38. Terminal Cretaceous Sedimentary Sequence recognized in the Northernmost Japan based on Planktonic Foraminiferal Evidence

By Kunio KAIHO and Tsunemasa SAITO
Department of Earth Sciences, Yamagata University,
Yamagata 990

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Discoveries of anomalously high Ir concentrations in Cretaceous-Tertiary (K-T) boundary sediments from widely separated regions of the world (Smit and Hertogen, 1980; Alvarez et al., 1980; Alvarez et al., 1982) prompted the suggestion that an asteroid struck the Earth and caused mass extinctions at the end of the Cretaceous (Smit and Hertogen, 1980; Alvarez et al., 1980; Alvarez et al., 1982; Alvarez et al., 1984). In a wide region of the northwestern Pacific, continuous K-T boundary sections have as yet to be identified, preventing further elucidation of the K-T boundary event in this part of the world. The junction of upper Cretaceous and lower Tertiary strata can be observed at many localities in all the four major islands of the Japanese Archipelago, but at most sites the boundary is clearly disconformable. We report here the discovery of a continuous stratigraphic section spanning the K-T boundary in the eastern district of Hokkaido, northernmost Japan. This is the first paleontologicall documentation of the upper Maastrichtian and lower Danian strata in Japan.

The K-T boundary occurs in the upper part of the Katsuhira Formation exposed in the bed of a shallow stream of the Mokawaruppu River, about 4 km upstream of Kawaruppu Township, Tokachi District, Hokkaido (Fig. 1). Beds of the Katsuhira Formation dip steeply (~60°) in an upstream direction without any noticeable structural disturbance and are continuously exposed. Sampling of 10 cm interval was made from 10 meter below the K-T boundary to 3 meter above the boundary. The sedimentary sequence at this locality consists predominantly of a massive, dark gray siltstone bearing occasionally calcareous concretions (Fig. 2). A distinct, 6-10 cm thick grayish black claystone is the only lithological break in this otherwise monotonous sedimentary succession. Framboidal pyrites abound in the clay layer and pebble-sized calcareous concretions also occur occasionally. Two layers of light gray, non-fossiliferous lenticular limestone bracket the clay layer; the one above is 3 cm thick and one below is at most 2 cm thick. These limestone beds vary their thickness considerably in lateral directions and often pinch out altogether (Fig. 3).

Planktonic foraminiferal biostratigraphy enables correlation of a nearly 80-m thick section underlying the claystone with the Zone M3 of Smit (1982) of latest Maastrichtian age. Important species present include Rugoglobigerina hexacamerata, R. macrocephala, R. milamensis and Globotruncanella kefensoua (Figs. 2, 4). The occurrence of G. kefensoua is significant because this species characterizes the uppermost Maastrichtian sequence of Tunisia (Solakius, 1983), ranging from the uppermost Abathomphalus mayaroensis Zone through the overlying Globotruncanella falsocalcarata Zone. Solakius (1983) erected this species as a descendant of Globotruncanella havanensis (Voorwijk). We instead
believe it to be closely allied to *Globotruncanella petaloidea* (Gandolfi), because *G. havanensis* possesses a hispid dorso-peripheral test surface which distinguishes the smooth pitted surface of *G. petaloidea* and *G. keffensoura*. The lack of species diversity of late Cretaceous planktonic foraminifera from Hokkaido, particularly the total absence of species belonging to the genus *Globotruncana* can be ascribed to the high boreal latitude of the locality.

Fig. 1. Location of the Kawaruppu section exposing the K-T boundary sequence. Inset shows the studied section on an early Tertiary paleogeography of Japan (Maruyama and Seno, 1985), which would place the locality on a western continental slope of the “East Hokkaido Island” riding on the North American Plate (NAP). A paleostrait underlain by the Kula Plate (KP) crust separated this island from the main Hokkaido island located to the west. The Kula Plate has since been subducted, adjoining the two Cretaceous “islands” to one large island of the present-day Hokkaido.

Fig. 2. Diagram showing the lithology of the K-T boundary interval in the Kawaruppu Section, eastern Hokkaido. Stratigraphic ranges of planktonic foraminifera plotted relative to the zonation of Blow (1979) (A) and Smit (1982) (B), and fluctuations in abundance of benthic foraminifera (C) are also indicated. Lithologies: Siltstone (a); claystone (b); limestone (c); calcareous concretions (d); and tuff layer (e). Letter f marks the point of scale changes in sediment thickness, g for the entry of age diagnostic Paleocene planktonic forms and h extinction horizon of Cretaceous taxa. Benthic foraminifera abundances indicated: i, between 1,000 and 500 specimens per 100 g dry sediment washed on 150-mesh screen; j, between 499 and 250 specimens; k, one specimen only. Planktonic species symbols: 1, *Globigerinelloides multispina* (Lalicker); 2, *Rugoglobigerina hexacamerata* Brönnimann; 3, *Rugoglobigerina rugosa* (Plummer); 4, *Rugoglobigerina milamensis* Smith and Pessagno; 5, *Rugoglobigerina macrocephala* Brönnimann; 6, *Globotruncanella keffensoura* Solakius; 7, *Globotruncanella petaloidea* (Gandolfi); 8, *Rugoglobigerina scotti* (Brönnimann); 9, *Globigerinelloides volutus* (White); 10, *Eoglobigerina sp.*, type II of Blow (1979, pl. 60); 11, *Globigerina fringa* Subbotina; 12, *Globigerina eugubina* Luterbacher and Premoli Silva; 13, *Globigerina minutula* Luterbacher and Premoli Silva; 14, *Globorotalia pseudobulloides* (Plummer).
Foraminifera are totally absent in the grayish black claystone except for the basal one centimeter where only benthic species are present (Fig. 2). This foraminifera-barren interval is assignable to the Zone P₀ of Smit (1982) established for the K-T boundary sequence near Caravaca, Spain and at El Kef, Tunisia. The presence of a dark-colored clay layer practically devoid of calcareous microfossil is the well-established common trait of most land-exposed K-T boundary sections in Europe (Smit, 1982).

Globigerina fringa, G. eugubina and G. minutula occur in 2.6-m strata immediately overlying the grayish black claystone (Figs. 2-4). This interval is correlated with the G. eugubina Zone, zones P₁a and P₁b of Smit and Romein (1985). The Globigerina eugubina Zone was subdivided into subunits I through V by Smit and Romein (1985). Globigerina fringa occurs in a 10-cm bed immediately overlying the boundary clay. Therefore, this interval is correlatable with the subzone II of Smit and Romein (1985). The occurrence of large G. eugubina (0.16–0.24 mm) between 1.4 and 2.6 m above the boundary clay suggests the assignment of this interval to the subzone V (Fig. 2). At about 16 m above the clay, Globorotalia pseudobulloides first appears. From this level and upward, the sequence is correlated with the P₁c Zone of Smit (1982) and P.1 Zone of Blow (1979). However, further analysis of more closely spaced samples may show that G. pseudobulloides appears earlier than the 16-m above level.

Benthic foraminifera, on the other hand, show very little changes throughout the examined interval. Nearly the same group of species such as Silicosigmoilina futabaensis Asano, Spiroplectammina spectabilis (Grzybowski), Cyclammina asanoi Takayanagi and Anomalinoides sp. dominate all the assemblages. The absence of foraminifera in the grayish black claystone (Fig. 2) suggests either the sediment accumulation rate for this interval was extremely rapid thereby masking the presence of foraminifera or a temporal anoxic condition, as envisaged by the presence of pyrite frambooids, dissolved away calcareous test of foraminifera. However, the latter explanation can not account for the concomitant disappearance of agglutinated foraminifera whose shell should not be affected by calcite dissolution. Alternatively, missing benthic foraminifera may be interpreted to have resulted from local eliminations or extinctions of species, rather than dilution by a high sediment input. Besides the dominant species, the presence of taxa belonging to such genera as Haplophragmoides, Bulimina, Lenticulina, Guttulina, Gyroidina and Allomorphina, listed in decreasing order of abundance, indicates upper to middle bathyal depositional depths for the upper Katsuhira Formation. Ekdale and Bromley (1984) suggested a global sea-level
retreat coinciding with the K-T boundary, but any effect of it would be difficult to detect in our deep-water sequence.

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