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Silicate to silica alteration in basalts and rhyodacites of the Paraná volcanic province and formation of giant amethyst geodes

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The largest world producer of amethyst and agate geodes (600 ton/month) is the southern Paraná volcanic province, mostly Ametista do Sul (Brazil) and Los Catalanes (Uruguay). Considered as a late-magmatic phenomenon until recently, the formation of the geodes is now described as a low-temperature (<150 °C), epigenetic event (e.g. Hartmann et al., 2011). Amethyst and agate geodes are mined from a large variety of volcanic rocks, such as high-Ti (ca. 2 wt.% TiO2) Pitanga type basalt in Ametista do Sul, low-Ti (< 2 wt.% TiO2) Gramado type andesite in Los Catalanes, and low-Ti Palmas type rhyodacite in Caxias do Sul. Thus, the origin of the geodes is independent of the magma type, and the alternative, epigenetic origin is more plausible. The hydrothermal alteration sequence was caused by heating of the Guarani aquifer below the effusing Paraná magmas. The ascending nearly pure, hot water from this aquifer caused a sequence of alteration processes that evolved from silicate (smectite, zeolites) to silica (chalcedony, quartz, amethyst) formation. The completion of this sequence of processes was required for the formation of the valuable geodes. The opening of the cavities could have occurred by ballooning of the strongly altered volcanic rocks, consisting mainly of phyllosilicates, due to water vapor overpressure. The temperature of this process is delimited at ca. 130 °C by the occurrence of clinoptilolite. Stable isotopes (C, O, S) indicate very low temperatures (30-70 °C) for the filling of the geodes with silica minerals (chalcedony, quartz, amethyst) and some calcite and gypsum (Duarte et al., 2011). Further support of this result comes from integrated studies of field relationships, petrography, mineral chemistry, rock geochemistry, and fluid inclusions.

References

Duarte, L.C. et al., 2011. Miner. Deposita, in press.
Hartmann, L.A. et al., 2011. Int. Geol. Rev., in press.