

Appin Group, Grampian Caledonides

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Stephenson, D, and Gould, D. 1995. British regional geology: the Grampian Highlands. Fourth edition. Reprint 2007. Keyworth, Nottingham: British Geological Survey.

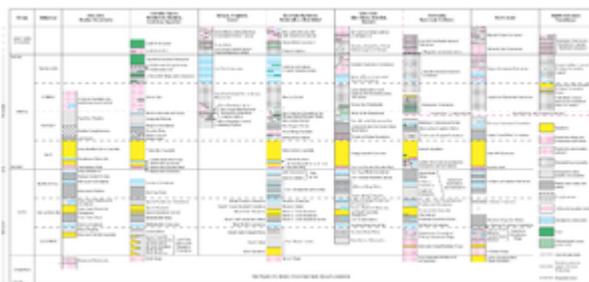
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Appin Group, introduction

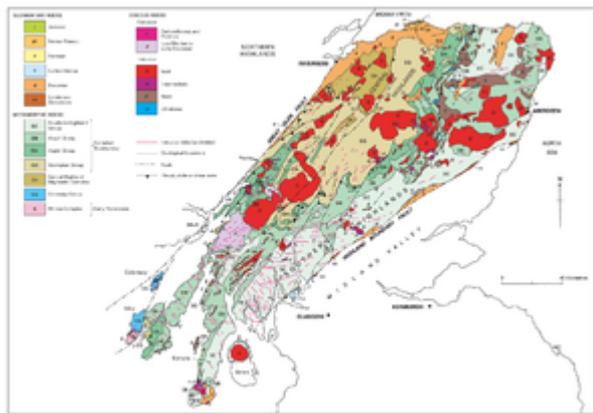
The Appin Group consists for the most part of a sequence of shelf sediments comprising pelites, semipelites, quartzites, calc-silicate rocks, limestones and dolostones, usually with rapid alternations of facies (Wright, 1988). Local successions are easily established and the group has been divided into three subgroups. Lateral facies changes are well documented in several areas, but certain key beds can be traced over large distances and there is an overall general consistency of facies from Connemara in western Ireland to the Moray Firth coast. Correlations between local successions have thus been made with reasonable confidence throughout the Grampian Highlands ([P915418](#)), aided in some areas by detailed studies of the whole-rock geochemistry of a variety of lithologies. Such studies have been more successful in the Appin Group than in other parts of the Dalradian succession (Lambert et al., 1981; 1982; Hickman and Wright, 1983; Rock et al., 1986). Of particular use are the geochemical studies of carbonate units, some of which retain distinctive geochemical characteristics over considerable distances (Rock, 1986; Thomas, 1989).



Composite lithostratigraphical sections (not to scale) of the Appin, Argyll and Southern Highlands groups. [P915418](#).

Rocks of the Appin Group crop out over some 2100 km² in a relatively narrow outcrop extending across the Grampian Highlands ([P915411](#)). Thick developments occur in Lochaber and around Appin, which are type areas for the two lowest subgroups, the Lochaber and Ballachulish subgroups ([P915419](#)). In the south-west a complete sequence, which continues up into the overlying Argyll Group, is recognised in the core of the Islay Anticline. South-eastwards from Appin, rapid facies changes and considerable attenuation occur ([P915420](#)). Higher parts of the group were either not

deposited, or are cut out by unconformities, or have been excised by tectonic dislocation in the Boundary Slide Zone. As a result, only a condensed and possibly incomplete sequence of Lochaber and Ballachulish subgroup rocks is present from Glen Orchy to Glen Lyon. A more complete although still condensed sequence, which passes up conformably into the Argyll Group, reappears to the north of Schiehallion and expands rapidly eastwards to Blair Atholl, the type area of the highest, Blair Atholl Subgroup. The complete sequence is then traceable north-eastwards to Braemar. To the north of the Cairngorm and Glengairn granites a similar succession has been traced northwards to link with the well-known Appin Group succession on the Moray Firth coast.

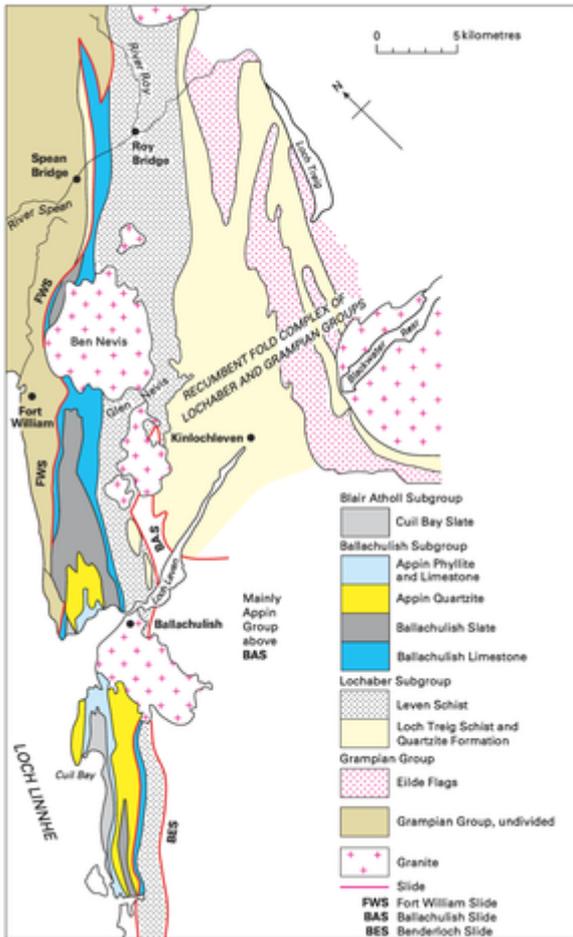


Solid geology of the Grampian Highlands.
P915411.

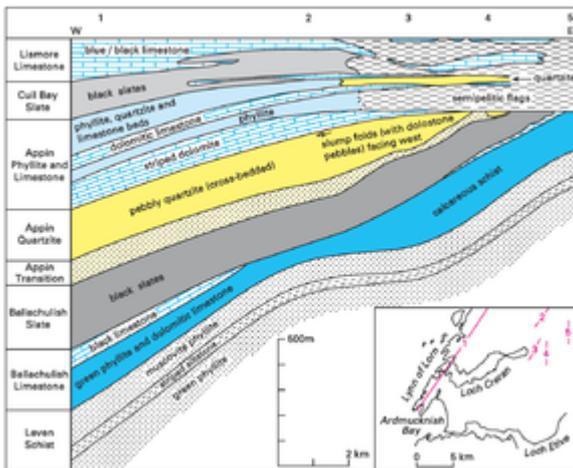
Lochaber Subgroup

In many areas a sequence of semipelitic and pelitic schists with lenticular interbedded quartzites at the base of the Appin Group conformably succeeds the underlying more psammitic rocks of the Grampian Group. This sequence, the Lochaber Subgroup, represents a depositional facies of alternating clean sand, silt and mud deposition in which individual units are traceable over strike lengths of tens of kilometres. However, individual quartzites do taper out laterally and the facies they represent may be diachronous. In the type area of Lochaber there are three major quartzite units, whereas elsewhere typically only one quartzite horizon is developed. Concomitant with the lateral thickness changes there are also observable detailed facies variations within each of the three quartzites of the type area. Consequently isolated quartzite units cannot readily be correlated with any of the three type-area quartzites.

The difficulties of correlation posed by sedimentary facies changes are compounded by the north-eastwards increase in regional metamorphic grade and by superimposed folding and shearing. Within the greenschist facies, isograds cut across the regional strike and the development of garnet in semipelitic schists increases towards the north-east. The polyphase deformation has caused repeated and locally overturned stratigraphical sequences resulting in complex outcrop patterns (as shown in figure 1 of Hickman and Wright, 1983)



Grampian and Appin groups in the Lochaber and Appin area (modified from Hickman, 1975 and incorporating results of BGS mapping to the north). P915419.



Appin Group facies changes in the Loch Creran area, based on correlation of strike sections and estimation of pre-tectonic thicknesses. P915420.

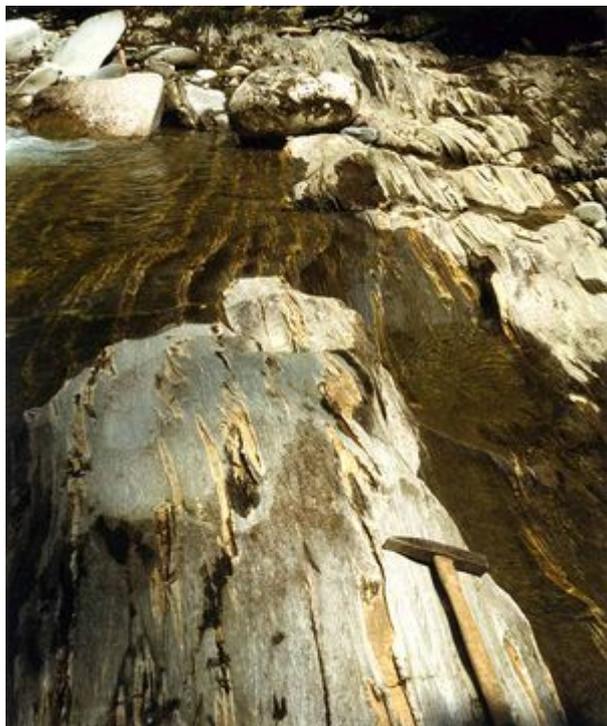
The main lithologies repeated in each formation within the Lochaber Subgroup retain common characteristics. The major quartzites are generally white and all are well bedded. Internal shallow-water sedimentary structures, such as cross-bedding, grading, ripple-marks, slump and dewatering structures, are well preserved. Variable amounts of K-feldspar and plagioclase are present, and both biotite and muscovite are commonly concentrated along bedding-parallel foliation planes. The

quartzites become finer grained and less feldspathic towards the north-east, a mineralogical change that is reflected in their whole-rock chemistry (Hickman and Wright, 1983). Intraformational contacts between quartzites and schists are commonly transitional over several metres with fine-scale interleaving of the two lithologies.

The schist formations generally consist of a groundmass of muscovite, biotite, quartz, plagioclase and K-feldspar with scattered porphyroblasts of biotite and, less commonly, garnet. All are less feldspathic than the underlying Grampian Group semipelites, a feature that is reflected by marked differences in whole rock chemistry between Lochaber Subgroup and older schists (Lambert et al., 1982; Winchester and Glover, 1988).

The major development of the Lochaber Subgroup lies between Glen Roy and Port Appin and includes the type area in the mountainous ground between Glen Nevis and Loch Leven ([P915419](#)). Here the contact between the Grampian and Appin groups is usually conformable, although lateral facies changes in both groups means that different lithologies are adjacent along the contact. In the north-western part of the type area an attenuated Lochaber Subgroup sequence is sandwiched in the Fort William slide zone between the Grampian Group and the Ballachulish Subgroup. The Grampian Group/Lochaber Subgroup contact, previously regarded as tectonic, has been reinterpreted by Glover (1993) as a localised unconformity. The upper contact of the Lochaber Subgroup with the Ballachulish Subgroup is conformable; in the Glen Roy area the two subgroups appear to interfinger.

In its type area the Lochaber Subgroup is divided into six units, with a maximum aggregate thickness of 4200 m (after Carruthers in Hinxman et al., 1923; Bailey, 1934). The succession has been partly formalised by Hickman (1975) who defined type sections for some of the units within a continuous section along the River Leven and Loch Leven around Kinlochleven. The basal *Eilde Quartzite* (600 m), best exposed around Loch Eilde Mor, consists essentially of flaggy, pink to white, feldspathic quartzites with schist and psammite intercalations. A pebble bed has been identified at about 200 m above the base. The *Eilde Schist* (400 m) comprises interbedded pelitic and semipelitic schists which become increasingly pelitic north-eastwards. The overlying *Binnein Quartzite* (400 m), which is best exposed on the hills around Kinlochleven, comprises relatively distinctive, fine-grained well-bedded ortho-quartzites. These are overlain by semipelitic schists with quartzite intercalations forming the *Binnein Schist* (400 m) in which the uppermost schists are locally graphitic with calcareous seams. In its type area on the southern slopes of Mam na Gualainn, the *Glencoe Quartzite* (400 m) is lithologically very similar to the type Eilde Quartzite. In parts it is also coarse grained and arkosic with discrete pebble beds. North-eastwards the upper quartzite beds become less feldspathic and resemble the Binnein Quartzite. The *Leven Schist*, around its type area near North Ballachulish, comprises a 2000 m-thick homogeneous sequence of greenish grey phyllites or schists ([P220305](#)) with thin quartzites (including the *Innse Quartzite*) confined to the lower transition zone with the underlying Glencoe Quartzite. However, north-east of the type area, a tripartite division is recognised in which basal dark phyllites or schists are overlain by striped siltstones with thin carbonates which in turn are overlain by pale greyish green phyllites or schists (Hickman, 1975; Litherland, 1980). The uppermost schists become increasingly calcareous and contain thin limestone bands in the Glen Spean area.



Leven Schist, Lochaber Subgroup, Allt Ionndrainn, Glen Roy district. Asymmetrical folds defined by an early foliation and lenses of dolomitic limestone. P220305.

The lateral and vertical facies variations in all six units, coupled with different interpretations of local and regional structures, have caused much debate about the stratigraphical framework of the subgroup in the Lochaber area, so far without complete agreement being reached (see Bailey and Maufe, 1960; Hickman, 1975; Treagus and King, 1978; Litherland, 1980; Anderton, 1985, 1988 and references therein). Consequently the policy of giving structurally isolated schists and quartzites local informal names remains valid at present.

In the northern part of the Lochaber area, near Loch Treig and Glen Spean, a local stratigraphy has been established, made up of the Loch Treig Schist and Quartzite Formation and the overlying Leven Schist Formation (Key et al., 1997). In this succession the three main quartzites of Lochaber are thin and are classed as members within the *Loch Treig Schist and Quartzite Formation*. North of Glen Spean the three quartzites die out. The overlying *Leven Schist Formation* is some 2200 m thick in the Glen Spean- Loch Treig area.

Between Ben Alder and Kingussie a series of tight, upright folds occurs at the north-western edge of the Ossian-Geal Charn Steep Belt and these include lithologies similar to those of the Leven Schist (Anderson, 1956). An informal local succession in the Kinlochlaggan Syncline has been assigned largely to the Lochaber Subgroup (Treagus, 1969; 1981). However, the rocks are at high metamorphic grade and are strongly deformed, and there is the possibility of an alternative correlation with the Grampian Group, in particular the limestone-amphibolite parts of the sequence being correlated with the Grantown Formation. The *Kinlochlaggan Boulder Bed* consists of about 40 m of bedded psammites and feldspathic quartzites, within which are two 7 m-thick beds of massive, unbedded psammite containing clasts up to 33 cm in maximum diameter. The clasts are sparsely distributed, unsorted and consist of a variety of intra- and extrabasinal rock types including granite. In common with the similar, more widespread boulder beds at the base of the Argyll Group, these have been interpreted as tillites, deposited from ice sheets (Treagus, 1981).

On Islay a regional plunge reversal exposes the upper part of the Lochaber Subgroup in the core of

the Islay Anticline (Rast and Litherland, 1970; Wright, 1988). Here the subgroup is divided into two units. The lower, *Maol an Fhithich Quartzite*, consists of massive, coarse-grained, cross-bedded quartzites with phyllites and pebble beds containing extrabasinal granite clasts. The overlying *Kintra Phyllite* or *Gleneedale Slate Formation* is composed of striped greenish, semipelitic phyllites or slates which become more calcareous upwards.

In the Southern Highlands, between Glen Orchy and Braemar, a thin development of the Lochaber Subgroup has been recognised, rarely exceeding a few hundred metres in thickness, in which few formations can be correlated with the type area (Roberts and Treagus, 1979; Treagus and King, 1978; Treagus, 1987; Upton, 1986). Throughout much of this area the junction with the underlying Grampian Group lies within a zone of high strain, some 500 m to 2000 m in thickness (formerly the Iltay Boundary Slide Zone—Chapter 4.) In this zone several formations are strongly attenuated or even excised locally along slides. However, in some areas, there is a continuous overall stratigraphical transition from the Grampian Group into the Lochaber Subgroup. The reduced thickness of the latter is not solely attributed to deformation in the slide zone; there would seem to be considerable sedimentological thinning in this central area of the Southern Highlands as there is in many of the succeeding Appin Group formations. In the Schiehallion area the *Beoil Quartzite* is overlain by highly tectonised pelites of the *Beoil Schist* and by calcareous pelites of Leven Schist type, the *Meall Dubh Striped Pelite* (Treagus and King, 1978; Treagus, 1987). Leven Schist-type lithologies follow on from the Grampian Group Struan Flags in the 'Banvie Burn Series' of Glen Tilt (Bailey, 1925); and south-west of Braemar highly strained mica-schists at the base of the Lochaber Subgroup are succeeded by striped psammites, silty mica-pelites and pelites with calc-silicate lenses (Upton, 1986).

South and west of Tomintoul a poorly defined association of micaceous psammites with thin lenticular quartzite units overlies the Grampian Group conformably. Farther north, between Bridge of Brown and Glenlivet, Grampian Group psammites grade upwards into slaty semipelites and calcareous semipelites. These beds probably represent a thin development of the Lochaber Subgroup.

The Lochaber Subgroup thickens markedly farther north around Dufftown and between Keith and the north coast around Cullen (Peacock et al., 1968; Read, 1923; 1936). Here a thick sequence of flaggy, micaceous psammites and semipelites, the *Findlater Flag Formation*, rests conformably upon massive psammites and quartzites of the Grampian Group. At least two prominent flaggy quartzites occur within the Findlater Flags and bands of garnet-biotite-schist and gneiss are recorded. Calc-silicate lenses mark a transition into more persistent banded grey, cream and pale green calcareous psammites and semipelites locally termed the *Pitlurg Calcareous Flag Formation* and *Cairnfield Calcareous Flag Formation*. These are characterised locally by tremolitic amphibole occurring either as pervasive aggregates or as monomineralic bands (Stephenson, 1993). Limestone bands occur locally in the upper parts of the formations. These herald the more extensive limestone development in the Ballachulish Subgroup as in the type area of Lochaber.

Ballachulish Subgroup

This subgroup, more than any other in the Dalradian, exhibits a remarkable continuity of lithological type; key elements of the classic sequence in the Lochaber-Appin area can be traced from north-west County Mayo to the Moray Firth coast.

Four formations are recognised in the Lochaber-Appin area ([P915418](#) and [P915419](#)), each of which exhibits a transitional passage into the overlying formation (Bailey, 1960; Hickman, 1975; Litherland, 1980). The lowest, the *Ballachulish Limestone Formation*, comprises grey-green

calcareous phyllites, cream and grey dolostones, dark bluish grey limestones and intercalations of slaty pelite. The phyllites resemble those of the upper part of the Leven Schist and are commonly amphibolitic. In its type area, around Ballachulish and Onich, the formation is about 250 m thick. In the north of Lochaber the formation can be traced around fold closures in the area of Glen Roy, but is attenuated and terminates along the Fort William Slide ([P915419](#)). Farther east, in the core of the Kinlochlaggan Syncline, the *Kinlochlaggan Limestone* has been equated with the Ballachulish Limestone, but this correlation is not yet confirmed. Towards the south, in Appin, the formation is more psammitic. The *Ballachulish Slate Formation* has a similar areal distribution to the preceding formation. In the type area at Ballachulish, a transitional zone of intercalated slate and carbonate is followed by up to 400 m of black slates and graphitic phyllites. These bear large cubes of pyrite and were quarried extensively for roofing slates which may be seen throughout Britain. In the top 100 m, graded psammite and quartzite intercalations on scales from a few millimetres to about a metre become numerous, forming a distinctive *Appin Transition 'series'*.

The *Appin Quartzite Formation* is a massive to blocky, well-bedded, locally feldspathic quartzite which is about 300 m thick in its type area, but it thins considerably to the north-east like the quartzites of the Lochaber Subgroup. Grain size and feldspar content increase both upwards and laterally to the south-west, where the quartzite becomes markedly pebbly. Sedimentary structures such as cross-bedding, ripple marks and graded bedding are ubiquitous. The overlying *Appin Phyllite and Limestone Formation* consists of an alternating sequence of carbonate rocks and phyllites with flaggy psammites and thin quartzites. It attains a total thickness of up to 400 m in the type area. Carbonates, often dolomitic, are more prevalent in the lower part and include the pure, white Onich Limestone. The distinctive 'tiger-rock' of Bailey (1960), which consists of regularly spaced 5 to 10 cm layers of deep yellow-weathering dolostone and dark phyllite, occurs at several stratigraphical levels. Marked facies changes occur south-westwards towards the Firth of Lorn where the phyllites grade into more psammitic units and pass locally into calcareous quartzites.

South-west of the type area, representatives of the Appin Quartzite and the Appin Phyllite and Limestone Formation crop out on small islands in the Firth of Lorn, east of Lismore. Farther to the south-west, after a gap of 75 km, the subgroup crops out in the core of the Islay Anticline. Here the *Kintra Limestone*, *Cnoc Donn Slate*, *Cnoc Donn Quartzite* and the *Cnoc Donn Phyllite and Limestone* can be matched confidently with the formations of the Appin district, with little variation in facies (Rast and Litherland, 1970).

To the south-east of Appin the type succession thins rapidly across strike and changes in character ([P915420](#)). Hence, in Glen Creran the Ballachulish Limestone Formation become limestone-free, the limestones of the Appin Phyllite and Limestone Formation are reduced to small lenses, the accompanying slates and phyllites pass into flaggy semipelites, and the Appin Quartzite dies out (Litherland, 1980). The lower part of the sequence may be cut out by an unconformity and local non-sequences within the Appin Phyllite and Limestone Formation suggest some syndepositional tectonic control.

Farther to the south-east, beyond the Etive Granite Complex, the Ballachulish Subgroup is generally absent, apart from a few small outliers of calcareous schists above the Lochaber Subgroup in the Loch Dochard, Glen Orchy and Ben Dorain areas. These are probably Ballachulish Limestone equivalents (Bailey and Macgregor, 1912; Thomas and Treagus, 1968; Roberts and Treagus, 1979). The outliers underlie the main Boundary Slide, which in this area is thought to have excised the remainder of an Appin Group succession already attenuated by sedimentological factors as in the Glen Creran area.

The attenuated Ballachulish Subgroup reappears eastwards as a condensed sequence totalling only 100 m at Errochty Water, but increasing to 700 m in Strath Fionan, north of Schiehallion (Treagus

and King, 1978). The subgroup continues to the Loch Tay Fault at Foss where it is displaced north-eastwards to the Blair Atholl area (Smith and Harris, 1976). It may then be traced in continuous outcrops north-eastwards to Braemar (Upton, 1986). Throughout this continuous strike length of some 65 km the succession can be matched almost bed for bed with that in the type areas of Lochaber and Appin (see [P915418](#) for local names). Such distinctive lithologies as the graphitic schists, the Appin Transition 'series' at the base of the main quartzite and the crystalline white limestones and 'tiger rock' in the topmost limestone and phyllite formation are found throughout this section.

The subgroup is well developed to the north of the Cairngorm and Glengairn granites and can be traced as far as the Keith area. The *Mortlach Graphitic Schist* is several hundred metres thick in Glenlivet but thins locally to 5 or 6 m. A dark limestone, the *Dufftown Limestone*, is commonly present at or near the base of the schist, and other limestones occur locally in the lower part. Minor quartzites also occur locally. At the base of the *Corryhabbie Quartzite* there is a transitional unit of interbedded pelite and psammite which is thick in the south but is reduced to a few metres farther north, where thickly bedded psammites pass up into the main clean, cross-bedded quartzite, typical of the subgroup. More psammites are followed by the *Ailnack Phyllite and Limestone Formation*, consisting of phyllitic semipelites, with several thin white limestones, calc-silicate bands and one more-persistent banded limestone member.

North of Keith marked facies changes, probably associated with NW-trending growth faults (Chapter 16), and increased structural complexity make individual units difficult to trace, so that formations become ill defined. The graphitic character of the lower part of the subgroup is locally much reduced and thick, persistent limestones are absent. A condensed sequence of limestone and graphite-schist is seen around Deskford, but in boreholes on the coast at Sandend Bay the graphitic schist is over 300 m thick and is overlain directly by phyllites and limestones with no intervening quartzite.

Blair Atholl Subgroup

This subgroup maintains a generally constant lithology of dark pelites and limestones from Connemara to the Moray Firth, although local successions differ in detail, making bed-for-bed matching difficult. In some areas, notably Islay and the Central Highlands, the upper part is less pelitic with thinly banded phyllites, psammites, limestones and dolostones comprising a distinctive 'pale group'.

In the Appin area, the Appin Phyllite and Limestone Formation of the Ballachulish Subgroup is overlain by the distinctive *Cuil Bay Slate Formation* ([P915419](#)). This comprises some 300 m of dominantly dark grey, pyritiferous pelitic and semipelitic slates with minor dark grey limestone beds and some more-psammitic bands (Hickman, 1975). The slates pass upwards through a finely banded passage series into the *Lismore Limestone Formation*, a 1 km-thick sequence of banded, blue-grey, flaggy limestones with thin black slate members, which forms the island of Lismore. It is also seen as an inlier in the core of the Loch Don Anticline in south-eastern Mull. Hickman (1975) has divided the formation into fifteen members and recognises several limestone-slate cycles, in each of which a thick limestone passes through a transitional, banded, argillaceous limestone into a slate. Both the limestones and the slates are pyritiferous and graphitic. Slump folds and syndepositional breccias indicate periods of sediment instability.

Owing to the south-westerly plunge of the major folds, any higher beds of the subgroup which may have been deposited in the Appin-Lismore area lie beneath the Firth of Lorn, but an extended sequence has been recognised in the Islay Anticline (Rast and Litherland, 1970). Here, dark graphitic slates and phyllites (*Bharradail Phyllite Formation*), followed by the bluish grey *Ballygrant*

Limestone are equated with the Cuil Bay Slate and Lismore Limestone respectively ([P915418](#)). They are overlain by more dark grey phyllites with graded quartzose or calcareous bands, the *Mullach Dubh Phyllite*, and a distinctive banded, partly oolitic and stromatolitic, thin-bedded limestone, the *Islay Limestone* (Spencer, 1971).

To the south-east of the Appin area, in Glen Creran, the Blair Atholl Subgroup thins and the slates pass into semipelitic flags, although the limestones persist ([P915418](#); Litherland, 1980). The facies changes are similar to some of those in the underlying Ballachulish Subgroup and the Blair Atholl Subgroup is also absent eastwards from Glen Creran due to a presumed combination of sedimentary thinning and movement on the Boundary Slide.

In the Schiehallion area, rocks of the Blair Atholl Subgroup reappear east of Loch Errochty in stratigraphical continuity with the Ballachulish Subgroup and a complete sequence, 250 to 350 m thick, is present between here and the Loch Tay Fault at Foss ([P915418](#)) (Treagus and King, 1978). A lower sequence consisting of three alternations of dark pelites and dark grey limestones is equated with the Cuil Bay Slate and Lismore Limestone. The pelites are commonly graphitic and kyanite-bearing. The overlying non-graphitic pale 'group' is generally composed of psammitic ribs in a graded pelitic or semipelitic matrix. Local bands of pure quartzite contain ripple cross-laminations, channels and sedimentary dykelets. At the top of the subgroup is a pale cream-weathering dolomitic marble containing tremolite and phlogopite, equated with the Islay Limestone.

Across the Loch Tay Fault, in the area around Blair Atholl, a similar continuous succession of Ballachulish and Blair Atholl subgroups has been demonstrated (Smith and Harris, 1976). This constituted the original type succession for the Blair Atholl 'series' (Bailey, 1925; Pantin, 1961). Thick bands of dark graphitic limestone in the lower part of the Blair Atholl Subgroup are a distinctive feature in this area and have been quarried extensively. The main formations can be followed north-eastwards through the Glen Shee area almost to Braemar (Upton, 1986).

North of the Cairngorm and Glengairn granites the Blair Atholl Subgroup consists mainly of mid to dark grey semipelitic schists, locally pelitic, graphitic and calcareous. A prominent thick bluish grey limestone formation, the *Inchrory Limestone*, occurs in its central part and minor limestones occur locally in the lower part. Maximum developments of the subgroup occur in Upper Donside and the Braes of Glenlivet. Farther north, around Edingight, black graphitic pelites with staurolite are interbedded with thin bands of blue-grey limestone. The limestones thicken considerably around Fordyce and constitute the only part of the subgroup exposed on the north coast.

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