Analyzing the Allende meteorite through the Raman spectral peak positions of (Fo-Fa): Fast method to characterize range of Fe in chondrites. T. P. Donato[1]; B. L. Nascimento-Dias[2], M. E. Zucolotto[1]. Department of Geology and Paleontology, PPGEO, National Museum of Rio de Janeiro[1] and Department of Physics, Federal University of Juiz de Fora, PPGF[2], Brazil. (tatiane18.tpd@gmail.com, bruno.astrobio@gmail.com).

Introduction: Chondrites are considered the most primitive meteorites in the solar system and have this denomination because of the chondrules in their matrix. These rocks are collected and classified annually, this being an important factor because, from the different properties found among the chondrites, it is possible to know the environment in which they were formed. The main objective of this work is to show an alternative means of classifying chondrites, such as their effectiveness through the evaluation of the contents of Fayalite (Fa) in the olivine present in Allende and the determination of the range of Fe existing in the meteorite [1] using the Raman spectroscopy technique.

Methodology: A fragment of the Allende Meteorite was used as sample. It was provided by Dr. Maria Elizabeth Zucolotto, had already been duly classified and came from the collection of the National Museum of Rio de Janeiro.

The Raman spectra were obtained using Confocal SENTERRA BRUKER from the Federal University of Juiz de Fora (UFJF). The Instrument is equipped with a thermoelectrically cooled CCD (ANDOR DU420-OE) with a spectral resolution of ~ 4 cm^{-1} in the range 100–4000 cm^{-1} (50 x 1000 micrometer gap) and continuous automatic calibration (theoretical accuracy 0.1 cm^{-1}). The analyzes were performed with a 100X objective in the Raman microscope and a standardized 632.8 nm laser with Si chip at 5 mW was used for excitation.

Results: The typical Raman spectrum of olivine exhibits two main peaks, here called Peak A, with Raman displacement in the range of 814-824 cm^{-1}, and Peak B, in the range of 836-857 cm^{-1}. The limits of these Raman displacement bands correspond to the final members of the Fayalite (Fa) and Forsterite (Fo) olivine. While the intermediate portions correspond to the percentage of molar Fa in the displacements of the peaks, having a linear correlation with the composition of olivine (figure 1) [2].

This correlation was made from the Raman displacement of Peak A and Peak B obtained from olivine grains considered as reference material, as representative of the entire Fa content range. The best fit curves, providing the correlation between the Fa content and the expected Raman displacement for Peak A and Peak B, as calculated by the reference material, are [3]:

$$\text{Fa mole\%} = -9{,}13x_A + 7524 \quad (1)$$
$$\text{Fa mole\%} = -4{,}70x_B + 4025 \quad (2)$$

Equations 1 and 2 represent the expected displacement of Raman's peaks correlated to the presence of Fe in chondrites through Olivine [4]. In this case, xA is the Raman displacement corresponding to Peak A and xB is the Raman displacement corresponding to Peak B. The measurement results were perfectly combined with the correlation between Peak A and Peak B (Figure 2).

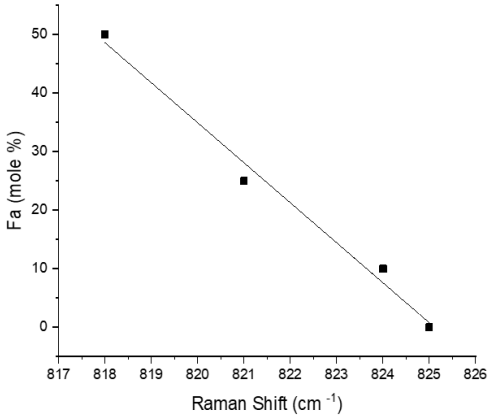
Discussion: Data for peaks A and B, in general, are well known and distinguish common chondrites (H, L and LL) ([4], [5]). This pattern was used as a model and helped to build parameters in the analyzes performed. It is possible to observe that the data are consistent with the linearity properties proposed by the literature, which has not presented this methodology with carbonaceous chondrites yet.

The peak position versus composition graph shows a good correlation for the samples used as reference (figure 3). The correlation curve obtained from the reference olivines is consistent with the literature data, as well as the peak graph versus outlined peak in Figure 4 is also consistent with a polynomial correlation curve [3].

Finally, from the analysis of the spectral peaks positions of Olivine present in the Allende meteorite, done through Raman spectroscopy, it can be understood that there is little Fe in its matrix. Therefore, the proportion of metallic Fe is less than 3%, while the Fayalite content range is between $Fa_{26\text{-}32}$. In the case of the Allende meteorite fragment analyzed in this work, the average Fa value is 29 [6].

Conclusion: Raman spectroscopy proved to be effective in capturing the presence of Fe in chondritic meteorites and classifying them in an alternative way. Although the exact amount of iron present in the sample is not entirely clear, this type of methodology provides a quick answer regarding the proportion of Fa in the meteorite. In addition, through the analysis carried out, it was found that, in Allende, there is a very low iron presence, with amounts less than or equal to ordinary chondrites (LL).

References: [1] Weisberg, M. K. et al. (2006). *Meteorites and the early solar system II*, 1-34**.** [2] Pittarello, L., et al. (2015). *Meteoritics & Planet. Sci.*, *50*(10), 1718-1732. [3] Kuebler, K. E. et al. (2006). *GCA 70*(24), 6201-6222. [4] Hutchison, R. (2004). *CUP*, *Vol*(2), 1-482 . [5] Van Schmus, W. R., & Wood, J. A. (1967). *GCA*, *31*(5), 747-765. [6] Norton, O. R., & Chitwood, L. (2008). *Springer Science & Business Media.* 96-242.



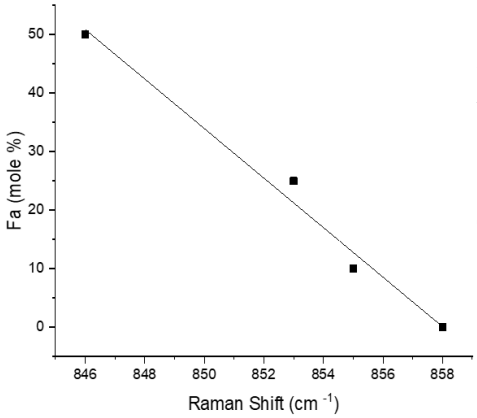
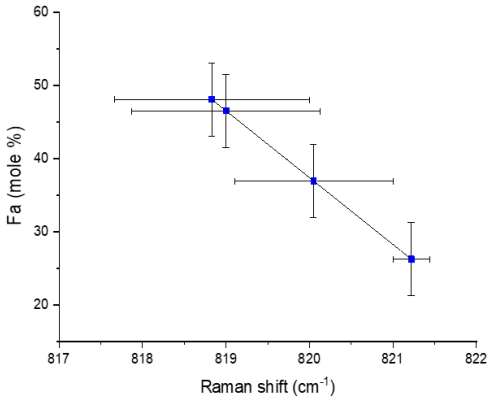


Figure 1: Reference values for Olivine, such as Faialite present in chondrites, where there is a corresponding Trend ([2], [3]).



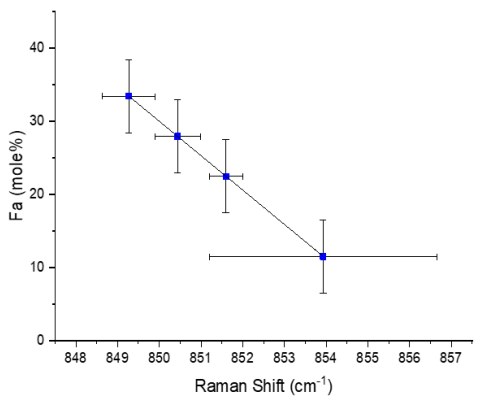
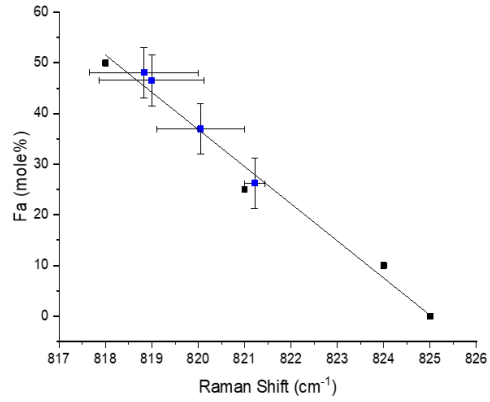


Figure 2: Values found through Raman spectroscopy analysis in the Allende meteorite, which correspond to the reference of the presence of Olivine-Fa in the sample.



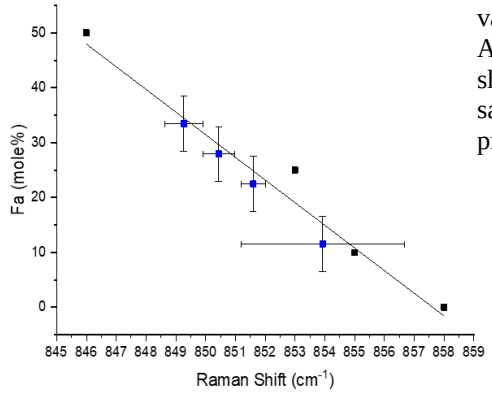


Figure 3: Reference values compared to Allende's values. Trend showing the relations of samples with the presence of Fa.

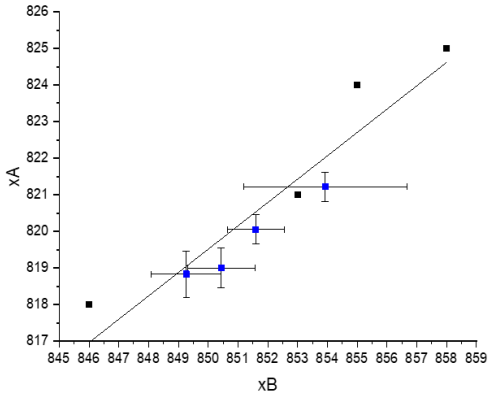


Figure 4: Correlation of the xA and xB peaks, of the Raman spectroscopy bands, with reference presented in the literature. Trend relating Fa uptake and Fe content in the sample.