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QUANTIFYING THE MEASUREMENT REQUIREMENTS NEEDED TO UNDERSTAND THE ORIGIN OF THE GALILEAN SATELLITE SYSTEM

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Abstract. One of the primary science objectives of the JUpiter ICy moon Explorer (JUICE) mission is to characterize the origin and evolution of the Galilean satellites. Here we discuss the observational tests that could be performed via a Ion and Neutral Mass Spectrometer (INMS) aboard the JUICE mission and that would shed light on the formation circumstances of the Galilean satellite system.

Keywords: Origin of Jupiter and its satellite system, Cosmochemistry, Spacecraft missions

1 Introduction

The history of the Jovian system can be divided into three main phases: the formation of Jupiter, the formation of its satellite system and its secular evolution to its present day state. Three different sets of formation conditions can be considered regarding the Galilean satellite system: 1) unaltered building blocks from the protosolar nebula (Mousis & Gautier 2004; Horner et al. 2008), 2) altered materials where a significant fraction of the volatile components have outgassed before the formation process (Mousis et al. 2009a), and 3) building blocks that were vaporized in the subnebula of Jupiter before coalescing in the formation process, i.e. the Jupiter mini-solar system formation scenario (Prinn & Fegley 1981). Cassini has shown that the Saturn system seems to fall largely into category 2 (Waite et al. 2009; Mousis et al. 2009b) but the size of Jupiter and its relative distance from the Sun may favor process 3 for the Galilean satellites. Here we discuss the observational tests that could shed light on the formation circumstances of the Galilean satellite system.

2 Key measurements

Figure 1 displays the different key observations that could constrain the origin of the Galilean satellite system. These measurements are divided into two categories: determinations of the noble gas abundances and measurements of the isotopic ratios.

2.1 Noble gas abundances

INMS measurement of the ratios of the noble gases in the satellite environments, particularly Ar, Kr and Xe would allow comparison with bodies that likely formed in the solar nebula, such as comets, and thereby constrain whether the material from which the icy satellites formed was primarily circumsolar or circum-Jovian.

2.2 Isotopic ratios

The deuterium-to-hydrogen ratio in water, compared to that of the well-determined primordial value and that in terrestrial ocean water, gives an indication of the extent to which water in planetesimals experienced elevated temperatures for durations sufficient for re-equilibration with the surrounding hydrogen-rich gas (Horner et al.

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2008). Measurement of the ratios of noble gases to CH_4 and the $^{12}C/^{13}C$ and D/H ratios provides constraints on the origin of any methane that might be present either primordially or as a product of hydrothermal reactions in the interiors of Europa and Ganymede (Jehin et al. 2009; Mousis et al. 2009c). The origin of methane as primordial or a later product of internal processing would provide a supplementary constraint on the temperature history of the disk.

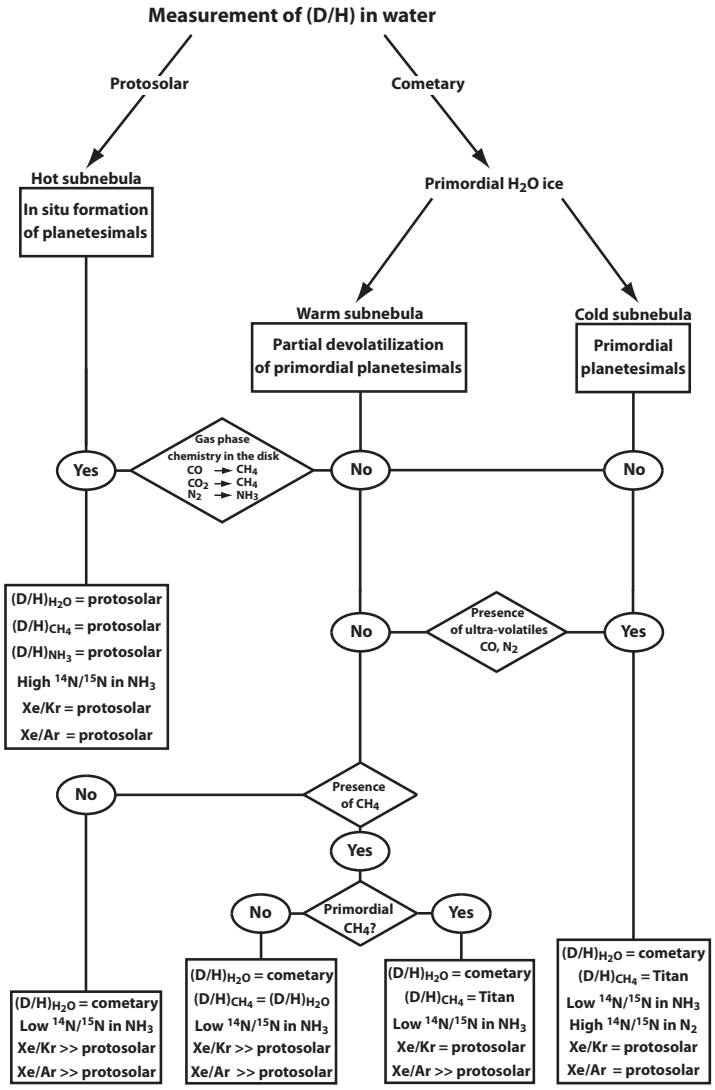

Fig. 1. Observational tests derived from different formation scenarios.

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