12th Australian Geological Convention

Perth, 26 - 30 September 1994

GEOLOGICAL SOCIETY OF AUSTRALIA INCORPORATED

ABSTRACTS NUMBER 37

Geoscience Australia - 1994 and Beyond

GEOLOGICAL SOCIETY OF AUSTRALIA, ABSTRACTS NO.37
12th Australian Geological Convention, Perth, September 1994

FRACTAL CHARACTERISTICS OF NUCLEATION AND GROWTH TYPE MICROSTRUCTURES

Michael R. Riedel
University Potsdam, Projectgroup Thermodynamics, Telegrafenberg A43, D-14473 Potsdam, FR Germany.

The microstructure development during nucleation and growth processes is examined within the framework of the classical Kolmogorov model (constant nucleation rate within the metastable phase, constant growth rate of the nucleated grains) using 3D computer simulations. The arising spatial pattern in time may be characterized by two different morphological functions, the grain size distribution (gsd) and the cluster size distribution (csd), respectively. Both functions reveal a characteristic behaviour in dependencce of the transition degree x and are completely scaleable by the inherent Avrami time $\tau_{AV} = (IY^3)^{-1/4}$ and Avrami length $\delta_{AV} = (I/Y)^{-1/4}$ (I = nucleation rate, Y = growth rate).

The gsd evolves from a starting nearly rectangular shaped distribution to a distribution with a logarithmic depencency for small grains at completed transformation, whereas the csd is generally dominated by an exponentially decreasing function due to the grain impingement during the transition.

The mean grain size and mean cluster size is plotted vs. scaled time in δ_{AV} units. the formation of a continuous chain of new phase grains (percolation transition) is observed at 30% transformed volume. The geometry of a cluster near the percolation transition has a fractal characteristics with a fractal dimension of ~2.5. The presence of preferred sites of nucleation (heterogeneous nucleation) such as grain boundaries significantly modifies the microstructures when the spacing of nucleation sites larger than the Avrami length, the main effects being a reduced percolation threshold and an elongated grain shape.

These results are applied to the case of the olivine $\Rightarrow$ modified spinel transition in subducting slabs. The grain-size reduction due to first-order phase transformations can dramatically reduce the strength of subducting slabs that in turn will affect the fate of subducted slabs. Using the experimental data on the kinetics of olivine $\Rightarrow$ spinel transformation, we have simulated the microstructural evolution during this phase transformation for a realistic p,T-profile in a subducting slab. A significant grain size reduction will occur only for a fast subducting slab, implying that the amount of weakening associated with this phase transition depends on the velocity of subduction. Thus the overall strength of slabs will vary considerably from one to the other and the strength of slab will also change locally as a result of lateral temperature variation.

Some consequences to the origin of deep focus earthquakes as well as the applicability of the results to other geophysical processes like crystal settling in a solidifying magma chamber are discussed.