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Some guidelines for the practical application of Fry's method of strain analysis

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Abstract—A systematic analysis of patterns in artificial and natural point distributions is presented in order to demonstrate how the nature and degree of anticlustering of point distributions affect the character of Fry diagrams derived from them. Ideally anticlustered artificial point distributions illustrate the nature of the dependence between the degree of anticlustering and the minimum number of points required in such a distribution if it is to reveal strain accurately by Fry's method. In addition, these distributions provide straightforward results which aid in the interpretation of less ideally anticlustered natural point distributions.

The results from the artificial distributions may be used to estimate the minimum number of points required for strain determination in natural distributions of varying degrees of anticlustering, as long as the anticlustering is sufficiently strong. However, application of the results from the artificial distributions to less strongly anticlustered natural point distributions shows not only that the existence of a vacancy field is an insufficient criterion for determining whether or not Fry's method is appropriate for strain determination but also that the nature of the anticlustering in these natural distributions limits the effectiveness of enhancing strain definition by increasing the number of points composing the distribution.

INTRODUCTION

In 1979, Fry introduced a simple yet elegant method of determining finite strain in rock (Fry 1979, Hanna & Fry 1979). Aside from being relatively rapid and practical, the method has the advantage of being suited to rocks which do not contain plastically deformed elliptical markers. The resultant increase in the variety of rock types used for strain analysis is illustrated by recently reported analyses using Fry's method on blue quartz in porphyroid gneiss (Lacassin & van den Driessche 1983), feldspar megacrysts in mylonitic granitoids (Stone & Schwerdtner 1981), blue amphibole in schist (Mawhin 1984), and biotite-hornblende aggregates in plutonic rocks (Schwerdtner *et al.* 1983).

Fry's method does require that the distribution of strain markers be anticlustered as opposed to random. In many rocks, the grains, or potential strain markers, are neither strongly anticlustered nor random. Although Fry (1979) noted that the more a distribution departs from random toward strongly anticlustered, the greater the certitude in determination of the strain ellipse, he only presented examples of strongly anticlustered and random distributions.

Since the method is being applied to an increasing number of rock types, it is beneficial to investigate the character of Fry diagrams which result from weakly to moderately anticlustered point distributions in addition to those which result from strongly anticlustered and random point distributions. Such an investigation leads to a better understanding of how to interpret Fry diagrams.

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ARTIFICIAL POINT DISTRIBUTIONS

It is instructive to begin by examining the character of Fry diagrams which result from artificial, ideal, two-dimensional point distributions of systematically varying degrees of anticlustering. An anticlustered distribution is described by a preferred minimum distance between points; random point distributions and hexagonal grids of points are considered to be end-member cases.

The geometry of a hexagonal grid of points is such that the minimum allowable distance between points is $1.075\rho^{-1/2}$, where $\rho^{-1/2}$ is the point density. Given a fixed point density, this is the maximum attainable minimum distance between points. In a random or Poisson distribution, there are no constraints on the positioning of points, and thus the minimum allowable distance is zero By allowing the minimum distance between points in distributions of fixed point density to vary between the minimum value of zero and the maximum value of $1.075\rho^{-1/2}$, it is possible to generate point distributions of systematically varying degrees of anticlustering.

This is done in practice by eliminating all points from a random distribution which are within a distance x of another point, where x is a number between zero and $1.075\rho^{-1/2}$. Since this procedure obviously reduces the number of points in the distribution, more randomly positioned points must be added to the distribution and the process of elimination repeated until the desired density, i.e. that used to calculate the minimum distance between points, is attained. In the following discussion, this minimum distance between points is referred to as the cut-off distance.

Obviously, a cut-off distance of zero results in a random distribution of points whereas a cut-off distance of $1.075\rho^{-1/2}$ results in a hexagonal grid of points. As the cut-off distance increases from zero to $1.075\rho^{-1/2}$, point distributions of increasing degree of anticlustering are produced, because the area of the distribution in which points are located by a random process is systematically reduced.

It is useful to have some method whereby the degree of anticlustering of these distributions may be quantified. One approach, which has been used by plant ecologists and geographers (Clark & Evans 1954, Thompson 1956, Greig-Smith 1964, Dacey 1960, 1964, King 1962, 1969), is to calculate and compare mean distances between various groups of neighboring points, since the degree of anticlustering of a distribution is a function of the areal spacing of points. Although several complex methods of analyzing patterns in point distributions have been devised (Dacey 1960, 1964), for the purposes herein, it is sufficient to calculate the mean distance between first-order or nearest neighbor points, that is

$$\bar{d}_1 = \sum_{i=1}^{n} d_{i1}/n$$

where d_{i1} is the distance from point i to its nearest neighbor and n is the number of points in the distribution.

The mean first-order neighbor distances for a random point distribution and a hexagonal grid of points are $0.50\rho^{-1/2}$ and $1.075\rho^{-1/2}$, respectively (Dacey 1962, 1964). The mean first-order neighbor distance of any anticlustered distribution of points lies between $0.50\rho^{-1/2}$ and $1.075\rho^{-1/2}$. The closer the value lies to $1.075\rho^{-1/2}$ the greater the departure from randomness and the greater the degree of anticlustering.

In theory, this analysis applies only to isotropic, that is unstrained, point distributions. The influence of strain on $\bar{d}_1$ is determined empirically by calculating the mean first-order neighbor distances of strained versions of artificial distributions produced by various cut-off distances. The effect is to decrease $\bar{d}_1$ from its value in the corresponding unstrained distribution, but the change is only significant at high degrees of anticlustering. For example, for artificial distributions generated by cut-off distances less than $0.40\rho^{-1/2}$, $\bar{d}_1$ decreases, on the average, by only $0.02\rho^{-1/2}$ for strain ratios ranging from 2:1 to 6:1. For artificial distributions generated by cut-off distances greater than $0.60\rho^{-1/2}$, the decrease is commonly greater than $0.05\rho^{-1/2}$, with the magnitude of the decrease increasing with increasing strain ratio. Therefore, although it is more accurate to determine neighbor statistics from unstrained distributions, reasonably representative neighbor statistics can be determined from weakly to moderately strained versions of distributions characterized by low degrees of anticlustering.

This statistic gives a general idea of the degree of anticlustering but is insensitive to some of the more subtle aspects of the nature of the anticlustering. It should be realized that the artificial point distributions are ideal versions of anticlustering since all points rigidly obey the cut-off distance constraint. As such, they provide an important starting point for developing an understanding of the relationship between the character of Fry diagrams and the degree of anticlustering. From these straightforward results, it is possible to develop a better understanding of how to interpret Fry diagrams which result from natural point distributions which are unlikely to be as ideally behaved as the artificial point distributions.

Fry diagrams which result from the artificial point distributions

Fry diagrams which result from unstrained and strained artificial point distributions produced by cut-off distances ranging from $0.20\rho^{-1/2}$ to $0.80\rho^{-1/2}$ are shown in Fig. 1. The pairs of Fry diagrams in this Figure are arranged such that the degree of anticlustering increases toward the bottom of the page and the number of points increases toward the right. Each pair shows the Fry diagrams derived from the unstrained (left side of each pair) and strained (right side) versions of a given distribution. In all cases, the incurred strain is a right-lateral simple shear of $\gamma = 1$; thus, the inferred strain ellipse should have an ellipticity of 2.7 and a long axis oriented 32° anticlockwise from horizontal. The illustrated numbers of points are one hundred and two hundred, since these are numbers commonly used in practical applications of strain analysis. The illustrated degrees of anticlustering are represented by distributions generated by cut off distances of $0.20\rho^{-1/2}$, $0.40\rho^{-1/2}$, $0.60\rho^{-1/2}$ and $0.80\rho^{-1/2}$. The mean values of $\bar{d}_1$ which characterize these artificial distributions are also given in Fig. 1.

Two features are noteworthy. The first is that, although all Fry diagrams are characterized by a central vacancy field, which of course reflects the fact that the distributions are generated by eliminating points from random distributions which are within a certain minimum distance of each other, the number of points which surround and thus serve to define the shape and orientation of the vacancy increases significantly both with the number of points in and the degree of anticlustering of the distribution. The second is that a girdle of high point density exists only for strongly anticlustered distributions. For distributions generated by cut-off distances of $0.20\rho^{-1/2}$ and $0.40\rho^{-1/2}$, no girdle is apparent, whereas for distributions generated by cut-off distances of $0.60\rho^{-1/2}$ and $0.80\rho^{-1/2}$, high point density girdles are not only apparent but their prominence increases with increasing degree of anticlustering.

For the sake of simplicity, distributions which result in Fry diagrams which are characterized by girdles of high point density are designated strongly anticlustered, and distributions which result in Fry diagrams which are characterized by vacancy fields but no surrounding girdles of high point density are designated weakly anticlustered. However, it should be realized that a gradation in degree of anticlustering exists.

Contrasts in point density in a Fry diagram are used to determine the strain ellipse. For the strongly anticlustered artificial point distributions, density variations which reflect the strain exist at the inner and outer edges of the girdle of high point density. For the weakly

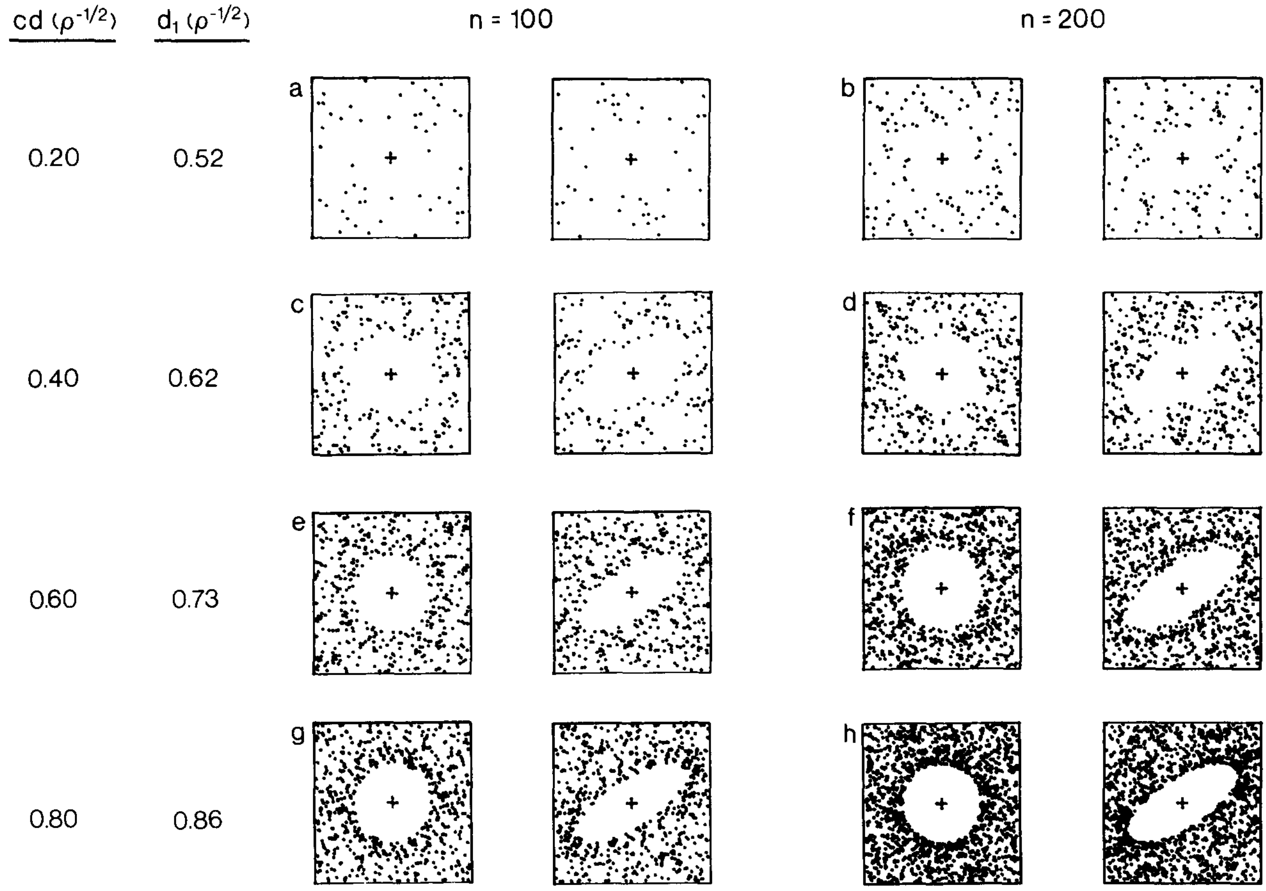

Fig. 1. Fry diagrams produced from artificial point distributions. The left side of each pair of diagrams shows the Fry diagram derived from the unstrained version of a given distribution; the right side, the diagram derived from the strained version in which the strain is a right lateral simple shear of $\gamma = 1$. The degree of anticlustering of the distributions, as indicated by the cut-off distance (*cd*) and mean first-order neighbor statistic, increases toward the bottom of the page and the number of points (*n*) increases toward the right. See text for discussion.

anticlustered artificial distributions, a density variation exists at the edge of the vacancy field. Beyond the edge of the vacancy, the point density in the Fry diagram is nearly uniform.

With respect to definition of the strain ellipse, the following generalizations can be made. Firstly, the addition of more points to a weakly anticlustered distribution does not result in the eventual development of a girdle of high point density; it simply results in an increase in the number of points which lie directly adjacent to the vacancy field. Secondly, for the more strongly anticlustered distributions, the strength of the girdle of high point density is largely controlled by the degree of anticlustering; whereas the addition of more points increases the absolute point densities in the region of lower point density, it does not increase the relative contrast in point density between the two regions.

In addition, it should be noted that if the number of points which lie adjacent to the vacancy is low, the probability for error in determination of the strain ellipse from the shape and orientation of the vacancy field is high. In some unstrained distributions, these points in the Fry diagram may be relatively evenly spaced about the vacancy field and define a nearly circular vacancy field. In others, these points may be rather unevenly spaced and the vacancy field may appear elliptical. The magnitude of the error in strain determination is dependent upon how this ellipse and the strain ellipse are superposed.

This is the case for the Fry diagrams in Fig. 1(d) which result from an artificial distribution described by two hundred points and a cut-off distance of $0.40\rho^{-1/2}$. Since the diameter of the vacancy in the unstrained state varies depending upon the direction in which it is measured, the shape of the vacancy does not accurately reflect the strain. In this example, the strain ratio is underestimated although the orientation of the elliptical vacancy is approximately correct. Thus, strain can only be accurately determined from these weakly anticlustered artificial distributions if a relatively large number of points lies directly adjacent to the vacancy field.

Required number of points in the artificial distributions

In both the weakly and strongly anticlustered artificial point distributions, the greatest contrast in point density exists at the cut-off distance since this marks the transition from the region of essentially no points in the central part of the diagram to either the inner edge of the peak in point density or the inner edge of that part of the Fry diagram of nearly uniform density. Since the precision of resolution of the strain ellipse increases as the density contrast increases, it is useful to examine how the number of points which lie directly adjacent to the vacancy field varies with the degree of anticlustering.

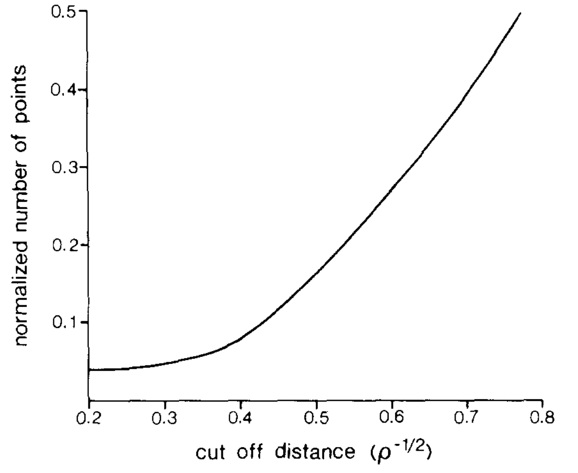

Fig. 2. Relationship between the cut-off distance used to generate an artificial point distribution and the normalized number of points in the Fry diagram which lie within the annulus whose inner edge lies at a distance from the center of the Fry diagram which is equivalent to the cut-off distance and whose width is 10% of the cut-off distance. See text for discussion.

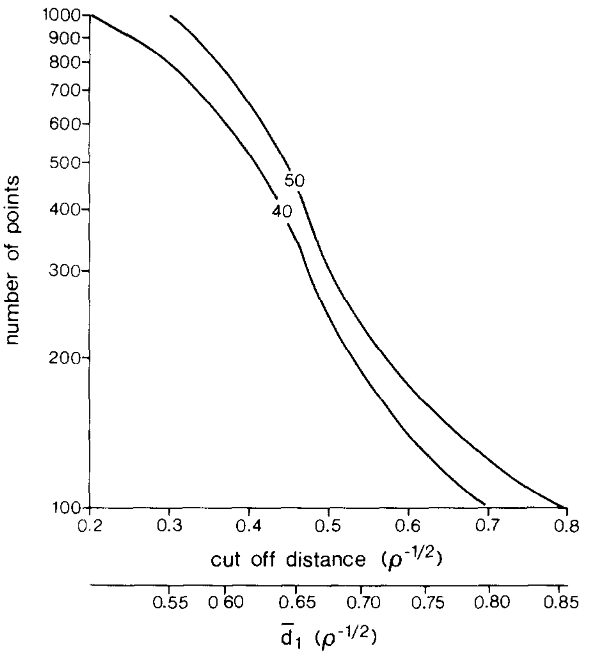

Fig. 3. Relationship between the degree of anticlustering and the number of points which must be in an artificial distribution if the resultant Fry diagram is to have a specified number of points within the annulus as defined in the text; labels on curves indicate the specified number of points. The degree of anticlustering is shown on the abscissa by the cut-off distance and the corresponding mean first-order neighbor distance (note that the ordinate is a log scale). See text for discussion.

In the artificial distributions, the vacancy field can be considered to be defined by those points which lie within a narrow annulus whose inner edge lies at a distance from the center of the Fry diagram which is equivalent to the cut-off distance. The outer edge is defined as the cut-off distance plus ten per cent of the cut-off distance. Although this upper limit is somewhat arbitrary, the number of points which lies within this annulus is only used for comparative purposes, and thus, precise definition of the upper limit is not critical.

The number of points which lie within this annulus is determined for the distributions of varying degree of anticlustering; this number is normalized by dividing it by the number of points composing the distribution. Figure 2 illustrates the relationship between the normalized number of points and the cut-off distance. Not only does the normalized number of points increase with increasing degree of anticlustering, but the rate of increase increases with increasing degree of anticlustering.

These results can be used to determine the minimum number of points necessary to produce a Fry diagram with a sharply defined vacancy field. Inspection of the Fry diagram in Fig. 1(g) indicates that, in order for a vacancy to be well defined, about fifty points (Fig. 2) must lie within the annulus whose width is ten per cent of the radius of the vacancy. From the results shown in Fig. 2, it is possible to calculate the number of points which must be in a distribution generated by a particular cut-off distance if the resultant Fry diagram is to have fifty points within this annulus and thus have a vacancy field which is as well defined as that of Fig. 1(g). Figure 3 shows the relationship between the calculated number of points and the cut-off distance. Also shown on the horizontal axis are the mean $\bar{d}_1$ values to which the cut-off distances correlate. Since the vacancy field in Fig. 1(g) is so well defined, fifty points may be a slight overestimate. For the sake of comparison, the curve showing the number of points which must be in the distribution if forty points are to lie within this annulus is also shown in Fig. 3.

This analysis shows that, even for ideally anticlustered point distributions, the required minimum number of points increases markedly with decreasing cut-off distance or degree of anticlustering. Whereas about one hundred points are sufficient for very strongly anticlustered distributions, more than eight hundred points are necessary for very weakly anticlustered distributions.

NATURAL POINT DISTRIBUTIONS

Natural point distributions derived from geologic materials show a range in degree of anticlustering; the mean $\bar{d}_1$ of ooids in a well sorted oolitic limestone, quartz grains in a well sorted sandstone, quartz and feldspar grains in a poorly sorted graywacke, and feldspar grains in a protomylonitic granodiorite (Fig. 4) varies from $0.79\rho^{-1/2}$ to $0.58\rho^{-1/2}$ (Table 1). However, the nature of this anticlustering is not as ideal as it is for the artificial distributions. This is because, although there is in general a certain preferred minimum distance between points which is reflected by values of $\bar{d}_1$ greater than $0.50\rho^{-1/2}$, this minimum distance is not as rigidly realized as it is for the artificial point distributions. In other words, a certain proportion of points which do not conform to the preferred minimum distance also exist.

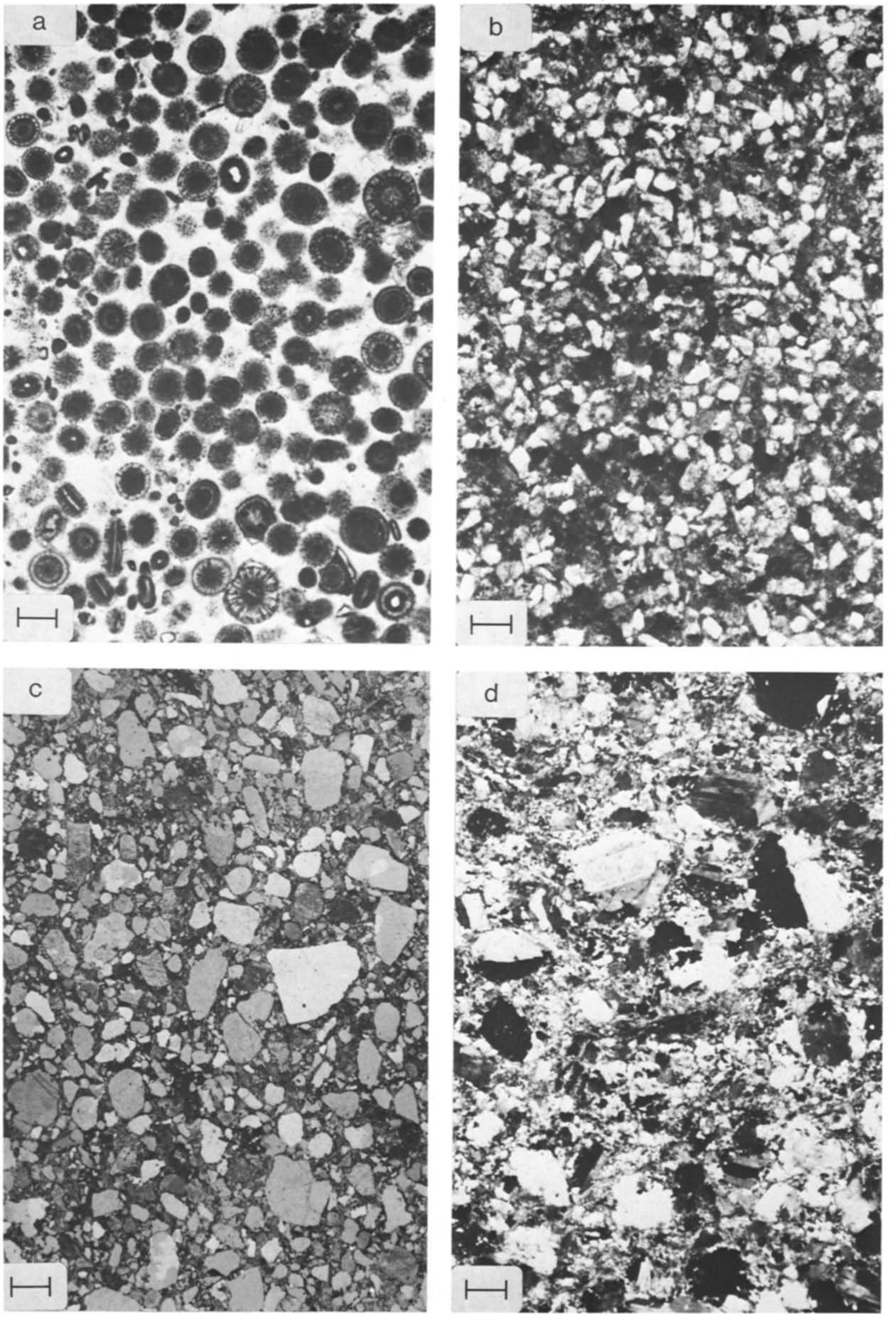

Fig. 4. Photomicrographs of (a) oolitic limestone, Jurassic Stump Formation, Wyoming (scale bar is 0.35 mm); (b) well sorted sandstone, Jurassic Stump Formation, Wyoming (scale bar is 0.50 mm); (c) poorly sorted graywacke, Precambrian Chelmsford Formation, Ontario (scale bar is 1.0 mm); (d) protomylonitic granodiorite, Pinaleño Mountains, Arizona (scale bar is 1.0 mm).

Table 1. Mean first-order neighbor statistics for the different rock types

Rock type	Locality	References	mean $\bar{d}_1$ ($\rho^{-1/2}$)
Oolitic limestone	Wyoming Overthrust Belt	Imlay (1953) Wanless *et al.* (1955)	0.79 ± 0.03
Well sorted sandstone	Wyoming Overthrust Belt	Wanless *et al.* (1955)	0.70 ± 0.02
Poorly sorted graywacke	Sudbury Basin	Rousell (1972)	0.66 ± 0.01
Protomylonitic granodiorite	Pinaleño Mountains	Thorman (1982) Naruk (1986)	0.58 ± 0.02

The best way to illustrate the nature of this anticlustering and its effect upon resolution of the strain ellipse is to examine Fry diagrams which result from natural point distributions of progressively decreasing degree of anticlustering and compare them with Fry diagrams derived from the artificial distributions.

Fry diagrams derived from the natural distributions

The distribution of oolites in the oolitic limestone is characterized by a mean $\bar{d}_1$ of $0.79\rho^{-1/2}$. According to Fig. 3, the necessary minimum number of points for an artificial distribution with such a mean is 100–130. Figure 5(a) is a Fry diagram which results from a distribution of 109 oolites. There is both a prominent girdle of high point density and a fringe of low point density just internal to it. This reflects the fact that, in addition to there being a large proportion of points which conform to a preferred minimum spacing, there is a small proportion of points which do not. Because the boundary between these regions of high and low point density is relatively sharp and visually distinct, it is possible to define the strain ellipse accurately.

A mean $\bar{d}_1$ of $0.70\rho^{-1/2}$ characterizes the distribution of quartz grains in the well sorted sandstone. Although these grains are well sorted, the presence of patchy matrix material and scattered opaques diminishes the degree of anticlustering expected for a distribution of nearly equal sized grains. The necessary minimum number of points for an artificial distribution with a mean of $0.70\rho^{-1/2}$ is 200–250 (Fig. 3). Figure 5(b) is a Fry diagram derived from 245 quartz grains. Although a girdle of high point density exists, the density contrast at its outer edge is not nearly as distinct as it is for the oolitic limestone. This is simply because the degree of anticlustering is not nearly as high for the quartz grains as it is for the oolites. Again, there is a fringe of low point density directly internal to the girdle of high point density, reflecting the fact that not all the points in the distribution conform to the preferred minimum spacing between points. However, a sufficient number of points mark the inner edge of the region of high point density for the density contrast between high and low point density to be resolved visually.

For the strongly anticlustered natural point distributions just discussed, the results of the artificial point distributions may be used to derive the approximate minimum number of points required for accurate defi-

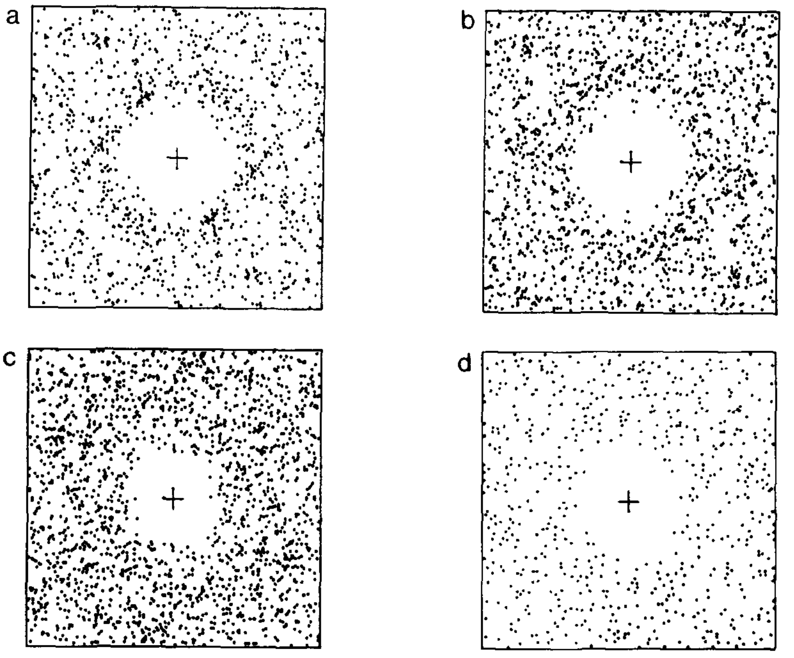

Fig. 5. Fry diagrams for the rocks shown in Fig. 4. (a) Oolitic limestone, Stump Formation (109 points); (b) well sorted sandstone, Stump Formation (245 points); (c) poorly sorted graywacke, Chelmsford Formation (290 points); (d) granodiorite, Pinaleño Mountains (227 points).

Table 2. Mean first-order neighbor statistics for different size classes of grains in the graywacke and granodiorite

	mean $\bar{d}_1$ ($\rho^{-1/2}$)	
	Graywacke	Granodiorite
All n grains	0.66 ± 0.01	0.54 ± 0.02
$n/2$ Largest grains	0.63 ± 0.02	0.58 ± 0.02
$n/2$ Smallest grains	0.48 ± 0.01	0.40 ± 0.03
$n/2$ Intermediate grains	0.54 ± 0.02	0.45 ± 0.03
Fifty largest grains	0.59 ± 0.02	0.55 ± 0.02
Fifty smallest grains	0.43 ± 0.02	0.37 ± 0.04

nition of the strain ellipse. However, it should be emphasized that in the natural distributions the strain ellipse is not defined by the edge of the vacancy but by the boundary between the inner region of low point density and the surrounding region of high point density. Thus, it is extremely important that the number of points in the distribution be sufficient for clear demarcation of this boundary.

In the graywacke and granodiorite, it is not intuitively obvious which grains constitute the most anticlustered distribution; the neighbor analysis is used to determine the most anticlustered grain population. The grains in these two rock types are divided into several populations based on size, and the population with the largest mean $\bar{d}_1$ selected for further investigation. In both rock types, the various grain populations show a wide range in mean $\bar{d}_1$ (Table 2). (Values less than $0.50\rho^{-1/2}$ indicate that the point distribution is clustered.)

In the graywacke, all the grains constitute the most anticlustered population. It is noteworthy that the population defined by the $n/2$ intermediately sized grains, the one intuitively expected to be the most anticlustered because it excludes the extreme size fractions, is actually one of the populations most approaching random. In the granodiorite, the $n/2$ largest grains are the most anticlustered.

The distribution of quartz and feldspar grains in the graywacke is characterized by a mean $\bar{d}_1$ of $0.66\rho^{-1/2}$. According to Fig. 3, the necessary minimum number of points for an artificial distribution described by such a $\bar{d}_1$ is 290–380. A Fry diagram derived from 290 grains in the graywacke is shown in Fig. 5(c). The degree of anticlustering in this distribution is too low for there to be a girdle of high point density. However, a vacancy field exists.

Unlike the previous two examples, there is no clear boundary between regions of high and low point densities. For such a rock type, it is unreasonable to conclude that there is no fringe of low point density and that all points rigidly conform to a preferred minimum spacing. This is supported by the fact that the number of points adjacent to the vacancy field is less than expected for an ideally anticlustered distribution of the same $\bar{d}_1$ and number of points. There is a fringe of low point density, but the increase in point density from zero in the central part of the diagram to that characteristic of most of the diagram is gradual. Thus, it is extremely difficult to accurately identify the boundary external to which the point density in the Fry diagram is nearly uniform. Without a sensitive means of detecting subtle variations in point densities, there is no recourse but to use the rather diffuse edge of the vacancy to determine the strain.

In such a case, use of the edge of the vacancy field is prone to error. As discussed in the section on artificial point distributions, even if a distribution is ideally anticlustered, the edge of the vacancy may not accurately reflect the strain if too few points serve to define it. Since the transition from zero point density in the center of the diagram to that characteristic of most of the diagram is gradual, fewer points lie adjacent to the vacancy field than in a Fry diagram which results from an artificial distribution of a similar number of points and $\bar{d}_1$. In addition, if there are some entirely randomly distributed points in the distribution, the vacancy field will be further distorted. Although these may not compose too much of the distribution, their effect can be significant since so few points serve to define the vacancy field. Thus, it must be concluded that the shape and orientation of the edge of the vacancy field does not reliably reflect the strain ellipse.

The same problem plagues the distribution of the $n/2$ largest feldspar grains in the granodiorite. The mean $\bar{d}_1$ of $0.58\rho^{-1/2}$ which characterizes these grains indicates that this distribution is weakly anticlustered. Although the sample of granodiorite is deformed, the degree of anticlustering of the feldspar grains is low enough for the incurred strain to have little effect on the mean first order neighbor statistic. In further support of this conclusion is the fact that neighbor statistics for more strongly deformed samples are statistically indistinguishable from those of this sample. One of the purposes of including this rock rather than an undeformed granodiorite is to show that, in practice, it is not always necessary to use undeformed samples to determine representative neighbor statistics.

Figure 5(d) is a Fry diagram derived from only 227 feldspar grains since this particular size population requires identification at the thin-section scale and the number of grains in a given thin section is limited. This Fry diagram illustrates how easily vacancy fields may be misinterpreted if there is not an understanding of the nature of anticlustering.

According to Fig. 3, the necessary minimum number of points for an ideally anticlustered artificial distribution with $\bar{d}_1$ equal to $0.58\rho^{-1/2}$ is about 700–900. Even though many fewer points have been used to generate the Fry diagram of Fig. 5(d), a vacancy field exists, and it is tempting to use its shape and orientation to define the strain ellipse. The simple fact is that too few points lie adjacent to the vacancy field for there to be any confidence that its shape and orientation define the strain. Even if 700 points are used, the vacancy field may be misleading since not all the points in the natural distribution may rigidly conform to the characteristic preferred minimum spacing.

These results show how the simple existence of a vacancy field is not a sufficient criterion for determining whether or not a weakly anticlustered natural point distribution is appropriate to Fry's method of strain analysis. Given the fact that a Fry diagram by its very nature is a bilaterally symmetric pattern and that human beings from the day they are born learn to perceive the world in terms of pattern recognition, it is not unlikely that significance may be imparted to a Fry diagram where none exists. Thus, extreme care must be taken in the interpretation of Fry diagrams which result from such weakly anticlustered distributions. More refined analyses of pattern in point distributions may elucidate the extent to which such distributions may be used to approximate strain.

DISCUSSION

Very little work has addressed either the description of patterns in point distributions derived from geologic materials or the factors which control these patterns. An understanding of the nature and variability of anticlustering in point distributions is requisite for the interpretation of Fry diagrams; the ideal, artificial point distributions presented in this paper are a step toward such an understanding.

Fry diagrams which result from the strongly anticlustered artificial distributions are characterized by a girdle of high point density, the prominence of which is largely dependent on the degree of anticlustering of the point distribution. Fry diagrams which result from the weakly anticlustered artificial distributions are characterized by a vacancy field but no surrounding girdle of high point density; beyond the edge of the vacancy field, the point density is nearly uniform. Analysis of these Fry diagrams shows that the minimum number of points required to be in the distribution if it is to accurately reveal strain by Fry's method increases considerably as the degree of anticlustering decreases.

These artificial distributions are used as a guide in the interpretation of Fry diagrams which result from natural point distributions. The natural point distributions considered in this paper show a range in degree of anticlustering as reflected by the range in value of the mean first-order neighbor distance. However, the nature of this anticlustering is not as ideal as it is for the artificial distributions. Since the minimum spacing between points is not rigidly conformed to, the transition from the region of essentially no points in the center of the diagram to the inner edge of the region of maximum point density is gradual rather than abrupt.

In the Fry diagrams derived from the strongly anticlustered natural distributions, there is a clear demarcation between the inner fringe of low point density and the surrounding girdle of high point density, given a sufficient number of points. The artificial distributions provide guidelines for deciding on the necessary minimum number of points for distributions of varying degrees of anticlustering. In the Fry diagrams derived from the weakly anticlustered natural distributions, there is little distinction between the inner region of low point density and the surrounding region of high point density. Application of the results from the artificial point distributions shows how use of the shape and orientation of the vacancy field to define the strain ellipse is susceptible to error.

A shortcoming of many methods of strain analysis is lack of knowledge of the amount of error in the strain determination; Fry's method is no exception. Before 'error bars' can be determined for Fry's method, it is necessary to have some method of determining objectively the strain ellipse from the Fry diagram. Before such a method can be devised, it is necessary to have a clear understanding of how anticlustering varies in point distributions and how this variability affects the character of Fry diagrams. It is hoped that the ideas presented in this paper, in addition to preventing misinterpretation of some Fry diagrams and providing guidelines for selection of the appropriate number of points for strain analysis, will help lay the groundwork for such undertakings.

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