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MIDDLE PLEISTOCENE SEDIMENTATION AND PALAEOGEOGRAPHY OF THE DZIERŻONIÓW BASIN, SUDETIC FORELAND, SOUTHWESTERN POLAND

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Abstract. The Dzierżoniów Basin contains deposits of three glacial stages: older Elsterian, younger Elsterian and older Saalian (Odranian). The first and the last are represented by tills and thin, discontinuous proglacial (transgressive) deposits. Younger Elsterian represents both transgressive glaciofluvial/glaciolacustrine deposits and a till, as well as deglaciation suite. The latter is represented by extensive glaciolacustrine suite, formed in the ice-contact lake, and series of glaciofluvial deposits. Glacial palaeotransport was from northwest during both Elsterian stadials. During Odranian, two ice lobes occurred, one flowing from north and the second one from northeast. Holsteinian fluvial series occur directly on younger Elsterian deglaciation suites. They represent gravelly or sandy-gravelly sequences deposited by braided rivers. Holsteinian age is inferred from geological position. No pollen data are available. Elsterian and Holsteinian deposits have been tectonically shifted and slighty deformed. The amplitude of tectonic movements is ca 30 - 40 m. Age of the tectonic movements is, most probably, post-Odranian. Younger Saalian (Wartanian) and Upper Pleistocene sequences are represented mainly by fluvial deposits (valleys) and loess or slope deposits (uplands). Deep valleys were formed during the Odranian/Wartanian interstadial, possibly because of increased uplift and regional tectonic movements.

Abstrakt. Kotlina Dierżoniowska zawiera osady trzech zlodowaceń: starszego stadiału zlodowacenia Elsterian, młodszego stadiału tego zlodowacenia i starszego stadiału zlodowacenia Saalian (Odranian). Najstarsze i najmłodsze osady glacjalne reprezentowane są przez gliny i cienkie, nieciągłe pokrywy transgresywnych osadów glacifluwialnych. Osady młodszego stadiału zlodowacenia Elsterian zawierają osady zarówno z transgresji, w tym gliny, jak i z recesji lądolodu. Osady recesyjne reprezentowane są głównie przez osady zastoiskowe, formowane w proglacjalnym zbiorniku typu ice-contact. Transport glacjalny w czasie obu stadiałów zlodowacenia Elsterian był z północnego-zachodu. W czasie zlodowacenia Odranian Kotlina Dzierżoniowska była pod wpływem dwóch lobów lodowcowych, jednego transgredującego z północnego wschodu a drugiego z północy. Osady rzeczne z interglacjału mazowieckiego (Holsteinian) leżą bezpośrednio nad osadami recesyjnymi zlodowacenia Elsterian. Są one reprezentowane przez żwiry i piaski ze żwirami deponowane w warunkach rzeki roztokowej. Wiek tych osadów został określony na podstawie pozycji geologicznej; brak jest danych paleobotanicznych na potwierdzenie tej hipotezy. Osady zlodowacenia Elsterian i interglacjalne osady rzeczne ulegały ruchom tektonicznym. Ich amplituda dochodzi do 30 - 40 m. Wiek ruchów tektonicznych został określony w przybliżeniu na okres po ostatniej transgresji lądolodu (post-Odranian). Osady stadiału Warty i górnego plejstocenu reprezentowane są w Kotlinie Dzierżoniowskiej przez serie rzeczne (doliny) oraz lessy i osady stokowe (wysoczyzny). Głębokie rozcięcia dolinne powstały prawdopodobnie po ostatniej transgresji lądolodu (interstadial Odranian/Wartanian), częściowo jako odpowiedź na wzmożone, glaciizostatyczne ruchy podnoszące lub bardziej regionalne ruchy tektoniczne.

Key words: Pleistocene stratigraphy, glacial and fluvial deposits, neotectonics, Sudetic Foreland, Southwestern Poland

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INTRODUCTION

The paper presents sedimentological and structural data from three outcrops: Dobrocin, Uciechów and Grodziszcze, all located within the Dzierżoniów Basin, Sudetic Foreland (Fig. 1). These data are suplemented by archival borings of this region. Our data and interpretation differ from that of the former works on Quaternary of this region (Barsch & Finckh, 1924; Dathe & Finckh, 1924; Pernarowski, 1963; Szponar, 1974, 1986; Walczak-Augustyniak, 1977; Szałamacha & Walczak-Augustyniak, 1976; Walczak-Augustyniak & Szałamacha, 1978) and lead us to present a new model of the Middle Pleistocene sedimentation in the Dzierżoniów Basin. A preliminary model was formerly presented by authors in Ibek (1991) and Krzyszkowski (1993).

Most of presented data come from eastern part of the Dzierżoniów Basin, with two large outcrops, Dobrocin and Uciechów, and many archival borings, whereas western part of the basin has almost no borings and limited number of good outcrops with glacial deposits (Krzyszkowski, 1993) (Fig. 1). In spite of such unequal documentation, it seems that the model presents correctly sedimentation history on all sides of the basin.

Methods, including the petrological investigations, have been described separately in Czerwonka & Krzyszkowski (1992) and Badura *et al.* (1992).

GEOMORPHOLOGY AND GENERAL GEOLOGY

The Dzierżoniów Basin is an intermontane basin bordered from all sides by high mountain ridges or at least hills (Fig. 1). Its southwestern boundary is formed by a 400 m high scarp of the Sudetic Marginal Fault (Oberc & Dyjor, 1969), which separates the Sowie Mts (1015 m a.s.l.), a part of Sudeten, from the Sudetic Foreland (Fig. 2B). The northern and southern boundaries (Kiełczyn Hills, 462 m a.s.l.; Bielawa Hills, 455 m a.s.l.) are also distinct, with tectonic scarps up to 50 - 100 m. The eastern boundary at the Krzyżowe Hills (407 m a.s.l.), a part of Niemcza Hills, although not forming one line, is also quite distinct and forms a 50 - 75 m high scarp (Fig.2A). Northwestern and northeastern boundaries of the Dzierżoniów Basin are much less distinct

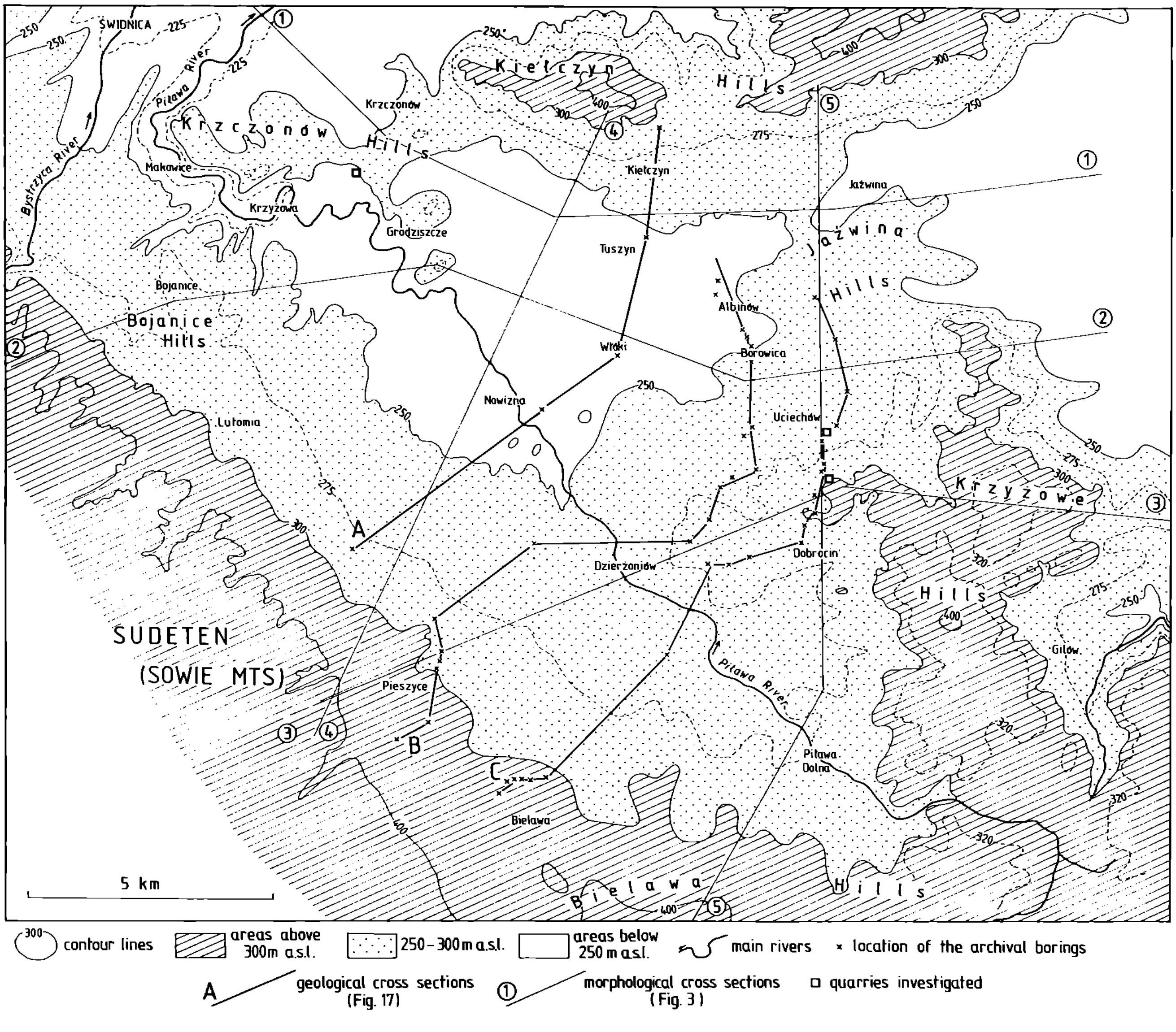


Fig. 1. The Dzierżoniów Basin at the Sudetic Foreland and location of sites investigated

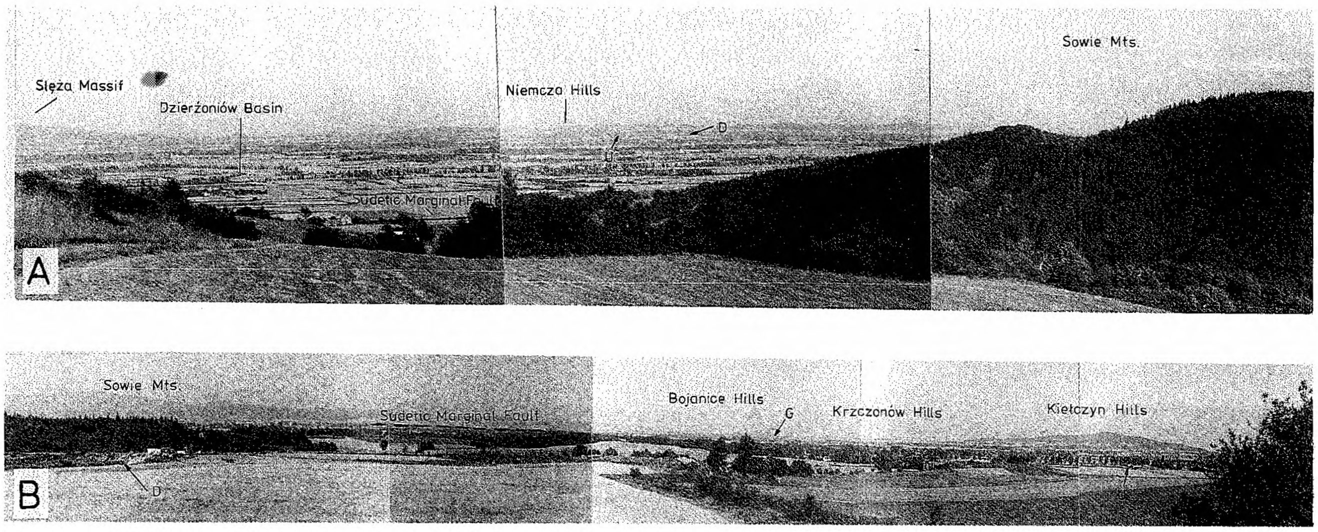


Fig. 2. General overview for the Dzierżoniów Basin: A. from Sowie Mountains to NE, on the left side is visible the "flat region" with alluvial veneers (northwest on the left); B. from Dobrocin quarry to the west, at the foreground hilly landscape between Dobrocin and Uciechów (southwest on the left); in both views: D – Dobrocin quarry, U – Uciechów quarry, G – Grodziszcze quarry

and are indicated only by small and isolated hills with relative heigth up to 20 - 30 m. These are: Bojanice (290 m a.s.l.) and Krzczonów (285 m a.s.l.) Hills in the northwest, and Jaźwina Hills (279 m a.s.l.) in the northeast. These two last hill groups form "gates" of the Dzierżo-niów Basin, opened to other regions (Fig. 2A, B). The northwest "gate" is used recently by main river of the basin, the Piława river (Fig. 1) and both "gates" were used extensively by rivers and glaciers during the Pleistocene (Pernarowski, 1963). The basin interior can be subdivided into three parts. The southwestern part, bordered with the Sowie Mts, represents a gently inclined to northeast (ca 2°) alluvial fan (the Upper Terrace level) . The northwestern and central parts of the basin form a flat region at about 240 - 250 m a.s.l., whereas the eastern part of the basin is characterized by generally higher (260 - 320 m a.s.l.) and hummocky morphology (Figs. 1, 3).

Morphology of the Dzieżoniów Basin is structurally controlled (Oberc, 1972). The basin is located at the northern flank of the Sowie Góry gneiss block (Fig. 4A) (Grocholski, 1967; Żelaźniewicz, 1987), with gneiss outcrops at all its boundaries, except Kiełczyn Hills with serpentinites (Maciejewski, 1963, 1968). The southwestern, southern, northern and very probably also eastern boundaries are tec-

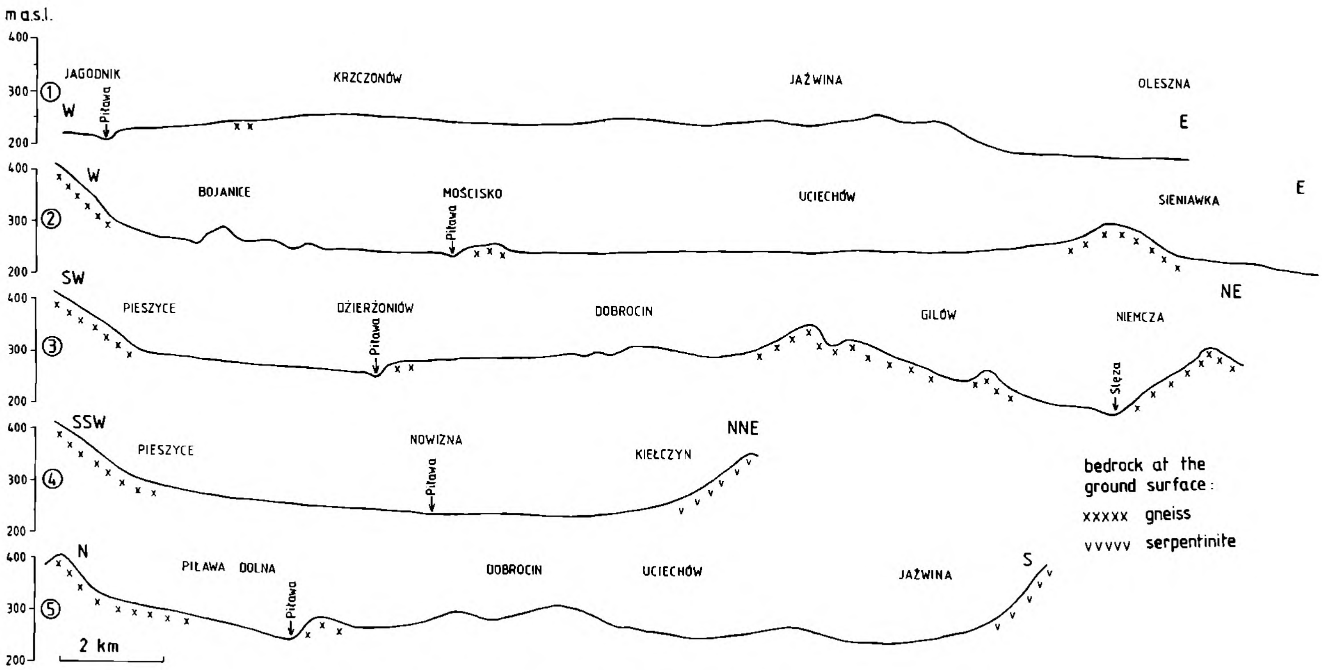


Fig. 3. Morphological profiles throughout the Dzierżoniów Basin (for location see Fig. 1)

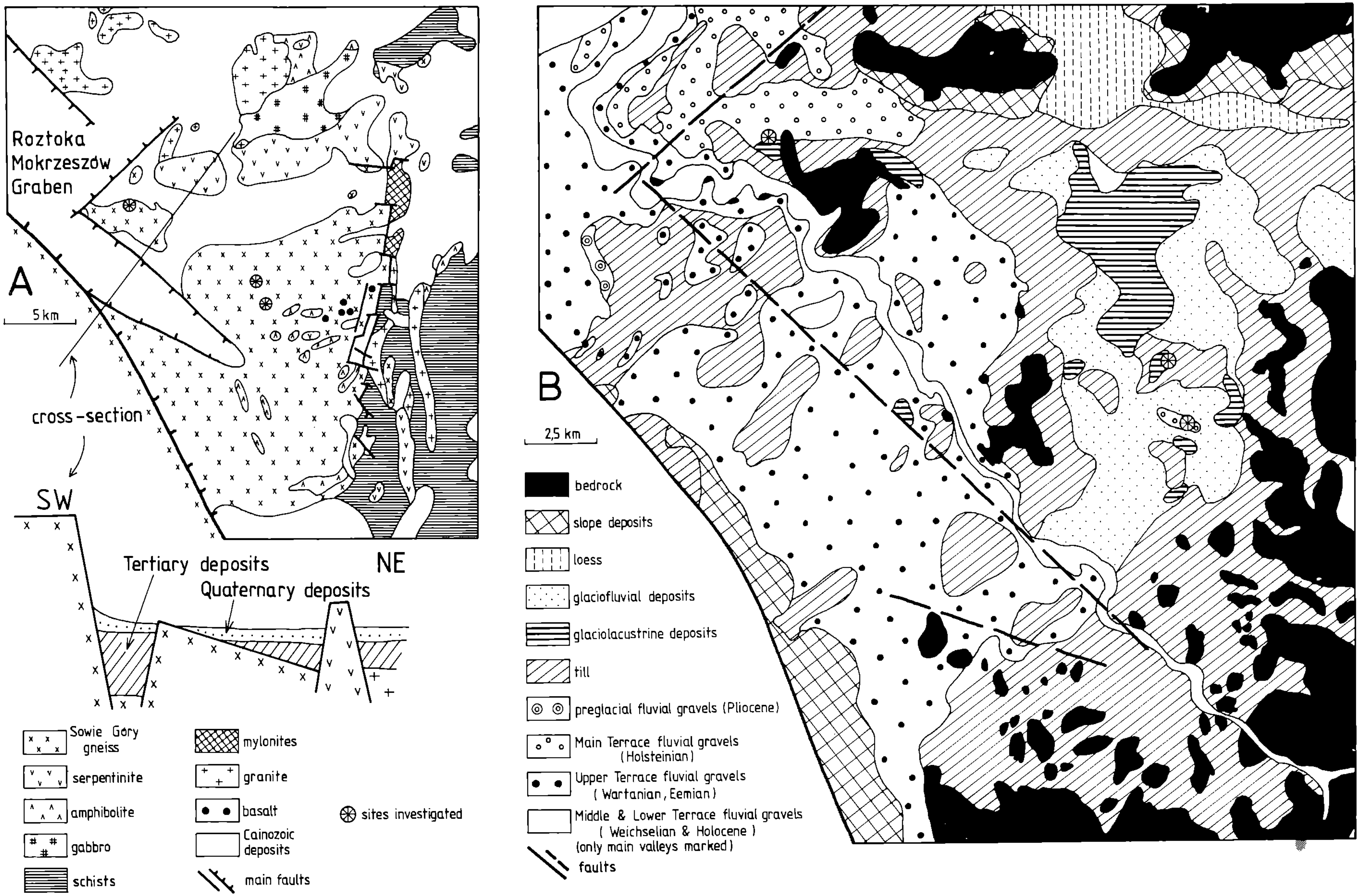


Fig. 4. Geology of the Dzierżoniów Basin and its neighbourhood: A. with no Quaternary deposits (after Bossowski *et al.*, 1981); B. simplified surficial geology (after Barsch & Finckh, 1924, Dathe & Finkh, 1924; Grocholski, *et al.*, 1981; Szałamacha & Walczak-Augustyniak, 1976; Walczak-Augustyniak & Szalamacha, 1978, and materials of the authors)

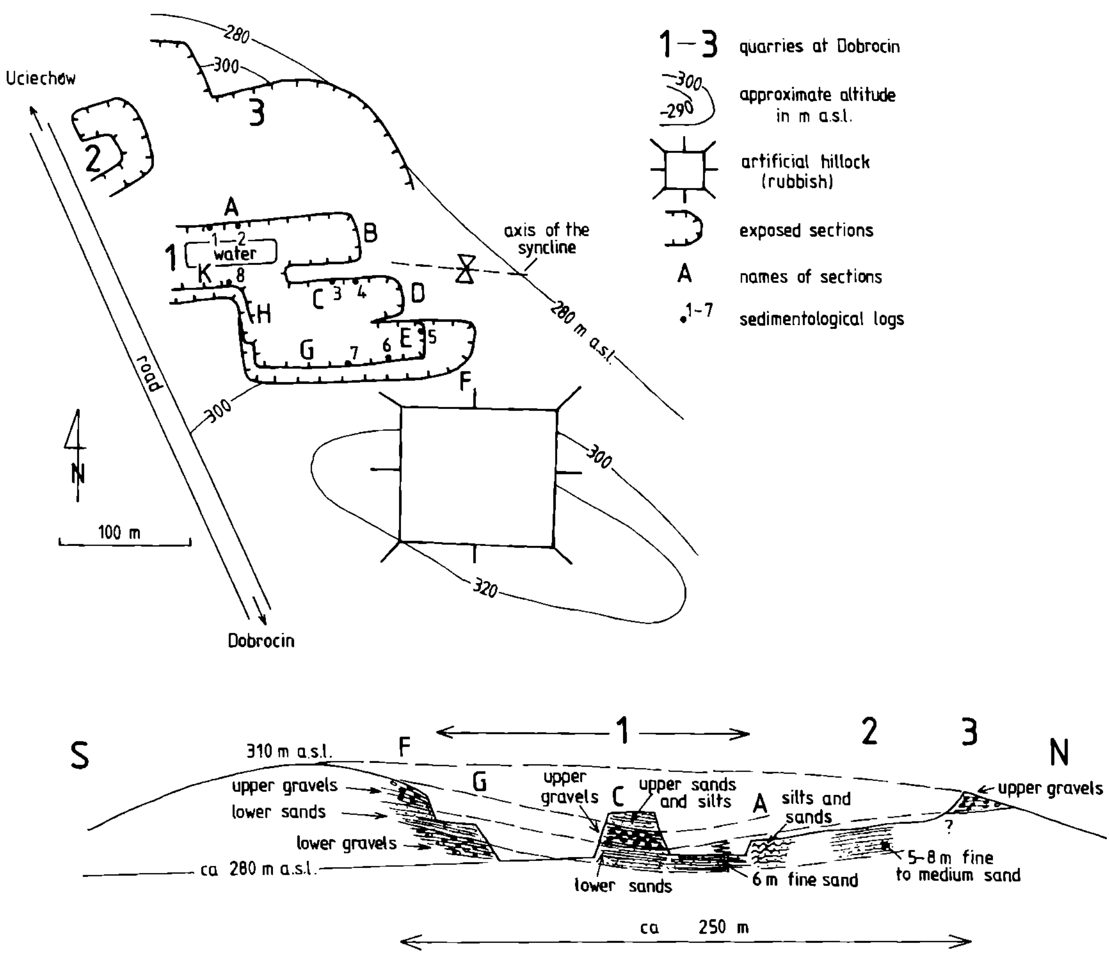


Fig. 4. A simplified map of Dobrocin quarry with location of sections and sedimentological logs (*above*) and cross section throughout quarries near Dobrocin with correlation of lithostratigraphic units (*below*)

tonic and follow fault zones in the bedrock. The Dzierżoniów Basin is composed of two sub-basins. The western one is a part of the Roztoka-Mokrzeszów Graben (Dyjor & Kuszell, 1977; Grocholski, 1977) and form 2 - 3 km wide graben zone, paralell to the scarp of the Sudetic Marginal Fault (Fig. 4A). Thickness of the Cainozoic deposits reaches here up to 200 m (Bossowski, 1975). The eastern basin is located on the tilted gneiss block, where gneiss is outcroped only at the graben boundary (Fig. 4A). Thickness of the Cainozoic deposits reaches here only up to 40 - 60 m.

Surficial geology well correlates with morphological zones. The Bojanice and Krzczonów Hills are formed mainly of glacial deposits (moraine plateau) with extensive outcrops of the Lower and Middle Pleistocene fluvial deposits (Krzyszkowski, 1993) and some gneiss hills. The southwestern part of the basin as well as the northwestern part of the flat region are formed of post-glacial (post-Odranian) alluvial veneers, with some, isolated patches of glacial deposits. The northeastern part of he flat region is formed of glacial deposits (tills), with extensive outcrops of Pleistocene (glaciolacustrine) and/or Neogene clays and silts. The eastern, hummocky part of the basin, including the Jaźwina Hills, is formed mainly of glaciofluvial sands and gravels with some glaciolacustrine deposits and tills, as well as some gneiss hills (Fig. 4B).

From the above it follows that the bedrock structure controls the basin boundaries, but surficial deposits have only little connections with the bedrock, e.g. the Roztoka-Mokrzeszów Graben is not clearly visible in local morphology. Thus, recent landscape and surficial deposits depend, in majority, on sedimentation and erosion rates during the Quaternary.

DESCRIPTION AND INTERPRETATION OF DEPOSITS

DOBROCIN

Dobrocin quarry is located 1.5 km north of village Dobrocin, at the top of the highest hill in this region (322.4 m a.s.l.). The quarry contains three outcrops (Fig. 5). The old one, numbered 3, is poorly preserved with only 1 - 2 m of non-calcareous gravels near the ground surface. The new outcrop, numbered 2, contains some small, up to 5 - 8 m high sections of medium to fine grained, cross (St, Sr) and

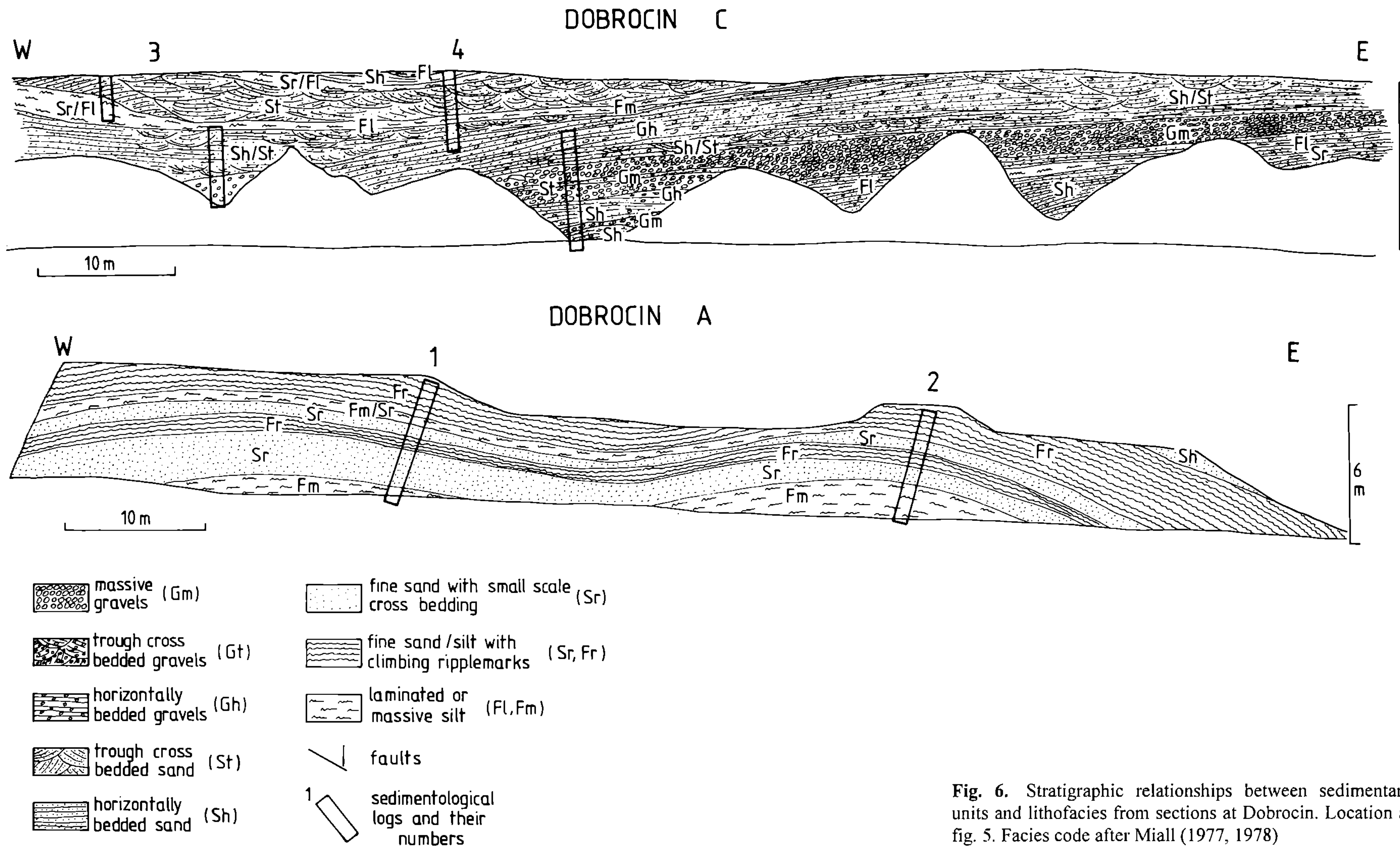
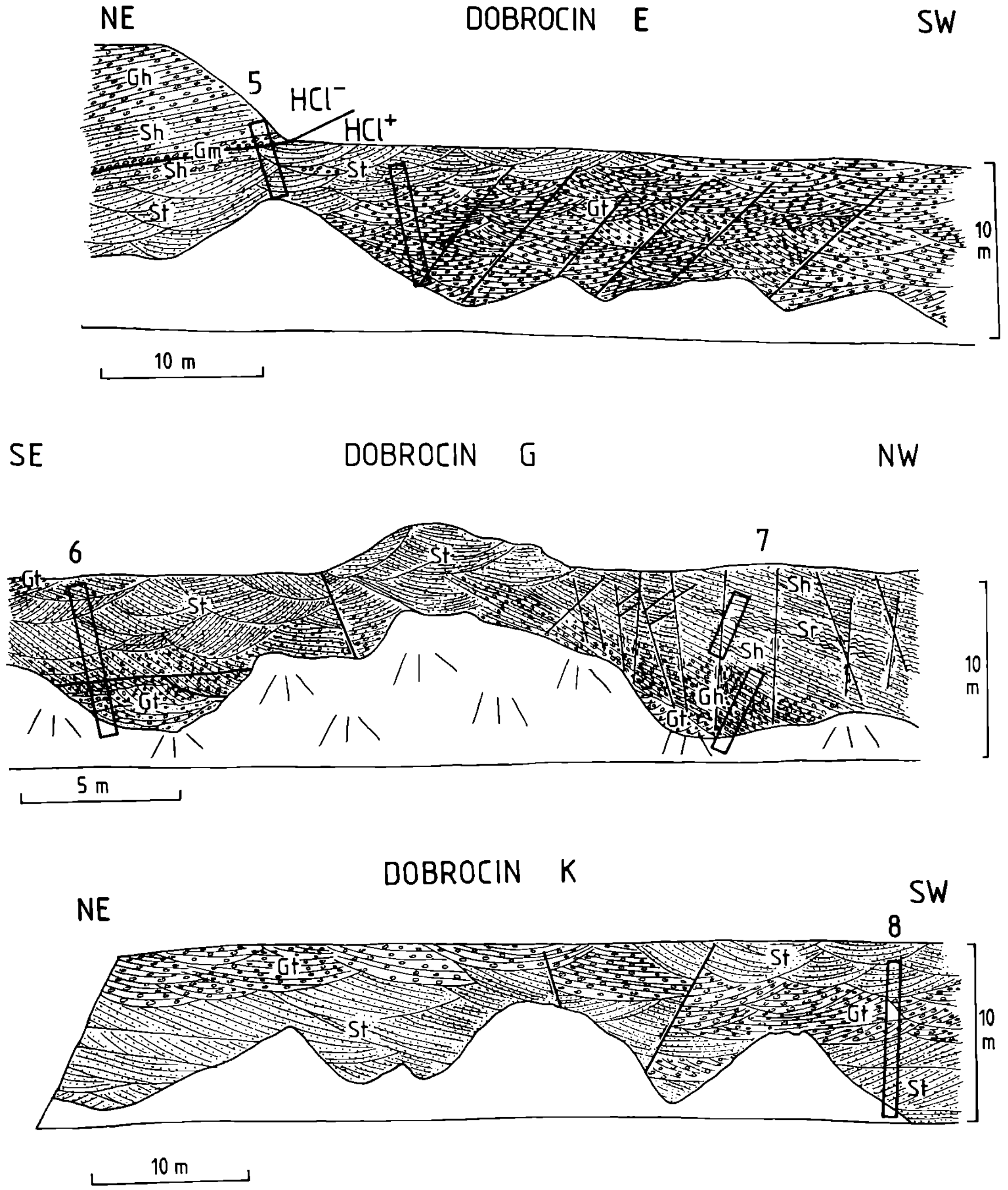


Fig. 6. Stratigraphic relationships between sedimentary units and lithofacies from sections at Dobrocin. Location at fig. 5. Facies code after Miall (1977, 1978)



horizontally (Sh) bedded sands. Palaeoflow directions obtained from St structures are 122 - 302° here. In turn, the main outcrop, numbered 1, contains several sections, of total lenght up to 500 m, in two levels. Each level contains sections from 5 to 10 m high (Fig. 6). Total thickness of the exposed sequence is over 20 m. Detailed sedimentological and structural data, which are presented below, come only from Dobrocin 1.

Lithostratigraphy

Five sections, A, C, E, G and K (Fig. 5) have been described in detail; the others were not well exposed during the investigation period (1989-1992). Lithologically, the sequence may be subdivided into four units, which occur in superposition: lower gravels, lower sands, upper gravels and upper sands and silts. Stratigraphically, they may be grouped into two series: the Lower Member (lower gravels and sands) and the Upper Member (upper gravels and upper sands and silts). The main difference between them is lack of calcium carbonate in the Upper Member. However, there is neither distinct erosion boundary nor a rapid change in lithofacial characteristics between two members defined. Hence, deposits of Dobrocin 1 are interpreted as stratigraphically uniform sequence and named the Dobrocin Formation. The Upper Member is exposed at sections C, D and F, where both as whereas series, together with the boundary between the calcareous and non-calcareous deposits, are exposed at section E (Figs. 6 - 10), and sections G, H and K

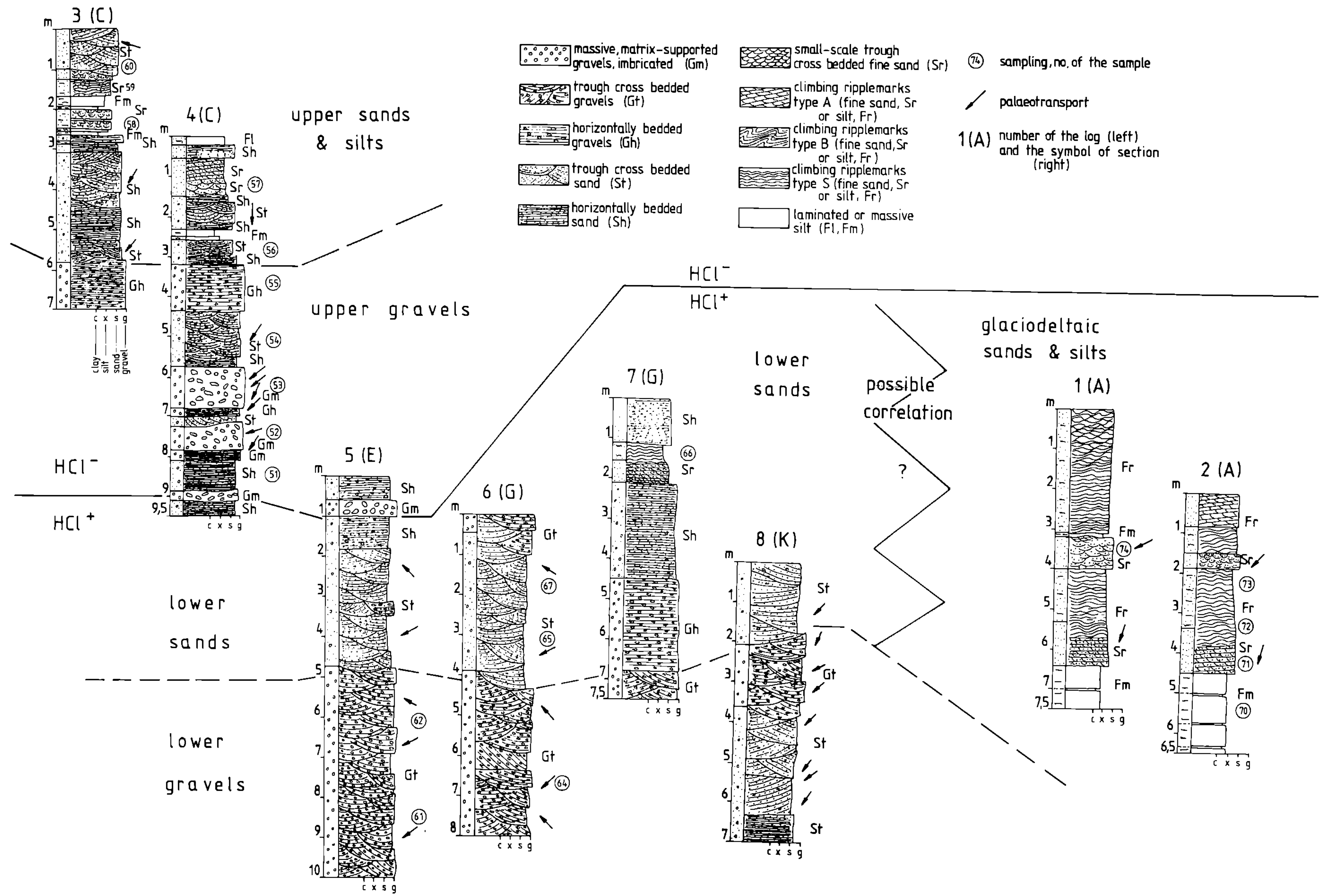


Fig. 7. Sedimentological logs of deposits at Dobrocin 1. Location at fig. 5. Facies code after Miall (1977, 1978)

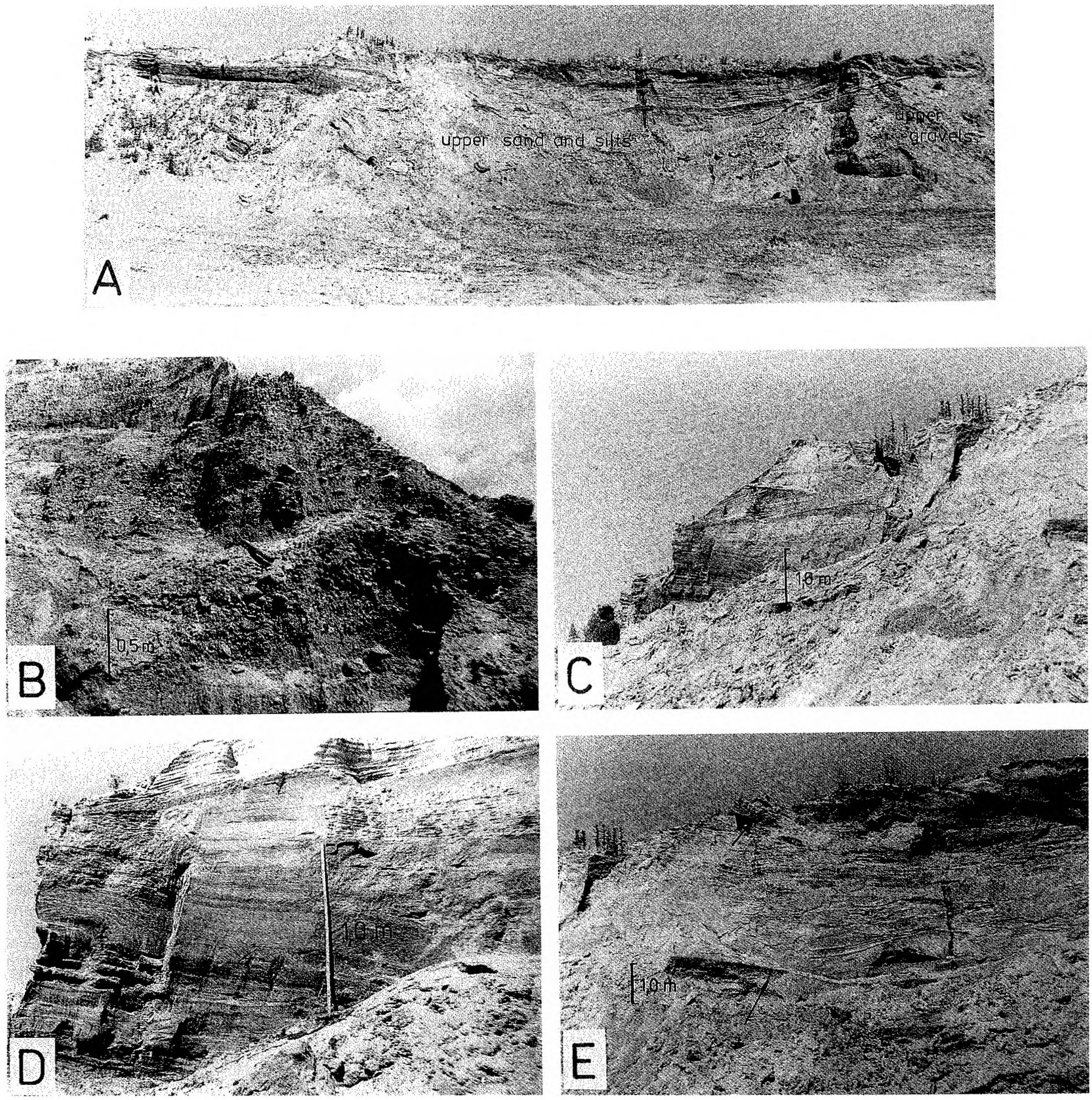


Fig. 8. Sediments of the Upper Member at section Dobrocin 1C. **A.** general overview for the section, the scarp is about 10 m high; west on the left; **B.** imbricated gravels of the Gm facies of the upper gravels; **C.** silt/fine sand suite and cross-bedded sands of the upper sand and silt unit; **D.** detailed view of the silt/fine sand sequence; **E.** the topmost sequence with cross bedded sands interbedded with fine-grained layers (*arrows*)

contain only the Lower Member. Section A contains calcareous silts and fine sands, which cannot be clearly correlated with the other series due to isolated position of section. Section B was completely covered by slumps (Fig. 5). A correlation with the lower sands of the Lower Member is possible (Fig. 7).

The sediments are gently inclined to the S, SW and W at sections C, E and G and to N and E at section A (Fig. 11), being most probably a part of the synclinal form with the axis between sections C and A (Fig. 5). The sequence is crossed by a set of normal faults, which have no preferable orientation and very often forming the conjugate systems (Fig. 11).

Correlation of series from different sections is presented at the cross-section in Fig. 5, which is supplemented by additional data from outcrops 2 and 3. Moreover, a 6 m thick series of fine sands has been reported in the water basin between sections A and K (personal communication from the owner of the quarry).

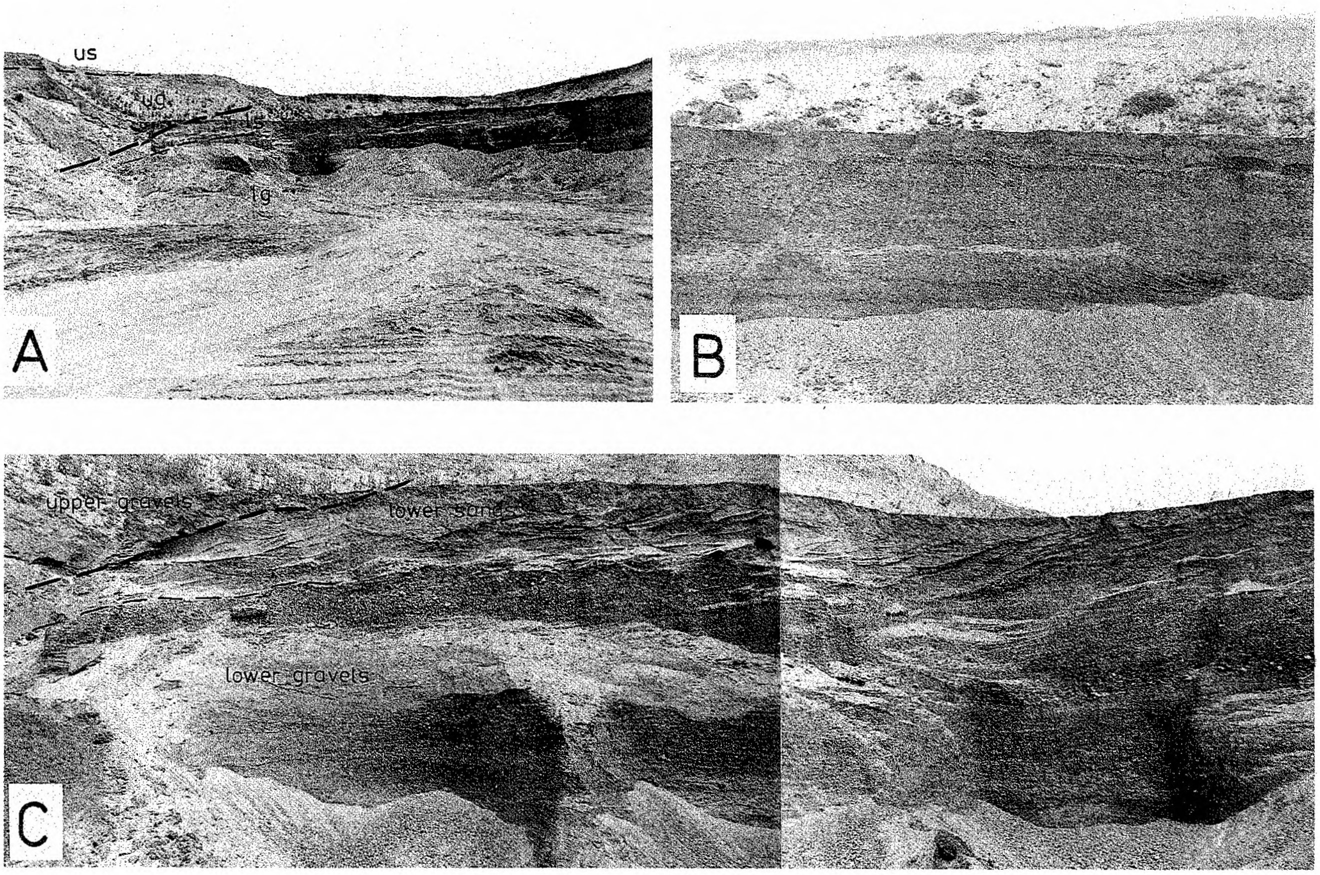


Fig. 9. Sediments of the section Dobrocin 1E. **A.** General overview with boundary between Lower and Upper Members; **B.** Lower gravels with visible cross-bedding and normal faulting; **C.** lower gravels and lower sands, note very distinct cross bedding and gradual transitions between lithological units (the section is 10 m high; northeast on the left)

Sedimentary petrology

The twofold division of sediments at Dobrocin 1 is confirmed by petrological data. The Lower Member contains about 40% of the northern rocks, including 16 - 20% of the Baltic limestones (Fig. 12) and up to 60% of local rocks, mainly milk quartz (18 - 23%), Sowie Góry gneiss (14 - 16%), quartzites (6 - 8%), porphyres (3 - 5%) and serpentinites (1 - 4%). The Upper Member, in turn, has only 20 - 25% of northern component, and only the resistant rocks (mainly the Scandinavian crystalline rocks, Mesozoic sandstone, flint) and no limestones. Local component of the Upper Member is characterized by large increase of milk quartz (19 - 31%) and serpentinites (3 - 10%), as well as abundant Sowie Góry gneiss (11 - 19%), quartzites (5 - 11%) and porphyres (3 - 8%).

Local rocks show different source areas. The Sowie Góry gneiss is outcroped around the Dzierżoniów Basin. This gneiss, together with milk quartz, quartzite and porphyre represent together a typical rock assemblage found in deposits of the River Bystrzyca (Krzyszkowski, 1993). The latter is present at the northwestern boundary of Dzierżoniów Basin (Bojanice and Krzczonów Hills, Fig. 4B). Serpentinites may come from the Kiełczyn Hills (N or NE source) or from small outcrops of serpentinites in the east of the Dzierżoniów Basin (Fig. 4A). An occurrence of two local gravel assemblages in one fluvial series but indicating different source areas, one in the northwest (porphyre, milk quartz, quartzite) and second in the north, northeast or east (serpentinite) may be explained only by former glacial mixing. This is quite satisfactory explanation for the Lower Member, with 40% of northern component suggesting a glaciofluvial origin of deposits, but it is not enough for the Upper Member. Lacking of limestones suggests rather fluvial origin of the series.

Heavy minerals (Fig. 12) also differentiate sediments into two members. The Lower Member is garnet-predominated (27 - 61%), with amphibole (9 - 26%) and epidote (6 - 13%). The other minerals are infrequent, from 2% to 8% . The Upper Member is bipartite. The lowermost part of the Upper Member has almost the same mineral assemblage as the Lower Member, i.e. garnet (40 - 54%) and amphibole (6 - 27%) (Fig. 12). The upper part, which represents a majority of the Upper Member, is amphibole predominated (48 - 88%). Other minerals are in average between 2% to 8%. Summarizing, both members have similar minerals, but they differ clearly from each other in mineral assemblages. The lower one contains in average garnet (47%), amphibole (14%) and epidote (10%), and can be interpreted as the glacially derived one (glaciofluvial). The upper assemblage contains practically more than 50% of amphibole, when the

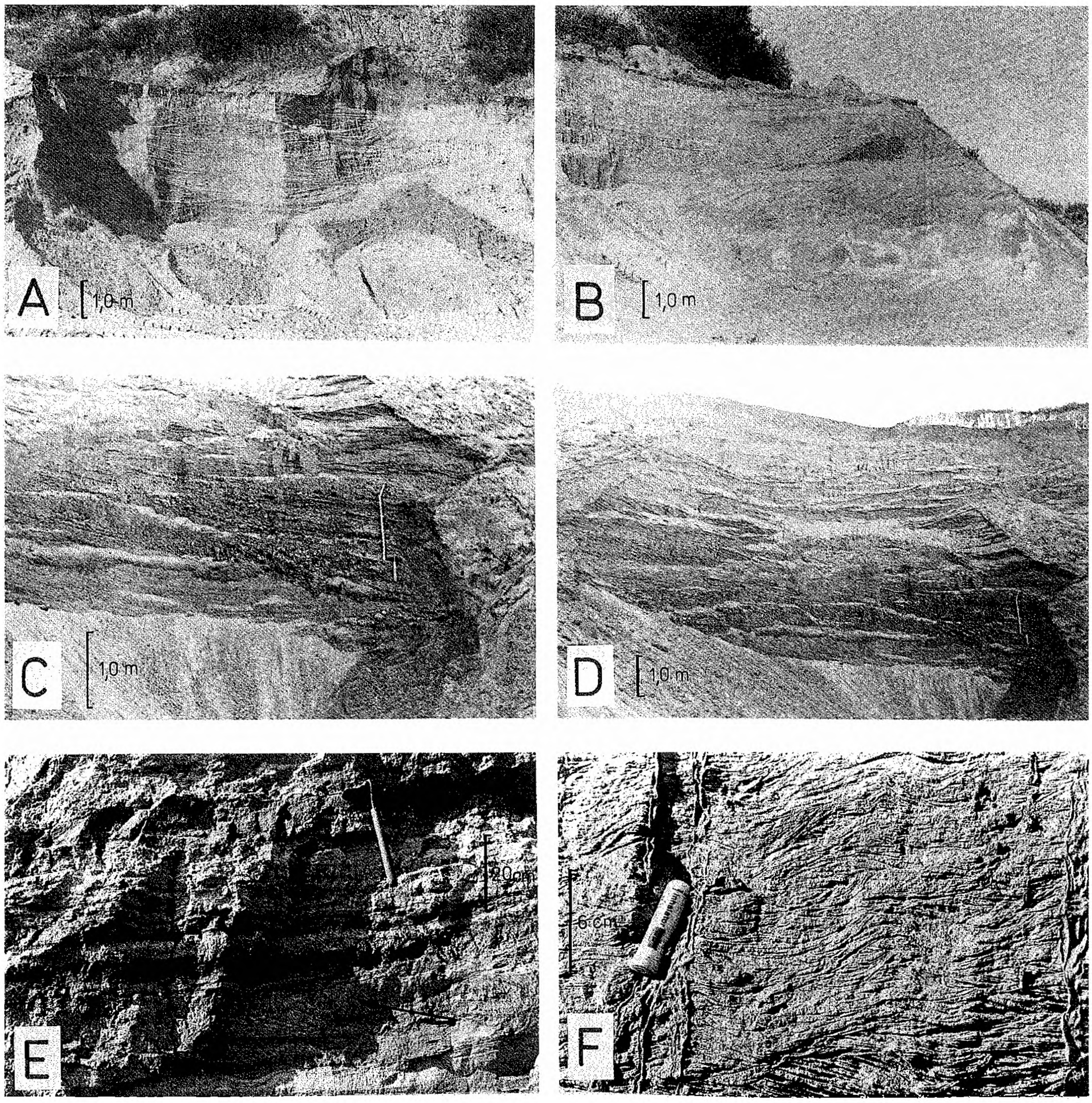


Fig. 10. Sediments at section Dobrocin 1K (**A, B**) and Dobrocin 1G (**C, D**) – note distinct cross-bedding and lithological changes in vertical profiles; **E.** Grodziszcze: varved clays with layers of deformed sands (*arrow*); **F.** Grodziszcze: deltaic fine sands with ripple cross-lamination

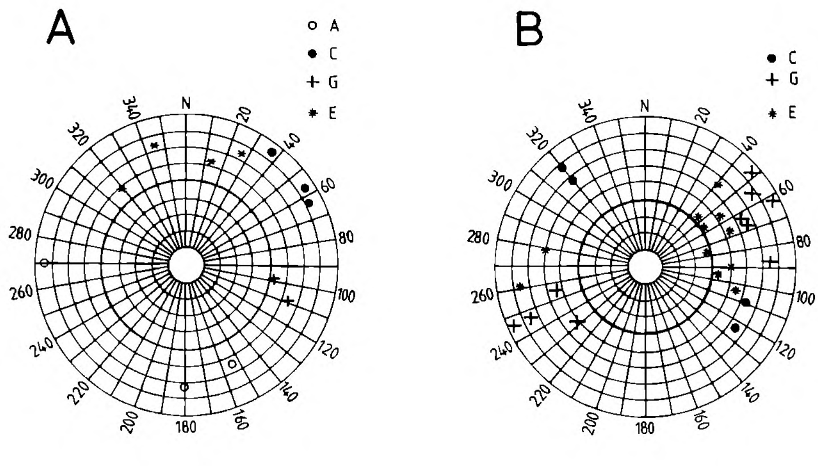


Fig. 11. Dips of strata (**A**) and orientation of faults (**B**) at Dobrocin 1. A, C, G, E – sites with structural measurments, compare with figs 5 and 6. Schmidt stereonet, southern hemisphere

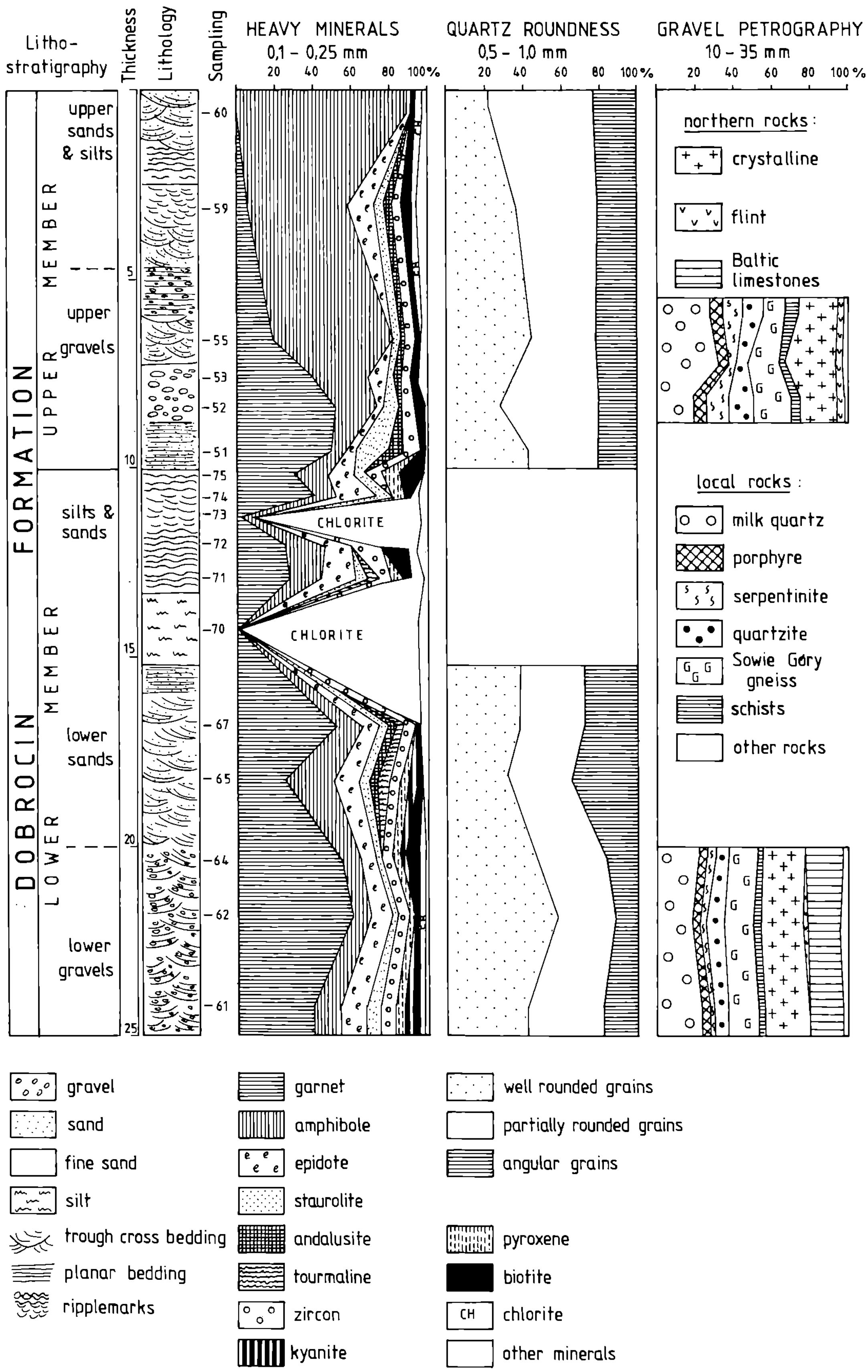


Fig. 12. Lithostratigraphy and petrological properties of deposits at Dobrocin

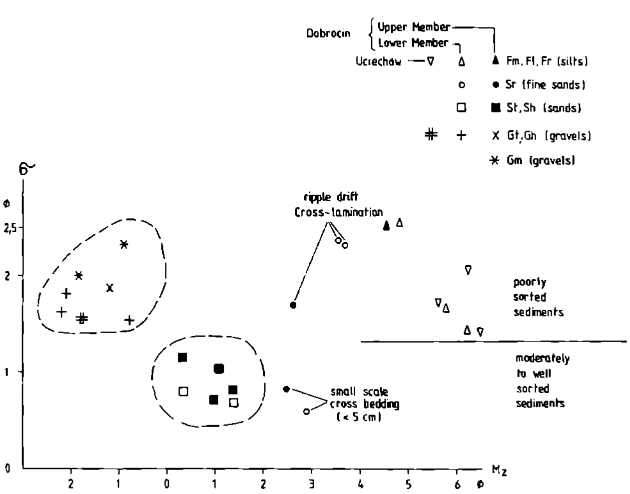


Fig. 13. Grain size characteristics of sediments at Dobrocin 1. Note similarities between deposits from different lithostratigraphic units. Lithofacial code after Miall (1977, 1978)

lowermost part of the sequence is excluded. Amphibole may be interpreted as the very local component, which may come from amphibolite outcrops found frequently in the east of the Dzierżoniów Basin (Fig. 4A).

Silts and fine sands of the section A contain a large quantity of chlorite in the finest sediments (up to 96%), but samples from sands indicate mineral assemblage similar to Lower Member (Fig. 12).

Roundness of quartz grains does not differ much in both series described (Fig. 12), except probably an increase of partially rounded grains at the top of Upper Member, with simultaneous decrease of well rounded grains.

Characteristics and origin of sediments

Lower Member

The Lower Member has been described in detail at three sections: E, G and K (Figs. 6, 7).

The lower gravels are 7 - 10 m thick and form laterally and vertically homogeneous layer, with only trough cross-bedded gravels (sections E and G) (Fig. 6; Fig. 7 -logs 5, 6 and 7) or with trough cross-bedded gravels and pebble sands. Occasionally, horizontal bedding occurs (section K) (Fig. 6; Fig. 7 - log 8, Figs. 9, 10). The trough structures are in average 0.3 - 0.6 m high, with some larger structures up to 1.2 m. The lenghts of structures may reach up to 4 - 5 m. Average size of gravels is between -4 ϕ – -6 ϕ, with minor portion of cobbles -6 ϕ – -7 ϕ in diameter. Matrix consists of granules and coarse sand (medium size varies from -0.5 ϕ to -2.5 ϕ, sorting between 1.5 ϕ to 2.0 ϕ) (Fig. 13). Palaeotransport in all sections is from NE to SW or SE to NW (Figs. 7, 14).

The lower sands are 4-7 m thick and form less uniform bed. Each section (E, G, K) has different sequence (Fig. 6; Fig. 7 - logs 5, 6, 7 and 8). Section E contains trough cross-bedded pebble sands (Fig. 9C) and horizontally bedded pebble sand. Section K contains practically only trough cross-bedded sand and pebble sand, with occasional trough cross-bedded gravels (Fig. 10C, D). The last structures are quite similar to those of lower gravels. Section G contains, in turn, trough cross-bedded sand and pebble sand (Fig. 10A, B) as well as horizontally bedded sand or gravels and fine to medium sand with small-scale cross bedding and climbing ripple structures. The size of troughs (St) is similar to the same structures noted in the lower gravels. Single gravels may reach up to -5.5 ϕ – -6.5 ϕ in diameter. Sediments are much better sorted (sorting between 1.5 – 2.0 ϕ, mean size varies from 0 to 3 ϕ) (Fig. 13). Palaeoflow is from NE to SW or SE to NW (Figs. 7, 14).

The boundary between lower gravels and lower sands is distinct (Fig. 9A, 10D). Palaeoflow and sediment petrological features (Fig. 8) are, however, similar in both units. It seems, that the Lower Member represents stratigraphically uniform, fining upwards unit. The lower gravels represent most probably a gravelly outwash fan ("upper fan") where cross-beeded structures were formed in deep channels. The lower sands represent most probably a braided outwash of the less energetic "middle fan", where cross and horizontally bedded sands represent channels with an average discharge, and gravelly troughs – the channels from floods. The sequences of fine to medium sands with ripple structures may represent abandoned channels (Williams & Rust, 1969; Smith, 1974; Eynon & Walker, 1974; Boothroyd & Ashley,

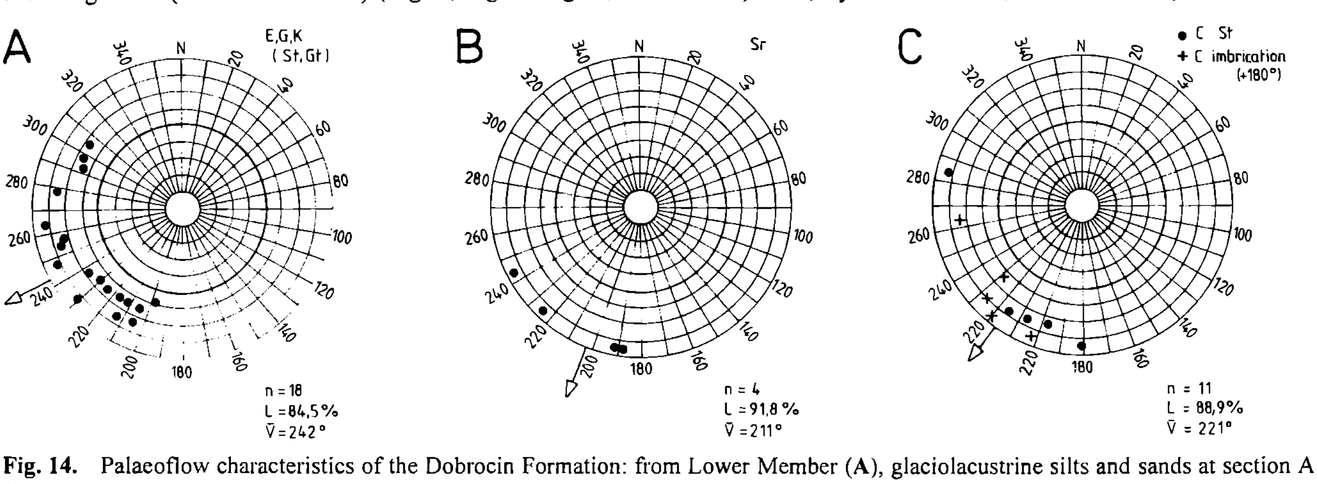


Fig. 14. Palaeoflow characteristics of the Dobrocin Formation: from Lower Member (**A**), glaciolacustrine silts and sands at section A (**B**) and Upper Member (**C**). Schmidt stereonet, southern hemisphere. n – number of measurments, L – vector amplitude, V – mean azimuth

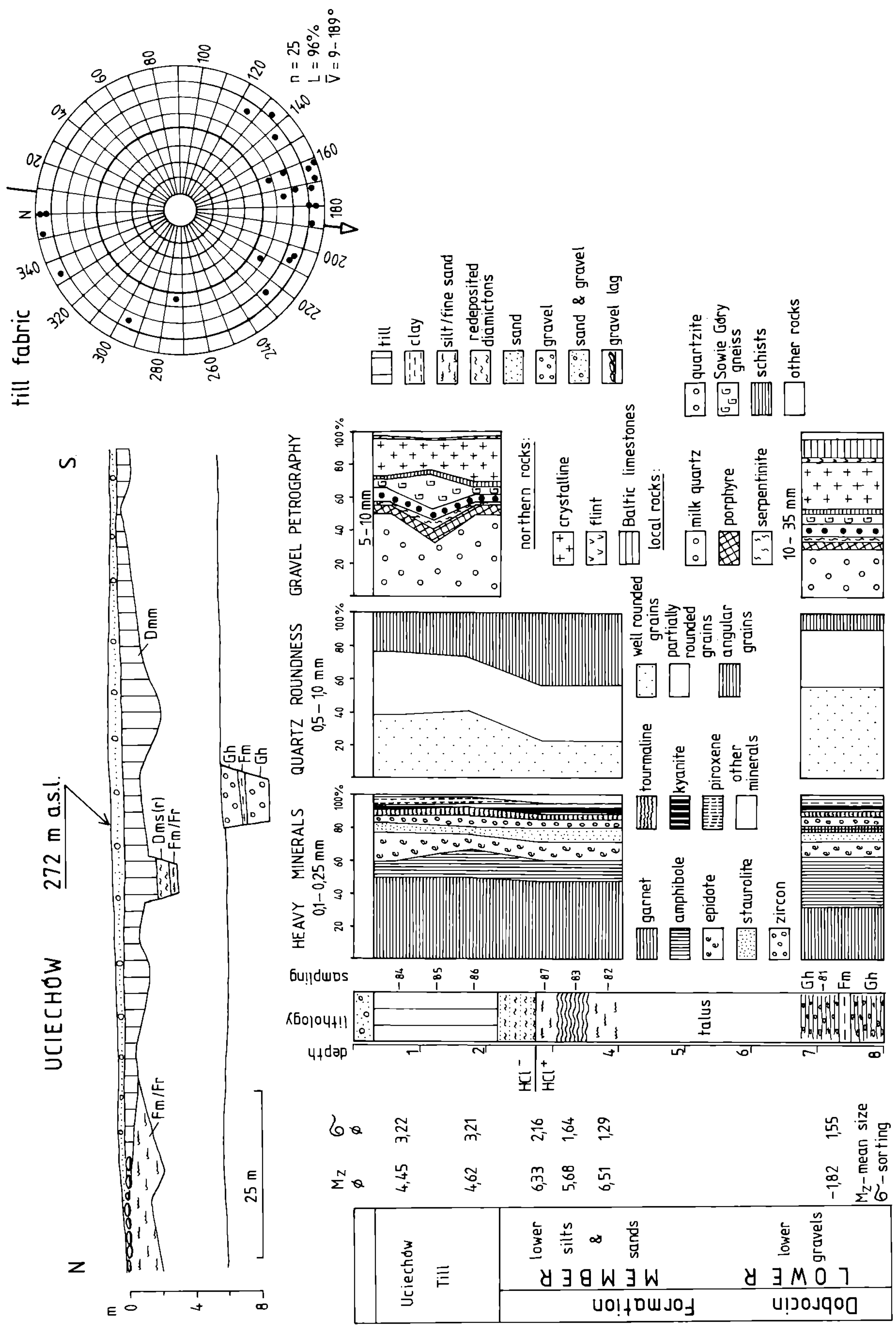


Fig. 15. Lithostratigraphy and petrological properties of deposits at Uciechów

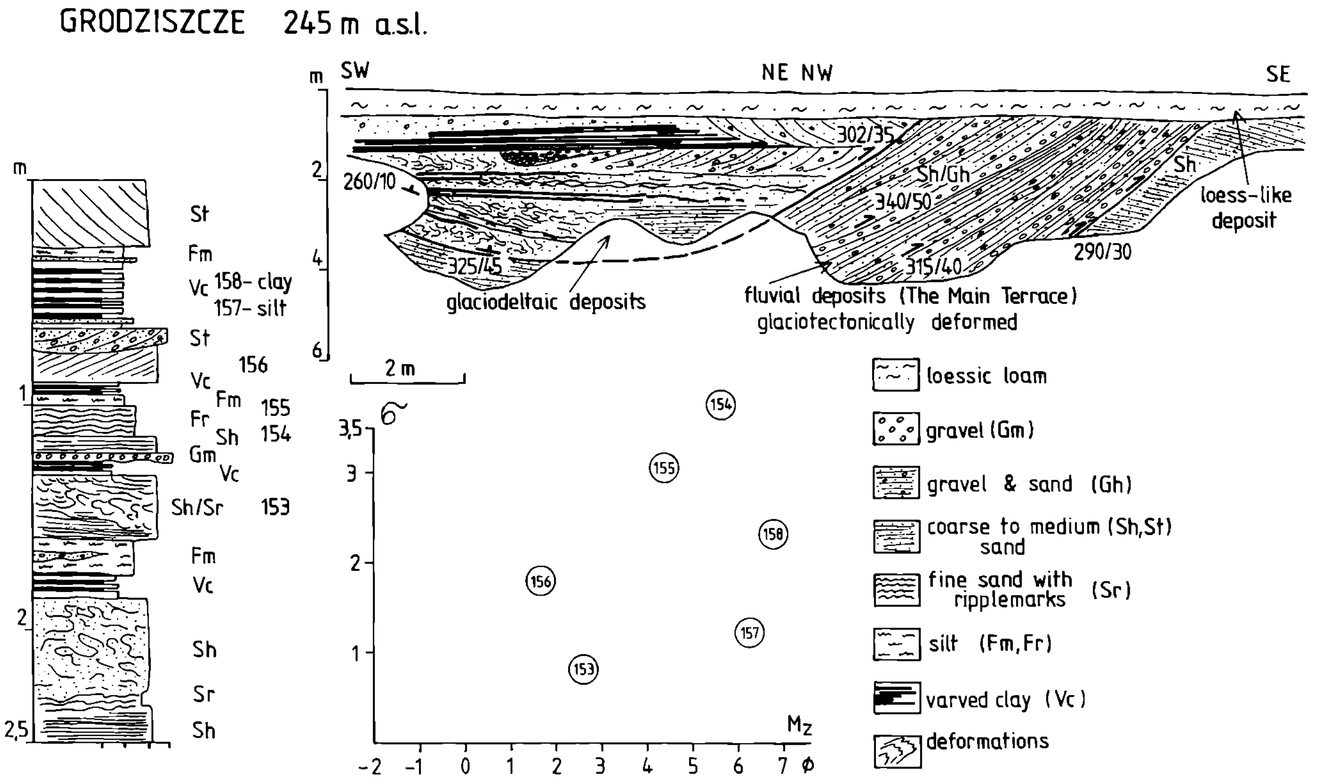


Fig. 16. Characteristics of glaciolacustrine sediments at Grodziszcze: general position at the section (*upper right*), sedimentological log and sampling (*lower left*) and grain size characteristics

1975; Gustavson, 1975; Zieliński, 1993).

Silts and sands at section A

Section A contains ca 7 m thick sedimentary sequence which differs much from other sediments in the quarry (Fig. 6). I is represented by 1 - 1.5 m thick, light-grey, massive silts (mean grain size, Mz 5.9 ϕ , sorting, 1.8 ϕ) with single, 1 - 2 cm thick, dark-brown laminae of the clayey silts at the bottom and up to 6 m thick sandy-silty unit at the top. The last one contains two fining upwards cycles. The lower one is represented by climbing ripple sands of type A at the base (Mz 2.8 ϕ, σ 0.6 ϕ), and very fine sand/sandy silt (cohesive deposit) with climbing ripples of type B and S at the top (Mz 3.6 - 6.3 ϕ, σ 1.4 - 2.4 ϕ). The upper cycle is represented by fine sands with small-scale cross bedding at the base and sandy silts with climbing ripples of type S, B and A at the top (Fig. 7 - logs 1 and 2).

The above described sediments may represent a sequence of the gently inclined delta, where sandy deposits represent distributory channels and cohesive deposits intrachannel areas with deposition from suspension (Cohen, 1979; Leckie & McCann, 1982; Ashley *et al.*, 1985). High content of calcium carbonate and mineralogical features suggest that silts and sands at section A correlate with the Lower Member (Fig. 5). Accepting that, they may represent a glaciodeltaic sequence. Palaeoflow direction is from NE or NNE to SW or SSW (Figs. 7,14).

Upper Member

The Upper Member is up to 10 m thick and it has been described in detail only in section C (Figs. 6, 8).

The upper gravels are composed of: ca 2 m thick horizontally bedded pebble sands or gravels (Gh) with thin layers of massive gravels (Gm) and silts (Fm, Fl) or fine sands with ripple structures (Sr) at the base; and two other sedimentary cycles at the top. These sedimentary cycles contain massive gravels (Gm), trough cross-bedded pebble sand (St) and horizontally bedded pebble sand or fine gravel (Sh, Gh). The lower cycle is ca 1 m and the upper one ca 3 m thick (Fig. 7 - logs 3 and 4).

Gravels of the Gm facies are up to -7 – -8 ϕ in diameter. They are well imbricated (Fig. 8B) and comprise coarse sand/granule matrix. Mean size of deposit is between -0.5 to -2 ϕ , sorting 2 - 2.5 ϕ (Fig. 13). Trough cross-bedded structures are ca 30 - 50 m high and up to 1 m wide. Palaeoflow measured from imbrication and cross-bedding is from NE to SW (Fig. 7 - logs 3 and 4; Fig. 14).

The upper sands and silts are composed of alternating layers of horizontally or trough cross-bedded sands (Mz 0 - 1.5 ϕ, σ 0.6 - 1.2 ϕ) (Fig. 8C, E) and fine-grained deposits (Fig. 8D). The latter contains fine sands with small-scale cross-bedding (Mz 2.5 ϕ, σ 1.8 ϕ) or climbing ripple structures (A and S types) (Mz 2.7 ϕ, σ 1.7 ϕ), laminated fine sand and silt (Fl) and massive silts (Fm) (Mz 4.5 ϕ, σ 2.5 ϕ). Sandy units are usually thicker than fines and reach up to 1 - 2 m, whereas the fine-grained deposits are usually from 10 to 50 cm thick and exceptionally up to 1.5 m in the log 3 (Figs.7, 8A, C and D). Upper boundaries of fine-grained deposits are usually erosional. Sandy troughs are most often between 30 - 80 cm high and 1.0 - 1.5 m wide; at the top of

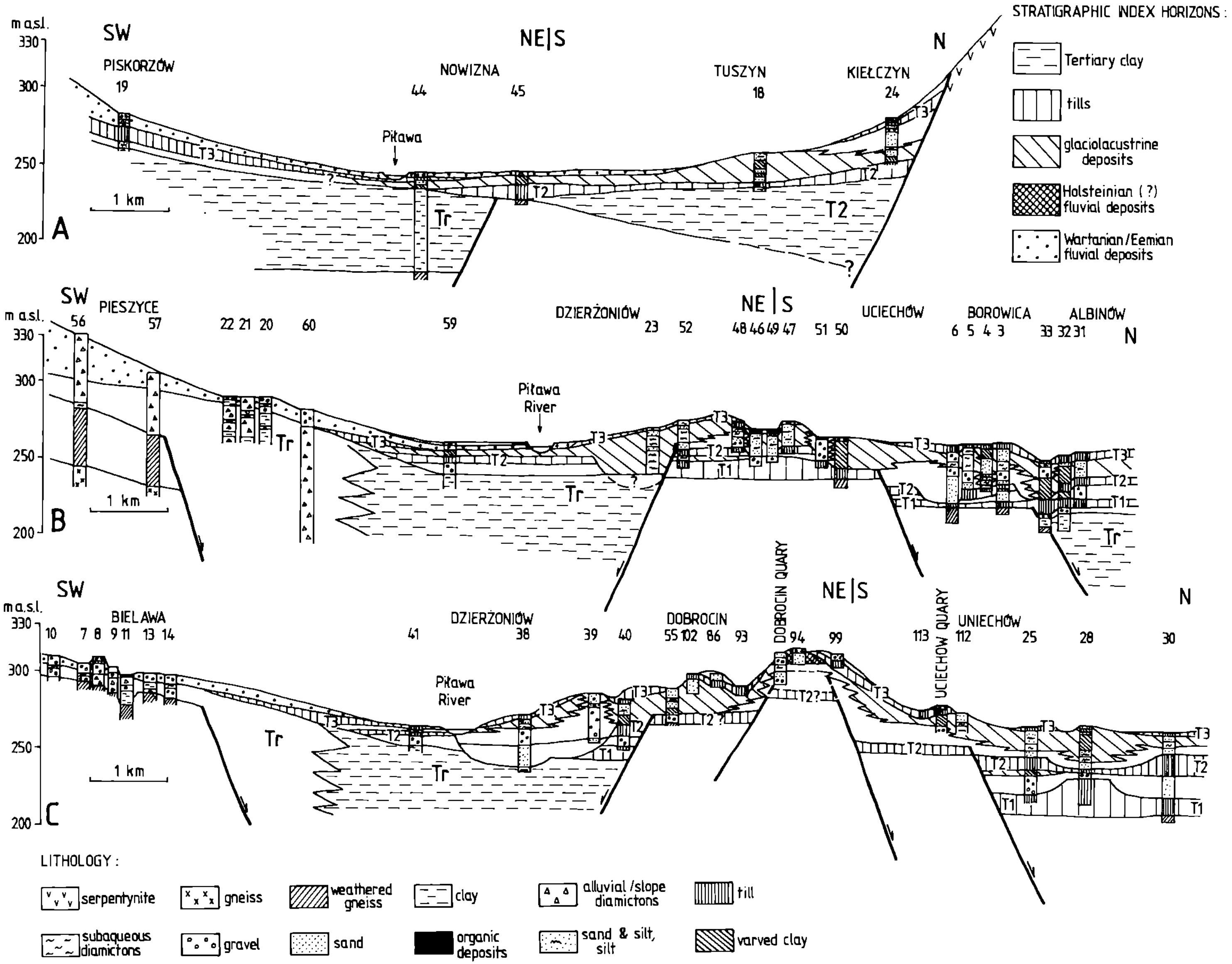


Fig. 17. Geological cross sections throughout the eastern part of the Dzierżoniów Basin (for location see fig. 1). Tr – Tertiary deposits, T1 – older Elsterian till, T2 – younger Elsterian till, T3 – the Uciechów Till (Odranian, lower Saalian)

sequence with some larger structures up to 1 m high. Palaeoflow measured in cross-bedded structures is from NE to SW or E to W (Fig. 7 - logs 3 and 4; Fig. 14).

Deposits of the Upper Member represent one sedimentary environment, most probably a braided river, although with changing palaeodischarge, which is marked by lithology: mainly gravelly at the bottom and sandy at he top. Massive, imbricated gravels represent the longitudinal bars of the gravel-bearing braided river (Williams & Rust, 1969; Smith, 1974, Eynon & Walker, 1974; Miall, 1977). Trough cross-bedded sands and horizontally bedded sands or gravels at the top of massive units may represent channel deposits. The horizontally or trough cross-bedded sandy deposits from the upper part of the sequence represent also channel deposits, but from less energetic conditions. In turn, fine-grained deposits may represent abandoned channels and deposition during low water stages. The facies assemblage from the Upper Member well corresponds with the model of mixed braided river (Saskatchewan River facies model after Miall, 1977, 1978).

UCIECHÓW

The Uciechów quarry is located about 0.5 km east of village Uciechów (Fig. 1). All sections of this quarry, except the eastern one, were covered by slumps during the investigations. The eastern section was also not well preserved (Fig. 15). Deposits have been observed only at the lowest part of section and at its top. At the base, there are horizontally bedded gravels with ca 10 cm thick clay layer. At the top of the section, there are fine sands/sandy silts with climbing ripple structures or massive silts and clays which are quite similar to that of section A of Dobrocin 1 (Fig. 9); alternating thin layers of sands and tills (ca 40 cm) (flow till sequence?); and ca 2 m thick till horizon. The latter is reddish-brown, decalcified and completely weathered. Laterally, the till transits into boulder lag. There is 0.5 - 1.0 m of carbonate-free sand above the till and at the ground surface.

Gravel petrography and heavy minerals suggest (Fig. 15) that sediments at Uciechów may correspond with the Lower Member of Dobrocin, with the lower gravels and glaciodeltaic silts and sands (section A), respectively. An additional unit, the till, lies directly above the glaciolacustrine sequence. Gravel petrography of the till is very similar to gravels below. This suggests similar source of material, for both glaciofluvial deposits and the till.

The till bed of Uciechów has been named the Uciechów Till, athough it cannot be formalized, yet, due to pausity of data.

GRODZISZCZE

The Grodziszcze outcrop is located ca 0.5 km west of village Grodziszcze. It contains ca 5 - 6 m of the glacitectonically deformed sediments (Fig. 16). Stratigraphically lower sediments are represented by fluvial gravels of the Bystrzyca River, which belong to the Main Terrace sequence of possible Holsteinian age (Krzyszkowski, 1993). The 2.5 m thick glaciolacustrine sequence is observed above fluvial gravels. The deformed sediments, described above, are covered discordantly by 0.5 m loessic loam which lies at the ground surface. In the neighbourhood, the till bed was documented at patches on the ground surface (Fig. 4B) and covers both fluvial gravels and glacial deposits. Stratigraphically it should be placed between loessic loam and glaciolacustrine sequence.

The glaciolacustrine sequence is complex. It contains four layers of varved clays, each 10 - 40 cm thick (Fig. 10) which are separated from each other by medium to small-scale cross-bedded sands (Sr, St) (Fig. 10F), horizontally bedded sands (Sh) and fine sands/sandy silts with climbing ripple structures (Fr). Sporadically, there are also gravels (Gm) and massive silts (Fm). A part of sandy sediments are strongly deformed (Fig. 10E). Varved clays are represented only by several silty-clayey couplets; the most thick layer consists of 6 couplets. The black clays are 0.5 - 1.0 cm thick and light grey silts never exceed 5 cm.

The sequence as a whole may represent a glaciodeltaic environment, where varved clays may originated at the lower delta slope in quiet areas between distributary channels. The latter were predominated by sand deposition (Asley, 1975; Ashley *et al.*, 1985; Cohen, 1979, Leckie & McCann, 1982). The glaciolacustrine/glaciodeltaic sediments of Grodziszcze, although not identical with those of Dobrocin 1A and Uciechów, represent a similar environment.

ANALYSIS OF BOREHOLE DATA

The borings concentrate in the NE part of the Dzierżoniów Basin, between Uciechów, Tuszyn and Nowizna, and near Dzierżoniów (Fig. 1). The western part of the basin has inadequate number of borings to present there a cross section. The archival boreholes have been used, and hence only lithological descriptions of cores were available.

The geological cross-sections (Fig. 17) show, that the elevated area between Dzierżoniów, Dobrocin, Uciechów and Włóki represents the horst, the Dobrocin-Włóki horst, with the gneiss bedrock at least 270 - 280 m a.s.l. near Dobrocin quarry and steeply dipping to the north and the west. Some borings, which come down to the bedrock, indicate lack of Neogene deposits at the horst, with the Pleistocene till or sand directly on gneiss. These new data allow to change the interpretation of lateral extent and generally diminish the Neogene deposits in the Dzierżoniów Basin in comparison with older maps (Fig. 4A) (compare with Bossowski *et al.*, 1981; Grocholski *et al.*, 1981).

The northeastern part of the Dzierżoniów Basin contains 30 - 50 m of Pleistocene deposits. These are represented by tills and other diamictons, silts, varved clays, sands and gravels; occasionally also with loess at the ground surface (Fig. 17). The Neogene clays have been described in borings at 210 - 220 m a.s.l., i.e. 30 - 40 m below ground surface. Most often they are superimposed by tills; more rarely by sands and gravels. The latter are also described as glacial deposit. If interpretation of deposits of archival borings is correct, we must reduce much the thickness of Neo-

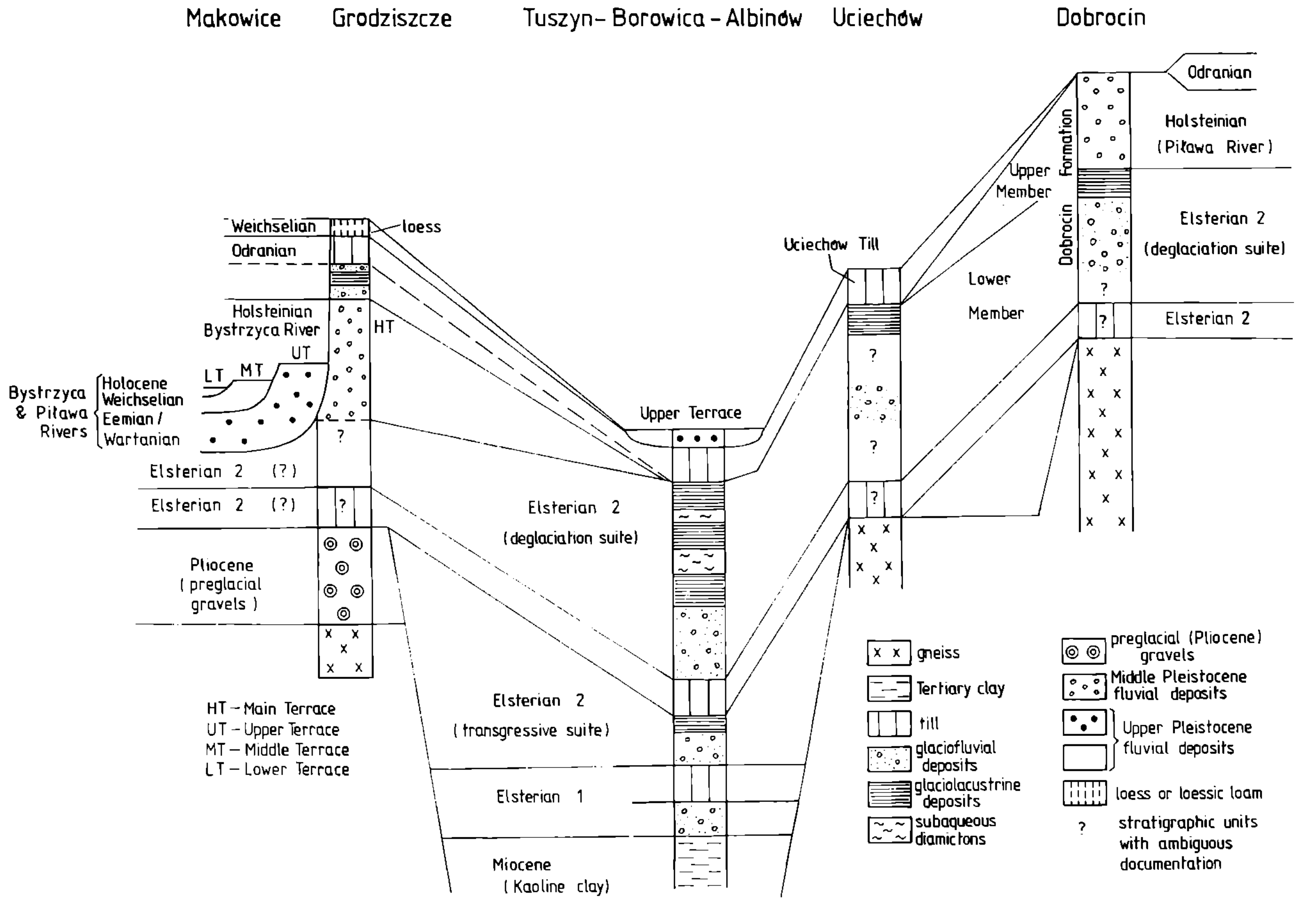


Fig. 18. Stratigraphy of the Pleistocene deposits in the Dzierżoniów Basin

gene series and its vertical extent in the basin. On older maps (Barsch & Finckh, 1924; Dathe & Finckh, 1924; Szałamacha & Walczak-Augustyniak, 1976; Walczak-Augustyniak & Szałamacha, 1978; Grocholski *et al.*, 1981), the Neogene deposits are marked on the ground surface, up to 250 - 270 m a.s.l.. In the light of data from borings, it seems that clays on the ground surface are represented rather by the Pleistocene glaciolacustrine deposits than Neogene series (Figs. 4B, 17). None of borings in the northeast part of the basin has reached the base of Tertiary deposits; thus we suppose that they are about 30-50 m thick (Fig. 17).

The southwestern part of the Dzierżoniów Basin (Roztoka-Mokrzeszów Graben) contains up to 30 m of the Pleistocene deposits, but very often, in the valley of Piława river, they are reduced to 10 - 15 m. The top of Tertiary clays are at 240 - 250 m a.s.l. herein. Total thickness of the Neogene series is from 50 m near Dzierżoniów up to 200 m near Lutomia (Bossowski, 1975).

The Pleistocene sequence of the Dzierżoniów Basin is composed of four series: the lower till and sand/gravel; the middle till and silt/sand/gravel; the upper series of alternating silt, varved clay, sand, diamictons (till) and occasionally gravels, which are all strongly laterally variable; and the uppermost till.

Only in a few borings, sandy-gravelly series occurs below the lower till. In turn, gravels and sands are present quite commonly between the lower and middle tills as well as varved clays and silts (Fig. 17). The lower till is from a few metres to 15 m thick, and lies on gneiss or Tertiary deposits, or occasionally on Pleistocene gravels. The middle till is from 2 to 10 m thick. The upper boundaries of these tills are, most probably, erosional (Fig. 17). Till beds lie usually at 220 - 240 m, except the Dobrocin-Włóki horst area, where these tills were found at least at 250 - 260 m a.s.l.. The upper till is usually thinner, from 1 to 5 m, and occurs usually at ground surface at different altitudes, from 250 to 320 m a.s.l. (Fig. 17). The upper till may be easily correlated with the Uciechów Till from Uciechów quarry and it represents the youngest glacial advance in the region. The series, lying between the middle and upper tills, is very complex. Strong lateral lithological variability, from coarse gravels to varved clays in neighbouring borings as well as the occurrence of many diamicton (till) beds within this fine grained series make some problems with interpretation (Fig. 17). It seems that this series may represent a complex glaciolacustrine sequence, where coarse deposits (sands, gravels) may represent the upper delta, fluvial deposits; sands, silts, clays with diamicton (till) and gravel layers may represent the proximal part of the glacial, ice-contact lake; and fine sands, silts and varved clays may represent distal parts of this lake (Rust & Romanelli, 1975; Ashley *et al.*, 1985). The thickness of the described series is from 5 m to 25 m. The maximum thickness of varved clays or mixed sequences of varved clays and diamictons is 10 - 15 m,

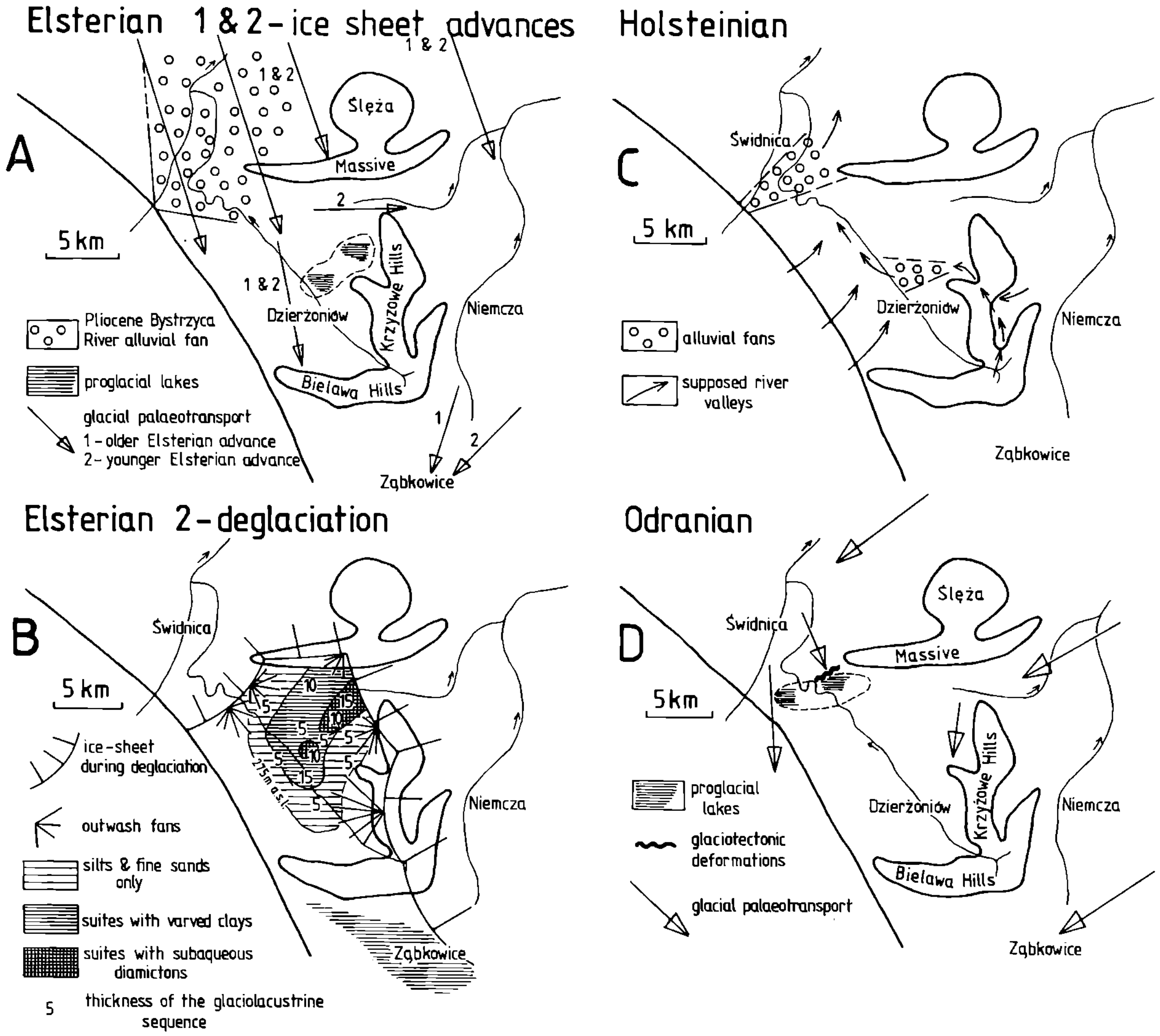


Fig. 19. Palaeogeographic interpretation of four case events (**A-D**) during the Middle Pleistocene in the Dzierżoniów Basin. Detailed discussion in the text

although thickness of the entire glaciolacustrine series is very variable, being 10 - 20 m in the NE part of the basin and near Dzierżoniów and below 10 m (usually 5 m) between these two areas. The zone of reduced thickness of the glaciolacustrine series well corresponds with the gneiss horst Dobrocin-Włóki. In the instance of this horst, lower boundary of the varved clay/silt series lies higher, from 260 to 300 m a.s.l., than in the subsided areas (220 - 250 m a.s.l.) (Figs. 17, 18).

INTERPRETATION

STRATIGRAPHY

The stratigraphic interpretation of the data presented above is quite difficult, especially because the lithostratigraphic sequence from borings is ambiguous. Also, the correlation of lithostratigraphic units from borings and quarries is quite difficult, as they have no good marker layers. The model presented below takes into account the following data (see also Fig. 17, 18):

1. In the Dzierżoniów Basin there are three glacial horizons, including three tills, which presumably represent three ice-sheet advances: two from Elsterian and one from older Saalian glaciations. Although we noticed more till layers in the borings, all the others than these three we interpreted as glaciolacustrine diamictons (subaqueous tills). From regional studies (Badura *et al.*, 1992; Czerwonka & Krzyszkowski, 1992; Krzyszkowski & Czech 1995), we stated that only three glacial horizons are well documented in SW Poland. The occurrence of any more glacial advances is unlikely. This view contradicts with the interpretation of Walczak-Augustyniak (1977).

2. The Lower and Upper Members of Dobrocin quarry have no erosional boundary, and from sedimentological description it seems that these two series were deposited continuously, although the lower one represents a glaciofluvial outwash and/or glaciodeltaic suites, and the upper one fluvial environment (braided river).

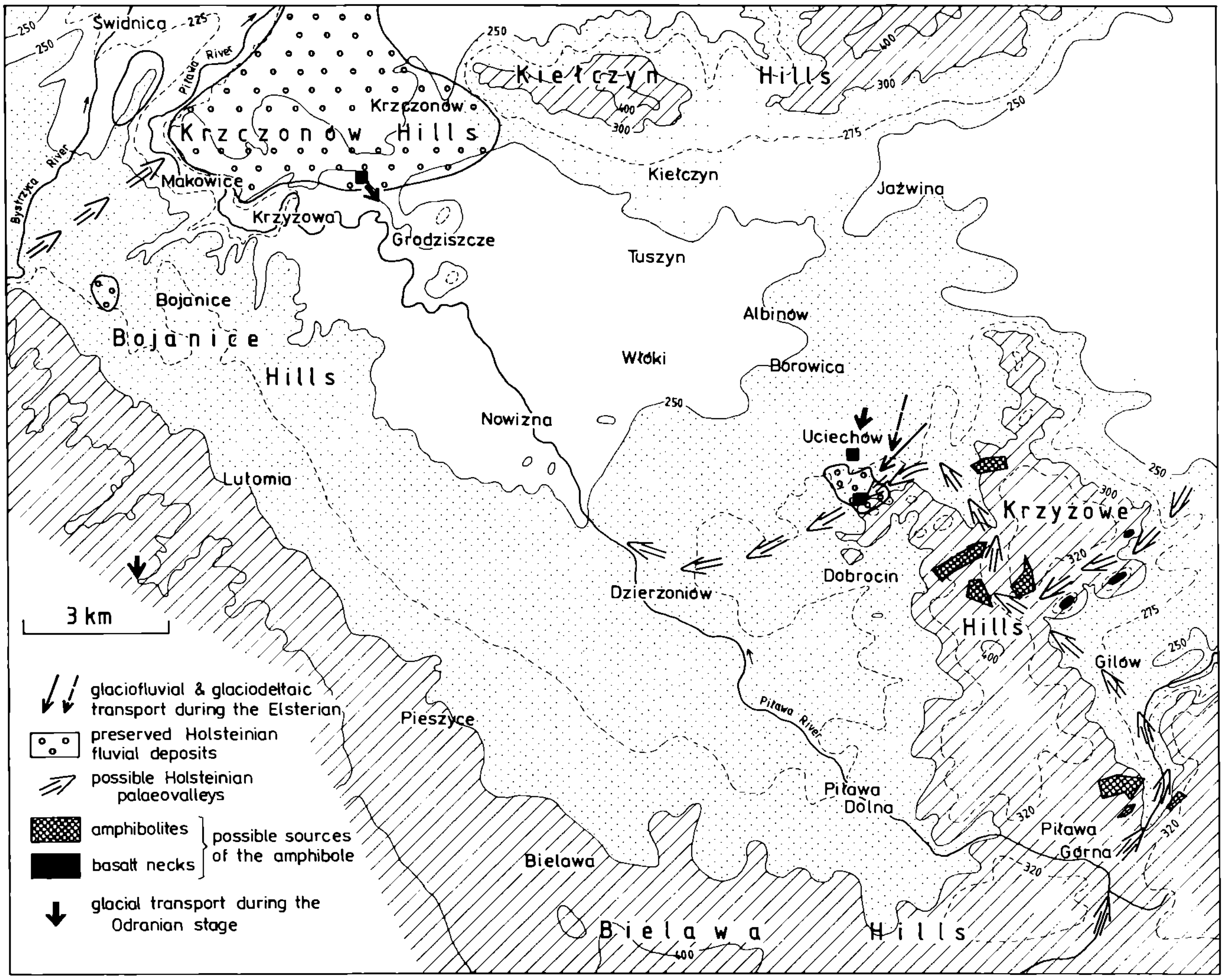


Fig. 20. Palaeoflows documented in fluvial and glacial sediments of Dobrocin, Uciechów and Grodziszcze quarries. Possible Holsteinian river courses are discussed in detail in the text. Altitude: *white* – below 250 m a.s.l., *dotted* – 250-300 m a.s.l., *lined* – above 300 m a.s.l

3. The glaciodeltaic silts of Dobrocin and Uciechów represent the same stratigraphic unit and they correlate, most probably, with the upper (glaciolacustrine) series from the borings. This unit is interpreted to represent a deglaciation series after decay of the Younger Elsterian ice-sheet (middle till). The erosional forms at the top of the middle till may represent tunnel valleys.

4. The deposits from Uciechów and Dobrocin quarries are covered by the youngest, Uciechów Till (Saalian) (Figs. 4B, 17) and are underlain, most probably, by lower and middle tills (Elsterian) or at least by the last one (Fig. 17).

5. The Pleistocene stratigraphy of the western part of the Dzierżoniów Basin was discussed ealier by Krzyszkowski (1993). In the latter zone, the Elsterian glacial deposits are not well documented and the Saalian one lie on fluvial deposits of the Main Terrace of the Bystrzyca River (Holsteinian?).

6. The most controversial interpretation is the status of fluvial deposits at Dobrocin (Upper Member of the Dobrocin Formation). They have never been defined before as fluvial, and were usually interpreted as glaciofluvial deposits (Pernarowski, 1963; Szponar, 1974, 1986). Their position between the Elsterian sequence (till and deglaciation series) and the Saalian till suggests similar age as the Main Terrace of the Bystrzyca River, i.e. Holsteinian. It must be stressed, however, that there was continuous sedimentation of braided rivers since the beginning of ice sheet decay, to the beginning of the Holsteinian at least.

7. All the other interpretations are consequent to these above. The idealized model of the Pleistocene stratigraphy of the Dzierżoniów Basin is presented in Fig. 18.

PALAEOGEOGRAPHY

Glaciofluvial deposits of the Dzierżoniów Basin contain mixed material of the Bystrzyca River alluvium and serpentinites. Only one logical explanation is that the Elsterian ice-sheets advanced from north, crossing both Bystrzyca preglacial (Pliocene) alluvial fans and Kiełczyn Hills with serpentinites (Figs. 4, 19A). This local ice movement well

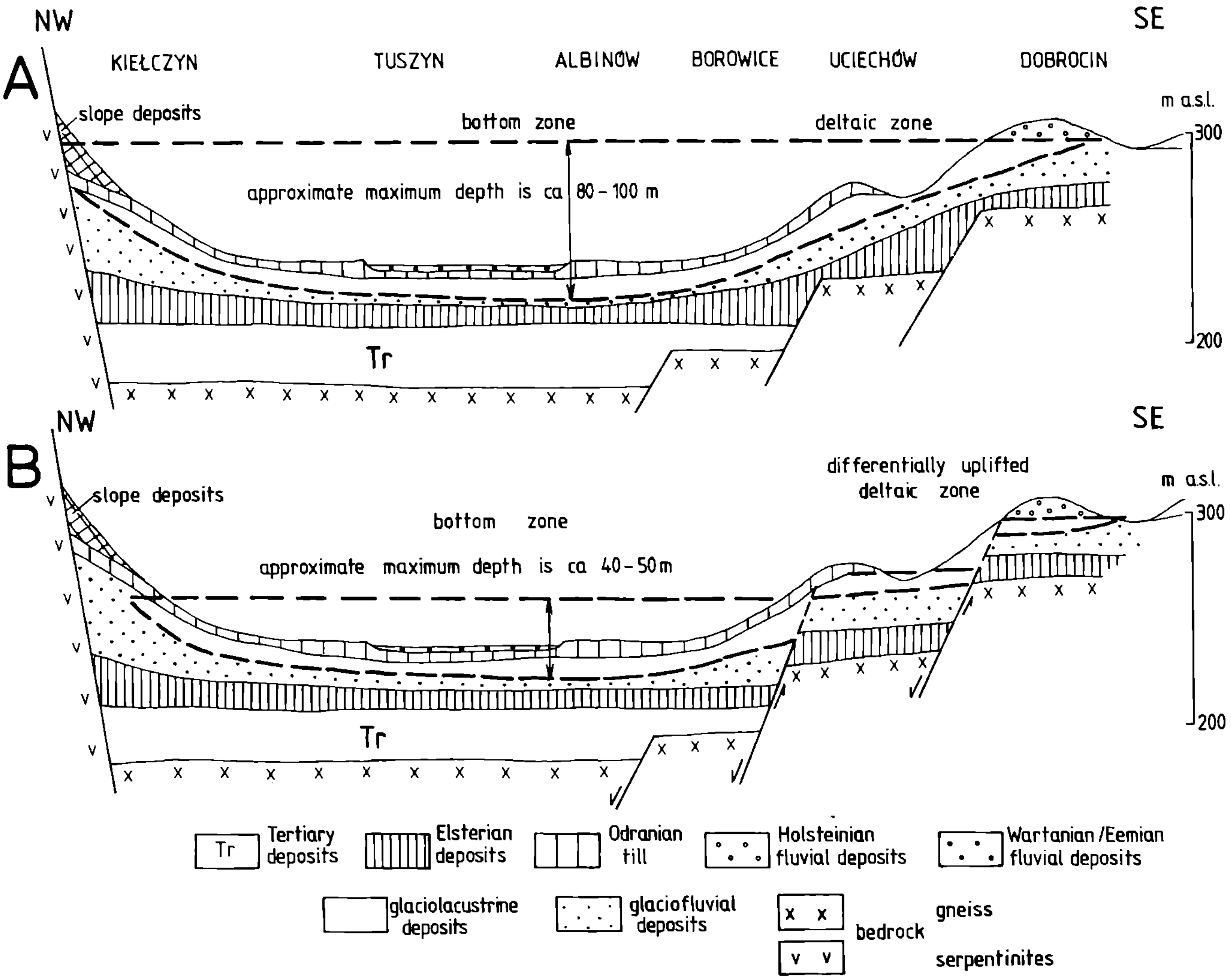


Fig. 21. Two alternative models of glaciolacustrine sedimentation during the deglaciation phase of the younger Elsterian stadial in the Dzierżoniów Basin. **A.** – with stable basement; **B.** – with inferred neotectonic movements (compare with fig. 19, discussion in the text)

fit with the regional one, which for the Elsterian is generally from northwest on the Silesian Lowland (Czerwonka & Krzyszkowski, 1992) and from northwest or north in the northern part of the Sudetic Foreland (Krzyszkowski & Czech, 1995). An occurrence of thin layers of varved clays and silts directly below the middle till (Figs. 17, 18) suggests that short-living proglacial lake may have been formed during the advance of the Younger Elsterian ice-sheet (Fig. 19A).

A partial decay of the Younger Elsterian ice-sheet in the Dzierżoniów Basin created conditions available for a large and relatively long-living proglacial lake (Fig. 19B). This was most probably an ice-contact lake in its NE part, where fine-grained deposits are interbedded with gravels, sands and diamictons. Other marginal zones represented, most probably, gently inclined deltas supported by braided rivers, e.g. deposits from Dobrocin and Uciechów quarries (Fig. 19B).

The subsequent decay of Elsterian ice-sheet and opening of "gates" of the Dzierżoniów Basin in the NW and NE caused drainage of the lake and consequently the fluvial deposition started. In the westernmost part of the basin, an extensive alluvial fan of the Bystrzyca River has been formed (Krzyszkowski, 1993) (Figs. 4B, 19C). In the eastern part, the fluvial deposits were documented in one, isolated position at Dobrocin. Measurments in cross-bedding and imbrication suggest palaeoflow from the NE. The results of heavy mineral analyses suggest palaeoflow from Krzyżowe Hills with amphibolite outcrops (NE to SE). Gravel petrography indicates only the redeposition of older glaciofluvial deposits.

The analysis of topographic and geological maps has indicated possible position of the ancient river valley as presented in Fig. 20. It seems, that this river represented pre-Piława River.

Recently, Piława River has been running SE-NW, from Piława Górna directly to Dzierżoniów. During the Holsteinian, this river had run at first northwards, to Gilów Basin, and than to NW, to Dobrocin and at the end to SW to Dzierżoniów (Figs. 19C, 20). This river course has never exceeded altitude 320 m a.s.l., and is well marked by wide valleys, dried up or with small rivers (Fig. 20), and covered later by the Saalian glacial deposits.

During the older Saalian, the Dzierżoniów Basin was again covered by an ice-sheet. It advanced from two directions: from N (Krzyszkowski & Pijet, 1993a) or NW (glaciotectonic deformations at Grodziszcze) in the western part of the basin, and from NE or N in the eastern part of the basin (Uciechów) (Figs. 15, 19D, 20). Small, short-living proglacial lakes may have been formed between these two ice lobes, with the example of glaciodeltaic sequence at Grodziszcze (Fig. 19D).

Post-glacial (post-Odranian) history of the region starts from general incision and formation of deep valleys. At this time, the new valley of Piława River was formed. Later, new valleys were filled with fluvial deposits of the Upper Terrace (Younger Saalian), which covered extensively central part of the basin (Fig. 4B). The Upper Pleistocene history is characterized by an alternating incision and aggradation in river valleys (Middle and Lower Terraces) and loess-like deposits formation at the uplands.

POSSIBLE TECTONIC MOVEMENTS DURING THE PLEISTOCENE

When interpreting the post-Elsterian proglacial lake we have ignored some data. Lower boundary of the glaciolacustrine series at the Dobrocin-Włóki horst lies at 270 m a.s.l. (Uciechów quarry) and at ca 300 m a.s.l. (Dobrocin quarry), i.e. ca 40 - 70 m higher than lower boundary of glaciolacustrine deposits in borings at Borowica, Albinów and Tuszyn. Moreover, glaciolacustrine deposits are very thin in the horst zone (Figs. 17, 19B). There are two possible interpretations. The first one suspects an inactive horst covered with at least 80 m deep water, with the deltaic, shallow water deposition in the most elevated zone near Dobrocin and Uciechów (Fig. 21A). The second interpretation suspects the tectonic uplift of the Dobrocin-Włóki horst after the Elsterian.

In this case, glaciolacustrine sediments were deposited originally in much lower position, and then uplifted into different heights (Fig. 21B). This model explains additionally why Holsteinian gravels are preserved only at Dobrocin – they have reached watershead position after uplift, whereas in other, lower parts of the basin they were moved out by younger rivers during Upper Pleistocene erosion phases. Deposits at Dobrocin quarry are deformed into wide-radius folds which are associated with normal, conjugate faults (Fig. 11). Both these features are characteristic for large-scale gravity tectonics, rather than for glaciotectonics or dead-ice melting deformations. It seems, that the uplift of the Dobrocin-Włóki horst as well as all mountain ridges around the Dzierżoniów Basin may be connected with the glacio-isostatic rebound. This might have happened after the Elsterian or after the last glaciation (older Saalian). The older Saalian age of tectonic uplift in central Sudeten was documented by Krzyszkowski & Pijet (1993b) and Pijet & Krzyszkowski (1994). Hence, deep incision and formation of new river valleys after decay of the older Saalian ice-sheet might have been induced due to tectonic movements, too.

DISCUSSION

Two opposite models have been concluded for deposits of the Dzierżoniów Basin by former authors. Pernarowski (1963) interpreted all sandy and gravelly deposits as glaciofluvial series, infilling the basin during cold stages. The hilly landscape, in his opinion, is erosional and post-glacial. Szponar (1974, 1986) interpreted the deposits also as glaciofluvial, but hilly landscape was interpreted as kames or kame plateau, consequently being deposited during the deglaciation. Both interpretations are unsatisfactory, mainly because the fluvial (local) series have been interpreted as glaciofluvial series. The erosional origin of hills by Pernarowski (1963) is acceptable, but we suggest also the Pleistocene tectonic uplift for the highest hills near Dobrocin (Dobrocin-Włóki horst). In older works, sandy-gravelly deposits were always connected with the older Saalian glaciation. We have interpreted them as the Elsterian deposits, and also a part of them as the Holsteinian fluvial series.

Borings of the Dzierżoniów Basin were interpreted formerly by Walczak-Augustyniak (1977). She found four glacial horizons, including one pre-Elsterian, and the Holsteinian lacustrine deposits. We disagree with this interpretation. The occurrence of pre-Elsterian till is unlikely, taking into account a regional context (Badura *et al.*, 1992; Czerwonka & Krzyszkowski, 1992; Krzyszkowski & Czech, 1995). Pollen diagram (Szczypek, 1977) from "lacustrine" deposits shows clearly mixed pollen, both Tertiary and Quaternary, and must represent redeposited material. The mixed pollen assemblages are quite common in proglacial lakes, which was also documented in the Sudeten and Sudetic Foreland (Jaworska 1971, 1973).

CONCLUSIONS

1. The Dzierżoniów Basin contains deposits of three glacial stages: older Elsterian, younger Elsterian and older Saalian (Odranian). The first and the last one are represented by tills and thin, discontinuous proglacial (transgressive) deposits. The younger Elsterian deposits contains both transgressive glaciofluvial/glaciolacustrine deposits and a till as well as deglaciation suite. The last one is represented by and extensive glaciolacustrine suite, formed in the ice-contact lake, and series of glaciofluvial deposits.

2. Glacial palaeotransport was from northwest during both Elsterian stadials. During Odranian, two ice lobes have been documented, one flowing from the north and the second one from northeast.

3. Holsteinian fluvial series occur directly on younger Elsterian deglaciation suites. They represent gravelly or sandy-gravelly sequences deposited by braided rivers. Possible Holsteinian fluvial deposits have been documented for the first time in the Dobrocin quarry. Holsteinian age is inferred from the geological position. No pollen data are available.

4. Elsterian and Holsteinian deposits have been tectonically uplifted on the Dobrocin-Włóki gneissic horst and slighty deformed. The uplift is ca 30 - 40 m. Age of uplift

may be post-Elsterian or post-Odranian. The last one is preffered.

5. Younger Saalian (Wartanian) and Upper Pleistocene sequences are represented mainly by fluvial deposits (in valleys) and loess or slope deposits (on uplands). Deep valleys were formed during the Odranian/Wartanian interstadial, possibly because of increased uplift and regional tectonic movements.

Acknowledgements

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Streszczenie

Środkowoplejstoceńska sedymentacja i ewolucja paleogeograficzna Kotliny Dzierżoniowskiej na Przedgórzu Sudeckim, południowo-zachodnia Polska

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Artykuł przedstawia badania sedymentologiczne i strukturalne z trzech odkrywek: Dobrocin (Fig. 5-10), Uciechów (Fig. 15) i Grodziszcze (Fig. 16), położonych w Kotlinie Dzierżoniowskiej na Przedgórzu Sudeckim (Fig. 1, 2) oraz przedstawia analizę wierceń archiwalnych z tego obszaru (Fig. 17). Rzeźba Kotliny Dzierżoniowskiej jest uwarunkowana tektonicznie, i praktycznie wszystkie jej granice przebiegają wzdłuż linii tektonicznych. Centrum kotliny to płaska równina utworzona z osadów aluwialnych, a jej NW i E obrzeża tworzą obszar pagórkowaty, zbudowany głównie z osadów glacjalnych (Fig. 3, 4). Kotlina Dierżoniowska zawiera osady trzech zlodowaceń: starszego stadiału zlodowacenia Elsterian, młodszego stadiału tego zlodowacenia i starszego stadiału zlodowacenia Saalian (Odranian) (Fig. 17, 18). Najstarsze i najmłodsze osady glacjalne reprezentowane są przez gliny i cienkie, nieciągłe pokrywy transgresywnych osadów glacifluwialnych. Osady młodszego stadiału zlodowacenia Elsterian zawierają osady zarówno z transgresji, w tym gliny, jak i z recesji lądolodu. Osady recesyjne reprezentowane są głównie przez osady zastoiskowe, formowane w proglacjalnym zbiorniku typu ice-contact (Fig. 19B). Transport glacjalny w czasie obu stadiałów zlodowacenia Elsterian był z północnego-zachodu (Fig. 19A). Osady glacifluwialne z fazy recesji zlodowcenia Elsterian w odkrywce Dobrocin były deponowane z północnego-wschodu (Fig. 14, 20). W czasie zlodowacenia Odranian Kotlina Dzierżoniowska była pod wpływem dwóch lobów lodowcowych, jednego transgredującego z północnego-wschodu a drugiego z północy (Fig. 19D). Osady recesyjne zlodowacenia Elsterian i osady zlodowacenia Odranian zostały scharakteryzowane na podstawie badań w odkrywkach (Fig. 12-16); pozostałe osady występowały tylko w wierceniach (Fig. 17). W odkrywce Dobrocin, w stropie profilu, znaleziono osady rzeczne o miąższości około 10 m, które posiadają bardzo specyficzne cechy petrologiczne (Fig. 12). Przede wszystkim nie zawierają one skał węglanowych i są całkowicie odwapnione. Zawierają głównie skały lokalne, w tym serpentynity, oraz niewielką domieszkę odpornych skał północnych. W składzie minerałów ciężkich dominuje amfibol, który pochodzi najprawdopodobniej z wychodni amfibolitów bezpośrednio na wschód od odkrywki (Fig. 20). Kierunek ten jest także zgodny z kierunkiem paleotransportu określonym dla rynnowych warstwowań przekątnych (Fig. 14). Omawiane osady zinterpretowano jako serię z początków interglacjału mazowieckiego (Holsteinian). Leży ona bezpośrednio ponad osadami recesyjnymi zlodowacenia Elsterian i jest reprezentowana przez żwiry i piaski ze żwirami deponowane w warunkach rzeki roztokowej. Na podstawie analizy map topograficznych i geologicznych stwierdzono przypuszczalny przebieg doliny kopalnej z tego okresu (Fig. 19C, 20). Wiek omawianych osadów został określony tylko na podstawie pozycji geologicznej; brak jest danych paleobotanicznych na potwierdzenie tej hipotezy. Osady zlodowacenia Elsterian i interglacjalne osady rzeczne ulegały ruchom tektonicznym. Jest to także udokumentowane w seriach osadowych, gdzie obserwuje się wielkoskalowe deformacje osadów i liczne uskoki grawitacyjne (Fig. 5, 6, 11). Amplituda ruchów tektonicznych dochodzi do 30 - 40 m (Fig. 21). Wiek ruchów tektonicznych został określony w przybliżeniu na okres po ostatniej transgresji lądolodu (post-Odranian). Osady stadiału Warty i górnego plejstocenu reprezentowane są w Kotlinie Dzierżoniowskiej przez serie rzeczne (doliny) oraz lessy i osady stokowe (wysoczyzny). Głębokie rozcięcia dolinne powstały prawdopodobnie po ostatniej transgresji lądolodu (interstadiał Odranian/Wartanian), częściowo jako odpowiedź na wzmożone, glacio-izostatyczne ruchy podnoszące lub bardziej regionalne ruchy tektoniczne.