Natural Environment Research Council

BRITISH GEOLOGICAL SURVEY

Mineral Reconnaissance Programme Report

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No. 80

Mineral investigations in the Ben Nevis and Ballachulish areas of the Scottish Highlands

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Mineral investigations in the Ben Nevis and Ballachulish areas of the Scottish Highlands

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BEN NEVIS

Introduction

Molybdenite in the Ben Nevis igneous complex was observed by Haslam (1965) and placed on record by Gallagher and others (1971). The purpose of the present investigation was to examine the distribution and mode of occurrence of the mineralisation and assess its significance.

Drainage geochemistry

Stream sediments and panned concentrates were collected from streams draining the igneous complex and analysed by XRF for Ce, Ba, Sb, Sn, Pb, Zn, Cu, Ca, Ni, Fe, Mn, Ti, U, Sr, Zr and Mo. The results are summarised in Table 1, and sample localities and high results (in stream sediments Cu ⩾40 ppm, Zn ⩾110 ppm, Mo ⩾ 8 ppm, Pb ⩾70 ppm and U ⩾40 ppm, and in panned concentrates Cu ⩾30 ppm, Zn ⩾90 ppm, Mo ⩾8 ppm and Pb ⩾35 ppm) are shown in Figure 1.

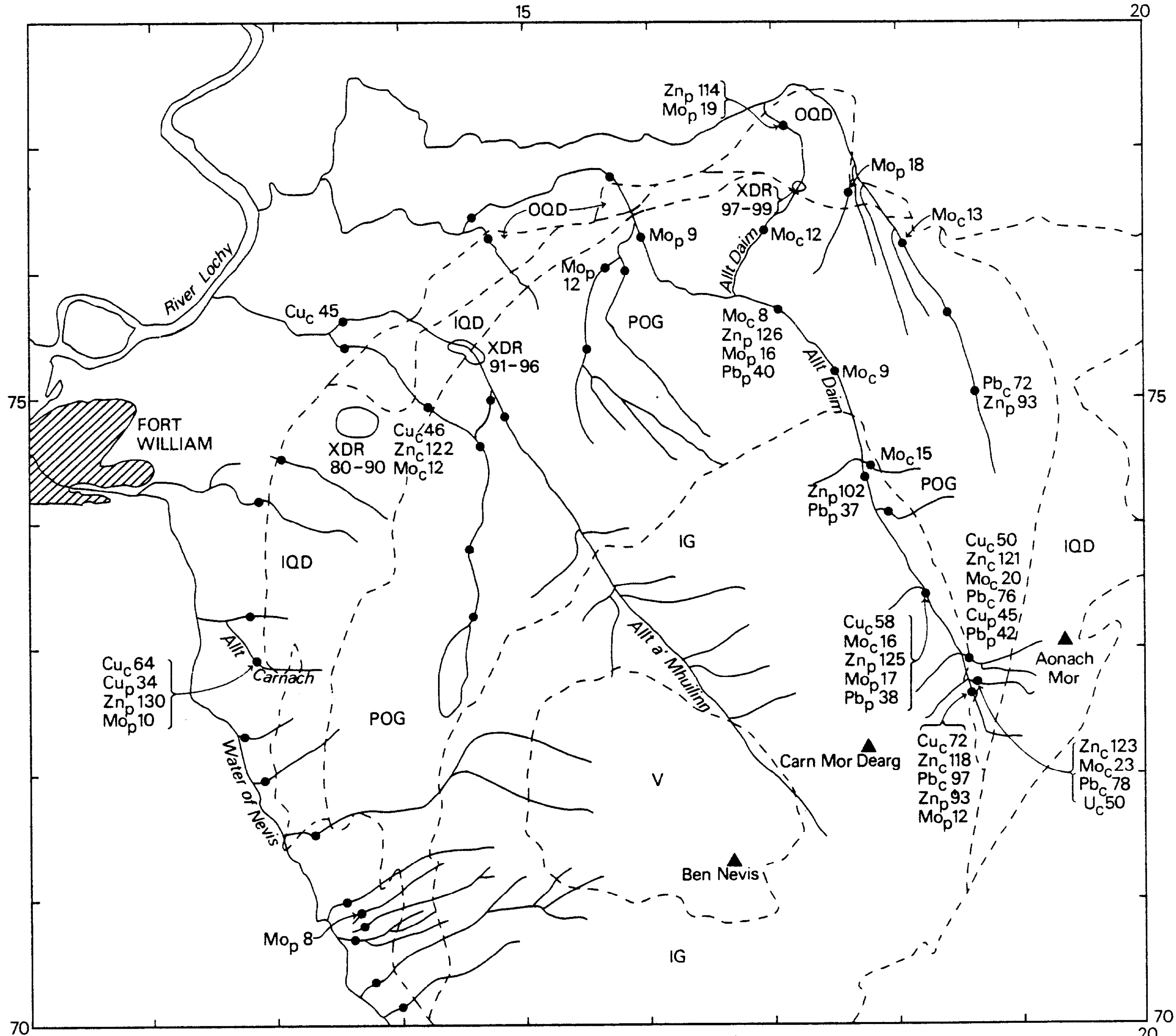
Table 1 Summary statistics for stream sediment and panned concentrate samples, Ben Nevis

	42 stream sediments			43 panned concentrates		
	min.	max.	median	min.	max.	median
Ce	29	131	66	34	407	114
Ba	455	942	682	248	926	593
Sb	<7	7	<7	<7	8	<7
Sn	<6	10	<6	<6	17	<6
Pb	20	97	36	11	42	22
Zn	20	123	64	14	130	58
Cu	<3	72	14	<3	45	7
Ca(%)	0.7	2.1	1.3	0.5	3.5	1.5
Ni	9	70	30	5	115	29
Fe(%)	1.8	11.4	5.2	1.0	27.3	5.8
Mn	330	3510	600	230	3210	740
Ti(%)	0.3	0.9	0.5	0.3	2.6	0.6
U	<4	50	<4	<4	20	<4
Sr	220	660	510	160	690	410
Zr	410	1920	860	150	4060	580
Mo	<2	23	4	<2	19	3

All values in ppm except where otherwise stated

The Allt Carnach in the west of the area drains the contact between the Inner Quartz Diorite and the Ballachulish Limestone. Pyrite-bearing calc-silicate rocks are exposed in the stream bed (Haslam, 1965), and these are presumably the source of the high metal values.

The principal area of high metal values in the drainage samples is at the headwaters of the Allt Daim in the east of the area, in streams draining the outer contact of the Porphyritic Outer Granite on the steep western slopes of Aonach Mor, where both sample types show high values for Mo, Cu, Pb and Zn. The geology of this area has not been examined, so the source of the metals is not known.



OQD Outer Quartz Diorite IQD Inner Quartz Diorite POG Porphyritic Outer Granite IG Inner Granite

V Volcanic rocks

Fig.1 Ben Nevis igneous complex, showing localties of rock samples (rings with XDR numbers) and drainage samples (dots). Anomalous results for stream sediment (c) and panned concentrate (p) samples are given in ppm. Geology from Haslam (1965,1968)

Above-background levels of Mo also occur elsewhere in streams draining the outer part of the Porphyritic Outer Granite, in particular in the north and northeast.

Geology and rock geochemistry

Appinite xenolith locality

An area at [Grid Reference NN 134 750] is characterised by abundant xenoliths of appinite and other rock types enclosed in diorite (Haslam, 1965, 1970). The diorites are more altered than elsewhere in the complex, and the area was, therefore, examined for traces of sulphide mineralisation. Analytical data for 11 rock samples are given in Table 2. XDR 82 is from a xenolith of sulphide-rich diorite, containing disseminated pyrite and chalcopyrite, and contains 0.3% Cu. Other samaples contain less than 200 ppm Cu. The copper mineralisation would seem to be too low grade and too localised to have any economic potential.

Allt a'Mhuilinn

A trace of molybdenite had previously been noted in hybrids at the merging contact between the Inner Quartz Diorite and the Porphyritic Outer Granite, at [NN 145 754]. Further examination of these hybrids failed to reveal any molybdenite, but traces of pyrite and chalcopyrite were observed, and five samples collected from the area contained 6-115 ppm Cu (Table 2).

Allt Daim

Plates of molybdenite up to 2 cm across occur in a pegmatitic phase in the Outer Quartz Diorite [NN 170 763] (Haslam, 1965). The Porphyritic Outer Granite outcrops within 50 m of this locality, and its magma permeated the Outer Quartz Diorite. The pegmatitic phase and the molybdenite are manifestations of this permeation. Specimens XDR 97-99 (Table 2) are from near the molybdenite locality. XDR 97 and 98 contain a little disseminated chalcopyrite. The high W content of XDR 98 (92 ppm) suggests the presence of scheelite but this mineral was not observed.

Conclusions

The distribution of molybdenum in the drainage samples suggests that any molybdenite mineralisation in the area is associated with the outer margin of the Porphyritic Outer Granite. In this geological environment, molybdenite is most likely to occur as small vein-type concentrations similar to that described in the lower reaches of the Allt Daim. Such occurrences would not be expected to have any economic potential.

The above background levels of Cu, Zn, Mo and Pb in drainage samples from the upper part of Allt Daim are unexplained. While it would be of some interest to trace the source of these metals, which appears to lie within the Inner Quartz Diorite or the Porphyritic Outer Granite, the metal values are not high enough to justify follow-up investigations.

SATELLITE IGNEOUS BOSSES NEAR BALLACHULISH

Introduction

Several minor igneous bodies near to the Ballachulish igneous complex were examined for indications of sulphide mineralisation. Their localities are

Table 2 Analytical data for outcrop rock samples, Ben Nevis

Sample Number (XDR)	Description	Ce	Ba	Pb	Zn	Cu	Ca (%)	Mn	Ag	Rb	Th	Sr	Y	Mo	W	Li	Na_2O (%)	K_2O (%)
Appinite xenolith locality																		
80	Diorite	39	890	11	74	<3	3.6	830	<2	40	7	1287	15	<2		14	4.1	1.6
81	Pegmatite in diorite	<10	274	24	<1	<3	0.4	40	<2	112	26	174	3	<2		2	3.8	4.5
82	Diorite (sulphide-bearing)	57	1462	9	67	3063	4.2	620	4	28	3	1676	22	4		18	4.7	1.4
84	Diorite	34	1376	19	84	58	2.8	630	<2	43	5	1335	15	2		12	4.4	2.4
85	Diorite	45	769	8	91	50	4.3	880	3	11	<3	1615	16	<2		11	3.9	0.7
86	Diorite	41	1349	13	75	17	3.6	770	<2	18	<3	1525	17	2		16	4.5	1.4
87	Diorite	46	1404	12	75	193	3.6	790	<2	27	<3	1627	16	2		17	4.4	1.7
88	Diorite	15	694	<6	84	<3	4.4	770	<2	<2	<3	2075	8	5		10	4.0	0.5
89	Diorite	59	1105	20	65	98	2.2	480	<2	79	12	956	16	2		18	4.4	3.3
90	Diorite	37	1115	9	90	13	3.9	980	2	34	<3	1657	14	<2		20	3.7	1.4
Allt a'Mhuilinn																		
92	Hybrids between Inner Quartz Diorite and Porphyritic Outer Granite	53	1095	12	31	77	1.3	310	<2	112	15	872	15	<2		19	4.2	4.2
93	Hybrids between Inner Quartz Diorite and Porphyritic Outer Granite	55	1213	16	28	115	1.5	300	<2	105	14	844	15	<2	7	20	4.5	3.9
94	Hybrids between Inner Quartz Diorite and Porphyritic Outer Granite	43	1151	20	24	110	1.1	280	<2	110	21	651	16	<2	<3	20	4.4	4.1
95	Hybrids between Inner Quartz Diorite and Porphyritic Outer Granite	57	1105	11	30	64	1.5	310	<2	119	16	798	16	<2		16	4.0	4.7
96	Hybrids between Inner Quartz Diorite and Porphyritic Outer Granite	35	1183	14	64	6	2.1	540	<2	67	6	1069	13	<2	<3	24	4.6	4.2
Allt Daim																		
97	Hybrids between Outer Quartz Diorite and Porphyritic Outer Granite	56	1114	23	76	70	1.7	580	2	152	11	733	22	32	3	26	4.8	2.8
98	Hybrids between Outer Quartz Diorite and Porphyritic Outer Granite	64	501	12	71	38	1.7	610	<2	134	9	699	17	6	92	32	4.5	4.5
99	Hybrids between Outer Quartz Diorite and Porphyritic Outer Granite	71	1498	37	45	5	1.1	320	2	160	37	1080	17	<2		44	5.7	2.1

All values in ppm except where otherwise stated shown in Figure 2. Some of them are drained by streams from which stream sediments and panned concentrates were collected. The results (Haslam and Kimbell, 1981, pp. 6, 15-17) do not suggest the presence of any important mineralisation.

The boundaries of the igneous bosses drawn on Figure 2 are taken from Muir (1950) and from the one-inch geological map, sheet 53. In some places these boundaries were seen to be in error, but no remapping was undertaken.

Rock samples were collected for microscopic examination and for determination of Cu, Pb, Zn, Ag (atomic absorption) and Be, B, V, Cr, Co, Ni, Y, Nb, Mo, Sn, Ba (emission spectrography). Results are given in Table 3.

Results

White granite

On the northwest margin of the Ballachulish igneous complex, at [NW 026 595], there is a small area of Dalradian rocks, referred to the Appin Quartzite, cropping out between the granodiorite and the sea (Figure 2). Between the quartzite and the granodiorite is a narrow strip of so-called "white granite" (Walker, 1924; Muir, 1950; Bailey and Lawrie, 1960, p. 188). The white granite is composed mainly of oligoclase, with minor orthoclase and quartz. Amphibole and mica are pale and iron-poor, the iron being contained in pyrite which, according to Walker (1924), is occasionally cupriferous.

In the present survey, samples were collectd from the white granite and the neighbouring rocks (Table 3). XDR 200 and 201 contained pyrrhotite and pyrite, 202 and 204 contained only pyrite, and 203 had no sulphides. Chalcopyrite was not observed in any of the samples and the Cu contents were in the range 0-30 ppm. XDR 200 contained 48 ppm Mo, though no molybdenite was observed in the rock.

Eastern margin of Ballachulish igneous complex

A brief examination of the kentallenites mapped at [057 577] and [058 568] (Figure 2) showed them to be unaltered. No sulphides were seen.

Glen Duror (W)

An area of appinitic diorite mapped at about [003 550] is poorly exposed. A brief examination of exposures in a northern tributary of the River Duror showed no evidence of sulphide mineralisation.

Glen Duror (S)

In the vicinity of [038 527] there are one (Geological Survey Sheet 53) or two (Muir, 1950) bodies of appinitic diorite. The rock is well exposed in the Allt Chlach-bhoidheach, which crosses the outcrop between about [038 527] and [0375 5285]. To the east of this stream there is thick drift cover. On the hillside to the west, exposures are moderate. The contacts with the pyroxene mica diorite of the Ballachulish igneous complex are gradational (Muir, 1950).

Nineteen samples were collected from the igneous rocks. The rock type is variable, with diorite, appinitic diorite, pyroxene-rich diorite and hornblendite. The samples were mostly from the area mapped as appinitic diorite, with a few from the pyroxene mica diorite of the Ballachulish igneous complex. Every specimen contained disseminated pyrite and most contained

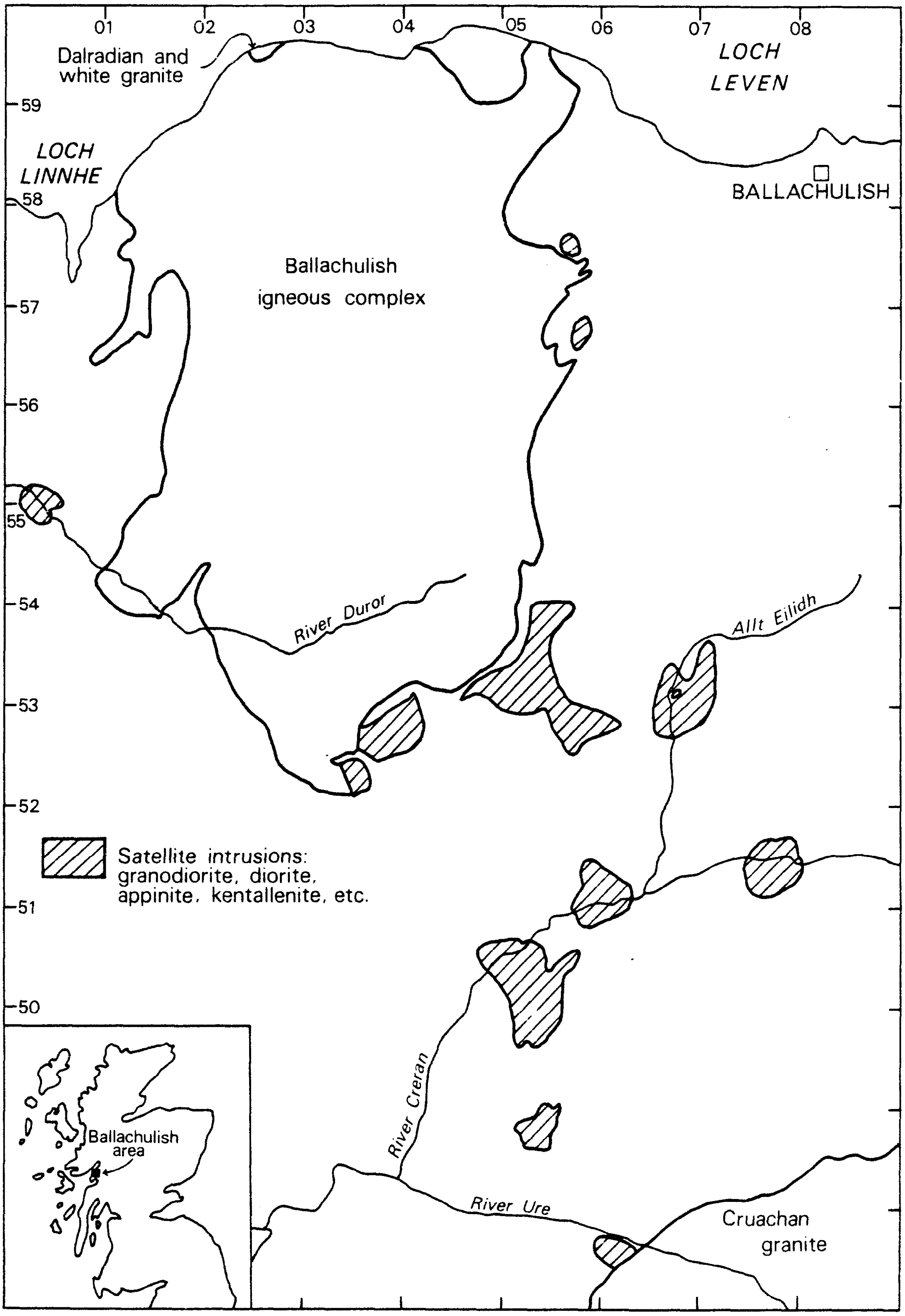


Fig. 2. Sketch map of the Ballachulish area showing the areas described in relation to the Ballachulish igneous complex and the Cruachan granite

disseminated chalcopyrite. Cu values were in the range 25-130 ppm (Table 3), the higher levels being generally in the coarse-grained hornblende-rich or pyroxene-rich rocks. Alteration (development of sericite and chlorite) is no more than normal for this type of rock, and the sulphides could be primary magmatic minerals.

Glen Duror (E)

A body mapped as appinitic diorite, with a small area of peridotite, outcrops around [053 532]. It is well exposed, and outcrops were examined in some detail. Much of the body is a fine-grained dioritic rock, similar to the quartz diorite of the main Ballachulish pluton. The outcrops observed do not agree with the published map, but the area was not remapped. Coarse-grained appinitic rocks outcrop over an area of approximately 500 m x 1-200 m between [0540 5360] and [0535 5310]. These appinitic rocks are variable in composition and locally contain xenoliths of quartzite and hornfels. There may be similarities with the explosion breccias of Ardsheal Back Settlement [NM 976 569] (Bowes and Wright, 1961) and Glen Charnan [NN 122 517] (Bowes and others, 1963), but more detailed studies would be required to confirm this. Except in the diorites in the western limb of the outcrop, pyrite, pyrrhotite and chalcopyrite are generally present in both diorites and appinites, being most abundant in the latter. Analysed specimens show copper contents of up to 200 ppm (Table 3). Little alteration is evident in the sulphide-bearing specimens and the mode of occurrence of the sulphides is consistent with a primary magmatic origin.

Ballachulish Slates

Three samples taken from near the contacts with the Glen Duror appinitic diorites showed trace element contents similar to those of five samples from the Ballachulish quarries (Table 3). The only result of note was 360 ppm Cu in one of the quarry samples.

Allt Eilidh

In the valley of Allt Eilidh, at about [070 530] there is a small boss of granitic rock, described by Bailey and Lawrie (1960, p. 193) as trondhjemite and compared by those authors to the white granite at the northwest of the Ballachulish igneous complex on acount of the presence of pyrite. The area underlain by this rock is no longer flooded (the dam that was constructed in the early years of this century having been breached some 50 years later) but exposures are poor. Two samples were collected from stream-side exposures near the southern end of the boss, and seven other samples from float. The rock contains zoned sodic plagioclase, subordinate orthoclase and quartz, and a little biotite, partially chloritized. Disseminated pyrite is widespread, but of variable abundance. It is occasionally accompanied by pyrrhotite and rarely by traces of chalcopyrite. Other accessories are apatite, ilmenite and magnetite. The widespread distribution of the pyrite suggests that the sulphides are of primary magmatic origin. The metallic trace element contents are consistently low (Table 3).

Within the trondhjemite, Bailey and Lawrie (1960, p. 193) record a small outcrop of cortlandtite. Float fragments of this type showed a range of mineralogical composition, the minerals being olivine, hornblende, clinopyroxene, minor biotite and plagioclase. One specimen contained disseminated pyrite and another had disseminated pyrrhotite and chalcopyrite. Trace element contents are shown in Table 3.

Glen Creran (E)

The diorite [078 515] in Glen Creran is poorly exposed. Two float samples were collected. One of them contained traces of chalcopyrite and the analysis shows 110 ppm Cu (Table 3).

Glen Creran (central)

The diorite at [060 510] is seen in scattered boulders and in outcrop beside the River Creran. It is a uniform coarse diorite, and contains traces of chalcopyrite. The trace element contents are low (Table 3).

Glen Creran (W)

Kentallenite outcrops beside the River Creran near [050 505], and a few boulders are found to the north. It contains rare pyrite and chalcopyrite, but the copper content is low (Table 3). Southwest of the river, the rock is a coarse hornblende diorite. It is quite well exposed, but no mineralisation was seen.

Glen Ure (N)

The small dioritic body at [053 488] contains a central area of medium-grained diorite, which exceptionally bears pyrite and traces of chalcopyrite (XDR 273, Table 3). In the west and northwest the rock is a coarser appinitic diorite, which commonly contains pyrite and traces of chalcopyrite (XDR 274) and there is another appinitic area to the south.

Glen Ure (S)

A small area of diorite at [062 477] is in contact with the Cruachan granite. No sulphides were seen, and trace element contents are low (Table 3).

Conclusions

Disseminated pyrite, sometimes accompanied by pyrrhotite and/or chalcopyrite, is quite common in the dioritic, appinitic, trondhjemitic and ultrabasic rocks near the Ballachulish igneous complex. Chalcopyrite is never present in more than trace quantities, and the highest copper content is 240 ppm. It may be noted that one sample of the Ballachulish slates from the main Ballachulish quarry at [085 582] contained 360 ppm Cu.

The sulphides in the igneous rocks are disseminated, with no mineralised veinlets or other evidence of post-consolidation mineralisation. It is, therefore, probable that the sulphides are primary phases, unlike the sulphides introduced into appinitic rocks in the Ardsheal peninsula (Rice and Davis, 1979).

ACKNOWLEDGEMENTS

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The drainage geochemical samples in the Ben Nevis area were collected by Mr K Turton.

Table 3 Analytical data (ppm) for outcrop samples, Ballachulish

Sample Number (XDR)	Cu	Pb	Zn	B	V	Cr	Co	Ni	Y	Ba
<u>White granite locality</u>										
200 White granite	15	10	10	<10	37	342	<10	10	15	2510
201 Appin Quartzite	20	10	20	18	37	28	12	20	38	174
202 Appin Quartzite	10	10	10	22	10	286	14	<10	5	<100
203 White granite	<3	10	20	11	14	264	<10	<10	16	814
204 Granodiorite	30	10	40	<10	83	40	13	30	28	1690
<u>Glen Duror (S) (19 samples)</u>										
median	60	20	50	<10	184	76	38	85	32	1170
minimum	25	10	10	<10	149	<10	20	<10	23	441
maximum	130	40	80	16	348	538	74	444	50	2150
<u>Glen Duror (E) (19 samples)</u>										
median	25	20	40	18	138	120	30	92	23	1350
minimum	10	10	20	<10	76	36	12	21	14	502
maximum	200	30	60	37	350	527	80	190	50	2690
<u>Ballachulish slates, hornfelsed</u>										
226 Glen Duror (E)	10	20	50	60	135	133	<10	31	56	1180
227 Glen Duror (E)	30	20	110	100	82	91	18	50	46	530
251 Glen Duror (S)	30	60	80	32	72	86	18	51	50	650
<u>Ballachulish slates, not hornfelsed (5 samples)</u>										
median	30	20	110	115	97	76	13	41	46	534
minimum	20	10	20	92	95	67	<10	31	35	328
maximum	360	30	130	205	105	89	25	54	54	635
<u>Allt Eilidh trondhjemite (9 samples)</u>										
median	10	10	50	<10	69	31	12	25	24	1410
minimum	20	10	30	<10	65	18	<10	19	14	1210
maximum	10	20	50	<10	94	60	14	31	39	1570
<u>Allt Elidih cortlandtite</u>										
232	90	10	20	<10	138	615	45	175	27	392
233	40	10	40	<10	127	1370	75	345	11	385
<u>Glen Creran and Glen Ure</u>										
230 Glen Creran (E)	110	20	70	<10	218	132	48	145	22	1080
231 Glen Creran (E)	60	10	50	<10	163	193	29	129	23	792
207 Glen Creran (central)	20	10	70	<10	202	322	46	106	20	824
208 Glen Creran (central)	70	20	40	13	188	259	37	93	20	852
228 Kentallenite, Glen	45	10	60	26	197	771	74	665	21	748
229 Creran (W)	60	10	60	20	263	760	78	504	23	915
273 Glen Ure (N)	30	30	40	16	88	36	17	29	25	1170
274 Glen Ure (N)	240	20	40	<10	394	466	60	195	35	201
275 Glen Ure (S)	80	20	40	25	177	279	35	106	22	806

The samples were also analysed for Ag (all results <5 ppm), Be (all <4 ppm), Nb (all <30 ppm), Mo (all <4 ppm, except white granite XDR 200 with 48 ppm) and Sn (all <5 ppm).

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