**Title**

Microstructure evolution during the static recrystallization of cold-worked Carrara marble

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**Abstract**

Recrystallization processes occur during plastic deformation (dynamic) or static annealing of rocks and minerals, through the formation and movement of grain boundaries. Recrystallization may have profound effects on lattice preferred orientations (LPOs) and microstructures. It is therefore vital to gain insight into recrystallization mechanisms in order to interpret the deformation and/or annealing history of rocks from their frozen-in microstructures. Additionally, if reliable models of the rheological behavior of minerals and rocks are to be produced, there is an urgent need for microstructural changes to be incorporated into a mechanical state variable of general form that describes recrystallization quantitatively.

In an effort to work towards these goals, this study quantifies LPOs and microstructural variations as a function of pre-strain, annealing temperature and annealing period in cold-worked and then statically recrystallized Carrara marble. Thirty two samples were analyzed using electron backscatter diffraction (EBSD). Calcite c-axes, and poles to mechanical e-twin planes, are clustered in a direction sub-perpendicular to the stress direction. The strength of the LPO decreases, albeit slightly, with the progress of static recrystallization. Both optical analyses and EBSD show that significant microstructural changes occur. During the initial deformation most of the strain is accommodated by twinning. This results in strain incompatibility, and therefore accumulation, at grain boundaries and at the intersection between different sets of twins. During annealing, recovery and sub-grain rotation recrystallization are active mechanisms that form small, strain free recrystallized grains, predominantly along existing grain boundaries and deformation twin lamellae. Against the prediction of existing recrystallization models, the small recrystallized grains have high misorientation angle relationships with each other and both low and high misorientation angle relationships with their parent grains. This is interpreted as due to the recovery and recrystallization of both, parent and twin grains to form new, twin-free daughter grains which show a wide range of low to high (near twin) angle boundaries. Recurrent misorientation angles are 30°, 60° and 90°, possibly owing to a strong crystallographic control on the statically recrystallized microstructures. Readily formed, high energy, high angle boundaries, lead to the onset of rapid grain boundary migration that forms irregularly-shaped recrystallized grains. The newly formed grains have LPOs similar to those of the pre-existing grains, but weaker. A simple conclusion from the analysis of previously cold-worked and then annealed Carrara marble is that high angle misorientation relationships and weaker LPOs may be generated in some recrystallized microstructure without the aid of the grain boundary sliding mechanism.