SEG 100 Conference: Celebrating a Century of Discovery

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Game Changers: The First Hundred Years: Analytical Techniques

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Geochemistry develops chemical principles allowing us to understand how the Earth formed and how it works. It can also be used directly to help discover mineral resources and keep the planet habitable. The potential applications of these tools over the last century have been highly dependent on the development of analytical techniques. We have only been able to get an absolute age for the Earth in 1956. Nowadays, we can have precise U-Pb ages with precision down to 0.2 myrs for Archean rocks and less than 10 kyrs for Tertiary rocks, including in systems that were considered earlier on to be undatable (e.g., layered intrusions' source of large reserves of PGEs, Cr, and V and other metals such as Cu, Ni, and Au). The amount of material that is required for analysis has decreased from grams to milligrams and more recently to very tiny amounts as low as a few picograms. Another major analytical game-changer over the last decade has been the development of in situ techniques allowing for analyses of trace element concentrations simultaneously with isotopic compositions (Pb, for instance, in thin sections, or Hf in zircon grains) for provenance determination or/and U-Pb age dating. The split-stream techniques ((MC)-ICP-MS) are fundamentally transformative to unravel complicated metal distribution patterns and to define their association with mineral phases, the chemistry of which can also be determined in situ. They complete high throughput methods for measuring almost every geologically relevant element to below-average crustal concentrations routinely and rapidly. Simple developments such as pXRF allow instantaneous determination of elemental compositions on the field, now with a precision that competes with that of analyses in the lab – a game-changer for mineral exploration. Community initiatives such as EARTHTIME are key for high-precision dating used in porphyry systems, timescale calibration, etc. With increased sensitivity, these techniques can now be applied to use U-Pb to date carbonates or accessory phases such as monazite, titanite, rutile, and scheelite. Proper QA/QC requires access to different approaches, such as Raman microscopy, microdrilling, and thermoionization instruments. Another completely new field is the application of multi-collector ICP-MS for the analyses of transitional metal isotope compositions such as Fe, Cu, Zn, and Mo, among others that allow the deciphering of the processes leading to the concentrations of these metals in ore deposits or at the other end the process to determine their paths in the environment.

This keynote will review the significant analytical developments over the last decade and show some new game-changing applications.