Geochemical exploration through cover: past, present, and future

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Modern geochemical exploration arguably started in the early XXth century when Victor Moritz Goldschmidt developed the geochemical laws of the distribution of chemical elements in Earth systems. These laws allowed an unprecedented understanding of element mobility, trapping, and associations that revolutionized the appreciation of processes including ore deposit formation, hydrothermal alteration, supergene enrichment, and geochemical dispersion. Direct or indirect application of these laws underpinned countless mineral deposit discoveries by geochemical techniques for decades. Many of those deposits, however, were located at or close to the Earth's surface.

The relentless growth in world population, combined with societal pressure to deliver ongoing economic growth and aspirations to better living standards by poorer nations, drives rising demand for resources worldwide. Discoveries of major mineral resources that are easily accessible at or near the Earth's surface are becoming rarer and those that are known are being produced relentlessly. This inexorably drives current and future mineral exploration toward deeper resources that are more difficult to discover. There is a continuum of scenarios from deep deposits in bedrock-dominated terrain, through those covered by but a few meters of in-situ weathering profiles or soils, to those concealed by 10s to a few 100s of meters of transported (allochthonous) sedimentary cover. The current arsenal of geochemical techniques includes (1) targeting sampling media that are or have been in contact with deep environments (groundwater, soil gas, biota including deep-rooted plants and termitaria), and (2) using chemical extractions on surface materials that have the potential to isolate ions or molecules that may have moved up through a regolith profile post-mineralisation (e.g., weak extractions, nanoparticles, soil hydrocarbons).

The future challenges of exploration geochemistry will be dominantly in these covered terrains. I believe that a combination of (1) more powerful data analysis techniques, including advanced multivariate statistics accounting for the compositional and geospatial nature of geochemical data and machine learning, and (2) the integration of geochemical data with other geoscientific data, such as geophysics, geology and spectroscopy, hold exciting promise for the future.