

The role of brines in metamorphism and anatexis

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A number of observations point to a potentially wide participation of brines in high grade metamorphic processes. Those are findings of alkali and alkali earth halides as daughter crystals in fluid inclusions; appreciable amount of Cl measured in granite melt inclusions in minerals and direct observations on high temperature halides present in intergranular space in the high grade rocks [1]. Thermodynamic mixing properties of concentrated water-salt fluids at high P-T differ greatly from those of water-non-polar gas mixtures: the former are characterized by a large negative deviation from ideal solutions [2], while the latter exhibit positive deviation from ideality. This difference has two major petrologic implications: unlike water-gas fluids, the presence of brines strongly increases melting temperature of quartzofeldspathic rocks and decreases dehydration of water-bearing minerals. Operation of brines may help to resolve the “granulite paradox”: extensive dehydration without hole-sale melting. New experimental results [3] show that there is a large range of P-T space in which subsolidus deep crustal metasomatism may take place at low H₂O activity via migrating fluids. Brines may implant K₂O and silica into the mid-crust and thus condition it for anatexis. Brine-assisted anatexis differs greatly from rock melting in pure H₂O or in CO₂-H₂O fluids. Large changes in feldspar compositions in equilibrium with melts can result from small shifts in fluid compositions. Contours of constant fluid H₂O on the solidus minimum (H₂O isopleths) have strongly positive dP/dT slopes. As a consequence, rising accumulations of granitic magma may be fluid saturated and even increase their melting capacity with decreasing depth because of the great pressure dependence of H₂O activity in salt solutions. These results offer an explanation for mid-crust migmatization and granite production: rising hot brines may provoke rock melting at some threshold of decreasing depth in the range 15-20 km. Because of their enhanced capacity for metasomatism, leading to eventual melting at appropriate conditions of temperature, pressure and H₂O activity, concentrated brines should be considered as possibly important agents in crustal evolution.

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The origin of lithium in playas in Nevada, USA: Constraints by lithium isotope ratio

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Lithium is an industrially useful element with extremely low reduction potential whose compounds are used in many ways, especially in secondary lithium-ion batteries. Highly concentrated lithium resources are often formed in salt crusts and playas by evaporative enrichment, and lithium-rich brine in playas is a major raw material for lithium production. Moreover, lithium isotopic ratios ($\delta^7\text{Li}$) have recently been identified as a tool for investigating water-rock interactions [1, 2]. Thus, to determine the origin of lithium in playas, we conducted leaching experiments to evaluate the effect of leaching processes on $\delta^7\text{Li}$. Then we determined lithium and strontium isotopic ratios and contents and trace element contents of various lacustrine and evaporite deposit samples collected from playas in Nevada, USA. In samples from the playas, $\delta^7\text{Li}$ values were much lower than those in river water [3] and groundwater samples [1] from around the world, but they were close to those of upper continental crust [4]. On the basis of temperature dependence of lithium isotope fractionation during water-rock interactions [5], these results indicate that the highly concentrated lithium in playas was supplied mainly through high-temperature water-rock interactions associated with local hydrothermal activity and not directly by low-temperature weathering of surface materials. This study, which is the first to report lithium isotopic compositions in playas, demonstrated that $\delta^7\text{Li}$ may be a useful tracer for determining the origin of lithium and evaluating its accumulation processes in playas.

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