Investigating frost cracking in alpine limestone through fracture propagation using 3D-CT scans

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1 Introduction

Temperature fluctuations across the freezing point and the presence of moisture can cause cryogenic stresses to accumulate, leading to fracture propagation, also known as “frost-cracking” (Draebing et al., 2022). This weathering process significantly affects sediment production in rock slopes at the macro- and microscale (Musso Piantelli et al., 2020). Therefore, it is important to know the role of microfabrics as an influencing factor on fracturing efficacy.

This study aims to experimentally investigate frost-cracking on a microscale in the Quinten limestone. The Quinten limestone is abundant in the Helvetic Nappes of the Swiss Alps (figure 1). Our samples differ in their tectonic history, which resulted in spatially different rock fabrics. This allows us to study the effect of tectonic preconditioning on frost cracking in this lithology.

2 Study Site

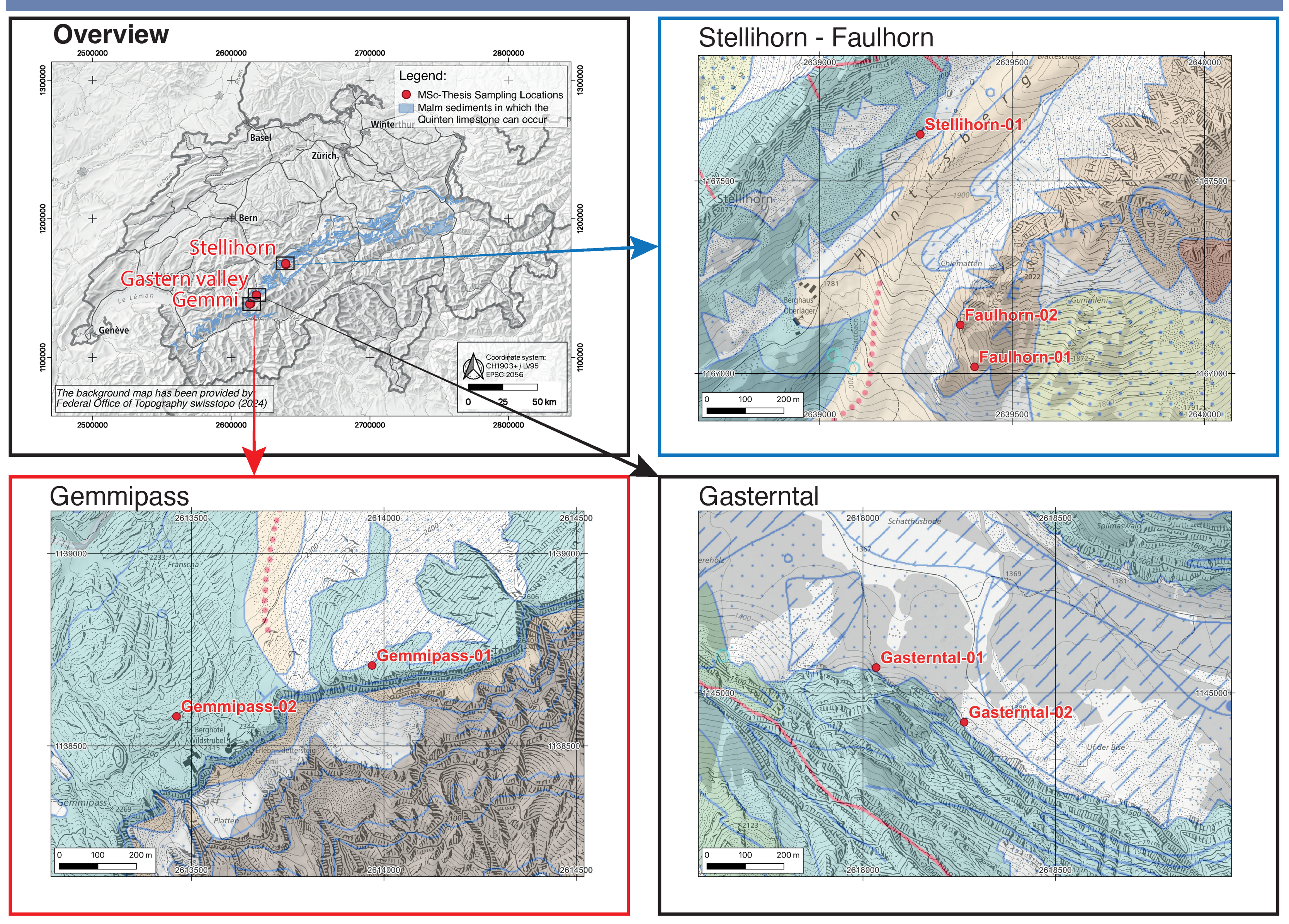

Figure 1: *The abundance of Malm deposits in the Swiss Alps (blue). Red dots indicate sampling sites.*

3 Methodology

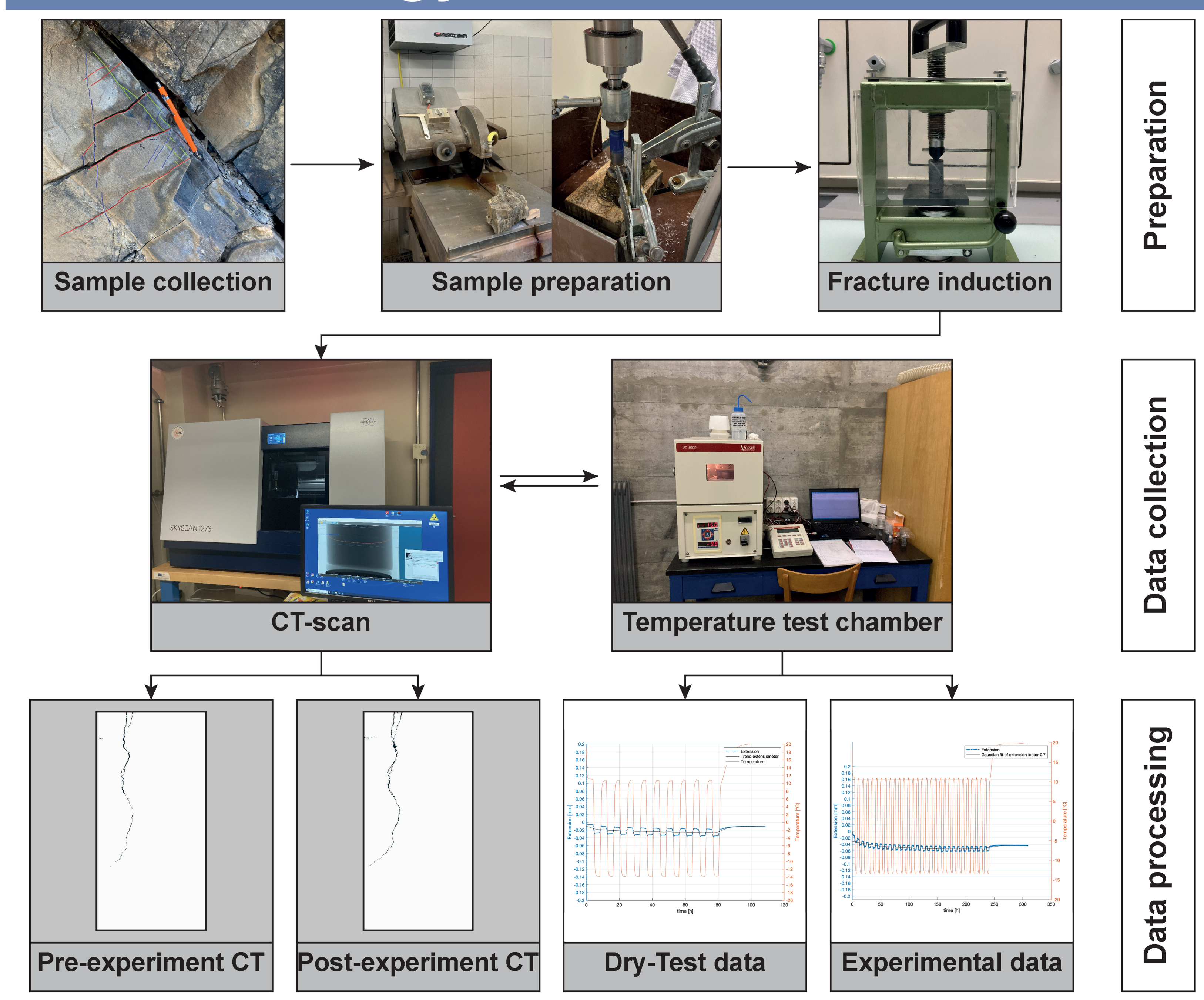

Figure 2: *Workflow diagramm for the fracture experiments*

4 Results

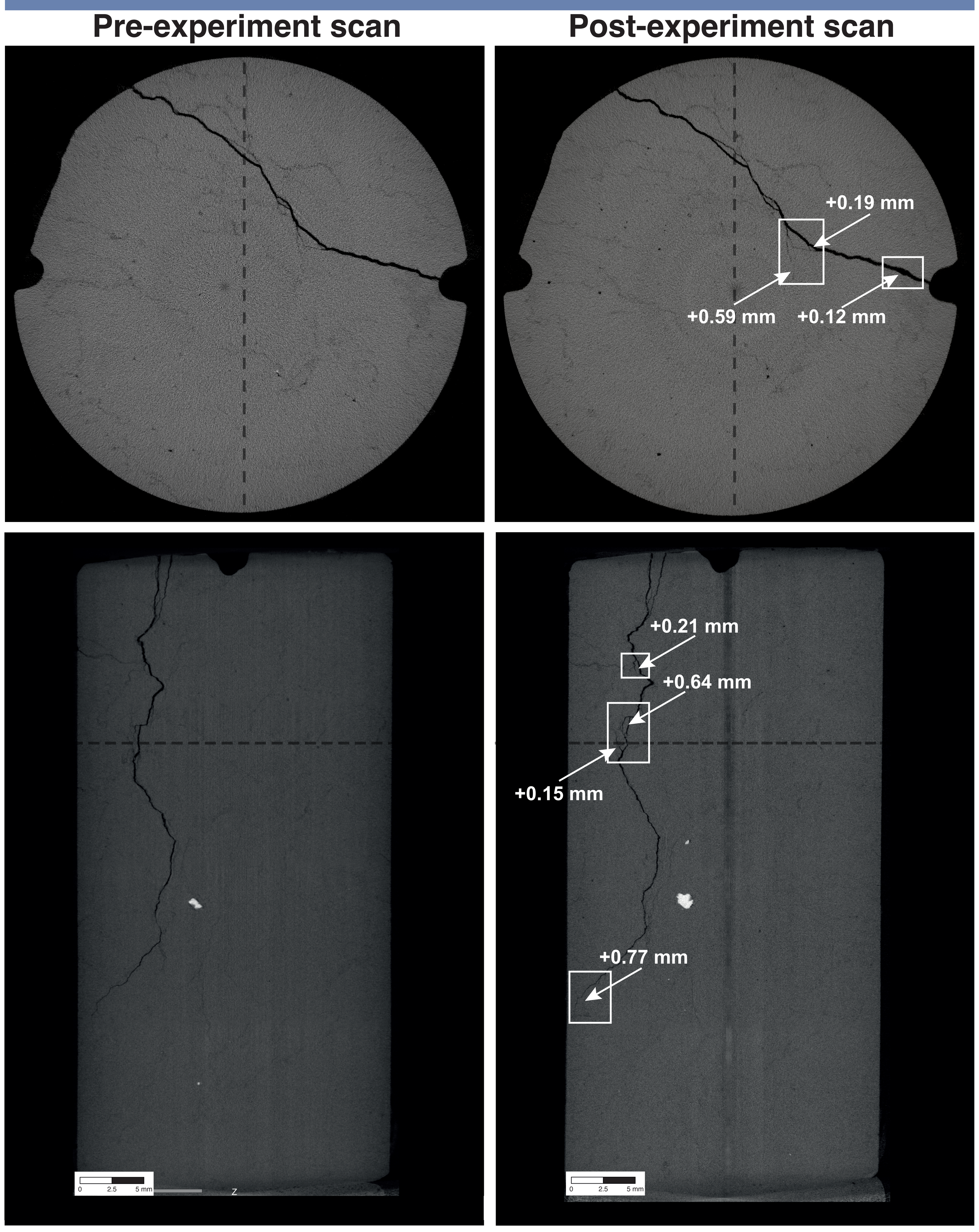

Figure 3: *Images of the CT-Scan “Stellihorn 01”. The image's grayscale reflects the density variations, with darker areas showing lower densities (like fractures or pores) and lighter areas denoting higher densities. The white rectangles indicate the areas of fracture propagation or widened.*

5 Conclusions and Outlook

The experiments carried out, indicate that in the saturated state, cooling rates of -0.41 [°C/min] are sufficient to enlarge a fracture. As seen in Figure 3, the fracture does not just propagate in one section. It appears that the fracture follows the pre-existing less dense structures. Further, it shows that a resolution of 10 μm is suitable for quantifying the fracture dimensions. However, further experiments are necessary to refine our understanding of fracture propagation across various samples of Quinten limestone.

This study will be continued with further experiments. By including an extensometer, the material’s response throughout the experiment is also recorded. That will enrich the dataset for a more comprehensive analysis of the fracture behavior.

6 References

Draebing, D., Mayer, T., Jacobs, B., and McColl, S.T., 2022, Alpine rockwall erosion patterns follow elevation-dependent climate trajectories: Communications Earth & Environment, v. 3, p. 21, doi:10.1038/s43247-022-00348-2.

Musso Piantelli, F., Herwegh, M., Anselmetti, F.S., Waldvogel, M., and Gruner, U., 2020, Microfracture propagation in gneiss through frost wedging: insights from an experimental study: Natural Hazards, v. 100, p. 843–860, doi:10.1007/s11069-019-03846-3.

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