MINERALOGICAL COMPOSITION OF THE MEXICAN ORDINARY CHONDRITE TYPE METEORITE: A RAMAN, INFRARED AND XRD STUDY

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Introduction: The Raman microprobe (RMP), infrared (IR) and XRD analysis have been applied to the examination of mineralogical composition of seven mexican meteorites [1]: Aldama (b) (Chihuahua, 25°03′N, 106°00′00W, an ordinary chondrite H5 type, 1996), Cosina (Guanajuato, 21°10′N, 100°52′W, an ordinary chondrite H5 type, 1844), El Pozo (26°56′N, 105°24′W, an ordinary chondrite L5 type, 1998), Escalon (Chihuahua, 27°00′N, 104°00′W, an ordinary chondrite H4 type, 1976), Nuevo Mercurio (Zacatecas, 24°18′N, 102°08′W, an ordinary chondrite H5 type, 1978), Pacula (Hidalgo, 21°03′N, 99°18′, an ordinary chondrite L6 type, 1881), Zapotitlan Salinas (Puebla, 18°20′N, 97°30′W, an ordinary chondrite L4 type, 1984).

Method: RMP measurements were performed with the ultimate research grade benchtop the Perkin-Elmer Raman StationTM 400 using the 785.14 nm excitation line of an He–Ne laser in the spectral range between 100 and 3500 cm^{-1}. An integration time of 50 and 100 scans was enough to get acceptable signal to noise ratio at a resolution of 4 cm^{-1}. SpectrumTM software was used for data collection and experimental analysis. This instrument performed the rapid mapping that provided the powerful capability to visualize the distribution of mineral species across the surface of the sample. An internal color alignment camera provides visual feedback to aid sample positioning and focusing using a Windows®-based “Video in Window” camera (magnific tion ×30). It is particularly useful when looking at small or inhomogeneous samples. The spectra were recorded on a X, Y mapping stage (covering an area of 2.00-2.00 mm) with the step of 100 µm, acquiring around 400 Raman spectra. Data interpretation was facilitated using the Spectrum v5.0.2 software, AutoIMAGE v5.0.1 (Perkin-Elmer) and the Spectrocalc software package GRAMS (Galactic Industries Corporation, NH, USA). Map parameters were following: map height 2 mm, map width 2 mm; points 20×20, point sampled 400; point interval X axis 100.00 µm, Y axis 100.00 µm; scan parameters - start 100 cm^{-1}, end 1100 cm^{-1}, interval 2.00 cm^{-1}, scan per point 5, exposure time 10.00, number of exposures 5, number of background 5; detector temperature of start and end of collection -49 °C: software version 6.3.132. The IR absorption spectra were measured by an FTIR Bruker Tensor 27 spectrometer, scanning from 4000 to 400 cm^{-1} and using the KBr pellet method. XRD diagrams of the powdered samples were produced using a Siemens XRD 5000 diffractometer. Operating conditions were Cu Kα radiation (λ=1.5406 Å), 40 kV, 30 mA, resolution 0.01°, and an interval of record 2Θ=5.0-70.0°. The diagrams were recorded in step-scan mode with steps of 0.02° 2Θ and a counting rate 100 spectrum per step; 2Θ values were corrected using silicon (a = 5.43088 Å) as an internal standard.

Result and Discussion: A detailed comparative Raman, infrared and XRD study of these meteorites was performed. Mineralogical compositions of all mexican ordinary chondrite type meteorite are very close. The spectroscopic study of these chondrites demonstrated that basic, first order information on the mineralogy could be obtained using in situ Raman measurement procedure. Data obtained from the IR spectra and X-ray analysis supported the Raman measurements. At the same time, with just the aid of the XRD technique the presence of some metallic phases (kamacite, taenite, troilite and chromite) was detected. These minerals did not demonstrate characteristic Raman spectra because Fe-Ni metals have no active modes for Raman spectroscopy and troilite is a weak Raman scatterer. The results obtained by these analytical techniques, have shown some mineralogical features of mexican chondrite meteorites: a) RMP measurements revealed principal characteristic bands of the major minerals: olivine, two polymorph modifications of pyroxene (OPx and CPx) and plagioclase (An_{14-20}). Some bands of the minor minerals (hematite and goethite) were also identified; b) Mg rich olivine, forsterite was found to be nearly 81.3–90.1%; c) Two polymorph modifications of pyroxene were identified as orthopyroxene and clinopyroxene (OPx and CPx) with general predominance of the former; d) Feldspars were mainly found as high temperature plagioclase (mostly sodium and potassium alumino-silicate); e) Raman mapping microspectroscopy was a key part in the investigation of chodrites meteorite’s spatial distribution of the main minerals because these samples are structurally and chemically complex and heterogeneous [2]. The mineral mapping by Raman spectroscopy has provided information for a certain spatial region on which a spatial distribution coexists of the three typical mineral assemblages: olivine; olivine + orthopyroxene; and orthopyroxene. Accesory mineral phases in these meteorites are: native copper, pentlandite, merrilite, chlorapatite. Two-pyroxene thermometry has shown that the thermal history of some chondrules of ordinary chondrite type H5 suggest formation temperatures much greater than 1200 ºC. Some Ca-rich pyroxenes reached a minimum temperature formation (at ~ 800°C) that could be reflecting prograde thermal metamorphism well inside the chondritic parental body.

References: [1] Sanchez Rubio G. et al. 2001. Las meteoritas de Mexico. UNAM. [2] Ostrooumov M. and Hernandez M. 2011. *Spectrochimica Acta Part A* 83: 437-443.