A CATHODOLUMINESCENCE/X-RAY MICROPROBE STUDY OF VARIOUS SEDIMENTS FROM INDIA AND ANTARCTICA

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Introduction:

This note reports the results of a simultaneous cathodoluminescence (CL)/x-ray microprobe study on a variety of sediments from India and Antarctica. This research was prompted by the increasing appreciation of the potential of TL for dating Quaternary sediments. Identification of the dominant luminescent mineral phase(s) in such samples, in conjunction with previous studies of the TL properties of various mineral groups, would be useful in gaining information on the process and mechanism of sun-bleaching, maximum bleachable TL levels, the role of retrapping (David, et al., 1981; Levy, 1982) and the dependence of bleaching on initial dose and UV/sunlamp dose-rate. In addition, knowledge of the luminescent mineral type is desirable for optimizing detector optics to select desirable phases of polymineralic samples. Previous mineralogic studies on loess by Weir, et al., 1978, have suggested that quartz and feldspars are the major minerals in this material.

Experimental Details:

Three types of sediments were studied in the present work:

1) Dune sands from Thar desert in India
2) Loess deposits in Kashmir
3) Dust trapped in glacial and Antarctic ice.

Fine grain discs of these samples were analyzed. The samples had been previously treated with HCl to eliminate post-depositional carbonates. In addition, the polymineralic, 90-105 µm grain fraction from several dune sands was studied. Most of the fine grain samples were coated with 200A of carbon for SEM studies. The coarse grains were coated with 100A of gold to eliminate luminescence caused by charging of the grains. The scanning electron microscope's cathodoluminescence system had an EMI 6255 photomultiplier tube with S-13 response and the x-ray system was an Ortec Si(Li) detection assembly. Individual bright luminescent grains were detected in the cathodoluminescence mode and were then microprobed by focussing and stabilizing the electron beam on each of these grains. Generally, the ten brightest grains on each fine grain disc were microprobed. The mineral types were assigned by identifying the major elements present in the x-ray spectra and the relevant details have been described earlier (Singhvi and Zimmerman, 1978). The results are given in Table 1. The frequency distribution of the occurrence of each mineral phase is given in Table 2.

Results:

1) In most cases, K-feldspar is the dominant CL mineral, which in view of its substantially high TL sensitivity is expected to dominate the polymineralic TL. In view of the broad similarities of glow curves of other sediments with those mentioned above, it appears logical to conclude that, in general, feldspar dominates sediment TL.

Table 1: Cathodoluminescence/x-ray microscope analysis of fine grain samples of glacier dust, loess and dune sands

Sample	K-feldspar	Plagio-clase	Quartz	Apatite	Zircon	Other
GLACIER DUST						
Nehnar						
NG-2	6	1	1	0	0	2
NG-9	3	0	6	0	0	0
NG-13	4	2	3	0	0	0
NG-16	0	1	3	4	0	1
NG-20	1	2	5	2	0	0
NG-29	3	4	1	1	0	0
NG-39(I)	3	2	3	1	0	0
NG-39(II)	4	0	5	0	0	0
NG-40	4	0	3	3	1	0
NG-48	2	0	8	0	0	0
NG-52	5	0	5	0	0	0
Changme-Khangpu						
CK-61-81	7	3	0	0	0	0
CK-61-81	7	3	0	0	0	0
CK-90-81	6	1	3	0	0	0
Zemu						
Z-26-I	5	0	5	0	0	0
Z-26-II	8	1	1	0	0	0
Z-27	6	2	1	1	0	0
Antarctica						
ANB-4	10	0	0	0	0	0
ANC-3	3	7	2	0	0	0
2-6A	2	0	1	0	0	7
NG-2	1	1	5	0	0	2
X	8	0	2	0	0	0
LOESS						
Dilpur						
TL-L-1	8	0	1	0	0	0
TL-L-1	2	0	0	0	0	0
TL-L-2	10	0	0	0	0	0
TL-1-3	7	2	1	0	0	0
TL-L-6	8	0	0	0	0	0
DUNE SAND						
Amarpura						
TL-S-7	6	3	0	0	0	0
TL-3-8	6	0	3	0	0	0
TL-5-9	10	0	0	0	0	0
Langhnaj						
TL-5-10	10	0	0	0	0	0
TL-5-11	2	0	0	0	0	0

Table 2: Frequency of mineral types

Sediment type	K-feldspars	Plagioclase	Quartz	Others
Glacier dust	0.45	0.14	0.29	0.06 apatite 0.06 misc.
Loess	0.90	0.05	0.05	---
Dune sand	0.85	0.075	0.075	---

2) Glacier dust samples were much brighter in CL than loess and dune sand samples. A possible explanation is a surfacial coating of iron compounds (e.g., haematite) on grains from dune sands and loess that may alter the transparency and luminescence efficiency of grains (Gardner and Pye, 1981).

3) Comparison of these data with glow curve shapes suggests that in general a broad glow peak at around 250°C is due to K-feldspars whereas a shoulder about 350°C is most likely due to Quartz. This is supported by glow curves of HF-etched samples that yield a glow peak at around 380°C. It is interesting to note that similar results have also been obtained by Debenham and Walton (1982) who were able to separate feldspar emission from quartz emission (see their Figs. 1 & 2) using filters (Schott and Jena-UG11, transmission peaking at 325 nm and Corning-5-58, transmission peaking at 410 nm).

4) The CL minerals in coarse grain fractions of dune sands are generally the same as those in the fine grain fractions, K-feldspar, quartz and plagioclase.

Conclusion:

This study has shown that K-feldspar generally dominates Indian and Antarctic sediment CL and, therefore, probably dominates the TL from these materials. This result suggests that more effort should be initiated to understand feldspar properties.

References:

M. David and C. M. Sunta. (1981) Ind. J. Pure & Appl. Physics 19, 1041.

P. W. Levy (1981) PACT 6, 224.

A. H. Weir, J. A. Catt and P. A. Madgett (1971) Geoderma 5, 131.

A. K. Singhvi and D. W. Zimmerman (1979) Archaeometry 21, 73.

R. Gardner and K. Pye (1981) Progress in Physical Geography, 5(4), 514.

N. C. Debenham and A. J. Walton (1983) Pact 9, (in press).