Thermoluminescence Study of Japanese Antarctic Meteorites XVI.

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Introduction: Induced TL (thermoluminescence), the response of a luminescent phosphor to a laboratory dose of radiation, reflects the mineralogy and structure of the phosphor, and provides valuable information on the metamorphic and thermal history of meteorites. Especially the sensitivity of the induced TL is used to determine petrologic subtype of unequilibrated ordinary chondrites [1]. Natural TL, the luminescence of a sample that has received no irradiation in the laboratory, reflects the thermal history of the meteorite in space and on Earth. Natural TL data thus provide insights into such topics as the orbits of meteoroids, the effects of shock heating, and the terrestrial history of meteorites [2]. Usually natural TL properties are applied to find paired fragments [3-5].

We have measured TLs of 216 Yamato and 136 Asuka unequilibrated ordinary chondrites [6]. This time we measured induced and natural TL properties of thirty Yamato unequilibrated ordinary chondrites (H3: 13, L3: 12, LL3: 3, L/LL3: 2) from Japanese Antarctic meteorite collection [7]. Sampling positions of these chondrites were measured by GPS.

Paired fragments: As reliable pairing approach, TL properties within large chondrites were analyzed, taking advantage of the fact that serial samples from these meteorites are known to be paired. Then a set of TL pairing criteria: 1) the natural TL peak height ratios, LT/HT, should be within 20%; 2) that ratios of raw natural TL signal (LT) to induced TL signal (TL Sensitivity) should be within 50%; 3) the TL peak temperatures should be within 20℃ and peak widths within 10℃ was proposed [3].

Above pairing criteria were applied to the 30 samples. Figure 1 shows how to search fragments satisfying the pairing criteria 1) and 2). We found 6 TL potential paired fragments. . They constructed one H3 and five L3 groups.

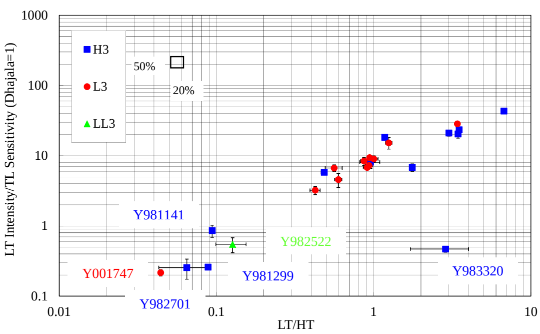

Fig.1. Ratio of LT to TL Sensitivity vs. LT/HT ratio to search fragments satisfying the pairing criteria 1) and 2).

Primitive ordinary chondrites: Most of the chondrites had TL sensitivities over 0.1 (Dhajala=1), corresponding to petrologic subtype 3.5-3.9. Four chondrites, Y982703 (LL3), Y983367 (LL3), Y983312 (L/LL3), and Y983499 (L/LL3) were revealed to be primitive ordinary chondrites, petrologic subtype 3.0-3.1, 3.0-3.1, 3.0-3.2 and 3.1, respectively. They are not conflicted to olivine heterogeneity as shown in Fig.2. It is particularly significant in understanding the nature of primitive material in the solar system.

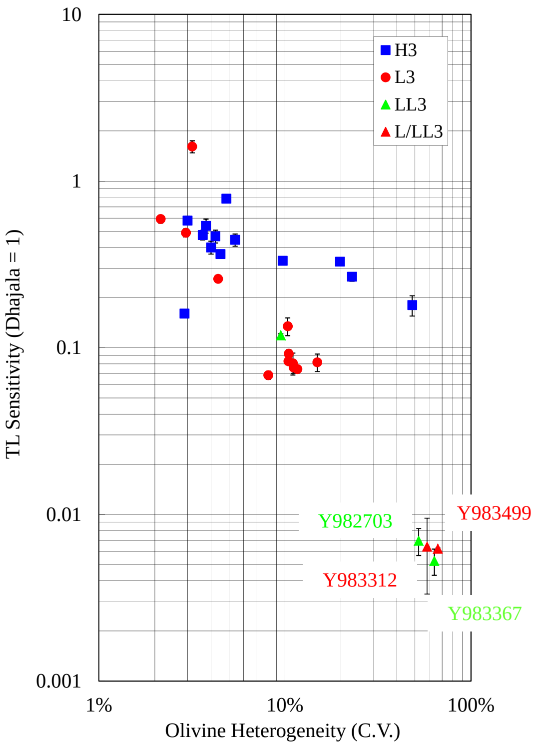

Fig.2. Dhajala-normalized TL sensitivity vs. olivine heterogeneity

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References:

[1] D. W. G. Sears *et al.*, *Proceedings of Lunar and Planetary Science 21* (1991) 493-512. [2] P. H. Benoit *et al.*, *Icarus 94* (1991) 311-325. [3] K. Ninagawa *et al.*, *Antarctic Meteorite Research 11* (1998) 1-17. [4] K. Ninagawa *et al.*, *Antarctic Meteorite Research 15* (2002) 114-121. [5] K. Ninagawa *et al.*, *Antarctic Meteorite Research 18* (2005) 1-16. [6] K. Ninagawa *et al.*, *36th Symposium on Antarctic Meteorites* (NIPR, Tokyo), (2013) 56-57. [7] *Meteorite Newsletter 21 & 22.*

Table Thermoluminescence data of unequilibrated Japanese ordinary chondrites

Meteorite	Class	Natural TL: LT/HT	Natural TL: LT (10^3 counts)	Natural TL: LT Peak Temp. (℃)	Natural TL: HT Peak Temp. (℃)	Induced TL: TL Sensitivity (Dhajala=1)	Induced TL: Peak Temp. (℃)	Induced TL: Width (℃)	Induced TL: TL Subtype	LT /TL Sens. ($x10^3$)	Low Ca-Py Heterogenity (C.V.)†	Ol Heterogenity (C.V.)‡	Ol Subtype	Recom-mended Subtype
Y982522	LL3	0.13 ± 0.03	0.1 ± 0.0	212 ± 1	364 ± 6	0.12 ± 0.00	131 ± 2	117 ± 3	3.5	0.5 ± 0.1	23%	10%	3.9	
Y982701	H3	0.06 ± 0.02	0.1 ± 0.0	216 ± 7	368 ± 2	0.33 ± 0.01	125 ± 1	129 ± 4	3.6	0.3 ± 0.1	54%	10%	3.9	
Y982703	LL3					0.007 ± 0.001	118 ± 5	80 ± 6	3.0-3.1		89%	52%	≤3.4	3.0-3.1
Y982740	H3	3.50 ± 0.01	11.1 ± 0.2	220 ± 2	367 ± 2	0.48 ± 0.03	165 ± 4	134 ± 2	3.6-3.7	23.4 ± 1.6	11%	4%		
Y982783	H3	1.18 ± 0.00	14.3 ± 0.0	242 ± 6	362 ± 6	0.78 ± 0.03	171 ± 5	128 ± 1	3.7	18.3 ± 0.6	7%	5%	3.9	
Y982896	L3	0.87 ± 0.04	0.7 ± 0.0	263 ± 1	358 ± 9	0.08 ± 0.01	134 ± 12	139 ± 5	3.4-3.5	8.4 ± 1.1	53%	15%	3.8	
Y982897	L3	1.00 ± 0.06	0.7 ± 0.1	255 ± 5	351 ± 3	0.08 ± 0.01	129 ± 13	137 ± 8	3.4	9.0 ± 1.0	41%	11%	3.8	
Y982898	L3	0.94 ± 0.02	0.7 ± 0.0	268 ± 3	357 ± 5	0.07 ± 0.00	154 ± 2	148 ± 10	3.4	9.4 ± 0.3	68%	12%	3.8	
Y982900	L3	0.60 ± 0.03	0.4 ± 0.1	270 ± 13	364 ± 2	0.08 ± 0.01	156 ± 5	150 ± 2	3.4-3.5	4.6 ± 1.0	44%	11%	3.8	
Y982901	L3	0.93 ± 0.05	0.7 ± 0.0	261 ± 14	357 ± 18	0.09 ± 0.01	125 ± 15	152 ± 8	3.4-3.5	7.2 ± 0.4	31%	10%	3.9	
Y982902	L3	0.91 ± 0.05	0.6 ± 0.0	262 ± 1	369 ± 5	0.08 ± 0.00	146 ± 1	135 ± 16	3.4	6.8 ± 0.4	29%	10%	3.9	
Y982904	L3	0.56 ± 0.07	0.5 ± 0.0	262 ± 4	345 ± 10	0.07 ± 0.00	162 ± 7	153 ± 3	3.4	6.7 ± 0.7	37%	8%	3.8	
Y983088	H3				385 ± 4	0.18 ± 0.03	150 ± 6	136 ± 3	3.5-3.6		53%	48%	3.5	3.5-3.6
Y983104	L3				354 ± 9	0.13 ± 0.02	154 ± 7	146 ± 5	3.5		24%	10%	3.9	
Y983112	H3	3.44 ± 0.06	8.2 ± 0.8	211 ± 5	365 ± 10	0.40 ± 0.04	150 ± 5	127 ± 2	3.6-3.7	20.5 ± 2.7	25%	4%		
Y983312	L/LL3					0.01 ± 0.00	311 ± 50	279 ± 49	3.0-3.2		91%	58%	≤3.4	3.0-3.2
Y983320	H3	2.86 ± 1.15	0.3 ± 0.0	218 ± 0	354 ± 2	0.54 ± 0.05	174 ± 2	138 ± 2	3.6-3.7	0.47 ± 0.05	4%	4%		
Y983367	LL3					0.005 ± 0.001	89 ± 0	50 ± 4	3.0-3.1		76%	64%	≤3.4	3.0-3.1
Y983499	L/LL3					0.01 ± 0.00	86 ± 3	57 ± 7	3.1		88%	66%	≤3.4	3.1
Y983914	H3	6.74 ± 0.06	6.9 ± 0.1	216 ± 2	358 ± 6	0.16 ± 0.01	144 ± 3	136 ± 5	3.5	43.2 ± 2.1	42%	3%		
Y984134	H3	0.95 ± 0.14	3.0 ± 0.5	241 ± 0	373 ± 1	0.36 ± 0.00	164 ± 5	159 ± 0	3.6	8.1 ± 1.5	20%	4%		
Y000411	H3	1.76 ± 0.06	3.0 ± 0.3	222 ± 1	376 ± 3	0.44 ± 0.04	174 ± 1	156 ± 0	3.6-3.7	6.8 ± 0.8	8%	5%	3.9	
Y001141	H3	0.09 ± 0.00	0.5 ± 0.1	219 ± 1	373 ± 11	0.58 ± 0.03	173 ± 1	165 ± 1	3.7	0.9 ± 0.2	4%	3%		
Y001283	L3	3.41 ± 0.09	45.8 ± 2.1	234 ± 5	373 ± 0	1.61 ± 0.13	179 ± 3	153 ± 6	3.8	28.4 ± 2.7	4%	3%		
Y001299	H3	0.09 ± 0.00	0.1 ± 0.0	206 ± 1	390 ± 8	0.47 ± 0.04	172 ± 1	153 ± 5	3.6-3.7	0.26 ± 0.02	6%	4%		
Y001318	H3	3.01 ± 0.05	5.6 ± 0.4	224 ± 1	378 ± 5	0.27 ± 0.02	161 ± 1	158 ± 2	3.6	21.0 ± 2.0	50%	23%	3.7	
Y001382	L3	1.25 ± 0.06	7.5 ± 1.3	257 ± 6	395 ± 6	0.49 ± 0.03	178 ± 4	148 ± 5	3.6-3.7	15.2 ± 2.8	6%	3%		
Y001383	L3	0.42 ± 0.03	1.9 ± 0.2	271 ± 7	406 ± 2	0.59 ± 0.03	190 ± 0	166 ± 3	3.7	3.2 ± 0.4	2%	2%		
Y001468	H3	0.48 ± 0.02	1.9 ± 0.1	247 ± 1	380 ± 1	0.33 ± 0.01	178 ± 2	154 ± 1	3.6	5.8 ± 0.4	22%	20%	3.7	
Y001747	L3	0.04 ± 0.00	0.1 ± 0.0	223 ± 3	395 ± 3	0.26 ± 0.00	160 ± 2	157 ± 4	3.6	0.22 ± 0.02	21%	4%		