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Ultrasonic Probing of Stress Changes in a Natural Cliff Undergoing Thermal and Frost Stress

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Rock fracturing plays a key role in shaping mountain landscapes and natural hazards. Weathering agents, such as daily thermal variations, rain and frost, are among the main triggers of the weathering and fracturing process. However, the mechanisms involved are not well quantified, and questions remain about stress variations in natural cliffs.

To better quantify the effect of thermal variations, periods of rain and frost on in situ mechanical properties at centimeter scale, field recordings were made using reproducible active ultrasonic sensors to measure both wave velocity and changes in wave form. The Abraham pillar above the Chauvet cave in southern France (Mediterranean climate) and the Tête Noire pillar in Wallis (Alpine climate) were equipped for periods ranging from several weeks to several months.

At the Abraham pillar site, thermal variations and rain events were studied. The results show a temporal evolution as daily cycles in velocity variation correlated with air temperature and solar radiation, while a significant drop in wave velocity after rain is revealed. At the Tête Noire pillar site, frost periods were studied. The results show a significant increase in wave velocity when temperatures fall below 0°C. Using thermo-acousto-elastic modelling, it is then possible to assess several in situ stress processes as a function of different weather conditions. Furthermore, ultrasound waveforms of both side reveal temporal variations, suggesting an evolution in micro-crack properties.

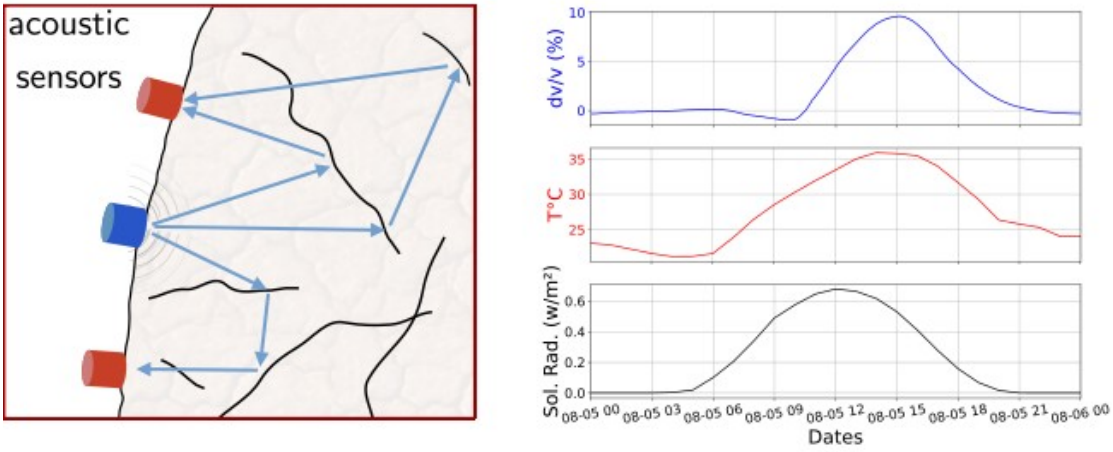

Figure 1: Illustration of the effect of solar radiation on temperature and acoustic velocity at a rock face.

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