ATMOSPHERIC CHEMISTRY OF HOT EARTH-LIKE EXOPLANETS. II. LITHOPHILE ELEMENTS NA, K, FE, SI, MG, AL, CA, AND TI

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Introduction: Recent discoveries have shown that some super-Earths, such as CoRot-7b [1], can be very hot. Here we discuss atmospheric chemistry for an Earth-like planet hot enough to vaporize the atmosphere + hydrosphere + crust. In [2], we gave results for the major volatile elements H, C, N, O, and S. Here we discuss results for Na, K, Fe, Si, Mg, Al, Ca, and Ti. These results will be useful in planning spectroscopic studies of the atmospheres of hot super-Earths.

Atmospheric Composition: Our methods are described in [2]. Figure 1 shows the most abundant gas for each element as a function of temperature. Less abundant gases are not shown.

Sodium, Potassium: Significant amounts of the alkalis enter the gas as NaCl and KCl at ~2000 K. At ~2400 K, the chlorides react with water vapor to form NaOH and KOH. At higher temperatures, NaOH and KOH dissociate to oxides, which in turn dissociate to monatomic and singly ionized gases.

Iron, Silicon, Magnesium: Iron enters the gas as $Fe(OH)_2$ at ~2400 K. Above ~4000 K, $Fe(OH)_2$ decomposes into Fe and FeO gas. At 4000 K, SiO gas is the most abundant gas in the atmosphere, followed by O_2 and monatomic O. Silicon is also found in SiO_2 gas, which dissociates at higher temperatures, and monatomic Si above ~5000 K. Above 4000 K, Mg is present as MgO and monatomic Mg, with smaller amounts of hydroxide gases.

Aluminum, Calcium, Titanium: Below ~4500 K, Ca and Al are in the planet. Above this temperature, they form oxide gases. Aluminum is found mainly in AlO, AlOH, and monatomic Al, with lesser amounts of Al_2O, AlO_2, Al_2O_2, and AlO^-. Calcium is mainly CaO and monatomic Ca, with lesser amounts of CaOH and $Ca(OH)_2$. The major titanium gas TiO_2 peaks at ~4000 K, and decomposes into TiO at higher temperatures.

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References: [1] Legér, A., et al. 2009 *A&A*, 506, 287. [2] Schaefer, L. & Fegley, B. 2010. *MAPS*, abstract, this meeting.

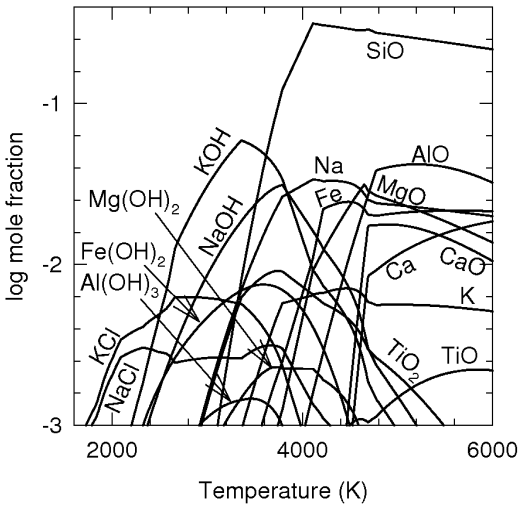

Figure 1. Major gases of the lithophile elements as a function of temperature for a total pressure of 100 bars.