WHAT TOOK PLACE AT THE PERMO-TRIASSIC BOUNDARY? COSMIC SPHERULES AS MESSENGERS OF A NEARBY SUPERNOVA EXPLOSION. Cs. H. Detre, *Geological Institute of Hungary, Budapest, Stefania ut 14. H-1143, Hungary*, I. Tóth, *Konkaly Observatory, P.O. Box 67, H-1525 Budapest, Hungary (tothi@ogyalla.konkaly.hu)*, A. Gucsik, *Dept. of Earth Sciences, Yamaguchi University, 1677-1, Yoshida, Yamaguchi, 753, Japan*, Á. Kiss, I. Uzonyi, *Institute for Nuclear Research, ATOMKI, Debrecen P.O. Box 51, H-4001, Hungary*, Sz. Bérczi, *L. Eotvos University, Dept. of Petrology and Geochemistry, H-1088 Rakoczi ut 5., Budapest, Hungary*.

Introduction: The major mass extinctions of taxa both on continents and in Permian oceans were taken place during the greatest extinction level of the geologic history of our planet ∼250 Myr ago. It is manifested by the Permo-Triassic (P/Tr) boundary [1-10]. However, our knowledge is fuzzy relating the quintessential causes of this global catastrophe of life on our planet. The *spherula stratigraphy* could be a useful method to study the past history of the Solar System in finer temporal resolution as it was suggested by [11]. It was concluded earlier that the microspherules found in the P/Tr boundary cannot be associated with impact events or other associated processes [12]. The microspherules in Japan and China P/Tr samples were analysed applying PIXE method have shown that their chemical composition show that they origin is interstellar [13–17]. We give here a brief summary on our new analyses of cosmic spherules extracted from geologic samples found in Hungary in the P/Tr.

Laboratory analysis of spherules from P/Tr boundary: The P/Tr geologic- and biostratigraphic boundary is really a remarkable visible feature. of The most prominent geologic sites of P/Tr boundary in Hungary contain a litologically sharp boundary: the black fauna-rich, i.e. the characteristically Permian fossil layers suddenly alter into a much more light-grey coloured carbonate rocky geologic feature in which the Permian fossils have presented yet but with a very rapidly diminishing occurence until few meters (maximum ten meters) in thickness and after it the Permian fossils extint (in the early-Triassic). The boundary between the strata of black fossils and the light-grey coloured carbonate rock is very sharp. It is very important: at about one meter above the black coloured end-Permian boundary layer a *sharp and remarkable spherula layer* presents (its thickness is about few centimeters only). Thus the P/Tr boundary manifests itself by definite, sharp narrow geologic and biostratigraphic boundary level as well as a sharp and narrow spherula layer allowing to determine a sharper geochronology. The preliminary analyses of the microspherula rich P/Tr samples collected in Hungary also confirmed the interstellar origin [11,18]. >Recently new careful analyses were carried out by PIXE method. Two principal sampling sites of the P/Tr spherules in Hungary are adequate for the laboratory studies: (1) *Gerennavár* and (2) *Mt. Bálvány* in the *Bükk* mountains in Northeast of the country. These samples from the P/Tr boundary were embedded in limestones and this closed cherty environment excluded any later natural and industrial impurities. In this work we report the results obtained from PIXE analysis of the (1) sampling site and the results of (2) sampling site will be published later. Three subsamples of the (1) site were studied and these were denoted as G I/1/1, G I/1/2 and G I/2. The samples can be divided into two morphologically different types: spherical-shaped and plate-shaped "spherules". Proton-beam with energy of ∼MeV was applied to study spherules with micro-PIXE analysis. a The careful study of correlation between the penetration depth and information content yielded self-consistent PIXE results. All subsamples from the (1) sampling site show strong concentrations in Fe, Ni and Zn; with some Al, Si Cu, Sn and Pb. The very important fact that the cc. of the Ni is significant: it has more than 2.25±0.17%, thus these spherules are extraterrestrial. The aluminium- and trace-element composition prove the interstellar origin. However, in some subsamples the interplanetary (Solar System) origin is revealed from the No. (1) samples but the majority of samples show interstellar origin.

Discussion and conclusions: What caused the spectacular extinctions of taxa at the end of the Permian period? It is obvious that the P/Tr boundary is a consequence of complexity of various events. Connecting the strange chemical composition changes of gases (superanoxia, enrichment of carbon dioxide) both in the atmosphere and sea some authors considered the models of enormous volcanic activities as flood-basalt volcanism [19,20]; sea-floor volcanism, global climatic changes. Otherwise it is obvious that the orogenic porcesses had been damped until the end-Permian period [21]. At this point the study the microspherules found in the P/Tr boundary helps to understand the situation. The possibility of the extraterrestrial impact events as explanation of the end-Permian mass extinctions were supported by discovering some shocked quartz grain in P/Tr [8,22]. However, there is an obvious difference between the known truly shocked quartz, which is riddled with thin, straight parallel planar structures called deformation features (PDFs). Similar features can be observed in the P/Tr quartz but doesn't show as clearly as in a truly shocked grain. However, it is interesting that both the P/Tr and K/T events belong to the same cosmic cycle of periodicity: so-called shorter Holmes cycle with a characteristic period around 30 Myr [23,24]. Obviously, an impact related extinction would have happened in a geologic instant but the consequences of a heat shock should be found in P/Tr layer as fossil wild fire both in the cases of continental and oceanic impacts because of the hight temperature generated in the impact event(s). In spite of the remarkable, chronologically sharp definite P/Tr boundary this rather corresponds to a longer interval than a shorter impact event on the geologic time scale. Of course, it cannot be excluded the existence of impact events created shocked quartz grains but these impacts did not cause the P/Tr mass extinctions. Although most of the old terrestrial impact craters with age of 250 Myr eroded but there is no traces of relicts of significant impact craters from the P/Tr. The effects of the supernovae in the interstellar dust grains were summarized by [25]. We quote here our former arguments [26] that the big P/Tr crisis of life on Earth is the consequence of explosion of a nearby supernova, which could be the cause “silent" mass extinction changing the atmospheric chemistry and climate (e.g. dry climate) without enormous orogenic or impact events. This could be due to the enhanced radiation level and radiation induced changes in the environment as well as induced biologic mutations (accomodation problems of mutants). The enormous electromagnetic energy and corpuscular particle output of a supernova reaching the terrestrial environment could be the source of dramatic changes in the atmosphere. The supernova explosion could generate other terrestrial paleoenvironmental effects [27,28]. These can be identified in sediments [28]; and also studied by ^{210}Pb–^{226}Ra methods due to the effects of thermoluminescence as described by [30], however, these methods were applied for sediments influenced by holocene or historical and distant supernova explosions. How can the spherules relate to the supernova event? Thousand – few thousands of years after of a very nearby supernova explosion the expanding interstellar gas and dust can reach and penetrate into the heliosphere. The interstellar dust can be moved away by supernova shock wave front and the dust grains both can be created and destructed by the expanding supernova shell. The moving dust grains can be sources of that interstellar dust which collided with the atmosphere of Earth and sedimented into geologic layers as spherules. Recent spacecraft detections of the high velocity interstellar dust particles [31] support the possiblity of the atmospheric penetration and spherula-forming processes related to these micrometeoroids. The former studies of spherules performed in Japan revealed the interstellar spherules in the P/Tr boundary. The recent studies of morphology and chemical composition of P/Tr spherules which were collected in Hungary support the idea of a nearby supernova explosion in the P/Tr thus we prefer this to explain the catastrophic P/Tr mass extinctions.

References: [1] Rampino and Stothers (1984) *Science* 226, 1427-1431. [2] Erwin (1994) *Nature (London)* 367, 231-236. [3] Kerr (1995) *Science* 270, 1441-1443. [4] Knoll et al. (1996) *Science* 273, 452. [5] Martin (1996) *Science* 274, 1549-1550. [6] Vermeij and Dorritie (1996) *Science* 274, 1550. [7] Monastersky (1997) *Science News* 151, 74-75. [8] Retallack and Holse (1997) *Science* 277, 1748-1749. [9] Isozaki (1997) *Science* 276, 235-238. [10] Isozaki (1997) *Science* 277, 1748-1749. [11] Detre et al. (1997) *LPSC 28th*, NASA/LPI, Houston, 297-298. [12] Yin et al. (1994) *Albertiana* 14, 15-31. [13] Miono et al. (1993) *Nucl. Instrum. Methods in Phys. Res.* B75, 435-439. [14] Miono (1996) *Internat. Meeting on Spherules and Global Events* KFKI Rep. 1995-05/C, Budapest, 23-24. [15] Miono et al. (1996) *Nucl. Instrum. Methods in Phys. Res.* B109, 612-616. [16] Miono and Chengzhi (1997) *An Internat. Meeting of the IGCP 384*, 1997, Eger, Hungary. *Spaerula No. 2*. Submitted. [17] Miono et al. (1997) *Sphaerula No. 2*. Submitted. [18] Szarka (1995) *Internat. Meeting on Spherules and Global Events* KFKI Rep. 1995-05/C, Budapest, 83-98. [19] Rampino and Stothers (1988) *Science* 241, 663-668. [20] Renne and Basu (1991) *Science* 253, 176-178. [21] Holser and Shoenlaub (1991) *Abhandl. d. Geol. Bundesanstalt*, Band 45, Wien, 1-232. [22] Retallack et al. reported by Kerr (1996) *Science* 274, 1080. [23] Clube and Napier (1986) *The Galaxy and the Solar System*, eds. Smoluchowski et al., Univ. of Arizona Press, Tucson, pp. 260-285. [24] Rampino and Haggerty (1996) Earth, Moon, Planets, 72, 441-460. [25] Anders and Zinner (1993) *Meteoritics* 28, 490-514. [26] Toth (1997). *Terrestr. Impacts and Spherule Sympos.* (TISS) 1997, Tokyo. *Sphaerula No. 3*. Submitted. [27] Shklovskii (1966) *Supernovae*. New-York: Wiley-Interscience Publ. John Wiley and Sons. [28] Aikin, Chandra, and Stecher (1980) *Planet. Space Sci.* 28, 639. [29] Brakenridge (1981) *Icarus* 46, 81-93. [30] Cini and Bonino (1982) *Il Nuovo Cimento* 5, 488-494. [31] Dubin and Soberman (1997) *Astrophys. J.* Submitted.