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HABITUS OF GYPSUM CRYSTALS FROM THE OLIGOCENE OF THE ZIMMERSRÖDER GRABEN (HESSEN, NORTHERN GERMANY)

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The habitus of gypsum crystals from Oligocene clay deposits as exposed in a lignite quarry at Zimmersrode (Hessen, Germany) is described and compared with literature data. Comparatively few twins were encountered; invariably, contact twins with growth face (100) were collected. Of prime importance for the genesis of gypsum is the weathering of pyrite and/or marcasite, which were not found in the quarry visited but observed in a nearby lignite pit at Neuenhain.

Key words — Crystal morphology, gypsum, Oligocene, Germany.

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Contents

Introduction

Numerous references to mineral occurrences in Cainozoic strata of the Niederhessische Senke (northern Germany) are to be found in the literature. However, the number of mineral species recorded from the area is very limited: vivianite (Betz & Schöffmann, 1979; Bongaerts, in prep.), the FeS_2 modifications pyrite and marcasite, and gypsum (Wilke, 1979) in particular have been mentioned. The last-named mineral is a product of the chemical weathering of pyrite and marcasite (Dean & Ross, 1976).

In the present paper the habitus of gypsum crystals from these strata is described. For this purpose we used material collected from a lignite quarry at Zimmersrode (Hessen) in 1989. Many of these crystals are well developed, which greatly facilitated the goniometric study and proper orientation of the crystals.

Geographical setting

In the vicinity of Borken (Hessen), *c.* 33 km SW of Kassel, are situated numerous quarries that work lignite in opencast mining; a number of these are still in operation. The lignite to be excavated occurs in thick layers, and is of Eocene age. It lies at the base of the Tertiary sedimentary sequence in the extended Niederhessische Senke, the bedrock consisting of Mesozoic rocks. Overlying the lignite locally is basalt, the age of which has not yet been precisely determined; Ritzkowski (1968) assumes a Late Oligocene-Early Quaternary age.

At other localities thick clay lenses overlie the lignite; these were deposited during the Eocene to Early Pleistocene (Günz glacial period) (Steckhan, 1952).

The quarry we visited is situated close to the outskirts of Zimmersrode, near Borken, and is exploited by Preussen Elektricitäts Aktiengesellschaft (Figure 1). This pit lies in the Zimmersröder Graben, which is part of a complex, tectonically influenced landscape. Upon a first inspection of the lowermost parts of the rather steep quarry walls, a large concentration of gypsum was found in the northwestern part of the pit. The original position of the gypsum in the sequence could be located. It occurs *c.* 6 m below surface, the matrix consisting of a heavy, dark grey clay of Oligocene age (Blanckenhorn, 1950). All material used in the present study was collected from this occurrence.

Mineralogical characteristics

Class VI sulphates, hydrate with very large cations (Strünz, 1977).
$CaSO_4.2H_2O$, monoclinic-prismatic
Gypsum (= selenite)

Gypsum is the most commonly occurring of the sulphate minerals and may form under different conditions. Geographically, its distribution in clays extends from the occurrence described herein to Cainozoic strata in Belgium, and Oligocene (Rupelian) clay in particular, amongst other localities. Vochten & Stoops (1979) described gypsum crystals from a clay pit at Betekom (province of Antwerp).

In The Netherlands gypsum has been recorded from clays at Ootmarsum and Winterswijk, as weathering products of pyrite. As early as 1860 Staring presented a brief survey of a number of gypsum occurrences in The Netherlands, mentioning aggregates from Oldenzaal (...''knollen van te zamen gebakken gipskristallen, de grootste ter grootte van eene vuist''...) (Staring, 1860, p. 193). Morphologically, these crystals display little variation. In comparison with the crystals found at Zimmersrode, they are smaller.

Very large crystals from German Tertiary clay deposits have been found at Dürkheim (20 km west of Ludwigshafen); Schneider (1984) noted a largest diameter of 26 cm of a crystal aggregate. Gypsum crystals in evaporitic deposits may reach enormous dimensions: Babel (1987) described from Polish evaporites crystals with an overall length of 3.5 m, and mentioned lengths of up to 7 m for Cyprian specimens.

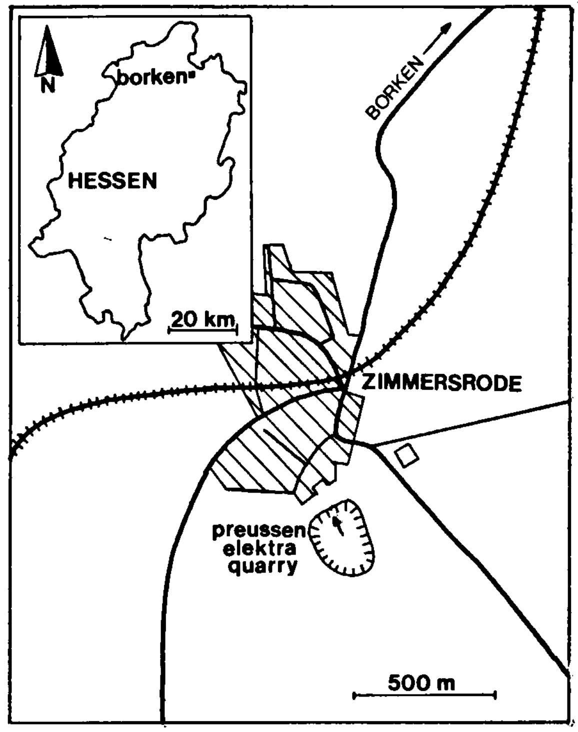

Fig. 1. Location of the collection site. South of Zimmersrode the lignite quarry of Preussen Elektricitäts AG is situated. The arrow points at the site of collection of the gypsum crystals described herein.

The Zimmersrode crystals described below show a remarkably simple morphology. The colour is invariably white; some, however, show many inclusions, which bring about a dark grey colour. The inclusions are not only found distributed regularly as very fine particles but also as grains and lumps (Pl. 1, figs 1, 2); their occurrence is not related to any growth zones. Transparency (interpreted according to [010]) of crystals without inclusions is very high.

At Zimmersrode the gypsum occurs roughly in four forms: in euhedric crystals, in subhedric crystals, in aggregates and in twins. Euhedric crystals are characterised by the combination {120}, {010} and {011} (position of unit cell according to Cole & Lancucki, 1974), with especially the pinakoid {010} strongly developed (Fig. 2). Recent research into the atomic structure of gypsum has led to a change in the dimensions of the unit cell, and in the orientation in relation to the crystallographic axes.

With one exception, all crystals studied are ex-

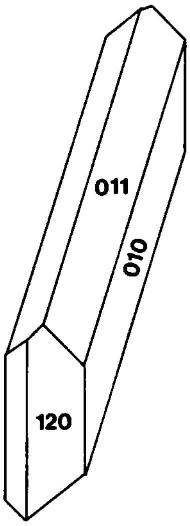

Fig. 2. The combination of faces that characterises gypsum, the extension is along [100]. Dominance of a prism {120} is commonly found in crystals.

tended along [100]. This exception involves a well-developed crystal the dimensions of which are incorporated into Fig. 3 (marked with an arrow, in the right-hand corner of the diagram). In addition to this peculiarity this crystal shows a very dominant {$\bar{2}$03} face, and together with {120} it has a bent circumscription, the surface being very rough. The convex shape of this domatic plane is a common phenomenon, as is the rough surface. England (1982, especially well visible in fig. 4) reported from clay deposits at Lake Gilles (South Australia) gypsum crystals with an identical form of {$\bar{2}$03}. On (010) there are obvious growth configurations; these are also seen on the other crystals (Pl. 1, Fig. 3). The ($\bar{2}$03) face, which is exceptionally large in the above-mentioned specimen, is also seen in a few other crystals, but is then invariably small.

Most of the gypsum collected consists of subhedric crystals. The faces {010} and {011} are always very well developed. The limit towards [100] is absent because of the contact between these faces, which is always of very irregular shape. On account of this face combination most of the subhedric crystals show a chip-shaped habitus. In most specimens, (010) and (011) show strong grooves, as a result of which the edges of these faces are faint. Crystal aggregates occur frequently. The direction

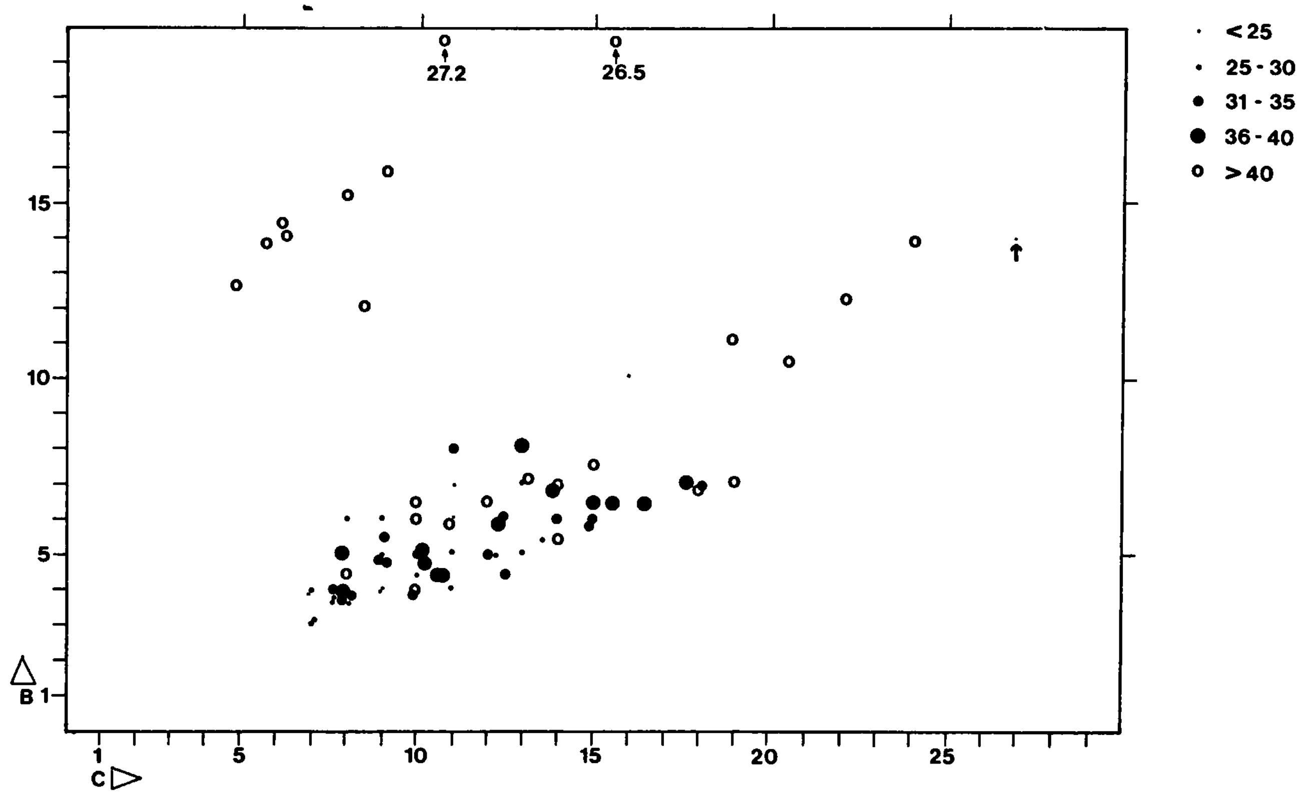

Fig. 3. Diagram representing the lengths (in mm) of the gypsum crystals studied according to [100], [010] (B) and [001] (C). The legend gives the lengths according to [100]. A total of 77 crystals were measured, these are considered typical of the gypsum occurrence at Zimmersrode. Another smaller concentration is found in the upper left-hand corner; these seven crystals were found in close proximity. The arrow points at the short-prismatic crystal referred to in the text. From these values an average of A 37: B 6: C 13 can be deduced.

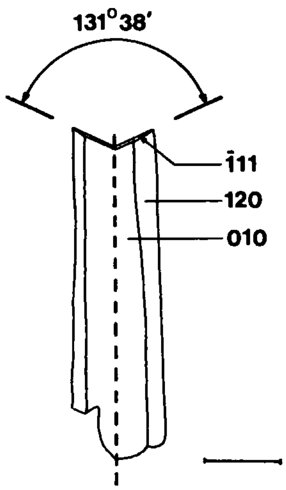

Fig. 4. Contact twin according to (100), which results in a typical swallow-tail twin. Scale bar is 10 mm. Rutten Collection, no. 750.

of growth of the individual crystals is primarily according to [100].

Remarkable in some of these aggregates is a strong flattening which causes them to resemble rosette-like structures. It is well possible that an obstruction within the sediment caused this two-directional growth pattern. The aggregates were found with the flattening parallel to the bedding planes in the clay. In most cases, the position of {010} faces of the euhedric and subhedric crystals collected directly from the matrix was parallel to the stratification as well.

Gypsum twins, contact as well as penetration twins, are common. Vochten & Stoops (1978) recorded almost exclusively penetration twins. Amongst the Zimmersrode crystals only very few twins were observed: invariably these are contact twins on (100) (swallow-tail twins). The angle (represented in Fig. 4) is 131°38' [faces($\bar{1}$11)]. Penetration twins were not found. A single subhedric crystal turned out to be a twin during etching. Prior to the etching the crystals were split along the (010) face, after which one of the planes was etched with a natriumhydroxide solution. The straight line dividing the above twin into two parts establishes that it is indeed a twin: a contact twin according to (100) (see Pl. 1, Fig. 4). This line is a fine suture, and the etching did not turn it into a deeper and wider groove, as was observed by Raju (1980) on a contact twin. The etching structures that developed on (010) correspond with the ones illustrated by Raju (1980, fig. 2). Considerable deficiences in the crystal lattice were not observed during etching.

A few of the crystals show traces of deformation, which are present as transformation in the direction of [001]. Most show this only very slightly.

Microscopic analysis of some of the aggregates revealed the presence of halotrichite. The chemical composition of this mineral is $Fe^{+2}Al_2(SO_4)_4 \cdot 22H_2O$ (monoclinic); it belongs to the halotrichite group, which is a group of monoclinic sulphates (alum family) (Fleischer, 1987). The halotrichite is confined to a few cavities in some of the aggregates. The genesis of this mineral probably postdates the collection of the aggregates on which it is found. Remarkable in this respect is the smell of sulphur emitted by the matrix which is still present on these aggregates. Only on the adhering matrix is halotrichite found. It occurs as acicular crystals, and at some places these are so closely spaced as to form fibrous silky bundles ("hair salt"). The colour is white, and their average length is 0.5 mm.

Discussion

As far as their morphology is concerned, the Zimmersrode gypsum crystals do not differ significantly from crystals recorded from other Tertiary strata outcropping in the area. In fact, they are closely comparable with crystals found in similar deposits. Their face combinations are very simple, the extensions are according to [100], {010} being dominant.

During a visit to an abandoned lignite quarry near Neuenhain, a few km south of Zimmersrode, identical crystals were collected. These were not found *in situ*, and their prolonged stay in water gulleys has caused a slight abrasion. Particularly the edges of the crystals were worn. Pyrite nodules were found here, as were limonite concretions.

PLATE 1

Fig. 1. Deep-lying inclusions, consisting of lumps of clay. Scale bar is 1 mm. Bongaerts Coll., no. 973/2.

Fig. 2. View of (010). The cleavage along (111) is visible as vertical stripes. The blots (black) are inclusions in the crystal. Scale bar is 1 mm. Bongaerts Collection, no. 973.

Fig. 3. Growth configurations, somewhat abraded, present on (010). Scale bar is 1 mm. Bongaerts Coll., no. 973/1.

Fig. 4. Etching structures on (010). The horizontal white line represents the growth plane of a contact twin. This is also demonstrated by the symmetry seen in the etched holes at both sides of this line. Scale bar is 1 mm.

PLATE 1

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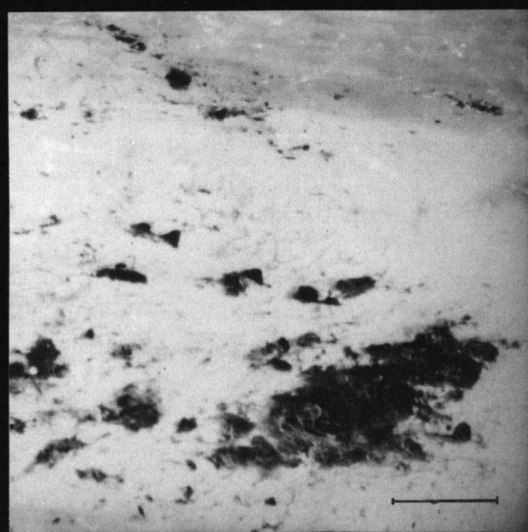

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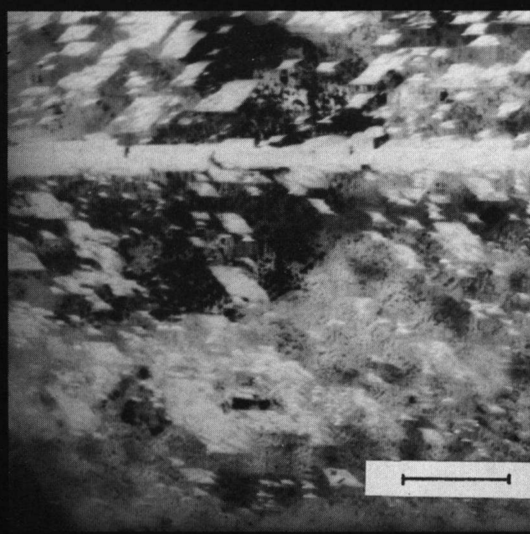

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At Zimmersrode the occurrence of halotrichite and the rather strong smell of sulphur indicate the presence of pyrite. Through masking by other substances or because of the very fine distribution throughout the sediment this could not be observed by light microscopy.

As mentioned earlier, the genesis of gypsum is tied to the weathering of FeS_2, which process liberates sulphate ions. Calcium ions are present because of the dissolution of calcareous substances such as $CaCO_3$. This milieu is characterised by a very low pH. Some researchers claim that a tendency towards prismatic growth is induced by a low pH. Experimental research by Cody (1979) appears to substantiate this claim; however, Cody questions this in view of occurrences in nature.

The habitus of the flattened aggregates has been brought about by obstruction within the sediment. Inclusions (clay particles) are also much commoner in these aggregates than in individual crystals. This is explained by the fact that a gypsum crystal growing in such a manner with a minimum space will incorporate foreign particles more readily.

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