Timing of Brittle Deformation in the Cañon City Embayment, CO: Laser Ablation U-Pb Dating of Carbonate Fractures

Marc Center & Andreas Möller

Department of Geology, The University of Kansas, Lawrence, KS, 66045 USA, m749c859@ku.edu, amoller@ku.edu

INTRODUCTION

- The Colorado Front Range and its tilted sections of sedimentary rocks are one of the most iconic geological features within the United States. Extensive sections of Paleozoic to Mesozoic units are exposed in the Cañon City embayment (Fig. 1). Tilting and formation of the embayment is the result of the late Cretaceous Laramide Orogeny. Further uplift of the Rocky Mtns. occurred during Neogene times (e.g. Karlstrom et al. 2012)
- This study tests the feasibility of U-Pb carbonate dating of brittle deformation features in the Colorado Front Range, specifically in the Canon City embayment. We hypothesize that these are associated with Front Range uplift.
- Samples from fault surfaces were collected in the Temple Canyon area (Ordovician Harding Fm.), the Harding Fm. along Shelf Road, and the Marsh-Felch Dinosaur Quarry area (Jurassic Morrison Fm.) (Fig. 1). The latter site yielded famous dinosaur specimen, e.g. the Stegosaurus at the Smithsonian Museum.

Cañon City Embayment

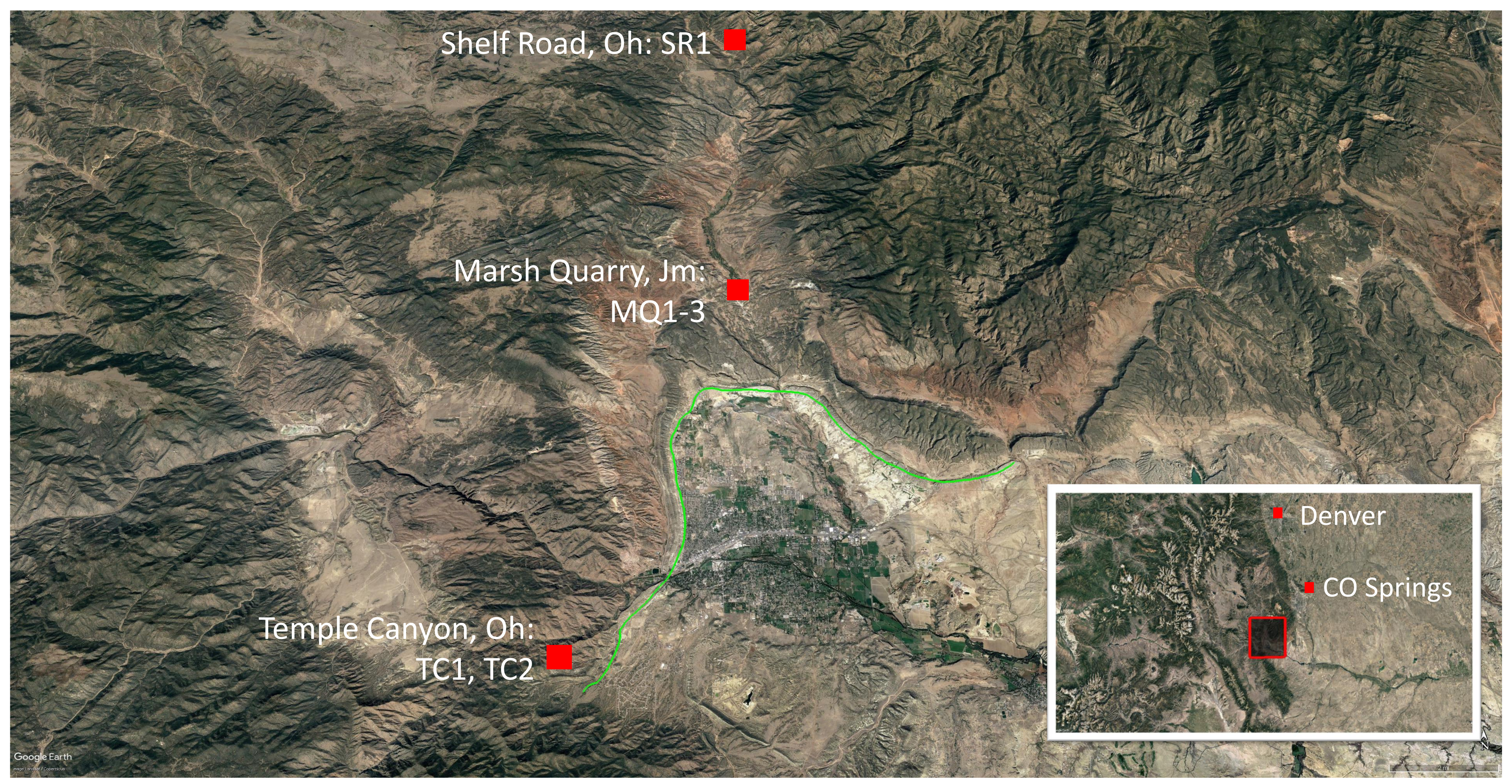

Fig.1: Satellite view of the Cañon City, CO area from Google Earth with sample locations. Steeply dipping Cretaceous Dakota Sandstone (Kd) outlined in green highlights the Rocky Mountain Front Range around the city. Red squares highlight sample locations, labeled with sample identifier. Overview map outlined in white shows the Rocky Mountain belt with research area outlined in red.

METHODS

U-Pb isotopes were analyzed in polished thick sections (ca. 100 µm) and unpolished surface samples of carbonate veins by laser-ablation ICP-MS at the University of Kansas, using a Photon Machines Analyte.G2 193nm excimer laser and Thermo Element2 mass spectrometer. Pb isotope fractionation was calibrated to NIST614 glass, U-Pb fractionation was corrected using reference material DBTL *Hill et al. (2016) and validated with WC1 (Roberts et al., 2017)

REFERENCES

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Karlstrom, K.E., Coblentz, D., Dueker, K., Ouimet, W., Kirby, E., Van Wijk, J., Schmandt, B., Kelley, S., Lazear, G., Crossey, L.J. and Crow, R., 2012. Lithosphere, 4(1), p.3-22.

CONCLUSIONS

- U-Pb carbonate results range from Cretaceous to Neogene.
- A precise date of 110.4±1.4 Ma from a 2 cm-wide carbonate vein in the Jurassic Morrison Fm. coincides with basin formation and the Sevier Orogeny, predating Rocky Mtn. uplift and Laramide deformation. This is contrary to the initial hypothesis.
- A younger fracture yields data with higher uncertainty, consistent with Laramide deformation. Most carbonate veins crosscutting the Morrison Fm. have too little radiogenic Pb for precise dating.
- Carbonate-filled fracture in the Ordovician Harding Fm. Along Shelf Road gives scattered data, interpreted as result of multiple fluid-flow events from Cretaceous (basin formation) to Neogene (Rocky Mtn. uplift) times.
- A more detailed study over a wider range of units along the Front Range will explore the deformation history further.

U-Pb LA-ICP-MS RESULTS

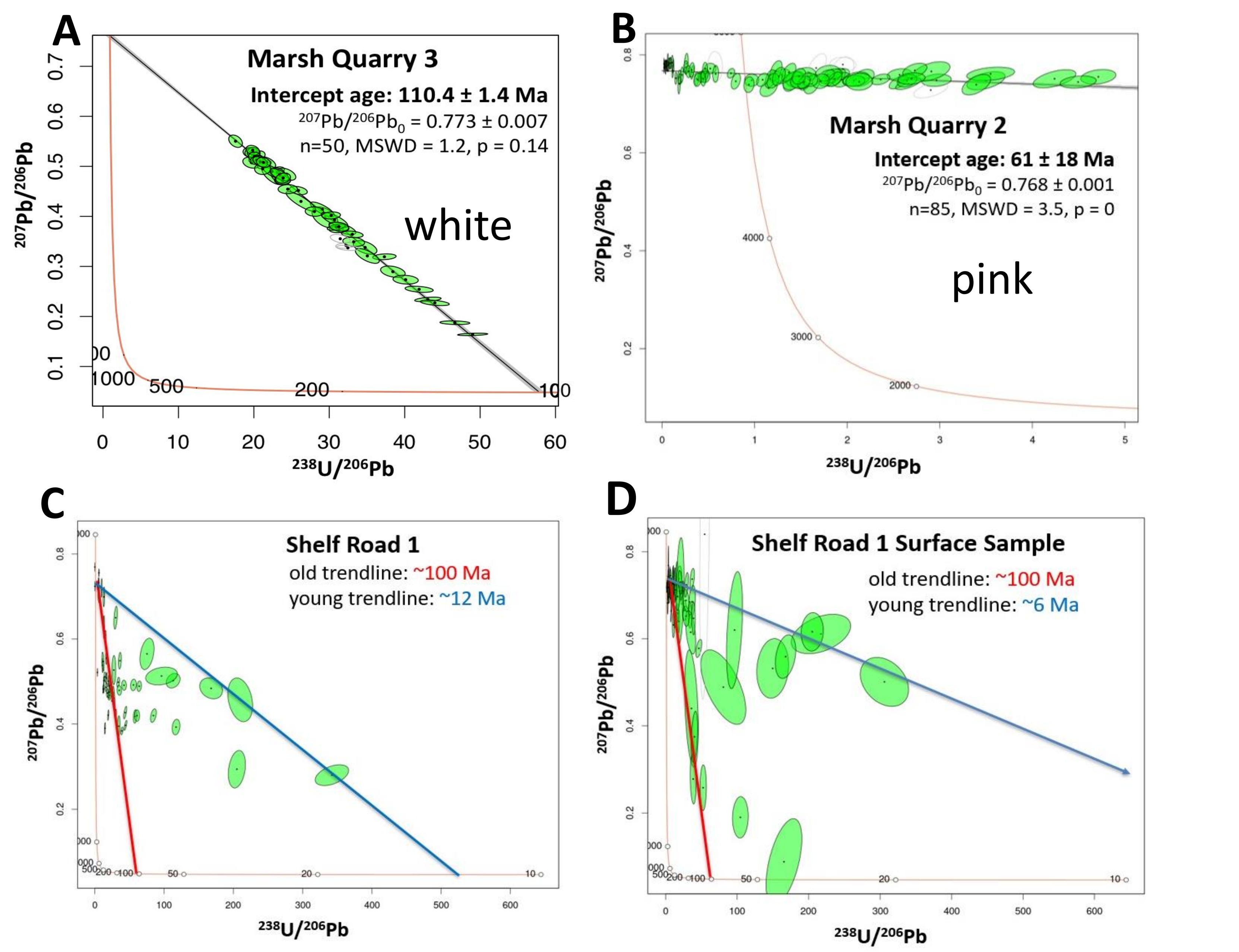

Fig. 2: TW-concordia diagrams for U-Pb carbonate dating of brittle deformation features in the Cañon City embayment. **A:** precise age for MQ3, **B:** limited spread in U-Pb gives imprecise Laramide age of vein MQ2-2, consistent with field evidence (Fig. 3A). **C:** Scattered U-Pb data of SR1 indicates different events between >100 Ma and 12 Ma. **D:** surface analyses of SR sample yields a similar range, but youngest array indicates a ca. 6 Ma event.

ACKNOWLEDGEMENTS

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OUTCROP & SAMPLE DOCUMENTATION

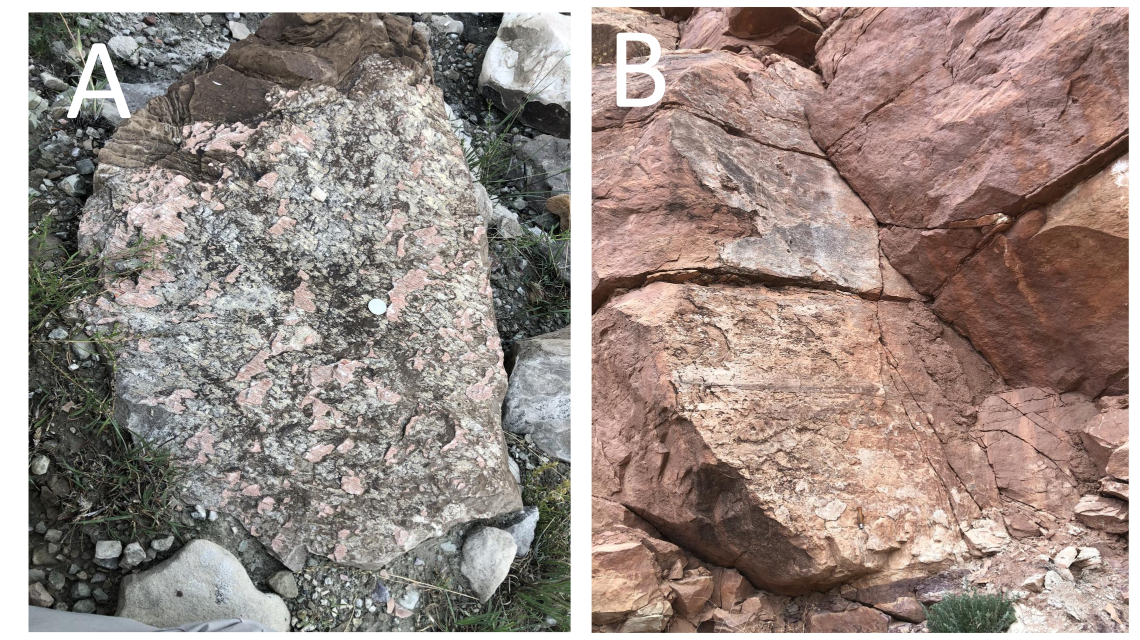

Fig.3a: outcrop photo of carbonate-filled veins at the Marsh-Felch quarry. Note pink carbonate over-grows white vein generation. Samples MQ1-3

Fig.3b: outcrop photo of Ordovician Harding sandstone at Shelf Road. Note slicken-lines. Sample SR1.

Fig.3a outcrop photo for sample TC2, carbonate-cemented, strongly deformed Ordovician Harding sandstone at Temple Canyon. Dominated by fractured quartz grains, the carbonate cement was not coarse enough to be analyzed by LA-ICP-MS.

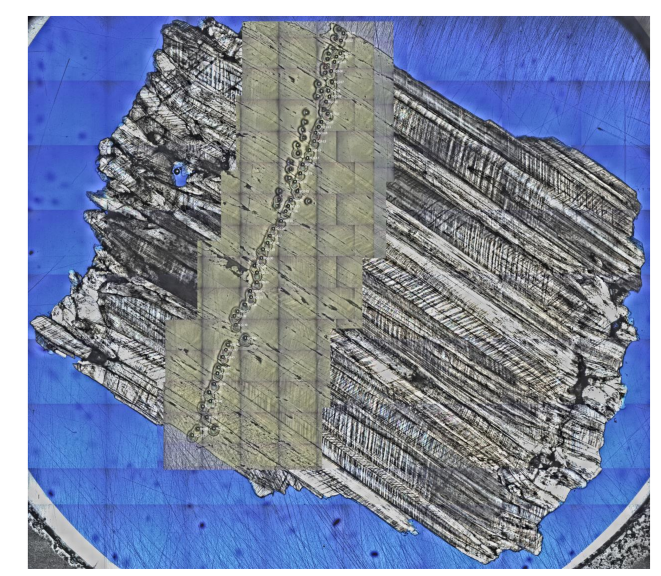

Fig. 4: MQ3 sample, polished epoxy mount, transmitted light microscope image, note fibrous growth. Overlaid are reflected light images showing the traverse of laser spots (130µm diameter).

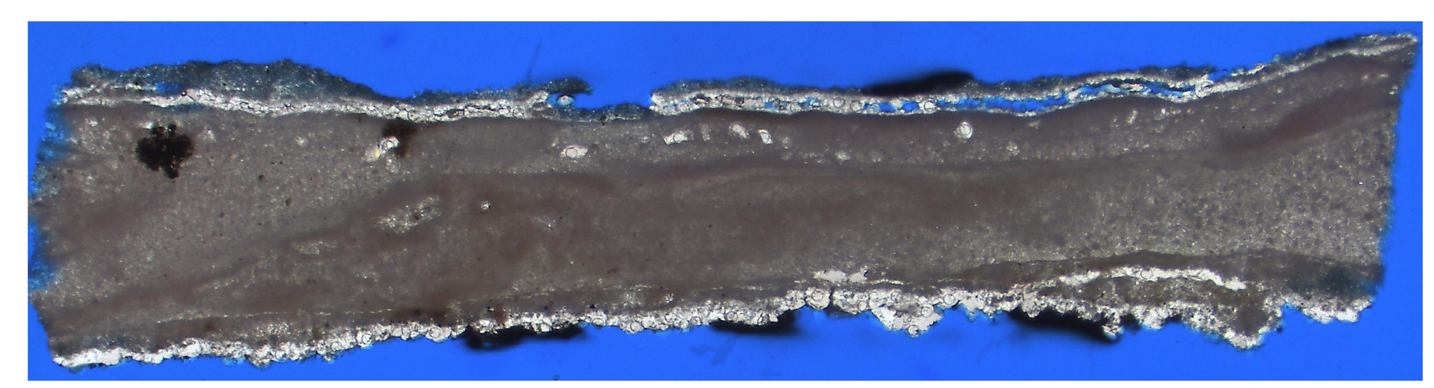

Fig. 5: SR1 sample, polished mount in reflected light. Carbonate material visible on top and bottom of the sample as bright layers, and in scattered grains throughout the vein.

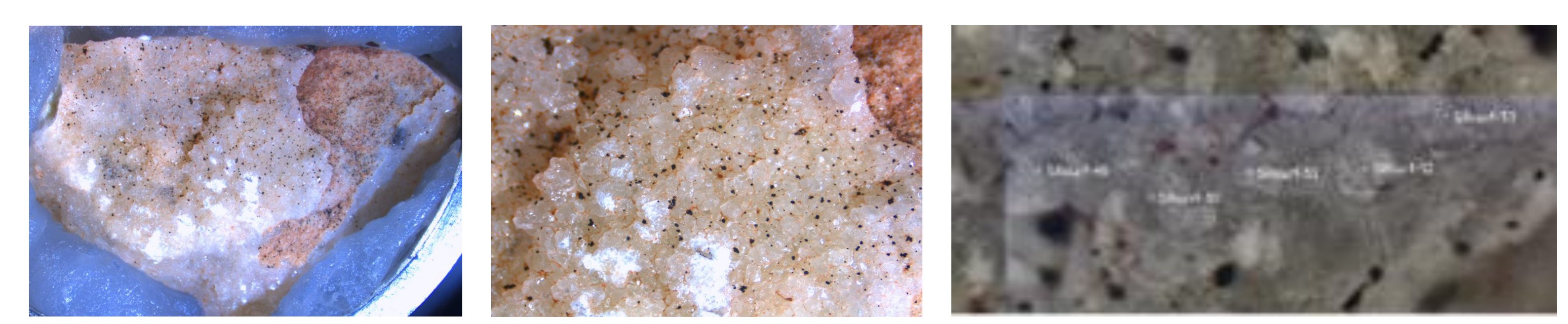

Fig. 6: Images for Shelf Road Surface sample (Ordovician Harding Fm). **Left:** sample in holder with museum wax. **Center:** close-up of surface, note euhedral carbonate crystals on Harding sandstone. **Right:** reflected light image from the laser showing an example of the surface ablation.