CURRENTLY FLOWING WATER ON MARS. T. Motazedian[1,2], [1]Dept. of Geological Sciences, University of Oregon, 97403, [2]Arkansas-Oklahoma Center for Space and Planetary Sciences, University of Arkansas, 72701.

Introduction: Newly-formed dark slope streaks on Mars appear to indicate currently flowing water [1]. Dark streaks on crater and valley walls begin upslope at point sources aligned along a common rock layer. They widen downslope and anastamose where interrupted by positive relief in the topography. These dark streaks have no topographical relief and passively overlay existing surface features, except where they bifurcate around dunes and knobs and crater rims. Images of the same places taken months apart show that new streaks have formed with time intervals of months. The dark streaks are among the youngest Martian surface features, as they are never overlain or cut by other features such as craters and eolian dunes. These dark streaks are especially common around Olympus Mons. It is possible that geothermal activity driven by volcanic heat melts subsurface ice, releasing a brine that dissolves surrounding minerals. This brine has a low freezing temperature, allowing it to flow at the Martian surface. The dissolved minerals precipitate from solution, leaving behind dark streaks of rock varnish. The dark streaks appear where the water table is intersected, as in craters and valleys.

Characteristics: Dark slope streaks are particularly concentrated around Olympus Mons volcano, in the region from 90°W to 180°W longitude and 30°S to 30°N latitude. The dark streaks always appear on slopes, mostly inside craters and valleys, but also on small hills. They are almost always located below Martian sea level (zero elevation). The dark streaks occur in clusters of parallel streaks, wherein the upslope ends of the streaks are aligned with a common rock layer [Fig. 1] [2].

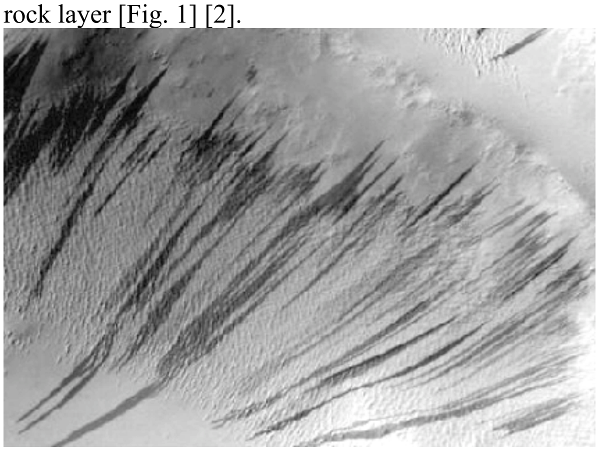

Figure 1. Dark streaks inside crater. Top right of image is crater rim, bottom left is crater floor. MOC Image E03-02458.

The dark streaks exhibit no preferred orientation with respect to slope aspect (e.g. north-facing slopes). The streaks are narrow upslope and widen downslope. The bottom terminuses are not aligned. Some of the dark streaks display strong anastamosing patterns [Fig. 2], bifurcating around protruding topographic barriers.

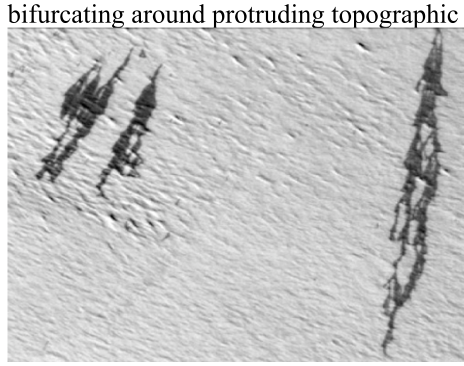

Figure 2. Anastamosing dark streaks. Top of image is upslope. MOC Image E02-00308.

The dark streaks passively overlay other surface features without disturbing them or causing erosion. The dark streaks themselves have neither positive nor negative relief; they appear as if they are stains on the existing topography [Fig. 3].

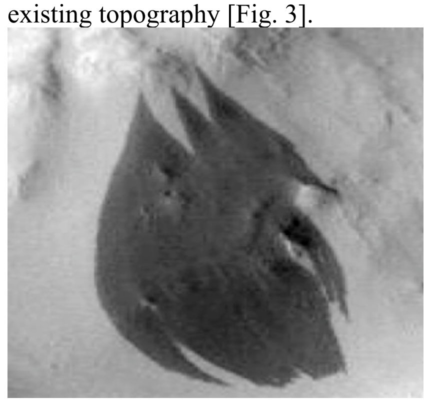

Figure 3. Dark streak which appears to be staining the surface. Top of image is upslope. MOC Image E04-02259.

Streaks that encounter a crater on a slope enter the crater from above and rarely exit the crater at the downslope end. Within a crater, the angle of a dark streak viewed obliquely breaks where it encounters the crater floor [Fig. 1]. The dimensions of the dark streaks typically range from 10 to 60 meters wide and 300 to 1500 meters long.

Time Frame: These dark slope streaks are among the youngest of all Martian surface features, as they are never observed to be cratered or overlain by other features such as dunes or crater ejecta. Lighter-toned streaks are commonly intermingled with darker streaks, with the darker streaks overlaying the lighter ones.

Photographs of the same area taken at different times show that new dark streaks are currently forming [3] [Fig. 4]. New streaks have been observed to form in periods as short as six months. This demonstrates the existence of a currently-active, short-term process of surface change on Mars.

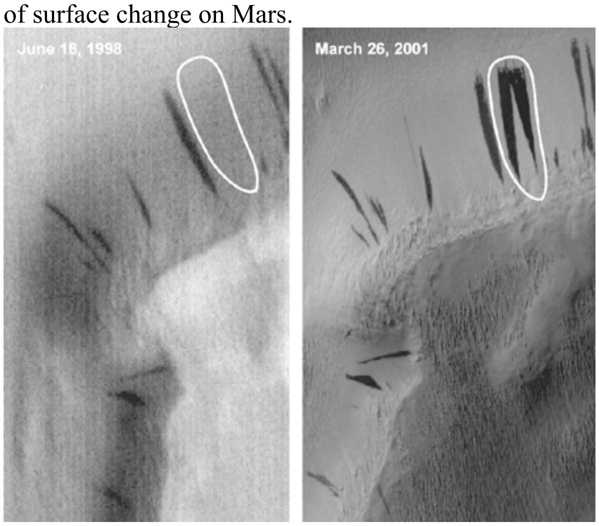

Figure 4. Two images of the same area, with new streaks present in the later photo. MOC Images SP2-37303 and E02-02379.

Comparison To Other Dark Surface Features: Dark slope streaks differ from other dark Martian surface features in a number of ways. They possess sharp boundaries [Fig. 3], as opposed to the gradational, hazy margins of dust-devil tracks [4] and wind streaks [5]. The dark slope streaks also show a more uniform, evenly-saturated tone across their expanse than do other dark Martian features. Unlike dust-devil tracks, which are erratic in shape and direction, the dark slope streaks follow similar trends in shape, distribution, and direction. Unlike wind streaks, which form on plains, the dark slope streaks always occur on slopes.

Origin: There are a few processes which could be responsible for forming these dark slope streaks. Mass movements, such as debris flows or dust slides, could have stripped away the light-colored surface dust to reveal darker material beneath [6]. This theory is problematic for a number of reasons. No deposits of removed dust or debris are visible near the streaks. The dark streaks overlay eolian dunes and other positive-relief surface features without causing erosion, which is not typical of mass movements. The point source origin of all the dark streaks with no apparent source scar is also inconsistent with mass movement, as is their occurrence in clusters of parallel streaks. Some of the shapes of these dark streaks, particularly the anastamosing patterns, suggest a liquid flow uncharacteristic of gravity-driven mass movements of dry material.

Eolian processes do not appear to be a likely cause of these features because of the sharply-defined boundaries and uniform tone of these dark streaks, and their consistent downslope attitude. The streaks bear distinctive shapes (bar-shaped, wedge-shaped, and anastamosing) which are rarely (if ever) replicated by wind streaks and dust-devil tracks. The specific distribution of these streaks, downslope in craters and valleys, is not consistent with formation by the broad, plains-sweeping action of the wind.

Liquid flow is the most promising process for explaining these features. Geothermal activity surrounding Olympus Mons may be causing ice to melt or otherwise driving liquid water from aquifers. Possibly the liquid dissolves salts in the aquifer to form a brine, that leaches metals from silicates. The salts in the solution lower the freezing temperature, allowing water to flow at the Martian surface. As the brine flows down slopes it leaves behind a trail of rock varnish from dark minerals that precipitate from solution. If the streaks are indeed black or dark brown (this is difficult to determine from black and white photos), pyrolusite or goethite are two candidate minerals that could precipitate where aqueous Mn^{2+} or Fe^{2+} are oxidized when the brines encounter the atmosphere. The lighter-toned streaks are likely to be older streaks that have been coated with light-colored surface dust.

The dark slope streaks originate from distinct geologic horizons below the Martian surface, where the water/ice table has been intersected by crater and valley walls. The point source origin of the dark streaks seems to indicate the piping of groundwater, as opposed to an aquifer-wide, broad flow. The anastamosing of the dark streaks is highly indicative of dynamic fluid flow. The fact that these streaks make no topographical material build-up or erosion is consistent with small volumes of liquid trickling gently down a slope. The sharply-defined terminuses of the dark streaks implies that the flows end where their liquid source is exhausted, having been consumed in coating surface dust and soaking into the ground.

References: [1] Motazedian T. (2002) *NSF REU Program in Space & Planetary Sciences, Arkansas-Oklahoma Center for Space and Planetary Sciences*, 17-18. [2] The author acknowledges the use of Mars Orbiter Camera images processed by Malin Space Science Systems that are available at http://www.msss.com/moc_gallery/. [3] Edgett K.S. et al. (2000) *LPS XXXI*, Abstract #1058. [4] Rifkin M.K. and Mustard J.F. (2001) *LPS XXXII*, Abstract #1698. [5] Edgett K.S. and Malin M.C. (1999) *LPS XXX*, Abstract # 1135. [6] Sullivan R. et al. (2000) *LPS XXXI*, Abstract # 1911.