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GEOPETAL STRUCTURES AS INDICATORS OF TOP AND BOTTOM

(Pl. I—II and 2 Figs.)

Struktury geopetalne jako wskaźniki stropu i spągu

(Pl. I—II i 2 fig.)

Abstract. The geological significance of intraskeletal geopetal structures has been examined. It has been proved that the possibility of an early lithification of internal sediments questions the diagnostic value of partial sedimentary infillings of fossils as indicators of top and bottom.

Numerous criteria of defining the top and bottom of beds are known (Shrock, 1948) but the geopetal structures (the term introduced by Sander, 1936) belong to the more often used in the field practice. The partial sedimentary infillings of rock cavities are considered the more useful and the partial infilings of fossils are commonly used to define the top and the bottom (Shrock, 1948; Shamov, Hecker, 1966; Richter, 1968; Seilacher, 1973).

In general partially infilled are the shells of brachiopods (Müller, 1951, Richter, 1968; Eder, 1971) and borings of lithophags (Pl. 2). Geopetal structures are also characteristic for fossils of complicated inner structures e.g. shells of ammonites (Seilacher, 1971, Wendt, 1973), skeletons of sponges (Krantz, 1972), shells of rudists (Bein, 1976) but other fossils may also be partially infilled (see e.g. Horowitz, Potter, 1971).

Particulary favourable conditions for the formation of intraskeletal geopetal structures are created by minimal sedimentation which is why in stratigraphically condensed sequences partial infillings of shells are very common (the author's observations on the Callovian deposits in Cracow Upland). Rapid burying of fossils in sediment (e.g. during storms) may also be the cause of incomplete sedimentary infillings. It must be added that partially infilled are mainly fossils buried in coarse-grained sediments.

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Intraskeletal geopetal structures are used in defining the top and bottom according to the assumption that the upper part of the cavities (empty or usually filled with sparry calcite) indicates the top of the bed (Shrock, 1948). It has been repeatedly justified that these structures are usuful in determining the tops and bottoms of rock complexes void of bedding (see Cullison, 1938, Shamov, Hecker, 1966). With the help of the detailed analysis of the orientation of geopetal structures the re-interpretation of geological structure of areas of complicated tectonics has been carried out (Richter, 1968).

The partial infillings are widely used as fossil „Wasserwage" (Richter, 1968) and as depositional paleoslope indicators, too (Broadhourst, Simpson, 1967; Eder, 1971; Playford et al. 1976).

The application of partial sedimentary infillings of fossils in determining of tops and bottom and in solving other geological problems is in the question however and the possibility of mistakes will be taken into account. It is taken for granted that the intraskeletal sediment is lithified during diagenesis before any likely deformations of beds, but it is seldom taken into account that there is the possibility of an early lithification of internal sediment still before or soon after the buryial of a shell in a sediment (Wendt, 1973). The early submarine lithification or carbonate sediments is already well documented (see Bathurst, 1976; Milliman, 1974a, b) and evidence of this is known both from recent environments (Taft et al., 1968; Shinn, 1969) and from ancient ones (Purser, 1969; Kaźmierczak, 1974). Most suggestive are examples of the early lithification of internal sediments infilling the voids in reef structures (Ginsburg, Shroeder, 1973).

The early lithification of carbonate sediments in the shallow water environments is well known but examples of the submarine lithification of deep water sediments are also observed (Fischer, Garrisson, 1967, Gevirtz, Friedman, 1969; Milliman, Müller, 1973, Bathurst, 1974, Schlager, James, 1978). It has been assumed that with suitable parameters of temperature and salinity it is not so much the depth as the very slow sedimentation is the most important factor favouring the lithification of sediments (Milliman, 1974a Milliman, Müller, 1975; Müller, Fabricius, 1971). It is worth mentioning that the lithification of intraskeletal sediments comes about more quickly in comparison with the lithification of the surrounding sediments (Seilacher, 1971) and additionally the intraskeletal spaces filled with sediment may very quickly be filled with aragonite or Mg-calcite (Moberly, 1973; Focke, Gebelein 1978).

If the inner sediment is lithified the gravitational displacement inside the shell is not possible and in the case of the re-deposition of the shell it can be expected that the intraskeletal geopetal structures will be arranged variously, not parallel either to itself or to the bedding.

Thus the possibility of the early lithification of sediments questions the diagnostic value of partial fossil infillings in defining the top and bottom.

A number of examples questioning the unequivocal interpretation of intraskeletal geopetal structures has been provided by stratigraphically condensed sediments of Middle Callovian from Rudno region near Krzeszowice, Cracow Upland. These sediments are well dated stratigraphically, horizontally imbedded and they are normally stratified. The top of beds is shown by stromatolitic structures which are good geopetal structures (Playford et al., 1976). Numerous ammonite shells which occur below the stromatolite bed in marls with Fe-ooids are usually partially filled with carbonate sediment. The geopetal intraskeletal structures sometimes show the diagonal arrangement both in relation to one another and to the surface of bedding (Fig. 1, Pl. 1, figs. 1 - 3) and some of them represent „the reversed geopetal structures" (Pl. 1, fig. 1, 2) which are characterized by the filling of the lower part of the shell by the sparry calcite and the upper part by sediment! The inference that the shells were redeposited after the partial sedimentary infilling and its early lithification, is justifiable.

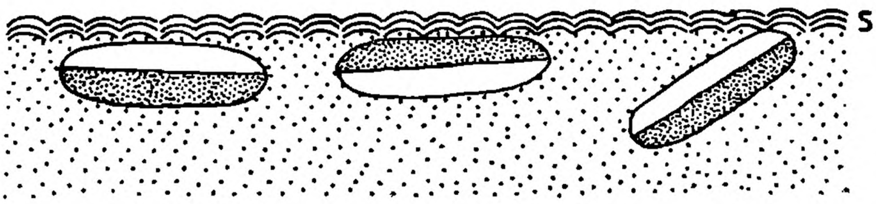

Fig. 1 Diagram showing the relation of geopetal structures in shells of ammonites to the bedding. Middle Callovian, Rudno, Cracow Upland, dense stippling — internal sediment, white — calcite, S — stromatolite layer

Fig. 1. Diagram obrazujący stosunek struktur geopetalnych w muszlach amonitów do uławicenia. Środkowy kelowej, Rudno, Wyżyna Krakowska gęsto punktowane — osad wewnętrzny, bez szrafury — kalcyt, S — struktury stromatolitowe

Still another but particularly suggestive example of the limited application of intraskeletal geopetal structures for defining the top and bottom of beds is shown in fig. 2. In different parts of an ammonite phragmocone from pelagic limestones of the Upper Callovian of Zalas quarry in the Cracow Upland are observed geopetal structures reversed in relation to one another. From different parts of the some phragmocone different stratification of beds can be defined. In this case, the formation of successive generations of interskeletal carbonate sediments was divided by lithification processes and the reversing of shells during their redeposition.

It is noteworthy that shells may be redeposided even under very calm sedimentary conditions in consequence of the burrowing activity of organisms (see Clifton, 1974, Toots, 1965). At last, it must be mentioned that the upper surface of the infillings need not indicate the original horizontal surface. The gravitational displacement of se-

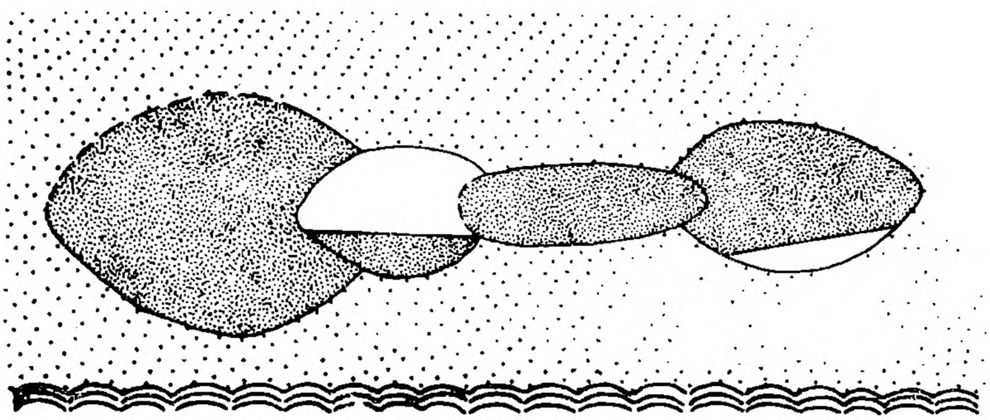

Fig. 2. Geopetal structures in a phragmocone of an ammonite, Upper Callovian, Zalas, Cracow Upland, dense stippling — internal sediment, white — calcite, S — stromatolite layer

Fig. 2 Struktury geopetalne w muszli amonita, górny kelowej, Zalas, Wyżyna Krakowska, gęsto punktowane — osad wewnętrzny, bez szrafury — kalcyt

diment within the shell may be hindered if the inner walls of the shell or the surface of inner sediment are covered by mucilage film (see Sherman, Skipwith, 1965).

Therefore caution is justifiable in the application of intraskeletal geopetal structures in defining the top and bottom and in interpretating the depositional paleoslope.

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STRESZCZENIE

W pracy rozpatrzono geologiczne znaczenie wewnątrzmuszlowych struktur geopetalnych (Sander, 1936; Shrock, 1948) używanych często do określania stropu i spągu warstw zaburzonych tektonicznie (Richter, 1968) oraz sposobu zalegania kompleksów skalnych pozbawionych uławicenia (Cullison, 1938; Shamov, Hecker, 1966). Struktury geopetalne stosowane są też jako kopalne poziomice i służą do określenia pierwotnego nachylenia powierzchni depozycyjnej (Broadhourst, Simpson, 1967; Eder, 1971).

Stosowanie wewnątrzmuszlowych struktur geopetalnych do rozwiązywania problemów geologicznych wymaga jednak dużej ostrożności. Na ogół uważa się, że osad wypełniający częściowo muszle ulega lityfikacji w procesie diagenezy przed ewentualnymi tektonicznymi deformacjami warstw, ale rzadko brana jest pod uwagę możliwość wczesnej lityfikacji osadu wewnętrznego jeszcze przed pogrzebaniem lub wkrótce po pogrzebaniu muszli w osadzie (Wendt, 1971).

Wczesna podmorska lityfikacja osadów wapiennych dobrze już udokumentowana zarówno w środowiskach płytkowodnych (Shinn, 1969; Ginsburg, Schroeder, 1973; Bathurst, 1976) jak i głębokowodnych (Milliman, Müller, 1973) podważa diagnostyczną wartość wewnątrzmuszlo-

wych struktur geopetalnych do określania stropu i spągu warstw. W przypadku redepozycji muszli częściowo wypełnionych osadem już zlityfikowanym struktury geopetalne nie muszą być równoległe ani do siebie, ani do uławicenia (fig. 1). Szereg takich przykładów, w tym „odwrócone struktury geopetalne" (osad znajduje się w górnej części muszli zamiast w dolnej!) zostały stwierdzone przez autora w osadach środkowego i górnego keloweju w rejonie Krzeszowic (fig. 1, 2, Pl. 1, Fig. 1-3).

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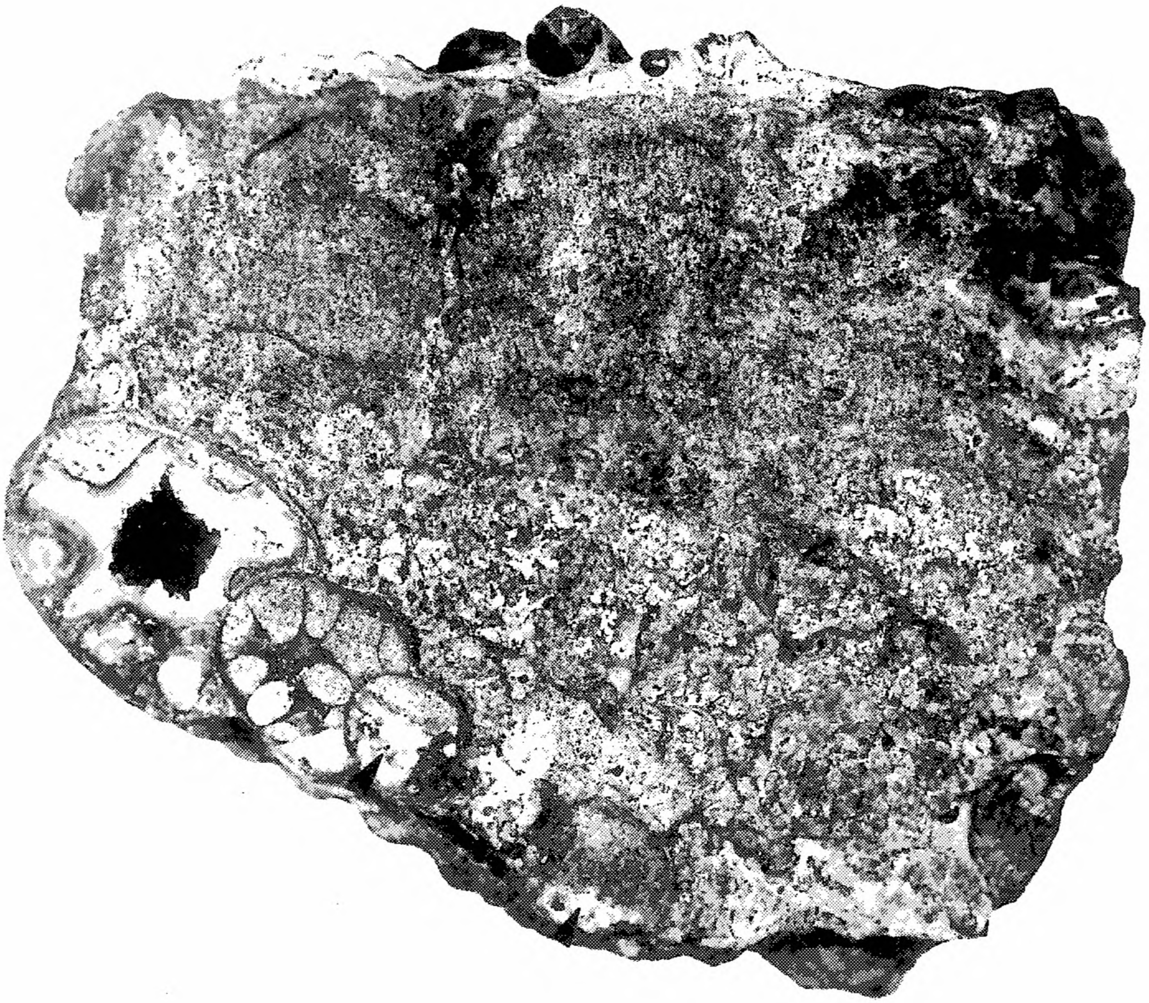
OBJAŚNIENIA PLANSZ — EXPLANATION OF PLATES

Plate — Plansza I

Fig. 1—3. Shells of ammonites (Pseudoperisphinctidae) geopetally infilled by sediments. Arrows indicate the parts of shells filled with spary calcite. Visible stromatolitic structures encrusting the shells of ammonites. Middle



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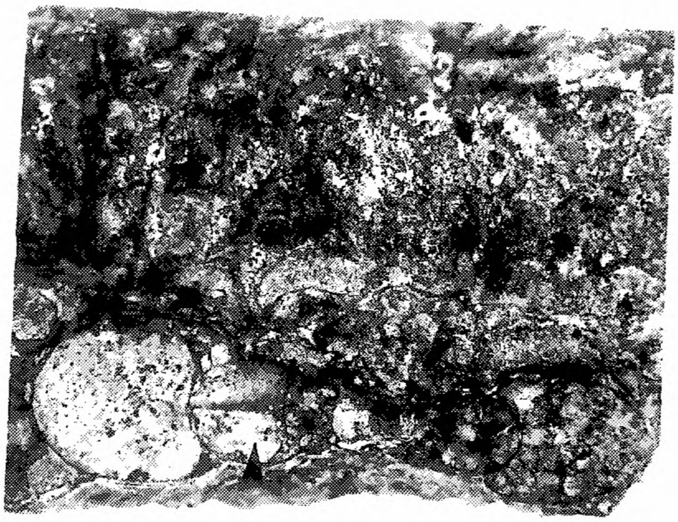

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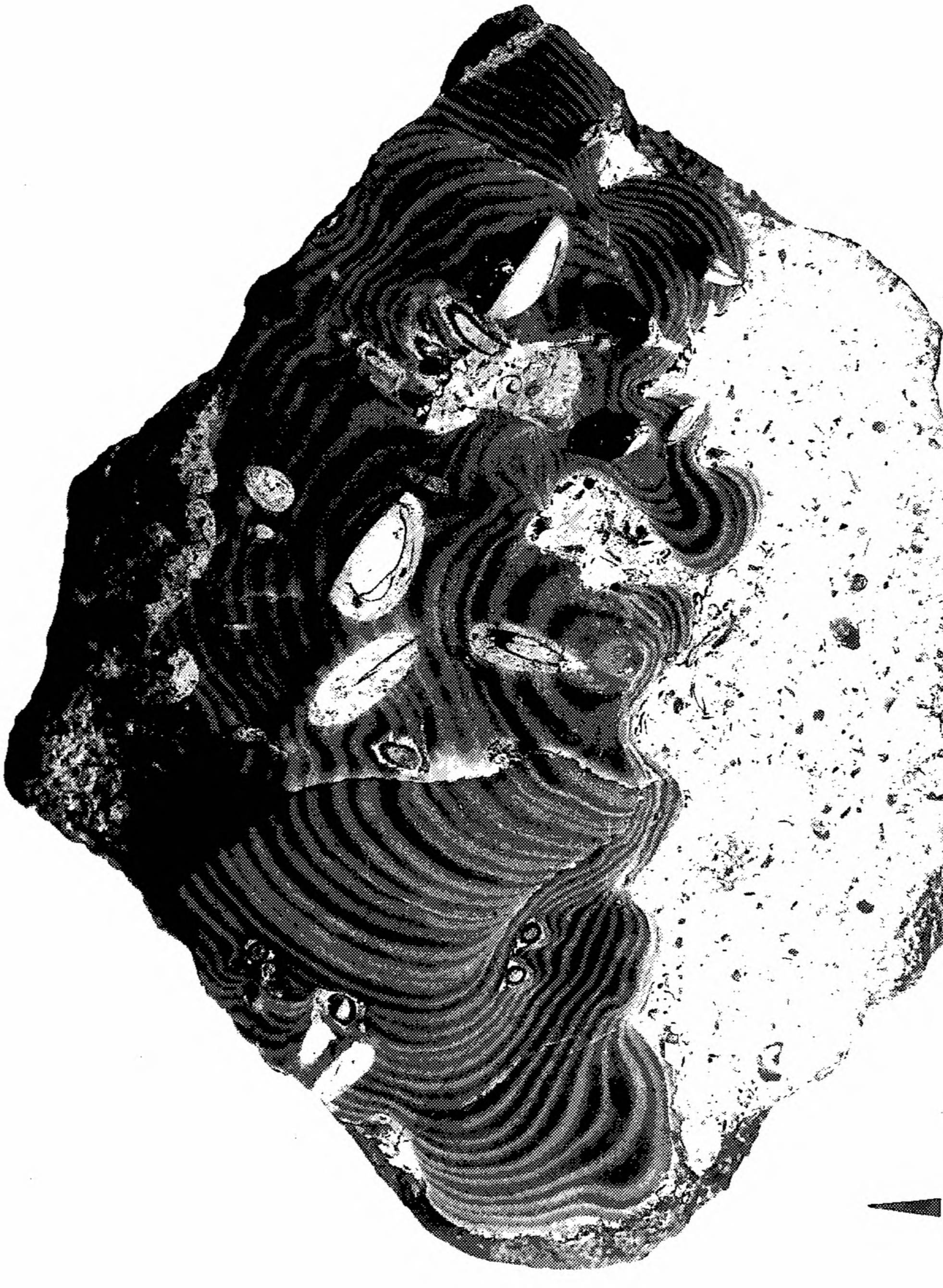

Callovian, Rudno, Cracow Upland. Natural size. 1—2 „reversed geopetal structures"; 3 — normal geopetal structure

Fig. 1—3. Muszle amonitów (Pseudoperisphinctidae) ze strukturami geopetalnymi. Strzałki wskazują partie muszli wypełnione kalcytem. Widoczne struktury stromatolitowe inkrustujące muszle amonitów. Środkowy kelowej, Rudno, Wyżyna Krakowska, wielkość naturalna. 1—2 „odwrócone struktury geopetalne"; 3 — normalna struktura geopetalna

Plate — Plansza II

Geopetal structures in lithophags borings cutting the structures of solenoporacean algae

Geopetalne struktury w wydrążeniach małży-skałotoczy przecinających struktury glonu z nadrodziny Solenoporacea

Photo by K. Fedorowicz