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# Harris Bay

## Highlights

The site is the type area for harrisite, a rock containing spectacular growths of olivine crystals. It contains arguably the best-exposed contact of layered gabbroic rocks against (granitic) country rocks in the BTVP, which shows, firstly, the intrusive nature of the gabbros and, secondly, evidence for extensive partial melting of the earlier granite.

## Introduction

The Harris Bay site (Figure 3.11) contains exposures of ultrabasic rocks belonging to the Western Layered Series and the Central Series of the Rum Central Complex. Unusual cumulate features are well-developed in the rocks of this site including tharristic, or crescumulate, olivine textures and poikilo-macrospherulitic plagioclase textures. In addition, the site is also of special significance because it contains excellent exposures of the contact between the ultrabasic rocks and the earlier granitic rocks of western Rum; evidence for partial melting of the granite by the mafic rocks is particularly convincing (Greenwood, 1987).

Wadsworth (1961) identified at least four petrographically distinct stratigraphic units in the layered ultrabasic rocks within the site. At Harris Bay these are underlain by unusual eucritic cumulates which were termed the Harris Bay Series. Later investigations within the site by McClurg (1982) and Volker (1983) assigned part of Wadsworth's Western Layered Series to the later intrusive Central Series. The view that harristic olivines represent local coral-like growth from the floor of the magma chamber (Wadsworth, 1961) has been modified by Donaldson (1982).

## Description

The Western Layered Series, which occupies most of the site, comprises the Harris Bay, Transitional and Ard Mheall series (Wadsworth, 1961). Eucritic gabbros of the Harris Bay Series form the lower part of the succession, above which a 50 m thick gradational unit, the Transitional Series, passes up into feldspathic peridotites of the Ard Mheall Series (c. 380 m thick). Unlike the Eastern Layered Series, layering is on a scale of a few metres to centimetres, dipping gently to a centre just east of An Dornabac, but nearly flat lying in Harris Bay. The layering is frequently defined by texture rather than modal layering. The later intrusive Central Series, recognized by McClurg (1982) and verified by Volker (1983), occupies a north–south strip up to 2 km wide from the south coast to the Long Loch and Minishal. Central Series rocks crop out on the eastern edge of the site and include rocks previously designated by Wadsworth (1961) as the Dornabac and Ruinsival series. The Central Series is characterized by predominant feldspathic peridotite and peridotite breccia, together with minor dunite, allivalite and gabbro.

The characteristics and subdivisions of the ultrabasic and basic layered rocks within the Harris Bay site are summarized in (Table 3.2) (after Wadsworth, 1961).

The majority of ultrabasic rocks within the Western Layered Series are feldspathic peridotites containing varying proportions of olivine, plagioclase, chrome-spinel and diopsidic augite. There is a great variety of cumulate igneous textures in these rocks, signifying the interest of the site. Harristic textures (Wager and Brown, 1951), or crescumulate textures (Wager and Brown, 1968), were first described from Harris Bay by Harker (1908). Unusual poikilo-macrospherulitic textures are also found here which take the form of massive radial, braid-like growths of plagioclase (Donaldson *et al.*, 1973).

The harristic (olivine crescumulate) textures characterize the rock that was termed harrisite by Harker (1908). They were formed by large skeletal growth of forsteritic olivine. The individual crystals, or bundles of crystals, may be up to 2 m in length and often form coral-like growths from the planar surface provided by an underlying normal olivine cumulate (cf. Wadsworth, 1961, plate 4). Good examples of this type of harristic texture can be seen in the Transitional Series close to the road near Harris [NM 340 964] and at many places on Ard Mheall in the overlying Ard Mheall Series. Radiating, and

sometimes apparently isolated pods of harrisitic-textured rock also occur, particularly within the eucritic Harris Bay Series in coastal exposures near Harris Lodge [NM 337 957].

Massive radial and braid-like growths of poikil-itic plagioclase crystals enclosing numerous olivines occur within igneous breccias a short way north-east of Loch an Dornabac, just north of the site at [NM 357 977]. These individual radial growth structures range in size from 0.15 m to almost a metre in diameter and up to fifteen radiating crystals have been found growing out from a single nucleus. The term poikilo-macrospherulitic has been applied to these structures (Donaldson *et al.*, 1973). In some growths there is a radial symmetry. The feldspar textures resemble the 'lace' or 'honeycomb' textures described by Brown (1956) from the Eastern Layered Series. The feldspars involved in these structures have grown *in situ* and support current views that 'diagenetic' processes are of considerable importance in the crystallization of igneous cumulates (for example, Irvine, 1987).

Extensive zones of peridotite breccia occur within the Central Series ultrabasic rocks of the site. The breccias contain rounded, irregular and angular blocks of feldspathic peridotite lying randomly in a more feldspathic ultrabasic matrix, often approximating the mineralogy of allivalite. In places the breccias contain blocks which themselves display layering or even slumping. Clearly, the source for the blocks was a well-lithified cumulate. Wadsworth (1961) mapped an extensive zone of breccia, the Lag Sleitir Breccia, transgressing the Harris Bay, Transitional and Ard Mheall series. These breccias are well exposed in the stream sections where the Allt Lag Sleitir and the Abhainn Rangail join [NM 346 956]. Wadsworth demonstrated that many of the blocks were derived from the Ard Mheall Series and considered that the breccias formed along a fault scarp within the magma chamber. An extensive zone of breccias cutting the Ruinsival Central Series was also thought to have such an origin.

Numerous other occurrences of breccia have been recorded from the same general area (Donaldson, 1975; Volker, 1983) and to the north around the Long Loch and Barkeval (McClurg, 1982). Structures within these breccias suggest formation by either intraformational slides, brittle deformation or plastic deformation. The transgressive nature of the Lag Sleitir Breccia towards the Western Layered Series is one of the stronger pieces of evidence which justifies the establishment of the Central Series of ultrabasic rocks and gabbros (McClurg, 1982; Volker, 1983).

The ultrabasic rocks are cut by numerous intrusions of gabbro. These are clearly later than the host rock which they vein but, as their margins show no signs of chilling, they would appear to have been intruded before the surrounding rocks had cooled. Wadsworth (1961) suggested that they formed from a magma closely related to that from which the ultrabasic rocks formed. The most unusual of these intrusions is the Glen Duian Gabbro, an assemblage of numerous thin gabbroic sheets which intrude the layered eucrites of the Harris Bay Series with surprisingly constant conformity to the layering. These are well exposed in the low cliffs bordering Glen Duian Burn close to the road bridge at Harris [NM 338 960].

**(Table 3.2) Harris Bay: subdivisions of the ultrabasic and basic layered rocks** (modified from Wadsworth, 1961, table 1, with amended Western Layered Series).

	Thickness	Distinctive features
Upper Ruinsival Series	~ 330 m	Both Ruinsival series show an upwards gradation from olivine cumulates often with feldspar to feldspar-olivine cumulates often with pyroxene. Exposure is generally poor and the sequence is complicated by transgressive later intrusions, zones of igneous breccia and structural disturbances. In places, gravity stratification, rhythmic layering and slump structures occur.
Lower Ruinsival Series*	~ 500 m	

Transition Layer	~ 0.5 m	Olivine-feldspar cumulate. Variable dips (5°–50°) in all directions but predominantly in general easterly direction.
Dornabac Series	~ 130 m	Olivine-feldspar and feldspar olivine cumulates often with streaky or rhythmic layering and frequently with slump structures and evidence of gravity stratification. Layering dips at 35° to 40° to the east and southeast. The rocks show similarities to the allivalites of the Hallival–Askival area. Feldspathic peridotite breccia at the base of the Central Series cuts transgressively across all Western Layered Series units. Olivine and olivine-feldspar cumulates with rhythmic layering throughout. Harrisitic cumulates are intimately associated with normal cumulates and are very prominent within the lower half to two-thirds of the sequence and they are also locally important higher in the series. The layering has a general dip of 5° to 10° (exceptionally 15°) to the south-east or east.
Ard Mheall Series	~ 400 m	Olivine-feldspar cumulates, often with pyroxene, of both harrisitic and normal types. Olivine is more abundant than in the Harris Bay Series, while the content of feldspar is higher than in the Ard Mheall Series.
Transition Series	~ 50–60 m	Essentially eucritic mesocumulates in texture with olivine, feldspar and ubiquitous pyroxene as cumulus phases. Olivine is the most abundant phase and forms distinctive tabular crystals exhibiting igneous lamination in the normal cumulates. Intercalations of generally thin harrisitic cumulates (crescumulates) richer in feldspar and pyroxene than those of the Ard Mheall Series occur. Layering dips at low angles (5–10°) to the north-east.
Harris Bay Series	~130–140 m	* Now termed the Long Loch Group (of Volker and Upton, 1990). <b>Part of Central Series:</b> Upper Ruinsval Series to Ard Mheall Series

**Amended (1982) Western Layered Series:** Ard Mheall Series to Transition Series

The Harris Bay Series is in contact with the Western Granite at Harris Bay. Along the coastal section from the Mausoleum [NM 336 956] to Gualain na Pairce, the pinkish-weathering granophyre is well exposed and material from this section has been used for radiometric age determinations, giving a date of 59 Ma (Dagley and Mussett, 1981). The granophyre is cut by numerous basaltic sheets and dykes striking more-or-less parallel to the coast. Near the contact the granophyre becomes very tough and takes on a bluish-grey colour. In the cove 200 m south-west of Harris Lodge, the dull, altered granophyre is separated from the Harris Bay Series by a zone, of variable width (2–10 m), of acid hybrid rock containing acicular amphibole and plagioclase crystals. The Harris Bay Series eucritic rocks are layered to within a metre of the contact with hybridized rocks and there is little or no disturbance of the layering at the contact. The contact exposures at the south-east end of Harris Bay provide outstanding examples of intrusion breccias where the basic/ultrabasic rocks have come into contact with acidic rocks; this is a common phenomenon on Rum and it provides a particularly clear example of melting, or partial melting of acid rock by a later mafic intrusion (Figure 3.12). The intrusion breccia zone is several metres wide on the east of Harris Bay but less than a metre in width on the west where layered ultrabasic rocks are virtually in contact with baked granophyre on the coast close to the Mausoleum (Emeleus and Forster, 1979).

Although not strictly part of the Tertiary geology, a final feature of this site merits a mention. Harris Bay is backed by a series of fine raised beaches at about 30 m. These are Quaternary storm beaches which consist almost exclusively of cobbles and boulders of granophyre and arkose; the paucity of basic and ultrabasic rocks is very striking and indicates their poor resistance under conditions of prolonged mechanical weathering. This may, in part, explain their relative scarcity in the basal and intralava conglomerates of the Fionchra site.

## Interpretation

The formation of the Western Layered Series, partly exposed in the Harris Bay site, was probably contemporaneous with the Eastern Layered Series (Emeleus, 1987), the intrusion of the picritic magmas being partly controlled by the Main Ring Fault. However, in the Harris Bay site, the Western Layered Series has intruded and cut the western granophyre mass causing a zone of hybridization and brecciation. The granophyre-Layered Series contact in Western Rum has all the characteristics of an original igneous feature and not a fault as previously suggested (Wadsworth, 1961). This feature, together with the roof contacts to the ultrabasic intrusion which are exposed in the Cnapan Breaca and Dibidil sites and on Ard Nev north of this site, and the continuation of the undisturbed layering up to the margins of the complex, suggest that the layered ultrabasic rocks crystallized essentially *in situ* in relation to these contacts.

Unlike the Eastern Layered Series of the Askival–Hallival site, the Western Layered Series and the Central Series contain predominantly feldspathic peridotites and layering involving allivalite is only sporadically developed. It has been suggested that feeders for the successive batches of new magma may have been sited in the western part of the complex, spreading magmas across the chamber floor to the east (Emeleus, 1987), causing peridotite rocks to develop near the feeder(s) and allivalites at the furthest extremities.

The gabbroic cumulates of the Harris Bay Series were formed from a magma considerably less basic than the overlying feldspathic peridotite cumulates. Wadsworth (1961) considered that this could reflect primary differences in magma composition, contamination of more basic magma with granophyre, or the result of strong crystal fractionation in a very thick unit of which the Harris Bay Series is the top. The overlying Transitional Series may represent, according to Wadsworth, gradual replacement of the basaltic magma of the Harris Bay Series with the more mafic magma of the Ard Mheall Series.

The contrasted thicknesses of intrusion breccia along the intrusion contact either side of Harris Bay may be explained by the movement of rheomorphic acid magma, together with inclusions, along the contact. Partially brecciated dykes in granophyre at the eastern exposure indicate that little movement occurred apart from shattering of the edge of the mafic pluton by the acid magma. On the western exposures, acid magma is seen intruding back into the mafic complex in cliffs near the Mausoleum; this probably represents an injection of low-density rheomorphic magma formed at the contact zone and which subsequently moved up and away from its source (cf. Greenwood, 1987).

The layered peridotites and breccias of the Central Series were intruded after the Western Layered Series. They cut across the Transitional and Ard Mheall members and also transgress the Main Ring Fault on its northern and southern margins. The long axis of the Central Series parallels the Long Loch Fault which probably had a strong influence on the emplacement of the Central Series (McClurg, 1982) and possibly controlled the feeder conduits to the whole Layered Series.

The formation of harrisites has been conventionally explained by the upward growth of olivines from the crystal mush on the floor of the magma chamber during periods of quiescence. Wager *et al.* (1960) regarded this texture as a special kind of crescumulate. Donaldson (1982) agreed that most harrisites have such an origin, but argued that some unusual occurrences must have crystallized within the crystal mush. This concept was supported by occurrences of discontinuous, lensoid layers of harrisite; cumulate layers terminating against harrisite; isolated lensoid masses of crescumulate; tongues/lobes of harrisite protruding up into overlying cumulate layers; coarse, randomly orientated hopper and branching olivines growing upwards and downwards in the centres of harrisite lenses. Donaldson postulated that a process of filter-pressing concentrated a differentiate of upwards-migrating intercumulus melt which collected beneath layers of low permeability in the crystal mush. These accumulations of melt were thought to be capable of propagating laterally as sill-like injections and crystallizing as harrisites. The poikilo-macrospherulitic plagioclase growths (Donaldson *et al.*, 1973) also probably have a similar, post-depositional 'diagenetic' origin.

Donaldson (1977b) examined the morphology of the olivines in the harrisitic rocks and found that their features could be reproduced in the laboratory. These experiments indicated that crystallization of the branching olivines in harrisites involved crystallization with 30°–50° under-cooling of the magma. The skeletal and dendritic olivine crystals in the harrisites were found to show notable similarities to the spinifex-textured olivines of Archaean ultramafic rocks (Donaldson, 1974).

## Conclusions

The ultrabasic/gabbroic layered rocks of Harris Bay belong to the Western Layered Series and they comprise a lower gabbroic unit which grades into overlying feldspathic peridotite. The intrusion of the later Central Series, which contains spectacular ultrabasic breccias, is also demonstrated by this site. The ultrabasic rocks can be shown to have intruded against the Western Granophyre, the contact being an igneous feature and not a fault as previously proposed. This contact is one of the best exposed in the British Tertiary Volcanic Province between low-melting-point country rocks and later high-temperature mafic intrusives. The site is, however, of special interest as the ultrabasic and gabbroic rocks show many textural characteristics which are as yet unknown in, or not as well-developed in, other layered intrusions. The site is the type locality for harrisite, displaying spectacular crescumulate olivines of both cumulate and post-cumulate origin. Pioneering work on the origin of these rocks has been carried out at this site.

## [References](#)



	Thickness	Distinctive features	
PART OF CENTRAL SERIES	Upper Ruinsival Series	~ 300 m	Both Ruinsival series show an upwards gradation from olivine cumulates often with feldspar to feldspar-olivine cumulates often with pyroxene.
	Lower Ruinsival Series*	~ 500 m	Exposure is generally poor and the sequence is complicated by transgressive later intrusions, zones of igneous breccia and structural disturbances. In places, gravity stratification, rhythmic layering and slump structures occur.
	Transition Layer	~ 0.5 m	Olivine-feldspar cumulate. Variable dips (5°-50°) in all directions but predominantly in general easterly direction.
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AMENDED (1962) WESTERN LAYERED SERIES	Ard Mheall Series	~ 400 m	Olivine and olivine-feldspar cumulates with rhythmic layering throughout. Harrisitic cumulates are intimately associated with normal cumulates and are very prominent within the lower half to two-thirds of the sequence and they are also locally important higher in the series. The layering has a general dip of 5° to 10° (exceptionally 15°) to the south-east or east.
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*(Figure 3.12) Intrusion breccia at the contact of ultrabasic rocks with earlier granite. Eastern end of Harris Bay. Harris Bay site, Rum. (Photo: C.H. Emeleus.)*