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A tale of an orbicule in the Gangdese batholith: petrographic, geochemical and microstructural perspectives on its formation

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Owing to their intriguing appearance and unusual occurrence, as well as their significance in addressing magmatic processes, orbicules have attracted attention from geologists all over the world. We discovered an orbicule-bearing boulder in the Linzhi region of the Gangdese batholith, southern Tibet. The orbicules are composed of dioritic shells around monzodioritic cores, in a dioritic matrix (~28.8 Ma). They typically have a single shell, composed of elongate and radially oriented hornblendes, with interstitial plagioclase. Zircon Lu-Hf and whole-rock Sr-Nd isotopes reveal that the original magmas of both the orbicule matrix and orbicule core were relatively juvenile ($\varepsilon_{Hf}(t)$ = +2.2 – +6.0 for matrix and +1.2 – +3.9 for core; $\varepsilon_{Nd}(t)$ = -1.68 – -1.46 for matrix and -3.65 – -2.52 for core). Hornblende composition further indicates that the original magmas of the matrix and the orbicule cores were water-rich, with H_2O contents >4 wt%. In combination with the whole-rock geochemistry, these results suggest that the orbicules were formed in a post-collisional setting, from magma generated by partial melting of the juvenile thickened lower crust of the Lhasa terrane (Ma et al., 2024).

The euhedral hornblende grains in the matrix exhibit consistent orientation between CPO and SPO results, similar to the alignment of euhedral plagioclase grains. The alignment and compaction of orbicules aligns with the foliation defined by the preferred orientation of hornblende and plagioclase within the matrix. The hornblende in the shell displays undulose extinction texture. EBSD indicates that subgrain deformation is the primary factor controlling this undulose extinction. Additionally, bladed biotite laths are oriented perpendicular to and cross-cut the radial hornblende crystals. Integrating these observations, we propose that the orbicules likely settled to the bottom or accumulate beneath a roof, or were driven into lateral re-entrants or fractures (Moore and Lockwood, 1973). They are densely packed within a confined space. In the meantime, mechanical concentration of the orbicules also triggered the repacking of the crystallizing hornblende and plagioclase grains within the matrix, further influencing their orientation and texture.

References

Moore JG, Lockwood JP, 1973. GSA Bulletin, 84: 1-20

Ma XX et al, 2024. GSA Bulletin, 136: 110-130