THE METAMORPHIC HISTORY OF CO AND CV CHONDRITES INVESTIGATED BY THE THERMOLUMINESCENCE METHOD A.I. Ivliev, N.S. Kuyunko, A.Ya. Skripnik, and M.A. Nazarov
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INTRODUCTION The CO chondrites are similar to type 3 ordinary chondrites in several respects [1]. They are both chondritic in bulk composition, with non-volatile elemental abundances generally within about 30% of the CI values. Thus the two groups are mineralogically very similar, consisting of olivine, pyroxene, plagioclase, metal and sulfide. Like the ordinary chondrites the CO chondrites appear to constitute a metamorphic sequence [2-4]. However, they also differ from ordinary chondrites in several respects. They are isotopically different [5, 6], element ratios show small but significant differences [7, 8], they contain refractory amoeboid inclusions, and their chondrules are smaller [2, 9]. Unlike type 3 ordinary chondrites, CO chondrites often contain primary calcic feldspar [10], presumably associated with the refractory inclusions. Keck and Sears [3] also found that the thermoluminescence (TL) sensitivity of the (110-120)°C peak increased by a factor of 100 with increasing metamorphism, while the TL sensitivity of a second TL peak at 230°C was not metamorphism-dependent. They suggested that the first peak was caused by feldspar formed by devitrification of chondrule glass, a situation analogous to that of type 3 ordinary chondrites [11, 12], while the 230°C peak was due to primary (i.e. non-metamorphic) feldspar, perhaps associated with refractory inclusions.

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

The purpose of the present paper was to study of CO and CV 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 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 CONCLUSIONS 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 the 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 subtype others Acfer 202, Dar Al Gani 078, and Dar Al Gani 303 CO chondrites, the SaU 085 CV chondrite, and Dhofar 535 ungrouped chondrite (Table). The received 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 metamorphosed chondrites. They demonstrate no detectable induced TL. It confirms mineralogical data on very unusual feldspar occurring in these meteorites.

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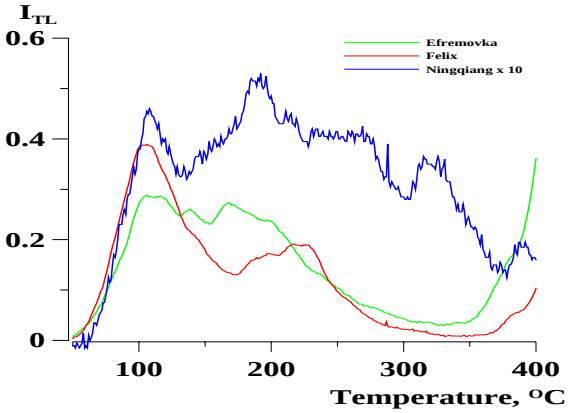

Fig. 1. Glow curves of CO, CV, and CK chondrites.

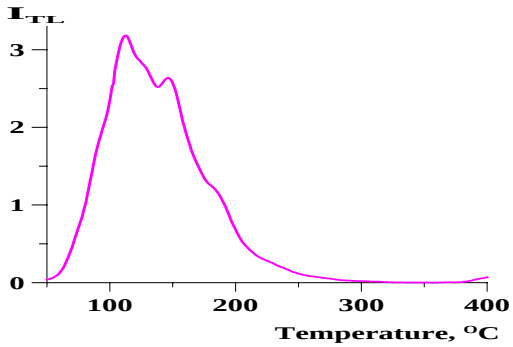

Fig. 2. Glow curve of Coolidge CV chondrite.

Table. Observed results of a peak height (ITL) of glow curves
(130 OC) 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]
Ornané	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.

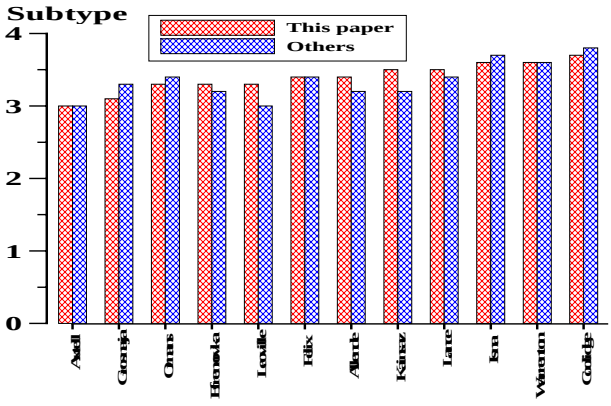

Fig. 3. Comparison of observed data of a metamorphism degree of carbonaceous meteorites investigated in different labs.