acta geologica polonica

Vol. 22, No. 1 Warszawa 1972

ANDRZEJ RADWAŃSKI & PIOTR RONIEWICZ

Permian (Zechstein) littoral structures in the Holy Cross Mts

ABSTRACT: At the Zelejowa locality in the Holy Cross Mts a number of littoral structures related to the Upper Permian (Zechstein) transgression were noted. They are represented by cliff rubbles consisting of breccia material accumulated at the foot of cliff, and various forms of psefitic accumulation, as elongate littoral bank continuing more or less parallel to the shoreline. These structures made possible the reconstruction of morphology of the littoral zone and hydrodynamic conditions prevailing during the transgression of Zechstein sea.

INTRODUCTION

The Upper Permian (Zechstein) deposits in the Holy Cross Mts have focused the interest of geologists for a long time (*cf.* Czarnocki 1923, Samsonowicz 1929) because of their transgressive character related to a marine transgression entering the Variscan massif, folded during the Middle or Upper Carboniferous. Among relics of these deposits (*cf.* Fig. 2*A*), various conglomerates (*cf.* Czarnocki 1923, 1948; Samsonowicz 1929; Kostecka 1962, 1966a, b) directly overlaying the Variscan substrate and undoubtedly connected with the first stage of transgression predominate. At Zelejowa locality near Chęciny in SW part of the Holy Cross Mts (*cf.* Fig. 2*A*), the authors noted abrasion structures covered with these conglomerates. The abrasion structures and surrounding areas of psefitic deposition are the subject of the present contribution.

CHARACTERISTIC OF THE LITTORAL STRUCTURES

Zechstein rocks with littoral structures outcrop at the eastern end of Zelejowa village, on the northern slopes of Zelejowa Hill (Fig. 2*B*). The Zechstein substrate is built of Middle Devonian (Givetian) limestones (*cf.* Fig. 2*A*). Within the outcrops, through which the cross-section was taken (Fig. 2*C*), a few zones of Zechstein deposits differing in lithology were distinguished.

In the first zone, comprising the upper slopes up to the crest of Zelejowa Hill, small patches of breccia were noted. The breccias fill up small irregularities in the substrate and, in places, form a thin veneer covering outcrops of Givetian limestones. Psefitic material of the breccias, derived from the nearby areas is poorly sorted and cemented with carbonate-ferruginous material with finegrained matrix. Down the slope (C_1 in Fig. 2*C*) a fissure a few meters wide and filled with blocks and boulders of Givetian limestone, differing in size, was noted. The largest blocks reach 1 m in diameter (Fig. 1*a*) and represent different types of Givetian limestones (*Stromatopora* limestones, cf. Fig. 1*b*, *Amphipora* and coral limestones, etc.) of which Zelejowa Hill is built. Due to poor selection and roundness, and lack of bedding, this material is of breccia character, with finer-grained matrix and carbonate-ferruginous cement. This breccia crops out from the Quaternary sand cover, overlaying it along uneven erosional boundary.

In the next zone (C_2 in Fig. 2*C*), the Givetian substrate outcrops from beneath Zechstein cover in the form of a number of small knolls on the recent surface. Around the knolls, along and down the slope, psefitic material of an intermediate character between breccia and conglomerate fills numerous pockets and fissures and forms small patches covering the substrate (*cf.* C_2 in Fig. 2*C*). This material is indistinctly bedded and consists of clastic finer-grained material, from a few to 20 cm in diameter, cemented with the same matter as the breccia discussed above.

Close by the footslopes of Zelejowa Hill, below the latter zone, the Givetian substrate covered in places with patches of conglomerates outcrops again.

Further to the north, a small ridge, a few meters high, continues over 200 m distance to the west and gradually merges with slopes of Zelejowa Hill (Fig. 2*B*). This ridge is entirely built of well-bedded conglomerates (C_3 in Fig. 2*C*) composed of rounded, often discoidal, pebbles exhibiting along-ridge orientation (diagram 2 in Fig. 2*B*). Psefitic material reaches up to 10 cm in diameter and is far more diversified than previously, whereas cement is the same. Along the cross-section through the northern slope of Zelejowa Hill (Fig. 2*C*), in an old excavation and road cut, the conglomerate layers slope gradually towards the slopes of the ridge, maximally up to 15—20°, concordantly with the hill outline. Within the inclined layers, indistinct cross-bedding, dipping under an angle up to a few degrees may be noted. Moreover, the largest planes of flat pebbles which occur in these layers are oriented in the same direction as the inclination of the layers (*cf.* diagram 3 in Fig. 2*B*).

The following regularities in the development of Zechstein deposits under discussion are to be stressed:

The roundness and sorting of psefitic material increases successively from the upper slopes of Zelejowa Hill towards the ridge in Zelejowa village. Similar changes in bedding were noted. These changes are accompanied by changes in psefitic material, which becomes more and more diversified in composition and decreases in size. Taking into account the substrate surface and structural properties of the deposits such as inclination of layers, orientation of pebbles, etc., particular zones of the outcrops may be interpreted as follows:

The coarse and angular material (Fig. 1 and C_1 in Fig. 2*C*) represents

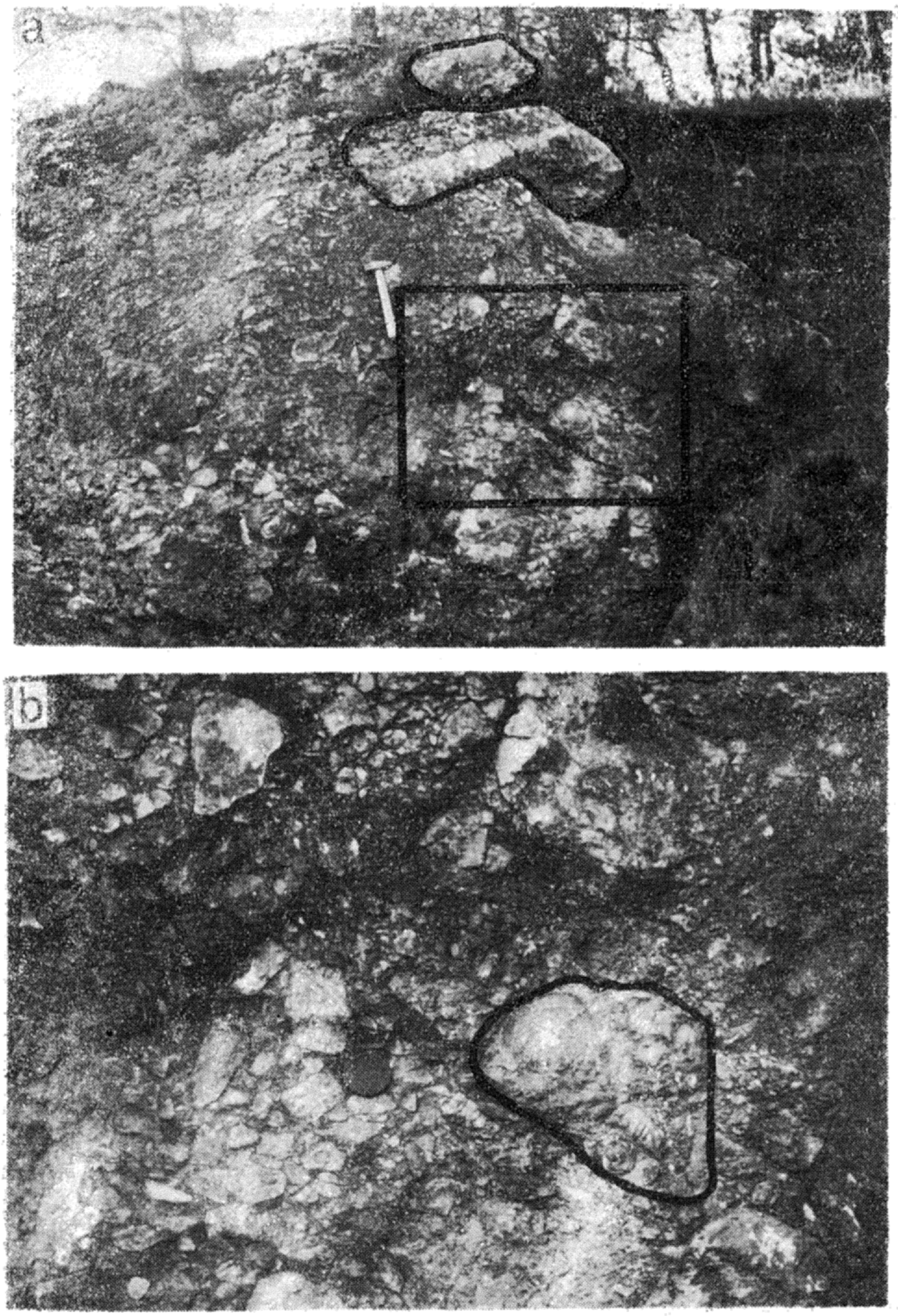

Fig. 1

Detailed view of the Permian (Zechstein) cliff breccia at Zelejowa village, cropping out in erosional fragments preserved under the cover of Pleistocene sands (*cf.* section *K-L* and photo C_1 in Fig. 2)

a — General view on breccia; two largest blocks are lined (rectangled is the area of photo *b* in this figure)

b — Close-up view of the preceding photo; lined is an irregular block of the Devonian (Givetian) stromatoporoid limestone (spherical colony of *Stromatopora* sp. is visible in its left upper part) a pile of the coarsest psefitic material preserved in the depression of the Givetian substrate. The size of material and the lack of selection, as well as bedding indicate that this pile is of littoral rubble character and consists of blocks accumulated along the rocky shore. Part of this material presumably originated as a result of abrasional shore destruction; the rest was presumably derived from older terrestrial rubbles covering slopes of Zelejowa Hill prior to the Zechstein transgression. Patches of breccia covering upper slopes of Zelejowa Hill are relics of similar deposits preserved in small depressions of the substrate. Orientation of flat pebbles in this zone (diagram *1* in Fig. 2*B*) is random. Such orientation presumably resulted from waving which was disturbed by irregularities of shoreline and bottom in surf zone of this rocky shore.

The course of such irregularities may be traced in detail in the next zone (*cf.* C_2 in Fig. 2*C*), which is in the form of subaqueous rocky bench. Locally, its flat surface continuing on the same level under the breccia cover of the former zone, may represent a part of abrasion platform.

Below this bench, in depressions of the Givetian substrate, finer-grained, better-rounded material carried by waving and littoral currents out of the shore, was accumulated in places.

All deposits of the discussed zones exhibit consequent changes corresponding to changes in hydrodynamic factors active from surf zone to shallow sub-littoral zone, extending at different altitudes on slopes of Zelejowa Hill submerged during the transgression.

Psefitic material accumulated on the ridge at Zelejowa village (*cf.* Fig. 2*B*) exhibits features of distinct, longer-distance transport. The course of this ridge and structural features of the conglomerates building it (fan-like inclination of layers on ridge slopes, cross-bedding, orientation of pebbles) indicate that this ridge is a relict of Zechstein deposition; within the gravelous accumulation bench, it had the form of long, gravel bank continuing somewhat obliquely to the shoreline. The material was derived presumably from the middle and western parts of Zelejowa Hill and transported by quick littoral current, more or less parallel to the shoreline. Fan-like inclination of layers resulted from pouring the material in front of the bank; in places this pouring is confirmed by obscure cross-bedding (*cf.* smaller arrows in Fig. 2*B*). Orientation of flat pebbles presumably resulted from the pebbles poured over the bank slope or from the activity of waves breaking on the bank slope. Interaction of both these factors is also possible.

Deposits of the littoral bank, being allochthonous in character, were transported from the source areas c. 0.5—1.0 km distant. In the area of Zelejowa village these deposits form the larger and somewhat branched lobate banks continuing from the crest of Zelejowa Hill and exhibiting consequent sequence of structural features. Hence these banks are relics of final deposition stage of littoral Zechstein deposits. Presumably they correspond to the stage of ultimate carrying of littoral sediments out of different shore zones and spreading them over the sub-littoral gravelous bench; this material covered all older littoral deposits, not outcropping on the surface at present. It is probable that the pre-Zechstein substrate lowers significantly in this zone (*cf.* Fig. 2*C*); the lack of borehole data however precludes unequivocal determination of its trends.

PALAEOGEOGRAPHICAL REMARKS

The littoral Permian deposits under discussion are related to the Zechstein transgression, which entered the massif of the Holy Cross Mts from the west. Its bays occupied depressions of synclinal structure or anticlinal zones subsequently cut. Then the landscape relief represented the young stage, and in places the mature stage of landscape development; sea shores were of the ria type (*cf.* Kostecka 1966a) and distinct altitude differentiation. The extent of Zechstein deposits preserved (*cf.* Fig. 2*A*) correspond to certain preliminary period of transgression, when the bottoms of the largest valleys of the western part of the Holy Cross Mts were filled with deposits. Later, in the next stage of transgression the more eastern parts of these valleys had to be also filled with deposits; but the maximal extent of Zechstein deposition, as well as ultimate shoreline cannot be defined (*cf.* Czarnocki 1923) because Zechstein sedimentary cover was removed together with the whole Mesozoic cover after the Laramide uplift of the Holy Cross Mts during the early Tertiary (Głazek & Kutek 1970, 1972).

The littoral deposits of the transgressing Zechstein sea in the Holy Cross Mts are the only Zechstein deposits of that kind hitherto identified; although since the early twenties these psefitic Zechstein deposits were interpreted as littoral and somehow related to the course of shoreline, substrate structure and availability of older, coarse-clastic terrestrial waste (*e.g.* Czarnocki 1923, 1948; Samsonowicz 1929; Kostecka 1962, 1966a, b) [1]. These littoral deposits occur within the limits of a bay entering the Variscan massif of the Holy Cross Mts through synclinal zone (Gałę-

[1] Suggesting such older terrestrial wastes, the dominance of terrestrial processes in formation of the lower part of the conglomerates or at least gravels forming them was taken into account. These gravels were estimated to be of fanglomerate origin, and connected with torrential agents of Lower Permian (Rothliegende) age (*cf.* Czarnocki 1923, 1948; more openly — Kostecka 1966a, b). These suggestions seems to be valid in the case of the origin of coarse clastic wastes. However, the authors accept the Zechstein age for the discussed conglomerates. Actually the index fossil, brachiopod *Horridonia horrida* (Sow.), appears in the upper part of conglomerate sequence (Czarnocki 1923, Kostecka 1966a, b), but it is impossible to prove that it delimits accurately the beginning of the Zechstein stage there. This brachiopod was not an eulittoral form and it may not appear at the very beginning of marine transgression. Hence, the whole lower part of the conglomerate sequence may be included in the Zechstein cycle as well. Moreover it seems that the presented reconstruction of processes forming the structures under discussion points to marine littoral rather than terrestrial sedimentary environment.

zice syncline, *cf.* Fig. 2*A*). This bay was presumably almost 20 km long and 1.5—2 km wide. Areas of psefitic deposition were connected with more elevated shore zones. Where shores were lower and bay wider, besides psetific deposition a carbonate sedimentation took place in central part of the basin. In that part the limestones and marls with *Horridonia horrida* (Sow.) and numerous pelecypods were recorded (*cf.* Czarnocki 1923, Kostecka 1966a, b). Where the bay was narrower and shores more steep and morphologically differentiated, accumulation of psefitic material predominated. The area studied represents the latter zone of deposition (*cf.* Fig. 2*A*). On the opposite margins of the bay (in relation to cross-section line; *cf.* Fig. 2*C*) in about 1.3 km distance, some small irregularities of the substrate, surfacing from conglomerate cover, were noted. These conglomerates vary in thickness along the northern shores of the bay and are estimated to reach *c.* 100 m in places (Czarnocki 1923, Kostecka 1966a, b); this variation presumably resulted from differentiation of depositional conditions within littoral zone and differences in substrate elevations. The discussed littoral Zechstein deposits cover the top parts of recent hills here, *e.g.* Mt. Czerwona. Hence during the transgression, these hills at the very most formed only the lower piedmont parts of lofty mountain range. The Dyminy anticline (*cf.* Fig. 2*A*), cut morphologically to the present state after the Laramide uplift mentioned above (*cf.* Głazek & Kutek 1970, 1972), could have been this range [2].

The character of processes active in mountain ranges surrounding the bay may be inferred from the analysis of conglomerate cement. The cement consists of fine-detrital limestone material (substrate rocks) and material of terra rossa character (Czarnocki 1923), which may represent residual matter of karst weathering (*cf.* also Kostecka 1966b). Weathering phenomena active in neighbouring areas built of Devonian (Givetian-Famennian) limestones [3] were very close to weathering processes recently developing in limestone-mountain areas of the Mediterranean zone or were even more intense.

COMPARISON WITH OTHER FOSSIL LITTORAL STRUCTURES

It should be stressed that development of the Zechstein littoral structures under discussion and the pattern of littoral deposition are identical to that which proceeded in other geologic epochs in similar morphologic settings. Similar examples may be cited from highly diver-

[2] This Laramide uplift of the Holy Cross Mts could have changed hipsometric interposition of Zechstein deposits in particular areas; if this was the case, it may be assumed that the deposits of the Variscan structural stage were not at their present position before that time. Hence it is possible that during the Zechstein transgression the Dyminy range was less pronounced in the morphology than at present and was covered with Zechstein deposits over much greater areas.

[3] This fact indicates that (*cf.* Fig. 2*A*) post-Variscan downcutting of the landscape prior to the Zechstein transgression reached only a thick cover of Middle-

sified littoral Eocene deposits of the Tatra Mts (*cf.* Roniewicz 1966, 1969, 1970) and Tortonian deposits of the Holy Cross Mts (*cf.* Radwański 1964, 1965, 1969, 1970).

Local preservation of the Zechstein cliff and associated deposits at Zelejowa, resulted from favourable landscape configuration and burying which was sufficiently rapid to prevent destruction already in the Zechstein sea, is an interesting and perhaps extremely rare case for the Paleozoic series.

The complete lack of boring animals in these Zechstein littoral deposits arouses some interest. These animals are typical for Recent and Caenozoic, and occasionally Mesozoic littoral zones of a carbonate substrate. The lack of these animals here may be explained by the fact that this specific ecologic assemblage, to which the boring animals generally belong, had not yet developed. It seems that this assemblage was gradually developing in time, and approached the significance similar to the present not before the Upper Triassic and Liassic times (*cf.* Radwański 1959, 1968), reaching its present position in the Tertiary (Roniewicz *op. cit.*; Radwański 1964, 1965, 1969, 1970).

Institute of Geology
of the Warsaw University
Warszawa 22, Al. Żwirki i Wigury 93
Warsaw, October 1971

REFERENCES

CZARNOCKI J. 1923. Le Zechstein dans les montagnes de Święty Krzyż. — Spraw. PIG (Bull. Serv. Géol. Pol.), vol. 2, nos. 1/2. Warszawa.

— 1938. Kielce (Carte géol. gén. de la Pologne, feuille 4). Warszawa.

— 1948. Przewodnik XIX Zjazdu Polskiego Towarzystwa Geologicznego w Górach Swiętokrzyskich w r. 1947 (Guide pour XX Réunion de la Société Géologique de Pologne dans les Montagnes de Ste Croix en août 1947). — Rocz. PTG (Ann. Soc. Géol. Pol.), vol. 17. Kraków.

GLAZEK J. & KUTEK J. 1970. The Holy Cross Mts area in the Alpine diastrophic cycle. — Bull. Acad. Pol. Sci., Sér. Sci. Géol. Géogr., vol. 18, no. 4. Varsovie.

— & — 1972. The Holy Cross Mts area in the Alpine cycle, and some related tectonic problems. — Acta Geol. Pol., vol. 22, no. 3 (*in press*). Warszawa.

KOSTECKA A. 1962. Characteristic of Zechstein conglomerates in Gałęzice-Bolechowice syncline (Holy Cross Mts). — Kwartalnik Geol. (Quart. J. Geol. Inst. Pol.), vol. 6, no. 3. Warszawa.

— 1966a. The Permian facies of the Gałęzice-Bolechowice syncline (Holy Cross Mts). — Bull. Acad. Pol. Sci., Sér. Sci. Géol. Géogr., vol. 14, no. 3. Varsovie.

— 1966b. The lithology and sedimentation of the Zechstein strata of the Gałęzice-Bolechowice sycline (Holy Cross Mts). — Prace Geol. PAN, Oddz. w Krakowie (Geological Transactions), No. 33. Warszawa.

-Upper Devonian carbonate formations of this part of the Holy Cross Mts (*cf.* Czarnocki 1923, Kostecka 1966b); it reached Cambrian deposits building anticlinal cores in the northern and north-eastern parts of the Holy Cross Mts (*cf.* Samsonowicz 1929; Czarnocki 1938, 1948; see also right upper part of Fig. 2A of the present paper).

RADWAŃSKI A. 1959. Littoral structures (cliff, clastic dikes and veins, and borings of Potamilla) in the high-tatric Lias. — Acta Geol. Pol., vol. 9, no. 2. Warszawa.
— 1964. Boring animals in Miocene littoral environments of Southern Poland. — Bull. Acad. Pol. Sci., Sér. Sci. Géol. Géogr., vol. 12, no. 1. Varsovie.
— 1965. Additional notes on Miocene littoral structures of Southern Poland. — *Ibidem*, vol. 13, no. 2.
— 1968. Petrographical and sedimentological studies of the high-tatric Rhaetic in the Tatra Mountains. — Studia Geol. Pol., vol. 25. Warszawa.
— 1969. Lower Tortonian transgression onto the southern slopes of the Holy Cross Mts. — Acta Geol. Pol., vol. 19, no. 1. Warszawa.
— 1970. Dependence of rock-borers and burrowers on the environmental conditions within the Tortonian littoral zone of Southern Poland. *In:* T. P. Crimes & J. C. Harper *(Ed.)* — Trace Fossils (Geol. Journal Special Issues, No. 3). Liverpool.
RONIEWICZ P. 1966. New data on sedimentation of Eocene organodetrital limestones in the Tatra Mts. — Bull. Acad. Pol. Sci., Sér. Sci. Géol. Géogr., vol. 14, no. 3. Varsovie.
— 1969. Sedimentation of the Nummulite Eocene in the Tatra Mts. — Acta Geol. Pol., vol. 19, no. 3. Warszawa.
— 1970. Borings and burrows in the Eocene littoral deposits of the Tatra Mountains, Poland. *In:* T. P. Crimes & J. C. Harper *(Ed.)* — Trace Fossils (Geol. Journal Special Issues, No. 3). Liverpool.
SAMSONOWICZ J. 1929. Le Zechstein, le Trias et le Liasique sur le versant nord du Massif de S-te Croix. — Spraw. PIG (Bull. Serv. Géol. Pol.), vol. 5. Warszawa.

A. RADWAŃSKI i P. RONIEWICZ

CECHSZTYŃSKIE UTWORY LITORALNE NA GÓRZE ZELEJOWEJ W GÓRACH ŚWIĘTOKRZYSKICH

(Streszczenie)

Przedmiotem pracy jest analiza cechsztyńskich utworów litoralnych odsłaniających się na północnych stokach Góry Zelejowej koło Chęcin w Górach Świętokrzyskich. Wśród utworów tych (fig. 1—2) zwraca uwagę głazowisko klifowe (fig. *1a*, *b* oraz fig. *2B*, *C*) zachowane w wycięciu podłoża stanowiącym fragment ściany klifowej, oraz podłużny nasyp żwirowy (*por.* fig. *2B* oraz C_3 na fig. *2C*) utworzony przez prąd litoralny znoszący materiał ze skalistych wybrzeży zachodnich partii Zelejowej. Rozważane utwory, które zachowały się dzięki sprzyjającej lokalnej konfiguracji linii brzegowej i szybkiemu pogrzebaniu pod młodszymi osadami cechsztyńskimi, stanowią rzadki przypadek paleozoicznych utworów litoralnych.

Instytut Geologii Podstawowej
Uniwersytetu Warszawskiego
Warszawa 22, Al. Żwirki i Wigury 93
Warszawa, w październiku 1971 r.