LA-ICP-MS elemental maps of Huronian pyrite: no atmospheric oxygen ahead of the GOE

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Putative detrital pyrite occurs in Palaeoproterozoic Huronian conglomerates at multiple stratigraphic levels. It is found in placer deposits some of which also contain uraninite, zircon and monazite. Whole rock Pb isotope data suggest that uraniferous conglomerates were mainly sourced from evolved Neoarchaean granites in the Superior Province.

The notion of detrital pyrite pebbles has provoked controversy, because their texture and geochemical signatures can be interpreted both as primary or modified, with opposing implications for palaeo-atmospheric significance. Modern 2D trace element mapping with laser-ablation inductively-coupled-plasma mass-spectrometry reveals, in much greater detail, interior structures within pyrite. In this regard, trace element maps hold greater promise than major elements [1]. The maps permit investigation of the history of pyrite crystals and can see through secondary overprint, revealing a clearer picture of Palaeoproterozoic atmospheric conditions.

Here we report elemental maps of rounded and euhedral-subhedral pyrite grains from the basal polymict conglomerates of the ca. 2.4 Ga Mississagi Formation, Huronian Supergroup. The maps reveal the common existence of striking rounded detrital cores, variably modified by hydrothermal overgrowth. The detrital origin of pyrite grains is readily demonstrated from rounding of individual grains and cores implying sediment transport. Truncated cores of originally rounded detrital fragments also require abrasive action. Since pyrite is unstable under oxidising conditions, survival of detrital pyrite in a fluvial environment after transport in aerated river water implies that the contemporary atmosphere was devoid of free oxygen. Significantly the conglomerate was deposited *after* the first glaciation leading to the Great Oxygenation Event.

Sedimentological data and statistical analysis of pyrite size, shape and morphology permit reconstruction of a depositional environment characterised by fault-controlled braided rivers with local drainage. It appears that the southern margin of the Superior Province was cratonised at 2.58-2.62 Ga via emplacement of U, Th and K-rich granites into the uppermost crust. Less than 200 Ma later, the lithosphere had sufficient mechanical strength to sustain fault-controlled topography and the uppermost, heat-producing crust was already unroofed.

[1] Ulrich, T., et al. (2011). Econ. Geol. v.106, p.667-686.