UNIVERSITÀ DEGLI STUDI DI TRENTO

Dipartimento di Ingegneria Civile, Ambientale e Meccanica

Data	**16 maggio 2013**
Ora	**14:30-16:30**
Luogo	**2B, Mesiano**

Creep fractures control plate tectonics

Prof. Klaus Regenauer-Lieb

School of Earth and Environment, University of Western Australia

Abstract

According to our current understanding, the mechanical behaviour of Earth's tectonic plates is governed by the strong brittle-elastic top of the crust. At a temperature of about 300°C, rock strength is controlled by slow ductile creep, which is thought to relax elastic stresses and thus to suppress earthquakes and localized deformation. Therefore, the brittle regime appears to control earthquakes and the formation of localized fault zones such as plate boundaries. Recently, numerical models and measurements of episodic tremors indicate that deformation of the strong brittle crust may be driven from below. Thus, the question arises: who is the master and who is the slave during the deformation of Earth's plates? We present new evidence from deep wells in Central Australia tapping into hot granite and numerical simulations indicating that ductile shear zones are indeed the main driver for the deformation of the plates. Our field data reveal fractures in the granite that terminate upwards at a temperature of 230°C. Fracture stimulation surprisingly led to a downward propagation of new fractures into the ductile regime. Moreover, fluids harvested from these fractures are of deep igneous origin with no connection to surface waters. Numerical models considering creep damage suggest that episodic creep fractures supported by high fluid pressures can explain these unexpected observations. Our findings provide a new explanation for longstanding paradoxa 1, 2: (1) pervasive and localized fluid transfer through dense, hot crystalline rock; (2) slow earthquakes in the ductile regime; (3) the seismic reflectivity of the lower crust; and (4) the low electrical resistivity of the lower crust. This new perspective paves the way for a fresh look at the generation of earthquakes, mining and exploration of deep-earth resources, and the long-term mechanics of the Earth.

Compaction Band formation: Acoustic instability or creeping flow pattern?

Dr. Emmanuil Veveakis
CSIRO, Earth Science and Resource Engineering, Australia

Abstract

Compaction bands are periodic localized features that form during irreversible compression of porous Earth Materials and especially reservoir rocks. Natural Earth materials are porous media, filled with fluids (liquids, gases or combinations thereof), therefore mechanical compaction is competing with the capability of the fluid to diffuse. Most studies so far have focused on a description of the mechanical dissipation during compaction and have ignored the fluid diffusion. Here it is shown that by including the fluid feedback, the elastodynamic failure mode of compaction band -expressed through the eigenvalue problem of the acoustic tensor- could turn into a creeping flow pattern. The addition of the fluid along with the required viscous regularization provides a simple bifurcation pattern, and an analytic solution for the observed periodicity of compaction bands. This finding allows a robust physical model of compaction based on the essential fluid and solid dissipation mechanisms involved, and provide a powerful scaling relationship for periodic compaction bands, correlating periodicity with hydromechanical parameters. We show that compaction band formation does not necessarily require extreme loading conditions, as suggested by brittle failure considerations, but could readily appear in the creeping flow regime. Based on this we infer that compaction bands may be more widespread than previously thought as they can appear under previously overlooked natural slow loading conditions.

Thermo-chemo-mechanics of fault reactivation: Solving the paradox of earthquakes in the ductile regime

Dr. Emmanuil Veveakis

Abstract

Rocks at depth move on tens of kilometers in millions of years, but sometimes in an unusually lubricated narrow shear plane, as thin as millimetres. Famous examples include the exposed Glarus, Mc Connell and Naukluft Thrusts. Those thrusts typically display a layer of about 1m thickness with highly localised deformation in its centre. Geological observations and experimental evidence independently infer repeated slippage events, similar to the observed episodic tremors in subduction zones. How is it possible to explain those highly localised events in a high temperature domain where rocks tend to deform by slow and pervasive ductile creep? Here we resolve this paradox and show that the coupling of two fundamental feedback processes, namely shear heating and chemical pressurization, can explain the observations. We present a theoretical thermo-chemo-mechanical model which reconciliates all observations in a time sequence where slow creep deformation raises the temperature in the shear zone through shear heating, activates chemical decomposition, releasing highly over-pressured fluids and lubricating a very localised high strain zone at the centre. The theory also explains displacements of tens of kilometers on mm-cm thick bands, as well as the periodicity of those fast events. We thereby explain the local source of highly pressurised fluids that was previously assumed to access and fracture the rock formation. This finding provides a coherent and quantitative causal relationship between the episodic tremors in Megathrusts and geological observations in exposed thrust systems. This fundamental approach provides chronological explanation of the episodic tremors and opens new ways for understanding and quantifying the physics of earthquake mechanisms in the ductile realm.

Enquiries to: Dr Francesco Cecinato, francesco.cecinato@unitn.it, tel. 2585