**19. On the Tuffaceous Conglomerate at Northwestern
Part of Koike in the Sakawa Basin,
Shikoku, Japan^{*)}**

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Although T. Kobayashi (1950) stated briefly on the tuffaceous conglomerate containing corals (*Yatsengia* ? sp. and *Chaetetes bocki*) in the limestone pebbles, exposed at the northwestern part of Koike in the Sakawa basin, Kochi Prefecture of Shikoku, the detailed description has not been published. We had a chance to visit the old quarry located at the northwestern part of Koike, ca. 650 m north of Sakawa Station and collected some rock samples there (see Fig. 1). The present paper deals with the Carboniferous fauna such as fusulines, smaller foraminifers and bryozoans found in the limestone pebbles of the tuffaceous conglomerate.

According to the explanatory text of the geological map of Sakawa town edited by Katto (1982), the Takaoka Formation of the Jurassic complex, which is composed mainly of sandstone and shale with exotic blocks of limestone and chert, is distributed in this area. The exposure of the tuffaceous conglomerate is about 15 m wide and 5 m high. Small red chert lenses (ca. 1 m long and 30 to 40 cm thick) are intercalated in the conglomerate member. Small conodont fauna including *Diplognathodus lanceolatus* Igo, *D. sp. cf. D. oertlii* Kozur and *Hindeodus minutus* (Ellison), which indicates early Middle Permian in age (see Fig. 2), is extracted from these chert lenses. The contact between the tuffaceous conglomerate member and the surrounding sediments is not observed.

The tuffaceous conglomerate is composed mainly of limestone pebbles in association with the pebbles of basalt and dolerite. Weak lamination is partly developed. The limestone pebbles consist mainly of oosparite and pelmicrite, but micrite, biolithite and pisosparite are also included. It is notable that the calcareous pisolites measure up to 6 mm in maximum diameter. These pebbles are angular to subangular but occasionally round in shape and 0.2 cm to 5 cm in size. Matrix is cemented by highly calcareous tuff.

The fossil remains were found only in the limestone pebbles, but could not be found in the matrix. The following species were discriminated in the limestone pebbles (see Fig. 3).

FUSULINES: *Eostaffella akiyoshiensis* Sada, *E. etoi* Ota, *Millerella sp. cf. M. marblensis* Thompson, *Pseudonovella carbonica* (Grozdilova & Lebedeva), *Ozawainella mosquensis* Rauser-Chernoussova, *O. angulata* (Colani), *Nankinella sp.*, *Eoschubertella toriyamai* Ishii, *E. obscura* (Lee & Chen), *E. lata* (Lee & Chen), *Fusulinella minutissima* Ishii, *F. pygmaea* Ishii, *F. elegantula* Ishii, *F. bocki* (Möller), *F. sp. cf. F. simplicata* Toriyama, *Fusulina sp. cf. F. kanmerai* Ishii, *F. sp. cf. F. shikokuensis* Ishii, *Beedeina higoensis* (Kanmera), *B. lanceolata* (Lee & Chen), *B. sp.*

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SMALLER FORAMINIFERS: *Calcisphaera* spp., *Earlandia* sp., *Tuberitina bulbacea* Galloway & Harlton, *Diplosphaerina* sp., *Eotuberitina* sp., *Neotuberitina* sp., *Climacamina* spp., *Tetrataxis* sp., *Globivalvulina* sp., *Endothyra* ex gr. *bowmani* Phillips emend. Brady, *E.* spp., *Omphalotis* sp. cf. *O. samarica* (Rauser-Chernoussova), *Bradyina* spp., *Eolasiiodiscus* spp., *Brunsia* sp.

BRYOZOANS: *Fistulipora* sp., *Meekoporella* sp., *Streblascopora* sp., *Girtypora* sp. cf. *G. sakagamii* Sugimura, *Fenestella* sp., *Penniretepora* sp.

Among these taxa, fusuline fauna is most important in consideration of the geological age. It can be recognized three groups showing different ages, but all of them indicates Carboniferous in age.

The first group is represented by *Eostaffella akiyoshiensis* Sada, *Millerella* cf. *marblensis* Thompson and *Pseudonovella carbonica* (Grozdilova & Levedeva). *E. akiyoshiensis* Sada was originally described from the *Millerella* zone of Akiyoshi Limestone Group, which is correlated with the Serpukhovian. In the Akiyoshi Limestone Group, it is known that *E. akiyoshiensis* Sada ranges up to the *Profusulinella beppensis* zone of the Upper Bashkirian. In the present fauna, however, the typical Bashkirian elements such as *Pseudostaffella* and *Profusulinella* are not found. Accordingly it is highly probable that the provenance of the limestone pebbles is lacking in the Bashkirian age. From the above mentioned facts, the geological age of this fusuline group is estimated as the Serpukhovian.

The second group is characterized by several species of *Fusulinella*, *Fusulina* and *Eoschubertella*. Among them, *Fusulinella pygmaea* Ishii, *F. minutissima* Ishii and *Eoschubertella obscura* (Lee & Chen) are dominant. This fauna is very close to that of the Itadorigawa Group, especially of the It₂ zone, in western Shikoku reported by Ishii (1958, 1961, 1962). The Itadorigawa Group is characterized by *Fusulina*, *Eoschubertella*, *Fusiella* and rather primitive *Fusulinella*, and is correlated with the Lower Moscovian. It may correspond to the lower part of *Fusulinella* zone in Japan. It is noteworthy that *Eostaffella etoi* Ota occurs in association with the typical Itadorigawa elements of *Fusulinella* and *Fusulina*. *E. etoi* Ota has been known from the *Millerella yowarensis* zone to the middle part of the *Profusulinella beppensis* zone in the Akiyoshi Limestone Group. Therefore the stratigraphic range of *E. etoi* Ota may extend to the lower part of *Fusulinella* zone.

The third group includes *Beedeina higoensis* (Kanmera), *B. lanceolata* (Lee & Chen), *B.* sp. and *Ozawainella mosquensis* Rauser-Chernoussova. Among these fusulines, *B. higoensis* (Kanmera) and *B. lanceolata* (Lee & Chen) are important as an age indicator of the Late Moscovian, the *Beedeina* zone.

The smaller foraminiferal fauna from the pebbles is compatible with the fusuline data in consideration of the geological age.

All of the bryozoan genera are known also from the Carboniferous part of the Akiyoshi Limestone Group. Unfortunately the specific name of these bryozoans cannot be given because of the poor and fragmentary specimens, but *Girtypora* sp. seems to be very close to *G. sakagamii* Sugimura (1985) which was described from the *Profusulinella beppensis* zone of the Akiyoshi Limestone Group.

In conclusion, the present fauna in the limestone pebbles of the tuffaceous conglomerate indicates the Serpukhovian to Late Moscovian in Carboniferous age, although the typical Bashkirian fusuline element is lacking. Moreover the

post-Upper Carboniferous fusulines are not obtained at all.

Recently, Isozaki (1985) restudied the Yasuba conglomerates in his Shingai Formation in the northern subbelt of the Chichibu Belt in central Shikoku. According to him, the conglomerates are revealed to be exotic in origin, and it can be classified into three types: Type I, Type II and Type III. He estimated that the conglomerate Types I and III, poor in terrigenous coarse clastics, are inferred to be sediment-gravity-flow deposits which were essentially accumulated at the base-of-slope along the outskirt of ancient seamount whose top was capped by organic reef or carbonate mound, and the Type II, rich in terrigenous materials, is supposed to have deposited in some area adjacent to ancient Kurosegawa land (arc or microcontinent). From the viewpoints of its lithology and fossils contained, the present tuffaceous conglomerate closely resembles the limestone conglomerate of Inomine located at ca. 5.5 km northeast of Koike, which was reported as a type of the Yasuba conglomerates containing the Moscovian fusulines in the limestone pebbles by Toriyama (1945), and the conglomerate Type I by Isozaki (1985). It can be estimated that this tuffaceous

Fig. 1. Map showing the locality of the tuffaceous conglomerate.

Fig. 2. The Permian conodonts from the chert lens. 1, 2: *Diplognathodus lanceolatus* Igo. 3, 4: *Diplognathodus* sp. cf. *D. oertlii* Kozur. 5: *Hindeodus minutus* (Ellison). All are in $\times 10$.

Fig. 3. Some fusulines and bryozoans from the limestone pebbles. 1: *Beedeina higoensis*, $\times 15$. 2: *Eostaffella akiyoshiensis*, $\times 60$. 3: *Millerella* sp. cf. *M. marblensis*, $\times 60$. 4: *Eostaffella etoi*, $\times 60$. 5: *Eoschubertella lata*, $\times 60$. 6: *Pseudonovella carbonica*, $\times 60$. 7: *Ozawainella mosquensis*, $\times 60$. 8: *Fusulinella minutissima*, $\times 25$. 9, 10: *Fusulinella elegantula*, $\times 25$. 11: *Fusulinella pygmaea*, $\times 25$. 12: *Eoschubertella toriyamai*, $\times 60$. 13: *Eoschubertella obscura*, $\times 60$. 14: *Beedeina lanceolata*, $\times 25$. 15: *Fusulina* sp. cf. *kanmerai*, $\times 25$. 16: *Fusulina* sp. cf. *F. shikokuensis*, $\times 25$. 17: *Girtypora* sp. cf. *G. sakagami*, $\times 15$.

conglomerate was initially accumulated around the seamount during the early Middle Permian (the lower part of the *Parafusulina* zone), however, because the Takaoka Formation is considered to be the Jurassic, the present conglomerate should be exotic block.

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