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TWO DIFFERENT VOLCANIC ASH-FALLS OF ALLERÖD AGE IN HIGH BELGIUM[1]

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ABSTRACT

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In the last 15 years several authors have mentioned the occurrence of volcanic ash in high Belgium. Because different preparation techniques have been used, the quantitative results cannot be compared. Applying the same method to different ash layers, two volcanic ash-falls of Alleröd age are distinguished: the 'Brackvenn ash-fall' (14C age: 10 830 ± 45 a B.P.) and the 'Konnerzvenn ash-fall' (14C age: 11 030 ± 160 a B.P.).

INTRODUCTION

Volcanic heavy minerals in Belgium were first studied by TAVERNIER & LARUELLE (1952) and GULLENTOPS (1952). GULLENTOPS (1954) identified volcanic heavy minerals in two separate ash-falls. In this paper I draw attention to the upper ash that was reported by GULLENTOPS (1954) to occur in undated deposits of the last half of the last glacial period. HULSHOF ET AL. (1968) discovered a volcanic ash layer in a peat-bog in the vicinity of Vance (Lorraine belge). The authors, using a pollen diagram and correlating the heavy mineral suites with the uppermost 'Laacher See-Tuff', deduced that the ash-fall occurred in the Alleröd Interstadial. Since then about twenty papers have dealt with volcanic ash in Belgium which can be correlated with the 'Laacher See-Tuff'. Only seven of these papers present quantitative results about heavy mineral suites (Table I).

Refering to quantitative differences of heavy mineral suites in high Belgium, PISSART & JUVIGNÉ (1980) proposed the occurence of a single non-homogeneous ash-fall of Alleröd age in this area. After discovering a further ash layer in high Belgium, I suggest in this paper the occurrence of two different ash-falls which took place in a very short time-range at the end of the Alleröd.

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DISCUSSION OF HEAVY MINERAL INVESTIGATIONS IN VOLCANIC ASH-FALLS

In a previous paper, I discussed the origin of volcanic ash in western and middle Europe (JUVIGNÉ, 1976) and underlined the difficulty in comparing volcanic heavy mineral suites from data in the literature. In that paper I briefly mentioned different preparation techniques as the most probable cause.

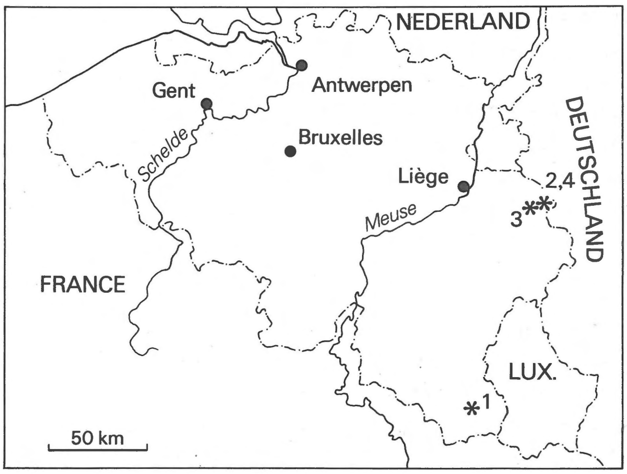

Fig. 1
Localities at which samples were collected. The numbers correspond to Table II.

Table I
Heavy mineral suites of volcanic ash in Belgium, which have been correlated with tephra from Laacher See volcano (Eastern Eifel). Values are expressed in percent. The corresponding methods used by authors are summarized below.

MINERALS	Hulshof et al., 1968	Gullentops In: Woillard, 1975	Bastin et al., 1974	Juvigné, 1976	Juvigné, 1977	Bastin & Juvigné, 1978: upper layer	Bastin & Juvigné, 1978: under layer	Pissart & Juvigné, 1980
Brown hornblende	—	—	95	60	—	59,3	71,2	57,1
Brown amphibole	41,3 to 43,5	—	—	—	—	—	—	—
Basaltine	—	47	—	—	—	—	—	—
Basaltic hornblende	—	—	—	—	45,7	—	—	—
Augite	—	26	—	—	—	—	—	—
Clinopyroxenes	—	—	—	5	—	2,3	6,9	31,4
Pyroxenes	39,3 to 45,5	—	—	—	37,5	—	—	—
Titanite	13 to 17,2	15	5	35	12,2	38,5	21,9	11,4
Zircon	—	—	—	—	—	—	—	—
Apatite	—	6	—	—	3,4	—	—	—
Magnétite	—	4	—	—	—	—	—	—
Biotite	—	2	—	—	0,2	—	—	—
Undetermined	—	—	—	—	0,9	—	—	—
Preparation technique								
Chemical treatment	$H_2O+HCl+HNO_3$	N.C.	$HCl+HNO_3$	$HCl+HNO_3$	N.C.	N.C.	N.C.	N.C.
Grain-size range in µm	10-500	N.C.	44-297	63-420	44-420	63-420	63-420	100-420
Method for separation	N.C.	N.C.	Centrifuge	Centrifuge	N.C.	Centrifuge	Centrifuge	Centrifuge
Method for counting	N.C.	N.C.	Ribbon method	Ribbon method	Ribbon method	Ribbon method	Ribbon method	Ribbon method

Remarks
1. The total numbers of grains counted was mentioned in only one paper (Hulshof et al., 1968). Hence, it is the only suite for which confidence intervals could be calculated.
2. N.C. = no comments by authors.

All data from the literature relating to quantitative heavy mineral suites of Alleröd age in Belgium are shown in Table I.

I intentionally mention the different terms used by authors for each group of heavy minerals. This introduces one difficulty in comparing the data with each other. Concerning amphiboles, the vaguest term is brown amphibole and the most precise is basaltic hornblende. In spite of the impossibility of observing all necessary properties for each amphibole in the slides, after my own determinations it can be surmised that basaltic hornblende would be the most appropriate term for all the grains of the group. Similarly, it may be convenient to preserve the term clinopyroxene only for the grains of the second group. However, the composition of clinopyroxene is so variable that no correlation is possible without details on the chemical content.

The techniques used for sample analysis are summarized in Table I. Because it is well known that chemical treatment, grain-size, method for separation and counting can introduce apparent differences in heavy mineral assemblages, we can conclude that the volcanic heavy mineral suites reported cannot be compared. Such a comparison would only be possible if a single researcher investigated each sample applying the same preparation techniques and making identical misidentifications.

RECENT INVESTIGATIONS

In 1981, I discovered another ash layer in the Konnerzvenn area (Hautes Fagnes) in a thin peat layer in the rampart of a palsa remnant investigated by PISSART (1983, this issue). The peat layer was dated at 10.830 ± 45 a B.P. (GrN-10.579). To correlate this new ash layer, I restudied each previously known ash layer which is still accessible in Belgium and applied the same preparation techniques to all the samples.

Four ash layers were investigated. From each of them, five samples were collected at horizontal intervals of about 2 m. Sample locations are given in Table II and Fig. 1.

Preparation techniques

The 16 samples were rigorously treated by the same method:
- boiling in water to dissociate the grains;
- sieving with water, using a screen of 63 µm to remove admixed loess from samples C and D;
- drying in a drying oven at 105°C;
- mineralogical separation in bromoform using a centrifuge;
- mounting of heavy minerals on slides in Canada balsam;
- counting, using the ribbon method.

Table II
Localities of the investigated ash layers

Locatities	Samples
1. Vance (Lorraine belge): peat bog along the Arlon-Florenville road	A_1 to A_5
2. Konnerzvenn area (Hautes Fagnes): in peat layer number 9 of an ancient periglacial hill described by Pissart & Juvigné (1980, p. 75, fig. 29 Designation 'tuf de la Konnerzvenn' was given to the ash layer. Peat containing volcanic ashes was dated at 11 030 ± 160 a B.P. (GrN- 8891).	B_1 tot B^5
3. Brackvenn are (Hautes Fagnes): ashes mixed in the silt layer number 9 of the rempart of an ancient periglacial hill described by Bastin et al. (1974, p. 344, fig. 4). Designation 'tuf de la Konnerzvenn' was given to the volcanic material.	C_1 to C_5
4. Konnerzvenn area (Hautes Fagnes): in the lower half of a 1 cm thick organic layer described by Pissart, (1983, this issue) fig. 5, layer number 6. Organic layer was dated at 10 830 ± 45 a B.P. (GrN – 10 579). Hence, the ash-fall should be a little older.	D_1 to D_5

Remark:
According to the interpretation of a pollen diagram of Bastin (Bastin et al., 1974), the ash-fall at locality 3 occurred between the Arcy-Stillfried B interstadial and the Tursac oscillation. Despite this interpretation, we later suggested the possibility that the ash-fall occurred in the Alleröd (Pissart & Juvigné, 1980).

No chemical treatment was applied. Only those grains wider than 84 μm were counted, using a graduated ocular. The choice of this minimum size is justified since platy grains wider than 63 μm can pass diagonally through the 63 μm-screen. Biotite was not considered because its density range is partly above and partly below the bromoform density which is also slightly variable.

TRANSPARENT HEAVY MINERAL SUITES

The results of our investigations (Table III) distinguish four groups of minerals, one of which the clinopyroxenes, is divided into three types based on both morphology and colour (see description in legend of Table III).

The mean values in Table III have been calculated according to the total number of grains determined within each of four sets of five slides from samples A, B, C and D. After application of standard error at the 99,4% level of confidence, some of the lowest percentages do not overlap. The deviation of apatite might be explained by its weathering within the profile and the deviation of clinopyroxene by the difficulty to classify the non-typical grains.

However, after application of the same standard error to the mean values listed in Table III, two populations could be distinguished:

– A and B are characterized by about 51% basaltic hornblende, 32% clinopyroxenes, 12% titanite, and 5% apatite. Clinopyroxene of type 3 dominates.

– C and D contain approximately 58% basaltic hornblende, 9% clinopyroxenes, 32% titanite, and 1% apatite. Clinopyroxene of type 2 dominates.

Table III
Transparent heavy mineral suites of samples A, B, C, and D from localities 1 through 4 (Table II).

Minerals	Samples A_1 through $_5$			Samples B_1 through $_5$			Samples C_1 through $_5$			Samples D_1 through $_5$		
	m.P.	M.V.	M.P.	m.P.	M.V.	M.P.	m.P.	M.V.	M.P.	m.P.	M.V.	M.P.
Basaltic hornblende	42,8	49,6	56,4	49,2	53,1	57,0	55,2	59,0	62,8	50,6	57,2	63,8
Clinopyroxenes: type 1	3,3	4,5	5,7	1,0	1,2	1,4	0,1	0,1	0,1	—	0,0	—
type 2	0,6	0,8	1,0	0,7	0,8	0,9	4,5	5,3	6,1	6,1	8,1	10,1
type 3	20,6	25,8	31,0	26,7	30,0	33,3	3,2	3,8	4,4	1,0	1,3	1,6
Titanite	10,1	13,2	16,3	9,9	11,5	13,1	28,4	31,8	35,2	26,3	32,1	37,9
Apatite	4,5	6,0	7,5	2,9	3,4	3,9	—	0,0	—	1,0	1,3	1,6
Total number of counted grains		1.111			1.921			1.877			1.118	

– M.V. = mean values;
– M.P./m.P. = maximum and minimum percentages after application of standard error at the 99,4% level of confidence interval;
– Description of each type of clinopyroxene:
Type 1: elongate, prismatic, sometimes with growth-features; often gray-green to green-violet. Possibly titanoaugite.
Type 2: visible face presents a parallel striae set; they are acicular or saw-edged; very often lawn-green. Possibly aegyrine-augite.
Type 3: thick set grains without striae or any other traces of cleavages; different shades of green. Possibly augite.

This distinction of two populations is also supported by the recent results relating to the lobe of the May 18, 1980 eruption of Mount St. Helens, Washington, U.S.A. (JUVIGNÉ & SHIPLEY, 1983). Using three sets of 16 samples collected along short transects (1 mile), these authors demonstrate that, after application of standard error at the 95.4% level of confidence, the 16 values overlap in each set for each heavy mineral.

GRAIN SIZE

The analysis was limited to basaltic hornblende and titanite because apatite is not numerous and different types of clinopyroxene cannot necessarily be compared with each other. The apparent width of each grain has been measured with the microscope using a graduated ocular.

Because the individual curves of basaltic hornblende and titanite appeared to be the same in the five samples from each layer, a single curve represents all hornblende and titanite of the same locality (Fig. 2). The curves of samples C and D appear to be identical and can be distinguished from that of sample B which is a little finer. This also suggests the distinction of two different populations of ash-falls.

Curves A and B, which relate to the same ash-fall but were collected about 120 km from each other, indicate that sample A is coarser than sample B. The coarser grain size of sample A may signify closer proximity to the axis of the lobe (JUVIGNÉ, 1976, 1980). The 1980 eruptions of Mount St. Helens have shown, however, that tephra is not necessarily distributed symmetrically about the lobe axis with respect to grain size. The coarsest grains lie in the direction of high altitude, high velocity winds, while dispersal of finer tephra is controlled by the trajectory of low altitude, low velocity winds (SARNA-WOJCICKI ET AL., 1981).

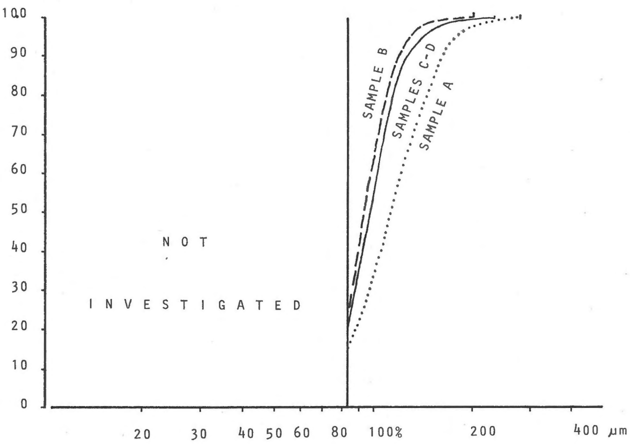

Fig. 2
Grain-size of both basaltic hornblende and titanite of 4 samples. The letters correspond to samples described in Table II.

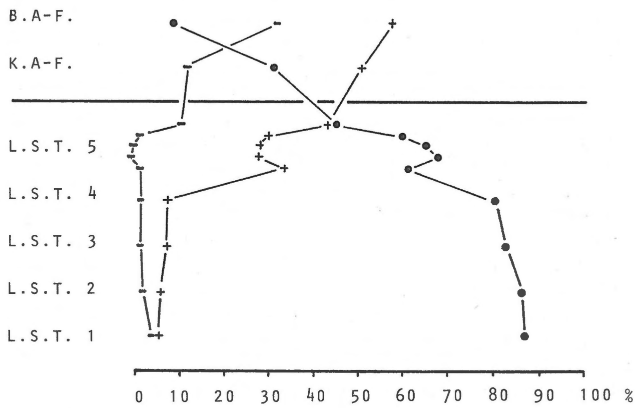

Fig. 3
Evolution of percentages of three groups of heavy minerals in the Laacher See tephra set after data from Frechen (1971). Mean values for 'Brackvenn ash-fall' and 'Konnerzvenn ash-fall' after data from Table III.

L.S.T. 1 through 5: 'Laacher See-Tuffe' 1 through 5 after Frechen (1971); K. A-F. = 'Konnerzvenn ash-fall'; B. A-F. = 'Brackvenn ash-fall'; ● = clinopyroxene; + = basaltic hornblende; – = titanite.

EVIDENCE OF BOTH 'KONNERZVENN ASH-FALL' AND 'BRACKVENN ASH-FALL' IN A SINGLE PROFILE

Evidence of two tephra layers within a single profile was found only at locality number 2 (Table II). There, PISSART & JUVIGNÉ (1980) discovered the 'Konnerzvenn ash-fall' and found a further enrichment in volcanic material within layer M8, about 2 m above the tephra layer. This enrichment was explained as reworking of the 'Konnerzvenn ash-fall'.

Data from PISSART & JUVIGNÉ (1980) show that the volcanic heavy mineral suite of layer M8 is still approximately 61% basaltic hornblende, 12% clinopyroxene and 27% titanite. This suggests that it might be the 'Brackvenn ash-fall'.

Our further investigations to find the second ash-fall in the other three localities were not successful. This indicates the discontinuity of the deposit and/or the effect of subsequent erosion.

CORRELATION OF BOTH ASH-FALLS WITH THE TEPHRA IN EASTERN EIFEL

The Laacher See tephra set of Alleröd age has been divided into 5 units called 'Laacher See-Tuff' 1 through 5. Their heavy mineral suites have been described by FRECHEN (1971; 1976).

Both 'Brackvenn ash-fall' and 'Konnerzvenn ash-fall' can be correlated with any 'Laacher See-Tuff' unit if one considers the results of FRECHEN (1976). Quantitative differences of heavy minerals suites can be explained by variations with distance from the volcano as suggested by FRECHEN (1976) within the Laacher See area. Similar variations have been recently demonstrated using the example of the May 18, 1980 eruption of Mount St. helens, Washington, U.S.A. (JUVIGNÉ & SHIPLEY, 1983).

Comparing our analyses with results published on the 'Laacher See-Tuff' by FRECHEN (1971), the 'Brackvenn ash-fall' and the 'Laacher See-Tuff 5' revealed identical heavy mineral suites, and the 'Konnerzvenn ash-fall' might be an uppermost 'Laacher See-Tuff 5' if one extrapolates the trend of mineralogical variations of the Laacher See tephra set as shown in Fig. 3. This possibility is supported by the recent discovery in the Laacher See area of another Laacher See ash-fall younger than the 'Laacher See-Tuff 5' (WINDHEUSER & BRUNNACKER, 1980).

CONCLUSION

We found evidence for the occurrence of two different ash-falls of Alleröd age in high Belgium:

- the 'Brackvenn ash-fall', with about 58% basaltic hornblende, 9% clinopyroxene, 32% titanite, and 1% apatite; 14C age is a little older than 10 830±45 a B.P.
- the 'Konnerzvenn ash-fall', with about 51% basaltic hornblende, 32% clinopyroxene, 12% titanite, and 5% apatite; 14C age is about 11 030±160 a B.P.

Both tuffs were erupted in the Eastern Eifel probably by the Laacher See volcano.

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