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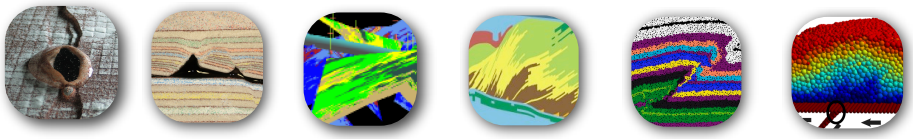

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Organization

GeoMod2018 is organized mainly by the Geomodels Research Institute (University of Barcelona) and the Institut de Ciències de la Terra Jaume Almera (ICTJA - CSIC). Specifically by:

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Dr. Oriol Ferrer García (UB)
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Topic sessions

ORAL CONTRIBUTIONS

- **Deformation geometries controlled by weak layers in the crust and lithosphere** (Ernst Willingshofer, Dimitrios Sokoutis, Antoine Auzemery, Katharina Vogt and Stefan Luth) (***keynote***)
- **New improvements on LitMod package: A tool for integrated geophysical-petrological modelling of the crust and upper mantle** (Ajay Kumar, Manel Fernàndez, Ivone Jiménez-Munt, Montserrat Torne and Jaume Vergés)
- **Influence of acial mechanical strength on the morphology and dynamics of mid-ocean ridges: From laboratory experiments to the Earth and Venus** (Anne Daville, Eric Mittelsteadt and Aurore Sibrant)
- **Effect crustal heat production and mantle potential temperature on rifting and break-up: Insight from 2D and 3D modelling** (Laetitia Le Pourhiet and Julia Costa da Sousa)
- **Factors controlling back-arc extension or overriding plate shortening – a numerical modeling study of ocean-continent subduction systems** (Sebastian Wolf and Ritske Huismans)
- **The interplay between slab's morphology and kinematic and surface topography** (Arthur Briaud, Roberto Agrusta, Claudio Facenna, Francesca Funiciello and Jeroen van Hunen)
- **Backarc rifting behind narrow oceanic basins** (Zoltán Erdős, Ritske S. Huismans and Claudio Faccenna)
- **Continental ice sheets and continental break-up** (John Armitage, David Ferguson, Kenni Petersnen and Timothy Creyts)

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- **Ambiguous kinematic indicators resulting from heterogeneities under high finite strain** (Bernhard Grasemann and Marcin Dabrowski) (***keynote***)
- **Strain localisation and weakening processes in viscously deforming rocks: Numerical modeling based on laboratory torsion experiments** (Maximilian Döhmann, Sascha Brune, Livia Nardini, Erik Rybacki and Georg Dresen)
- **Physical modelling of a single round inclusion in simple shear: impacts of strain-softening rheology** (Laura Quigley, David Boutelier, Christoph Schrank and Klaus Regenauer-Lieb)
- **Numerical modeling of shear localisation in anisotropic materials** (Tamara de Riese, Lynn Evans, Enrique Gomez-Rivasm Albert Griera, Ricardo A. Lebensohn, Maria-Gema Llorens, Hao Ran, Till Sachau, Ilka Weikusat and Paul D. Bons)
- **How a state- and rate-dependent friction and its coupling to porosity evolution influence the deformation dynamics of the lithosphere** (Antoine B. Jacquey and Mauro Cacace)
- **Lithosphere weakening mechanisms influenve on subduction zones migration** (Jessica Munch, Taras Gerya and Kosuke Ueda)
- **Opening of the Porcupine Basin – Numerical and analogue models** (Bruno C. Vendeville, Louise Watremez, Tom Detollenaere, Laetitita Le Pourhiet and Cédric Bulois)
- **The emergence of heterogeneities during rifting and their controls on long-term continental lithosphere extension** (V. Morena Salerno and Fabio A. Capitano)

S6 – Geofluids and their influence on deformation… Pag. 87

- **Mechanical behavior of fluid-lubricated faults** (Chiara Cornelio, Elena Spagnoulo, François Passelègue, Stefan Nielsen, Giulio Di Toro and Marie Violay) (***keynote***)
- **Fluid-assisted mobilization of particles in sheared granular media: 3D CFD-DEM simulation of stick-slip dynamics in faults with granular gouge** (Omid Dorostkar, Paul Johnson, Robert Guyer, Chris Marone and Jan Carmeleit)
- **The coupling between compaction and pressurization in cyclically sheared granular layers: Implications for soil liquefaction** (Einat Araronov, Shahar BenZeev, Liran Goren, Parez Stanislav and Toussaint Renaud)
- **Fluid flow within the mechanical stability domain of fault zones in shales** (Frédéric-Victor Donze, Alexandra Tsopela, Yves Guglielmi, Pierre Henry and Claude Gout)
- **Fluid escape structures from reacting and deforming rocks** (Yury Podladchikov) (***keynote***)
- **Fluid injection in single fractures: Induced seismicity and influence on the fracture slip regime** (Guillem Piris, Enrique Gomez-Rivas, Ignasi Herms, Xavier Goula and Albert Griera)
- **Appraising the link between tectonics and natural hydraulic fracturing coupling geomechanical and basin simulation: Application to the Neuquen Basin** (Renaud Traby, Nicolas Guy, Antoine Bouziat, Daniele Colombo, Jeremy Frey, Marie-Christine Caca-Stenz and Tristan Cornu)

Fluid injection in single fractures: induced seismicity and influence on the fracture slip regime

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S6 Geofluids and their influence on deformation

Introduction

The so-called Enhanced Geothermal Systems (EGS) are characterized by a stimulation phase that aims to increase fluid flow and heat transfer between wells by increasing the permeability and transmissibility of the reservoir. This is achieved by injecting fluids at high-pressure in order to increase the apertures of existing fractures, enhance their sliding and/or generate new ones. However, this technique induces low-magnitude seismicity that occasionally results in damage at the Earth's surface. Numerical simulations able to reproduce the hydro-thermo-mechanical behaviour of geological reservoirs are an essential tool for the evaluation and forecasting of induced seismicity in such systems. In this study, the numerical code CFRAC (e.g. McClure, 2012) is used to systematically evaluate how the orientation of fractures with respect to the maximum compressive stress (□) influences seismicity, the injection rate and the fracture sliding behaviour.

Results

The results show that three main seismic regimes can be distinguished. The first type are orientations that do not require a large fluid overpressure patch on the fracture before the onset and nucleation of a seismic event. A small perturbation of strength is enough to produce a critical load and fracture reactivation. The size of the rupture surface is larger than the size of the pressurised patch, and therefore, slip along the fracture can expand outside of the pressurised front leading to situations of uncontrolled rupture propagation. The fractures oriented between α =40º and α=14º follow this behaviour.

The second type of response is defined by fracture orientations that require longer injection times before the onset of fracture slip. In this case, the onset of dynamic slip requires that a large part of the fracture is first uniformly pressurised. Seismic events in this case are not located near the injection point, but into the pressurised front. They are characterised by high slip velocities and surface run-outs that can expand outside of the pressurised region, but are still able to produce rupture surface along the whole fracture distance. The fracture orientation ranges between 5º≤ α <14º and 40º≤ α ≤45º. Finally, a third case with the fracture oriented $\alpha \leq 5º$ can be defined. In this case, dynamic slip is not observed and fracture propagation is arrested due to the increase of the dynamic friction coefficient during the raise of the slip velocity. The accommodation of loading, and therefore the accommodation of a finite displacement along the fracture, takes place by means of slow motion events (i.e. low-magnitude seismicity) or by aseismic flow.

References

Piris, G., Griera, A:, Gómez-Rivas,E., Herms, I., Goula, X. (2017). Induced Seismicity in pressurised single fractures a numerical approach. Geogaceta, 61, 95-98.

McClure, M. W. (2012). Modeling and Characterization of Hydraulic Stimulation and Induced Seismicity in Geothermal and Shale Gas Reservoirs, PhD dissertation, Stanford University, Stanford, California, 349 p.

Keywords

Induced seismicity, EGS reservoir, discrete fracture, fluid injection.

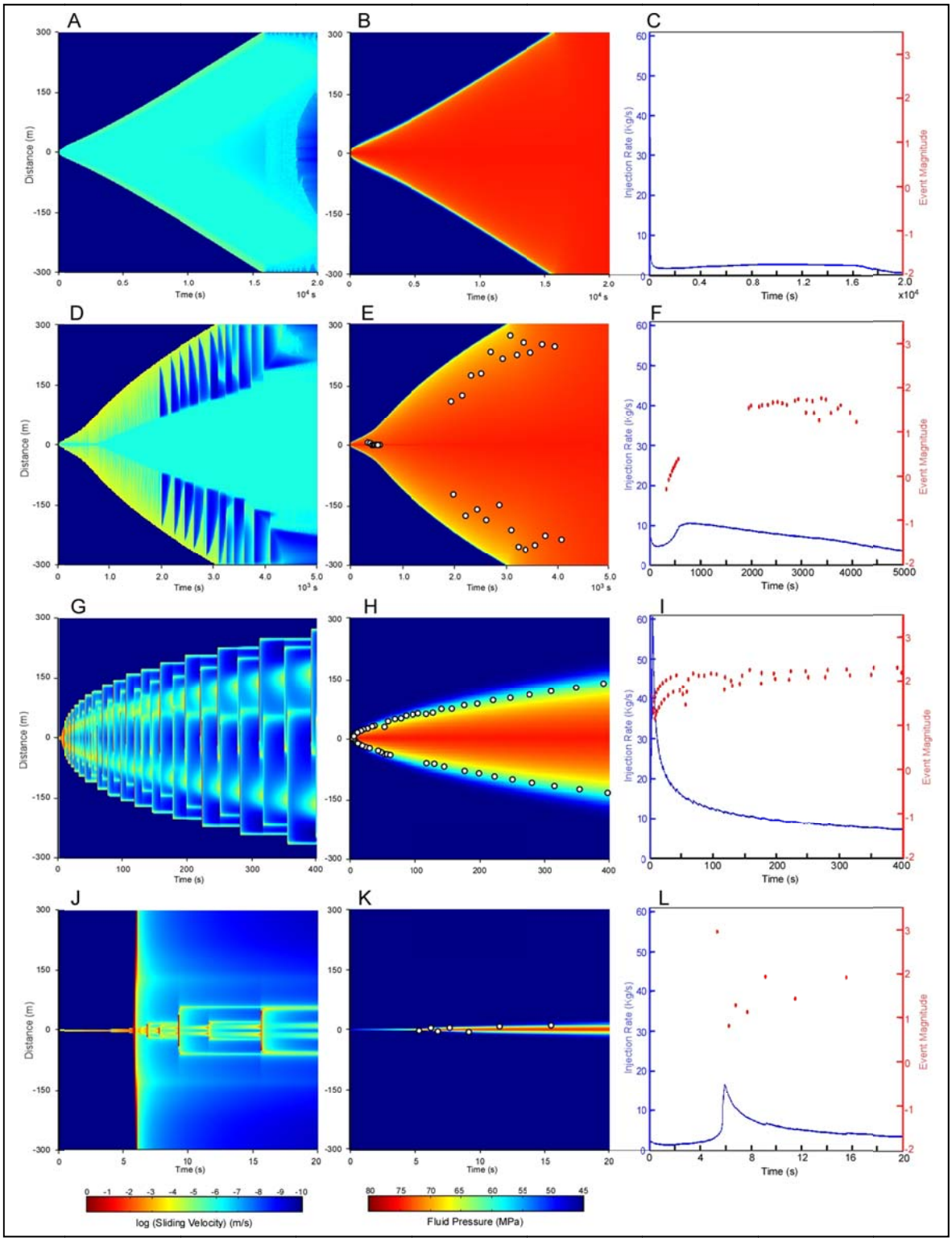

Figure 1: Sliding velocity (m/s), fluid pressure (MPa), injection rate (kg/s) and event magnitude evolution along fracture distance and time elapsed (s) for model θ =88° (A-C), θ =86° (D-F), θ =76° (G-I) and θ =60°(J-L). White points indicate hypocentre of seismic events. Fracture orientation (θ) was defined as the angle between the principal compressive stress σ1 and the fault normal.