Application of ultrasonic soundwave velocity for investigation and documentation of Bronze Age rock art in Tanum, Sweden

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The Bronze Age rock carvings in Tanum, Western Sweden, have been the topic of research for more than a century, and in 1994 the area was designated as world heritage site due to the exceptional density and quality of the engravings. Although the meaning of the depictions and their role in Bronze Age society is widely discussed (Horn et al. 2020, Skoglund et al. 2022, Tilley 2021), while very little is known about the carving process itself (Lødøen 2015). For this study we focus on carvings made in the monzogranitic Bohus granite.

Here we present pieces to the puzzle on why the Bohus granite was such a great canvas and why the people at the time were able to carve in this hard rock. The glacial polished surface of the Bohus granite created not only a great contrast to the later carved images, but also impact the rock properties of the upper few mm to cm (Blackburn et al. 2019, Siman-Tov et al. 2012). We present data from soundwave measurements of 4 localities (panels), which indicate the pressure release after the melting of the glacier resulted in surface parallel microfractures (relaxation fractures), causing a weakening of this uppermost layer with its polished surface. Comparing the depth of the carved images, using advanced 3D photogrammetry analysis, with the thickness of this top layer shows that none of the images are deeper than the thickness of that layer. We believe that this weakened top layer is a key element for the Bronze Age artists to be able to carve the rock with tools available at the time.

The impact of the carving process itself created another generation of microfractures. Those are expected to mostly incline medium to steep and are therefore already by orientation differentiable from the relaxation fractures. The increased fracture density inside a carving comparing to the surrounding matrix leads to a decrease in soundwave velocity. This provides us with a tool for documentation of the images as well as monitoring their state of weathering. While monitoring the effect of local weather changes on the signal we found heat stress to be one of the most important ones. Especially during the spring to early summer month, the temperature variation in the rock from heating through sun radiation in change with the still freezing temperature at night are stressing the rock to a high extend, and increases the risk of rock spalling, which will damage the carvings.

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