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Multi-stage evolution of frost-induced microtextures on the surface of quartz grains – experimental study

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Sand-sized (0.5–1.0 mm) grains of mechanically-crushed vein quartz were subjected to the frost action under controlled, laboratory conditions. Defined temperature changes from -5˚C up to +10˚C provide cyclic freeze-thaw (FT) process, and thus simulate periglacial conditions. A total of 1000 FT cycles were simulated under low (213 mg/l) and high (1954 mg/l) water-mineralization conditions (LMW, HMW, respectively). Microtextural analysis of grain surfaces was undertaken using SEM (scanning electron microscope) before experimental run (0 FT cycles, i.e. reference sample) and after 50, 100, 300, 700 and 1000 FT cycles. Each time twenty randomly selected grains from each sample were analysed at low (~100-150x) and high (~1000x) magnification. The frequency of occurrence of individual microtextures on grains from a given sample was estimated, and frost-induced imprints were counted on each grain. The degree of surface coverage with a precipitated crust was determined qualitatively (low/high) and its elemental composition was determined by EDX (Energy-dispersive X-ray spectroscopy).

The results of this experimental simulation indicate that four mechanical microtextures can be considered as diagnostic ones for the frost weathering process. These are: small- and large-sized conchoidal fractures (cf, CF, respectively) along with small- and large-sized breakage blocks (bb, BB, respectively). Two predominant outcomes in the course of micro-scale frost weathering have been identified: a) a physical aspect of the process evidenced by numerous cf, CF, bb, BB microtextures during first 300 FT cycles; followed by b) a chemical aspect resulting in the precipitation of surficial crusts and obliteration of grain microrelief. The complexity of frost-originated microtextures and their location on grain surfaces reflect three stages in the evolution of frost-induced microrelief: 1 – initial, development of CF, 2 – progress, development of cf, and 3 – advanced, dominated by bb and BB growth; summarized as: crack -> CF -> cf -> bb -> BB. This evolution may, however, be influenced and interrupted by the grain refreshing process, when cracking and detachment during the formation of CF reveal the fragments of fresh, unweathered surface of grain. This frost-induced refreshment causes the grain to lack some / most of the mechanical frost-originated microtextures. It may occur many times at each stage (1, 2, 3) of the weathering process and the cycle of development of frost-originated microrelief (crack -> CF -> cf -> bb -> BB) is thus repeated. The term '*renewal of frost weathering*' has been introduced here for this event. The obtained results indicate that microtextural characteristics of frost-weathered grains depends largely on the mineralization of water involved in the process. It seems that frost weathering of the quartz grains enveloped with HMW is more effective than of these poured with LMW.

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