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PALEOBOTANICAL EVIDENCE ON THE ORIGIN OF JAPAN SEA

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Abstract

Early Cretaceous vegetation of Primorye and Japan was differentiated into inner and outer belts due to the differences in percipitation imposed by mountain ranges. At Berriasian-Valanginian time both western Japan and eastern Primorye belonged to the inner belt. Principal mountain range was situated along the median line of Japanese Islands. After the Hauterivian interval of nondeposition a rain shadow was removed from the eastern Primorye probably by drifting of Japanese Islands away from the continent. This initial episode of Japan Sea formation coincided with the large scale Pacific floor spreading at Hauterivian time. The eastward migration of geosyncline belts of Eastern Asia is to be explained rather by westward movement of Asiatic continental plate than by expansion of the continent.

Introduction

The origin of marginal seas of the Japan Sea type is among the crucial problems of new global tectonics. The controversal versions of marginal sea formation have been recently reviewed by PACKHAM and FALVEY (1971), KARIG (1971) and others. The island arcs are thought to be produced by plunging of one "thin" plate under the other (INMAN and NORDSTROM, 1971) or when the lithosphere consumption begins at some distance from the continental margin (DEWEY and HORSFIELD,1970) It follows that the island arcs have never formed a part of the continent (MITCHELL and READING, 1971). On the other hand some authors have claimed that marginal basins of Japan Sea type are neooceanic, formed by rifting of continental margin and oceanward migration of trench-arc system (MURAUCHI and DEN, 1966; DITZ and HOLDEN, 1970; PACKHALM and FALVEY, 1971). The "diapir model" of marginal sea development have been accepted by KARIG (1971), MATSUDA and UYEDA (1971) and others. The present paper is not intended for comprehensive discussion of the marginal sea problem. Its goal is to offer the independant evidence emerging from paleobotanical researches.

Several biogeographers have suggested dry land connections between the continental Asia and Japan judging from a resemblance of insular biota to that of the continent. However a land bridge might have been established during the Pleistocene eustatic fall of sea level. On the evidence of marine palynology the Yamato seamounts have emerged above sea level at the Late Pleistocene time. The emerging islands might have served as stepping stones for terrestrial plants and animals. Thus general similiarity between insular and continental biotas has little bearing on the problem of Japan Sea origin.

Early Cretaceous floristic belts of South Primorye and Japan

KIMURA (1961) subdivided the Late Jurassic-Valanginian plant assemblages of Japan into inner (Tetori) and outer (Rioseki) belts, their boundary running near to the median line of the island arc. The presence of several *Dictyozamites* species is the most obvious distinguishing feature of the inner belt. On the whole, at least one third of the inner belt species are distinctive (MINATO *et al.*, 1965).

At South Primorye the Berriasian and Valanginian deposits crop out between the

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upper reaches of Sutschan River and the Japan Sea coast. They consist chiefly of interbedding sandstones and shales which yielded abundant plant remains together with *Neocomites*, *Beriasella*, *Aucella* and other marine invertebrates. The fossil plant collections contain *Sphenopteris nitidula* (YOK.) OISHI, *Sagenopteris petiolata* OISHI, *Dictyozamites falcatus* (MORRIS), *D. kawasakii* TATEIWA, *Otozamites Klipsteinii* (DUNK.) SEW., and *Nilssonia schaumburgensis* (DUNK.) NATH. (KRASSILOV, 1967) which are characteristic species of the inner belt floristic assemblages of Japan.

Extensive plant collections are obtained from the coal-bearing Nicanian deposits of Barremian-Albian age. The contact of coal-bearing formation with underlying Valanginian beds is a disconformity representing the time-interval of nondeposition roughly equivalent to the Hauterivian stage. The Nican Group fills two depressions of the Paleozoic basement: Sutschan basin to the east and Sujfun basin to the west. At Sutschan basin the coal-bearing deposits have sparse marine shells and their upper part is interlayered with marine *Trigonia* beds, whereas the Sujfun sequence is entirely nonmarine.

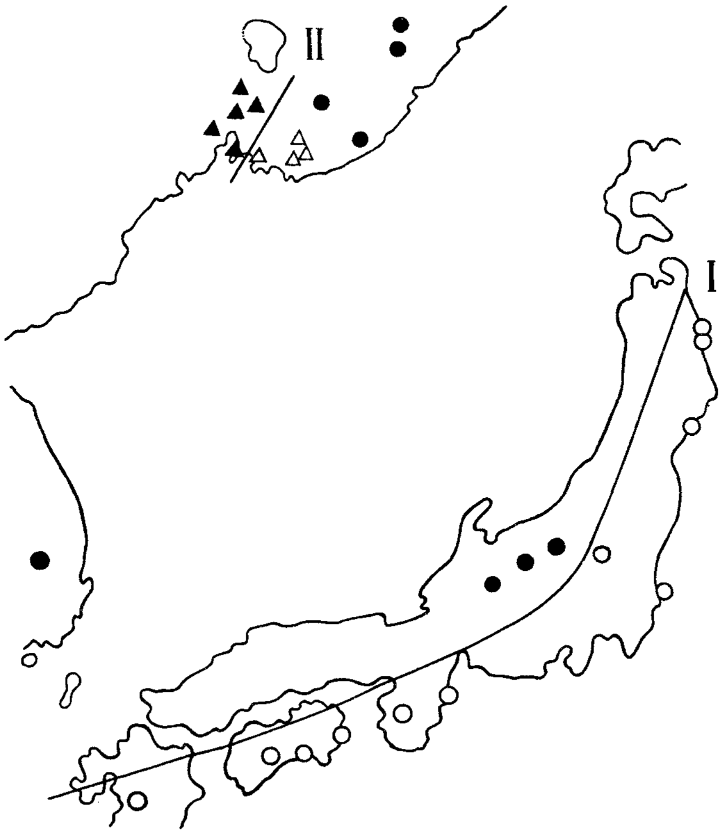

Fig. 1. Differentiation of Early Cretaceous vegetation of South Primorye and Japan. (Japanese part after KIMURA, 1961). Filled circles – inner zone of Berriasian-Valanginian age; open circles – outer zone of the same age; filled triangles – inner zone of Barremian-Albian age; open triangles – contemporaneous outer zone.

The Sutschan assemblages are dominated by *Elatides asiatica* (YOK.) KRASSIL., *Athrotaxopsis expansa* FONT. and other Taxodiaceous conifers. The cycadophytes are comparatively rare. Few angiosperm leaves with deeply lobed or compound blades are collected from the upper horizons just below and above the *Trigonia* beds. These assemblages are thought to represent the maritime conifer forest. The contemporaneous Sujfun assemblages are immensely rich in cycadophytes including two *Dictyozamites* species. The conifers are referred to the Araucariaceae, Podocarpaceae, *Cephalotaxus, Torreya* and *Athrotaxites*. Some of them are assumed to be of shrubby aspect. Together with cycadophytes they probably constituted shrubby evergreen communities inhabiting the drier sites of Mesozoic landscape. Several angiosperm species with entire leaves come from the upper part of coal-bearing strata.

Although there are considerable differences between the Berriasian-Valanginian and the Barremian-Albian taphofloras, the Sujfun assemblages can be recognized as corresponding to the inner belt whereas the Sutschan ones reveal the characters of outer belt.

The Nican deposits grade upward into green tuffaceous sandstones and red shales containing only sparse plant fragments. In the vicinity of Vladivostok this formation has numerous interbeds of conglomerate.

Discussion

The geological structures of Primorye and Japan Islands are controlled by long-living faults which are parallel to the coasts. These faults are responsible for disposition of mountain ranges. It is well known that mountain ranges orientated along the coasts have profound effect on percipitation casting a rain shadow on the inner provinces. Thus the differentiation of Cretaceous vegetation of Primorye and Japan into inner and outer belts appears to be related to the differences in percipitation imposed by mountain ranges. This suggestion is in accord with the paleoecology of Sutschan Taxodiaceous forests as contrasting with the presumably chaparral-like cycadophyte communities of Sujfun depression. The existence of elevations between the Sutschan and Sujfun depressions is evidenced by the large amount of coarse sediments deposited to the north of Muraviov peninsula.

Up to the Valanginian time both western part of Japan and eastern part of Primorye belonged to the inner floristic belt. From the Barremian onwards, the inner belt comprised only western part of Primorye (Sujfun depression) whereas its eastern part (Sutschan basin) belonged to the outer belt. The contemporaneous Monobegawa flora of Japan is but little known. However it seems to be of "outer" aspect. At the end of Albian time the climate of Primorye became rather dry (red beds).

From this evidence we can surmise that the principlal mountain ranges of Berriasian-Valanginian time have been situated along the median line of Japanese islands casting a rain shadow on the western part of Japan as well as on the eastern part of South Primorye. It follows, that these territories have been continuous or at least have not been separated by water body of considerable dimensions though they were subjected to sea invasions from the north. During the Hauterivian interval of nondeposition the rain shadow has been removed from eastern Primorye and the maritime vegetation has established there. This change was probably caused by drifting of Japanese Islands away from the continent. These conclusions agree with the results of KAWAI *et al.* (1969), who dates the initial drifting episodes by the beginning of early Cretaceous (about 120 m.y.). The drifting along longitudinal faults appears to be combined with strike-slip motions along subordinate system of latitudinal faults analogous to the transform faults of oceanic lithosphere. The strike-slip displacements are probably responsible for the bending of ancient floristic belts of Japanese Islands. The reduction of percipitation in Primorye at post-Albian time can be related to the rise of coastal ranges consequent to asymmetrical spreading of the Japan Sea floor.

Marginal sea formation at western Pacific is accompanied by eastward migration of geosyncline regime which is especially evident during Cretaceous period. Early Mesozoic eugeosyncline of eastern Sikhote-Alin migrated to Sakhalin at Early Cretaceous time. Eastern Sikhote-Alin had turned into miogeosyncline which was replaced by terrestrial volcanic belt at Cenomanian-Turonian time. Simultaneously the miogeosyncline regime was established at western Sakhalin. At the end of Cretaceous the western Sakhalin was also embraced by terrestrial volcanism (KRASSILOV, 1972).

Several authors have related this motion of tectonic zones to expansion of the continent. However marginal deltaic facies have deposited close to the present coast line at Permian and even at Devonian time. This excludes a considerable expansion of the continent. Alternative mechanism of westward displacement of Asiatic plate passing over a "hot zone" would probably better explain the eastward migration of geosyncline regime.

It is worth mentioning, that the most ancient basal sediments of the Western North Pacific occurring on the Shatsky Rise have been recently dated by Late Hauterivian-Early Barremian (DOOGLAS and MOULLADE, 1972) which is in agreement with my dating of intial stage of Japan Sea formation. The latter was evidently correlated with other drifting events in Western Pacific.

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