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Origin of two types of nelsonite in the Damiao anorthosite complex, North China Craton

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The ~1.7 Ga Damiao anorthosite complex in the North China Craton contains abundant Ti–magnetite–dominated ore deposits. Field and petrographic observations indicate two types of nelsonite (Fe–Ti–P ores): Small–scale banded– or brecciated–textured nelsonite, occurring as veins between the non–altered anorthosite and oxide–apatite gabbronorite, and large–scale massive–textured nelsonite, occurring as discordant late–stage dikes cross–cutting altered anorthosite with irregular but sharp boundaries. Apatite of the banded– or brecciated–textured nelsonite displays stronger negative Eu and Sr anomalies than apatite of the spatially related oxide–apatite gabbronorite, suggesting that sufficient plagioclase had crystallized before apatite crystallization; and such apatite is also characterized by remarkably low–F and high–REE contents, which is interpreted as a geochemical break resulted by liquid immiscibility. It indicates that the banded– or brecciated–textured nelsonites and associated Fe–Ti–P–rich clinopyroxenite crystallized from Fe–Ti–P–rich immiscible liquid, with mangerite as the corresponding Si–rich immiscible conjugate. Compared to the massive–textured nelsonite associated with anorthosite worldwide, the massive nelsonite in the Damiao anorthosite complex is characterized by much smaller amounts of TiO_2 (<9%) and makes up a surprisingly large abundance with widespread cogenetic alteration products. The strong similarity of REE contents and distribution for apatite between the massive–textured nelsonite and spatially related oxide–apatite gabbronorite indicates a progressive evolution. Extensive fractional crystallization of residual ferrobasaltic magma plus latest hydrothermal processes is probably responsible for the formation of large-scale massive-textured nelsonites.