THERMOLUMINESCENCE STUDIES OF CARBONACEOUS CHONDRITES

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INTRODUCTION: Carbonaceous chondrites are similar to type 3 ordinary chondrites in several respects [1]. The groups are mineralogically very similar, consisting of olivine, pyroxene, plagioclase, metal and sulfide. Like the ordinary chondrites carbonaceous chondrites appear to constitute a metamorphic sequence [2-4]. However, they differ also from ordinary chondrites in several respects. Carbonaceous chondrites are isotopically different [5, 6], element ratios show small but significant differences [7, 8]; they contain refractory inclusions, [2, 9]. Unlike type 3 ordinary chondrites, carbonaceous chondrites contain often primary calcic feldspar [10], presumably associated with the refractory inclusions. Keck and Sears [3] found that the thermoluminescence (TL) sensitivity of the 110-120°C peak increases by a factor of 100 with increasing the metamorphism grade, while the TL sensitivity of a second TL peak at 230°C is not metamorphism-dependent. They suggested that the first peak is related to feldspar formed by devitrification of chondrule glass, a situation analogous to that of type 3 ordinary chondrites [11, 12], while the 230°C peak is due to primary (i.e. non-metamorphic) feldspar, perhaps associated with refractory inclusions.

Compositional equilibration between refractory inclusions and ferromagnesian components, and homogenization of matrix olivines, suggest that the CV chondrites suffered various levels of parent-body metamorphism [13-15]. Since CV chondrites are represented by oxidized and reduced subgroups, a single metamorphic suite is precluded although two parallel series are possible [13]. The petrographic, mineralogical and bulk compositional differences among CV chondrites indicate that the TL sensitivity of the ~ 110-130 °C TL peak reflects the abundance of ordered feldspar, especially in chondrule mesostasis, and reflects, therefore, parent-body metamorphism [16].

The purpose of the present paper was to study carbonaceous chondrite metamorphism using the TL-device of the Vernadsky Institute and the scaling procedure proposed by [1, 16].

EXPERIMENTAL: The measurements of TL induced by X-rays were carried out for 21 carbonaceous chondrites. Nine CO3, eight CV3 and four CK chondrites were studied. Samples weighing from 0.7 g up to 1.0 g were crushed and powdered in a jasper mortar. Then a magnetic fraction was removed from the powders using a manual magnet. Three 2 mg aliquots of each non-magnetic fraction were measured using the TL device. After measurements of natural TL (the heating up to 500 ^{O}C), the samples were irradiated with X-rays for two minutes and then induced TL was measured. The experimental procedures have been described in more detail earlier [17-19].

RESULTS AND DISCUSSION: The results of induced TL measurements are given in Table, where I_{TL} is the TL peak height at the temperature of about 130 ^{O}C. The values of I_{TL} were normalized to I_{TL} of the Dhajala chondrite (I_{TL} Dhahala = 1). The subtypes determined by this study and others [1, 16] are shown also in the table. The star symbol (*) marks the recommended petrographic type. The glow curves of TL of CO, CV and CK meteorites of different types - are shown on Fig. 1. The majority of investigated chondrites have a composite shape of glow curves with peaks in the temperature range of 110-130 ^{O}C. There are also some peaks at > 150^{O}C. However Coolidge is different from others. It shows only two peaks at ~ 130 ^{O}C and ~ 150 ^{O}C (Fig. 2). Such shape of TL peaks is most typical for glow curves of ordinary chondrites. The chondritic subtypes obtained in this study and determined by [1, 16] for the same meteorites coincide very well (Table, Fig. 3) and, therefore, the method applied in our laboratory is suitable for determination of the metamorphic grade of carbonaceous chondrites.

Here we report first the subtypes of Acfer 202, Dar al Gani 078, and Dar al Gani 303 CO chondrites, the SaU 085 CV chondrite, and the Dhofar 535 ungrouped chondrite (Table). The obtained subtypes do not conflict with results of petrographic and other investigations. In addition, subtypes of Dhofar 015 (CK3), Ningqiang (CK – ungr), Karoonda –(CK4), and Maralinga –(CK4) were first determined. The obtained results indicate that CK chondrites are unique among carbonaceous chondrites. They demonstrate no detectable induced TL. It confirms mineralogical data on very unusual feldspar occurring in these meteorites.

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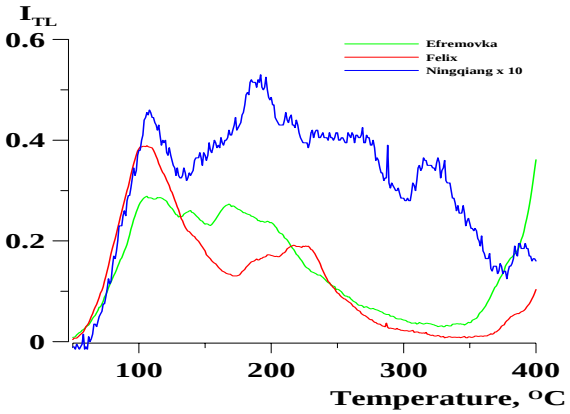


Fig. 1. Glow curves of CO, CV, and CK chondrites.

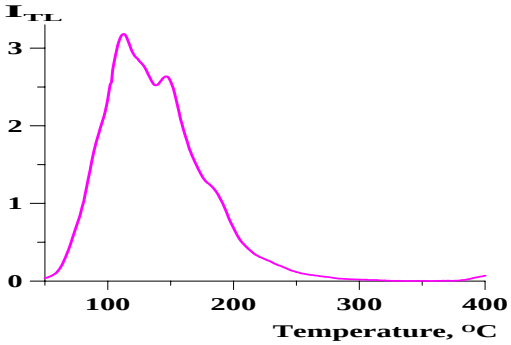


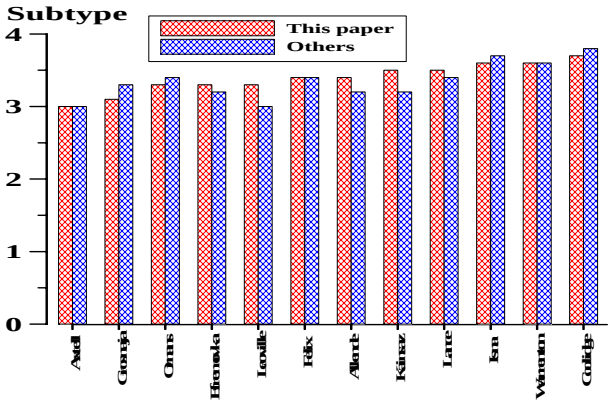
Fig. 2. Glow curve of Coolidge CV chondrite.

Table. Observed results of a peak height (I_{TL}) of glow curves (130 ^{O}C) and degree of metamorphism carbonaceous chondrites.

Meteorite	Type	I_{TL} (I_{TL} Dhajala=1)	Subtype	
			This paper	Others
Felix	CO	0.106	3.4	3.2-3.5 (3.4*) [1]
Isna	CO	0.356	3.6	3.6-3.8 (3.7*) [1]
Kainsaz	CO	0.245	3.5	3.1-3.5 (3.2*) [1]
Lancé	CO	0.200	3.5	3.4-3.7 (3.4*) [1]
Ornanć	CO	0.077	3.3	3.3-3.6 (3.4*) [1]
Warrenton	CO	0.342	3.6	3.5-3.8 (3.6*) [1]
Allende	CV	0.145	3.4	3.1-3.6 (3.2*) [16]
Axtell	CV	0.008	3.0	3.0-3.3 (3.0*) [16]
Coolidge	CV	0.913	3.7	3.8->3.8 (3.8*) [16]
Efremovka	CV	0.070	3.3	3.0-3.6 (3.2*) [16]
Grosnaja	CV	0.022	3.1	3.0-3.3 (3.3*) [15]
Leoville	CV	0.060	3.3	3.0-3.6 (3.0*) [16]
Acfer 202	CO	0.079	3.3	3.5 [20]
DAG 303	CO	0.044	3.2	—
DAG 078	CO	0.059	3.3	—
Dhofar 535	Ungr.	0.030	3.2	—
SaU 085	CV	0.171	3.5	—
Dhofar 015	CK	0.212	3.5	—
Karoonda	CK	0.008	3.0	—
Maralinga	CK	0.013	3.0	—
Ningqiang	CK	0.029	3.1	—

(*) - Recommended petrographic type.

Fig. 3. Comparison of observed data of a



metamorphism degree of carbonaceous meteorites investigated in different labs.