AIRIE

APPLIED ISOTOPE RESEARCH

January 2018

The AIRIE Program has pioneered Re-Os (rhenium-osmium) technology, and is the global leader in setting protocols for dissecting sample media to determine geologic age. Since 1995, AIRIE has produced state-of-the-art Re-Os geochronology and Os isotopic tracer studies, based on forward-thinking geologically-based insights. Two multi-collector Triton mass spectrometers were built and specifically tuned for Re-Os analytical work. Our collaborating partners span 80 countries and our discoveries have benefited an enormous cross-section of the geosciences, from atmosphere to deep earth. We address fundamental scientific questions and use the results to both advance science and enhance discovery in the petroleum and mineral industries. The analytical facility is located at Colorado State University, with research and funding driven through the CEED Centre of Excellence at University of Oslo. The AIRIE Program, salaries and operations, is funded solely by grants and contracts; we receive no support from CSU for the Program.

Re-Os isotope geochemistry enlightens our understanding of how metal and hydrocarbon resources are created, interrelated, and where they are located.

Metals **– Our work has led directly to discovery of ore, while challenging long-standing models for ore formation. AIRIE established the protocols for successful Re-Os TIMS dating of molybdenite, from mineral separation to interpretation of isotopic data. We developed a double Os spike to address young (or low Re) molybdenites, sharing this approach with the geochemistry community. We acquired and characterized a molybdenite reference material (RM #8599) from the Henderson molybdenum mine in Colorado – now distributed by NIST for global inter-laboratory comparison. We work with other sulfide and oxide minerals such as pyrite, arsenopyrite, chalcopyrite, and magnetite to provide age and source information through Re-Os isochrons.**

Hydrocarbons **– Our work with hydrocarbons includes direct dating of organic material in potential source rocks, and dating *in situ* and migrated bitumen and oil. In 2016, we published the first Re-Os isochron for a crude oil. We work with the hydrogenous component in black shales, and for hydrocarbons, we analyze components of the asphaltene and maltene fractions in oils. Re-Os analyses of hydrocarbons are used to model maturation-migration in both conventional and unconventional systems. Our work on sulfides and organic material in shales helps calibrate Earth's timescale, and determine rates for sedimentologic, bio-evolutionary, and tectonic processes, giving perspective on ancient climates, oceans, global correlation of fauna, and atmospheric evolution. We provided the first absolute age for the rise of atmospheric oxygen.**

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AIRIE PROGRAM, COLORADO STATE UNIVERSITY: RE-OS PUBLICATIONS

Holly Stein (Founding Director, Senior Research Scientist and Professor)
Judith Hannah (Professor)
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Svetoslav Georgiev, Gang Yang, Rich Markey (Research Associates)
Vineet Goswami and Nicole Hurtig (Post-Docs)
Marisa Boraas-Connor and Jenna DiMarzio (Graduate Students)

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Refereed Journal Papers:

Tripathy, G.R., Hannah, J.L., Stein, H.J. (in review) Refining the Jurassic-Cretaceous boundary: Re-Os geochronology and depositional environment of Upper Jurassic shales from the Norwegian Sea: *Palaeogeography, Palaeoclimatology, Palaeoecology*.

Hurtig, N.C., Georgiev, S.V., Stein, H.J., and Hannah, J.L. (in review) Re-Os in oil – in the company of water: *Geology*.

Boomeri, M., Moradi, R., Stein, H.J., and Bagheri, S. (submitted) Geology, Re-Os age, ^{34}S and ^{18}O isotopic composition of the Lar Cu-Mo deposit, southeast Iran: *Ore Geology Reviews*.

Georgiev, S.V., Zimmerman, A., Yang, G., Goswami, V., Hurtig, N., Stein, H.J., and Hannah, J.L. (revised version resubmitted) Comparison of chemical procedures for Re-isotopic measurements by NTIMS: *Chemical Geology*.

Goswami, V., Hannah, J.L., Stein, H.J. (revised version submitted) Why terrestrial coals cannot be dated using the Re-Os geochronometer: Evidence from the Finnmark platform, southern Barents Sea and the Fire Clay coal horizon, central Appalachian basin: *International Journal of Coal Geology*, (January 8, 2018).

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