Laboratory testing of the ice-salt intrusions and extrusions in craters for determining Mars landing site

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The observation of gullies on Mars indicates the presence of liquid water near the surface in recent times [1, 2, 3, 4, 5&6].The formation of these gullies strongly depends on, temperature-pressure (of duruicrust, ice and atmosphere), the height of the crater-rim, height of the aquifer cut off layer and depth of the crater, as well as on the size of the impact structure, and the rising rate of ice or salt-ice mixture. The concentric and radial features may also relate to similar processes [20]. Sulfate **salt** formation in the regolith [7, 8] can be a major sink for H_2O [9]. Salts have the potential to significantly lower the freezing point of water [10, 11] for water cycling. The warmer and colder periods also are characteristic of terrestrial history [12, 10&11]. The hydrologic model [13] provides an interpretive framework for ground-ice and groundwater which is responsible for major Hesperian outflow channels [e.g.14, 13]. The northern lowlands are the most likely location for groundwater held under such conditions [13]. The water ice accumulated during winter can undergo transition to the liquid by temperature [15, 4, and 5] and also rising ice from below in craters (seeFigs1to4).The experiments and photo geology by author suggest rise of the ice after impact generated especial water cycling in the crater, which brine of the duricrust flow down slope into the crater, but the brine of the rising ice- salt mixture flowed opposite outward from the center of the raised ice-salt mixture to the rims. This out flow (upslope from the base to top of the crater walls) circulation generated youngest secondary salt deposition with white color in the crater area consist the crater rim [20,16,17].However the gullies showed similar secondary salt in as new deposits of channel flow[20]. The salt, ice, ice-salt mixture and ice rock mixture can flow as a viscous or power low material depending of the grain size, strain rate [18, 21] &temperature [10]. The flowing material can rise as pillows,cones,walls and diapirs after impact(Figs 1 h to q).When the relatively warm ice of a diapir reaches these patches which, being salty, have much lower melting points than regular water they completely melt into pockets of liquid brine, which can erupt to the surface[20].All models in this paper is analogue of a Martian unnamed Crater by HRSC(Fig1a)on board ESA's Mars Express spacecraft, near the Martian north pole. The 35 km wide impact crater is located on Vastitas Borealis, at approximately 70.5° North and 103° East (seeWWW.NASA.Gov[19]). The models by author here, will give further insights on the existence of diapirs or pillows of ice beneath craters(Figs 1,2). I used NASA's images of craters to interpret their morphology, evolution, and features (subscribed). Any discordance in dips between crater interior and surroundings or outflow direction indicates local deformation and intrusion or extrusion of ice or ice-salt mixture. The ice salt mixture can formed salt sheets as caps in top of the pillows[20],but the framework for ground-ice may consist three salt or salt-ice-rock mixture sheets above the main ice rock mixture(or pure ice). The analogue scale models performed for craters on Phobos, which the ice or the ice rock mixture covered by 1 km overburden(basalt or deposits)but is applicable for Martian condition. The shear strength every time increased in the layers between the viscous sheets, but it should be constant in the main ice-salt mixture of the base of the crater. For any type of V/B(Viscous forces/Brittle forces) ice and the overburden(with horizontal constant thickness overburden) in the models(PDMS) needs lateral extension or contraction[21]. Even if viscous forces are law, fluid source deform the cover(with changes in thickness) by pressure forces. Static pressure forces do not depend on time or strain rates[21].The initiation of a rising portion of ice is also important for the ice pillows[16,17,and 20]. The pressure forces are high where the density contrast between ice and rock cover is high and when the overburden be thinned by impact crater, and the ice initiated to rise by impact push. If an impact generated a crater with depth of ¼ to ½ of cover deposits(Figs 1&4) ice starts to rise. In experiments a viscous layer (PDMS) with 20 mm thick covered by sand(Martian' moon deposits) with 10mm in thickness. A ball of rock fall into the model artificially(Fig3) with distances 10-30 cm. The P/B(pressure/Brittle strength) ratio in models was high. The shaping of the ice rise was from a roller, to conical pillow and the pillow and finally a narrowing passive diapir(Figs 1 h-q &2) which may extruded on the surface of crater(Figs1 c,d,e&f).The size of the rising ice intrusion and extrusion is mainly confirm with size and height of the natural example on Mars(Figs1 a,b,c,d).For understanding the shaping and size of the ice intrusion-extrusions on Martian craters, I neglect the overburden deformation during the impact crater process. With lateral extension(Figs2,3,4) and contraction size of the rising ice increased which is not responsible for Martian conditions(Fig1a; see also[19]). The rate of rise increased with lateral tectonics and the diapir was larger than the prototype(natural) example on Mars(Figs1a,b,c,d), which suggest that tectonic activity in this area of Mars is weak(Fig1a).With decreasing the strength of the overburden by impact , and faulting(Fig3), the operation of the pressure forces and viscous forces generated larger ice pillows in the center .The evolution of the rising ice in all experiments was in the same external shaping in the profiles(Figs 1 h to q &4) but different size external shapes in the map view(Figs 1 b,c).The ice started to rise from a pillow to conical pillow and narrowing passive diapir(Figs1,4) , which may closed in the stem, or be spread in the base of crater on the recent deposits(Fig 2d).However the existence of the salt cap for ice extrusion(Fig1 a) and also a salt cover in the basal crater(see[19,20]) suggest that some intrusions may spread below the roof and rise the basal crater from the primary hight.The experiments suggest that the craters are the best areas for water exploration , because the ice or ice-salt mixture raised in center of craters. The craters and the gullies on Mars hints about the origin of ice pillows or ice extrusions in tectonically inactive regions. In order to fully test our observation of craters, gullies and rising ice or rising salt, we need further detail photo geology and modeling.

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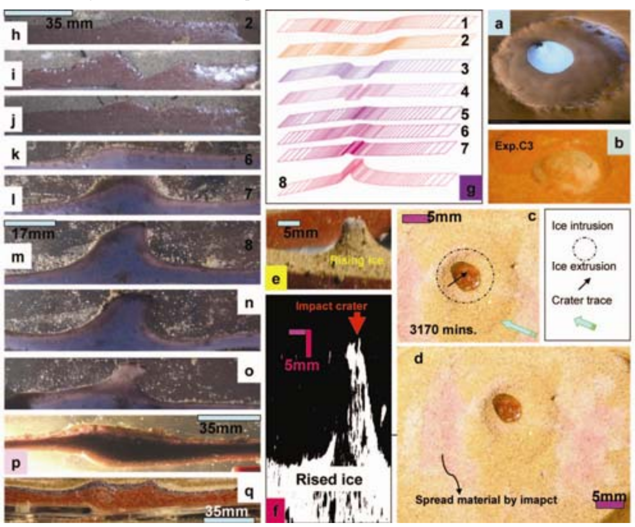

Fig1-a)This image, taken by the High Resolution Stereo Camera (HRSC) on board ESA's Mars Express spacecraft, show an extrusion patch of water ice covered by salt cap sitting on the floor of an unnamed crater in north pole(see www.NASA.Gov[19]). b) The analogue model by author on impact and sin tectonic extension. c, d) the extrusion of ice after 3170 minutes. In model with no lateral tectonic suggest,downbuilding growth of ice long time after impact. The ice intrusion rim is wider than ice extrusion rim suggested narrowing ice diapir column to top. e, f) profiles with conical narrow ice passive diapirs.In Fig f the y direction exaggerated. The white is ice and black is cover. g) Evolution of the rising ice after impact. The numbers from 1 to 8 showed these evolve. p,q) the rising ice can generated in contract ional regime. The shaping is similar but the ice in the more passive state with less tectonics(Figs a,c,d) is smaller and fit with prototype. The model of Fig1c simulated the natural structure of rising ice in Fig1a.Other extensional and contractional experiments by author (b) dose not math with prototype (a). h,i,j)Three shape of the step down structure after impact before or during the ice rise. k)The ice pillow formed. l)The ice raised as a mature pillow. m,n)The ice column flow sideways as asymmetric domes. p)The step down and pillow stage may generate in contractional setting when the ice sheets flow convergence to the central crater. o)The pillow later generated two noses of new diapiric ice in the ground just beneath the impact crater.

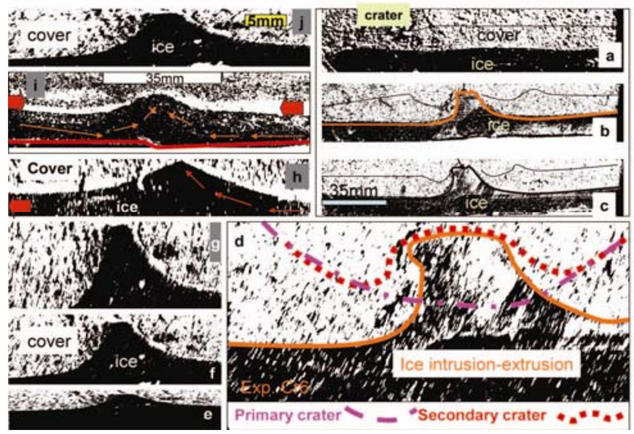

Fig2-A small crater generated just a small step in ice b)The salt extrusion after extension which the crater is wider in compare to fig c. d)The rising ice intruded into basal part of crater and raise the base from pink line to red line. The ice is passive in extension(j), contraction(i) and little extension(h) with similar to passive ice of the models with pressure only(e,f,g). The shaping is mostly narrowing ice.

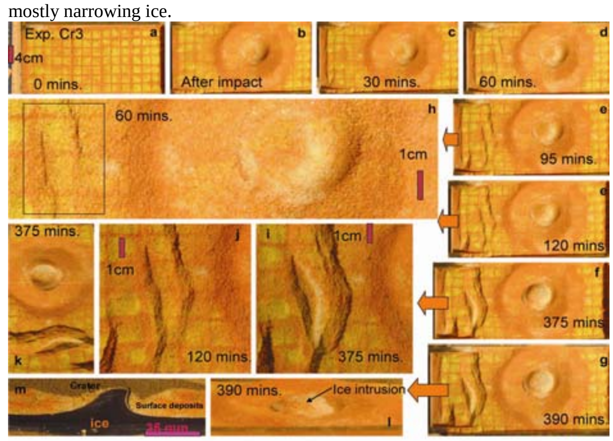

Fig3-Rising evolution in an extensional model after impact(by author). The impact crater generated fault in the model, which did not form in the models of fig1c&d.The ice diapir merged to the constant wall opposite to extension direction. The increasing distance and weight of the impact ball generated increasing in the fault frequency and fault zone widening.

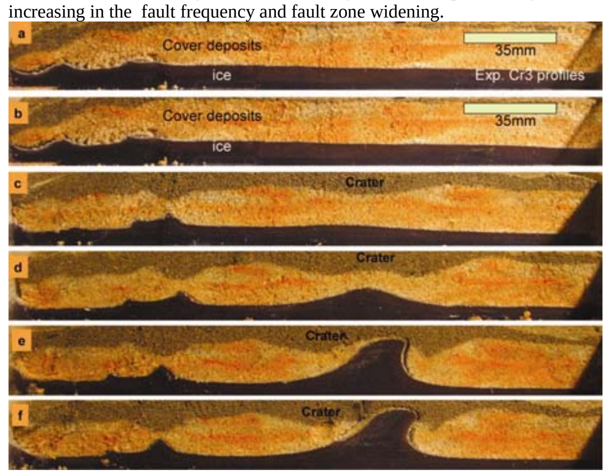

Fig4-The profiles of the Model by author in Fig3 show that any fracture on Mars may result to ice-salt mixture rising. The ice evolve from a pillow(c,d) to a narrow conical asymmetric diapir(e,f).The extension rate was high in this experiment. With increasing extension% the size of rising ice increased both in the crater and in the extensional faults in the left hand side. The top of the model (consist crater) covered by grey sand for better understanding of internal and external structures after impact.