Mineralogical controls on cold desert weathering

Conference or Workshop Item

MINERALOGICAL CONTROLS ON COLD DESERT WEATHERING

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Introduction: Antarctic weathering of meteorites has often been found to be spatially variable and difficult to predict on a micro and macro scale [e.g. 1, 2, 3]. The present study looks at micron scale textural and chemical changes to support potential explanations for heterogeneous patterns of alteration.

Samples and Methods: Rim and interior thin sections from the L6 chondrites QUE 94214 and ALH 78130 were studied. Thick sections of rim and interior samples of QUE 94214 were used for LA-ICP-MS. All analyses were carried out at The Open University. Textural analysis was carried out using reflective and transmitted microscopy and a FEI Quanta 3D dual beam scanning electron microscope fitted with an Oxford Instruments 80 mm X-MAX energy dispersive X-ray detector. Mineral analysis was obtained from a Cameca SX100 electron probe. Trace element analysis was carried via LA-ICP-MS on an Agilent 7500 s quadrupole mass spectrometer coupled to a New Wave 213 nm Nd–YAG laser system using a 50µm spot size.

Results: In both sample pairs, visible weathering was observed in kamacite, taenite, troilite, olivine and pyroxene (in rims and interiors). Alteration products from the weathering are Fe-oxyhydroxides which form in veins and in halos around altering opaque phases. Pitting of olivine and laminar alteration of pyroxene can be seen to occur around these areas of opaque weathering. Textural maps have been created of the sections, and from these, targeted analysis of mineral chemistry has been performed in areas of optically visible rust and with increasing distance from sample rims. EMPA analysis shows that with increasing proximity to grains of weathered metals and sulphides, an increase in FeO wt.% can be seen in olivines. This is accompanied by a decrease in Mg#. In areas of optically visible rust, we can also see a decrease in SiO_2 wt.% with respect to increasing FeO wt.%.

When comparing olivines in rim and interior samples, we see in one sample pair a clear decrease in SiO_2 wt.% in the rim compared to the interior of the meteorite. FeO wt.% shows a weak increase and a distinct spreading of values as proximity to the fusion crust increases. An increase of the Fe/Mn to Fe/Mg ratio in the rim can also be seen from LA-ICP-MS data.

Discussion and Conclusions: From the decrease of SiO_2 wt.% with increasing FeO wt.% and the decreasing Mg# with proximity to weathering opaque minerals, we infer that this is a dissolution of the olivine that is being replaced with Fe oxyhydroxides. This is likely to be caused by acidification of the altering fluid in the meteorite when the dissolution of troilite adds sulphuric acid to the system [4], which enhances olivine dissolution. The dissolved olivine is then transported. This pattern is much stronger and easily discernable than the distance from fusion crust and appears to be a stronger control on olivine alteration.

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