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SHIMANTO GEOSYNCLINE AND KUROSHIO PALEOLAND

T. HARATA,* K. HISATOMI,** F. KUMON,** K. NAKAZAWA,**
M. TATEISHI,** H. SUZUKI,*** and T. TOKUOKA**

* *Department of Earth Science, Faculty of Education, Wakayama University, Wakayama, Japan*
** *Department of Geology and Mineralogy, Faculty of Science, Kyoto University, Kyoto, Japan*
*** *Faculty of Technology, Dōshisha University, Kyoto, Japan*

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The late Mesozoic to early Neogene geosyncline in the Outer zone of Southwest Japan has been studied in detail in the Kii Peninsula by the Research Group for the Shimanto Geosyncline. The existence of the Kuroshio Paleoland to the south of the geosyncline was inferred by various sedimentologic evidences. The Shimanto belt in the Kii Peninsula is divided from north to south into three zones of Cretaceous, Eocene and Oligocene to lower Miocene. In these belts thick geosynclinal sediments were accumulated showing coarsening upward. The southward migration of the basin occurred in Cretaceous/Eocene, Eocene/Oligocene, and in early Miocene. In the present paper the reconstruction of paleogeography of the Shimanto geosyncline was attempted and the Kuroshio Paleoland was discussed in relation to the geohistory of the Philippine Sea. In spite of the detailed geologic survey in the Kii Peninsula there is no evidence of large exotic blocks nor tectonic mélanges, and this does not support the plate tectonic model of the Pacific-type orogeny for the Shimanto belt.

1. *Introduction*

The Shimanto belt was a geosynclinal area throughout the late Mesozoic to early Neogene. The Shimanto belt had long been an area of *terra incognita* because of monotonous and thick clastic sequences (mostly composed of sandstones and mudstones), complicated geologic structure, and of being barren of fossils. Geologic mapping of the Shimanto terrain in the Kii Peninsula has been done in the last decade by the Research Group for the Shimanto Geosyncline. The existence of a former land mass (Kuroshio Paleoland) to the south of the geosyncline was inferred by them in 1970. The Kuroshio Paleoland existed up to the early Neogene and was submerged thereafter to an oceanic depth. This hypothesis was based mainly on paleotransportation analysis, indicating the supply of clastic materials not only from the continental side but also from the Pacific Ocean side. It was also inferred from the frequency and size distribution of exotic clasts of orthoquartzite of probably Precambrian age in the Shimanto belt. The present writers describe briefly the Shimanto supergroup in the Kii Peninsula and discuss the Kuroshio Paleoland and its bearing in the development of the Shimanto geosyncline. The Kuroshio Paleoland must have an important meaning in relation to the geologic development of the Philippine Sea and that of the Western Pacific region.

2. *The Shimanto Supergroup in the Kii Peninsula*

The Shimanto belt contacts northward with the Chichibu belt, which consists of middle to upper Paleozoic and Mesozoic strata, along the Butsuzo tectonic line. It is divided into three zones from north to south, i.e., the Hidakagawa (Cretaceous), the Otonashigawa (probably Eocene) and the Muro (Oligocene to lower Miocene) groups. These were already reported by HARATA (1965), TOKUOKA (1967, 1970), KISHU SHIMANTO RESEARCH GROUP (1970, 1975, 1977), HATENASHI RESEARCH GROUP (1975), SUZUKI (1975) and TATEISHI (1978). A generalized geologic map is shown in Fig. 1.

Hidakagawa group (KISHU SHIMANTO RESEARCH GROUP, 1975, 1977). The Hidakagawa group attains 12,000 m in thickness and is divided into three formations. Its geologic age is assigned roughly as Cretaceous (mainly upper Cretaceous). There is little fossil evidence in the Kii Peninsula.

The lower (Nyunokawa) formation,* 2,200 m in thickness, is composed of shales and muddy flysch in the lower part, and of normal to sandy flysch and thick-bedded sandstones in the upper part. The Nyunokawa conglomerates of 400 m thick are intercalated

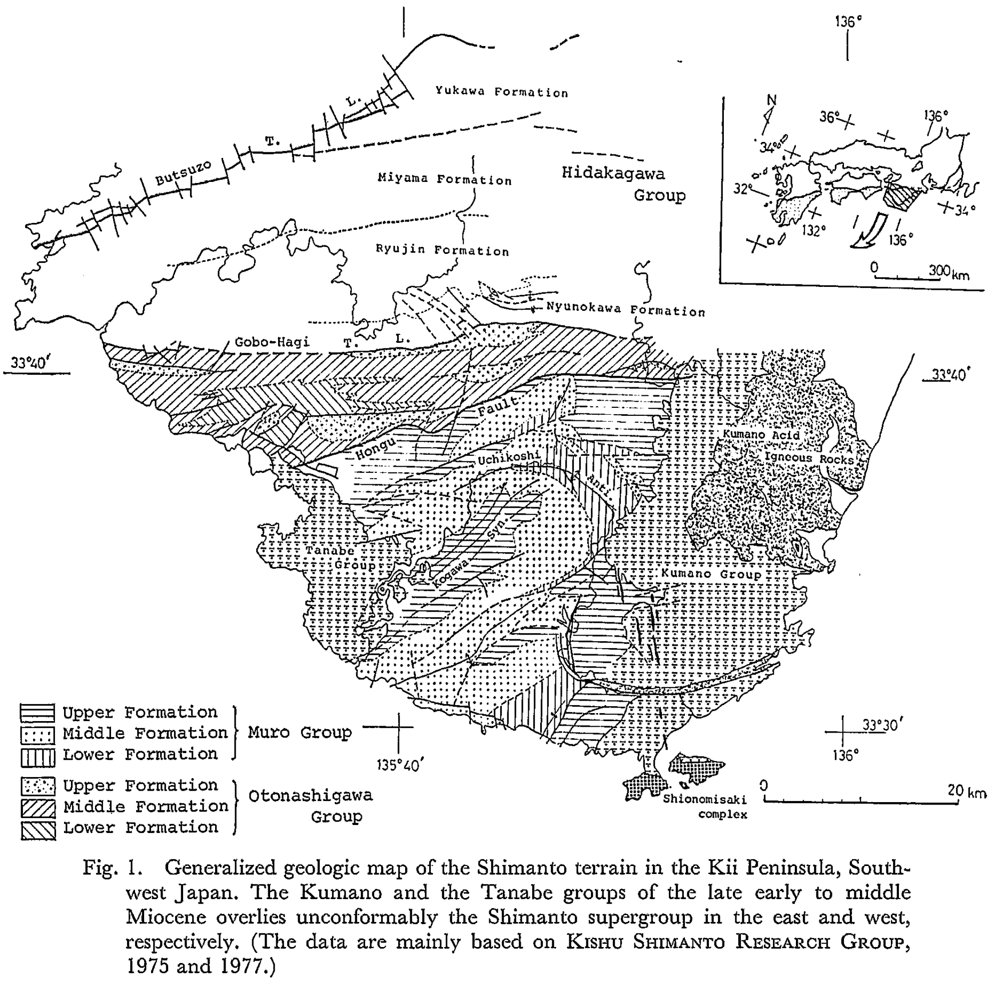

Fig. 1. Generalized geologic map of the Shimanto terrain in the Kii Peninsula, Southwest Japan. The Kumano and the Tanabe groups of the late early to middle Miocene overlies unconformably the Shimanto supergroup in the east and west, respectively. (The data are mainly based on KISHU SHIMANTO RESEARCH GROUP, 1975 and 1977.)

* In Fig. 1, the Yukawa formation in the north is shown as the correlative of the lower formation.

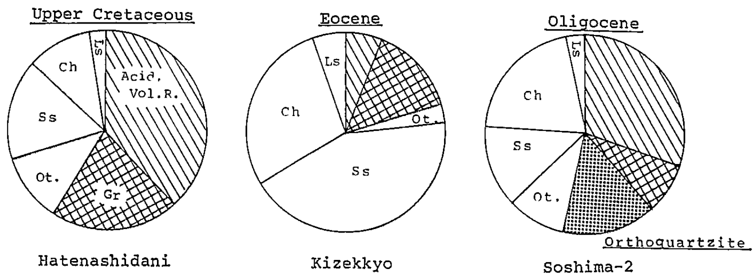

Fig. 2. Representative compositions of conglomerates. These conglomerates are thought to have been supplied from the Kuroshio Paleoland.

in the top of the formation. The clasts are pebbles, cobbles and sometimes boulders, consisting of acidic volcanics (mostly rhyolite), granite, sandstone, chert, etc., among which acidic volcanic rocks are most abundant (Fig. 2).

The middle (Ryujin) formation, 3,000 m in thickness, is characterized by predominant shale and muddy flysch, occasionally accompanied with sandy flysch. Greenstones yeilded by submarine volcanism and rhyolitic tuffs supplied by subaerial volcanic activity are sometimes intercalated in the formation. A large body of greenstone with pillow structures is located in the eastern part of the Hidakagawa zone (Shiida *et al.*, 1971).

The upper (Miyama) formation, 7,000 to 7,500 m thick, is composed of massive sandstones and sandy flysch. Several greenstone layers of less than several tens of meters are intercalated in shaly parts. These are sometimes accompanied by radiolarian cherts.

It is somewhat difficult to find sole markings due to severe tectonic deformation. However, current markings can be found in the Hidakagawa group. The sediments of the lower formation were mostly transported by lateral currents from SE to NW, while those of the middle formation by longitudinal currents from E to W. In the upper formation lateral currents from N to S are found in addition to eastern longitudinal currents.

Otonashigawa group (Hatenashi Research Group, 1975). The Otonashigawa group attains to more than 1,600 m in thickness. Its geologic age may be assigned to the Eocene although no reliable fossil evidence has been obtained in the Kii Peninsula. The lower half is rich in mudstones and muddy flysch, while the upper half is rich in sandstones and sandy flysch, comprising a coarsening upward sequence as a whole. In the southern part of the belt the Kizekkyo conglomerates, about 100 m in thickness are intercalated in the uppermost part of the group. The clasts are of pebble to cobble, sometimes boulder size, composed of sandstone, chert, granite, etc. (Fig. 2). Current markings are well developed. The longitudinal currents from E to W are dominant in the lower half, while lateral ones from S to N, which are accompanied with proximal facies, are found in the upper half of the southern part.

Muro group (Kishu Shimanto Research Group, 1975). The Muro group, 7,500 to 9,000 m thick, is divided into the lower, middle and upper formations. The geologic age can be assigned to the Oligocene to early Miocene by molluscan fossils. The lower part (1,200 m) is composed mainly of mudstones and muddy flysch, and the middle part (2,500 to 3,000 m thick) is composed predominantly of sandy flysch and thick-bedded massive sandstones intercalated with several conglomerates. The upper part (3,000 to 4,000 m thick) consists mainly of mudstones and various types of flysch. Conglomerates with

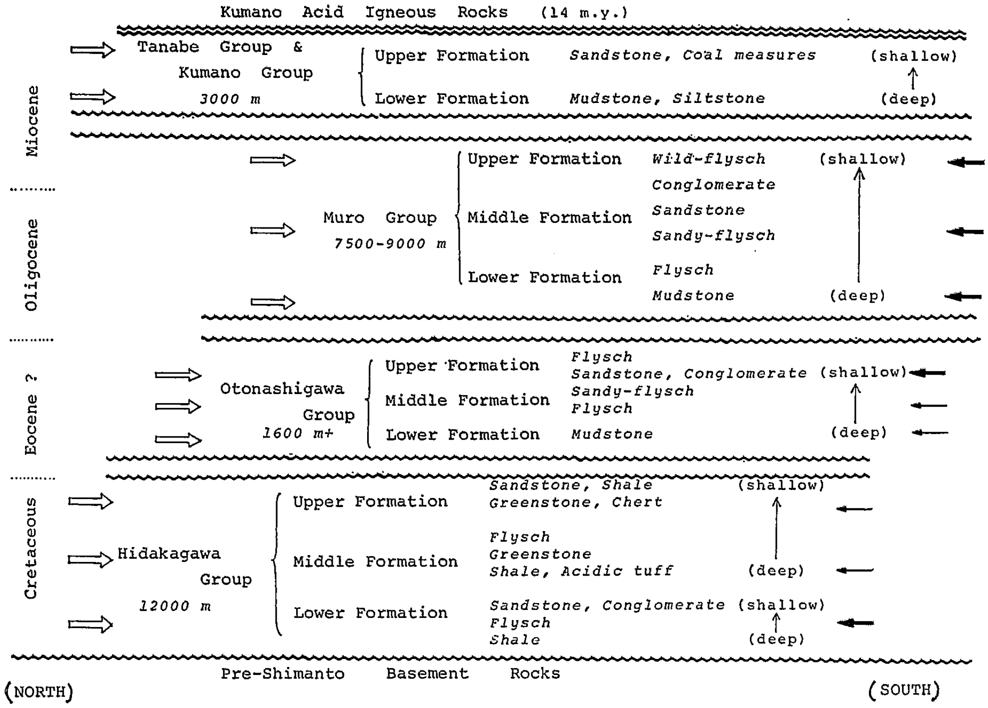

Fig. 3. Schematic illustration of the development of the Shimanto geosyncline in the Kii Peninsula. Arrow indicates a direction of sediment supply.

sandy matrix, muddy conglomerates and angular-fragment bearing mudstones are intercalated in the upper part.

The conglomerates with sandy matrix in the middle and upper parts contain abundant clasts of rhyolite, and subordinate ones of chert, sandstone, granite, and orthoquartzite (Fig. 2). The occurrence of orthoquartzite clasts, which were precisely descri bedby TOKUOKA (1970), is limited to the area south of the Uchikoshi anticline in the Muro zone. Typical flysch facies are well developed and a number of sole markings are found in the Muro group. The paleocurrents in the zone are variable as a whole. However, it is likely that the main currents are longitudinal from E to W or from ENE to WSW but lateral ones from the north and south are also frequent. There are found channel structures in the southern coastal area in the Kii Peninsula. Careful observation of channel walls and paleocurrent analyses of the filling sediments by means of sole markings and grain fabrics of conglomerates and thick-bedded sandstones led to a conclusion that the channels were excavated by south current and filling materials were transported from the same direction (TATEISHI, 1978).

The development of the Shimanto geosyncline in the Kii Peninsula is schematically shown in Fig. 3. There are several cycles of upward coarsening megasequences in the Shimanto supergroup, that is, two cycles in the Hidakagawa group and each one cycle in the Otonashigawa and Muro groups respectively. These sequences reflect the change of sedimentary environment from deep to shallow, suggesting gradual filling-up of the sedimentary basins. Furthermore it is likely in the Shimanto belt in the Kii Peninsula that,

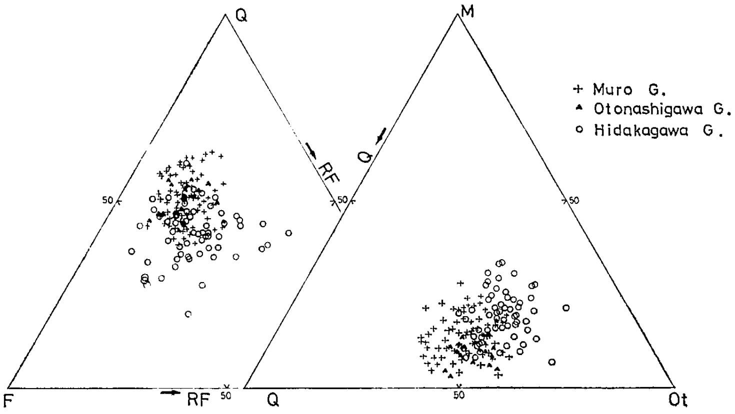

Fig. 4. Properties of massive and thick-bedded sandstones in the Shimanto supergroup in the Kii Peninsula. Q, quartz; F, feldspar; RF, rock fragments; M, matrix; Ot, the others except quartz and matrix.

after filling up the basin of the Hidakagawa belt, the depositional axis migrated southward to the Otonashigawa belt. Similar southward basin migration can also be deduced from the Otonashigawa to the Muro basins. In addition to the migration of the basins, there are found some changes in sedimentary sequences. Muddy facies, sometimes accompanied with greenstones and cherts, are dominant in the Hidakagawa group, while sandy facies prevail in the Otonashigawa group. Sandy facies dominate in the Muro group, frequently accompanied by conglomerates. Moreover, there are some differences in the properties of massive and thick-bedded sandstones among these groups (Fig. 4). These observations may reflect the change of the sedimentary environment of the Shimanto supergroup from eugeosyncline to miogeosyncline. Terrigeneous materials were supplied from both sides of the basins as shown by arrows in Fig. 3.

3. *Paleogeographic Reconstruction of the Shimanto Geosyncline*

Paleogeographic reconstruction of the Shimanto geosyncline was attempted on the basis of facies analysis (especially distribution of conglomerates and massive sandstones), paleocurrent analysis by sole markings and grain fabrics of sandstone and conglomerate, channel structure analysis in proximal turbidites, and the occurrence of exotic clasts of orthoquartzite. Hypothetical paleogeographic maps of three stages in the Shimanto geosyncline are offered in Fig. 5. The paleogeography of the early Miocene is added in the same figure, the data of which are adopted from K. Hisatomi and the Hatenashi Research Group. The Kii Peninsula is meridionally extended by one and half times considering the shortening of each belt after deposition.

Hidakagawa stage (late Cretaceous). The longitudinal currents were dominant in the axial part, by which sediments of distal turbidite and/or shale were transported. In the eastern part there is found a submarine (basic) volcano which forms a mound. Acidic tuffs, which may have been derived partly from acidic volcanic activity on the Kuroshio

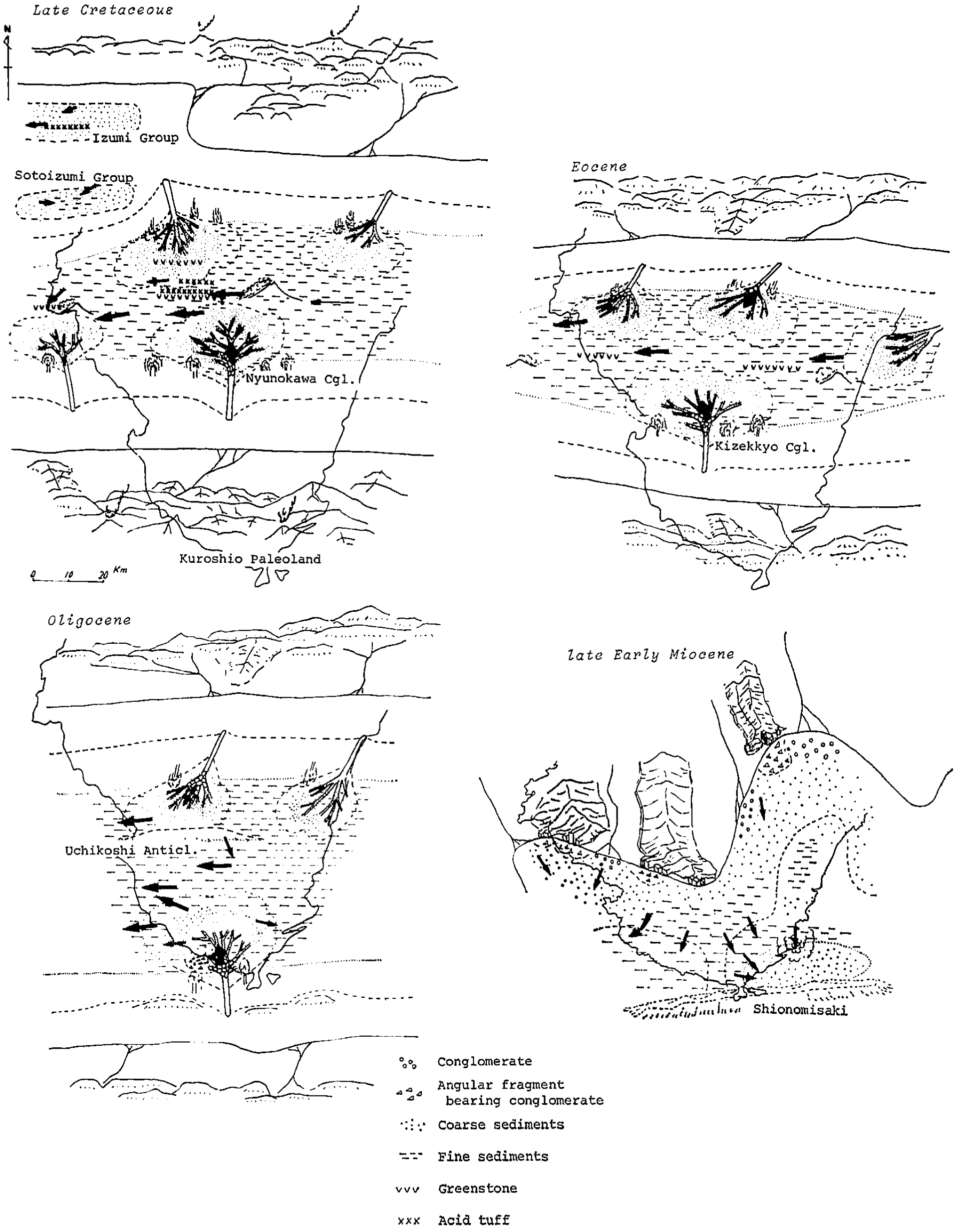

Fig. 5. Paleogeography of the Shimanto geosyncline in the province of the Kii Peninsula. The basin in each stage of the geosyncline situated between two land areas (Asiatic Continent in the north and Kuroshio Paleoland in the south), from which clastic materials were supplied through submarine channels. The successive southward migration of the basin is noticeable.

Paleoland, are frequently intercalated in the sequence. In the southern part of the basin proximal turbidites (thick-bedded sandstone and conglomerate) were frequently transported from the Kuroshio Paleoland forming a deep-sea fan and channel system. Similar fans and channel systems existed in the northern part. In the northern shelf area there were two troughs represented by the Izumi and Sotoizumi groups. The northern land area was a part of the Asiatic Continent, where acidic volcanism and plutonism were occurring quite extensively.

Otonashigawa stage (Eocene). After the filling of the basin of the Hidakagawa stage, the axis of depositional site shifted slightly southward. Longitudinal currents from E to W were dominant throughout the basin. Submarine (basic) volcanism is inferred somewhere outside the Kii Peninsula, from which volcanic materials were supplied to the basin in small quantity. A deep-sea fan developed in the southern part of the basin, which is interpreted from the presence of proximal facies of the Kizekkyo conglomerates and sandstones. There were similar deep-sea fans in the northern part of the basin.

Muro stage (Oligo-Miocene). After the filling of the former basin, the succeeding one was born to the south. Eastern longitudinal currents were still dominant in the basin. However, an upheaval zone was formed along the axial part (Uchikoshi anticline) of the basin at a later stage to yield complicated paleocurrents. Terrigenous materials were supplied from the south by submarine channels in the southern part of the basin, while those of the northern part were supplied from the northern land area. In the south there are found many exotic gravels of orthoquartzite and slump deposits, all of which were transported from the south.

Kumano and Tanabe stage (late early Miocene). After the filling of the Muro basin, a great tectonic movement occurred, changing the Shimanto geosyncline to the land area. Simultaneously the Kuroshio Paleoland which had supplied vast materials to the geosyncline subsided beneath the area. The new basin of the Kumano and Tanabe groups was formed upon the Shimanto belt. These groups overlie the severely folded and faulted strata of the Shimanto supergroup with pronounced clinounconformity. Terrigenous materials were supplied from the northern land area and were deposited on the submarine shelf and slope. Recent investigation around Cape Shionomisaki area, the southern end of the peninsula, by Y. Miyake and K. Hisatomi reveals volcano-plutonic activity of basic to acid composition early in this stage. They concluded that the igneous complex formed tectonically upheaved submarine ridge which trapped the sediments. It is highly probable that a remnant of the Kuroshio Paleoland constituted this ridge.

4. *The Kuroshio Paleoland and Its Bearing in the Development of the Shimanto Geosyncline*

The existence of the Kuroshio Paleoland can be inferred from various geologic evidences. It must have been located in the area now occupied by the continental slope off the Kii Peninsula, although no direct evidence has been obtained there. Pre-Shimanto basement rocks (sandstones, cherts, etc.) are inferred from the study on the Kuroshio Paleoland, from which a large amount of volcanic materials were supplied to the geosyncline. As shown in Fig. 6, the upheaval and erosional movements progressed on the Kuroshio Paleoland in accordance with the depression and deposition in the Shimanto geosyncline. In the later (Muro) stage erosion of the Precambrian basement of the paleoland was suggested by the presence of orthoquartzite gravels very similar to those of Sinian age. The submergence of the paleoland occurred finally in the early Miocene.

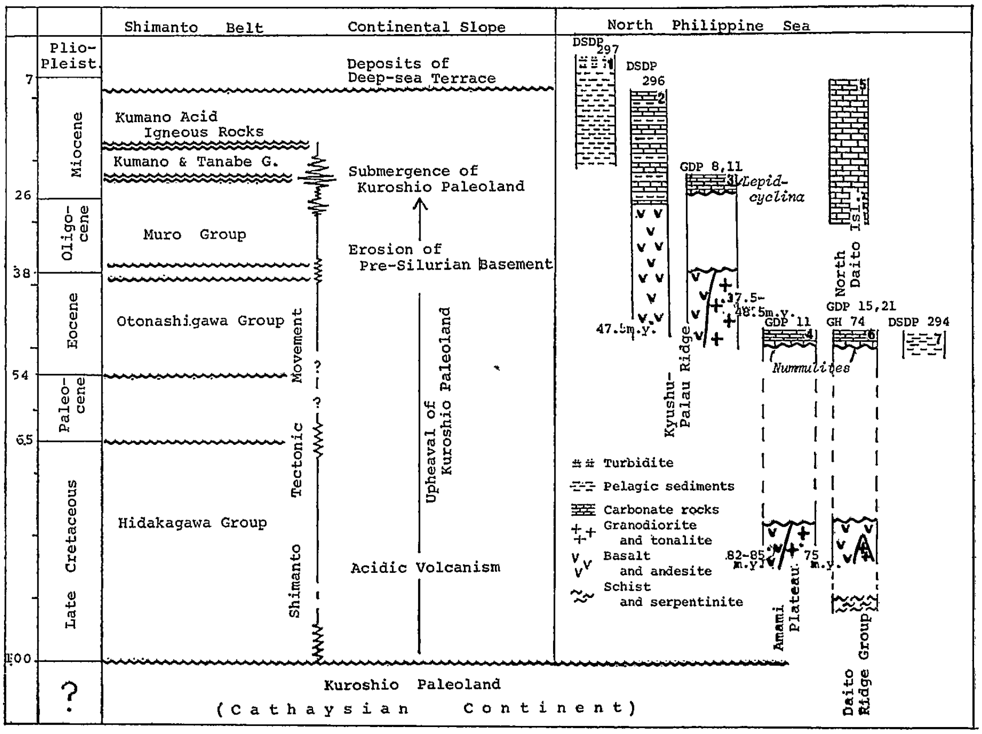

Fig. 6. The geohistory of the Shimanto geosyncline and Kuroshio Paleoland and their relation to that of the Philippine Sea. 1, KARIG *et al.* (1975); 2, KARIG *et al.* (1975), OZIMA *et al.* (1977); 3, MIZUNO *et al.* (1977a), MIZUNO *et al.* (1977b), SHIBATA and OKUDA (1975), SHIBATA *et al.* (1977), SHIKI *et al.* (1975); 4, KONDA *et al.* (1977), MATSUDA *et al.* (1975), MIZUNO *et al.* (1976), MIZUNO *et al.* (1977b), SHIKI *et al.* (1975); 5, HANZAWA (1940–41); 6, MIZUNO and KONDA (1977), MIZUNO *et al.* (1976), MIZUNO *et al.* (1977b), SHIKI *et al.* (1975), YUASA and WATANABE (1977); 7, KARIG *et al.* (1975).

As shown in the reconstruction (Fig. 4), the depositional site of the Shimanto geosyncline can never have been a trench facing to ocean, but was an inner-arc basin or arc-trench gap. No pelagic sediments are found in the Shimanto belt in the Kii Peninsula. An environment shallower than deeper bathyal or abyssal is preferred for the Shimanto geosyncline. In spite of the detailed geologic survey in the Kii Peninsula there is no evidence of large exotic blocks due to gravity sliding nor tectonic mélanges and long distance thrusting. This does not support the plate tectonic model of the Pacific-type orogeny proposed for the outer (Shimanto) belt of Southwest Japan by SUGIMURA and UYEDA (1973).

As to the birth and development of the Philippine Sea there must have been an intimate relation to the geohistry of the Shimanto geosyncline, including the Kuroshio Paleoland. Late Cretaceous/Eocene, Eocene/Oligocene, early Miocene and late Middle Miocene crustal movements are known in the Shimanto terrain. Similarly, the presence of late Cretaceous/Eocene, Eocene/early Miocene and middle Miocene hiatuses have been revealed by DSDP and GDP explorations in the Philippine Sea (Fig. 6). These events indicate considerable vertical movements and subaerial erosion at least in plateau and ridge areas.

From the sedimentological view point the Kuroshio Paleoland was as large as the present Japanese Islands. There is no evidence of the paleoland prior to late Cretaceous. However, the presence of orthoquartzites very similar to that of the Sinian in the Asian Continent suggests that the paleoland extended further south to the present Philippine Sea in the late Precambrian. There remains a large gap in the geologic record since then. Several scientists (LIU, 1959; LIU *et al.*, 1973; MINATO *et al.*, 1965; etc.) suggested that the "Cathaysian Continent" extended to the Philippine Sea in late Precambrian and Paleozoic time. These considerations should be taken into account in reconstructing the birth and development of the Philippine Sea.

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