Accretion of terrestrial planets from oligarchs in a turbulent disk

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Introduction

We have investigated the final accretion stage of terrestrial planets from Mars-mass protoplanets that formed through oligarchic growth in a disk comparable to the minimum mass solar nebula (MMSN), through N-body simulation including random torques exerted by disk turbulence due to Magneto-Rotational-Instability. For the torques, we used the semi-analytical formula developed by Laughlin *et al*. (2004). The damping of orbital eccentricities (in all runs) and type-I migration (in some runs) due to the tidal interactions with disk gas are also included.

Without any effect of disk gas, Earth-mass planets are formed in terrestrial planet regions in a disk comparable to MMSN but with too large orbital eccentricities to be consistent with the present eccentricities of Earth and Venus in our Solar system. With the eccentricity damping caused by the tidal interaction with a remnant gas disk, Earth-mass planets with eccentricities consistent with those of Earth and Venus are formed in a limited range of disk gas surface density ($\sim 10^{-4}$ times MMSN). However, in this case, on average, too many planets remain in terrestrial planet regions, because the damping leads to isolation between the planets.

Results

We have carried out a series of N-body simulations including the random torques with different disk surface density and strength of turbulence.

We found that the orbital eccentricities pumped up by the turbulent torques and associated random walks in semimajor axes tend to delay isolation of planets, resulting in more coagulation of planets. The eccentricities are still damped after planets become isolated. As a result, the number of final planets decreases with increase in strength of the turbulence, while Earth-mass planets with small eccentricities are still formed. In the case of relatively strong turbulence, the number of final planets are 4-5 at 0.5-2AU, which is more consistent with Solar system, for relatively wide range of disk surface density ($\sim 10^{-4}$-10^{-2} times MMSN).

References

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Distribution of mercury and methylmercury in deep-sea surficial sediments of the Mediterranean Sea

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This communication presents the results of the investigation of the distribution, speciation and methylation of mercury in sediments of the Mediterranean Sea. The samples were collected at different locations in the Western and Eastern Basin of the Mediterranean during the cruise of the Italian research vessel Urania in summer 2003 as part of MERCYMS project. Total mercury (Hg_T) and methylmercury (MeHg) in pore water and sediments were determined down the sediment profile and coupled with other biogeochemical parameters, including organic carbon content. The diffusive fluxes of Hg_T and MeHg were calculated to estimate the importance of sediment-water exchange as potential sources of Hg_T and MeHg. In addition, the radioactive isotope ^{197}Hg was used to determine the methylation potentials. The concentrations of Hg_T in sediments ranged between 0.06 and 2.23 nmol g^{-1} and vary irregularly with depth, which may reflect changes or redistribution during diagenetic processes. No correlation between Hg_T and organic carbon content was found, but a relatively high proportion of MeHg to Hg_T of approx. 2.0% was observed. The integrated flux of Hg_T was estimated to be 109 kmol year^{-1} and agrees well with the mass balance calculation preformed for total underwater emissions of Hg_T in the Mediterranean Sea of 80 kmol year^{-1} by Rajar *et al*., 2007. The emissions of MeHg were estimated to be 14 kmol year^{-1} and indicate that deep-sea sediments could be an important source of the MeHg content in marine biota. It was found that accumulation of MeHg in surficial sediments of the Mediterranean is not directly related to the potential rates of bacterial Hg methylation. Much of the MeHg produced in the sediments is lost to the overlying water. Our results suggest that MeHg production depends on partitioning of Hg(II) influenced by the organic carbon content in the sediment. Reduction of organic carbon in sediment could increase pore water Hg(II) and enhance bacterial production of MeHg.

These are the main results of a first study performed on Hg speciation, partitioning and methylation potential in deep sea sediments, giving a new insight into deep sea Hg biogeochemical cycling.