PROVENANCE OF THE TERRESTRIAL PLANETS; G. W. Wetherill, DTM, Carnegie Institution of Washington, Washington, D.C. 20015

A fundamental problem in geochemistry and cosmochemistry is the location and relative contribution of the source regions in the preplanetary disc from which the present planets are presumed to have formed. This problem has been addressed by use of a more general model for the later stages of growth that simultaneously includes both the terrestrial planet region and the asteroid belt (1). Our Solar System should be considered but one of a number of possible planetary systems of this class. This model succeeds in predicting many of the attributes of the observed Solar System, such as the spontaneous clearing of the asteroid belt, the relative velocities of the surviving asteroids, and the characteristics of the final large bodies in the terrestrial planet region. It is now found that this same model predicts that all of the terrestrial planets receive significant contributions from ~ 10^{26}g "planetary embryos" (2) extending from about 0.5 to 2.5 AU. Nevertheless, there is a correlation between the final heliocentric distance and the average provenance of the planets. The weighted average provenances of "Mercury" and "Venus" are usually between 0.9 and 1.2 AU, whereas that of "Earth" is somewhat larger (~ 1.3 AU), and that of "Mars" usually has an average provenance between 1.5 and 2.0 AU.

59 new simulations of the "nominal model" (1) were used to obtain these results. In my previous work, comparison of 115 nominal simulations with 226 variants of the model show that such differences have little effect on the final results. From these 59 simulations, 13 cases were selected that met assumed criteria for resemblance to our Solar System. The relationship between the final semimajor axes of these bodies and their weighted (by mass) provenance is shown in Fig. 1a. The corresponding relationships with their masses are shown in Fig. 1b. The provenance of "Earth" for a typical simulation is shown in Fig. 2a and that for Mars in Fig. 2b.

In the final asteroid belt, residual test bodies with initial semimajor axes > 2 AU tend to cluster in the outer asteroid belt (2.75 to 3.5 AU), whereas the inner asteroid belt contains a major contribution from bodies having initial semimajor axes between 1 and 2 AU (Fig. 3). The latter may be expected to be more chemically similar to the terrestrial planets than objects now observed in the outer asteroid belt. One may speculate that this could be related to the ~ 1 AU wide "stratigraphy" observed in the asteroid belt (3).

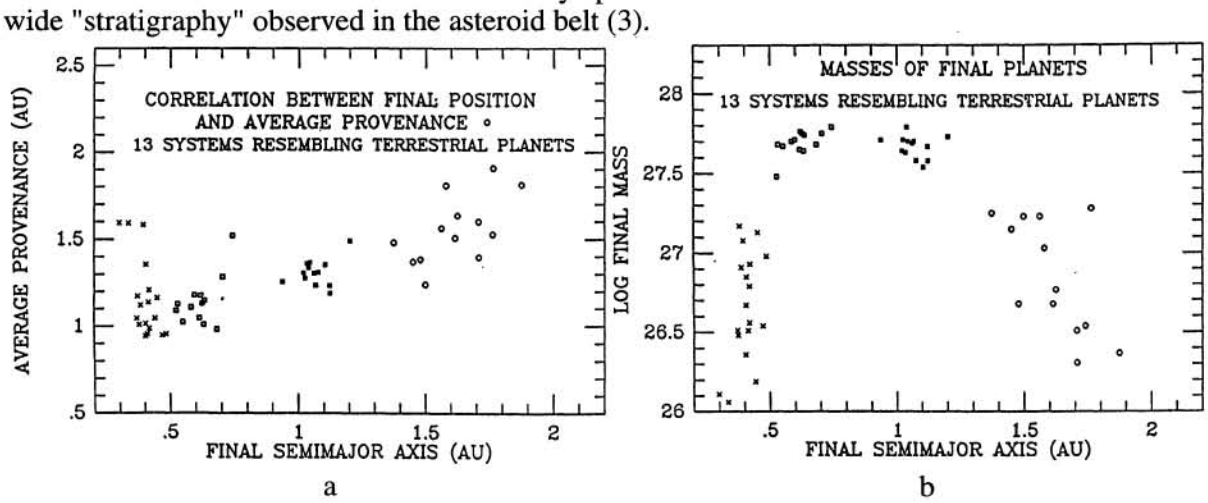

Fig. 1 a. Relationship between average provenance and final semimajor axis. Symbols: "Mercury" (x), Venus (open squares), Earth (solid squares), Mars (open circles).

b. Relationship between final masses and final semimajor axes. Symbols same as in (a).

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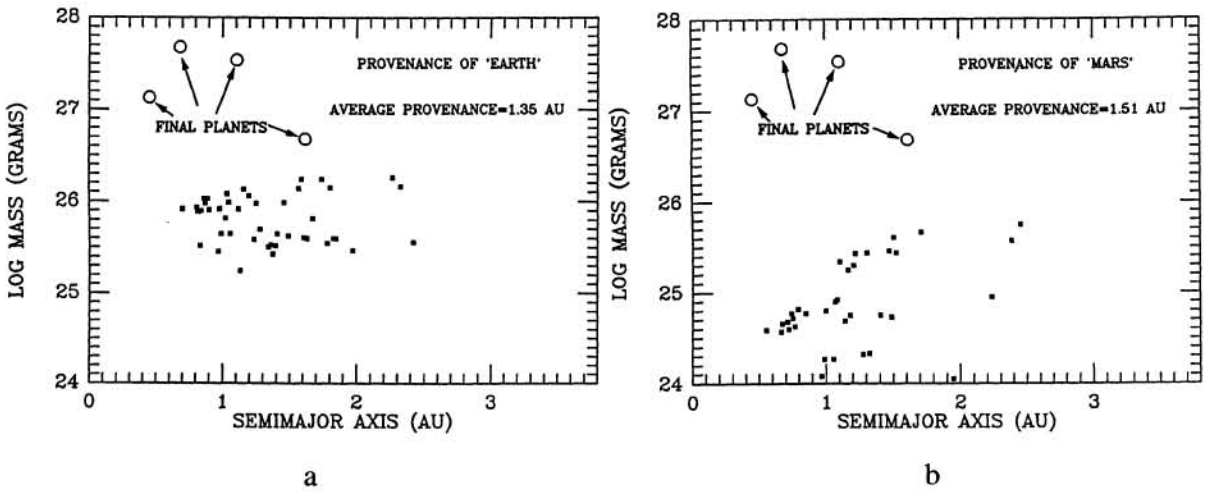

Fig. 2a. Provenance of "Earth" for a typical simulation.
Fig. 2b. Provenance of "Mars" for a typical simulation.

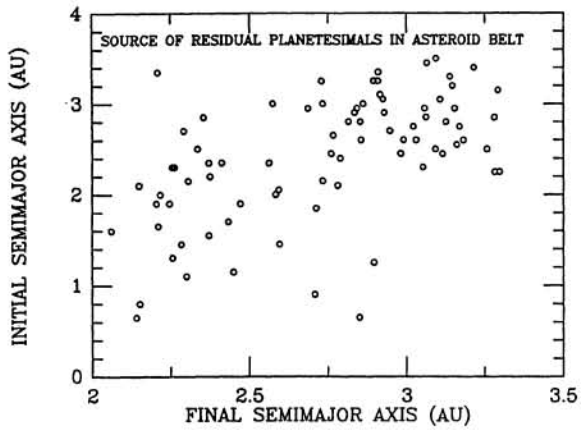

Fig. 3. Final distribution of test bodies in the asteroid belt.

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