

Occurrence of silica polymorphs nanocrystals in tuffaceous rocks, Province of the Mesa Central, Mexico, and their formation from subcritical Si-rich fluids

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ABSTRACT

Cristobalite-tridymite blade nanocrystals cemented by SiO₂-glass and tridymite nanocrystals fill separately SiO₂-glass spherules released by explosive volcanism, in rhyolitic tuffs from the Province of the Mesa Central, Mexico. This paper presents the mineralogy of silica polymorphs, occurrence, and process of formation in the Province of the Mesa Central. The understanding of the origin of these pure SiO₂-polymorphs, their association with high-temperature minerals, fractionation of magmas, and role of volatiles contribute to our knowledge on silica minerals, their technological implications and damaging health effects.

Results indicate that a precursor magma, from which kyanite crystallized, partitioned into an immiscible Fe-rich magmatic liquid that crystallized Fe-cordierite, Fe-amphiboles, and fayalite and into a siliceous melt that led to low-temperature glasses of 78.22–80.01 wt% SiO₂ and Si/Al ratio 4.07–5.65. Presence of amphiboles, sulfur in cristobalite-tridymite crystals and alunite suggest association of volatiles. The crystallization of silica polymorphs is associated with the dissolution of water vapor and volatiles in the precursor magma, establishing a silicate melt–water system of two critical points, one of them at pressure and temperature near the critical point of water and another close to the critical point of SiO₂, and defining a critical curve between them and supercriticality at pressures and temperatures lower than the critical point of SiO₂. Decreasing the ambient conditions from supercritical to subcritical would have allowed the separation of liquid and gases and the crystallization of cristobalite-tridymite and tridymite nanocrystals from the vapor phase. Cristobalite single crystals were not formed and transformation of cristobalite and tridymite to quartz did not occur. We conclude that glasses did not crystallize cristobalite or tridymite. Components in excess of the pure phases precipitated as nanoparticles of siliceous glass forming agglomerates, some containing iron hydroxides and alunogen.

Keywords: Silica polymorphs, cristobalite, tridymite