Geochemistry of Mesopotamian clay tablets and strontium cycle in West Asia

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In this study, we present bulk chemical compositions and Sr-Nd isotopic ratios of cuneiform clay tablets ubiquitously excavated from Mesopotamia aiming to pin the place of origin by comparing characteristic physical feature of tablet clay and sediments from Meosopotamia. The obtained data were further compared with the compositions of meteoric water and river water in West Asia to discuss circulation of strontium and other elements, that involves interaction between rock/sediments, water and atmosphere.
Bulk chemical analyses on tablet clay samples revealed that they contain ~1% Na_2O, whereas CaO contents reached up to ~10%, implying that secondary Ca-carbonates were accumulated in pore spaces in original sediments during diagenesis or during preservation of the clay tablets. Ca-carbonate fills the pore-space under the optical microscope and was also detected by XRD analyses. The Ca-carbonate may have added artificially as a cementing material to achieve and maintain appropriate material properties for writing. TiO_2 (0.6%), Ni and Cr contents (> 100 ppm) are high as a felsic magmatic rock and imply some influence of mafic rocks, such as ophiolites. Samples from Nuzi (upstream of Tigris) has higher Ti/Fe ratio compared to Euphrates samples.
All the clay tablet samples show a weak Eu-anomaly and LREE enriched pattern, but they have different REE concentrations. Bulk Sr-Nd isotopic ratios were plot in a narrow range: 0.70835 to 0.70895 for $^{87}Sr/^{86}Sr$ isotopic ratio, 0.51237 to 0.51243 for $^{143}Nd/^{144}Nd$. To evaluate the influence of Ca-carbonates in the tablet, we leached clay samples using acetic acid. Sr isotopic ratios of the leachate were approximately 0.7080 and plot in much narrower range. The obtained Sr isotopic ratio is similar to that of average Turkish meteoric water and Caspian Sea water (0.7082), but significantly lower than marine Sr isotopic ratios (0.7092). Iranian meteoric water has slightly higher value than Turkish meteoric water, but still lower than the marine Sr isotopic ratio. Sr isotopic ratio in the meteoric water is generally controlled by composition of aerosol (loess), especially soluble material such as carbonates. Our results indicate that Ca-carbonate cements (caliche or calcrete) formed at the surface condition have a great influence on the strontium circulation in the atmosphere of West Asia.

Keywords: Mesopotamia, Strontium cycle, clay tablet, cement, meteoric water, sediments