Petrogenesis of alkaline mafic rocks from Sivas, Central Anatolia: New insight into ancient continental assembly and break-up

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Alkaline mafic lavas are a common feature of intraplate extensional volcanic settings. We examine mafic lavas from Sivas, Central Anatolia, in order to understand controls on their genesis in a setting with a complex tectonic history extending over the past 1.3 billion years. Continental assembly and break-up, both associated with geochemical modifications to the associated lithosphere, has long played a significant role in Anatolia. The present tectonic regime consists of a complex juxtaposition of rift, strike-slip, and transtensional faulting and an overall WSW movement of the continental microplate.

We identify two groups of alkaline lavas that record different petrogenetic histories. Select incompatible trace element variations (e.g., Ti, Zr) indicate that abundant basalts and basaltic andesites (BBA) evolved by fractional crystallization of a frequently-erupted parental magma with ~9 wt.% MgO. The BBA lavas have overall smooth primitive mantle normalized incompatible trace element patterns that suggest derivation from a source region geochemically similar to that of ocean island basalts. In contrast, basanites erupted over a small geographic area show little fractionation but rather represent individual magma batches with different degrees of partial melting. These lavas exhibit enrichments in Ba, Th, and U and depletions in Rb, Hf and Ti that are characteristic of melts derived from metasomatized lithosphere. Pb abundances in both groups are anomalously high, though this feature is more pronounced in the basanites, suggesting interaction with a Pb-rich continental component.

In general, Sr-Nd-Hf radiogenic isotopic signatures of the BBA lavas are less radiogenic than those measured in the basanites. The BBA and basanite groups overlap in eNd-eHf isotope space, plotting on and above the mantle array between data fields for oceanic basalt-like and continental lithosphere-like compositions. The least radiogenic BBA lavas ($^{87}Sr/^{86}Sr$ 0.7040-0.7044; $^{143}Nd/^{144}Nd$ 0.51278-0.51280) approach compositions of asthenospheric melts. Radiogenic Pb isotope compositions of both groups plot within the range of Indian MORB. Nd model ages of Sivas lavas are consistent with a DUPAL-like source region with Rodinia (~1.2 Ga) continental lithosphere affinity. The observation that basanitic lavas are found only to the southeast of a major strike-slip fault suggests that post-Miocene faulting either controls or reflects significant subsurface chemical heterogeneity related to topography across the lithosphere-asthenosphere boundary.

Reduction of biogenic and abiogenic Fe(III) minerals by humic substances

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Humic substances (HS) have been shown to shuttle electrons between microorganisms and poorly soluble electron acceptors such as Fe(III) minerals. HS can be reduced by a wide variety of microorganisms including Fe(III)-reducing, sulfate-reducing and dechlorinating bacteria, but also chemically for example by sulfide. In contrast to the reduction of the HS, the second electron transfer step from reduced HS to the Fe(III) minerals proceeds abiotically and is controlled mainly by the properties of the Fe(III) minerals, such as their redox potential. The electron transfer from HS to the Fe(III) minerals is rate limiting for the whole electron shuttling process, but only little is known about the dynamics and limitations of this second electron transfer step itself. This is in particular the case since most laboratry studies were carried out under geochemical conditions differing significantly from those typically encountered in the environment. Thus, the importance of humic substances as electron shuttles under environmental conditions is currently unknown.

To elucidate some of the remaining questions, we aimed to quantify the rate and extent of electron transfer between reduced and non-reduced HS and various Fe(III) minerals. We focused, in particular, on the difference between reduction of biogenic vs. abiogenic Fe(III) minerals by HS. Our studies showed that more electrons were transferred from chemically reduced HS to biogenic than compared to abiogenic Fe(III) minerals. Since biogenic and abiogenic Fe(III) mineral suspensions were normalized to the same BET surface area, it could be ruled out that this outcome resulted from a difference in specific surface area between the mineral suspensions. Furthermore, our results indicate that laboratory experiments with abiogenic Fe(III) minerals might significantly underestimate the amount of electrons transferred between HS and Fe(III) minerals and, as a result, they might also underestimate the importance of HS electron shuttling in environmental systems wherein minerals might be of mainly biogenic origin. This is of great importance, since electron transfer via humic substances has the potential to contribute significantly to the electron fluxes in the environment and thus might affect the fate of organic and inorganic pollutants.