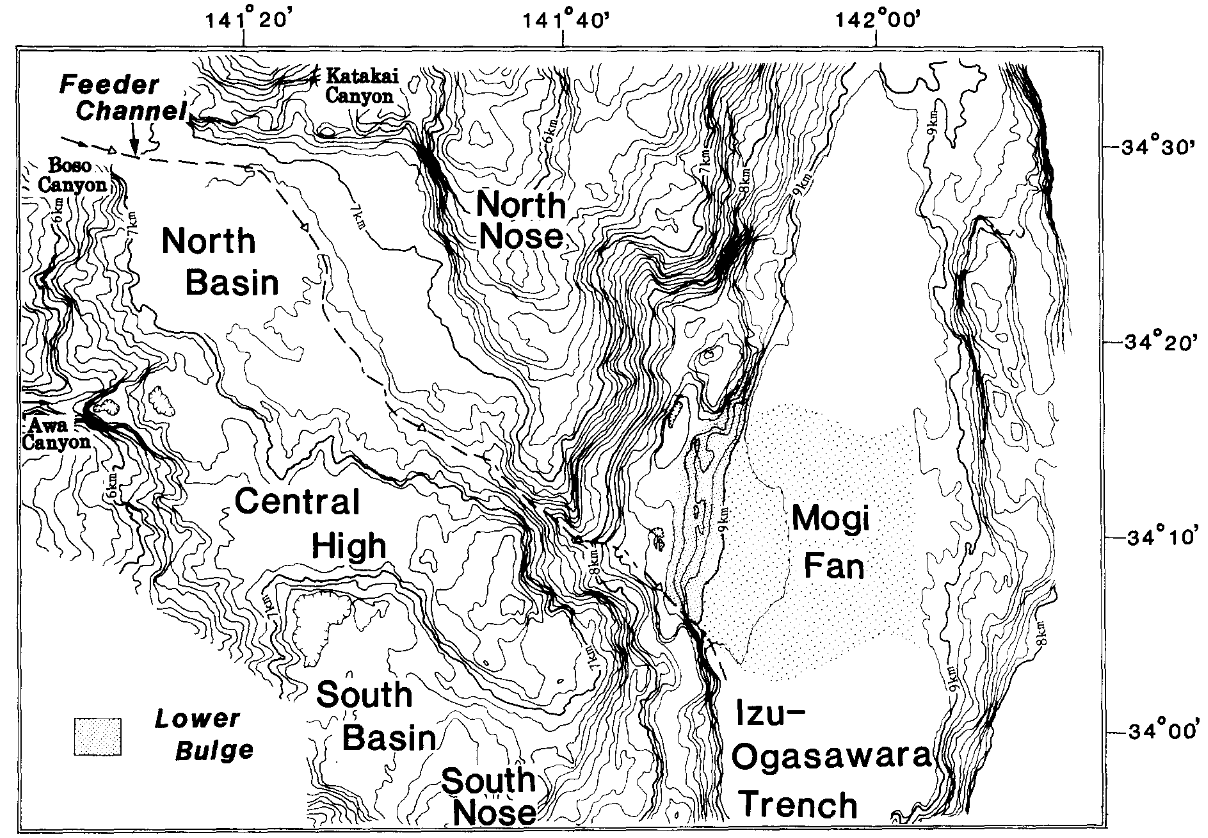

Fig.4. Seabeam bathymetric map of the inner slope basins. Compiled from Kato et al. (1985) and the KAIKO 1 Research Group (1986). Contours at 100 m intervals. Note the topographic contrast between the higher North Nose bulge and the lower bulge.

Mogi Fan to be divided into three parts: the upper, middle and lower fan (Fig.5). The Mogi Fan is clearly a single fan as shown in Fig.3. The average thickness is estimated to be about 50 m when comparing with the topographic level between the fan mound and the mean depth of the adjacent trench floor.

Upper fan

The upper fan is an apparent topographic mound, located in 9000–9100 m of water (Figs.3 and 4). It has a very steep gradient of approximately 30 m/1000 m (1:33). A large, single submarine channel, approximately 3 km wide, with well-developed levees on both sides can be traced up to 3 km eastward. There is little data to judge whether the channel pattern is meandering or not. The elevation of the levees above the channel floor is about 25 m. The southern levee is higher than the northern one and also has a steeper slope. The outer levee gradient is about 30 m/1000 m, similar to that of the inner levee slopes. The levees are very narrow and this suggests that sedimentation on the levees was very active. The channel floor is approximately 90 m above the general Izu–Ogasawara Trench floor. Judging from the morphology, the channel seems to be depositional, implying vertical aggradation processes for the construction of the upper fan. The acoustic characteristics of the upper fan are essentially highly reflective (Fig.5), and characterized by poor or no subbottom penetration. According to Nardin et al. (1979) and Damuth (1980), these acoustic reflection characteristics reflect coarse-grained, thick-bedded turbidites. We interpret

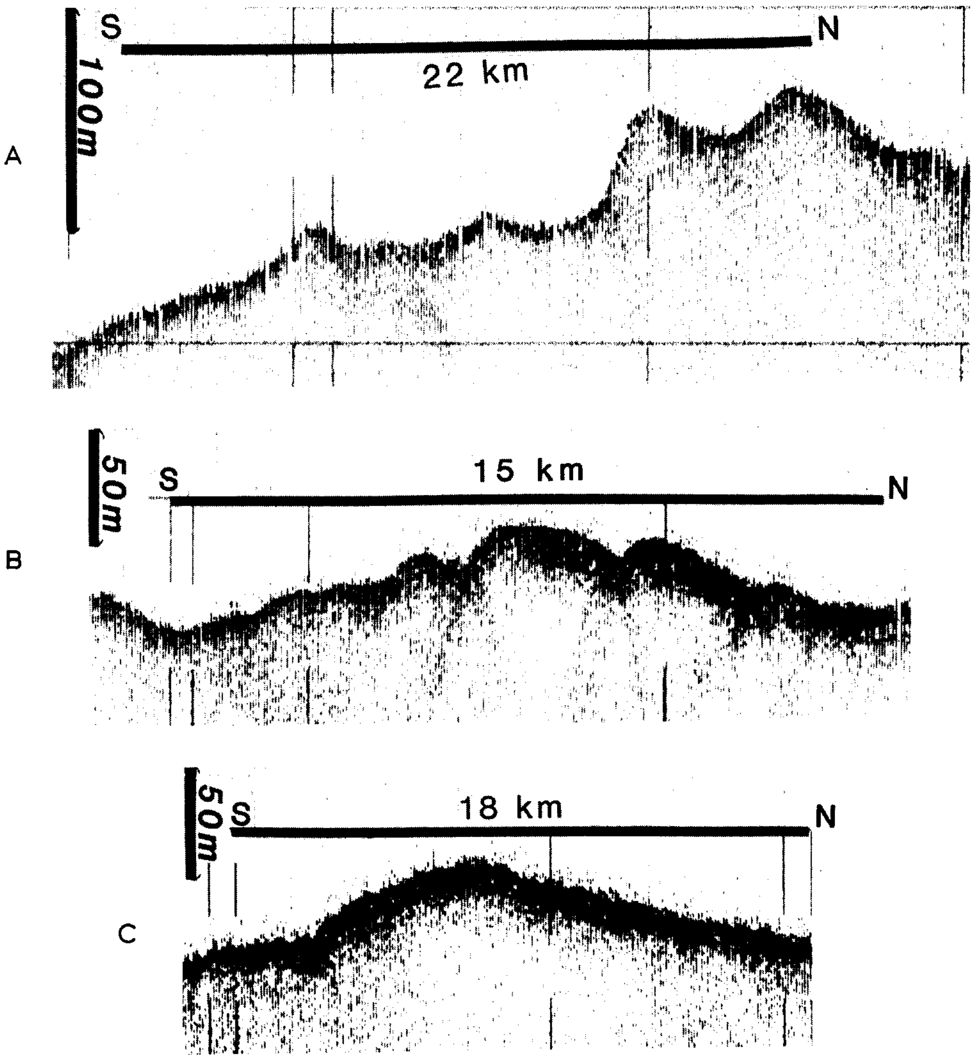

Fig.5. Representative 3.5 kHz records. *A* — upper fan; *B* — middle fan; *C* — lower fan. Location of profiles shown in Fig.2.

the distinctive mounded feature of the upper fan as being mainly composed of a channel–levee complex, consisting mainly of coarse-grained turbidites.

Middle fan

The upper boundary of the middle fan is defined by the 9040 m contour where the main single channel divides into three distributary channels, each with poorly developed levees, and with depositional lobes at their termini (Fig.3). However, the distribution of the channels and lobes is limited to the northern part of the fan. A topographic bulge, extending NW–SE, is found in the southwestern part of the fan. It seems to be a structural high resulting from dextral fault movement along the plate boundary. Another noteworthy feature is the small depression that extends N–S in the outer part of the middle fan near the 9160 m contour. The gradient of the upper middle fan is 16 m/1000 m (1:63).

Field observations suggest that probably only one channel was active at a given time, with the middle one, although inactive at present, being the most recently active. The size of the channels ranges from 2.0 to 2.5 km in width, and from 10 to 30 m in depth. It seems that there are no distinctive levees. Downfan, the channels appear to become erosional features. There is no evidence that these channels have undergone channel migration.

A slide mass, up to 3 km wide, occupies the southern part of the middle fan. The relief of the slide mass surface is probably irregular and the thickness is poorly defined, but is at least several metres. Judging from the topography, the slide mass was produced by mass movement from the upper fan near the 9020 m water depth.

The lower part of the middle fan shows gentle gradients, averaging 10 m/1000 m (1:100). Three lobes are recognized as convex-upward bulges on the fan surface (Fig.6) and are probably not separated from the well-defined distributary channels. According to Mutti and Normark (1988), this feature of channel–lobe transition suggests that turbidity current-flow down the channel would be composed dominantly of sandy and coarser grained sediments. The size of these lobes ranges from 1.5 to 3.5 km in diameter, and from a few metres to 20 m in height (Fig.6). The surface of the lobes is generally flat and smooth, and they appear to be free of channels. Of the three lobes, the middle seems to have the lowest relief and the smallest dimensions. On 3.5 kHz profiles acoustic characteristics within the lobes show that they are less reflective than the channel-fill sediments. It is suggested that the lobe sediments are composed of finer detritus than the channel-fill deposits of the upper fan.

Lower fan

The lower fan is characterized by a smooth mounded shape with gentle gradients (Fig.3). The boundary between the middle and lower fan is poorly defined and is placed where the distributary channels and lobes terminate. The lower fan can be traced laterally to the front of the western flank of the outer slope. Seismic data, although limited, indicates that the lower fan exhibits a smooth surface, and has no mesotopographic or channel features extending from the middle fan. The lower fan tends to dip towards the north and south along the trench axis, and not towards the east. Its gradient averages 2 m/1000 m (1:500).

The acoustic characteristics on 3.5 kHz profiles show uniform layering; subbottom reflectors are laterally continuous throughout the lower fan and parallel to the sea floor. According to Nardin et al. (1979) and Chough et al. (1985), this characteristic reflects the fine-grained nature of the sediments. From these observations, we consider that the lower fan is composed mainly of thin-bedded distal turbidites.

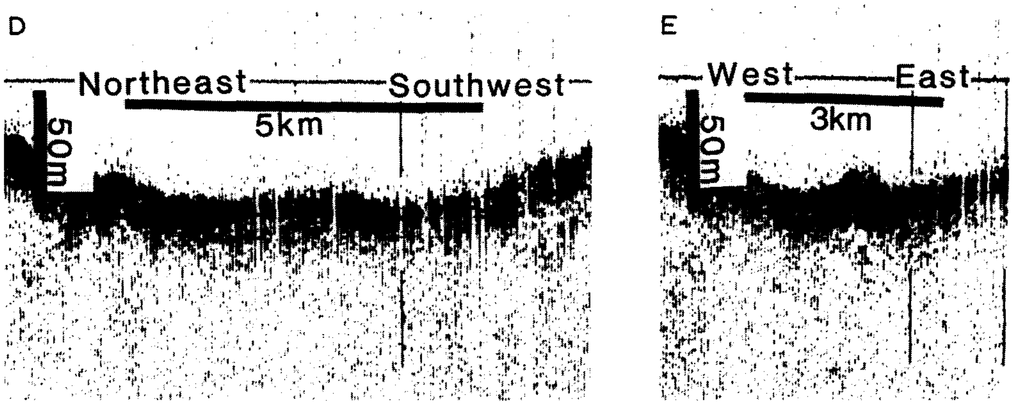

Fig.6. 3.5 kHz records of the sedimentary lobe. Profile *D* is parallel to the long axis of the lobe. Profile *E* is the cross section. Location of profiles shown in Fig.2.

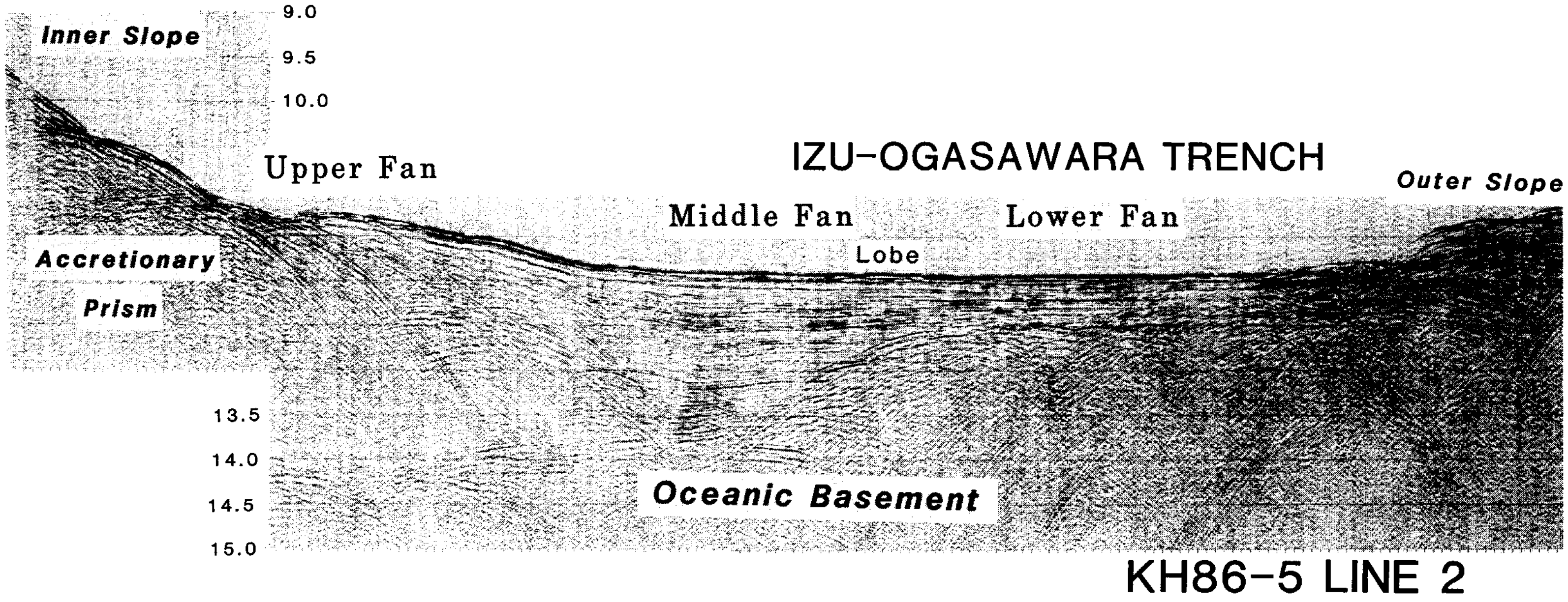

Fig.7. Seismic reflection profile crossing the Mogi Fan. From the KH86-5 cruise. Trackline position shown in Fig.2. Scale = seconds TWT.

Figure 3 shows that the morphology of the lower fan opens towards the outer slope of the topographic depression on the outer part of the middle fan. One possibility is that the lower fan morphology could be modified by the deposition resulting from the reflection of fine-grained turbidity currents against the outer slope. No trench axial channel is seen in the basin, suggesting that most turbidity currents passing through the middle fan have deposited their sediments on the lower fan. Thus, the turbidites could be thickly deposited here.

Seismic profiles

Several seismic reflection profiles were collected in the study area. Among them, two records (KAIKO leg 2, line 83 and KH86-5, line 2) are important because they cross the Mogi Fan from approximately west to east (Fig.7). These two profiles highlight the internal structure through the fan from the outer slope to the North Nose. KH86-5 line 2 shows that trench-fill sediments exceed 1 km in thickness beneath the Mogi Fan, and that they seem to be thickest in the Izu–Ogasawara Trench (Fig.7). An acoustic basement, interpreted as oceanic crust, is exposed on the highs of the outer slope. This oceanic crust reflector can be traced laterally, through a series of extensional faults, beneath the lower fan onto an area of the middle fan. However, deformational structures resulting from tectonic compression, represented by folds and reverse faults in the record, can be recognized in the trench-fill sediments and farther west in the bulge of the North Nose. Compressional deformation features can be found in the upper-middle to upper fan, but no distinct deformation is recognized in the lower-middle fan and lower fan. The degree of deformation, judging from the magnitude of displacement and frequency of faults, tends to increase towards the inner slope from the inner part of the middle fan. However, distinctive subbottom layers can be traced laterally from the lower fan to the middle fan, but not as far as the upper fan.

This profile indicates that the upper fan has undergone the highest degree of tectonic deformation, and that it is incorporated directly into the North Nose, i.e., the tectonic deformation of the Mogi Fan is thought to be concentrated within the upper fan. It seems that part of the western region of the fan has already been incorporated into the accretionary prism.

Discussion

As shown in Fig.5, the morphology of the Mogi Fan is really not particularly unique. In comparing characteristic features of the Mogi Fan with modern analogues in different structural settings, the Navy Fan in San Clemente Basin in the California Borderland (Normark, 1970; Normark et al., 1979; Normark and Piper, 1984/1985), is the most similar. There are several morphological similarities in favour of this: (1) the fan dimensions, (2) the distributional pattern of inferred fan sediments, and (3) the characteristics of the channels and lobes, and their transitional pattern (fig.1, Normark and Piper, 1984/1985). Firstly, the diameter of the Mogi Fan is about 360 km, and that of the Navy Fan is 320 km (Normark et al., 1984/1985a). These are relatively small deep-sea fans (Table 1). This suggests that the Mogi Fan apparently expresses only one stage of fan growth, like in the Navy Fan.

Concerning the second point, the acoustic characteristics of the 3.5 kHz profiles suggest that the nature of the fan sediments gradually changes from the upper fan to the lower fan. The upper fan is characterized by poor or no subbottom penetration and the sea floor is highly reflective. The middle fan is a less reflective surface but shows minor acoustic penetration. Even layering of multiple subbottom reflectors is characteristic of the lower fan. Coarse-grained turbidites are believed to fill the channels and form the lobes, probably with downfan gradations, and towards the lower fan, fine-grained turbidites may become common. Thus, it appears that on the basis of sediment dispersal, the Mogi Fan may be referred to as a "poorly efficient fan" as

TABLE 1

Dimensions and maximum slope gradients of deep-sea fans

Fan	Area (km^2)	Slope gradient	Reference
Mogi	360	33/1000 (1.8°)	This paper
Navy	240	13/1000 (0.8°)	Normark and Piper (1984/1985)
Astoria	2.3×10^4	18/1000 (1.0°)	Nelson (1984/1985)
Magdalena	6.0×10^3	16/1000 (1.0°)	Kolla and Buffer (1984/1985)
Mississippi	2.7×10^5	18/1000 (1.0°)	Bouma et al. (1984/1985)
Amazon	3.8×10^5	24/1000 (1.4°)	Damuth and Flood (1984/1985)
Monterey	7.7×10^5	14/1000 (0.8°)	Normark et al. (1984/1985c)
Rhône	7.6×10^5	8/1000 (0.4°)	Normark et al. (1984/1985b)
Indus	1.4×10^6	5/1000 (0.1°)	Kolla and Coumes (1984/1985)
Bengal	3.4×10^6	2/1000 (0.1°)	Emmel and Curray (1984/1985)

proposed by Mutti (1979). A similar sediment dispersal pattern is also reported from the Navy Fan (Normark et al., 1979).

Third, the Mogi and Navy fans show good similarities in intrafan morphology, e.g., they have small and poorly developed levees along the main channel. In addition, the levee relief dies out downfan. Further, they have depositional lobes of similar dimensions at termini of the distributary channels and the channels and lobes are attached to each other.

On the other hand, the Mogi Fan seems to indicate some unique morphological characteristics, most of which do not reflect an original sedimentary geometry, but display morphological modification in response to the tectonic deformation during and after fan construction.

An example of the deformation during fan construction is the polarization of the depositional site of the channel and lobes on the fan. In this respect, the distributary channels and lobes are restricted to the northern half of the fan, because the southern part includes structural highs produced by the fault movement along the plate boundary. Thus, channel migration did not reach the south, where tectonic uplift owing to fault movement would be active. Further, as can be seen from Table 1, the maximum gradient of the upper fan in other deep-sea fans in less dynamic tectonic settings is fairly constant, ranging from 10 to 24 m/1000 m. However, the upper fan segment of the Mogi Fan has a very steep gradient of up to 30 m/1000 m (1:33), probably caused by tectonic movement. Such steepness of the inner fan is inferred to be the cause of sea-floor instability, and could serve to explain the mass movement that provides the slide mass on the upper part of the middle fan.

On the other hand, the Seabeam bathymetric map (Fig.4) does not reveal any feeder channel related to the Mogi Fan on the lower bulge in the North Nose. This indicates that the feeder channel on the lower bulge has been tectonically destroyed after fan construction.

To build up a trench fan, progradation of the trench-fill sediment provided from a point source would need to overcome tectonic erosion of the sediment resulting from plate subduction (Piper et al., 1973; Von Hunee, 1974; Scholl, 1974; Schweller and Kulm, 1978). If the depositional rate (T), the convergent rate (v) and dip (θ) of the subducting oceanic plate are matched, the sediment progradation and the erosion resulting from the subduction will continue in equilibrium, i.e., the sediment accumulation balances the attrition of the trench-fill sediments. According to Thornburg and Kulm (1987), the relationship of the three independent factors is given as: $T = v \tan \theta$. Given a convergent rate of 9.8 cm/yr (Seno et al., in prep.), and a dip angle of the oceanic plate of approximately 141 m/1000 m (1:7.1), a depositional rate of approximately 14 m/1000 yrs is required to build up a trench fan across the Izu–Ogasawara Trench. However, this value is the calculated minimum rate and we believe that the real sedimentation rate of the Mogi Fan would be greater than this value. Considering that the average thickness of the Mogi Fan reaches approximately 50 m, about 3600 years would be needed to construct the Mogi Fan before the final fan progradation stage. Thus, this suggests that the Mogi Fan is a short-lived deep-sea fan.

It is justifiable to discuss how such a high rate of the sediment deposition has been possible in the Izu–Ogasawara Trench. The rapid uplift of the provenance region as a result of the collision of the Izu–Bonin Ridge with Honshu is likely to have played a prominent part. Judging from the onshore geology (Amano et al., 1986), abrupt uplift of Central Honshu, behind the Izu Peninsula, has taken place since approximately 1 Ma B.P. The uplifted region is a good source of clastic material that can be eroded and transported to the Izu–Ogasawara Trench via the Sagami Trough. However, clastic materials produced during the uplift of Central Honshu have not been continually provided to the Mogi Fan. It is noteworthy to mention that formation and progradation in several fans occurred during sea-level decreases (Shanmugam et al., 1984/1985), e.g., the Mississippi Fan (Feeley et al., 1984/1985). We speculate that sea-level reduction could trigger high sedimentary input to the Mogi Fan.

Our scenario for the reconstruction of the Mogi Fan is shown in Fig.8. The construction and destruction of the Mogi Fan seems to relate to both sea-level change and subduction tectonics. A considerable amount of clastic material transported via the axial channel of the Sagami Trough, was deposited during the Würm maximum episode. At the initial lowering of sea level, rapid destruction of the fan-deltas located around the Sagami Trough would have taken place, transporting abundant clastic sediments to the deep-sea basin. Because of the volume of sediments involved, the sedimentation rate would be sufficient to overcome tectonic deformation thus enabling fan formation. Judging from the relationships of the channel–lobe system, the dimensions of the fan, and the well-defined cone morphology, the development of the Mogi Fan was thought to be similar to the growth pattern of the Navy Fan during the maximum stage of this sea-level reduction (Normark et al., 1979). With the sea-level rise after the Würm maximum episode, the sediment became trapped onshore and in

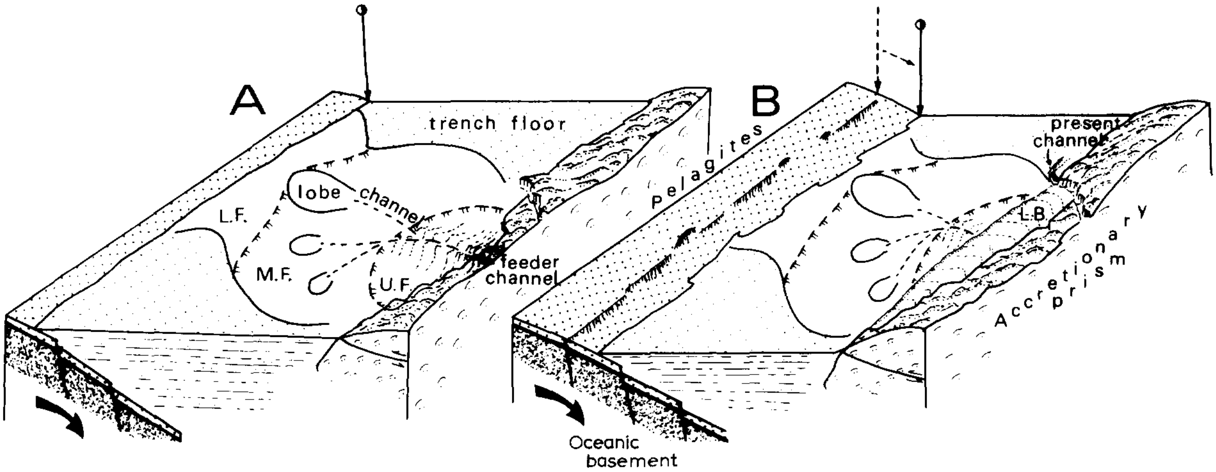

Fig.8. Schematic model of the Mogi Fan. Sediment supply was high enough to overcome the tectonic deformation resulting from the plate subduction. This would cause fan progradation into the trench, taking place during lowered sea level (A). With rising sea level (B), the Mogi Fan becomes starved, and is eventually abandoned. Solid and dashed arrows represent the magnitude of the plate convergence. *L.F.*, *M.F* and *U.F.* — lower, middle and upper fan respectively; *L.B.* — lower bulge.

the shallow marine environments. The Sakawa Fan-delta located on the mouth of the Sakawa River that drains into the Sagami Trough is an example. It traps abundant clastic sediment on a prograding shelf edge and upper slope. Accordingly, the sediment input to the trench basin decreased, and thin hemipelagic sediments instead of thick-bedded turbidites began to cover the trench basin. As the tectonic deformation continued, the deformation of the Mogi Fan gradually increased. Finally, the relationship of the Mogi Fan and the bulge of the North Nose behind the fan suggests that the upper part of the Mogi Fan has been incorporated into the bulge of the North Nose. As a result, the feeder channel connected to the Mogi Fan was shifted to its present location with the simultaneous development of the lower bulge, and the fan was abandoned as a short-lived fan representing one stage of growth. We consider that the characteristic features of the Mogi Fan, mentioned above, could represent the general features of a deep-water fan that is typically developed in active tectonic settings. In addition, we believe that trench fans would exhibit a similar fan development to that of the Mogi Fan.

Conclusions

(1) The Mogi Fan is an even-shaped partial cone, 18 km in diameter, located in the Izu–Ogasawara Trench on the trench triple junction off Boso Peninsula, in a water depth exceeding 9 km. Combined morphological and acoustic data indicate that the Mogi Fan is a single deep-water fan with a point source, and that it can be divided into an upper, middle and lower fan. In the middle fan, three divergent channels and sedimentary lobes can be defined. Based on the affinity of morphological features, the channel–lobe relationships and the fan magnitude, the Mogi Fan is similar to the Navy Fan in the South San Clemente Basin, California Borderland.

(2) The Mogi Fan is a short-lived fan. Several morphological features indicate that the Mogi Fan is presently inactive, and that it has been modified by tectonic movements. The bathymetric map shows that no feeder channel from the North Basin to the Mogi Fan can be recognized on the bulge of the inner slope. In addition to the tectonic modification, the seismic records show that the upper fan has been incorporated into the lower bulge, suggesting that the latter is an accretionary prism formed from the partially consumed upper fan segment.

(3) The behaviour of the Mogi Fan is closely related to sea-level changes and subduction tectonics. The formation of the fan would have initiated during the last lowering of sea level, and then maximum fan progradation would have taken place during the low sea-level stand. A tremendous amount of detritus was inferred as being provided mainly from the collision zone between the Izu–Bonin Ridge and Honshu. With the rise in sea level, sediment supply to the trench abruptly decreased and fan progradation ceased. Thus, tectonic deformation resulting from plate subduction has been transferred to and expressed in the fan. As a result, the Mogi Fan is still being destroyed and accreted into the inner slope bulge.

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