CRUSTAL DICHOTOMY: UNIVERSAL FOR TERRESTRIAL PLANETS?

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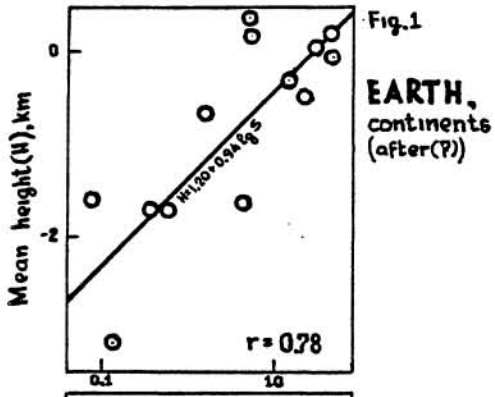
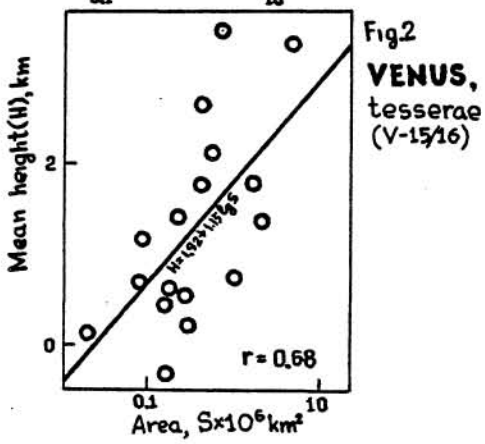
APPROACH AND PROBLEM. Let's look at planetary crusts so as to disregard details and quantitative differences but to emphasize similarities.

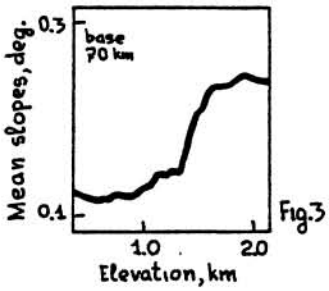
There are two global topography provinces - lowlands and highlands - on the Moon, Mercury, Mars, and Earth. The planetary lowlands are related to be mostly volcanic (basaltic) plains everywhere, whether they are lunar maria or the terrestrial ocean floor. The planetary highlands look similar on the Moon, Mercury, and Mars but dissimilar to the Earth continents. Note, however, that all the highlands, whether they are densely cratered terrains on the smaller planets or the variegated terrain on Earth continents, are related to be mostly non-volcanic, in contrast to the planetary lowlands. Most of highland material on the Moon, Earth, probably Mercury, and possibly Mars was found to be essentially feldspathic, whether it is lunar ANT-breccias rich in Ca-plagioclase or Earth continental basement igneous/metamorphic rocks rich in alkaline feldspars (1,2). The essentially feldspathic material composing the highland non-volcanic terrains will be termed TERRA crust, as distinct from essentially BASALTIC crust composing the lowland volcanic terrains.

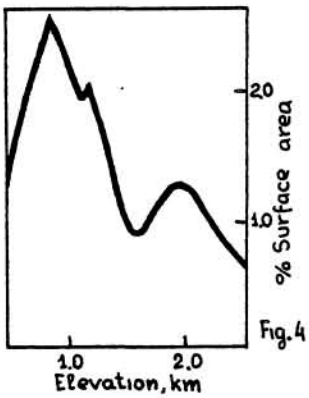
The principle of crustal dichotomy deduced by A.A.Yaroshevsky and C.P.Florensky in 1981 says (1, p.231): "Light, essentially feldspathic crust is predominant in the planetary highlands, and heavy, essentially basaltic one - in the lowlands with the basaltic volcanism being superposed on thick terra crust; it appears to be a fundamental trait of the crust structure and history for all terrestrial planets." For all? - But what about Venus?

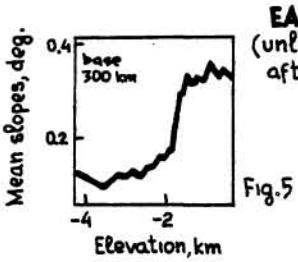
TERRA CRUST ON VENUS? The basaltic crust in the Venus lowlands is evidenced by both morphological and chemical data (3), the presence of terra crust needs to be testified. The first hint was the high K, U and Th contents measured at Venera 8 landing site (4), the data seem to be indicative of nonbasaltic (4), possibly syenitic material (5). Later shoshonite-like major elements composition measured at Venera 13 landing site (6) hinted at terra crust contamination as believed for terrestrial shoshonites. Alas! The geology of these sites is still unknown. Venera 15/16 survey evidenced unusual terrain named tessera which have no direct planetary analogue, but it is highland non-volcanic terrain (3) and, in this respect, resembles planets terra crust outcrops. Here we show additional similarities. The tesserae are found to form a correlation between their area and mean height (FIG.1), just as the Earth continents do it (FIG.2). Also, the tessera highlands are bordered by scarps which are marked by a jump in the mean slopes/elevation profile on small bases (FIG.3) and by minimum in the regional hypsometric curve (FIG.4), as well as the Earth continental slopes are marked, though on global scale (FIGS.5 and 6).

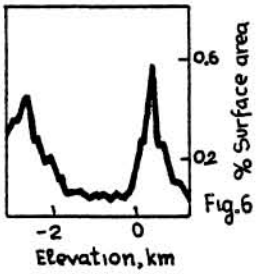












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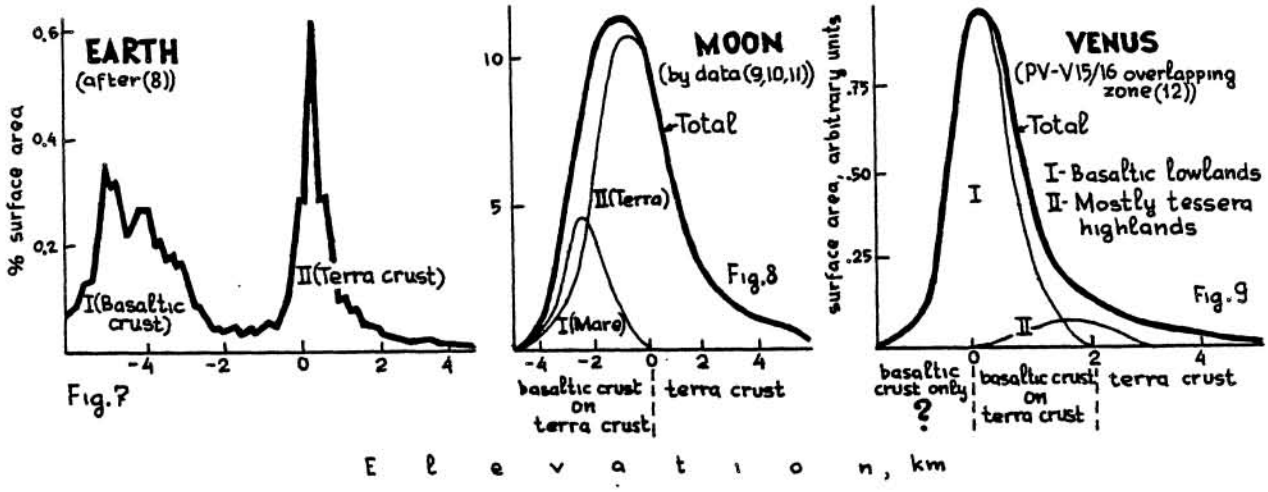
A total hypsometric curve of Venus is essentially unimodal. Comparing with bimodal hypsogram on Earth (FIG.7) it looks contradictory crustal dichotomy. However, on the Moon the crustal dichotomy is so obvious as on Earth, but the hypsogram is essentially unimodal(FIG.8) as on Venus (FIG.9). The Earth-Moon hypsogram difference corresponds to their well-known lowlands crust structure difference: only basaltic crust is in the Earth oceans while basaltic crust and terra crust beneath are in the Moon maria. So, unimodal hypsorgam for Venus can just reproduce the lunar case: the presence of terra crust under the observed basaltic crust,as seen from overlapping of the basaltic (I) and terra (II) elevation gaussians in FIGS.8 and 9.



Alas! The composition of tessera material is still unknown. But all above reasons combined suggest the tessera highlands be the outcrops of terra crust and rolling plains be the terra crust buried under basalts. To date it is rather conservative to say that Venus is not, at least, in conflict with the principle of crustal dichotomy. So, the principle is standing as an empirical generalization.

CRUSTS HISTORY AND ORIGIN. Let's search for similarities in the planets crust history, going not from the beginning, as usually (e.g.(13)), but from the end which is the present state (approach of (1)).The observed terra crust material on Earth is recycled mostly by crustal processes with volatiles, and the terra crust material on the Moon is recycled too though mostly by impact process in dry environement (11). On this basis, the lunar terra crust turns out to be no more primary than terrestrial one, both being recycling products and, in this sense, secondary.

The primary crust idea (13) is based on the assumption that first some initial crust had been formed by igneous (primary) process and then it was involved in other (secondary) processes. There is another assumption that all the planet recycling processes began simultaneously early (14,1). The crust recycling results in rejuvenated ages of the terra crust rocks (1,13). However, the crust emplacement time is certainly no later than 3.8 BY ago for the Moon (11). It is probably the case for Mercury and Mars too (1). For Earth there is increasing evidence from the oldest rocks studies that before 3.8 BY ago the terra crust had existed and involved normal erosion/sedimentation processes (e.g.15). Also, this time is known to be the era of heavy bombardement. Hence, in the crust emplacement time exogenic processes including impact played along with others such as igneous and metamorphic. Which of them will be chosen primary, it is model-dependent.

Endogenic mantle melting is evident to be primary for basaltic crust formation. It is traditionally applied for terra crust origin too. But is that so? As an example, the early differentiation could be achieved not only through endogenic, but through exogenic e.g. impact processes, not only by melting/cristallization, but by vaporation/condensation (e.g.16), and not only from mantle source, but from impactors one as well. Thus, for terra crust formation even looking apparent statement "endogenic mantle melting", in fact, contains the hypothesis in each word. To date the planets terra crust origin appears to be fundamentally unclear.

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