# SELLING OUR SCIENCE (BUT NOT AT ALL COSTS)

**Triple Point** raises issues of broad interest to the readers of *Elements* and explores different aspects of our science (teaching, publishing, historical aspects, etc.), our societies, funding, policy, and political issues. Contact Bruce Yardley (B.W.D. Yardley@leeds.ac.uk) if you have an idea for a future topic.


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Journalists who specialize in communicating science to the public say that their most difficult task is persuading scientists that if they want to be heard they must present a message that the public will be interested in hearing about, rather than lecturing people on what they think the public ought to want to know. The great science communicators manage to do both, of course. Quite understandably, many of us are not just interested in doing basic research; we also hope that our research will be of practical value. And here, just the same pitfalls and pratfalls await, as we endeavor to develop practical applications for our basic research results that can help industry to solve "real-world" problems. It is all too easy for us to decide that industry should be interested in what we do, rather than listening to find out what problems they actually face. Unfortunately, if industry or government funders feel they have been duped into paying for something that did not help them, a whole sector of the scientific community may be dismissed for a long time to come.

In a recent Web discussion, members of the fluid inclusion community bemoaned the fact that fluid inclusion studies are not used routinely in exploration for mineral deposits. The main reason for this omission is that many (most?) academic inclusionists who consult for industry are unable to separate the theoretical or experimental basis for the technique from its practical application in the field, leaving the explorationist confused as to how to apply the information provided. Additionally, fluid inclusions by themselves cannot prove the existence of economic mineralization (although they are often "sold" to industry with that intent). At best, they can direct you to that part of the system where mineralization is likely to occur, if it exists at all. Drilling, assays, and the current economic environment will determine if that occurrence is economic or not.

Inclusionists with only academic experience do not always know what type of information is useful in exploration. Many exploration reports include abundant data on homogenization temperatures and salinities—but from an exploration point of view, this information may not be useful. For example, we are unaware of any porphyry copper system where the mineralization is characterized by a unique fluid inclusion temperature. In exploration, the most useful information often can be obtained from petrography alone, even from simple grain mounts. Doing the unnecessary measurements just adds to the cost and time to complete the study.

The genetic link between boiling and gold deposition was established by careful experimental and theoretical studies during the 1970s to 1990s. However, it is not necessary to understand the underlying phase equilibria and thermodynamics to apply the results in exploration—one only needs to know how to identify the former presence of boiling fluids: that is, coexisting liquid-rich and vapor-rich fluid inclusions and distinctive mineral textures.

A major obstacle associated with most attempts to use fluid inclusions in exploration is the disconnect between the questions a company is seeking to answer and the data requested. Often, an exploration geologist will request homogenization temperatures and salinities of fluid inclusions. After some discussion it generally becomes clear that the questions the company has cannot be answered with homogenization temperatures and salinities. Our recommendation to anyone studying fluid inclusions as part of an exploration program is to first ask, "What questions are you trying to answer?", rather than, "What data do you want me to collect?" Often, the questions are: What type of hydrothermal system are we in? Where are we vertically (or laterally) within the system? Are we on the periphery of a large system and, if so, which direction do we go to find the center? Have we reached the bottom of the boiling horizon? And so on. These questions can often be answered from simple petrographic examination of samples, without the need for detailed quantitative or analytical data.

Over the years academic experts have offered numerous workshops on the application of fluid inclusions in exploration. These workshops are great—but it is important to separate the "research" component from the "exploration" component. The presenters at the workshops are often outstanding scientists who have excellent academic reputations but little practical experience in the application of fluid inclusions in exploration. Thus, industry attendees at these workshops come away with the wrong impression of the type of data needed in exploration. They request the data that are talked about in the workshops, but these data are intended to help us understand how the deposits formed and are generally not very useful in exploration.

Fluid inclusions can be used effectively in exploration, but only if we in the academic community provide the information that explorationists need. The reason that industry does not embrace fluid inclusions more is that the academic fluid inclusion community has failed to make the distinction between basic research aimed at understanding deposit genesis and the application of those research results to the discovery of new deposits.

Another vibrant area of research at present is mineral growth, and there are many excellent studies underway related to the growth of carbonate minerals. Carbonate scaling is a major industrial problem, and a fundamental understanding of how these minerals nucleate and grow will contribute greatly to minimizing it. Understanding the long-term growth of carbonate minerals in reservoirs into which $CO_2$ has been injected is a vital part of the long-term safety case for deep carbon capture and storage (CCS) in reservoirs and aquifers, which must be good enough to persuade the public to allow CCS to go ahead. However, some researchers claim that studying the growth of carbonate minerals in mafic or ultramafic rocks will allow us to solve the problems of climate change by directly fixing carbon dioxide into minerals. The largest CCS pilot projects at present sequester of the order of 1 million tonnes of $CO_2$ per year. Imagine 1000 of those schemes up and running and you are getting to the point where there is a small but finite impact on atmospheric levels of $CO_2$. Before we could precipitate a significant proportion of those $10^9$ tonnes per year as carbonate minerals, it is quite likely that we would first impact on climate by changing the Earth's albedo as we cover the planet in white dust! Large-scale injection pilot projects are operating today in ideal circumstances, but there are outstanding issues to resolve before the technology can be applied more widely. At best, throwing CCS research money at direct mineral capture and storage risks deflecting resources away from a rapid solution to an immediate and urgent problem. At worst it reinforces the view that academia has nothing practical to offer, leaving industry emboldened to make mistakes with long-term consequences.

Basic science has much to offer applied science in the medium to long term, but quick fixes to society's problems are unrealistic and should not be expected. We must better engage and interact with the applied scientists and engineers who might benefit from our ideas, and we must listen to their concerns and problems before offering solutions that are designed to address those problems and not just to allow us to continue a favorite line of research. If we don't do this, we have only ourselves to blame for the perceived lack of appreciation and funding for our science that will result. To quote Pogo, "We have met the enemy, and he is us."

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