The Lewisian pegmatites of South Harris, Outer Hebrides.

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Summary. A number of representative examples of the Lewisian acid pegmatites of South Harris are described, and the presence of the following minerals has been established: quartz, albite, microcline, biotite, muscovite, magnetite, beryl, spessartine, gahnite, columbite, monazite, zircon, pyrite, epidote, tourmaline, apatite, thorite, uraninite, thorogummite, uranophane, kasolite, betafite (?), and allanite. Spectrographic, optical, and X-ray powder data are given for some of these minerals, together with chemical analyses of magnetite, biotite, columbite, gahnite, and spessartine. It is believed that gahnite, uranophane, and the pyrochlore mineral (probably betafite) are recorded for the first time from Britain.

As early as 1901 Heddle described a number of minerals from the 'graphic granites' or pegmatites of South Harris at Chiapaval and Roneval. From Chiapaval green muscovite, biotite (haughtonite), microcline, blue quartz, garnet, and beryl were noted, and analyses of the micas given. From the Roneval sheets oligoclase, microcline, magnetite, and biotite were mentioned, with analyses of the last two minerals. Magnetite and microcline were noted from the pegmatites around Stromay.

Later, in 1927, Jehu and Craig remarked on the abundance of these acid pegmatites, especially towards the margin of the granite-gneiss in the Loch Langavat valley (1927, pp. 481–483). A general description was given: 'The felspar is usually microcline, sometimes orthoclase enclosing in perthitic fashion a plagioclase near albite. The perthitic structure is often visible in hand specimen, but also occurs on a microscopic scale. The only other common constituent is a dark mica, in rather small and irregular plates, and another constituent, though less common than the mica, is magnetite in irregular masses an inch or more in length.'

Davidson (1942, pp. 108–109) quoted analyses of the potash feldspars from Chiapaval and Sletteval and an analysis of the latter pegmatite. Robertson (1945) described the Chiapaval and Sletteval sheets, mainly

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in connexion with the extraction of potash feldspars, and recorded the presence of topaz in the Chiapaval pegmatite.

Recently these pegmatites have been mapped in more detail (Dearnley, 1959). In the Loch Langavat belt the pegmatites form concordant pods within the paragneisses, but to the south-west cross-cutting sheets are common, as noted by Kursten (1957, p. 21). In the field two main groups of pegmatites may be recognized: pegmatites with magnetite and biotite and only minor muscovite, and pegmatites with muscovite and only minor biotite and magnetite. Transitional types occur and locally pegmatites almost free from magnetite and micas may be found. Pegmatites of the first group are more common in the Loch Langavat valley (one notable exception occurs to the north-west of Scara Ruadh), and include the large sheets of Sletteval, Roneval, and Beinn Tharsuinn. Pegmatites of the second group occur in the Obbe to Northton paragneiss belt and include the Chiapaval sheet.

Mineralogy.

During the examination of these pegmatites a number of interesting minerals have been found (von Knorring and Dearnley, 1959, pp. 255–256) and it is the purpose of this paper to describe these occurrences. Three pegmatites have been studied in some detail, at Loch a' Sgurr, near Finsbay, at Sletteval, and at Chiapaval. The Sletteval and Chiapaval sheets are thick cross-cutting pegmatites, the former a first group and the latter a second group pegmatite of the present classification. The Loch a' Sgurr pegmatite is a concordant first group variety.

Loch a' Sgurr pegmatite. This pod-like pegmatite is a magnetite–biotite-bearing variety typical of numerous lenses throughout the Loch Langavat valley. Good exposures across the core of the lens have been made by road blasting and the sheared contacts with the surrounding paragneisses are quite clear. The bulk of the pegmatite consists of pink and white albitic plagioclase, some microcline, and quartz. Magnetite segregations up to 6 inches in length are common and are frequently associated with a greenish-yellow mica. Locally the feldspar is a brick-red colour near to the magnetite lenses and in these cases a distinct radioactive anomaly can be detected due to uraninite, thorite, and monazite. Yellow powdery coatings of uranophane on fracture surfaces are common. A list of the minerals identified in the pegmatite comprises: quartz, albite, microcline, biotite, magnetite, epidote, zircon, spessartine, pyrite, allanite, uraninite, thorite, monazite, and uranophane.

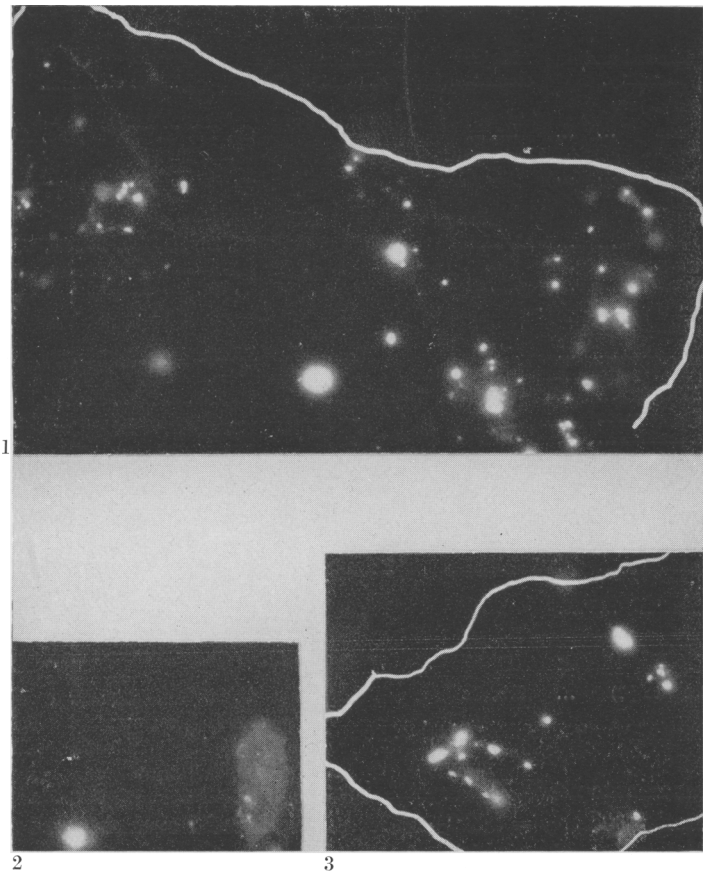
Magnetite is common and often forms streaky lenses within the pegmatite. A partial analysis (table I) indicates only a minor content of TiO_2, and may be compared with a magnetite analysed by Heddle (1901, p. 97), from the 'great granite vein on the east of Roneval' (? Sletteval pegmatite). Epidote occurs as scattered light green crystals, and also intergrown with the albitic plagioclase. Zircon is common and forms euhedral opaline-grey to dark brown slender crystals, showing the prism {100} combined with the pyramid {111}. Frequently a zonal growth is apparent. The zircon is metamict and contains inclusions of magnetite. It is at times overgrown with minute grains of uraninite.

TABLE I. Chemical composition of magnetite from the Loch a' Sgurr pegmatite.

	1.	2.
TiO_2	0·90	—
Fe_2O_3...	67·20	68·10
FeO	27·80	29·10
MnO	0·13	0·50
Al_2O_3...	—	0·62
CaO	—	0·17
MgO	—	0·60
SiO_2	—	1·00
Insol....	1·10	—
	97·13	100·09

1. Magnetite, Loch a' Sgurr pegmatite. Partial anal. O. von Knorring.
2. Magnetite, granite vein east of Roneval. Heddle, 1901, p. 97.

An autoradiograph (fig. 1) indicates that the zircon is sometimes slightly radioactive and in some crystals minute uraninite inclusions are seen. Spessartine garnet is a minor constituent and has a refractive index ($1{\cdot}800 \pm 0{\cdot}003$) close to the analysed spessartine from Chiapaval (table V). Pyrite is locally common. Allanite occurs as small, black, glassy metamict crystals. Uraninite is present in small amounts, sometimes as inclusions in magnetite or monazite, sometimes within feldspar crystals. It may be either black or a dark greenish colour. An autoradiograph (fig. 1) shows well-defined bright spots due to uraninite crystals included in magnetite, and fig. 2 shows similar uraninite grains in monazite. Thorite occurs in a brown glassy metamict state and only gives an X-ray diffraction pattern after heating. Monazite is quite common, often as inclusions in the magnetite but also within the feldspar. It is brownish-red in colour, often showing good crystal faces and occurring in crystals up to $\frac{1}{4}$ inch in length. The optic axial angle is small (+) and the refractive index $\gamma = 1{\cdot}842 \pm 0{\cdot}003$. An autoradio-



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2 3

FIGS. 1–3. Autoradiographs. FIG. 1 (*top*): Loch a' Sgurr pegmatite. ×2. Exposure 14 hours. Bright spots are uraninite, the more diffuse areas are monazite and zircon. Note the uranophane coatings along fractures. FIG. 2 (*bottom left*): Loch a' Sgurr pegmatite. ×2. Exposure 24 hours. Monazite crystal approximately parallel to {010} shows as a diffuse image with bright uraninite inclusions. FIG. 3 (*bottom right*): Sletteval pegmatite. ×2. Exposure 14 hours. Thorite and thorogummite inclusions in biotite crystals.

graph (fig. 2) shows a section of a monazite crystal approximately parallel to {010}, giving a diffuse radiation picture and containing small uraninite inclusions. The radioactivity is probably mainly due to the thorium content, as in the case of the Chiapaval monazite (table II). Uranophane occurs as yellow powdery films on fracture surfaces. It

TABLE II. Qualitative spectrographic analyses of South Harris Lewisian pegmatite minerals.*

Mineral and locality.	Major elements.	Minor elements.	Trace elements.
Loch a' Sgurr			
Zircon	Zr, Si	—	Ca, Hf, Y, Yb, Sc, Fe, Al, Pb, Mg, Ti, Mn
Uraninite	U	—	Si, Pb, Y, Fe, Ca, Mg, Mn, Zr, Al
Sletteval			
Biotite	Al, Si, Fe	K, Ti, Mg, Mn	Ca, Li, Na, Rb, Zn, Co, V, Ga
Microcline	Si	K, Na, Al	Rb, Ca, Fe, Li, Mg, Pb, Mn
Thorite	Th, Si	Ca, U	Y, Pb, Al, Mn, Fe, Mg, Ti
Chiapaval			
Muscovite	Al, Si	K, Fe	Li, Na, Rb, Mg, Mn, Ga, Ti, Ca, Be, Zn, Nb
Microcline	Si	K, Al, Na	Rb, Fe, Ga, Pb, Ca, Mg
Black quartz ...	Si	—	Ca, Mg, Al, Fe, Mn, Pb, Ti
Columbite	Nb	Ta, Mn, Fe	Ba, Ti, Ca, Si, Zr, Mg
Columbite	Nb	Ta, Mn, Fe	Ba, Ti, Ca, Si, Zr, Mg, Al, Pb
Monazite	Ce, Th, P	Nb	Ba, Ti, Ca, Si, Zr, Mg, Al, Pb, Fe, Mn, Y, La, Nd
Zircon	Zr, Si	Hf	Ca, Fe, Al, Mg, Mn, Pb, Th, Y, Nb
Gahnite	Zn, Al, Fe	Mn, Si, K	Li, Na, Rb, Ca, Ba, Cu, Mg, Ga, Ti, Cr
Kasolite	Pb	Th, U, Si	Fe, Mg, Mn, Ca, Ba, Al, Zr, Nb, Y
Kasolite-like mineral	Th, Si	Pb, U	Fe, Mg, Mn, Ca, Ba, Al, Bi, Zr, Nb, Y
Betafite (?) ...	Nb, Ca	Fe, Mn	Y, Pb, Mg, Si, Ti, Zr

* Analysts: Misses J. M. Rooke and A. M. Swallow.

forms minute needle-like crystals in radial groups and aggregates. The refractive index $\gamma = 1{\cdot}699 \pm 0{\cdot}003$, the optic axial angle is small (−), and the elongation positive ($\gamma = c$); the interference colours are abnormal blues of the first order. The X-ray diffraction pattern shows excellent agreement in spacings and intensities with uranophane from the Ruggles pegmatite (Frondel *et al.*, 1956). On the autoradiograph (fig. 1) the thin faint lines are due to uranophane coatings along fractures. It is believed that this uranophane occurrence is the first to be reported from the British Isles.

Sletteval pegmatite. On the Sletteval ridge two large parallel sheet-like pegmatites occur, the lower of which has been quarried for potash feldspar. The country rocks are garnet-metagabbros and metadiorites of the South Harris igneous complex (Dearnley, 1959).

Albite, potash-feldspar, and biotite books make up the bulk of the pegmatite, but scattered magnetite crystals are quite common. Apatite

crystals up to 2 inches in length occur sporadically and small spessartine and zircon crystals have been found in heavy mineral separations. Allanite occurs locally in small amounts, and one example of a flattened elongated crystal 2 inches in length has been found.

Thorite and thorogummite are found as small inclusions in many of the biotite crystals; they range in size from about $\frac{1}{10}$ inch to $\frac{1}{4}$ inch across, but are not common. The thorogummite occurs as glassy red or as earthy red-brown grains, the latter sometimes forming an outer rim or completely replacing the former, and sometimes seen as replacements of the thorite crystals. The red and the brown crystals are not metamict since they give a thorogummite X-ray diffraction pattern without heating, but the pattern is much clearer after heating to 950° C. for 1 hour. The refractive index of these isotropic grains is $1{\cdot}610 \pm 0{\cdot}003$, which indicates that they are thorogummite rather than thorite. Yellow thorite crystals are closely associated with the thorogummites. These are quite metamict and isotropic with a refractive index of $1{\cdot}685 \pm 0{\cdot}003$ and a density of 4·30 before heating. When the crystals are heated to 950° C. for 1 hour the X-ray diffraction pattern indicates that thorianite is the major constituent, but weak lines of thorite are also present. When the heating is carried out at 1400° C. for 17 hours the mineral changes to the monoclinic dimorph of thorite, huttonite, see fig. 4. These results are in accord with the work of Frondel (1953, p. 1015) who stated that 'Microcrystalline thorogummite and metamict thorite react differently when heated to 1000°. The former develops the tetragonal, the latter the monoclinic polymorph of $ThSiO_4$. ThO_2 also is formed in both cases.'

In the Sletteval thorites examined, the weight loss on heating to 1400° C. was 22·6 %, and the final refractive index and density were respectively 1·750 and 4·80.

A qualitative spectrographic analysis of the yellow thorite is given in table II, from which it is seen that the mineral is a uranium-bearing variety. An autoradiograph (fig. 3) shows high radioactivity associated with each thorite or thorogummite grain in the biotite.

The biotite from Sletteval often occurs in fairly large books, some of which are narrow and elongated, apparently along fracture surfaces. In addition to thorite and thorogummite, inclusions of small white crystals of apatite often occur within the biotite books. An analysis is given in table IV and is very close to that of a similar pegmatitic biotite from Mansjö, Sweden (Eckermann, 1925). The analysis also compares favourably with the average composition of granitic and pegmatitic

TABLE III. X-ray powder data (Cu-$K\alpha$ radiation) for betafite from the South Harris pegmatites.

	1.		2.			1.		2.	
hkl.	*d*, Å.	*I.*	*d*, Å.	*I.*	*hkl.*	*d*, Å.	*I.*	*d*, Å.	*I.*
	—		3·99	3		—		1·63	1
	—		3·55	1		—		1·59	1
	—		3·28	1	266	1·55	s	1·55	6
	—		3·19	2	444	1·48	w	1·485	1
222	2·97	vs	2·98	10		—		1·355	1
004	2·58	m	2·57	2	008	1·29	w	1·290	1
	—		2·49	3	266	1·18	w	1·181	2
	—		2·20	1	048	1·15	m	1·154	3
	—		2·00	1	448	1·05	w	1·050	1
044	1·82	s	1·82	8		—		1·025	1
			1·70	2	666	0·99	m	0·990	2

1. Betafite, Chiapaval pegmatite, South Harris.
2. Betafite, Madagascar, Frondel *et al.*, 1956, p. 101.

TABLE IV. Chemical analyses of biotite from the Sletteval pegmatite and of columbite from the Chiapaval pegmatite. Analyst, O. von Knorring.

	1.	1a.				2.	2′.	2a.	
SiO_2	35·75	Si	5·45	$z = 8·00$	SiO_2	1·25	—		
Al_2O_3	17·10	Al	2·55		Al_2O_3				
			0·52		ZrO_2	0·10	—		
TiO_2	2·94	Ti	0·34	$Y = 5·64$	FeO	12·41	12·57	$Fe^{\cdot\cdot}$ 2·45	3·80
Fe_2O_3	3·59	$Fe^{\cdot\cdot\cdot}$	0·41		MnO	6·69	6·78	Mn 1·35	
FeO	18·84	$Fe^{\cdot\cdot}$	2·40		Nb_2O_5	65·20	66·06	Nb 7·00	8·14
MnO	0·67	Mn	0·09		Ta_2O_5	12·56	12·73	Ta 0·82	
MgO	8·14	Mg	1·85		TiO_2	1·84	1·86	Ti 0·32	
Li_2O	0·05	Li	0·03			100·05	100·00		
CaO	0·04	Ca	0·01	$X = 1·81$					
Na_2O	0·08	Na	0·02						
K_2O	9·17	K	1·78						
H_2O^+	3·72	OH	3·78	3·87					
H_2O^-	0·04	F	0·09						
P_2O_5	nt. fd.								
F	0·18								
Cl	nt. fd.				Sp. gr.	3·03			
S	n.d.				$\beta \approx \gamma$	1·635			
	100·31								
O = F	0·08								
	100·23								

1. Biotite from the Sletteval pegmatite, South Harris.
1a. Atomic ratios of biotite to 24(O, OH, F).
2. Columbite from the Chiapaval pegmatite, South Harris.
2′. Anal. 2 recalculated to 100 % omitting SiO_2, Al_2O_3, and ZrO_2.
2a. Atomic ratios of columbite to 24 oxygen atoms.

biotites as given by Rankama and Sahama (1949, p. 156). Individually, however, pegmatitic biotites differ considerably in chemical composition. The major variations appear to be in the iron, magnesia, water, and fluorine contents. The titania is generally around three per cent. except in the extreme iron-rich varieties, where both magnesia and titania are low.

Trace elements detected in the Sletteval biotite are: Rb, Zn, Co, V, and Ga. It is a relatively iron-rich type with refractive index of $\beta \approx \gamma = 1{\cdot}635 \pm 0{\cdot}003$, and a specific gravity of 3·03.

The Sletteval pegmatite is the only one examined that shows signs of zoning. From the contact inwards a zone of graphic granite is followed by a zone rich in microcline and biotite. Irregular masses of white and bluish quartz are common towards the core.

Chiapaval pegmatite. This large pegmatite sheet, 1½ miles north-west of Northton, runs from Faodail an Taobh Thuath to just north-west of Rudh' an Teampuill, in a north-east to south-west direction. It dips north-west into the slope of Chiapaval and in places is up to 80 feet thick. The pegmatite has been opened up at the north-western end and quarried for potash feldspar. The following mineral assemblage was recorded from the quarried portion of the sheet: quartz, albite, microcline, muscovite, biotite, magnetite, beryl, columbite, gahnite, spessartine, uraninite, thorite, kasolite, a kasolite-like mineral, a betafite-like mineral, zircon, monazite, allanite, blue and black tourmaline, and pyrite. The bulk of the pegmatite consists of quartz and feldspar with muscovite and minor biotite and magnetite. A partial analysis of the muscovite indicated the presence of 4·60 % iron oxide, calculated as Fe_2O_3. The other minerals are present in only small amounts in the pegmatite as a whole but are locally abundant.

Columbite usually occurs as small crystals although specimens up to 1½ inches in length have been found. They are frequently associated with quartz, feldspar, spessartine, and gahnite and locally with muscovite, monazite, and uraninite. Well-formed individual crystals are not common. The specific gravity for a number of separate grains ranges from 5·50 to 5·70, which places them in the columbite range of the tantalite–columbite series. A determination of the specific gravity of the analysed material, by the Berman balance, indicated a value of 5·61, which compares with the calculated specific gravity, from the formula sp. gr. $= (5{\cdot}20 + 0{\cdot}03 \times Ta_2O_5\ \%)$, of 5·58. An analysis of one crystal is given in table IV. On the basis of the ionic radii Ti has been placed in the Nb and Ta group, rather than with Fe and Mn. The ratio

$(FeO+MnO):(Nb_2O_5+Ta_2O_5+TiO_2)$ shows a slight departure from the theoretical ratio of 4:8. The calculated unit cell dimensions from the best lines on the powder diffraction pattern gave the following values: *a* 5·11 Å., *b* 14·21 Å., *c* 5·75 Å., which are close to those recorded previously for the columbite–tantalite series (Sturdivant, 1930, p. 89). Qualitative spectrographic analyses for two columbite crystals are recorded in table II.

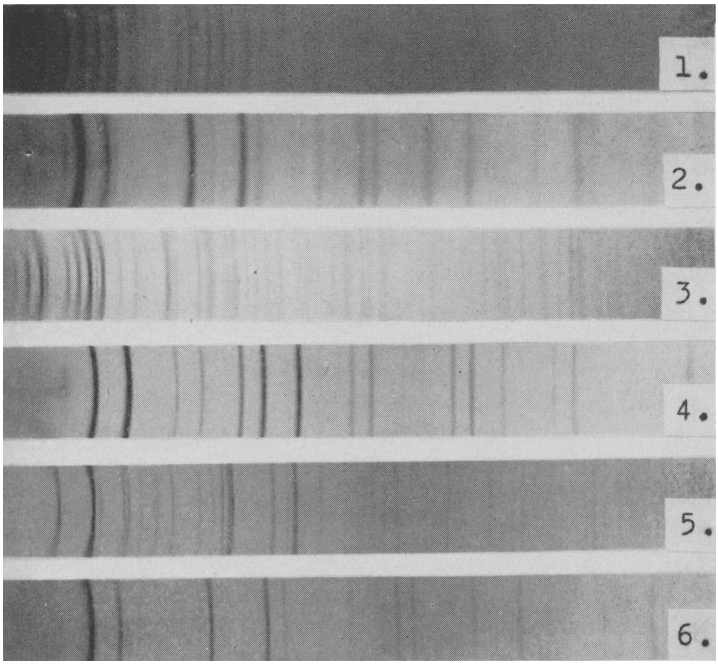

FIG. 4. X-ray powder diffraction photographs. 9 cm. camera, Cu-$K\alpha$ radiation. 1: Uranophane, Loch a' Sgurr pegmatite. 2: Thorite heated to 950° C. for 1 hour. Thorianite is the main constituent. Sletteval pegmatite. 3: Thorite heated to 1400° C. for 17 hours. Huttonite is the main constituent. Sletteval pegmatite. 4: Gahnite, Chiapaval pegmatite. 5: Columbite, Chiapaval pegmatite. 6: Betafite (?), Chiapaval pegmatite.

The zinc spinel, gahnite, occurs sporadically, sometimes in relatively large crystals, but also in irregular masses often associated with muscovite. The specific gravity, as determined on the Berman balance, is 4·55, the refractive index is 1·795±0·003, and the calculated unit-cell dimension is 8·10 Å. for the analysed specimen in table V. The analysis

compares closely with a pegmatitic gahnite from the Rosendal pegmatite, Kimito, Finland (Pehrman, 1948, p. 330). Kullerud (1953) has determined the temperature of formation of the Rosendal blende (von Knorring, 1946) as approximately 535° C. It is interesting to note that in the Rosendal occurrence the coexisting blende and gahnite have similar zinc:iron ratios, in the blende 5·6 and in the gahnite 5·4, suggesting that the iron content in gahnites may also be a function of the temperature of formation. In the analysis of the Chiapaval gahnite the ratios do not exactly correspond to the theoretical ratios, and this probably indicates the presence of some 1·4 % Fe_2O_3 in the total iron percentage. Trace elements detected in the analysed gahnite are: K, Li, Na, Rb, Ca, Ba, Cu, Be, Ga, Ti, and Cr. In the Kimito gahnite Pehrman (1948) records the presence of Li, Cd, Be, In, and Ga.

TABLE V. Chemical composition of gahnite, spessartine, and an oligoclase–zoisite intergrowth from South Harris.

	1.	2.	3.	1a.		2a.
SiO_2	0·12	36·10	57·71	Al ... 15·91		Si ... 23·6
TiO_2	nt. fd.	n.d.	—	Zn ... 6·40	8·13	Al ... 16·1
Al_2O_3... ...	55·91	20·87	25·09	Fe ... 1·60		$Fe^{\cdots}$ ... 2·0
Fe_2O_3... ...	n.d.	4·10	0·29	Mn... 0·09		$Fe^{\cdot\cdot}$ ... 8·9
FeO	7·90	16·20	0·04	Mg... 0·04		Mn ... 11·9
ZnO	35·85	—	—			Mg ... 0·5
MnO	0·42	21·47	0·04			Ca ... 0·4
MgO	0·12	0·57	n.d.			
CaO	tr.	0·51	8·12			
Na_2O... ...	—	—	7·33			
K_2O	—	—	0·74			
H_2O+ ...	—	—	0·84			
H_2O- ...	—	—	0·12			
P_2O_5	—	—	tr.			
	100·32	99·82	100·32			

1. Gahnite from the Chiapaval pegmatite. Total iron taken as FeO. Anal. O. von Knorring.
1a. Gahnite, atomic ratios to 32 oxygen atoms.
2. Spessartine from the Chiapaval pegmatite. Anal. O. von Knorring.
2a. Spessartine, atomic ratios to 96 oxygen atoms.
3. Oligoclase–zoisite intergrowth, Loch Vallarip. Anal. J. R. Baldwin.

Spessartine garnet is a fairly common constituent of the pegmatite and is locally abundant, forming irregular masses up to 6 inches across. The refractive index is 1·805±0·003, and the specific gravity 4·19. A calculation of the unit cell dimension from the powder diffraction pattern gave a value of 11·60 Å. From the analysis (table V) the ratios $RO:R_2O_3:SiO_2 = 2{\cdot}61:1:2{\cdot}49$. If all the iron is calculated as FeO,

however, the ratios become 2·94:1:2·97, and on this basis the constituent molecules of the garnet may be calculated as spessartine 54·5 %, almandine 41·2 %, pyrope 2·7 %, and grossular 1·6 %.

Allanite and zircon are present in the pegmatite in small amounts. The allanite is always metamict. Zircon is commonly associated with the radioactive mineral assemblages; it is brownish pink in colour and forms curved intergrown crystal aggregates, the type known as cyrtolite. The minor hafnium content of the zircon is notable. Rankama and Sahama (1950, p. 568) have indicated that 'the minerals with a high Hf:Zr ratio are more strongly radioactive than are the zircons and zirconium silicates with a lower content of hafnium'. This is consistent with the presence of thorium in the Chiapaval zircon (table II) and its association with uraninite and thorite.

Uraninite occurs in the pegmatite but is not common. Frequently it is closely associated with the columbite and often forms small inclusions within the latter. The specific gravity determined by Berman balance on one such inclusion was 10·28 and from the powder diffraction pattern of this individual the unit cell dimension has been calculated as 5·45 Å.

Kasolite, thorite, and monazite are sparingly distributed throughout the pegmatite, but two or more minerals may be in close association, often in small aggregates with spessartine, columbite, and zircon. Thorite and a pyrochlore mineral, probably betafite, are metamict and give X-ray powder patterns only after heating. A qualitative spectrographic analysis of the betafite is given in table II, and the X-ray powder data in table III, from which the unit cell dimension has been calculated as 10·30 Å. Kasolite, a hydrated uranium–lead silicate, is associated with uraninite and columbite, and a kasolite-like mineral, predominantly a thorium–lead silicate but with an X-ray diffraction pattern similar to kasolite, is seen surrounding uraninite as an olive-green rim.

Loch Vallarip pegmatite. Small pegmatitic veins composed essentially of a very distinctive pink feldspar are found just west of Loch Vallarip in the Rodilpark area of South Harris, cutting garnet-metagabbros of the igneous complex. In thin section the feldspar is seen to consist of large crystals of well-twinned oligoclase (An_{25}). A considerable amount of zoisite occurs in parallel arrangement with the feldspars or sometimes irregularly arranged and coalescing into larger aggregates. All the feldspar is crowded with minute flecks of sericite and scapolite, and locally slightly larger plates of scapolite, muscovite, and quartz occur. A few small allanite grains with epidote rims are present, but the total amount of these inclusions in the feldspar is small. An analysis of

the feldspar is given in table V from which the composition may be calculated in terms of a single feldspar phase of composition $Or_{4\cdot5}Ab_{67\cdot0}An_{28\cdot5}$, or approximately as oligoclase 82·0 % and zoisite 15·0 %. A modal analysis indicates the proportions oligoclase 80 %, zoisite 16 %, other minerals 4 %. Owing to the extreme difficulty of measuring such an intimate intergrowth these figures can only be an approximation, but they compare well with the recalculated analysis.

A qualitative spectrographic analysis of the intergrowth indicated the presence of the following elements in trace amounts: Rb, Sr, Ba, Be, Ga, Cu, Mg, Ti, Pb, V, Cr, Mn, and Fe.

The calculated composition of the original feldspar phase before replacement by the oligoclase–zoisite intergrowth is very close to the feldspar from an intermediate pegmatite from the Port Eisgein area (Dearnley, 1959, p. 227) which has a composition $Or_{5\cdot5}Ab_{61\cdot2}An_{33\cdot3}$. This pegmatite belongs to the late stage minor intrusives of the igneous complex and not to the subsequently intruded acid-pegmatites associated with the granitic injection complex. It is possible that exsolution in the Loch Vallarip feldspar was produced by retrograde metamorphism and access of water during the intrusion of the acid injection complex.

General observations.

Most of the pegmatites in South Harris are believed to be genetically connected with the granitic injection complex of the area. On the basis of their rare-element content they are closely related, although their bulk compositions may vary considerably. It is thought that the original pegmatitic material consisted of granitic solutions and that after emplacement only a limited exchange of material has taken place. Rearrangement of elements has occurred at various stages during metamorphism. At the south-eastern end of the Loch Langavat valley in particular, a number of pegmatites have been affected by retrograde metamorphism with the subsequent formation of epidote, possibly induced by the dynamic effects associated with the Outer Isles Thrust Plane. A significant feature from the mineralogical point of view is the striking development of magnetite in the biotite-bearing pegmatites, which appears to be connected with a partial disappearance of biotite. Another peculiarity of all the pegmatites in South Harris is the scarcity of tourmaline. Although a substantial number of rare-element minerals have been observed, they are of sporadic occurrence and their distribution is limited. Compared with other areas there is a close resemblance with numerous pegmatites from the Iveland and Evje districts in South

Norway (Barth, 1947) and with pegmatites from the Bancroft area of Ontario, Canada (Satterly, 1957).

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