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Flow folds of viscous ice-rock mixture in Phobos and Deimos(Martian moons)

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Introduction: Mars has two very small satellites called Phobos and Deimos(Hall 1887 reviewed in[7]) with 22.2 and 12.6 km across respectively[15]which surfaced by deposits[5]as a thick regolith or dust and with a significant interior ice or ice and rock mixture[8,4&6]. The small rocky moons of Mars, Deimos and Phobos, are irregular in shape and comparable in size to the asteroid Gaspra (Fig1[7]).

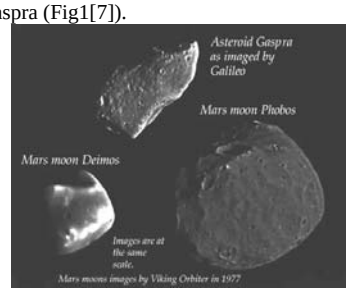

Fig1-Martian moons Phobos,Deimos and the asteroid Gaspra(see www.NASA.Gov).

All Martian moons have irregular shapes(to ellipsoid), testament to their violent histories(Figs2&4). Their surfaces are distinctly different, most likely because of very different impact histories(Fig3 from www.NASA.Gov).but the lines in this fig seen both in the phobos and Deimos[12,13]but presented sharp on the phobos.

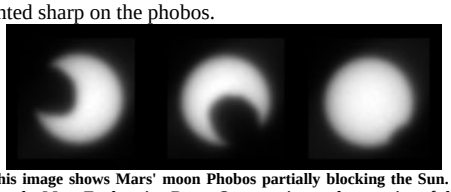

Fig2-This image shows Mars' moon Phobos partially blocking the Sun. It was taken by the Mars Exploration Rover Opportunity on the morning of the 45th Martian day, or sol, of its mission. This event is similar to solar eclipses seen on Earth when our Moon passes in frontoftheSun.Imagecredit:NASA/JPL/Cornell(seewww.NASA.Gov).

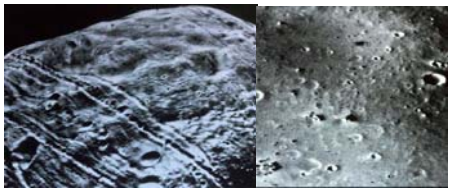

Fig3-Phobos(left)and Deimos(right) from JPL NASA Gov.

The cover soil increased in thickness after every 24 hours in the small protype model (subscribed).The experiment suggest that the ice act as cement for the primary rock mixture but very rapidly after few hours cover soil formed by the evaporation of ice matrix to vapor. The ice matrix evaporated very fast and the wet soil change to dry soils after few minutes(subscribed).Therefore the ice rock mixture decreased in the volume and contracted in two type of the external shape as ellipsoid and the spherical(Fig4).

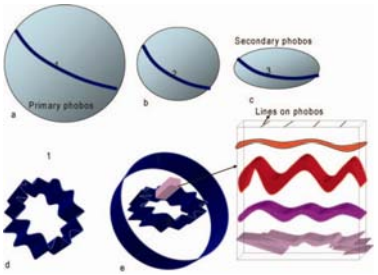

Fig4-Shrinkage of the moon by evaporation of the ice matrix. b)spherical shrinkage c)ellipsoid shrinkage d)shrinkage folds in section2 of b e)shrinkage folds in the section3 of c compare to the primary phobos. F)The folds from top to the bottom in the upper most part of phobos.

The PDMS 36[10] suggested for modeling viscous materials like salt or ice [9, 1, 2&3]. Sand and PDMS mixture is good material for the simulations of the Ice and basalt articles in the Martian moons[15]. The experiments showed that the ice and rock mixture flow but slowly in compare to pure ice[12,13].However the ice rock mix sheets are surrounded by other sheets suggest forming of upright folds in the upper part of the suture fronts of viscous sheets(Fig4f).The ice or salt can extrude or intrude in the craters by down building or up building processes([14,19]Fig5 here). The numbers of craters show that they may operate on the gentle rising of the ice-rock mixture to generated some lines of fold axis or joints.The presence of ice and rock mixture suggest that it may some extrusion or intrusions in the craters as Mars[14,19] but the experiments suggested that the ice and rock mixtures or salt and rock mixture in Martian moon are down built and had not more power to be extruded when the very thick or when the ice content is too low (Fig6).The flow of the rocks and ice mixture or salt-rock mixture just folded as upright type folds with rising in some areas and the spreading in other areas base on the shortening and extension in global Martian moons(Fig4).Therefore by shrinkage of the whole icy moon(Fig4) and by the evaporation of the ice cement(subscribed by author) the cover of soil increased in thickness and the changes in the thicknesses generated upright folds(Fig6). The blue marker on the Figs6 d,e,f showed that there is shortening as gentel upright folds and there are no faults(figs 6 a,b,c).The lines on the cover assumed to form by folding in the experiment.The folds in the cover soil are more gentle in compare to salt(on Mars) or ice-rock mixture(on Martian moons).

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density(numbers) when the ice-rock mixtures have some big volcanic blocks(left in Figs6 g,h).

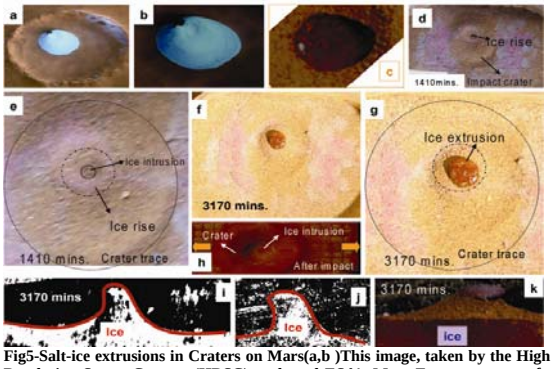

Fig5-Salt-ice extrusions in Craters on Mars(a,b)This image, taken by the High Resolution Stereo Camera (HRSC) on board ESA's Mars Express spacecraft, show an extrusion patch of water ice covered by salt cap sitting on the floor of an unnamed crater in north pole(see www.NASA.Gov[7] c d,e,f,g,h,I,j,k)the experiments of down building diapirism after impactc (After Aftabi 2008[14,19]).

However the ice-rock mixture rose in the right and left hand side because of the thinning of the cover soil. It shows that some extensions are possible in the Martian moons with rising ice-rock mixture.
The dips of the basal detachments are important for the size of upright folds and centers of rises in the blind ice-rock mixture(Figs 6 g,h).Rising in the ice-rock mixture with thin overburden generated big pillow on the Martian moons.

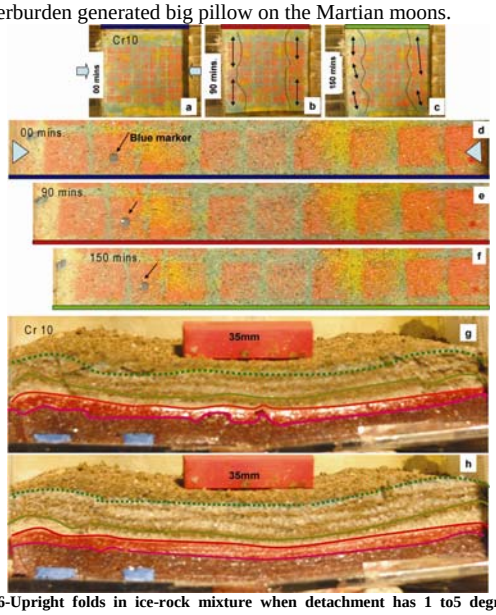

Fig6-Upright folds in ice-rock mixture when detachment has 1 to5 degrees deeps.

modeling method by the PDMS 36 and plastalina(Fig7[15,17])and field studies on viscous sheet at Qum Kuh (Fig8) on Earth(Iranian salt glacier in Qum area[16,17]) and also photo geology of the Martian moons[12,13] suggest that the flow folds change from top to lower part of the flowing sheet on Phobos(Fig4). The folds may link with the joint sets on phobos(Fig5e)and formed by elastic movements(subscribed).

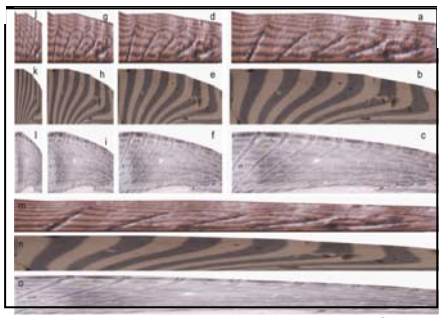

Fig7- modeling method by the PDMS 36(c,f,I,l,o) and plastalina(a,b,d,e,g,h,ijm,n).Fig prepared by old and new experiments AfterRamberg,(1981)[18]Talbot&Aftabi(2004)[9].

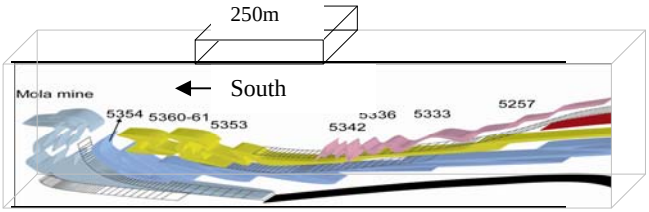

Fig8-Folds in glacier on Qum Kuh Central Iran(Earth).

The structure between salt and ice(and ice rock mixture) is very similar[2], because they are viscous material. The deformation lines on phobos are more than Deimos suggested higher content of ice-rock mixture on phobos.With special thanks to Hans Ramberg Tectonic Laboratory and C.J.Talbot.

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