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Ultrasonic monitoring of high-pressure metamorphic reactions in Griggs-type apparatus

Julien Fauconnier (1), Julien Gasc (1), Arefeh Moarefvand (1), Clémence Daigre (1), Damien Deldicque (1), Loïc Labrousse (2), and Alexandre Schubnel (1)

(1) ENS, Géosciences, Paris, France, (2) ISTeP, Sorbonne Université, Paris, France

A new high pressure Griggs-type apparatus, equipped with an ultrasonic transducer, was developed at the École Normale Supérieure (Paris, France). This press can deform 5 mm diameter core samples at a maximum pressure of 5 GPa and temperature of 1 000 °C. A 5 MHz ultrasonic transducer is located below the sample assembly, glued to the base plate. During the deformation of a sample, this transducer can be used to perform passive and/or active acoustic surveys.
In passive mode, acoustic emissions (AEs), whose amplitude are above a defined threshold, are recorded. The use of a sensor sensitive to both P and S-waves allows for a rough estimate of the source/sensor distance and therefore allows to discriminate between AEs in the sample or in the assembly.
In active mode, the transducer is used in a pulse-echo configuration where it alternates between sending short acoustic pulses (100 ns wide every 2.5 ms) and recording the reflected elastic waves. Up to 10 ns variations in travel time of the reflected elastic wave on the top of the sample can be detected by cross-correlation method, which, for a 10 mm sample with an elastic wave velocity between 5 and 10 km/s, represents a 1 % velocity change. Travel time variations and deformation piston displacement data can then be used to calculate P-wave and S-wave velocity variations during the experiment.
Such experimental setup can help to gather new data on topics like brittle/ductile transition, metamorphic reaction kinetics in non-hydrostatic conditions or metamorphic reaction and deformation feedbacks. This communication will present some exemples of application such as transformational faulting of olivine/spinel germanate and quartz α/β transition in non-hydrostatic conditions with the help of passive and active ultrasonic monitoring, respectively.