LARGEST IMPACT FEATURES ON VENUS: NON-PRESERVED OR NON-RECOGNIZABLE ?

Olga V.Nikolaeva (Vernadsky Institute, 19 Kosygin str. 117975 Moscow Russia)

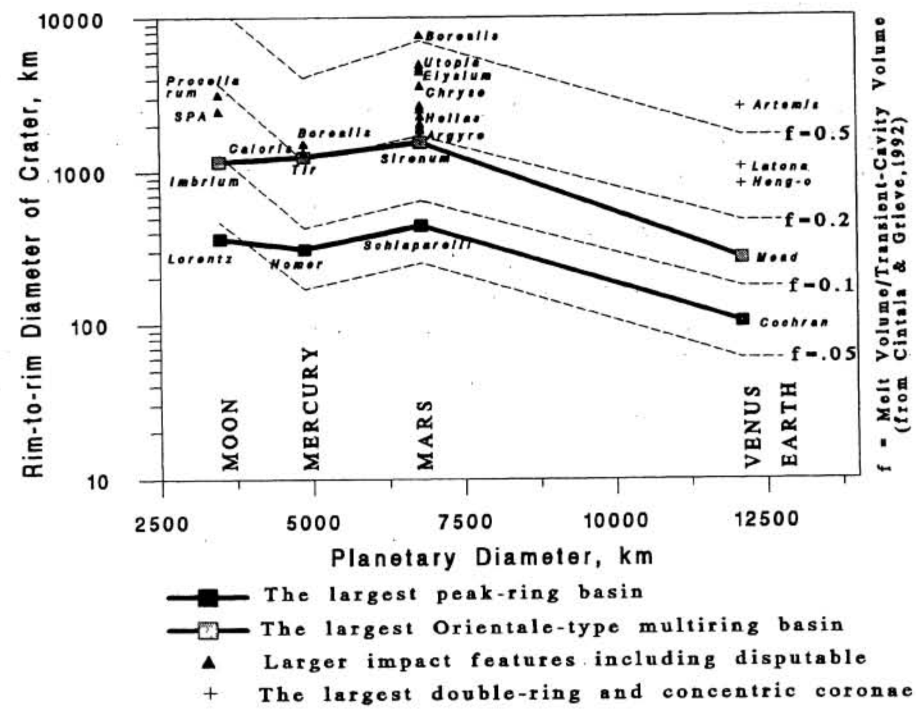
Conventional explanation of a lack of impact craters with diameters >300 km on Venus [1] is that they formed during the intense bombardment era and had lunar-like morphology, but they are not preserved now because of rapid viscous relaxation of their topograpy or/and high endogenous reworking of surface. Other explanation invokes failure to recognize these larger craters because of their non-lunar-like morphology from the moment of formation [2, 3], since larger gravity of Venus relatively to the Moon results in that largest craters on Venus may form within the mass of shock melted material while comparably sized lunar craters would be still almost "dry" [4-7]. To test this hypothesis, morphologies and rim-crest diameters of the largest peak-ring and Orientale-type basins and all larger impact features on Moon, Mercury, Mars, and Venus were compiled and compared to rim-crest diameters of model craters with different melt volume/transient-cavity volume ratios from [6]. Results show that the final diameters of model craters formed at depth of melting about twice of transient cavity depth correspond to changeover from a planet-similar morphology of all the smaller basins on any terrestrial planet to a planet-specific morphology of all the larger basins on Moon(?), Mercury, and Mars. On Venus, these largest impact features are not found and instead, a Venus-specific morphology of the largest concentric coronae appears in this size range. The coronae were suggested to form over sites of mantle upwelling and modified by subsequent volcanism and gravitational relaxation [e.g., 8-10]. The results here suggest that mantle upwelling - the first and necessary step of the corona formation models - may be induced by impact event (as a result of transient cavity collapse) and operated under cover of hot, slowly cooled impact melt in the areas of thinned crust and/or thermally active regions.

DATA ON THE LARGEST OBSERVED IMPACT FEATURES. Largest impact features on Moon, Mercury, Mars, and Venus can be groupped into three morphological types: peak-ring basins, Orientale-type multiring basins, and all the larger features whose morphology has not a lunar analogue. The morphology of a peak-ring basin (inner ring expressed as a ring of central peaks and the outer ring, as the crater rim crest.) were recognized to be similar on Moon, Mercury, Mars, and Venus [11-14]. Diameter of the largest peak-ring basin is 365km (Lorentz) on Moon [11], 310 km (Homer) on Mercury [11,12], 442 km (Schiaparelli) on Mars [11], and 104 km (Cochran) on Venus [14]. Basins of Orientale-type (at least three rings expressed as rim crests) were recognized to be similar too on all these planets [11-14]. Diameter of the largest Orientale-type basin is 1160 km (Imbrium) on Moon [11], 1250 km (Tir) on Mercury [11], 1548 km (Sirenum) on Mars [13], and 270 km (Mead) on Venus [14]. On each of the planets, except with Venus, there are still more larger impact features. Examples of these are: lunar Procellarum (D 3200 km) and South Pole-Aitken (D 2500 km) circular features with unclear morphology [15]; mercurian Caloris basin (D 1340 km) measured by fitting circles to the fragments of mapped rim crest [12]; martian Argyre-type structures ($1850<D>2700$ km) with an annulus and concentric graben, Chryse-type structures ($3600<D>4970$ km) with numerous concentric rings expressed as scarps, massifs, and channels [13], and Borealis (D 7700 km) which is a global circular depression interpreted as either impact basin [16], or mantle-plume structure [17]. So the morphology of the impact features larger than the largest Orientale-type basin is specific for a given planet.. On Venus, no impact features larger than the largest Orientale-type basin were recognized. Although a specifically venusian large circular features (coronae) have been suspected to be impact-induced by size distribution [2] and morphology [3]. The largest concentric-double ring corona (Latona) is 870x750 km in size, the largest concentric corona (Heng-o) has diameter of 1060 km, and unique corona (Artemis) is 2600 km in diameter [8]. Diameter values of all the largest features mentioned above are shown in Figure as a function of planet size.

THEORY ON IMPACT MELT PRODUCTION IN DIFFERENTLY SIZED CRATERS. Based on scaling relations, Cintala and Grieve [6] calculated and showed graphically impact melt volume/transient-cavity volume ratios as a function of rim-crest crater diameter for each of terrestrial planets. I transformed their graph into set of curves which demonstrate theoretical dependence between the diameter of craters with different values of melt volume/transient-cavity volume ratio on each of the planets and the planet size (dotted lines in Figure). Under calculations [6], all targets were assumed to be anorthosite and have a temperature of 273K except for Venus, for which diabase target and 700K was used. Typical impact velocities (from[18]), 23.6 for Mercury, 19.3 for Venus, 17.8 for Earth, 4.1 for Moon, and 12.4 km/s for Mars were employed [6].

RESULTS OF THE OBSERVED/MODEL DATA COMPARISON. Diameters of the largest observed impact features and model craters produced different volumes of impact melts are compared in the Figure. The Figure demonstrates two items. FIRST. Interplanetary trends of the largest both peak-ring and Orientale-type

LARGEST IMPACT FEATURES ON VENUS: Nikolaeva O.V.



basin diameters (solid lines) are seen to be in parallel with those of model crater diameters (dotted lines) for all the planets except for Moon. The lunar discrepancy might be due to underestimation of the Moon's impact velocity value used [6] because of much closer lunar orbit in past. At least, according to [11] the best fit of the highland crater curves of Moon and Mercury gives a Mercury/Moon impact velocity ratio of 2.18 rather than 1.67 used in [6]. (Though other causes are possible too). With this correction in mind, the model diameter trends are in surprisingly good agreement with observationaldata for the largest both peak-ring and Orientale-type basins. **SECOND.** Diameters of the largest Orientale-type basins observed on the planets are seen to correspond to those of model craters with the melt volume/transient-cavity volume ratio less than about 0.2. Diameters of the larger impact features whose morphology is a planet-specific (see above) fall in the range of the ratios of about 0.2 to 0.5 for Moon (with taking the correction above into account), Mercury, and Mars. For Venus, the diameter values of the largest concentric coronae - a specifically venusian circular structures, fall in this range. Models of the corona formation require mantle upwelling as the first and necessary step followed by volcanism and gravitational relaxation [9,10]. The result of interplanetary comparison shown in the Figure opens a possibility that the mantle upwelling could be induced by impact event of such a scale that volume of impact melt was of some 0.2 from transient-cavity volume, or depth of melting about twice of transient cavity depth (from fig.2 in [6]). The mantle upwelling as a respond on transient cavity collapse could operate under cover of hot, slowly cooling impact melt. The impact-induced corona formation is favoured, perhaps, by thinned crust (plains) and thermally active areas (linear zones).

REF: [1]Schaber G.G.et al.(1992)*JGR*,97,13257. [2]Nikolaeva O.V. et al.(1986)*Geokhimia*,5,79.[3]Hamilton .B. 1992)*LPI Contr* No 790,33. [4]Melosh H.J (1989)*Impact cratering*,Oxford,245pp. [5]O'Keefe J.D.and Ahrens T.J.(1992)*LPI ontr*.No790,25.[6]Cintala M.J.and Grieve R.A.F.(1991)*LPSC XXII*,215. [7]Grieve R.A.F.and Cintala M.J.(1992)*LPSC XXIII*, 451. [8]Stofan E.R.et al.(1992)*JGR* 97,13347.[9]Squyres S.W.et al.(1992)*JGR*,97,13611. [10]Janes D.M.et al.(1992)*JGR* 97, 16055. [11]Pike R.J.and Spudis P.D.(1987)*Earth, Moon,and Planets* 39,129. [12]Pike R.J.(1988)In: *Mercury* (F.Vilas et al.,eds.)336,Univ.Arizona,Tucson. [13]Schulz R.A.and Frey H.V.(1990)*JGR* 95,14175. [14]Alexopoulus J.S.and McKinnon W.Q.B.(1992)*JGR*(in press). [15]Wilhelms D.E.(1978)In:*The Geologic History of the Moon*,US Gov.Print. Office,Washington, 302 pp. [16]Wilhelms D.E.and Squyres S.W.(1984)*Nature* 309,139.[17]McGill G.E.and Dimitrou A.M.(1990)*JGR*,95, 12595. [18]Strom R.G.and Neukum G.(1988)In:*Mercury* (F.Vilas et. al.,eds.)336,Univ.Arizona,Tucson.