Geophysical Research Abstracts,
Vol. 11, EGU2009-1195, 2009
EGU General Assembly 2009

Grain growth kinetics of carbonates: Implications for rheology and closure temperature

J. Newman (1), A.K. Kronenberg (1), W. Lamb (1), N.E. Davis (1,2), P. Wheelock (3,4)

(1) Center for Tectonophysics, Department of Geology and Geophysics, Texas A&M University, College Station, TX 77843-3115 USA, (2) Now at: Chesapeake Energy Corp, 6100 N. Western Ave., Oklahoma City, OK, 73118, USA, (3) Materials Preparation Center at Ames Laboratory, Iowa State University, 111 TASF, Ames IA 50011-3020, (4) Now at: Technology Department, Rolls-Royce Corp, P.O. Box 420, Speed Code W-05, Indianapolis, IN 46206-0420

Grain sizes of rocks influence the rates at which deformation, diffusional exchange, and reaction occur. In turn, grain growth kinetics depend on grain boundary mobilities that are affected by composition, solute segregation, porosity and secondary phases at grain boundaries. In this study, we explore the rates of grain growth of stoichiometric dolomite ($CaMg(CO_3)_2$), calcite ($CaCO_3$), and magnesite ($MgCO_3$) at temperatures T = 700 - 800^{o}C and confining pressure P_c = 300 MPa (effective P_e = P_c - P_{CO2} = 170 - 270 MPa). Dry, fine-grained aggregates of the three carbonates were synthesized from high purity powders by hot isostatic pressing (T = 600^{o}C, P_c = 300 MPa, for 9 hours to 5 days). Initial mean grain sizes of the three hot isostatically pressed carbonates were 1.4, 17, and 1.1 μm, respectively, for $CaMg(CO_3)_2$, $CaCO_3$, and $MgCO_3$, with porosities of 2, $<$1%, and 28% by volume. Grain sizes of all carbonates coarsened during subsequent isostatic annealing at 700 and 800^{o}C, with mean grain sizes reaching 3.9 μm for dolomite, 27 μm for calcite, and 4.1 μm for magnesite annealed for times up to 6 x 10^5 s (or 1 week). Earlier studies of grain coarsening in calcite have shown that fine, isolated pores at grain boundaries effectively pin these boundaries. In this study, we find that grain coarsening of magnesite depends on large connected pores as well; magnesite densified by triaxial compression (to 14% porosity) shows a doubling in the grain growth rate constant K. Grain growth of dolomite is much slower than either the rates of calcite or magnesite; assuming normal grain growth, its rate constant K ($\simeq$ 5 x 10^{-5} μm^3/s) at T = 800^{o}C is less than that for calcite by 3 orders of magnitude and less than K for magnesite by a factor of $\sim$30. Given that Mg and Ca of dolomite are fully ordered ahead and behind of advancing grain boundaries, the low grain boundary mobility of dolomite may be explained by larger diffusional jump distances than are involved in grain growth of the end-member carbonates. The large difference in grain growth rates for dolomites and calcite marbles has important implications for the relative viscosities of these carbonates when conditions favor grain size sensitive flow for one or both phases. It also has implications for effective closure temperatures for cation exchange and the calcite-dolomite geothermometer.