CATHODOLUMINESCENCE OF EQUILIBRATED AND UNEQUILIBRATED EUCRITES AND THE DISCOVERY OF MULTIPLE SILICA POPULATIONS; J.David Batchelor, Cosmochemistry Group, Department of Chemistry and Biochemistry, University of Arkansas, Fayetteville, AR 72701.

Introduction Cathodoluminescence (CL) photomosaics are useful in understanding the thermal histories of meteorites and interpreting thermoluminescence (TL) data. CL mosaics confirmed that the increase in TL sensitivity of ordinary chondrites with increasing petrologic type is due to devitrification of feldspathic glass (1). They are useful in identifying luminescence colors, and with petrographic microscopy or microprobe studies, in identifying luminescent phosphors.

Equilibrated eucrites have higher TL sensitivities (brighter luminescence per radiation dose) than unequilibrated eucrites, and the TL sensitivity values have been used to assign petrologic types to eucrites (2,3). For ordinary chondrites, the variation of TL sensitivity with degree of metamorphism is due to the devitrification of feldspathic glass in chondrule mesostases. Since the eucrites contain far less glass than ordinary chondrites, CL studies were undertaken of an equilibrated eucrite, Juvinas (type-5), and an unequilibrated eucrite, Pasamonte (type-2), to identify the cause of the TL variation and to further understand the metamorphic history of eucrites.

The CL colors of feldspar are dependent on composition. In general, alkali feldspars (sodic or potassic) luminesce blue, while calcic feldspars luminesce yellow or green, possibly due to Mn substitution for Ca. This effect is seen in terrestrial feldspars (4-6) and probably in the primitive ordinary chondrite Semarkona (1). The yellow-green peak first appears in the CL spectra of plagioclase with An>11 (4) and is the dominant visual color for samples with An>39 (6). This color shift is probably the reason for the decrease in TL sensitivity with increasing An content noted for plagioclase (7), as the TL rig uses a blue bandpass filter. A red-IR band, not visually apparent, is present in all terrestrial samples but lacking in lunar samples (4). This band is likely due to Fe^{3+} (8).

The CL colors of silica are less well understood, but in general, quartz shows two spectral peaks, one red (620 nm) and one blue-green (450 nm). The blue-green peak is found in quartz of high-temperature (plutonic) origin, and the red peak in quartz of low-temperature origin (low-grade metamorphic rocks, or high-grade metamorphic rocks which cooled slowly) (9,10).

Experimental CL images were obtained of petrographic thin sections of Juvinas (USNM 439-1) and Pasamonte (USNM 897-2). Exposures were made on a Nuclide Corp. "Luminoscope" operated at 12 keV and 9 uA. Photographic exposures were for 2.5 minutes on Kodacolor Gold 400 ASA film, processed in C-41 chemistry at a local photolab. Transmitted light mosaics were also made under crossed polars to aid in interpretation and mineral identification. Mineral identification was aided by the use of EDX spectra taken on a Cambridge Stereoscan 600 SEM with a Kevex 3201-600 x-ray detector.

Results As expected, the predominant luminescence color in both eucrites is yellow. The luminescence intensity of individual feldspar grains is greater in Juvinas than in Pasamonte. (The photos record dim yellow luminescence as a brownish color.) Most feldspar grains in Juvinas show a uniform yellow color, although one grain shows zoned extinction under crossed polars and has brighter CL in the interior, perhaps due to Fe-quenching at the rim. Most feldspar grains in Pasamonte show no zoning under crossed polars, but are zoned in the CL mosaic, with brighter interiors. Pyroxene is either non-luminescent or shows very faint red luminescence.

Under crossed polars, Pasamonte shows what appeared to be a few euhedral feldspar laths which were less transparent and more fractured than the rest, but these luminesce blue-green, and EDX spectra show them to be silica. There are also anhedral areas of an intergrowth of non-luminescent pyroxene and dull-red luminescing silica. Juvinas shows the same blue-green luminescing silica laths, and in addition, traces of anhedral red-luminescing silica which seems different from that in Pasamonte. It luminesces a brighter red, lacks the pyroxene intergrowth, and is clouded with minute round, opaque inclusions, including blebs of Ni-free iron. In some cases, this red-luminescing silica appears to be corroding into adjacent green-luminescing silica.

Discussion The increase in petrologic sensitivity with increasing petrologic type for the eucrites is due to an increase in brightness of the luminescence from crystalline feldspar. No glass is observable in the feldspar by optical microscopy, so the mechanism of the increase is uncertain. Devitrification of sub-microscopic glass is a possibility, but migration of transition metal or REE activator ions is also a possibility, as is structural transformation. It is apparent that the use of a yellow-sensitive TL apparatus would give higher signals for eucrites than the current blue-sensitive equipment. This may prove useful for TL studies of meteorites with calcic feldspar but low TL sensitivity, such as diogenites, class C mesosiderites, and SNCs.

It is likely that the green-luminescing silica is a plutonic, high -temperature form. Detailed investigation of the chemistry and morphology of the red-luminescing silica is still underway, but it seems evident that this is a lower temperature form, possibly a product of pyroxene reduction, and that this reaction is further advanced in the more heavily metamorphosed Juvinas. The existence of these two types of silica further constrains the metamorphic history of eucrites. It is independent evidence for metamorphic differences between eucrites, and the fact that red-luminescing silica still exists in Juvinas may enable us to tighten the upper limit of metamorphic conditions established from TL properties of feldspar and O-isotope thermometry (3).

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