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Thermoluminescence and metamorphism of CO and CV carbonaceous chondrites

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The purpose of the present paper was study of metamorphism carbonaceous chondrites on TL-device of GEOCHI RAS with usage of the scale linking value of a subtype to intensity of glow curve TL. These results have shown good coincidence of carbonaceous chondrite subtypes, obtained by us and in other laboratories.

Key words: thermoluminescence, carbonaceous chondrites, metamorphism

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Introduction

The CO chondrites are similar to type 3 ordinary chondrites in several respects [*Sears et al.,* 1991]. 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 [*McSween*, 1977a, *Keck and Sears,* 1987; *Scott and Jones,* 1990]. However, they also differ from ordinary chondrites in several respects. They are isotopically different [*Clayton et al.,* 1976, *Clayton and Mayeda,* 1984], element ratios show small but significant differences [*Anders et al*., 1976, *Kallemeyn, Wasson,* 1981], they contain refractory amoeboid inclusions, and their chondrules are smaller [*McSween*, 1977a, *Rubin,* 1989]. Unlike type 3 ordinary chondrites, CO chondrites often contain primary calcic feldspar [*Van Schmus,* 1969], presumably associated with the refractory inclusions. Keck and Sears [*Keck and Sears,* 1987] 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 [*Guimon et al.,* 1985, *Guimon et al.,* 1988], 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 [*McSween,* 1977b, *Peck,* 1984, *Scott et al.,* 1988]. Since the CV chondrites consist of both oxidized and reduced subgroups, a single metamorphic series is precluded although two parallel series are possible [*McSween,* 1977b]. The petrographic, mineralogical and bulk compositional differences among the CV chondrites indicate 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 [*Guimon R.K., et al.,* 1995].

The purpose of the present paper was study of metamorphism CO and CV chondrites on TL-device of GEOCHI RAS with usage of the scale linking value of a subtype to intensity of glow curve TL, proposed [*Sears et al.,* 1991, *Guimon R.K., et al.,* 1995].

Experimental

The measuring induced by X-rays TL in 21 samples of carbonaceous chondrites carried out, composition which one included following types: CO3 - 9, CV3 - 8 and CK - 4 samples. Samples, is weight from 0.7 up to 1.0 g, were broken up and are crushed to jasper mortar box. The magnetic fraction was removed with the help of a manual magnet. From a non-magnetic fraction was ready till three probes

of each sample is weight on 2 mg. After measuring natural TL (the heating up to 500 ^{O}C), samples were irradiated with X-rays within two minutes and then induced TL was measuring. The device for measuring TL, preparation of samples and requirements of an irradiation are in more detail described in [*Ivliev et al.,* 1995, 1996, 2002].

Results and conclusions

The results of measured induced TL in investigated samples of carbonaceous meteorites are listed in table, where I_{TL} - peak height TL at the temperature of about 130 ^{O}C. The value of I_{TL} was gauged rather I_{TL} of a meteorite Dhajala, assumed for 1. In a column "Others" the boundaries of measuring of a subtype obtained as both TL and other methods [*Sears et al.,* 1991, *Guimon R.K., et al.,* 1995]. By symbol (*) are marked the recommended petrographic type. In a fig. 1 the glow curves of TL of carbonaceous meteorites of different types CO, CV and CK are shown. Large part of the investigated meteorites has the composite shape of glow curves with peaks in the field of temperature: (110-130) ^{O}C and, as a rule, some peaks in field > 150^{O}C. The exception compounds only meteorite Coolidge, shown only peaks in field ~ 130 ^{O}C and ~ 150 ^{O}C (fig. 2). Such shape of TL peaks is most typical for glow curves of ordinary chondrites [*Newton et al.,* 1995].

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*) [*Sears et al.,* 1991]
Isna	CO	0.356	3.6	3.6-3.8 (3.7*) [*Sears et al.,* 1991]
Kainsaz	CO	0.245	3.5	3.1-3.5 (3.2*) [*Sears et al.,* 1991]
Lancé	CO	0.200	3.5	3.4-3.7 (3.4*) [*Sears et al.,* 1991]
Ornanć	CO	0.077	3.3	3.3-3.6 (3.4*) [*Sears et al.,* 1991]
Warrenton	CO	0.342	3.6	3.5-3.8 (3.6*) [*Sears et al.,* 1991]
Allende	CV	0.145	3.4	3.1-3.6 (3.2*) [*Guimon R.K., et al.,* 1995]
Axtell	CV	0.008	3.0	3.0-3.3 (3.0*) [*Guimon R.K., et al.,* 1995]
Coolidge	CV	0.913	3.7	3.8->3.8 (3.8*) [*Guimon R.K., et al.,* 1995]
Efremovka	CV	0.070	3.3	3.0-3.6 (3.2*) [*Guimon R.K., et al.,* 1995]
Grosnaja	CV	0.022	3.1	3.0-3.3 (3.3*) [*Scott et al.,* 1988]
Leoville	CV	0.060	3.3	3.0-3.6 (3.0*) [*Guimon R.K., et al.,* 1995]
Acfer 202	CO	0.079	3.3	3.5 [*Newton et al.,* 1995]
Dar Al Gani 303	CO	0.044	3.2	—
Dar Al Gani 078	CO	0.059	3.3	—
C4V3 N13^{+}	CV	0.030	3.2	—
CVII-3^{+}	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	—

+ - Working title of a meteorite.
(*) - Recommended petrographic type.

For check out of device and the procedures of examination of a degree of metamorphism carbonaceous chondrites were carried out measuring in 12 meteorites, samples which one coincide with studied in papers [*Sears et al.,* 1991, *Guimon R.K., et al.,* 1995]. These results, reduced in the table and in a fig. 3, have shown good coincidence of carbonaceous chondrite subtypes, obtained by us and in other laboratories. The obtained results testify that the method of TL measurement, applied by us, is suitable for study of a degree of metamorphism carbonaceous chondrites. On this basis the subtypes three CO chondrites were studied: Acfer 202, Dar Al Gani 078, Dar Al Gani 303, taking place in a collection of

meteorites GEOCHI RAS, and two CV chondrites recently entered a collection: C4V3 N13 and CVII-3. The received values of subtypes are well compounded with the data of petrographic and other investigations. Besides, the measurings in four samples CK chondrites are carried out: Dhofar 015 -CK3, Ningqiang - CK - ungr: Karoonda - CK4 and Maralinga -CK4. The obtained results indicate, that the CK chondrites are unique among metamorphosed chondrites in showing no detectable induced TL, which is consistent with literature data that suggests very unusual feldspar in these meteorites.

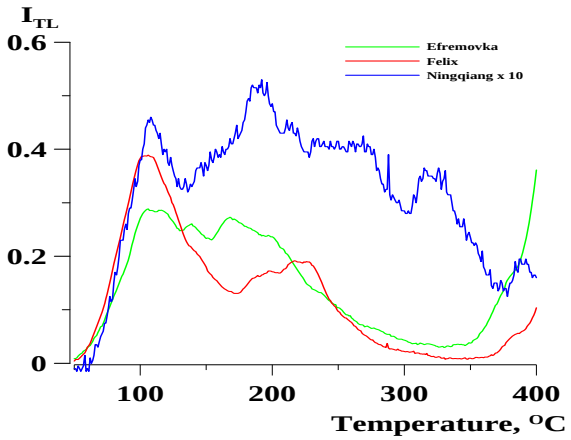

Fig. 1. Glow curves of CO, CV, and CK chondrites

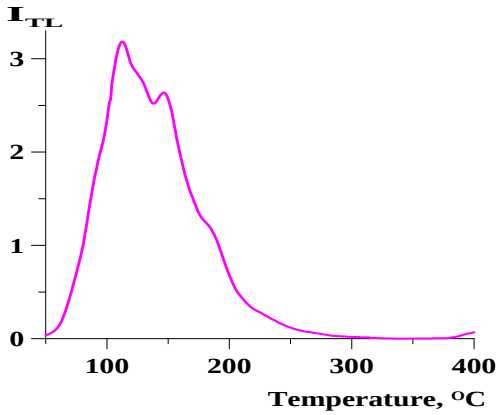

Fig. 2. Glow curve of Coolidge CV chondrite

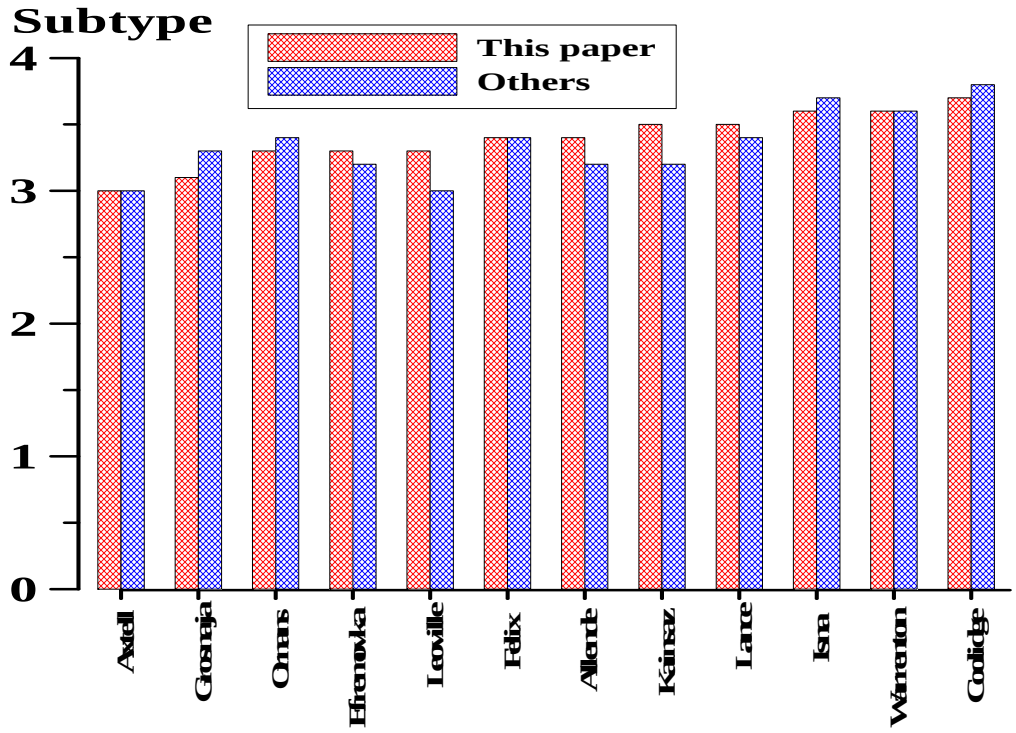

Fig. 3. Comparison of observed data of a metamorphism degree of carbonaceous meteorites investigated in different labs

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