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Fracture geometry of pseudotachylyte generation zones: a study of shear fractures formed during seismic events

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Abstract—The orientation and movement sense of shear fractures in pseudotachylyte generation zones developed in the Ikertôq shear belt, West Greenland are described, and the fracturing sequence is inferred. The generation zones occur in strongly foliated gneisses, and consist of concordant, usually paired, principal displacement shear fractures (paired shears), on which most melt was generated, and a system of minor shear fractures. Minor shear fracturing was most intense between principal displacement shear fractures, and most melt intruded from these paired shears inwards with respect to the zone. Intrusion of injection veins of pseudotachylyte off the principal displacement shear fractures, is believed to be contemporaneous with minor shear fracturing in the generation zones.

Generation zones affect intact rocks, and individual principal displacement shear fractures have a maximum displacement of 4.6 m. Paired principal displacement shear fractures are up to 3 m apart, and have a maximum observed length of 1 km. In all the zones described, the fracturing appears to be the result of a single episode of slip. Both dextral and sinistral generation zones occur within the study area, and have different geometries. In each case the displacement is strike-slip.

INTRODUCTION

PSEUDOTACHYLYTE has now been recognised from several major fault zones. It is clear from the field relationships typical of this rock that in such zones generation is by frictional sliding. Sibson (1973) has shown that slip rates in the range 0.1 to 1.0 m s^{-1} will cause melting after small displacements in dry rocks. These slip rates are compatible with the 1–10 s range of rise-times for medium to large earthquakes having displacements in the range 0.5–5.0 m (Sibson 1978). Thus pseudotachylyte is probably generated often during earthquake faulting of dry rocks, and field study of the rock provides an additional source of information concerning earthquake processes.

Although much is now known of the conditions under which pseudotachylyte can form (Sibson 1973, 1975), rather less attention has been paid to the fracture geometry associated with its generation. Where work of this sort is possible, an insight into the nature of fracturing during earthquake faulting can be gained. Furthermore it may be possible to place constraints on geophysical models of the earthquake source, which are based largely on seismological data.

The Ikertôq shear belt in West Greenland has been intermittently active since the early Proterozoic (Watterson 1975). As a consequence of uplift and crustal thinning by erosion following the main phases of deformation in the shear belt, the present erosion level exhibits a variety of rocks deformed in the ductile, ductile–brittle and brittle modes. The main displacements in the shear belt occurred between *ca* 2600 Ma (Kalsbeek 1979) and *ca* 1700 Ma (Hickman 1979) and produced the homogeneously deformed gneisses which are now exposed. The geometry of the ductile deformation is described by Escher & Watterson (1974).

Ductile strain formed a strong foliation which is uniformly orientated on a regional scale near the northern and southern boundaries of the shear belt where, on the coast, later brittle deformation is most intense. Some effects of this anisotropy on fracturing during pseudotachylyte generation are evaluated below, and it is probable that the fracture geometry described here only develops in strongly foliated rocks. Nevertheless it should provide a basis for comparison with fracturing during pseudotachylyte generation in different rock types, with various degrees of planar anisotropy.

Level of formation of the brittle deformation products

Brittle deformation in the Ikertôq shear belt is characterised by the formation of rocks of the cataclasite series and pseudotachylyte (using the fault-rock terminology of Sibson 1977). At most localities brittle-deformation products post-date products of ductile straining and are therefore likely to have formed at higher levels in the shear belt (Grocott 1977a). Nevertheless, intrusion of a swarm of basic dykes at a time when the gneisses were at high temperatures (Escher *et al.* 1976), together with the occurrence of some cataclasites and pseudotachylytes which were deformed in a ductile manner, indicate that brittle deformation was not confined to the upper levels of the shear belt (see also Sibson 1980).

The brittle deformation products described here have not been affected by subsequent ductile deformation. The belief that they formed at high levels is supported by widespread hydration of hornblende to chlorite in zones of brittle deformation (Grocott 1977b). Furthermore, palaeomagnetic pole positions inferred from seven sampled pseudotachylytes differed from the poles obtained from country rock gneisses (J. D. A. Piper, pers. comm.). Morgan (1976) has demonstrated that the blocking temperature with respect to magnetisation direction was possibly as low as 200°C in these gneisses. As the pseudotachylytes contain different magnetisation direc-

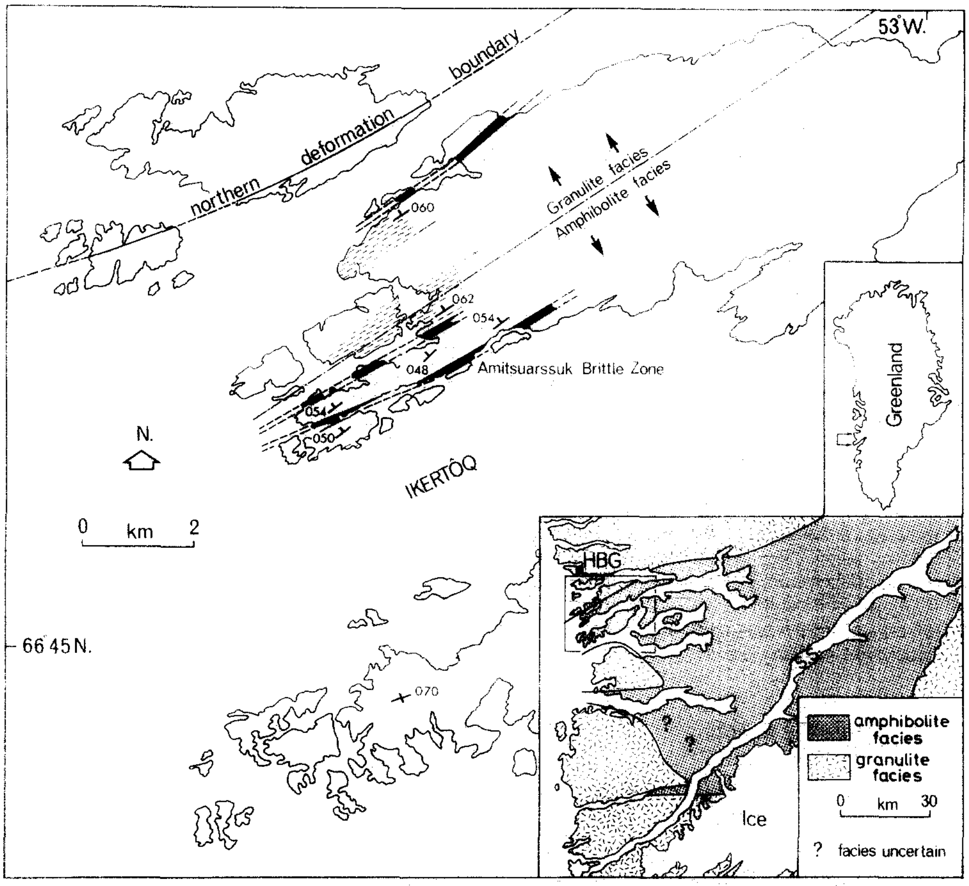

Fig. 1. Structural map. The northern boundary of the Ikertôq shear belt. Brittle deformation zones are shown in black. Other areas where generation zones occur more sporadically and are not concentrated into brittle deformation zones are shown by a dashed ornament. Inset metamorphic facies map. S.S.:—Søndre Strømfjord, HBG:—Holsteinborg.

tions to the gneisses, they must have formed when country rock temperatures were even lower, in all probability at depths of less than 10 km.

Metamorphic grade of the country rocks

Throughout much of the shear belt early ductile deformation is associated with retrogression from granulite to amphibolite facies at the present level of erosion and with subhorizontal movements within a vertical shear plane (Bak *et al.* 1975). In the northern boundary region a younger zone of southeast directed ductile overthrusting reworks older structures. This zone contains a facies boundary parallel to, but 5 km south of, the shear belt deformation boundary (Fig. 1) (Grocott 1979). Thus a 5 km zone of granulite facies gneisses occurs within the shear belt at its northern boundary, and like the amphibolite facies gneisses to the south, contains a strong uniformly orientated foliation.

Strongly deformed granodioritic gneisses of granulite and amphibolite facies in the northern part of the shear belt contain younger pseudotachylyte and cataclasite. In rocks of both facies the geometry of the brittle deformation shows a similar range of features. Furthermore, hydration reactions, of which the most important is the breakdown of hornblende to chlorite, occur on each side of the facies boundary.

HIERARCHY OF THE BRITTLE DEFORMATION

Brittle deformation in the study area can be considered at two scales.

Scale 1

Three brittle deformation zones are recognised in this part of the shear belt, each having a length of at least 10 km and a width of 100–200 km. (Fig. 1). Systematic summation of displacements across the study area has not been attempted, but across the Amitsuarssuk brittle zone (Fig. 1), the total dextral displacement indicated by offset Precambrian dykes is about 100 m. The brittle zones contain abundant pseudotachylyte and cataclasite, and have a marked topographic expression. The fault rocks also occur outside the brittle zones, where they form much more diffuse belts of brittle deformation. The two northern brittle zones are parallel to the regional strike, but the southern brittle zone trends slightly more west than the foliation (Fig. 1).

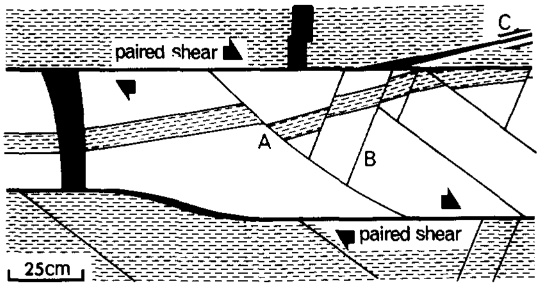

Fig. 2. Elements of a dextral pseudotachylyte generation zone. The three minor shear fracture groups A, B and C do not offset the largely concordant paired shears. Fracture groups A and B are conjugate.

Scale 2

Each brittle zone contains many pseudotachylyte generation zones, the principal elements of such generation zones being illustrated schematically in Fig. 2. The common situation where fracturing is in lithologically uniform granodioritic gneiss is considered. Nevertheless individual zones differ, and such differences must ultimately be related to the particular physical conditions under which each zone formed.

Most generation zones consist of paired principal displacement shear fractures (paired shears) on which most pseudotachylyte was generated (Figs. 3a and 4), and a system of minor shear fractures (Figs. 3b and 4c). Paired shears have a separation range between 3 m and a few centimetres, most of the examples described here being between 1.5 m and 15 cm apart. Larger examples can be traced for up to 1 km. At most places along the length of a zone paired shears are concordant to the foliation outside the zone and are planar and parallel (Figs. 3a and 4). Locally one of the surfaces, generally the lower in the steeply northward dipping gneisses of the area, cuts obliquely towards or away from the other (Fig. 4).

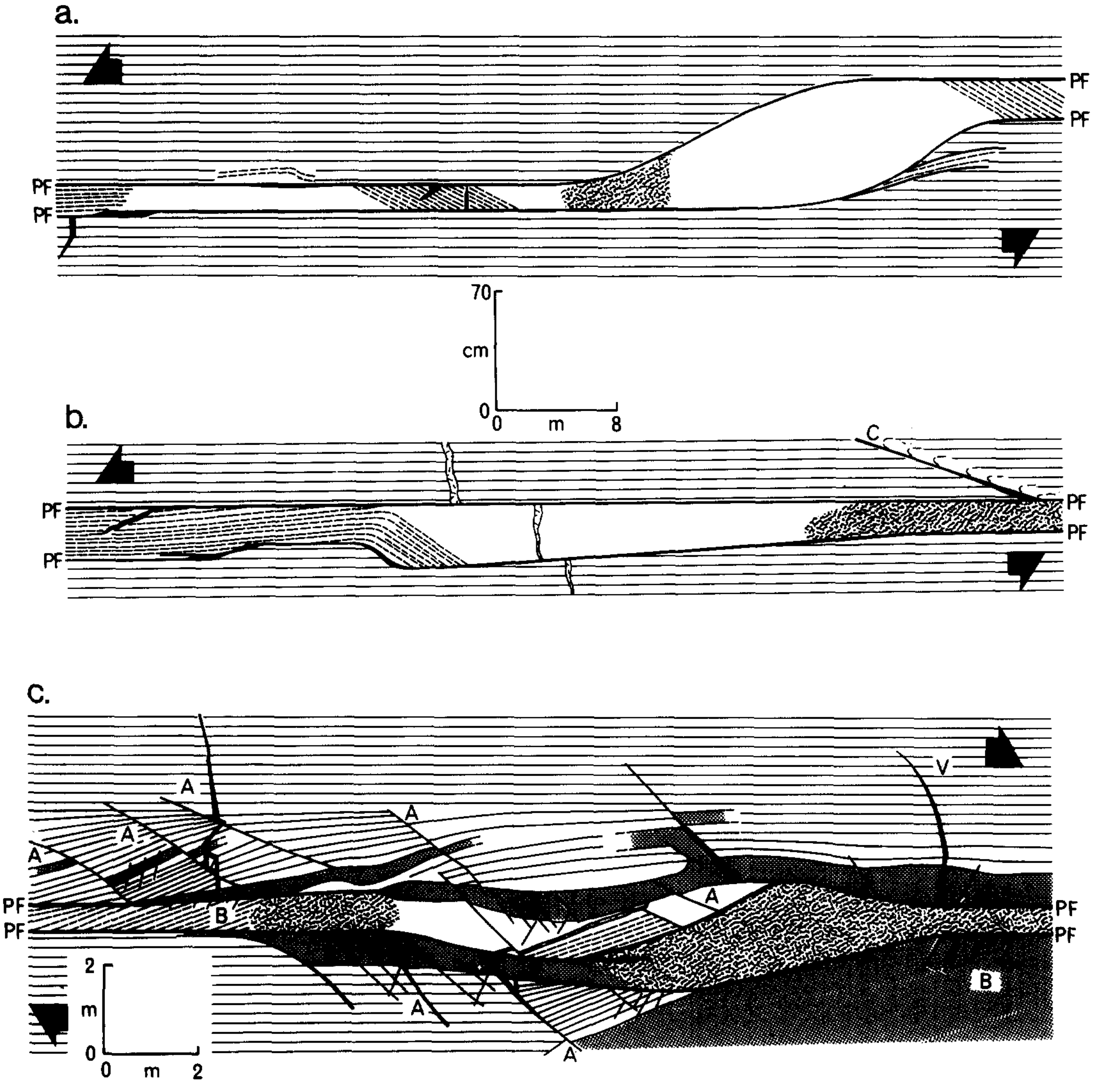

Fig. 4. Pseudotachylyte generation zones. (a) and (b) Different sections of the same zone developed in lithologically homogeneous gneiss. Foliation is indicated by dashed lines within the zone, full lines outside the zone. Thick black lines indicate pseudotachylyte. Zones of pseudotachylyte breccia are shown by irregular stipple, and pegmatite veins are shown by random dashes. (c) Zone developed in granodioritic gneiss with amphibolite bands. Amphibolite bands are shown by dots. Members of minor shear fractures in groups A and B are indicated. PF indicates the locations of the paired shears. Pseudotachylyte vein V is referred to in the text.

Thus over the length of the zone the distance between paired shears can change abruptly. The overall impression, frequently gained, is one of general parallelism between paired shears and the foliation outside the zone.

The displacement across paired shears can be estimated where discordant pegmatites are cut by a generation zone. The displacement may be found simply where intersecting planar pegmatites are offset. Often the displacement must be estimated using the horizontal component measured from offset pegmatites, and the movement direction obtained by one of the methods described in a later section. The displacement across the upper paired shear of the generation zone shown in Figs. 4(a) and (b) amounts to 4.6 m and was the largest encountered. Notice that the lower paired shear in this generation zone shows a smaller displacement (0.8 m).

Minor shear fracturing is commonly intense between paired shears, and occurs to a variable but usually lesser extent in the gneisses surrounding generation zones (Fig. 3a). Where minor shears and paired shears intersect, paired shears are not offset (Fig. 3b). Displacements on minor shears rarely exceed 10 cm, and only small amounts of pseudotachylyte were generated on them. The foliation cut by minor shears between paired shears is commonly rotated during movement (Figs. 3a and 4). In many examples this rotation is slight, but may reach 40–50°. Some foliation between paired shears is tightly folded, but more usually the folds associated with rotation of the foliation are open structures (Figs. 3a and 4b). As the volume of melt generated on paired shears increased it was injected from these surfaces (Figs. 3b and c), preferentially into the zone between the paired shears. This process may have isolated blocks of gneiss between pseudotachylyte veins and the paired shears, which became free to rotate independently, possibly producing a pseudotachylyte breccia between the paired shears (Fig. 3d), and effectively destroying earlier minor shear fracture patterns and the open folds in the foliation.

Within larger generation zones melt may also have been generated on subsidiary paired surfaces, and along single surfaces which coincide with a lithological boundary (Fig. 4c). The fracture geometry of generation zones developed where the gneiss shows marked lithological variation is commonly more complex than that described above (compare Fig. 4c with Figs. 4a and b).

It should be emphasised that the generation zones described are the result of a single episode of slip. Some paired shears cut ductilely deformed dark aphanitic bands which may be older pseudotachylyte. However, major brittle reshear of the generation zones, which formed above the ductile–brittle transition, does not occur.

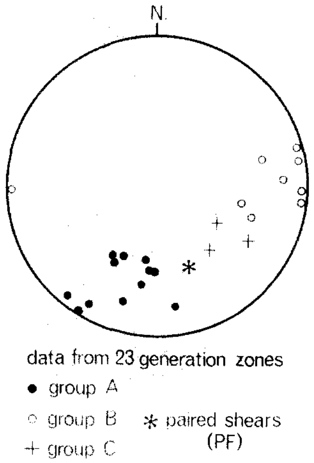

Fig. 5. Lower hemisphere projection of poles to minor shear fractures in the Amitsuarssuk brittle zone.

GEOMETRY OF PSEUDOTACHYLYTE GENERATION ZONES

Within brittle deformation zones

Measurement of the orientation and horizontal movement sense on minor shear fractures within the Amitsuarssuk brittle zone, reveals the pattern illustrated in Fig. 5. Three groups of minor shear fractures are apparent. Fractures with a steep dip and a N–S strike generally display a sinistral movement sense, although along some of these fractures a displacement sense was not measurable. Such fractures have inconsistent age relationships to the WNW–ESE trending dextral minor shears, which dip at moderate-to-high-angles to the NNE. These two fracture groups (A and B in the figures), are therefore interpreted as conjugate. Displacements on the dextral group generally exceed those on the sinistral group.

The mean value for the angle θ between these groups of minor shears is 84° (see Fig. 6 for the definition of θ). The mean value in eight zones in which this angle was directly measured is 83°. Figure 6 shows that these minor shear fractures are almost symmetrically arranged with respect

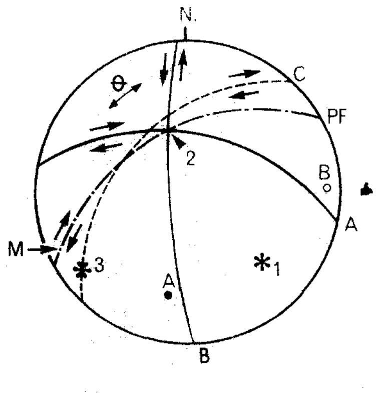

Fig. 6. Generalisation of Figs. 5 and 7(a) to show mean orientations of minor shears associated with dextral generation zones. Both planes and poles to conjugate minor shears are plotted (A, B), together with planes indicating the mean orientations of minor shear fractures in group C and the paired shears. Points 1, 2 and 3 indicate the orientations of the principal stresses which were localised within the zone when conjugate minor shears in groups A and B were formed. Point M is the probable movement direction on the paired shears, see text for details. Angle θ between groups A and B referred to in the text is measured as shown in the figure

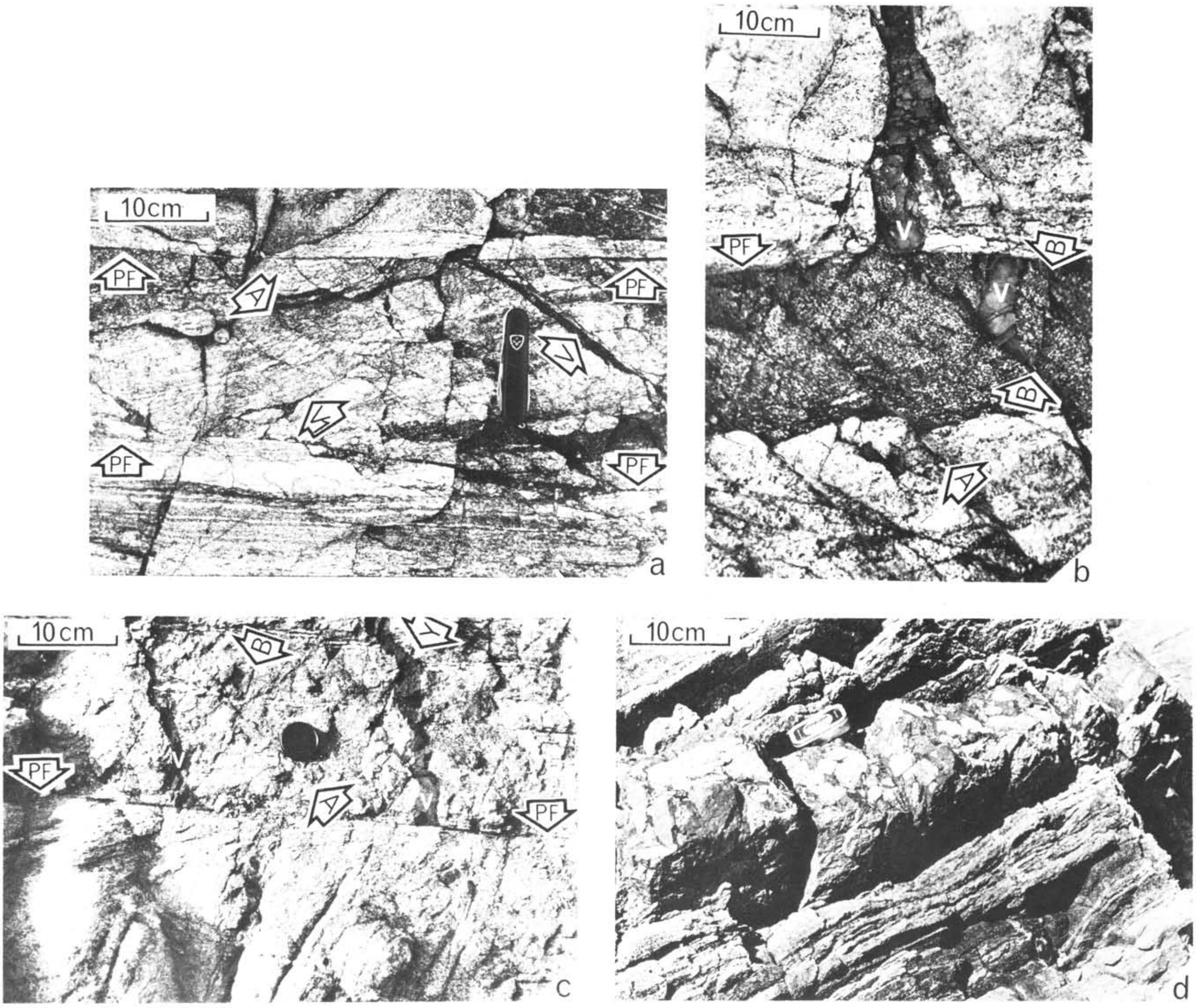

Fig. 3. Dextral **pseudotachylyte** generation zones. (a) Paired shears (PF), each with a thin discontinuous sliver of pseudotachylyte. Minor shear fractures of group A are shown (A), and an open fold of the foliation between the paired shears. Injection veins of pseudotachylyte (V), follow minor shears. (b) Minor shears of group A are shown offsetting the lower boundary of an amphibolite band. The upper boundary of this band is a principal displacement shear fracture. A second group of minor shear fractures is indicated (B). Veins of pseudotachylyte (V), branch from the generation surface at right angles. (c) Principal displacement shear fracture (PF), and injection veins of pseudotachylyte (V). The larger vein approximately bisects the conjugate minor shear fracture groups A and B near to the paired shear. At point (Y), the vein changes trend where it intersects a minor shear fracture of group A. (d) Pseudotachylyte breccia, with rotated blocks of gneiss in a matrix of pseudotachylyte generated on the boundary paired shears.

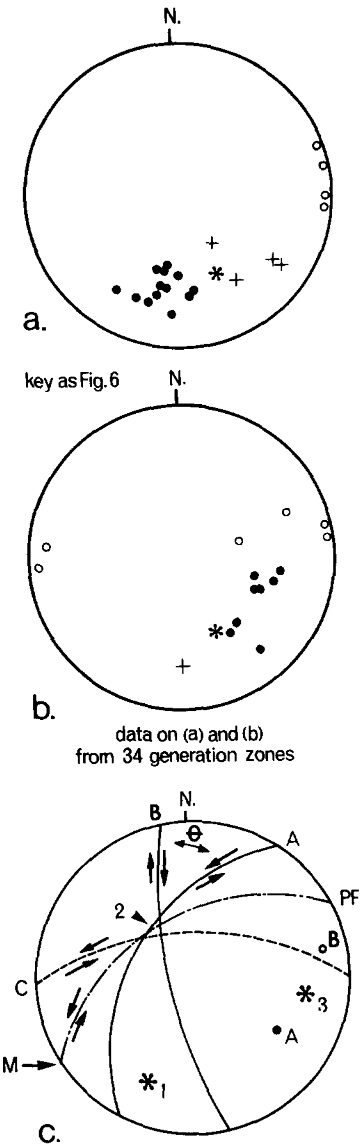

Fig. 7. Lower hemisphere projection of poles to minor shear fractures external to brittle deformation zones. (a) Fracture geometry in dextral zones. (b) Fracture geometry in zones believed to be sinistral. (c) Generalisation of (b) to show the mean orientation of minor shear associated with generation zones believed to be sinistral. Symbols as in Fig. 6.

to the paired shears. Their intersection lies within the plane of the paired shears. However, the bisector of the compressional angle between the minor shear groups (the σ_1 direction of conventional shear fracture analysis), is everywhere slightly anticlockwise of a direction which is symmetrical with respect to the paired shears.

A third group of minor shear fractures has a NE trend, displays a dextral movement sense, and dips at moderate angles to the NW. These fractures appear to branch from the paired shears, and make a small angle with the foliation (Fig. 4b, fracture C). Moderately large volumes of melt may have been generated on these surfaces, and some wedge-shaped zones of pseudotachylyte breccia form between them and the parent shear. Many shear fractures of this type have a marked drag effect on the surrounding gneissic banding, much more so than any other shear fractures. Typically they show larger displacements than other groups of minor shears.

Paired shears associated with these three groups of minor shears offset pegmatites in a dextral sense. Data on the orientation and movement sense of minor shears in the other two brittle zones is less complete. It seems that the same three groups of minor shears are present, and that the probable horizontal movement sense was also dextral.

Outside brittle deformation zones

In generation zones outside the main brittle zones, minor shears are again common (Figs. 7a and b). The same three groups as formed the fracture set in the Amitsuarssuk brittle zone can be recognised (Fig. 7a). In addition, three further groups forming a second set are found (Fig. 7b). In this second set the N–S fractures (group B) are dextral and the NE–SW fractures (group A) are sinistral. By geometrical analogy with minor shears of the first set these two groups are believed to be conjugate. The WNW–ESE group of minor shears (group C) shown in Fig. 7(b) are sinistral. They are analogous to the third group of cross-cutting shears described in the Amitsuarssuk brittle zone.

The data are rather scanty for the second set, but the mean angle between the two groups believed to be conjugate, measured in four generation zones, is 44°. Furthermore, although the intersect of these fracture sets also lies within the plane of the paired shears, the perpendicular bisector of the acute angle between them makes a smaller angle with the paired shears, and lies clockwise of an ideal symmetrical relationship (Fig. 7c), when comparison is made with the conjugate minor shears in the Amitsuarssuk brittle zone.

The orientation and movement sense of minor shears of this set is most easily reconciled with sinistral horizontal displacement on the paired shears. Unfortunately, no-

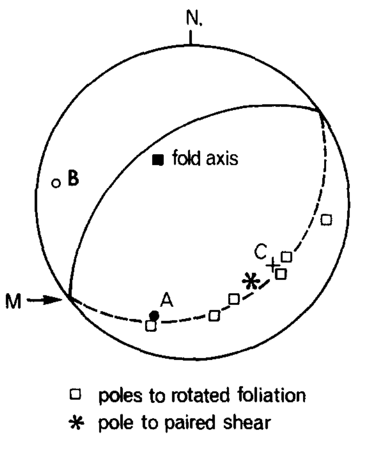

Fig. 8. Lower hemisphere projection of fracture geometry of a dextral generation zone. Orientations of minor shear fractures in groups A, B and C, together with the paired shears are shown. The dashed π girdle is drawn through poles to rotated foliation within the zone. M is the likely movement direction, see text for details.

where in the zones studied were offset pegmatites and well developed minor shear fractures observed together.

Foliation rotation

A representative illustration of the geometrical relationship between rotated foliation and shear fractures in generation zones is given in Fig. 8. The data shown in Fig. 8 were measured in a dextral generation zone. Poles to all three groups of minor shear fractures and the paired shears, tend to plot along a girdle, indicating a common intersection direction. Poles to rotated foliation lie close to the same girdle. Thus the fold axis lies approximately within the same plane as the paired shears, and the axis plunges in a similar direction to the intersection line between the fractures.

Geometry of pseudotachylyte injection veins

Most melt was generated on paired shears. In some instances these fractures exhibit a zone of cataclasite cut by pseudotachylyte, whilst others are relatively clean cut. Once melt was formed, there is much evidence that it tended to leave the generation surfaces (Figs. 3 and 4). Minor shear fractures commonly continue the line of the vein beyond its termination. Many veins have a shear offset across them, and it is often difficult to decide if the fractures they occupy are those which propagated ahead of the intruding vein, or if the vein dilated older fractures. It is emphasised that the pattern of minor shear fractures described earlier was established by measuring barren fractures, fractures extending beyond vein terminations, and fractures containing pseudotachylyte. The veins themselves are almost never cut by fractures, thus solidification of the melt followed movement on the minor shear fractures.

The relationships between minor shears and injection veins have been studied mainly in dextral generation zones. Where the volume of melt is small relative to generation zone width, the following vein-fracture relationships are common.

(1) The vein is perpendicular to the generation surface and there is no offset of markers across it. Close to the generation surface it approximately bisects conjugate minor shears in some generation zones (Figs. 3c and 9a).

(2) Adjacent to the generation surface the relationship is comparable to situation (1), but the vein gradually curves away from being orthogonal to the generation surface. It is not known if offset of markers across the vein becomes apparent as its trend changes (see Fig. 4c, vein V).

(3) Again the relationship is comparable to situation (1) but there is offset of markers across the vein. This occurs in generation zones where minor shear fractures in group B make an angle of about 90° with the generation surface.

(4) Any of the above types of vein may change trend where they intersect a minor shear fracture (Figs. 3b, lower injection vein, and 9a).

(5) The vein branches from the generation surface obliquely along any of the minor shear directions, and markers are offset across the vein (Fig. 3a, vein V). Veins may also leave the generation surface parallel to the rotated foliation (Fig. 3a, vein V_1).

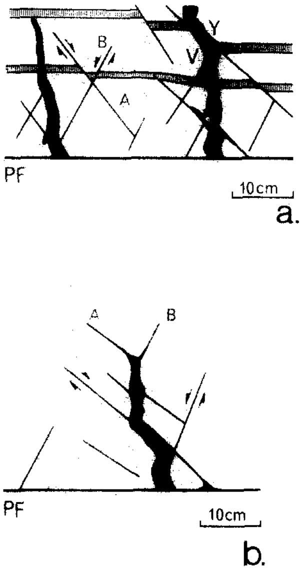

Fig. 9. Relationships between veins and minor shear fractures. (a) Sketch of part of Fig. 3(c) highlighting vein-fracture relationships. Examples of minor shear fractures in groups A and B are labelled. Vein V changes trend and develops an offset where it intersects a minor shear fracture of group A at point Y. (b) Sketch showing minor shear fractures of groups A and B which can be traced in one direction only away from the vein tip, and which probably propagated as the vein intruded.

These relationships become much less systematic as melt volume increases. They may be associated with any of the following features at vein terminations.

(1) No discernible fracture continues beyond the vein termination.

(2) A minor shear fracture which the vein has intersected and partially dilated may be traced in two directions away from the vein termination (Fig. 3b, lower injection vein).

(3) One or two minor shear fractures extend beyond the vein termination (Fig. 9b).

(4) Vein intersects another generation surface.

Injection veins show a preference to intrude inwards with respect to a zone, rather than away from it. Pseudotachylyte veins may also occur in the plane of the paired shears, particularly where these are locally irregular (Figs. 4a and b).

DISCUSSION

Development of the pseudotachylyte generation zones

A satisfactory model for the deformation sequence of these generation zones must consider the following factors.

(1) The timing of the rotation of the foliation between paired shears.

(2) Whether minor shears are older or of the same age as paired shears.

(3) The timing of melt generation with respect to minor shear fracture formation.

During minor shear fracturing and melt injection, rotation of the foliation is probably inevitable. In many generation zones which do not reach the stage of pseudotachylyte breccia formation, the observed rotation of the foliation cannot be fully accounted for in this way (Figs. 3a and 4). In these examples, particularly where the rotated foliation makes a high angle to the paired shears and is sharply truncated, the space problem implied by the geometry can only be resolved if rotation either pre-dates much of the displacement on paired shears, or large dilations of the zone during slip are postulated. In many zones, although the degree and rotation sense of the foliation may be the same over several metres, segments of opposite rotation sense and fold hinges also occur (Figs. 3a and 4). It is suggested that deformation in generation zones begins by the formation of open folds during flexural slip on the foliation. The early geometry of these folds is uncertain, as they are generally severely disrupted due to the development of the paired shears and increasing displacement. The observation that the fold axes associated with the rotated foliation tend to lie within the plane of the paired shear is consistent with the idea that the folds are related to the same movement direction as the paired shears. A simple mechanical analogy prompted by this relationship suggests that the movement direction may be given by a line perpendicular to the fold axis within the plane of the paired shears (Fig. 8).

Minor shear fractures are probably not older than the paired shears for the reason that minor shear fracturing is commonly much more intense between paired shears than external to them (Fig. 3a). If the minor shears were older, it would be remarkable if the locus of their termini lay within planar zones later to be followed by the paired shears. The lack of offset of the paired shears by the minor shears requires fulfilment of the geometrical criterion that displacement on the minor shears should decrease to zero at the intersection with the paired shear, before movement on minor shears during slip on the paired shears is admissible. Insufficient data have been collected to test adequately if this criterion is satisfied, so that although minor shears do not post-date paired shears, and the greater intensity of minor shearing between paired shears suggests that they are not older, the synchronism of the structures remains to be proved.

Regarding timing of the melting with respect to minor shear fracture formation, it is probably significant that the minor shear fracture patterns are systematic despite observation being made from barren fractures, fractures containing pseudotachylyte, and fractures extending beyond vein terminations. Although where veins change trend and follow minor shear fractures, or cut across minor shears, the local age relationship is clear, in the same generation zone minor shear fractures of similar orientations and movement senses may occur at the vein termination. Here they are interpreted as those which propagated ahead of the intruding vein (Fig. 9b, shears A & B). Such observations, taken with the systematic character of the minor shear fracture pattern, suggest that minor shear fracturing and vein injection occurred at the same time in these generation zones.

The particular vein-fracture relationship in which the vein branches from the paired shear orthogonally, and there is no offset of markers across the vein, indicates tensile fracturing, particularly where the vein bisects conjugate minor shear fracture groups (Fig. 3c). At terminations of such veins, one or two minor shear fractures may occur with trends which are different from those of the vein itself, and they can be interpreted as having propagated ahead of the vein (Fig. 9b). No attempt is made here to interpret such relationships in detail. Whether tensile fracturing will accompany melt generation, and the relationship between tensile fractures and minor shears, will be determined by changes in the stress tensor during faulting. The variables likely to be important are outlined below.

The following sequence of events is suggested on the basis of the above arguments.

(1) Initial displacements form a system of low amplitude asymmetric folds by flexural slip along the gneissic foliation.

(2) Displacement becomes concentrated along parallel paired shear fractures, and the older folds are disrupted, cataclasite then forms on the shear fractures.

(3) Melting begins on paired shears and minor shear fracture groups develop, principally between paired shears.

(4) Slip finishes before the pseudotachylyte solidifies.

Rotation of the principal stresses

Many authors of analyses of second-order fracturing in fault zones argue for the reorientation of the principal stresses during displacement. This is true for both models where minor shear fracturing pre-dates movement on the principal shear (e.g. Morgenstern & Tchalenko 1967), and models involving secondary faulting (e.g. Chinnery 1966, Price 1968, Lajtai 1969).

Rotation of stress trajectories during displacement is suggested by the fracture geometry of the generation zones described here. The principal stress orientations inferred from conjugate minor shears are shown in Figs. 6 and 7(c). Assuming that any changes in internal friction during the displacement sequence do not affect the geometry, stress trajectory rotation is necessary to account for the second-order fractures. This is particularly clear in dextral generation zones, where the angle between σ_1, inferred from minor shear fracture orientation, and paired shears is 78° (Fig. 6). It is rather unlikely that this orientation of σ_1 pertained at the time of paired shear fracture initiation, irrespective of possible changes in internal friction, and allowing for the influence of the gneissic foliation on fracture orientation (Donath 1961). Consequently, if conjugate minor shears are initiated after movement begins on the paired shears, a rotation of σ_1 away from the generation surfaces during development of dextral generation zones is postulated.

The third group of shear fractures in many generation zones (group C in the figures) cannot be accounted for by rotation of σ_1 away from the paired shears during movement. Their existence suggests the occurrence of more complex changes in the stress tensor during movement. Clearly it is not a simple matter to relate such complex rotations of the stress trajectories to a single cause. Both dynamic and static models of second-order fracturing cited above may be relevant. Furthermore, thermal stresses may play a part in the fracturing, as may the stresses consequent on volume increase accompanying melting. Much more basic geometrical data are needed before full interpretation of the fracture patterns can be attempted. Neither can an attempt be made to account for the differences in the fracture geometry of dextral generation zones and those believed to be sinistral.

Movement direction

The intersections of fractures in both dextral and sinistral generation zones tend towards a common orientation, which lies in the foliation. This direction is presumably constrained by the foliation. If it can be interpreted as the σ_2 principal stress axis, then the movement direction in the paired shears will be 90° away from this axis in the fracture plane. For many generation zones the movement direction estimated in this way implies strike-slip displacement. This movement direction is consistent with that estimated from the geometry of rotated foliation in many zones (Fig. 8).

CONCLUSIONS

Both dextral and sinistral strike-slip pseudotachylyte generation zones are recognised in the northern part of the Ikertôq shear belt.

Pseudotachylyte generation zones in strongly foliated gneiss are shown to have a systematic fracture geometry. This account has sought to emphasise the similarities which exist from zone to zone. Further work must seek to explain the differences. In particular more knowledge of displacements is required, and of how displacements vary along each zone. Any relationship between zone width, length, displacement ahd degree of anisotropy should be explored. In addition, differences in minor shear fracture geometry must be confirmed. A greal deal of basic data still remains to be collected from these zones.

Because it seems certain that the paired shears represent part of a major earthquake fault, a comparison of generation zone size, displacement, and possibly estimates of stress drop derived from these data, with those known from recent earthquake faulting may allow constraints to be placed on geophysical models of earthquake sources.

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