
Chapter 5 Tertiary sediments

Palagonite tuffs

In northern Skye the earliest volcanic activity of which there is any record resulted in the formation of basic tuffs. These consist of volcanic dust, 'ashes', lapilli and bombs ejected with explosive violence from the vent and deposited in shallow lakes lying on a peneplaned surface of Jurassic rocks. That they were laid down under water is clear, for they are closely associated with shales and flagstones which are crowded with plant debris and the tuffs themselves are largely composed of sideromelane (super-cooled glass) and include some typical pillow lavas and globe-breccias. They are similar to the tuffs of the Palagonite Formation of Iceland (Wilson, 1937, pp. 77–8; Anderson, 1949, p. 785).

The Palagonite Tuffs are brown and yellow deposits composed of (i) angular fragments of pale-brown translucent glass (sideromelane) carrying microlites of plagioclase and augite with occasional small olivine crystals; (ii) the sideromelane fragments altered to a pale green cryptocrystalline substance 'palagonite'. The alteration spreads from the margins and cracks of the larger fragments whereas smaller fragments may be entirely converted into a chloritic material; (iii) fragments of opaque black vitreous slag (Tyrrell, 1949). Included in these tuffs are: (a) thin irregular lava flows of limited extent, very vesicular, often showing pipe amygdales several inches in length. (b) loose, roughly spherical masses of lava with very vesicular centres and a tachylitic crust, the vesicles frequently arranged in concentric layers. (c) smaller globular masses of lava, some of which have the characteristic appearance of 'bombs'. (d) still smaller rounded fragments of vesicular basalt with a tachylitic crust, i.e. lapilli.

The lava flows, in particular those seen in the tuffs just north-east of Portree, frequently exhibit typical pillow structure. Quite apart from the associated plant sediments, the conchoidal fracture (Bogen or Aschenstruktur), and the cryptocrystalline nature of the smaller basalt fragments, and the vesicular globular and pillowy nature of the larger masses clearly indicate deposition in water.

The formation of Palagonite Tuffs very similar to those in Skye has been discussed by Peacock (1926), Nielson and Noe-Nygaard (1936) and Noe-Nygaard (1936, 1939, 1940), who claim that the Icelandic Palagonites were formed under the ice-cap which accounts for the drastic chilling shown by the fragments composing these tuffs. But Nielson and Noe-Nygaard (1936) have shown that features characteristic of modern sub-aerial accumulations, i.e. deflation surfaces with hamada formation, solifluxion phenomena with desert pavements and stone polygons, and surfaces with desiccation cracks are present within the Palagonite Formation. Moreover the palagonite tuffs of the Snake River Plateau of Columbia, like those of Skye, cannot have been formed under glacial conditions (see Peacock and Fuller 1928, Fuller 1931). The essential factors required to produce palagonite tuffs of the type described above are likely to have been a very fluid lava extruded into water. The rapid chilling of the basalt combined with the explosive generation of steam would probably be sufficient to shatter it into the glassy shards so typical of the deposit. The extensive surfaces exposed to alteration would accelerate the breakdown into chlorite. It is possible, as Peacock has suggested, that the presence of hot springs or volcanic gases may be important factors in the conversion of sideromelane into palagonite, or in the case of the Skye deposits the warm climate and the heating up of the shallow lakes in which they were deposited by prolonged eruption.

Details

The most complete section of the Palagonite Tuffs in North Skye is that exposed in the sea-cliff below Craig Ulatota. Here the lowest portion is a pale greenish-brown sandstone with wind-rounded quartz grains overlain by some 70 ft of coarsely fragmented tuff with abundant olivine crystals. A thin imperistent porphyritic olivine-basalt lava flow, up to 5 ft in thickness, follows, overlain by 30–40 ft of brown vitreous tuff containing plant fragments.

Northwards, the fragmental portion of the tuffs increases until at Fuirnean it is about 120 ft in thickness. Here it contains numerous bombs, some of large size, and lava 'globes'.

In a tributary of Lon Druseach, ½ mile west of the cliff top, the following section is exposed:

Section in Gully on south side of Lon Druseach, 950 yd east of the road, 2½ ml. N. W. of Portree

	feet	inches
	Palagonite Tuffs:	
5.	Basalt lava; pipe amygdales in base	
4.	22	0
	Palagonite tuff with pillow lavas	
3.		9
	Thin lava flow with pipe amygdales	
2.	2	4
	Thin bedded, brown tuff	
1.		2
	Hard, olive-green tuff	
	Great Estuarine Series:	
	14	0
	Soft sandstone with calcareous bands	

The olive-green beds at the base of the tuffs contain poorly preserved plant fragments, amongst which the late W. N. Edwards identified *Ginkgo* (probably *G. gardneri* Florin), a possible *Equisetum*, an obscure conifer twig and a number of indeterminate dicotyledonous leaves. A fragment of wood 6 ft long by 8 in wide was found in Bed 4 which Edwards compared with the conifer *Cryptomarites*.

In Wilson's preliminary account (1936, p. 82) five genera of dicotyledons with *Sequoia*, *Ginkgo*, and a grass were reported as from this section and were identified by Professor T. Johnson. Wilson also commented on the abundance of *Ginkgo* in Skye as compared with its rarity at Ardtun. As Starkie Gardner recorded in 1887, *Ginkgo* is in fact abundant at Ardtun. In Skye the dicotyledons are the most abundant fossil plants but Edwards, who examined the same material as Johnson, claimed these to be indeterminate generically.

The Palagonite Tuffs are well exposed in the sea-cliff east of Lon Druseach particularly between Sithean Bhealaich Chumhaing and Rubha na h-Airde Glaise. Some 60 ft below the top of the scree-slope, a crystal-vitric tuff is exposed containing automorphic olivines and labradorites in a matrix of clear yellow and dark-brown glass. Above this the tuffs are amygdaloidal and include an impersistent, and in places, columnar basalt. About 30 ft below the top, a sandy mudstone containing angular quartz grains and numerous fragments of glass is interbedded with the tuffs. Above is a yellow-brown, vitric tuff with dark glass shards and a few olivine and labradorite crystals in a lighter coloured, glassy matrix and apparently deposited in or by water. This tuff, about 4 ft thick, weathers into small caves below an overlying pillowy, nonporphyritic tholeiitic basalt with pipe amygdales up to 3 in long filled with stilbite and analcime. The junction of this lava with the flat-bedded, fine-grained tuff below is smooth but highly irregular. Locally it shows small scale ropy structure and similar wrinkled surfaces occur within the lava itself. Irregularly shaped pillows up to several feet across can be seen nearby, sometimes with red bole penetrating between them.

Twelve feet above the first is a second mudstone and over it amygdaloidal lavas and tuffs form the remainder of the section up to the base of the first persistent lava-flow. Both here and in Lon Druseach the tuffs are in places full of zeolites and amygdaloidal chalcedonic silica.

Tuffs and ashy shales with plant remains cut by a 4-ft dyke are exposed in the gully just west of Bile (Beal) Chapel, S.E. of Torvaig and again in the gorge of the River Chracraig, below a waterfall and just west of Portree Lodge [NG 488 439]. Here, 3 to 4 ft of dark ashy shales rich in plant debris are exposed below the first continuous lava flow which is responsible for the low waterfall.

A good section of the upper part of the Palagonite Tuffs may be seen in Camas Ban, Portree Bay, where the tuffs include bombs from 1 to 6 in in diameter. The base of the first continuous lava-flow is well seen; it is vesicular but not noticeably chilled. A wedge of sill thinning from 15 ft to nothing in a distance of 50 ft, has a thick tachylitic margin about 9 in wide.

Another wedge of sill in the centre of the bay has well-marked but highly irregular columnar jointing at the contact, the columns being about 6 in in diameter. The plant beds must be present in Camas Ban, though they are no longer exposed, for lignite was once worked here.

Eastwards the tuffs are poorly exposed. At Udairn they contain numerous thin impersistent lava flows some of them exhibiting pillow structure. A little over a mile south of Ben Tianavaig the tuffs are exposed in the sea-cliff. Only a little palagonite is present, instead the section consists mainly of dark greenish, ashy mudstones and coarse agglomerates of basalt fragments. Near the base is a thin band of black shale, above which is sandy mudstone and shale with lenticles of sandstone. The shale contains plant fragments.

At Creagan na Sgalain on the north side of Tianavaig Bay the plant beds are well seen:

Section 400 yd N. of Creagan na Sgalain

	Palagonite Tuffs	ft	in
7.	Carbonaceous shale and coal	40	0
	Dolerite sill		
6.	Massive bedded sandstone with thin shaly partings	20	0
5.	Flaggy beds with plant debris	1	0
4.	Thin flaggy beds ¼ in thick		6
3.	Carbonaceous shale	6	0
	Dolerite sill	20	0
2.	Carbonaceous shale	1	0
1.	Greenish sandstone	2	0
	Inferior Oolite sandstone	15	0

The carbonaceous shale with coal was believed by Lee (1920, p. 56) to be the equivalent of the Oil-Shale which is found at the top of the Inferior Oolite further north. The Oil-Shale however, is cut out by the transgressing lavas north of Portree.

These plant-bearing sediments are seen at intervals in the sea-cliff south of Tianavaig Bay in association with sill as far as Peinchorran. Here the upper part of the tuffs, above a sill, forms a steep bank below the village of Peinchorran but is poorly exposed. Eastwards is a peaty flat formed by the top of the sill which crops out as Torr Mor and Ton Beag, below which the lower part of the Palagonite Tuffs can be seen in the sea-cliff. Immediately under the sill is a thin coal overlying sandy micaceous and carbonaceous shales. Below, and extending to sea-level is white sandstone 60–70 ft thick, thin-bedded, calcareous, and with occasional white quartz pebbles and ironstone nodules.

These beds are faulted back and appear again on the beach just west of the mouth of Allt na Ba Grasion in Loch Sligachan.

Inland the Palagonite Tuffs are usually obscured by scree and landslip. It is evident however that as far north as Staffin and Flodigarry the tuffs are present in considerable thickness for large masses can be seen in the landslip. In the upper reaches of Abhainn Gremiscaig is an interesting section showing coals, once worked, and fire-clay in dark brown Palagonite Tuff. Tuff with a plant bed is exposed in the Lealt River ■ mile E.S.E. of Baca Ruadh, and 30–40 ft of bedded tuff containing bombs, with a 4-ft red bole on top were seen in the landslip east of Cam Liath. These exposures are in landslip and therefore not in situ.

Four miles W.N.W. of the last section the base of the lavas is exposed in Glen Uig. Here Corallian and Kimmeridge Clay shales form an inlier surrounded by lava on all sides. The basal tuffs are to be seen where the River Conon leaves the inlier at Peinchonnich represented by 15 ft of black shales and chocolate-brown clay with feldspar crystals below lava, and 800 yd further west just above the weir Knox recorded the following section:

6. Lava. The base of the flow is uneven with many included fragments of shale for 4–5 ft, above which it is dark and vesicular and partly rotted. Above a variable thickness of this the lava is a compact, fine-grained basalt.
5. Soft shaly beds with thin coaly films about 1 ft 0 in
4. Dark brown ashy material with coaly films about 1 ft 6 in
3. Grey-green fireclay, sandy and ashy
2. Flaggy sandstone several feet
1. Basalt lava, vesicular top.

The lava at the base of this section is probably one of the impersistent flows in the Palagonite Tuff sequence. At one time coal was worked here so that much thicker seams must have been present than those now visible. At Peinvraid on the north-east side of the inlier are black shales and thin ashy and sandy beds with coaly films like those recorded above.

In Vaternish Palagonite Tuffs are exposed at intervals at or near sea-level on both shores of Loch Bay associated with an irregular sill. On the eastern shore the tuffs contain fragments of fossilized wood as at Clach Bhuidh [NG 266 549] and at Lower Halista lignite was at one time sufficiently abundant to be worked for fuel. A lenticle of sandstone in lava on the shore ½ mile north-west of Creag nam Bodach, Loch Dunvegan, probably indicates the proximity of the basal tuffs.

That the Palagonite Tuffs include plant-bearing sediments was first noted by Wilson in 1935 about 600 yd due west of the south end of Loch Fada. The exposures are poor but about 30 ft of sediments are present consisting of a well-bedded, black, carbonaceous shale, coaly matter, palagonite tuff and a dark-grey, fine grained, shaly, bed in which the plant remains were found. This rock consists of a dark-brown, indeterminate clayey groundmass in which are embedded numerous grains of quartz, feldspar, and glauconite together with much carbonaceous matter.

Interbasaltic sediments

Considerable periods of time apparently intervened between the eruptions of individual lava-flows, during which the surfaces were exposed to weathering. Thus, in general the flows are separated by lateritic clays or boles produced by the decomposition of the lava. Much longer time-intervals, however, occurred between the eruptions of the fissures from which the various groups of lavas were extruded, and during these periods soils developed and in some cases a cover of vegetation. The deposits formed during these quiescent interludes were not extensive and probably not continuous. Moreover, the lava field is now much broken up by faulting so that it is a matter of considerable difficulty to relate these deposits to each other and to the episode to which they belong. That some explosive volcanic activity took place during these periods is evident by the accumulation of tuffs and agglomerates accompanying the sediments.

The lens of agglomerate 30 yd long and 4 ft thick on the west side of Lyndale Point and the sandstone in the lavas ½ mile N.W. of Creag nam Bodach in Loch Dunvegan appear to be deposits on the surface of the Vaternish lava group overlain by the porphyritic basalts of the Ramasaig group. For details of the lava groups see p. 81. This contact has not been seen elsewhere but probably lies below later lavas south of Loch Snizort Beag.

The interval between the Vaternish and Ramasaig groups and the overlying Osdale mugearite-basalt group appears to have been of longer duration and extensive plant-bearing sediments were laid down over much of the area. At the waterfall in the stream running from Suidh 'Fhinn to Sulishadermore, just west of Portree, are shaly sediments baked by a dyke which appear to be in this category. A conglomerate of lava pebbles, dark shales and thin coaly beds crops out in the Tungadal River, 1 mile N.E. of Roineval and similar sediments were found about ½ mile N.W. of Meall an Fhuarain. Both these deposits appear to lie between the Vaternish and Osdale groups of lavas.

The interlude between the Ramasaig and Osdale lava groups is separated by trachytic ash with sandstone and shaly sandstone with plants exposed in the Hamra River, Glendale, Duirinish (Figure 13), in all about 20 ft of sediment.

Three miles to the south-east 25–30 ft of sediments are again exposed in this category in Glen Osdale W.S.W. of Healaval Mhor. Here sandstones and conglomerates and shaly plant beds contain the most extensive and important leaf

impressions so far found in any of the Scottish interbasaltic deposits apart from Ardtun. The slabs crowded with leaves are similar to those from Ardtun though on the whole the plants are not so complete or well-preserved. The late Sir A. C. Seward and the late Mr. W. N. Edwards examined this material and, with the exception of an obscure fertile shoot at present indeterminate, referred them all to characteristic Ardtun species belonging to the genera *Quercus*, *Corylus* and *Platanus*.

Some two miles S. E. of Glen Osdale about 10 ft of conglomerates and muddy sandstones are exposed in Forse Burn (Figure 13) apparently at the same horizon as the two previous localities.

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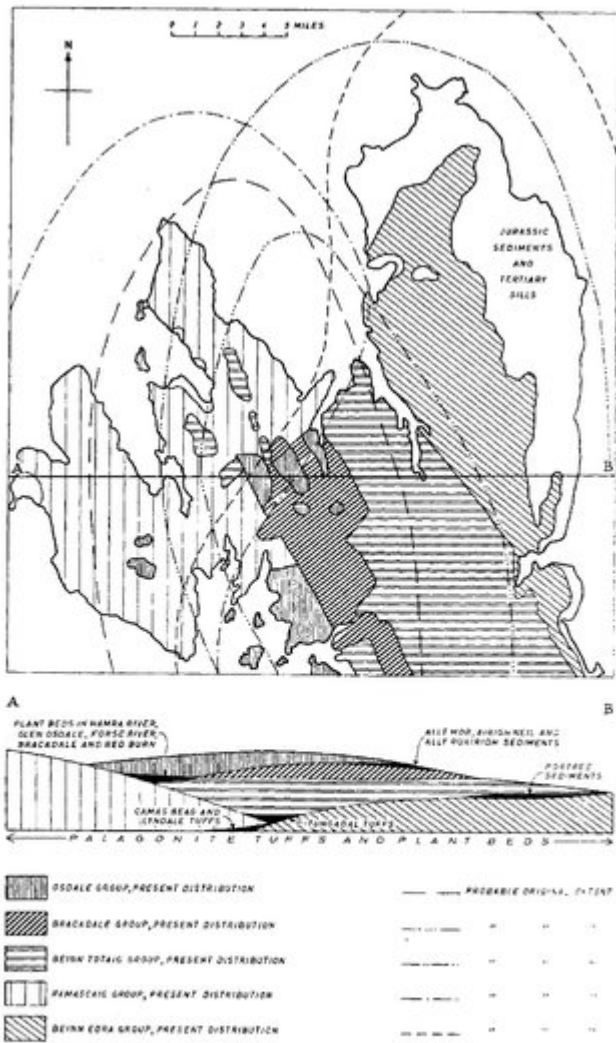


FIG. 13. Sketch-map showing the outcrops of the main lava-groups and section showing their mutual relationships. The suggested former limits of the groups are projected from the known thickness of the present day remnants. Intervals, between extrusive episodes are represented in many places by plant-bearing sediments and tuffs.

(Figure 13) Sketch-map showing the outcrops of the main lava-groups and section showing their mutual relationships. The suggested former limits of the groups are projected from the known thickness of the present day remnants. Intervals, between extrusive episodes are represented in many places by plant-bearing sediments and tuffs.