Radiolarians, bivalves and the J/K boundary in the Birafu Formation, southern Kurosegawa Belt, Central Shikoku, SW Japan

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ABSTRACT: The Oxfordian–Berrissian Birafu Formation in the southern Kurosegawa Belt (Permian accretion terrane), Central Shikoku, SW Japan, yields micro- and mega-faunas that contribute to the biostratigraphy across the Jurassic-Cretaceous boundary. The type section consists of turbiditic sandstone and mudstone with an upward-fining tendency in the lower members (A1-A3). The middle members (B1-B2) are coarse sandstone and mudstone with muddy limestone intercalations, whereas the upper member C is characterized by a fine-grained turbiditic succession. Radiolarians define the assemblage zones (AZ): *Kiihura spinula* AZ (Oxfordian) in member A2, *Loopta primiva* AZ (Tithonian) in the upper part of member A3, and *Pseudodactylintra carpathica* AZ (Berrissian-lower Valanginian) in members B2 and C. These give at least an Oxfordian-Berrissian total time-range to the Birafu Formation. The mixed marine and brackish bivalve assemblage of members B1 and B2 (lower part) comprises *Grammatodon takien-sis* Tamura, *Pterotrignia toyamai* (Yehara) and *Ctenoides tosanus* Kimura, the range of which is Late Jurassic to Earliest Cretaceous, and *Agulkerella nagatoensis* (Ohta), *Milia japonica* Tashiro and *Isoplinna japonica* Tashiro and Kozai, having an Early Cretaceous range. The concurrent range of Jurassic to Cretaceous bivalves and exclusively Cretaceous species is significant for the clarification of bivalve evolution across the Jurassic-Cretaceous boundary. The Berrissian appearance of Cretaceous marine and non-marine bivalves takes place while Late Jurassic marine bivalves still survived. We consider Member B1 as Berrissian with the J/K boundary situated at its base.

Key words: Bivalves, radiolarians, J/K boundary, Kurosegawa, Japan

1. INTRODUCTION

Jurassic to Cretaceous non-marine, shallow marine and slope basin deposits are widely scattered over Japan. In Northeast Japan, some formations straddle the J/K boundary. The Isokusa Formation of the Karakuwa Group yields latest Jurassic and earliest Cretaceous ammonites with abundant bivalves (Sato, 1958; Hayami, 1960; Takahashi, 1973). The Ayukawa Formation of the Ojika Group yields Berrissian ammonites and bivalves. The Koyama Formation of the Somanakamura Group yields ammonites and bivalves that indicate Tithonian and Berrissian ages. All these Late Jurassic and earliest Cretaceous bivalve faunas are very similar.

Southwest Japan is subdivided structurally into the Inner and Outer zones. In the Inner Zone, the J/K boundary falls within the non-marine deposits (Kobayashi and Suzuki, 1939; Hirano, 1971). The J/K boundary remains often concealed in the marine deposits of the Outer Zone (Tanaka, 1989), except in the Birafu Formation of the Sakashu Belt (a part of the Chichibu Superbelt), in the Monobe area of Central Shikoku (Ishida and Kozai, 2004).

Complementing the initial find of bivalves and ammonites by Yehara (1923), Kobayashi and Fukuda (1947), the discovery of radiolarians, ranging from Oxfordian to Berrissian and the further identification of Jurassic marine bivalves and of an association of marine and brackish-water Cretaceous mollusks (Morino et al., 1989; Kozai et al., 2004) initiated the discussion of the remarkable correlation between radiolarians and particularly the earliest Cretaceous bivalves in the Birafu Formation.

The radiolarian biostratigraphy sets accurate age constraints for the completely different bivalve associations in the late Jurassic (Kimmeridgian-Tithonian) and Early Cretaceous (Hauterivian-Barremian). This exceptional situation may shed light on the evolution of the bivalve faunal association across the Jurassic-Cretaceous boundary in Japan. Detailed studies of Late Jurassic (Oxfordian-Tithonian) bivalves were carried out by Tamura (1959a-d, 1960a-c), Hayami (1961) and Kimura (1951, 1956), whereas for the Early Cretaceous (Hauterivian-Barremian) bivalves, investigations were done by Hayami (1965a,b). Ohta (1973, 1974) and Tashiro and Kozai (1984, 1986, 1988, 1989, 1991, 1994). Hayami (1961) identified three bivalve association groups: Hettangian-Aalenian, Bajocian-Bathonian and Callovian-Tithonian. He also pointed out that some of the younger Jurassic elements survived into the earliest Cretaceous. Later, the J/L faunal turnover was placed within the “Neocomian” (Hayami, 1975).
2. GEOLOGICAL SETTING

The Inner and Outer zones of southwest Japan are separated by the Median Tectonic Line. The Outer Zone is subdivided into the Sanbagawa, Chichibu and Shimanto superbelts. In eastern Shikoku, the Chichibu Superbelt has been subdivided from north to south into five belts: the Kumasoyama Belt, the Masaki, Yoshigahira and Sakashu belts and the Nakagawa Belt (Ishida and Kozai, 2003). The Masaki Belt is composed of Permian accretionary complex (PAC) with Upper and Lower Cretaceous slope basin deposits (SL), e.g. the Monobegawa Group. The Yoshigahira Belt is a tectonic unit that was formed after the sedimentation of the Lower Cretaceous SL; it consists of the Siluro-Devonian Kurosegawa Tectonic Zone sensu stricto, Permian-Triassic and Jurassic accretionary complexes (AC), and Lower Cretaceous SL. The Sakashu Belt is composed of Permian AC with Siluro-Devonian blocks, uppermost Permian, Middle-Upper Triassic, Jurassic and Lower Cretaceous SLs. The Birafu Formation (Morino et al., 1989) is one of the slope-basin deposits within the Sakashu Belt (Kozai et al., 2004). The Birafu Formation extends between the Nankai Group (Yoshigahira Belt) and Monobegawa Group (Masaki Belt) to the North and the Nakagawa Belt to the South (Fig. 1).

3. DISTRIBUTION AND STRATIGRAPHY OF THE BIRAFU FORMATION

The Birafu Formation is exposed in Central Shikoku, east of Tosanyamada (Kochi Prefecture), striking generally ENE-WSW and dipping steeply south. The type section of the Birafu Formation is located at Ogawa along the Nishinokawa River, where a thickness of 725 m was measured (Fig. 2). The formation is subdivided into six members (Fig. 3).

Member A1 is composed of alternating beds of dark gray mudstone and sandstone. In the lower part of the member, 1 cm to 10 cm thick sandstone layers are well graded. Parallel and current ripple laminations are also observed. In the upper part of the member, the sandstone beds become thicker. The total thickness of the unit A1 is approximately 40 m.

Member A2 contains medium-grained massive sandstone, muddy sandstone, sandy mudstone, mudstone and tuff. The muddy sandstone bed of unit A2 contains fragments of bivalves. The Kimeridgian ammonite Axioceras kurisakense Kobayashi and Fukada was described from this member by Kobayashi and Fukada (1947). The member is topped by a mudstone (32601R) with tuff intercalation. The mudstone yields Oxfordian radiolarians. This unit is approximately 80 m thick.

Fig. 1. Tectonic subdivision of the Chichibu Superbelt in East Shikoku (modified after Ishida and Kozai, 2003; Kozai and Ishida, 2003).