Geophysical Research Abstracts,
Vol. 11, EGU2009-6324, 2009
EGU General Assembly 2009

Formation of Jupiter and Saturn and the Origin of Their Atmospheres: Current Constraints and Future Prospects

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The supersolar elemental ratios (relative to H) of C, N and S and the heavy noble gases, Ar, Kr and Xe, at Jupiter have led to various hypotheses for explaining the elemental enrichment. Despite their differences in the delivery of the heavy elements, all these hypotheses require cold planetesimals—icy or clathrate—as starting material. However, the O/H determined from water, is unknown, but is critical, as water was presumably the original carrier of all heavy elements to the gas giant planets. At Jupiter, the Galileo probe could not measure water in the well-mixed atmosphere as the probe entered a meteorologically anomalous (five-micron) hot spot, whereas the Cassini Saturn orbiter was not designed for measuring water. At Saturn, reliable determination of only one heavy element, C (from CH4) has been made, but the determination of the other heavy elements is beyond the remote sensing capability of the Cassini orbiter. While the 2011 Juno Mission is expected to measure the deep atmospheric abundance of water, hence O/H, at Jupiter, the missing suite of heavy elements, helium, and the critical isotopes of hydrogen, nitrogen, carbon and helium in Saturn would require an entry probe. A comparison of such data for the two gas giant planets is essential to fully constrain the models of the formation of the gas giant planets and the origin of their atmospheres. <www.umich.edu/ătreya>