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Effect of Initial Chondritic Composition on the Differentiation of the Planetesimals in the Early Solar System

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***Abstract:-*The detailed numerical simulations for the differentiation of the planetesimals have been developed using ^{26}Al and ^{60}Fe as the heat sources. The two different scenarios have been used for the planetary differentiation. These scenarios deal with the origin of the basaltic achondrites either by the partial silicate melting, or from the residual melt left subsequent to the crystallization in a cooling magma ocean. In order to develop the numerical simulation, we have solved the radial heat conduction partial differential equation numerically using the finite difference method with the classical explicit approximation. In the present paper, differentiation of the planetesimals has been performed with the consideration of different bulk initial chondritic compositions. The initial composition of the planetesimals same as that of L, LL, CI and CV chondritic compositions have been considered.**

***Key words:* Accretion, Chondritic composition, Differentiation, Kaidun meteorite**

I. INTRODUCTION

Several thermal models have been developed in order to understand the thermal evolution and the differentiation of the planetesimals (e.g.,Sahijpal 1997, 2006; Sahijpal et al. 1995, 2007; Ghosh and McSween 1998; Merk et al. 2002; Bizzarro et al. 2005; Hevey and Sanders 2006, Sahijpal et al. 2007, Gupta and Sahijpal 2007, 2008, 2009, 2010; Neumann et al. 2012). Sahijpal (1997) developed thermal models for the radiogenic heating of asteroids with the temperature dependent thermal diffusivity for an undifferentiated body. Ghosh and McSween (1998) proposed the possible cases of the differentiation of the planetesimals on the basis of uncertainty in the timing and duration of the core formation with respect to the onset of silicate melting and crust formation and developed a model with instantaneous accretion of the planetesimal. Bizzarro et al. (2005) developed the thermal models using ^{26}Al and ^{60}Fe as heat sources. Hevey and Sanders (2006) modeled the melting of planetesimals heated by ^{26}Al using finite difference method and incorporated thermal convection. Sahijpal (2006) and Sahijpal et al. (2007) have numerically simulated the planetary differentiation of linearly accreting planetesimals of radii in the range of 20-270 kilometer, with the gradual growth of an iron core due to the flow of $(Fe\text{-}Ni)_{metal}$-FeS melt towards the centre of the planetesimals. This comprehensive work deals with the two different possible cases of the planetary differentiation (Ghosh and McSween 1998), one in which initiation of the segregation of the core occur at 1213 K-1233 K, followed by silicate melting and the extrusion of the basaltic melt at higher temperature and second in which initiation of the core formation occur at 0.4 fraction of silicate melting without considering the crust-mantle differentiation. Gupta and Sahijpal (2010) numerically simulated two distinct planetary differentiation scenarios i) the partial melt origin of the basalts, and ii) the origin of the basalts from the residual melts of equilibrium crystallization in a cooling magma ocean. Gupta and Sahijpal (2010) made an attempt to understand the thermal evolution and differentiation in Vesta and other differentiated asteroids within these two distinct scenarios. This work was mostly focused on the initial H chondritic composition of the planetesimals as the melting of these chondrites can be well understood both theoretically and experimentally (Taylor et al. 1993; McCoy et al. 2006). Neumann et al. (2012) have shown that the differentiation in planetesimals depends strongly on the formation time, accretion duration, and accretion law cannot be assumed as instantaneous. Iron melt segregation starts almost simultaneously with silicate segregation and lasts between 0.4 and 10 Myr. Recently the Bryson et. al. (2016) calculated the initial heating due to the decay of ^{26}Al over the first ~5 Myr and used this parameter to estimate the depths and timing of internal melting within both types of body and then modeled the subsequent cooling of these bodies over tens of millions of years. In the present work, in order to understand the influence of the initial bulk compositions (Taylor et al. 1993; Righter and Drake 1997) on the planetary differentiation, we have considered four different sets of initial bulk composition of L, LL, CI and CV chondrites and two binary combinations of 70% of LL and 30% of CI, and 70% of L and 30% of CV chondritic compositions with the linear accretion of the planetesimals. Non linear accretion of the planetesimals has also been considered for some set of simulations with initial H chondritic composition.

II. METHODOLOGY

Differentiation of the planetesimals has been performed with different initial bulk chonritic compositions. We have considered the compositions same as that of L, LL, CI and CV chondrites (table 1; Jarosewich 1990). For the present work, we have used the similar numerical technique and parameters as used earlier (Sahijpal et al. 2007, Gupta and Sahijpal 2010). We have solved the heat conduction equation for spherical symmetry using classical explicit method. We have used ^{26}Al ($t_{1/2}$ = 0.7 million year) and ^{60}Fe ($t_{1/2}$ = 1.5 million year) as the heat sources with the decay energies of ~3 MeV in order to determine the thermal profiles as a function of time. The effect of sintering has been incorporated in the temperature range 670-700 K (Hevey and Sanders 2006). The solidus and liquidus temperature for Fe-FeS melt and silicate has been considered in the range 1213-1233 K and 1450-1850 K, respectively. Differentiation of the planetesimals has been considered in the temperature range 1450-1850 K. The partial melt scenario and the residual melt scenario for the differentiation of the planetesimals has been considered (Gupta and Sahijpal 2010). We have considered the gradual growth of the Fe-FeS core in the center of the planetesimals at 40% melting of the bulk silicates. The Al silicates melt moves upward at 20% melting of the silicates and form crust in case of partial melt scenario of the differentiation of plantesimals. The effect of thermal convection has been incorporated. We have considered the consolidated bodies of radii 20, 50, 100 and 270 km. Thermal diffusivities, specific heats and the densities of the planetesimals with different initial bulk composition of the planetesimals have been considered (table 2) (Yomogida and Matsui 1983; 1984).

III. RESULTS

Detailed Results for the differentiation of the planetesimals has been mentioned with bulk initial composition of the planetseimals same as that of L, LL, CI and CV chondrites (tables 3-8).

IV. DISCUSSION

4.1 Influence of the initial bulk composition on the differentiation

In order to understand the influence of the initial bulk composition on the differentiation of the planetesimals, we have run partial melt scenario and residual melt scenario for the differentiation of the planetesimals with set of different initial bulk compositions of the planetesimals. The differences in the bulk compositions significantly control the thermal evolution of the planetesimals. We have observed that the extrusion of the basaltic melt and the initiation of the segregation of the core occur fastest in the numerical simulations with initial CV chondrite composition, and slowest in the numerical simulations with initial CI chondrite composition (tables 5 and 6). In the case of PM model, for simulations PM100-1-1-2(-6)-CV, PM100-1-1-2(-6)-L, PM100-1-1-2(-6)-LL and PM100-1-1-2(-6)-CI, extrusion of the basaltic melt occur at time 1.30 Myr, 1.41 Myr, 1.42 Myr and 1.55 Mr, respectively (tables 3-6). For simulations PM20-2-0.001-2(-6)-CV initiation of the segregation of the core occur at 3.65 Myr, but for simulations, PM20-2-0.001-2(-6)-L, PM20-2-0.001-2(-6)-LL and PM20-2-0.001-2(-6)-CI temperature does not reach even so high to initiate the segregation of the core.

For simulations PM50-1-1-2(-6)-L, PM50-1-1-2(-6)-LL and PM50-1-1-2(-6)-CI initiation of the segregation of the core occur 0.25 Myr, 0.3 Myr and 0.62 Myr later as compared to the simulation PM50-1-1-2(-6)-CV and in the case of simulations PM100-2-0.1-2(-6)-L, PM100-2-0.1-2(-6)-LL and PM100-2-0.1-2(-6)-CI, initiation of the segregation of the core occur 0.77 Myr, 1.05 Myr and 2.72 Myr later as compared to the simulation PM100-2-0.1-2(-6)-CV (tables 3-6).

Similarly, in case of RM simulations, for simulations RM20-2-0.001-2(-6)-CV, RM20-2-0.001-2(-6)-L and RM20-2-0.001-2(-6)-LL initiation of the segregation of the core occur at 3.02 Myr, 3.62 Myr and 3.74 Myr, but in the case of RM20-2-0.001-2(-6)-CI, temperature does not reach even so high to initiate the segregation of the core. For simulations RM50-1-0.1-2(-6)-L, RM50-1-0.1-2(-6)-LL and RM50-1-0.1-2(-6)-CI, initiation of the segregation of the core occur 0.16 Myr, 0.17 Myr and 0.36 Myr later as compared to the simulation RM50-1-0.1-2(-6)-CV (tables 3-6). In the case of simulations RM100-2-1-2(-6)-L, RM100-2-1-2(-6)-LL and RM100-2-1-2(-6)-CI, initiation of the segregation of the core occur 0.67 Myr, 0.78 Myr and 2.25 Myr later as compared to the simulation RM100-2-1-2(-6)-CV and for simulations RM270-1-1-2(-6)-L, RM270-1-1-2(-6)-LL and RM270-1-1-2(-6)-CI, initiation of the segregation of the core occur 0.14 Myr, 0.15 Myr and 0.34 Myr later as compared to the simulation RM270-1-1-2(-6)-CV.

Further, the size of the core depends upon the mass abundance of the Fe that segregates to form the core. Although the growth of the core initiates rapidly in the case of numerical simulations with CV chondrite compositions, but in these cases sizes of the core are 20% of the sizes of the body (table 5). For example, for simulations PM270-1-1-2(-6)-CV and RM270-1-1-2(-6)-CV, growth of the core terminates at 54 km in 2.59 Myr and 2.20 Myr, respectively, from the formation of CAIs and for simulations PM270-2-1-2(-6)-CV and RM270-2-1-2(-6)-CV, the growth of the core terminates at 27 km in 4.70 Myr and 3.69 Myr from the formation of CAIs (table 5).

Table 1 Composition of different chondrites (Jarosewich 1990).

Chemical Composition (wt %)	L	LL	CV	CI
Fe_{metal}	7	2.44	0.16	9.49
Fe (FeS)	3.7	3.68	2.58	5.78
Fe (FeO)	11.3	13.53	20.87	3.6
S	2.1	2.11	2.07	3.4
Ni	1.2	1.07	1.41	-
Al	1.2	1.2	1.7	0.9

Table 2 Thermal diffusivities, specific heats and the densities of the planetesimals with different initial bulk composition of the planetesimals (Yomogida and Matsui 1983; 1984).

1	Thermal diffusivity of unsintered planetesimal (κ_i)	(in the range 250-670 K)
	CI chondrites	7.0×10^{-10} $m^2 s^{-1}$
	CV chondrites	7.0×10^{-10} $m^2 s^{-1}$
	L chondrites	5.4×10^{-10} $m^2 s^{-1}$
	LL chondrites	6.1×10^{-10} $m^2 s^{-1}$
2	Thermal diffusivity of sintered planetesimal (κ)	(in the range 700-1450 K)
	CI chondrites	$(7.0\text{-}4.9) \times 10^{-7}$ $m^2 s^{-1}$
	CV chondrites	$(7.0\text{-}4.9) \times 10^{-7}$ $m^2 s^{-1}$
	L chondrites	$(5.4\text{-}4.6) \times 10^{-7}$ $m^2 s^{-1}$
	LL chondrites	$(6.1\text{-}4.8) \times 10^{-7}$ $m^2 s^{-1}$
3	Density of the sintered planetesimal	
	CI chondrites	2,750 kg m^{-3}
	CV chondrites	2,750 kg m^{-3}
	L chondrites	3,600 kg m^{-3}
	LL chondrites	3,010 kg m^{-3}

Table 3 The growth of the $(Fe\text{-}Ni)_{metal}$-FeS core and the initiation of the extrusion of the basaltic melt for the differentiation of planetesimals with initial bulk L chondritic composition.

No.	Simulations[a]	Fe-FeS core[b]					Initiation of the extrusion of basaltic melt[c]
	Radius = 20 km	**0^+ km**	**2 km**	**4 km**	**6 km**	**8 km**	
1	PM20-1-0.001-2(-6) L	1.86	1.86	2.00	2.37	none	1.39
2	RM20-1-0.001-2(-6) L	1.49	1.50	1.50	1.53	none	-
3	PM20-2-0.001-2(-6) L	none	None	none	None	none	3.14
4	RM20-2-0.001-2(-6) L	3.62	3.67	3.88	None	none	-
5	PM20-1-0.1-2(-6) L	1.89	1.91	2.07	2.46	none	1.40
6	RM20-1-0.1-2(-6) L	1.50	1.52	1.55	1.60	none	-
7	PM20-2-0.1-2(-6) L	none	None	none	None	none	3.16
8	RM20-2-0.1-2(-6) L	3.69	3.74	4.06	None	none	-
	Radius=50 km	**0^+ km**	**5 km**	**10 km**	**15 km**	**20 km**	
9	PM50-1-0.001-2(-6) L	1.85	1.85	1.85	1.88	none	1.38
10	RM50-1-0.001-2(-6) L	1.49	1.49	1.49	1.49	none	-
11	PM50-2-0.001-2(-6) L	4.37	4.38	4.42	5.95	none	3.13
12	RM50-2-0.001-2(-6) L	3.60	3.61	3.61	3.73	none	-
13	PM50-1-0.1-2(-6) L	1.87	1.89	1.94	2.01	none	1.39
14	RM50-1-0.1-2(-6) L	1.50	1.53	1.57	1.60	none	-
15	PM50-2-0.1-2(-6) L	4.43	4.47	4.64	6.38	none	3.15
16	RM50-2-0.1-2(-6) L	3.63	3.67	3.76	3.99	none	-
17	PM50-1-1-2(-6) L	2.01	2.26	2.66	2.88	none	1.43
18	RM50-1-1-2(-6) L	1.56	1.70	1.97	2.19	none	-
19	PM50-2-1-2(-6) L	5.08	5.72	none	None	none	3.24
20	RM50-2-1-2(-6) L	3.89	4.26	4.78	5.41	none	-
	Radius=100 km	**0^+ km**	**10 km**	**20 km**	**30 km**	**40 km**	
21	PM100-1-0.1-2(-6) L	1.86	1.89	1.94	1.98	2.59	1.39
22	RM100-1-0.1-2(-6) L	1.49	1.53	1.57	1.60	1.72	-
23	PM100-2-0.1-2(-6) L	4.40	4.47	4.58	4.74	none	3.14
24	RM100-2-0.1-2(-6) L	3.63	3.67	3.77	3.85	none	-
25	PM100-1-1-2(-6) L	1.93	2.25	2.69	2.94	none	1.41
26	RM100-1-1-2(-6) L	1.52	1.72	1.98	2.28	2.63	-
27	PM100-2-1-2(-6) L	4.67	5.44	8.16	None	none	3.19
28	RM100-2-1-2(-6) L	3.75	4.23	4.85	5.52	none	-
	Radius=270 km	**0^+ km**	**27 km**	**54 km**	**81 km**	**108km**	
29	PM270-1-1-2(-6) L	1.88	2.28	2.78	3.26	none	1.40
30	RM270-1-1-2(-6) L	1.50	1.77	2.11	2.51	none	-
31	PM270-2-1-2(-6) L	4.48	5.60	8.96	None	none	3.16
32	RM270-2-1-2(-6) L	3.66	4.40	5.28	6.41	none	-

[a] The simulations are titled according the choice of the various parameters. These parameters are separated by hyphens. In order these parameters are;

i) the simulations types PM and RM and the radius of the planetesimals subsequent to complete sintering

ii) the onset time, T_{Onset}(Myr, Million year), to initiate the accretion of a planetesimal from the time of the formation of the CAIs with the canonical value of $(^{26}Al/^{27}Al)_{initial} = 5\times10^{-5}$

iii) the accretion duration, $T_{Duration}$(Myr), of the planetesimal.

iv) an initial value 5×10^{-7} [represented as 5(-7)], 1×10^{-6} [represented as 1(-6)] and 2×10^{-6} [represented as 2(-6)] for the $^{60}Fe/^{56}Fe$ ratio at the time of formation of the CAIs with the canonical value of $(^{26}Al/^{27}Al)_{initial}$.
v) LL, L, CI and CV in the 5th position indicate the initial chemical composition same as that of LL, L, CI and CV chondrites
[b] Time (Myr) taken for the Fe-FeS core to grow to a specific size. Five different arbitrary choices of the core sizes have been considered. With respect to the final radius of the completely sintered planetesimal, these core sizes are expressed in percentage. In order these are 0^+% (initiation of core formation), 10%, 20%, 30% and 40%. All time spans mentioned in the table are measured with respect to the formation of the CAIs with the canonical value of $(^{26}Al/^{27}Al)_{initial} = 5\times10^{-5}$.
[c] Time obtained for the initiation of the extrusion of the basaltic melt for PM simulations with respect to the formation of the CAIs with the canonical value of $(^{26}Al/^{27}Al)_{initial}$.

Table 4 The growth of the $(Fe\text{-}Ni)_{metal}$-FeS core and the initiation of the extrusion of the basaltic melt for the differentiation of planetesimals with initial bulk LL chondritic composition.

No.	Simulations[a]	Fe-FeS core[b]				Initiation of the extrusion of basaltic melt[c]
	Radius = 20 km	**0^+ km**	**2 km**	**4 km**	**6 km**	
1	PM20-1-0.001-2(-6) LL	1.91	1.92	2.32	none	1.40
2	RM20-1-0.001-2(-6) LL	1.50	1.50	1.51	1.61	-
3	PM20-2-0.001-2(-6) LL	None	none	None	none	3.21
4	RM20-2-0.001-2(-6) LL	3.74	3.82	4.32	none	-
5	PM20-1-0.1-2(-6) LL	1.94	1.97	2.40	none	1.41
6	RM20-1-0.1-2(-6) LL	1.52	1.53	1.58	1.66	-
7	PM20-2-0.1-2(-6) LL	None	none	None	none	3.24
8	RM20-2-0.1-2(-6) LL	3.81	3.92	None	none	-
	Radius=50 km	**0^+ km**	**5 km**	**10 km**	**15 km**	
9	PM50-1-0.001-2(-6) LL	1.91	1.91	1.91	2.36	1.40
10	RM50-1-0.001-2(-6) LL	1.50	1.50	1.50	1.54	-
11	PM50-2-0.001-2(-6) LL	4.65	4.65	5.17	none	3.21
12	RM50-2-0.001-2(-6) LL	3.72	3.72	3.73	4.24	-
13	PM50-1-0.1-2(-6) LL	1.92	1.96	2.01	2.45	1.40
14	RM50-1-0.1-2(-6) LL	1.51	1.54	1.59	1.64	-
15	PM50-2-0.1-2(-6) LL	4.71	4.79	6.50	none	3.22
16	RM50-2-0.1-2(-6) LL	3.75	3.81	3.96	4.50	-
17	PM50-1-1-2(-6) LL	2.06	2.40	2.88	3.22	1.44
18	RM50-1-1-2(-6) LL	1.56	1.75	2.07	2.37	-
19	PM50-2-1-2(-6) LL	5.44	6.65	None	none	3.32
20	RM50-2-1-2(-6) LL	4.50	5.39	None	none	-
	Radius=100 km	**0^+ km**	**10 km**	**20 km**	**30 km**	
21	PM100-1-0.1-2(-6) LL	1.92	1.96	2.01	2.48	1.40
22	RM100-1-0.1-2(-6) LL	1.51	1.54	1.60	1.64	-
23	PM100-2-0.1-2(-6) LL	4.68	4.78	4.96	7.76	3.21
24	RM100-2-0.1-2(-6) LL	3.73	3.82	3.95	4.32	-
25	PM100-1-1-2(-6) LL	1.98	2.41	2.94	3.30	1.42
26	RM100-1-1-2(-6) LL	1.53	1.78	2.13	2.48	-
27	PM100-2-1-2(-6) LL	4.97	6.36	None	none	3.26
28	RM100-2-1-2(-6) LL	3.86	4.54	5.57	7.94	-
	Radius=270 km	**0^+ km**	**27 km**	**54 km**	**81 km**	
29	PM270-1-1-2(-6) LL	1.93	2.45	3.08	3.84	1.41
30	RM270-1-1-2(-6) LL	1.51	1.85	2.31	2.85	-
31	PM270-2-1-2(-6) LL	4.77	6.74	None	none	3.23
32	RM270-2-1-2(-6) LL	3.78	4.80	6.36	9.65	-

Table 5 The growth of the $(Fe\text{-}Ni)_{metal}$-FeS core and the initiation of the extrusion of the basaltic melt for the differentiation of planetesimals with initial bulk CV chondritic composition.

No.	Simulations[a]	Fe-FeS core[b]				Initiation of the extrusion of basaltic melt[c]
	Radius = 20 km	**0^+ km**	**2 km**	**4 km**	**6 km**	
1	PM20-1-0.001-2(-6)-CV	1.66	1.66	1.97	none	1.28
2	RM20-1-0.001-2(-6)-CV	1.35	1.35	1.35	none	-
3	PM20-2-0.001-2(-6)-CV	3.65	3.85	None	none	2.77
4	RM20-2-0.001-2(-6)-CV	3.02	3.03	3.17	none	-
5	PM20-1-0.1-2(-6)-CV	1.69	1.71	2.04	none	1.28
6	RM20-1-0.1-2(-6)-CV	1.35	1.38	1.42	none	-
7	PM20-2-0.1-2(-6)-CV	3.71	3.94	None	none	2.79
8	RM20-2-0.1-2(-6)-CV	3.05	3.08	3.24	none	-
	Radius=50 km	**0^+ km**	**5 km**	**10 km**	**15 km**	
9	PM50-1-0.001-2(-6)-CV	1.66	1.66	1.66	none	1.28

10	RM50-1-0.001-2(-6)-CV	1.34	1.34	1.34	none	-
11	PM50-2-0.001-2(-6)-CV	3.61	3.62	3.75	none	2.77
12	RM50-2-0.001-2(-6)-CV	3.01	3.02	3.03	none	-
13	PM50-1-0.1-2(-6)-CV	1.67	1.71	1.77	none	1.28
14	RM50-1-0.1-2(-6)-CV	1.34	1.39	1.43	none	-
15	PM50-2-0.1-2(-6)-CV	3.64	3.70	3.97	none	2.78
16	RM50-2-0.1-2(-6)-CV	3.03	3.09	3.18	none	-
17	PM50-1-1-2(-6)-CV	1.76	2.07	2.42	none	1.31
18	RM50-1-1-2(-6)-CV	1.39	1.61	1.94	none	-
19	PM50-2-1-2(-6)-CV	3.87	4.50	6.11	none	2.84
20	RM50-2-1-2(-6)-CV	3.14	3.39	4.04	none	-
	Radius=100 km	**0^+ km**	**10 km**	**20 km**	**30 km**	
21	PM100-1-0.1-2(-6)-CV	1.66	1.71	1.77	none	1.28
22	RM100-1-0.1-2(-6)-CV	1.34	1.39	1.44	none	-
23	PM100-2-0.1-2(-6)-CV	3.63	3.70	3.82	none	2.77
24	RM100-2-0.1-2(-6)-CV	3.02	3.09	3.18	none	-
25	PM100-1-1-2(-6)-CV	1.71	2.10	2.51	none	1.30
26	RM100-1-1-2(-6)-CV	1.36	1.63	2.01	none	-
27	PM100-2-1-2(-6)-CV	3.73	4.56	6.22	none	2.81
28	RM100-2-1-2(-6)-CV	3.08	3.52	4.21	none	-
	Radius=270 km	**0^+ km**	**27 km**	**54 km**	**81 km**	
29	PM270-1-1-2(-6)-CV	1.68	2.15	2.59	none	1.29
30	RM270-1-1-2(-6)-CV	1.36	1.70	2.20	none	-
31	PM270-2-1-2(-6)-CV	3.67	4.70	None	none	2.79
32	RM270-2-1-2(-6)-CV	3.05	3.69	None	none	-

Table 6 The growth of the $(Fe\text{-}Ni)_{metal}$-FeS core and the initiation of the extrusion of the basaltic melt for the differentiation of planetesimals with initial bulk CI chondritic composition.

No.	Simulations[a]	Fe-FeS core[b]					Initiation of the extrusion of basaltic melt[c]
	Radius = 20 km	**0^+ km**	**2 km**	**4 km**	**6 km**	**8 km**	
1	PM20-1-0.001-2(-6)-CI	2.18	2.25	none	None	none	1.53
2	RM20-1-0.001-2(-6)-CI	1.68	1.68	1.70	1.78	none	-
3	PM20-2-0.001-2(-6)-CI	none	none	none	None	none	3.73
4	RM20-2-0.001-2(-6)-CI	none	none	none	None	none	-
5	PM20-1-0.1-2(-6)-CI	2.23	2.29	none	None	none	1.54
6	RM20-1-0.1-2(-6)-CI	1.71	1.72	1.77	1.83	none	-
7	PM20-2-0.1-2(-6)-CI	none	none	none	None	none	3.78
8	RM20-2-0.1-2(-6)-CI	none	none	none	None	none	-
	Radius=50 km	**0^+ km**	**5 km**	**10 km**	**15 km**	**20 km**	
9	PM50-1-0.001-2(-6)-CI	2.15	2.15	2.15	2.39	none	1.53
10	RM50-1-0.001-2(-6)-CI	1.68	1.68	1.68	1.68	1.89	-
11	PM50-2-0.001-2(-6)-CI	6.27	6.58	none	None	none	3.73
12	RM50-2-0.001-2(-6)-CI	4.83	4.83	4.96	5.96	none	-
13	PM50-1-0.1-2(-6)-CI	2.17	2.19	2.24	2.65	none	1.53
14	RM50-1-0.1-2(-6)-CI	1.70	1.72	1.77	1.81	1.99	-
15	PM50-2-0.1-2(-6)-CI	6.54	7.29	none	None	none	3.75
16	RM50-2-0.1-2(-6)-CI	1.77	1.93	2.17	2.50	none	-
17	PM50-1-1-2(-6)-CI	2.38	2.65	3.27	3.66	none	1.58
18	RM50-1-1-2(-6)-CI	1.93	2.17	2.50	None	none	-
19	PM50-2-1-2(-6)-CI	none	none	none	None	none	3.92
20	RM50-2-1-2(-6)-CI	6.42	none	none	None	none	-
	Radius=100 km	**0^+ km**	**10 km**	**20 km**	**30 km**	**40 km**	
21	PM100-1-0.1-2(-6)-CI	2.16	2.19	2.25	2.30	3.11	1.53
22	RM100-1-0.1-2(-6)-CI	1.69	1.72	1.77	1.81	1.95	-
23	PM100-2-0.1-2(-6)-CI	6.35	6.49	6.87	None	none	3.73
24	RM100-2-0.1-2(-6)-CI	4.88	4.97	5.19	5.59	none	-
25	PM100-1-1-2(-6)-CI	2.25	2.61	3.27	3.62	none	1.55
26	RM100-1-1-2(-6)-CI	1.73	1.94	2.23	2.55	2.98	-
27	PM100-2-1-2(-6)-CI	8.40	none	none	None	none	3.82
28	RM100-2-1-2(-6)-CI	5.33	6.73	11.59	None	none	-
	Radius=270 km	**0^+ km**	**27 km**	**54 km**	**81 km**	**108km**	
29	PM270-1-1-2(-6)-CI	2.19	2.65	3.36	4.11	5.40	1.53
30	RM270-1-1-2(-6)-CI	1.70	2.01	2.39	2.82	3.54	-
31	PM270-2-1-2(-6)-CI	6.72	none	none	None	none	3.77
32	RM270-2-1-2(-6)-CI	5.00	7.06	none	None	none	-

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