

Frozen in motion: A controlled *in vitro* experiment of freeze-thaw impact on lithic artifact displacement and use wear patterns

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Abstract:

Frost-induced artifact displacement is a well-documented phenomenon at Pleistocene archaeological sites across Eurasia, often complicating archaeological interpretations, as evidenced at Quinçay site in France. However, the extent of artifact movement and surface alterations caused by freeze-thaw cycles remains unclear. Similarly, distinguishing between frost-induced wear and anthropogenic use-wear on stone tools is challenging. Previous experiments - conducted either in controlled laboratory conditions or in nature- reported minimal to no artifact displacement of few dozens of millimeters, which contradicts evidence of spatial redistribution of artifacts due to freeze-thaw cycles in several Pleistocene sites. These experiments also reported

modest to no frost-related surface modifications (e.g., polish on flint artifacts). Importantly, these previous studies had restricted durations, involving a limited number of freeze-thaw cycles, and many of the experiments in nature lacked sufficient control over contributing variables.

To better understand the effects of frost on artifact displacement and micro-surface alterations and, therefore use-wear preservation, we conducted a long-term controlled laboratory freeze-thaw experiment, subjecting lithics to 42, 330 and 600 cycles using a climatic chamber. Our goal was to systematically test the impact of freeze-thaw cycles across various sediments and lithic types. We considered a number of variables, namely varying sediment types like fine-grain clay, coarse and fine sand to gravel mixed with clay, with a fine-grain mix of silt and sand sediment sieved from Quinçay cave. Also, sediment volume, water saturation, temperature (both ambient and within the sediment), and artifact deposition depth, were controlled. Concerning the lithic morphology, we included a selection of lithic tools – unused flakes and cut flint blocks of similar dimensions and weight, with scrapers, Châtelperronian-type points and bladelets- previously used on hide, wood or bone.

Our results show that after 330 cycles lithics buried in sediments with a relatively fine-grained matrix (clay, Quinçay sediment, or gravel mixed with clay) experienced significant vertical displacement, often reorienting toward a vertical position and moving closer to the surface compared to the lithics buried in sandy sediments. Also, after 600 cycles, some lithics displayed downward movement, and smaller pieces often rotated during displacement after both 330 and 600 cycles. Micro-wear analysis showed alteration polish from freeze-thaw, which appears to correlate with the sediment type and composition.

This study provides evidence for the development of microscopic surface modifications due to lithic movement in extended freeze-thaw cycles. Our study helps to establish a basis for using micro-wear analysis as a proxy to assess site formation processes, and to systematically analyze the post-depositional history of lithics in different contexts, while better interpreting use-wear on Eurasian paleolithic artifacts.

Key-words: controlled experiments, freeze-thaw, use-wear modifications, lithic movement, polish

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