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Regeneration of some brachiopod shells

ABSTRACT: Traces of regenerated damages are displayed by some shells of terebratuloid brachiopods, *Cancinithyris biplicata* (Sowerby), from the Albian of Annopol-on-Vistula. Two main types of regeneration are distinguished: one, involving concentrical accretion of new shelly matter, and another, in which regenerating layer is simultaneously accreted on both sides of a damage, and forms a regenerational suture; the regeneration of the transitional type is also possible.

INTRODUCTION

Some specimens of *Cancinithyris biplicata* (Sowerby) with traces of regeneration of damages (Text-fig. 1 and Pl. 1) were found in a rich assemblage of Albian brachiopods (*cf.* Popiel-Barczyk 1972) collected by Dr. R. Marcinowski at Annopol-on-Vistula, Central Poland. The capability of brachiopods to regenerate shell damages has hitherto been reported only by several authors (Ivanova 1949, Sarycheva 1949, Williams & Rowell 1965). More attention was paid to the process of regeneration in mollusks (*cf.* Mutvei 1964), in which the damages are usually attributed to the activity of predators (*e.g.* Papp & *al.* 1947, Papp 1949, Radwański 1969, Bishop 1975).

The size of regenerated damages is highly variable in the material studied, ranging from small fragments of the shell margin to large parts of the shell (Pl. 1, Figs 1—5). The variability in shape and size of the damages suggests that they were caused by mechanical agents which played an important role in the formation of the phosphorite-bearing Albian deposits of the Annopol section as well as of these from other parts of Poland (*cf.* Radwański 1968, Marcinowski 1974).

MORPHOLOGY OF REGENERATED SHELLS

In the material collected, two types of shell regeneration, differing in the mode of accretion of successive healing layers, are distinguishable.

The first type is revealed by regeneration of minor (Pl. 1. Figs 1—2) or medium-size damages (Pl. 1. Fig. 3 and 3*a*) through gradual healing by accretion of shelly matter in direction towards the center of the damage. Some differentiation in the rate of accretion along the front of regeneration is recognizable (Text-fig. 1*A*-*B*). Generally, the smaller the distance to undamaged margins of commissure, the lower the rate of accretion. In that type the reduction in number of mantle cells producing calcite fibres is interpreted as necessitated by gradual reduction of the front of regeneration during the repair of the shell loss.

The second type is revealed by regeneration of larger damages through more or less uniform accretion of new layers of shell on both

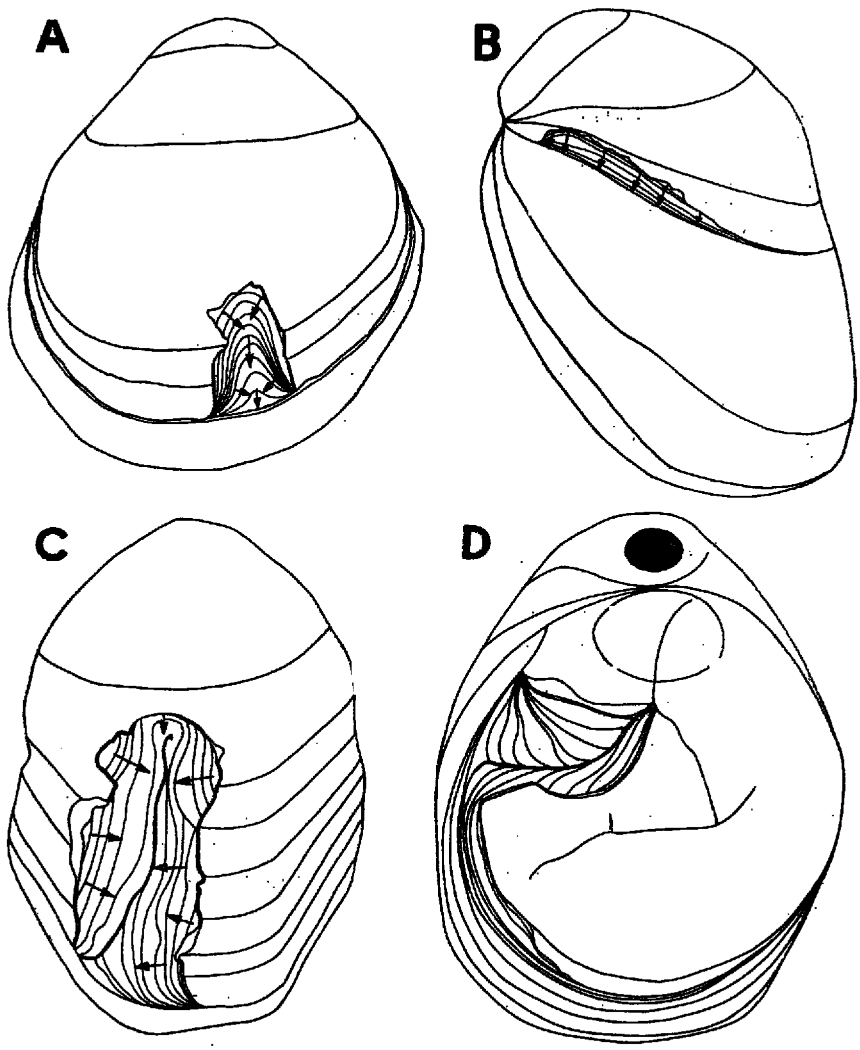
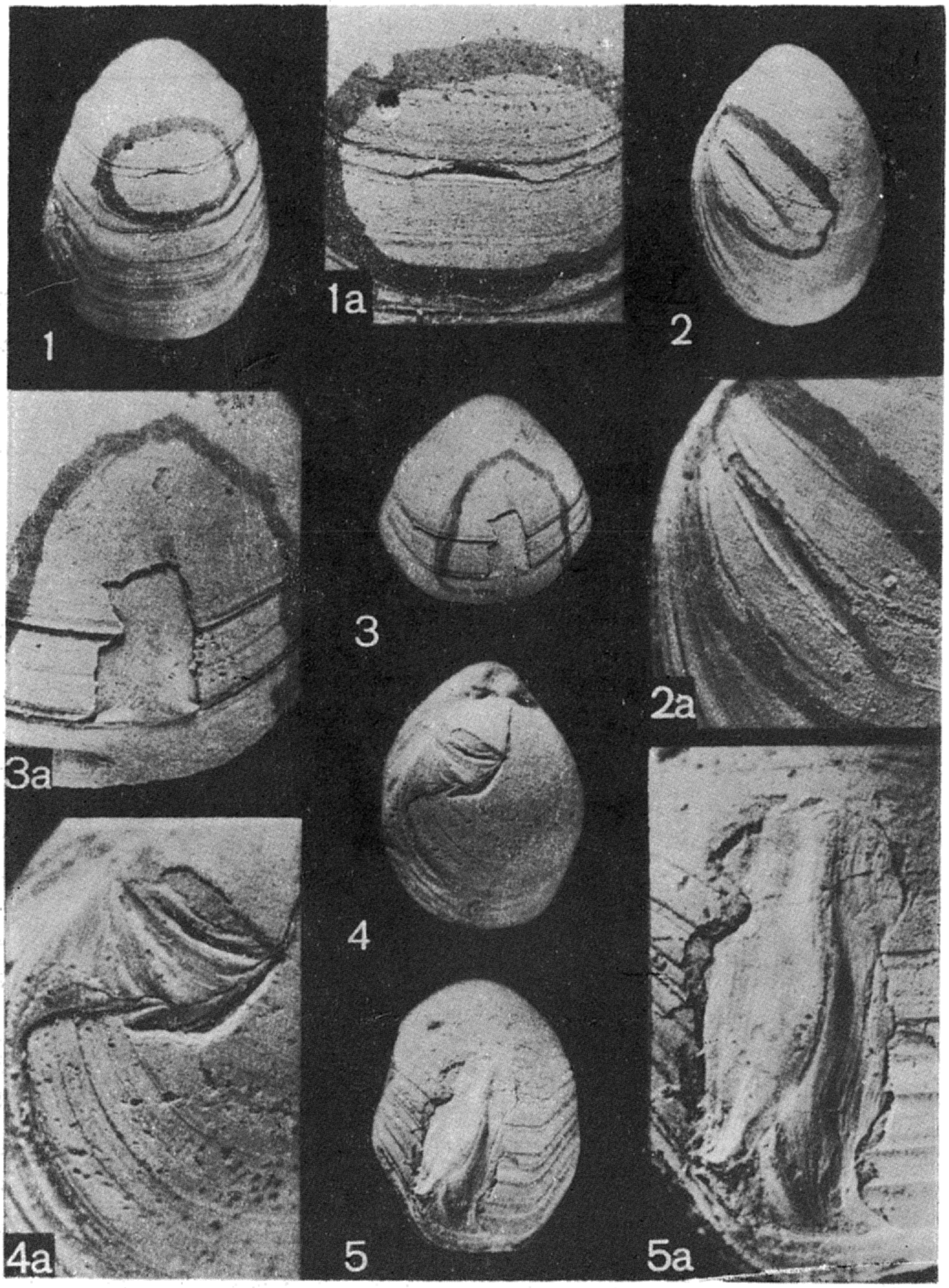
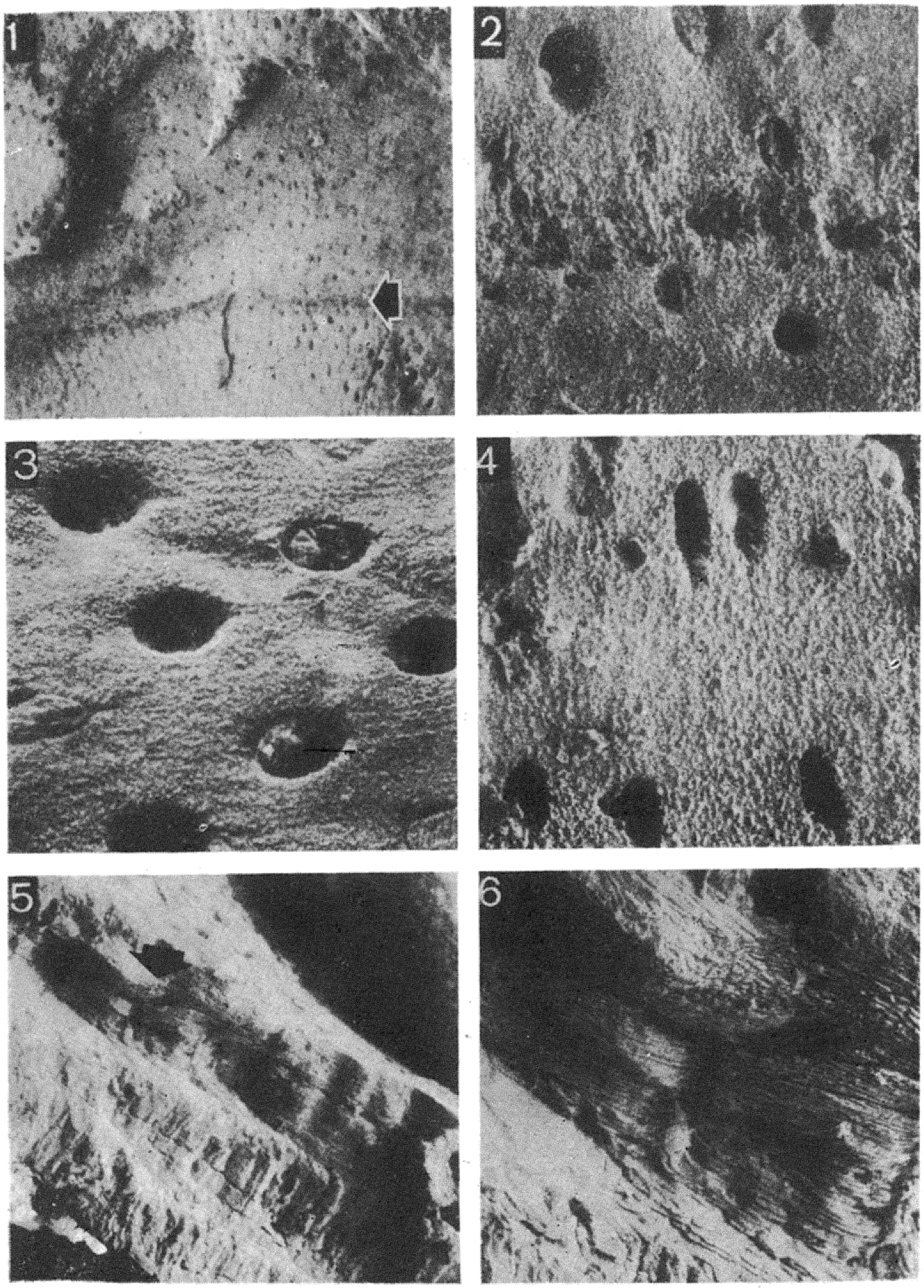


Fig. 1. Schematic outlines of the regenerated damages in shells of *Cancinithyris biplicata* (Sowerby) from the Albian at Annopol-on-Vistula; the arrows indicate growth direction in regenerated damages

The specimens are presented by photos in Pl. 1 (opposite page), as follows: A Pl. 1, Fig. 3, 3a; B Pl. 1, Fig. 2, 2a; C Pl. 1, Fig. 5, 6a; D Pl. 1, Fig. 4, 4a



1–5 — Shells of *Cancinithyris biplicata* (Sowerby) [magnified twice] from the Albian at Annopol-on-Vistula, and their regenerated parts (magnified × 5 in figures indicated *a*).



SEM photos of shell fragments of *Cancinithyris biplicata* (Sowerby) from the Albian at Annopol-on-Vistula

1 regenerated fragment of the shell, × 30 (arrowed is the part magnified in Fig. 2); *2* fragment of the growth line (arrowed in Fig. 1), × 300; *3* surface of non-destroyed shell, × 300; *4* surface of regenerated shell, × 300; *5* chip of the shell at the regenerational suture (arrowed), × 100; *6* close-up view of the part arrowed in preceding figure, × 300 sides of the shell loss (Pl. 1, Fig. 5 and 5*a*). The accretion here leads to origin of regenerational suture (Text-fig. 1*C*).

There is also possible a transitional type of regeneration, connected with nonuniform and independent accretion of shell matter on both sides of the loss towards its center (Text-fig. 1*D* and Pl. 1, Fig. 4, 4*a*); it is also leading to the development of the regenerational suture.

The length of the regeneration front does not change throughout the regeneration of the second or the transitional type. This may have some influence on the rate of healing the damage, providing that the rate of secretion is proportional to the number of $CaCO_3$-secreting cells.

MODE OF REGENERATION

Regenerated damages are situated in various places on ventral or dorsal side of the shells studied (Pl. 1, Figs 1—5). Attention should be paid that the regeneration also appears in the case of very large damages connected with large loss of the shell (Pl. 1, Fig. 5, 5*a*) and even of those situated in places of attachment of retractory muscles (Pl. 1, Fig. 4, 4a).

Damage and loss of a fragment of the shell is always accompanied by destruction of a corresponding part of the mantle fold together with its generative zone. The regenerated part of the shell is characterized by less numerous, often smaller and somewhat randomly arranged pores (Pl. 2, Figs 1—4). This may indicate that intensification of shell regeneration takes place at the expense of other processes of the shell development. Some changes in shell microstructure marked at the growth lines (Pl. 2, Fig. 2) are presumably related to those in generative zone of the mantle (*cf.* Dunlop 1961, Sass & Manroe 1967). The period of regeneration is connected with a cessation of growth on the whole shell (Text-fig. 1*A-D*) which may indicate that: (*1*) the regeneration was proceeding very rapidly, (*2*) the shell growth was retarded for the time required for complete regeneration of the lacking fragment, or, which is also possible (*3*) that both the shell growth was impeded and the regeneration was very rapid. When the lacking shell fragment had been supplemented, the further shell growth continued normally. There are no greater differences in microstructure of normal and regenerated shell layers, both in character and thickness of the primary layer as well as in structure of the prismatic layer (Pl. 2, Figs 5—6).

The further study of regeneration processes in brachiopods may certainly be instructive for the recognition of both their life conditions, as well as of their teratological embarassments.

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REGENERACJA MUSZLI U ALBSKICH BRACHIOPODÓW *CANCINITHYRIS BIPLICATA* (SOWERBY) Z ANNOPOLA NAD WISŁĄ

(Streszczenie)

Przedmiotem pracy jest analiza zregenerowanych uszkodzeń muszli (*por.* fig. 1 oraz pl. 1—2) u brachiopodów *Cancinithyris biplicata* (Sowerby) występujących w fosforytonośnych utworach albu w Annopolu nad Wisłą. Wśród badanych okazów wyróżniono dwa typy regeneracji. Pierwszy, wykazujący koncentryczny przyrost warstwy regenerującej (fig. 1*A-B* oraz pl. 1, fig. 1—3), oraz drugi, w którym warstwa regenerująca przyrasta po dwóch stronach uszkodzenia równocześnie (fig. 1*C* oraz pl. 1, fig. 5); oba wyróżnione typy mogą się również kombinować (fig. 1*D* oraz pl. 1, fig. 4). Badane uszkodzenia muszli brachiopodów przypisać należy czynnikom hydrodynamicznym.
