Spatial Correlations Between Silicate and Metal Weathering in Antarctic Chondrites

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Understanding cold desert weathering and micron scale alteration of minerals is an integral part of comprehending meteorites history and appropriate curatorial practices [1]. It also forms and important part of understanding parent body processes on bodies with similar frigid conditions such as Mars [2]. Part of this is understanding how individual minerals react differentially to similar environments. As part of this, weathering on a micron scale must be understood. Building on previous studies [e.g. 3,4,5], we have therefore undertaken a study of olivine weathering in L6 chondrites to better understand processes and causes of cold desert alteration.

Samples and Petrography

Samples used in this study are rim and interior sections of the L6 chondrite Queen Alexandra Range 94214, given the designations QUE 94214, 10 (rim) and QUE 94214 8 (Interior) [1]. The primary minerals are: olivine, (37.3 vol. %, Fa_{22-26}), low Ca pyroxenes (24.7 vol. %, $En_{78}Fs_{22}Wo_{2}$), microcrystalline intergrowth of feldspar, olivine and pyroxene (14.1 vol. %), feldspar (10.9 vol. %, $An_{9}Ab_{84}Or_{7}$), fizzed troilite (5.0 vol. %), polycrystalline kamacite (3.1 vol. %), taenite (1.3 vol. %), and the accessory phases (6.7 vol. %) chromite, chlorapatite, and whitlockite.

Phases weathering, in order of weathering susceptibility:

- Kamacite
- Taenite
- Troilite

} Creates veins and haloes of Fe-oxyhydroxides (Figs. 1+2)

- Olivine
- Pyroxene

} Preferentially altering in the presence of troilite weathering, demonstrating pitting and partial dissolution (Fig. 1). Veins radiating from weathering opaques show sawtooth chemical expansion [6].

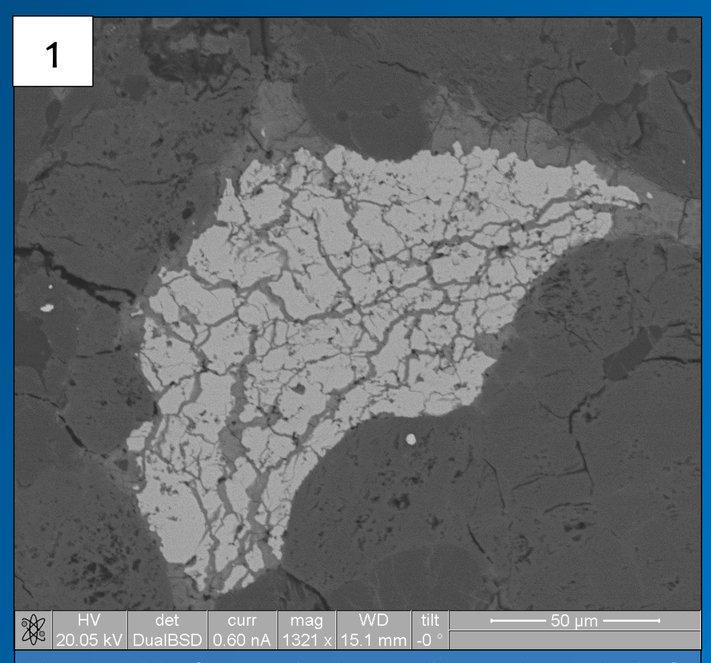

Fig. 1 – BSE of a weathering troilite grain, typical of sample. Veins and alteration products consist of Fe-oxyhydroxides. Surrounding olivines have pitting and are showing putative boxwork alteration.

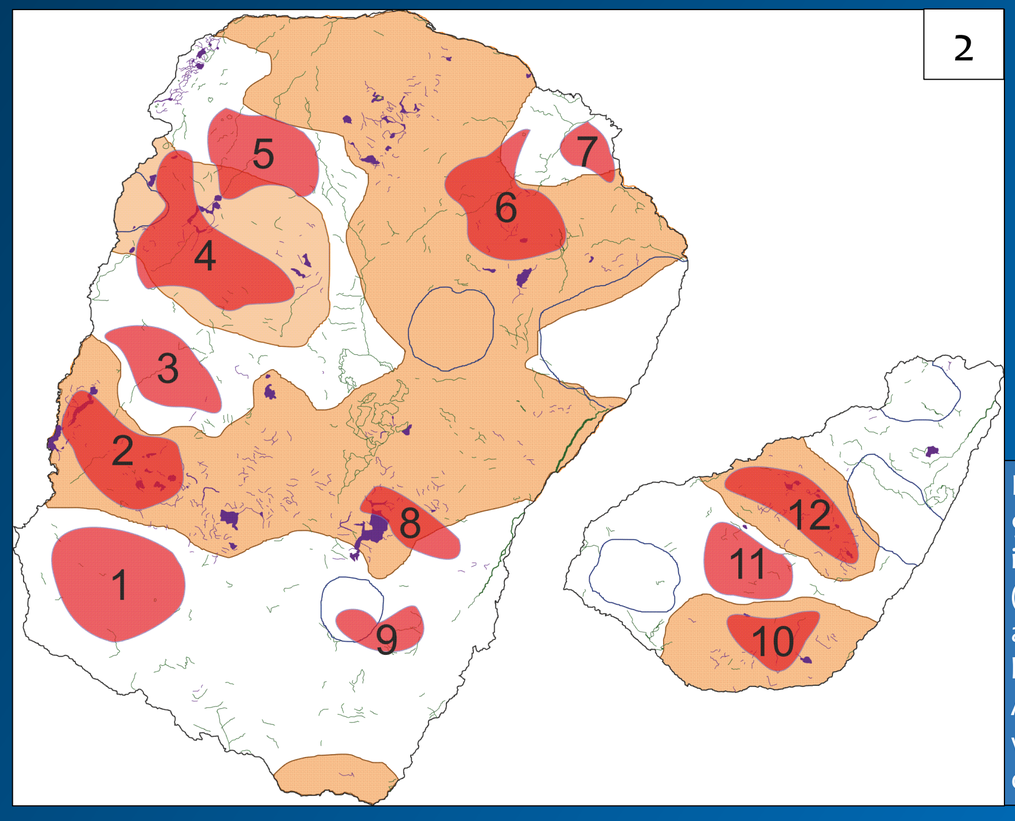

Fig. 2 – Detailed textural map of interior section QUE 94214, 8, built up from optical information, BSE images, and element maps, showing open fractures (green), chondrule relict (blue), alteration minerals and veins (purple), optically visible rust (orange) and locations of olivines measured (numbered red). Alteration radiates from kamacite, taenite and troilite weathering, these veins form in clusters that form optically visible iron staining.

EMPA data

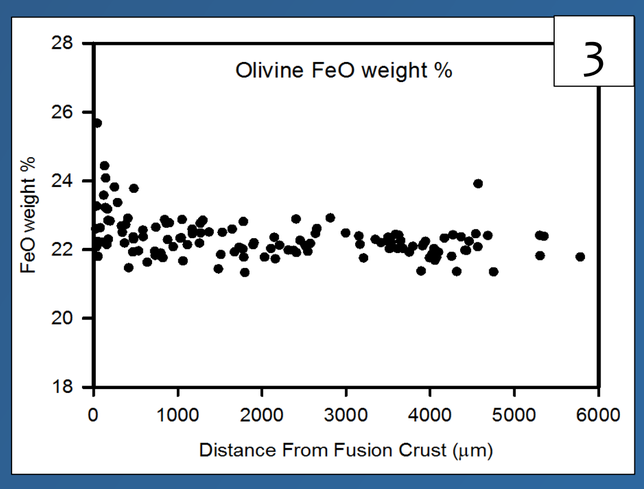

Fig. 3 – FeO wt. % of 130 olivines measured in QUE 94214, 10 , plotted against distance from fusion crust. Within 500 µm of the fusion crust, the spread of values is large (between 21.5-24.5). Between 500-2300 µm the spread decreases to 21.5-23, at 2300-3000 µm the range decreases to 21.5-22.5.

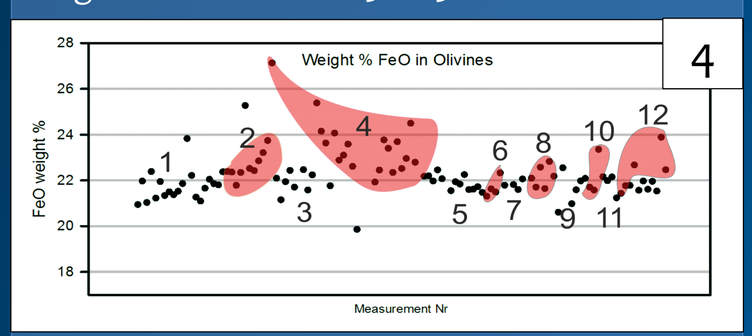

Fig. 4 – FeO wt. % of 120 olivines measured in QUE 94214, 8, plotted with groups on olivines from Fig. 2 superimposed. Olivines in areas of optical rust show greater FeO wt. % spread. There is also an increase in FeO compositional range in the interior of the meteorite in proximity to metal degradation (Fig. 2).

This is accompanied by an overall systematic decrease of 0.6 FeO wt. % and increase of MgO wt. % by 0.5 with 600 µm distance from the fusion crust.

Discussion and Conclusions

Three separate weathering patterns are observed. Firstly, the initial 500 µm from the fusion crust shows a wider spread of composition, beyond this the presence of rust staining causes a heterogeneous pattern of alteration independent of distance from the rim of the sample. The local compositional variation is controlled by locally weathering metal grains. The third pattern is a systematic decrease in Fe content and increase of Mg content, reflecting the relative cation mobility [7]. The preferential alteration of silicates adjacent to weathering troilite is likely a result of liberation of S from the troilite which forms an acidic fluid, speeding silicate alteration [8]. In conclusion, beyond the initial 500 µm of the sample, the amounts of silicate weathering is heterogeneous and controlled by metal weathering, and so an interior sample is not a guarantee of more pristine silicates.

Ongoing work and Next Steps

Ongoing work includes the investigation of trace elements using LA-ICP-MS. So far it has been observed that increasing distance to opaques weathering results in increase in Ca, Cu and K, and a decrease in Al.

Next steps are intended to be oxygen isotope analysis and noble gas isotope analysis.

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