Fire-driven mineral and geochemical differentiation at the Earth's surface

David T. Murphy[1], Stefan C. Löhr[2], Luke D. Nothdurft[1], Robert Bolhar[3], Sandra Piazolo[2], Coralie Siegel[1]

[1]Department of Earth, Environmental and Biological Sciences, Queensland University of Technology, Brisbane 4000, QLD, Australia
david.murphy@qut.edu.au

[2] Department of Earth & Planetary Sciences, Macquarie University, North Ryde 2109, NSW, Australia
stefan.loehr@mq.edu.au

[3] School of Geosciences, University of the Witwatersrand, Bramfontein 2001, South Africa

Fires potentially exert a significant influence on the mineralogy and geochemistry at the soil to air interface, an environment that is otherwise dominated by low temperature processes. Maghemite-rich nodules are present in soils globally, have been intepreted as fire related, so potentially represent a new sampling medium to asses the impact of fire.

We use detailed petrographic and mineralogical analyses of the nodules to demonstrate that maghemite occurs as part of a high temperature mineral assemblage including hematite and χ-alumina[1]. The nodule mineral assemblage and microfabric is indicative of fire-induced dehydroxylation and sintering of non-magnetic precursors at temperatures greater than 600 ^{o}C[1]. Therefore, comparison to non-magnetic precusors offers insights into the geochemical impact of fire.

Our results show that magnetic nodules are depleted in Si, Y, Zr and HREE but enriched in Fe and Cr relative to co-located, precursor non-magnetic nodules. Magnetic nodules also show variable but distinctly low Y/Ho (21.4±0.4) and Zr/Hf (29.3±0.8). In situ laser ablation analyses show that this is largely due to χ-alumina with no involvement from zircon[1].

We propose a multi-stage process of formation where fire transforms non-magnetic nodule precursors into proto-magnetic nodules. Preferential loss of the weathering-sensitive components then results in geochemical differentiation of magnetic nodules relative to their non-magnetic precursors. We suggest that the elevated Zr/Hf and Y/Ho ratios previously reported for Australian fluvial sediments reflect, at least in part, the long history of palaeo-fires in the catchments of these rivers. In addition, since magnetic Fe nodules are demonstrably related to fire, they may represent a promising, directly dateable record of severe fires, which can complement the sedimentary charcoal record.

[1]Löhr et al (2017). *Geochimica Et Cosmochimica Acta*, *200*, 25–41.