Dispersal of glacial erratics from Lennoxtown, Stirlingshire

R. A. SHAKESBY
Hereford College of Education, Hereford

SYNOPSIS

Dry stone walls are used to trace fans of glacial erratics from outcrops of two small, adjacent but distinctive bodies of essexite near Lennoxtown, Stirlingshire. Contour maps of data point values representing erratic frequency in the walls reveal classic patterns of fans of erratics. A marked contrast in the rate of decline in the frequency of the two varieties in the walls down-ice from the outcrops is attributed to the difference in the spacing of joints in the two rock types. The action of crushing on the closely-jointed variety during glacial transport is believed to have produced erratics generally too small for wall-building within a short distance of the outcrop, whereas blocks of the more massively-jointed variety are still common in the walls up to 20 km from the source. Divergent flow of erratic-bearing ice is suggested as the main agent responsible for spreading erratics in directions at variance to that of general ice flow. Although inferences about glacial processes are made from the wall data, the restricted size range of wall stones has necessitated careful interpretation of the results.

INTRODUCTION

Although glacial erratics have for long been cited as tangible evidence of former glacier ice flow direction, few attempts have been made in the British Isles to study the frequency distribution of fans of erratics. The present paper describes research carried out in the Central Lowlands that aims to rectify this deficiency using dry stone walls to trace in detail fans of erratics from two adjacent出crops of essexite near Lennoxtown, 10 km NE of Glasgow (Fig. 1). Whilst the usefulness of dry stone walls in tracing erratics has already been discussed (Morrissey and Romer 1973) this study is believed to be the first to investigate quantitatively erratic frequency using walls as the data source.

The Lennoxtown essexite consists of two distinct rock types. That forming the SW outcrop comprises a closely jointed porphyritic microgabbro or dolerite with euhedral, titanauligite phenocrysts set in a groundmass of mainly augite, olivine and plagioclase (MacDonald and Whyte 1969; MacDonald 1973). The essexite in the NE outcrop is non-porphyritic and the joints are much farther apart.

These two rock types were chosen as the sources for tracing erratics for four main reasons. Firstly, they cover a combined total area of only c. 0.05 km², thus providing source outcrops of limited extent. Secondly, hand specimens of both varieties of...
essexite are easily recognized. Thirdly, there are no other similar outcrops in the area that might have given rise to erratics located down-ice from the Lennoxtown outcrops. Fourthly, the Lennoxtown essexite has never been quarried (Peach 1909).

In the area studied (Fig. 1) field boundaries frequently consist of dry stone walls except on the high parts of the Campsie Fells, on alluvial deposits, on raised beach material and on the peat-covered Millstone Grit of the NE and SE parts of the area. The majority of the walls were built in the second half of the eighteenth century of stones gathered from the adjacent land. Thus where a wall rests on glacial deposits the stones within it can be regarded as a representative sample of glacially-transported material of a size suitable for wall-building (i.e. cobbles and boulders).

METHODS

On the basis of this last assumption the fans of glacially-transported essexite stones were delimited and values representing the number of essexite stones per unit area of wall (length \( \times \) height) derived. Only those walls that consisted of glacially-transported material were analysed. Other walls built of quarried material or blocks from only one source could be easily distinguished and were rejected.

The heights of 10 m lengths of wall were recorded to the nearest 10 cm together with a note of the presence or absence of any porphyritic or non-porphyritic essexite stones. To calculate the amount of essexite represented by the essexite stones in the walls, the results from 10 m lengths were combined to form 200 m sections. The areas of wall and total numbers of essexite stones for all the 10 m lengths in a section were
derived and the following calculation made for porphyritic and non-porphyritic varieties

\[ E = \frac{n}{\Sigma (L \times H)} \times 10^7 \]

where \( n \) is the number of essexite stones in a section of wall and \( \Sigma (L \times H) \) is the sum of the areas (length \( L \) \( \times \) height \( H \), expressed in \( \text{cm}^2 \)) of all the 10 m lengths making up the section of wall. The factor \( 10^7 \) was included to make all values of \( E \) greater than unity except where no essexite stones were found (\( E = 0 \)).

Values of \( E \) were calculated for 478 data points which are shown as dots located in the centre of the section of wall they represent in Figure 1. Walls were analysed \( W \) of the outcrops to confirm previous reports (Peach 1909; McCallien 1938) that no essexite stones were present. The lack of walls on raised beach deposits terminated the analysis in the east of the study area. In the \( N \) and \( S \), walls were investigated as far as was necessary to establish the limits of the fan or as was possible in terms of the walls available. Values of \( E \) for the porphyritic essexite variety ranged from 0 to 941, and for the non-porphyritic variety from 0 to 482.

Contour maps (Figs 2 and 3) were interpolated from the data point values using the standard procedure of the SYMAP computer mapping system (Muxworthy 1972). For the present investigation this system was considered preferable to other computer mapping techniques in that the interpolated surface still passes through rather than between the original data point values (Shepard 1968). Hand contouring of the maps was rejected in order to avoid the possibility of operator bias.

A closely fitting border was placed around the data points to stop further interpolation by SYMAP and a barrier to interpolation was set up immediately \( NW \) of the outcrops to prevent an erroneous value gradient being interpreted between the high and nil values of data points \( SE \) and \( NW \) of the outcrops respectively.

Fig. 2. SYMAP contour map of non-porphyritic essexite \( E \) values. • essexite outcrops.
FIG. 3. SYMAP contour map of porphyritic essexite E values. © essexite outcrops.

INTERPRETATION

Figure 2 shows the classic features described by other workers investigating fans of erratics (e.g. Shaler 1893; Lundqvist 1935; Gillberg 1965):

1. The mapped limits of the distribution of erratics broaden from the outcrop. A comparison of Figure 2 with the map of the distribution of essexite boulders from Lennoxtown by Peach (1909) indicates that he delimited only the major axis of the distribution as shown by the present investigation (Shakesby 1976).

2. A major axis of high erratic frequency following the alignment of the major ice stream that moved along the southern scarp of the Campsie Fells (Price 1975) is evident. The curved course of the major axis up to 10 km down-ice of the source clearly reflects the influence of the steep scarp of the Campsie Fells on the direction of the ice stream. Beyond this distance the southward deviation of the major axis may also indicate the influence of another ice stream that flowed SSE from Stirling (as shown by striae in Fig. 1) to meet the essexite-bearing ice stream in the area immediately west of Larbert (Burke 1969; Price 1975).

3. Values representing erratic frequency decline both along the major axis in the direction of ice movement and perpendicular to it.

The asymmetry of the fan of essexite erratics is a feature not found in many other fans of erratics. The well defined northern boundary is closer to the major axis than is the southern boundary. The steepness of the southern scarp slope of the Campsie Fells itself appears not to have been the main reason for the more limited extent of the fan north of the major axis since on the Campsie Fells erratics were found that had been transported up the scarp and deposited at a height of 250 m above the source and only 3.5 km from it. There is, however, a correspondence between incursions of the fans of erratics on to the Campsie Fells and interruptions in the generally smooth scarp face.
and it is suggested that these interruptions have allowed erratic-bearing ice moving along the scarp to diverge northwards.

No large-scale obstruction like the Campsie Fells exists S of the major axis but there are a number of small-scale obstacles in the form of drumlins and rock knolls. Erratic-bearing ice forced to flow around a succession of such obstacles provides the most likely explanation for the greater extent of the fan of erratics S of the major axis compared with the N where such obstacles are sparse and major extensions of the northern limit of the fan coincide with the few interruptions in the steep scarp of the Campsie Fells that occur.

Meltwater as the main agent responsible for the fan-shaped distribution of essexite erratics is unlikely since mapped meltwater channels are virtually unidirectional (Sissons 1963). Furthermore, since in the study area there is no evidence for any major change in the direction of ice movement during the last glaciation (Price 1975) nor positive identification of deposits from an earlier glaciation, it cannot be argued that the fan of erratics was formed by ice flowing in different directions during the last glaciation or during separate glaciations.

Figure 3 shows two main similarities to Figure 2. Firstly, the maps indicate a similar direction of ice transport. Secondly, E values decline rapidly for both essexite types away from the outcrops towards a lower shading level where the values decline more slowly.

There is also an important contrast between these figures: there is a rapid decline in the frequency of porphyritic essexite stones in the walls with distance from the source whereas the non-porphyritic stones are represented by an uninterrupted shaded area for almost 20 km from the outcrop. This contrast is unlikely to reflect significantly different volumes of material eroded from the outcrops since E values are of the same order of magnitude and sometimes higher for the porphyritic than the non-porphyritic variety within a short distance of the outcrops. It is more likely to have resulted from the action of crushing on the essexite stones during glacial transport, the close spacing of joints on the porphyritic variety causing its erratics to become broken down into stones too small for wall-building. The boulder-sized, coarsely jointed blocks of the non-porphyritic variety, on the other hand, would still be large enough for inclusion in the walls.

It is clear that in exploratory work of this nature the questions raised by the methodology may be as useful as those raised by the results obtained. The inferred close relationship between bedrock jointing and erratic size indicates the need for caution in studying the lithological composition of till using only a fraction of the total particle size range. This need for caution therefore also applies to reliance on the 'size-selective' walls as the only data source in such studies, and other techniques (e.g. investigation of the percentage weight content of erratic material in till) are required for a complete analysis of the glacial dispersal of erratic material from a source (Shakesby 1976). Nevertheless careful interpretation of the E value distribution maps has enabled inferences to be made concerning the processes operating on rock frag-
ments in glacial transport. Further application and refinement of such techniques will hopefully contribute to a better understanding of glacial dispersal and comminution.

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REFERENCES


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