CHEMICAL PROBES OF SATURN'S DEEP ATMOSPHERE. Bruce Fegley, Jr. and Ronald G. Prinn, MIT, Cambridge, MA 02139.

The detection of PH_3, CO, and GeH_4 on Jupiter (1-5) led to extensive calculations on the chemistry of Jupiter's deep atmosphere (6-9). These calculations indicate that PH_3, CO, and GeH_4 are chemical probes of Jupiter's deep atmosphere and that their observed abundances may be due to rapid vertical mixing from the 800-1100 K levels in the atmosphere. Furthermore it has been demonstrated that the vertical mixing rates independently estimated from the Jovian heat flux are rapid enough to quench the Jovian CO abundance at about the 1100 K level (8).

PH_3 has been detected on Saturn and an upper limit set on the GeH_4 abundance (10). However no calculations on the chemistry of Saturn's deep atmosphere are available. We present the preliminary results of thermochemical calculations for a near solar composition model of Saturn's deep atmosphere. Our results are useful to: (a) interpret the abundance of observed chemical probes such as PH_3 in terms of vertical mixing from specific atmospheric levels, (b) to predict other chemical probes of Saturn's deep atmosphere, and (c) to place firm upper limits on gas abundances from deep atmospheric sources.

Figure 1 illustrates the equilibrium abundances for some gases along the Saturn adiabat. CH_4 is the most abundant carbon gas at $T \leqslant 2000$ K. C_2H_6 is the second most abundant carbon gas at $T < 1380$ K and CO is the second most abundant carbon gas at $T > 1380$ K and is potentially observable through upward mixing. NH_3 is the most abundant nitrogen gas at $T \leqslant 2000$ K. Nitrogen abundances of solar and 2X solar were used in the calculations. N_2 is the second most abundant nitrogen gas and is a potential chemical probe of the deep atmosphere (9). The abundance of CH_3NH_2 is also shown.

Phosphorus abundances of solar and 2X solar were used in the calculations. In both cases PH_3 is oxidized to P_4O_6 in the 800-1000 K range. The P_4O_6 subsequently condenses as $NH_4H_2PO_4(s)$ at about 390 K. These calculations also assume a solar oxygen abundance on Saturn. The most abundant oxygen gas is predicted to be H_2O, which has not yet been detected. The observed PH_3 mixing ratio of $\sim$2X solar could be provided by rapid vertical mixing from the $T \sim 1250$ K level with the assumptions mentioned above.

The H_2S and HF abundances shown in Figure 1 are calculated assuming solar S and F abundances. Neither gas has been observed yet on Saturn. The H_2Se and GeH_4 abundances shown are calculated assuming solar Se and Ge abundances. GeH_4 is converted to GeS and GeSe at $T \sim 730$ K. The GeH_4 mixing ratio on Jupiter is $\simeq 7 \times 10^{-10}$ (11) while the upper limit for Saturn is only 10^{-10} (10). However rapid Jupiter-like vertical transport from the $T \sim 1250$ K level which could provide the observed PH_3 abundance will give a GeH_4 mixing ratio of about 4.5×10^{-9} (i.e. 45 times the observed upper limit). A possible explanation is that vertical mixing on Saturn is less rapid than that on Jupiter — we analyse this possibility based on theoretical estimates of the rates of PH_3 and GeH_4 destruction. Finally, H_2Se, which has not yet been observed, is predicted to be a potential chemical probe. It is converted to GeSe(s) at $T <$ about 520 K.

References: (1) S.T. Ridgway (1974) BAAS **6**, 376. (2) R. Beer and F.W. Taylor (1978) Ap. J. **221**, 1100-09. (3) H.P. Larson et al (1977) Ap. J. **211**, 972-79. (4) H.P. Larson et al (1978) Ap. J. **219**, 1084-92. (5) U. Fink et al (1978) Icarus **34**, 344-54. (6) S.S. Barshay and J.S. Lewis (1978) Icarus **33**, 593-611. (7) B. Fegley and J.S. Lewis (1979) Icarus **38**, 166-79. (8) R.G. Prinn and S.S. Barshay (1977) Science **198**, 1031-34. (9) R.G. Prinn and E.P. Olaguer (1981) JGR **86**, 9895-99. (10) H.P. Larson et al (1980) Ap. J. **240**, 327-37. (11) V. Kunde et al (1982) Ap. J. **263**, 443-67.

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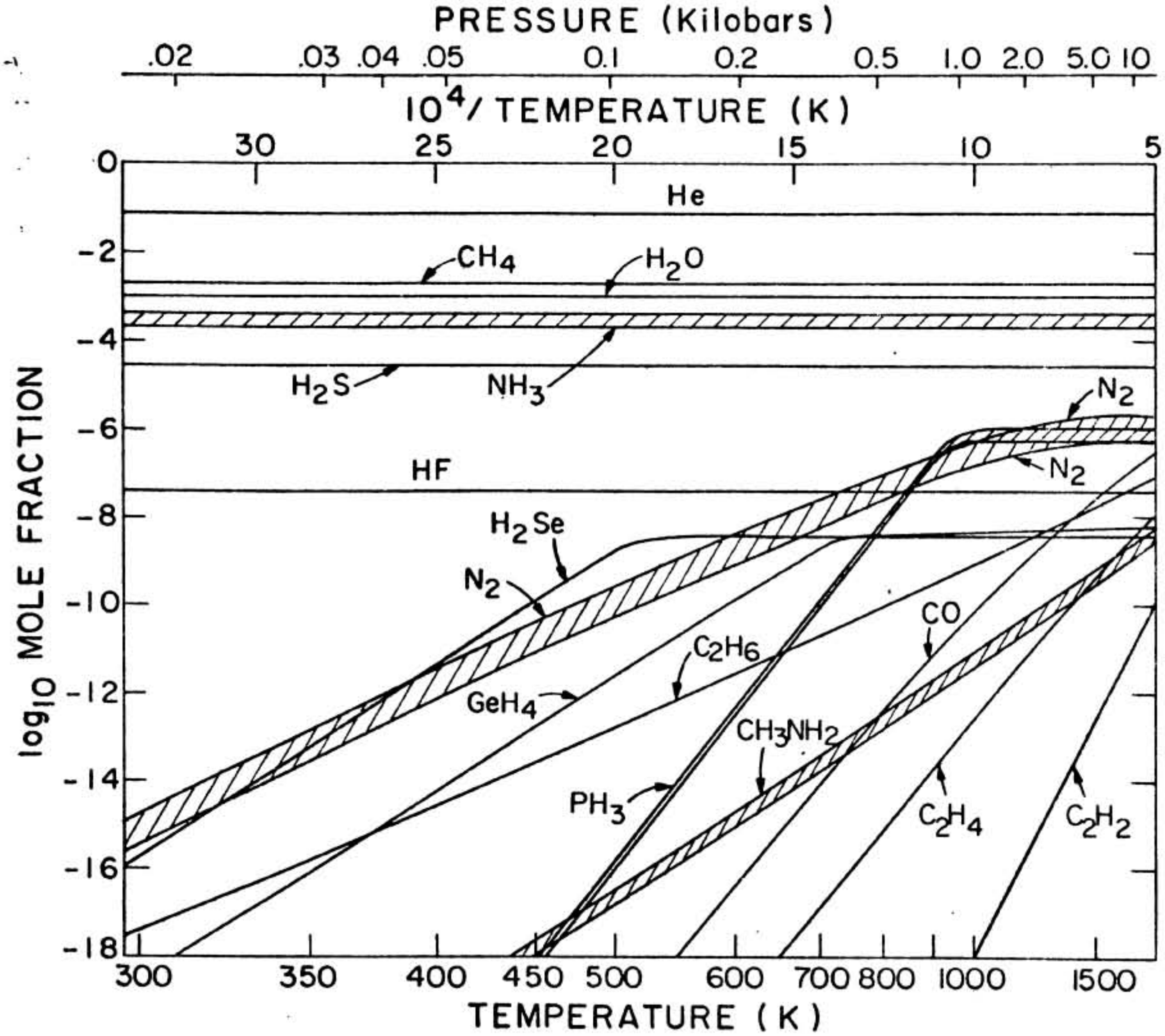

Figure 1: Equilibrium abundances of some gases along the Saturn adiabat. H_2 is present at a mole fraction of 0.922. Calculations were done for solar and 2X solar abundances of N and P.