

AUSIMM NELSON DISCUSSION GROUP (NDG)

"Enjoying learning from each other"

Induced Seismicity and Mineralizing Process: EQ Uses and Abuses

Emeritus Professor Rick Sibson, Geologist

5.00pm Friday 13 May 2016

Differential stress is ubiquitous in the Earth's crust within plate interiors as well as along plate boundaries, with seismogenic crust generally partitioned into the three 'Andersonian' stress provinces critically stressed close to brittle/frictional failure. Formation and reactivation of faults and fractures is induced by two principal drivers - increasing differential stress ($s_1 - s_3$), and/or pore-fluid pressure, P_f . Three basic varieties of brittle failure may occur within intact rock - formation of extension fractures, formation of shear fractures or faults, and formation of hybrid extensional-shear fractures. However, if existing planar fractures are favourably oriented for re-shear, they may be reactivated and inhibit other forms of fracturing.

In recent years, injection of fluid into the crust down boreholes (mostly with $z < 5$ km, but up to 9 km deep for the KTB borehole) has become a standard industrial technique for *enhancing fracture permeability* at depth applied to: (1) enhanced oil/gas extraction by 'fracking' of tight reservoir rocks; (2) heat mining by circulating fluid through hot rock in enhanced geothermal systems (EGS); (3) deep disposal of waste fluids into the basement; (4) CO₂ capture and storage (CCS); and (5) solution \pm bio-mining. The type of fractures that develop and their orientation depend on the level of differential stress relative to rock tensile strength and the orientation of the tectonic stress field. While in some cases these may be reasonably well known, the presence of inherited fault-fracture systems (often unknown) in the basement, with potential for reactivation presents a hazard. In Oklahoma, where deep disposal of waste brines from oilfields has become widespread over the past 6-7 years, seismicity has increased by nearly 3 orders of magnitude with events ranging up to $M 5.7$.

Notably, much hydrothermal mineralization is hosted on faults of comparatively low displacement, or has developed at 'sweet-spots' within an existing fault-fracture system. The implication may be drawn that hydrothermal mineralization develops through analogous processes involving focused injection of (over-pressured?) hydrothermal fluids: (1) into near-intact crust, self-generating and mineralizing low-displacement fault-fracture meshes; or (2) at localities along existing fault systems, activating and extending existing faults and fractures.

Rick graduated with BScHons in Geology from the University of Auckland in 1968 before gaining an MSc and PhD (1977) from Imperial College, London, researching the structure of the Outer Hebrides Thrust zone. He taught structural geology at Imperial College (1973-1981) and at UC Santa Barbara (1982-1990), before returning to New Zealand as Professor of Geology in the University of Otago (1990-2009). His research focuses on the structure of crustal fault zones and the mechanics of shallow crustal earthquakes with coupled interests in crustal fluid flow and dynamic controls affecting the development of fault-hosted mineralisation.

What: *Seismicity and Mineralizing Process: Uses and Abuses of human induced earthquakes and faulting*

When: Friday 13 May 2016 5pm

Refreshments: Wine selection, beer, soft drinks and gourmet finger food

Where: Golder Associates (Level 3, 295 Trafalgar Street) - above Café Affair -

Corner of Selwyn Place and Trafalgar St. Entry at back. Contact Carol Foote, 03 548 1707 for assistance

Parking: Available Selwyn Place or Trafalgar Square

PREVIOUS MEETING: *Geology- A Mining Engineers' Perspective: What mining engineers need geologists to be!* **Al Tattershall, Mining Engineer.** Regardless of the arousing title, Al led a discussion on how professionals in different disciplines must work together and align their inputs and capabilities and the consequences of not doing so. Adventures and misadventures were explored arising from both alignment and lack thereof. One area of concern pertained to the hiatus between exploration teams and development teams where the explorationists move on and developers are unaware of some important aspects of their findings and knowledge.

FUTURE EVENTS: June 10: *Geometry and reactivation history of inverted faults in the Taranaki Basin: Controls on petroleum traps and migration:* Francesca Ghisetti

• **Proposed:** *Geology and Mining Field Excursions to Cobb Valley(Springtime) and D'urville Island (Summertime)*

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