CATHODOLUMINESCENCE MICROSCOPY AND SPECTROSCOPY OF FORSTERITE FROM THE TAGISH LAKE METEORITE: AN IMPLICATION FOR THE LUMINESCENCE-BASED ASTROMINERALOGY.

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Introduction: The Tagish Lake meteorite fell by fireball event in January 2000 [1]. This meteorite is an intermediate between CM and CI chondrite, original preatmospheric weight was 200 kg [1], classified as CI2 chondrite [2]. Tagish Lake meteorite is brecciated, matrix-dominated material, which contains chondrules with less than 1 mm diameter, altered Calcium-Aluminium-rich (CAIs) up to 2 mm in diameter, magnetite, invidual grains of olivine, Ca-Fe-Mn carbonates (mainly mixture of magnesite and siderite), Fe-Ni sulfides including pyrrhotite (Brown et al. 2000).

Results: The analyzed chondrules are less altered, which is an intermediate between granular and barred texture (Fig. 1). The mesostasis composed of both of phyllosilicates and carbonaceous material. In both of chondrules, olivines show zoned mosaicism, which may correspond to inhomogenity. The major part of the selected grain is composed of a mineral-fragment rich groundmass, which contains a strongly altered forsterite chondrule. Cathodoluminescence spectral features have broad luminescence centres at 400-460, 600-650 and 700 nm. In some parts of the selected grain, peak intensities at 600-700 region are relatively high (Fig.2). After correction of CL spectra, a peak at 400 nm, shoulders at 600-650 and 700-800 nm can be identified as follows. In energetic CL spectra, broad shoulders occur at 0-2 eV region, and broad peak appears at 2.5-3.5 eV region (Fig. 3).

Discussion: The broad luminescence center at 400 nm corresponds to structural defect. The variation of luminescence intensity in chondrule, determine chemical inhomogenity due to low degree of thermal metamorphism [3]. At duller red luminescence centers, the olivine has fayalitic component, whereas light luminescent patches are purely forsterites. The fractures in chondrules are non-luminescent, which is driven by either enrichment of divalent Fe due to terrestrial weathering, or shock-driven lattice defect. The blue luminescence centre at several areas is addressed to instrinsic defect centre. This defect centre associated by either Al^{3+} substitution for Si^{4+} ions or lattice deformation due to Ca and Ti ions [3,4]. The broad emission at 650 nm is assigned to Mn^{2+} impurity centre in M2 position of forsterite [3]. The broad emission bands at 720 nm and also in higher wavenumber range are attributed to Cr^{3+}activator in the M1 and M2 sites and interstitial positions of forsterite [3].The activation energies for red emissions are centered at 0.8 and 1.74 eV, where the 1.74 eV peak corresponds to Cr^{3+}, 1.94 Mn^{2+}. The activation energies in blue region appears as broad band at 3.15 eV, which of FWHM is 1 eV, which corresponds to defect centre [3].

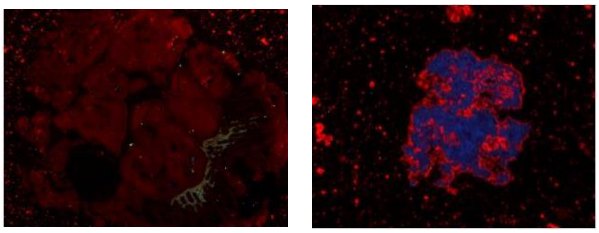

Figure 1. *Cathodoluminescence imaging of the analyzing area of "Tla" (left) and "Tlb" (right).*

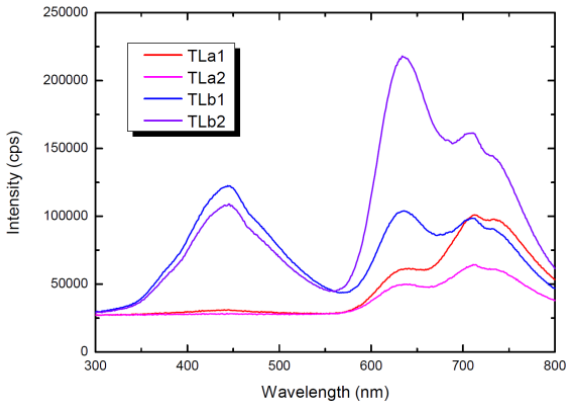

Figure 2. *Cathodoluminescence spectral properties of Tla and Tlb are in the Tagish Lake meteoric forsterite showing three major regions centered at 400-460, 600-650 and 700-800 nm reimaging of the analyzing area of "Tla" (left)d "Tlb" (right).*

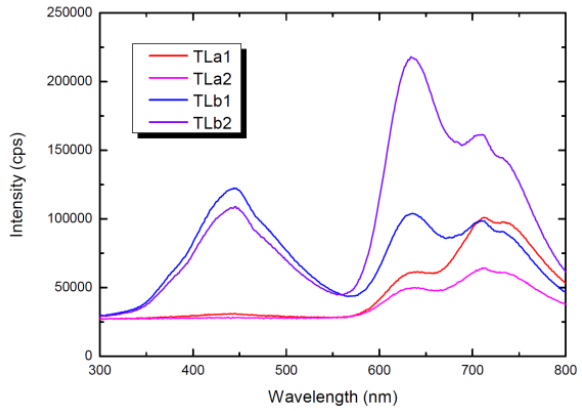

Figure 3. *Intensity vs energy plot of the Tagish forsterite.*

Conclusions: The CL zonation corresponds to thermal quenching, chemical inhomogenities in chondrules. The blue CL emission is caused by lattice defect. The CL properties of Tagish Lake forsterite depends on distribution of activator elements (Cr, Mn), and quenching element (Fe^{2+}), and crystal lattice defect. Scanning Electron Microscope-Cathodoluminescence (SEM-CL) microscope and spectrscope provide an adequate background for the analysis of different Earth and Planetary materials that require the non-destructive, easy-to-use, and relatively rapid analysis. In this case, SEM-CL would provide a powerful method for the study of the the above-mentioned samples, which can aid to understand more about the crystallization environment of minerals in the Early Solar system, for instance.

References: [1] Brown, P.G. et al. (2000) *Science, 290/5490*, 320-325. [2] Grady, M.M., et al. (2002) *MAPS, 37*, 713-735. [3] Nishido, H. et al. (2013) *Geochronometria 40/4*, 239-243. [4] Steele, I.M. (1986):. *Am. Min.*, 71, 966-970.