# RETRODEFORMATION OF FOSSILS – A SIMPLE TECHNIQUE

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ABSTRACT. We describe a simple and quick method of restoring photographic or line-drawing images of deformed fossils, using a Canon CLC 300 laser copier in place of computer hard- and software; it will help in the identification of material from deformed rocks. As an example, retrodeformation of the trilobite *Angelina sedgwickii* Salter rapidly gave results that compare favourably with previous restorations of the same species.

TO the structural geologist, deformed fossils, in particular those with bilateral symmetry or known angles and dimensions, provide valuable information on the state of strain in a rock. They are easily measured and analysed using the strain techniques described by Ramsay (1967), and Ramsay and Huber (1983). On the other hand, this deformation is troublesome to the palaeontologist. Features used for specific discrimination, such as measurements and length-to-width ratios, become altered. An assessment of strain is essential for the determination of deformed fossils, but because palaeontologists rely so much on illustration, the restoration of images of deformed fossils is also important to their interpretation. This was tellingly demonstrated by Hughes and Jell (1992) who, by computer-based analysis of a population from deformed rocks, were able to assign seven earlier-described taxa to a single species and to published restored illustrations. Cooper (1990) described various techniques for restoring deformed fossils, and their limitations and underlying assumptions.

The purpose of this note is to draw attention to one of the techniques for restoration mentioned by Cooper (1990, p. 331). It is so quick and simple that we believe it will be of value to anyone identifying or describing deformed fossils. The technique is akin to that described by Hughes and Jell (1992), but instead of using a computer it uses the 'anamorphic zoom' facility available on the Canon CLC 300 (colour laser copier). This facility enables a pair of orthogonal axes ($x$ and $y$) to be independently enlarged or reduced, thereby allowing one to 'squash, or 'stretch' a line-drawing or half-tone photograph of the deformed fossil by a predetermined amount. This 'retrodeformation' (Williams 1990) takes only a few moments and comparatively high quality images can be produced. The relative expense of operating the colour copier means that it is appropriate to calculate the amount of deformation, rather than to use trial-and-error, to obtain good retrodeformed images. The amount of deformation can be calculated by a variety of techniques (Ramsay and Huber 1983; Cooper, 1990) which provide the shape and orientation of the strain ellipse in the deformed rock. The ratio of the major to minor axes of this ellipse can then be used for the ratio of the enlargement or reduction for the $x$ and $y$ axes on the copier.

The example given here is based on the trilobite *Angelina sedgwickii* Salter, 1859, from the Tremadoc Series of North Wales. This species is known from numerous more or less complete specimens, but all of them are distorted. Fortey and Owens (1992*a*) reviewed several attempts to restore *Angelina sedgwickii*, and compared these restorations with an undeformed cranidium described from Shropshire (Fortey and Owens 1992*b*).

A photograph was used of a slab with two fairly complete specimens which lie at different angles to a tectonic lineation (Text-fig. 1). The fossils occur in a deformed but poorly-cleaved silty mudstone; the bedding and regional ($S_1$) cleavage are nearly orthogonal to each other, and the cleavage trace on the bedding surface is indicated by a weak intersection lineation. It is assumed that this intersection lineation is parallel to the maximum extension direction in the rock. Lines were

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TEXT-FIG. 1: *Angelina sedgwickii* Salter, 1859. Upper Tremadoc, 820 m north of Minfordd British Rail station (Grid Ref. SH 394 600). British Geological Survey GSM 102628 (A. J. J. Goode coll.). A, as preserved, x 1; B, the same figure retrodeformed. The thick vertical line represents the trace of the cleavage on the bedding; the short lines indicate the sagittal and transverse lines for each trilobite.

drawn on the photograph parallel to the tectonic lineation, and, for each trilobite, the sagittal line and a transverse line at the base of the cephalon. These could be drawn to an accuracy of about one degree.

Three graphical methods, the Mohr Circle, Breddin curves, and Wellman's method (Cooper 1990) were used to determine the ellipticity (R) of the strain ellipse. The results are summarized in Table 1, and show close agreement between the different techniques.

TABLE 1. Comparison of estimates of strain ratio for the fossils in Text-figure 1, determined by three different techniques. $\psi$ = angular shear strain, $\phi'$ = orientation angle.

| | Breddin curve | Mohr circle | Wellman method |
|---|---|---|---|
| Upper specimen | | | |
| $\psi = +37°$ | 2·01 | 1·996 | |
| $\phi' = 26$ | | | 2·08 |
| Lower specimen | | | |
| $\psi = +18°$ | 2·00 | 2·02 | |
| $\phi' = 6$ | | | |

To prepare the retrodeformed image we aligned the photograph on the copier such that the tectonic lineation was parallel to the $y$ axis (this is made easy by trimming one edge of the photograph, or its mount, parallel to the lineation), and dialled enlargement/reduction values of $x$ and $y$ in the ratio 2·02:1·0. In order to make the restored image (and the strain ellipse) equal in area to the original, values of $x$ = 142 per cent, and $y$ = 70 per cent were used (we are assuming here that deformation is homogeneous, and are ignoring any extension or compression normal to the plane of bedding). The copier was set to reproduce in black and white, but 'full colour' copies, even of black and white prints, can give very good results.

The resulting image is, we believe, the best representation so far of the undeformed shape of Welsh examples of *A. sedgwickii*. The sagittal and transverse lines on each are practically at right angles, namely 90° on the upper example in Text-figure 1, and 89° on the lower. The trilobites, which are of similar size and therefore about the same stage of growth, have the same proportions. Table 2 gives a comparison of our restoration with those given in Fortey and Owens (1992*a*, text-figs 2, 4 and 5): of these Salter's restoration is too broad and that of Appleby and Jones is too narrow; Ramsay and Huber's reconstruction is closest to ours. Although the morphological effects of tectonic strain are removed by this technique, in the present instance the image of the cleavage trace, captured on the photograph, remains, and can be seen striating the surfaces of the trilobites.

TABLE 2. Proportions of restorations of *Angelina sedgwickii* as given by Fortey and Owens (1992*a*) compared with Text-fig 1.

| | Length/width of cephalon | Length/width of glabella |
|---|---|---|
| Salter's 'broad form' | 0·40 | 1·10 |
| Appleby and Jones | 0·62 | 1·56 |
| Ramsay and Huber | 0·48 | 1·20 |
| Fortey and Owens | 0·47 | 1·08 |
| Fig. 1, upper specimen | 0·48 | 1·22 |
| Fig. 1, lower specimen | 0·49 | 1·25 |

The chief advantages of this method are its rapidity, the fact that not only drawings but photographs can be reshaped, and that no computer set-up is required (the facility being available in many high-street copying services). The Analogue Video Reshaper (Appleby and Jones 1976) and the computer technique outlined by Boyce (1990) are more adaptable, but it is less easy to obtain publication-quality figures from them. The microcomputer apparatus described by Williams (1990) is very suitable for trial and error experimentation, but does not give good images of photographs and half-tone plates; it could, however, be used in conjunction with the Canon copier to provide publishable retrodeformed figures, in much the same way as Hughes and Jell (1992, p. 319) described.

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