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Ore formation in porphyry-type deposits during incrementally built magma chamber and fluid sparging

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Porphyry-type mineralizations are commonly associated with an underlying magma chamber from which a volatile phase exsolves from the crystallizing magma. We suggest a model of fluid sparging during multiple successive intrusions yielding metals concentration within the gas phase. Metals enrichment by 3-4 orders of magnitude takes place during the magmatic stage prior to hydrothermal effects, resulting from a competition between diffusion and advection of the volatile phase. The model explains why a single intrusion is not efficient enough to lead to economically viable ore deposit, though it also involves a gas phase percolating within a crystalline mush. During multiple intrusions, metals segregate from the new melt to the gas phase by diffusion, as long as the gas has not overcome a critical saturation level (about 20 % gas). Adding gas exsolved, about 4 % at each new magma recharge, overcomes this level. Then, the diffusion process switches toward advection, since the bubbles get interconnected, enhancing the transport of a gas phase enriched in metals. Once advected, the enriched gas phase turns into hydrothermal circulation during which metals condensate. Two non-dimensional numbers, Péclet and Stefan numbers, respectively rule diffusion and advection of elements while heat is lost through cooling. The model also examines the total duration of the process that re-establishes after 4-6 recharges in magma. It also provides an explanation why intrusions are barren or enriched, although they result from similar conditions of magma genesis. Development of a zoned alteration pattern may serve as a guide for prospection.