

CATHODOLUMINESCENCE AND MINOR ELEMENTS IN MURCHISON SiC GRAINS. Ian M. Steele¹, Roy S. Lewis² and Sachiko Amari^{2,3}. ¹Dept. of Geophysical Sciences, ²Enrico Fermi Institute, University of Chicago, Chicago, IL 60637; ³McDonnell Center for the Space Sciences and Physics Department, Washington University, St. Louis, MO 63130-4899.

Silicon carbide (SiC) grains separated from primitive meteorites are true interstellar grains (e.g. [1]). Because these grains are relatively rare, micron sized, and exhibit a wide range of isotopic and chemical signatures, techniques which provide rapid nondestructive classification are of interest as they may point to particular grains for detailed examination. We examined the Murchison size separate KJG [2]. Eighteen grains of 1 to 3 microns pressed into gold on sample mount CHRL 103 were individually measured by electron microprobe for both elemental abundances and cathodoluminescence (CL). Titanium ranges from <40 ppmw to 0.83 wt% and V from <40 to 700 ppmw and correlates linearly with Ti. Neither element correlates with Al. Cathodoluminescence is shown by all grains with an intensity range of 40x. Three broad CL emission peaks are present but none appear to correlate with the three measured elements.

Minor elements: Previous ion microprobe analysis of Murchison grains [3] has shown that Al, Ti, V, Fe and Zr were present in most SiC grains at concentrations above the detection level of wavelength dispersive electron probe analysis. Here we report data for Al, Ti, and V using a 20kV focused beam and 50nA incident current. To resolve V K α from the generally near equal Ti K β , a wavelength scan which includes these two peaks was made for each grain to observe the background profile. Because the largest SiC grains in this separate were approximately 3 microns, the excited volume for x-ray generation can be expected to be larger than that of the grain as evidenced by a small gold peak in the energy dispersive spectrum. The beam position on each grain was adjusted to minimize this peak and hence maximize the major Si K α peak. Because all analyzed SiC grains were of near equal size, this Au peak was used as a reference and grains showing high Au peaks were judged too small for accurate comparison of concentration data. The net intensities for each element were referenced to polished, bulk standards without corrections for matrix effects as these are considered minor compared to counting statistics and uncertainties in absorption due to particle shape and size. While SiC was the phase of interest, corundum and hibonite were also present [2] and together accounted for about 25% of the grains.

Cathodoluminescence: (CL) has proved useful for recognition of textures due to variations of element concentrations or uncertain causes such as defects [4]. In some cases the cause of CL can be assigned to specific elements but often the cause is unknown. All SiC grains analyzed emitted CL and both the intensity and wavelength of this CL were recorded during elemental analysis to possibly correlate CL spectral features with minor element chemistry. While very weak and probably below detection by eye, efficient collection and intensification provided spectra in integration times of 30 seconds. Three broad peaks occur in these SiC spectra but the relative intensities vary among grains. Typical examples are shown in Fig. 1. A peak common to all spectra is centered near 5400Å but may vary slightly in position although this can also be influenced by contributions from other peaks. One grain (F5-62) was found to show only this 5400Å CL emission. Most grains showed a second peak near 4600Å forming a weak shoulder on the main 5400Å peak. A third peak in the red near 6700Å is usually not present or of minor intensity relative to the main 5400Å peak. In two grains (F5-55 and E6-40) it had an intensity greater than the 5400Å peak. Table 1 gives the concentrations of Al, Ti, and V as well as relative intensity of 5400Å CL peak, and a qualitative indication of magnitude of the two other CL peaks.

Discussion: Aluminum and Ti are detected in all grains, V in most. However, due to its low concentration and the Ti K β interference, V is close to the detection limit of 40 ppmw as determined by counting statistics. The correlation between Ti and V is good (Fig. 2), much better than in [3], also shown in Fig. 2. Here 17 of the 18 grains fit a linear correlation with an atomic Ti/V ~9.8 (regression equation: V{ppmw} = Ti{wt.%} x 1097 +19). Our better correlation is likely due to the smaller range and mean in grain sizes, 1 - 3 μ m vs 1.5 - 23 μ m. Grain size has been recognized as an important parameter correlating with the chemical and isotopic measurements e.g. [3], [5]. That the Ti/V ratio is so close to the solar atomic ratio of 8.19 [6] is surprising, given the difference in condensation temperatures of their carbides [7]. Aluminum, as noted in [3] varies in concentration with no evident correlation with other parameters. Chromium in all of our grains was <40 ppmw, the detection limit. Grain E6-35 alone had Ni and Fe

CATHODOLUMINESCENCE AND MINOR ELEMENTS Steele, I.M., et al.

detectable by energy dispersive analysis at the 1-5% level, but was otherwise indistinguishable from the other grains.

The CL spectra vary among samples with only the 5400Å peak present in all samples. Its intensity varies by 40x but its intensity does not correlate with Al, Ti or V. Likewise a red peak is present either as a shoulder or as a distinct peak but its presence also does not correlate with any of the 3 measured elements. The blue peak at 4600Å is present in all but one sample (E6-62) but is not observed to be greater than the 5400Å peak in any sample. While CL is especially easy to observe and quantitatively record, it shows no apparent correlation with chemistry as determined here. The variation may be due to elements not determined (Fe?), differences in SiC structure, or defect structure. This latter possibility may reflect different cosmic ray exposure times, a parameter known to vary among grains.

References: [1] Zinner, E., Tang, M. and Anders, E. (1989) Geochim. Cosmochim. Acta 53, 3273-3290; [2] Amari, S. et al. (1994) Geochim. Cosmochim. Acta 58, 459-470; [3] Virag, A. et al. (1992) Geochim. Cosmochim. Acta 56, 1715-1733; [4] Yacobi, B.G. and Holt, D.B. (1990) "Cathodoluminescence Microscopy of Inorganic Solids", Plenum Press; [5] Hoppe, P. et al. (1994) Astrophys. J. 430, 870-890; [6] Anders, E. and Grevesse, N. (1989) Geochim. Cosmochim. Acta 53, 197-214; [7] Lodders, K. and Fegley, B. (1992) Meteoritics 27, 230-231.

Table 1. CL intensity and Ti, Al, V contents for 18 SiC grains from Murchison KJG.

Coord	#	I (5400Å)	Ti (wt%)	Al (wt%)	V (ppmw)	I (4600Å)	I (6700Å)	
F5	55	79	0.06	0.31	<40	+	+++	
	62	469	0.23	1.31	352	-	-	
	67	89	0.87	0.23	332	+	-	
	70	44	0.44	0.18	412	+	+	
	73	89	0.38	0.36	469	+	-	
	42	319	0.05	0.29	58	+	-	
E6	23	129	0.11	0.18	215	++	+	
	12	139	0.21	0.87	195	-	-	
	22	84	0.40	1.75	424	+	-	
	25	54	0.32	2.17	391	+	-	
	37	59	0.24	0.67	244	++	+	
	34	94	0.63	3.26	688	++	-	
	35	59	0.07	2.47	86	++	-	
	39	19	0.12	1.06	179	++	++	
	40	89	0.21	0.23	244	++	+++	
	14	24	0.20	5.27	312	+	-	
	E5	43	12	0.03	0.42	<40	+	-
	30	69	0.01	0.36	<40	+	+	

Notes: Coord - grid location; # - grain within coord; I (5400Å) - relative CL intensity based on 30sec integration; I(4600Å) and I(6700Å) indicates absence (-) or presence (+) with qualitative Intensity.

Fig. 1. Typical CL spectra from SiC. Three peaks are present near 4600, 5400, and 6700Å as indicated by vertical lines. The 5400Å peak is present in all SiC grains analyzed.

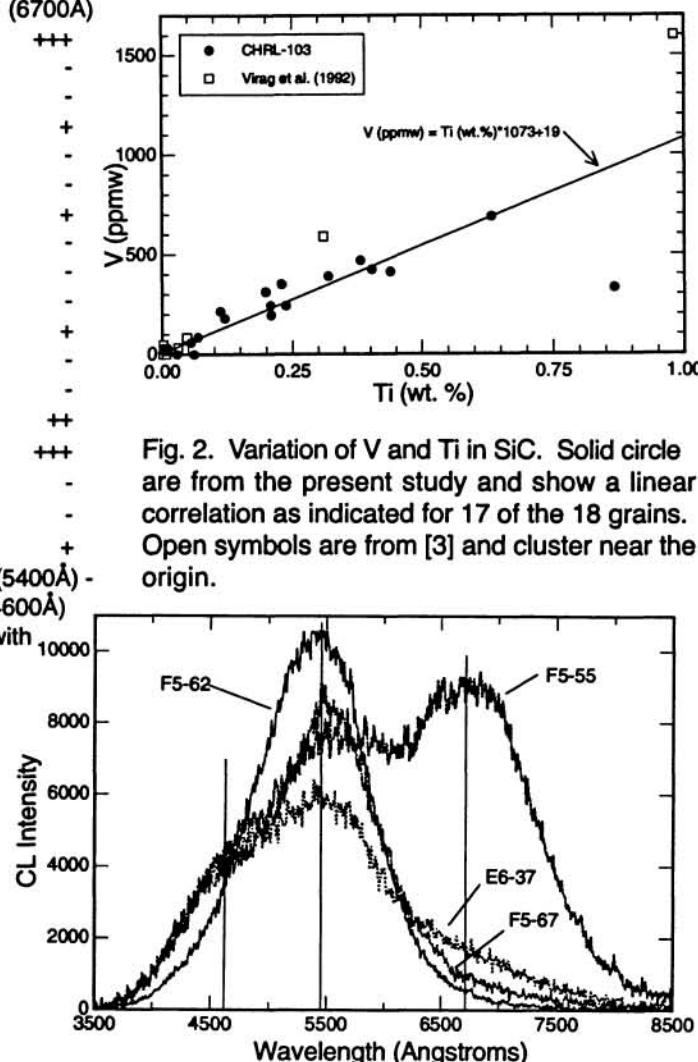


Fig. 2. Variation of V and Ti in SiC. Solid circle are from the present study and show a linear correlation as indicated for 17 of the 18 grains. Open symbols are from [3] and cluster near the origin.

