| Riv. It. Paleont. Strat. | v. 98 | n. 3 | pp. 325-338 | Novembre 1992 |
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# PHOTOGRAPHY: A CONVENIENT TECHNIQUE FOR RECORDING SERIAL TRANSVERSE SECTIONS OF BRACHIOPODS

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*Key-words*: Brachiopods, Techniques, Methods, Photography.

*Riassunto.* Le sezioni seriali trasversali, insostituibile strumento conoscitivo dei caratteri interni dei Brachiopodi quando le valve della conchiglia non si possono disarticolare, sino ad oggi sono state rappresentate attraverso disegni. La tecnica grafica però non permette una corretta e fedele riproduzione dei caratteri interni, perchè si avvale di strumenti ottici (camera lucida, projectina) e della presenza di un operatore, quindi di elementi che operano una filtrazione dell'immagine riducendone la veridicità. Anche la scelta del tipo di disegno può costituire un ulteriore filtro. Con questo tipo di tecnica inoltre non viene riprodotta la matrice in cui le strutture interne sono conservate, impedendo così di capire se la mancanza di un carattere sia imputabile a fenomeni diagenetici o se effettivamente l'esemplare ne sia privo.

Per questi motivi viene proposta un'altra tecnica per rappresentare i caratteri interni dei Brachiopodi: la fotografia. I vantaggi che si ricavano da questa metodologia, per altro già utilizzata nella rappresentazione di altri gruppi di Invertebrati, sono notevoli.

Oltre ad ottenere una nitida e reale riproduzione dei caratteri interni, la fotografia permette di analizzare altri dati relativi all'ultrastruttura della conchiglia e all'ontogenesi delle strutture; consente di distinguere con più chiarezza gli elementi penetrati nella cavità interna durante la diagenesi che, in sezioni seriali trasversali, si possono confondere per dimensioni e posizione con le strutture interne del guscio. Da ultimo, ma non banale, la tecnica fotografica comporta tempi e costi nettamente inferiori rispetto alla tecnica grafica.

*Summary.* A review of the bibliography coupled with the Authors' personal experience shows that drawing, as a technique for recording serial transverse sections of Brachiopods is inadequate and inaccurate. Especially structures such as the brachidium, septalium, but also cardinalia, even in optimal state of preservation can be drawn only imprecisely: more so where diagenesis has occurred. Further, drawing always involves filtering data, thus altering the original information. For this reason we are opting for photography as a far truer and more accurate technique than drawing for recording serial transverse sections of the internal structures of Brachiopoda.

## Introduction.

The importance of the investigation of the internal characters in taxonomic studies of the phylum Brachiopoda is beyond dispute, hence the need for them to be

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- Financial support from MURST 60% (N. Fantini Sestini).

correctly recorded for accurate legibility and comparison.

Clearly, this is not a problem when shells can be disarticulated, thus permitting immediate analysis of the internal characters that have been preserved; it can become so in the case of whole shells whose internal characters are known through acetate peels of serial transverse sections.

The Authors do not dispute serial transverse sections as a method for investigating internal structures, a method whose value is universally acknowledged; nor the technique for taking them, already widely discussed by several Authors in the past and recently reviewed in detail by Sandy (1986); what they are arguing in this paper is the technique by which such sections are recorded. A brief historical review shows that both in the past (eg. Suess, 1854; Bittner, 1980) and up to the present time internal structures have been represented by drawings.

In reviewing the genus *Diplospirella* (Benigni & Ferliga, 1990), the Authors found graphic representation inadequate, insofar as it did not permit the characters observed to be accurately recorded; thus they decided to adopt an uncommon technique: the direct reproduction of a series of photographs of peels. Subsequent experience (Benigni & Ferliga, 1992) has now induced the same Authors to suggest this technique as a standard method of representation.

The illustrations in this article are from papers by the present Authors; each illustration compares a drawing made through a projectina, with an equivalent enlargement of a photograph of the same peel.

**Drawing technique: disadvantages.**

The drawing of serial transverse sections involves the aid of optical apparatuses (camera lucida, projectina) that permit the tracing of the internal structures of Brachiopods. This is not in itself a disadvantage; however, with these apparatuses there is perforce a loss in crispness of image which obstructs a clear reading of the characters.

The worker tracing the image is already at a disadvantage, insofar as he is receiving a prefiltered stock of data. This disadvantage increases according to the state of preservation of the specimen. With equal apparatuses, a well-preserved shell with dark micritic infilling, in which the internal calcite structures can be seen to emerge sharply, is more legible than a specimen whose internal morphology is blurred by a mosaic of calcite crystals.

Whatever the apparatus used, the need for a worker to trace the magnified image of the peels on to a paper support is a disadvantage, since he may be filtering information dependent upon the state of preservation of the specimen.

Infact, there are simple, but massive structures, such as muscle scars and cardinal processes that are easily recognizable and rarely damaged or broken during diagenesis, thus well preserved and easy to draw. Often, they require no interpretation, the drawing providing an effective image of the structure itself. Conversely, more fragile structures such as the brachidium are easily damaged and frequently crushed with frag-

ments scattered in the infilling sediment of the shell. Here, drawing can only partially record, or may not even record them at all, without resort to inference. Even the use of broken lines or question marks, symbols that in any case are not codified, is not a sufficiently clear pointer to the real condition of the specimen.

Again, filtering may be the result of the choice of type of drawing. If, as stated by Sandy (1986), inked-in drawings point up the morphology and spatial relations of individual components, line drawings also point up particular characters of the ultrastructure, such as the arrangement of the fibres of the shell and of the cardinal region. Clearly, the latter technique yields a greater number of data, hence the quantity of information is dependent upon the worker's subjective selection.

A further limitation to drawing as a recording technique is that it is virtually impossible to show the infillings of the shell thereby losing information regarding the diagenetic processes to which the specimen has been subjected. The absence of such data makes it impossible to understand if the lack of a structure is attributable to diagenetic phenomena (recrystallization, dissolvement, formation of the internal mould) or to an objective absence of diagenesis. Ultimately this, too, filters the image, as regards elimination of data (Tab. 1).

## Practical problems related to drawing.

The foregoing refers solely to problems related to investigational methods. There are also "practicalities" connected with having to publish the datum.

The drawing obtained through the use of optical apparatuses is a pencil "sketch"; to arrive at the finished product in print requires several stages and reductions from the original magnified image, thereby often reducing clarity and obscuring the smallest details. Further, such steps imply a degree of drawing skill on the part of the investigator, or the need to enlist the services of a professional artist with a knowledge of paleontology. In either case, this results in a loss of time; the use of a specialized artist also involves additional costs.

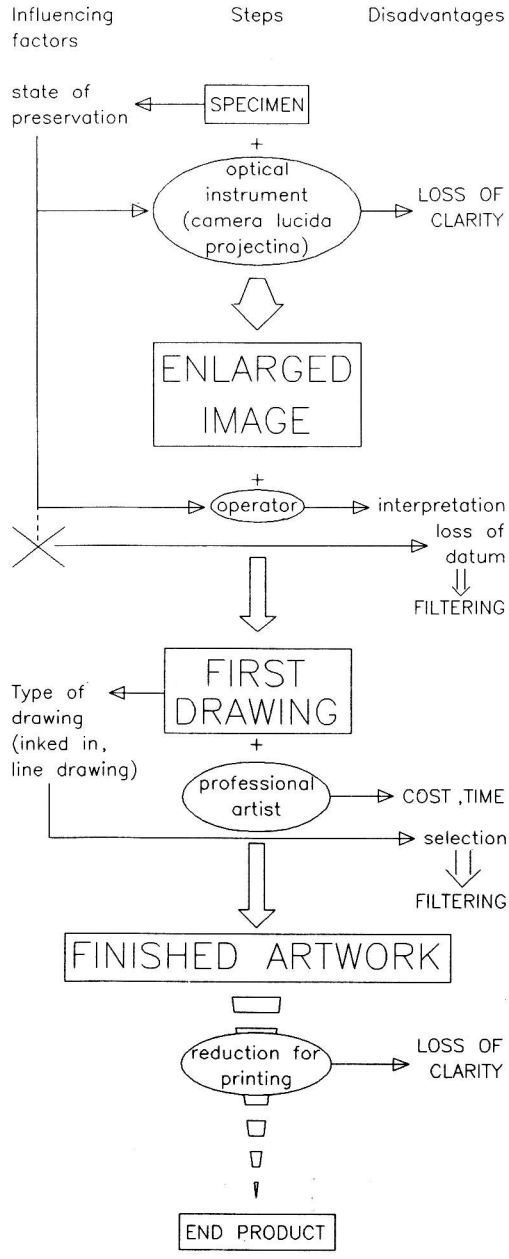
## Photography vs drawing.

Photography of peels permits the different morphological characters to be recorded more clearly and to advantage, than can be done by drawing. The morphological characters to be investigated are those most likely to undergo filtering; since they are taxonomically significant, it is desirable for them to be accurately recorded.

### a) Teeth, septa.

Teeth and septa are structures which, as mentioned earlier, are fairly legible through optical apparatuses, usually more clearly through a camera lucida than with a projectina.

A review of the bibliography (Dagys, 1974; Alméras & Moulan, 1988) shows, however, that the projectina rarely allows accurate recording of the articualr space between teeth and dental sockets. Fig. 1 (peel from Benigni, 1978) is a significant example.




Tab. 1 - Sequence of steps for drawing peels.

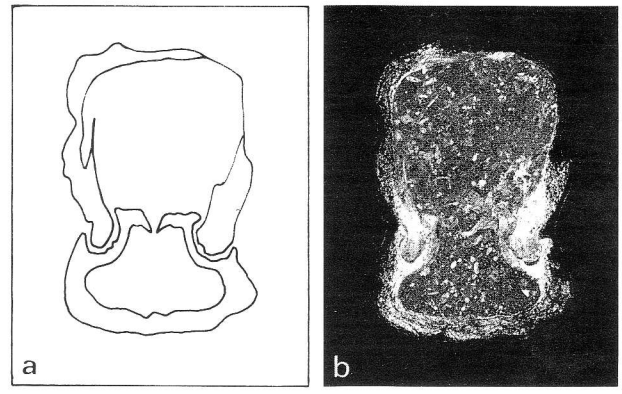



Fig. 1 - *Prionorhynchia palmaeformis* (Haas). Peel from Benigni (1978) at 2.3 mm from the umbo. The spatial relationship between teeth and dental sockets is truer and more accurate in the photograph (b) than in the corresponding drawing (a); x 5.

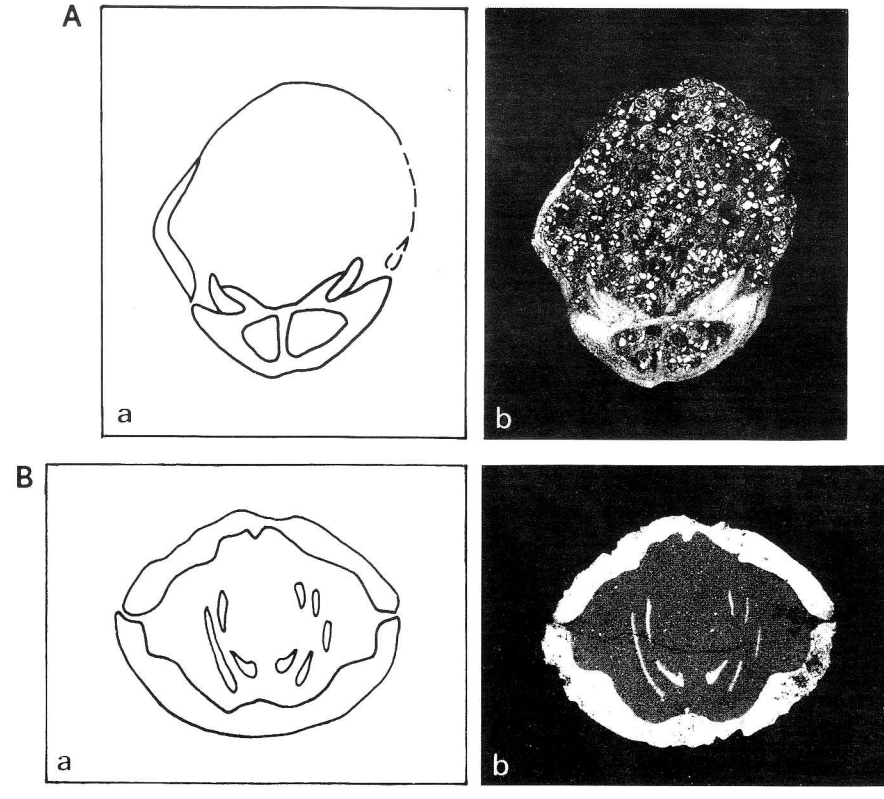



Fig. 2 - A) *Zeilleria rostellata* Kitchin. Peel from Alméras, Benigni & Tintori (1991) at 4.30 mm from the umbo. In the drawing (a) a continuous course of the septum has been inferred owing to the nature of the infilling sediment, whereas even at that distance, the photograph (b) shows a septum detached from the cardinal plates; x 4.2.
B) *Diplospirella wissmanni* (Münster). Peel from Benigni & Ferliga (1990) at 4.50 mm from the umbo. Unpublished drawing (a) in which presence of septum is confused with shell thickness. Compare with photograph (b) of same structure pointing up exact morphology and extension of septum; x 5.6.

The illustration of the median septum as obtained through the projectina in brachiopod valves does not always permit recording global, complete development. Examples of this are *Zeilleria rostellata* Kitchin, 1900 in Alméras et al. (1991) (Fig. 2A), *Diplospirella wissmanni* (Münster, 1841) in Benigni & Ferliga (1990) (Fig. 2B) and *Ivanoviella gaetanii* Alméras, Benigni & Tintori, 1991, in Alméras et al. (1991) (Fig. 6).

b) Septalium.

In this case, the problem of graphic representation is related to the slenderness of the structure, hence to the difficulty of defining the outline, especially the point of contact where it is buttressed by the median septum. On the contrary, photography disposes of this problem (Fig. 3).

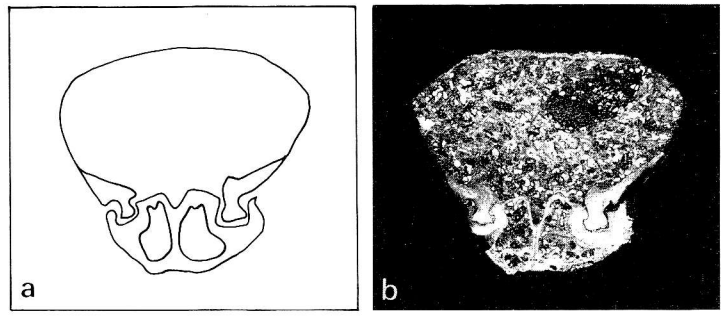



Fig. 3 - *Septaliphoria zacharlensis* Prosorovskaya. Peel from Alméras, Benigni & Tintori (1991) at 2.75 mm from the umbo. Contiguity of septalium and septum, the margins of the septalial plates, and the thickness of the septalium as a whole are not clearly rendered in the drawing (a); further the morphology of the teeth is not faithful. All the above structures are more clearly legible in the photograph (b); x 2.5.

c) Brachidium.

As already stated, the fragility and slender structure of the brachidium do not make for easy preservation, nor for easy reading from peels. In the case of "complex" brachidia, that is, spiralled, with one or two lamellae and a jugum, the projectina will usually give a clearer record only of that portion closest to the cardinalia, that is, crural bases and crura. The distal part, slender and totally incorporated in the infilling of the shell is more or less visible through optical apparatuses, depending on the contrast provided between the structure itself and the infilling sediment. To cite an example, the specimen of *Thecospira tyrolensis* (Loretz, 1875), reproduced in Benigni & Ferliga (1989): in the lateral portions, the spiral cone contrasts with the dark, micritic infilling, hence it can also be viewed through a projectina; in the central area, instead, the brachidium is blurred by the recrystallized infilling sediment, hence not revealed by the optical apparatus (Fig. 4).

On the other hand, even if the contrast structure/infilling is optimal, the

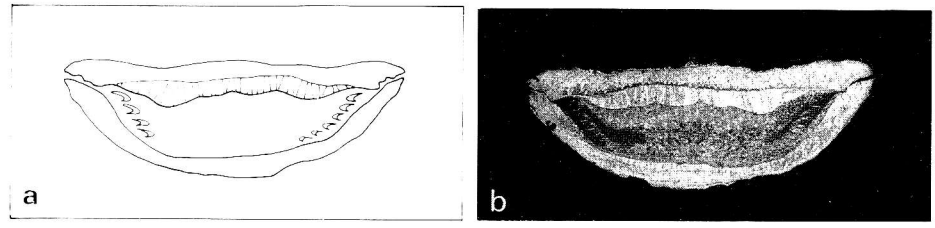



Fig. 4 - *Thecospira tyrolensis* (Loretz). Peel from Benigni & Ferliga (1989) at 7.2 mm from the umbo. The drawing (a) is an example of partial reading of data. The spiralia have been observed only laterally where the contrast between structure and infilling is sharp. The photograph (b) records the entire development of the spiralia; x 4.

slenderness and complexity of the brachidium may make it difficult to record it accurately. It is precisely the complexity of the jugum of *Diplospirella wissmanni*, with is thin apophysis and spines (Fig. 5) that induced the Authors to take photographs of the internal characters (Benigni & Ferliga, 1990).

Photography is an advantage not only for spiralled brachidia, but also for loop and crura. In particular, if the crural bases are very small (Fig. 6) they are not perceived through the projectina; this is not a problem with photography.

### d) Outline and thickness of valve.

The presence of a calcitic area in the internal mould, hence the virtual lack of contrast with the shell makes it hard to detect the outline of the internal surface of the valve. With drawing, there is a risk of either showing inexistent ridges and an erroneous shell thickness, or of omitting relevant data (Fig. 7).

## Photography: additional data.

In some cases, the use of photography yields additional data on particular characteristics; although such data may not be determining for systematic classification, they can often contribute significantly to a greater understanding of the specimen. Some examples:

### a) Ultrastructure.

A line drawing, at most can show the arrangement of the fibres in the secondary layer, whereas photography enables even the type of layer to be recorded, thus supplying evidence of the layers that have been preserved, and sometimes of other structures, such as punctae. These are significant data, especially in the present state of the art, since the ultrastructure is a very good basis for taxonomic classification. Thus, in investigations where this aspect is not uppermost, information on the ultrastructure of the shell, even in transverse sections, can be an invaluable aid for understanding taxa.

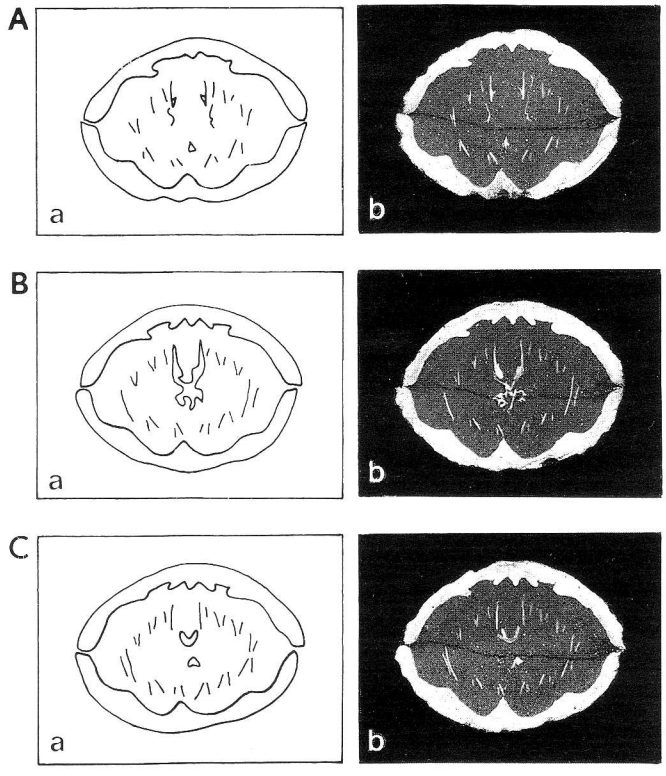



Fig. 5 - *Diplospirella wissmanni* (Münster). Same specimen as in Fig. 2. A) Peel at 5.70 mm from the umbo. Drawing (unpublished) (a) does not reveal presence of spines on lateral branch of jugum, which are recorded in the photograph (b).
B) Peel at 6.05 mm from the umbo. The complexity of the jugum with lateral and ventral apophyses is not perceived in the drawing (unpublished) (a). Further, the drawing technique does not permit illustration of the thickness between the components of the jugum. C) Peel at 6.22 mm from the umbo. Again, the drawing (unpublished) (a) does not show the dorsal apophyses, obscured by the closeness of the primary lamellae; x 4.

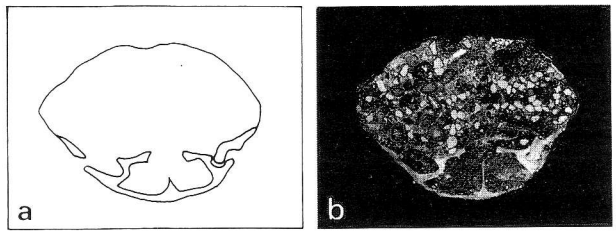



Fig. 6 - *Ivanoviella gaetanii* Alméras, Benigni & Tintori. Peel from Alméras, Benigni & Tintori (1991) at 1.70 mm from the umbo. In this specimen the crural bases are too small to be revealed by the projectina (a); likewise, the whole course of the median septum has not been rendered; x 2.5.

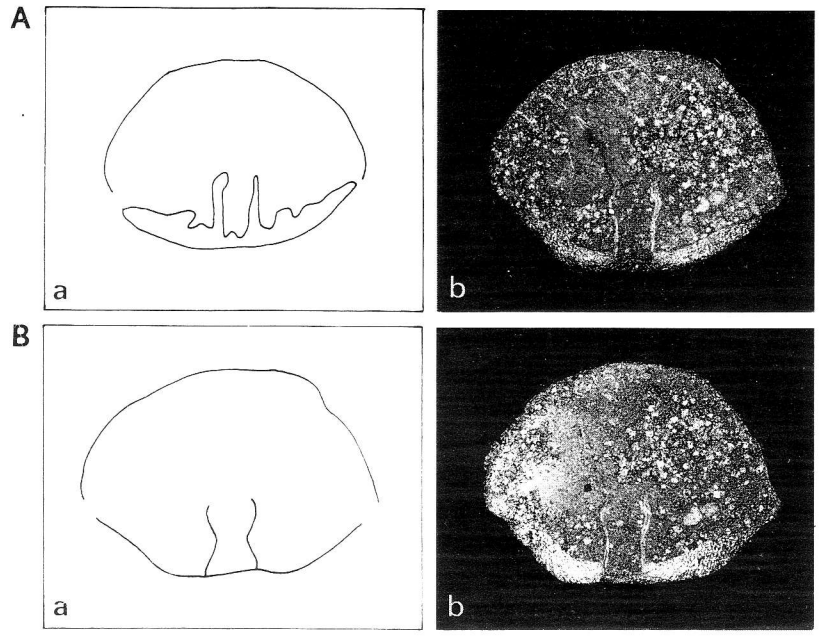



Fig. 7 - *Septocrurella rovedana* (Benecke). Peels from Benigni, Casati & Pirini Radrizzani (1982). A) 2.65 mm from the umbo. Lack of contrast between shell and infilling sediment has precluded drawing a precise outline of the shell; (a) clusters of crystals have thus been taken as part of the shell, inferring the presence of ridges. Compare with photograph (b), which shows up the contrast between shell and infilling; x 5. B) 2.75 mm from the umbo. Since the thickness of the shell is not perceptible, again, only the valve margin has been illustrated, a drawback overcome in the photograph; x 5.

b) Ontogenesis.

To be able to record, and not just sketch the actual development of the shell fibres is of special importance in the umbonal region, which coincides with the first stages of growth. Infact, as already noted by Baker (1988), where there has been no reabsorption in this region, the arrangement of the fibres in the secondary layer preserves traces of the internal structures of the neanic stage buried under successive fibres. These data are far from banal: whilst not essential for taxonomic purposes, they can still be used in further investigations. Fig. 8 (unpublished peel) is a clear example.

c) Doubtful cases.

In many cases, the infilling sediment, on observation, reveals extraneous fragments which have found their way in during burial, areas of recrystallization with blurred outlines, crusts of cement, late microfractures, which makes it even more difficult to effectively identify the characters of the brachiopod through the projectina, thus having to rely on inference. Photography faithfully records these characters, this way clarifying the situation.

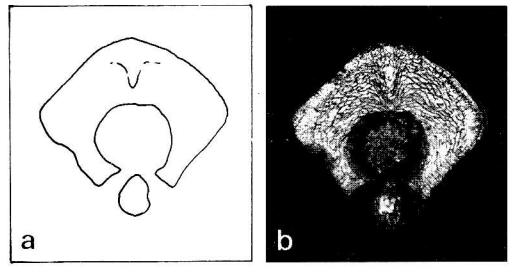



Fig. 8 - *Amphitomella hemisphaeroidica* (Klipstein). Peel from Benigni & Ferliga (investigation in progress) at 1.20 mm from the umbo. The arrangement of the fibres of the secondary layer cannot be distinguished through the projectina, hence the drawing (a) does not point up the relationship between median septum and covering fibres; x 12.5.

In this respect we cite the example of *Piarorhynchia* sp. (peels unpublished) (Fig. 9): the specimen shows infilling consisting of large calcite crystals, very light in color, with no contrast at all provided with the shell. In the dorsal area of the brachial valve there are two isodiametric crystals in a position corresponding to that of the crura, whose continuity can be seen in a succession of peels (Fig. 9a). These can be inferred as:

1) perfectly well preserved crura on which calcite crystals (cement) have grown;

2) random, but symmetrical arrangement of calcite crystals occurring during diagenesis (recrystallization).

In drawing these, possible options are (Fig. 9b-d):

b) to draw only the two calcite crystals in a significant position, inferring they are crura;

c) not to draw anything at all in the internal structure, this way losing the "filtered" datum;

d) more objectively, to draw all the visible items, not an easy task.

By photographing the peel, an objective image is infact obtained, leaving the way open to all manner of inference.

**Technical notes.**

The photographs included in this article were taken with a Wild M420 light microscope connected to a Wild MPS51 photocamera with autoexposure controlled by an MPS55 Wild Photoautomat exposure meter. A 125 ASA black and white film was used; as is known, greater sensitivity increases the "grain" of the image; less sensitivity may yield better results but, as it requires longer exposure, may reveal a blurred image. Only with very clear specimens, where the nucleus has recrystallized hence it is transparent, can this type of film be used successfully.

Exposure never exceeds 10" and the diaphragm of the microscope must always be left semi-open. The specimen is illuminated from below (transmitted light). Only in

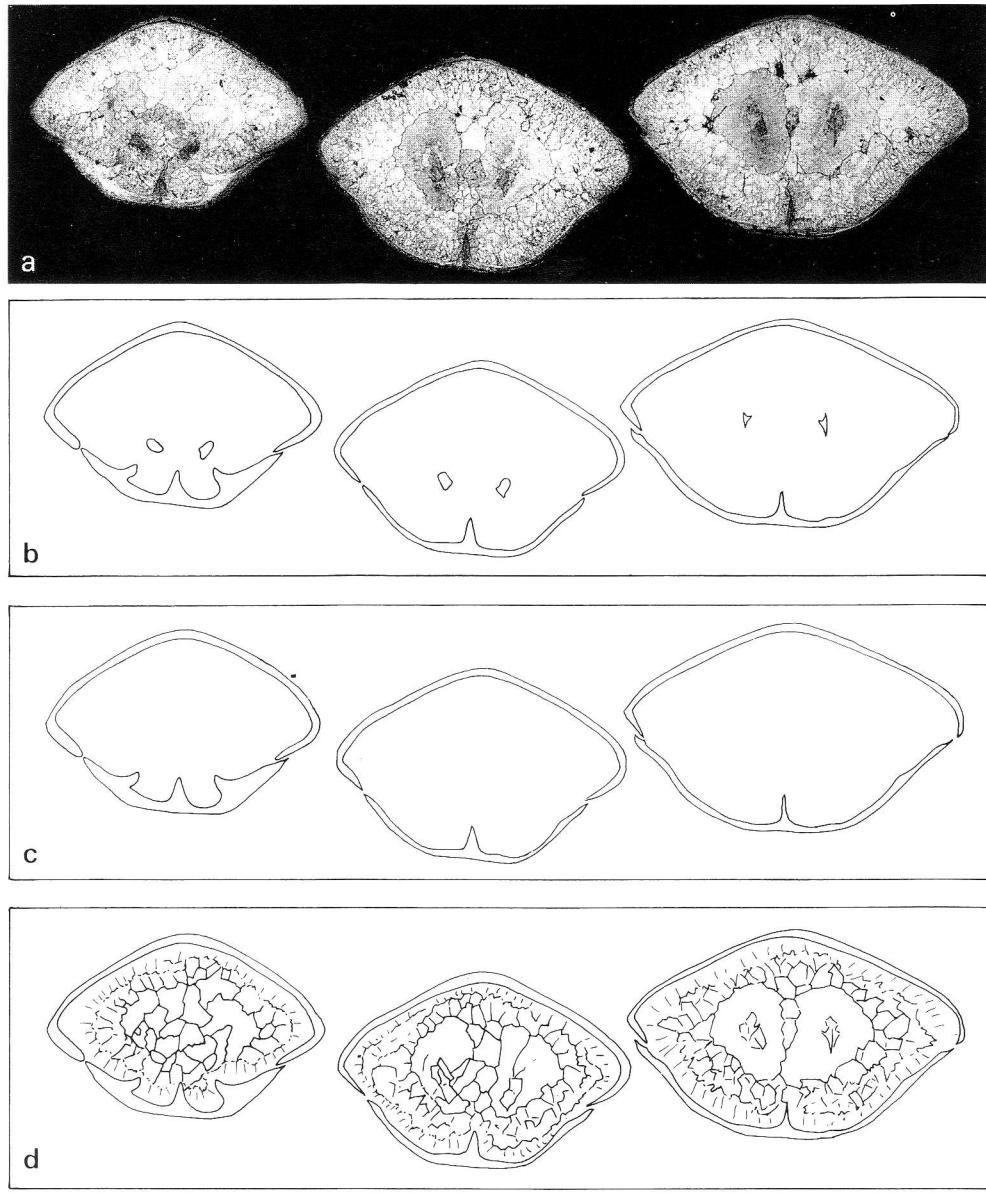


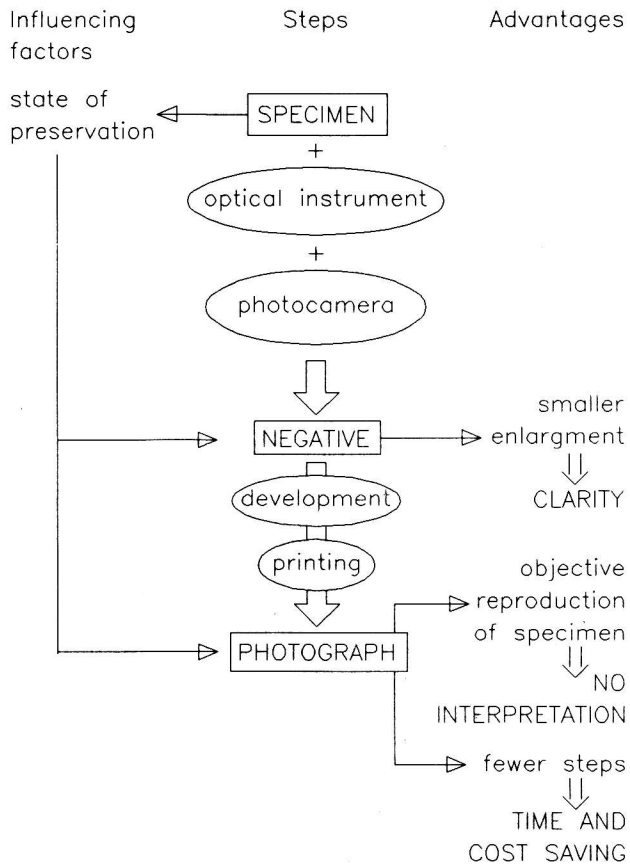

Fig. 9 - *Piarorhynchia* sp. (unpublished material). a) Sequence of photographs of crura; b) drawings of the same sequence: calcite crystals inferred as crura; c) drawings of the same sequence without median structures; d) drawings of the same sequence attempting to show crystalline mosaic (drawings by projectina); x 6.8.

certain cases, when there is virtually no contrast between matrix and structures, should combined illumination be provided, in which the upper light source (reflected light) is prevalent.

To focus the peel properly, it should be stretched flat, by placing it in a slide mount with glass.

The apparatuses used for the above photographs are very simple to operate, and do not require the aid of a specialized technician. A further advantage is time: infact, a few hours' work is sufficient to adequately record complete series of peels taken from several specimens. The costs involved are essentially those of the film, of developing and printing; only in certain cases, with especially small structures are enlargements necessary. Further, the services of a professional artist to prepare the finished artwork for printing are no longer required (Tab. 2).

Finally, the authors wish to point out that the technique described in this article as an innovation in the field of brachiopod paleontology has infact been currently used




Tab. 2 - Sequence of steps for photographing peels.

for some time in the investigation and representation of other taxonomic groups. A case in point is foraminifera, especially the oldest benthonic forms, investigated and determined on the basis of slender sections of the rock in which they are embedded, and corals, both habitually recorded photographically. The difference between thin sections and acetate peels, is virtually inexistent for the purpose of recording, and the same excellent results can be obtained by photographing the peels instead of the thin sections.

*Acknowledgements.*

The authors sincerely thank C. Rossi Ronchetti and M. Gaetani for critical review of the manuscript.

## REFERENCES

Alméras Y. & Moulan G. (1988) - Les Térébratulidés du Dogger Provençal (Paléontologie - Biostratigraphie - Phylogénie - Paléoécologie). *Docum. Lab. Géol. Lyon*, n. 101, 277 pp., Lyon.

Alméras Y., Benigni C. & Tintori A. (1991) - New Brachiopod faunas from the Middle Jurassic of Zanskar (Ladakh, India). *Riv. It. Paleont. Strat.*, v. 96 (1990), n. 4, pp. 427-460, Milano.

Baker P. G. (1988) - Location and interpretation of ontogenetic relics in the shell of adult brachiopods. *Lethaia*, v. 22, pp. 241-245, Oslo.

Benigni C. (1978) - Revisione tassonomica dei *Rhynchonellida* liassici di Ra Stua (Belluno) e Fanes (Bolzano). *Riv. It. Paleont. Strat.*, v. 84, n. 1, pp. 121-168, Milano.

Benigni C., Casati P. & Pirini Radrizzani C. (1982) - Stratigrafia del Giurassico dei dintorni di Foza (Altopiano di Asiago). *Riv. It. Paleont. Strat.*, v. 88, n. 1, pp. 45-74, Milano.

Benigni C. & Ferliga C. (1989) - Carnian *Thecospiridae* (Brachiopoda) from San Cassiano Formation (Cortina d'Ampezzo, Italy). *Riv. It. Paleont. Strat.*, v. 94 (1988), n. 4, pp. 515-560, Milano.

Benigni C. & Ferliga C. (1990) - *Diplospirella* Bittner, 1890 (Brachiopoda): Morphology and review of the Carnian species from the San Cassiano Formation (Cortina d'Ampezzo, Italy). *Riv. It. Paleont. Strat.*, v. 96, n. 1, pp. 39-76, Milano.

Benigni C. & Ferliga C. (1992) - *Anisactinella* Bittner, 1890 (Brachiopoda, Triassic): morphological structures and their functional meaning. *Riv. It. Paleont. Strat.*, v. 97 (1991), n. 3-4, pp. 275-306, Milano.

Bittner A. (1890) - Brachiopoden der alpinen Trias. *Abh. K. K. Geol. Reichsanst.*, v. 14, 325 pp., Wien.

Dagys A. S. (1974) - Triasovie Brachiopod. V. of 332 pp., Novosibirsk.

Sandy M. R. (1986) - Brachiopod systematics and the transverse serial sectioning method: some recommendations for this technique and clarification of a taxonomic problem assisted by this method. *Actes 1 Congr. Intern. Brachiopodes, Biostr. Paléoz.*, pp. 143-150, Brest.

Suess E. (1854) - Brachiopoden der Kossener Schichten. *Denkschr. Akad. Wissensch. Mat. Nat. Wien*, v. 7, pp. 29-64, Wien.