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Base of Quaternary deposits of the Baltic Sea depression and adjacent areas (map 2)

Neogeodynamica Baltica IGCP-Project 346

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1. Introduction

This brief description of Map 2 "Base of Quaternary deposits of the Baltic Sea depression and adjacent areas" summarizes regional reports of all authors listed on the map. Information from individual areas of the map concerning the elevation of the Quaternary base have already been published (e.g. SCHWAB & LUDWIG 1996; OSTAFICZUK 1999, and other publications listed in the references). The results of IGCP project 346 Neogeodynamica Baltica will be published to the full by GARETZKY et al. (in prep.).

The base of the Quaternary is of only limited use as a neotectonic reference horizon, because

- there is no horizon at or near the base of the Quaternary that can be used for stratigraphic and time correlation, i.e. the base of the Quaternary has no definite stratigraphic position;
- the relief of the Quaternary base provides only an indirect picture of the range of vertical movement since the beginning of the Quaternary;
- the specific sedimentation conditions caused in many areas a veil-like filling of the pre-Quaternary relief, i.e. there is only limited evidence on which can base a neogeodynamic interpretation;
- endogenic and exogenic processes were acting with quite a different intensity on regional and local scales in shaping the contours of the Quaternary base.

Despite these limitations in the accuracy and because of the strong exogenic reworking of the depth position of the Quaternary base, the relief of the Quaternary base shows a significant relationship to the regional pre-Quaternary geology of the studied area. Therefore, it is still possible to reconstruct the neotectonic history of the region for the short timespan since the beginning of the Quaternary. In parts of the region the tectonic history can be worked out by considering the interaction of endogenic and exogenic landscape-forming processes.

Unique features of the Quaternary base are developed in the following areas:

(1) the central Baltic Sea region including the Gulf of Bothnia (not shown on the map) and the Gulf of Finland;
(2) the area of the North Sea (only marginally touched);
(3) the northern part of Central Europe, especially the North German Lowlands and the adjacent lowland of western Poland (paleotectonically the post-Variscan part of the North German Basin);
(4) the southern border zone as transition to the southeast and central European mountain regions;
(5) the area of the East European craton.

2. Interpretation of the depth of the Quaternary base

In the research area, the relief of the Quaternary base varies by more than 1100 m (ranging from ≥ 500 m above sea level [a. s. l.] down to ≥ 600 m below sea level [b. s. l.]; not considered are the elevated top positions of the central and southeastern mountain chains). The areas with relatively specific development of the Quaternary base, listed above from (1) to (5), are partly characterized by a prominent depth-level or they are marked by strong devious gradients within the actual region. In the map, deep channels (tunnel valleys by Quaternary erosion) are a specific feature in northern central Europe. They are deeply cut into pre-Quaternary strata. East of the research area, where the Quaternary base relief is smoother, they are less deep.

The description of regions (1) to (5) in sections 2.1 to 2.5 is based both on the different levels of the Quaternary base and on their specific features. The five regional units can be further subdivided. OSTAFICZUK (1999) recognised 13 regional units in the research area, which are at least partly bounded by fault zones. A detailed description of all these areas will be given in the planned comprehensive publication (GARETSKY et al. in prep.).

[1]The authors dedicate this contribution to Dr. habil. Günter Schwab (†), Scientific Board member and German project leader of IGCP project 346. With his conceptional ideas on the central European neogeodynamics and his scientific results, Günter Schwab provided the essential basis for these investigations. We hope that this brief description of „his" map would meet with his full approval.

2.1 The central Baltic Sea area

In the central Baltic Sea, the Quaternary base lies on average at about 100 m b. s. l.; in more central areas it can descend to 150 m b. s. l., locally down to 200 m below sea level. It can be assumed that the NNE-SSW striking longitudinal axis of the trough-like to tongue-like depression in the Quaternary base is due to the activity of the Scandinavian continental ice sheet. The ice might have followed a pre-existing deep and exaratively and erosively deepened and broadened it. The younger ice streams also exarated older Quaternary sediments, resulting in a basal layer of younger Quaternary sediments and leading to a secondary „rejuvenescence" of the Quaternary basal deposits.
On the map, areas in the Baltic Sea coloured in dark green give an impression of the approximate width of these main ice streams, which extended to 100 m b. s. l. and were between > 60 and 120 km wide.

2.2 The North Sea area

In the eastern North Sea only local data about the depth of the Quaternary base were available during the period of study. Therefore the description is quite limited. But the continuous slope of the Quaternary base from 100 m b.s.l. to more than 300 m b. s. l. and the similar slope of the Rupelian base (shown on Map 1; more than 1300 m b. s. l. deep), allow us to conclude that continuous tectonically induced sinking took place during the Quaternary. The almost similar nearly N-S orientation of the isobaths in both maps and the thickness distribution of the Quaternary pile of sediments support this interpretation.
A summary of recent results on the Quaternary in the southern North Sea has been published by Streif (1996). Included is a report on the continuation of the channel structures (SCHWARZ 1996). Numerous seismic profiles show that the channel structures were mostly oriented N-S.

2.3 Northern Central Europe – North German Lowland, western Poland

In northern Central Europe and especially in the North German Lowland, a very special feature are the (older) Quaternary tunnel valleys (channels), incised by the first Pleistocene continental ice sheet, which presumably left a prominent imprint here. They are unique as for their extent and their smaller-scale features, which are not met with in other parts of the research area. Since their discovery as a complex phenomenon characterizing of the North German Lowland (GRUBE 1979, HINSCH 1979, KUSTER & MEYER 1979, HÖNEMANN et al. 1995), their origin has been widely discussed (e.g. EHLERS et al. 1984, VON BÜLOW 1990, 2000, EHLERS 1990, LIPPSTREU 1995, HABBE 1996, SCHWAB & LUDWIG 1996[2], EISSMANN 1997, LIPPSTREU et al. 1997, SMED 1998).

The deep channels described here were mainly not only eroded during the Elsterian ice age but mostly also refilled then. Younger channels cut in later Quaternary deposits are not considered here, although they are mainly related to the Quaternary base too. Detailed maps of the surface geology and morphology as well as cross-sections through the Quaternary strata of North Germany give an idea of the relatively shallow depth, the orientation and occurrence of the channels (LIPPSTREU et al. 1997). The North German Quaternary base displays a relatively monotonous level area at about 100 m b.s.l. (light green) cut by the Elsterian longitudinal channels. These channels are quite narrow with a mean width of only a few kilometers but locally more than 500 m deep. By correlating the former depth of the Quaternary base in the North German Lowland above all the channels, a NW-SE regular isobath system shows up crossing the channels and increasing in depth „inwards", the deepest lying approximately in the central part of the Central European zone of subsidence (see LUDWIG, this volume).

However, in longitudinal profiles of the channels, the Quaternary base displays numerous depth steps, locally in opposite directions, which may be the result of subglacial cavities (evorsion). High resolution seismic profiling across the channels reveals a prominent secondary broadening and flattening of the originally steeper channels due to gravitational sliding of the material on the flanks. As an example, Figure 1, taken from BUNESS & WIEDERHOLD (1999), shows the originally much steeper flanks of a channel.

The Elsterian channels shown at the map are deeply cut into the pre-Quaternary strata. In eastern North Germany they show an unsual NNE-SSW trend, but a more N-S trend in the adjacent areas to the west. The deep channels can be followed over more than 100 km, locally up to 150 km. Concerning the origin of the channels and the reconstruction of the interacting endogenic and exogenic landscape-forming processes, the more or less simultaneous beginning of the channels in the north and similarly their termination in the south is remarkable (see STACKEBRANDT et al. 2001). This suggests that former tectonic structures were reactivated. Moreover, the different trends of the channels in eastern and western North Germany may be due to different ice stream directions. Since the pattern and orientation of the subglacial erosional phases correspond to the ice-flow movement, i.e. the general ice dynamics, the ice can be inferred to have flowed from the NNE or NE in eastern North Germany, and from the north in western North Germany. VON BÜLOW (1990) suggests that the extremely deep downcutting of the Elsterian channels took place in a temporary marginal uplift or swell of the Earth's crust caused by glaci-isostasy, which was then cut into sub-

[2] This publication of some of the results of the IGCP project 346 includes a detailed description of the relief of the Quaternary base in North Germany, which was in fact Günter Schwab's last contribution on this topic. Numerous references are given to the work of the individual authors who dealt with the different parts of the thematic map.

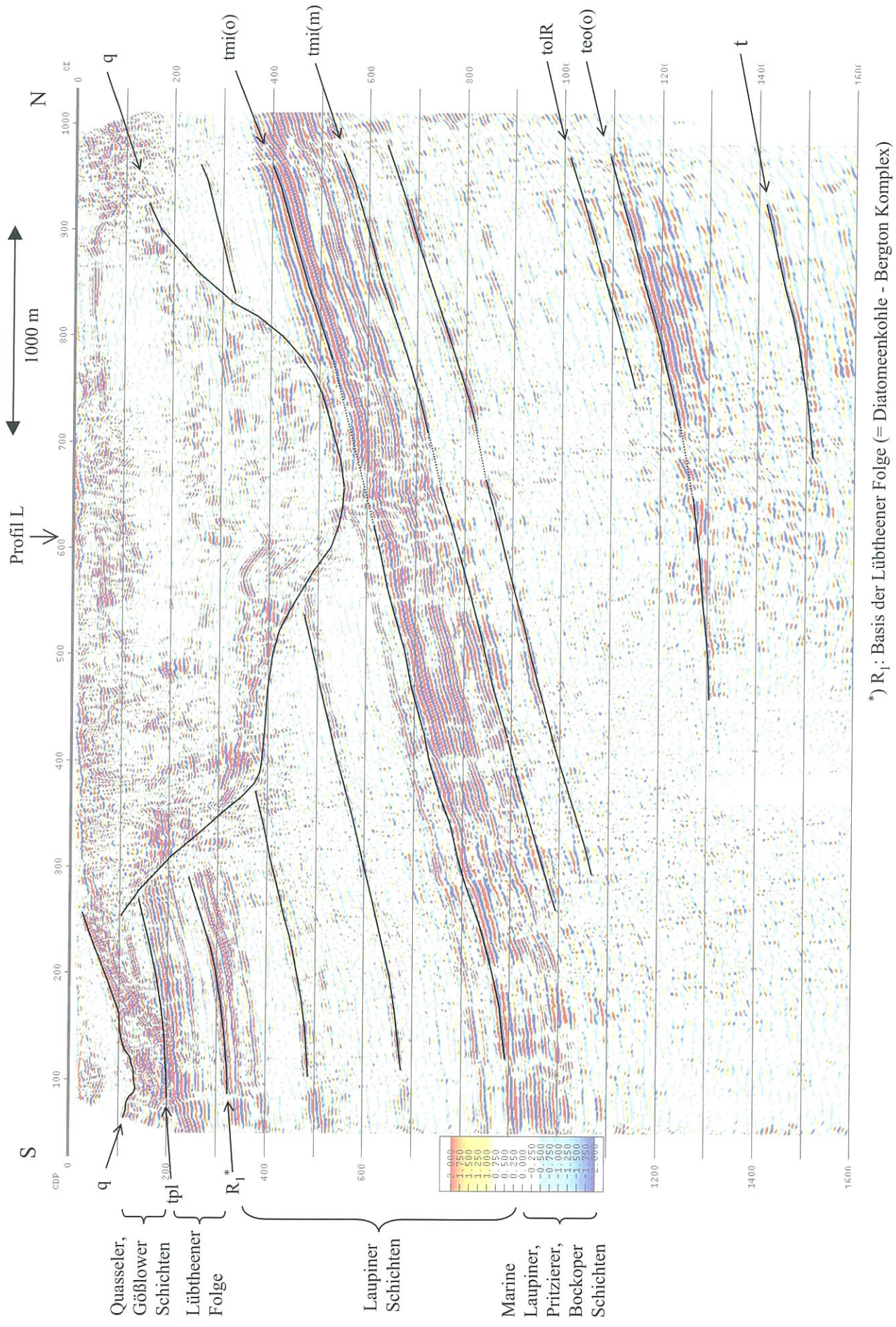

Fig. 1
Profile across a deep Elsterian channel (Hagenow channel, from Buness & Wiederhold *1999); notice the secondary widening of the channel by gravitational gliding of material on the flanks*

aquatically by the ice streams. But most authors postulate that the channels were formed subglacially under glaci-hydromechanical conditions. The channelling might have partly followed similarly oriented valleys already in existence in the pre-glacial fluvial systems. Nontheless, it remains problematic that the bottoms of the deepest channels are locally cut down much deeper than the plausible depth of the erosional base level at that time would allow one to assume.

Following EHLERS' (1983) suggestion of a clockwise rotating ice flow during glaciation and deglaciation, the differing orientation of the channels in eastern and western North Germany could reflect different phases of the ice flow. For Northwest Germany this would mean that the channels were cut during an early phase of the ice flow, whereas in Northeast Germany a later phase during the retreat of the Elsterian ice sheet is documented. This idea is supported by several findings, taking into account the general trend of the contours on the Quaternary base (see Map 2):

- the western Scandinavian provenance of the detritus in Elsterian moraines in Schleswig-Holstein (STEPHAN 1995),
- the upward change in younger Elsterian moraines of Lower Saxony from a western Scandinavian provenance to a more Baltic one (WOLDSTEDT und DUPHORN 1974, HOFFMANN und MEYER 1997),
- the movement directions of the Elsterian ice sheet (EHLERS 1990).

To the east, the area is characterized by an irregular but relatively smooth relief of the Quaternary base. Around longitude 16°E, the Quaternary base rises above sea level, but drops again in the vicinity of the Bight of Danzig. This zone of culmination of the Quaternary base is cut diagonally by the NW-SE striking Tornquist-Teisseyre Zone (TTZ). In the northwestern part of the area the shape of the Quaternary base is not influenced by the TTZ, but it is in the southeastern part (see section 2.4).

2.4 The southern marginal border as transition zone to the southeastern and central European mountain regions

In central and southeast Central Europe, south of the eye-catching coloured areas where the Quaternary base lies below sea level, there is a narrow, E-W trending area where the Quaternary base shows numerous small-scale features and rises to between 100 and >500 m above sea level. The rise of the Quaternary base to this higher level is irregular and step-like, the contours on the map having a saw-tooth appearance. The contours on this high Quaternary base area document a close genetic connection with the well-known regional NW-SE faults, as well as with the cross-features (e. g. Tornquist-Teisseyre zone, Oder lineament, major fault system of the Central German area, Elbe zone, and Osning fault system). The contours on the Quaternary base suggest that these earlier fault systems underwent recent reactivation.

The marginal border described here – on Map 8 called the „Central European uplift zone" – passes southwards into the mountain belt of the Alps and Carpathians. The high degree of neotectonic activity of this complex, roughly E-W trending mountain range had (together with the opening of the North Atlantic) great influence on our research area. However, the mountain belt was not covered by the present project.

2.5 The East European craton

East of the research area the relief of the Quaternary base is quite gentle. Two levels can be distinguished, clearly shown up as broad areas by the colouring on the map. The area of the Baltic republics including extensive areas of Russia, Belorussia and the Ukraine is characterized by an elevation of between 0 and 100 m a. s. l., only interrupted by a step-like rise of the Quaternary base to 200 m a.s.l., trending in a NW direction from the territories of Russia, Belorussia and the Ukraine into southern Estonia. To the south and east this step-like rise of the Quaternary base broadens and rises to elevations of between 100 and 200 m a. s. l., in some areas up to > 200 m above sea level.

Of higher significance is the deep Quaternary base in the direct prolongation of the central Baltic Sea basin to the south (Bight of Danzig, Königsberg region, western Lithuania). Here, the Quaternary base is at a depth of 0 to 100 m b. s. l., in the central zone down to 200 m below sea level. The contours and position of this zone allow a direct genetic correlation with a south-directed Elsterian ice stream. From the present-day coastline of the Baltic Sea this deepening of the Quaternary base can be traced for about 150 km into eastern Poland. There seems to be no connection between this area of a deep Quaternary base and the parallel, NW-SE trending Tornquist-Teisseyre zone on the southwestern margin. To the west, the Quaternary base rises to moderate elevations of 0 to 100 m a. s. l., until in western Poland the Quaternary base begins to descend to the deep level that it occupies beneath northeastern Germany.

In an overall E-W cross-section the general outline of the Quaternary base looks like a sine curve. This shape is a reflection of the ice dynamics in the region; however, the channels at the margin of the East European craton are strongly influenced by the crystalline rocks of the craton. These narrow erosional channels have a mean depth range of a few tens of meters; they are less pronounced than the channels in the North German region. There are also large differences in the orientation of the channels. In North Germany the deep Elsterian channels trend clearly N-S or NNE-SSW and show a very high degree of regularity, but on the East European craton the orientation of the channels is unclear; often they appear to show a dendritic pattern.

3. Conclusions on the neogeodynamics of the Baltic area from Map 2

Conclusions about the intensity, nature, regional extent and possible reasons for neotectonic activity can only be deduced from Maps 1 to 8 together. Therefore, an overall interpretation of the neogeodynamic crustal state of the peri-Baltic

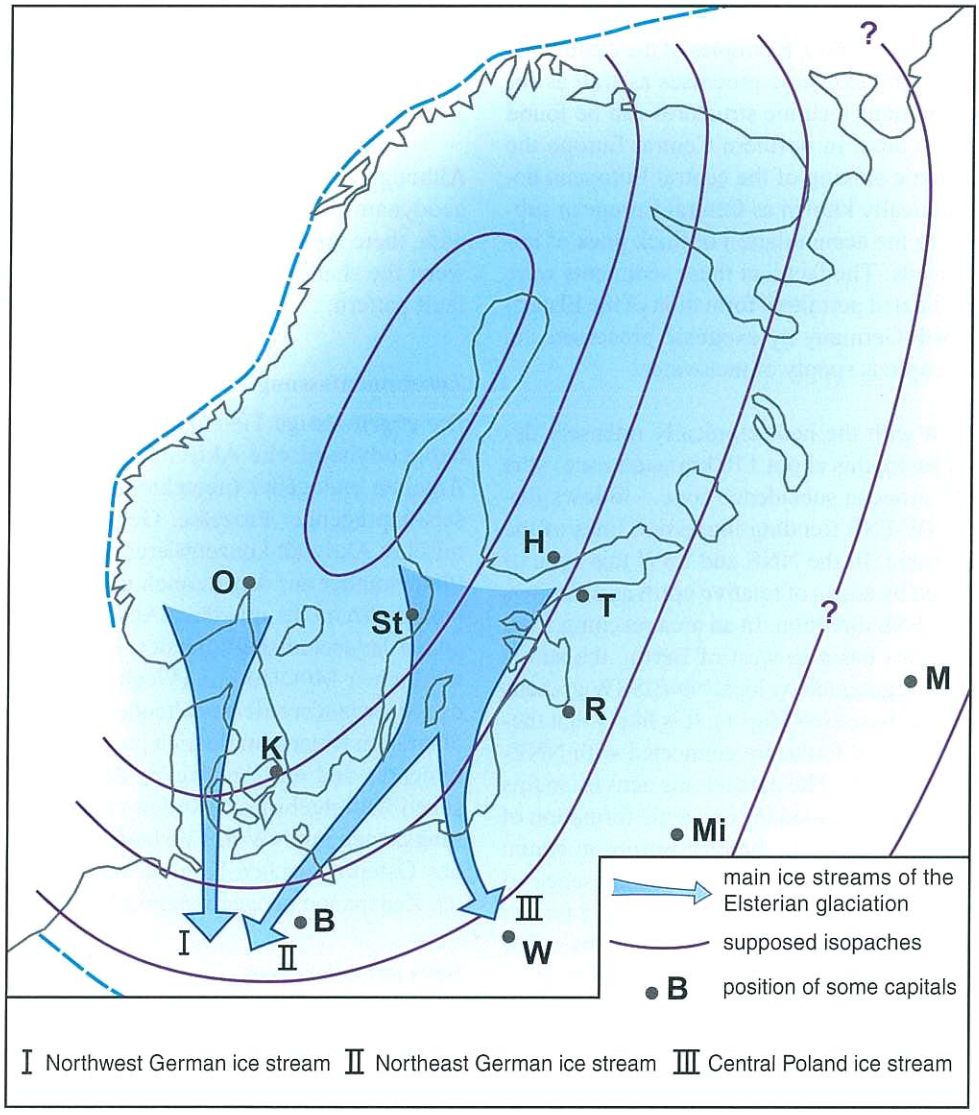

Fig.2 Subdivision of main ice streams of the Elsterian glaciation in northern Central Europe

region will be given in the comprehensive paper by GARETSKY et al. (this volume). However, in this chapter some observations will be made on certain aspects of neogeodynamic activity, as deduced from the hypsometric map „Base of Quaternary deposits of the Baltic Sea depression and adjacent areas".

Conclusions on the main Elsterian ice streams (i.e. NW German ice stream, NE German ice stream and central Poland ice stream):
The intense shaping of the landscape and formation of relief by the Scandinavian continental ice sheet moving along preferred paths permits specific information about the conditions of flow and extent of the Elsterian ice to be derived from the depth and relief of the Quaternary base. In contrast, information about the pre-glacial Quaternary sediments is poor. In the glacial and fluvioglacial erosional areas the older Pleistocene sediments were presumably removed (ŠLIAUPA et al. 1995, LUDWIG 2001). The base of the Quaternary consequently follows these major trough-like erosional zones. Interpretation of the relief of the Quaternary base over the whole of the region studied allows three main ice streams to be differentiated for the first Elsterian glaciation in northern Central Europe. From W to E these are (see Fig. 2)

- the N-S oriented Northwest German ice stream,
- the NE-SW oriented Northeast German ice stream, and
- the N-S to NW-SE oriented central-Poland ice stream.

This differentiation into several main ice streams is also confirmed by the correlation between channel orientation and main ice-flow directions, as well as by the change in provenance of the detritus mentioned in section 2.3.

Conclusions on the effectiveness of endogenic and exogenic processes for landscape generation, and on the possible posthumous relationships between old and young geologic and tectonic structures in the research area:
The possible relations between endogenic and exogenic landscape-forming processes and the origin of the deep Quaternary channels have already been mentioned, for ex-

ample by LUDWIG & SCHWAB (1995), VON BÜLOW (1990, 2000) and STACKEBRANDT (1999, 2001). Examples of the close association of endogenic and exogenic processes as well as for reactivated or posthumous tectonic structures can be found all over the research area. In northern Central Europe the continuous neotectonic sinking of the central European depression – neotectonically known as Central European subsidence zone – led to the accumulation of thick piles of unconsolidated sediments. The fact that these sediments were only slightly consolidated permitted formation of the Elsterian channels in North Germany by exogenic processes, i.e. glacial flow and a copious supply of meltwater.

Starting in the west with the neotectonically intensely deepened North Sea basin, this about 170 km wide zone – the so-called Central European subsidence zone – follows former NW-SE to WNW-ESE trending ingression lines of the Central European basin. In the NNE and SSW this zone of subsidence is flanked by zones of relative uplift and narrows telescope-like in an ESE direction. In an area reaching from the southern North Sea basin to west of Berlin, the subsidence zone has been segmented by local NNE-SSW grabens affecting the Rupelian base (see Map 1). It is likely that these neotectonically induced faults are connected with NNE-SSW faults in the basement. The neotectonic activity in this region therefore indirectly caused the exogenic formation of very deep Elsterian channels. On the East European craton deep channels were not formed owing to the presence of crystalline rocks near the surface. Here, apparently a former network of valleys was only somewhat deepened by a few tens of meters, forming trough-like channels (ŠLIAUPA et al. 1985).

The shaping of the overdeepened channels can be taken as an example of the interaction of endogenic and exogenic landscape-forming processes, whereas the steep slopes and high relief of the Quaternary base in the vicinity of NW-SE striking regional fault zones at the northern margin of the central and east European mountains are prominent examples of posthumous neotectonic movement on and/or reactivation of pre-existing geological structures.

Summary

It is possible to distinguish areas that differ with respect to the average elevation of the Quaternary base. These areas tend to correlate with differing regional geologic structures. The abrasional ice streams and the meltwaters did not eliminate the tectonic and neotectonic relief, but in many cases preserved it or modified it to correspond with the neotectonic pattern. The differences in the relief of the Quaternary base therefore permit to recognize areas of neogeodynamic activity with variable dominance of endogenic (neotectonic) and exogenic landscape-forming processes. Regions with relatively intense neogeodynamic activity occur on

- the area of the central Baltic Sea (dominance of exogenic, mainly erosive landscape-forming processes during the Quaternary),
- the area of northern Central Europe (formation of the overdeepened channels in the area of young, less compacted sediments), and
- the rise of the central and eastern European mountains (reactivated NW-SE regional fault zones).

Although large areas of the East European craton were neogeodynamically less active during the period being dealt with, there are very close relations in the eastern Baltic between the shallow channels, paleo-valleys and the fracture/fault pattern.

Zusammenfassung

Die gegenwärtige Tiefenlage der Basis des Quartärs belegt neogeodynamische Aktivitätsbereiche mit wechselnden Anteilen endogener (neotektonischer) und exogener landschaftsprägender Prozesse. Gebiete erhöhter neogeodynamischer Aktivität konzentrieren sich außerhalb der aktiven Plattenränder auf den Bereich der zentralen Ostsee (Dominanz während der quartären Ausgestaltungsetappe von exogenen landschaftsgestaltenden Prozessen), das Gebiet des nördlichen Mitteleuropa (Wechselwirkung endogener und exogener landschaftsgestaltender Prozesse, Ausbildung der übertiefen Rinnen im Bereich junger, unterkompaktierter Sedimente) und den Anstieg zu den mittel- und osteuropäischen Mittelgebirgsschwellen (reaktivierte regionale Störungszonen mit NW-SE-Verlauf). Dagegen sind weite Teile des Osteuropäischen Kratons während der hier behandelten Zeitspanne neogeodynamisch weniger intensiv aktiv.

Selected references

BÜLOW, W. VON (1990): Zur Entstehung der altpleistozänen Rinnen im Bezirk Schwerin. - Z. geol. Wiss. **24**, 3/4, S. 343-349, Berlin

BÜLOW, W. VON (2000): Ergebnisse und Ablagerungen seit dem Pliozän. - In: VON BÜLOW (Hrsg.): Geologische Entwicklung Südwest-Mecklenburgs seit dem Ober-Oligozän. - Schriftenr. f. Geowiss. **11**, S. 355-364, Berlin

BUNESS, H. & H. WIEDERHOLD (1999): Experiences with a vibrator system for shallow high-resolution seismic. - Extended abstracts book. EAGE 61st Conference and Technical Exhibition, Helsinki

EHLERS, J. (1990): Untersuchung zur Morphodynamik der Vereisungen Norddeutschlands unter Berücksichtigung benachbarter Gebiete. - Bremer Beitr. zur Geograhie und Raumplanung 19, Bremen

EHLERS, J. (1994): Allgemeine und historische Quartärgeologie. - 358 S., Stuttgart (Enke)

EHLERS, J., K. D. MEYER & H.-J. STEPHAN (1984): The pre-Weichselian glaziations of North-West-Europe. - Quaternary Science Reviews, Vol. **3**, p. 1-40, London

EISSMANN, L. (1997): Das quartäre Eiszeitalter in Sachsen und

Nordthüringen. - Altenbg. nat.wiss. Forsch. **8**, S. 1-98, Altenburg

FRANKE, D. & N. HOFFMANN (1999): Das Elbe-Lineament - bedeutende Geofraktur oder Phantomgebilde? Teil 1: Die Referenzgebiete. - Z. geol. Wiss. **27**, 3/4, S. 279-318, Berlin

FRANKE, D. & N. HOFFMANN (1999): Das Elbe-Lineament - bedeutende Geofraktur oder Phantomgebilde? Teil 2: Regionale Zusammenhänge. - Z. geol. Wiss. **27**, 3/4, S. 319-350, Berlin

GARETSKY et al.: Neogeodynamics of Baltic Sea Depression and adjacent areas - Explanatory notes to a map set at scales 1 : 1 500 000 and 1 : 5 000 000. - (in prep.)

GRUBE, F. (1979): Übertiefte Täler im Hamburger Raum. - Eiszeitalter und Gegenwart **29**, S. 157-172, Hannover

HABBE, K. A. (1996): Über glaziale Erosion und Übertiefung. - Eiszeitalter und Gegenwart **46**, S. 99-119, Hannover

HOFFMANN, K. & K.-D. MEYER (1997): Leitgeschiebzählungen von elster- und saalezeitlichen Ablagerungen aus Sachsen, Sachsen-Anhalt und dem östlichen Niedersachsen. - Leipziger Geowissenschaften **5**, S. 115-128, Leipzig

KOCKEL, F. (Hrsg.) (1996): Geotektonischer Atlas von NW-Deutschland 1 : 300 000. - Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover

KUSTER, H. & K.-D. MEYER,. (1979): Glaziäre Rinnen im mittleren und nordöstlichen Niedersachsen. - Eiszeitalter und Gegenwart **29**, S. 135-156, Hannover

LIPPSTREU, L. (1995): VI. Brandenburg. - In: BENDA, L.: Das Quartär Deutschlands. - S. 116-147, Stuttgart (Borntraeger)

LIPPSTREU, L., HERMSDORF, N. & A. SONNTAG (1997): Geologische Übersichtskarte des Landes Brandenburg 1 : 300 000, Potsdam

LUDWIG, A. O. & G. SCHWAB (1995): Neogeodynamica Baltica – ein internationales Kartenprojekt (IGCP-Projekt Nr. 346): Deutsche Beiträge zur Charakterisierung der vertikalen Bewegungen seit Beginn des Rupelian (Unteroligozän) bzw. seit Ende der Holstein-Zeit. - Brandenburg. Geowiss. Beitr. **2**, 2, S. 47-57, Kleinmachnow

LUDWIG, A. O. (1997): Ergebnisse zum neotektonischen Bewegungsverhalten der peribaltischen Region. - Brandenburg. Geowiss. Beitr. **4**, 1, S. 31-48, Kleinmachnow

OSTAFICZUK, S. (1999): Neogeotectonic features in the Sub-Quaternary surface. - Technika Poszukiwan Geologicznych. Geosynoptyka i Geotermia, v. 1, p. 77-81, Kraków

SCHWAB, G. & LUDWIG, A. O. (1996): Zum Relief der Quartärbasis in Norddeutschland - Bemerkungen zu einer neuen Karte. - Z. geol. Wiss. **24**, 3/4, S. 343-349, Berlin

SLIAUPA, A., REPECKA, M. & J. STRAUME (1995): The subquaternary relief of the eastern Baltic sea and adjacent territory. - Technika Poszukiwan Geologicznych. Geosynoptyka i Geotermia **34**, 3, p. 75-78, Kraków

SMED, P. (1998): Die Entstehung der dänischen und norddeutschen Rinnenthäler (Tunnelthäler) - Glaziologische Gesichtspunkte. - Eiszeitalter und Gegenwart **48**, S. 1-18, Hannover

STACKEBRANDT, W. (1998): Grundzüge des geologischen Baus von Brandenburg. - Brandenburg. Geowiss. Beitr. **5**, 2, S. 3-7, Kleinmachnow

STACKEBRANDT, W. (2001): Zur Neogeodynamik des nördlichen Mitteleuropas - Ergebnisse aus dem IGCP-Projekt 346: Neogeodynamica Baltica. - Z. geol. Wiss. **29**, 1/2, Berlin

STEPHAN, H.-J. (1995): I. Schleswig-Holstein. - In: BENDA, L.: Das Quartär Deutschlands. - S. 1-13, Stuttgart (Borntträger)

STREIF, H. (Koord.) (1996): Deutsche Beiträge zur Quartärforschung in der südlichen Nordsee. - mit Beitr. von E. FABER, J. HAHNE, W. HINSCH, U. JÜRGENS, B. MENKE, K.-J. MEYER, C. SCHWARZ, H. STREIF & V. ZÖLLMER. - Geol. Jb. **A 146**, 244 S., Hannover

WOLDSTEDT, P. & K. DUPHORN (1974): Norddeutschland und angrenzende Gebiete im Eiszeitalter. - 500 S., Stuttgart (K. F. Köhler)

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