Invited personnel：Yves Guéguen (Ecole Normale Superiour, Paris)

Host researcher：Tohru Watanabe (University of Toyama)

Period：16 July - 9 August 2016

Purpose : To attend the "international Symposium on Crustal Dynamics" and research meetings at Tohoku University, University of Toyama, Hiroshima University, and University of Tokyo

Seminar information:

25 July (Mon) 14:00-15:30 Graduate School of Environmental Studies, Tohoku University

"Fluids in the upper crust: elastic and transport properties"

Abstract: Fluid transfer in the upper crust (down to 15 km depth) takes place through cracks and pores networks. For low porosity rocks (<5%), cracks play a major role. At shallow depths, the temperature is low so that ductile deformation is not considered. Theoretical models provide an appropriate framework to interpret the elastic stiffness of crack rocks, and improve exploration and monitoring capabilities. From Effective Medium Theory (EMT), elastic stiffnesses are calculated to depend on porosity and two crack density tensors. Permeability and electrical conductivity are directly related to fluid transfer. Elastic properties may be useful to image where the fluid are, but they cannot give any direct information on fluid flow. Connectivity of the crack/pore network is of course required in the case of transport properties. Percolation models show that, in the isotropic case, the threshold crack density is ~0.13. This implies that, for lower crack densities, cracks are mostly isolated.

1 Aug (Mon) 10:30-12:00 Faculty of Science, University of Toyama

"Dispersion-attenuation of elastic wave due to pore-cracks-fluid"

Abstract: Dispersion and attenuation of elastic waves have been observed in crustal rocks. Existing theories and experimental measurements evidenced the existence of different energy-loss mechanisms. In rocks fully saturated by a Newtonian fluid, one major candidate is fluid flow at different scales, separating three regimes: the drained, undrained, and unrelaxed regimes. Here, two elastic transitions, between these three regimes are investigated. Both the cause and the consequence of the drained/undrained transition are evidenced. Because the second transition measured occurs at higher frequency, where no global fluid flow occurs, it in turn is associated to the undrained/unrelaxed transition. For both transitions, the amount of open microcracks seems to be the major contributor to the magnitude of attenuation.

3 Aug (Wed) 16:20-17:50 Faculty of Science, Hiroshima University

"Elastic wave velocities and permeability"

Abstract: Cracks play a major role in most rocks submitted to crustal conditions. Mechanically, cracks make the rock much more compliant. They also make it much easier for fluid to flow through any rock body. Relying on the Fracture Mechanics and Statistical Physics, we introduce a few key concepts, which allow to understand and quantify how

cracks do modify both the elastic and transport properties of rocks. The main different schemes, which can be used to derive the elastic effective moduli of a rock, are presented. It is shown from experimental results that an excellent approximation is the so-called non-interactive scheme. The main consequence of the existence of cracks on the elastic waves is the development of elastic anisotropy (due to the anisotropic distribution of crack orientations) and the dispersion effect (due to microscopic local fluid flow). At a larger scale, macroscopic fluid flow takes place through the crack network above the percolation threshold. Two macroscopic fluid flow regimes can be distinguished: the percolative regime close to the percolation threshold and the connected regime well above it. Experimental data on very different rock types show both of these behaviors.

8 Aug (Mon) 13:30-15:00 Earthquake Research Institute, University of Tokyo

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