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The Piracaia Monzodiorite, SE-Brazil: multiple injections and magma interaction in a dynamic magma chamber

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The 578±3 Ma old Piracaia Monzodiorite holds in its 30 km² a great variety of lithologies, which can be grouped in five units: coarse-grained monzodiorites (*Mdr*); fine-grained monzodiorites (*Mdf*); heterogeneous monzonites (*Mh*); syenites (*Sie*); quartz syenites and quartz monzonites (*Qsie*). The predominant K-rich monzodiorites are inferred to derive from a metasomatised subcontinental mantle, while the felsic rocks are akin to A-type granites. The magmas intruded in a late to postorogenic tectonic setting, resulting in a pluton with an ellipsoidal shape and moderate to strong foliation, especially along its borders. Mafic and felsic magmas interacted in different scales, generating hybrid rocks and a great variety of commingling structures, with characteristics that indicate the sequence of magma intrusion during the emplacement.

The physico-chemical crystallization parameters of primary and hybrid magmas were determined as references for the characterization of the magma interaction processes. *Liquidus* temperatures estimates based on apatite saturation are of 950-1050º C for the most primitive (*Mdf*) and 850-900º C for the more differentiated (*Qsie*) magmas. *Solidus* temperatures, based on hornblende-plagioclase equilibrium, are *ca*. 750º C for *Mdf*, and 650-700º C for *Qsie*. Depth of emplacement is estimated at 13-15 km (3,5 to 4,0 kbar), based on Al-in-hornblende geobarometry. H_2O contents estimated from the An content of plagioclase are 2.5-3.3% for *Mdf*, reaching up to 5% in quartz syenites. fO_2 estimates derived from Fe-Ti oxides oxythermometry and Fe/(Fe/Mg) ratios of amphibole and biotite show an important contrast among the units: whereas *Mdf* and *Mdr* are highly oxidized (~NNO buffer), *Qsie* and especially *Sie* and *Mh* are more reduced, often magnetite-free.

Two main events of magma interaction can be identified in the pluton evolution. In the first, monzodiorite (*Mdf*) magma mingled intensively with syenite (*Sie*), generating the heterogeneous monzonite (*Mh*) unit. The medium to fine grained texture of these rocks coupled with the relatively high *liquidus* temperatures estimated for both magmas suggests that cooling was relatively fast. On the other hand, the intense interfingering of monzodiorite and syenite portions, which maintain their identity in the millimeter scale, suggests a strong mechanical interaction, favoring the hypothesis that this took place, or at least initiated, during the ascent of magmas, previously to the emplacement.

In a second event the chamber was replenished with a new batch of felsic magma (*Qsie*), followed by several batches of monzodiorite (*Mdf*), which occupied the center of the pluton. This center body shows abundant evidence of mingling along its borders, such as enclaves, pillows and load cast structures. The mafic pillows are often disrupted and locally mingled with the quartz syenite magma, generating hybrid zones with very peculiar mineralogical and trace element chemistry at their contacts. These zones have abundant allanite, zircon, apatite and amphibole, and correspondently are anomalously rich in trace-elements such as LREE, Zr and P relative to the endmembers (*Mdf* e *Qsie*). These high concentrations are consistent with "diffusion fractionation" due to physical dispersion processes at the interface between contrasted magmas, which were preserved upon cooling.