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Mineral records of magma history

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Magmatic crystals become recycled during magma ascent through vertically extensive, complex plumbing systems, holding a rich record of magma history prior to volcanic eruption or magma emplacement. Crystal records therefore help reconstruct mush systems across tectonic settings, unveiling key events including the triggers of volcanic eruptions and the processes that drive accumulation of energy critical metals. Volcanic matrix (groundmass) provides a complementary record of true carrier melt composition over traditional whole rock data that is inevitably skewed for crystal rich samples.

Advancing microanalytical techniques make it possible to analyse discrete rock components at increasingly high precision and speed, helping resolve complex open-system magma dynamics through space and time. Mineral zoning, together with inclusion populations, provide key insights into magma storage conditions, including magma compositions, volatile contents, pressures, temperatures and oxidation states. Mineral textures include complex growth mechanisms that have traditionally been underexplored, such as sector zoning which develops in a wide range of minerals from pyroxene to zircon, recording dynamic magma histories and enhanced crystal growth in mafic to felsic magmas. Importantly, sector-zoned crystals can be related to distinct magmatic processes such as magma mixing and ascent prior to volcanic eruptions, magma degassing linked to the accumulation of rare earth metals in alkaline magmas, and magma recharge, differentiation and volatile exsolution feeding porphyry copper deposits in arc settings.

This keynote will provide an overview on crystal archives of magmatic processes using elemental and isotope compositions for a range of magmatic minerals. It will highlight state of the art research into reconstructing mush systems across geodynamic settings and magma compositions, decoding eruption triggers, and unravelling magmatic processes driving the accumulation of critical minerals.