Efficacy of classical and spectroscopic techniques for strain quantification in weakly shocked rocks: Results from experimentally impacted Taunus quartzite

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Plain Language Summary: Fry and R_f/ϕ methods are known techniques to classify strain in slow deformations. Their potential in assessing strain in a low-shock event remains uncertain. Therefore, an impact experiment was carried out on Taunus quartzite to check the efficacy of such classical methods, along with X-ray diffractometry, in estimating strain. The experimentally obtained strain values were then compared to iSALE simulations. Fry and R_f/ϕ methods showed some promise, but we believe they are false positives due to methodological limitations. XRD however showed potential, and we suggest that its effectiveness should be investigated further.

INTRODUCTION

- Traditional strain estimation techniques, such as the Fry and the R_f/ϕ method, have been extensively used in tectonically deformed rocks[1]. The use of such techniques in an impact event is yet to be explored.
- Essential differences between tectonic and impact cratering-led deformation are the strain rates[2][3] and peak pressures[4][5].
- An experiment was carried out to check the efficacy of such classical and spectroscopic (XRD) techniques in a low-shock event.

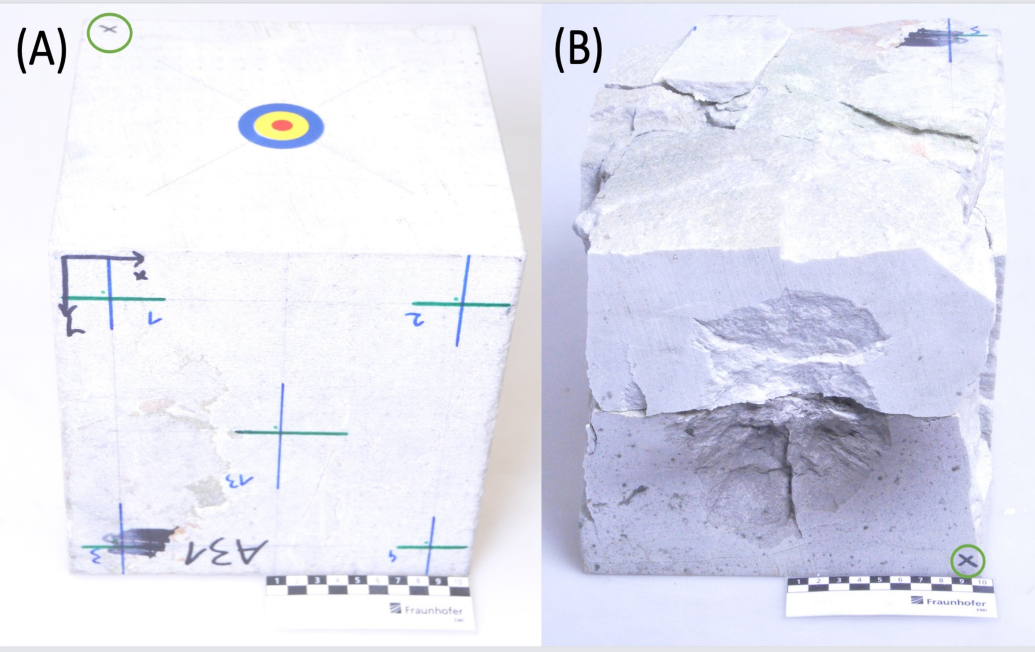

Figure: Photographs of the Taunus quartzite block (edge length 20 cm) (A) before and (B) after the impact experiment.

METHODS

- Strain analysis was carried out using three methods: (1) Fry, (2) R_f/ϕ , and (3) X-ray Diffractometry (XRD) on 47 samples (24 from target surface, 23 from subsurface).
- These results were then interpolated and compared to simulated strains in the transient stage from hydrocode modelling (iSALE).

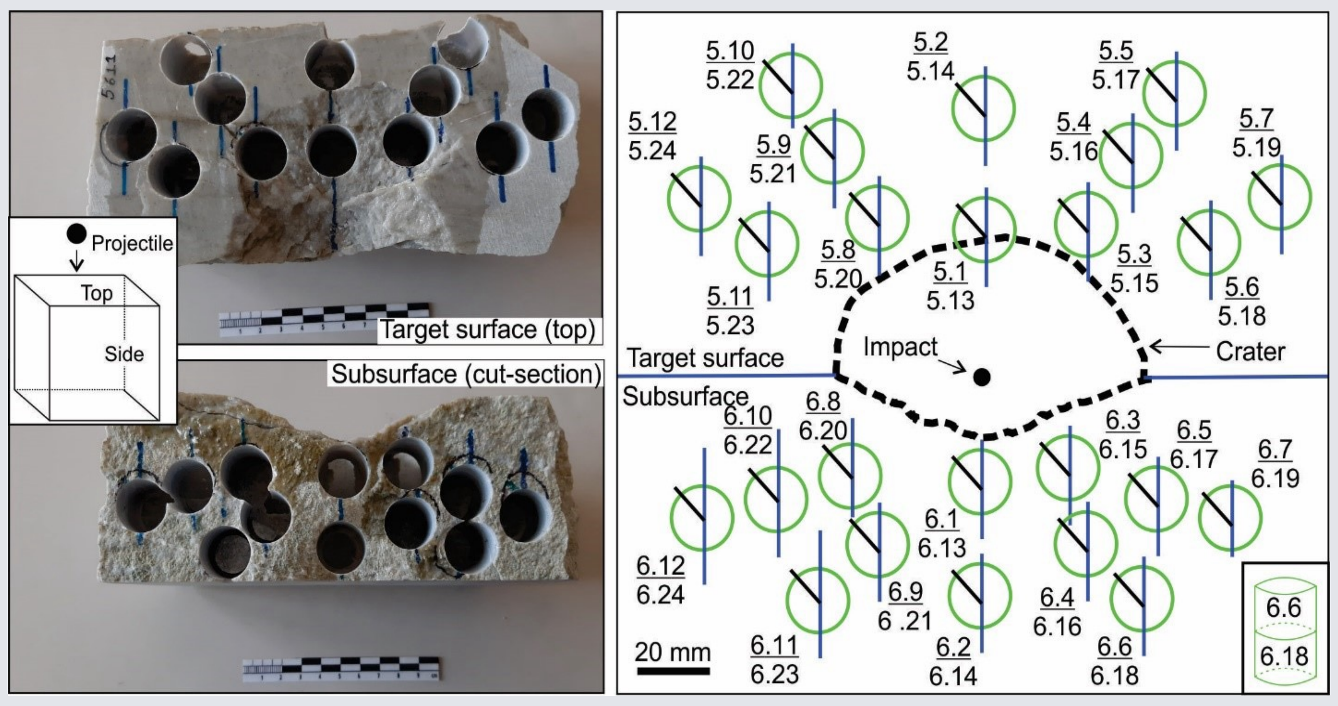

Figure: The figure and the images indicate the drill positions with respect to the crater. The black dashed circle denotes the approximate impact point.

RESULTS

A) Strain from Fry and R_f/ϕ analysis

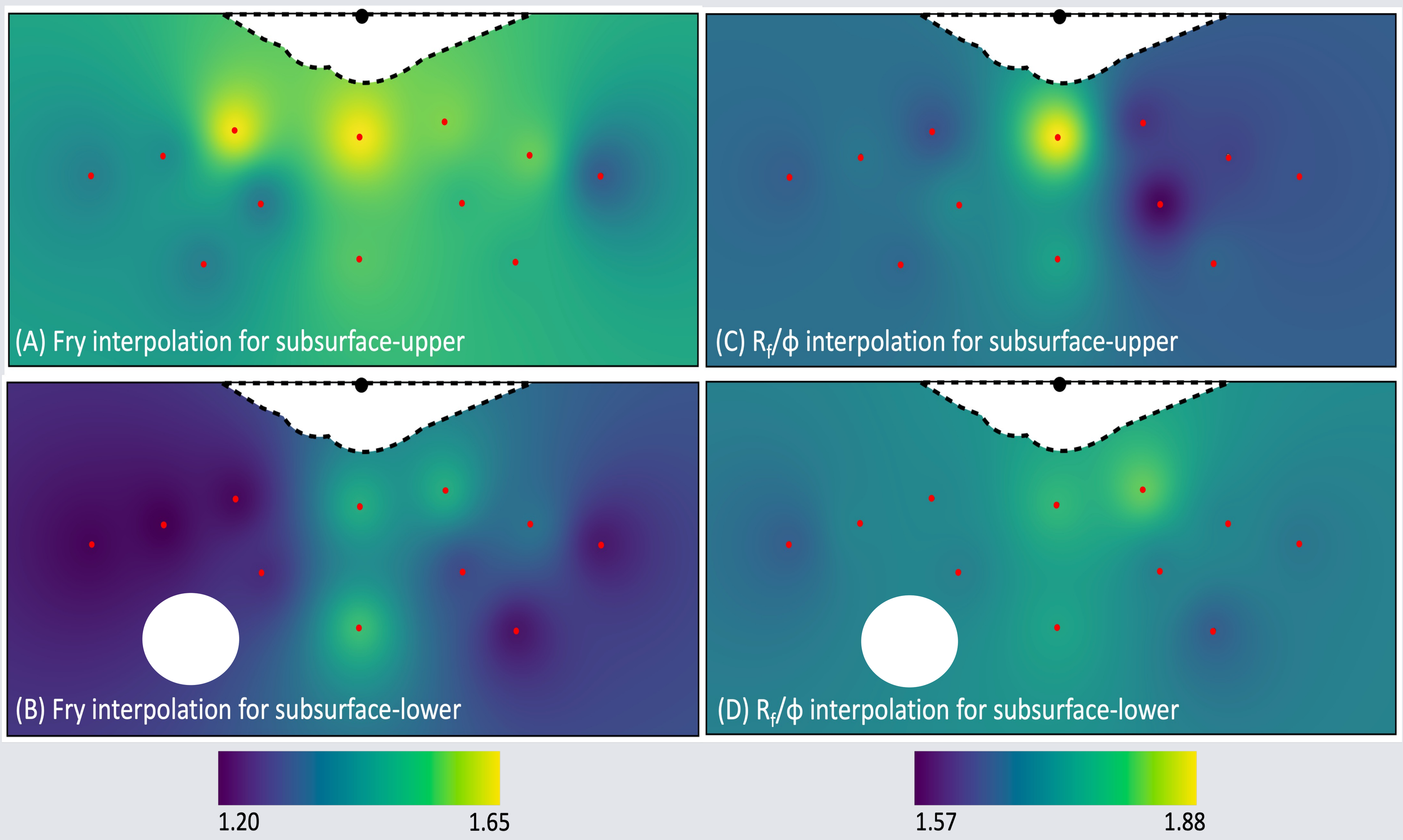

Figure: R values obtained from the Fry method (A and B) and R_f/ϕ method (C and D) interpolated with respect to the crater (for the subsurface). The white circle corresponds to sample 6.23, which was broken and hence not included in this study.

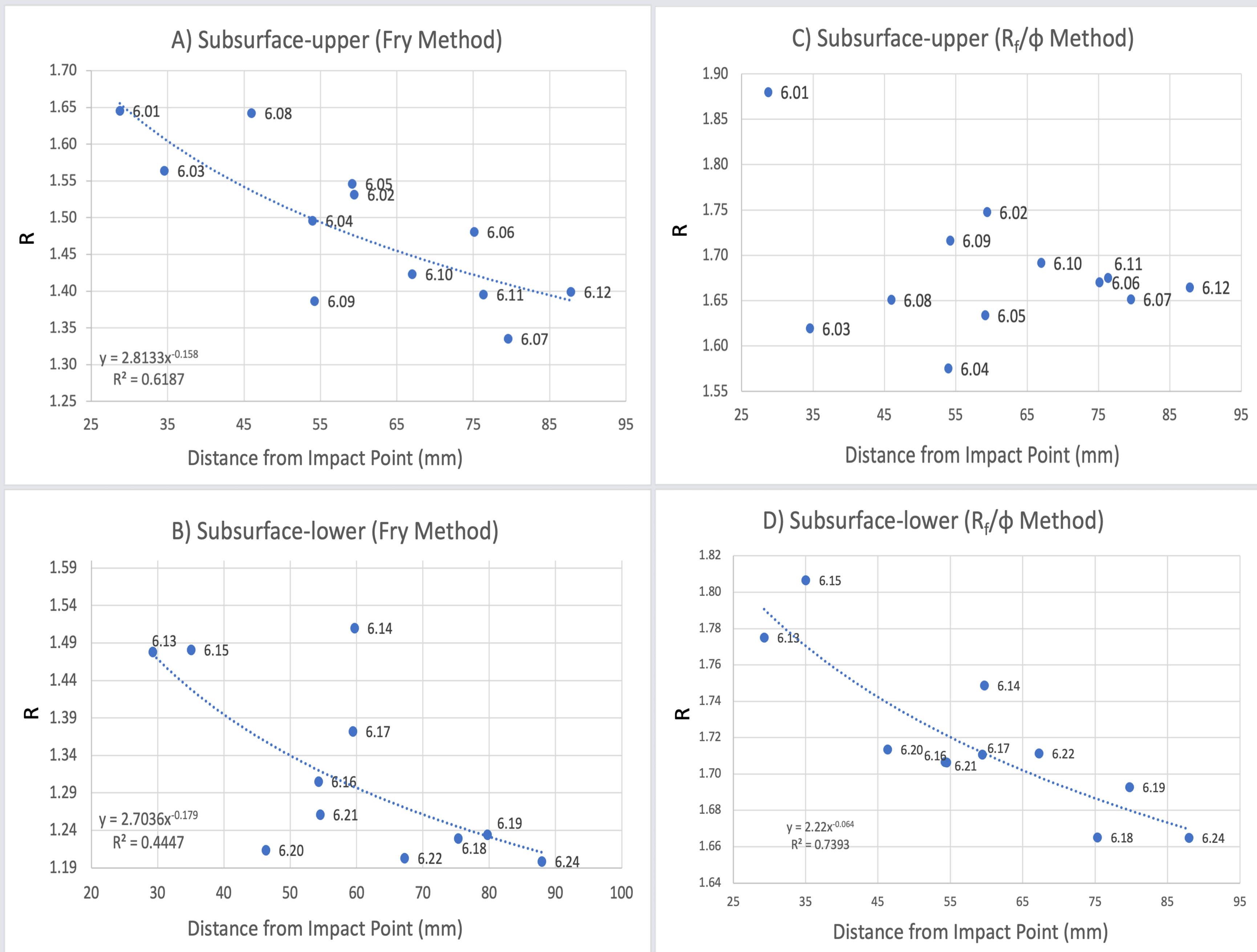

Figure: The average strain values calculated from the Fry (A and B) and R_f/ϕ (C and D) method plotted as a function of the distance from the impact point for subsurface-upper and subsurface-lower.

B) Strain from X-ray Diffractometry

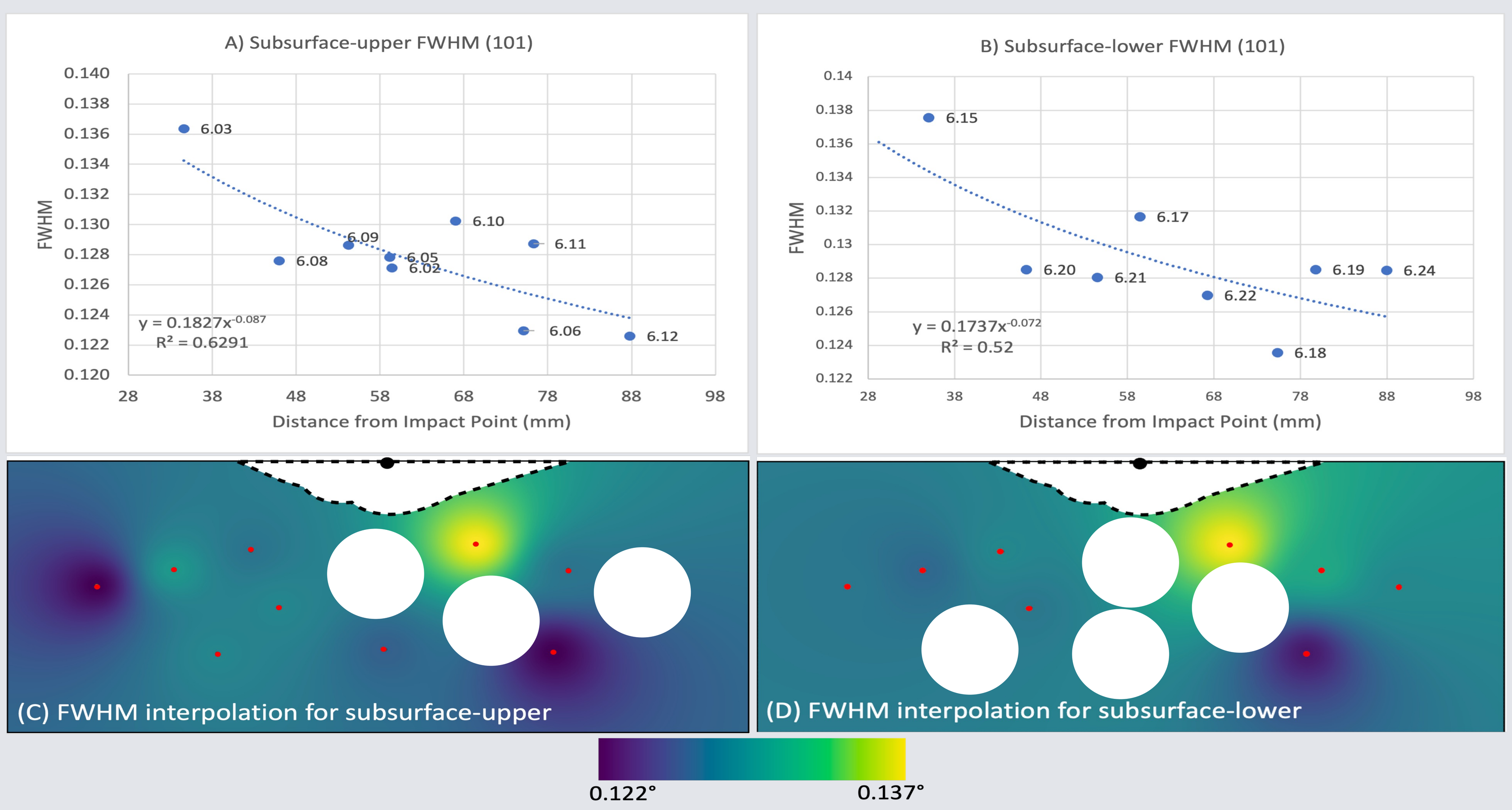

Figure: FWHM trend maps for XRD method plotted along with the interpolation map.

C) Strain from hydrocode simulation

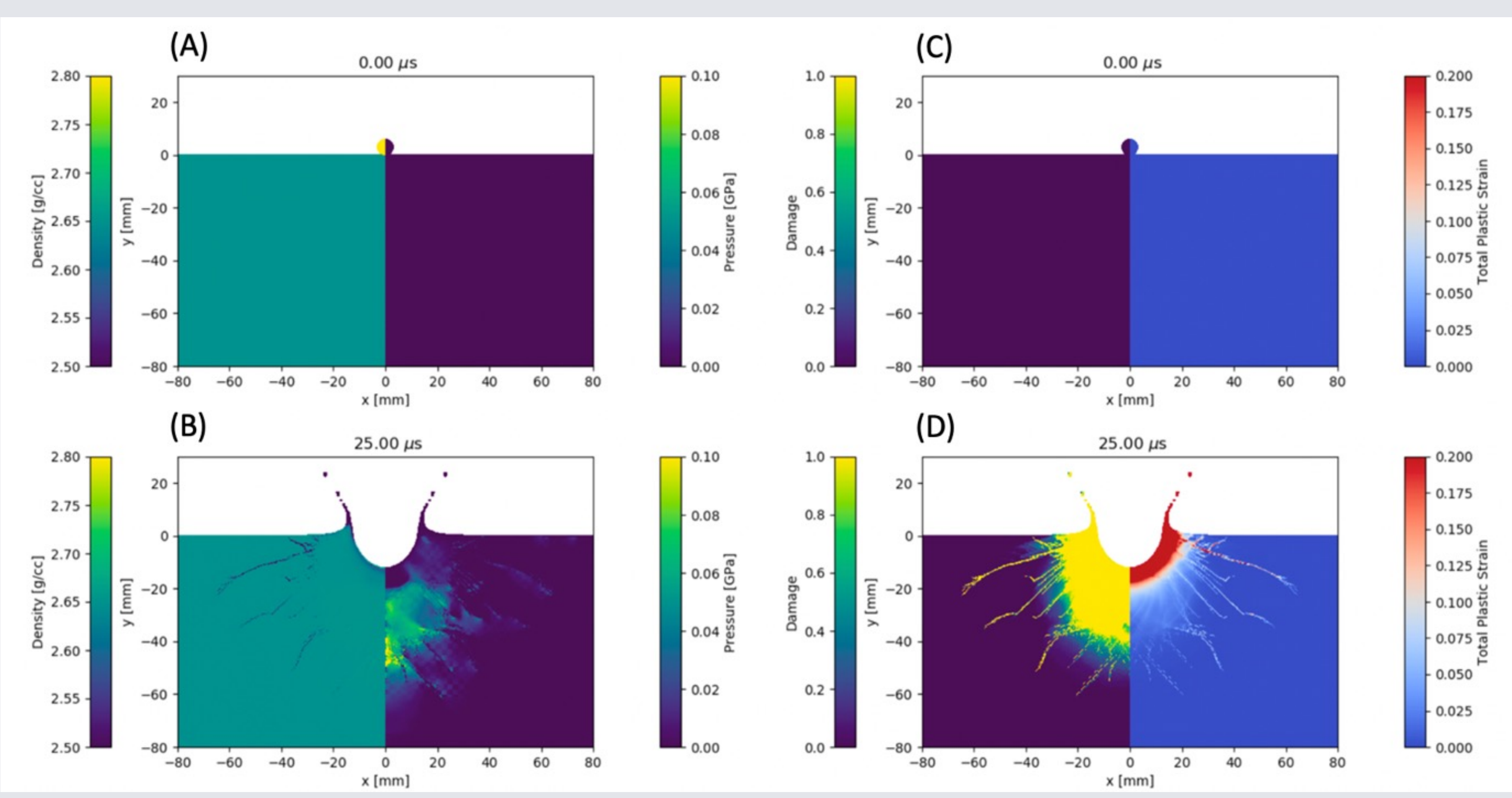

Figure: Results from iSALE simulations. (A-B) show pressure and density distribution. (C-D) show damage and total plastic strain after 0 µs and 25 µs.

DISCUSSIONS

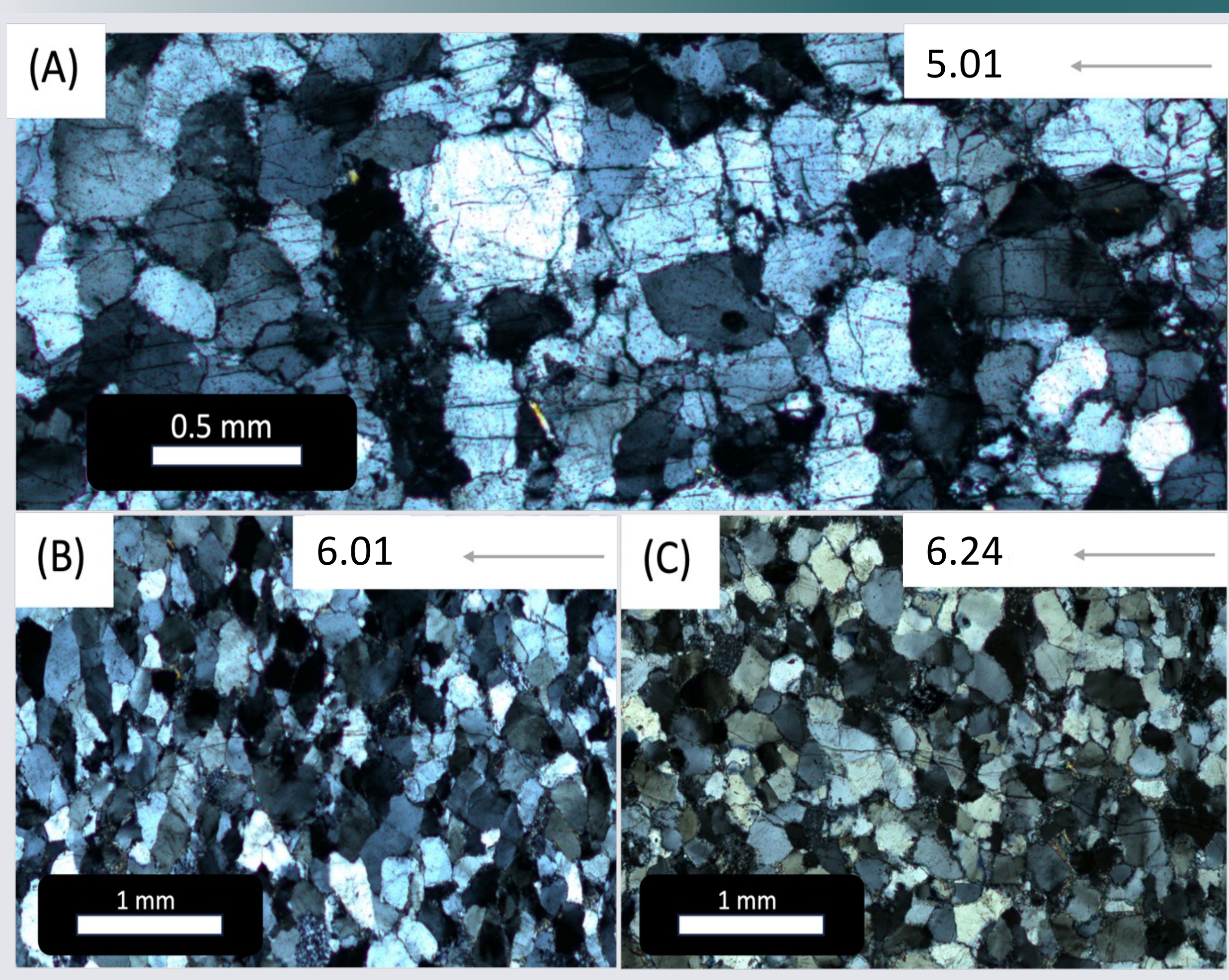

Figure: Thin section images from the experiment. The arrows indicate the direction of the point of impact.

- Microfracture features were observed on the target surface but not on the subsurface
- Fry and R_f/ϕ methods may not capture strain effectively due to methodological limitations[6][7].
- XRD measurements reflect strain in the lattice. Previous studies have shown the signature of low strain in quartz using XRD[8].

REFERENCES

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