IMPACT DEMAGNETIZATION OF THE MARTIAN CRUST: PRIMARIES VERSUS SECONDARIES.
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Introduction: The lack of magnetic anomalies within the giant martian impact basins, Hellas, Argyre, and Isidis is well-established by the Mars Global Surveyor magnetic data and has been estimated analytically [1.2]. In this paper we present numerical calculations of the shock wave decay in giant impacts, corresponding to formation of the martian basins and compare an input from direct impact and secondary impacts.

Numerical methods: To model formation of a large impact crater we use the two-dimensional SALEB code, originally developed by Amsden et al. [3] and recently modified by Ivanov [4]. The code is coupled with the ANEOS equation of state [5]. The modeled rock mechanics includes a strength model for intact and damaged rocks with gradual shear failure, an instant tension failure, dry friction for damaged rocks, the decrease of strength and internal friction close to melt temperature and shear strength increase with pressure increase. In addition to these familiar processes we also employ a model of acoustic fluidization [6].

Demagnetization by direct high-velocity impacts: The results of giant impact numerical simulations are shown in Fig.1. A 300-km-diameter projectile strikes vertically at 10 km/s. Transient cavity (TC) diameter is ~1130 km (probably, a bit larger than Argyre TC). Maximum shock compression drops rather quickly near the free surface: At a depth of 25 km (in the middle of a 50-km crust), it is below 1 GPa at a distance of 1000 km. It means that demagnetization is negligible beyond two TC radii.

**Fig. 1** Maximum shock pressure in the target after a 10 km/s, 300-km-diameter projectile impact. The black triangle shows the edge of the TC.

**Fig. 2** Ratio of target material volume compressed above 1 GPa to projectile volume for impact velocities of 1-4 km/s.

**Secondaries – Z-model:** Ejection velocity \( U_{ej} \) at a distance \( r \) from an impact point is: \( U_{ej} = U_s (r/\rho_{cr})^{1/2} \). \( U_s \) is a characteristic ejection velocity near the crater rim \( (r=\rho_{cr}) \), which may be defined as \( (4/15 g \rho_{cr})^{1/2} \) for a planet with gravity \( g \). \( Z \) is a coefficient, which may be defined from experiments, or from comparison with numerical models [7]. It varies between about 2 near the axial stream tubes to about 4 near the surface, with \( Z=3 \) as a reasonable overall approximation (Melosh 1989). The total volume ejected through the free surface between \( r \) and \( r+dr \) (the volume of a stream tube) is \( dV = (\pi r^2)/2 dr \). This material will be deposited within a ring with an inner radius \( s = r + U_{ej}^2/(2g) \), assuming a ballistic trajectory and ejection angle of 45°, and a width of \( ds = dr/(1-2Z U_{ej}^2/g) \). If all the material strikes the surface as a solid non-disrupted body, than we can estimate demagnetization of the crust as a function of distance from the impact site. The results are shown in **Fig.3** by dashed lines for 3 values of \( \rho_{cr} \). The effect strongly depends on the transient cavity size: while transient cavity differs by a factor of two (655 km versus 1544 km), the thickness of demagnetization differs...
by an order of magnitude (7 km versus 73 km). It is obvious that this estimate gives an upper limit of martian crustal demagnetization, as the real ejected volume consists of fragments of different sizes, which create separate (or overlapped) craters.

Fig. 3. Thickness of demagnetized crust (in km) as a function of distance from the impact point (measured in transient cavity radii). The corresponding transient cavity diameter is shown near each dashed line. Dashed lines show the upper limit of demagnetization (see text for details), thick solid lines – the lowest limit, and thin solid line for the largest basin is for a smooth interpolation between the two cases.

Conclusions and future study: Outside the transient cavity, demagnetization by secondary impacts (SI) is at least comparable with demagnetization in a direct shock wave. While the direct shock wave cannot demagnetize the uppermost layers of the crust because of a quick decay near the free surface, secondary impacts demagnetize exactly these upper layers. The effectiveness of SI-demagnetization decreases sharply with crater size. It is negligible for basins smaller than ~500 km. The relative inputs from the primary shock wave and secondary impacts depend on the magnetic carriers distribution in the crust: If magnetic minerals are mainly in the uppermost layers, thansecondaries may be of great importance.