

Natural analogs of belite sulfoaluminate cement clinkers from Negev Desert, Israel

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ABSTRACT

Ye'elimite-larnite rocks in the Hatrurim formation of the Negev Desert, Israel, are natural analogs of belite sulfoaluminate (BSA) cement clinkers. They have been produced by ultrahigh-temperature combustion metamorphism at ambient pressure of a calcareous sedimentary precursor. Their mineralogy consists of 35–50 vol% β -Ca₂SiO₄, 15–20 vol% ye'elimite, 7–15 vol% ferrites, and 15–20 vol% fluorapatite and/or fluorellestadite. A few grains of hatrurite (Ca₃SiO₅) and α' -Ca₂SiO₄ have been observed as well. The composition of α' - and β -Ca₂SiO₄ polymorphs by EPMA are near Ca_{1.96–1.98}Na_{0.01–0.02}Si_{0.96}P_{0.03}Al_{0.01}O₄, whereas ye'elimite has an approximate composition by EPMA of Ca_{3.99}Mg_{0.02}Ba_{0.01}Na_{0.02}K_{0.02}Al_{5.73}Fe_{0.16}³⁺Si_{0.10}S_{0.97}P_{0.02}O₁₆. The Al content of brownmillerite Ca₂(Fe_{1–x}Al_x)₂O₅ ranges from $x = 0.20–0.27$. Fe-analog of shulamitite (Ca₃Fe₂TiO₈) contains up to 15.1 wt% TiO₂. Ye'elimite-larnite rocks were derived from chalky sediments by burning of combustible gas with a T_{\max} at 1200–1350 °C. The mineral content, microstructure, and texture/fabric of the ye'elimite-larnite rocks imply that chalky and/or marly sediments with randomly distributed clay, phosphorite, and gypsum may be utilized as cheap naturally homogenized and pulverized mixtures for industrial production of BSA cement clinker, as an environment-friendly alternative to ordinary Portland cement (OPC).

Keywords: Ye'elimite-larnite rocks, sulfoaluminate clinkers, Ca₂SiO₄ polymorphs, marly raw materials, combustion metamorphism