**INTRODUCTION**

The fall of the Tatahouine meteorite was observed in 1931 (Lacroix 1931). It has recently attracted attention due to the presence of terrestrial nanobacteria associated with carbonates (Barrat et al. 1998; Barrat et al. 1999; Gillet et al. 2000a). This meteorite was classified as a diogenite based on mineralogical (Lacroix 1932) and isotopic (Clayton and Mayeda 1996) arguments. Diogenites are orthopyroxenite cumulates believed to have originated from asteroid 4-Vesta during an extensive magmatic event at 4.6 b.y. (e.g., Drake 1979; Binzel and Xu 1993; Warren 1997; Lugmair and Shukolyukov 1998). Only 25 such meteorites have been identified to date. Such objects provide unique observations of magmatic and impact events in the early solar system and thus deserve careful investigation.

Orthopyroxene has been widely investigated in Tatahouine (e.g., Lacroix 1932; Mittlefehldt 1994). Because reactions due to shock occurred after the magmatic processes ceased, the characterization of other constituent phases could help to determine the shock conditions of the meteorite. A study of accessory minerals that formed in situ in Tatahouine, as some minerals are better markers of pressure and temperature conditions than orthopyroxene. In this paper, we present a mineralogical study of new mineralogical characteristics of the Tatahouine diogenite.

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**EXPERIMENTAL TECHNIQUES**

Polished thin slices of the Tatahouine meteorite were prepared from a hand specimen of the Tatahouine meteorite collected in 1994 by A. Carion. Additional petrographic observations documenting mosaicism in orthopyroxenes were performed on petrographic thin sections of the meteorite (sample no. 1643) supplied by the Museum National d'Histoire Naturelle de Paris.

For the scanning electron microscope (SEM) observations and X-ray energy dispersive spectrometry (EDS) chemical analyses, thin sections were carbon-coated using a Baltec modular high-vacuum coating system MED020. Operating conditions of the JEOL JSM6301-F microscope were 20 kV accelerating voltage and a sample-to-objective working distance of about 15 mm.

Transmission electron microscopy (TEM) samples were prepared from petrographic thin sections of orthopyroxene crystals displaying mosaicism (see below). Several petrographic thin slides removed from the sections were mounted on Cu grids, then thinned by an argon-ion beam in a Gatan PIPS ion mill operated at 3 kV and 10° on each gun, and finally coated with a thin film of carbon to prevent charging. The samples were studied with a JEOL 2000 EX transmission electron microscope operating at 200 kV and equipped with a Tracor-Northern TN 5400 FX energy-dispersive X-ray analyzer. EDS analyses were obtained in scanning transmission mode with a relatively large probe of about 100 nm.

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**ABSTRACT**

The mineralogy of the Tatahouine diogenite was investigated by optical microscopy, Raman micro-spectrometry, and scanning and transmission electron microscopies. Inclusions of α-cristobalite in orthopyroxenes, locally in symplectic association with chromites, or associated with metal, have been characterized for the first time in a diogenite. Mosaicism of the orthopyroxenes indicates shock effects in the meteorite. The shock history of the meteorite must be consistent with the presence of vein-like structures containing inclusions of well-crystallized cristobalite, a low-pressure, high-temperature phase. Several possible mechanisms to account for these observations are discussed. The simplest one, consistent with all observations, is that a shock event would have occurred in a hot orthopyroxenite, either before extensive cooling of the asteroid, or in materials heated by previous impacts and maintained hot under an ejecta blanket.

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**Cristobalite inclusions in the Tatahouine achondrite: Implications for shock conditions**

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