METALLIC ASTEROIDS: REMNANTS OF PRIMORDIAL PLANETESIMALES OR CORE FRAGMENTS OF A DIFFERENTIATED PLANETARY BODY. E. N. Slyuta, Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, 119991, Kosygin St. 19, Moscow, Russia. slyuta@mail.ru.

Introduction: Before a detailed study of the chemical composition and abundances of trace elements, the hypothesis that iron meteorites are products of fractional crystallization of the single molten core of a large differentiated parent body [1] was not called into question. For the first time, the assumption that the various chemical systems could be a result of the evolution not of one differentiated planetary body, but multiple asteroidal sized bodies, some of which were subjected to melting while the others were not, was suggested by [2]. Contradictions were growing.

Chemical arguments: In terms of the Ni, Ga, Ge, and Ir content, iron meteorites fall into 16 chemical groups with an alphanumeric designation IA–IVB [3]. The chemical groups of iron meteorites are not elements of a continuous series, but unrelated (discrete) chemical and petrological systems [3]. Each of the chemical groups is characterized by its own cooling rate [3,4]. The existence of a large number of meteorites with an abnormal chemical composition, which are outside the chemical classification, is supposed to indicate the existence of other chemical groups, the number of which can be more than 50 and which can simply be underrepresented on the Earth [5]. Other evidence is the diverse microstructural features and different abundances of Ni, C, P, and other elements, including rare elements (ref. in [6]), which would be impossible to explain by the molten iron core of one or even several parent bodies.

Differentiation arguments: The diameter of the parent bodies of IIIAB iron meteorites, the most widespread group, was also estimated from the cooling rate data not to exceed 40–50 km and, considering the insulating properties of the loose regolith layer, 30 km [7]. However, the maximum diameter of the majority of parent bodies of iron meteorites appeared not to exceed 20 km, and the maximum possible diameter of differentiated parent bodies, 200 km [8,9]. The formation of a core in such a small body is a virtually impossible event because, in addition to the metal component, it requires the melting of associated silicates [10]. The analysis of the size, quantity, and composition of the family of the largest metallic asteroid 16 Psyche showed that this asteroid never belonged to a hypothetical family of a disrupted differentiated parent body and was more likely to be a preserved primordial planetesimal [11].

Physicomechanical and gravitational deformation arguments: The formation of a metal core in a differentiated asteroid body, as well as the possible formation and existence of a metallic planetary body in the past, can only be a result of gravitational plastic deformation [6,12,13]. Gravitational deformation is accompanied by the consolidation of the material, closing of pores, and development of characteristic structures and static twins, depending on the dominant deformation mechanism [6,12]. The relatively high porosity of iron meteorites (~5%) [6] is clearly contrary to the "nuclear" hypothesis of their origin because the melt temperature and the pressure in the core of the parent body must have destroyed the porosity.

The lack of plastic deformation in iron meteorites indicates that the iron meteorites investigated [6] had never been subjected to gravitational deformation. Consequently, they had never been part of any metallic planetary body or part of a massive iron core that had formed in the parent body as a result of the differentiation into the iron core and rocky mantle. Thus, the physical and mechanical data [6] are also a strong argument against the hypothesis of the origin of iron meteorites and metallic asteroids from the iron core of a differentiated parent body.

Summary: Perhaps, parent bodies of these meteorites could have been aggregates of iron and silicate particles, which were formed as a result of metal–silicate condensation and fractionation already in the protoplanetary nebula [14], or even in the protosolar nebula [15]. For example, group IIE meteorites are also samples of small metal clusters that appear to have formed in the process of segregation of metal particles in the silicate matrix, not in the iron core [16]. In view of these contradictions, it was suggested that the parent bodies of iron meteorites are remnants of planetesimals formed in the area of terrestrial planetary bodies [6]. As a result of the subsequent collisional evolution and orbital perturbations, these bodies were partially scattered in the main belt region, where they are, in fact, strangers [17].

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