Annales Societatis Geologorum Poloniae (1987), vol. 57: 189-201
PL ISSN 0208-9068

LATE CRETACEOUS SUBMARINE SLUMP IN THE INOCERAMIAN BEDS OF MAGURA NAPPE AT SZCZAWA (POLISH WEST CARPATHIANS)

Marek Cieszkowski, Nestor Oszczypko & Witold Zuchiewicz

Institute of Geological Sciences, Jagiellonian University, 2A Oleandry Str., 30-063 Kraków, Poland

Cieszkowski, M., Oszczypko, N. & Zuchiewicz, W., 1987. Late Cretaceous submarine slump in the Inoceramian Beds of Magura nappe at Szczawa, Polish West Carpathians. *Ann. Soc. Geol. Polon.*, 57: 189–201.

Abstract: A huge submarine slump, 35 m thick, occurs in the Upper Cretaceous (Senonian) Inoceramian Beds in the Szczawa village, Polish West Carpathians. The slump body consists of four scales and of overturned folds, imbricated and pinching out. Source area of the slumped material was situated on the southern slope of the Magura basin. This and other slumps in the lower part of the Inoceramian Beds of the Nowy Sącz facies unit are probably related to synsedimentary tectonic movements.

Key words: submarine slumping, Laramian movements, Magura nappe, Polish West Carpathians.

Manuscript received September 1986, revision accepted December 1986.

INTRODUCTION

Numerous small submarine slumps, usually affecting one or two beds (*cf.* Książkiewicz, 1958; Dżułyński, 1963) occur in the Polish Carpathians. Some of these slumps are associated with dense cohesive gravity flows (*sensu* Middleton & Hampton, 1976). Poor quality of exposures in the flysch zone of the Carpathians does not allow for recognition of large-scale slump bodies. According to Książkiewicz (1958), large slumps do not occur frequently and are limited to the Upper Godula Beds, Upper Cieszyn Shales, Inoceramian Beds and Lower Istebna Beds, the thickness of slump sequences not exceeding 40 to 55 m.

A large submarine slump has been examined by the authors within the lower complex of the Inoceramian Beds of the Magura nappe in the Szczawa village, Outer West Carpathians.

GEOLOGICAL SETTING

The slump in question (Figs. 1, 2) is situated in the lower part of the Inoceramian Beds, in the southern, Nowy Sącz (Bystrica), facies zone of the Magura nappe (*cf.* Oszczypko, 1973; Mahel, 1974).

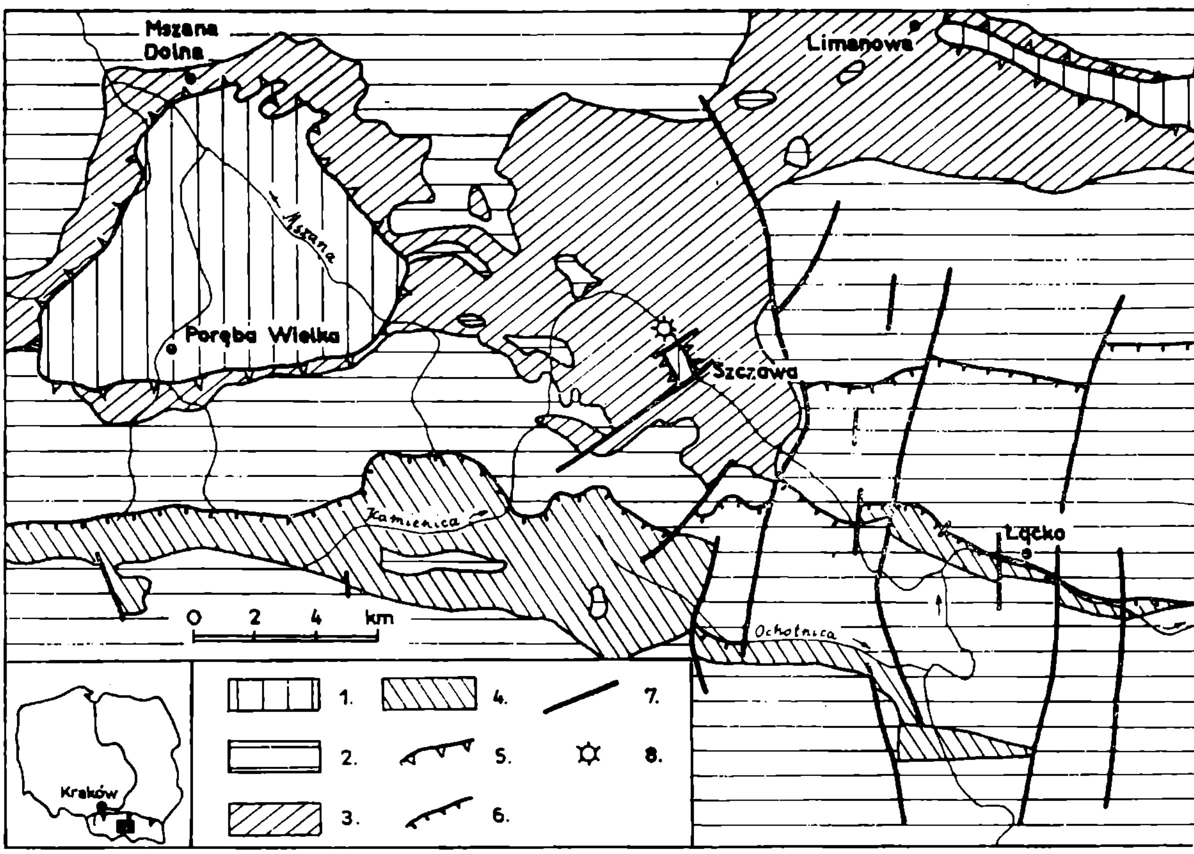

Fig. 1. Geological setting of Magura nappe near Szczawa. *1* — series occurring within tectonic windows; *2—4* — Magura nappe; *2* — Palaeogene, *3* — Inoceramian Beds (Senonian—Paleocene); *4* — Szczawnica Formation (Paleocene—Lower Eocene); *5* — main thrusts; *6* — subordinate thrusts; 7 — faults; *8* — location of slump

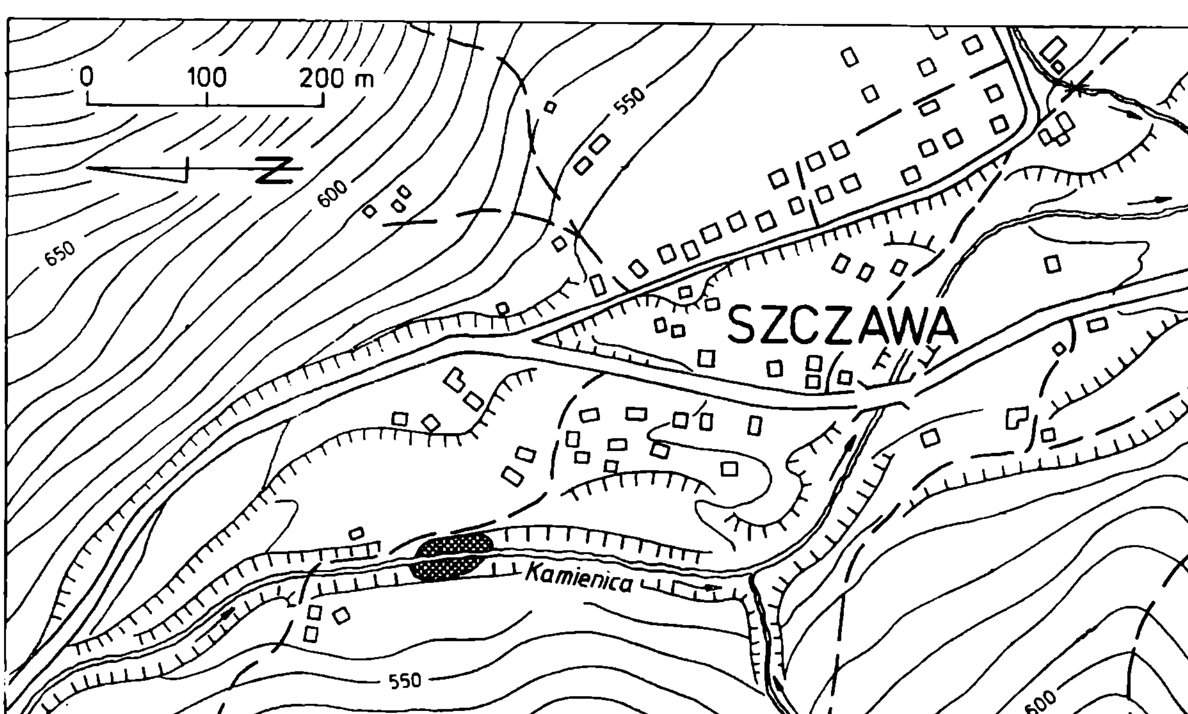

Fig. 2. Sketch showing location of slump exposure (hatched)

The Inoceramian Beds (Upper Senonian—Palaeocene) cover vast areas in the Magura nappe. Locally, they are underlain by variegated shales (Turonian—Lower Senonian). The topmost part of these beds, in turn, is covered by Palaeocene—Lower Eocene variegated shales. The tectonically reduced thickness of the Inoceramian Beds ranges between 300 and 400 m.

The most complete section of the Inoceramian Beds can be studied near the southern margin of the Mszana Dolna tectonic window (Burtan *et al.*, 1978; Burtan & Łydka, 1978), as well as near the margins of the tectonic window of Szczawa (Chrząstowski, 1971).

The section (Fig. 3A) begins with a series of thick bedded, biotite-feldspatic sandstones, at least 50 m thick. These sandstones pass upwards into thin- to medium-bedded turbidites, 100 m thick, composed of fine- to very fine-grained sandstones, intercalated by dark-grey mudstones and shales, as well as by infrequent thin layers of pelitic limestones. These deposits are overlain by a 250 m thick series composed of medium- to thin-bedded, fine-grained sandstones, showing T_{c-e}, more rarely T_{b-e} Bouma sequences. These alternate with thin layers of grey and green shales and with light-beige marls. The series comprises numerous layers of pelitic limestones (*cf.* Cieszkowski *et al.*, 1986) and isolated, thick-bedded and graded sandstone -beds. A Maastrichtian ammonite *Saghalinites wrighti* Birkenlund has been found at the base of this series (Haczewski & Szymakowska, 1984).

This part of the section is overlain by a series, 200 m thick, composed of thick-bedded (0.5—4 m), medium- to very fine-grained grey sandstones, displaying T_{ab}, rarely T_{abc} Bouma sequences. Top parts of sandstone layers contain mud clasts. The series is overtopped by a thin layer of red shale.

The youngest series, 300 m thick, comprises thin-bedded turbidites, including several thin intercalations of red shales. There occur fine- to very fine-grained sandstones, showing T_c conv., rarely T_{bc} Bouma sequences. Shales are grey and greenish, noncalcareous, and are several to several tens of centimetres thick. A complex of thick-bedded sandstones, 50 m thick, occurs in the middle part of this series. The series comprises also several slump beds, 1 to 1.5 m in thickness. Directions of palaeotransport are shown in Fig. 3.

SUBMARINE SLUMP AT SZCZAWA: LITHOLOGY AND INTERNAL STRUCTURE

The lowermost part of the Inoceramian Beds exposed at Szczawa contains a sequence, 35 m thick, of strongly deformed deposits, closely resembling a submarine slump (Figs. 3B, 4). The lower contact of this slump body with underlying thick-bedded sandstones is very sharp (tectonic?) while the upper contact with thin-bedded flysch deposits is a sedimentary one.

Four units (A—D, *cf.* Figs. 3B, 4) showing different degree of deformation, could be distinguished. Two of them (A, C) reveal imbricated structure while the intervening ones (B, D) display folding and subordinate imbrication. All these units are composed of thin- to medium-bedded, fine to very fine-grained, grey sandstones showing

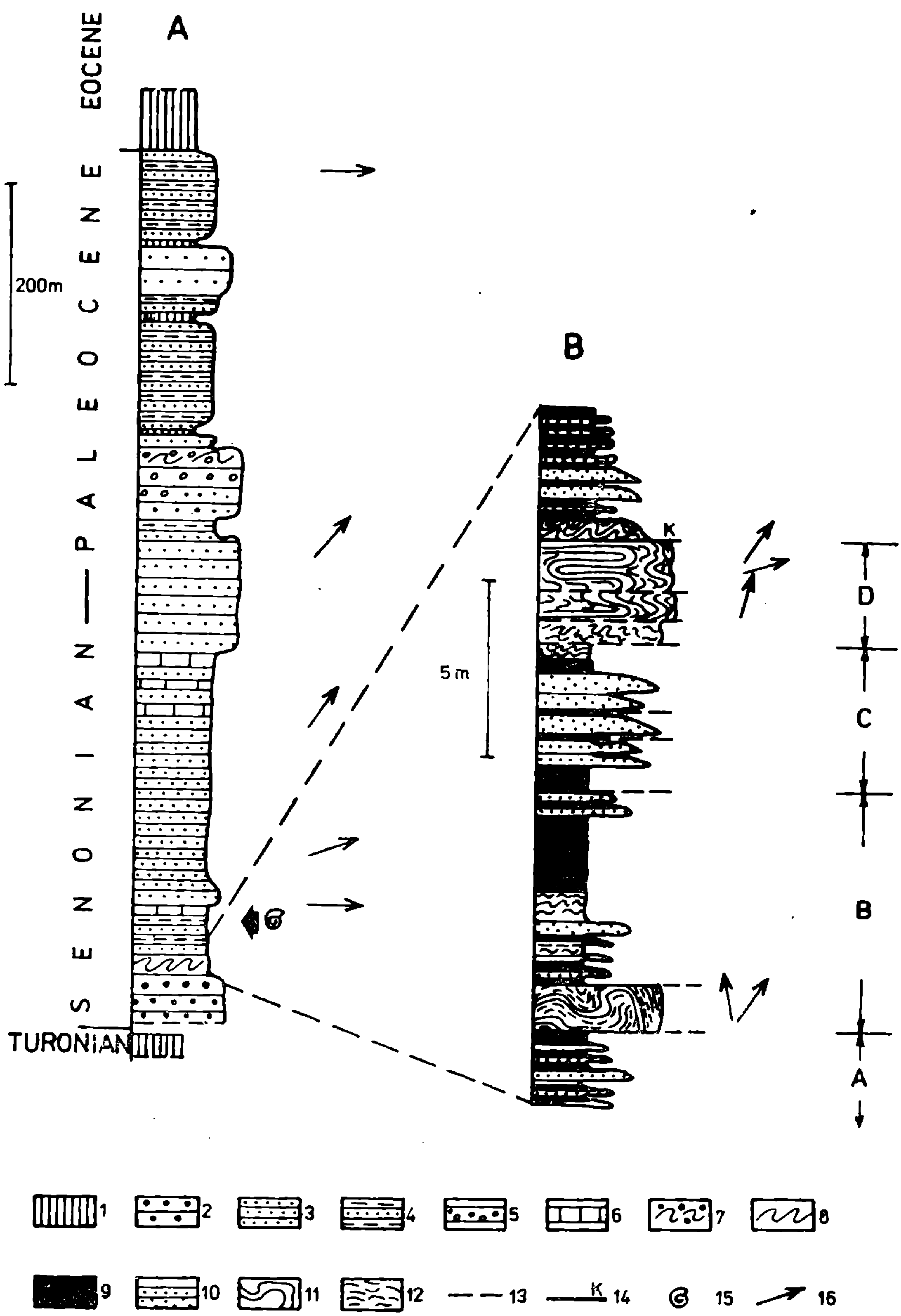

Fig. 3. Lithostratigraphic column of Inoceramian Beds in vicinity of Szczawa. *1* — variegated shales; *2* — thick-bedded, biotite-feldspar sandstones; *3* — medium- and thick-bedded turbidites; *4* — thin-bedded turbidites; *5* — conglomerates; *6* — turbiditic limestones; *7* — pebbly mudstones; *8* — slump body; *9* — pelites; *10* — sandstones; *11* — slump sheets and folds;

T_b, T_{bc}, and T_c Bouma sequences. The intervening noncalcareous, greenish and grey mudstones frequently display silky lustre. These mudstones are composed of quartz (36%), muscovite (22%), opaque Fe minerals (4%), calcite (3%), K-feldspar (26%), biotite (1%) and lithoclasts (1%). The mudstones contain illite-sericite cement (29%) of the porous and regeneration types. These deposits are horizontally laminated and slightly metamorphosed. In between, there also occur thin (5—10 cm) layers of siliceous mudstones. At the top of the slump body there appears a layer of grey, pelitic limestone, 7 cm thick. The slump series dip at 10 to 35° to the north and north-west.

Unit A (5 m thick) is composed mostly of subhorizontally dipping shales and thin-bedded sandstones. Shales are internally disturbed and faulted, while thin layers of sandstones are disrupted and pilled one upon another or form isolated, irregular fragments. Medium-bedded sandstones are usually discontinuous and form lense-like boundins, 1 m long. The whole unit is divided by several slip surfaces into discordantly packed complexes. Differences in strike directions attain 30° while those in dip values do not exceed 10°. The base of this unit is not exposed. The underlying complex, however, contains similarly developed sandstones and shales, including a 80 cm thick layer of muscovite-biotite, silicified, fine-grained sandstones.

Unit B comprises several fine-grained sandstone beds of medium thickness, interbedded with shales bearing thin sandstone intercalations. These deposits crop out on the left bank of the Kamienica river and could be traced for 10 to 15 metres. They show traces of intense folding and, in the upper part, they form an asymmetric anticline gently plunging to the NNW, under unit C. To the south, the eastern limb of this anticline has been folded into low-dipping small folds whose axes are disrupted by transversal faults. The western limb, in turn, passes into subhorizontally lying complex of sandstones and shales, exposed in the right bank. The total thickness of this sequence attains 8 to 10 m.

Unit C, 5—6 m thick, is built of horizontally lying medium- to thick-bedded sandstones, intercalated by clayey shales and siliceous mudstones (Figs. 5, 6). Despite intervening discontinuities, the sandstone beds are nearly concordant. Small--scale slips along bedding planes are responsible for subordinate disruption of lamination within the sandstones beds.

In the right bank of the river, the highest sandstone bed passes upwards to a 1 m thick shale complex, containing very thin intercalations of fine-grained sandstones. Top part of this complex is strongly deformed and brecciated. There occur numerous small drag folds, produced due to relative motion of the overlying unit D. The upper part of these deposits is cut by a fault dipping to the northwest.

Unit D is composed mostly of several medium-bedded sandstone layers, interlayered with shales and thin-bedded sandstones (Figs. 5—6). This part of the section

---

12 — brecciated mudstones and claystones; *13* — slip surfaces; *14* — calcite vein; *15* — finding of ammonite *Saghalinites wrighti* Birkelund; *16* — palaeotransport directions; *A*, *B*, *C*, *D* — slump units

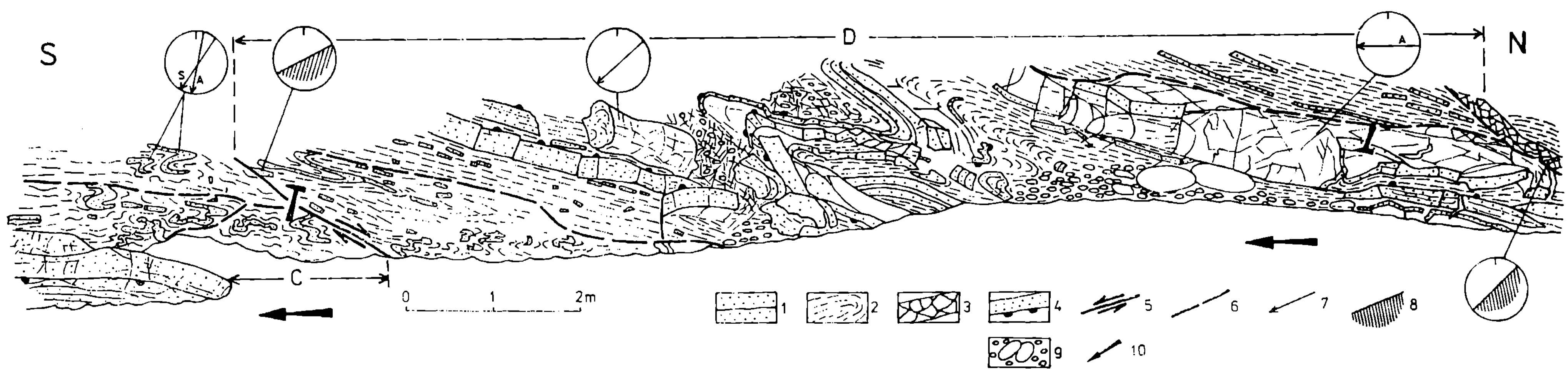

Fig. 5. Upper part of slump sequence exposed on right bank of Kamienica river. *1* — thick-bedded sandstones; *2* — shales; *3* — calcite vein; *4* — sole markings; *5* — inferred sense of movement along slip surfaces; *6* — scale boundaries; *7* — axes of slump folds; *8* — attitude of slip surfaces; *9* — recent gravel; *10* — sense of the river flow; *S* — synclines; *A* — anticlines

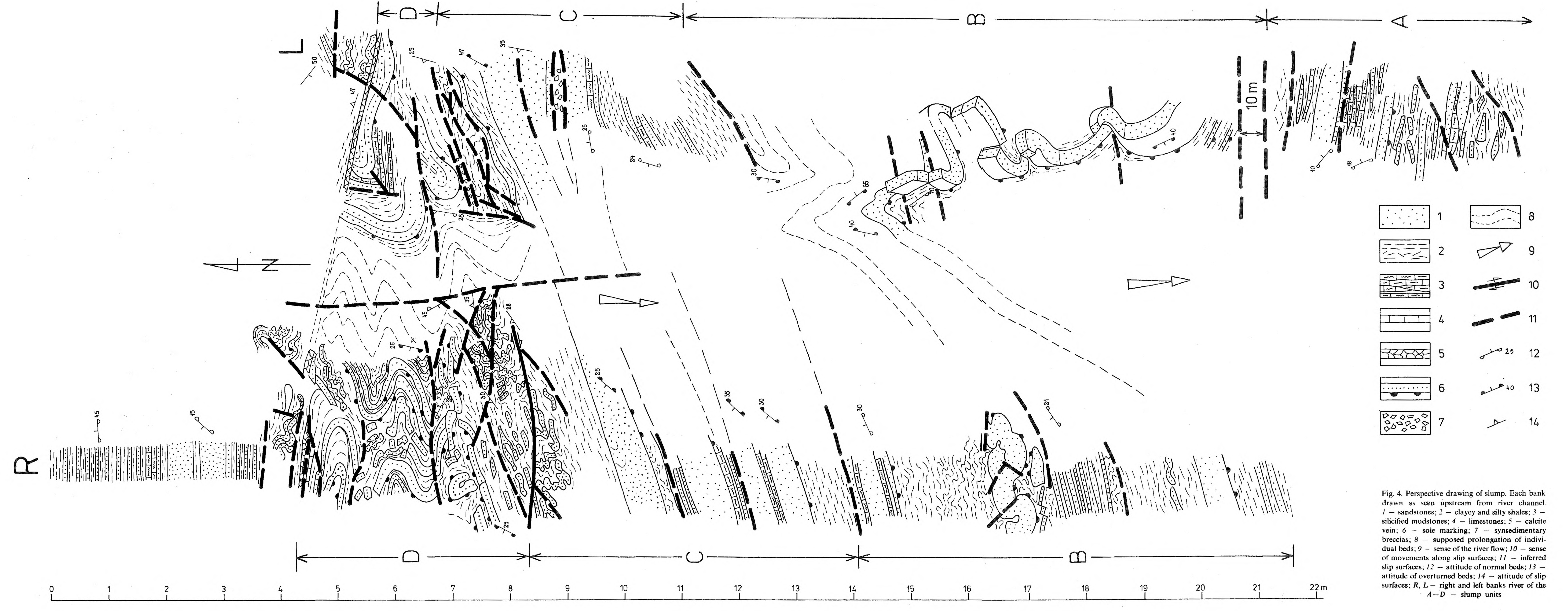

Fig. 4. Perspective drawing of slump. Each bank drawn as seen upstream from river channel. *1* — sandstones; *2* — clayey and silty shales; *3* — silicified mudstones; *4* — limestones; *5* — calcite vein; *6* — sole marking; *7* — synsedimentary breccias; *8* — supposed prolongation of individual beds; *9* — sense of the river flow; *10* — sense of movements along slip surfaces; *11* — inferred slip surfaces; *12* — attitude of normal beds; *13* — attitude of overturned beds; *14* — attitude of slip surfaces; *R, L* — right and left banks river of the *A–D* — slump units

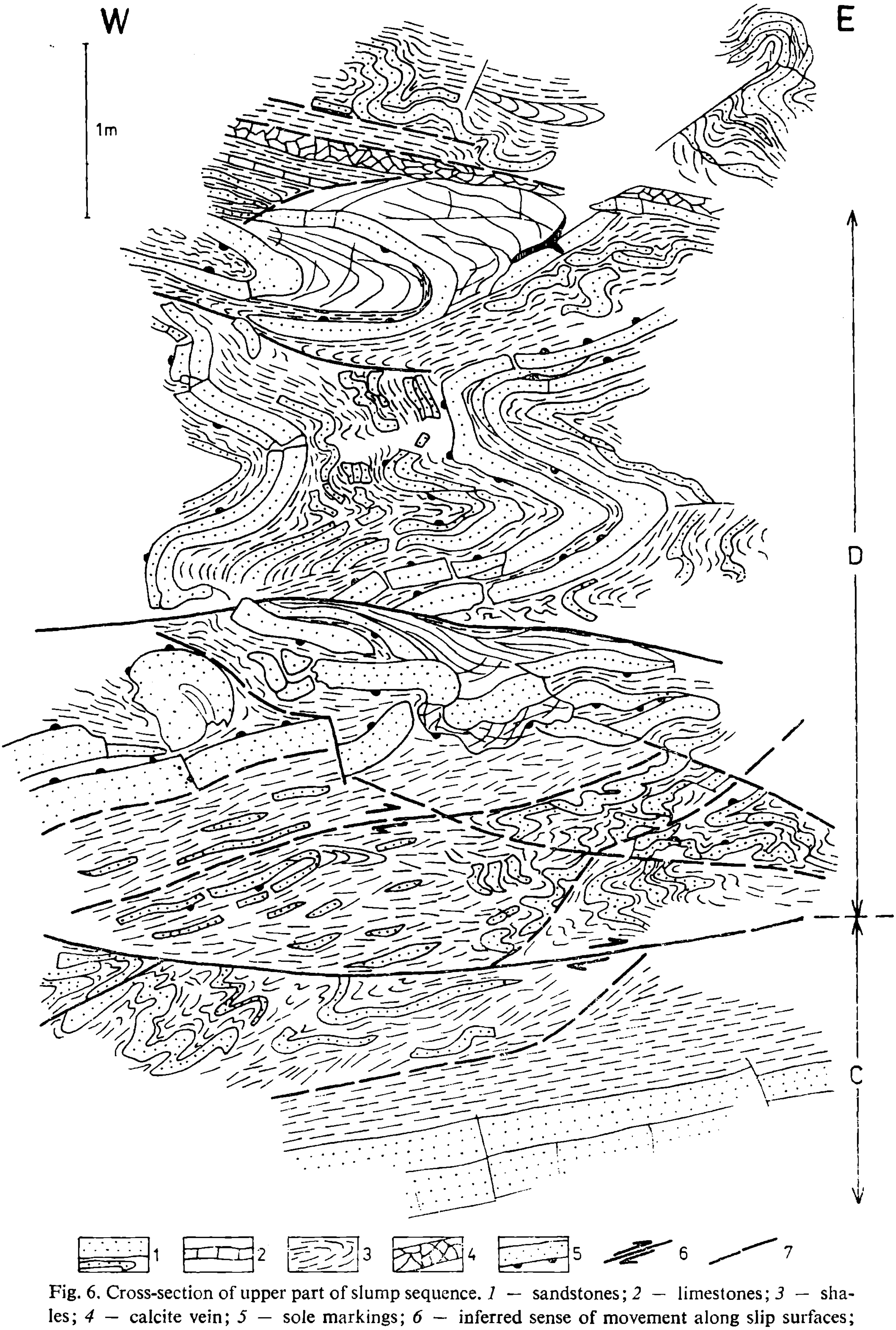

Fig. 6. Cross-section of upper part of slump sequence. *1* — sandstones; *2* — limestones; *3* — shales; *4* — calcite vein; *5* — sole markings; *6* — inferred sense of movement along slip surfaces; *7* — scale boundaries

is folded into cascade-type small folds, piled one upon another and subordinately imbricated by a series of faults parallel to axial planes of the folds. Moreover, fold axes are displaced by transversal faults and joints. In the upper part of this unit, stretching at a distance of 7 m, there appears a horizontal anticline formed by a medium-thick sandstone layer, its hinge cut by a dense network of joints (Fig. 6). These are mainly bending and shear-type joints, usually filled by calcite. In addition, joint fissures are sometimes filled in by quartz crystals. The overlying, discordant shale complex contains a thin intercalation of pelitic limestone. On the left side of the Kamienica river, several scales and imbricated synclines could be traced at the prolongation of the structures visible on the right-hand bank. Unit D is cut at the top by a calcite vein, 10 to 15 cm in thickness, dipping towards the north-west (right bank) or NNE (left bank). Higher up, there comes a thin sandstone-shale complex covered by turbidites which overlie the slump body.

The above described units show a number of sedimentary features commonly regarded as typical of submarine slumps (*cf.* Woodcock, 1976, 1979; Rupke, 1978). Axes of slump folds are preferentially oriented NNE—SSW to W—E, that is, obliquely or perpendicularly to the dominant direction of structures bordering the tectonic window of Szczawa (N—S). The presence of small-scale folds displaying irregular trend of axes, as well as numerous slumped sheets and folded lumps (Fig. 6), together with different styles of folding exemplified by a wide variety of deformational structures, may suggest plastic mechanism of deformation. Some of the slumped sheets resemble horizontal folds (unit D, Figs. 4, 6) while the others are strongly disintegrated. Sandstone layers frequently contain folded lumps of shales. There also occur synsedimentary breccias, like those at the base of unit D (Fig. 4). Deposits of the units A—D, although heavily jointed, contain neither open fractures nor cleavage. Small faults and joints filled in by calcite resulted mainly from subsequent folding and thrusting of the Magura nappe.

MECHANISM OF SLUMPING: AN ATTEMPT AT INTERPRETATION

Minimum thickness of the slump series is 35 m. Orientations of fold axes and slip surfaces has been measured and projected on the stereographic net in order to eliminate the influence of subsequent tectonics. Structural elements are best recognized in units C and D. Fold axes are scattered but trend parallel to slip surfaces. Dominant orientation of thrusts within unit C is NW and it changes to NE in the overlying unit D. Judging from the orientation of fold structures in the lower unit B, we can suppose that the probable strike of the slip surface was oriented W—E. The attitude of the slump-terminating calcite vein, occurring at the top of unit D, approaches that of two dominant slip directions, namely NW and NE. Fold vergence indicates that the slump moved down a palaeoslope inclined to the north.

It should be emphasized that the uppermost slump anticline of unit D shows traces of right-lateral rotation relative to the underlying structures. Slip surfaces dip gently and the angle of dip does not exceed 10°. This may indicate a relatively low inclination of the basin slope.

Lithological character of the slump series, together with its structural style allow us to suppose that we are dealing with one slump body, composed of several scales. The degree of disintegration and the intensity of deformations within the slump increase upwards. Hence, the initial stages of slumping could have represented motions of the „deck of cards" type, while during the subsequent stages the movements were more pervasive and disruption of thrust beds, together with their folding took place. This type of submarine slump belongs to incoherent (*cf.* Helwig, 1970) mass flow deposits (*sensu* Kruit *et al.*, 1975) where reductional shear stresses act within the mass as a whole. Diversified intensity of intra-slump deformation indicate that these deposits had not yet reached complete lithification when the slide occurred.

PALAEOGEOGRAPHICAL IMPLICATIONS

Towards the end of the Early Cretaceous (Aptian, Albian), the West Carpathian basin attained its maximum width, estimated at 200 km (Książkiewicz, 1962) to 900 km (Birkenmajer, 1986). According to Birkenmajer (1986) the Magura basin, underlain by a crust of oceanic type, was then 500 km across. During the Cenomanian the deposition within the whole Outer Carpathian basin became uniform, as expressed by the predominance of green clays with manganese nodules, radiolarian clays and radiolarites. In the Turonian, however, variegated clays were being deposited. This type of sedimentation persisted along the southern margin of the Magura basin, on the so-called Czorsztyn ridge, until the close of the Campanian (Birkenmajer, 1977). During the Senonian, sedimentation of the Inoceramian Beds began in the remaining part of the basin. These deposits are represented by thin- to medium-bedded turbidites, including thick-bedded sandstone complexes. These turbidites were shed mainly from the Silesian ridge which formed the northern rim of the Magura basin. Deposition of the Inoceramian Beds in this basin lasted up to the end of the Paleocene.

At the end of the Campanian, the area of the Pieniny Klippen Belt underwent folding and uplift. Meanwhile, subduction of the oceanic crust of the Magura basin under the continental crust of the Czorsztyn block had started (*cf.* Birkenmajer, 1986). Sediments laid down in the southern part of the basin were partly folded due to subsequent shortening. During Maastrichtian time, in the southernmost part of the Magura basin (Grajcarek unit), coarse-clastic sedimentation of the Jarmuta Formation, of the molasse, proximal flysch or wild-flysch character began (Birkenmajer, 1977).

We can relate the origin of the Szczawa slump series to the process of Late Senonian shortening of the Magura basin along its southern, active margin. Deposits contained in the slump units originated on the southern flank of the basin, as suggested by palaeotransport directions (*cf.* Fig. 3A, B). Late Senonian folding was responsible for the increase in inclination of the seismically active, southern slope

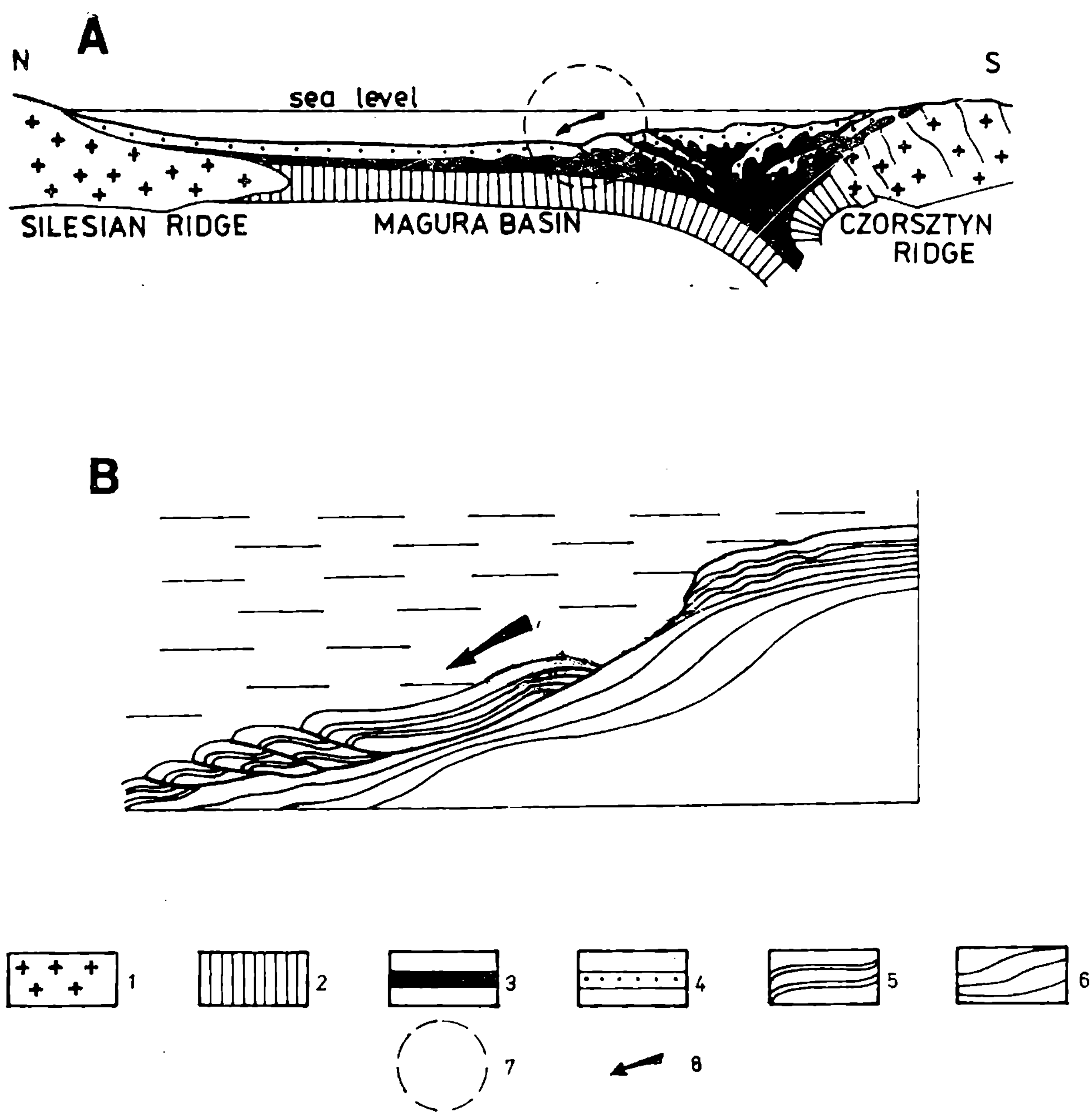

Fig. 7. Tectonic setting of slump. *A*. Palaeotectonic model of the Magura basin in the Late Senonian (after Birkenmajer, 1986, modified). *1* — continental crust; *2* — oceanic crust; *3* — Jurassic and Lower Cretaceous deposits; *4* — Upper Cretaceous deposits. *B* — Model of slump development. *5* — deposits affected by slump; *6* — undisturbed deposits; *7* — possible zone of slump formation; *8* — sense of sliding

on which gravity slides were likely to occur. These movements affected semiconsolidated deposits, which became strongly plastically folded. Individual slump scales were piled one upon another and underwent further internal deformation. The uppermost scale, represented by unit D, reveals the strongest deformation. Gently dipping surfaces of slip suggest that their origin might have been associated with bedding surfaces.

Assuming that besides Late Laramian thrusting of the Grajcarek Unit, there also occurred Early Laramian northward thrusting in the Magura basin, we can consider another model of the Szczawa slump formation. The uplifted front of the overthrusting nappe allowed for the formation of orogenic landslides (*cf.* Abbate & Sagri, 1981). Further disintegration and contortion of slump sequences might have lead to the formation of large slumps like that described by Książkiewicz (1958) from the Inoceramian Beds at Poręba Wielka (see Fig. 1). These deposits were distinguished by Burtan and Łydka (1978) as the wildflysch-type Poręba Wielka Beds. As compared to the Szczawa slump, the deposits exposed at Poręba display a much stronger, liquefaction-produced disintegration, especially well pronounced in the upper part. At the base of both, the Szczawa and Poręba slump sequences, there occur feldspar-biotite sandstones and mudstones, representing the northern facies of the Inoceramian Beds. Moreover, the oldest Cenomanian deposits of the Magura series, drilled at Obidowa, are thrust over Senonian—Palaeocene Inoceramian Beds of the northern facies (*cf.* Cieszkowski, 1985). These thrusts have hitherto been considered the manifestations of Early Miocene tectonics, but their older age cannot be excluded. Any solution to this problem requires additional sedimentological and stratigraphical studies.

Late Cretaceous shortening of the Magura Basin lead to the uplift of the southern source area supplying detritic material to the Inoceramian Beds during Maastrichtian and Palaeocene times. The mobility of this region is documented by the presence of thick-bedded muscovitic sandstones, covering vast area in the Nowy Sącz and Krynica zones of the Magura nappe (*cf.* Książkiewicz, 1962; Cieszkowski & Oszczypko, 1986). These sandstones, frequently of the fluxoturbidite and debris-flow types, display palaeotransport directions from the south, south-west and south-east.

Further shortening of the Magura basin proceeded during the Maastrichtian and Paleocene, leading to the formation of numerous submarine slumps in the Inoceramian Beds. Subsequent remodelling of the basin resulted in a far-reaching facies differentiation in the Eocene.

REFERENCES

Abbate, E. & Sagri, M., 1981. Olistostromes in the Oligocene Macigno Formation (Florence area). In: Ricci Lucchi, F. (ed.) *2nd Europ. Reg. Meet. IAS, Bologna*, pp. 163—203.

Birkenmajer, K., 1977. Jurassic and Cretaceous lithostratigraphic units of the Pieniny Klippen Belt, Carpatians, Poland, *Studia Geol., Polon.* 45: 1—158.

Birkenmajer, K., 1986. Stages of structural evolution of the Pieniny Klippen Belt, Carpathians. *Studia Geol. Polon.*, 88: 7—32.

Burtan, J. & Łydka, K., 1978. On metamorphic tectonites of the Magura Nappe in the Polish Flysch Carpathians. *Bull. Acad. Polon. Sci. Ser., Sci. Terre*, 26: 95—101.

Burtan, J., Paul, Z. & Watycha, L., 1978. *Objaśnienia do szczegółowej mapy geologicznej Polski 1:50 000, ark. Mszana Górna.* (In Polish). Wyd. Geol., Warszawa, 68 pp.

Chrząstowski, J., 1971. Mineral waters of Szczawa as connected with the geological constitution. (In Polish, English summary). *Probl. Zagosp. Ziem Górskich*, 9: 99—136.

Cieszkowski, M., 1985. Stop 21: Obidowa. In: Birkenmajer, K. (ed.), *Main Geotraverse of the Polish Carpathians (Cracow—Zakopane). Guide to Exc. 2. Carpatho-Balcan Geol. Ass., Cracow.* Geological Institute, Warszawa, pp. 18—54.

Cieszkowski, M. & Oszczypko, N., 1986. Development of the Magura Nappe in the peri-Klippen zone. (In Polish, English summary). *Prz. Geol.*, 34 (6): 327—334.

Cieszkowski, M., Oszczypko, N. & Zuchiewicz, W., 1986. Turbiditic limestones in the Ropianka

Formation at Szczawa, Magura Nappe. Polish West Carpathians. *7th Reg. Meet. Sedim. IAS, Kraków. Abstracts.* pp. 48–49.
Dżułyński, S., 1963. Directional structures in flysch. (In Polish, English summary). *Studia Geol. Polon.*, 12: 1–136.
Haczewski, G. & Szymakowska, F., 1984. Finding of ammonite *Saghalinites wrighti* Birkelund in Cretaceous of Magura Unit (West Carpathians). (In Polish, English summary). *Kwart. Geol.*, 28: 649–654.
Helwig, J., 1970. Slump folds and early structures, NE Newfoundland, Appalachians. *J. Geol.*, 78: 172–187.
Kruit, C., Brouwer, J., Knox, G., Schöllnberger, W. & Vliet, A. van, 1975. Un excursion aux cones d'alluvions en eau profonde d'age Tertiaire pres de San Sebastian (province de Guipuzcoa, Espagne). *9th Int. Congr. Sedim., Nice, Exc. 23*, Nice, 75 pp.
Książkiewicz, M., 1958. Submarine slumping in the Carpathian flysch. (In Polish, English summary). *Rocz. Pol. Tow. Geol.*, 28: 123–150.
Książkiewicz, M. (ed.), 1962. *Geological Atlas of Poland*, fasc. 13. Wyd. Geol., Warszawa.
Mahel, M. (ed.), 1974. *Tectonics of the Carpathian-Balkan regions.* D. Stur Geol. Inst., Bratislava.
Middleton, C. V. & Hampton, M. A., 1976. Subaqueous sediment transport and deposition by sediment-gravity flows. In: Stanley, D. J. & Swift, D. J. P. (eds). *Marine Sediment Transport and Environmental Management.* J. Wiley, New York, pp. 197–218.
Oszczypko, N., 1973. Geological structure of the Nowy Sącz Basin. (In Polish, English summary). *Biul. Inst. Geol.*, 271: 101–197.

Streszczenie

PÓŹNOKREDOWE OSUWISKO PODMORSKIE W WARSTWACH INOCERAMOWYCH JEDNOSTKI MAGURSKIEJ W SZCZAWIE (POLSKIE KARPATY ZACHODNIE)

Marek Cieszkowski, Nestor Oszczypko & Witold Zuchiewicz

W Szczawie, w niższej części warstw inoceramowych stwierdzono serię osuwiskową miąższości 30 m (Fig. 1), złożoną z czterech łusek. W stropowej części tego podmorskiego osuwiska występuje kilka obalonych fałdów (Fig. 3–5). Ruchami osuwiskowymi zostały objęte cienko i średnioławicowe turbidyty, zawierające w stropie pojedyncze grubsze ławice piaskowców. Zróżnicowana intensywność deformacji wskazuje, iż osuwisko rozwinęło się w osadach częściowo skonsolidowanych. Pomiary orientacji powierzchni osiowych fałdów osuwiskowych, a także obserwacje kierunków przemieszczeń na płaszczyznach poślizgu dowodzą, że ruch mas osuwiskowych odbywał się z SE ku NW, prostopadle do kierunku prądów zawiesinowych (Fig. 7).

Powstanie serii osuwiskowej w Szczawie można wiązać z procesami skracania basenu magurskiego wzdłuż jego południowego obramowania (por. Birkenmajer, 1985). W procesy osuwiskowe zostały wciągnięte osady zdeponowane na południowym skłonie basenu. Późnosenońskie ruchy fałdowe spowodowały wzrost nachylenia sejsmicznie aktywnego skłonu, co umożliwiło rozwój grawitacyjnych ruchów

masowych. Poszczególne łuski osuwiskowe nasunęły się na siebie kaskadowo, ulegając dalszym wewnętrznym deformacjom.

Biorąc pod uwagę późnosenoński wiek jednostki Grajcarka, najbardziej południowej jednostki płaszczowiny magurskiej, można sądzić, iż w tym samym czasie zostały uformowane niewielkie płaszczowiny przemieszczające się ku północy. Na spiętrzonych czołach płaszczowin mogły powstawać osuwiska typu orogenicznego, przemieszczające się zgodnie z nachyleniem skłonu. Dalsza dezintegracja mas osuwiskowych mogła sprzyjać formowaniu rozległych olistostrom, takich jak seria opisana z warstw inoceramowych w Porębie Wielkiej (por. Książkiewicz, 1958; Burtan & Łydka, 1979).