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Experimental study of deformation processes within an aggregate under isotropic conditions

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Deformation experiments are generally conducted at high deviatoric stress conditions, which often do not occur in natural conditions. However, deformation of a grain aggregate submitted to an "external" isotropic pressure (P_c) is closely related to the pore fluid pressure (P_f). At the contact between grains, the effective pressure ($P_{eff}=P_c-P_f$) is higher than along the free surface ($P_{eff} \approx P_f$), which triggers deformation processes at the grain contacts: dissolution, fracturation or eventually sintering, depending on the size of the contact area. Since P_{eff} decreases rapidly with increasing the surfaces of the contacts, the intensity and process of deformation is likely to change in time.

In order to study the deformation of a grain aggregate submitted to an isotropic pressure corresponding to upper crustal conditions, cold-sealed vessel experiments have been conducted at 200MPa and 350˚C, using calibrated glass spheres $\pm$ micas and 0-5wt% water. The process and intensity of deformation could be estimated after the experiments, from the final shape of the deformed spheres observed with a SEM. Four processes of deformation have been identified in the experiments: viscous flow (creeping), sintering, pressure-solution and fracturing. Therefore, ductile and brittle deformation processes are observed under the same P-T conditions. Deformation is in all cases very fast and mostly occurs at the very beginning of the experiments. The size of the contacts between the spheres (resulting from ductile deformation) is not homogeneously distributed within the aggregate. It indicates that even in our ideal assemblage under isotropic pressure, stresses and deformation are localized along preferred directions that are indicative of "stress bridges".

These experiments show that the deformation process of even very simple systems

subjected to isotropic pressure is complex and time dependant. Although the use of glass spheres does not model the deformation of crystalline solids at the same P-T conditions, they might be a good analog to study the behaviour of mineral aggregates at higher temperature.