High precision analysis of radiogenic Sr isotope ratios of modern and quaternary oceans

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Radiogenic Sr isotope ratio ($^{87}Sr/^{86}Sr$) have long been used to date sedimentation ages of marine carbonates and carbonate rocks. The $^{87}Sr/^{86}Sr$ ratio of the ocean over geological timescales are well constrained and used as a basis of Sr isotope stratigraphy (e.g. McArthur et al, 2012). Unlike the other age determination techniques, Sr isotope stratigraphy does not require continuity of the sediment layers. Therefore, Sr isotope stratigraphy is a powerful tool to date young discontinuous sediment samples, such as partially eroded costal sediments and sediments in the active fault zone. However, there is a technical bottleneck to use Sr isotope stratigraphy for precise dating of quaternary sediments. The variation of the seawater $^{87}Sr/^{86}Sr$ during the quaternary period is very small (from 0.70903 to 0.70917). Ultra-high precision and accuracy of analysis with errors better than 4 ppm is required to discriminate between 100 ky cycle of glacial-interglacial periods.

In this study, we have examined technical methodology to analyze $^{87}Sr/^{86}Sr$ ratio by thermal ionization mass spectrometry (TIMS) with high precision and accuracy. We found that the typical analytical precision of the static multi-collection technique was ca. 10 ppm and is limited by gain calibration errors as well as faraday cup aging effect in a time scale of week and longer. This observation is in contrast with previous studies which claimed analytical precisions better than 10 ppm by using static multi-collection TIMS (Ando et al., 2010; Mokadem et al., 2015). On the other hand, multi-dynamic technique allows $^{87}Sr/^{86}Sr$ to be analyzed with ppm order analytical errors. Repeated analyses of NIST 987 and modern seawater gives $^{87}Sr/^{86}Sr$ ratios of 0.7102566 ± 0.0000032 (2SD, n = 24) and 0.7091816 ± 0.0000027 (2SD, n = 21), respectively. Modern seawater $^{87}Sr/^{86}Sr$ value corresponds to 0.7091731, when normalized to NIST 987 = 0.710248. We will also discuss the results of quaternary sediments.