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Thermal history, differentiation and accretion of Rhea

Leszek Czechowski
Institute of Geophysics, Warsaw University, ul. Pasteura 7, 02-093 Warszawa, POLAND
email: lczecho@fuw.edu.pl tel: (48) (22) 55 46 850 Fax: (48) (22) 82 22 387

Abstract

Thermal history of Rhea during and after accretion is investigated. Our results confronted with Cassini observation indicate that Rhea accreted between 2 and 3 My after origin of CAI.

1. Introduction

Rhea is built of mixtures of rocks and ices. The rocky component is believed to be of chondritic composition. Analysis of the Doppler data acquired by the Cassini spacecraft yields the mass of Rhea and the quadrupole moments of its gravity field with unprecedented accuracy. Iess et al. [1] conclude: "the data exclude fully differentiated models […] The one model that fits the gravity data and is self-consistent […] is an "almost undifferentiated" Rhea, in which a very large uniform core is surrounded by a relatively thin ice shell containing no rock at all".

We investigate the conditions necessary for the partial differentiation of Rhea.

2. Our model and results

We consider the following heat sources: decay of short and long lived radioactive isotopes (i.e. Al^{26}, Fe^{60}, Mn^{53}, K^{40}, Th^{232}, U^{238}, U^{235}), and the heat of accretion. The model assumes that the accretion starts some time after formation of CAI. Time of starting t_{ac_beg} and duration of accretion t_{ac_dur} are the parameters of the model. The model includes the heat transfer by conduction and by convection. The viscosity of ices just before melting η_0 is the third parameter of the model.

We have found that partial differentiation is possible only for the narrow range of parameters. Figure 1 presents radius of the molten part in Rhea versus time for t_{ac_beg} = 0.8 My, $\eta_0 = 10^{11}$ Pa s, and for the following values of t_{ac_dur} : 0.6, 0.8, 1, 1.2, 1.4 My. For t_{ac_dur} = 0.6 My one could observe almost total melting of the satellite. For t_{ac_dur} = 1.4 My only small part of the body is melted. This fact indicates that Rhea accreted between 2 and 3 My after origin of CAI.

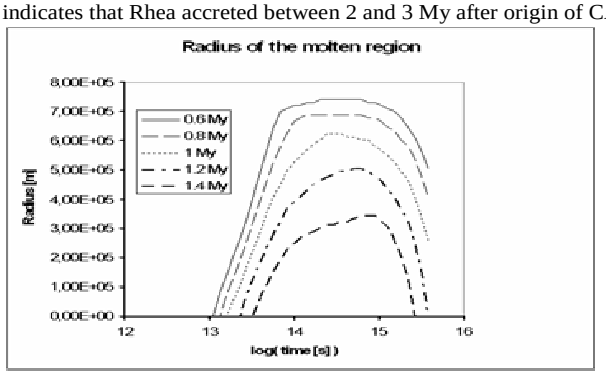

Fig. 1 Radius of molten region versus time. The t=0 corresponds to the forming CAI. Accretion starts at t_{ac_beg} = 0.8 My. Different durations of accretion are considered: 0.6, 0.8, 1, 1.2, 1.4 My.

Acknowledgments

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References

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[2] Czechowski, L. 2009, 'Parameterized model of convection driven by tidal and radiogenic heating'. *Adv. Space Res.* 38, 788-793.