TWISTED FILIFORM MAGNESIAN CALCITE FROM CARBONATE ROCKS OF THE RUSSIAN PLATFORM

Tamara T. Abramova
Lomonosov Moscow State University, Moscow, Russia, skalka@geol.msu.ru

Leili L. Panas'yan
Lomonosov Moscow State University, Moscow, Russia

Mikhail S. Chernov
Lomonosov Moscow State University, Moscow, Russia

Vyacheslav N. Sokolov
Lomonosov Moscow State University, Moscow, Russia

Vladimir M. Ladygin
Lomonosov Moscow State University, Moscow, Russia

Olga I. Gusarova
Lomonosov Moscow State University, Moscow, Russia

Ernst M. Spiridonov
Lomonosov Moscow State University, Moscow, Russia

Twisted whiskers of magnesian calcite occur in strongly dolomitized Kasimovian limestone in the Archangelsk Region and in the Podolian rocks of the Moscow area, in low magnesian Moscovian limestone in the Moscow area, and fragments of dolomitized limestone from the Don moraine at the outskirt of Moscow. Whiskers of calcite are epigenetic and result from water related to Quaternary glaciation of the Russian Platform.
5 figures 6 references.

Whiskers are a comparatively rare morphology for many mineral species, but are especially characteristic of gypsum, anhydrite, chrysotile and amphibole asbestos, tourmaline, zeolites, chalcedony, millerite, boulangerite and other acicular sulfides, malachite, supergene Fe, Cu, Mg, and Ni sulfates, ice, and rock salt (Maleev, 1971, Krasnova & Petrov, 1997). Fine linear whiskers of calcite were described from limestone caves in Bulgaria (Maleev & Filipov, 1974). So called rock milk (rock sour cream), "mondmilch (montmilch, bergmilch)" formed by noncemented aggregates of calcite whiskers about 0.0001 mm thick and up to 0.1—0.2 mm long were documented from limestone caves near Luzerne, Switzerland (Seemann, 1979; Fischer, 1988).

T.T. Abramova and L.L. Panas'yan have described filiform calcite from carbonate rocks of the Moscow area, L.L. Panas'yan, from carbonate rocks of Archangelsk Region, and M.S. Chernov, from fragments of carbonate rocks in moraine at the outskirts of Moscow. Backscattered electron images of chips and determination of chemical composition of carbonates in these rocks were made with a LEO-1450-VP scanning electron microscope equipped with an INCA-300 energy-dispersion system (SEM-EDS), V.N. Sokolov and M.S. Chernov, analysts, Laboratory of Electron Microscopy, Division of Engineering and Environmental Geology, Geology Department, Lomonosov Moscow State University. BSE images were obtained with a Jeol JSM-6480LV scanning electron microscope equipped with an Inca Energy-350 energy-dispersion system, E.V. Guseva, analyst, Laboratory of Local Analytical Techniques, Division of Petrology, Geology Department, Lomonosov Moscow State University.

Filiform calcite from the central Russian Platform

Filiform calcite occurs in Mg-poor pelitomorphic organogenic limestone of the Myachkovo Unit of Late Carboniferous age in the Moscow area (Fig. 1). This white (milky) limestone were mined in the Middle Ages from open pits on the banks of the Moscow river (within the ancient valley of the Moscow river), where Cretaceous and Jurassic deposits enriched in Fe-rich minerals had been removed from Carboniferous carbonate rocks during the pre-glaciation period. In the ancient valley, Carboniferous limestone was affected by Quaternary glaciers and eroded by glacial waters, imparting a milky coloration. Numerous houses in white-stone Moscow were

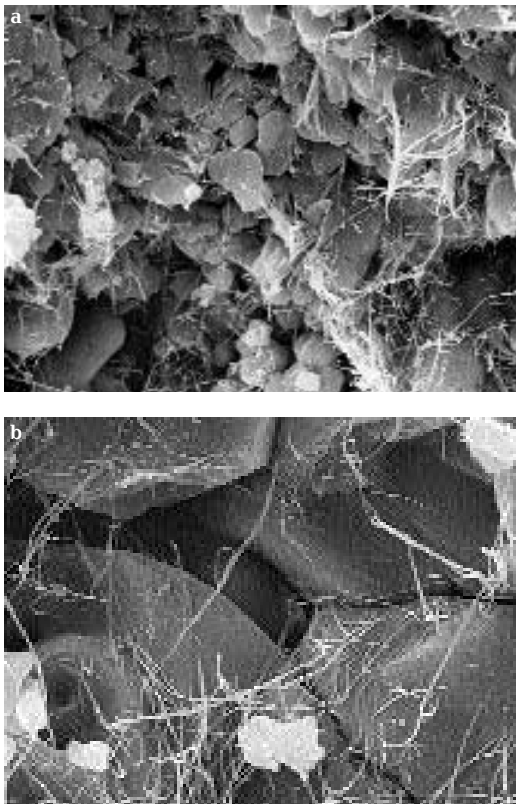


Fig. 1. Myachkovo limestone from the Moscow river valley. BSE images: (a) twisted whiskers of calcite-2 and their segregations in cavities between grains of calcite-1; (b) whiskers of calcite-2 on grains of calcite-1 and in their interstices. A thin film of hydromica covers the grains of calcite-1. Locally, minute rhombohedra of calcite-3 overgrow whiskers of calcite-2.

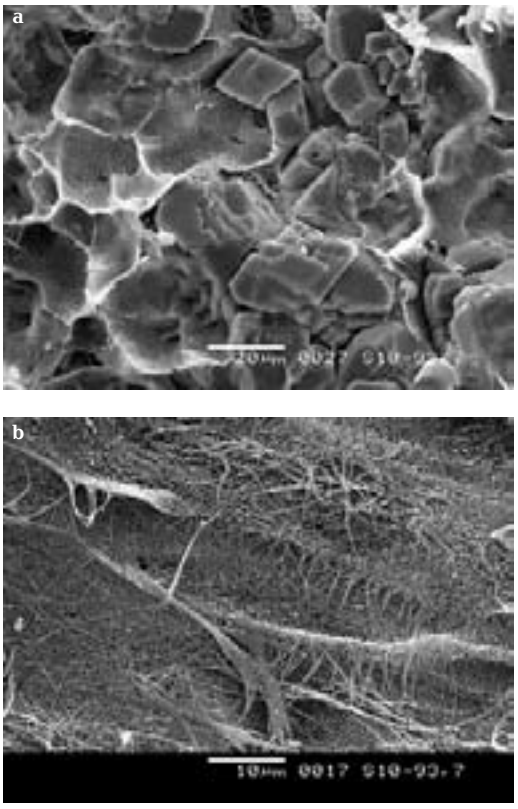


Fig. 2. BSE images of highly dolomitized Podolian limestone from the Moscow river valley. (a) Segregations of fibers of magnesian calcite and palygorskite between dolomite crystals. (b) Segregations of twisted fibers of magnesian calcite and palygorskite.

built with blocks of this limestone, for example, the historical monument in the Museum "*The Chambers of the Romanov Boyars of 15th–17th centuries*" (Zaryad'e, near the Moscow Kremlin). Samples of limestone were collected 10 cm below the surface of the stone masonry of the building. Pelitomorphic limestone consists of small grains of three generations of calcite with minor dolomite and clay minerals. Substantially dissolved oval grains of calcite-1 ranging from 0.001 to 0.02 mm in size (Fig. 1a) constitute the main part of limestone. Rounded and variable shaped etching pits are abundant on the surface of the calcite-1 grains (Fig. 1b).

Usually curved and twisted whiskers of calcite-2 and their aggregates overgrow calcite-1. Numerous fibers appear to grow from the partly dissolved grains of calcite-1 (Fig. 1b). The thickness of the calcite fibers is less than 0.0002 mm; the length is up to 0.02–0.06 mm and more. In cross-section, the fibers are rounded; flat faces are absent on sides of the fibers. The fibers are occasionally twisted into complex loops and rings. The calcite fibers can interweave, forming a mat 1–5 fibers thick. Felted segregations of filiform calcite are local.

Rare regular-shaped rhombohedra of calcite-3 up to 0.002 mm in size and their small segregations overgrow filiform calcite-2.

Similar generations of calcite were found in Middle Carboniferous Podolian dolomitized limestone from drill core in the area of the Krasnay Presnya embankment of the Moscow river (Figs. 2, 3). Here, dolomite crystals ranges from 0.005 to 0.2 mm in size (usually, from 0.02 to 0.07 mm) and subordinate calcite-1, is smaller than 0.005 mm. Twisted fibers of magnesian calcite-2 and their segregations fill interstices between grains of dolomite and calcite (Fig. 3) or coat dolomite crystals (Fig. 2). Tiny segrega-

tions of leather-stone, palygorskite (light grey, centre of Fig. 3c), are frequently associated with magnesian calcite.

Filiform magnesian calcite of the northern Russian Platform

Whiskers of calcite were identified in milky carbonate rock in the Archangelsk Region (northwestern Russian Platform). This rock is the clay-poor highly dolomitized Kasimovian limestone that is underlain by bauxite of the Plisetsk deposit. Fine porous microcrystalline rock was sampled from drill core at a depth of 50–90 m. The rock is composed of rhombohedra of dolomite and clusters of smaller calcite crystals covered with thin films of clay minerals. According to X-ray powder diffraction data, dolomite is approximately 90%, calcite, 5% of the rock. The insoluble residue consists of quartz, less abundant potassium feldspar and clay minerals, and does not exceed 3% of the rock (by volume). According to X-ray powder diffraction data, the clay minerals are hydromica (illite) and minor illite-smectite and palygorskite.

The size of the dolomite rhombohedra ranges from 0.02 to 0.1 mm (Fig. 4a). The chemical composition of the dolomite corresponds to $Ca_{0.99\text{-}1.04}Mg_{1.01\text{-}0.96}[CO_3]_2$; the average composition (on the basis of 3 analyzed points) is $Ca_{1.009}Mg_{0.991}[CO_3]_2$; Fe, Mn, and Sr are below their detection limit. The central part of the dolomite crystals is usually leached and/or replaced by calcite.

Calcite occurs as three generations of different individual crystals. Most of them pertain to calcite-1. Crystals of calcite-1 are nearly equant or slightly elongated, usually oval, occurring infrequently as regular scalenohedra; the crystal size ranges from 0.002 to 0.01 mm (Fig. 4). The surface of calcite-1 crystals are frequently covered by etch figures, including channels, benches and other forms (Fig. 4c). The chemical composition of calcite-1 corresponds to $(Ca_{0.96}Mg_{0.04})[CO_3]$.

The twisted whiskers of calcite-2 are of particular interest. In cross-section, the whiskers are rounded and their thickness ranges from 0.00004 to 0.00008 mm (usually, about 0.00005 mm) (Fig. 4c). Flat faces are absent on the sides of the calcite fibers. The fibers of calcite are of 0.02–0.1 mm long, are frequently curved, and adhere to form thicker fibers or mats. Fibers of calcite like to grow from the surface of dissolved calcite-1 grains (Fig. 4c). Aggregates of the calcite fibers frequently cover dolomite rhombohe-

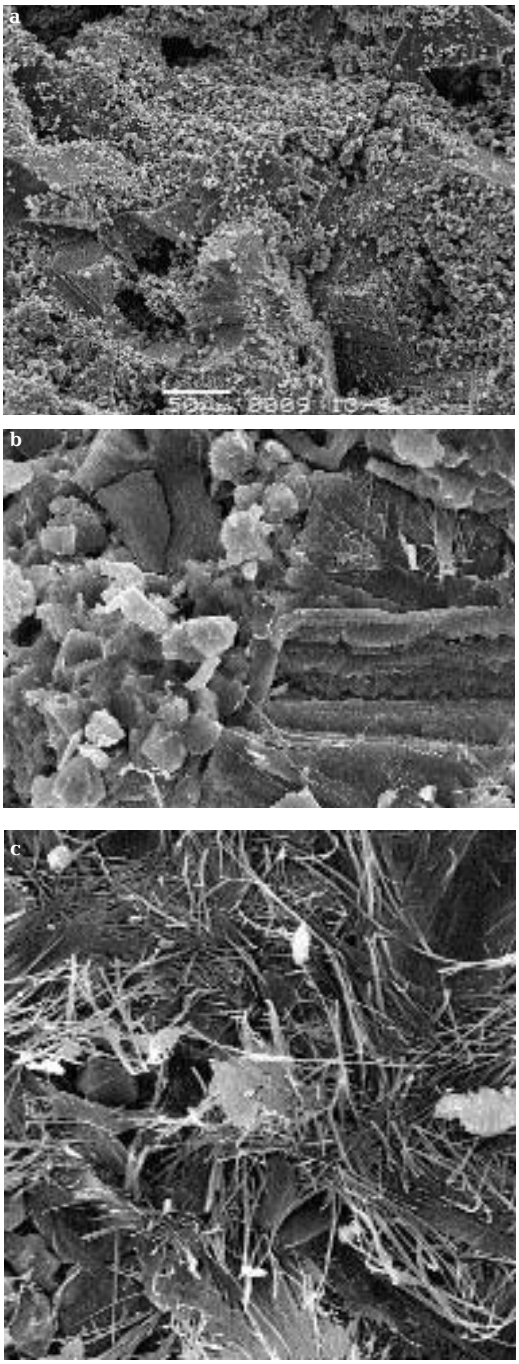


Fig. 3. Podoloian dolomitized limestone from the Moscow river valley. (a) BSE images of rock composed of rhombohedra of dolomite and minute crystals of calcite-1; dolomite crystals are significantly leached. (b) BSE image of whiskers of magnesian calcite-2 between grains of dolomite and calcite-1. (c) BSE image of separate twisted whiskers and their segregations of magnesian calcite-2. Rare crystals of calcite-3 (white) adhere to these whiskers.

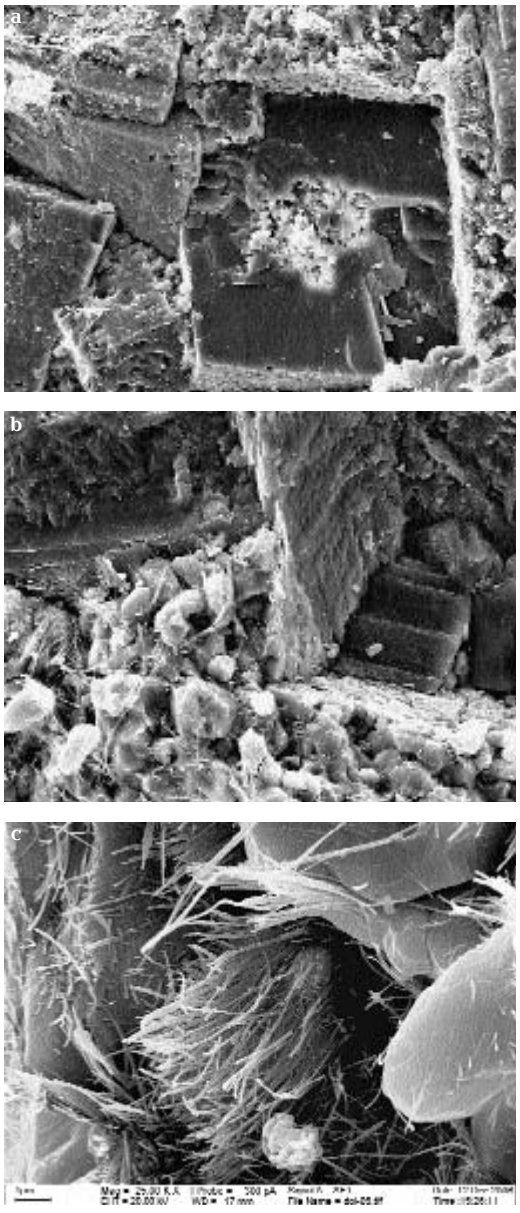
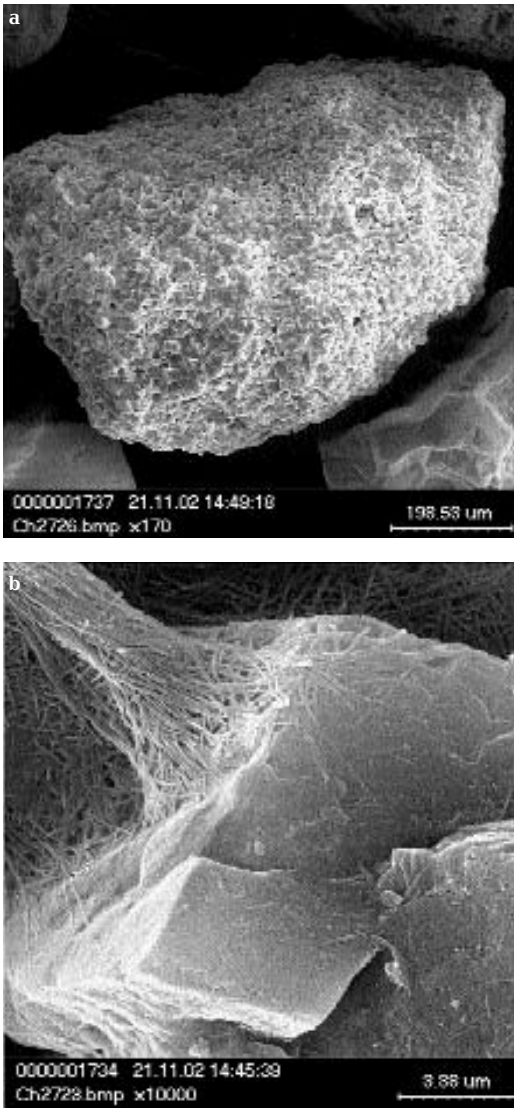


Fig. 4. BSE images of highly dolomitized Kasomovian limestone from the Archangelsk Region. (a) Rocks consist of dolomite rhombohedra and grains of calcite-1. The centres of dolomite rhombohedra are partly leached and partly replaced by calcite (white). Filiform magnesian calcite-2 fills the interstices between grains of dolomite and calcite-1. (b) Twisted fibers of magnesian calcite and their segregations fill interstices between grains of dolomite and calcite-1. (c) Twisted fibers of magnesian calcite-2 have overgrown the dissolved surfaces of calcite-1 grains with a thin film of hydromica.

Fig. 5. BSE images of a 0.8 mm fragment of dolomitized limestone from clays of the Don moraine from southwest Moscow. (a) General view. (b) Detail of this fragment: segregations of twisted fibers of magnesian calcite around dolomite crystals.



dra. In isolated areas, filiform calcite is slightly twisted and its segregations are similar to rock milk (rock cream). The chemical composition of the Archangelsk filiform calcite corresponds to $(Ca_{0.877}Mg_{0.123})[CO_3]$, Mg-rich calcite. The presence of magnesian calcite was confirmed by X-ray diffraction.

Calcite-3 is much rarer. It occurs as tiny isolated rhombohedra and aggregates of rhomohedra, and overgrows dolomite and fibers of calcite-2. Size of the calcite-3 grains ranges from 0.0001 to 0.001 mm. They are pure calcite in composition.

Filiform calcite on the surface of small fragments of carbonate rocks from Quaternary moraine in the central part of the Russian Platform

Twisted filiform magnesian calcite that is similar to that described above occurs on the surface of fragments of dolomitized limestone from moraine clays at the outskirts of Moscow (Fig. 5). Clay samples of the Don moraine were collected from a drill hole at a dept of 12 m. Filiform calcite grew on the surface of small fragments of limestone in the moraine subsequent to deposition of the latter during thawing of the Quaternary glacier.

Probable mechanism of formation of filiform calcite on the Russian Platform

Commonly, natural whiskers grow onto a microporous substrate, and the size of the whiskers is defined by the size of the pores, i.e. the interstices between the crystals of the substrate (Maleev, 1971). The whiskers of calcite in Carboniferous carbonate rocks of the northern and central Russian Platform have probably grown on crystals of dissolved calcite covered by an extremely thin film of hydromica from solutions enriched in Ca and Mg. The late epigenetic generations and aggregates of filiform calcite significantly altered the texture of the carbonate rocks and affected their properties.

Whiskers of relatively soluble compounds such as calcite are the latest and are only moderately stable in general. The filiform calcite and milky coloration of the host carbonate rocks result from waters related to the Quaternary glaciation of the Russian Platform (Spiridonov *et al.*, 2007).

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