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New Ar-Ar Data on Nakhla Minerals

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The nakhlites contain iddingsite, halite and gypsum/anhydrite formed by weathering on the Martian surface (Gooding et al., 1991; Bridges and Grady, 1999). Recently, Swindle et al. (2000) have reported a K-Ar age for iddingsite of ~650Ma in Lafayette that is significantly younger than the crystallisation age of the host meteorite at ~1.3Ga. During an earlier Ar-Ar study of Nakhla we noted that the majority of Cl is released at high temperature and correlates with lowering of the $^{40}Ar/K$ ratio (Gilmour et al., 1998). This could be explained by Ar release from either a younger Cl-rich mineral phase, or a water-soluble phase that has lost some radiogenic ^{40}Ar by partial dissolution. A more mundane explanation is that the age decrease is related to recoil of ^{39}Ar during irradiation. The low apparent ages obtained during Ar-Ar experiments, together with the presence of Martian weathering products of young age prompted us to reinvestigate the Ar-Ar systematics of Nakhla. Age spectra for Nakhla bulk, mineral separates and an acid etched sample are shown in Figure 1. The bulk meteorite and pyroxene show a similar pattern of reasonably consistent ages over 80% of the ^{39}Ar release, followed by a decrease in apparent age and increase in Cl/K at high temperature. In contrast, the olivine and acid etched samples do not contain a Cl-rich component and ages do not decrease at high temperature. More than 90% of the ^{39}Ar in the samples is released <700ºC with a peak at 500 ºC. In contrast, >50% of the Cl-derived ^{38}Ar is released >700ºC from the bulk and pyroxene with the peak at 1000ºC. The total ^{39}Ar release from the pyroxene equates to 1351ppm K which is about 35% higher than obtained from the bulk sample. K contents of the olivine and acid treated samples are 55 and 1785ppm respectively. Ca-derived ^{37}Ar shows a bimodal release with a minor peak occurring at the same temperature as the main release of ^{39}Ar, and a major release >1000ºC interpreted to be from pyroxene. Since only 10% of ^{39}Ar is released above 1000ºC most of the K must be located in a different phase from pyroxene. Possible hosts for K include melt inclusions or iddingsite although, there are mass balance constraints for either of these phases being the major K-bearing phase. If melt inclusions containing up to 6wt% K_2O (Harvey and McSween, 1992), were the major K-bearing phase then they are expected to be present at a level of 3.3wt% in pyroxene and some 20 times lower in olivine. This is inconsistent with petrographic observations indicating a higher abundance of melt inclusions in olivine compared with pyroxene. Melt inclusions contain 0.4wt% Cl (Harvey and McSween, 1992), however the peak ^{39}Ar release corresponds with a minimum in the Cl/K ratio (Figure 1). The main release of ^{39}Ar from pyroxene occurs at 500ºC, similar to that in terrestrial clay minerals. However, attributing all of the K released to iddingsite is problematic in giving unrealistically high clay contents of 30wt% in pyroxene and 1wt% in olivine, these are much higher than previous estimates of only 20-30ppm "rust" (Gooding et al. 1991). It would also imply the iddingsite was formed 1.4Ga ago in conflict with the 650Ma age in Lafayette (Swindle et al., 2000).

The release of Cl-derived ^{38}Ar at high temperature in the pyroxene separate may be from a phosphate mineral (chlorapatite). Phosphate minerals are soluble in acids and their dissolution may account for the absences of a high Cl/K component from the acid etch sample.

Recoil of ^{39}Ar from K-rich phase(s) into the host pyroxene appears to the most likely explanation for lowering of the $^{40}Ar/K$ at high temperature. The low apparent ages are therefore not believed to have geological significance. The average age obtained from the Nakhla samples analysed in this study is 1397±16Ma. This is similar to previously reported isotopic ages of ~1.3Ga for Nakhla and Lafayette and the same (within uncertainties) as recent Sm-Nd ages of 1.37±0.02 for Gonvernador Valadares and.1.36±0.06 for Chassigny (recent summary in Shih et al., 1999).

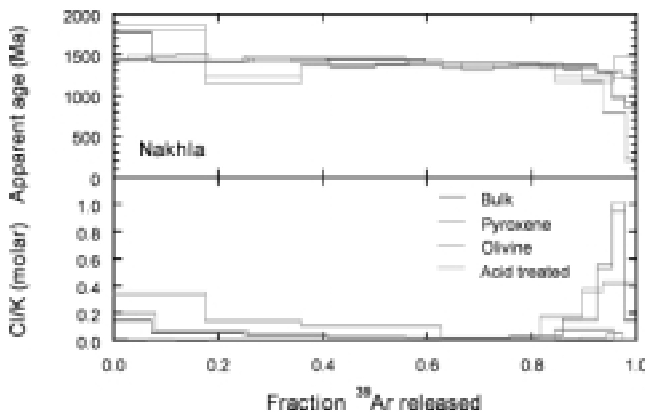

Figure 1: Ar-Ar data for Nakhla minerals

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