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The influence of intergranular, supercritical water on the elastic properties of amphibolite

Juliane Kummerow, **Frank R. Schilling**

GeoForschungsZentrum Potsdam in der Helmholtz-Gemeinschaft, Dept. 4, Telegraphenberg, D-14473, Potsdam, Germany (jule@gfz-potsdam.de / Fax: +49 331 2881402)

Dehydration processes are assumed to influence the mechanical strength of rocks. Nonetheless, little is known about the petrophysical signature of mineral reactions. The present study depicts a first approach to monitor the influence of supercritical fluids on the elastic properties of rocks. For this a high pressure/ high temperature ultrasonic set-up was developed, capable of investigations at *undrained* conditions, where water remains in the system. P wave velocities of a low porous amphibolite were deduced in an internally heated gas-pressure vessel at 900 MPa and temperatures up to 750 °C.

Based on numerous previous laboratory experiments, it is established that at drained conditions an increase of temperature leads to a slight linear decrease of elastic wave velocities, which is generally attributed to the intrinsic change of elastic properties of the rock matrix. At undrained conditions (this study), the amphibolite is characterised by an alternation of considerably decreasing and increasing P wave velocities up to 700 °C. This observation indicates pore-fluid pressure induced changes in the porosity and permeability of the rock. A significant reduction of P wave velocities was observed, accompanied by an increasing porosity. This reveals the dominance of grain boundary effects and the minor influence of the elastic moduli of the rock-constituent minerals on the T dependency even at high confining pressure. In total, four different stages could be resolved: (1) Rather unexpectedly, already up to $\sim$ 400 °C a considerable reduction of velocity and an increase of porosity were observed. $(\partial \mathrm{v}_p/\partial T)_{P_c}$ values vary in a wide range of -1.09 $\times 10^{-3}$ to -1.64 $\times 10^{-3} [kms^{-1}K^{-1}]$, which correspond to a deviation from intrinsic values by a mean factor 5. As these observations are made far below dehydration conditions, the most plausible explanation seems to be the thermal expansion of ppm amounts of water adsorbed to the intergranular space. The interconnectivity of pores and therefore the permeability is regarded to be low, leading to the development of a high pore fluid pressure due to thermal expansion and the dilation of isolated voids and penny shape cracks with a low aspect ratio. (2) A time-dependent re-increase of velocities between $\sim$ 400 and 550 °C is attributed to hydraulic fracturing of the sample in consequence of pore pressure excess and the subsequent crack closure by collapse and mineral precipitation during fluid drainage. (3) The sample compaction results in a reduction of permeability and provokes the fluid pressure to rise again due to the dehydration of minor rock-constituents. This is displayed by a second decrease of velocities between $\sim$ 550 and 650 °C. (4) At higher temperatures the tensile strength of the sample is exceeded again, causing a further hydrofracturing event, linked to the expulsion of fluids out of the sample and a re-increase of velocities.

It is assumed that the medium grained, euhedral crystals of the amphibolite favour the loss of grain contacts. This effect is additionally amplified by accessory mica and chlorite on the grain boundaries, as in combination with adsorbed water they form effective lubricants and may enhance sliding at grain boundaries. The experimental results show that in this case already small amounts of supercritical water lead to an almost complete loosening of grain contacts and thus effect the elastic properties of the rock dramatically.