NEW APPROACHES TO DETECT TRUE ELEMENT RESIDENCE IN REGOLITH MATERIALS

Robert Hough[1], Ravi Anand[1], Chris Ryan[2], Marc Norman[3], David Belton[2], Barbara Etschmann[2], Cajetan Phang[1] & Cathy Harland[4].

[1]CRCLEME, CSIRO Exploration and Mining, 26 Dick Perry Avenue, Kensington, Perth, Western Australia.
[2]CSIRO Exploration and Mining, MARC group, School of Physics, University of Melbourne, Victoria, 3010, Australia.
[3]Research School of Earth Sciences, Australian National University, Canberra, ACT 0200, Australia.
[4]Australian Synchrotron Research Program, ANSTO, c/o Advanced Photon Source, Chicago, USA.

For regolith scientists to truly determine metal anomaly formation in both *in situ* and transported regolith, it is necessary to more effectively characterise where elements of interest reside. The scale-independent heterogeneity of regolith materials is well documented and this complexity must limit the value of assumptions derived from the results of bulk sampling. A combination of Laser Ablation Inductively-Coupled Plasma – Mass Spectrometry (LA-ICP-MS) transect analyses and Synchrotron based X-Ray Fluorescence (SXRF) and proton microprobe element mapping was used to constrain element distributions within residual and transported iron oxide nodules.

Transect mapping methods are utilised to reveal the element distributions in a sample; this is driven by the complexity even at thin-section scale of individual regolith materials. Transects obtained by LA-ICPMS can be collected quickly and over large parts of a sample while providing concomitant analysis of a large numbers of elements (e.g., Le Gleuher *et al.* 2003). This provides a powerful qualitative technique to illustrate element residence in complex materials. Element mapping with high spatial resolution is challenging and we use full spectral data acquisition with synchrotron and proton probe based microprobes to allow us to gain maximum value from acquired data sets with good limits of detection. Mapping using SXRF involves collection of full spectral element maps. The format allows us to interrogate the data after acquisition and ratify the results presented in the maps directly using the actual spectra from which they were derived on a pixel by pixel basis. We do this using the Dynamic Analysis method using the GeoPIXE Software developed at CSIRO (Ryan *et al.* 1995). This technique projects quantitative major and trace element images from primary full-spectral data streams and rejects artefacts from overlapping peaks in the spectra and from background.

Weathering of gold/base metal deposits typically includes specific mineral associations with key elements like Au, Cu, Pb, As and Zn. Iron oxide nodules occurring in ferruginous residuum and transported sediments at the Moolart Well gold prospect in Western Australia are anomalous for these elements and provide a good example to study *in situ* metal residence and speciation. Transects using LA-ICP-MS show the distribution of elements over whole nodules (Figure 1) and suggest gold is preferentially hosted by authigenic nodules and authigenic cutans to residual nodules. Copper is also concentrated in the cutans and spikes of Zn can be seen to occur in specific areas within nodules. Mapping by SXRF identified the distribution of *in situ* Cu and Zn in samples that have low bulk concentrations (Figures 2a, b, c). The As distribution is closely related to Fe (Figure 2d) and is highest in the more hematitic, residual core of the nodules. X-ray absorption near edge structure (XANES) analyses revealed the presence of both As(III) and As(V) in residual nodules. Speciation mapping using the two XANES edges, as constrained by As standards, demonstrates that As(V) dominantly occurs within high Fe hematitic veins, whereas As(III) has a more homogeneous distribution throughout the nodule. The goethite occurring in discrete areas of the cutan seems to preferentially desorb any As. Isolated hotspots of Zn and Cu that occur in some nodules and closely relate to high concentrations of Fe and Ni reside within resistant chromite grains that are themselves weathering to magnetite. Such hotspots in the element maps represent significant element concentrations that can swamp more subtle signatures

Studies of metal siting and speciation show that even very fine-grained, minor mineral phases can be important hosts for pathfinder elements; the same is true for studies of bioaccumulation of metals in vegetation.

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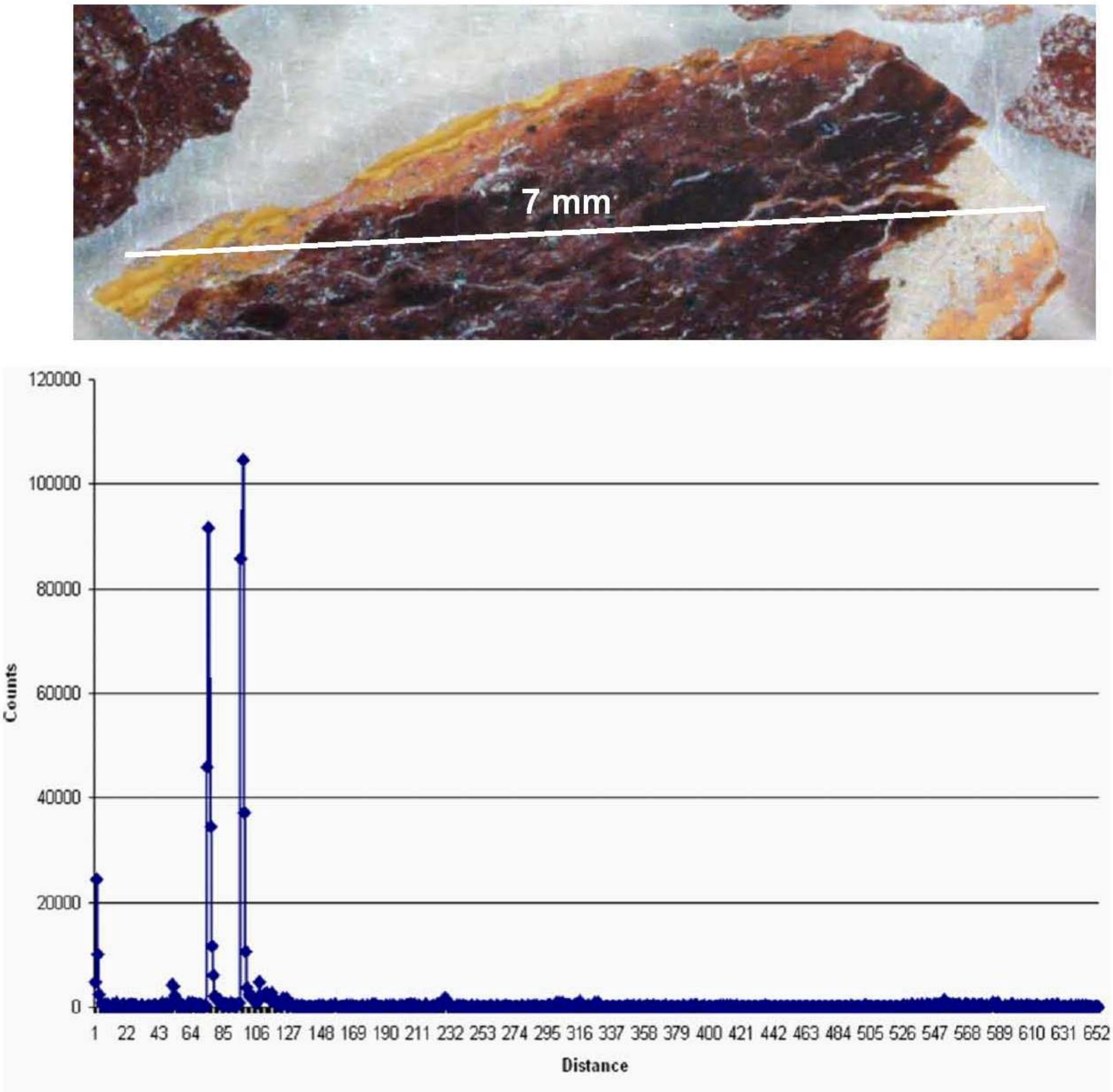

Figure 1. LA-ICP-MS transect showing Au distribution across a detrital nodule. The gold is hosted by the younger generation, goethite rich cutan.

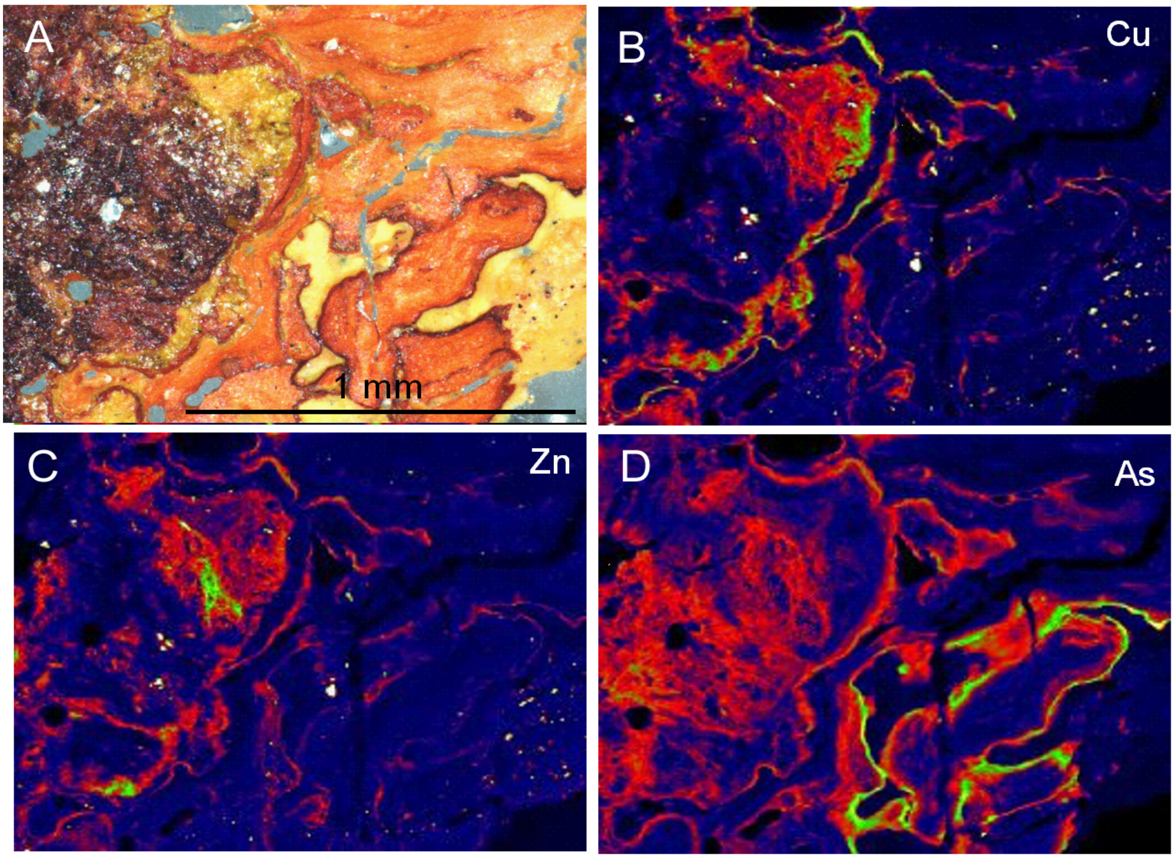

Figure 2. (a) Optical micrograph of a saprolitic nodule from the Moolart Well prospect. SXRF maps of the same area for (b) Cu, (c) Zn and (d) As.