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Submission on the IPGT High Temperature Downhole Tools Paper

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On behalf of the New Zealand Geothermal Association

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The New Zealand Geothermal Association (NZGA) would like to thank the International Partnership on Geothermal Technology (IPGT) for the opportunity to comment on the paper entitled "High Temperature Downhole Tools – Recommendations for Enhanced and Supercritical Geothermal Systems"[1].

The NZGA is an independent, non-profit association that provides information on geothermal phenomena and utilisation for industry, government and educational organisations. In addition, the NZGA, as a member of the International Geothermal Association, contributes to the international exchange of information within the geothermal development industry. NZGA membership comprises participants, regulators, and interested parties within the geothermal community. It totals 319 members currently.

New Zealand is not a signatory to the IPGT. NZGA continues to advocate within Government for this and makes this submission in expectation that eventually New Zealand geothermal industry and developers will benefit from IPGT developments.

Overall Organization of the Paper

We found this paper to be succinct, but somewhat disjointed. It would have been helped by an introduction that restates the brief given to the authors.

Following a statement of the scope of the report (through a restatement of the brief), the report should then have addressed the definition of "high temperature", rather than EGS. We recognise that EGS (Enhanced or Engineered Geothermal System) is a particular interest of IPGT, being an area requiring large investment in research and development. However, high temperature geothermal applications are broader than EGS, so a review of high temperature applications would cover the interests of IPGT while avoiding the need for some of the later discussion in the report about developing a suitable scale of application in order to reduce or spread development costs.

In New Zealand, we have some hydrothermal fields with measured reservoir temperatures of the order of 340°C. There are now programmes here to drill "hotter and deeper", which may somewhat parallel work being done in Iceland, though there is no immediate intention to

[1] http://internationalgeothermal.org/Working_Groups/High_Temperature_Tools.html

target magma. It is particularly in this “hotter and deeper” context that New Zealand will be interested in the further development of high temperature tools.

In looking at the content of the report, it seems to have restricted itself to instrumentation and control, whereas the expertise of the authors could readily have allowed a discussion of drilling tools and possibly of pumps. It could be that these aspects were excluded in the brief, as it is noted that IPGT has working groups associated with “lower cost drilling”, “zonal isolation/packers” and “stimulation procedures”. It is also noted that the US government is specifically encouraging the development of high temperature pumps, whereas pumped geothermal developments are currently limited to around 200^{o}C.

The report would also have been helped by a section which considered processes which may be experienced in a well. During drilling as an example, mud, water or foam will be injected into the well to undertake various functions. It could be that some required measurements and functions can be undertaken during these processes to avoid the need for high temperature functionality.

Finally, the paper should have a set of conclusions that summarises the findings of the paper and presents a possible future path for development.

Overall we were pleased with the content of this report, and know that the experience of the various contributors made for a well-founded and broad paper.

<u>The Section Entitled “Defining EGS”</u>

See earlier comments on what should have been placed at the front of the report.

Given that the subtitle for the report indicates a broader coverage than EGS, then perhaps this section should have been retitled and amended to cover the new geothermal environments requiring high temperature tools.

While this section does give a simple definition of EGS, there is no similar description in the report of “supercritical geothermal systems” referred to in the subtitle.

There seems to be an assumption that “high temperature” for an EGS environment does mean a capability to withstand 300 or 400^{o}C or more. However, until limitations with pumps are overcome, then high temperature for EGS development may mean 200^{o}C. There are exceptions such as that found in the old US Fenton Hill trials or in the Australian Cooper Basin developments.

Similarly this section could cover Hot Sedimentary Aquifers (HSAs) as are being targeted in parallel with EGS developments in Australia. A distinction is often made between these. It can be argued that the highest temperatures measured in Australian geothermal wells, while described as EGS developments, are actually in HSAs, particularly the Great Artesian Basin.

It should be kept in mind that there is always interest in enhancing production (or injection) from any geothermal resource whether the temperature is especially high or not. A degree of enhancement/stimulation is sought for ordinary hydrothermal fields, as well as those that may start with a high degree of impermeability.

If this section considered all of the new environments requiring the development of high temperature tools, then it could also cover the “hotter-deeper” hydrothermal environments envisaged for New Zealand where temperatures encountered are expected to be in the range between 340^{o}C and critical conditions around 374^{o}C.

Current State of Technology

The report could be enhanced with a comprehensive list of currently available technologies that have been applied in a geothermal / high temperature environment. The following is an example of some of the technologies that have been applied in New Zealand.

- Acoustic Formation Imaging Tool (AFIT), provided by Tiger Energy. A summary of its application at Wairakei was presented by Katie Mclean at the last Stanford Workshop.

- Downhole Fibre Optic sensing of well temperatures has been successfully applied by Western Oilfield Services in a geothermal environment. This technology can also be applied to pressure measurement. It remains to be seen how long this technology will survive in a geothermal environment.

- Downhole bubbler systems are a relatively low tech solution that has be applied in New Zealand for long term measurement of downhole pressure. These systems are low cost and can provide continuous pressure measurement in a high temperature environment.

Technological Needs

Technology development is critical to the success of geothermal development around the world. At present the available tools provide a reasonable suite of data for the resource characterisation. The immediate development needs in New Zealand are in the following areas.

- High temperature E-Field Measurements-while-Drilling (MWD) and Logging-while-Drilling tools to provide real-time data would be very useful, particularly when unbalanced drilling with aerated fluids when downhole pressure and temperatures are parameters that need to be carefully managed.

- High temperature steerable drilling assemblies with E-Field real-time control.

- High temperature reservoir characterisation tools (resistivity, porosity, density, seismic, etc) could also be useful, but further research is required to determine their application in a geothermal environment.

- Downhole production temperature measurement combined with 2-phase orifice plate flow measurement could provide real-time data on well performance.

Other Comments

Some recognition needs to be given to the future development in the geothermal space. Historically the industry has not had the support of the large industry players in the oilfield industry. However the size of the geothermal market is beginning to attract these large players as they see the opportunities that are available. For example, Schlumberger's recent purchase of GeothermEX and their desire to enter the geothermal space (http://www.slb.com/services/additional/geothermal.aspx). These companies have large R&D budgets and a wealth of resources and experience in the area. Aligning with these industry players will enable fast development of new technologies; however their level of support will ultimately be driven by the size of the market or potential market for these new technologies. Developments need to leverage off the existing and future market in "conventional" geothermal (hydrothermal systems) to drive tool development.

There is some discussion in the section on "Further Utilization" about material corrosion. We are aware that there is some risk of people reinventing the wheel here. Extensive work has been done on geothermal corrosion over many decades in New Zealand, including in fluids directly in touch with magma on a volcanic cone named White Island. This experience and associated expertise is available through a company called Quest Integrity in New Zealand.

The following advice has been provided by Quest Integrity:

1. The target of 500^{o}C for downhole tools might exceed the temperature limit for carbon steel (400^{o}C) but there are many low alloy steels and super 12% Chromium steels capable of operating up to 500^{o}C. Iron-nickel base alloys are capable of

pertaining up to 700°C, whereas nickel-based alloys and cobalt-based alloys can go much higher.

2. The NACE MR0175/ISO 15156 (2003) standard has 3 parts with Part 3 discussing corrosion resistant alloys for H_2S service. The standard should be adhered to for EGS applications as many of the existing and developed downhole environments will result in hydrogen charging of the alloys used and the failure mechanisms will be the same as when H_2S is present as in conventional geothermal. The near magma environments for example will produce gaseous H_2S and this will readily dissolve in any injected water. HCl may also be present giving risk of acid fluids.

3. The EGS discussion document has misinterpreted the NACE/ISO standard with regard to limitations on temperatures of 200-230°C. There are specific temperature/H_2S limits on some alloys and not on others. These limits describe Stress Corrosion Cracking susceptibility and clearly some alloys are only suitable for lower temperature service. Alloys having higher hardness are only suitable for higher temperature service i.e. > 105°C as below this temperature they may experience Hydrogen Embrittlement. Duplex stainless steel alloys are temperature limited to about 232°C because they embrittle at higher temperatures (at 270°C they might have a 10 year service life, at 400°C perhaps only a few months) but they are quite suited for many geothermal applications.

4. Selection of candidate materials for the EGS systems can be done with reference to other industries where similar environments are encountered and although this exercise is not trivial the EGS discussion document has not considered the process industry experience or downstream hydrocarbon processes that are at much higher temperatures. The selection process for instrument developers could be simplified by the development of a small alloy properties database that considers the downhole containment or operational needs, the likely environment and the expected performance of selected alloys as a function of time of exposure. Alloy availability might be an important parameter whereas at this stage cost might be later consideration. Once these materials limits are understood the developers may be encouraged to develop new designs that use these alloy properties to advantage. Testing would be focused on alloys having a high likelihood of success.

New Zealand is well placed to provide advice on materials for higher temperature geothermal applications. Currently Quest Integrity does not have government funding to participate in a research activity but it is prepared to provide such service worldwide in a consulting capacity.

Once again, thank you for the opportunity to comment and we trust you will find these comments helpful.

Yours faithfully

Brian White
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New Zealand Geothermal Association