INTERIOR STRUCTURE OF MARS.

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Introduction. Based on available chemical models of the planet [1,2,3,4,5], a new set of global models of the Martian interior has been constructed. The model comprises four submodels - a model of the outer porous layer, a model of the crust, a model of the mantle and a model of the core. The first 10- 11 km layer is considered as an averaged transition from regolith to consolidated rock. The mineral composition of the crustal basaltic rock varies with depth because of the gabbro-eclogite phase transition. As a starting point for mantle modeling there have been used experimental data obtained by Bertka and Fei [6,7] along the areotherm, iron content of the mantle being varied. New high P-T measurements of the density of Fe (γ-Fe), FeS and FeH enable us to refine the core model. Taking into account available chemical models and the fact that noticeable amount of hydrogen could enter the Martian core during its formation [8], such parameters as ferric number of the mantle (Fe#), sulfur and hydrogen content in the core are varied.

The construction of Martian interior structure models. *Crust.* In the crust models of Babeiko and Zharkov [9], there is a transition in the outermost 10-km layer from highly porous Martian regolith ($\approx$1.6 g/cm^3) to consolidated rocks (3.2 g/cm^3). Because of the gabbro-eclogite phase transition, the increase of density with depth in the consolidated crust depends strongly on the temperature gradient.

Mantle. For the modeling of the density profiles in the mantle, we use the experimental results of Bertka and Fei [6,7]. They have performed high-pressure multi-anvil experiments with an analog of the Dreibus and Wänke composition [10] to determine the model mineralogy up to core-mantle boundary pressures along a model areotherm. The Martian mantle are assumed to consist of 12 mineral assemblages. The weight fraction of each mineral assemblage is calculated from the mass balance of the experimental products.We added $\delta\rho_i$ to the B-F mantle density profile (Fe#25), when calculating the models with lower and higher iron content. When increasing Fe# by 1 $\delta\rho$ is increased by about 0.01 g/cm^3 for olivine zone, 0.0083 g/cm^3 for β-zone, 0.011 g/cm^3 for γ-zone and 0.0125 g/cm^3 for perovskite zone.

Core. The Martian core composition is considered to be sulfur-rich, consisting of Fe with 14.2 wt % S, 7.6 wt % Ni [10]. New high P-T measurements of the density of Fe (γ-Fe) and FeS [11] enable us to refine the core model by Zharkov [8]. In this study the Martian core is assumed to be a mixture of iron-nickel alloy, sulfur and some amount of hydrogen. The addition of 10 mol % of hydrogen to the iron reduces its density by 0.16 g/cm^3 [8]. Experimental data of high-PT phases of γ-Fe and FeS [11] were obtained for a solid state and the temperatures of about 1300-1600K. When the temperature is increasing from 1600K to 2100K, the density decreases by about 0.125 g/cm^3. When melting core material, the density decreases by about 0.2-0.3 g/cm^3

Modeling. In our modeling we varied the following parameters: ferric number of the mantle (Fe#), sulfur content in the core (S_{core}) and hydrogen content in the core (H_{core}). Core mass (M_{core}), core radius (r_{core}), pressure at the core-mantle boundary, crust thickness, dimensionless value for the moment of inertia, calculated bulk Fe content, weight Fe/Si ratio and the thickness of a perovskite layer for the calculated models are listed in Table.

Figure 1 shows the core radius as a function of the Martian mantle Fe# for different amount of hydrogen in the core (0-70 mol %), assuming a core composition of 14 wt % S (according to the DW model) and a 50-km-thick crust. If there is no hydrogen in the core, the Fe/Si ratio ranges from 1.34 to 1.37, and Fe# ranges from 0.26 to 0.21, respectively. The following tendency is seen: the presence of hydrogen leads to the increase of the Fe/Si ratio and the decrease of Fe# in the mantle due to the increase of the core radius. The incorporation of 50 mol % of hydrogen into the core leads to the increase of Fe/Si ratio up to about the chondrite ratio.

We have calculated a series of Martian interior models with core density profiles calculated for core compositions ranging from pure Fe (0 wt % S) to FeS (36 wt % S). Figure 2 indicates the relation between the core radius, the mantle Fe#, the sulfur content in the core and the moment inertia factor. The Fe/Si ratio is lower than the chondrite ratio for any of these models.

The higher sulfur and hydrogen content in the core and the smaller mantle Fe#, the less likely a perovskite layer exists.

Conclusion. Based on available chemical models of the planet [1,2,3,4,5], a new set of global models of the Martian interior has been constructed. Quantitative studying the effect of hydrogen in the core on planetary structure is one of the main goals of the paper. If there is no hydrogen in the core, a model produces a Fe/Si ratio that is smaller than the chondritic value of 1.71. The presence of hydrogen in the core significantly increases the Fe/Si ratio up to about 1.7, and reduces the melting temperature of the core material. To satisfy the bulk chondritic ratio, more than 50 mol % of hydrogen must be incorporated into the core. Then, a problem of consistency of the cosmochemical DW model with the internal structure model of the planet is solved. It will confirm the idea that terrestrial planets were formed from chondritic material. This is a fundamental problem on the formation of Mars and its evolution.

The determination of the core radius continues to be of great importance, in case of a reliable determination of the core radius uncertainties concerning the composition of Mars will be resolved. From cosmochemical point of view, it is difficult to assume that the core contains more than 20 wt % of sulfur. The radius of such core is about 1600 km. Therefore, if the core of Mars turns out to be larger, hydrogen could be such an admixture element. According to numerical modeling hydrogen increases the core radius and decreases Fe# of the mantle.

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Table. Parameters of the models

Models	Fe#, mantle	S_{core} (wt%)	H_{core} (mol%)	M_{core} (wt%)	r_{core} (km)	P_{core} (GPa)	h_{crust} (km)	I/MR^2	Bulk Fe (wt%)	Fe/Si ratio	Δr_{pv} (km)
M0	0.25	14	0	14.3	1436	23.6	50	0.3671	23.6	1.34	83
	0.25	14	0	14.4	1438	23.6	80	0.3669	23.7	1.34	82
	0.25	14	0	14.2	1430	23.6	10	0.3675	23.5	1.34	86
M1	0.20	14	30	19.3	1625	21.3	50	0.3643	24.5	1.48	-
M2	0.22	14	30	18.0	1590	21.7	50	0.3656	24.6	1.46	-
M3	0.24	14	30	16.8	1551	22.2	50	0.3669	24.7	1.45	-
M4	0.25	14	30	16.2	1532	22.4	50	0.3676	24.8	1.44	-
M5	0.22	14	0	16.2	1529	22.9	50	0.3650	23.5	1.36	31
M6	0.22	14	50	19.6	1662	20.8	50	0.3662	25.6	1.55	-
M7	0.22	14	70	21.7	1753	19.7	50	0.3669	27.0	1.68	-
M8	0.22	0	0	13.2	1327	25.4	50	0.3639	23.3	1.31	202
M9	0.22	20	0	17.6	1568	22.0	50	0.3654	23.3	1.38	-
M10	0.22	36	0	23.3	1816	18.9	50	0.3674	22.9	1.46	-

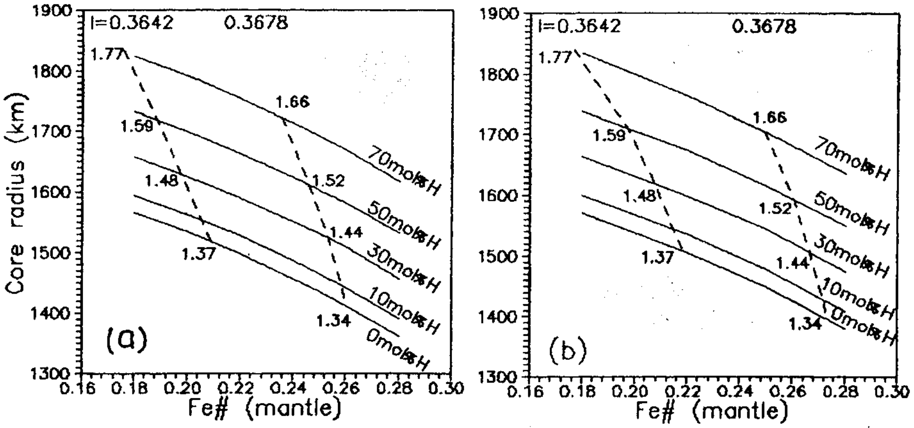

Fig. 1. Core radius as a function of Martian mantle Fe# , assuming a core composition of 14 wt % S and a 50-km-thick crust (a), and a 100-km thick crust (b) for different amount of hydrogen in the core (0-70 mol %). Dashed lines show the lower (left) and upper (right) limits of the moment inertia factor. Fe/Si ratio is given for boundary models.

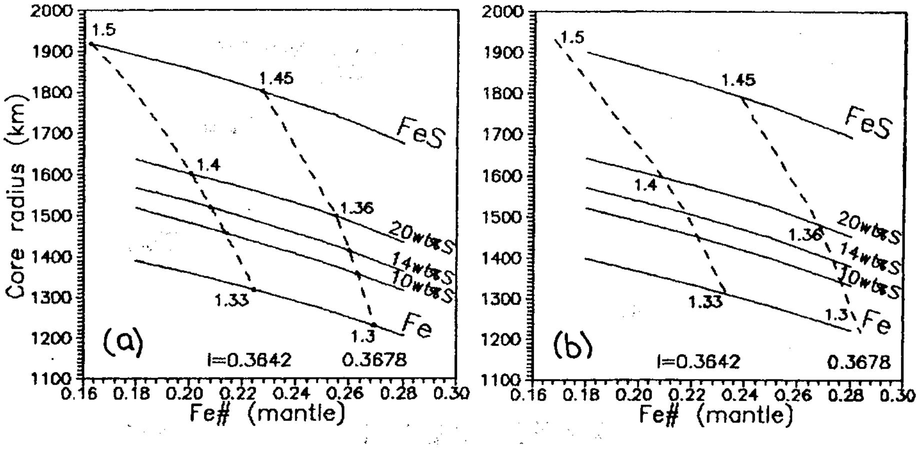

Fig. 2. Core radius as a function of Martian mantle Fe# for a core composition ranging from 0 wt % S (Fe-core) to 36 wt % S (FeS core) assuming a 50-km thick crust (a) and a 100-km thick crust (b). Dashed lines show the lower (left) and upper (right) limits of the moment inertia factor. Fe/Si ratio is given for boundary models.