American Mineralogist, Volume 86, pages 215–224, 2001

Crystallization processes in migmatites

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ABSTRACT

An important prerequisite for interpreting microstructures in plutonic and metamorphic rocks is understanding crystallization processes. This study uses crystal size distribution (CSD) and grain shape parameters to investigate mineral-reaction-controlled crystal growth and melt solidification in migmatites of the Bayerische Wald (Variscan Orogeny, Germany). Partially molten rocks were studied because they allow the simultaneous investigation of crystallization of a melt and the growth of solid products of a metamorphic reaction. CSD and shape factors were obtained for three different minerals: (1) cordierite in a diatexite, where the melt remained in the system; (2) K-feldspar in a segregated K-feldspar + quartz leucosome; and (3) plagioclase from a segregated plagioclase + quartz leucosome. Cordierite crystals exhibit a nearly linear CSD pattern and subeuhedral crystal shapes. K-feldspar grains display an approximately linear CSD except for a marked increase at large crystal size classes. K-feldspar grains are characterized by strongly lobate grain boundaries. The CSD of plagioclase crystals is nearly linear, with a slight decrease at small crystal size classes. Plagioclase shape factors also indicate lobate grain boundaries, however, with lower values than K-feldspar. Cordierite CSD and shape data are consistent with interface-controlled crystallization. The CSD indicates that nucleation and growth is the rate limiting step during the cordierite-producing reaction, in contrast to porphyroblast growth in solid rocks where mass transfer is typically rate limiting. CSD combined with information on the duration of crystallization yields growth rates of 10^{-17} to 10^{-18} m/s. The plagioclase data are consistent with magmatic crystallization and are well-described by the communicating neighbor theory. The K-feldspar data also indicate magmatic crystallization. The “overproduction” of large grains of K-feldspar reflects the interplay between nucleation and growth rates at the initial stage of crystallization. Because of different environments between solid and anatectic rocks, the CSD may help to decipher metamorphic from anatectic migmatites.