A NEW PETROLOGICAL STUDY OF NYÍRÁBRÁNY, AN ORDINARY CHONDRITE FROM HUNGARY. M. Mészáros[1], Z. Ditrói-Puskás[1], T. Váczi[2], Á. Kereszturi[3]. [1]Dept. of Petrology and Geochemistry, Eötvös Loránd University of Sciences, [2]Dept. of Mineralogy, Eötvös Loránd University of Sciences [3]Research Center of Astronomical and Earth Sciences, Konkoly Astronomical Institute. E-mail: m.mariann13@gmail.com .

Introduction: The Nyírábrány meteorite fell on 17th of July, 1914 in Hajdú-Bihar County, Hungary (N 47º33' E 22º1.5') [1] and was named after the village in the vicinity where it fell. The meteorite was recovered as a single stone with mass of 1104 g (Figure 1.) [1]. According to a previous study [1] it was classified as an LL5 brecciated ordinary chondrite.

The first investigation on Nyírábrány was carried out more than 30 years ago [1]. At that time no advanced instrumental analysis methods were available, the chemical composition of the main silicate phases (e.g. olivine, pyroxenes) was determined by optical methods. In 2004 [2] re-investigated Nyírábrány with five other meteorites from the Carpathian Basin, but no detailed analyses were made.

The aim of this work was to carry out a more detailed study of Nyírábrány and re-investigate its classification as an LL5-type ordinary chondrite, moreover to complete the classification with a shock stage as defined by [3] and a weathering grade according to the weathering scale of [4].

Figure 1. Image of the Nyírábrány meteorite section

Methods: We used a thin section of Nyírábrány for the optical microscopic analysis to identify the main mineral phases and chondrules, and to observe their textural features. For the SEM-EDX investigation we used the same thin section to determine the chemical composition of the minerals, to identify minor components and examine the textural features in details. The same thin section was used also for Raman microspectroscopy to estimate the degree of shock metamorphism of the meteorite.

Results: The main mineral phases in Nyírábrány are olivine, pyroxenes, plagioclase and opaque minerals (Fe-Ni, troilite and chromite). Minor amounts of cristobalite and Cl-apatite were also identified in the meteorite, as well as small amounts of recrystallized glass in some of the chondrules. The presence of cristobalite and its texture indicates that the cristobalite-bearing chondrule in Nyírábrány could have experienced a temperature as high as ~2000 K [5], while the presence of Cl-apatite could be the evidence that halogen-rich fluids affected the chondritic material on the parent body [6]. Refractory inclusions in Nyírábrány were not identified.

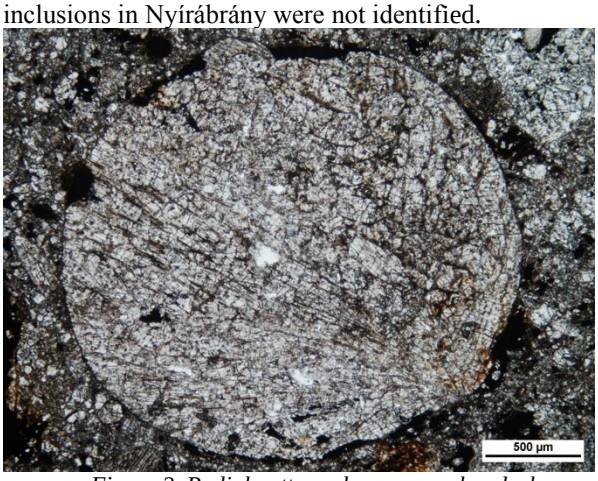

Figure 2. Radial patterned pyroxene chondrule

The chondrules appear in diverse sizes (Figures 2., 3.), mineralogical compositions and textures, like porphyritic olivine, radial pyroxene, poikilitic olivine-pyroxene and barred pyroxene chondrules. In some cases chondrules are well-defined, in other cases they are completely diffuse which makes difficult to define their exact abundance. The size of well-defined chondrules varies from a few 100's µm to about 2 mm. Some of the chondrules are broken.

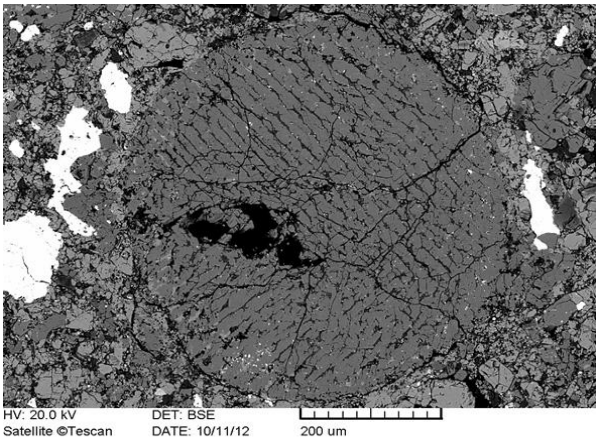

Figure 3. BSE image of a barred pyroxene chondrule

Sztrókay et al. [1] classified Nyírábrány as an LL5 ordinary chondrite. The results of this study showed that it cannot be clearly classified as an LL-type chondrite because it shows some features that are typical of L-chondrites:

- Previously [1] measured 3.47 wt% Fe-Ni-metal content which is typical of the LL-type. This observation was confirmed by the current measurement of 1.32 vol% metal content.
- Based on our investigation the average Fa-content of olivines is 26.7 mol%, while previous studies measured 25 mol% [1] and 27-28 mole% [2]. These data suggest that Nyírábrány is a transition type between L and LL chondrites.
- The average Fs-content of low-Ca pyroxenes is 20.5 mol%, which is typical of L-chondrites.

Discussion: According to these chemical features (Table 1.) we concluded that Nyírábrány is an L/LL-type ordinary chondrite. For an exact classification a more detailed investigation is needed, including trace element measurements and oxygen-isotope analyses.

Chemical composition		Type of OC
Fe-Ni (vol%)	1.32	LL
Fa (mol%)	26.7	L/LL
Fs (mol%)	20.5	L

Table 1. Main chemical features of Nyírábrány

On the basis of the petrological type scheme of [7] Nyírábrány was classified as a type 5 ordinary chondrite [1]. Kubovics et al. [2] described Nyírábrány as a heterogeneous meteorite, which includes fragments of different petrological types. Our investigation confirmed this observation and we concluded that Nyírábrány can't be exactly classified as a type 5 ordinary chondrite, because some of its features indicate a weaker thermal metamorphism:

- The composition of plagioclase [8] and the presence of augite [9] preclude petrological type 6.
- All the olivines and the majority of pyroxenes are homogeneous, the inhomogeneity of zoned pyroxene-crystals is usually less than 5%, which indicates petrological type 4.
- The majority of chondrule pyroxenes are monoclinic, which is typical of petrological type 4.
- The majority of chondrules contain only a small amount of recrystallized glass, which indicates petrological type 4-5.
- Some chondrules are well-defined, while others are diffuse, which indicates petrological type 5.
- The matrix is crystalline, it is composed of different sizes of mineral grains, which is typical of petrological type 4-5.

We also studied the degree of shock metamorphism of Nyírábrány according to the criteria of shock stages as defined by [3]. We observed the following optical features of olivines: sharp optical extinction in all of the grains, irregular and planar fractures (Figure 4.). No undulatory extinction was observed even in the planar fractured crystals. On the basis of these features Nyírábrány is an S2 ordinary chondrite. This observation was supported by the Raman microspectroscopic investigation of the olivines. A small band broadening was measured both at the 820 cm^{-1} and the 850 cm^{-1} band positions compared to the unshocked terrestrial reference, which confirmed that Nyírábrány experienced a very low (S2) degree of shock metamorphism.

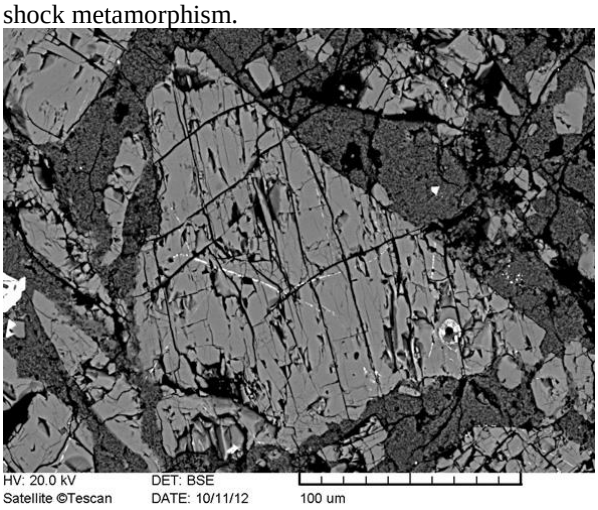

Figure 4. Planar fractured olivine crystal in a porphyritic olivine chondrule. BSE image.

On the basis of Wlotzka's weathering scale [4], the oxidation state of opaque minerals indicates a weak terrestrial weathering (W2) for Nyírábrány.

Conclusion: According to the chemical, mineralogical and textural features Nyírábrány can be classified as an L/LL4-5S2W2 ordinary chondrite.

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