DETERMINATION OF THE VOLATILE ABUNDANCES IN HOT JUPITERS FROM THEIR PARENT STAR METALLICITIES – THE CASE OF COROT-2B.

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Introduction: The atmospheric compositions of Jupiter and Saturn provide important constraints about their formation processes, internal structures and thermodynamic conditions in the primitive solar nebula during the epoch of planetesimal formation. The observed supersolar volatile abundances of gas giants is suggested to be due to the accretion into their envelopes of planetesimals composed of rock and ices, formed out of the gas phase of solar composition is consistent with the so-called core-accretion model. [1-4].

Recent advances in the characterization of transiting hot-Jupiters now allow one to derive the abundances of major C- and O- bearing molecules in their atmospheres. Here we utilize the approach developed to investigate the relationship between the composition of Jupiter and Saturn and their formation mechanism in the solar nebula. We seek the best possible match of the abundances of C and O volatiles in the hot-Jupiter CoRoT-2b [5]. We then predict the abundances of N, S and P bearing volatiles in the envelope of this hot-Jupiter and derive the mass of heavy elements to match the abundances derived from observations.

Methodology: We have assumed that the disk composition corresponds to that of the parent star as to our best knowledge, there is no detailed investigation about the composition of the star CoRoT-2. We assumed also that the disk elemental abundances correspond to the protosolar values [6] multiplied by the ratio of the CoRoT-2 and solar metallicities. In our approach, we first computed the composition of planetesimals (rocks + ices) formed in the disk. The abundances of silicate and metal compounds formed in the disk gas phase has been calculated with the use of the HSC Chemistry software. The list of compounds used in our calculations is taken from [7]. The software computes the abundances of solid phases at equilibrium for given gas temperature and pressure. Figure 1 represents the relative amounts of these compounds formed in the stellar nebula surrounding the star CoRoT-2 as a function of the disk temperature. We considered the abundances at a fixed temperature of ~200 K, slightly higher than the condensation temperature of water in the protoplanetary disk. Once the abundances of silicates and metals condensed in the disk have been calculated, we determined the residual abundances of O, C, N, S and P that have not been incorporated in solids during their formation and were left over in the disk in gas phase. Elemental abundances were used to compute the main volatile molecules residing in the disk before condensing or being trapped in clathrates [3, 4, 8]. We took the disk chemical conditions to be oxidizing. In this case, O, C, N, S and P are postulated to exist only as molecular species of H_2O, CO, CO_2, CH_3OH, CH_4, N_2, NH_3, H_2S and PH_3. We set $CO/CO_2/CH_3OH/CH_4$ = 70/10/2/1, N_2/NH_3 = 10/1 and H_2S/H_2 = 0.5 in the gas phase [9]. Once the global composition of planetesimals has been determined, we adjusted their mass in the envelope of CoRoT-2b in order to provide the best fit for the O and C abundances derived from observations.

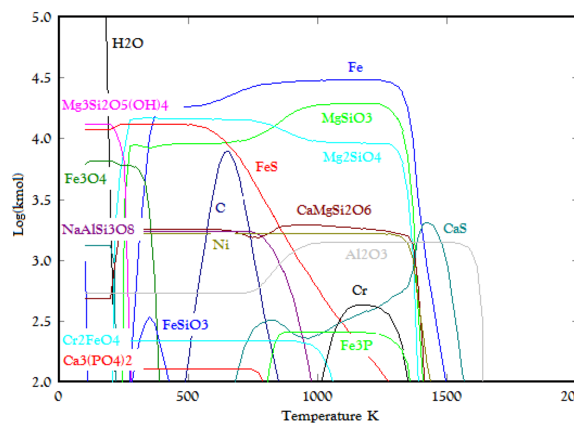

Figure 1. Composition of rocks and metals condensed in the stellar nebula surrounding CoRoT-2 host star as a function of the disk temperature. Total disk pressure is assumed to be 10^{-4} bar.

Results and discussion: We used the O and C atmospheric abundances retrieved by [5] to calibrate our calculations. Two cases defined by [5] are investigated, namely the Oxygen Rich Planet (ORP) and Carbon Rich Planet (CRP). We opted to fit the most abundant volatile in the atmosphere of CoRoT-2b, i.e. O and C in the ORP and CRP cases, respectively. Table 1 represents these two fits and the corresponding predictions for the N, S, P abundances in the envelope. The total mass of ices accreted into the envelope of CoRoT-2b in the ORP case is 5.7 *Earth-masses*, including 0.7 *Earth-masses* of water ice. In the CRP case, the total mass of ices accreted to the envelope is 4.5 *Earth-masses*, including 0.5 *Earth-masses* of water ice.

An important issue is that the O and C abundances retrieved from observations in the envelope of CoRoT-2b are lower than the assumed stellar values. On the other hand, the volatile abundances have been found to be supersolar in the envelopes of Jupiter and Saturn as well. This property deserves to be investigated in the near future as the core-accretion model invoked for the formation of close-in gas giants is found to be consistent with envelopes holding superstellar metallicities.

Table 1. Calculated (ORP and CRP fits) and measured (ORP and CRP) volatile abundances in CoRoT-2b for ORP and CRP cases (see text).

X/H_2	ORP fit	CRP fit	ORP	CRP
O	3×10^{-4}	4×10^{-4}	3×10^{-4}	2×10^{-4}
C	2×10^{-4}	2.7×10^{-4}	1×10^{-4}	2.7×10^{-4}
N	4.1×10^{-5}	5.2×10^{-5}	-	-
S	8.7×10^{-6}	1.1×10^{-5}	-	-
P	3.3×10^{-7}	4.2×10^{-7}	-	-

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