TWO APPROACHES TO STUDYING COSMOGENIC RADIONUCLIDES IN CHONDRITES.

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Introduction: Cosmogenic radionuclides produced by galactic cosmic rays (GCR) in chondrites during their motion in space are natural detectors of the GCR intensity and variations along the chondrite orbits (2-4 AU from the Sun) during ~ $T_{1/2}$ of the radionuclides before the chondrite fall.[1]. It should be specified that the GCRs of E>100 MeV are considered, because the GCR effects of softer energies are lost from the near-surface layers due to their ablation in atmosphere. The contents of cosmogenic radionuclides are measured practically in all chondrites with known dates of fall. There are two approaches to processing the data.

Approach 1: In the majority of works in the field (see e.g., the comprehensive paper [2]), a conception of GCR solar modulation, embodied in only one modulation parameter *M*, is used. It is a priori introduced into the calculation of cosmogenic radionuclide production rates, so that the latter qualitatively demonstrate the 11-year variations observed in GCRs near the Earth. However, the modulation parameter *M* is based on the so-called force field model [3], in which the effects of drift and convection are neglected, i.e. the most important processes in 3D heliosphere are not taken into account [4]. Hence, a part of the scientific information is lost, and even a qualitative regularity of the GCR variations along the chondrite orbits may be not the adequate one.

Approach 2, elaborated in [1,5, etc.], has a very transparent structure. It consists of three stages: **1.** Measurement of the contents of cosmogenic radionuclides in fallen chondrites (i.e. the cosmogenic radionuclide production rates (H_r) along the chondrite orbits during ~ $1.5T_{1/2}$ of the radionuclides before the chondrite fall). **2.** Calculation of their production rates ($H_\oplus$) in the identical chondrites, using the GCR intensity at 1 AU for the similar periods of the radionuclide accumulation along the chondrite orbits. It is possible, because the monthly stratospheric data of balloon measurements of GCRs (E>100 MeV) are available since 1957 [6]. **3.** The comparison of the measured and calculated data allows us to reveal possible variations of the cosmogenic radionuclide production rates between the meteorite orbits (2-4 AU) and 1 AU for different periods of the solar activity (studying the meteorites with different dates of fall). Indeed, the gradient of the cosmogenic radionuclide production rates may be expressed as $G=(H_r/H_\oplus-1)/(r-1)\cdot 100\%$ per 1 AU without any speculation.

Conclusion: Certainly, the gradients of the cosmogenic radionuclide production rates must not be directly compared with the gradients of the GCRs, but they show a tendency, some important regularities over the long-time scale, which are useful for the correlative analysis with other processes in the heliosphere. Such a new set of the homogeneous data on the long-time scale cannot be available at present in rare expensive direct measurements in space, so that the advantage of the approach is evident.

References: [1] Lavrukhina A. K. and Ustinova G. K. 1990. *Meteorites as probes of cosmic ray variations.* (Nauka, Moscow). [2] Povinec et al. 2015. *Meteoritics & Planetary Science* 50:273-286. [3] Caballero-Lopez, R.A. and Moraal H. 2004. *Journal of Geophysical Research* 109: A01101,doi:10.1029/2003JA010098. [4] Zhao L.L. et al. 2013. *Ibid, Space Physics* 119: 1493-1506, doi:10.1002/2013JA019550 [5] Alexeev V.A. and Ustinova G.K. 2006. Geochemistry International 44: 423–438. [6] Stozhkov Yu.I. et al. 2009. Advances in Space Research 44: 1124-1137.