STUDY OF THERMAL METAMORPHISM OF CHONRITES BY DIFFUSIONAL FADING OF CHONDRULE RIMS OF ANTARCTIC NIPR METEORITE SAMPLES. T. N. Varga[1], Sz. Bérczi[1], T. P. Varga[2], [1]Eötvös University, Institute of Physics, H-1117 Budapest, Pázmány P. sétány 1/a. Hungary (vargatn@caesar.elte.hu, bercziszani@ludens.elte.hu,), [2]VTPatent Kft. H-1111 Budapest, Bertalan L. u. 20. Hungary, (info@vtpatent.eu)

Introduction: We studied the diffusion process in four Antarctic meteorite samples (L3 L4 L5 L6 chondrites) from the Japanese NIPR institute, and also compared them with samples of different origin: Mezőmadaras (L3), Knyahinya (L5), and Mócs (L6). In the van Schmus Wood petrologic classification series the diffusion rim is an important criterion in determining the state of thermal metamorphism. In this study our goal was to determine the diffusion process of the thermal metamorphism from the clear rim to the very diffuse one. By following the process of the heating of small bodies during the calculation of diffusion lengths, we could also approximate the possible duration of the process.

Theoretical background: In the texture of chondritic meteorites there are circular objects, known as chondrules. These texture elements can be found with clear edges, or with varying degrees of diffuse rim in different chondritic meteorites. During the thermal metamorphism inside meteorites, the Mg-Fe, the Mg-Ca and the Fe-Ca diffusions are among the most significant processes [1,2,3].

In this study we examined which diffusion process can describe the gradually disappearing rim of the chondrules, and how can this process be studied with optical microscope and a parallel calculation of the blur caused by the diffusion migration.

The chondrules consist of mainly olivine, pyroxene and also smaller amounts of feldspar and FeNi [4]. In these minerals we studied the diffusion in the olivine and pyroxene. The diffuse rims of chondrules were thus examined by the comparison of two different approaches.

Experimental procedure With optical microscopy the thickness of the diffusion rims (remnants of the original sharp rim) can be approximated.

L3 chondrite - Yamato 74191. Well developed chondritic texture. It contains mainly chondrules from olivine and pyroxene, and a devitrified brown glass also occurs (Fig. 1).

L4 chondrite - Yamato 74355. Chondritic texture with well developed chondrules of olivine and pyroxene (Fig. 2).

L5-6 chondrite - Yamato 790957. Less well defined chondrules, mainly from pyroxenes (Fig. 3.)

L6 chondrite - Allan Hills 769**.** Chondritic texture, poorly defined chondrules. In a large pyroxene grain olivine inclusions can be found, the pyroxene grain itself is also surrounded by olivine grains (Fig. 4.)

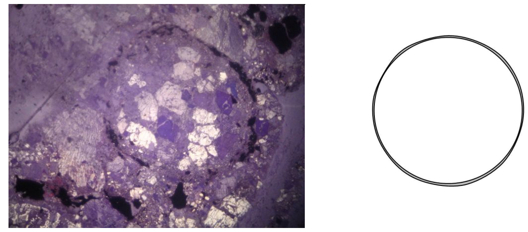

Fig. 1. *Chondrule from Yamato 74355. (L3)*

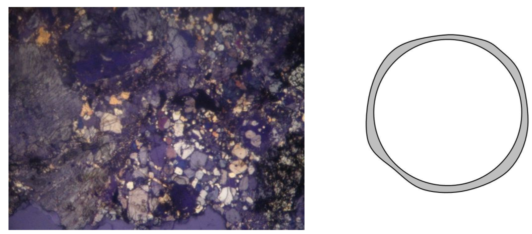

Fig. 2. *Chondrule from Yamato 74355. (L4)*

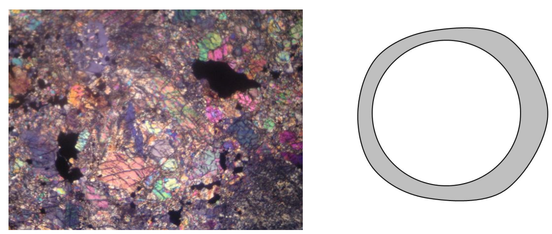

Fig 3. *Chondrule from Yamato 790957. (L5-6)*

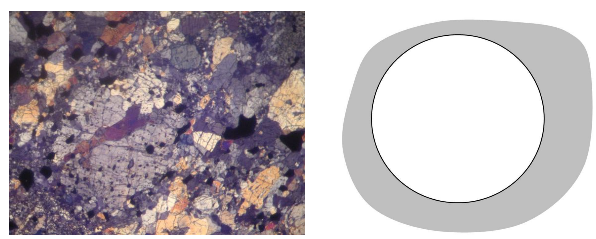

Fig. 4. *Chondrule from Allan Hills 769. (L6)*

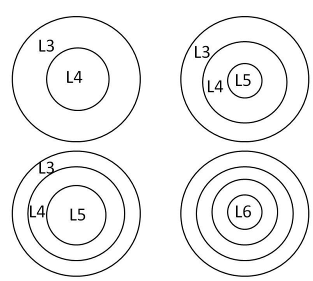

Fig. 5. *The distribution of petrological classes in the L parent body during its evolution (Onion shell model)*

Comparison: To understand the process to a fuller extent, the available Hungarian L chondrites were also examined. These samples are: Mezőmadaras L3.7 (Fig. 6.), Knyahinya L5 (Fig. 7.), Mócs L6 (Fig. 8, 9).
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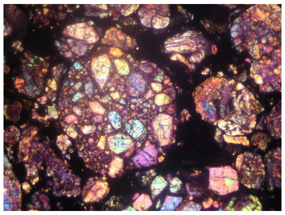

Fig 6. *sample L3.7*

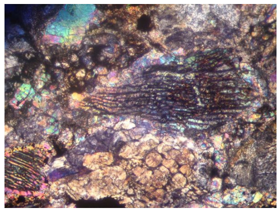

Fig. 7. *sample L5*

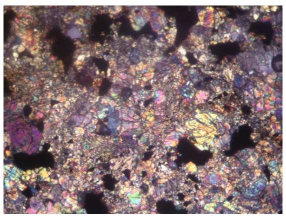

Fig. 8. *sample L6*

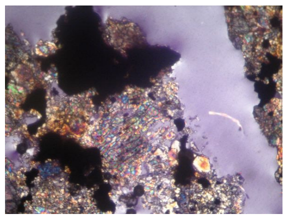

Fig. 9. *sample L6*

Our results: On one hand the broadening of the chondrule rims were observed, in fact this was done to approximate the possible inaccuracies in determining the rim size On the other hand, from theoretical considerations we gave approximations to the average diffusion lengths of the atoms in the heated material, in a given time.

This diffusion length is proportional to the time and temperature. We calculate the distance covered by different elements (Fe, Mg, Ca) in different minerals at different temperatures.

Estimation of diffusional length The equation for the length of diffusion is: $L^2 = D^*t$, where $L=\sqrt{D\cdot t}$, D is the diffusion constant, t is time [5]. The two different sets of data were compared, and from this comparison some interesting problems can be formulated.

By approximating (measuring) the vagueness of chondrule rim, in chondrites sorted according to the van Schmus Wood metamorphism series, we could approximate the time required for the different stages.

Time:	1 My	2 My	5 My	10 My	
Olivine	1.5mm	2.2mm	3.6mm	4,9mm	Fe-Mg
Pyroxene	1.4mm	1.9mm	3.0mm	4.3mm	Mg-Fe

Table 1. *The change of diffusion length in different minerals, depending on time.*

Knowing the temperature of the states of the van Schmus Wood series, the calculated data can be used to scheme the time series of the heating of the chondritic body.

Chondrite type	L3-L4	L4-L5	L5-L6	elements
Rim thickness	3 μm	7 μm	12 μm	--
Required time (pyroxene)	0,2y	1,2y	3,7y	Mg-Fe
Required time (olivine)	0,3y	1,4y	4y	Fe-Mg

Table 2 *The time required for given distance in olivine (and with different constants in pyroxene) T= 1220 K*

Considering the different diffusion speeds in different minerals, it is recognizable that in chondrules the pyroxenes reach the equilibrium state faster than the olivines.

The time available in small bodies, approximately 5-10 million years is enough for most of the chondrules to disappear and thus the material of the small body can become primitive achondritic in the most heated zones.

Conclusion: The presented measurements and calculation can enhance the sense of scale required to understand the time and spatial scale of diffusion processes which changed the materials of small bodies.

Acknowledgement: Authors express their thanks to Prof. Hideyasu Kojima (NIPR Institute, Tokyo, Japan) for the loan of the Antarctic samples.

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