Introduction - Oblique Impact Craters & Impact Structures formed by several Impactors

Prepared by Harry K. Hahn

To understand what happens when an asteroid or comet impacts on a planetary body, here a few examples of oblique impact craters and impact structures formed by several impactors (→ impactors which broke apart) :

Here we don't consider the case where the impact angle is 90° and a simple circular impact crater is formed.

The following images show what happens if an impactor (asteroid of comet) impacts on the surface of a planet or moon in a shallow angle, and what impact structures are formed by impactors which break apart just before impact

The following facts of such "oblique impacts" with a shallow impact angle should be kept in mind :

1.) An elliptical impact crater is formed during impact

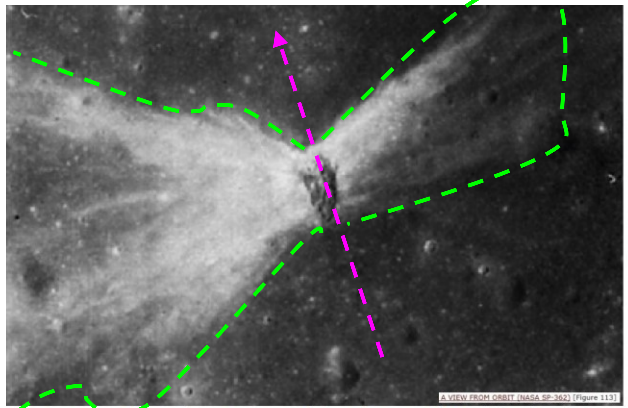
2.) Oblique impacts (2) produce a butterfly-shaped ejecta blanket with two mostly forward directed wings

3.) The ejecta blanket is formed by multiple ejecta lobes

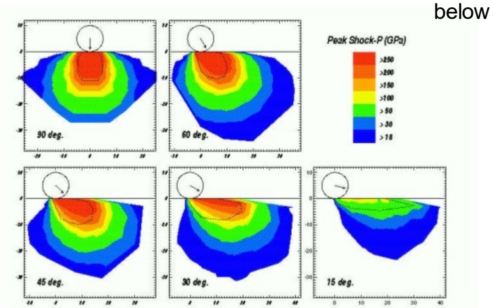
4.) The smaller the impact angle the more ejecta is thrown out without being melted → see below

5.) There is often a blow-out rim on the rear end of the crater visible. (the crater has a flat end)

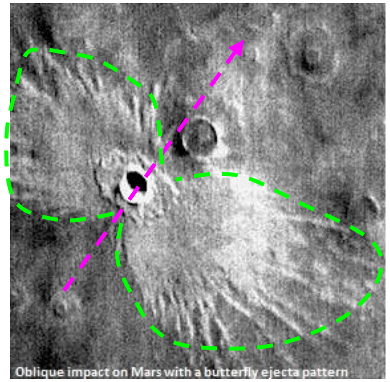
6.) At multiple impact craters "ejecta strings" along the borders between the separate shock fronts are caused (accumulation of ejecta along lines)



Elliptical Impact Crater on the Moon. The crater is approximately 1 km long and it is surrounded by a Butterfly-shaped Ejecta blanket. It was probably caused by a group of impactors. The main impactor probably already desintegrated when it reached the moon's Roche Limit

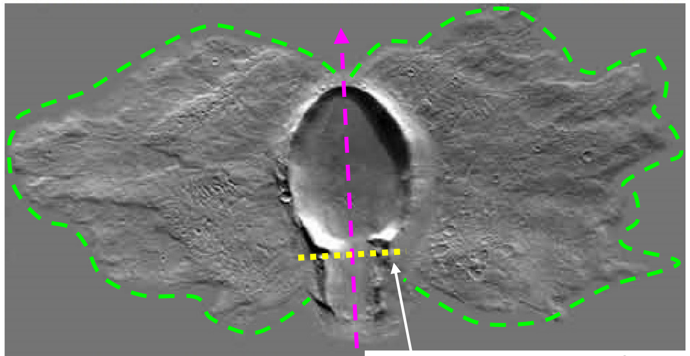


In the range of shock pressures at which most materials of geologic interest melt or begin to vaporize, we find that the volume of impact melt decreases by at most 20% for impacts from 90° down to 45°. Below 45°, however, the amount of melt in the target decreases rapidly with impact angle. Compared to the vertical case, the reduction in volume of melt is about 50% for impacts at 30° and more than 90% for a 15° imapct. These estimates do not include possible melting due to shear heating, which can contribute to the amount of melt production especially in very oblique impacts.



Oblique impact on Mars with a butterfly ejecta pattern

Imaging of the surface areas of our solar system's terrestrial planets and moons has show that approximately 5% of all craters are created during low angle of incidence [oblique] impacts. These events create a set of recognizable characteristics: oval shape, butterfly ejecta pattern, "no-fly" ejecta area up field, and "blow-out" rim down field. These are sometime seen in a "train" of craters, where the impactor had been fragmented to a stream of individual components due to atmospheric disruption or Roche tidal disruption prior impact

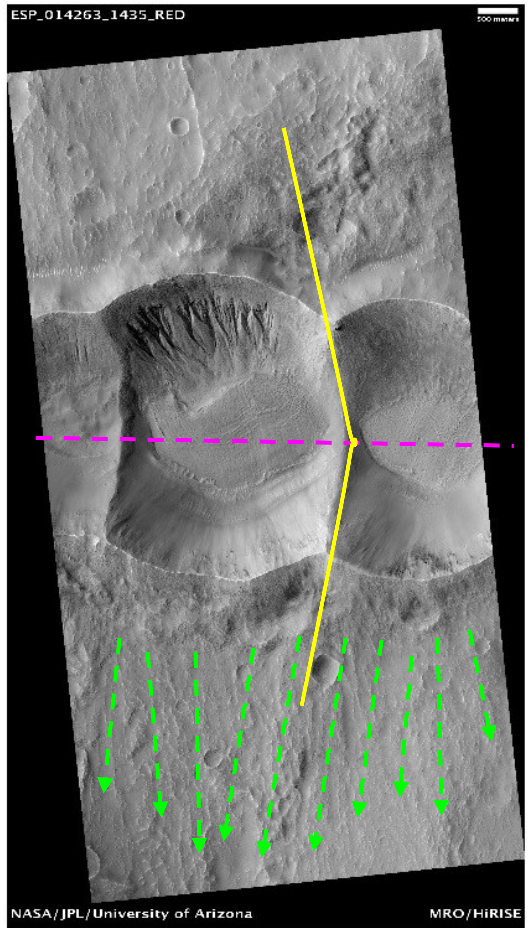


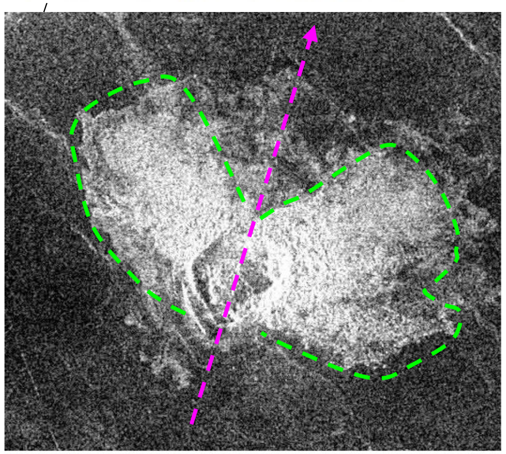
blow -out rim on rear end of crater

Example Mars Impact with Butterfly Ejecta distribution
Credit: NASA / JPL / ASU / mosaic by Emily Lakdawalla

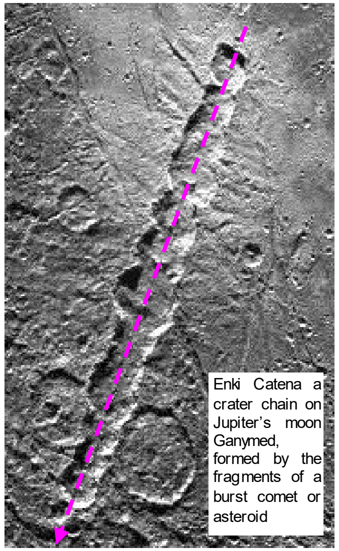
Owing to the atmospheric drag, a string of fragmented impactors would differentiate during decent, with the larger bodies tending to travel further than smaller ones.

We call special attention to the work of Schultz and Stickle (Lost Impacts), which explains how shallow angle of incidence (oblique) impacts generate "impact" structures that are significantly different from the classic, better understood, crater planforms. We proposed the Saginaw impacts to have been at an angle of less than 5 degrees - nearly tangential. The craters generated would manifest

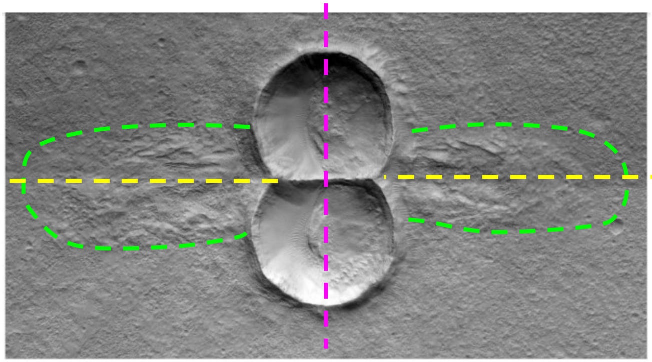




A 50 km wide radar image showing an 8 km diameter impact crater on Venus. The asymmetric distribution of the bright ejecta indicates that this crater was formed by an oblique impact, by a approx. 200 m object arriving from the south at a speed of maybe 20 km/s.



Enki Catena a crater chain on Jupiter's moon Ganymed, formed by the fragments of a burst comet or asteroid



22. On to Mars next - this image shows a remarkable double crater with a shared rim and North-South trending ejecta deposits. These two craters must have formed simultaneously. Image acquired in February, 2011 by NASA's High Resolution Imaging Science Experiment (HiRISE), a camera on board the Mars Reconnaissance Orbiter (MRO). (NASA/JPL/University of Arizona)# ■ #