Kinetic and geologic controls on olivine spinifex textures in komatiites

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Cooling rate experiments on a komatiite combined with field observations of spinifex and non-spinifex cooling units in the Barberton Mountainland, South Africa and Abitibi Belt, Quebec allow evaluation of the factors controlling the development of olivine spinifex textures. Cooling rate eperiments were performed starting at the dry and wet liquidus at rates between 100 and 3 ºC/hr. Dry experiments were conducted in a variety of sizes and types of crucibles. Decreasing crucible volume promotes olivine nucleation while increasing crucible size leads to development of spinifex-like textures. In the largest crucible (60 ml), where surface area is at the minimum, spinifex-like olivine crystals grow at slow (3 ºC/hr) cooling under anhydrous conditions. In comparison, H_2O-saturated cooling experiments at 200 MPa grow the largest spinifex-like olivine crystals that extend the entire length of the capsule, even in the small capsule volume of the wet experiments. We have found that water dramatically increases growth rate and decreases nucleation rate, promoting the development of spinifex textures..

In Barberton, massive cooling units display no spinifex texture, and contain mineral compositional evidence consistent with dry crystallization. In contrast, mineral compositional evidence from the Barberton spinifex units indicates crystallization in the presence of 3 to 6 wt. % H_2O [1]. Previous explanations of olivine spinifex textures called upon large amounts of superheat and rapid cooling. However, rapid cooling from superliquidus temperatures is inconsistent with the equant olivine microphenocrysts in the Barberton and Abitibi komatiite chill margin, which instead indicate emplacement at supercooled conditions. These thick spinifex units are emplaced as inflated flows, leading to conductive cooling below a pile of pillowed flows [2]. The coarsest spinifex crystals (30 to 50 cm long) grow in their slowest cooled centers (2 m from the upper chill margin). The textures of the large crystals are better explained by slow cooling rates in the presence of H_2O because nucleation rate is lowered and growth rate is enhanced. Moreover, the large amount of H_2O dissolved in the komatiite melt lowers the liquidus and enhances undercooling in the cooling units when the magma is emplaced at a lower pressure at its site of final solidification.[1]Parman *et al*. (1997) EPSL, 150, 303-323. [2] Dann et al. (2007) Precambrian Geol., v. 15, Chap. 5.4.