Evaluating the robustness of Pb-Pb ages of meteorites

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A variety of methods for acquiring Pb-Pb data to constrain the ages of meteorites and their components exist today, all capable of yielding ages with varying levels of complexity. Regardless of the method employed, basic measures exist to evaluate the degree of confidence in a calculated age, including:

1. The analyses should yield sufficient spread in Pb-Pb space (courtesy of either stepwise dissolution methods and/or analyzing separate mineral concentrates from a single sample) to yield an internal isochron free of any model or presumed initial Pb isotopic composition that cannot be independently verified,
2. The array defining an isochron must represent mixtures of in situ radiogenic Pb and only one other source of common Pb, most typically initial Pb or, less typically, secondary contaminant Pb. At least one analysis that is more radiogenic than modern terrestrial contaminant Pb assures that the resulting array does not reflect a binary mix of initial Pb and terrestrial contaminant Pb,
3. Back projection of the isochron should yield a permissible isotopic composition for an initial Pb component given the context of the object being dated (except atypical cases where it is presumed that only contaminant common Pb exists as the non-radiogenic component),
4. The U isotopic composition of the object being dated must be known by direct measurement,
5. All U and Pb isotopic analyses must be corrected using an internal measure of instrumental isotopic mass fractionation,
6. All errors on final ages should reflect errors for the Pb and U isotopic measurements and assumptions therein,
7. Analyses of accepted, appropriate standards run concurrently with the samples and using the same protocols should be reported with the geochronological results,
8. When stepwise dissolution is employed, at least the acid type and concentration, exposure time and temperature should be reported in the data table,
9. When feasible, critical ages should be verified by an independent research group in a second laboratory.

While these criteria may be obvious, there is presently no standardization of data presentation or consistent culture of critical evaluation of the confidence level of ages for meteorites that would include exploring alternative interpretations where appropriate. Where the listed criteria are not fulfilled, practitioners of Pb-Pb geochronology of meteorites have the obligation to make clear the assumptions and/or shortcomings of each data set. Only through such an open dialogue regarding the true robustness of each age will we publish results that can be used confidently by the meteoritics community at large. Towards this end, we are working to erect an absolute Pb-Pb chronological framework for the early solar system based on FUN and normal CAIs, chondrules and differentiated bodies that will be evaluated by these criteria.

The role of ArxA in photosynthesis-linked arsenite oxidation by bacteria from extreme environments

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Background

The metabolic process of photosynthesis-linked arsenite oxidation (arsenophototrophy) has likely existed on earth since 2.7 - 3.5 billion years ago [1]. However, it is poorly understood and has only been identified in thermal springs on Paoha Island of Mono Lake, CA [2]. As this metabolism utilizes solar energy to convert the more toxic arsenite to the less toxic arsenate, it has implications for bioremediation. The arsenite oxidase ArxA is thought to be responsible for the oxidation of arsenite in arsenophototrophy. However, the first and only isolated arsenophototroph, *Ectothiorhodospira sp.* str. PHS-1, has not proven amenable to genetic manipulations. This makes genetic confirmation through gene disruption or deletion of the *arxA*-like gene in the organism impossible, leaving the hypothesis unconfirmed. The first aim of this work is to study the microbial ecology of anoxygenic arsenophototrophs in arsenic-rich environments other than Mono Lake and secondly, to isolate and develop an arsenophototroph which can serve as a genetic model for arsenophototrophy.

Materials

Water, sediment, microbial mat and tufa collected from Big Soda Lake (Churchill County, NV), Mono Lake and various hot springs in the Mammoth Lakes (CA) area were used for enrichment culturing and functional gene analyses.

Results

Currently *arxA*-specific primers have successfully amplified products from 15 out of 18 environmental samples, and all products so far cloned and sequenced show high homology to existing *arxA*-like sequences. Additionally, strains containing *arxA*-like sequences and capable of arsenite oxidation belonging to the genera *Ectothiorhodospira* and *Halomonas* have been isolated. One strain in particular, *Ectothiorhodospira* sp. str. BSL-9 is aerotolerant, grows well on plates, and is susceptible to common antibiotics, making it a potential model for arsenophototrophy.

Conclusions

This work demonstrates that ArxA is unlikely limited to the Mono Lake area and may be widespread in arsenic-rich environments. It is also a necessary stepping-stone in actualizing a genetic model for photosynthesis-linked arsenite oxidation.

[1] Oremland et al. (2009) *Geomicrobiology Journal* **26**, 522-536
[2] Kulp et al. (2008) *Science* **321**, 967-970