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IDENTIFICATION OF A BENTONIC ASH LAYER BY CRYSTAL MORPHOLOGY OF ITS ZIRCON POPULATION (BED 79, HASSELBACHTAL, RHEINISCHES SCHIEFERGEBIRGE)

by

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(5 figures and 1 plate)

ABSTRACT.- The highly altered volcanic ash layer of Bed 79 in the Hasselbachtal Section, Rheinisches Schiefergebirge, close to the base of the Carboniferous, contains a population of magmatogenic, idiomorphic zircons with distinctive crystal morphological features. The ash was air-borne and at Hasselbachtal was far from its source. The ash layer is therefore likely to have had a wide original distribution and should be present in other rock successions of the same age deposited in a low energy hydrodynamic environment.

KEY-WORDS.- Tephrostratigraphy, Carboniferous, Zircon, Bentonite, Germany.

1.- INTRODUCTION

The Hasselbachtal section in the northern Rheinsches Schiefergebirge is situated north of the town of Hagen-Hohenlimburg (Sheet 1:25000, 4611 Hohenlimburg, R. 07000, H. 94220). A detailed description of the section has been published by Becker *et al.,* (1984).

Nodular limestones of late Devonian (Wocklum Limestone) and early Carboniferous age (Hangenberg Limestone) are separated by about 5m of siltstone (Hangenberg Shale). The highly altered volcanic ash layer (Bed 79), is situated within the lower part of the Hangenberg Limestone, some 0.35 m above the lowest bed (Bed 84) to have yielded the conodont *Siphonodella sulcata*. The ash layer is within either the *sulcata* Biozone, the oldest zone of the Carboniferous, or the next yougner *sandbergi* Biozone (Becker, 1988, Fig. 3). Radiometric age determinations of zircons from the ash layer have been published by Claoué-Long *et al.* (1990), Kramm *et al.* (1991) and are discussed further in this volume (Claoué-Long *et al.*). The importance of the ash layer lies in its proximity to the base of the Carboniferous.

2.- DESCRIPTION AND MICROSCOPIC INVESTIGATION OF THE ASH LAYER

Bed 79 is a metabentonite ash layer about 10 mm thick.Its main mineral constituent is a montmorillonite-illite, mixed layer clay, resulting from the alteration of volcanic ash. The whitish clay contains stable, accessory magmatogenic minerals such as altered biotite and unaltered zircon. Zircons were extracted by the use of a refined heavy mineral separation method (Winter, 1981). Investigations of the zircons, using both an optical microscope and a Scanning Electron Microscope, show that they are euhedral crystals of short-prismatic (Pl. 1: f,g,h) to normal-prismatic (Pl. 1: a,b) elongation. The maximum length of the zircons is about 150 µm, and their maximum width about 80 µm.

3.- SCANNING ELECTRON MICROSCOPY OF CRYSTAL MORPHOLOGY

Scanning Electron Microscopy of zircon populations from Devonian bentonitic, air-fall ash layers and from keratophyric volcanic horizons have shown that different volcanic layers can be identified by

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HASSEL 1

PR.	110	110>>110>//			100>100>>100		
301	20	3	0	0	0	0	0
302	20	4	0	0	0	0	0
303	21	4	0	0	0	0	0

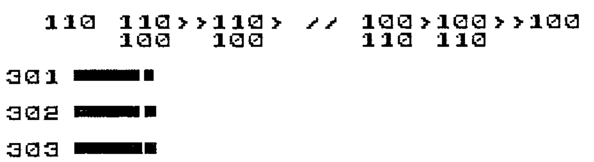


Fig. 1.- Frequency distribution of prisms, types of habit (110) and (110) >> (100)

HASSEL 1

PR.	111	111>>111>//			311>311>>311		
301	6	15	1	0	0	0	0
302	3	15	4	3	1	0	0
303	6	9	5	1	1	0	0

Fig. 2.- Frequency distribution of pyramids (111) and (311). Type of habit (111) to (311) > (111)

HASSEL 1

PR.	111	111>>111>//			331>331>>331		
301	0	0	2	1	0	0	0
302	0	0	0	0	0	0	1
303	0	0	0	1	0	1	0

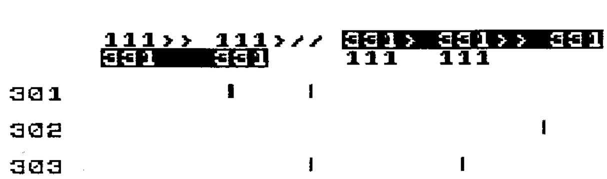


Fig. 3.- Frequency distribution of pyramids (111) and (331). Types of habit (111) > (331) to (331)

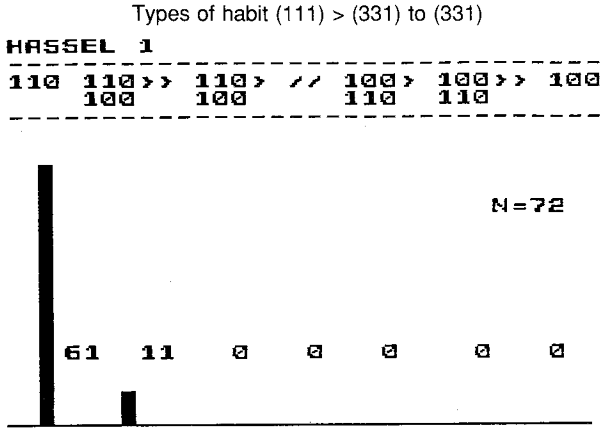


Fig. 4.- Total population of zircons (N=72). Frequency distribution of prisms (110) and (110) >> (100) within the total spectrum of seven types of habit

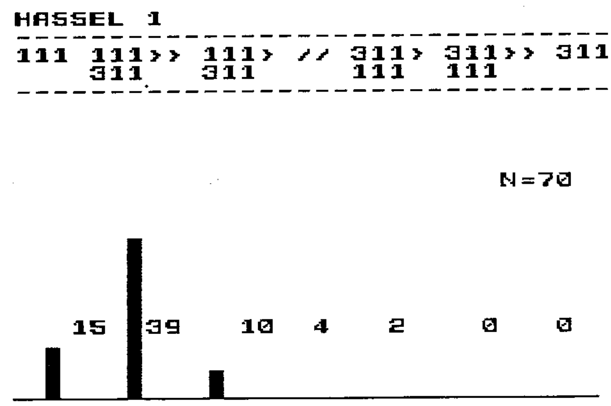


Fig. 5.- Total population of zircons (N=70). Frequency distribution of pyramids (111) to (311) > (111) within the total spectrum of seven types of habit

significant features of the forms developed and the habit of the zircons. These investigations, which were based on the study of 15,000 zircons, have produced evidence of wide ranging variations in the morphology of magmatogenic zircon populations (Winter, 1981, 1982, 1984). Morphological variations were caused by variable physico-chemical parameters within the parent magma which controlled the rate of growth of crystallographic planes. Differing rates of growth of crystal faces were responsible for dominance or suppression of certain crystallographic planes, and lead to characteristic morphologies of the zircon population of an individual ash layer. This technique has been applied to the Lower/Middle Devonian boundary beds of the Eifel-Ardennes regions. It was found that morphological variations in zircon populations within a series of bentonitic ash layers could be used for precise tephrostratigraphic correlation of three index sections in Belgium and Germany (Winter, 1981).

Sample Hassel 1, from Bed 79, Hasselbachtal yielded a zircon population containing 72 individual crystals. All the zircons are perfectly idiomorphic and sharp-edged. Magmatically correded zircons are absent. The sample was subdivided into three - Series 301, 302 and 303 - each containing 23 to 25 zircons, which were morphologically analyzed; the results are illustrated in morphograms (a morphogram is a special type of histogram, showing the frequency distribution of the different types of habit). The results are as follows :

The distribution of prisms (110) and (100) is restricted to the outer left side of the morphological spectrum of seven possible habits shown in the morphogram (Fig. 1). The pure (110) type (Pl. 1 : a,c,f-h) is predominant; type (110) >> (100) (see Pl. 1: b) makes up only between a fifth and a sixth of the population (Fig. 4). In some examples of the latter type, (100) is very small (Pl. 1: e).

The distribution of pyramids (111) and (311) covers a broader spectrum (Fig. 2). The modal morphology is represented by the (111) >> (311) type (Pl. 1: a,b,e,f,h), flanked by pure (111) (see pl. 1: c,d) and (111) > (311). The central part of the spectrum (Fig. 2), is occupied by only a few zircons showing (111) // (311) or (311) > (111). A rare but very characteristic morphological feature of the zircon population of Bed 79 is the additonal combination with steeper (331)-pyramidal crystal faces (Pl. 1: g). Within the total population of 72 crystals, this combination was confirmed in six examples. The observed combinations ranging from (111) > (331) to pure (331) pyramids are shown in Figure 3. The frequency distributions of prism types (110) to (100) and pyramid types (111) to (311) of the total zircon population of the ash layer investigated by Scanning Electron Microscopy are shown in Figures 4 and 5.

Expansion cracks characterizing metamict zircons of malacon type (see Winter 1981, Table 6) occur rarely in the Hassel 1 populations. Only about 10 % of the zircons show expansion cracks; where cracks are developed, they are few (Pl. 1: c,g). Inclusions of crystals, probably of apatite, within the zircons are also rare (Pl. 1: a). The presence of an idiomorphic zircon population is evidence of the acid to intermediate composition of the parent ash. The parent volcanic centre of Bed 79 is unknown. There are no reports of volcanic activity near the Devonian-Carboniferous boundary in the northern part of the Rheinisches Schiefergebirge. 10 mm is a typical thickness for an air-borne ash far from its source.

Search for the ash layer in other sections crossing the Devonian-Carboniferous boundary should be sucessful where sedimentary depositional environments were dominated by low energy hydrodynamic conditions.

BIBLIOGRAPHY

BECKER, T., 1988.- Ammonoids from the Devonian-Carboniferous boundary in the Hasselbach Valley (Northern Rhenish Slate Mountains). *Cour. Forsch.-Inst. Senckenberg,* Frankfurt a. M., 100 : 193-213.

BECKER, T., BLESS, M.J.M., BRAUCKMANN, C., FRIMAN, L., HIGGS, K., KEUPP, H., KORN, D., LANGER, W., PAPROTH, E., RACHEBOEUF, P., STOPPEL, D., STREEL, M. & ZAKOWA, H., 1984.- Hasselbachtal, the section best displaying the Devonian-Carboniferous boundary beds in the Rhenish Massif (Rheinisches Schiefergebirge). *Cour. Forsch.-Inst. Senckenberg,* Frankfurt a. M., 67 : 181-191.

CLAOUE-LONG, J.C., JONES, P.J. & ROBERTS, J., 1992.- The age of the Devonian-Carboniferous boundary. *Ann. Soc. Géol. Belg.,* 115 (2) :531-549.

KRAMM, U., LORK, A. & PAPROTH, E., 1991.- Datierung der Grenze Devon-Karbon. *Zbl. Geol. Paläont.,* Stuttgart, Teil 1 (H. 5) 1991 : 1336-1338.

WINTER, J., 1981.- Exakte tephrostratigraphische Korrelation mit morphologisch differenzierten Zirkonpolulationen (Grenzbereich Unter-/ Mitteldevon, Eifel-Ardennen). *N. Jb. Geol. Paläont. Abh.,* Stuttgart, 162 : 97-136.

WINTER, J., 1982.- Habits of Zircon as a Tool for Precise Tephrostratigraphic Correlation. *In :* Einsele, H. & Seilacher, A. (Eds.): Cyclic and Event Stratification. Springer-Verlag, Berlin, Heidelberg, New York.

WINTER, J., 1984.- Identifizierung von Keratophyr- Horizonten durch Tracht und Habitus ihrer Zirkone (Unterdevon, Rheinisches Schiefergebirge). *Z. dt. geol. Ges.,* Hannover, 135 : 501-527.

PLATE 1

Magmatogenic zircons from Bed 79

a-h: scale bar in lower right corner : 10 µm

a) Normal-prismatic zircon. Left side : (111) >> (311) with (311) very small. Right side : Disturbance of growth by crystal inclusion (? apatite), (111) > (311). Pure (110)-type.

b) Normal-prismatic zircon. Pyramids : left side : (111) >> (311). Right side : (111) > (311). Prisms (110) >> (100).

c) Prism (110) and pyramid (111). Expansion cracks.

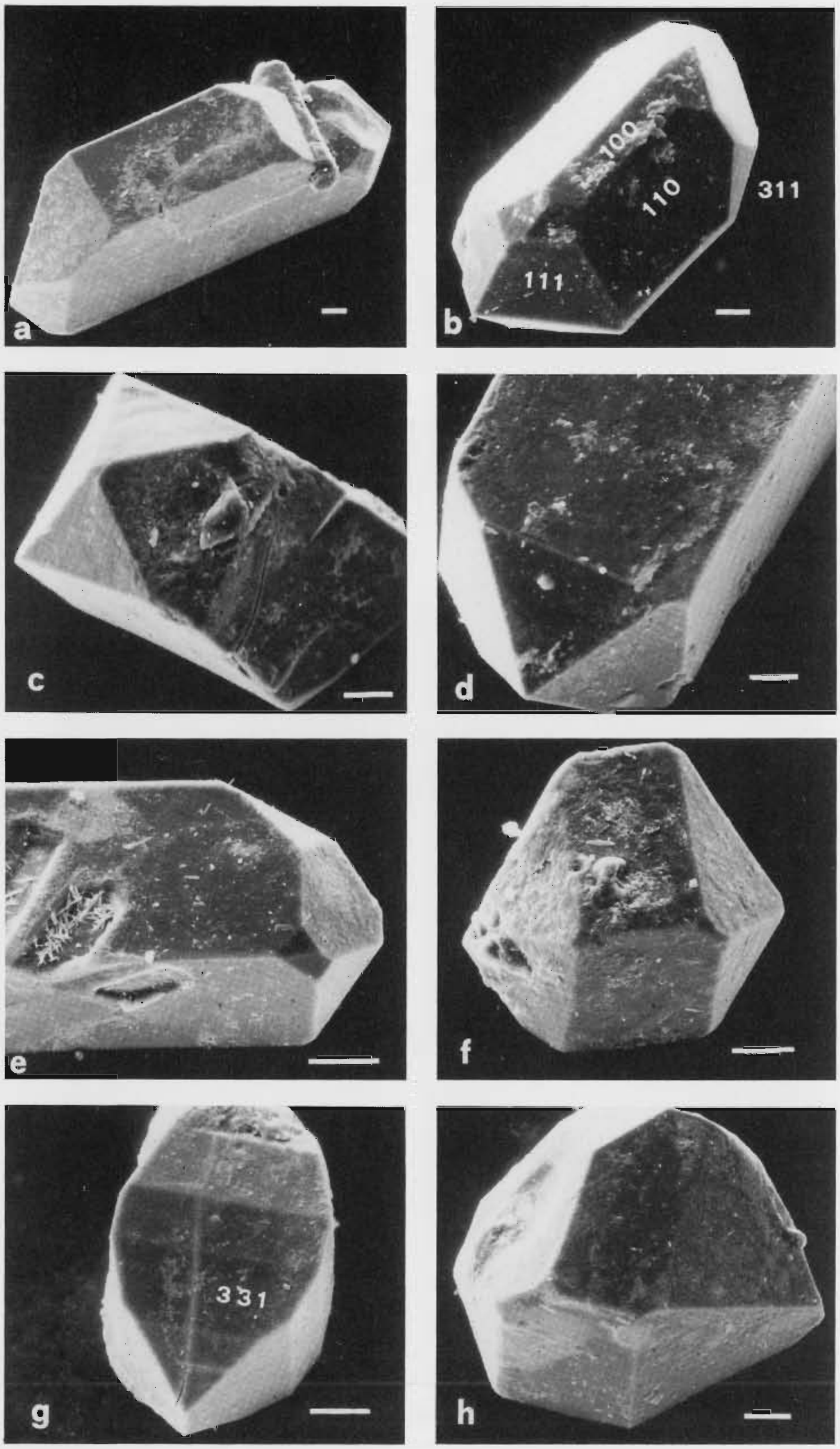
d) Prism (110) and (111)-termination.

e) Normal-prismatic zircon with impressions of preformed crystals (left side). Prism (110) >> (100) with (100) very small (width < 0.001 mm). Pyramids (111) >> (311).

f) Short-prismatic zircon with prism (110) and pyramids (111) >> (311) with (311) very small (right corner).

g) Short-prismatic zircon with prism (110) and pyramids (111) // (331) showing expansion cracks.

h) Short-prismatic zircon with prism (110). Left side : pyramids (111) >> (311), right side : pyramide (331).


a
100
110
311
111
b
c
d
e
f
331
g
h