Sandstone weathering:

New approaches to assess building stone decay

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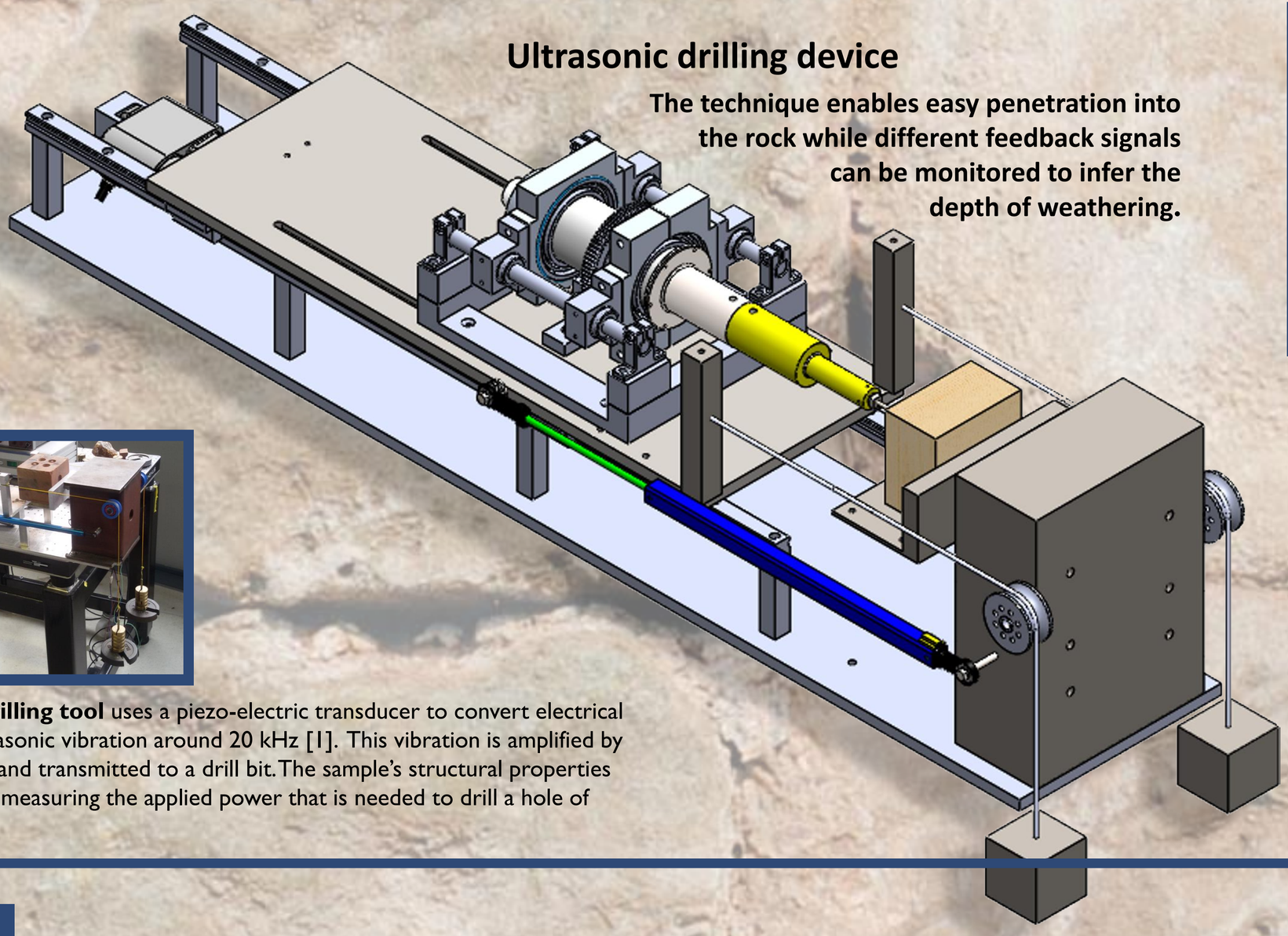
INTRODUCTION

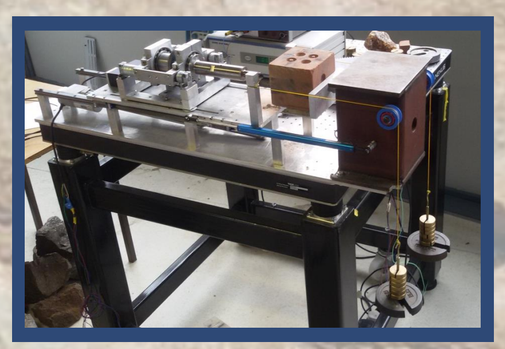
New approaches to assess masonry decay are required to help in the preservation of built heritage especially in Scotland. Consistent methods of measurement and empirical data analysis to evaluate the progress of weathering have to be defined to substantiate the classification of stone decay. Our project aims to identify the exact length scale (nanometre to centimetre) and timescale (seconds to years) of weathering processes. Developing new minimally invasive tools will improve our assessment of the state of decay and help to determine which stone(s) need to be replaced. The project focusses on assessing sandstones with **ultrasonic drilling tools** to investigate any variation in structural properties. Spatial changes in one dimension are analysed with a **laser interferometer**.

METHODS

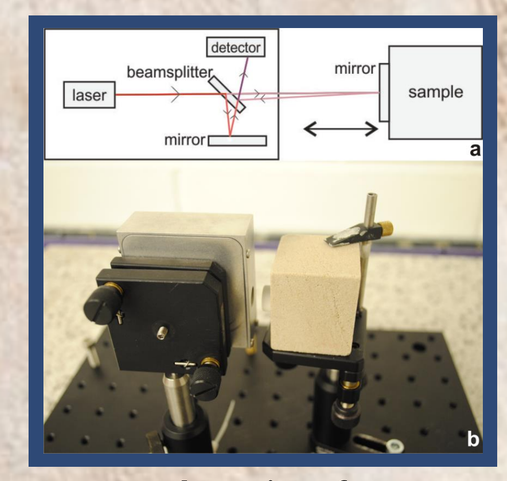
Ultrasonic drilling device

The technique enables easy penetration into the rock while different feedback signals can be monitored to infer the depth of weathering.





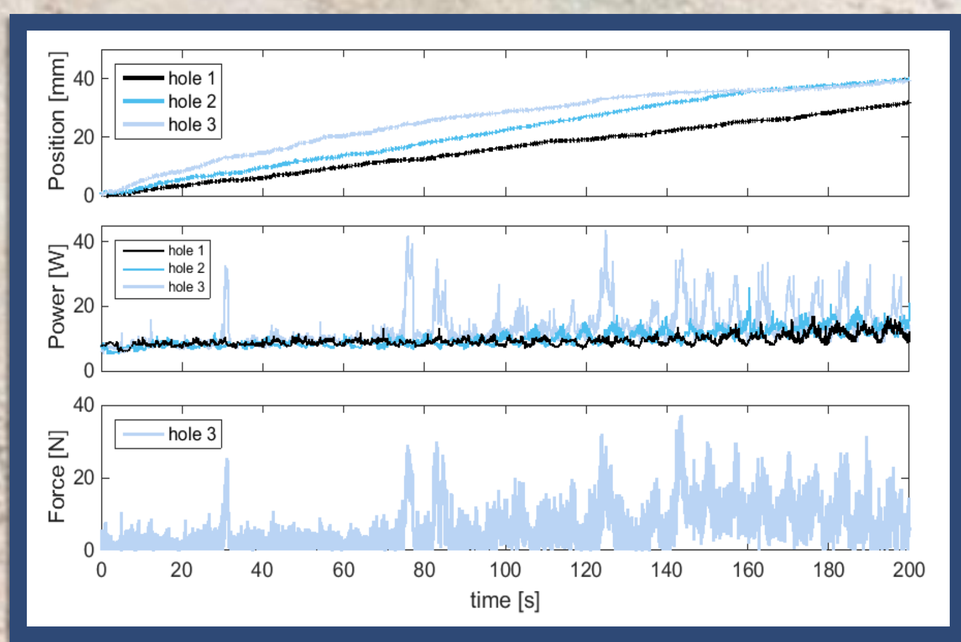
The **ultrasonic drilling tool** uses a piezo-electric transducer to convert electrical energy into an ultrasonic vibration around 20 kHz [1]. This vibration is amplified by an ultrasonic horn and transmitted to a drill bit. The sample's structural properties can be deduced by measuring the applied power that is needed to drill a hole of some millimetres.



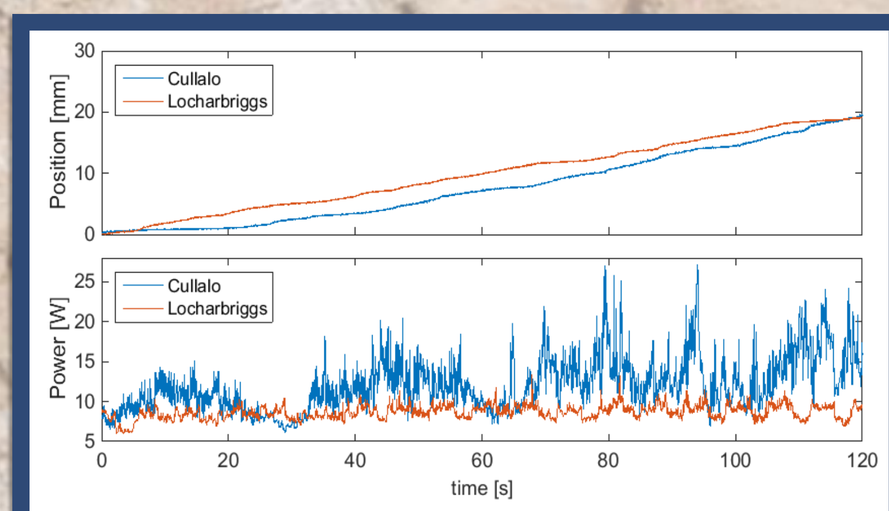
Laser interferometer
Measuring the expansion and contraction of stones can tell us what is happening in the inside of a rock. Laser interferometer provide a precise (nanometre scale) measurement of the stone's movement.

RESULTS

The penetration rate and the power consumption vary for different porosities and rock hardness.



During drilling the position, the power consumption and the force on the sample can be monitored. The figure on the left shows three drilled holes with a diameter of 3 mm into Locharbriggs sandstone. For each hole the rate of progress is almost constant; the variation is caused by the wear of the Cobalt drill bit as well as dust accumulation after a depth of 25 mm. The *weight on bit* is 5 N for the drilling process. The force experienced by the sample is proportional to the power consumption (see third hole.)



Different sandstone types (Locharbriggs, Cullalo) can be distinguished as he power consumption varies as well as the rate of progress.

CONCLUSION

- The ultrasonic drilling tool allows the identification of changes in the structure of a sample while drilling a hole to a depth of up to 4 cm. By measuring the power required to drill, structural changes (including porosity) at depth within the sample can be mapped. Investigations with weathered samples and salt accumulation in the pores will follow.
- The use of ultrasonic tools enables penetration of the rock with less damage to vulnerable stone and a fast progress rate into hard materials with a reduced wear effect on the drill bits. The drill bit material needs to be improved for abrasive sandstones (HSS and/or diamond tip).
- The developed techniques allow for better prediction of the decay processes, including upscaling from the lab to the field, and can potentially be used in situ on historical buildings under site conditions.

References: [1] Li, X., Harkness, P., Timoney, R., Bolhovitins A., Lucas, M., 2015: A Motion Control System Design for an Ultrasonic Percussive Coring/Drilling Unit. AIAA SPACE conference 2015, Pasadena

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