The Water Cycling and Secondary Ice-Salt Structures in the Gullies and Crater on Mars

Pedram Aftabi, Geological Survey of Iran, PO Box 13185-1494, Tehran, Iran;Ped_Aftabi@yahoo.com

Our understanding of Martian gullies could be important in the design of Mars spacecraft missions, and landing sites. The water-ice exploration on Mars is an enigmatic and questionable works, because the H2O ice is minimum in that planet in compare to CO2 ice [1, 2]. Sulfate salt formation in the regolith [3, 4] can be a major sink for H_2O. The salt is as old as the Solar System, so the water trapped inside the salt is also ancient. There appears to be a global crust of salt enriched materials on the surface of Mars, probably in the form of Sulphate salts, NaCl, (Mg, Ca) CO3 [3] and jarosite or epsomite MgSO4.7H2O [4]. Most salt contains at least some H_2O as hydrous minerals and as fluid inclusions, either intracrystalline or intercrystalline [5], and the ice can be dirty with low amount of water content [6, 7].

The possibility of acidic brines in the planet Mars suggest better understanding of salt and ice mixtures on Mars planet. Malin& Edgett[8]made the initial announcement of the discovery of Martian gullies in Mars Global Surveyor MOC images[23]. Christensen[9]proposes a different model in which melting of an overlying snow pack provides the source of water to erode gullies. Geothermal heated ground ice has also been invoked as source water forming the gullies[10]. Perhaps the gullies formed during warmer periods. Salts have the potential to significantly lower the freezing point of water[11]. The gullies formed by debris flows initiated by ground water saturation and/or by drainage of water from cliffs higher on the slopes[8,12,and 13].The salt of the brine rapidly deposit on the surface of new channel with white color as secondary salt by rapid evaporation. The brines hypothesis is strengthened by studies of Martian meteorites that show the rocks with salt minerals halite, anhydrite [14]. The water source from shallow aquifers (perhaps 200 to 300 meters beneath surface) contains 35wt% to 100wt% water-ice buried beneath a shallow layer of ice-free material[15]. The groundwater seepage from shallow aquifers and subsequent surface runoff [16] formed the gullies. The new experiments by author suggest that chloride salt never freeze to ice shell but epsomite salt lower the freezing point very little, and formed ice shells(Fig3 j). Water is constantly in motion, called water cycling [17]. The liquid water of icy plates transported to the salt or salt-ice mixture and flow as rivers over the slopes of craters(Fig1) or other big cavities as gullies both on Martian moons[6,7]and mars planet[8,16]. This cycle is through the high pressure area to low pressure areas during climatic and structural changes[11,6,7].Viscous fluids flow down pressure gradients under the influence of boundary conditions[18,19,20]. Channels(Fig1), of course, are the most striking features of the gully systems; they generally begin deep and broad at a specific exposed rock layer, and then taper down slope. Another source of energy for melted water brine is changes in the internal and external heat. The heat can be converted to motion by internal convection [21, 22, and 18]. The experiments by author(Fig2) suggest that the salt and ice mixture in bottom of an ice sheet are the first freezing crystals in the bottom and the last in top of the ice sheet, but the flowing brine every time generated different sheets of ice salt mixture on top. The fast evaporation of ice in the ice salt mixture of the top layer leads to forming a thin sheet of salt (epsomite) on top of the ice sheet(Figs 3 a to i). .In Martian position the salt or salt-ice mixture of the cut off layer(exposed in craters)may act as a cap for ice but transported the brine to the low pressure areas as new gullies(Fig1m). The water and sand generated a sandstone with ice cement when frizzed [6, 7].After every 24 hours generated 1 mm soil in the small scale model [6, 7].In other experiments with epsomite brine and sand the sandstone with salt and ice cement generated soil very slow with rate of 0.5 mm after every 96 hours (see Fig 3c) and act as barrier for ice evaporation. At some point, the barrier became too thin and extruded the liquid under pressure(Figs 1 g to m) . It breaks through the surface into the atmosphere, where it evaporates quickly due to the sudden drop in pressure(Figs 3k,l). However the liquids in other Duricrust barriers flow under pressure and flow out and down slop in the crater slopes. The duricrust mostly consist of epsomite salt and ice mixture with high amount of soil and old dust which is enriched of water(Figs 1m &3d-g). The gullies are very young and may currently be forming(Fig1) on Mars because in authors experiments gullies formed very fast(in few seconds) by change in the atmosphere temperature in small scale ice models(Figs 3k,l). These rivers later filled by deposits (by storms or wind)and covered the secondary salt(Fig1m) . A series of concentric ,radial and polygonal structures formed in the map view of craters and gullies (Figs 1 a to f), because of stages of icing and deicing periods, evaporation of brine, viscous flows of rising ice(Fig2),and thermal changes. The rise of the ice after impact is an important factor in water cycling on Mars(subscribed and Fig2 here)which helped to gullies formation by Martian water cycling in the slopes(subscribed). The experiments here showed that the convectional movements of brines by temperature changes is more penetrative around the craters and gullies(Fig1) because the salt deposits are very conductive for melting but they are barrier for rapid evaporation of ice(Figs2 b,c). Evidences of water brine cycling distinguished with separation of a white circular secondary salt rim around the craters by author's photo geology studies on NASA's pictures(in prep.).The Polygonal fractures in salt generated polygonal dry rivers (Figs4a, c) and polygonal rising brine flow (Fig4 b, f).The polygonal features generated brine evaporation and formed salt walls (Figs 4b, f) which surrounded high content salt brine (Fig4).The secondary salt and teepee structures on Earth is a key for Martian secondary structures in gullies and craters (Figs 4 &1).

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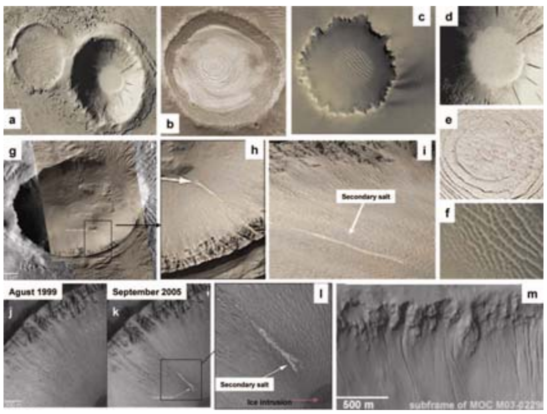

Fig1-a,b,c)Different craters on Mars with radial, concentric and polygonal features(consist fractures). a&d) is Martes Valles Double Crater,show a double crater with radial fractures and probable a Martian cusp ice rise through the crater center. b&e)Sediment Filled Crater with concentric structural morphological lines suggest that the conical passive ice pillow spread sideway below the surface deposits. c&f)Victoria Crater suggest evaporation of brine in the middle of crater where the ice rise as a passive pillow(subscribed).All these morphological and structural features suggest water cycling on Mars g,h&i)A mosaic of MOC images using HiRISE color data and overlain on THEMIS) image V16997005, show evidences of water flow and secondary salt deposition. The scale bar is 1km.Part of the evidence showed in different views on h&i. j&k)Picture no MOC2-1619 Show new Gully deposit in a Crater in the Centauri Montes Region on Mars between Aug.1999 to Sep.2006(7 years). Show that the gullies may be so young that some of them could still be active today. m)The groundwater seepage from shallow aquifers and subsequent surface runoff(After [8,16];see www.NASA.Gov).

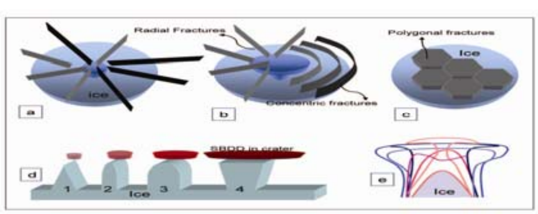

Fig2-Radial and concentric and polygonal fractures and rising ice after impact see analogue models by Aftabi which subscribed or published in LPI.

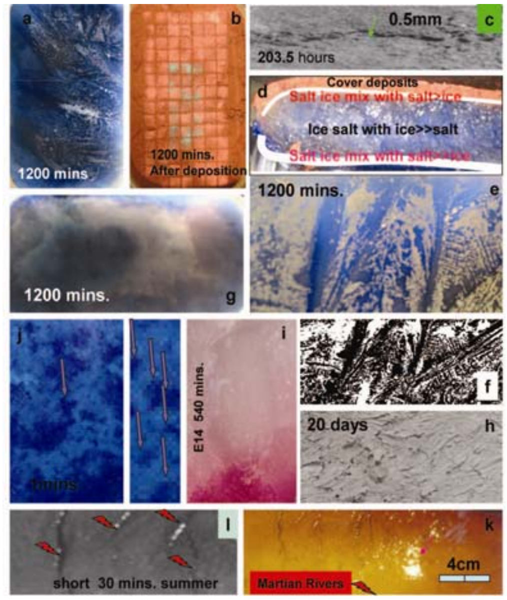

Fig3-Aouthor's experiments: brine with low to medium amount of epsomite(25 m/l) salt generated ice sheet with blue color(a) and thin sheet of salt on top in white color(e,f) and salt ice mix with high amount of salt with white to purple color in bottom(g).The sheet(b,d)covered by sand. The brine penetrated to sand and made sandstone with epsomite and ice cement. The sandstone cover acted as cap lower the evaporation of ice(c).An ice shell with epsomite generated pinched crust of salt with polygonal, radial and concentric fractures(h).High amount of epsomite(>75m/l)showed similar manner which most of the salt deposited as dark pink but the brine penetrated to top and formed thin sheet of epsomite salt on top. The brine with high amount of halite never frizzed but ice-salt crystals formed after few seconds and deposited in the base(j).The ice sheet with topographic changes generated dry rivers in model, because the brine evaporated very fast in few seconds at -27 degrees.

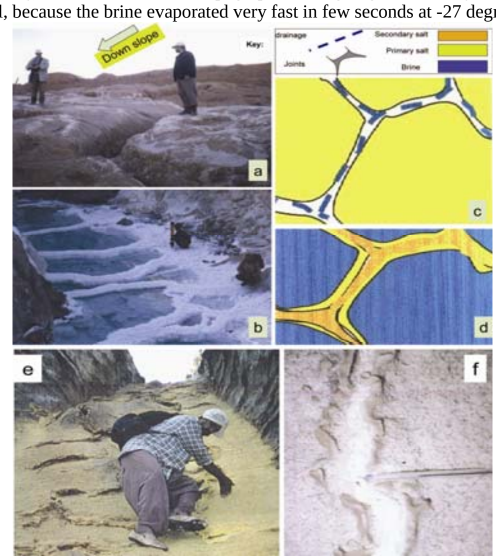

Fig4-Polygonal fractures in salt on Earth(in Iran)generated polygonal dry rivers(a,c) and polygonal rising brine flow (b,f).The polygonal features generated brine evaporation and formed salt walls(b,f)which surrounded high content salt brine(b)Every time the brine intruded the middle of crack(f) from as a flowing material beneath the salt sheet and intruded into fractures mainly down slope(e) like brine flow down slope in crater walls. The salt and ice define pseudo stratigraphy. Blue is brine and yellow is salt.