

## DOES LAFAYETTE = NAKHLA? NOT NECESSARILY SO, BASED ON 4.2K MÖSSBAUER SPECTRA OF ALL OF THE SNC METEORITES

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**Introduction.** In previous Mössbauer spectral studies of many of the SNC meteorites [1,2], attention was drawn to the close similarities of spectrum profiles between Lafayette [3] and Nakhla [4], which were once suggested to be identical meteorites [5]. These observations lead to the acquisition of Gobernador Valadares [6] and another specimen of Nakhla [7], as well as Zagami [8] and Shergotty [8,9], for Mössbauer spectral measurements at 4.2K. Results reported here demonstrate that there are subtle differences between the three nakhlites (Nakhla, Lafayette, and Gobernador Valadares), as there are for three of the shergottites (Shergotty, Zagami, EETA 79001/lithologies A and B) and olivine-dominated Chassigny and ALHA 77005 [2], indicating that all eight of the SNC meteorites discovered to date fell independently to Earth.

**Meteorite Samples.** The British Museum (Natural History) was the source of ~100 mg chips of Nakhla, Gobernador Valadares and Zagami, while the Mineralogical Museum at Harvard University provided samples of Nakhla. The latter specimen enabled portions to be extracted from the fresh interior and black vitreous fusion crust of the meteorite. Samples of Shergotty (fragment A; [9]) and shergottite EETA 79001 (lithologies A and B; [10]) were also obtained. Each meteorite sample was pulverized to <45 microns, mixed with sucrose, and encapsulated in small plastic cylinders for Mössbauer spectral measurements at 4.2K and room temperature. Other experimental details are described elsewhere [1,2].

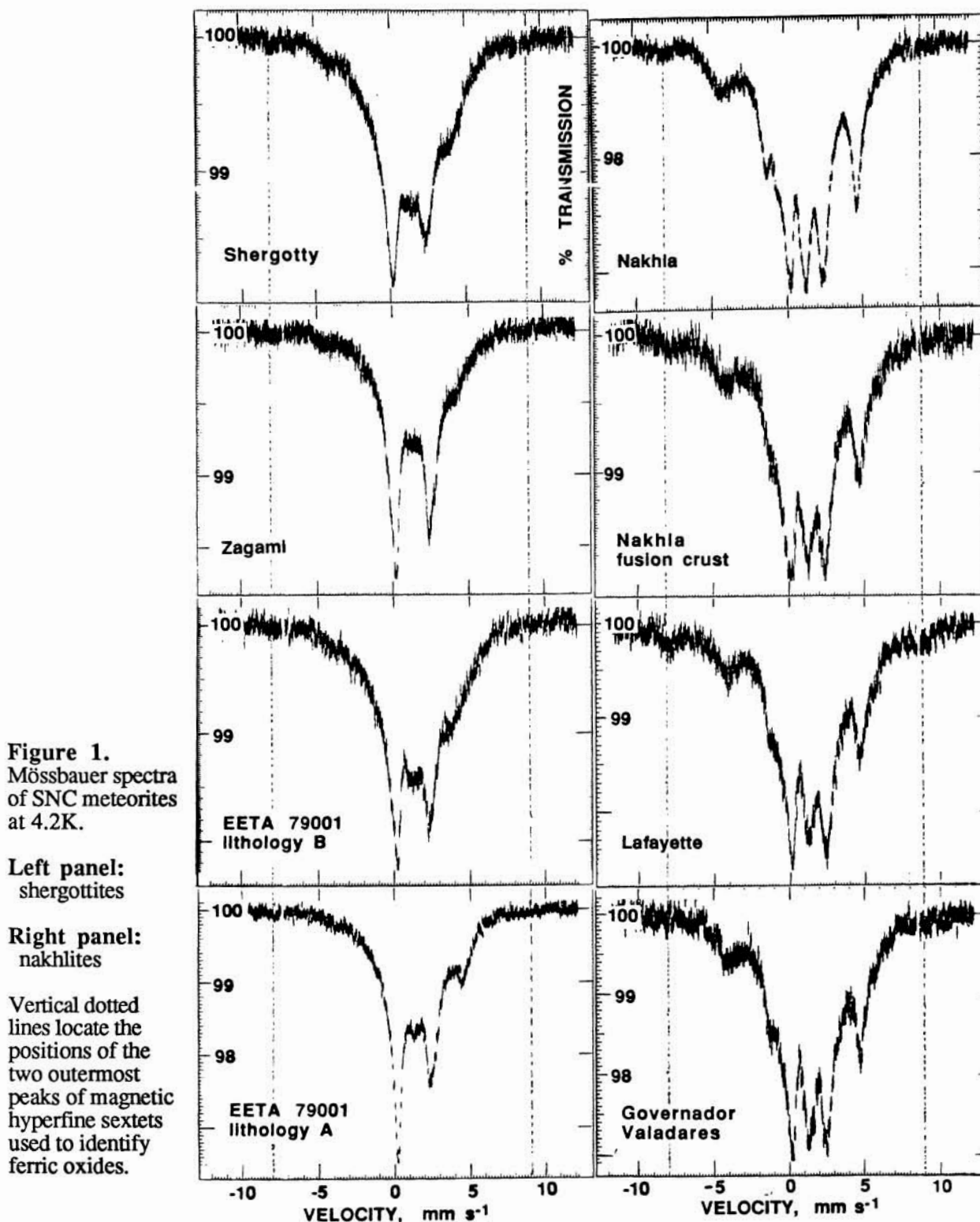
**Results.** Compiled in Figure 1 are the 4.2K Mössbauer spectra of suites of three of the shergottites (left panel) and the three nakhlites (right panel). The nakhlite spectra are complex due to the onset of magnetic ordering of Fe<sup>2+</sup> ions in olivine [11] demonstrated previously [2,12] for olivine-rich Chassigny, Brachina, and ALHA 77005. Three of the olivine peaks at -4.2, +1.3 and +4.6 mm s<sup>-1</sup> are particularly sensitive to variations of composition and temperature [11], requiring that the temperature be rigidly maintained at 4.2K during spectrum acquisition. Figure 1 (right panel) shows that the 4.2K spectra of all three nakhlites resemble one another closely. Weak broad features at -7.8 and +8.7 mm s<sup>-1</sup> attributed to Fe<sup>3+</sup>-bearing phases are present in the spectra of all three nakhlites, and are caused by nanophase goethite + phyllosilicate assemblages comprising iddingsite [13] of preterrestrial origin [14,15]. The ferric features are particularly conspicuous in the spectrum of Lafayette and cannot be due entirely to fusion crust impurities. Overall, the spectrum profile of Lafayette more closely resembles that of Gobernador Valadares than Nakhla.

The shergottite spectra illustrated in Figure 1 (left panel) are dominated by absorption by Fe<sup>2+</sup> ions in pyroxenes, the subtle differences of spectrum profiles reflecting differences of modal proportions of augite, low Ca pyroxenes and olivine [10,16]. The very weakly developed Fe<sup>3+</sup> peaks around -7.8, -4.5 and +8.7 mm s<sup>-1</sup> in Shergotty and Zagami are attributed to ~2% titanomagnetite reported in these meteorites [8]. The 4.2K spectrum profiles of the shergottites are clearly different from the nakhlites and the chassignites described earlier [2,12].

**Discussion.** The small but perceptible differences of Mössbauer spectral profiles between Lafayette and Nakhla indicate that they are separate meteorites. Whereas events relating to the fall of Nakhla in 1912 are well documented [4,7], details for Lafayette prior to 1931 (when it was first recognised as a meteorite in the collection at Purdue University) are ambiguous [3,5]. The two meteorites were once proposed to be identical [5] based on similarities of Xe isotopic data, bulk compositions, modal mineralogies, K-Ar and cosmic ray exposure ages [5,17,18] and Mössbauer spectra [2]. The discovery of the third nakhlite, Gobernador Valadares, with similar Mössbauer spectra and K-Ar and cosmic radiation ages to Nakhla and Lafayette [19], coupled with the fact that shergottites, themselves, also have virtually identical K-Ar and cosmic radiation ages, compositions, mineralogies [18,20] and Mössbauer spectra (Fig.1), would appear to dispell doubts that Lafayette is merely a mislabelled piece of Nakhla [18]. The three nakhlites may be genetically related, however, but their subsequent exposure histories in space and oxidative weathering reactions on Earth have produced slight differences of Fe<sup>2+</sup>/Fe<sup>3+</sup> contents observed in the Mössbauer spectra. Alteration along cracks associated with shock metamorphism may be responsible for some of the FeOOH associated with iddingsite found in the three nakhlites [7,14]. However, chemical weathering on the surface of the Earth may have contributed to some of the FeOOH found in Gobernador Valadares. The high FeOOH content of Lafayette remains anomalous if, indeed, it was collected soon after falling to earth by the Purdue University student fishing near Lafayette [3].

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