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THE FOLIATED GRANITIC ROCKS OF WESTERN ALDERNEY, CHANNEL ISLANDS: FABRIC ORIGIN AND INTERPRETATION OF $^{40}Ar/^{39}Ar$ MINERAL COOLING AGES

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Traditionally, the foliated granitic rocks of Western Alderney have been considered to represent deformed and metamorphosed basement or early Cadomian plutonic rocks. We present textural evidence which suggests that the dominant fabric is magmatic in origin and weakly modified by solid-state deformation during initial pluton cooling. Subsequent reworking is not penetrative and took place at only low temperatures, ie. low greenschist facies. We therefore consider the effects of post-emplacement deformation and metamorphism to be minor, and interpret recently obtained $^{40}Ar/^{39}Ar$ mineral ages as dating cooling following pluton emplacement.

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INTRODUCTION

Western Alderney comprises a complex of variably foliated granitic to quartz dioritic rocks (Figure 1). These are in faulted contact with undeformed and non-metamorphosed plutonic rocks (Central diorites and Bibette Head granodiorite; Figure 1). Lower Palaeozoic, continental sedimentary rocks (Alderney Sandstone) rest unconformably upon foliated granite at Val du Sud and upon Central Diorite at Bluestone Bay (Went, 1991; Figure 1). Although all units are cut by minor intrusions, a north-east-trending porphyritic microgranite dyke swarm cuts the foliated granitic rocks, but does not cut either the Central diorites or the Alderney Sandstone, allowing a relative geological history to be erected. Brewer and Power (1986) and Power *et al.* (1990) describe three main divisions of the foliated granitic rocks in western Alderney: 1) quartz diorites, which comprise the bulk of the complex, 2) K-feldspar granites which crop out in the south and 3) the Fort Tourgis quartz diorite in the north. Although they did not identify discrete contacts between these components and thus considered them to form a single pluton, they distinguished between the Fort Tourgis quartz diorite and the main quartz diorites on the basis of geochemical differences, which they suggested could be the result of contamination of the Fort Tourgis quartz diorite by a basic component. Brewer and Power (1986) and Power *et al.* (1990) suggested that the foliation formed after pluton solidification during regional deformation and metamorphism. In this contribution we argue that

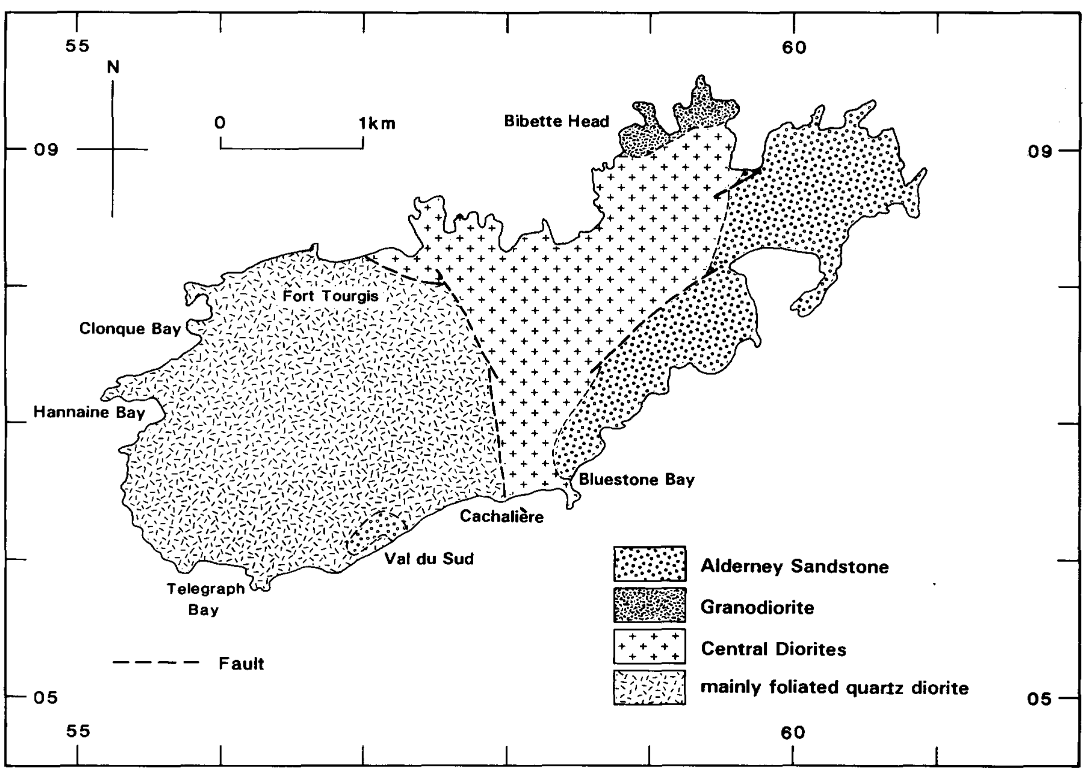

Figure 1: Simplified geological map of Alderney. Minor intrusions omitted.

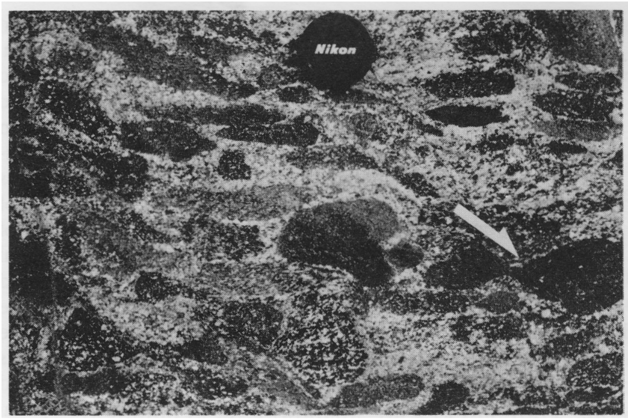

Figure 2: Elongate microdiorite enclaves within quartz diorite at Fort Tourgis. Arrow shows direction of displacement across magmatic shear zone. Diameter of lens cap = 52 mm.

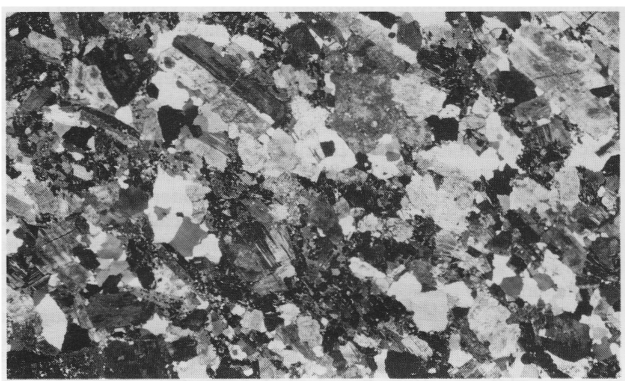

Figure 3: Fabric within quartz diorite from Fort Tourgis. The fabric is mainly defined by strongly aligned, euhedral plagioclase and amphibole prisms. The only weak ellipticity of interstitial quartz and mafic aggregates, suggests the alignment is mainly magmatic in origin. Long axis of photomicrograph = 25 mm. XPL.

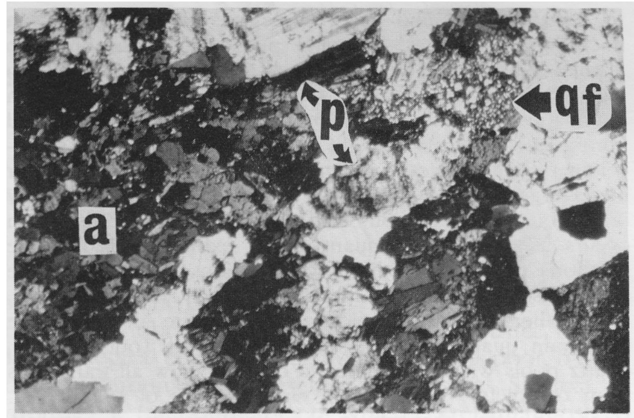

Figure 4: Microtextures within quartz diorite at Fort Tourgis. qf = quartz/feldspar, chequerboard intergrowth; a = recrystallized aggregates of hornblende and biotite; p = euhedral, zoned plagioclase. Long axis of photomicrograph = 8 mm. XPL.

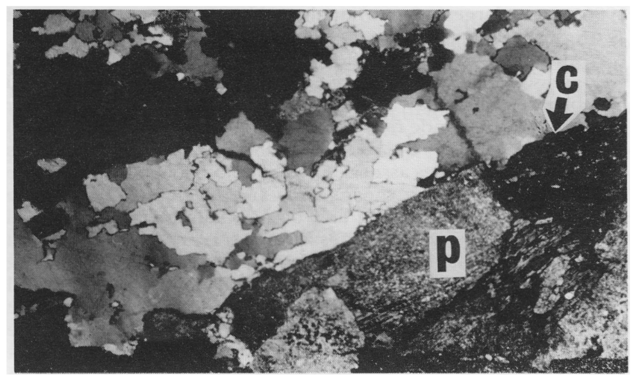

Figure 5: Quartz microstructure within quartz diorite from Telegraph Bay. Note complex and intricate sub grain boundaries resulting from grain boundary migration (centre of field of view) suggesting some high temperature deformation of quartz (cf. Gapais & Barbarin 1986): p = sericitised plagioclase; c = chlorite replacing original mafic minerals. Long axis of photomicrograph = 4 mm. XPL.

the quartz diorites at Fort Tourgis have undergone only weak and localized low temperature, postsolidification deformation and metamorphism, and interpret the dominant deformation fabrics and microtextural features as forming during, and shortly following emplacement. This interpretation suggests that recently acquired $^{40}Ar/^{39}Ar$ mineral ages for the quartz diorite at Fort Tourgis date cooling following emplacement (Dallmeyer *et al.,* in press).

FIELD RELATIONSHIPS

The foliated granitic rocks are predominantly quartz dioritic to tonalitic in composition. Enclaves of hornblende microdiorite are common, especially in the area around Fort Tourgis (Figure 2). The enclaves contain variable proportions of plagioclase phenocrysts and sometimes display highly crenulate margins. They may also form trains of rounded to elongate enclaves (Figure 2). These complex relationships are consistent with magma-mingling and partial mixing between a mafic magma and the quartz diorite host (eg. D'Lemos, 1986). Some semi-pelitic enclaves occur on the south coast near Cachalière (Figure 1), enclosed within weakly foliated megacrystic granite. Also at Fort Tourgis centimetre to metre-thick sheeting of quartz diorite and more granodioritic components is common. The sheet contacts, although sometimes indistinct, parallel the deformation fabrics. A north-east—south-west striking foliation which dips steeply north-west is defined by shape orientation of quartz pools and mafic aggregates, and by alignment of plagioclase and amphibole. Where mineral prisms are strongly aligned (eg. quartz diorites at Fort Tourgis), or quartz pools are elongate (eg. Telegraph Bay), a moderate north-north-east plunging lineation is defined. In many areas the foliation is poorly developed and in the field it may be difficult to identify with confidence (eg. south coast and Clonque Bay). Several generations of minor intrusions cut the foliated rocks. The sequence is: 1) minor aplite veins, 2) numerous, north-east-trending, metre-wide porphyritic microgranites and 3) microgabbro and lamprophyre. Rarely, at Fort Tourgis, the primary foliation bends into ductile shear bands which strike north-north-east—south-south-west and develop gently plunging stretching lineations, sub-parallel to those defined by the mineral prisms. More commonly, the early grain-scale foliation is cut by centimetre-wide dark shear zones which are often well developed along the margins of microgranite dykes. Late, mainly north-west—south-east trending, brittle faults cut all rock units, and fault zones are often iron-stained and associated with quartz veining and clay gouge.

PETROGRAPHY AND MICROSTRUCTURES

The quartz diorites and tonalites are medium to coarse-grained and mainly consist of plagioclase, quartz and biotite in various proportions, associated with variably replaced hornblende, secondary chlorite and minor accessories. Deformation fabrics within quartz diorites are defined by the moderate to strong alignment of long axes of euhedral hornblende and plagioclase prisms and by weakly ellipsoidal quartz pools (dimensions up to *c*.10x6x5 mm) and mafic aggregates (Figure 3). Within microdiorite enclaves, euhedral plagioclase laths are also aligned. Around Fort Tourgis quartz pools consist of *c*.750μm equant, strain-free grains with relatively straight grain boundaries. Mafic aggregates consist of strain-free biotite and hornblende (Figure 4). Single grains of dark brown to straw-yellow pleochroic biotite and green hornblende may enclose or be overgrown by *c*.350μm euhedral laths of randomly orientated, secondary biotite and ore. The amphibole also often occurs as clusters of equant grains exhibiting 120° triple junctions consistent with recrystallization (Figure 4). Some plagioclase grains contain blebs of regularly arranged quartz, while others display chemical zoning (Figure 4). Unlike the multigrain quartz aggregates within the Fort Tourgis rocks, quartz pools within other quartz diorites show all transitions from completely undeformed single grains of quartz (eg. Hannaine Bay), through to the development of subgrain boundaries with increasing pool ellipticity (eg. Telegraph Bay). Where these sub-grain boundaries form, they are extremely crenulate and complexly sutured (Figure 5), consistent with high grain boundary mobility and migration (cf. Gapais and Barbarin, 1986). Some large (*c*.2mm) unaltered biotite grains, interpreted as original magmatic crystals, exhibit microkinking.

All rocks show some effects of low grade deformation and retrogressive metamorphism. Original brown biotite and hornblende grains may be retrogressed to chlorite (Figure 5), or biotite and hornblende may be pseudomorphed by fine (*c*.30μm) green/tan biotite + quartz + ore. Secondary phyllosillicates commonly fill fractures associated with the original positions of the mafic minerals, but no shear bands are developed. Plagioclase shows variable sericitisation and occasionally microcracks filled with quartz + chlorite. Numerous late faults are spatially associated with the most intense areas of low grade metamorphism (eg Telegraph Bay). Discrete zones of brittle shearing show elliptical to rounded, cataclastic fragments of quartz aggregates set in a fine groundmass (*c*.50μm) of quartz, strongly sericitised plagioclase and a green mica (biotite? + chlorite). Rare ductile shear zones at Fort Tourgis show a mylonitic fabric defined by aligned *c*.450μm biotite laths and dynamically recrystallized aggregates of strain-free and twinned plagioclase grains (*c*.200μm), and only accessory quartz. The recrystallization of plagioclase and biotite suggests that the shear zones formed at at least amphibolite facies temperatures (Simpson, 1985).

DISCUSSION

In the majority of quartz diorites, although the dominant grainscale fabrics (Figure 3) are defined by the sub-parallel alignment of plagioclase and hornblende prisms, the only weak ellipsoidal shape of the quartz pools suggests that mineral alignment occured prior to the crystallization of the quartz. Therefore, the fabric is largely magmatic in origin. The retrogressive features and localised brittle-ductile shear zones suggest only weak, low temperature solid-state reworking of the pluton. There is no evidence for widespread and penetrative solid-state deformation within the greenschist fades. However, some very high temperature solid-state deformation is suggested by extensive grain boundary migration within quartz pools (Figure 5) at a homogenous grain-scale (Gapais and Barbarin, 1986; Gapais, 1989), and more rarely by the gradation of magmatic fabrics into high temperature shear zones. These high temperature deformation features need not imply metamorphism at high grades, but instead, may suggest that some quartz diorites continued to be deformed just after solidification while the pluton was cooling from initially high, intrusive temperatures. As such, these features imply that deformation of the quartz diorite was broadly coeval with the time of emplacement.

At Fort Tourgis intimate textural relationships between biotite and amphibole, plagioclase intergrowths and aggregates of hornblende and quartz (Figure 4), all indicate partial recrystallization of original igneous phases. This could result from either 1) static recrystallization during regional metamorphism, or contact metamorphism caused by, for example, emplacement of a dyke swarm and/or igneous complex to the east, or 2) reaction of disequilibrium xenocrysts following from mixing between contrasting magmas during initial formation of the pluton. Regional metamorphism is considered an unlikely factor due to the lack of a penetrative, solid-state deformation fabric and random orientation of replacive phases. Distinction between features formed during either contact metamorphism or magma-mixing is more problematic. Contact metamorphism is less favoured, due to the local and heterogeneous nature of recrystallization (often in the same thin section) and retention of oscillatory zoning in feldspars. There is also no apparent spatial relationship between the development of the microtextures and the proximity of possible heat sources. Microgranite dykes are present throughout the whole of western Alderney, yet the textures observed are mainly recorded in the magma-mixed rocks around Fort Tourgis. No clear-cut variation in texture is recorded in the quartz diorite as individual dykes are approached. Textural features and field relationships, including chequerboard-type intergrowths in feldspar, feldspar/quartz intergrowths, partial recrystallization of mafic phases, abundant microgranitoid-type enclaves and overall heterogeneity are all consistent with partial reequilibration following magma-mixing (eg. Vernon, 1991).

$^{40}Ar/^{39}Ar$ cooling ages of *c*.560 Ma have been obtained for hornblende and biotite from the Fort Tourgis quartz diorite (Dallmeyer *et al.,* in press). Such ages record cooling of hornblende through *c*.500°C and biotite through *c*.325°C (see also D'Lemos *et al.,* 1992 and references therein). Evidence presented here indicates that the Fort Tourgis quartz diorite retains mainly primary igneous features. Deformation and metamorphism postdating initial pluton cooling is mainly of a low temperature nature and substantially below that required to cause resetting of $^{40}Ar/^{39}Ar$ systematics. Therefore, it seems most plausible that the obtained ages date post-magmatic cooling following emplacement of the Fort Tourgis quartz diorite. Given the lack of discrete contacts between components of the foliated granitic rocks of western Alderney and their general similarity, it may be reasonable to interpret the phases as forming a single pluton (cf. Brewer and Power, 1986; Power *et al.,* 1990). Therefore, *c*.560 Ma is likely to reflect the approximate emplacement age of the quartz diorites of western Alderney as a whole.

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