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THE SANDSTONE AND LIMESTONE BEDS FROM THE MONT PANISEL BORING: PETROGRAPHICAL CHARACTERISTICS, LITHOSTRATIGRAPHY AND DIAGENESIS OF SILICA-CEMENTED SANDSTONES IN THE YPRESIAN OF BELGIUM

by

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ABSTRACT

Several sandstone and sandy limestone beds were encountered in the Mont Panisel boring. Their petrographical characteristics, lithostratigraphy and diagenesis were studied. The upper 17 m of the boring (Mont Panisel Member), contains ten layers of silica cemented sandstones. Their cement mainly consists of opal, with some patches of chalcedony. In the Mons-en-Pévèle Member (17-65 m) two layers of sandy limestone were encountered. In the same member, a bed of opal cemented sandstone was sampled in an outcrop at the Mont Panisel. A study of stone facies distribution showed that the type of opal-cemented sandstones found in the Mont Panisel and Mons-en-Pévèle Members is a very common one in different Ypresian deposits between Mons and the North Sea coast.

The silica of the cement is of biogenic origin. Large amounts of sponge spicules were deposited during conditions of lower supply of detrital material. Their very unstable amorphous opal-A was dissolved and recrystallised as more stable opal-CT or chalcedony. The occurrence of layers and intraformational slabs of porcellanite indicates a phase of diagenesis shortly after deposition. But the main stage of diagenesis, the cementation of the sandstones as we find them now, took place after they were buried deep enough to be no more affected by erosional phases, accompanying a regression, as no reworked layers are found in a basal gravel of a Tertiary deposit. The exact time of the diagenesis is difficult to be fixed.

RESUME

Plusieurs bancs de grès et de calcaire gréseux ont été rencontrés dans le sondage du Mont Panisel. Leurs caractères pétrographiques, leur lithostratigraphie et leur diagénèse ont été étudiés. Dans la partie supérieure du sondage (0-17 m), le Membre du Mont Panisel contient dix couches de grès siliceux. L'élément principal de leur ciment est de l'opale-CT, avec quelques inclusions de chalcédoine. Dans le Membre de Mons-en-Pévèle (17-65 m), deux couches de calcaire gréseux, au ciment micritique, ont été percées. Dans ce même membre, un banc de grès siliceux a été échantillonné dans un affleurement au Mont Panisel. Un aperçu de leur distribution lithostratigraphique a démontré que des bancs de grès à ciment d'opale, comme ceux qu'on trouve dans le site du Mont Panisel, se rencontrent dans plusieurs dépôts yprésiens entre Mons et la Mer du Nord.

La silice du ciment est d'origine biogène. Pendant des périodes d'apport réduit de matériel siliciclastique terrigène, du sédiment riche en spicules de spongiaires se déposait. Ces spicules se composaient d'opale-A une variété très instable. Par dissolution et recristallisation, de l'opale-CT et de la chalcédoine se formaient. La présence de cailloux intraformationels et de couches de

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porcellanite indiquent qu'une phase de diagénèse a eu lieu très vite après la sédimentation. Le stade de diagénèse principale, formant les bancs de grès comme on les trouve maintenant, ne s'est produit que quand le sédiment était enseveli asssez profond pour qu'une phase d'érosion, accompagnant une régression, ne les pouvait affecter non plus, puisqu'on ne trouve pas des bancs remaniés dans un gravier de base tertiaire. Le moment exact de cette phase est difficile à fixer.

SAMENVATTING

In de boring van de Mont Panisel werden verschillende banken zandsteen en zandige kalksteen bemonsterd. Hun petrografische kenmerken, lithostratigrafische verspreiding en diagenese werden onderzocht. In het bovenste deel van de boring, het Lid van de Mont Panisel (0-17 m), werden tien steenbanken aangetroffen. Hun cement bestaat hoofzakelijk uit opaal-CT, met enkele insluitsels van chalcedoon. In het Lid van Mons-en-Pévèle (17-65 m) werden twee lagen zandige kalksteen met een micrietcement aangeboord. In een ontsluiting van dezelfde afzetting werd op de Mont Panisel een zandsteenbank met een opaal-cement aangetrofffen. Een onderzoek van de faciesvespreiding toonde aan dat het type zandsteen met een opaalcement, zoals werd aangetroffen in de boring, voorkomt in verschillende afzettingen van het Ieperiaan tussen Mons en de Noordzee.

Het cement is van biogene oorsprong. Grote hoeveelheden sponsspiculen konden worden afgezet tijdens perioden van verminderde terrigene aanvoer. Hun bestanddeel, opaal-A, was zeer onstabiel. Door oplossing en herkristallisatie werden opaal-CT en chalcedoon gevormd. De aanwezigheid van laagjes en intraformationele keien porcellaniet wijzen op een diagenesefase kort na de sedimentatie. De belangrijkste diagenesefase, de vorming van de steenbanken zoals we ze nu aantreffen, vond plaats toen het gesteente reeds diep genoeg begraven was om buiten het bereik te zijn van met regressies gepaard gaande erosiefasen, vermits er geen herwerkte veldsteenbanken worden aangetroffen in enig Tertiair basisgrind. Wanneer deze diagenesefase juist plaatsvond is echter moeilijk te achterhalen.

KEY WORDS

Mont Panisel boring, Ypresian, silicification, diagenesis.

MOTS CLES

Sondage du Mont Panisel, Yprésien, silicification, diagénèse.

SLEUTELWOORDEN

Mont Panisel boring, Ieperiaan, verkiezelingen, diagenese.

1. INTRODUCTION

The Mont Panisel, in the neighbnourhood of Mons, is the southwesternmost outlier of the Paniselian, defined by Dumont (1851). A 65 m deep stratigraphical boring (Belgian Geological Survey - BGS - 151E340) was drilled at the site, in order to allow a multidisciplinary study of the Ypresian deposits occuring at this hill. A description of the project, with a lithological section and the first interpretations, was presented by Dupuis *et al.* (1988). They proposed the following limits : 0-17 m : Mont Panisel Member, 17-65 m : Mons-en-Pévèle Member. Both lithostratigraphical names are according to the definitions of Steurbaut et Nolf (1986), who concluded that the deposits from the "Paniselian" type section at the Mont Panisel have to be considered as the southern facies of the older Egem Member (Yd). This lateral facies was named Mont Panisel Sand Member.

Sandstone beds, named "Fieldstone" are a common feature in the "Paniselian", and a large number of them were struck in the borehole, most of them in the upper ten meter. Samples were taken at the following depths : 0.25 m, 1.4 m, 2.1 m, 4.05 m, 6.2 m, 6.7 m, 7.1 m, 8.7 m, 9.7 m, 13.3 m, 18.35 m, 36.0 m and 36.25 m. The layers are 5-10 cm thick. In the present contribution, petrographical characteristics, lithostratigraphical distribution and diagenesis of the sandstone layers occurring at the Mont Panisel site and of coherent beds in the Ypresian in general, are discussed.

The sandstones show a greenish grey colour, they contain glauconite and sometimes a single white bivalve shell is observed. Polished surfaces of samples usually look mottled, with burrow shafts. Only the lowermost levels (36.0 and 36.25 m) look different. They are yellow and they contain calcium carbonate.

Thin sections of samples from all the stone levels were studied with the petrographical microscope. Thin sections of calcareous rocks were stained with Alizarine-S and K-ferricyanid (method of Evamy 1963). This method allows to distinguish ferroan and non-ferroan calcite. X-ray diffraction was applied to check mineralogy. Pieces of stone layers were also investigated with the Scanning Electron Microscope (Philips SEM 505 at the Laboratory for Electron Microscopy of the State University of Gent).

2. COHERENT BEDS FROM THE MONT PANISEL BORING: PETROGRAPHY

2.1. Introduction

The petrographical investigation allowed to distinguish two groups. Both the lowermost coherent layers (36 and 36.25 m), occurring in the Mons-en-Pévèle Member, are sandy limestones. All the other beds, which are part of the Mont Panisel Member, have a siliceous cement.

2.2. The siliceous sandstones

Quartz is the main component : its content ranges between 43 and 53 %. The grains are baldy sorted and angular to subangular. The sandstones contain about 5 % of glauconite, present as rounded grains of the same size as quartz. The cement (40 to 50 % of the sandstones) consists of rather pure opal. Locally, small patches of granular chalcedony are found. A photomicrograph from the common sandstone type, found in the boring, is shown on Plate I.1.

In most of the sandstones, a large amount of siliceous fossils is present (up to 4 %). Most of them are elongated and rounded sponge skeleton particles. The fossils observed are solution voids, most, but not all of them filled up afterwards with opal or chalcedony. Many infilling sequences are observed. The most common successions are :

- an outer phase of short-fibrous chalcedony, followed by radial-fibrous chalcedony ;
- a central core of opal, surrounded by radial-fibrous chalcedony ;
- short-fibrous chalcedony, between two zones of opal.

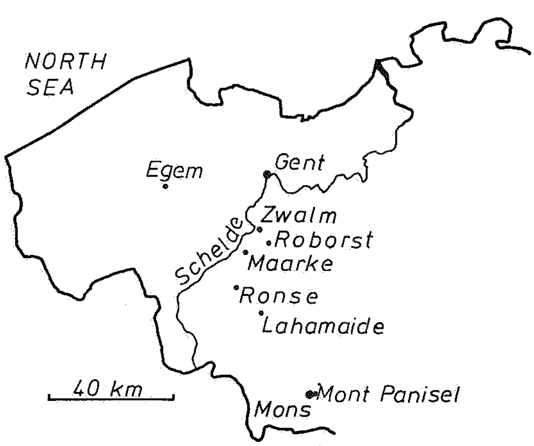

Figure 1 : Location of the Mont Panisel and the other places mentioned in the text.

In some cases, the solution void has been extended ouside the original space of the spicule and was also later on filled with chalcedony. This is one of the reasons for the occurrence of irregularly shaped chalcedony patches within the cement. The few white bivalve shells were silicified and now consist of opal. Their original texture has been largely preserved.

Generally, the sandstones are homogeneous. Sometimes, pellets of nearly pure opal are observed. On hand specimens, they appear as grey mat inclusions. Sedimentary structures are rare. If they are present, they consist of horizontally laminated sequences of alternating quartz- and opal rich laminae, up to 4 mm thick. The only sample displaying well-preserved structures is the layer collected at 7.1 m. In other samples, most of the structures seem to have been largely destroyed by bioturbation. Locally, remains of burrow shaft walls are preserved as streaks of opal and clayey material.

X-ray diffraction analyses revealed that the cement, pellets and silicified bivalve shells consist of opal-CT. Observed with the SEM, the cement is usually arranged as lepispheres, spherical aggregates of plate shaped crystals, their diameter ranging between 3 and 10 um.

Most of the sandstones don't show proper characteristics, except for two the layers at 4.05 and 13.3 m. The layer collected at 4.05 m (Pl. I.2) is very rich in siliceous skeletons. A lower amount of quartz (36 %) and more opal matrix (55 %) than in the average sandstones was counted. The mean diameter of the quartz grains is finer than in the other layers. The layer struck at 13.3 m (Pl. I.3) shows a close packed fabric, with 63 % of quartz, 5 % of glauconite and only 32 % of cement, formed by rims of opal around the detrital grains and chalcedony in the middle of the intergranular space. Locally, the whole cement is opal, but the close-packed structure remains. The grain size is only slightly coarser than in the other layers in the boring. The texture observed in this sample is very common in the sandstones from the Vlierzele sands, but the grain size distribution in the latter is much coarser than in the Mont Panisel samples.

2.3. The sandy limestones

The sandy limestones levels collected at 36.0 and 36.25 m (Pl. I.4) are cemented by fine grained, slightly ferrous micrite. Due to the relative high amount of calcite matrix (68 %), the texture is matrix-supported. Rather fine, angular quartz grains are floating in the cement (12 %). Glauconite grains (4 %) are usually coarser than the quartz grains. The largest ones are lobate and their longest axis may amount up to 0.7 mm. About 16 % of calcareous fossils was counted, mainly small foraminifera tests and a few nummulites. Some iron-rich (about 3 % of FeCO) sparite crystals were observed within the matrix^3. They probably represent infillings of fossil cavities.

2.4. Coherent rocks from other outcrops at the Mont Panisel

Close to the drilling site, at an outcrop along a hollow road, similar sandstone beds as in the boring cores were sampled. They number six, in an exposed section of about 4 m high. This distribution is comparable to the upper part of the boring. The nature of the surrounding sediment and the petrographic characteristics of the sandstones from this outcrop are the same as the layers in the cores between 0 and 10 m.

At the other side of the hill, at the place named Bocage, in the side of another hollow road, a brittle sandstone bed was exposed within fine grained sand. This sandstone (Pl. I.5) is cemented by opal, but its texture is different from the other silica-cemented layers in the neigbourhood. The quartz grains are of the same size as those in the sandy limestones collected at 36.0 and 36.25 m in the cores. Counting results yielded : 50 % of quartz, 46 % of opal matrix and 4 % of glauconite. No fossils were observed, but some solution voids indicate that the sandstone originally contained bivalve shells and was decalcified afterwards.

Dupuis *et al.* (1988) considered the section in the boring below 17.3 m as the Mons-en-Pévèle Member, sensu Steurbaut & Nolf (1986). This member often contains sandy limestone beds, rich in *Nummulites-planulatus-elegans* (the Grès de Pève or Zandbergen limestone). Usually, these coherent beds are cemented by rather coarse, clear sparite, and not by a mass of micrite or very fine grained sparite, as it is the case with the samples (36 and 36.5 m) from the Mont Panisel boring. Furthermore, the normal matrix/quartz ratio in the Zandbergen limestones is about 1/1, compared to 5/1 in the samples from the Mont Panisel boring. A stone facies like the sandy limestones from the boring has not been observed until now.

The occurrence of opal-cemented sandstones, like the one from the Bocage outcrop, is not uncommon in the Mons-en-Pévèle Member. In the preliminary study of the boring (Dupuis *et al.*, 1988), a correlation was proposed between the sandstone at the Bocage outcrop and the coherent beds at 36.0 and 36.25 m. However, the former is an opal cemented sandstone and the latter are micritic limestones. Because of their different petrographical characteristics, this correlation cannot be confirmed.

PETROGRAPHICAL CHARACTERISTICS OF SILICEOUS SANDSTONES IN THE YPRESIAN IN ITS OUTCROPPING AREA

3.1. Mont Panisel Member

Sandstone layers ressembling those of the Mont Panisel Member at its type locality and occuring in sandy clay deposits with similar lithological characteristics, were found in several outcrops between Mons and the Zwalm valley.

An outcrop was made along the former railroad Ronse-Lessines, at the hamlet of Schoonboeke/Beaufaux (Fig. 2). The trench has been described by Delvaux (1884), during the construction of the railroad. Since many years, the rails have been replaced by a walking and cycling track. Under a thin cover of soil material, glauconitic sandy clay with sandstone beds appears. The sediment shows horizontal laminations, sometimes wit grey clay layers up to 1 cm. Much of the structures has been destroyed by bioturbation. The sediment looks the same as that in the type section and in the boring of the Mont Panisel and was originally correlated with the Pittem clay.

Six sandstone layers were sampled in the Schoonboeke outcrop (Fig. 3). They are cemented by opal, and in thin sections, they ressemble those of the Mont Panisel, except for

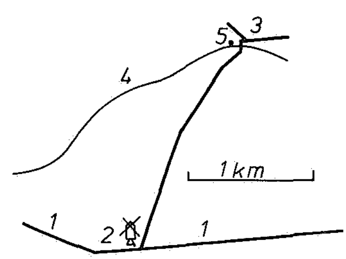

Figure 2 : Detailed location of the Schoonboeke outcrop :

1. Road Ronse-Lessines
2. Windmill "Chat Sauvage"
3. Schoonboeke hamlet
4. Old railroad track Ronse-Lessines
5. Outcrop (slope of railroad trench)

some details. They contain more glauconite (sometimes more than 10 %). The samples from the Mont Panisel are richer in sponge spicules. The sandstones from Ronse have more clay dispersed in their opal matrix. Their sedimentological structures are better preserved (alternations of horizontal sandy and opaline laminae, about 1 mm thick). In the sandy parts, quartz grains are close packed, and sometimes, patches of chalcedony are found in the cement. Other sandstone samples are homogeneous, but they contain inclusions of opal, just like the samples from the Mont Panisel.

Sandstone beds comparable to those from Schoonboeke and the Mont Panisel were found in the Roborst claypit, in the Zwalm area, from a profile occurring under the Merelbeke Member and thus in a stratigraphical position different from the Pittem Member.

3.2. Egem Member

Sandstones cemented by opal also occur in the Egem Member. No outcrops of this beds are known, but in a boring in Gent (B.G.S. 55E62), five layers were struck (8.5 m, 18.8 m, 20.0 m, 21.5 m and 26.15 m). All these layers have similar petrographical characteristics. They consist of quartz grains (37-41 %), glauconite (9-14 %), opal cement (42-46 %), some chalcedony cement patches (1-4 %) and calcareous and siliceous fossils (1-4 %). Glauconite grains are of the same size as quartz. Calcareous fossils include bivalve shells, echinoid spines and foraminifera. The matrix contains a lot of dispersed calcite particles. The sandstone facies from the Egem Member in Gent looks largely similar to samples from the Mont Panisel boring and Ronse.

3.3. Pittem Member

In the type area of the Pittem Member, sandstone beds could be studied in the Ampe quarry at Egem. Five layers are found in the Pittem Member. The lowermost one, at the base of the Member, is 60 cm thick and continuous. The other four beds are thinner (15 cm) and occur as levels of isolated sandstone plates.

The lower part of the basal layer contains reworked fossils from the underlying Egem member. Observed with the microscope, the sandstone shows a very impure opal-CT-cement, rich in pyrite, clay and particles of $CaCO_3$. About 50 % of cement, 40 % of quartz and 10 % of large, lobate glauconite grains, usually larger than the quartz grains were counted. Study with the SEM showed that lepisphere structures are the most common type of cement (Pl. II.1). Locally, unarranged platy structures or massif cement are observed. Lepispheres have been formed upon the surface of quartz grains and subsequentely filled in the intergranular space. They clearly appear as a void-filling and not as a remplacement texture, a feature that was observed in all the opal-cemented sandstones in the Ypresian (Pl. II.4). The structure of the sandstone looks very mottled and seems to have been strongly bioturbated. Sandstones with this composition and texture are often observed in the Pittem Member. Large, lobate glauconite grains, their diameter approaching 1 mm are characteristic for this facies. In the second layer in the Egem outcrop, 18 % of glauconite was counted. In sandstone beds found in temporary outcrops in Meilegem and Munkzwalm, in the municipality of Zwalm, glauconite content may amount up to 26 % (Pl. I.6). Flat inclusions (1 cm) of spiculites, cemented by opal, are found in the sandstone. Sponge spicules are filled in with secondary chalcedony. Sometimes, a secondary solution void was formed from the cavity of the dissolved spicule before it was filled with chalcedony.

The third layer in the Egem pit is completely different, with its finer grained but rather well sorted quartz fraction (49 %) in a pure opal-CT-matrix (42 %). Glauconite grains (7 %) are rounded and of the same size as the quartz grains. Due to slight but regular alternations in the quartz/cement ratio, the sandstone bed is finely laminated. The structures are sometimes cut by a single burrow. Inclusions of spiculite were also observed in this layer.

In both the uppermost layers, a badly sorted but usually very fine silty sediment was found, in a matrix of clayey opal (45 %). Glauconite (7-8 %) is also fine grained.

3.4. Vlierzele Formation

In the sands of the Vlierzele Formation, many outcrops of sandstone beds have been reported between Mons and Knokke. The layers generally appear as hard, quartzite-like rocks. The cement consists of rims of opal-CT around the quartz- and glauconite grains, and chalcedony in the remaining intergranular void space (Pl. II.2). The chalcedonic cement, observed with crossed polarisers, consists of two phases : an outer rim with a short-fibrous texture and a central zone with radial-fibrous of granular material. Cementation took place in several phases, as opal-CT layers show well developed lepispheres and two generations of chalcedony can be distinguished.

In the region between Gent and Brugge, the relative amount of opal cement becomes more important. Some sandstones are very rich in lignite (Aalterbrugge Bed).

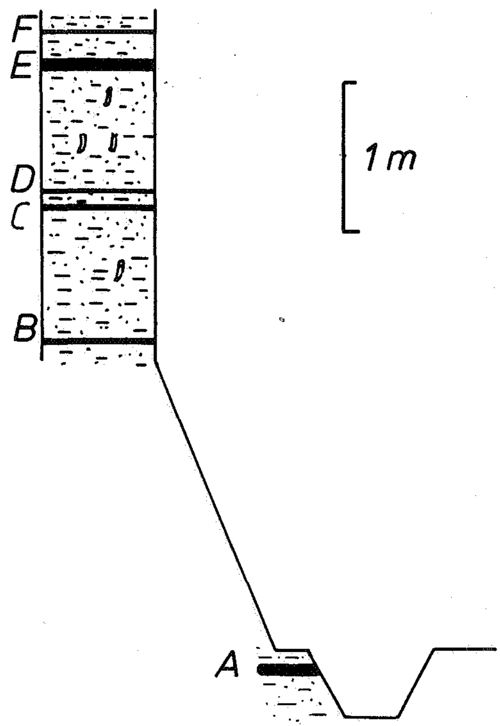

Figure 3: Section of the railroad trench at Schoonboeke. The Mont Panisel Member is exposed, with 5 sandstone layers (A - F).

Under the SEM, the cement often appears as a compact mass (Pl. II.4). The different optical phases of chalcedony are not discernable, and the opal rims are sometimes hardly visible.

A second, less common type of coherent rock, occurring in the Vlierzele sands, is porcellanite. It is found as lenticular inclusions in the sandstone beds, as infilling in burrows and cavities of former mollusc shells, but also as thin (1 cm) layers, laterally from the sandstone plates. Porcellanite is white, porous, and consists nearly completely of opal and is often rich in sponge spicules. They are comparable to the spiculite inclusions, found in the sandstones from the Pittem Member in Egem.

4. DIAGENESIS OF THE SILICA-CEMENTED SANDSTONES

Volcanism is often invoked to explain high amounts of non-detrital silica, but no indications for such activity are found in the Ypresian in Belgium. It seems more obvious that siliceous skeletons provided the source material for the cement. Periodical deposition of large amounts of sponge spicules and even of spiculite beds was allowed during local lowerings of supply of detrital material.

The occurrence of layers and reworked slabs of porcellanite indicates a phase of diagenesis shortly after deposition. On the other hand, not only one reworked pebble of silica cemented sandstone has been found in a basal gravel of an overlying Eocene deposit. Thus, the main stage of diagenesis, the cementation of the sandstones as we find them now, took place after the sediment was buried deep enough to be no more affected by erosional phases, accompanying a regression. The time of the diagenesis is difficult to be fixed.

Factors influencing silica diagenesis were discussed by Williams *et al.* (1985a, 1985b). Siliceous skeletons mainly consist of the very unstable amorphous opal-A. Different steps in the transformation towards stable quartz can be observed. Shortly after sedimentation, a slightly more stable form of amorphous opal, opal-A' can form by dissolution and reprecipitation of biogenic silica. This could explain the early stage of diagenesis, leading to the formation of porcellanite, able to resist local erosion and reworked as intraformational cobbles.

Cementation of the sandstone beds took place by infilling of intergranular pores by opal-CT, or first by rims of opal-CT, followed by chalcedony. Amorphous opal-A from the siliceous skeletons or opal-A' was dissolved and recrystallised in the pore space, starting upon the surface of quartz grains. Williams *et al.* (1985a, 1985b), pointed out that clay minerals may lower the concentration of dissolved silica by means of adsorbtion. Carbonate minerals are more favourable for opal-CT crystallisation. Calcite provides Mg-ions, and Mg(OH) is considered as a very important nucleation material for opal-CT lepispheres. In the opal-cemented sandstones of the Ypresian, the occurrence of biogenic calcareous mud seems to have been of more influence than the adsorbtion by the ambient clayey sediments. The immediate crystallisation of chalcedony during the later phase of diagenesis (e.g. in the Vlierzele Formation) may be explained by the progressive lowering of the concentration of dissolved silica below the solubility of opal-CT, as the available amount of siliceous skeletons became exhausted or either by lower amounts of biogenic calcite.

The combination of sandstone layers and spiculite deposits indicates that cementation took place at the levels with the highest concentration of biogenic silica.

Replacement textures are rare. Calcite shells and tests are sometimes silicified, as it was observed in the samples from the Mont Panisel boring. Their original texture is well preserved.

The silica-cemented sandstone beds were formed due to diagenetical reworking of biogenic silica, often deposited in relative high amounts. This type of sedimentation took place more than once during the Ypresian. According to Carver (1980), who studied similar looking sandstones in the Tertiary of the United States, such biogenic silica deposits occur all over the world in Paleocene, Eocene and Miocene sediments.

5. CONCLUSIONS

The Mont Panisel Member contains silica cemented sandstone beds. Most of the cement consists of opal-CT, derived from dissolution of sponge spicules. Calcedony was formed during a second cementation phase, either as infilling of remaining intergranular space, in moulds of fossils and in secondary pores around these moulds.

At the Mont Panisel site, two kinds of coherent beds are found in the Mons-en-Pévèle Member. In the boring, two limestones beds were struck. In other localities in this member, nummulitic limestones are found, with coarse sparitic cement. These nummulite beds were deposited by a combination of lower siliciclastic supply and storm conditions (Fobe, in press). The micritic limestone from the Mont Panisel probably represents a fine grained end member of this facies. In the same member, opal-cemented sandstone was sampled in an outcrop at the Mont Panisel, but it was not encountered during the boring.

An overview of the different stone facies shows that the type of opal-cemented, fine grained sandstone, as it was encountered in the Mont Panisel boring, is very common throughout the Ypresian deposits in Belgium. It is often difficult to use the petrographical characteristics of these stones for lithostratigraphical correlation over a longer distance. Similar looking samples may be found also in the Mons-en-Pévèle and Pittem Members. Fieldwork, considering also the lithostratigraphy of the surrounding deposits, allows to conclude that the stone facies found in the Mont Panisel Member probably extends from Mons to the region of Zwalm and further into the Egem Member in the area of Gent. The only Ypresian sandstones showing some proper characteristics are the layers with large glauconite grains, occurring locally in the Pittem Member (between Egem and Zwalm) and the relatively coarse grained stone beds in the Vlierzele sands, found in many of its outcrops between Mons and Brugge.

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Plate I

Scale bars represent 0.25 mm

I.1 : Sandstone with opal-CT cement, Mont Panisel Member, Mont Panisel boring, 9.07 m. Needle-shaped particles are sponge-spicules. This picture represents the common type of sandstone found in the Mont Panisel Member.

I.2. : Sandstone with opal-CT cement, Mont Panisel Member, Mont Panisel boring, 4.05 m. This sample is finer grained than the other sandstones, and richer in siliceous skeletons (needle-shaped and well rounded particles).

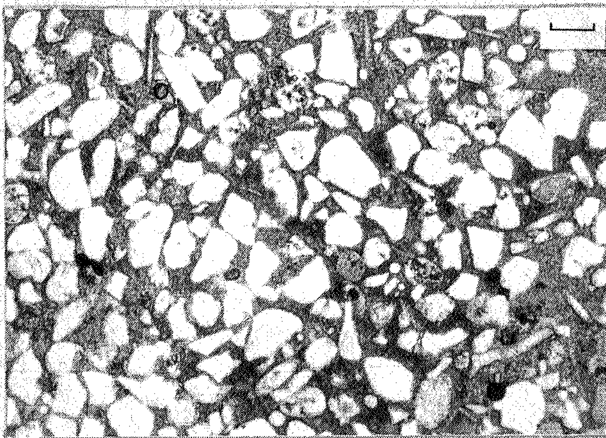
I.3 : Sandstone from the Mont Panisel Member, Mont Panisel boring, 13.3 m. This layer is cemented by opal, observed here as dark rims around the quartz grains and by chalcedony, filling in the remaining void space and appearing white on the picture. The fabric is closer packed than in the other layers.

I.4 : Sandy limestones, cemented by micrite, from the Mons-en-Pévèle Member, Mont Panisel boring, 36.0 m. The limestone is loosely packed, contains calcareous microfossils, a test of *Nummulites planulatus-elegans* and large lobate glauconite grains.

I.5 : Opal-cemented sandstone form the Mons-en-Pévèle Member, sampled at the Bocage outcrop at the Mont Panisel.

I.6 : Sandstone from the Pittem Member (Munkzwalm hamlet, Zwalm). the cement consists of opal-Ct. The sandstone may contain about 25 % of large, lobate glauconite grains.

Plate 1



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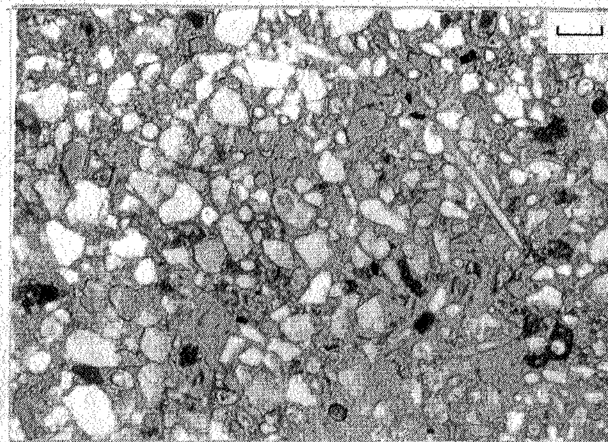

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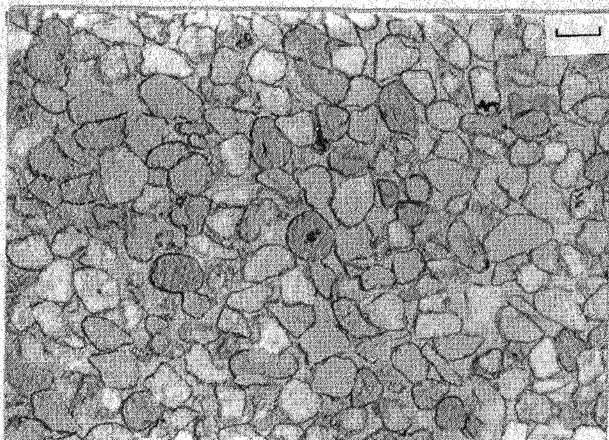

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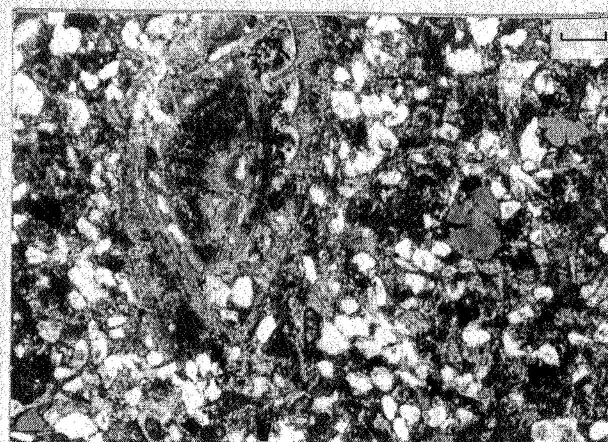

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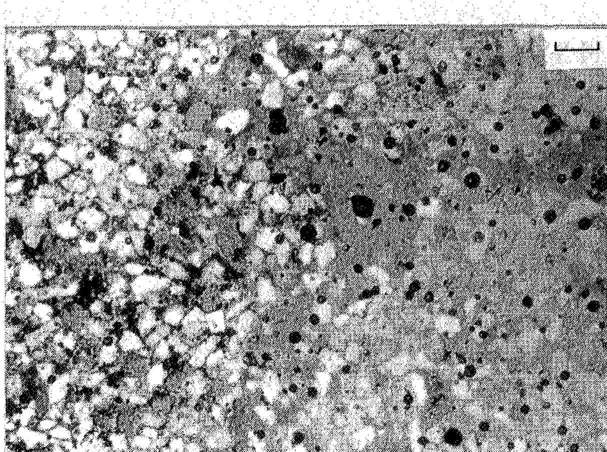

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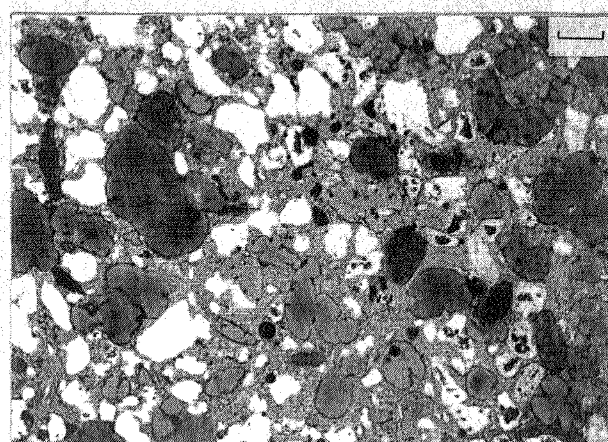


6

Plate II

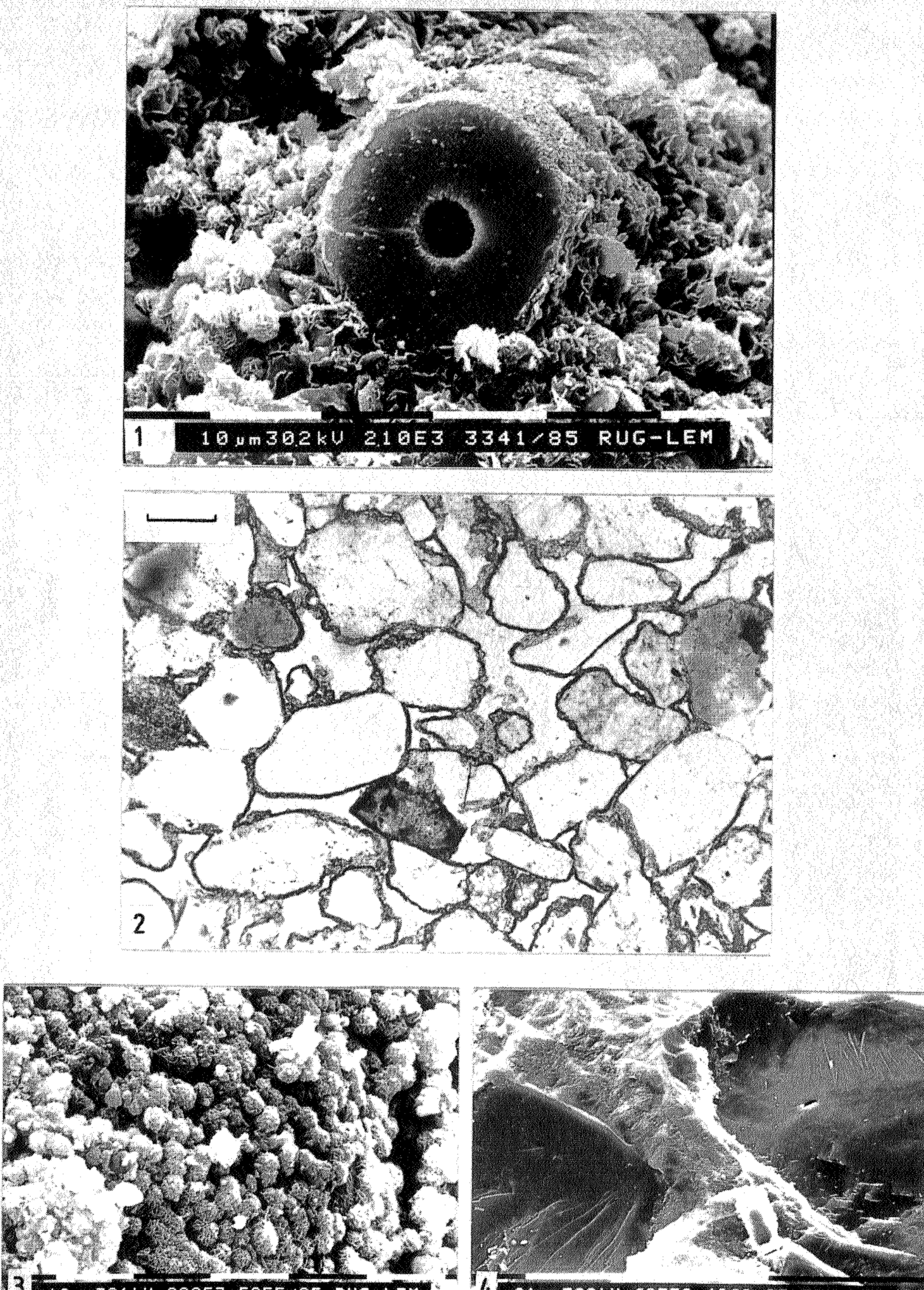
II.1 : SEM-photograph of a piece of a sandstone layer from the Pittem Member, showing a part of a sponge spicule with a hollow shaft, surrounded by lepispheres and blady crystals of Opal-CT. At the left side, lepispheres are seen attached at the surface of a a quartz grain. Provenance : Egem pit, basal sandstone bed of the Pittem Member.

II.2 : Microphotograph of a sandstone from the Vlierzele sand, Zwalm region. The quartz and glauconite grains are surrounded by opal-CT rims. Remaining void space consists of chalcedony. Scale bar = 0.1 mm.

II.3 : Opal-CT lepispheres covering the surface of a quartz grain in a sandstone from the Egem Member (Gent, Merelbeke lock), demonstrating the void-filling character of the cement.

II.4 : The opal-chalcedony cement in the sandstones from the Vlierzele Formation is often more compact than opal-CT cements. Opal and chalcedony phases can hardly be discerned and the cleavage surface went through the quartz grains (dark zones left and right) in stead of around them (compare Pl. II.3). Provenance : Lahamaide.

Plate 2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2
3
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4
0.1mm300kV 625E2 4269/85 RUG-LEM