DATING OF SECONDARY MINERALS IN NAKHLITES

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Introduction: nakhlites are a group of martian clinopyroxenites, currently 13 in number, that have a tightly-constrained crystallization age of 1320 ± 40 Ma [1]. They are thought to emanate from either a single lava flow, or closely-allied series of flows [2], and following their crystallization, have experienced aqueous alteration. Secondary alteration products include clay minerals, carbonates, sulphates and halite, which form complex assemblages and intergrowths. It is not clear what the relationship is between the different minerals: they may have formed by gradual evaporation following a single episode of fluid incursion [3], or over an extended period of time following several episodes of aqueous activity. The latter case is supported by spectral data from widespread regions of the martian surface, where overlying units of secondary minerals have been employed to produce a relative chronology [4]. Direct measurement of the age of the secondary products in the meteorites has been difficult – the minerals are fine-grained and not easy to separate from their host silicates. Where results have been obtained, they indicate formation ages of around 600 Ma for phyllosilicates [5]. We have used Rb-Sr dating of Nakhla and Y 000593 in an attempt to determine a series of ages for different components within the meteorites.

Technique: We carried out a sequence of leaches on samples of between 200 – 500 mg powdered whole rock meteorite. The sequence was designed to remove increasingly insoluble components, and started with cold water, followed by hot water, cold then hot 0.025M HCl, cold then hot 0.25M HCl, then hot 2.5M HCl, hot 6M HCl and finally hot HNO_3-HCl. Each leachate was split, with one aliquot analysed by ICP-MS to determine Rb and Sr abundances, and the remainder taken for Sr isotope analysis by TIMS.

Results: were a bit bizarre, to say the least, with a maximum $^{87}Sr/^{86}Sr$ ratio in the cold water leachate from Nakhla of 0.7574. Ratios of this magnitude are more usually associated with evolved rocks rather than soluble components within basalts. The $^{87}Sr/^{86}Sr$ decreased with increasing acid strength, converging on a value around 0.702, compatible with an age of > 1000 Ma.

Discussion: our modelling of the components extracted by sequential leaching suggests that halite will be dissolved in cold water, phyllosilicates will start to give up their loosely-bound ions in weak HCl, with those more firmly-bound dissolving out in stronger HCl. Carbonates (mainly siderite) will be removed by hot 0.25M HCl, then the silicates will start to be attacked by 6M HCl. Duplicate measurements from 2 separate splits of Nakhla gave elevated values of $^{87}Sr/^{86}Sr$ in the cold water extract thought to be associated with halite. Further interpretation will be forthcoming in the fullness of time.

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