



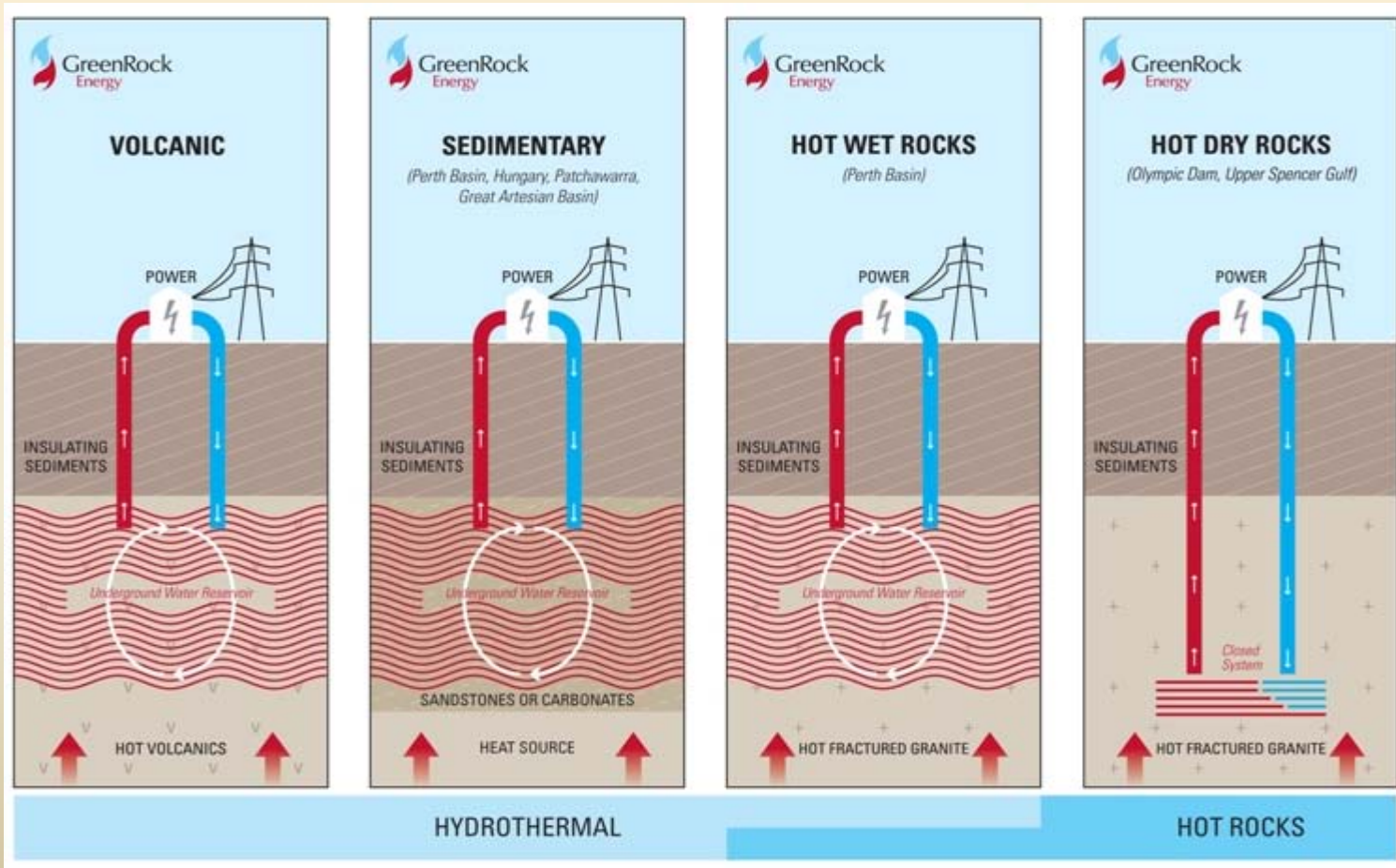
Enhanced Geothermal Systems – The Technical Challenge

Melanie Vonthethoff

AGEG TIG 11 – Drilling and Well
Construction



Types of Geothermal

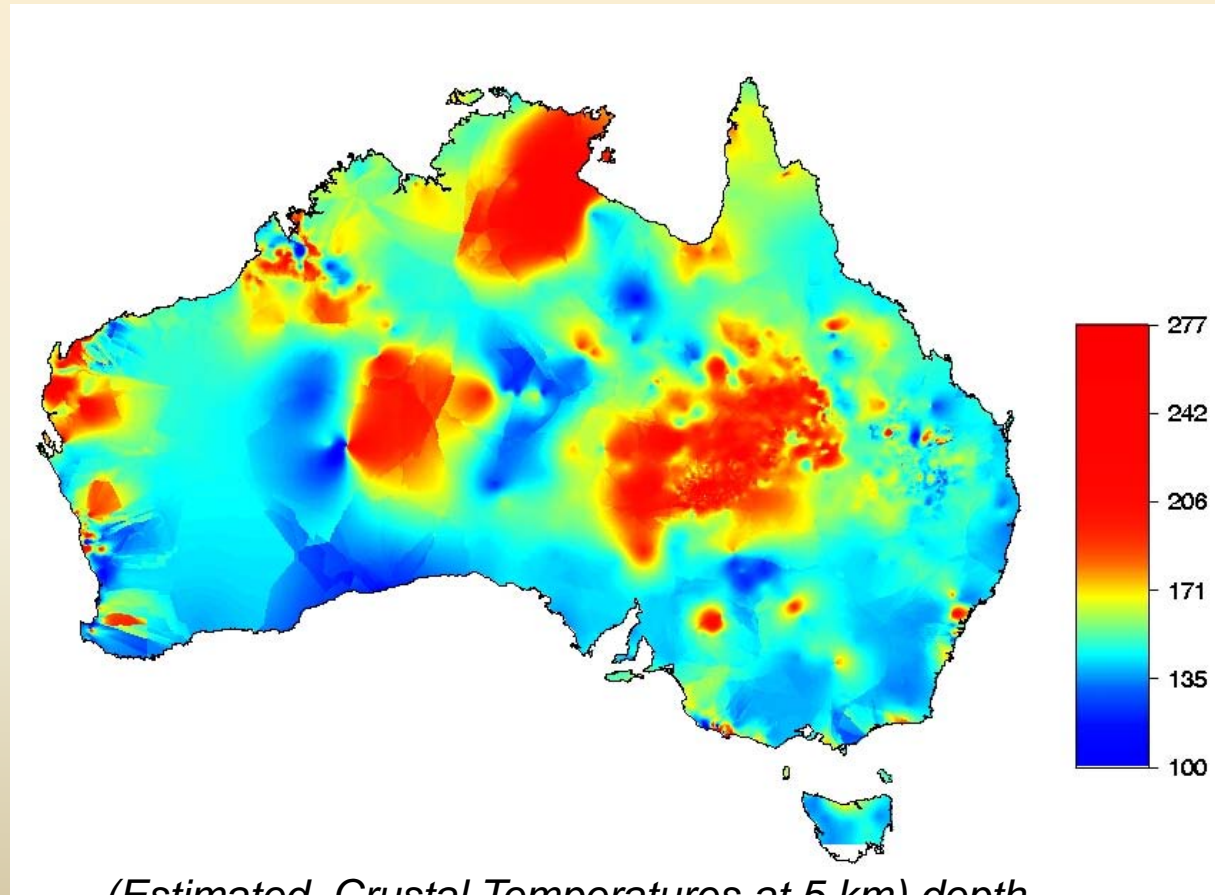




Australia vast resource potential

- 48 Geothermal Companies
- >US\$1.2 Billion

- GDP
 - AU\$ 49Million
- Geodynamics
- Petratherm
- Torrens Energy
- Greenrock
- Hot Rock Ltd
- Greenerth Energy
- Panax Geothermal



(Estimated Crustal Temperatures at 5 km) depth

Map derived from the AUSTHERM05 database of Chopra & Holgate 2005.
Image is 2007, Dr Prame Chopra, Earninsite.com Pty Ltd.

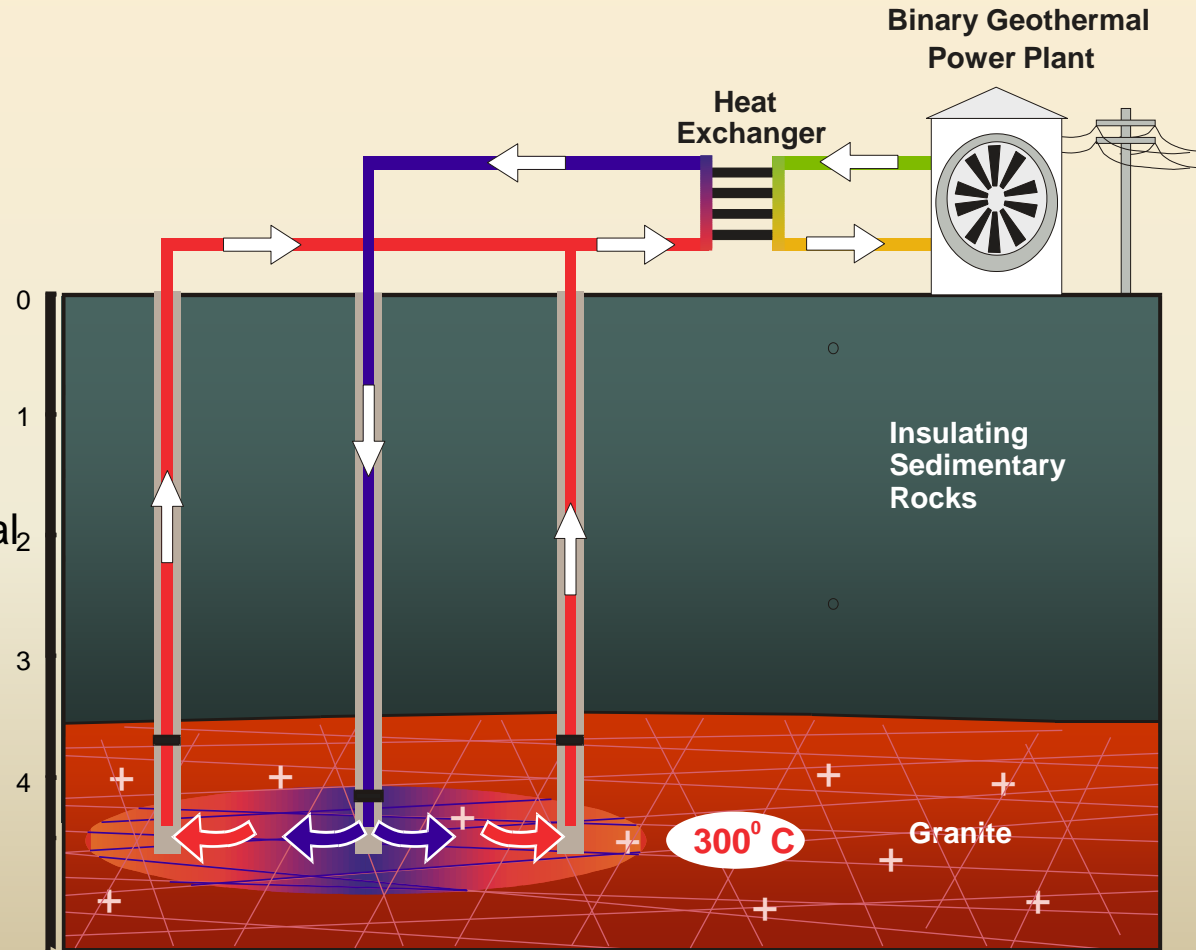


Enhanced Geothermal Systems

- **Reservoir In Place**
 - Hot (300°C @ 5,000m)
 - Pre-existing fracture system
 - Water-saturated
 - Over-pressured

- **Core Technologies Exist**
 - Oil and gas industry
 - Conventional geothermal₂ industry
 - Conventional power generation

- **Closed Loops = Zero Emissions**
 - Injector / Producer sets





Differences between Oil and EGS Wells

- Reservoirs

- Granites, water filled and dry fractures
- Crystalline hard igneous vs sedimentary rocks
- Reservoir fluids, sour and altered. Acidic gases, superheated fluids.
- Some reservoirs overpressured
- Fracture permeability rather than matrix permeability
- Typically in highly stressed regions
- High reservoir temperatures (285°C at 5000m)
- Reservoirs typically need to be simulated to improve permeability. Primarily improves permeability through shearing rather than creating new fractures.
- Stimulation propagates single fractures such that zonal isolation is required for reservoir development.





- Casing Design
 - Extreme changes in temperature during installation, stimulation, production and injection
 - High axial loads in casing strings
 - Casing design needs to consider;
 - cycling loading
 - annulus pressure build up and
 - material selection
 - Sour service and the behaviour of fluids at extreme temperatures will influence material selection

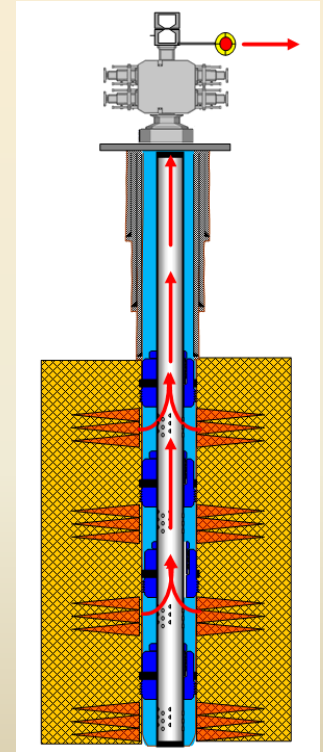
- Cement Design
 - Limitation of Portland cement based formulations to temperature and corrosive formation fluids in some cases.
 - Thermal cycling of brittle cement chemistries will result in poor CBL over time and channelling of fluids
 - Alternatives required such as Calcium Aluminium Phosphates.



- Drilling fluids
 - WBM are typically used to reduce potential damage to fractures. Oil based muds would tend to be lost to fractures more readily and then form damaging emulsions.
 - Fractures are more prone to damage from high solids laden drilling fluids than matrix permeability
 - UHT (>177°C) viscosifying polymers do not exist in the oilfield. Only clays will remain stable at EGS type temperatures.
 - At UHT the characterisation of fluids are modified significantly. Reaction kinetics, solubilities, viscosities, corrosive properties become severely altered.
 - Flowline temperatures are extremely high. HSE concerns, deterioration and corrosion of surface equipment. Significant mud cooling is required.
 - Evaporation is high.
 - Mud properties on surface do not reflect mud properties downhole.
 - There is now testing equipment in Australia which can test to EGS temperatures.
- Logging
 - Temperature limitations on wireline and logging tools. Particularly with electronic components.



- Drilling related issues
 - Hard rock drilling
 - Ultra HT environment – limits bit life, limits availability of tools – MWD, motors, directional drilling (back to basics)
 - Drillpipe corrosion a significant issue. Corrosion resistant coatings for DP not readily available in Ultra HT environments
- Completions
 - Compressive and tensile loading extreme – depending on well type and if well is simulated.
 - Large variations in temperature currently preclude use of wells as swing producers/injectors. Wells must be design for one or the other.
 - Ultra High Temperature elastomers required (sealing systems and packers)
 - Stress Load cases drive requirement for non-standard tubing casing sizes.
 - Completion equipment often bespoke design.
 - Significant borehole breakout requires high expansion ratio sealing systems to effect isolation between fracture intervals.





Sharing knowledge

- AGEG – Australian Geothermal Energy Group
 - TIG 11 Well Construction and Drilling
- IPGT – International Partnership for Geothermal Technology (USA, Australia and Iceland)



AGEG TIG 11 / IPGT – Drilling and Well Construction

- Lower cost drilling (optimised performance)
- Zonal Isolation
- Temporary sealing of fractures
- Lower Cost Exploration Drilling
 - Deep Slimhole Exploration Group



Events of Interest

- TIG 11 monthly conference call
 - Next meeting - June 9
 - To join email: lauren.barendrecht@geodynamics.com.au
- Australian Geothermal Energy Conference
 - Adelaide, November 17 – 19
 - www.ausgeothermal.com
- World Geothermal Congress 2015
 - Jointly hosted Australia and New Zealand
 - Melbourne



Thank you!