Evaluation of Ar-Ar ages of Individual Mica Grains for Provenance Studies of Loess, Long Island, NY

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Loess was studied on the SUNY Stony Brook Campus and from Caumsett State Park 40 Km to the west. The loess was deposited after the last glacier retreated from Long Island some 20,000 years ago. The loess overlies till and there are no overlying sediments. The loess on the SUNY Stony Brook Campus has three modes: fine sand (250 microns), silt (20 microns), and clay (<2 microns). The sand in the loess is probably wind blown sand.

The occurrence of wind blown sand suggests that the loess was transported by strong katabatic winds flowing off the glacier to the north. Long Island is a good place to evaluate mica ages for provenance studies of loess derived by a glacier from local bedrock because the Ar-Ar and K-Ar mica ages in the bedrock north of Long Island change essentially continuously from New Jersey and New York in the west to New England in the east, from 900 to 200 Ma respectively.

Lewis and Stone, 1991, suggest that a glacial lake occupied the Long Island Sound basin to the north of Long Island as the last glacier retreated. Streams carried glacial sediments to the lake from Connecticut and areas to the north. As the level of the glacial lake lowered, the glacial sediments deposited in the lake were exposed and may be a dominant local source for the loess.

Muscovite ages for the loess from Caumsett State Park range from 275 to 375 Ma. Muscovite ages for loess on the Stony Brook campus are somewhat younger dominantly 225 to 300 Ma. The younger ages are consistent with a more easterly source. One grain of muscovite has an age of 1002 Ma, suggesting that it may have a source further to the west.

Ages for biotite from the loess range from 44 to 1804 Ma with the majority between 250 to 400 Ma. Some of the biotite ages range from 500 to 850 Ma consistent with derivation from Grenville sources to the west. Biotite with ages greater than 1100 Ma most likely has a mid-continental source to the west. Some of the biotite grains with ages younger than 200 Ma may have been affected by weathering.

These results suggest that the micas were derived mostly from the north or west, consistent with transport by prevailing westerly winds or southerly katabatic winds. The use of single grain mica Ar-Ar dating is a promising method for provenance study of loess.

Reference

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Oxygen isotope fractionation between aragonite and water at low temperatures

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Calcium carbonate is one of the most important minerals in reconstructing ocean paleotemperature by means of oxygen isotope analysis. However, significant discrepancies in oxygen isotope fractionation factors between two $CaCO_3$ polymorphs, calcite and aragonite, have been observed for the data from theoretical calculations, experimental measurements, and natural observations. The purpose of this study is to investigate the influence of carbonate precipitation rate on oxygen isotope fractionation by chemical synthesis experiments, and to determine the equilibrium fractionation factors between aragonite and water during inorganic precipitation of $CaCO_3$.

The experiments were carried out by means of the slow precipitation method, in which the $Ca(HCO_3)_2$ solutions were prepared either by dissolving solid $CaCO_3$ or $NaHCO_3$ in aqueous solutions. The phase compositions and morphologies of synthetic minerals were detected by XRD and SEM techniques. The effects of aragonite precipitation rate and excess dissolved CO_2 gas in the initial $Ca(HCO_3)_2$ solution on oxygen isotope fractionation between aragonite and water were investigated. For the $CaCO_3$ minerals slowly precipitated by the $CaCO_3$ or $NaHCO_3$ dissolution method at 0 to 50°C, the rate of aragonite precipitation increased with temperature. Correspondingly, oxygen isotope fractionations between aragonite and water deviated progressively farther from equilibrium. In addition, an excess of dissolved CO_2 gas in the initial $Ca(HCO_3)_2$ solution results in an increase in apparent oxygen isotope fractionations. As a result, the experimentally determined oxygen isotope fractionations at 50°C indicate disequilibrium, whereas the relatively lower fractionations obtained at 0 and 25°C from the solution with less dissolved CO_2 gas and low precipitation rates indicate a closer approach to equilibrium.

Combining those lower values at 0 and 25°C in this study with data derived from the two-step overgrowth technique at 50 and 70°C (Zhou and Zheng, 2002), a fractionation equation for the aragonite−water system at 0 to 70°C is obtained as follows:

$$10^3 \ln\alpha = 20.44 \times 10^3/T - 41.48.$$

Discussion concerning the kinetic mechanism of oxygen isotope disequilibrium argues for this equation to be a close proxy for thermodynamic equilibrium fractionation in the low-temperature mineral. Therefore, the discrepancies in $CaCO_3$–H_2O fractionation factors between different published synthesis experiments may reflect steady-state equilibrium fractionations obtained during aragonite precipitation and subsequent polymorphic transition to calcite at different run conditions.

References

Zhou G.-T. and Zheng Y.-F. (2002) *Geochim. Cosmochim. Acta*, 66, 63-71.