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Indicator stone counts on Elsterian and Saalian sediments from eastern Germany

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Hoffmann K., Meyer K.-D. (1999) — Indieator stone eounts on Elsterian and Saalian sediments from eastern Germany. Geol. Quart., 43 (2): 233–240. Warszawa.

Indicator stone counts of the coarse gravel fraction and evaluation by the mean erratic source location (TGZ) method were carried out on tills and meltwater deposits in Saxony, Saxony-Anhalt and Lower Saxony. In samples from the first Elsterian till, a high proportion of stones from Dalarna are identified, with a relatively low proportion of the Åland stones. In Saxony, the first and second Elsterian tills can be distinguished by the higher proportion of the eastern Baltic stones in the second till. The glacial and glaciofluvial sediments of the Drenthian Stadial (Saalian) are characterised by many Swedish indicator stones, but with a lower proportion from the Dalarna area. In Lower Saxony and Saxony-Anhalt, the Younger Drenthian deposits are distinguished by high flint eontents, while the Warthian Stadial (Saalian) is typified by the eastern Baltic provenances with high proportions of the Åland stones and the Palaeozoic dolomites and limestones. The results of the indicator stone counts illustrate a clear shift in source area from the north-west in the Elsterian to the south-east in the Saalian as well as successively from west to east in the glacial deposits investigated in Germany.

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INTRODUCTION

Indicator stones have been transported by an ice sheet. They have a restricted distribution and consist of distinctive rock types. Each type has a known source, where the bedrock can be demonstrated to consist of the same rock type. Indicator stone counts have been used since the 1930s in northern Germany and the Netherlands for lithostratigraphic classification of glacial deposits such as tills and glaciofluvial sediments, although the methods used today are slightly different. In this paper, new counts are presented from eastern Germany (Saxony, Saxony-Anhalt, and eastern Lower Saxony) and compared with older counts from northern Germany (Lower Saxony and Schleswig-Holstein). The proportions of other rock types apart from the indicator stones are also considered when carrying out stratigraphic dating and correlation. Flint, nordic crystalline rocks, Palaeozoic limestones and dolomites are given as percentages of nordic stones, and the quartz, lignite and other more local rock types are given as percentages of the whole sample.

METHOD

The method involves determination of the mean erratic source location or TGZ (the German Theoretisches Geschiebezentrum) based on G. Lüttig (1958), which is widely used in northern and eastern Germany. Stones belonging to the coarse gravel fraetion (2–6.3 cm) are separated from the sample consisting of 500–1000 stones from a till or glacial gravels by sieving, and the indicator stones are identified. In contrast to other methods of stone counting, which involve sorting the clasts into major rock groups only, the indicator stones are examined in detail to identify the type, variety and provenance of each. The coordinates of the geographic midpoints of the souree areas of different individual types of

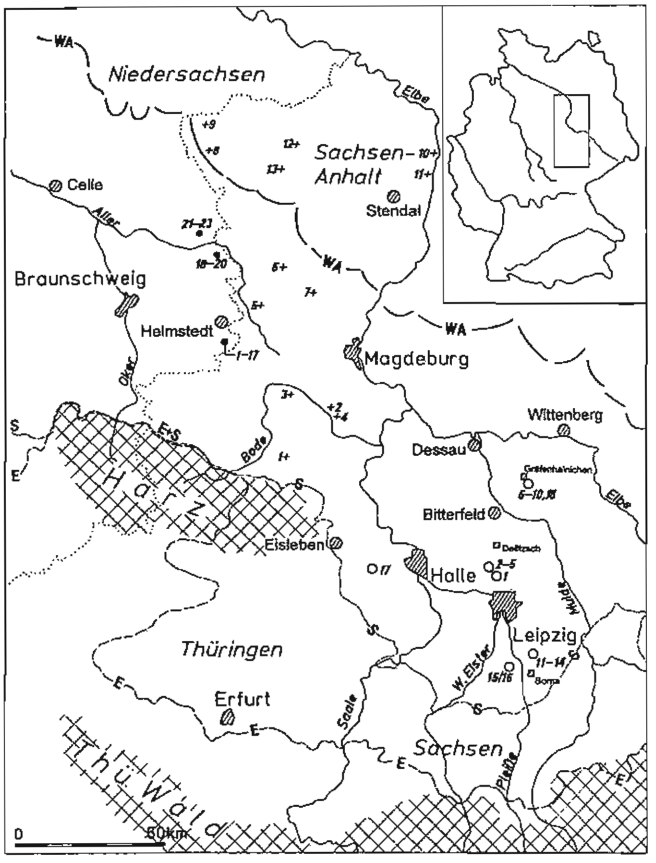

Fig. 1. Sample localities

o — nos. 1-18 — Leipzig basin (Leipziger Tieflandsbucht), + — nos. 1-13 — western Saxony-Anhalt (westliches Sachsen-Anhalt), • — nos. 1-23 — eastern Lower Saxony (östliches Niedersachsen); ice limits: E — Elsterian, S — Saalian (Drenthian Stadial), WA — Saalian (Warthian Stadial); chequered area — hill country

indicator erratics are added and averaged. The result is a geographical location for each sample, the mean erratic source location (TGZ), and this permits the individual samples to be compared. In each sample there should be at least 30 indicator stones. Recently the method has been improved with respect to the type of presentation by P. Smed and J. Ehlers (1994). The method has also been recently successfully used in Poland (J. Burdukiewicz, K.-D. Meyer, 1991; M. Böse, M. Górska, 1995).

STUDY AREA

The samples are separately numbered in the three working areas: the Leipzig basin, western Saxony-Anhalt, and eastern Lower Saxony (Fig. 1). The same numbers are used in the diagrams showing the mean erratic source locations of the individual areas (Figs. 2, 4, 6). In this paper, the individual exposure will not be discussed nor evidence presented for the stratigraphic age will be given, which is dealt with by K. Hoffmann and K.-D. Meyer (1997), and others referred to in the literature.

LEIPZIG BASIN

The Leipzig basin (Fig. 1) was overridden twice by the ice sheet during the Elsterian, and two 5–8 m thick tills were deposited in patches, the first and second Elsterian tills. The first Elsterian ice advance in the Quaternary in this region extended the furthest southwards (Fig. 1). The Saalian till (Drenthian ice limit in Fig. 1) is subdivided into up to three units in the Leipzig area as a result of relatively small ice front oscillations during its retreat. Since no indicator stone counts have been carried out in this region, it was the objective of this study to examine the indicator stone potential of the region (E. Richter *et al.*, 1986) and to determine the typical indicator stone assemblages of the individual stratigraphic units. Altogether 17 samples from tills and one sample from meltwater gravels were taken from the open-cast lignite mines in the Leipzig basin. The samples mostly come from the stratigraphically known positions (L. Eissmann, 1975, 1994; L. Eissmann *et al.*, 1995).

In the Leipzig area the following trends were observed. The first Elsterian till is characterised by a high proportion of the Dalarna indicator stones (up to 30%) and very low proportions of the Åland stones. The TGZ values are in the northwestern sector of the diagram (Fig. 2). The basal parts of the first Elsterian till have highest amounts of quartz in the Leipzig basin (e.g. no. 15 — 65% and no. 6 — 62%). Since it

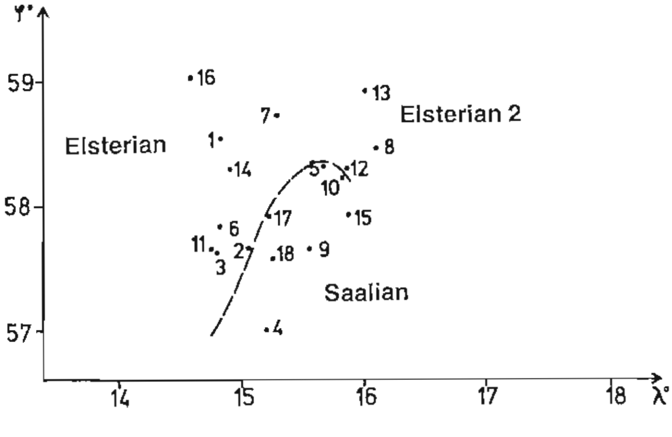

Fig. 2. Mean erratic source locations (TGZ) for the Elsterian and the Saalian deposits from the Leipzig basin

1 — g1E, Breitenfeld mine; 2, 3 — g1E, Delitzsch SW mine; 4 — g1S1, Delitzsch SW mine; 5 — g2S1, Delitzsch SW mine; 6, 7 — g1E, Gröbern mine; 8 — g2E, Gröbern mine; 9, 10 — gS1, Gröbern mine; 11, 12 — g1E, Witznitz mine; 13, 14 — g2E, Witznitz mine; 15 — g1E, Schleenhain mine; 16 — g2E, Schleenhain mine; 17 — gS1, Amsdorf mine; 18 — gfS1, Gröbern mine; g — glacial, gf — glaciofluvial, 1 — first till, 2 — second till, E — Elsterian, S1 — Saalian (Drenthian Stadial); coordinates: ψ — latitude N, λ — longitude E

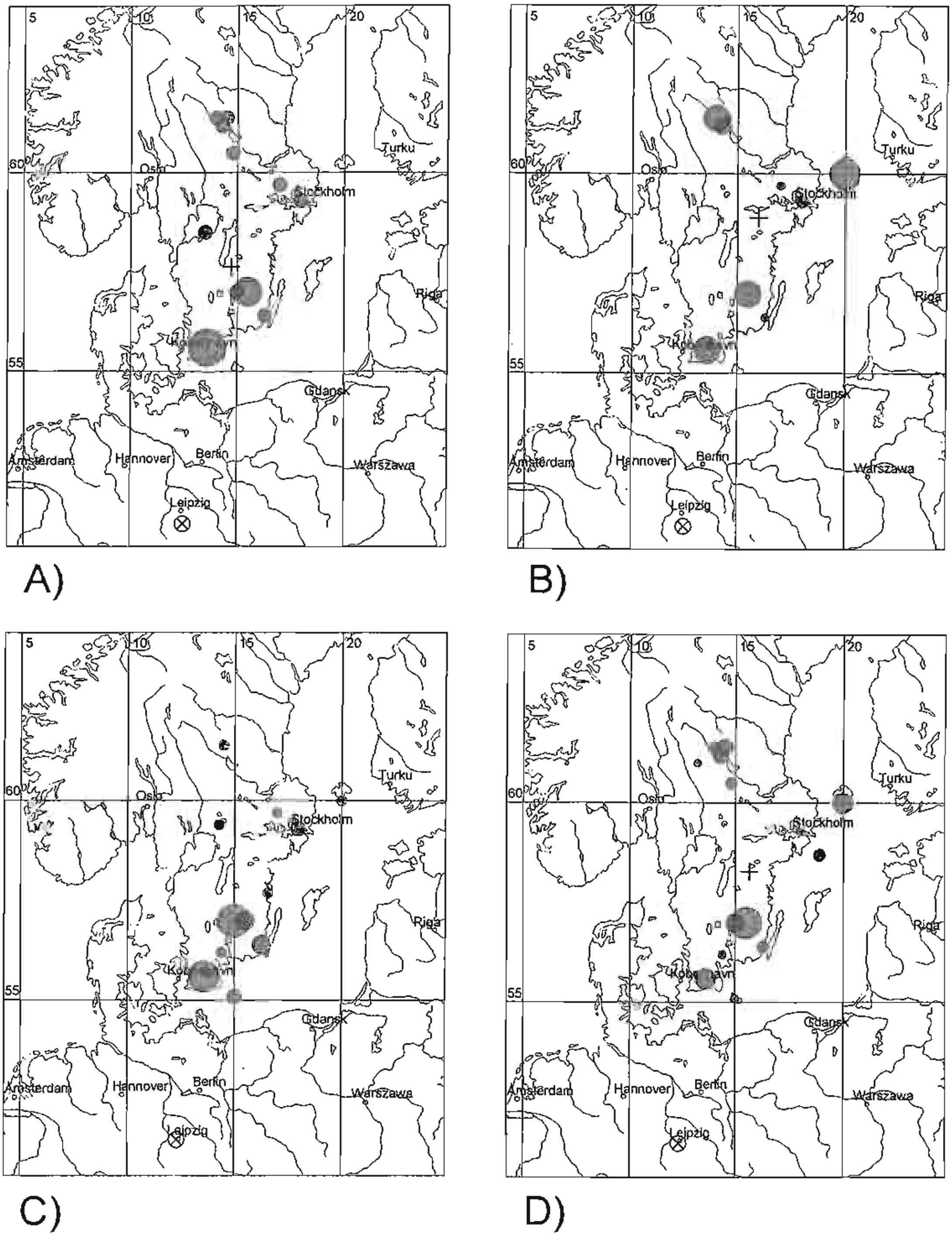

Fig. 3. Examples of stone counts from tills in the Leipzig basin

A — first Elsterian till, Witznitz mine (no. 11 in Fig. 2); B — second Elsterian till, Witznitz mine (no. 13 in Fig. 2); C — first Saalian till, Delitzsch SW mine (no. 4 in Fig. 2); D — second Saalian till, Delitzsch SW mine (no. 5 in Fig. 2); ⊗ — sampling site, + — mean erratic source location (TGZ); circles denote sources of indicator stones, and the size of the circle indicates the percentage of stones from this source

was the first ice sheet in this area, the Elsterian ice sheet entrained the extensive Tertiary, Early Pleistocene and early Elsterian gravel terraces (about 80% of quartz; L. Eissmann, 1982). The TGZ of the samples from the upper third of the first Elsterian till lie more in the northern part of the diagram (Fig. 2), between the samples from the base of the first Elsterian till and those of the second Elsterian till. They are characterised by high flint and chalk content. The content of the Dalarna indicator stones is as high as in the basal part (e.g. no. 7 — 31%). The quartz content of the samples from the

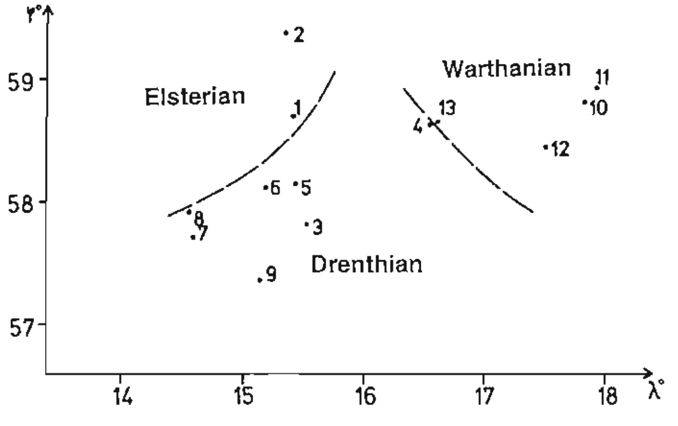

Fig. 4. Mean erratic source locations (TGZ) for the Elsterian and the Saalian deposits from western Saxony-Anhalt

1 — e/G/gf, Hoym; 2 — e/G/gf, Wolmirsleben; 3 — D/G/gf, Hadmersleben; 4 — D/G/gf, Unseburg; 5 — D/G/gf, Eimersleben; 6 — Dj/G/gf, Calvörde; 7 — Dj/G/gf, Haldensleben; 8 — Dj/G/gf, Drebenstedt; 9 — Dj/G/gf, Kleistau; 10 — WA//Mg, Altenzaun; 11 — WA//Mg, Arneburg; 12 — Xp, Zierau; 13 — WA//Mg, Brüchau; e — Elsterian, D — Drenthian, Dj — younger Drenthian, WA — Warthian, Mg — till, G — gravel, gf — glaciofluvial, Xp — stones collected in the field; coordinates: ψ — latitude N, λ — longitude E

upper part of the first till (5–39%) is markedly lower than that of the samples from the basal part.

The second Elsterian till is characterised by a varying content of the Dalarna stones and a high content of the Åland stones. The TGZ is located more to the NNE of the diagram (Fig. 2). For example there are 10 out of 43 indicator stones from Åland; this shows clearly a Baltic character of the till. In spite of the Baltic character, the Palaeozoic limestone content is still lower than in the second Saalian till of this area. The quartz content in the second Elsterian till is primarily a result of reworking of glacial and glaciofluvial deposits belonging to the first Elsterian glacial advance.

The Saalian (Drenthian) tills have a south to middle Swedish stone content; they are moderately of eastern Baltic provenance and have a moderate Palaeozoic limestone content (e.g. no. 4 — 22%), and a relatively low flint content. During the Drenthian Glaciation, a content of the eastern Fennoscandian material increased (L. Eissmann, 1986). Samples from the upper part of the Saalian till (nos. 5 and 10) are therefore Baltic in character, mainly due to the high content of the Palaeozoic limestones (e.g. no. 5 — 39%) and relatively little flint (no. 5 — 15%). This is consistent with older observations that the flint content is inversely proportional to the content of the eastern Fennoscandian stones (J. Hesemann, 1931). These samples lie in the northeastern part of the diagram, near those from the second Elsterian till. This and the low flint content preclude any correlation with the younger Drenthian till in Lower Saxony. The quartz content of all Saalian tills studied in this project lies under 10% for the grain size investigated.

WESTERN SAXONY-ANHALT

In western Saxony-Anhalt (Fig. 1) there is only a single Elsterian till. It is overlain by deposits of three Saalian advances (maximum extent after W. Knoth, 1995, and the Warthian maximum extent in Fig. 1).

The objective of the sampling was to search for an east Baltic stone assemblage (many Åland rocks, high limestone and dolomite contents) in the so-called red Altmark till (in German: Roter Altmärker Geschiebemergel), as is known from the Warthian deposits of the Lower Saxony Region (K.-D. Meyer, 1983). Another aim was to investigate whether a till from a later advance (SIII in the sense of A. G. Cepek, 1967; A. G. Cepek *et al.*, 1975) is present above the Warthian till. There are three samples of tills (10, 11 and 13) and nine from glaciofluvial gravels (1–9); the sample 12 is a collection of pebbles picked up from fields.

The samples 1 and 2 (Fig. 4) are the Elsterian outwash sediments. The sample 1 contains a total of 29 indicator stones, but only three from Åland, ten from Dalarna, and thus the TGZ lies in the far north-west of the diagram. In the sample 2 the Dalarna content is 16 out of 34 indicator stones and is higher. The high flint content of these samples is conspicuous (51 and 54%). The samples 3–5 were collected from outwash gravels of the first Drenthian advance. The TGZ values are very similar to the values for this stratigraphic unit from the adjacent parts of Lower Saxony. The flint content is only half that in the Elsterian samples (nos. 1 and 2). The sample 3 contains 24 indicator stones, 7 of which originate from the Åland Islands, and is thus clearly of the Baltic provenance. The TGZ values of the glaciofluvial deposits of the younger Drenthian advance (nos. 6 and 9) are different from those of the older Drenthian. However, the flint content is high, twice as high in the younger Drenthian.

The composition of the stone assemblage of the Warthian Stadial is clearly different from that of the Drenthian Stadial of the Saalian Glaciation. The sample 10 was taken from a gravel-rich, reddish till, and in this out of 312 pebbles, only three were of flint (1%), but 55% were of the Palaeozoic limestones and 14% of dolomites. Among the 19 indicator stones, there were seven from Åland, which included three Baltic red quartz porphyries. The sample 11 had a very similar composition: 50% Palaeozoic limestones, 20% dolomites, and 3% flint, and among the 22 indicator stones 10 were from Åland and one each from Ångermanland and Nystad.

Since good exposures are rare in the western Saxony-Anhalt, the sample 12 was collected as an exception, from a heap of stones just outside the village of Zierau; it turned out to be almost free of flint (3%). Among the 21 indicator stones, nine were Åland rocks and two red quartz porphyries from the

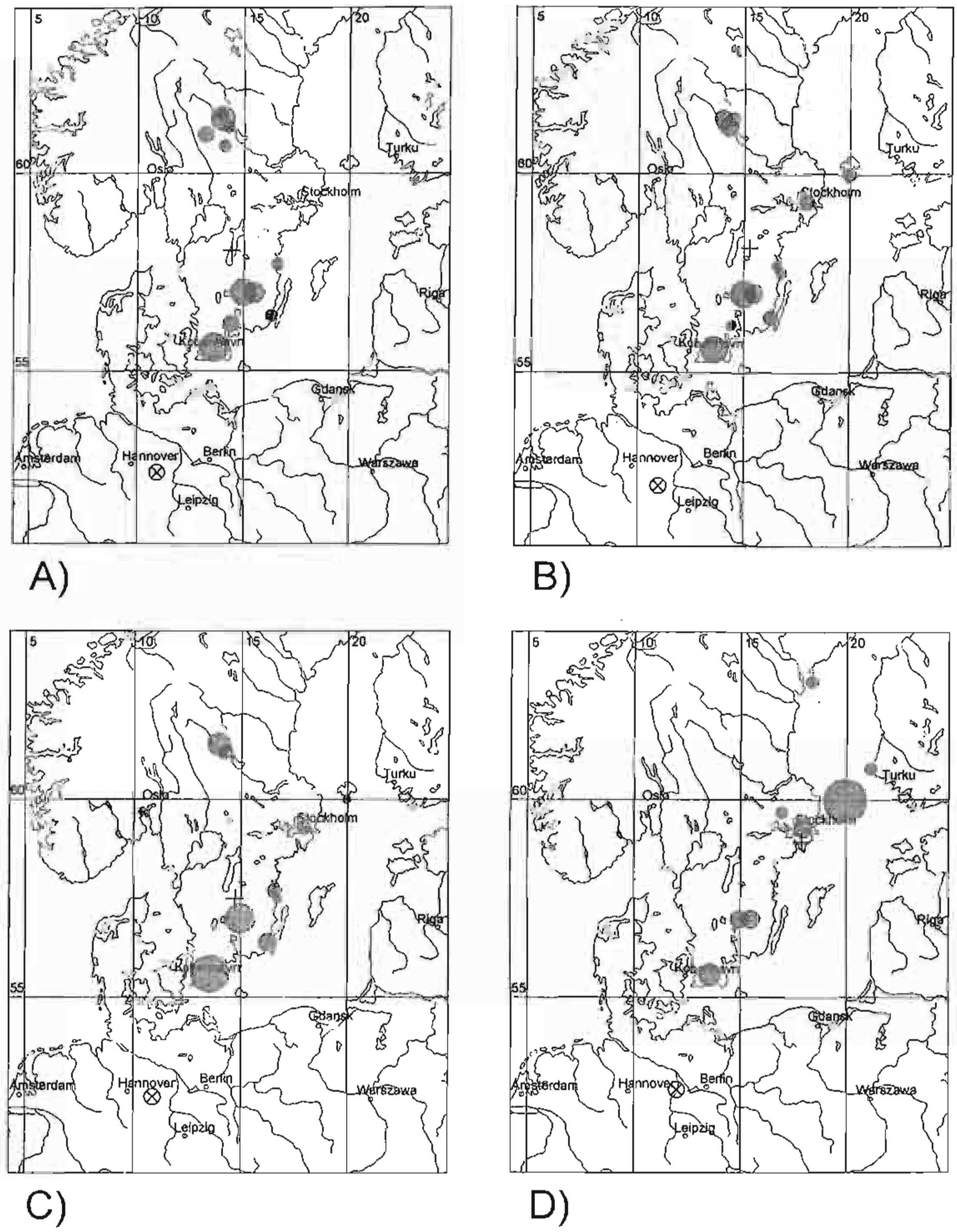

Fig. 5. Examples of stone counts from tills in Saxony-Anhalt and Lower Saxony

Lower Saxony: A — Elsterian till, Velpke (no. 18 in Fig. 6), B — Drenthian main till, Schöningen mine (no. 16 in Fig. 6), C — younger Drenthian till, Rühen (no. 23 in Fig. 6); Saxony-Anhalt: D — Warthian till, Arneburg (no. 11 in Fig. 4); ⊗ — sampling site, + — mean erratic source location (TGZ); circles denote sources of indicator stones, and the size of the circle indicates the percentage of stones from this source

Baltic Sea area, the TGZ lying very near the samples 9 and 10. The sample 13 indicates that not all the Warthian tills are so extremely eastern Baltic in nature, since out of the 37 indicator erratics "only" nine Åland rocks, 33% Palaeozoic limestones, 5% dolomites and 17% flint were counted — perhaps due to reworking of the Drenthian material.

EASTERN LOWER SAXONY

In the eastern part of Lower Saxony (Fig. 1), two Elsterian and three Saalian advances are known (K.-D. Meyer, 1976, 1982, 1995). This region has yielded 17 erratic collections

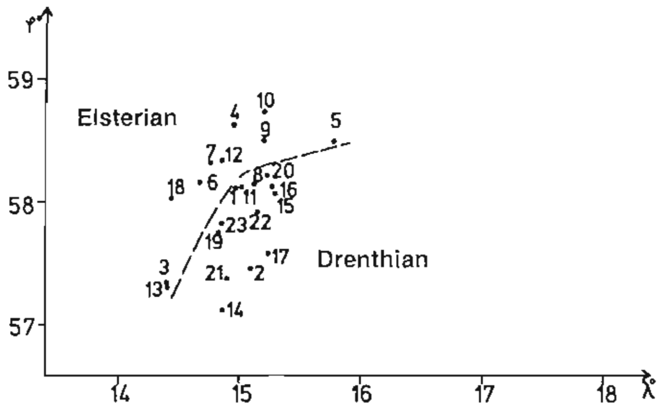

Fig. 6

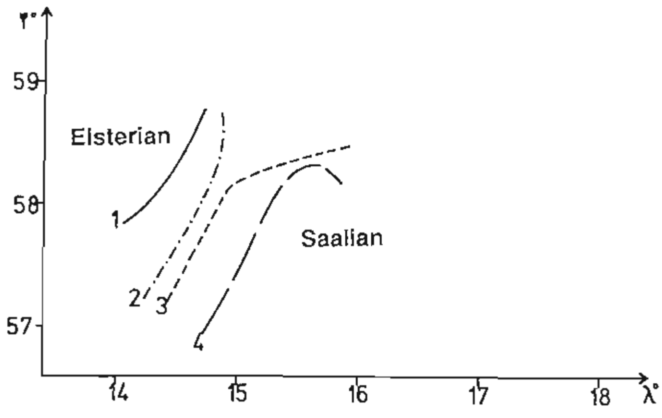

Fig. 7

Fig. 6. Mean erratic source locations (TGZ) for the Elsterian and the Saalian deposits from eastern Lower Saxony

1, 16 — D//Lg, Schöningen mine; 2, 15 — D/G/gf, Schöningen mine; 3, 4, 7, 8, 13, 14 — e/G/gf, Schöningen mine; 5 — e/G, Schöningen mine; 6, 9, 10, 12, 17 — e//Mg, Schöningen mine; 11 — D//Mg, Schöningen mine; 18 — e//Mg, Velpke; 19 — Dj/G/gf, Grimsbusch; 20 — Dj/G/gf, Velpke; 21 — Dj/G/gf, Brechtorf; 22 — Dj/G/gf, Rühen; 23 — Dj//Lg, Rühen; e — Elsterian, D — Drenthian, Dj — younger Drenthian, Mg — calcareous till, Lg — decalcified till, G — gravel, gf — glaciofluvial

Fig. 7. A shift of the boundary between the Elsterian and the Saalian TGZs from north-west to south-east

Elsterian/Saalian TGZ boundary from glacial deposits in: 1 — East Friesland and Oldenburg (K.-D. Meyer, 1970), 2 — northern part of Bremen (H. C. Höfle, 1983; S. Wansa, 1994), 3 — eastern Lower Saxony (this paper), 4 — Leipzig basin (this paper)

from the opencast lignite mine at Schöningen near Helmstedt, not far from the western boundary of Saxony-Anhalt. Six more samples come from the Oebisfelde area. The individual samples are discussed in detail in the relevant papers (J. Ehlers *et al.*, 1984), and the complicated stratigraphy in the Schöningen mine is also discussed. B. Urban *et al.* (1988) and B. Urban (1994) have produced summaries of the work.

In the Schöningen mine a thick and non-weathered Elsterian till was studied, a stratigraphic position of which is clearly given by the Holsteinian Interglacial deposits above, covered in turn by the Drenthian till. The Elsterian samples (Fig. 6), tills and outwash gravels, all usually contain little or no Åland material. This is also the case for gravels overlying the Elsterian till, which theoretically could represent a younger Elsterian advance. The proportion of the Dalarna indicator stones is in contrast mostly high; the sample 4 contained 20 out of 51. There is hardly any Norwegian material. The TGZ values of the Drenthian of eastern Lower Saxony lie in the area that is typical for the Drenthian material in the rest of Lower Saxony (Fig. 6), although exceptions occur (G. Lüttig, 1958; K.-D. Meyer, 1983).

DISCUSSION

Evaluation of indicator stone counts on the Elsterian and the Saalian deposits from the Leipzig basin (Saxony), Saxony-Anhalt and the adjacent part of Lower Saxony documents a marked shift in the boundary between the Elsterian and the Saalian TGZs as a function of the sampling locality (Fig. 7).

The indicator stone spectra of the first Elsterian advance are not the eastern Baltic in character, as was supposed previously; they are primarily characterised by stones from south to central Sweden. It is especially noticeable that there is a considerable proportion of stones from Dalarna (up to 30%). Values as high as this are also known from the north-western Lower Saxony, i.e. East Friesland and Oldenburg (K.-D. Meyer, 1970; H. C. Höfle, 1983; S. Wansa, 1994); the high counts for Norwegian indicator stones, predominantly rhomb-porphyry, become considerably lower in the eastern Lower Saxony and in counts from Saxony not a single example was found. Instead, the proportion of the eastern Baltic rocks, especially those from the Åland Islands, increases towards the east, and this is especially the case for the second Elsterian till.

In the eastern Lower Saxony, the deposits of the older Saalian (the Drenthian) contain mostly southern to central southern Swedish stones, smaller amounts of Dalarna, but a significant content of the Åland material. The "younger Drenthian" till and outwash, known by a high content of flint, continues into Saxony-Anhalt; there appears to be no correlation with the "Leipzig Phase" (second till of the Drenthian in Saxony). This phase is characterised by a high percentage of the Palaeozoic limestones and small amounts of flint.

The Warthian in both Lower Saxony and western Saxony-Anhalt is typically known for its extremely high amounts of the eastern Baltic rocks (Åland material, Palaeozoic limestones and dolomites) as well as low counts of flint. In order to correlate the individual stadials and the corresponding ice limits, it would be necessary to obtain further counts, particularly from Poland.

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ZESPOŁY ERATYKÓW PRZEWODNICH W OSADACH ZLODOWACEŃ ELSTERY I SOLAWY WE WSCHODNIEJ CZĘŚCI NIEMIEC

Streszczenie

Określono spektrum zespołów eratyków przewodnich z gruboziarnistej frakcji żwirowej i średnie położenie obszaru źródłowego materiału eratycznego TGZ (niem. German Theoretisches Geschiebezentrum) dla glin i osadów wodnolodowcowych Saksonii, Saksonii-Anhalt i Dolnej Saksonii (fig. 1), zgodnie z metodyką zaproponowaną przez G. Lüttiga (1958). W próbkach z dolnej gliny zwałowej zlodowacenia elstery stwierdzono znaczącą zawartość materiału z Dalarny i stosunkowo mało z Wysp Alandzkich. W Saksonii obie gliny zwałowe zlodowacenia elstery można odróżnić na podstawie wyższej zawartości materiału wschodniobałtyckiego w glinie górnej (fig. 2, 3). Osady lodowcowe i wodnolodowcowe stadiału drenthe (zlodowacenie solawy) zawierają wiele wskaźnikowego materiału szwedzkiego, lecz mniej z obszaru Dalarny. W Dolnej Saksonii i Saksonii-Anhalt, osady młodszego stadiału drenthe charakteryzują się wysoką zawartością krzemieni, natomiast osady stadiału warty — pochodzeniem wschodniobałtyckim z dużą zawartością materiału z Wysp Alandzkich oraz dolomitów i wapieni paleozoicznych (fig. 5, 6). Otrzymane wyniki wskazują na wyraźne przemieszczenie obszaru źródłowego z północnego zachodu podczas zlodowacenia elstery na południowy wschód podczas zlodowacenia solawy, jak również stopniowo z zachodu na wschód (fig. 7).