Origins: From the Protosun to the First Steps of Life
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Discovering periodic sublimation on main-belt primitive asteroids near perihelion and its possible astrobiological significance

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Abstract. Discovered periodic sublimation activity on four main-belt primitive asteroids led us to conclusions about possible origin of those and similar bodies (or their parent bodies) near or beyond the snow line in the early Solar System making incorporated in them a considerable water ice stock. Water differentiation of the bodies owing to ^{26}Al decay and their internal thermal evolution might have created conditions for water soluble organics and prebiotic compounds formation. Subsequent longtime periodic changing temperature and other physico-chemical parameters (due to spinning and moving around the Sun) in the near-surface layers of primitive asteroids have led probably to formation of more complex organic compounds of astrobiological significance.

Keywords. asteroids, spectroscopic methods, sublimation of ices, activity of the Sun, solar wind, astrobiology

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Based on the data of reflectance spectroscopy, we have discovered simultaneous sublimation activity on four main-belt primitive asteroids 145 Adeone, 704 Interamnia, 779 Nina, and 1474 Beira being simultaneously near their perihelion distances in September 2012 (Busarev *et al.* 2015; Busarev *et al.* 2018a). As follows from Mie theory and numeric modeling (Hansen & Travis 1974), observed maxima in reflectance spectra of the asteroids in the near-UV or visible spectral ranges point to dispersion of light in a subtle regular coma of frozen H_2O micron-sized particles around each of the asteroids.

We have confirmed sublimation activity three of the asteroids (Nina, Interamnia and Adeona) at their next passages of perihelion in 2016-2018 using data obtained at four observatories and, correspondingly, established periodicity of this process for asteroids with considerable ellipticity of the orbit (Busarev *et al.* 2018b). Additionally, we noticed that last sublimation activity of the asteroids was less intense then previous one in 2012, which we connect with different solar activity (more strong in 2012) and its direct influence to extent and density of the sublimation coma (Busarev *et al.* 2018b). All considerable factors of solar wind (fluxes of protons, electrons and many other charged particles, as well as strong gradients of electric and magnetic fields) (e.g., McComas *et al.* 2003; Owens & Forsyth 2013) should influence the surface and sublimation coma of primitive asteroids.

The results led us to assumptions about origin of those and similar primitive bodies (or their parent bodies) near or beyond the snow line in the early Solar System making incorporated in them a considerable water ice stock. Water differentiation of such stone-ice bodies owing to ^{26}Al (and similar short-lived isotopes) decay and their internal thermal evolution within the first about 5 millions years might have created conditions for formation of hydrated silicates, water soluble and other organic compounds (e.g., Busarev *et al.* 2003; Busarev 2012). Subsequent longtime periodic changing temperature and other physico-chemical parameters in the near-surface layers of primitive asteroids (due to their spinning and moving around the Sun) have led probably to growing more complex organic compounds. As concluded from the study of kinetic principles of genesis and evolution of protobiopolymeric molecules (Varfolomeev *et al.* 2018), the thermocycles could provide the thermodynamic feasibility of formation of monomer-monomer bond and kinetic selection of more regular (developing) complexes. Presently, it is considered commonly accepted (Varfolomeev *et al.* 2018 and references herein) that action of radiation, temperature, electric and magnetic fields and so on to simple molecules (CO_2,hydrocarbons, HCN, etc.) under prebiological conditions can synthesize low-molecular-weight compounds (sugars, amino acids, nitrogen bases). As known, such compounds are found in carbonaceous chondrites (e. g., Dodd 1981) which are possible fragments of primitive asteroids. Thus, organic compounds formed with origin and evolution of primitive asteroids and delivered to Earth at the time of its heavy bombardment could form the basis for subsequent appearance of macromolecular systems (peptides, proteins, nucleic acids, etc.) and terrestrial life in the end.

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