

AGEG TIG Reports for AGEN Meeting # 5, 20 – 21 November 2008

1. TIG #4: Enhanced (Engineered) Geothermal Systems

2. TIG Leader(s) names with affiliation and email address:

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3. TIG Members names with affiliation:

Roy Baria	Geodynamics
Rob Jeffrey	CSIRO
Richard Hillis	Australian School of Petroleum
Martin Hand	University of Adelaide
Graham Heinson	University of Adelaide
John Foden	University of Adelaide
Yung Ngothai	University of Adelaide
Brian O'Neil	University of Adelaide
Allan Pring	University of Adelaide
Joel Brugger	South Australian Museum
Guillaume Backe	University of Adelaide
Anthony Budd	Geoscience Australia
Bruce Ainsworth	Australian School of Petroleum
Adrian Williams	Geodynamics
Adrian Larking	Greenrock Energy
Chris Matthews	Torrens Energy
Bertus de Graaf	Panax Geothermal
Graeme Beardsmore	Hot Dry Rocks
Phillippe Calcagno	BRGM
Peter Reid	Petratherm
Barry Goldstein	PIRSA
Tony Hill	PIRSA
Alexandra Long	PIRSA

4. Scope of TIG

Objective: Investigate technologies for enhancing geothermal reservoirs for commercial heat extraction

List of sub-TIG Topics:

Key issues to be addressed by TIG #4 include but not limited to:

Reservoir characterisation	3D Stochastic modelling and simulation of fracture networks
Fracture stimulation	Geochemistry, Corrosion and Scaling

What's not (and why)?

5. Lessons learnt

what has worked well?

what can work better?

ideas for improving performance:

6. Initiatives

Complete:

A PIRSA report titled 'A Steady-State Pressure Model for Water Flow in a Hydraulically Fractured Geothermal Reservoir' by William Cibich that includes a model that runs under Microsoft Excel was completed in February 2008

Tied Grant 4.3: Full life cycle water requirements for deep geothermal energy developments in South Australia – Draft report submitted by Hot Dry Rocks Pty Ltd for peer review in November 2008.

In Progress:

A number of Tied Grant projects are in progress including:

- Geochemistry, Corrosion and Scaling in HDR Energy Extraction Systems
- Adelaidean reservoir characterisation
- 3D reconstruction of the Adelaide Geosyncline

Planned:

- Compile a list of available numerical models (algorithms) for fracture characterisation and then evaluate these to determine the best model as well as the benefits and disadvantages of each. (Literature review plus model 'shootout').
- Scan for pre-existing Geothermal Data Handbooks and build up to include information learnt from overseas projects and to date from Australian projects.
- Promote international collaboration: create scholarships for students to study under experts overseas and to bring the knowledge back to Australia, also aim to bring technical experts to Australia to hold technical workshops going into detail on certain topics of interest.
- A literature review of EGS logging tools such as image logging, bore hole measurements etc. What tools should be used, which are the best to use, and what is not of value?
- Develop 3D stochastic modelling and simulation of fracture networks and fracture propagation in crystalline rocks (P A Dowd & C Xu, University of Adelaide) – see attached Project Outline.

Three-dimensional stochastic modelling and simulation of fracture networks and fracture propagation in crystalline rocks (P A Dowd and C Xu).

The following aims will build on previous innovative, internationally acknowledged, approaches to develop an integrated, three-dimensional, stochastic spatial modelling framework for the simulation of more reliable and realistic fracture networks for geothermal engineering applications.

Data integration

Aim 1. Derive a systematic and consistent framework for integrating the various types of data to obtain reliable and consistent parameters for stochastic models.

Stochastic conditional simulation of fractures and fracture networks

Aim 2. Incorporate multivariate spatial correlations in the stochastic fracture model so that more realistic fracture simulations can be achieved.

Aim 3. Establish a stochastic fracture propagation model for geothermal reservoir stimulation.

Aim 4. Derive a framework for conditioning three-dimensional fracture simulations by two-dimensional fracture data.

Generic assessment of simulated fracture networks

Aim 5. Derive a three-dimensional connectivity index as a generic property model to describe the flow characteristics and mechanical behaviour of three-dimensional fracture networks.

7. Tabulation of projects

Theme	Project Name	Summary of key project objectives, Key Contact and Links to Details	Research Partners
AGEG TIG 4 Engineering EGS	Geochemistry, Corrosion and Scaling in HDR Energy Extraction Systems	Determine the effect of variations in geochemical composition of circulating water on clogging of fracture networks in reservoir rock. Budget: \$110,000 (50% from sector participants)	<ul style="list-style-type: none"> ◆ U Adel (Ngothai & O'Neil) ◆ S.A Museum (Brugger) ◆ Ian Warke Inst. U of SA (Pring) ◆ Geodynamics (Wyborn) ◆ Petrathern (Reid) ◆ Eden Energy (Jeffress) ◆ Greenrock (Larking) ◆ Geothermal Resources (Johnson) ◆ PIRSA (Malavazos)
AGEG TIG 4 Engineering EGS	Full life-cycle water requirements for deep geothermal energy developments in South Australia	Water requirements for each step of geothermal through production will be quantified. An atlas of available water resources; processes for accessing these resources; and (possibly) software for calculating water requirements for specific projects will be developed. The aims are to allow individual project managers to manage water availability, and the industry to counter potential community concerns over water use for geothermal projects. Budget: \$33,000 (\$12,375 from PIRSA Tied Grant; balance from sponsor participants)	<ul style="list-style-type: none"> ◆ Hot Dry Rocks Pty Ltd (HDRPL: Beardsmore, Baria, Cordon, Walsh, Waining & Cooper) ◆ PIRSA (Hill) ◆ Panax (de Graaf)
AGEG TIG 4 Geology EGS	Adelaidean reservoir characterisation	Characterise Adelaidean rocks for their potential to serve as heat exchange reservoirs within geothermal insulators and potential for geosequestration reservoirs in the vicinity of coal-fired electricity plants in the Port Augusta region Budget: \$55,000 (\$27,500 from PIRSA Tied Grant; balance from sponsor participants)	<ul style="list-style-type: none"> ◆ U Adel. (Ainsworth) ◆ Petrathern (Reid) ◆ Eden Energy(Jeffress) ◆ Torrens (Matthews) ◆ PIRSA (Hill)
AGEG TIG 4 Geology EGS	3D reconstruction of the Adelaide Geosyncline	Produce a geologically and geophysically sound 3D model of the Adelaide Geosyncline from studies of outcrop geology (existing geological maps, satellite images analysis, field work) and potential field data (gravity and magnetic data) interpretation and forward modelling. Budget: \$248,324 (\$27,858 via PIRSA Tied Grant; balance from sponsor participants)	<ul style="list-style-type: none"> ◆ U Adel. (Backe & Giles) ◆ U of Pau (France); ◆ U of Toulouse (France) ◆ HDRPL (Beardsmore) ◆ Torrens (Matthews)

8. Teleconference on the topic of the AGEG Enhanced Geothermal Systems Technical Interest Group Priorities and Future Directions (3 PM, 29 September 2008). Present: Professor Peter Dowd, Doone Wyborn, Barry Goldstein, Alexandra Long

Through involvement with the EGS task group/Annex of the IEA (via Roy Baria on behalf of Geodynamics), four different fields of work have been identified:

1. Application of conventional Geothermal practices and technology to EGS
2. Data acquisition
3. Reservoir evaluation and characterisation to underpin predictive reservoir modelling
4. Geochemical studies – (rock - fluid interaction) predominantly concerned with scaling, corrosion and dissolution.

The priorities of these fields of work are (1) Reservoir Evaluation and (2) Geochemical studies. (Doone)

Some work is currently in progress at the University of Adelaide on the topic of geochemical studies, by a team led by Dr Yung Ngothai.

Professor Dowd informed that there is a grant application in progress for a project on the characterisation of fractures in rock masses, to identify networks and potential reservoirs. This work previously was focussed on a burial model for disposal of nuclear substances. The extension of this work fits well into the reservoir evaluation task. The project involves a stochastic fracture analysis model with software written specifically for this model as the accuracy and flexibility of available models on the market were not convincing. The model will be available via the University of Adelaide website.

It was agreed that a worthy project would be to create a 'menu' of available numerical models and then evaluate these to determine the best model as well as the benefits and disadvantages of each (reservoir model shoot-out).

Predictive reservoir characterisation would be beneficial to make it easier to know what to measure and how much to measure in order to know the fracture structure.

EGS characterisation should be a priority. Heat producing granites may or may not be homogeneous.

- o Determine the reliable extent of extrapolating well data.
- o Are characteristics specific to each well?
- o A geothermal reservoir data *EGS Handbook* (rock catalogue for EGS) should be created – containing all current data, or where and how to access existing data, and guidelines for characterisation
- o We should add how to access all of this information on the AGEG website.
- o Could use the Cooper Basin as a case study, and build on/extend this over time.
- o Use information and examples from other projects on this topic – e.g. the Japanese projects had open systems and Fenton Hill had tight systems – how did they manage these?
- o Include digitised well log data? There is data available already for Fenton Hill, Soultz and Rosemanowes – a DoE database incorporates all of these. Data handbook.
- o Look at methods to transform well log data into rock property information for models.
- o In the *EGS Handbook* – also include topics of water management. There are three systems to consider – open, tight and over pressured. What kinds of processes are required to manage water in each of these three systems?

Another topic is the use of tracers - there is a wealth of knowledge out there – it would be useful to distribute this to people to explain how to use tracers. Details of geochemical studies should be included.

Include site selection as a chapter:

- o What information is needed in order to select a site?
- o For example, outline the basic geological principles, parameters of rocks, fractures, range of thermal conductivities (vertical and horizontal) of rock types and of minerals etc.

A literature review could be completed by an honours student on EGS logging tools such as image logging, bore hole measurements. What tools should be used and what is not of value? Look at advanced logging technology. Could involve Schlumberger and Halliburton. Sandia has experience – but is restrained in criticism of tools it is offered an opportunity to review

For many topics, there are people and institutes overseas and around Australia with a high level of understanding (such as Peter Rose at the University of Utah on the subject of the use of tracers).

Scholarships should be created for students to study under these experts overseas and to bring the knowledge back to Australia. (requires funding)

Also aim to bring technical experts to Australia – hold technical workshops over a few days going into detail on certain topics of interest.

Ideas for workshops: University of Auckland on the topic of measuring micro seismicity and the deployment of measurement stations and the following data analysis.

Who else would be of interest to ask to come to Australia for a one day workshop? (Who is the 'best in the business'?)

On the topic of rock characterisation – who is working on this? Companies are gathering information together. Professor Dowd would like to contact others working on this (including Rob Jeffries at the CSIRO)

The topics that have been suggested are of high priority – the information is required to be of high quality.

In summary there were four main projects to come out of this meeting:

1. Compile a list of available numerical models (algorithms) for fracture characterisation and then evaluate these to determine the best model as well as the benefits and disadvantages of each. (Literature review plus model 'shootout').
2. Scan for pre-existing Geothermal Reservoir (Field) Handbooks and build up to include information learnt from overseas projects and to date from Australian projects.
3. Provide funding for international collaboration: create scholarships for students to study under experts overseas and to bring the knowledge back to Australia, also aim to bring technical experts to Australia – hold technical workshops going into detail on certain topics of interest.
4. A literature review could be completed by an honours student on EGS logging tools such as image logging, bore hole measurements...What tools should be used, which are the best to use, and what is not of value?