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A TRACE ELEMENT STUDY OF TERRACE MATERIALS FROM SOUTHERN LIMBURG, THE NETHERLANDS

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SUMMARY

The present paper deals with a trace element study of terrace materials in southern Limburg. Uncertainties and limitations of these types of studies are discussed and special attention is paid to matters like the relation between trace element content and heavy mineral association, metal ratios in various materials, and trace element trends in gravels of different age. It is suggested that discontinuities in these trends might represent important events in the development of the river system.

INTRODUCTION

During a geochemical survey in southern Limburg and the bordering Belgian territory, an investigation was made of trace element content of similar gravel layers at different terrace exposures. The investigation was mainly concerned with the measurement of hot HCl extractable lead and zinc in minus 120 mesh (minus 0.125 mm) sample fractions; these quantities

TABLE 1

Summary of analytical data with 95% confidence limits.

Terrace classification	Locality numbers	Mean hxPb (ppm)	Mean hxZn (ppm)	Ratio hxPb/hxZn	Rel. amount br.gr. hornblende in heavy mineral fractions
Pliocene gravels, Brunssum	1	15 ±2	9 ±1	1.7	–
Ubagsberg gravels	2	42 ±5	31 ±7	1.4	–
Kosberg and Krapoel	3a	47 ±4	50 ±5	0.9	–
	3b	55 ±5	45 ±5	1.2	–
	3c	74 ±13	106 ±20	0.7	–
	3d	58 ±6	46 ±6	1.3	–
Noorbeek	4	40 ±4	62 ±5	0.6	–
Margraten (hornblende rich section)	5	80 ±6	64 ±4	1.2	+++
Sibbe and Herkenrade	6	46 ±4	44 ±5	1.0	–
St. Geertruid and St. Pietersberg	7a	70 ±4	69 ±3	1.0	+++
	7b	76 ±4	78 ±5	1.0	++
	7c	60 ±12	64 ±12	0.9	+
	7d	60 ±4	62 ±4	1.0	+
Wilre	8	93 ±7	70 ±3	1.3	+++
Caberg and Gronsveld	9	67 ±6	57 ±4	1.2	+

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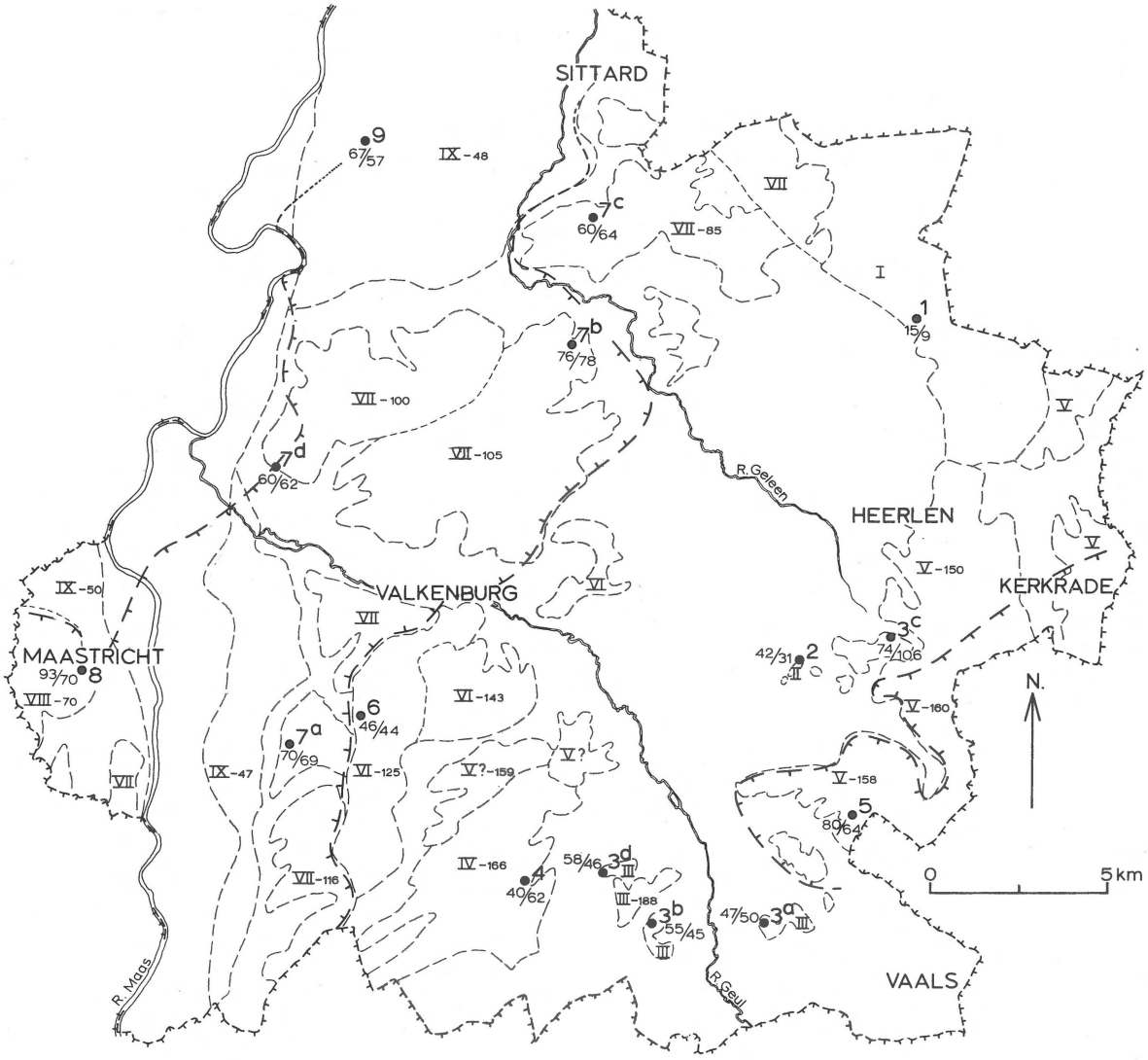

I Pliocene gravels of Brunssum
II gravels of Ubaghsberg
III terraces of Kosberg and Crapoel
IV terrace of Noorbeek
V terrace of Margraten
VI terraces of Sibbe and Herkenrade
VII terraces of St. Geertruid and St. Pietersberg
VIII terrace of Wilre
IX terraces of Caberg and Gronsveld

$\bullet^{7d}$ terrace exposure; numbers correspond with roman terrace numbers

$^{60}/_{62}$ $^{hxPb}/_{hxZn}$ values

VII-100 approximate elevation of terrace base

boundaries of terrace remnants

approximate limits of hornblende zones

Fig. 1
Locality map.

will further be denoted as hxPb and hxZn values.

A total of 320 samples were collected from single gravel layers of similar setting and texture, i.e. 100 samples from the quarry at Platte Bosse (exposure 5) and 16 samples at each of the other exposures that are shown on the map of fig. 1. All metal determinations were made with atomic absorption spectrophotometry and the analytical results, together with other relevant data, are summarized in table 1.

UNCERTAINTIES AND LIMITATIONS

On starting, the authors were well aware of the uncertainties involved in investigations of this kind.

A meaningful comparison of the results is not strictly possible, unless the various gravel layers sampled have similar chemical characteristics and the relative amounts of clay minerals, hydrous iron oxides and other minerals with strong metalsorbing properties do not show too great a variation. For these reasons materials containing lime were excluded and no samples were collected from layers apparently rich in hydrous oxides of iron or manganese. From practical experience gained in streamsediment surveys in geochemical exploration, it appears that the problem of variations in clay mineral content applies less to −120 mesh sample fractions, than to fractions that include coarser materials.

Another type of problem connected with a trace element study of terrace materials, is that present day trace metal values of minus 120 mesh fractions are likely not to be representative of the metal values at the time of terrace deposition. Factors that need consideration are contamination by migrating solutions, gradual metal leaching in time and additional supply of metal by decomposition in situe of coarse terrace materials.

The risk of sampling intensively leached or contaminated products can be reduced by careful selection of sample sites. Accordingly no samples were collected near the base of any terrace or very close to the present surface, nor from sections of gravel layers that showed clear evidence of solution phenomena or other adverse conditions. The effect of gradual metal leaching in time cannot be eliminated and has to be taken into account in data interpretation. Bearing in mind that lead is an element not as mobile as zinc, it is thought that more importance should be attached to hxPb data, than to data referring to hxZn.

From a comparison of the analytical data and actual field observations, including detailed observations at the Platte Bosse quarry, it was learnt that the hot extractable metal content of gravel layers is controlled as well by local and incidental conditions as by the regional position of the terrace and its allocation in existing terrace classifications, i.e. a time factor. This complex entity of controlling factors strongly reduces the applicability of trace element studies for the purpose of initial terrace classification and from this point of view the studies certainly are non competitive, neither with the morphological stu-

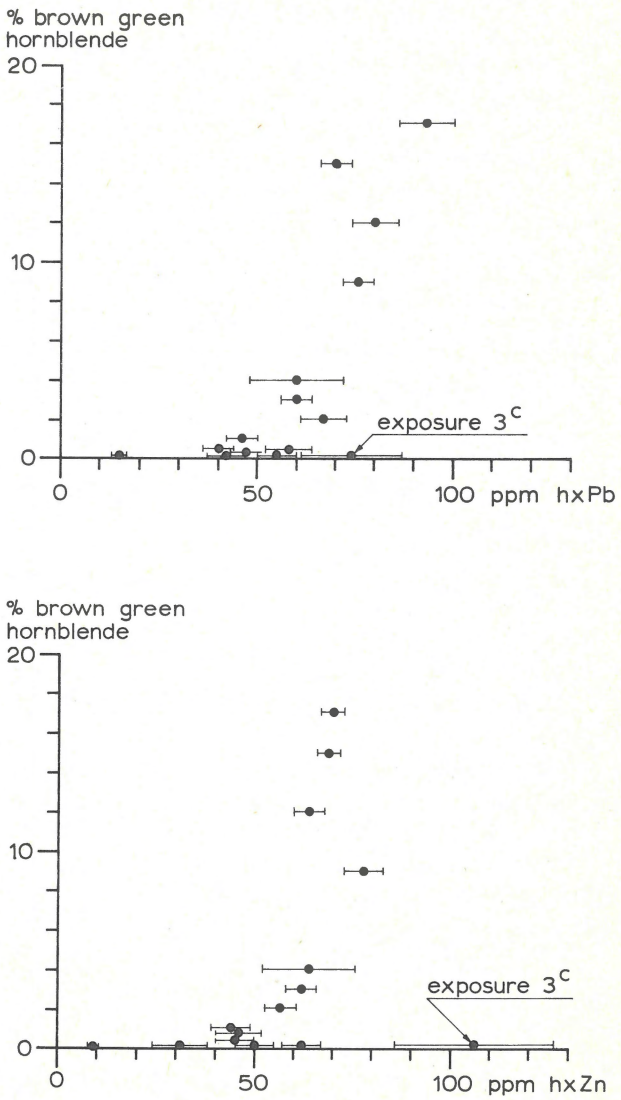

Fig. 2
Relation between hot extractable metal and hornblende content.

dies of Brueren (1945), nor with the petrological and mineralogical studies that were undertaken by van Straaten (1946) and Zonneveld (1949, 1955). However geochemical studies, like the present one, may well produce complementary information on the knowledge of terrace formation and from this point of view, the authors would like to draw attention to a few features that will be described in the following.

HOT EXTRACTABLE METAL AND MINERAL ASSOCIATION

A comparison of the data on heavy mineral composition of terrace materials from Zonneveld and the data of table 1, reveals a relationship between heavy mineral association, especially hornblende, and trace metal content, as demonstrated in the diagram of fig. 2. Samples from terrace materials with a mineralogical composition, approximating the B-Elsloo or Eysden association, show significantly higher metal values than those with a composition approximating the Limburg B association. The first two associations include brown green hornblende as a main constituent, whilst the latter association is characterized by the presence of large quantities of tourmaline and metamorphic minerals and the virtual absence of brown green hornblende. It should be noted that hornblende itself is not the actual carrier of hot extractable trace metals. The figures for trace metal content in the first instance do not represent the metal present in structural positions of silicates, but rather refer to metal ions sorbed to clay minerals and limonite, and metal present in HCl 1 : 1 ready soluble minerals.

The authors hesitate to draw any definite conclusions from the above relationship. The supply of hornblende may have been accompagnied by an additional supply of trace metals, or the periods of hornblende deposition might have coincided with a change in geochemical environment. Additional trace metals also may have been provided in situe, by decomposition of hornblende rich pebbles. Still another possible explanation of negative character that cannot altogether be excluded, is one based on the assumption of special post-depositional conditions of local significance that favoured both the decomposition of hornblende and the leaching of trace metals. All that can be said, is that probably the observed relationship is the result of a combination of complex processes.

METAL RATIO'S

The numerical value of the ratio mean hxPb/mean hxZn for the minus 120 mesh fractions of gravel samples from various exposures are listed in table 1. The figures decrease from 1.7 for the Pliocene gravels near Brunssum to 1.4 for the Ubagsberg gravels, and fluctuate between 1.3 and 0.9 for the gravels of most other exposures. The gravels of exposures 3^c and 4 show exceptionally low ratios; it is doubtful how this should be interpreted; in case of exposure 4 it might point to mixing or assimilation of fine grained terrace material. The information on metal ratios further suggests not to classify the gravels of the Ubagsberg and the Pliocene gravels of Brunssum in one and the same group. The Ubagsberg gravels appear either to be younger or to consist of material of different origin.

The origin of trace metals in the fine fractions of coarse terrace materials is likely to be extremely complex; however to a certain extent it must reflect the geochemical characteristics of the various supply areas. We have no information of this nature available from the southern Ardennes and northeastern France.

Some scanty information is available on the trace metal ratios of the minus 120 mesh fraction of sand and clay layers; samples from the terraces older than the Noorbeek terrace show metal ratios higher than 1.0 and samples from the relatively younger terraces show ratios in the order of 0.5 or less.

Present day metal ratios encountered in the minus 120 mesh fractions of fine grained stream sediments in the area of Epen-Aachen-Eupen-Verviers vary from 0.3 to 0.5 in streams draining Carboniferous, Devonian and Silurian formations, whilst slightly higher ratios are found in streams draining Cretaceous formations. The hxPb/hxZn ratio of sediments in rivers draining the Cambrian formations of "Hohe Venn" are strikingly different and exceed the figure 2.0.

The agreement between the metal ratios of sand layers belonging to the younger terraces and the metal ratios of recent streamsediments from the north east of Belgium and southern Limburg is noteworthy and possibly may point to a mainly local or nothern Ardennes origin of the material. The differences in metal ratios between the minus 120 mesh fractions of

sand layers and gravel layers confirm that these are two different quantities.

TRACE METAL TRENDS

In fig. 3A, mean hxPb values of the various exposures have been plotted in sequence of age of the relevant terraces, and grouped according to the simplified terrace classification presented in fig. 1. The plot shows an increasing trend in hxPb values from the older towards the younger terraces interrupted by five discontinuities, of which those marked D4, D5 and D6 coincide with discontinuities in the amount of brown-green hornblende. Fig. 3B shows the trend lines of hxPb, if exposures that are rich in hornblende

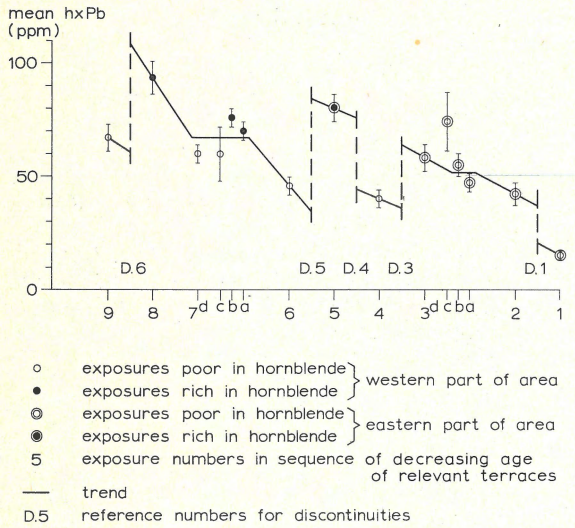

Fig. 3A
Trend and discontinuities in hxPb values.

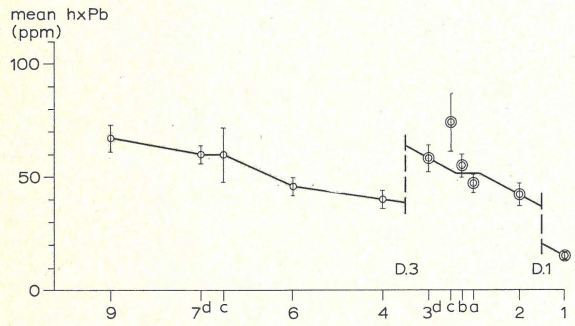

Fig. 3B
Trend and discontinuities in hxPb values, if exposures rich in hornblende are excluded (for legend see fig. 3A).

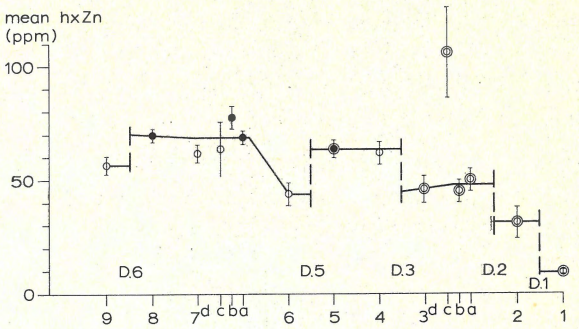

Fig. 3C
Trend and discontinuities in hxZn values (for legend see fig. 3A).

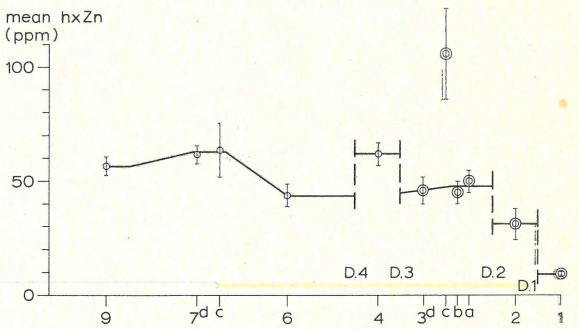

Fig. 3D
Trend and discontinuities in hxZn values if exposures rich in hornblende are excluded (for legend see fig. 3A).

are excluded. The erratic values of exposure 3C have not been further considered. Discontinuity D1 underlines the difference between the gravels of Brunssum and Ubagsberg. The hxPb discontinuities are partly confirmed by those for hxZn, as shown in fig. 3C and fig. 3D; an additional discontinuity, marked D2, may have to be introduced. The discontinuities D3 and D4 are accompagnied by changes in metal ratios.

A study of the diagrams of figures 3 in conjunction with the geographical position of the various exposures suggests a regional division between eastern and western terraces. This division is not exactly the same as a division according to relative age. Could this be the effect of a tributary, draining the Belgian lead-zinc district, south of the Netherlands border, like the present Geul?

Although it has to be recognised that next to other uncertainties the total number of localities in this study is too limited to overemphasize its results, it gives rise, at least for discussions' sake, to the following tentative grouping of different terraces into com-

plexes. The complexes are bounded by discontinuities. The discontinuities in turn may or may not represent major events in the history and development of the present river system.

Pliocene gravels of Brunssum
Kosberg and Crapoel Formations, possibly including the Ubagsberg's gravels as an older member
Noorbeek Formation?
Margraten Formation, rich in hornblende
Complex of Margraten Formation (poor in hornblende), Wilre Formation and the formations in between
younger terraces

In trying to obtain supplementary evidence on the above grouping, additional measurements of different geochemical quantities have been carried out like the determination of relative total extractable lead an zinc content of deslimed heavy mineral fractions and the determination of total zinc content in isolated magnetite fractions. In due course it became obvious that too great a number of determinations would have to be done in order to draw conclusions, based on an acceptable level of statistical significance. From a mere qualitative point of view, the information obtained confirmed the above grouping with the understanding that the Noorbeek Formation should not be included in the Kosberg-Crapoel complex and the discontinuity marked 6 should be shifted and positioned between the formations of St. Pietersberg and Wilre.

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