N65-83210
Code-None

Univ. of Pittsburgh
NsG-593
[redacted]
CR-59968
PP-6
Cat-13

Letter to the Editor of Nature

Luminescence of Orthopyroxenes

In an examination of several stony meteorites Derham and Geake[1] reported on the luminescence of three enstatite achondrites under proton excitation. A later report[2] concludes that enstatite, the major mineral in the meteorites, is probably responsible for all the observed luminescence. Each meteorite yields a spectrum in which red emission with a peak at 6700 Å is accompanied by a weaker blue peak 4000 Å. The red peak at 6700 Å in meteoritic enstatite has been attributed by Garlick[3] to $MgSiO_3$ containing manganese as an impurity. Sarver and Hummel[4] have shown both photo- and cathodo-luminescence occur in the red spectral region (6310 - 6830 Å) of Mn-activated magnesium germanates and silicates. The position of peak emission of enstatite activated with Mn(II) is extrapolated from $MgGeO_3$-$MgSiO_3$ enstatite solid solutions to be 6730 Å. This is near the value found in synthetic clinoenstatite activated with Mn(II), namely, 6720 Å. By examining crushed grains of the Bustee meteorite, Derham, Geake and Walker[2] were able to separate grains which luminesced blue from a mixture in which most of the grains luminesced red. The luminescence spectrum of the 'blue' grains differs from that of the 'red' grains and from the luminescence spectrum of the meteorite in that the red peak at 6700 Å is weaker than the blue peak at 4000 Å. X-ray powder analyses of 'red' and 'blue' grains showed both to be orthoenstatite.

Recent studies[5,6] have shown that orthoenstatite in enstatite achondrites is present in both ordered and disordered forms. We have made a preliminary examination of luminescence of orthopyroxenes and related minerals in an attempt 1) to delimit the occurrence of this phenomenon in

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a number of diverse samples and 2) to show whether any correlation exists between luminescence and disorder in $MgSiO_3$.

Samples were excited by X-rays from a tungsten tube operated at 50 pkv and 35 ma. Luminescence was observed visually for overall colour and through appropriate filters to obtain a crude estimate of the red and blue components of the emission. X-ray single crystal and powder techniques were utilised to investigate disorder in the orthopyroxenes. The results of this survey are presented in Table 1.

Mg-Silicates prepared in different laboratories from different starting materials yield similar luminescence. With the possible exception of the Stannern hypersthene, luminescence was observed only in orthopyroxenes containing little or no iron. None of the four terrestrial iron-bearing orthopyroxenes, all from plutonic environments, emit detectable luminescence. The presence of an appreciable amount of iron in the $MgSiO_3$ structure may inhibit the luminescence which is readily apparent in the virtually iron-free synthetic and meteoritic enstatites.

All of the disordered orthopyroxenes studied exhibit luminescence but there is no simple correlation between disorder and the intensity and colour of the light emitted. Differences in luminescence were found between ordered and disordered enstatites from the same meteorite (Khor Temiki and Pena Blanca Spring in Table 1). In both cases the luminescence of the disordered enstatite was weaker and the ratio of blue to red was higher. This suggests that some correlation does exist between the character of the luminescence and either disorder in the structure or some effect closely related to and perhaps cogenetic with disorder.*

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This work was supported in part by Grant NsG-593 from the National Aeronautics and Space Administration.

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* In a communication which reached us just before this letter was submitted for publication, Dr. Geake informed us of his continuing work on the Bustee meteorite. The X-ray powder patterns of 'red' and 'blue' grains from this meteorite[2] have been found to match those of ordered and disordered orthoenstatite, respectively.

(1) Derham, C.J., and Geake, J.E., Nature, 201, 62 (1964).

(2) Derham, C.J., Geake, J.E., and Walker, G., Nature, 203, 134 (1964).

(3) Garlick, G.F.J., Nature, 202, 171 (1964).

(4) Sarver, J.F. and Hummel, F.A., J. of Electrochem. Soc., 110, 726 (1963).

(5) Brown, W.L., and Smith, J.V., Zeit. Krist, 118, 186 (1963).

(6) Pollack, S.S., and Ruble, W.D., Am. Mineral., 49,983 (1964).

Table 1

Sample	Meteorite Class or Source	Structural State of Orthopyroxene	Luminescence: Colour	Luminescence: Relative Intensity of Red and Blue Emission*	Luminescence: Intensity
Meteorites					
Aubres	enstatite achondrite	disordered	red	red > blue	moderate
Bishopville	enstatite achondrite	ordered & disordered	violet	red ≈ blue	moderate
Bustee	enstatite achondrite	disordered	blue	no red	moderate
Cumberland Falls	enstatite achondrite	disordered	red	red > blue	moderate
Khor Temiki	enstatite achondrite	ordered	red	red > blue	moderate
Khor Temiki	enstatite achondrite	disordered	violet	blue > red	weak
Norton County	enstatite achondrite	ordered & disordered	red	red > blue	moderate
Norton County	enstatite achondrite	disordered	red	red > blue	weak
Pena Blanca Spring	enstatite achondrite	ordered	red	red > blue	moderate
Pena Blanca Spring	enstatite achondrite	disordered	blue	blue > red	weak
Pesyanoe	enstatite achondrite	ordered & disordered	red	red > blue	moderate
Manegaon	hypersthene achondrite	ordered	nil		
Shalka	hypersthene achondirte	ordered	nil		
Tatahouine	hypersthene achondrite	ordered	nil		
Stannern	pyroxene-plagioclase achondrite	disordered	blue	no red	weak
Novo-Urei	olivine-plagioclase achondrite		nil		
St. Marks	enstatite achondrite	ordered	nil		
Campo del Cielo	enstatite from hexahedrite	ordered	nil		
Marjalahti	olivine from pallasite		nil		
Mount Egerton	enstatite from stony iron	disordered	red and blue grains		moderate
Terrestrial Minerals					
Enstatite	Bamle, Norway	ordered	nil		
Enstatite	North Carolina	ordered	nil		
Bronzite	New Mexico	ordered	nil		
Hypersthene	Canada	ordered	nil		
Talc, white	New York		white	red > blue	moderate
Talc, green	Georgia		nil		
Plagioclase	from anorthosite		white	blue, no red	weak

(Table 1 - Continued)

Sample	Meteorite Class or Source	Structural State of Orthopyroxene	Luminescence		
			Colour	Relative Intensity of Red and Blue Emission*	Intensity
Synthetic Samples					
Enstatite & amorphous material	heated $MgSiO_3$ gel	disordered	white	blue > red	moderate
Enstatite	from General Electric	disordered	violet	blue > red	strong
Protoenstatite	heated $MgSiO_3$ gel		blue	no red	weak
Protoenstatite > clinoenstatite	heated $MgSiO_3$ gel		white		weak
Protoenstatite	heated white talc		red	red > blue	moderate
Forsterite	from General Electric		violet	blue > red	strong
Forsterite	from Harbison-Walker		violet	blue > red	moderate
Periclase	from Harbison-Walker		red	red > blue	moderate
Spinel, $MgO.Al_2O_3$	from Harbison-Walker		green		strong

* When viewed through appropriate filters.