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Numerical investigation of hydrothermal processes around magmatic bodies: heat transfer and fluid circulations leading to mineralization patterns.

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Abstract:

Many intrusion-related ore deposits have been suggested to derive from fluid circulation within the low permeability host rocks. We address here the hypothesis of magma emplacement as the main source mechanism for fluid circulation by a series of numerical models designed to investigate thermally driven fluid flow with temperature-dependent physical properties. The geometry of intruded magma, the role of stocks and apexes, and the appearance of fracture systems or faults around emplaced magma, have been studied through 73 coupled hydro-thermal numerical models, where depth-dependent permeability is assumed. For cases with no apexes, convective cells were observed at the two sides of the intrusion. Cell sizes were constant and the distance between them was controlled by the width of intrusion. When magma chamber geometry is varied, fluid velocity does not vary much. On the opposite, when stocks and apexes are present, the temperatures and fluid velocities are increased dramatically. When a system of fractures or faults are added next to intruded body, heat and fluids are transferred far from the intruded body, thus increasing fluid flow around magma body. Upwelling flow along fault is promoted with a sufficiently high heat advection to generate steep near surface thermal gradients. Long-lived, stable convection is generated during and after the emplacement for host rock/fault permeability contrast greater than 100. The Rock Alteration Index, which is proportional to the scalar product of the

velocity field by the thermal gradient, is related to the potential zones of mineralisation. The possibility of mineral trapping near the topographic surface and at the upper corners of intrusion is outlined in models with no apexes. Adding apexes to intruded body reduces the possibility of mineralization around the intrusion and replace it at the top of the apexes. The presence of fracture zone and/or faults hinders the formation of any ore deposit around the intrusion or near the topographic surface, but leads to probable mineralization inside fracture system and faults.