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Better Exploration is Needed to Reduce Resource Development Risk

By: Jeff Witter, PhD, PGeo, Mira Geoscience Ltd.

With resource risk a major obstacle for project development, it is crucial to improve exploration for geothermal resources.

Geothermal exploration is difficult – considerably more so than oil & gas or mineral resources exploration. As in the mining industry, we geothermalists explore in terribly complex geological environments, and have to drill through incredibly hard rock. However, the mining industry can take some comfort from the fact that their exploration targets are often only a few hundred meters deep: drilling to depths greater than 1,000 m is uncommon. Those of us exploring for geothermal resources commonly pursue targets 2 - 3 km underground (or deeper!). These drilling depths are similar to those confronted by the oil & gas industry. The oil & gas folks also get off easy, though: they commonly drill through relatively soft, flat-lying sedimentary rock with much simpler geology.

When it comes to actually locating the targeted resource underground, the mining industry has traditionally had an easier task than ours in geothermal, because some ore bodies

have a distinct geophysical signature (e.g. they're magnetic or extremely dense). Hot water, unfortunately, doesn't have such a signature. The lucky people in the oil & gas industry have 3D seismic technology which revolutionized oil & gas exploration in the 1980s, helping them pinpoint the right place to

01 Author measuring at Sherman Crater, Mt. Baker, U.S.



drill and find success. Geothermal explorers are also working to take advantage of 3D seismic technology, but so far it doesn't look as if it's going to be revolutionary for us. So what should we do?

Risk and Reward

Every year, the mantra of the geothermal industry is the same: The high up-front costs and high resource risk make geothermal unattractive to investors. It's strange that this two-fold challenge doesn't seem to deter investors as much in the mining or oil & gas sector, even though the same issues play a significant role in both these industries.

Sure, the economics are different for development projects in these sectors, but if there's money to be made, there ought to be interested investors out there. We just need to convince them that the return is worth the risk – and I think this is where we struggle.

Selecting exactly where to drill your multi-million-dollar geothermal production well is one of the most important decisions to be made in a geothermal exploration

program. No matter how much geothermal drilling insurance you have, if you keep drilling in the wrong place, your exploration program will fail. Simply put, to attract investment we must reduce resource risk by increasing drilling success. But how do we do that?

At its most basic, a great way to increase drilling success is to get better at selecting the right place to drill. In order to do that, we must explore better. In my view, this is where the oil & gas and mining sectors have a significant leg-up: they simply do exploration better. The geothermal industry needs to do the same.

How can the geothermal industry explore better? Here are a few ideas:

- Commit to exploring in 3D from the very beginning of an exploration project;
- Move away from conceptual exploration models; move towards evidence-driven, quantitative 3D models of the subsurface;
- Select and rank drilling targets quantitatively using multiple exploration criteria.



Commit to Exploring in 3D

We live in a three-dimensional world. As such, we should explore for geothermal resources by investigating the subsurface as a fully three-dimensional environment. Relying on two-dimensional cross-sections provides only a partial picture and is an inherently limiting approach. The best approach is to pursue a 3D exploration program from the very outset. Create a 3D exploration volume (even if there is limited data available) and systematically fill that volume with relevant geoscience data - and then interpret this data in 3D. The oil & gas and minerals industries have embraced 3D exploration and benefited greatly. Exploration in 3D is a more rigorous approach, leading to a better understanding of the subsurface which leads, in turn, to greater exploration success. Various software technologies already exist to help ge-

thermal explorers to work in 3D (GOCAD, Leapfrog, Earth Vision, Petrel, Geosoft Target, etc.). However, for some reason, by and large, the geothermal industry still seems stuck in yesterday's dominantly 2D approach to exploration. Ironically, the production side of the industry has already adopted a 3D approach. Numerical models of heat and mass transfer in geothermal reservoirs (meant to predict the performance of the reservoir over the life of the power plant) are unquestionably constructed in three dimensions. Why, then, is the exploration geoscience data not also habitually rendered and interpreted in 3D space? Such exploration data is collected for the sole purpose of identifying targets for multi-million-dollar wells. In my view, a 3D picture of the subsurface, generated from rigorously analyzed and interpreted 3D geoscience datasets, would go a long

way towards convincing would-be investors that we have done our due diligence to reduce drilling risk as much as possible prior to spending millions of dollars.

Quantitative, not Conceptual

Today, conceptual models of geothermal resources are commonly constructed in an attempt to characterize the subsurface and guide the targeting of geothermal wells. As an industry, we need to stop drilling concepts and start drilling targets selected from quantitative models. Some might

say the difference here is simply semantics. However, if we are trying to increase the confidence of investors who are unfamiliar with our industry, connotation is important. The definition of a concept is "something thought or imagined." Who, in their right mind, would risk a multi-million-dollar drilling program on a geothermal resource model that is thought or imagined? Seems pretty high-risk to me. No wonder investors shy away from geothermal. We need to raise confidence in the investment community by better communicating our

“The best approach is to pursue a 3D exploration program from the very outset”



independently-derived, quantitative evidence. The result is a robust, 3D architecture from which drilling targets can confidently be identified.

Rank Drilling Targets Quantitatively

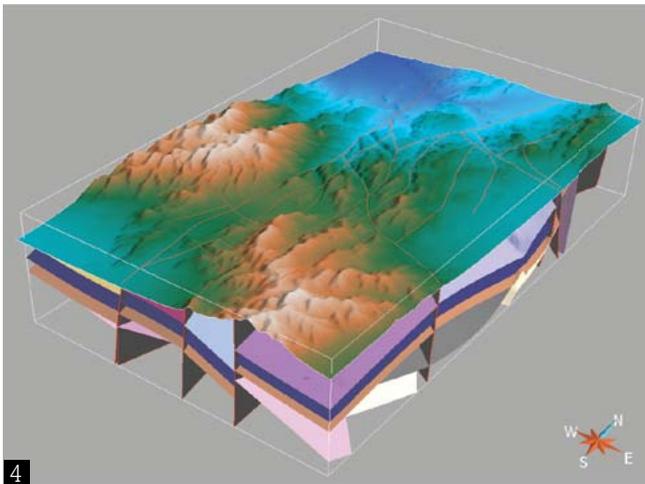
Deciding where to drill is of critical importance. That's the secret to reducing resource risk. The geothermal industry needs better tools for selecting better drill targets. The mining industry already has such tools and employs them. Statistical solutions are available which quantitatively rank drill targets based on a rigorous synthesis of all the available exploration data. These methods enable an explorer to prioritize drill targets from best to worst, while leaving transparent the multitude of reasons that one target is superior to another. Such an independent and quantitative approach is extremely valuable when used in conjunction with the expert opinion of geoscientists with decades of experience. This quantitative approach to drill targeting also provides independent validation of expert opinion (which may vary from expert to expert). I'm quite sure that more than one geothermal company has found itself in the position of having only enough funds to drill two or three wells while staring at a half-dozen seem-

ingly viable drill targets. Any tool that improves our ability to confidently select successful drill targets must be embraced by the geothermal industry.

Overall, in order to reduce resource risk, we in the geothermal industry need to spend more time doing our homework prior to commencing multi-million-dollar drilling programs. Due diligence in pre-drilling exploration is common in the oil & gas and mining industries, and can differentiate successful companies from unsuccessful ones. The geothermal industry would benefit greatly from having the patience to follow suit.

About the author:

Jeff Witter is a geoscientist by training, with a doctorate from the University of Washington. He joined the geothermal industry in 2008, when he led the exploration program at Sierra Geothermal Power Corp. His team at SGP was awarded two U.S. Department of Energy Innovative Exploration Technologies grants worth \$10 million, focused on the Alum and Silver Peak geothermal properties in Nevada. He is currently Senior Geoscientist and Acting Director of the Vancouver office of Mira Geoscience Ltd. in Canada. jeffw@mirageoscience.com - JW ♦



01 Field Work at Dorr Furmarole Field, Mt. Baker, U.S.

02 Jeff Witter

03 Investigating a geothermal system at Villarrica volcano in southern Chile

04 3D geological/geophysical models of McCoy area, central Nevada, U.S.

All Pictures: Jeff Witter

expertise. We need to convince the investment community that our geothermal exploration capabilities are rigorous, based on sound science, and better than mere concepts. We need to stop talking about 2D conceptual models. Instead, we need to construct data-rich 3D geothermal exploration models (like our friends do in the oil & gas and mining sectors). Such subsurface models are built from multiple lines of