# Identification of post-Variscan supergene evolution in marine cherts and residual silicified deposits from Belgium

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## Introduction

Identification of supergene evolution in rocks is a key issue for the recognition and reconstruction of paleosurfaces. Mineralogical, chemical and physical overprints resulting from subaerial exposition of sediments, however, may be obliterated due to further processes such as diagenesis, alteration or erosion. This paper describes two striking examples showing that indicators of supergene evolution have greater chance to be preserved in siliceous/silicified rocks due to the chemical and physical durability of quartz. But deciphering the geological history of such rocks with emphasis on paleosurface recognition requires a better knowledge of silicification processes.

## Supergene evolution in marine cherts: the Saint-Denis Silicite

The Saint-Denis Silicite is a 1 to 9 m thick sedimentary chert layer of Upper Turonian age outcropping in the neighbourhood of Mons, southern Belgium. The Silicite is a local, lateral variation of Chalk-with-flints deposits. The origin of the massive chert remained unclear until recent studies showing that it formed by multi-stage silicification during deposition and early diagenesis (Baele, 2003).

The Saint-Denis Silicite is interbedded within a thick, marine sedimentary sequence extending from Upper Cenomanian to Maastrichtian. Attentive examination of the Turonian chert suggests that unexpected, subaerial exposition occurred during the Upper Turonian or Coniacian: great lateral change in chert facies associated with silicification gradients and redox zones, collapse breccias, solution features such as microkarst-like cavities, etc.

Although each of these observations taken apart is disputable, the whole set is interpreted as a line of evidence for supergene evolution probably related to the worldwide sea-level fall that occurred in the Turonian-Coniacian transitional period (Haq *et al.*, 1987).

Additional observations make this interpretation more robust and highlight the role of silicification in increasing the chance of preservation of supergene evolution in sediments. Solution cavities located in redox boundaries along outer zones of pyritized chert have been colonized by microorganisms (fig. 1). Early (contemporary) silicification allowed the microbiota to be perfectly fossilized as goethitic filamentous mats entombed in clear, euhedral quartz crystals (microbialite). This preserved the biological remains from further marine diagenesis and its destructive effect (pyritization). Additionally, morphological relations of the microbial mats with cavity geometry strongly suggest that the environment was closely related to the fluctuating groundwater surface (gravity draping, wall-sticking mats). Comparisons with modern microbial mats also support the hypothesis of microbial growth within a thin film of percolating water and/or within the capillary fringe. Another similar indication can be found in iron carbonate (siderite) ooids occurring in association with the microbial mats (fig. 2). Geochemical analysis of the ooids shows a strong depletion in $Mg^{2+}$ which is typically observed in fresh-water iron carbonates (Mozley, 1989; Brown and Kingston, 1993). But in this case again, early silicification accounts for the fine preservation of such geochemical signature since siderite is highly sensitive to oxygen and readily oxidizes into goethite. This is clearly shown by the alteration into goethite which occurred only in the siderite globules located on the boundaries of the quartz crystal, not inside (fig. 2).

## Supergene evolution in residual silicified deposits: the “fagnolithes”

First described by Van den Broeck & Rahir (1910), the “fagnolithes” are quartz blocks and boulders lying scattered or clustered on the surface of Devonian limestone outcrops in Entre-Sambre-et-Meuse, southern Belgium

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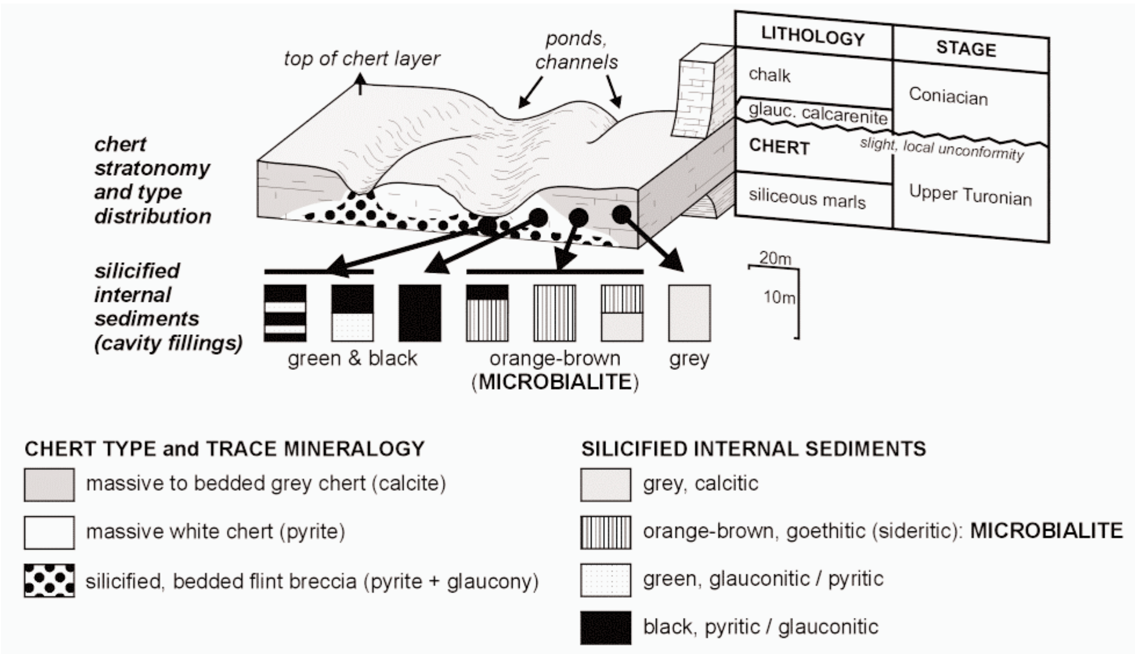


*Fig. 1.- Location of the ferruginized and silicified microorganisms (microbialite) in the Upper Turonian chert from south Belgium (Saint-Denis Silicite).*

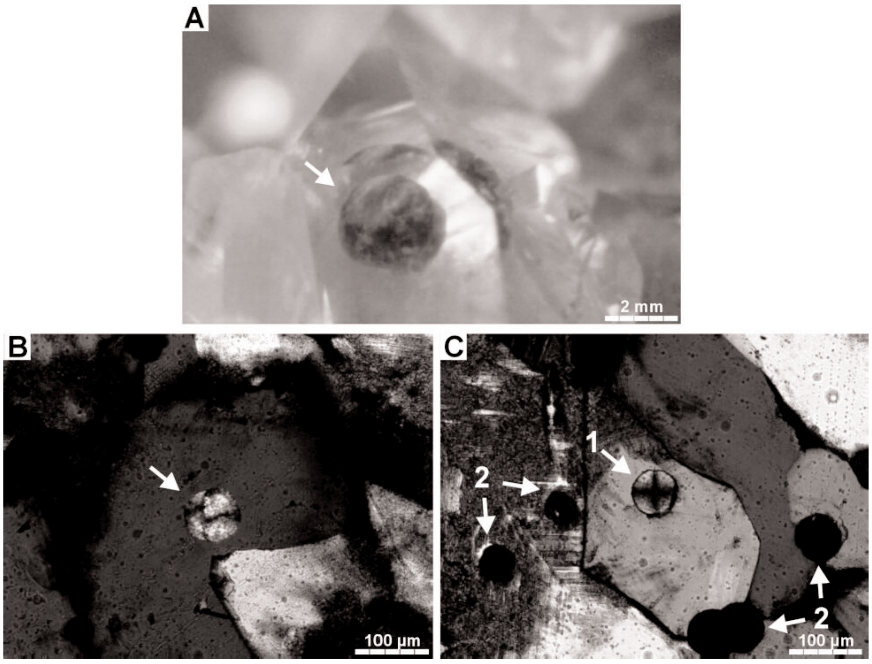


*Fig. 2.- Siderite ooids complety enclosed in one quartz crystal (arrow in A and B). In C, this situation clearly preserved the carbonate (arrow 1) against diagenetic and epigenetic overprinting such as oxidation into goethite (arrow 2). B and C: thin-section, plane-polarized and analysed light.*

(fig. 3). The blocks are found only on the few highest limestone plateaus (elevation above 260 m) within an area of 10 km$^2$ approximately. Based on both the macroscopic aspect of the rock and the observation of Tertiary sand "pockets" in the limestone (cryptokarsts), the blocks were readily interpreted as sandstone relics of a former sedimentary cover of "Landenian" age. This interpretation was further supported by Cayeux (1929) who made the first microscopic analysis of the "fagnolithes". Amazed by the unusual texture consisting of interlocking quartz needles, the author felt constrained to create a new class of sandstone texture ("quartzite microlithique") for which the "fagnolithes" remained the only representative sample for a long time.

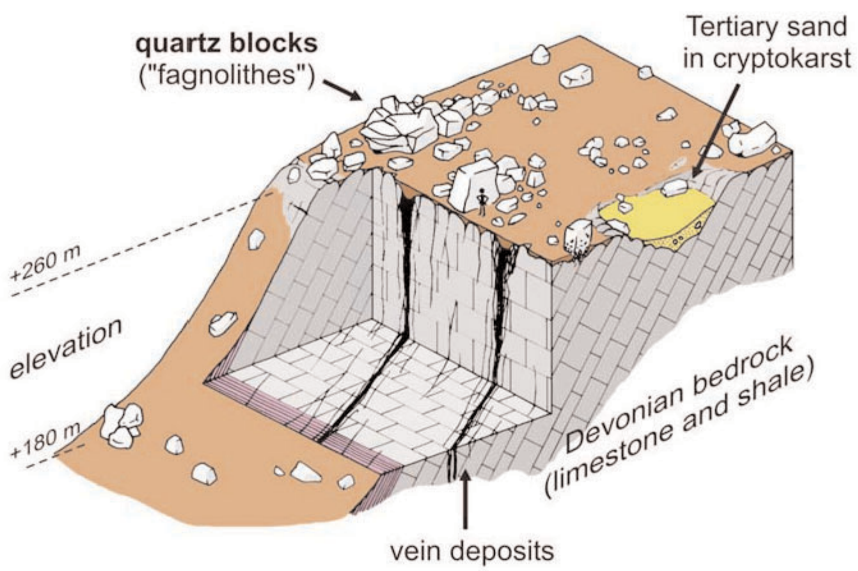


*Fig. 3.- Sketch diagram showing the distribution of the quartz blocks ("fagnolithes") from the Entre-Sambre-et-Meuse area, southern Belgium in relation to topography and geology.*

Later, Voisin (1987) argued that the "fagnolithes" first originated from hydrothermal silicification of the Devonian limestone and then from the collapse of the silicified bodies due to the dissolution of the "host" limestone basement. His interpretation is based on petrographic and paleontological evidence (carbonate inclusions, silicified fossils) but also on the dyke-like shape of some blocks and the occurrence of Pb-Zn-F-Ba mineralization.

Recent work shows that the blocks are relics of mineralized and silicified karst fillings (Baele, 1998). Evidences are provided by texture variations which are similar to those produced by the silicification of typical karst features such as speleothems, collapse breccias, slumpings within the internal sedimentary filling, etc. (fig. 4). The observation of both isopachous and geopetal cavity linings (quartz palisades) also allows the distinction between phreatic and vadose silicification processes respectively. These processes occurred in alternation with the filling of the cavities (mostly by dolarenites, speleothems and mineralization). Additionally, field relations, observation of faulting patterns within the blocks and mineral paragenesis indicate contemporaneous formation for both the vein deposits in the Devonian basement and the filling of the karst with subsequent silicification. It appears that silicification and fluorite deposition occurred in the subsurface system, where karst mainly developed, while dolomitization and sulphides mineralization took place in the basement underneath.

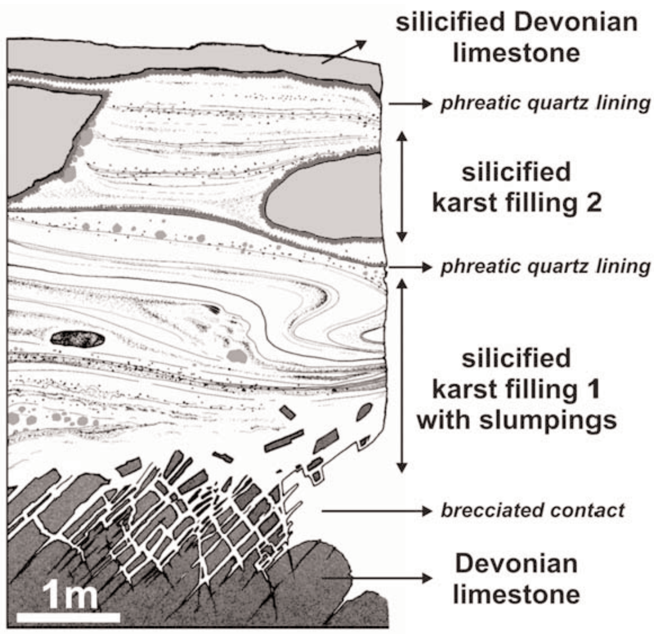


*Fig. 4.- The quartz blocks of the Entre-Sambre-et-Meuse ("fagnolithes") result from multi-stage history of karst filling with silicified sediments (1 and 2) and quartz linings. Middle grey spots within the fillings are euhedral crystals of fluorite.*

Given the interpretation above and the location of the blocks within a narrow elevation range, the quartz blocks are potential relics of a paleosurface. This is an opportunity for subsurface geology topics in this area of great sedimentary gap (from Stephanian to Upper Cretaceous – Lower Tertiary?). Also, the "fagnolithes" are a key material for the understanding of the mineral deposits extending across the south Ardenne massif. The quartz blocks intersect two distinct types of mineral deposits: the Pb-Zn-Ba(-F) veins in carbonate (Villers-en-Fagne, Vierves, etc.) and the F stratoids in silicified limestones (Givet, Doisches, etc.). But the key underlying this field of local geological research could open new perspectives in understanding regional metallogeny in relation to paleosurfaces as it has been well established for the Triassic-Liassic Pb-Zn-F-Ba deposits of central France and even north-west Europe (Davaine, 1980; Lagny, 1975; Samama, 1980).

## Perspectives

Description of rocks similar to the Saint-Denis Silicite and the Residual silicified deposits of the Entre-Sambre-et-Meuse ("fagnolithes") may be found in the literature. It is worth noting that many of these case occurrences still remain unclear and the indications for subaerial evolution often overlooked. This contribution illustrates that similar "problematic" siliceous and silicified rocks are interesting targets for paleosurface recognition, providing that the material is very carefully examined and interpreted in the light of newer knowledge on silicification processes.

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