GRAVITATIONAL EFFECTS OF FLOODING AND FILLING OF IMPACT BASINS ON MARS. David E. Smith[1] and Maria T. Zuber[2], [1]Laboratory for Terrestrial Physics, NASA Goddard Space Flight Center, Greenbelt, MD 20771, e-mail: David.E.Smith@nasa.gov, [2]Dept of Earth Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, 77 Massachusetts Ave., 54-918, Cambridge, MA 02139-4307, e-mail: zuber@mit.edu.

Introduction. The presence of large impact basins and the low northern plains that might have contained ice or liquid water at an earlier stage of Mars' evolution suggests that the global gravity field could have been different in the distant past than it is today. In addition, any significant change in the distribution of mass affects the moments of inertia and consequently and could conceivably change the position of the pole and the length of day. Similar effects could have been produced by large erosional processes, such as the removal of crustal material from the Arabia Terra region and subsequent re-depostion in the Chryse region of the northern plains [1]. We have endeavored to estimate the magnitudes of material that might have been involved in these processes and their possible effect on the gravity and dynamics of Mars. We have used present-day topography [2] and gravity field [3] as a starting point, recognizing that both the result of the processes that we are trying to study rather than the state at the times of interest.

Basin Volumes. The largest volume (arbitrarily defined below zero elevation) that could have been filled with H_2O in the past is the northern plains (Fig. 1a) , which occupy about 47% of the surface of the planet [2]. Because of its location, which is approximately symmetrical about the pole, the additional mass associated with flooding contributes largely to the zonal gravity field, particularly degrees 1, 2 and 3, with small changes to the moments of inertia. (Note: we do not account for flexural effects.) Hellas (Fig. 1b) is the largest impact basin, and if filled to the zero elevation level would only hold about 10% of the volume of the northern plains. But because of its location at 30 to 50S, 50 to 90^{o}E, it has the potential to have a larger effect on the moments. If suddenly filled today it would want to move toward the equator and because it is almost antipodal position to Tharsis it would move Tharsis southward [*cf.* 4].

The second largest impact basin was probably Utopia [5, 6] but today it is filled with sediments and volcanics [7], thus making the basin much shallower than it was originally. It appears to have been a Hellas-sized basin and therefore might have been a significant contributor to global-scale mass re-distribution.

Argyre, in comparison to Hellas, has only about 10% of the volume of Hellas as measured by today's topography, and has a relatively minor effect on the global mass redistribution.

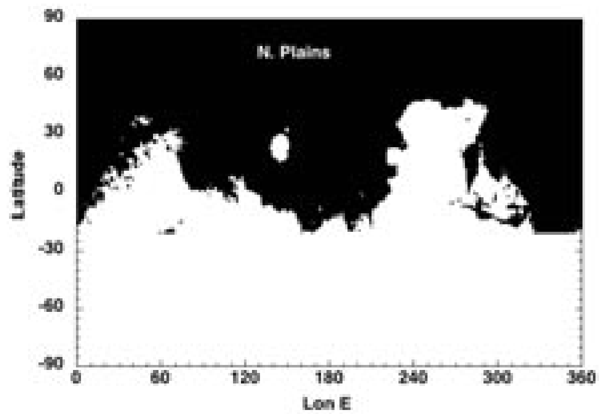

Fig 1a. The northern plains. Volume below zero elevation ~ 2 x 10^{17} m^3.

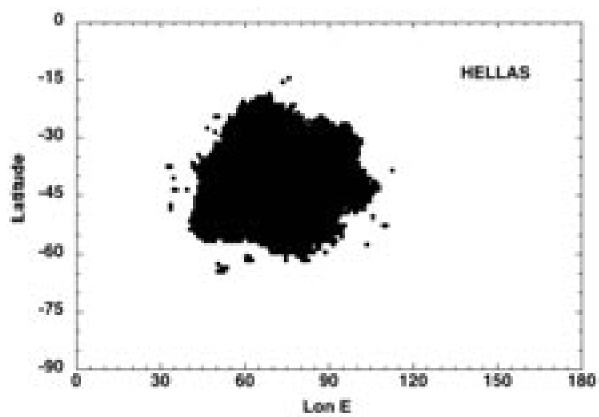

Fig 1b. Hellas impact basin. Present day volume below zero elevation ~ 2 x 10^{16} m^3.

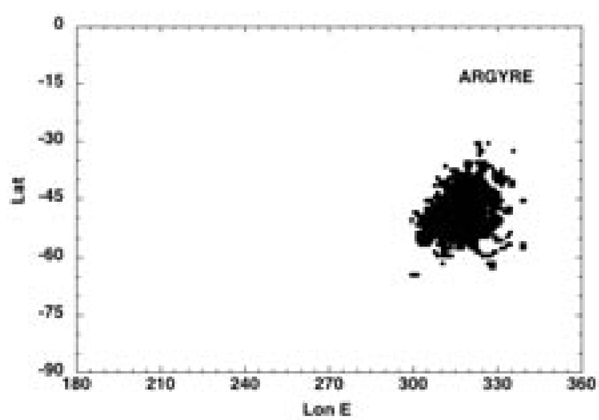

Fig 1c. Argyre impact basin. Present day volume below zero elevation ~ 2 x 10^{15} m^3.

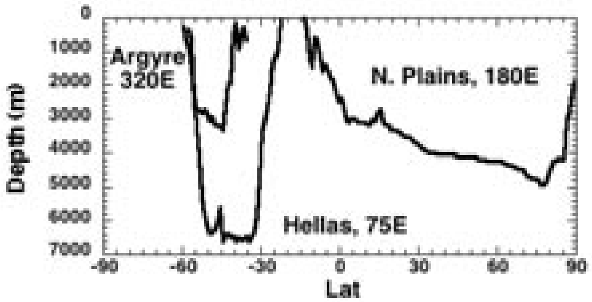

Fig. 2. Comparison of basin profiles from MOLA altimetry [2].

The magnitudes of changes in low degree zonal gravity field coefficients are given in Table 1 for the northern plains, Hellas and Argyre. To perform the calculation we treated the fill as sets of point masses on one degree squares, computed the potential via volume integration, and performed a spherical harmonic expansion [*cf.* 8].

The fill masses for the basins = vol x 10^3 kg for H_2O and these are to be compared with the total mass of Mars of 6.4 x 10^{23} kg. If flooded with H_2O, the mass within in the northern plains would be ~3x 10^{-4} of Mars, and correspondingly larger if a denser (*i.e.* sediment) fill material is assumed.

References. [1] Hynek B.M. and Phillips R.J. (2001) *Geology, 29,* 407. [2] Smith D. E. et al. (2001) *JGR, 106,* 23,689. [3] Lemoine F. G. et al. (2001) *JGR, 106,* 23,359. [4] Goldreich P. and Toomre A. (1969) *JGR, 74,* 2555. [5] McGill G. E. (1989) *JGR, 94,* 2753. [6] Smith D. E. et al. (1998) *Science, 279,* 1686. [7] Zuber M. T. et al. (2000) *Science, 287,* 1788. [8] Zuber M. T. and Smith D. E. (1997) *JGR, 102,* 28,673.

Table 1. Changes in low-degree gravity field coefficients due due to flooding of major basins.

N. Plains	
C1,0	0.98D-04
C2,0	0.20D-04
C3,0	0.23D-06
Hellas	
C1,0	-0.11D-04
C2,0	0.17D-05
C3,0	0.27D-05
Argyre	
C1,0	-0.13D-05
C2,0	0.46D-06
C3,0	0.78D-07