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Rock Column non-linearity estimated from ambient seismic noise, acoustics, and environmental forcings

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The mechanical behavior of natural sites is largely guided by vibrations of the Earth and environmental exposure, but damage is rarely assessed, except empirically. Rock pillars , such as the Abraham's pillar above the Chauvet-Pont d'Arc cave, or the Tete Noire pillar overhanging the road to the Trient village (Wallis) represent shining example of fragility that would benefit from monitoring. Those rock columns extend out from the cliff like natural tuning forks. For this study, we monitored dancing movements of those pillar over several months to several years to analyze their elastic response to weather conditions. Using ambient-seismic-noise-based methods, we identified the pillar's natural resonance modes. Through extensive monitoring of the sites, we observed the striking temporal evolution of these resonance frequencies on hourly, daily, seasonal, and pluriannual scales in response to changes in air temperature and insolation. Based on thermo-acousto-elastic modeling with a simplified 3D geometric structure, we determined how thermally-induced stress stiffening affects the rock material, by applying convective and radiative heat fluxes to the model. From the results obtained, we suggest a novel quantitative method based on daily observations that can estimate the level of damage within the rock material. Our work provides a foundation for distinguishing between reversible processes and damage for hazard studies in the frame of climate change. Moreover, on a short time scale, we have investigated the role of rain and frost. Such knowledge is crucial not only for the preservation of heritage sites but also for enhancing risk assessment protocols and informing conservation efforts worldwide, and territories accessibility.

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