Experimental evidence for coarsening of crystals and bubbles during thermal cycling of mafic and silicic magmas

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Porphyritic textures in igneous rocks are commonly interpreted as evidence for low nucleation rates and/or high growth rates, but experiments in both magma analog systems and ice cream show that temperature oscillations can promote crystal cannibalism and coarsening, and thus porphyritic texture. Here we show that thermal cycling significantly increases crystal and bubble size during experiments on a basalt at 1-atm in a gas-mixing furnace and on a water-saturated rhyolite at 100 MPa in a cold-seal furnace.

The basalt experiments clearly show that temperature cycling dramatically increases crystal sizes. Experiments were performed on an alkali basalt at 1160°C, Ni-NiO buffer, for durations of 20 to 120 hours. After thermal cycling with amplitudes of 5 to 20°C and periods of 20 to 40 minutes, the larger plagioclase crystals were ~20 times more massive, and the larger olivine crystals ~5 times more massive, than in comparable static experiments. Cycle amplitude and period interact in complex ways with crystal structure to produce coarsening, but all cycled experiments show increased coarsening compared to the experiments at constant temperature.

Initial results from experiments in a water-saturated rhyolitic system at 100 MPa and 810°C indicate that cycling of 10°C at a period of 40 minutes greatly increases the size of plagioclase (mass ratio ~12) and hornblende (~4). These results indicate that temperature cycling may offer a way to attack the kinetic problems inherent in experimental work in high-silica systems.

In both sets of experiments, thermal cycling caused marked coarsening of bubbles. Although the processes by which bubbles coarsen are probably different from those that govern crystal coarsening, the results are very similar. Thermal cycling greatly increases the size of bubbles and decreases their number, suggesting that thermal cycling could play an important role in degassing of magmas and ultimately in determining the explosivity of eruptions.

Jiaodong gold district, Northeast China: Discrepancies with orogenic gold mineralisation

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The world-class gold deposits of the Jiaodong Peninsula represent the most important gold-producing area in the world's leading gold-producing country. They are considered by some researchers to be orogenic gold deposits; however this study shows this classification ignores fundamental differences in mineralisation character.

Typical orogenic gold mineralisation is associated with compressional or transpressional tectonics in a collisional/accretionary setting and is commonly hosted in metamorphosed terranes. In Jiaodong, it is well accepted that mineralisation occured in extensional tectonics that included lithospheric thinning and large-scale granitic emplacement [1]; fieldwork from this study also shows evidence for mineralisation during normal faulting. Likewise, at the time of mineralisation Jiaodong was far inboard of the active subduction front (Paleo-Pacific Plate subducting benath the East Asian margin), and although metamorphosed Precambrian basement is present, mineralisation is almost exculsively hosted in Mesozoic granitic intrusions. Also, the Precambrian basement reached upper-amphibolite to granulite facies metamorphism at ~2.5Ga, resulting in devolitalization and making it unlikely that mineralisation is related to basement metamorphism [2].

Results from this study also illustrate that deposit scale characteristics are contrary to orogenic deposits, including high base-metal enrichment (600, 150, 35 times background for Cu, Pb, and Zn respectively) in the form of polymetallic mineralisation (chalcopyrite and galena) proximal to controlling faults in high-grade Au zones. Gold-associated enrichments include Ag, Bi, As ± Sb, Mo, W with low Au:Ag (0.005 to 1.66, average 0.4). Sulfur isotope analyses on pyrite show $\delta^{34}S$ values ranging from +6‰ to +13‰ with an average of +9‰.

These regional to deposit scale characteristics show that although Jiaodong deposits have some similarities to orogenic systems, major discrepancies exist. It is likely that dynamic processes in the lithosphere and asthenosphere (i.e. mantle lithosphere destruction, asthenospheric upwelling) were instead the regional drivers behind mineralisation.

[1] Mao, J. *et al.* (2008) *Ore Geology Reviews* **33**, 361–381.
[2] Zhao, G. *et al.* (2001) *Precambrian Research* **107**, 45–73.