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A Computer Program for the Determination of Finite Strain Using Fry Method

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Abstract: Fry method enables rapid estimate of finite strain from deformed aggregates such as clastic grains, fossil colonies, oolitic or pisolitic aggregates, prophyroblastic minerals or phenocrysts. It has an advantage over the other methods of finite strain analysis in its very quality of enabling rapid estimation with a reasonable degree of accuracy. Details of the software to prepare a plot using Fry method are outlined. This program has an advantage over other computer based programs on the world wide web in its aesthetic getup, small size, user friendliness and a help file.

The program is a freeware and can be downloaded by following the links on a software website http://www.al-structural-geology-software.com.FryPlotSetup.zip or http://www.al-structural-geology-software.com/FryProg/FryPlotProgSetup.exe

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INTRODUCTION

Several methods of determination of finite strain in naturally deformed rocks exist and two of these are most widely employed and popular, these being the Rf/Φ technique by Dunnet (1969) and the centre-to-centre method by Fry (1979a, 1979b). While Dunnet's method is ideally suited for the starting material with ellipsoidal objects, Fry method gives best results if the starting object shapes were spherical or equidimensional in shape having anticlustered distribution. Ramsay (1967, pp.195-197; see also Ramsay and Huber, 1983) devised a method of determination of finite strain from deformed aggregates based on the centre-to-centre distances between "nearest neighbours" components of the deformed material plotted against the orientations of the individual tie lines with reference to a chosen direction. This method is too time-consuming and laborious for practical construction and perhaps underestimates the total strain suffered by the rock. Fry (1979a, 1979b; see also Hanna and Fry, 1979) found a solution to this technique which rapidly computes the average strain for the entire population. The method consists in tracing on an overlay all the object centres while keeping the centre of the overlay fixed on one object centre. The process is repeated until all object centres are covered. This produces a vacant field in the centre of the overlay whose shape is an approximate estimate of the finite strain ellipse in the surface examined. This method ignores the processes or mechanisms that contribute to the finite strain state, but it can be used to know the overall shape change reasonably accurately. Ramsay's method works well for distributions where the identities of nearest neighbors are easy to determine from the shared boundaries such as mudcrack centers and colonial corals, but fails to yield meaningful results for other aggregates where the boundaries of objects are not so well defined. Fry technique has also been successfully applied to analysis of augens in gneissic or metamorphic rocks (Genier and Eparda, 2007). Fry method can be employed for aggregates of natural deformed material as long as the centres of the objects are well defined and grain boundaries are sufficiently well marked and distinctly noticeable. Besides, the centres of objects must be anticlustered or the centres must maintain uniform minimum distance from one another. In other words, the distribution of the object centres must be statistically isotropic.

GENERAL BACKGROUND

This method is probably the most successful and widely applied of all the methods of finite strain analysis. Erslev (1988) described a normalized method of Fry analysis which yields a remarkably improved resolution and definition of the central vacant hole. However, it should be noted that Erslev's technique requires more data (and hence more work) than mere measurement of center-to-center distances. The area of each of the exclusion zones surrounding centers must first be defined in order to calculate normalized center-to-center distances. Despite the wide usage of the Fry method, there are many objections to the technique and particularly to the method of ellipse fitting to the vacant hole. The central hole gets often vaguely defined owing to cut effects (Bhattacharyya et al. 1986; Crespi, 1986; Srivastava, 1995). They may be far from elliptical and may contain maverick points.

Fry method can be used even for the rocks which have undergone volume change during deformation. Many objects are not proper ellipses in cross section (Robin, 1977) and Fry method can handle non-elliptical shapes as well just as Robin's method does. In case of Fry method, the assumption of no primary sedimentary fabric is a significant constraint (discussion in Kusky and De Paor, 1988; De Paor, 1996). Unless the assumption of initial isotropy is fully justifiable, the elliptical void of the Fry plot must be called a fabric ellipse, not a strain ellipse. Some objects are quite unsuitable for Fry analysis, such as polycrystalline aggregates where grain boundary migration during deformation can drastically change the dimensions and shapes of grains; others such as feldspar crystals tend to undergo brittle fracturing during deformation, and may split into several fragments yielding wrongly overestimated population.

If the ellipse formed by the central hole is different, either in shape or in orientation, from the ellipse defined by the dense grouping of modal points just outside the central hole, then there may be two superimposed fabrics (see e.g. Lacassin and van den Driessche, 1983). Alternatively, data may have been taken from more than one mineral species or lithology, which have undergone differing strains. Ray and Srivastava (2008) and Mulchrone (2003) have suggested a least squares fitting to population which employs a computer based method based on a genetic algorithm. While Ray and Srivastava suggest a genetic algorithm, Mulchrone doesn't. However, we strongly believe that no method can be better than the solution to rely on the geologist's eye to fit the ellipse to the central hole. In the program written, the user has to choose his/her own judgment and draw the ellipse and therefore has much latitude.

This brief paper outlines the details of the software prepared by the authors to estimate the finite strain ratio from an aggregate of the natural deformed material such as oolites, pisolites or other fossils or deformed clastic grains in a sedimentary rock and porphyroblastic minerals or phenocrysts in metamorphic or igneous rock. The program is a freeware written in Microsoft Visual Basic 6 and can be downloaded by following a link on the web page http://www.a1-structural-geology-software.com/index.html. On the world wide web, this is the third downloadable freeware of the Fry method, the other two being GeoFryPlots by R. J. Holcombe (http://www.holcombe.net.au/software/rodh_software_downloads.htm) and a program written by De Paor (see e.g. De Paor, 1996). Our software has an advantage over the other two in its aesthetic sense of presentation with the use of attractive object controls, user friendly approach, a help file and small size. The software is compatible only with the Windows XP version and cannot run on earlier versions.

DETAILS OF THE SOFTWARE

The program consists of two components, a control in which the image of the material of deformed objects can be loaded and another an element on which Fry plot can be generated. Figure 1 shows the screenshot of the software. On the left hand side is a control called PictureBox control (intrinsic to Microsoft Visual Basic) into which the image of the deformed material in BMP, JPEG or GIF format is loaded. This control is made scrollable so that if the image is too large, it can be scrolled so that all object centres in the image can be accessed and digitized. On the right hand side is another PictureBox control on which the plot based on Fry method is generated. As the centres of objects are serially clicked on the image to the left hand side, a plot of the digitized image points begins appearing to the right hand side. Most interesting is the central portion of the plot, which is a vacant elliptical field free of any plotted points whose long and short axes define the average finite strain ratio in the surface of the image loaded. This is generated because each time the vectors related to one object centre are omitted. The vacant field and high density of points at the elliptical boundary of the vacancy are generated because points and not lines represent the object centre vectors and all vacant zones that separate the deformed objects are added up at the centre. Some of the highlights of the software are as follows:

1 Not only can the plot be generated on the same scale as the image but the user also has an option to make the plot on 50, 75, 125, 150, 200 and 300 per cent size of the original image, by adjusting the desired size by using a slider control provided for the purpose. When this option is exercised, it changes the scale property of the PictureBox control on which the plot is to appear. The image to be digitized maintains its size but the plot is generated on the desired scale.

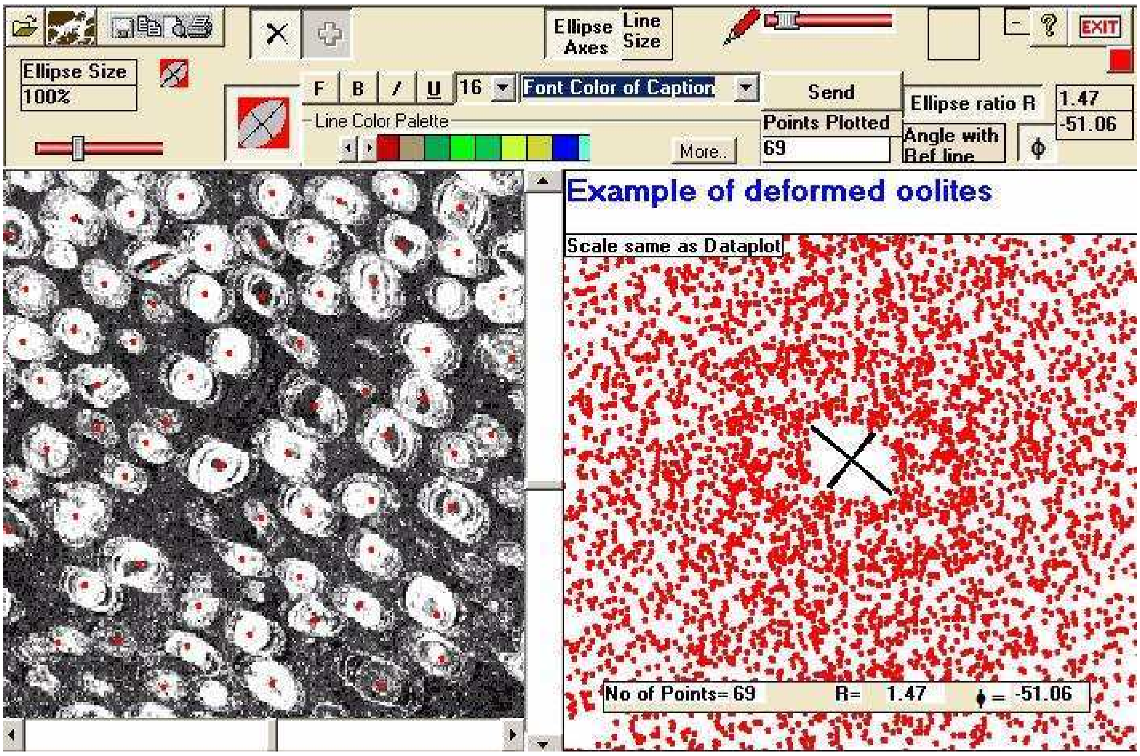

Fig.1. Screenshot of the software.

2 The size of the points on the plot can be varied between 1 and 10, this being the DrawWidth property of the PictureBox control. The property can be set before the plotting begins by using a slider control provided. Thus if the objects are fewer in number in the surface examined, large or thick size for the points may be chosen. If the population of objects in the surface is large, thin or small size may be chosen.

3 The colour of the points to be plotted can be chosen by the user. The user may also change the background colour of the plot. The colours can be set by using a palette given for the purpose or by getting the color dialog box. Because colors can be chosen for all the elements of a plot, the user may choose a particular color scheme for the plot.

4 The axes and the boundary of the ellipse can have a thickness desired by the user depending upon the DrawWidth property between 1 and 10. The colours of these can also be chosen. The whole of the elliptical vacant area can be "painted" in a color of one's choice before drawing the ellipse major and minor axes. The plot takes NS direction as the reference line to measure φ. This cannot be altered and the user must load a previously rotated image if a differently oriented reference line is desired. In a newer version, it will be possible to rotate the image through any desired angle before beginning to digitize.

5 The plot can be completely annotated with labels and title. The title can be entered via an input box string. The background and foreground colours of the labels and title can be changed using a palette provided or by calling a color dialog box. The font type and size of the title can also be changed by choosing from the drop down boxes provided for the purpose. The font type of the labels can also be changed.

6 After annotation, the plot can be captured via a separate capture control and taken to another window where it can be saved in a BMP format (GIF, JPEG or BMP) or copied to the clipboard for exporting to a third party program or sent to printer port for printing.

The program has an HTML help file, which can be loaded or unloaded at any time without disturbing the plot.

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