Fluid inclusions in granites and their relationships with present-day groundwater chemistry

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Abstract: Some granitic deep groundwaters have high chloride contents of which the origin is still unclear. Among the different possibilities, leakage of fluid inclusions trapped in primary minerals was proposed. This hypothesis is examined by studying four granitic sites with various hydrogeological features: drill-cores from Åspö (Sweden); Boettstein and Leuggern (northern Switzerland); outcropping granites and drill-core samples from Cauterets and Luchon in the Pyrenees (France); In Tounine granitic massif (Central Ahaggar, Algeria). With the exception of In Tounine, a part of the granite samples selected in each study site displays salt-rich fluid inclusions with salinities ranging from 22 to 26 eq. wt.% NaCl, calcium contents and minimal trapping temperatures typical of deep sedimentary brines. Most salt-rich fluid inclusions occur in secondary fluid inclusion planes in magmatic quartz, but were also found within fissure-in-filling calcite at Boettstein and Åspö.

The wide ranges of Cl/Br ratios in single rock samples, due to heterogeneities in fluid inclusion distribution in rock-forming minerals, and the variability of Cl/Br ratios in fluid reservoirs render the use of Cl/Br ratios for fluid-source tracing inaccurate. Only salt-rich inclusions in the Pyrenees samples show a relatively narrow range of Cl/Br ratios, similar to those of associated groundwaters.

Mass-balance calculations based on salinity estimates from microthermometry, crush-leach analyses and inclusion counting, coupled with the study of possible mechanisms for leakage, demonstrate that the relatively high salinity of deep groundwaters (Boettstein and Åspö) cannot only be accounted for by the leakage of fluid inclusions trapped in quartz. It cannot be totally excluded that fluid inclusions may be responsible for the major part of chloride in groundwaters with relatively low salinity (Leuggern 1647 m, Cauterets, Luchon, Ahaggar).

The leakage of secondary fluid inclusions trapped in primary minerals cannot be considered as the main process responsible for the high salinity of present-day deep groundwaters in the studied sites. However, the presence of secondary salt-rich inclusions indicates that sedimentary brines have already percolated the granites, a datum which is important for the evaluation of the hydrogeological history and for the understanding of the modalities of chlorine introduction in the crystalline basement.

Key-words: fluid inclusions, granite, chloride, bromide, groundwater, crush-leach.