MINERALIZED FRACTURES ON EARTH AND MARS AS WINDOWS INTO POTENTIALLY HABITABLE SUBSURFACE ENVIRONMENTS. S.L. Potter-McIntyre[1], R. Thomas[2], B.M. Hynek[2], M. Osterloo[2] [1]Southern Illinois University, Geology Department, Parkinson Lab Mailcode 4324, Carbondale, IL, 62901, pottermcintyre@siu.edu, [2]Laboratory for Atmospheric and Space Physics at University of Colorado, Boulder.

Introduction:
The subsurface on Earth is a habitable environment that contains a large portion of the total biomass on this planet [1]. Similarly, the subsurface of Mars may represent a past or even present habitable environment, and the planet's longest-lived potentially habitable environment [2]. Accessibility of the subsurface is difficult on both planets, but nevertheless, it is crucial to understand the variability of subsurface fluids and water/rock/biota interactions occurring in these environments because these inform not just present conditions for habitability, but the evolution of these environments over geologic time.

A valuable method for investigating the composition of subsurface fluids and the history of evolving fluid chemistries is to examine mineralization along fractures that have provided conduits for fluids to move from the subsurface upwards through the overlying strata and, in some cases, to flow out onto the surface. Terrestrial examples of mineralized fractures (faults and joints) are common in sedimentary rocks, and, because the fluids responsible for this mineral precipitation emanate from the subsurface, these precipitates record subsurface geochemical conditions potentially conducive to habitability. Cement precipitates could even preserve microbial fossils that were transported upward in migrating fluids and encased in the precipitating minerals. Cementation is also seen at fractures on Mars [e.g., 3,4,5], and it is hypothesized that this results from subsurface fluids migrating upward. Hence, it is important to recognize and interpret subsurface environments correctly because they preserve a history of water and redox reactions that provide sources of energy needed for life.

Discussion: Ten Mile Graben cold spring system, in southern Utah, U.S.A., is unique in that not only are there actively precipitating minerals on the land surface, but tufa terraces (<400ka) are preserved on paleoland surfaces (topographic highs) where the tufas have provided a caprock rendering these areas more resistant to erosion [e.g., 6,7]. Subsurface water/rock interactions are recorded in the mudrock cliff faces beneath these terraces and provide a three dimensional vantage point to observe both surface and subsurface precipitation associated with subsurface fluids moving to the surface. Ten Mile Graben also exhibits an exposed sandstone (stratigraphically below the mudrock that hosts most of the tufa terraces) that would have experienced subsurface fluid/rock interaction along selvages of fractures as the fluid moved through this unit to the surface. This sandstone shows evidence of removal of iron (oxyhydr)oxide cement ("bleaching") from the unit along these fractures that would have been buried when fluids were moving through. There is bleaching also in the lower portion of the unit, suggesting the fluid had some residence time in the paleo-reservoir before erosion exposed the formation. This field site shows that this type of fluid/rock interaction leaves distinct, mappable, and predictable patterns that can be used to recognize similar features from airborne data on Mars.

Spencer Flat in the Grand Staircase Excalante national Monument, also in southern Utah, hosts NE-striking joints that formed 22Ma and allowed infiltration of meteoric oxidizing water into the subsurface reservoir that contained Fe^{2+}-saturated fluid [8]. The mixing of the oxidizing fluid with the Fe^{2+} allowed for precipitation of thick iron (oxyhydr)oxide cementss along the faces of the joints [8]. The well-cemented joint faces are much more resistant to erosion than the surrounding rock, resulting in prominent en echelon ridges that extend >100m across the area. Unlike Ten Mile Graben, precipitation at this site occurred entirely within the subsurface, and was then exposed via denudation of the area, so it provides a direct window into the subsurface redox reactions and fluid chemistries that existed in the geologic past.

Conclusions: These terrestrial examples show mineral precipitation patterns on a range of scales (pore- to map-scale) that constrain the evolution of subsurface fluids and chemistry over geologic time – conditions that control habitability in the subsurface. These data also show how records of these subsurface environments are expressed on large scales that can be recognized from airborne data – both on Earth and on Mars.

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