13. *The Earth-Movements of the Sakawa Stage*

The Developments of the Japanese Islands. III

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In the Sakawa stage from Late Jurassic to Late Cretaceous, the tectonic belts were formed diagonally to those of the previous Akiyoshi stage (Kimura, 1987). Middle Jurassic or latest Cretaceous was transitional to the older or younger stage. In Middle Jurassic embryonal Eo-Nippon Cordillera (Kobayashi, 1941) and Abukuma-Kurosegawa land were formed, which separated the Japanese Jurassic fauna into the northern and the southern fauna (Matsumoto, 1978). The Tetori group in Hida area and the Karakuwa-Shishiori group in the eastern basin in southern Kitakami, of the northern fauna, and the Soma group in eastern Abukuma and the Torinosu group in Southwest Japan, of the southern fauna, began to deposit as predecessors of the strata of the Sakawa stage. However, the Toyora group in West Chugoku, the Hashiura group in the western basin of southern Kitakami and the strata in the northern and southern Chichibu geosynclines (Fig. 1) deposited in nearly the same basin with those of the Akiyoshi stage. The Middle Jurassic strata in the northern Chichibu contain many submarine sliding blocks and sometimes are said to be accretionary prism to continental Hida. However, the Middle Jurassic Samondake formation to the northwest of Gujo-Hachiman, distributed just to the south of the Tetori sedimentary terrain in Hida, is mainly composed of massive quartz-feldspathic sandstone, and has some submarine sliding blocks of the sandstone, but without pelagic blocks (Wakita, 1984). It was the deposits on the southern slope of the Tetori terrain, but not the accretionary strata. The Kodaragawa formation, just to the south of the Samondake, yields *Kepplerites* (*Seymourites*) sp., one of the representatives of the northern fauna, which shows connection of the Tetori sea with the southern Kitakami sea through the northern Chichibu.

The earth-movements in Late Jurassic have characteristics of the Sakawa stage. The Paleo-Ryoke granite belt, a missing belt at present, was made at first in this age, as shown by 149 Ma age of the Kinshozan granite in Kanto (Ono, 1983). The sea in the southern Chichibu geosyncline was closed in Late Jurassic and Eo-Nippon was united with the Abukuma-Kurosegawa land. On the oceanic side of the Torinosu sea, the Shimanto minor geosyncline was formed as a fore-arc basin and a continental shelf on the oceanic side of the northern part of the former Sambosan minor geosyncline. Thus, the minor geosyncline shifted toward the ocean. The terrestrial or shallow marine Toyonishi and Tetori groups covered the northern part of the northern terrain of Southwest Japan in Late Jurassic. However, geosynclinal sea remains in the northern Chichibu geosyncline in the Kuga and Mino areas.

In earliest Cretaceous, Eo-Nippon extended to West Hokkaido. The northern Chichibu sea in Southwest Japan was filled with the accumulation of giant sliding sheets (Kano, 1979) from the south, probably from the Paleo-Ryoke belt. The

land area expanded to northwest. However, brackish water entered the terrestrial Toyonishi basin in West Chugoku. The water connected with the brackish or shallow marine Ryoseki basins which were formed in the southern terrain just to the north of the former Kurosegawa land. The Ryoseki group has the same brackish fauna with the Toyonishi. The marine realm, therefore, is thought to

Fig. 1. Schematic paleogeographic map during the Sakawa stage. M.T.L.: Median Tectonic Line. P.M.T.L.: Proto-Median Tectonic Line. SK: Southern Kitakami. NK: Northern Kitakami. Y: Yatsushiro. T: Takato. K: Kinshozan. 1: Koshiki Knoll. 2: Kanmon. 3: Toyonishi. 4: Onogawa. 5: Uwajima. 6: Nichihara. 7: Kuga. 8: Yamaoku. 9: Izumi. 10: Gujo-Hachiman. 11: Toriashi.

have surrounded southwestern terminal of Eo-Nippon to the west of Kyushu. Later, the northern terrain of Southwest Japan was widely covered by the Early Cretaceous Kanmon group which yields the same fresh-water fauna with the Gueongsang group in South Korea, showing land connection in this age. The Ryoseki brackish basins changed to marine basins of Early Cretaceous Monobegawa and then to those of Late Cretaceous Soto-Izumi, although the size and site of the basins varied with ages. During the deformation, solid intrusion of serpentine occurred into the Early Cretaceous strata, producing the Kurosegawa tectonic zone.

In Hauterivian-Barremian, Rebun-Kitakami andesite belt was formed from West Hokkaido to Kitakami. The latest Jurassic or earliest Cretaceous Nikoro group in the Tokoro zone of East Hokkaido contains thick basaltic pillow lava. There was an oceanic crust area, the Nikoro belt covering East Hokkaido and western Okhotsk, when volcanism occurred in the Rebun-Kitakami belt. Granites distributed from West Hokkaido to Kitakami are of 120–110 Ma and those in Abukuma 110–90 Ma (Geol. Survey of Japan, 1982). Granites of those ages are rare in Southwest Japan at present. However, granites of 125–114 Ma are reported from Takato and Yatsushiro. The Aptian-Albian Monobegawa group in the southern terrain contain a great number of granite boulders which indicate the presence of a granite belt – the Paleo-Ryoke belt –.

A grand thrust fault – Proto-Median Tectonic Line – was produced between the Rebun-Kitakami andesite belt or the Paleo-Ryoke belt and the low temperature belt on the oceanic side (Kimura, 1980). The Kamuikotan metamorphism in Hokkaido or the Sambagawa metamorphism in Southwest Japan was produced by the overburden of the thrust mass of West Hokkaido or the Paleo-Ryoke belt. Overburden of submarine sliding sheets produced by the earth-movements may have also caused the metamorphism. Intense folding occurred in the Rebun-Kitakami belt and in parts of the former Sorachi geosyncline, and in Aptian the main part of the Sorachi changed to the Ezo geosyncline as a fore-arc basin and on the oceanic side of the basin the Hidaka geosyncline was formed probably as a continental shelf. The Ezo group sometimes covers clinounconformably the

weakly metamorphosed Sorachi group. Many Kamuikotan ultramafic and metamorphic rocks appear as solid intrusive masses into the Ezo group. The Ezo geosyncline extended toward south to the Cretaceous basin off Sanriku. In Aptian-Albian and Coniacian-Santonian, marine water transgressed upon the marginal part of Eo-Nippon, and the Miyako group and the Kuji or Futaba

Fig. 2. Developments of Southwest Japan during the Sakawa stage (Middle Jurassic and latest Cretaceous are the transitional stage to the older and younger ones). M.T.L.: Median Tectonic Line. P.M.T.L.: Proto-Median Tectonic Line. meta: Metamorphism. serp: serpentine solid intrusion. Kuro: Old Kurosegawa islands.

group deposited in the eastern part of Kitakami and Abukuma. The Miyako group covers with a remarkable clinounconformity the folded Barremian andesitic strata. The Hidaka group just to the east of the Ezo geosyncline is rich in submarine sliding deposits and of Valanginian-Aptian age. However the eastern Hidaka group is of Santonian-Campanian (Kiminami *et al.*, 1986). In the Tokoro zone to the east of the Hidaka area, the lowest Cretaceous Nikoro group is covered by the Coniacian-Santonian Saroma group. Further toward east, Campanian-Maastrichtian Nemuro group covers eastern Hokkaido. The Nikoro belt, the lowest Cretaceous oceanic crust area, was changed to continental shelf connected to the Hidaka geosyncline during Late Cretaceous time.

The Shimanto geosyncline is the southwestern continuation of the Ezo-Hidaka geosyncline through the Cretaceous sedimentary basin off Sanriku. The Cretaceous Shimanto supergroup deposited in a fore-arc basin. On the continental margin of the Shimanto geosyncline, there were lower Cretaceous shallow water realms (Nakazawa *et al.*, 1979). In Late Cretaceous one of them spread into the middle of the fore-arc basin in western Shikoku, and the Uwajima group deposited upon the Lower Cretaceous geosynclinal strata. Submarine

sliding occurred quite frequently on the slope of those shallow water realms, and abundant sliding blocks of quartz-feldspathic massive sandstone were transported into the deeper area. Some sliding blocks are of basalt. However, they are originally produced by small scale intrusions into the geosynclinal strata, but not as a member of ophiolite. On the other hand, the Shimanto supergroup contains a considerable amount of acid tuff. Acid tuff breccia supplied from a submarine ridge on the oceanic side of the fore-arc basin is also reported. The Shimanto supergroup does not have geologic structures of an accretionary prism (Yanai, 1984), although it is separated by some thrust faults.

In Late Cretaceous, Eo-Nippon and the northern terrain made a wide land area in Southwest Japan. Granite intrusion of 90–80 Ma occurred in the southern part of the northern terrain. The intrusion belt reach Koshiki Knoll, to the west of Kyushu. Younger intrusion of granite and rhyolite occurred generally in the northern part of the northern terrain. In the area of Eo-Nippon, Ryoke high temperature metamorphism occurred. The metamorphic age is of 100–90 Ma in Chugoku and of 80–60 Ma in the Chubu district. On the other hand, the Sambagawa high pressure metamorphic rocks have 110–70 Ma age. In West Kyushu Late Cretaceous marine invasion occurred into western end of Eo-Nippon. Turonian sea covered the Sambagawa belt in East Kyushu, where the Onogawa group deposited upon the metamorphic rocks of 95–91 Ma – Cenomanian –. The Sambagawa metamorphic rocks, to the south of the sedimentary basin of the Maastrichtian Izumi group in Kinki, have of 74–70 Ma. These show that the age of the Sambagawa rocks indicates the time of the removal of the overburden, and that the Ryoke metamorphism has been going on in the Chubu district when the Sambagawa metamorphic rocks of the Onogawa area have already cropped out.

The belts of granite and metamorphism, and fore-arc basins shifted toward the oceanic side from the Akiyoshi to the Sakawa stage. The change was caused by the change of subduction system. Through the Sakawa stage, the Japanese Islands were unstable. Extensive overthrusting of the high temperature belt along the Proto-Median Tectonic Line occurred upon the low temperature belt which changed to the high pressure metamorphic belts of Sambagawa and Kamuikotan. Such earth-movements formed Eo-Nippon, a framework of the present-day Japanese Islands, running from western Kyushu to West Hokkaido.

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