ENAA and SEM Investigations of Carbonaceous Meteorites of Potential Relevance to Astrobiology and the Distribution of Biospheres

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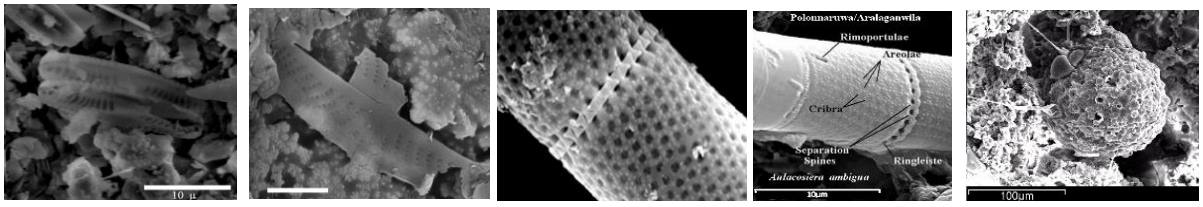
The origin and distribution of biospheres is one of the great unanswered questions of Science. The accepted paradigm is that Earth's biosphere arose after long, slow process of abiotic synthesis of organics and complex biomolecules in the primordial atmosphere and oceans resulted in the development self-replicating living cells. The alternative Hoyle-Wickramasinghe cometary panspermia hypothesis has gained support by recent discoveries of indigenous microfossils in meteorites and biological fractionation of carbon isotopes in clasts entombed in 4.4 Ga Jack Hills zircons. Evidence for life on Earth soon after the planet cooled leaves no time for a long, slow chemical and molecular evolutionary process anywhere in our Solar System. Hence the possibility that Earth life may have originated in ancient extrasolar planets and was delivered to Hadean Earth by interstellar comets merits consideration. SEM studies [**1**] at NASA/MSFC, Cardiff Univ. and LRB/JINR have shown the Orgueil (CI1), Murchison (CM2) and Polonnaruwa (C-Ung.) meteorites contain astonishingly well-preserved indigenous remains of extinct diatoms, cyanobacteria and hystrichospheres (Fig. 1).



a. **b.** **c.** **d.** **e.**

Fig. 1. Fossil diatoms in **a. b.** Orgueil; **c.** terrestrial diatom *Aulacoseira segariana*; **d.** Polonnaruwa morphotype of *A. segariana*; **e.** Hystrichosphere embedded in Polonnaruwa/Aralaganwila meteorite.

Epithermal Neutron Activation Analysis (ENAA) of carbonaceous meteorites at FLNP/JINR revealed the low-density Polonnaruwa stones have extremely high levels of long-lived, incompatible radiogenic Heat Producing Elements (^{40}K, 1.2 Ga; ^{238}U, 4.5 Ga; ^{232}Th, 14 Ga) [**2**]. They are unlike all known meteorites, but possess non-terrestrial oxygen isotope ratios, fractured zircons and Maskelynite consistent with asteroidal impacts bearing similarities to the Apollo 14 VHK Lunar KREEP basalts **[3]** and low-density boulders on asteroid Ryugu. These discoveries provide important insights for a possible mechanism for the interstellar cometary transfer of viable biospheres between extrasolar planets within the Galaxy and beyond.

References

[1] Rozanov, A.Yu., Hoover, R.B., Krasavin, E.A., Samyilina, O.S., Ryumin, A.K., Kapralov, M.I., Saprykin, E.A., Afanasyieva, A.N. *The Orgueil Meteorite (Atlas of Microfossils)*. 1-128. (2020).

[2] Hoover, R.B, Frontasyeva, M., Pavlov, S. "Epithermal Neutron Activation Analysis of Carbonaceous Chondrites and the Polonnaruwa/ Aralaganwila Stones." Aspects in Mining and Mineral Science 6(1), 669-679 (2020).

[3] Wallis, J., Wickramasinghe, N. C., Wallis, D. H., Miyake, N., Wallis, M. K., Hoover, R. B., Samaranayake, A., Wickramarathne, K., Oldroyd, A, "Physical, chemical, and mineral properties of the Polonnaruwa stones." Proc. SPIE 8965, 886508_1-24 (2013).