A "New" Meteoric Element: Phosphorous

John Plane, Kevin Douglas, Juan Diego Carrillo-Sanchez, David Bones, Thomas Mangan, Mark Blitz

Phosphorous, P, is a key biological element with major roles in replication, information transfer, and metabolism. Interplanetary dust particles contain ~0.1% P by weight, and meteoric ablation in the 1 μbar region of a planetary upper atmosphere can generate significant amounts of atomic P, which will then undergo atmospheric processing before deposition at the surface. Orthophosphate (oxidation state +5) is the dominant form of inorganic P at the Earth's surface; however, due to the low water solubility and reactivity of P(+5) salts, they have a poor bio-availability. In contrast, less oxidised forms of P (particularly oxidation state +3) are far more bio-available. It has been suggested that these reduced forms of P may have originated from extra-terrestrial material that fell to Earth during the heavy bombardment period. Previous studies have focused on the direct delivery of P to the surface in meteorites, to undergo processing through aqueous phase chemistry. In contrast, the atmospheric chemistry of P has so far been ignored.

Here we present the first study of the meteoric ablation of Phosphorous, and its subsequent chemical processing to form a variety of compounds in which P occurs in the biologically important P(+3) state. The ablation of PO – relative to Ca – was studied in the Leeds Meteoric Ablation Simulator, and a new version of the Chemical Ablation Model (CABMOD) was developed to include the thermodynamics of P oxides in a molten meteoroid. The kinetics of P, PO and PO_2 with a variety of atmospheric constituents were then studied using the laser flash photolysis/laser induced fluorescence technique. From this, an atmospheric model of P has been developed to demonstrate how the biologically important phosphorous acid (H_3PO_3) can form, and then react with meteoric metal species to generate bio-available metal hydrogen phosphites which deposit at the planetary surface.