

Exogenous Phosphorus Compounds in Early Chemical Evolution

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Over the years a number of research groups have considered the problem caused by the fact that the only source of phosphorus on the surface of the Earth, the mineral apatite, is a highly insoluble compound. Several possible solutions to this problem have been offered. These can roughly be divided into three categories: 1) solubilization and/or activation mechanisms for apatite (Lohrman and Orgel, 1971; Schwartz et al., 1975); 2) the possible sedimentation of phosphate minerals other than apatite with subsequent formation of condensed phosphate by metamorphism (Handschuh and Orgel, 1973; Gedulin and Arrhenius et al., 1993); and 3) formation of condensed phosphates as a result of volatilization of P_4O_{10} during igneous activity (Yamagata et al., 1991). Each of the proposed mechanisms has been criticized for various reasons, some more cogent than others (Keefe and Miller, 1995).

The identification of a suite of alkyl phosphonic acids in the Murchison meteorite has created a new perspective with regard to this problem (Cooper et al., 1992). It is probable that a significant proportion of the Earth's primitive atmosphere and hydrosphere are of exogenous origin (Chyba and Sagan, 1992). This in itself provides a strong incentive for studying the chemistry of phosphonic acids and considering their possible prebiotic role (De Graaf et al., 1995). Furthermore, because the C-P bond is considerably more stable to hydrolysis than the C-O-P ester bond, phosphonic acids would persist in the prebiotic environment even under extreme conditions. Recent studies in our laboratory demonstrate that reactive phosphonic acid derivatives are formed under reasonable prebiotic conditions via a number of pathways, including photochemically induced reactions of meteoritic phosphonic acids. These facts, as well as the results of model studies on phosphonic acid-based nucleotide analogues, suggest a possible role for these compounds as early genetic materials.

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