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Breccias in Magmatic-Hydrothermal Environments

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Large-scale, discordant breccia bodies can be significant components of magmatic-hydrothermal mineral systems. Brecciation can occur early or late during hydrothermal activity with diverse relationships to mineralization.

Early-formed breccias may form due to explosive release of high-temperature magmatic-hydrothermal fluids from a shallowly emplaced hydrous intrusive complex, with explosive brecciation creating pipes and/or dykes above the causative intrusion. The magmatic-hydrothermal fluids are initially in chemical and thermal equilibrium with the crystallising magma, producing high-temperature alteration of clasts and matrix and, in some cases, significant domains of high-grade mineralised breccia cement. These breccias define the highest-grade ores in some major porphyry Cu, Au, and Mo deposits (e.g., Rio Blanco, El Teniente, Productura, Chile; Soledad, Peru). Magmatic-hydrothermal breccias taper upwards and may contain distinctive tabular clast breccias ("shingle breccias") on their roofs and outer walls. Their distal expressions include sheeted veins with potassic or phyllic halos.

Maar-diatreme complexes are the products of catastrophic phreatomagmatic explosions that occur when magmas intrude active hydrothermal systems. Volcanic-hydrothermal breccia complexes commonly form late in the life of porphyry copper deposits (e.g., El Teniente, Chile; Tujuh Bukit, Indonesia) and early in the life of high-sulfidation (e.g., Yanacocha, Peru; Zijin, China), intermediate-sulfidation (e.g., Acupan, Philippines), and low-sulfidation epithermal Au deposits (e.g., Lihir, PNG). Some diatremes are mineralised, whereas others are barren. Concealed porphyry deposits have been discovered due to the recognition of mineralised clasts in diatreme breccias (e.g., Far Southeast, Philippines; Cuerpo 3, Chile).

Structural processes can result in the formation of mineralized and unmineralized breccias throughout the evolution of magmatic-hydrothermal systems. Tectonic-hydrothermal breccias can involve phreatic or hydraulic fracturing, abrasive wear, and/or implosion. Corrosive wear can produce solution collapse breccias in carbonate rocks and high-sulfidation epithermal environments. Overall, these diverse breccia types require systematic mapping and logging to fully unlock their exploration potential.