CONTACT STRUCTURES AT A GRANODIORITE INTRUSION,

PICCANINNY POINT, NORTH EAST TASMANIA

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(with two text-figures)

ABSTRACT

At Piccaninny Point, structures developed at the contact between the Piccaninny Creek Pluton and the Mathinna Beds have a bearing on the mode of emplacement of this body and other granodiorite plutons in north-eastern Tasmania. The contact has both concordant and irregularly discordant segments, and a dilational mode of intrusion is indicated. During the late crystallisation stage flattening of partially crystallised magma against the contact produced a secondary cataclastic foliation and flattened xenoliths, and caused injection of cross-cutting leucocratic dykes. Magmatic pressure on the wall continued after the marginal granodiorite had crystallised, producing conjugate faults and quartz gash-veining. The Piccaninny Point contact has features analogous to regional features of the granodiorite plutons of the Blue Tier Batholith to the north. The granodioritic plutons appear to have been emplaced by fracture controlled dilation, with upwelling of magma in the centre and lateral spreading against the walls.

INTRODUCTION

In a recent study of the Blue Tier Batholith in north-eastern Tasmania (Gee and Groves 1971), it was shown that the batholith was a composite, magmatic, post-tectonic intrusion displaying structures indicating several modes of emplacement. The internal and contact structures suggest processes such as structure-controlled lateral dilation, forcible intrusion, and vertical horsting.

A general sequence of emplacement was recognised from hornblende-biotite granodiorite, then biotite granite and adamellite and finally biotite-muscovite granite. The early granodiorite plutons are characterised by rectangular shapes in plan, a feature attributed to emplacement along fractures both perpendicular and parallel to the pre-intrusion fold axes. The adamellites were emplaced by a combination of upward displacement of roof blocks and lateral dilation of the country rock, resulting in regional fragmentation of the granodiorites. The muscovite-bearing granites were commonly emplaced as sheets with interconnecting dykes.

On both a regional and local scale, the mode of intrusion of the granodiorite plutons is complex with different mechanisms operating at various stages of intrusion. The contacts show evidence of fracture controlled dilation suggesting passive emplacement. However, there is also evidence of forcible intrusion reflected in such features as secondary foliation and ptygmatic folds in the granite, and deformation of the wall rock. On the foreshore at Piccaninny Point, 17 km south-east of St. Marys, a well exposed contact shows that deformation structures caused by forcible intrusion are later than, and superimposed upon, dilational structures related to passive emplacement.

PICCANINNY CREEK PLUTON

The Piccaninny Creek Pluton forms part of a composite granitic intrusion south of
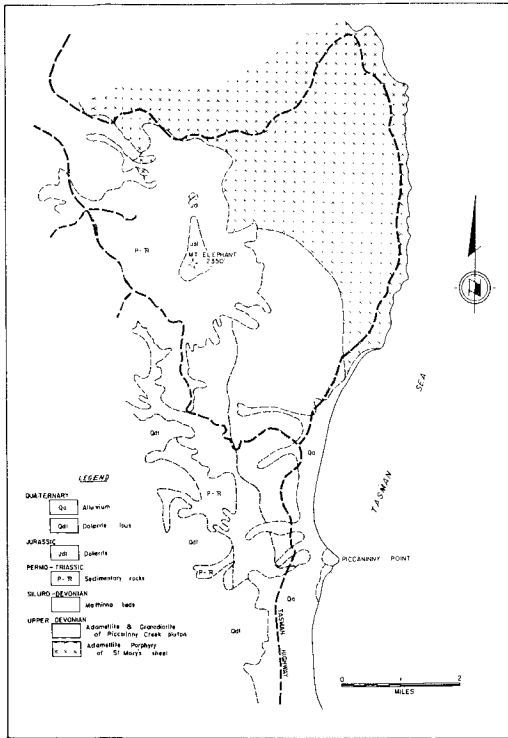
FIG. 1. - Geological sketch map of the surroundings of the Piccaninny Creek Pluton, eastern Tasmania (after McNeil 1965).

the main part of the Blue Tier Batholith (fig. 1). It is petrologically similar to the hornblende granodiorite plutons that were early-crystallised segments of the Blue Tier Batholith. The Pluton is composed of biotite-hornblende adamellite and biotite-hornblende granodiorite, which both comprise anhedral undulose quartz, zoned subhedral to euhedral andesine, biotite and hornblende, all poikilitically enclosed in K-feldspar (e.g. McNeil 1965). The rocks are generally massive, although characterised by fractured and undulose quartz and biotite, and in places they have a secondary foliation.

The Pluton is a steep-walled N-S trending, elongate mass that intruded both the St. Marys Sheet and the Mathinna Beds with sharp transgressive contacts. The granitic rocks and Mathinna Beds are unconformably overlain by Permian and Triassic sedimentary sequences and by Quaternary alluvium which partly obscure the regional distribution of pre-Permian bedrock (fig. 1).

PICCANINNY CREEK CONTACT

The contact at Piccaninny Point is between a foliated biotite-hornblende granodiorite and a hornfelsed sub-graywacke sandstone and siltstone. The structures at the contact are divided into the intrusive phase, the late-intrusive phase and the post-intrusive phase (fig. 2).

Intrusive Phase
    The contact is irregular, in places concordant and elsewhere breaking irregularly across bedding and tectonic folds at a high angle. In the discordant zones, granodiorite moulds around irregular edges of country rock, giving the impression of torn bedding. Extending south from the main mass, more or less along the bedding, is a granodiorite apophysis of similar composition to the main mass. In detail the dyke is discordant and has an irregular septum of country rock that is distended along its length. The actual contacts are sharp, and commonly have a thin selvage of more mafic granodiorite indicating some assimilation. There is no evidence of stoping. The general shape of the dyke wall irregularities is indicative of rupture and dilation.

    A weak primary banding, varying from a few cm up to 100 cm in thickness, occurs within both the main granodiorite and the apophysis that connects to the main mass. McNeil (1965) stated that in the apophysis the bands are of biotite granodiorite, biotite-hornblende granodiorite and biotite-hornblende trondhjemite. The banding is generally parallel to the dyke walls except in a few cases where one band transgresses another. Such features suggest an origin by sequential intrusion of magma of different compositions, rather than a flow banding.

    Two types of xenoliths occur in the granodiorite. The less common type consists of fragments detached from the immediate country rock. These xenoliths contain quartz, biotite and a little muscovite, and are petrographically identical to the hornfelsed

FIG. 2. - Geological map of part of the Piccaninny Point contact between biotite-hornblende granodiorite and the Mathinna Beds, showing also a diagrammatic summary of the structural sequence.

country rock. The more common type of xenolith is ovoid in shape, generally about
10 cm in diameter, and composed of quartz, biotite and K-feldspar. These xenoliths
bear no spatial relationship to the contact, and are probably far-travelled and of
deep-seated origin.

Late-Intrusive Phase
    A network of secondary dykes occurs within the main mass of granodiorite (fig.
2). The most northerly dyke has diffuse and gradational walls against granodiorite
at its point of origin, but towards the contact it widens to become a conspicuous
leucocratic dyke with sharp walls. It shows enrichment of K-feldspar and quartz, and
depletion of biotite and hornblende away from its point of origin. The smaller dykes
nearby are also leucocratic and grade into aplite towards the country rock.

    These dykes exhibit features of dilational emplacement. Earlier intersecting
planar structures may be matched (Williams and Groves 1967) and give a direction of
distention of $005°$ (true). Dyke wall irregularities may also be matched, but these
have been modified by flattening. Flattening of dyke wall irregularities has produc-
ed folds with steeply plunging axes and an axial surface foliation. The foliation is
a post-intrusive cataclastic structure that maintains a constant orientation of $000°$-
$005°$ (true) across dykes and dyke-wall irregularities. It is always oblique to the
trend of the apophysis and the primary banding, which together give the mean trend
of the main contact.

    Mesoscopically the foliation is expressed as streaked out aggregates of quartz
partly enveloped by biotite and hornblende giving an impersistent banding on the
scale of several millimetres. In thin section the original quartz crystals are
fractured and appear as strongly undulose and sutured aggregates which wrap around
the feldspars. Twin lamellae in plagioclase show micro-faulting and kinking, and bio-
tite flakes are strongly kinked.

    The far-travelled xenoliths are discoidal in all sections, and flattened in the
foliation with a maximum ellipticity (lineation) in the foliation plane plunging
gently to the north. There is no evidence of elongation in the plane of the primary
banding. Similar xenoliths in unfoliated granodiorite have subcircular outlines on
all joint faces. The shape of an "average xenolith" appears to have approximated a
sphere and therefore the xenoliths may be used as strain indicators following the
simple analysis of Cloos (1947). It is further assumed that there is no volume
change during flattening, and this is justified by the late cataclastic nature of the
deformation.

    The length, breadth, and the pitch of elongation of 30 xenoliths have been
measured on each of three joint faces, one lying in the foliation, another vertical
and perpendicular to the foliation, and the third surface gently dipping to the
north so as to include the lineation. If A, B and C are the maximum, intermediate
and minimum axes of the ellipsoids then the axial ratios are A/C = 2.63 ; A/B
(foliation plane) = 1.72 and B/C = 1.57. With respect to the sphere of equivalent
volume, A = 1.38; B = 1.30 and C = 0.53, indicating a 47% flattening across the
foliation plane, a 38% extension along an axis which plunges shallowly to the north
in the foliation place, and an extension of 30% along an axis which is nearly vertical
in the foliation place.

    Flattening in the country rock is expressed by a weak foliation close to the
contact, and ptygmatic quartz veins and boudinage away from the contact. Foliation
is due to a planar orientation of biotite flakes that wrap around porphyroblasts of
plagioclase. The quartz veins occur in irregular cross fractures and have been
flattened to simulate intense contortion. Gash veins in sets at an acute angle to
bedding are also present. Incipient boudinage with quartz-filled nodes occur at a
distance of about 20 m from the contact and appear to indicate a diminution of the
flattening away from this contact.

Post-Intrusive Phase

The post-intrusive structures are characterised by further quartz veins and conjugate faults. The quartz occurs in transverse pod-shaped veins that cut both the foliated granodiorite and the marginal ptygmatic structures.

The faults occur in both granodiorite and country rock. They form dextral wrenches trending $090°$ (true) and sinistral wrenches trending $120°$. The acute dihedral angle varies from $15°$ to $40°$ and the faults are approximately symmetrical about the foliation. The faults intersect about a near vertical axis that does not necessarily lie in the bedding. There is no consistent order of formation of the individual sets and statistically they can be regarded as contemporaneous. Reversed movement at some intersections is shown by secondary splay faults that run around the obtuse angle near the point of intersection, and connect the opposite pair. The sequence of formation which solves the room problem of conjugate faulting is shown in the inset (fig. 2).

MECHANICAL INTERPRETATION OF THE CONTACT

The concordant and discordant relations, together with the minor role of assimilation and the lack of evidence for stoping, suggest a dilational mode of intrusion. Further, the lack of marginal deformation that can be attributed to the primary intrusive phase suggests passive intrusion. The primary compositional banding is best explained by repeated intrusion of slightly different magma types during spasmodic dilation.

The kinematic unity of the structures of the late-intrusion and post-intrusion phase permits correlation between the stress and strain axes. All the structures of the late intrusive phase indicate east-west flattening of the granodiorite against its border and north-south distension before complete crystallisation. Leucocratic and aplitic dykes were emplaced, probably by pressure release, into east-west cross-trending steep fractures. Continued shortening caused folding of the dykes, flattening of the xenoliths, foliation of the granodiorite, and secondary dykes. Symmetry relationships indicate a pure shear, in which case the P *max* is directed horizontally at about $100°$, and P *int* is vertical.

Cataclastic borders have been noted at granite contacts elsewhere (e.g. Sherlock and Hamilton 1958) and are generally considered to result from continued upward movement of the partly consolidated magma against the wall. This interpretation does not apply to the Piccaninny Point contact which has a gently plunging weak lineation in the foliation that is caused by lateral flattening.

The conjugate faults of the post-intrusive phase are more or less symmetrical about the secondary foliation and indicate also a vertical P *int* and a P *max* directed towards $106°$. The direction of displacement on the faults indicates bulk E-W shortening and N-S distension.

CONCLUSIONS

The emplacement of granodiorite at Piccaninny Point is interpreted as dilational and passive. It is not until the late magmatic stage that evidence for magmatic pressure on the walls becomes significant. The foliated zone at Piccaninny Point is at least 200 m wide. The area to the east is covered by sea, but the foliation is probably a marginal feature.

Marginal cataclastic foliations, flattened xenoliths, and deformation in the contact aureole are features of the granodiorite plutons in the Blue Tier Batholith to the north. However, the marginal deformation on the regional scale is not sufficient to restore the country rock to its pre-intrusion state. The sequence of events at Piccaninny Point indicates that these are late stage effects and not major features of the emplacement of the plutons. The granodiorite plutons seem to have

intruded by fracture-controlled dilation, with upwelling of magma in the centre of the pluton and lateral spreading against the walls.

ACKNOWLEDGEMENTS

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