Age estimation of the mid-Pleistocene microtektite event in the South China Sea: A case showing the complexity of the sea-land correlation

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Abstract The present study confirms the stratigraphical position of microtektite layer being clearly located below the Brunhes/Matuyama (B/M) boundary. Based on the sedimentation rate derived from the stable isotopic and magnetic data of ODP Site 772A, cores 17957 and 17959 in the South China Sea, the age of the mid-Pleistocene impact event was estimated at 10—12 ka earlier than the Brunhes-Matuyama polarity reversal. However, the microtektites were found above the measured B/M boundary in the loess profile due to the downward deviation of the measured B/M boundary from its true position[1]. This demonstrates the complexity of paleo-magnetic records in the loess profiles which, in turn, causes the confusion in the sea-land stratigraphic correlation.

Keywords: microtektites Brunhes/Matuyama (B/M) boundary, mid-Pleistocene, sea-land correlation.

Among the known tektite and microtektite events in the Cainozoic, the mid-Pleistocene Australasian one is the youngest and largest with a coverage area of some the 1/10 earth surface from Australia to China[2]. In China, the Australasian tektites, named Leigongmo, have been widely found from Hainan Island and the southeastern coastland [3, 4], and its microtektites from the loess profile of China inland[2, 5, 6] and from deep-sea cores of the South China Sea[7]. The microtektite layer can serve as an important stratigraphical marker in the sea-land correlation of Quaternary sequences due to its wide distribution in both the sea and land and also to its occurrence position near the B/M boundary.

Since the 1990s, high-resolution studies on deep-sea cores taken from the Indian Ocean[8], Sulu and Celebes Seas[9], and South China Sea[7], have revealed that the microtektite layer is located just below the B/M boundary with an age of 12 ka earlier than the geomagnetic polarity reversal[9]. However, the microtektites were found above the B/M boundary in Chinese loess profiles. For example, in Luochuan section, the microtektites occurred 40—70 cm above the B/M boundary, and its age was estimated at about 0.72—0.724 MaBP[5]. This has caused serious confusion in the sea-land stratigraphic correlation[1]. In the present study, three deep-sea cores of the South China Sea have been analyzed to determine the actual stratigraphical position of the microtektites and to estimate its age. The clarification of this problem will be conductive to the actual stratigraphic correlation of sea-land sequences.

1 Material and method

A total of 96 sediment samples were taken from the sections around the B/M boundary of three deep-sea cores ODP Site 277A, 17957 and 17959 in the South China Sea. We put emphasis on Site 772A (16°39.00′ N, 117°42.00′ E, water depth 1529.5 m with a penetration of 361 m) as its high sedimentation rate during the last 1 Ma. The B/M boundary in Site 772A is located at a depth of 66.1 m[10], and from the section between 64 and 73 m in depth sediment samples at 10—20 cm intervals were taken and analyzed. A total of 277 microtektites were found from 4 samples at depths of 66.31, 66.51, 66.61 and 66.71 m respectively. The latter two samples contain the richest microtektite grains with an average abundance 17.0 and 33.6 grains per gram sediment. Cores 17957 (10°53.9′ N, 115°18.3′ E, water depth 2195 m, core length 13.84 m) and 17959 (11°08.3′ N, 115°17.2′ E, water depth 1 959 m, core length 14.40 m) were taken during the Sonne-95 Cruise in 1994[11]. The peak of microtektite abundance was found at 8.15—8.05 m intervals in core 17957[7] and at 13.60 m in core 17959. Well-preserved tests of planktonic foraminifera *Globigerionides ruber* were picked from the samples around the microtektite layer for stable isotope analysis using MAT 252 at the Laboratory of Marine Geology, MOE, Tongji University.

2 Age estimation of mid-Pleistocene microtektites in the South China Sea

As shown in fig. 1, both the peak of the microtektite abundance and the B/M boundary are located in the transition between oxygen isotope stages (MIS) 20 and 19 at cores 772A and 17957, and the former is just below the latter. This phenomenon was also found in ODP Sites 758B of the Indian

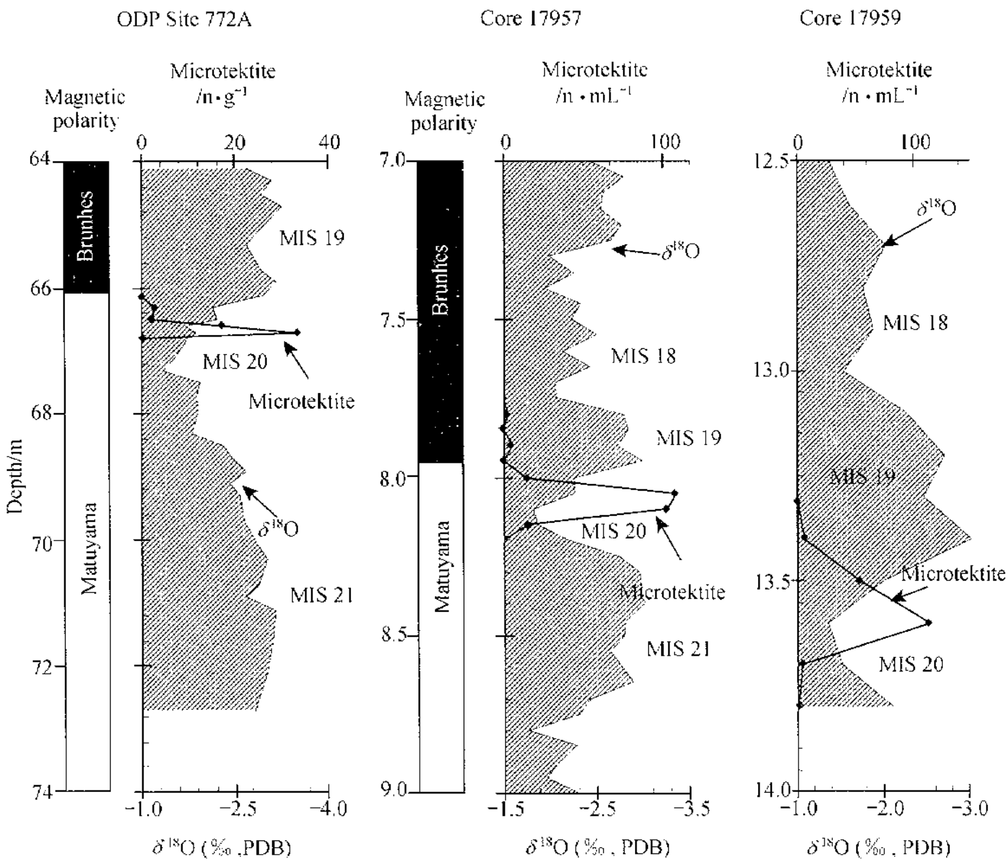

Fig. 1. Microtektite occurrence, oxygen isotopic records and the B/M boundary in cores 772A, 17957 and 17959 of the South China Sea.

Ocean[8], 769B of the Sulu Sea and 767B of the Celebes Sea [9]. Although there are no paleomagnetic data available from core 17959, the oxygen isotopic curve clearly shows the microtektite abundance peak at the MISs 19/20 transition.

Based on the paleomagenatic stratigraphy, the sedimentation rates of the studied cores have been calculated. As shown in fig. 1, the B/M boundary (age 790 ka[12]) and the upper boundary of Jaramillo normal subchron (age 990 ka[13]) are located at core depths of 66.1 and 78.20 m in Site 772A and at 7.95 and 9.67 m in core 17957[14]. The sedimentation rates were calculated as 6.05 cm/ka for Site 772A and as 0.86 cm/ka for core 17957, respectively. Using these average sedimentation rates of the interval between the B/M and Jaramillo boundaries, the age of the microtektite event can be estimated. As the peak of microtektite abundance is 60 cm below the B/M boundary at Site 772A, the microtektite age was estimated at 9.9 ka earlier than the B/M polarity reversal; at core 17957, with the microtektite peak 10 cm lower than the B/M boundary, the microtektites age is estimated at 11.6 ka before the B/M reversal.

3 Age estimation of the mid-Pleistocene microtektites in the India-Pacific Ocean

Schneider et al.[9] studied the microtektites from ODP Sites 769A of the Sulu Sea (8°47.14′ N, 121°13.16′ E, water depth 3 721.5 m) and 767B of the Celebes Sea (4°47.49′ N, 123°30.20′ E, water depth 4 905.3 m) and demonstrated the Australasian impact event to have preceded the B/M polarity reversal by about 12 ka. In ODP Site 758B from the Indian Ocean (5°33.037′ N, 90°21.670′ E, water depth 2 925.6 m), the peak of microtektite abundance is 26 cm below the B/M boundary. The sedimentation rate can be calculated as 1.65 cm/ka for the interval between the B/M boundary (10.65 m depth) and the upper boundary of Jaramillo subchron (13.95 m depth) (fig. 2). By using this sedimentation rate the age of the microtektites at Site 758B is estimated at 15.6 ka earlier than the B/M reversal. However, the elder estimated age is questionable due to the strong bioturbation within the sediment interval between the B/M boundary and the top of Jaramillo in the core[15].

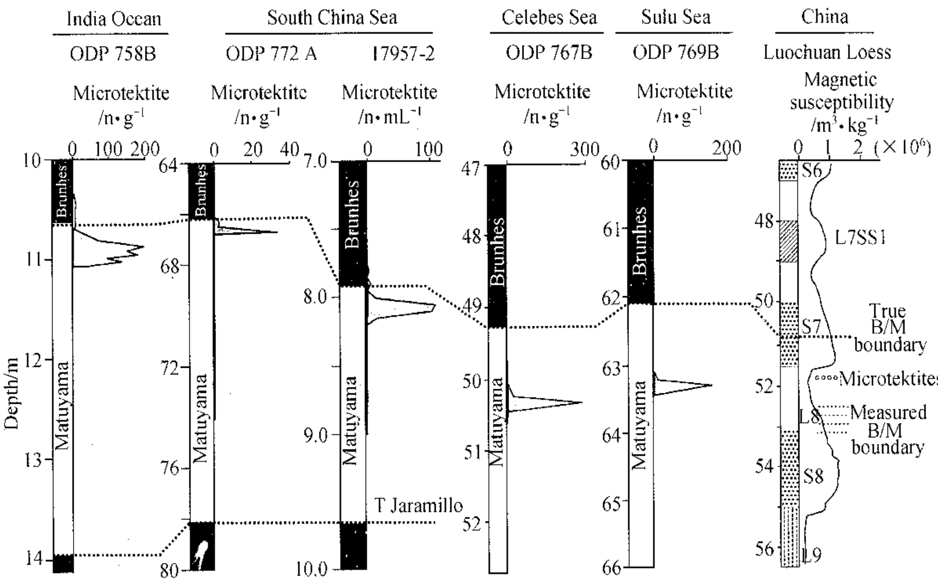

Fig. 2. The microtektite occurrence, the B/M boundary and the upper boundary of Jaramillo subchron at deep-sea cores from the Indian-Pacific region[7—11], and the microtektite occurrence, the magnetic susceptibility curve, the measured and true B/M positions in Luochuan loess profile[1, 5].

4 Discussion

From the above analysis, it can be concluded that the mid-Pleistocene microtektites is about 10—12 ka earlier than B/M reversal. Taking the age of B/M boundary as 790 ka[12], the Australasian impact event occurred during the period of 800—802 kaBP.

Unlike in the deep-sea, the microtektites in loess of China inland were found above the B/M boundary[5, 6]. In the Luochuan section, for example, both the microtektites and B/M boundary are located within loess L8 corresponding to MIS 20, and the B/M boundary is 40—70 cm below the microtektites[1, 5] (fig. 2). The discrepancy in the relative position of the B/M boundary and the microtektites between deep-sea sediments and loess reflects the complexity in the sea-land stratigraphic correlation.

It has been pointed out by many deep-sea data that the B/M boundary is located at the MISs 19/20 transition or in the earliest MIS 19[1, 9, 12]. The same is also found at Site 772A and core 17957 from the South China Sea (fig. 2). As both curves of the magnetic susceptibility and grain size of loess have been demonstrated to be parallel to the marine oxygen isotopic curve[16, 17], the loess L8 and its overlying paleosol S7 are well corresponding to the MIS 20 and 19 respectively. It is easy to see that the measured B/M boundary in loess is evidently lower than that in the deep-sea profile. Recently, Zhou and Shackleton[1] studied the position discrepancy of the microtektites and B/M boundary between loess and deep-sea profile and explained that the acquisition of remanent magnetisation in loess occurred at a certain depth substantially below the land surface, causing the measured position much lower than its true occurrence. Therefore, as shown in fig. 2, the true position of the B/M boundary should be 170—250 cm above its measured position in Luochuan loess. This is an example of the complexity in land-sea stratigraphic correlation.

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