DOUBLET CRATERS ON VENUS C. M. Cook, H. J. Melosh, and W. F. Bottke, Jr., Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

Radar images of Earth-approaching asteroids (e.g. 4769 Castalia and 4179 Toutatis) suggest that some of these bodies may be contact binaries [1]. Although no well-separated Earth-approaching binary asteroids have yet been found, the existence of double craters on Earth suggests they must exist (at least for short times) [2]. Of the large impact craters on Earth, 15% (3-5 craters out of 28) are double, having been formed by the simultaneous impact of two well-separated projectiles [3]. If double asteroids have impacted the Earth, it seems likely they have also impacted other planets, such as Venus. Venus is a good planet to survey for double craters because a resurfacing event occurring 500 Myr ago eliminated all older craters and erosion of its surface is almost nonexistent. Moreover, the crater population on Venus is significantly larger (935) than Earth's (140), increasing the likelihood that double craters will be found there in greater numbers. At the same time, the number of craters on Venus is not so great that there is a high probability of chance associations.

We examined the Magellan images of craters in the data base of G. Schaber as well as the craters indexed as multiple. Since there is a high probability of chance associations at great separation distances, the search was limited to all craters separated by 150 km or less. The search for multiple craters was limited to craters having diameters greater than 10 km because, at smaller diameters, nearly all multiple craters are caused by atmospheric breakup. Similarities and/or differences in overlapping ejecta blankets, angles of entrance, and the degrees of brightness were used to classify neighboring craters as (a) unlikely, (b) possible, or (c) probable doublets. The results of our search were compared to the predictions of a model in which craters are randomly distributed over the surface of Venus.

Our search resulted in the discovery of two nearly indisputable doublets among the adjacent craters and three among the multiple craters. The total number of craters separated by less than 150 km was 58, of which 28 are possible doublets. Of 24 multiple craters greater than 10 km diameter, 13 are possible doublets. The number of craters that should fall within 150 km by chance alone is about 63 ± 8. These findings are reiterated in Figs. 1 and 2. Fig. 1 illustrates that the number of craters occurring randomly increases as the separation distance increases. All craters and possible doublets follow the same general trend, although there are no craters or possible doublets for relatively small separation distances. Fig. 2 illustrates that among multiple craters, as the separation distance increases, the number of possible doublets increases until the separation distances are so great that there are no possible doublets or multiple craters at all. If it is assumed that all our possible doublets were paired, then the proportion of double craters on Venus is 4.4%. However, the number of observed neighbors (58) is indistinguishable from the number that would occur by chance. Therefore there are probably fewer than 10 doublets which, along with the multiple craters, gives us an abundance of 2.5% or less.

Why does Venus have a smaller proportion of double craters than Earth? Even if all possible doublets on Venus were paired, the proportion would still be lower than that derived from the terrestrial cratering record. Since the number of paired craters on Earth is small (3), it is possible that we have been mislead by the statistics of small numbers, and that the abundance of paired projectiles may be smaller than the current estimate. Another possibility is that the dense
atmosphere of Venus screens out the smaller members of true doublets and thus gives an apparent paucity of double craters on Venus. In any case, a few unquestionable paired projectiles do exist among the population of Earth and Venus-crossing asteroids.


**Doublet Craters on Venus**

![Graph showing correlation between crater separation distances and the number of craters for all craters (solid circles) and possible doublets (open circles). The curve represents the number of craters that would occur by chance for given separation distances.](image1)

**Multiple Craters on Venus**

![Graph showing correlation between crater separation distances and the number of craters for all multiple craters (solid triangles) and possible doublets (open triangles).](image2)