Provenance study of Swahili metals using lead isotopic analysis

T.R. FENN[1]*, D.J. KILLICK[1] AND J. RUIZ[2]

[1]Sch. of Anthropology, Univ. of Arizona, Tucson, AZ 85721, USA (*correspondence: tfenn@email.arizona.edu)
[2]Dept. of Geosciences, Univ. of Arizona, Tucson, AZ 85721

East Africa and Indian Ocean Trade

This research examines the provenance of non-ferrous metals found at East African Swahili sites dating from the late 1st and early 2nd millennium AD. Previous archaeological work on the Swahili Coast documented evidence of long-distance Indian Ocean maritime trade including imported objects from the Middle East, India and China [1, 2, 3]. Recent research has also examined the movement of specific commodities (e.g., ceramics, glass beads) from various regions of the Indian Ocean to the East African coast [4, 5].

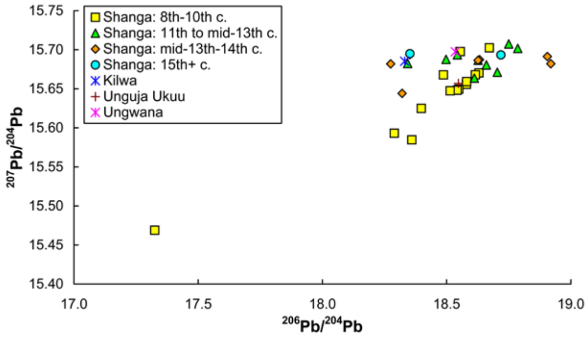

Figure 1: Lead isotopic ratios of non-ferrous metals from the Swahili sites of Shanga, Kilwa, Unguja Ukuu and Ungwana.

Metals Trade to the Swahili Coast

Very little research has been made on the movement of metals to the East Africa coast [6, 7]. The current research conducted elemental composition and lead isotopic analyses of more then 30 non-ferrous objects and has identified several different source regions supplied metal to the Swahili coast. Results indicate that Iran likely was a major source, but that metals also came from the Arabian Peninsula and China, but that none appear to have originated from India.

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Cation adsorption at the muscovite-electrolyte solution interface

P. FENTER[1]*, S.S. LEE[1], M. SCHMIDT[1], L. SODERHOLM[1], R.E. WILSON[1], C. PARK[2], K.L. NAGY[3] AND N.C. STURCHIO[3]

[1]CSE Division, Argonne National Laboratory, Argonne IL 60439 (*correspondence: Fenter@anl.gov)
[2] HP-CAT, Geophysical Laboratory, Carnegie Institution of Washington, Argonne, IL 60439,
[3]Dept. of Earth and Environmental Sciences, MC-186, University of Illinois at Chicago, Chicago IL 60607.

The interaction of ions with charged mineral surfaces is central to many geochemical processes, including the transport and bioavailability of dissolved species. The muscovite (001)-electrolyte interface is apparently simple, with a fixed lattice charge of the muscovite located below the surface and without under-coordinated surface oxygen sites that would lead to a strong pH dependent surface charge. Yet, we find that the adsorption structure of cations at this interfaces is unexpectedly complex.

Previously, we found that Rb^+ adsorbs in the ditrigonal site as an inner-sphere (IS) species, while Sr^{2+} adsorbs as both IS and outer-sphere (OS) species [1]. A systematic study of a range of divalent cations has shown that there exists a third adsorbed species, an extended OS species (OS_{ext}), and the partitioning between these three species is controlled by the cation hydration enthalpy [2]. Ongoing work has extended these observations to other multivalent ions (Y^{3+}, Th^{4+}) whose adsorption structure can be understood in the same context as that observed for divalent ions.

We have also explored the role of competitive adsorption to influence the distribution of adsorbed cations. Specifically we have found that the partitioning of cations between IS, OS and OS_{ext} species can change with the introduction of competing cations. Furthermore, the introduction of natural organic matter (in the form of dissolved fulvic acid) can dramatically alter the adsorbed cation distribution which is controlled by a balance between cation hydration, cation organophillicity, and cation-mineral interactions.

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