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# Introduction PRIAMOS (PRImordial Asteroid Mission to understand the Origin of the Solar system) - a sample return mission to a D-type near-Earth asteroid

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Small solar system bodies are remnants of the solar system's original protoplanetary disk that did not combine to form the more massive planets. These bodies include asteroids (main belt asteroids and Jupiter's Trojans), trans-Neptunian objects (TNOs), and comets. These objects formed over a wide range of heliocentric distances and have subsequently been distributed across the solar system by dynamical interactions with the giant planets. As such, understanding the provenance and genetic relationships among the solar system's small bodies is key for constraining the formation and primordial structure of the solar system, and the dynamical events that shaped its subsequent evolution. However, despite their importance, we lack key knowledge about how the distinct small bodies of the solar system are genetically related, how their formation locations varied in time and space, and how their chemical and physical properties have been modified over the history of the solar system. These knowledge gaps reflect that only a very few of these bodies have been visited by spacecrafts and, in particular, the strong bias in the sampling of these bodies by meteorites and past sample return missions. For instance, while the Hayabusa1 and 2 and OSIRIS-Rex missions have demonstrated the enormous scientific potential of sample return missions, and the enhanced scientific value of carefully curated returned samples over meteorites, they were known to return materials represented by meteorites. These all derive from main belt asteroids and as such predominantly represent objects that formed in the vicinity of Jupiter. As such, the next frontier is to return material from the outer solar system, which until now has remained largely unsampled, but which holds the key to understand how the solar system formed and evolved. Here the case is presented that, owing to their primitive nature, D-type asteroids present objects that formed at much greater heliocentric distance that any meteorite parent body. While their closest meteorite analog are carbonaceous chondrites, D-type material does not seem to be present in our meteorite collections, probably because this friable primitive material does not survive atmospheric entry. Moreover, D-type asteroids are predicted to be scattered TNOs, and so they may have originally formed in the far outer disk and derive from the same population of primordial bodies as comets. Thus, analyzing a D-type sample will make it possible to identify the primordial array of materials present in the protoplanetary disk and to test models of solar system formation and evolution by determining the genetic relationships among the most primitive small bodies of the solar system. For these reasons, we propose PRIAMOS (PRImordial Asteroid Mission to understand the Origin of the Solar system), a sample return mission to a D-type near-Earth asteroid (NEA). PRIAMOS would be the first European-led sample return mission and, for the first time, would return a relatively large mass of outer solar system materials to Earth. The investigation of these materials in ground-based laboratories will be transformative for our understanding of early solar system evolution and will pave the way for building a new holistic model of the solar system.

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