

Recent advances in geochemical interpretation for mineral exploration through the application of regolith terrain mapping and the power of new remote sensing and 3D visualisation techniques

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Near surface geochemical data derived from soil or lag samples in deeply weathered environments need to be interpreted with respect to regolith, geology and landform. Weathering liberates elements from the parent rock which can then be mobilised by chemical and physical processes. The chemical signature response to mineralisation is therefore a product of the geology (element source), regolith (residual, transported, enriched or depleted) and the landform. The landform may effect the degree to which the the regolith profile is preserved or whether elements are moved by physical erosion, for example, colluvial movement downslope. It follows, therefore, that large ore bodies do not necessarily have broad or strong geochemical signature (especially when buried beneath transported overburden), the strongest near surface geochemistry is not necessarily located over the best mineralisation and that there are times when we can expect and do find significant mineralisation beneath subtle or sporadic near surface geochemical results. Regolith terrain maps are produced to factor these variables into geochemical prospecting.

Traditionally regolith terrain maps have been generated from aerial photographs, satellite imagery and field traverses. This can be time consuming and require careful map compilation to correct for spatial errors inherent in using aerial photographs. Using recently developed techniques that incorporate digital elevation models, satellite imagery and on-screen digital mapping it is possible to map the terrain faster and with a higher degree of accuracy and therefore place geochemistry back in regolith terrain context more easily than has hitherto been possible. This is delivering better anomaly identification and improved drill targetting, especially when dealing with broad or sporadic geochemical anomalies, as demonstrated in examples from both Australia and Africa.

Fe and Zn isotopic variations in Finnish acid sulfate soils

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The use of high-resolution MC-ICP-MS has enabled high precision measurements of ⁵⁶Fe/⁵⁴Fe and ⁶⁶Zn/⁶⁴Zn isotopic ratios (reported as $\delta^{56}\text{Fe}$ and $\delta^{66}\text{Zn}$ values, respectively, in parts per mil units relative to the corresponding isotopic ratios of IRMM-014 and IRMM-3702 standards, respectively) in two Finnish acid sulfate (AS) soils (Rintala: 62°46.017'N, 22°36.822'E and Vassor: 63°9.484'N, 22°0.549'E). Finnish AS soils are characterized by low pH (<4) in the acidic horizon (located above the reduced sulfidic parent sediment) and extensive leaching of sulfuric acid and potentially harmful elements such as Zn, and retention of Fe as oxyhydroxides and jarosite [1, 2].

In the reduced parent sediment, the $\delta^{56}\text{Fe}$ values ($\pm 1\sigma$) were positive at Rintala and ranged from $(-0.01 \pm 0.02)\text{‰}$ to $(0.31 \pm 0.03)\text{‰}$, whereas the $\delta^{56}\text{Fe}$ values ($\pm 1\sigma$) were more negative at Vassor and ranged from $(-0.19 \pm 0.01)\text{‰}$ to $(0.16 \pm 0.01)\text{‰}$. This could be explained by more oxidised conditions during formation of the sediment at the former site [3]. The upward decrease of $\delta^{56}\text{Fe}$ towards the transition zone (i.e. the horizon between the reduced and oxidised material) is explained by redox driven processes, whereas the slight increase of $\delta^{56}\text{Fe}$ in the oxidised acidic horizon probably reflects precipitation of ferric minerals [4] and possibly some loss of isotopically-light Fe.

All measured $\delta^{66}\text{Zn}$ values ($\pm 1\sigma$) were negative and ranged from $(-0.49 \pm 0.01)\text{‰}$ to $(-0.01 \pm 0.03)\text{‰}$ at Rintala and from $(-0.36 \pm 0.02)\text{‰}$ to $(-0.15 \pm 0.02)\text{‰}$ at Vassor. Generally, the $\delta^{66}\text{Zn}$ values were slightly decreasing upwards, implying enrichment of the heavier isotopes in the leached Zn fraction. However, we do not have any isotopic data to support this assumption. Possibly this isotopically-heavy Zn has previously been adsorbed on oxides and hydroxides and is now released due to the acidic conditions [5].

More detailed studies on the partitioning, together with isotopic analyses, of Fe and Zn in Finnish AS soils are needed. Speciation of Fe and Zn will significantly contribute to the understanding of the isotopic variations in AS soils.