The Deposits of Loch Ness

by G. W. Lee and L. W. Collet
with analyses of selected samples by A. Wilson

ABOUT sixty samples of the deposits covering the floor of Loch Ness were collected by the members of the Lake Survey staff from various parts of the loch, and were examined according to the methods used in the *Challenger* Office for the study of marine deposits.

They may be classed as follows:—

(1) *Dark grey mud*, from the deep basin opposite Urquhart bay;

(2) *Ferruginous mud*, from the part of the Invermoriston deep basin opposite Horseshoe craig;

(3) *Peaty mud*, from the south-west end of the Invermoriston deep basin;

(4) *Yellow-grey clay*, from off Inverfarigaig and off Cherry island; and

(5) *Brown sand*, from shallow water off Urquhart bay.

(1) DARK GREY MUD.

The eleven samples of this mud are homogeneous and coherent when dry. A typical sample from 740 feet, opposite Urquhart bay, has the following mineralogical composition:—

Minerals (25 per cent.), mean diameter 0·1 millimetre. Of these particles quartz is the most abundant, often coloured red by a coating of iron oxide. Orthoclase, chloritic minerals, and limonite are also present.

Fine washings (75 per cent.), composed of vegetable matter (15·89 per cent.) and clayey matter (59·11 per cent.), with fine mineral particles and limonitic matter.

Chemical Composition.

Total silica	62·36
Ferric oxide	12·27
Alumina	9·38
Lime	tr.
Magnesia	tr.
Loss on ignition	15·89
	99·90

The high percentage of silica is due to the great proportion of quartz. The alumina is due to the presence of felspar and clayey matter. The defect 0·10 per cent. is probably due to the fact that the alkalies have not been estimated.

(2) Ferruginous Mud.

This type of sediment is limited to the part of the Invermoriston deep basin opposite Horseshoe craig. One of the samples was found after examination to be composed of:—

Minerals (29 per cent.), essentially represented by ferruginous grains, which are accompanied by quartz, orthoclase, chlorite, and hornblende. These mineral particles are angular, and have a mean diameter of 0·12 millimetre.

Fine washings (71 per cent.), composed of vegetable matter (18·46 per cent.) and fine minerals (52·54 per cent.), belonging to the species mentioned above.

Chemical Composition.

Total silica	37·44
Ferric oxide	24·48
Alumina	15·12
Lime	2·16
Magnesia	1·80
Loss on ignition	18·46
	99·46

The defect 0·54 per cent. is to be sought for in the alkalies.

As there is no clayey matter in this sediment, and as the microscopical investigation did not reveal the presence of many aluminous minerals, the high percentage of alumina, *i.e.* 15·12 per cent., is to be explained by the fact that the ferruginous grains are not made up of pure iron oxide, but of a mixture of this oxide with clay.

Although manganese was not estimated in the above quantitative analysis, it was found to be rather abundant in another sample.

(3) Peaty Mud.

This type of mud occupies a large area of the floor of the loch in the south-west end of the Invermoriston deep basin.

In order to show the differences in composition due to increase of depth, two descriptions will be given here.

First Sample. Depth 300 feet.

Minerals (35 per cent.), angular, mean diameter 0·2 mm.: orthoclase and acid plagioclase, greenish chlorite in large flakes, quartz, hornblende, and ferruginous matter.

Fine washings (65 per cent.), composed of vegetable matter (37·10 per cent.) and mineral particles (27·90 per cent.) belonging to the above-mentioned species.

Chemical Composition.

Total silica	47·88
Ferric oxide	5·58
Alumina	7·02
Lime	1·08
Magnesia	0·59
Loss on ignition	37·10
	99·25

Second Sample. Depth 445 feet.

Minerals (10 per cent.), angular, mean diameter 0·12 mm.: orthoclase and acid plagioclase, quartz, chlorite, hornblende, and ferrugineous matter.

Fine washings (90 per cent.), composed of vegetable matter (25 per cent.) and fine mineral particles (65 per cent.) of the same species as those mentioned under the heading: minerals, but chlorite and decomposed felspar are relatively more abundant.

Chemical Composition.

Total silica	46·03
Ferric oxide	10·41
Alumina	7·61
Lime	9·64
Magnesia	1·60
Loss on ignition	24·65
	99·94

Comparing the results of the investigation of these two samples, it will be seen that as the depth increases both the percentage and the diameter of the minerals decrease, the proportion of vegetable matter also decreasing.

The high percentage of lime in the second analysis is probably due to fragments of shells.

(4) Yellow-grey Clay.

One sample was taken off Cherry island in 95 feet, and eight samples off the south-east coast, east of Inverfarigaig, in 250 feet. This is very clayey in character, being soft to the touch and plastic when wet, coherent when dried, and taking in the latter state a light brown streak if rubbed with a hard smooth body.

The Cherry island sample is made up of—

Minerals (1 per cent.), angular, mean diameter 0·1 mm.: quartz, orthoclase, chlorite, and ferrugineous matter.

Fine washings (99 per cent.), composed of clay and very fine mineral particles

Chemical Composition.

Total silica	58·42
Ferric oxide	9·51
Alumina	24·58
Lime	0·52
Magnesia	3·74
Manganese	2·11
Copper oxide	0·65
Loss on ignition	0·59
	100·12

One of the eight other samples is made up of—

Minerals (29 per cent.), angular, mean diameter 0·1 mm.: quartz and decomposed felspar, with a decomposed ferrugineous mineral.

Fine washings (71 per cent.), composed of vegetable matter (4·2 per cent.) and clay and mineral particles (66·8 per cent.).

Chemical Composition.

Total silica	50·94
Ferric oxide	14·76
Alumina	19·80
Lime	6·58
Magnesia	3·61
Loss on ignition	4·20
	99·89

In these analyses the lime and magnesia probably belonged to some ferro-magnesian mineral, which was subsequently transformed into what is given here as "decomposed ferrugineous mineral," the advanced state of decomposition preventing its determination.

(5) Brown Sand.

To four samples of sediment dredged in 30 feet near the coast west of Urquhart bay we give the name of Brown Sand. One of the samples has the following composition :—

Minerals (69 per cent.), angular, mean diameter 0·2 mm., mostly made up of quartz, coloured reddish by a coating of iron oxide. Decomposed mica, hornblende, and plagioclase are also represented. The sand contains a few small fragments of rocks, 1 to 3 millimetres in diameter.

Fine washings (31 per cent.), composed of vegetable matter (4·4 per cent.) and fine mineral particles (26·6 per cent.). There is no clayey matter.

Chemical Composition.

Total silica	77·62
Ferric oxide	3·60
Alumina	5·20
Lime	5·88
Magnesia	2·20
Loss on ignition	4·40
	98·90

The alumina, lime, and magnesia are most likely due to the mica and hornblende, whilst the defect of 1·10 per cent. might represent the alkalies.

Conclusion.

Loch Ness includes two deep basins separated by a barrier formed by the delta of the Foyers river. The muds from the south-western or Invermoriston basin contain a large amount of vegetable or peaty matter, brought down the lake probably by the rivers Tarff and Oich, with mineral particles coming from the disintegration of the rocks, transported by the streams. Small concretions of peroxide of iron and dioxide of manganese were dredged at one station. The muds often gave the characteristic reaction of manganese. On the slopes the muds are sandy, and of a red-brown colour, due to the presence of oxide of iron.

The muds from the north-eastern or Urquhart basin contain far less vegetable matter than those from the south-western basin, which may be due to the Foyers barrier retaining the vegetable matter in the upper basin. In the north-eastern basin the vegetable matter increases with the depth, which is contrary to what is observed in the south-western basin. Off Urquhart bay the contour-lines approach each other very closely, and the vegetable matter brought down the lake by the river Enrick is carried towards the deeper part of the basin. Great differences are observed in the muds from the slopes on the two sides of the loch. On the north-western slope we find especially a red sandy mud, coming without doubt from the washing out of the shore, composed of Old Red Sandstone. On the south-eastern slope we have a fine yellow clay, with fragments of rocks and large mineral particles without vegetable matter. The deposition of the clay in this position may be due partly to the strong prevailing westerly winds of Loch Ness giving rise to waves and currents, which would carry the fine clayey matter brought down by the Inverfarigaig river towards the south-eastern shore. Three stones from a depth of 100 feet, opposite Inverfarigaig pier, were covered with a dark ring of manganese dioxide, marking out the line between the mud and water, as was pointed out by Sir John Murray and Mr. Robert Irvine in their valuable paper: "On Manganese Oxides and Manganese Nodules in Marine Deposits." *

* *Trans. Roy. Soc. Edin.*, vol. 37, p. 721 (1894).