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In-situ growth and chemical boundary layers of giant spherulites in rhyolitic dykes from Cheongsong, South Korea

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Spherulitic textures in rhyolites record cooling, crystallization and viscous flow in felsic magmas. Although spherulites in rhyolites are widely described, quantitative constraints on chemical–textural relationships between spherulites and groundmass remain limited, particularly for giant examples in rhyolitic dykes. We investigate giant spherulites (megaspherulites) in rhyolitic dykes of the Cheongsong area, South Korea, using detailed field and petrographic observations combined with electron microprobe (EPMA) line profiles, elemental mapping and geothermometric estimates, in order to better characterise spherulite growth and associated magma evolution in this unusually large and diverse megaspherulitic rhyolite system.

The spherulites are almost perfectly spherical, with diameters from a few centimetres to several tens of centimetres. They show a wide range of morphologies, including concentric, radiating and nested types, and several colour variants. In contrast, the rhyolitic groundmass exhibits well-developed flow banding that does not continue into the spherulites but bends smoothly around their spherical margins. Within individual dykes, both the size and abundance of spherulites increase from chilled margins towards dyke centres, and are systematically greater in thicker dykes than in thinner ones, indicating strong control by cooling conditions and thermal structure.

EPMA line profiles across spherulite–matrix boundaries show that some elements are relatively enriched within the spherulites, whereas several incompatible elements display a pronounced maximum immediately outside the spherulite rim and then decline outward, forming concentric chemical gradients in the groundmass. This pattern is interpreted as a chemical boundary layer developed ahead of the spherulite growth front in a high-viscosity melt or glassy matrix where convection was strongly suppressed. Together with the nearly perfect spherical shapes and the deflection of flow bands around the spherulites, these observations strongly support in-situ growth under stationary or very low-velocity melt conditions within the present rhyolitic dykes, rather than long-distance transport of fully formed spherulites in a mobile magma. Overall, the Cheongsong megaspherulitic rhyolites provide detailed mineralogical constraints on late-stage cooling, crystallization and viscous flow in shallow felsic magmatic bodies, and document an unusually large and morphologically diverse spherulitic system relevant to both rhyolitic magma evolution and the geoheritage assessment of felsic volcanic successions.