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Fluid-mediated mineral replacement reactions contributing to ore deposits formation

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Hydrothermal alteration of rocks is one of the key processes responsible for the remobilization and transport of metals in the earth crust. The migration of hydrothermal fluids along major tectonic structures typically results in the transformation of one mineral to another. At the microscale, porosity and fractures develop within individual mineral grains or along mineral grain boundaries. Such reaction-induced porosity can facilitate fluid migration and associated fluid-rock interactions, contributing to metal transport and accumulation and subsequently the formation of economic ore deposits. However, knowledge on such processes is still limited due to the complexity of the chemistry of natural fluids and rocks, and a lack of experimental constraints on reaction mechanisms at T-P conditions representative of various ore forming processes. In recent years, we performed hydrothermal experiments on some key mineral replacement reactions aiming for new insights on the influence of fluid chemistry and T-P conditions on the development of microscale textures that contribute to large-scale hydrothermal alteration and ore formation.

Experiments of magnetite replacement by hematite in acidic non-oxidative fluids show that the reaction can be catalysed by trace amount of dissolved cerium (Ce^{3+}). This catalytic effect facilitates magnetite dissolution and suppresses hematite nucleation, leading to the formation of large pores for enhanced fluids migration at the microscale. Experiments on feldspar alteration in a closed NaCl-H_2O system show that the alteration of sanidine ($(K,Na)AlSi_3O_8$) proceeds in two-stages: formation of albite ($NaAlSi_3O_8$) and later replacement of albite by K-feldspar ($KAlSi_3O_8$). This result reveals that the widely observed sodic and potassic alteration in hydrothermal ore forming systems could be triggered by single fluid without external interference on fluid alkali contents.

These new discoveries highlight the importance of better understanding of hydrothermal mineral alteration at the microscale for accurate determination of ore genesis model and the development of novel ore exploration and extraction methods.

References

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