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Report

Celebrating the 50th anniversary of CAIs discovery by Mireille Christophe Michel-Lévy

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Abstract—The scope of the present short report is to honour the discovery of CAIs in 1968 and her discoverer, the French mineralogist, Mireille Christophe Michel-Lévy.

In spring 1968, a paper describing an unusual chondrule in the Vigarano meteorite by Mireille Christophe Michel-Lévy appeared in the *Bulletin de la Société Française de Minéralogie et de Cristallographie* (Christophe Michel-Lévy 1968). Written in French, it was submitted October 30, 1967, and despite the name “chondrule,” it offered the first description and interpretation of a calcium-aluminum-rich inclusion (CAI). CAIs are now known to be the first solids to have formed in our solar system (e.g., Connelly et al. 2017). The scope of the present short report was to honor the discovery and the discoverer.

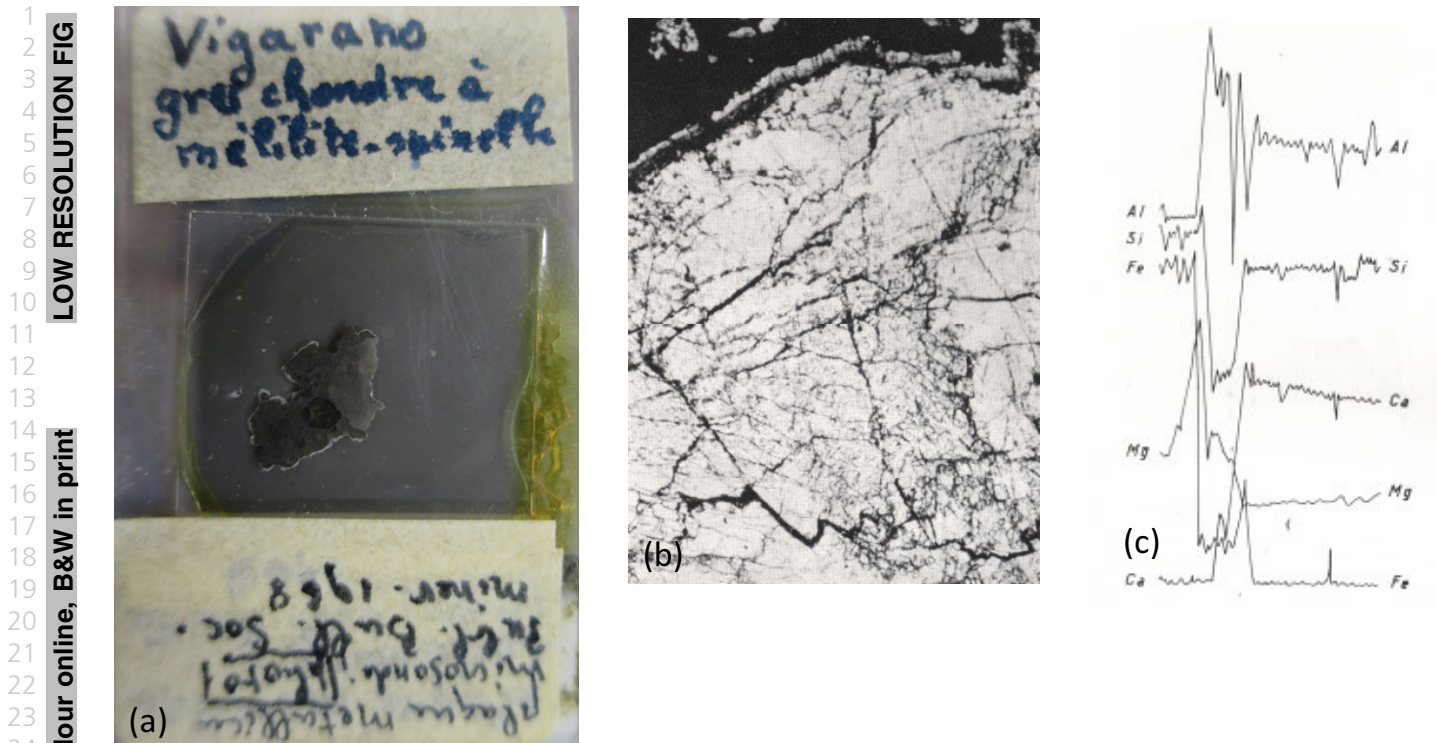
In 1968, Mireille Christophe was in her 40s. She was a CNRS researcher at the Laboratoire de Minéralogie-Cristallographie, part of the Université de la Sorbonne. After an early career dedicated to mineral synthesis, she had decided to devote herself to the study of meteorites, taking advantage of the large meteorite collection gathered at the nearby Muséum by Alfred Lacroix (Lacroix 1927). Before her study of Vigarano, she had published a couple of papers on meteorites (e.g., Christophe Michel-Lévy and Curien 1965). At that time, far fewer individuals worked on meteorites. As an example, 117 people attended the Meteoritical Society Meeting at Washington in 1966, while 539 were present in Berlin 50 years later. Meteorites were also less numerous. There were roughly 2020 known specimens in world's collections in 1966 (Hey 1966), while now researchers can count on more than 57800 samples to develop their research. The CV chondrite group, which had been defined by Wiik (1956), included eight specimens. Only five of them (the falls) had been described with some

detail (Mason 1963). Vigarano, which had fallen in 1910 in Northern Italy, had been examined only by a handful of authors (Rosati 1910a,b; Mason 1963).

The organization of the discovery paper sounds mildly familiar. In the introduction, Madame Christophe reports that she has worked on a thin section from the Muséum national d'histoire naturelle in Paris (Fig. 1). She discusses previous work and mentions that spinel has been reported previously by Mason (1963). Given the “extraordinary” nature of the chondrule she describes, she gives no real justification of her work. In addition to optical microscope, she uses two techniques, X-ray diffraction and electron microprobe, that were at the time quite “modern” and required some specific experience. At that time, it was mainly used for elementary profiles (Fig. 1), and quantitative analyses became accurate only a few years later.

In that exceptional millimeter-sized chondrule (Fig. 1), Madame Christophe reports to have found numerous titaniferous spinel grains whose abundance decreases outwards. Spinel grains are enclosed in melilite whose akermanite content (40–70%) is determined thanks to the electron microprobe. Some areas richer in titanium are interpreted to be rutile or perovskite. Finally, she observes a reaction rim made of spinel and other minerals too fine-grained to be identified. In addition to CAIs, she had discovered the so-called Wark-Lovering rims (Wark and Lovering 1977).

In the discussion, Madame Christophe notes that such a calcium and aluminum-rich object had never been seen before in a chondritic meteorite. She clearly states it is “a primary silico-alumino-calcic condensate.” From its



25 Fig. 1. a) Thin section used by Mireille Christophe. The large, presumably type B, CAI she discovered is on the right of the
26 sample. The label reads “Vigarano – gros chondre à méilite-spinelle”. b) Optical micrograph of the CAI originally published in
27 the 1968 paper. c) Electron microprobe profile published in the 1968 paper.

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30 composition, she calculates that the extraordinary
31 chondrule crystallized between 1400 and 1450 °C. She
32 observes that these temperatures are of the same order
33 than those calculated by Larimer (1967) for vapor
34 condensation from a gas. Finally, she remarks that this
35 object has reacted with the matrix, not during
36 metamorphism, but when it was still hot.

37 The importance of the discovery is considerable.
38 CAIs are probably among the most studied rocks on
39 Earth, of interest for both cosmochemists and
40 astronomers (e.g., Reipurth et al. 2007). An immense
41 deal of effort has been invested in measuring their ages,
42 which defines that of the solar system (Manhès et al.
43 1988; Connelly et al. 2017). The discovery is all the more
44 remarkable as CAIs are far less abundant and visible in
45 Vigarano compared to Allende that was to fall the
46 following year (in 1969), and where CAIs were
47 rediscovered (Marvin et al. 1970).

48 Remarkably enough, most of what would make later
49 on the importance of CAIs (early high-temperature
50 condensates made in a specific environment and
51 transported in the chondrite-forming region) had been
52 clearly identified by Madame Christophe in 1967.
53 Formation mechanisms and transport modes of CAIs are
54 now a subject of important research (Nittler and Ciesla

2016 for a review). Given the importance of the
discovery, it is a bit sad that this key paper is not more
quoted¹. I hope that the present note will contribute to a
wider reconnaissance of the key contribution Mireille
Christophe made to Meteoritics and Astrophysics.

Editorial Handling—Dr. A. J. Timothy Jul

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¹Possibly because it is published in French, in a relatively confidential journal, this paper is not referenced by ADS.

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