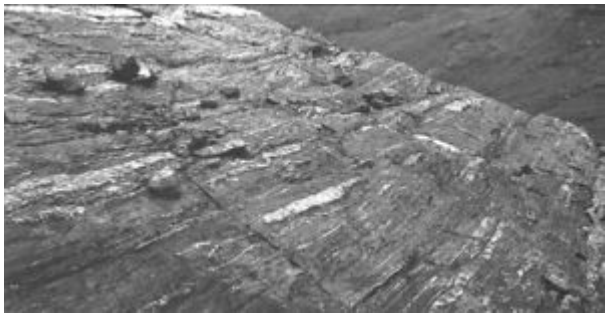
Migmatites, early igneous activity within the Caledonides, Northern Highlands of Scotland

From Earthwise
Jump to navigation Jump to search

Johnstone, G S and Mykura, W. 1989. British regional geology: Northern Highlands of Scotland. Fourth edition. Keyworth, Nottingham: British Geological Survey.
□

Contents

Migmatites, introduction



Migmatitic rocks: lit-par-lit gneiss. Loch Shiel Migmatite Complex, Coire nan Gall, Sgurr na Ciche area. P916024.

Granite-gneiss with neosome lits bounded by black biotite selvages. P219057.

Migmatitic rocks and pegmatites: lit-par-lit gneiss in an extreme form, with thick pegmatite bands showing a vague palimpsest banding. P916026.

Major intrusions, granite gneiss and migmatites within the Caledonides of the Northern Highlands. P915476.

The term migmatite is applied to a rock comprising an intimate mixture of a schistose host (normally metasedimentary) referred to as the palaeosome (Menhert, 1971) and granitic (usually pegmatitic) material, the neosome, which has been derived from the host by a process of partial melting (anatexis) or by a process of segregation involving volatile components, some of which may have been introduced from an extraneous source. Migmatites are the products of high- grade metamorphism which required the rock to be at or about sillimanite grade (c.700°C). The resulting rocks are lithologically very variable.

The typical rock of the migmatite complexes of the Northern Highlands Moines is a pelitic or semipelitic *lit-par-lit* gneiss, in which the palaeosome and neosome are intimately interbanded parallel to the foliation (P916024). As the migmatisation process preferentially concentrates quartz and feldspar in the neosome (leucosome) the relative increase in the biotite content of the

palaeosome commonly renders it a matter of difficulty to decide whether the host rock was originally a pelitic or a semipelitic metasediment. The neosome commonly has a black selvedge (melanosome) or restite, of black biotite (Plate 18). The body of the host rock is a much coarser grained than that of similar rocks outside the area of migmatisation, and there is a more distinct separation of mica and quartzofeldspathic material, the latter tending to aggregate into minute blebs or eyes (augen) rather than layers (P219057). (This more-or-less uniform material is sometimes referred to as 'permeation gneiss'; however, this term is best avoided because of certain genetic complications.) Within it, the quartzofeldspathic component aggregates gradually until it forms '*lits*' of coarse-grained granitic material (some of which are continuous along the foliation for several metres) giving a gneissic, banded (stromatic) appearance to the rock. Other concentrations are more distinctly lensoid, forming chains of small or large augen along the foliation. The spacing of the lits or augen chains is irregular.

The thickness of the neosome is variable, from barely discernable to several metres; it is evident that the thickest neosomes cannot be entirely of local origin. Possibly neosome material migrated from its source rock to aggregate in thicker bands. In places the neosome may make up large areas of country in which the host rock is only represented by relict streaks. The rock has become a nebulite. In the pelitic *lit-par-lit* gneisses the neosome (and the larger pegmatites probably derived from them) tend to be oligoclase-bearing (trondhjemitic) (P916026).

Lit-par-lit gneisses with a psammitic host are less common. As in the case of the pelite-hosted gneisses, the neosomes which have developed along the micaceous foliae commonly have biotite selvedges, but they are granitic rather then trondhjemitic in composition. The palaeosome may be much recrystallised to a coarse- grained rock; small porphyroblastic augen of potash feldspar are commonly found within it.

Within the migmatite complexes the host rocks themselves are commonly greatly altered. Coarse glassy quartzites result from the recrystallisation of siliceous granulites, and often resemble vein quartz. Calc-silicate bands acquire a vitreous lustre and contain basic plagioclase, indicative of high-grade metamorphism. Metadolerites and hornblende schists do not themselves readily form *lit-par-lit* gneisses but may be veined with pegmatitic material and streaked out to form poorly foliated hornblende gneiss (Read, 1931).

The migmatites of the Northern Highlands are all accompanied by pegmatite or granite vein stockworks whose members cross-cut the *lit-par-lit* neosomes; however, they may become indistinguishable from them in places. Like the neosomes, they are trondhjemitic. The pegmatites extend beyond the limits of the gneisses; they seem, however, to belong to two suites (see below), one of Precambrian and one of Caledonian age.

The migmatites lie in a belt extending from Morvern (and Mull) in the Southwest to Sutherland and Caithness, a zone which is largely controlled by the availability of susceptible host rocks within the pelitic strata of the Glenfinnan Division. It must, however, be emphasised that the migmatites are not confined to rocks of that division in the south, and in the northern part of the Northern Highlands they appear in rock groups whose position within the Moine sequence is uncertain.

The following three 'migmatite complexes', each with somewhat different characteristics, have been identified. The limits of each complex are indefinite and probably gradational.

Loch Shiel Migmatite Complex

The rocks of this complex extend from the Sound of Mull to Ross-shire (P915476). They consist of *lit-par-lit* pelitic gneiss with associated pegmatites (Plates 17, 18). The migmatisation is largely limited

in the east by the unresponsive psammites of the Loch Eil Division but, well within that division, thin bands of pelitic rocks show some evidence of quartzofeldspathic segregation. The migmatisation diminishes more gradually westwards and crosses the Glenfinnan/Morar Division boundary (the Sgurr Beag Slide). Cross-cutting pegmatites and, eventually, quartz veins, extend well beyond the limits of *lit-par-lit* gneiss. There is no development of a granite specific to the complex, such as is found in the Loch Coire Complex to the north (Read, 1931; Brown, 1967, 1971), and no division of the Loch Shiel Complex into separate mappable subunits seems profitable at present. Within the Loch Shiel Complex lie several extensive masses of trondhjemitic pegmatite, notably at Beinn Odhar near Glenfinnan, lie Choire at the head of Loch Morar and Coire nan Gall below Sgurr na Ciche. These large masses, which in the case of lie Choire measures 3x2 km, are apparently a further development of those gneisses of pegmatitic aspect which shown relict metasedimentary structures.

Loch Coire and Strath Halladale Complexes

These two migmatite complexes of Sutherland differ in major respects both from each other and from the Loch Shiel Complex. There is a need for comparative studies of all three in order to quantify just what these differences amount to. The two northern complexes are not simple *lit-par-lit* migmatites of alternating pelite/semipelite host and pegmatite neosome, but contain in addition various granitic bodies. These are thought to be either the ultimate product of migmatisation or part of a metasomatic process which resulted in the development of both migmatite and granite, possibly with the larger granite masses being truly magmatic (Brown, 1967).

The *lit-par-lit* gneisses could be the products of isochemical anatexis (Stevenson, 1971; Butler, 1965), but Brown (1967) and Cheng (1944) have shown that their formation requires the metasomatic introduction of sodium. In the Loch Coire Complex, Brown has followed Read in identifying the sheet-like form of the migmatites with an upward transition (seen on Ben Klibreck) from unmigmatised metasediments to structurally overlying migmatised rocks. The progression is through a zone of veins and sills distinct from the transected rock into a zone in which the two are intimately mixed to form banded migmatites, which themselves are cut by other veins and sheets. These veins are of oligoclase granite or pegmatite. Masses of oligoclase-bearing granite lie within the complex, of which the Loch Coire granite is the largest. It is weakly foliated. The rocks of the complex are cut by seams of pink aplite, probably of separate, later generation.

Although the migmatitisation phenomena of the north coast of Scotland were reported by Home and Greenly as long ago as 1898, little regional descriptive work has been published on the Strath Halladale migmatite complex. It appears that this comprises lit-par-lit migmatite of regional extent, with a more local migmatite associated with the early emplacement of a soda-rich granite found around the main outcrop of the Strath Halladale granite. This granite shows a foliation, and is considered by McCourt (1980) to be the same as that which forms the sheets and veins of the Loch Coire Complex. McCourt, however, cites evidence of feldspar zoning and quartz-plagioclase reaction, which he considers indicative of a magmatic origin for the rock. The migmatite and the sodic granites are folded, but the main mass of the Strath Halladale granite (previously classed with the migmatites) is of a later generation and is a true magmatic biotite granite. It is affected only by late-stage minor folding, and cannot be correlated with the migmatite complex.

Ardgour Granite Gneiss

Within the Loch Shiel migmatite belt and in the adjacent Loch Eil Psammite lie extensive outcrops of true granite gneiss (P915476). These outcrops, although disconnected, clearly form a related development from Ardgour to Glen Moriston.

The greater part of Ardgour Gneiss (possibly better referred to as the West Highland Granite Gneiss, as its outcrop in Ardgour is only a small part of the whole) consists of a coarse foliated microcline-oligoclase-quartz granite with subordinate biotite. The biotite defines a foliation along which pods of pegmatitic material, each margined by a biotite-restite selvedge, are commonly developed, giving a gneissose aspect to the rock. North of Sgurr Dhomhnuill, near Strontian, the rock has the appearance of a composite gneiss with augen of potash-feldspar and quartz developed both within the granite gneiss and in the surrounding pelitic migmatite. Elsewhere it is remarkably massive, and may even lose its biotite foliation, so that it strongly resembles a post-foliation granite. The various granite-gneiss bodies are emplaced in widely separate parts of the Moine succession and some of the bodies appear themselves to transgress the lithostratigraphical divisions of the enclosing schists. In a few places the junction with the country rock is clearly cross-cutting, suggestive of local mobilisation. Overall, however, its contacts with the pelitic migmatites are quite gradational.

The granite gneiss has been interpreted in various ways. Harry (1953) considered it to be part of the regional migmatites, deriving it by potash metasomatism following the initial phase of soda-metasomatism responsible for the *lit-par-lit* gneisses. Dalziel (1963) considered it to have formed in-situ by anatexis from a host rock of suitable composition. This interpretation was based partly on the evidence of the gradational contacts of the granite gneiss with the metasedimentary gneiss, and partly on the habit of its contained zircons; these, he claimed, had never crystallised in a magma (a point later disputed by Pidgeon and Aftalion, 1978). Mercy (1963) considered that it had passed through a magmatic phase, either as an in-situ melt or as a true intrusion. Harris (*in* Winchester, 1974) suggested that it could represent a series of tectonic slices of basement. Whatever its origin, there is general agreement that it was emplaced or formed prior to the second deformation of the region; Brook and others (1976; 1977) suggest, from Rb-Sr isotope dates, that it has undergone the Grenville phase of metamorphism ate. 1100 Ma.

The age of the migmatite complexes

The age of the migmatites and their accompanying pegmatites has been of vital importance in elucidating the history of deposition and metamorphism of Moine rocks of the Northern Highlands. In this respect the south-west part of the region, comprising the Loch Shiel Migmatite Complex, has been the most completely studied.

In that district, near Glenfinnan itself, the rocks were rendered schistose and were migmatitised prior to the folds of the second phase of deformation of the region (D_2 of P915510). Lensoid pegmatites developed along the migmatite layers give an age of 730–740 Ma (Rb-Sr and U-Pb methods; van Breemen and others, 1974). These ages are similar to those from other pegmatites cutting the Moines of the west central Northern Highlands (Long and Lambert, 1963; Giletti and others, 1961). On this basis the first metamorphism and folding of the Moine rocks was Precambrian, and the age of deposition of the Moine sediments could be considerably older than 750 Ma. Lambert (1969) has proposed the name ‘Morarian’ for the tectonothermal episode which gave rise to the pegmatites.

The migmatites and concordant pegmatites are cut by a later suite of transgressive pegmatites. These span the period of development of the D_2 folds, and continue over the period of D_3 development. These pegmatites give radiometric ages which relate them to a Caledonian episode around 450 Ma, and during this period the earlier migmatites were reworked (van Breemen and others, 1974). Separate Precambrian and Caledonian tectonothermal episodes seem thus to be well established on the basis of the ages so far determined, and consistent results seem to extend over a wide area. The problem that these results pose to the interpretation of the structural and metamorphic history of the northern part of the Northern Highlands has already been alluded to.

However, the Ardgour Granite Gneiss adds still more complexity to the problem. From a Rb-Sr whole rock isochron this mass has a Grenvillian age of about 1020 Ma (Brook and others, 1976). If the gneiss is a migmatite developed in situ (see discussion above) this implies a Grenvillian episode of migmatitisation, earlier than the Morarian. If it is intrusive then the sediments into which it was emplaced are older. As has been pointed out above Brook and others (1977) have presented evidence for a Grenvillian episode of folding and metamorphism in the Morar area, while Piasecki and van Breemen (1979a) and Piasecki and Wright (1981) consider that the whole Glenfinnan Division represents a Grenvillian basement on which later Morar rocks were laid down. Like the *lit-par-lit* migmatites,the Ardgour Gneiss has been reworked in the Caledonian, and is cut by the later suite of pegmatites.

The relationship of the migmatite complexes of Loch Coire and Strath Halladale to this time sequence is not firmly established, as much depends on the interpretation of the fold history of the area. An age of c.650 Ma (M. Brook, personal communication) has been proposed for the intrusion of the Strath Halladale granite. On this basis, most or all of the migmatitisation and much of the folding of the area would be Precambrian, a proposal which does not fit with the current deductions about the history of the area (Soper and Brown, 1971; Soper and Wilkinson, 1975).

Selected bibliography

Navigation menu

Personal tools

Namespaces

Variants

Views

- Edit
- View history
- PDF Export

□

More

Search

Search Go

Navigation

- Main page
- Recent changes
- Random page
- Help about MediaWiki

Tools

- What links here
- Related changes
- Special pages
- Permanent link
- Page information
- Cite this page
- Browse properties

- This page was last modified on 1 February 2018, at 12:51.

- Privacy policy
- About Earthwise
- Disclaimers
-
-