Progressive devolitization of greywacke from sub-critical to supercritical conditions

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The source of volatiles such as Cl, S and CO_2 in geothermal systems is an object of frequent debate. Early experiments concluded that they could be derived solely from water-rock interaction. Others infer that some component of magmatic input is necessary. We have conducted experiments to measure the volatiles released by a greywacke rock, typical of basement rocks in the Taupo Volcanic Zone, during progressive heating.

The rock used is a feldspathic litharenite composed of quartz, plagioclase, and lithic clasts in a matrix of quartz, feldspar, chlorite, and illite clays. Minor amounts of carbonate and pyrite are also present. The rock was crushed, sieved and cleaned ultrasonically to remove fine material. The experiment was conducted using a high temperature and pressure fluid-rock interaction simulator. Temperature ranged from ambient to 400ºC and pressure from 21 to 415 bar. The flow rate was maintained at 1 ml hr^{-1} throughout the experiment. A control experiment, using similar conditions, was conducted using crushed brazilian quartz. The fluid samples were analysed for major cations, sulfide, sulfate and chloride.

At ambient temperature, chloride values varied between 0.4 and 1.5 mg kg^{-1} while sulfate decreased from 40 mg kg^{-1} to below 2 mg kg^{-1}. The high sulfate values are attributed to dissolution of trace sulfate minerals in the rock. For the remainder of the experiment the sulfate values remained below 3 mg kg^{-1}, however, there is a correlation between temperature change and subsequent peaks in sulfate concentration. Between 100 and 200ºC, chloride remains around 0.5 mg kg^{-1} and H_2S around 0.1 mg kg^{-1}. After the temperature increase to 250ºC, chloride decreases below 0.5 mg kg^{-1}, while H_2S rises gradually to values of 2 mg kg^{-1}. H_2S concentration peaks at 300ºC reaching 7 mg kg^{-1} and then decreases to below 1 mg kg^{-1} at this temperature.

Two observations can be made from the experimental results. Firstly, most chloride appears to be removed from the rock before 300ºC is reached while at the same time, H_2S appears to be largely released after this temperature. Secondly, several peaks in volatile concentration coincide with temperature changes suggesting that thermally-induced microfracturing provides enhanced access to the fluid.