Annales de la Société géologique de Belgique, T. 109 - 1986, 603-607 Mai 1987

Sr ISOTOPIC ANALYSIS OF ANHYDRITES AND PSEUDOMORPHS OF CALCITE AFTER ANHYDRITE FROM VISEAN ROCKS OF HEUGEM (SOUTH LIMBURG, NETHERLANDS) AND ST-GHISLAIN (SW BELGIUM)[1]
Short note

by

Ulrich KRAMM[2] & Martin J.M. BLESS[3]

(2 figures, 2 tables and 1 plate)

RESUME.- Une analyse isotopique du Strontium d'anhydrite et de calcite pseudomorphe provenant d'anhydrite dans des calcaires du Viséen moyen suggère une origine synsédimentaire en même temps que le dépôt de carbonates en eau de mer normale. Les rapports $^{87}Sr/^{86}Sr$ sont très semblables à ceux d'anhydrites et celestite viséenne dans le sondage de St-Ghislain (SW Belgique).

ABSTRACT.- Sr isotopic analysis of anhydrite and calcite pseudomorphic after anhydrite from Middle Visean limestones suggest that the evaporites were formed synsedimentary with the deposition of carbonates in normal sea water. The $^{87}Sr/^{86}Sr$ ratios are very similar to those of Visean anhydrites and celestite from the St.-Ghislain borehole (SW Belgium).

INTRODUCTION

The Wales-London-Brabant Massif was surrounded by a large carbonate platform («Kohlenkalk» or Carboniferous Limestone) in *Dinantian* times. On this platform evaporitic precipitates locally formed from time to time during the Tournaisian (notably Eyam and Hathern boreholes in Central England; George *et al.* 1976) and Visean (notably St.-Ghislain borehole in SW Belgium and Epinoy borehole in NW France; Rouchy, 1986).

The presence of evaporites in Devonian and/or Dinantian rocks east of the Brabant Massif has been postulated because of the occurrence of small gravity lows in South-Limburg (the Netherlands; Kimpe *et al.*, 1978, Bless *et al.*, 1980b). In fact, the Heugem-1/1a borehole in Maastricht discovered a limited number of thin lenses of anhydrite and calcite pseudomorphic after anhydrite in Middle Visean (V2a) limestones (Bless *et al.*, 1981).

The Middle Visean rock sequence of Heugem is rather anomalous in several aspects. First of all it is extremely thick. At least 388 m have been drilled whereas the base of the Middle Visean has not been recognized. This is the more surprising since Middle Visean (V2a) rocks do not occur to the south in Hermalle-sous-Argenteau, Visé, Val-Dieu and Moresnet, or show a reduced thickness to the WNW in Kastanjelaan and Halen and to the *east* in the Aachen area (fig. 1; Bless *et al.*, 1980a, Kasig, 1980). Moreover, the Middle Visean of Heugem is marked by frequent high Zn content (often more than 1500 ppm Zn) and high C_{org} content (0.5 - 2 %), impoverished macrofossil assemblages and frequently restricted microfossil assemblages (radiolarians, sponge spicules, restricted marine ostracode assemblages). And finally, there is the presence of anhydrite and calcite pseudomorphic after anhydrite (Pl. 1, tab. 1) pointing to either ephemeral evaporitic conditions during the Visean or to the squeezing of pre-Middle Visean (Devonian?) evaporites into the Dinantian strata (Stoppel, 1982; Bless *et al.*, 1986).

1 Manuscrit reçu le 1er décembre 1986.

2 Institut für Mineralogie, Westfälische Wilhelms-Universität, Correnssstr. 24, D-4400 Münster, Federal Republic of Germany.

3 Natuurhistorisch Museum Maastricht, Bosquetplein 6-7, 6211 KJ Maastricht, the Netherlands.

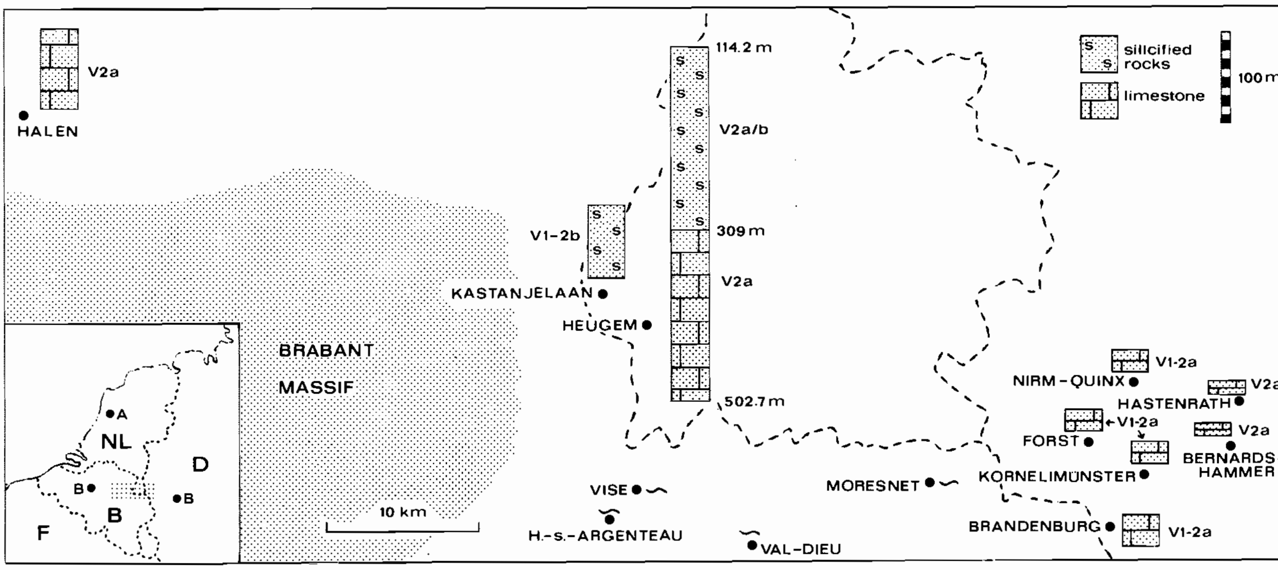


Fig. 1.- Distribution of Middle Visean rocks along eastern border of Brabant Massif showing extremely thick sequence recognized in Heugem borehole and sedimentary gap in Hermalle-sous-Argenteau, Visé, Val-Dieu and Moresnet. Anhydrite and calcite pseudomorphic after anhydrite was only observed in V2a between 309 and 502.7 m of Heugem-1a.

In order to shed some new light on the time of formation and the depositional environment of the evaporites in the Heugem borehole, the Sr isotopic compositions of some samples of anhydrite and calcite pseudomorphic after anhydrite have been investigated.

Sr ISOTOPIC ANALYSIS

Three samples from 390.9 m, 431.2 m and 457.45 m have been purified carefully by handpicking under the binocular to obtain 20 mg substance of each sample. For comparison four anhydrite samples and a celestite sample from the Visean of St.-Ghislain (Rouchy, 1986) have been prepared in the same way.

After decomposition of the sample with 6 N HCl, Sr was separated by conventional ion exchange techniques. The mass spectrometric analyses of the Sr composition have been carried out at the **Zentrallaboratorium für Geochronologie** in Münster with methods described by Kramm *et al.* (1983). The data were corrected for mass fractionation and the Sr standard NBS SR 987 ($^{87}Sr/^{86}Sr = 0.71014$) in the same way as done for the data of Phanerozoic sea water (Burke *et al.*, 1982), which are used here for comparison.

Table 1.- Occurrence of anhydrite (A) and calcite pseudomorphs after anhydrite (C) in Middle Visean (V2a) sequence of Heugem-1a (after Bless, Boonen, Bouckaert *et al.*, 1981).

363.00 m - C in dark-grey wackestone
367.00 m - C in dark-grey wackestone
390.90 m - C in dark-grey wackestone
391.25 m - C in dark-grey wackestone
397.00 m - C in thin sedimentary breccia
408.75 m - C in dark-grey wackestone-packstone
423.90 m - C in dark-grey wackestone with calcispheres
424.00 m - C in dark-grey grainstone with wackestone laminae
431.20 m - A as clouds and as partly calcitized enterolitic anhydrite with tepee texture in dark-grey to black wackestone
437.00 m - C in dark-grey grainstone
445.00 m - C in dark-grey grainstone
451.00 m - C in dark-grey grainstone
453.50 m - C in dark-grey grainstone
457.45 m - C in dark-grey grainstone
470.00 m - C as clouds in dark-grey grainstone
487.50 m - C in dark-grey wackestone
502.00 m - C as tiny nodules in dark-grey wackestone

The three Heugem samples are characterized by $^{87}Sr/^{86}Sr$ ratios which are identical within the limits of analytical error (tab. 2). The mean $^{87}Sr/^{86}Sr$ ratio is 0.70768. The values for the anhydrites from levels 2193.5 m, 2209.3 m and 2405.0 m of St.-Ghislain are slightly lower (mean $^{87}Sr/^{86}Sr = 0.70753$) than those of Heugem, whereas the Sr composition of the anhydrite from level 3107.0 m of St.-Ghislain is more radiogenic ($^{87}Sr/^{86}Sr = 0.70796$). The St.-Ghislain celestite data match those of Heugem within the range of error.

Comparison of the above Sr data with those of Phanerozoic sea water (fig. 2) yields two important conclusions.

The $^{87}Sr/^{86}Sr$ ratios fixed in the Heugem and St.-Ghislain samples (except that of level 3107.0 m in St.-Ghislain) are very low for Sr in seawater during Devonian and Carboniferous times. They are reached by sea water Sr exclusively during the Middle Mississippian of the North American time scale used by Burke *et al.* 1982), which correlates with the Visean age of the European time scale. This fact presents evidence for the Visean age of the anhydrites and calcite pseudomorphic after anhydrite in both St.-Ghislain and Heugem. It clearly indicates repeated ephemeral evaporitic conditions for the area east of the Brabant massif (South-Limburg) during Middle Visean times. The data do not support the hypothesis of squeezing of Devonian evaporitic rocks into the Dinantian strata of Heugem.

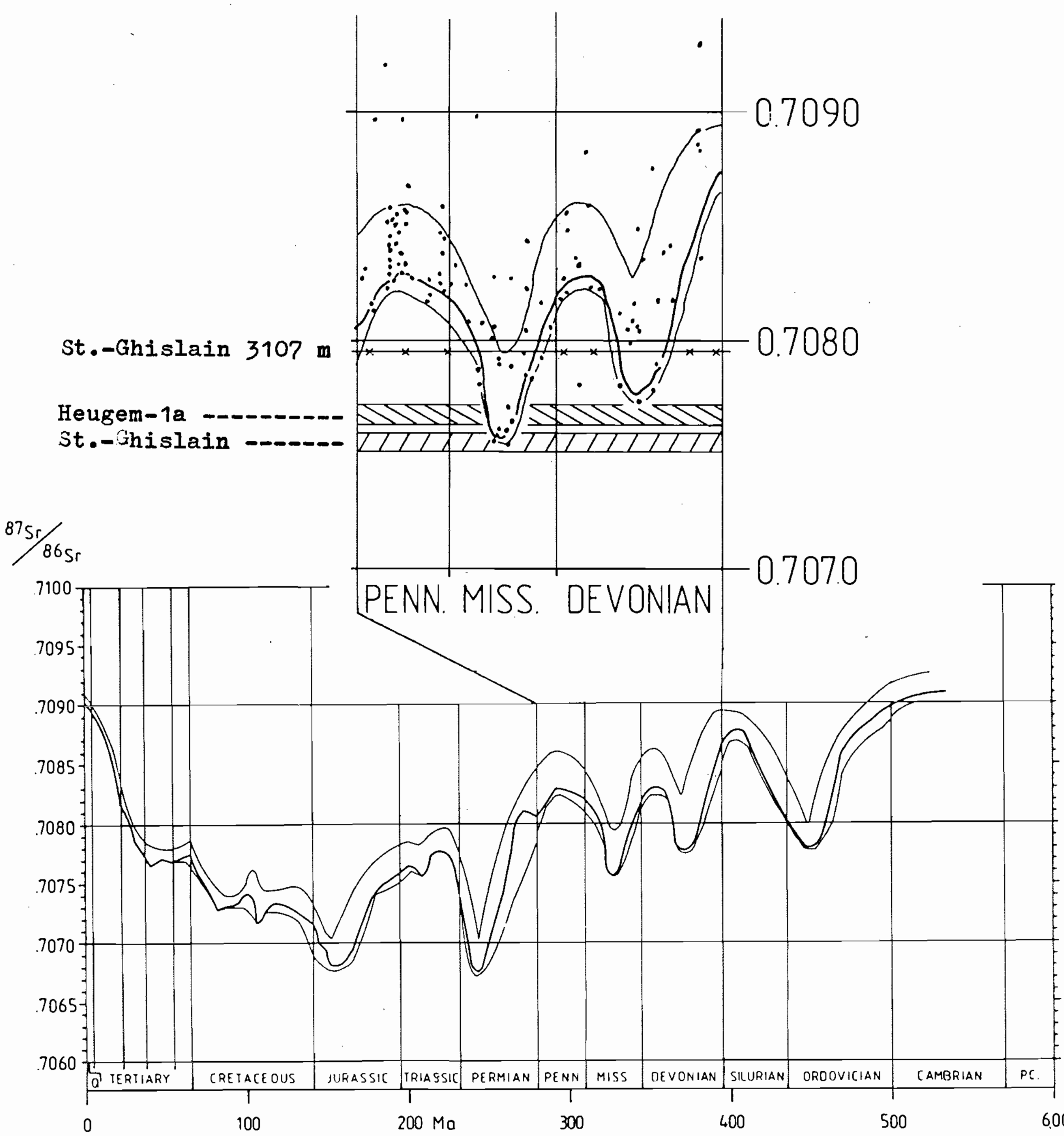


Fig. 2.- $^{87}Sr/^{86}Sr$ of seawater during Phanerozoic (after Burke *et al.*, 1982). In the magnified Devonian and Carboniferous part of the diagram the $^{87}Sr/^{86}Sr$ of samples from Heugem-1a (309.9 m, 431.2 m, 457.45 m) and from St.-Ghislain (anhydrites of levels 2193.5 m, 2209.3 m, 2405.0 m and celestite (? m), anhydrite of level 3107.0 m) are shown relative to the seawater isotopic composition. Dots represent $^{87}Sr/^{86}Sr$ ratios of marine sediments used by Burke *et al.* (1982) to construct the seawater evolution line.

Table 2.- Sr isotopic composition of anhydrite and calcite pseudomorphic after anhydrite (Calc. ps. Anh.) from cores of Heugem-1a (Maastricht, South-Limburg, the Netherlands) and from anhydrite and celestite of St.-Ghislain (SW Belgium). Stratigraphical levels in Heugem after Bless *et al.* (1981) and in St.-Ghislain after Groessens *et al.* (1979).

Drill core and sample number	depth	stratigraphical level	sample	$^{87}Sr/^{86}Sr$
Heugem-1a	390.9	V2a	Calc. ps. Anh.	0.70773 + 0.00006
Heugem-1a	431.2	V2a	(Anhydrite)	0.70766 + 0.00009
Heugem-1a	457.45	V2a	Calc. ps. Anh.	0.70764 + 0.00007
St.-Chislain 12305/10	2193.5	V2b	Anhydrite	0.70752 + 0.00005
St.-Ghislain 12305/15	2209.3	V2b	Anhydrite	0.70753 + 0.00007
St.-Ghislain 12305/35	2405.0	"V2a"	Anhydrite	0.70753 + 0.00004
St.-Chislain 12306/11	3107.0	V1b	Anhydrite	0.70796 + 0.00003
St.-Ghislain	?	?	Celestite	0.70760 + 0.00004

Secondly, the low Sr isotopic ratios of the Heugem samples suggest precipitation from seawater beyond the range of influx of fresh water from the back land, since this would have changed the Sr isotopic composition of the water to more radiogenic ratios. Sr isotopic investigations on the continental river discharge into the oceans show that the $^{87}Sr/^{86}Sr$ ratio can be bracketed between 0.7097 and 0.7113 today (Albarede *et al.*, 1981). It can be suggested that the mean $^{87}Sr/^{86}Sr$ ratio didn't change during Phanerozoic times.

The above observations favour the hypothesis of a synsedimentary (Middle Visean - V2a) origin of the anhydrite and calcite pseudomorphic after anhydrite in the Heugem area, where one may suppose the repeated occurrence of ephemeral evaporitic conditions in an otherwise somehow restricted marine (hypersaline?) environment. However, these ephemeral evaporitic conditions cannot explain the gravity lows observed in the South-Limburg area. The problem remains whether major evaporitic bodies may occur in lower (older) strata or not. In this context one might believe that the restricted depositional environment with transitory evaporitic conditions during Middle Visean time in the Heugem area only marks the end of a more pronounced (Lower Visean?) evaporitic period. At least in the Aachen area to the east pallisade calcite of Lower Visean age has been interpreted as a possible evaporitic precipitate by Kasig (1980). But for the time being this remains an open-ended question.

ACKNOWLEDGEMENT

The cooperation of L. Dejonghe, Brussels, H.R. Langguth, Aachen and H. Nielsen, Göttingen, who made samples of drill core St.-Ghislain available to us, is greatly acknowledged.

BIBLIOGRAPHY

ALBAREDE, F., MICHARD, A., MINSTER, J.F. & MICHARD, G., 1981.- $^{87}Sr/^{86}Sr$ ratios in hydrothermal waters and deposits from the East Pacific Rise at 21°N. *Earth Plan. Sci. Lett.* 55 : 229-236.

BLESS, M.J.M., CONIL, R., DEFOURNY, P., GROESSENS, E., HANCE, L. & HENNEBERT, M., 1980a.- Stratigraphy and thickness variations of some Strunio-Dinantian deposits around the Brabant Massif. *Meded. Rijks Geol. Dienst,* 32 : 56-65.

BLESS, M.J.M., BOSUM, W., BOUCKAERT, J., DURBAUM, H.-J., KOCKEL, F., PAPROTH, E., QUERFURTH, H. & VAN ROOYEN, P., 1980b.- Geophysikalische Untersuchungen am Ost-Rand des Brabanter Massivs in Belgien, den Niederlanden und der Bundesrepublik Deutschland. *Meded. Rijks Geol. Dienst,* 32 : 313-343.

BLESS, M.J.M., BOONEN, P., BOUCKAERT, J., BRAUCKMANN, C., CONIL, R., DUSAR, M., FELDER, P.J., FELDER, W.M., GOKDAG, G., KOCKEL, F., LALOUX, M., LANGGUTH, H.R., VAN DER MEER MOHR, C.G., MEESSEN, J.P.M.Th., OP HET VELD, F., PAPROTH, E., PIETZNER, H., PLUM, J., POTY, E., SCHERP, A., SCHULZ, R., STREEL, M., THOREZ, J., VAN ROOYEN, P., VANGUESTAINE, M., VIESLET, J.L., WIERSMA, D.J., WINKLER PRINS, C.F. & WOLF, M., 1981.- Preliminary report on Lower Tertiary - Upper Cretaceous and Dinantian-Famennian rocks in the boreholes Heugem-1 and Kastanjelaan-2 (Maastricht, the Netherlands). *Meded. Rijks Geol. Dienst,* 33 : 333-415.

BLESS, M.J.M., BOUCKAERT, J., PAPROTH, E. & STOPPEL, D., 1986.- Evaporites of Devono-Dinantian age in the southeastern Netherlands. *Bull. Soc. belge Géol.,* 95 :83-87.

BURKE, W.H., DENISON, R.E., HETHERINGTON, E.A., KOEPNICK, R.B., NELSON, H.F. & OTTO, J.B., 1982.- Variation of seawater $^{87}Sr/^{86}Sr$ throughout Phanerozoic time. *Geology* 10 : 516-519.

GEORGE, T.N., JOHNSON, G.A.L., MITCHELL, M., PRENTICE, J.E., RAMSBOTTOM, W.H.C., SEVASTOPULO, G.D. & WILSON, R.B., 1976.- A correlation of Dinantian rocks in the British Isles. *Geol. Soc. London Spec. Rep.,* 7 : 1-87.

GROESSENS, E., CONIL, R. & HENNEBERT, M., 1979.- Le Dinantien du sondage de Saint-Ghislain. Stratigraphie et Paléontologie. *Mém. Expl. Cartes Géol. Min. Belgique,* 22 : 1-137.

KASIG, W., 1980.- Dinantian carbonates in the Aachen region, Federal Republic of Germany. *Meded. Rijks Geol. Dienst,* 32 : 44-52.

KIMPE, W.F.M., BLESS, M.J.M., BOUCKAERT, J., CONIL, R., GROESSENS, E., MEESSEN, J.P.M.Th., POTY, E., STREEL, M., THOREZ, J. & VANGUESTAINE, M., 1978.- Paleozoic deposits east of the Brabant Massif in Belgium and the Netherlands. *Meded. Rijks Geol. Dienst,* 30 : 37-103.

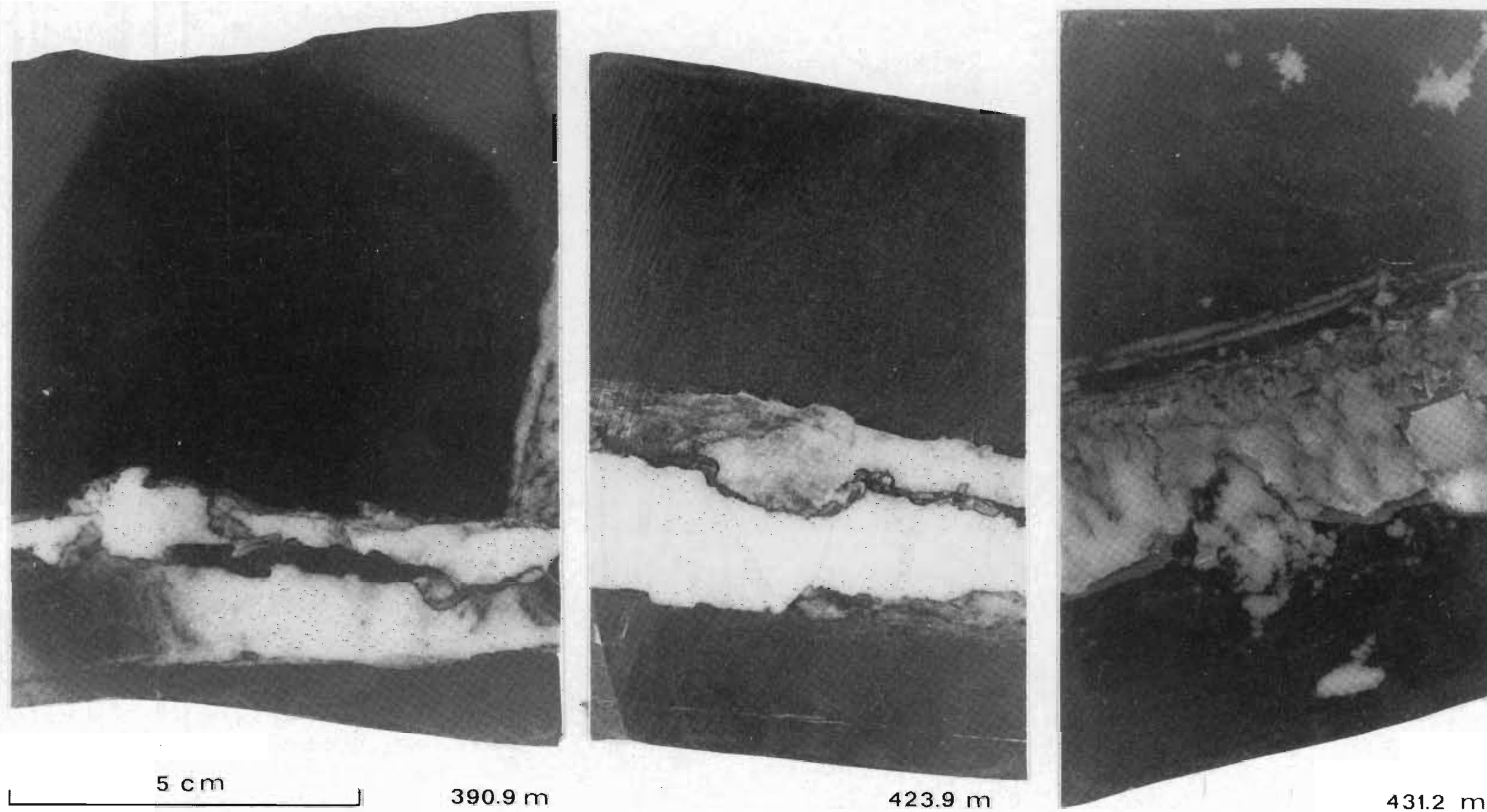
KRAMM, U., BLAXLAND, A.B., KONONOVA, V.A. & GRAUERT, B., 1983.- Origin of the Ilmenogorsk-Vishnevogorsk nepheline syenites, Urals, USSR, and their time of emplacement during the history of the Ural Fold Belt : A Rb-Sr study. *J. Geol.* 91 : 427-435.

ROUCHY, J.M., 1986.- Sédimentologie des formations anhydritiques givétiennes et dinantiennes du segment varisque Franco-Belge. *Bull. Soc. belge Géol.,* 95 : 111-127.

STOPPEL, D., 1982.- Halokinesis as a possible explanation for the paleogeographical differentiation of the Maastricht area during the Dinantian. *Public. Natuurhist. Gen. Limburg,* 32 : 54-55.

PLATE 1

Cores from Middle Visean (V2a) of Heugem-1a borehole showing calcite pseudomorphic after anhydrite in dark-grey wackestone (390.9 m and 423.9 m) and partly calcitized enterolitic anhydrite with tepee texture in dar-grey to black wackestone (431.2 m). Note that all three examples consist of relatively thick lower layer and distinctly thinner upper layer, in all cases parallel to bedding plane.


5 cm
390.9 m
423.9 m
431.2 m