XV. SEDIMENTS, STRUCTURE AND ORIGIN OF JAPAN SEA —CONCLUDING REMARKS—

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An interpretation of the main physiographic elements of the Japan Sea suggests that the ridges and rises correspond to continental structures while the basins represent oceanic features. The Japan Basin is approximately 3.5 km deep with an oceanic crust of 12 km thick while the Yamato Basin, approximately 2.5 km deep, has an oceanic crustal thickness of 16 km. Both layers are a little thicker than is typically reported in oceanic basins (MURAUCHI, 1973; LUDWIG *et al.*, 1975).

A calculated result from smooth anomalies with small positive highs (YOSHII, 1975) and crustal surface wave solution of earthquakes (ABE and AKI, 1971), it can be deduced that the lithospheric plate is approximately 30 km thick. Samples, reflection profiling and magnetic measurements results, all suggest that topographic highs are thinly covered by sedimentary rocks and composed predominantly of granitic rocks with minor intrusives and volcanics. Absolute datings of the granitic rocks give ages ranging for 197 my and 220 my on Yamato Ridge (SHIMAZU, 1968), 127 my on North Korean Rise (HONZA, 1978) and 138 my on Kita-Oki Bank (in this time).

Gravels of widely ranging composition (intrusives, volcanics, sedimentary rocks and metamorphic rocks) were dredged from Yamato Ridge. Some of these are in situ but others may be transported although the study area lies at the southern limit of ice-rafting in the Japan Sea. In general gravels are interpretes as in situ, at a particular site, where the composition of the sample is very similar, where dredge sites occurs a steep cliff or rugged sea bed, and when strong overpulls on the dredge occur.

Several layers are distinguished from results of the reflection profiling. These are: an upper stratified or opaque layer, an lower transparent layer, and acoustic basement. The opaque layer is recognized in the lower transparent layer in some of the areas. All the layers are horizontally distributed in the basins, but tilted and deformed by the structural movements on the ridges and in the troughs.

Combining the ages of sampled sediments reported here with results from the other report and DSDP drilling, the upper opaque layer is assigned to the Pleistocene and partly uppermost Pliocene; the upper transparent layer to the Pliocene and late Miocene; and the lower transparent layer to the Miocene (HONZA *et al.*, 1977; KARIG, INGLE *et al.*, 1975).

The upper opaque layer in the Abyssal Plain corresponds to turbidite units. The plain dips toward the SE which suggests that these sediments are derived from the coast of Siberia. The same layer also occurs in the Yamato Basin, where it dips to the NW, and in most of the smaller ridges and troughs in the surveyed area. In the small ridges and troughs it thinner and is a little different in character than on the Japan Abyssal Plain. The upper and lower transparent layers are widely distributed throughout the whole of

the Japan Sea, and are composed of diatomaceous fine sediments. The layers have rather uniform thickness and are deformed and eroded on the Yamato, Okushiri and Sado Ridges. This clearly suggests that the structural movements which formed these features have been active since the deposition of the upper transparent layer (HILDE *et al.*, 1973; HONZA *et al.*, 1977). This movement which also accompanied by faulting along the continental slope of the Japan Islands is related to the deepening of Japan Basin.

Fresh-water diatoms of late Miocene age have been reported from the northeastern margin of Takuyo Bank (BURKLE and AKIBA, 1978). However these results have not been confirmed, either by DSDP drilling (DSDP 302) or from cores taken during this cruise, four cores and nine dredged samples on Yamato Ridges. The reported fresh-water fauna may, therefore, be a local feature possibly an island during either late Miocene, or possibly early Miocene times (I. KOIZUMI, personal communication).

Two types of acoustic basement are distinguished in the area. One is a rather thick opaque layer with a smooth surface, while the other is rugged and may form a lower horizon to the former. The acoustic basement, with the smooth surface, has seismic velocities between 3.2–3.5 km/s, and is widely distributed in the Japan and Yamato Basins. Very little data on the composition of this basement is available. There is a possibility, however, that it may correlates with the Green Tuff of early Miocene age in the Tohoku area. Pyroclastic rocks correlated with the Green Tuff, along the coast of the Tohoku area, were drilled at DSDP Site 302 (KARIG, INGLE *et al.*, 1975). An early Miocene age to the basement may also be deduced or it is assumed that the sedimentation rates were constant during the Pliocene and Miocene.

Three tectonic stages are distinguished from reflection profiling: one during early Miocene, a second in late Miocene to Pliocene and a third in late Pleistocene. The first tectonic stage is very difficult to ascertain, but is correlated with the first phase of island arc activity of Tohoku area, which, at least in the coast area of Tohoku, was accompanied by volcanics with regional subsidence. The second stage involved the formation of Yamato and Okushiri-Sado Ridges which is recognized from deformation of transparent layers on the ridges. The latest stage was accompanied by faulting on the slopes along the Japan coast (HONZA *et al.*, 1977). All tectonic stages involved a deepening of the Japan and Yamato Basins which are seen both in structural movements and the distributional patterns of the sediments.

The formation of the Japan Sea was not an isolated event but an integral step in the evolution of the Japanese island arcs. One of the most active arcs during the final development of the Japan Islands is the Tohoku Arc (Fig. XV-1). The three tectonic stages which have been distinguished in Japan Sea can also be recognized on the frontal slope of Tohoku Arc (HONZA *et al.*, 1977). These facts suggest that the tectonics in Japan Sea also reflect those occuring in the frontal slope of the Tohoku Arc.

Three discrete island arcs have been active around the Japan Sea since Paleozoic and it was during movements associated with the formation of at least one of these arcs that the Japan Sea came into existence.

From consideration of the assumed distribution and configuration of oceanic and continental crust, two possible spreading models, to explain the origin of the marginal, Japan Sea basin, are examined. The first is a type of vertical fan-spreading which has differential spreading rates and directions (Fig. XV-2). The expantion is accompanied by

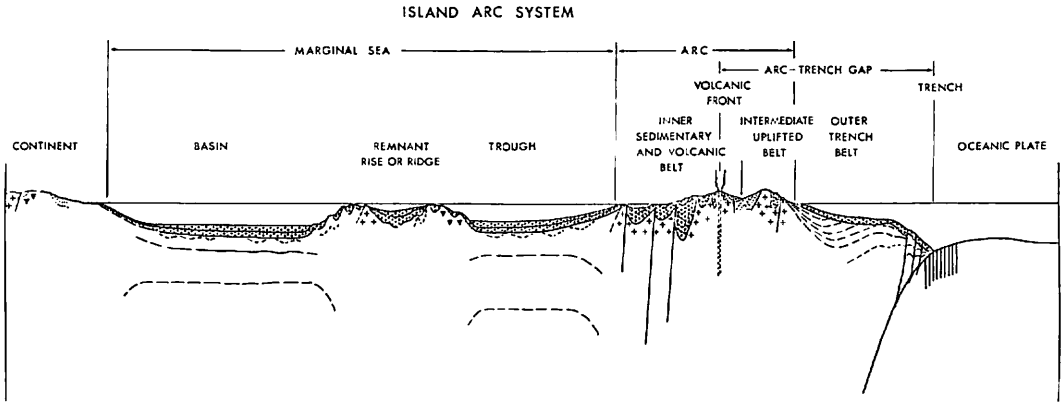

Fig. XV-1 A geological profile across the Tohoku Arc System which contains Japan Trench, Tohoku Arc and Japan Sea. The dotted layer is Neogene sediments and the deeper structure in the Japan Sea is sited from LUDWIG *et al.* (1975).

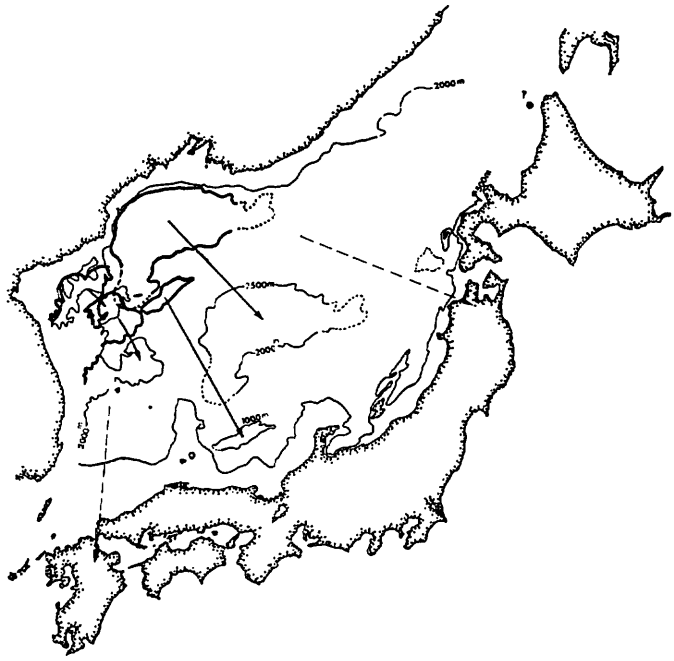

Fig. XV-2 A vertical fan-spreading model for the origin of Japan Sea. The expantion is accompanied by transcurrent faulting parallel to the spreading direction.

transcurrent faulting parallel to the spreading direction. However, onshore, no large transcurrent faults parallel to the spreading direction are recognized across the remnant Seinan (SW) Japan Arc. This suggests that the whole of SW Honshu (Seinan Arc) drifted as one unit in one direction.

With this fact onshore, another possible origin is a type of horizontal fan-spreading

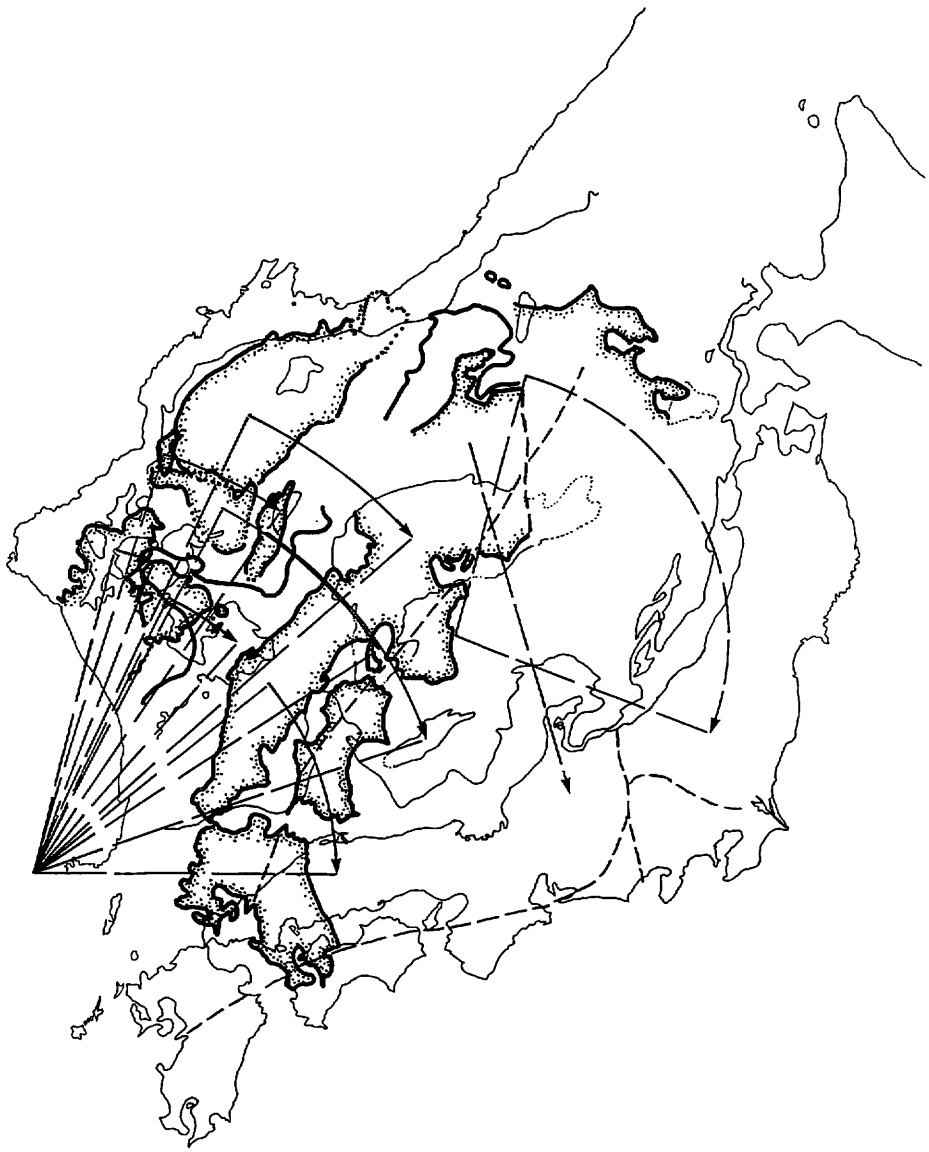

Fig. XV-3 A horizontal fan-spreading model for the origin of Japan Sea, which has a pole which extends from arc side.

with an axis of rotation along the coast of South Korea which has a pole which extends from arc side (Fig. XV-3). The model is in good agreement with magnetic lineation patterns in Japan Sea (ISEZAKI, 1975), assuming spreading takes place normal to the lineations, while the (paleogeographical) reconstruction on Fig. XV-3 is consistent with geological evidence. However, the geometry of the model (i.e. spreading direction) is difficult to reconcile with a spreading force related to the Neogene-Recent, subduction

of the Pacific Plate under the Tohoku Arc. If it is accepted that the formation of marginal basins is primarily related to plate subduction, then the above model can only be explained if it is assumed that main opening phase took place in Upper-Mesozoic-Early Paleogene Times in the Japan Sea.

As a final comment, it may be worth reconsidering the assumption that marginal basin are always formed by oceanic plate subduction. The direction and rate at which the continental plate moves may be an important factor which is worthy of further consideration.

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