

**A SEARCH FOR LARGE IMPACT BASINS IN THE SOUTHERN HEMISPHERE OF MARS** Herbert Frey, Geodynamics Branch, Goddard Space Flight Center, Greenbelt, MD 20771; Anne-Marie Reidy and Harry Wolfe, Astronomy Program, University of Maryland, College Park, MD 20742; Richard A. Schultz, Mackay School of Mines, University of Nevada, Reno, NV 89557.

### ***Introduction***

The most recent inventory of large impact basins on Mars includes 30 structures larger than 500 km [1]. The largest of these ( $D > 4000$  km) lie in the vicinity of the Elysium and Tharsis tectono-volcanic complexes, which may owe their origin to the effect of very large impacts on the early martian lithosphere [2, 3]. There appears to be a paucity of very large basins in the southern highlands and especially in the south polar region where only the 850 km wide South Polar Basin is recognized [1,4,5,6]. Many have pointed out that it is statistically unlikely for one hemisphere to be so underpopulated (although the formation of a very few very large impact basins may not be a statistical process). This then implies either (a) the mapping and recognition of large impact basins in the southern hemisphere is incomplete, or alternatively, (b) the concentration of the largest basins in one hemisphere is fundamental and probably related to the origin of the martian crustal dichotomy [2, 3]. Below we report recent progress in searching for large impact basins in the southern hemisphere of Mars and suggest several promising candidates for which evidence exists.

### ***Criteria for Searching and Recognizing Impact Basins***

Searching for evidence of large impact basins is not easy, even in the largely Noachian cratered terrain of the southern hemisphere. There are few portions of Mars that have not undergone significant resurfacing of one form or another [7]. The intense impact bombardment and subsequent volcanic, aeolian and polar resurfacing that affected the southern highlands could easily have nearly buried ancient impact basins, even of large size. Schultz et al. [8] describe criteria for identification of rings of the nearly obscured Ladon Basin. Like them, for identification of basin structure, we rely mostly on concentric distribution of relic scarps, massifs, dissected ancient terrain, indicators of subsurface structure (changes in orientation of channels, offsets in faults or linear features), and direct indicators of low topography (elevation data, valley networks, runoff channels, localized plains deposits). In general the structural indicators are less obvious than in the case of Ladon, which may explain why few impact basins have been found in the southern hemisphere.

To focus the search we adopt a strategy based on direct and indirect indicators of lowlying topography. Obvious closed depressions larger than about 300 km across in the current global topographic maps [9] were all examined. Assuming that any unrecognized large impact basin must be nearly buried, we also searched for regions devoid of very large impact craters. Large impact depressions may be good traps for volcanic, aeolian and polar deposits, all of which (if thick enough) may have obscured large craters which formed subsequent to the basin. Alternatively, late formation of a large basin may have eliminated earlier large craters. We have identified a number of large ( $> 1000$  km across), roughly circular regions which appear deficient in the population of craters larger than 100 to 150 km. As described below, several of these also have a concentric distribution of those features described above, and so may represent previously unrecognized impact basins. One of these, described in a companion abstract, may be a large, pre-Hellas structure that, together with Hellas, explains the Hesperian-age volcanism which overlies the southern rim of Hellas [2, 10].

### ***Candidate Basins in the Southern Hemisphere: Western Mars***

In Sirenum Terra a roughly circular, 900 km wide depression centered at 163°W, 63°S lies 2000 m below the ancient cratered terrain. The central 300 km wide low contains Hesperian plateau plains (*Hpl3*), surrounded on the north and west by *Npl1* and on the south by *Npld* units. At roughly 750-800 km from the center, ridged plains form a roughly concentric distribution. A thin (*Nplr*) ridged plains unit at 300-350 km also lies concentric to the topographic low. Craters

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larger than 150 km are absent within a roughly circular area 1000-1100 km across centered on the basin, but do exist outside this limit.

Further east in Sirenum Terra at 115°W, 62.5°S, a 2000 m deep basin lies between 6000 m peak elevations separated by more than 900 km. *Npl1* units are distributed in a concentric pattern roughly 250 km from the center. The *Npl1* units to the north and west contain craters 50-100 km in diameter, while to the south these even larger craters exist at distances of 600 km. An outer expression of this basin may be defined by *Npl1* and *Npld* units 600 km east and west of the center, and by *Npl1* units with craters larger than 100-150 km to the north, northwest, south and southwest of the basin.

A region of very smooth plains more than 300 km across and surrounded on the east, south and west by *Npl1* and *Npld* occurs at 80°W, 60°S in Aonia Terra. The central basin lies 500-1000 m lower than the surroundings and is obviously depopulated in craters smaller than 50 km. A roughly concentric distribution of *Npl1* and *Npld* units to the south lies about 350 km from the center. 50-100 km craters are partially buried to the east out to a distance of 150 km, and very large craters ( $D > 100$  km, including the 200 km Schmidt crater which opens toward the basin) are found only beyond about 800-900 km. At a distance of about 600 km from the basin center, Hesperian-age depositional units (*Hdu*, *Hdl*, *Hpl3*) form an incomplete arc on the south, west and northern sides.

***Candidate Basins in the Southern Hemisphere: Eastern Mars***

South Polar Basin is the most obvious impact basin, but its single recognized ring is unusual. The distribution of ridged plains units, outcrops of ancient terrain, ridges and scarps, and other features suggests that the influence of South Polar Basin greatly exceeds its 850 km diameter ring. It is likely that other nearly buried rings exist, perhaps at distances of 1130 and 1480 km (based on analogy with Ladon). Furthermore, there is good evidence that South Polar overlaps another basin of roughly similar size, centered near 200°W, 70°S. The combination of these two basins (assuming outer rings do exist for South Polar) may explain the asymmetric off-axis location of the south polar deposits *Apl*.

The evidence for a pre-Hellas basin centered at 328°W, 68°S is described in a companion abstract. This structure may be as much as 2400 km across, with major rings at 1080 and 1800 km diameter.

***Discussion***

Based on preliminary results, it appears there may be several ancient, previously unrecognized impact basins in the southern hemisphere. These basins are defined on the basis of concentric distribution of structures, outcrops and units, but have been found mostly by searching areas devoid of very large impact craters for which there is evidence of low topography. Further work is required to define the details of ring diameters, but several of these features appear to be in the 500-1500 km diameter class. No evidence has yet been found for very large impact basins ( $D > 4000$  km) like Elysium [11] or Utopia [12] which dominate and may be the origin of the northern lowland hemisphere of Mars [2,3]. Thus while the apparent paucity of impacts in the southern hemisphere may be due to incomplete recognition, the hemispherical crustal dichotomy may still be related to the location of those very few very large impacts, and especially to the fact that several of these overlap in the Elysium-Utopia and Tharsis regions [1,2,3].

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