Astrobiotechnology

A. STEELE AND J. TOPORSKI

Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Road, Washington D.C., 20015-1305, USA (a.steele@gl.ciw.edu)

A key issue in astrobiology research is and has been to understand the origin, evolution and distribution of life on Earth and the solar system. Consequently, crucial to this endeavour is the identification of means to both unambiguously detect evidence of life and demonstrate credible mechanisms for its formation. Efforts to identify traces of life in extraterrestrial materials or even remotely on the surface of Mars have resulted in ambiguous, non-conclusive information. Experimentation into pre-biotic processes involved in the formation of life have given a tantalizing but inconclusive glimpse into the possible formation conditions of life. As a result it has recently been proposed to pursue alternative technologies to help answer these challenges. Here we introduce an integration of approaches and technologies, developed and applied mainly in molecular biology and biotechnology with these astrobiology goals. The overall concept behind this approach is to employ these tools to detect specific astrobiologically and geobiologically relevant target molecules, to manufacture combinatorial libraries and screen thousands of relevant prebiotic reactions rapidly under different conditions. Possible instrumentation to help in the above goals are microarray technology, micropipetting and liquid handling systems, rapid fluorescence detection capabilities coupled to single molecule detection systems and lab-on-a-chip technology including chemical library chips. These techniques will be discussed and their implications for prebiotic chemistry and life detection postulated upon.

Power in partnership: Re-Os molybdenite and U-Pb zircon dating

H.J. STEIN, R.J. MARKEY AND J.L. HANNAH

AIRIE Program, Department of Geosciences, Colorado State University, Fort Collins, CO 80523-1482 USA (hstein@cnr.colostate.edu)

In the last decade, one of the most influential advances in ore geology has been the application of Re-Os to relate mineralizing processes to thermal and dynamic events in the crust, and to estimate mantle involvement in ore genesis. The impact of Re-Os applied to ore minerals has now proceeded demonstrably beyond the simple dating of ore deposits. In particular, successful development of the Re-Os chronometer for molybdenite has enabled temporal mapping of tectonic, metamorphic-metasomatic, and magmatic activity involving multiple terranes and major orogenic events, and has elucidated metallogenic history within this important framework. Mineral exploration programs have benefitted.

At the deposit scale, estimates for the age and duration of mineralization are dominated by $^{40}Ar/^{39}Ar$ dating of ore-associated hydrothermal micas and feldspars presumably formed in association with ore minerals. We have found that $^{40}Ar/^{39}Ar$ dating, in almost every case **(1)** underestimates the true age of mineralization, and **(2)** provides an unrealistically compressed history for the development of large ore-forming systems. Ore depositional events that have experienced subsequent tectonism or thermal overprinting, whether regional (later orogenic) or local (subsequent magmatic-hydrothermal events) should be addressed using Re-Os, preferably in combination with U-Pb zircon chronology in which multiple events may be discerned in overgrowths. U-Pb dating of minerals that typically form or recrystallize during metamorphism and metasomatism (e.g., monazite, xenotime), however, are subject to full or partial updating by younger events, particularly where fluids ingress or develop during the metamorphic process. U-Pb dating of monazite and xenotime as a means to date ore mineralization should be viewed with caution, as the ages, commonly stated at high precision, often reflect (or scatter about) the younger event(s) in a particular terrane. Scatter alone suggests that geologic accuracy may be compromised. In most cases, monazite and xenotime dating do not adequately test for older episodes of mineralization in overprinted terranes.

Molybdenite is the only significant, naturally-occurring host for Re. We note that Re concentration is controlled by the involvement of mantle in the ore-forming process. Crustally-derived ore systems have markedly low Re (low ppm to ppb) whereas subduction-related systems have markedly high Re (hundreds to thousands of ppm).

References

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