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Dergaon Meteorite: A Preliminary Geochemical Investigation

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A preliminary investigation of Dergaon meteorite has been undertaken for selective chemical composition of Fe, Al, Si, Cu, Mn and P and abundance of opaque and non-opaque mineral constituents in it. Preliminary petrographic investigations suggested that the Dergaon meteorite belongs to the chondritic class, having primary silicate minerals like olivine, pyroxene, minor plagioclase feldspar and glassy groundmass containing small droplets of iron and troilite. Opaque minerals mostly comprise of troilite, kamacite, taenite, schreibersite, chalcopyrite with minor cohenite, sphalerite, graphite and pyrite. Chemical analysis revealed that the meteorite is composed mainly of silicates (57.69%), iron (32.8%) and phosphorus (1.04%). Volumetric estimate by modal analysis roughly conforms the chemical data.

Key Words : Petrographic investigations, Modal analysis.

INTRODUCTION

Studies on meteorites are an interesting area as their falling to earth's surface in material form is quite a rare occurrence. In a recent American Chemical Society meeting, it was reported that some of the most ancient meteorites could reveal the chemical history of our solar system, particularly the less frequently encountered carbonaceous chondrites which were formed in oxygen-rich regions of the early solar system[1]. As their chemical composition resembles the sun more closely, they may contain the earliest record of the formation of solar system.

The Dergaon meteorite fell on March 2, 2001 at Olotagaon of Dergaon locality (long. 92°52′ E; lat. 26°41′ N), Assam, India. The meteorite has been registered in *Meteoritical Bull. USA*, **85**, 91 (Sept. 2001). Preliminary investigations have been carried out for selective chemical and mineral composition of this meteorite.

EXPERIMENTAL

The sample has been analyzed for its major and trace elemental composition as well as non-opaque and opaque mineral composition. Silica, alumina and phosphorus were determined by gravimetric method reported elsewhere while

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iron, lead, manganese and zinĉ were determined by atomic absorption spectroscopic method. Qualitative optical parameters were estimated in thin and polished sections and studied under transmitted and reflected light microscopy respectively. Glagolev-Chayes method was adopted to estimate the modal compositions of opaque and non-opaque minerals. Qualitative optical properties of minerals were also studied microscopically.

RESULTS AND DISCLISSION

Chemical constitution

Results of certain selective chemical constituents determined are presented in Table-1. The results indicate that the meteorite contains a higher percentage of iron and silica and poor percentage of alumina and phosphorous.

TABLE-1

Element	Percentage/ppm	Method adopted
Fe	32.80%	AAS
Si (as SiO2)	57.69%	Gravimetric
P	1.04%	–do–
Al (as Al_2O_3))	0.014%	–do–
Mn	9.40 ppm	AAS
Pb	1.66 ppm	–do–
Zn	0.465 ppm	–do–

Non-opaque minerals

Thin section study under transmitted light microscopy revealed that the meteorite is of chondritic class as it shows visible chondrule[2].

Non-opaque minerals formed here include mainly olivine, pyroxene and glass with minor plagioclase feldspar. Olivine and pyroxenes and other non-opaque minerals do not show homogeneity in their sizes. Some bigger olivine and pyroxene chondrules are up to 3 mm in diameter. Some of the olivine and pyroxene grains are plastically deformed into oblate spheroids and are fractured into pieces. Majority of olivine and pyroxene chondrules of smaller sizes are distinctly round. Radiating oval shaped monomineralic pyroxenes are common. Pyroxenes lack exsolution textures.

Several grains of pyroxenes together constitute to form a single composite chondrule. Most of the pyroxene chondrules are plastically deformed into pieces to form cellular box work pattern and found releasing iron into the cleavage planes (Fig. 2). Polycrystallinity of olivine chondrule, veining of olivine chondrule and also release of iron along veins are seen in certain olivine grains (Fig. 3).

Plagioclases show albite twining. Swinging of twin lamellae is common in the observed sections (Fig. 1). Glassy materials present show isotropism and contain mineral inclusions (Fig. 4).

Modal composition revealed that the studied meteorite is volumetrically composed of 62.5% silicate minerals including glasses, about 4% graphitc and remaining 32.5% opaque minerals.

Opaque minerals

Opaque minerals identified in the studied Dergaon meteorite include iron, troilite, schreibersite, chalcopyrite, sphalerite and pyrite (Figs. 5 and 6).

Iron is the most abundant opaque mineral found in the studied meteorite sections. It occurs as irregular patches. It is marked by yellowish white colour and high reflectivity. Etching shows poor development of intergrowth of taenite and kamacite, forming Widmanstatten structure and Neumarm lamellae. Taenite is white with yellowish tint, forming lamellae parallel to octahedral planes of Widmanstatten structure while kamacite appears with bluish grey coloured blue bands. Iron patches contain finer inclusions of troilite and schreibersite. Unlike certain other meteorites carbon is found here in the form of metastable cohenite (FeC).

Next to iron in order of abundance is troilite (FeS). In air medium troilites are pinkish brown in colour; troilite occurs as anhedral granular masses associated with iron. Both iron and troilite can be distinguished from their colour difference.

Schreibersite [$(Fe,Ni)_3P$] occurs as inclusions in three distinct forms and found mostly within the primary iron. It appears (a) as needle-like inclusions within iron, (b) as tablet-like inclusions in iron and (c) as strings of beads forming worm-like features (Fig. 6). Optically, schreibersite is white in colour and very weakly anisotropic.

Chalcopyrite ($CuFeS_2$) appears as minor irregular bodies in studied sections. Chalcopyrite forms anhedral aggregate interspersed with silicate minerals. Patches of chalcopyrites may reach a maximum width of 2.5 mm. Sphalerite (ZnS) grains are anhedral in shape. They occur as small isolated grains in silicate masses. Pyrite (FeS_2) grains are subhedral, minor in quantity; typical cubic morphology is rare.

The studied Dergaon meteorite contains both round and oval shaped chondrules of varying sizes. Mineralogically, the Dergaon meteorite can be comfortably placed in the olivine-hypersthene chondritic class of Mason [4]. Von Michaelis *et al.*[5] suggested that the chondrites bear a common signature in any of the elementa! ratios of Al/Si, Mg/Si and Ca/Si and placed them into three different groups, *viz.,* H, L and LL. Mason and Wilk[6] viewed that hypersthene-olivine chondrite represents the L group of chondrite. It is argued that, chemically, the L group is more oxidized and has the bulk Fe/Si ratio to lie within 0.50 to 0.65. However, the bulk Fe/Si ratios vary by a factor of 2 which is much larger than that observed in other groups[7]. The present observation suggested a value of 1.22. The composition of the studied meteorite suggests that the meteorite contains fairly good percentage of silica and iron but low in Al content. The chief contributor of Al is the mineral augite of the pyroxene group. A low percentage of Al is indicated by the absence of augitic pyroxene in the non-opaque constituent of the meteorite. Mineral hypersthenes of the same group, however, contain a

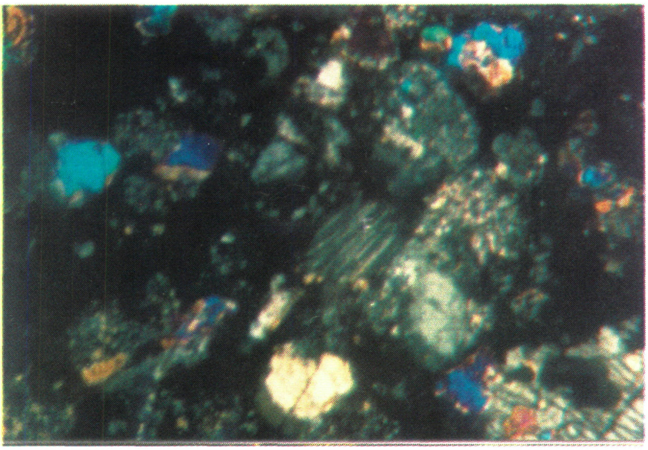

Fig. 1. Photomicrograph of thin section under transmitted light microscope showing visible chondrules of silicate mineral constituents. Most of the silicate chondrules are found shattered due to the effect of shock (x100; XPL).

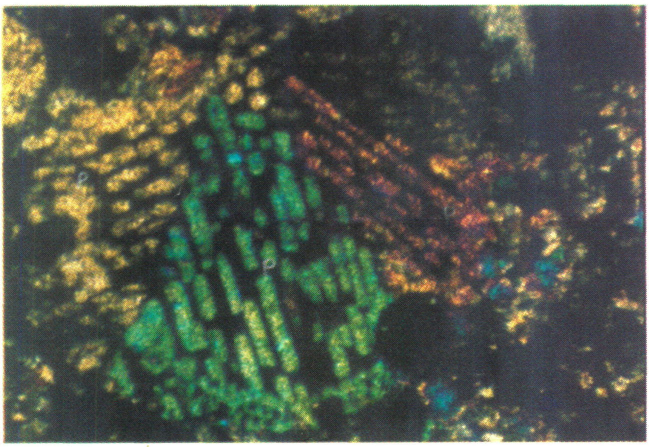

Fig. 2. Photomicrograph showing polycrystalline pyroxene chondrule plastically deformed and shattered partially (x150; XPL).

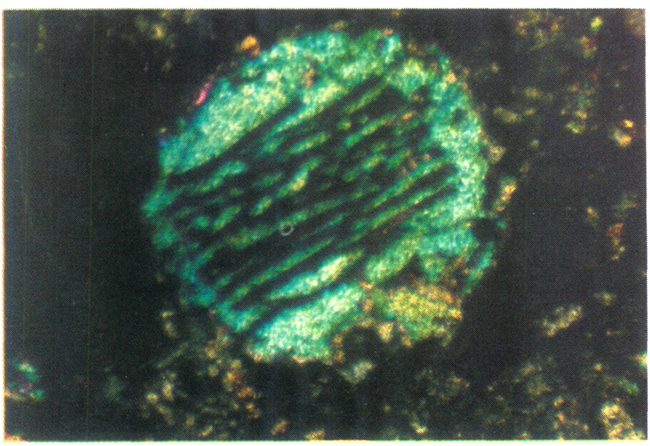

Fig. 3. Photomicrograph showing veining of olivine chondrule and release of iron along veins (observation under transmitted light microscope); certain olivine chondrules develop polycrystallinity (x150; XPL).

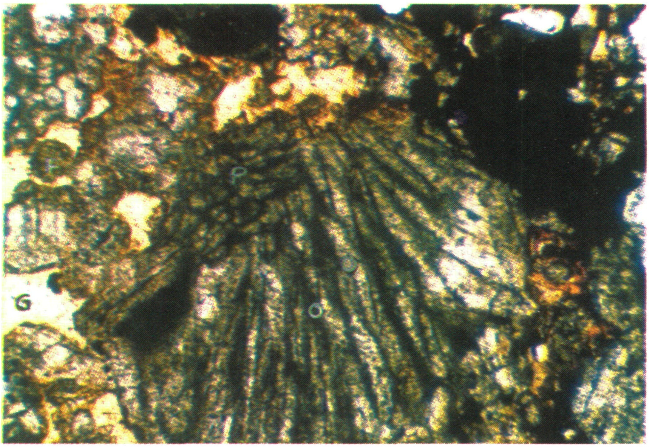

Fig. 4. Photomicrograph showing radiating lamellae of olivine (O) and pyroxene (P), glassy chondrules (G) of varying sizes and feldspar (F) showing albitic twining. Dark patches are the opaque minerals (under transmitted light microscopy) (x150; PL).

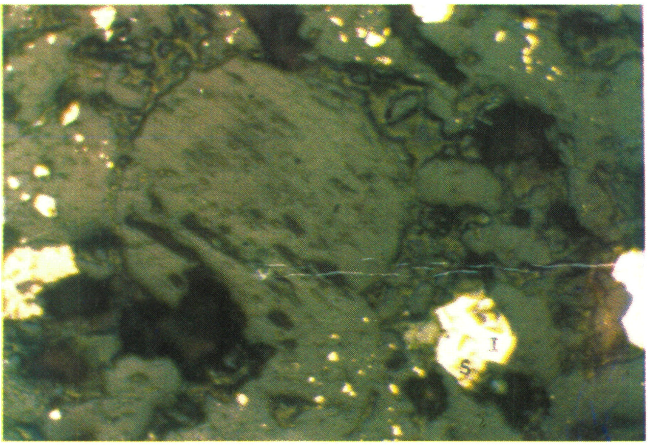

Fig. 5. Reflected light photomicrography of polished section, depicting siliceous chondrule, iron, troilite and porphyritic inclusions of metallic components into the silicate groundmass and also in silicate chondrules (PL; x150).

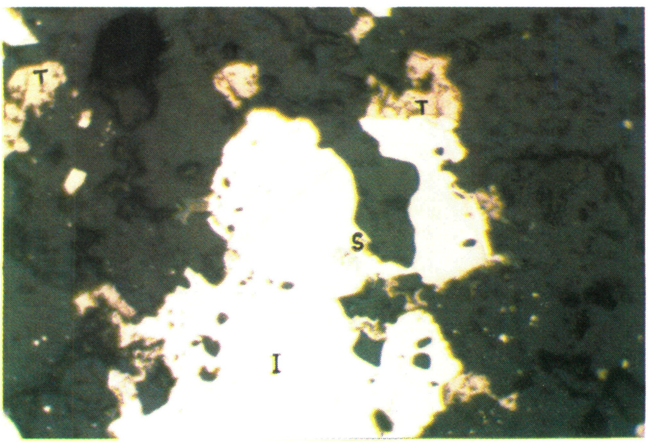

Fig. 6. Patches of iron (I) and troilite (T), schreibersite (S) seen under reflected light microscopy (PL; x150).

trace quantity of Al only. The chief contributor of P is the opaque mineral, schreibersite, where it remains as phosphide.

Unlike most of the chondrites, the Dergaon meteorite suffers shock phenomena. This is evidenced from (i) polycrystallinity and veining of olivine grains; (ii) deformation of pyroxene; (iii) fracturing of other silicate chondrules. and (iv) development of Neumann bands in kamacite etc. Neumann bands in kamacite are produced by compressional wave due to shock at relatively low temperature Baldanza and Pialli[8] suggested a temperature and pressure of 320°C and up to 25,000 atm. respectively for production of Neumann bands. Jain and Lipschutz[9] were of the opinion that about 65% of the iron meteorites have been subjected to shock pressures greater than 130 kb.. Wasson and Chow[7] favours a pressure of approximately 10 atm. for the production of Neumann bands. Deformation of olivine and polycrystallinity of olivine represent a very high shock pressure ranging from 50 to 450 kb.

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