THE ANTONIN L5 CHONDRITE FALL (POLAND): MINERALOGY AND PETROLOGY OF METEORITE, BOLIDE TRAJECTORY AND METEOROID ORBIT.

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Fireball observation and meteorite recovery: Three video cameras of the Czech part of the European Fireball Network recorded a daylight fireball on July 15, 2021. The whole fireball flew over the territory of Poland. The fireball was first detected at 3:00:11 UT at an altitude of 74 km and its trajectory had a slope of 53 degrees to the surface. The last detection was after 3.6 seconds at an altitude of 25 km. Even though the final part of the bolide was not recorded by the cameras, as the bolide flew behind the clouds or it was out of the field of view, the meteorite fall was very probable, since at the last detected point the fireball still had a velocity of about 13 km/s and the dynamic mass of the order of few tens of kilograms. The predicted fall area's coordinates were made public and soon after, on 3rd of August, one piece of meteorite was recovered, exactly in the predicted fall location for a given mass. The specimen was 352 g in mass, almost fully crusted by thick fusion crust. So far, no further specimens have been recovered.

Cosmogenic nuclides analysis: The recovered meteorite (before any subsampling) was tested for the presence of short-lived isotopes in order to verify time of its fall and connection to fireball event. The whole meteorite investigation was conducted with non-destructive methods of gamma-ray spectrometry. Two series of measurements were carried out 28 days after the meteorite fall and the results were converted to the day of meteorite fall. Twelve distinct short- and medium-lived cosmogenic isotopes were detected at the uncertainty level in the range of 6% to 8%. Most important, traces of the radionuclides with the half-life in range of 15-30 days were detected in the sample: ^{48}V (15.97 days of half-life) and ^{51}Cr (27.70 days). Both radionuclides indicate that the recovered meteorite is, indeed, fresh fall and has terrestrial age roughly one month before the time of analysis. This clearly confirms connection of recovered specimen with fireball-related fall event.

Petrology and geochemistry: The recovered meteorite represents ordinary chondrite, and has been classified as L5 chondrite of moderate shock index, S3. Classification and petrographic investigation of recovered specimens was performed with optical microscopy and electron microscopy. Chemical composition of minerals was analyzed with EPMA. Antonin is very well equilibrated chemically, but less equilibrated texturally. Many chondrules and glassy mesostasis are retained in the sample. Crystalline plagioclase is rare, and, if present, the crystals are smaller than 50 μm. Despite low degree of textural equilibration, minerals are chemically very homogeneous: olivine has content of Fa in range of 23.9–25.1mol%, and low-ca pyroxene shows the range of composition of 20.4–21.9mol% Fs and 0.7–2.0mol% Wo across the sample. Among opaque minerals, the major one is taenite with 29.9–36.5wt% Ni and 0.12–0.45wt% Co. Kamacite has 6.6wt% Ni (6.1–7.1wt% Ni) and 0.72wt% Co (0.49–0.85 wt%). No tetrataenite was identified.

The meteorite is apparently weakly to moderately shocked and unbrecciated. Olivine crystals reveal undulose extinction of light and minor planar fracturing. However, many textural features are present that indicate role of local shock melting at contacts of minerals of contrasting densities. Shock melt pockets, a few hundred micrometers in size, are very abundant at contacts of metal and plagioclase or troilite and plagioclase. Many metal grains show structure of plessitic intergrowths and majority of troilite grains are visibly porous. Unusual for ordinary chondrite, quite abundant in Antonin are metal-sulfide assemblages conatining patchy Ni-bearing sulfide. In these assemblages, Ni-rich and Ni-poor sulfide domains, tens of micrometers in size, are present. Ni-poor parts are compositionally similar to bulk rock troilite, having up to 0.5 wt% Ni and trace amount of Co and Cu (i.e., pyrrhotite with formula Fe_{1-x} S, where x=0.03–0.04). Ni-rich phase, mackinawite has up to 17wt% Ni and shows formula of $(Fe,Ni)_{1+x}$ S, where x=0.08–0.10.

Size of meteoroid and orbital elements: The initial mass of the meteoroid, based on the fireball observation, is determined to be between 50 and 100 kg, which corresponds to a radius of sphere of about 15-20 cm. Isotopic measurements by gamma-ray spectrometry match perfectly this determination, indicating pre-atmospheric radius in the range of about 20–25 cm. Before impact, the meteoroid orbited the Sun in an elliptical orbit with small semimajor axis (1.13 AU) and eccentricity (0.23), but with a relatively large inclination of 24.2 degrees to the orbital plane of the planets. The orbital elements are different from known other orbits of L chondrites. More details will be presented during the meeting and discussion about interpreted parent body features will be provided.