KINEMATICS MAPPING AND MONITORING OF ''SWISS CHEESE'' FEATURES IN THE POLAR ICY REGIONS OF MARS OVER TWO MARTIAN YEARS BASE ON HIRISE-MOC(NASA)IMAGES

P.Aftabi*(Pedram.Aftabi@gmail.com)

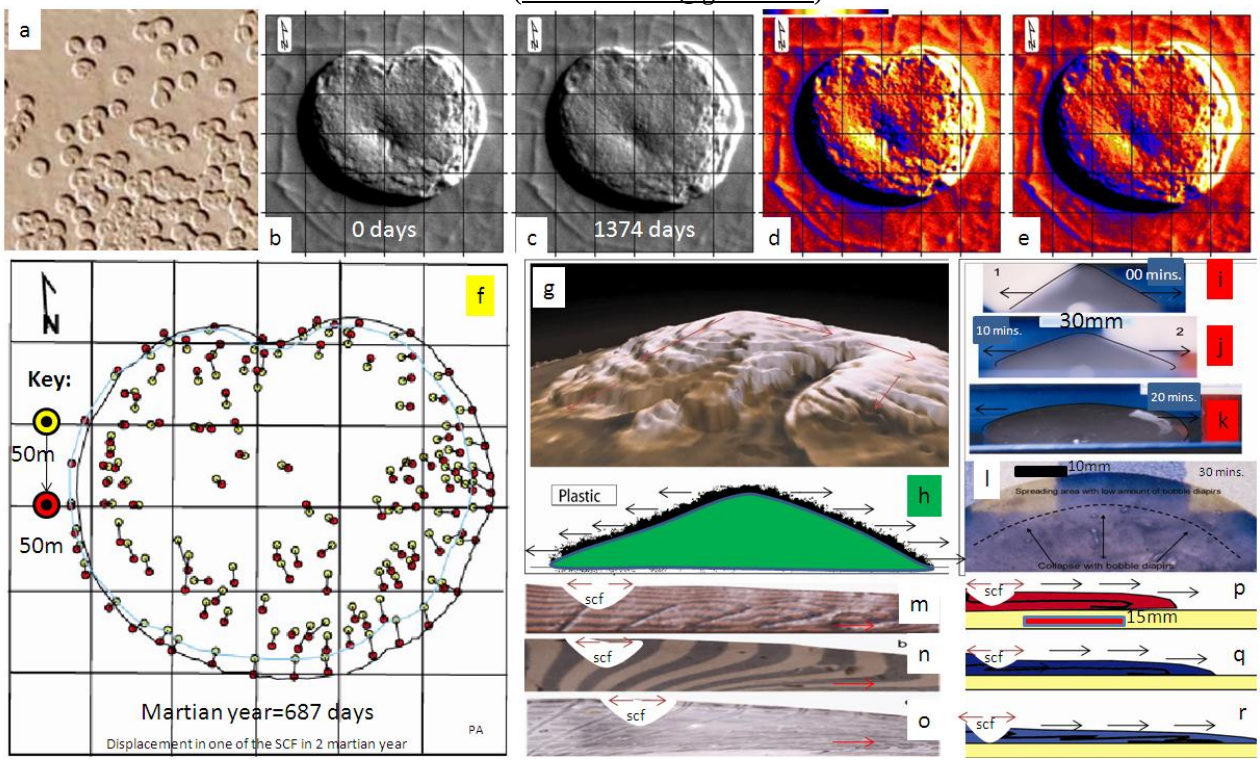

Fig- a) The ''Swiss cheese'' features explained by scientists and NASA.This landscape explained as a features expand several meters per year. b,c)The MOC images of NASA[1]8 m-deep pit(scf) at 86.9,353.3E separated by two Martian years.M09/00609(Fig b,Ls 237 degrees,1.4m/px and R08/01050(Fig c Ls 241 degrees,1.5 m/px) used for the monitoring. d,e)Same thermal images of the Fig b,c after 0 days and 1374 days respectively. The thermal color mapping STD gamma III) showed by blue-orange-yellow color. The orange colors and yellows are different in temperature with blue colors suggests that blue areas may be subsides but the brine flow upward. f) Displacement map and monitoring pit of Fig b,c base on pixel base morphologic features. g)The Northern polar cap of mars and its spreading shoed by arrows in 3D.Original Fig from NASA[1]. h,i)The ice polar caps(PDMS in exps.) are evolved from a plastic cone shape. j)Ice caps formed viscous-plastic semi conical sheet after 10 mins. Spreading. K,l)The ice cap finally spread as droplet shape sheet after 20 mins.

The ''Swiss cheese'' features explained by scientists and NASA in last decade[e.g. 1,9,15,16,17,18,20] .This landscape (Fig a) explained as a features expand several meters per year before by modeling[9].The mapping and monitoring of ''Swiss cheese'' feature(scf) example of this paper(Figb,c[1]) achieved by pixel markers and morphologic features and this type of mapping and measurements proposed by author. The research in this paper is spatially limited to a 300×300m data frame surrounding the pit(scf) and the country rock around it (Figs b,c,d,e&f) and is limited by data availability to temporally integrate all deformations occurring between two Martian years(Figa,b,c,d,f)or another words in 1374 days. A Martian year is about 687 days. My processing methods as pixel morphologic marker monitoring, reveal strain patterns and displacements by vectors. The direction of vectors are from yellow circle to red circle from center to center in the''Swiss cheese'' feature (scf-Figf). The MOC images of NASA[1]8 m-deep pit(scf) at 86.9,353.3E separated by two Martian years(Figs b,c).M09/00609(Fig b,Ls 237 degrees,1.4m/px and R08/01050(Fig c Ls 241 degrees,1.5 m/px) used for the monitoring. The Figs b,c first illustrated as example MOC image by Herkenhoff et al at 2006[2].Gridline spacing in Figs a,b&f are about 50 m and the expansion of pit mapped and monitored relative to fixed grid(Fig f).The orbital errors and determination of a reference phase level are very low according to high amounts of displacements. The changes in the spreading(expansion) rates showed by differ-

ent vectors(Figf).I applied a simple time-series analysis on the chain of marker mapping in order to estimate surface deformation of some selective pixels in this ‘‘Swiss cheese’’ feature(scf,Figf).I used also morphologic features to determine the displacements. The vector map showed high deformation areas in the rims of pit and low deformation areas in the center of pit(Figf).The low amount of movements in the center of pits suggest subsidence in this area by upward flow of brine (H2O or CO2 or mixtures of H2O-CO2 and salty water). Using high-resolution Mars Observer Camera (MOC) images from two separate years of MOC observations,Malin et al. [21,22] showed that the Swiss cheese has retreated on the order of 1-3 meters per Martian years. More recently, a similar rate of retreat has also been observed for the third Martian year of MOC observations ,Malin et al. [21,22].My mapping and monitoring showed that one of the pits on Mars expanded between 0.5m to 10 m per year(Fig d here).The research here suggest some of the pits may expand as flowing structures more described by other scientist[e.g. 21,22].The flow of brine and thermal changes in and around the pit(Figs d,e)generated by remote sensing as thermal color mapping STD gamma III. These pictures (Figs d,e)showed thermal changes as blue, orange and yellow colors. The changes in the colors suggest not only the thermal changes in and out of the pit but also flow of brine in and out. The orange colors and yellows are different in temperature with blue colors suggests that blue areas may be subsides but the brine flow upward (Blue areas in Figd,e). I suggest the readers to see original Figs in HiRISE[5] and MOC on the [3,4]web and descriptions by Herkenhoff et al(2006)[2]www.NASA.Gov[1]and other references[6,7].The morphological features also changes between 0 days to 1374 days. An unexpected result of doing systematic pixel marker mentoring and mapping analysis for pits is the discovery that most of the pits (scf) and their related ice sheets are actively deform and spread. The‘‘Swiss cheese’’ features(scf) expand sideways(Figs m.n,o,p,q) suggest that most of the ice sheets in the polar areas are spreading .The spreading of ice sheets illustrated before[e.g. 8,10,11,12] in the polar areas of Mars .the ice caps on mars explained before [e.g. 8,10,11,12,16,19].The Northern polar cap of Mars [1]showed in Fig g.[NASA,1].The vectors in this Fig show the flow directions in this ice cap illustrated before base on author experiments[8,12] .The models by author by PDMS[14,15] confirm the finding and suggest that the ice polar caps are evolved from a plastic cone shape(Figh,i) form to viscous-plastic semi conical sheet(Figj) and finally as spread droplet shape ice cap or spread ice sheets(Figk,l).The "Swiss cheese" features and pits spread radials in both sides related to the location in the ice sheets(Figs m,n,o,p,q,r).The ice sheets can be as indenters(Fig not included here) but the most of the sheets formed roll over folds with overturned to recumbent folds repeated in the ice sheet(in exps. By author-figs p, q, r).The pattern of strain markers by the author experiments (Fig o) compared with Hans Ramberg’s experiments [13, Fig, m, n here].All the experiments done base on Ramberg’s methods [13].The displacements and changes radials in the pits and the models here in this paper suggest that the spreading of ice sheets and flow of brines in the polar areas of Mars. The flow of water and ice in polar areas of Mars is very important for human missions in future. For the rates of expansions see fig f by using scale key bar. For the better looking of pictures and references use Zoom in object.

References:

[1]www.NASA.Gov.

[2] Herkenhoff, K., et al.,2006, Fourth mars polar science conference,2pp,pdf8009.[3]http://marsoweb.nasa.gov/hirise[4]http://hirise.seti.org/epo [5]McEwen,A.,etal.,2006,J.Geophys.Res.[6]Gulick,V.C.,McEwen,A and the HiRISE team,2005,Eos Trans,AGU 86(52),Fall meet,Suppl,Abstract P23A-0172. [7]Gulick, V.C., and the HiRISE science team, 2005, AAS DPS meeting 37, abstract 12-03. [8]Aftabi, P., 2006, Fourth Mars Polar Science Conference, 22pp, PDF 8059. [9]Byrne, S., &Zuber, M.T., 2006, Fourth Mars Polar Science Conference, 22pp, PDF 8035. [10]Durham, W.B et al., 2006, Fourth Mars Polar Science Conference, 22pp, PDF 8104. [11]Kreslavsky,M.A & Head,J.W.,2006, Fourth Mars Polar Science Conference,22pp,PDF 8028.[12]Aftabi,P.,2008,Science of Solar System Ices,2pp,PDF.9011.[13]Ramberg,H.,1981,Gravity ,Deformation and the Earth’s Crust,Academic press London. [14]Weijermars,R.,1986,Natur wissenschafen,Vol.73,p33.[15]Talbot,C.J.&Aftabi,P.,2004,GSL,V.161,p321-334.[15] Betz,E.O et al., 40th Lunar and Planetary Science Conference (2009),2pp,PDf 1363.[16]Byrne,S. & Ingersoll,A.P.,2003, Geophysical Research Letters, Vol. 30, NO. 13, 1696. [17] Kadish,S.J., et al.,2008, Geophysical Research Letters ,Vol. 35, L16104.[18] Campbell,J et al.,2015 ISPRS Working Group IV/8 Planetary Mapping and Spatial Databases Meeting.[19] MacClune,K.L. et al.,2003, Journal of Geophysical Research, Vol. 108, No. E4, 5031. [19] Tanaka, K.L &Fortezzo, C.M, 2012, Geologic Map of the North Polar Region of Mars, Prepared for the NASA by USGS, 11pp. [20] Becerra, P. et al., 2014, Eighth International Conference on Mars, 2pp, PDF1013. [21] Malin M. C. (2001) *Science*, 294, 2146-2148.[22] Malin M. C. et al. (2003) MGS MOC Press Release No.MOC2-367 at www.msss.com