Evidence for tectonically controlled hydrothermal fluid flow in relay zones on Mars from early HiRISE images. A. K. Davatzes[1] and V. C. Gulick[2], [1]NASA Ames Research Center (MS239-20, Moffet Field, CA 94035; adavatzes@mail.arc.nasa.gov), [2]NASA Ames/SETI Institute (MS239-20, Moffett Field, CA 94035; vgulick@mail.arc.nasa.gov).

Introduction: Using high resolution images from the HiRISE camera on the Mars Reconnaissance Orbiter, we observe evidence of groundwater flow in fracture systems associated with faults on Mars. Movement of groundwater to the surface of Mars through tectonic processes occurs at a range of scales from large catastrophic events to gradual continuous flow. A number of the large outflow channels on Mars originate at fossae [1,2] and may have formed due to tectonic pressurization [3]. We note that the source region of these large outflow channels, including Athabasca Valles and Mangala Valles, are at relays between fault segments (Fig. 1) [4]. These relays are regions where fault zones have an *en echelon* geometry between stepping segments. In terrestrial systems, relays tend to be regions of concentrated stress that can produce dilation manifested as high joint density [5], as well as point sources for hydrothermal outflow on Earth [6]. In general, large gradients in slip near fault tips locally concentrate stress and promote deformation. Where the tips of fault segments are close enough to interact, this region of intense deformation expands and merges. These regions can locally produce tensile stresses that cause joint formation and thus provide structural porosity necessary for storing fluids and structural permeability.

Two key outstanding problems with models of catastrophic outflow channels on Mars are 1) a mechanism for the rapid release of water to the surface and 2) the difficulty in sequestering the large volumes of water necessary beneath the surface. Joints at dilational relays would provide locally high permeability that extends from the surface to significant depths. This region would continue to dilate during a subsequent earthquake whereas the regions outside the dilational relays are likely to contract. This results in a pressure gradient that could drive fluid towards the high permeability relay and to the surface. Thus loading during earthquakes could cause catastrophic expulsion of large volumes of water, referred to as seismic pumping [7]. Grabens at the Martian surface likely represent emplacement of large dikes at depth [8]. High temperature fluid in contact with these large dikes could produce high fluid pressures that would exploit high permeability joint zones. The identified regions of catastrophic outflow occur in proximity to volcanic centers consistent with this hypothesis. The formation of long-lived hydrothermal circulation of ground water around these volcanic centers could periodically build up pressures sufficient for catastrophic outflow especially along the perimeter of these centers at fault relays. In addition, regions where water reaches supercritical conditions produces instability (e.g., significant pressure and density changes) in the ground water flow field. These hypotheses hinge on geometrically localized high permeability zones provided by high joint densities to create the large flood channels that are still visible on the surface of Mars.

The resolution of the HiRISE camera allows us to see joint sets in rock exposures on Mars clearly for the first time. Evidence for enhanced paleo fluid flow may be revealed by the presence and density of bleached (alteration) zones, veins and concretions. Although veins and concretions will commonly be too small to be resolved, bleaching can be seen in these images [9].

High Resolution Imaging Science Experiment (HiRISE): The High Resolution Imaging Science Experiment is orbiting Mars on board the Mars Reconnaissance Orbiter (MRO). HiRISE began its primary science phase in November 2006 and is collecting images of Mars at a resolution of 0.25 to 1.3 m/pixel. The swath width is about 6 km. The center 1.2 km swath is in color shifted to the near IR; objects as small as 1 meter across may be discerned [10].

Image PSP_001377_1685: This HiRISE image of Melas Chasma within the Valles Marineris valley network was taken on November 11, 2006 and contains layered rock with visible cross-sets. Much of the region is covered by dunes of dark dust, but some rock exposures are present. Figure 2 shows a subimage from the upper left portion of the image located at ~11.25 degrees South latitude, ~286.25 degrees East longitude. Image resolution is approximately 25 cm/pixel and the scene is illuminated from the west.

This region contains multiple faults associated with light-toned units that may indicate regions of bleaching by ground-water outflow focused within the faults and along joints. At the upper right part of the image is a zone of dense jointing with associated alteration.

Conclusions: Preliminary observations show many catastrophic outflows are sourced from relays between fault segments. Also, new high resolution data reveals high density joint sets proximal to a fault relay zone in the layered rocks of Melas Chasm. These joint sets are locally bleached indicating focused ground water outflow. Future work will identify other exposed regions proximal to faults at a range of scales to determine fracture density.

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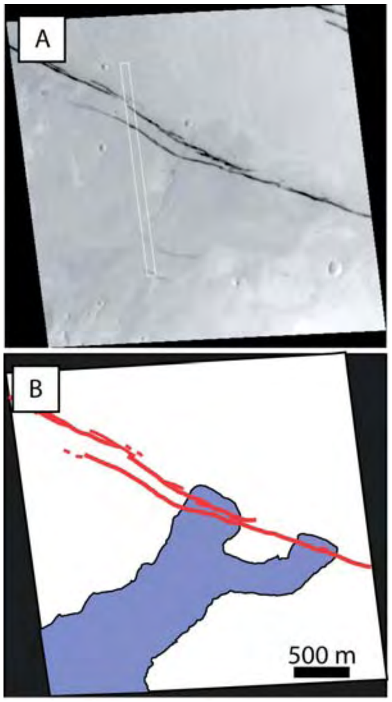

Figure 1 (right): The main source of Athabasca Valles is located at a relay where two grabens interact. This region is likely to be characterized by a high fracture density. (Image Credit: NASA/JPL/MSSS)

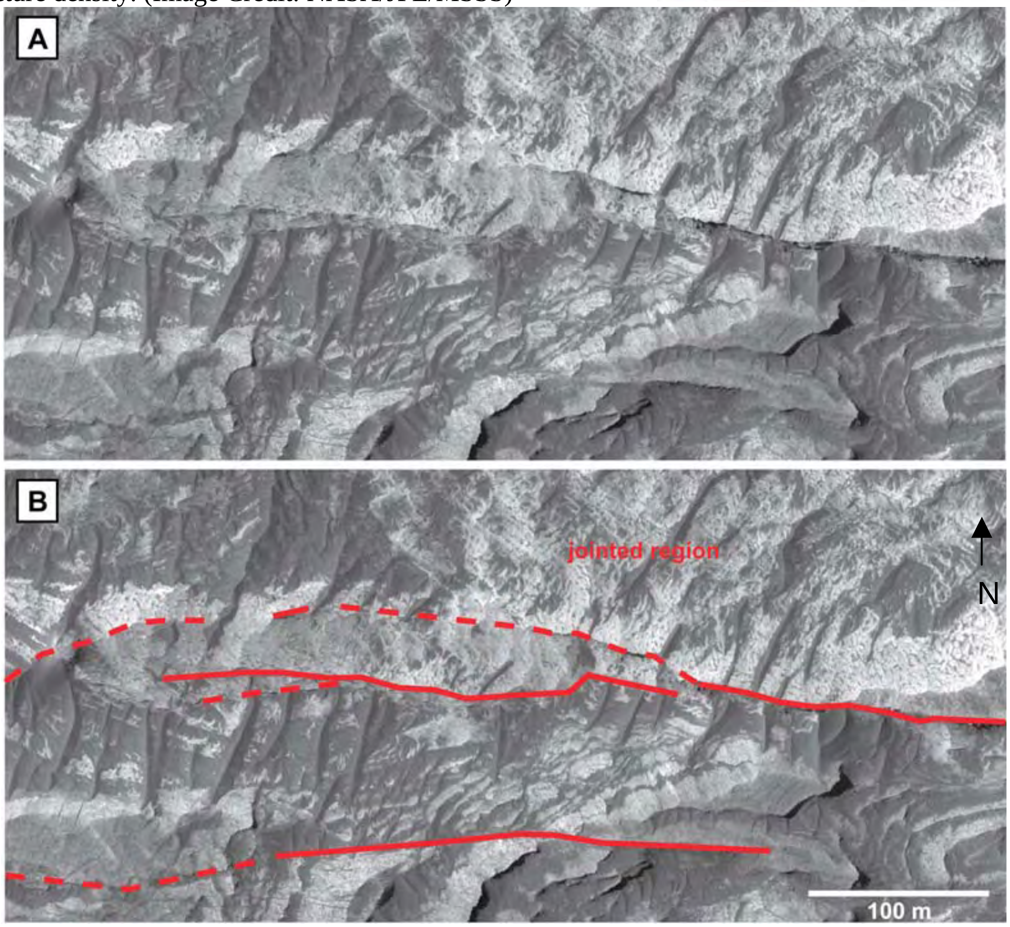

Figure 2: Subimage of PSP_001377_1685 in Melas Chasma showing bleaching of joint sets in the rock exposure north of the faults. The region between the fault sets also appears to be bleached. (Image credit: NASA/JPL/U. of Arizona)