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GENETICAL PROBLEMS OF BANDED AMPHIBOLITES IN THE FREDERIKSHÅB DISTRICT, SOUTH WEST GREENLAND

Abstract — Banded amphibolites are geochemically studied to determine the origin of their banding and of the amphibolites themselves. The more significant feature of the banding is given by an alternance of garnet-bearing layers and hornblende-plagioclase (-epidote-pyroxene)-bearing layers. Chemical trends of variation are investigated by means of statistical methods: a) by considering all the amphibolites together; b) by considering the normal amphibolites only; c) by considering the garnet-bearing amphibolites only. When all the samples are considered together, they generally show igneous-like variation trends and the garnet-bearing amphibolites behave as later differentiates in respect to the others. Neverthless, the chemical variations occurring between the two groups of amphibolite indicate that the garnet-bearing amphibolites were most probably not formed by an igneous fractionation process, but by a process of sedimentary alteration or possibly of metamorphic segregation. Therefore, the igneous-like trends of variation, at least in those cases when the correlation is largely dependent on the garnet-bearing group, cannot be considered as indicators of igneous origin for the amphibolites as a whole.

However, as also within the normal amphibolites there are many trends of igneous type, these are likely to be considered to be ortho-amphibolites. It is concluded that the actual amphibolites most probably derive from igneous rocks affected either by an alteration in a sedimentary environment (pre-metamorphic banding) or by segregation phenomena during the metamorphism (syn-metamorphic banding).

INTRODUCTION

The basement area between Qagssip kangerdluarssua and the inland ice, Frederikshåb district, South-West Greenland, is mainly formed by migmatitic gneisses, amphibolites and basic dykes. The description of the geology and petrology of this area can be found

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in RIVALENTI and ROSSI [1970]. The area has undergone a complicated metamorphic evolution characterized by an early increasing metamorphism in the amphibolite facies, extending to the lowest grade of the granulite facies (or upper almandine-amphibolite facies), followed by a decreasing metamorphism syncronous with migmatisation and extending to the low almandine-amphibolite facies. Two kinds of amphibolites are mainly present: discordant amphibolite dykes, clearly deriving from the metamorphism of basic igneous dykes, and concordant amphibolites. The concordant amphibolites are present either as continuous horizons or as small boundins embedded in the migmatites. In order to avoid as far as possible the effects of possible migmatitic contaminations, only samples collected from the continuous horizons and not macroscopically showing any sign of migmatisation are considered in this paper. The concordant amphibolites contain several lenses of ultramafic rocks and, in a few relictic occurrences, they have been found to be intercaled with meta-sedimentary rocks. The concordant amphibolites have a banded structure whose origin predates the period of migmatisation and decreasing metamorphism, as shown by field evidences. Three types of banding have been distinguished: i) alternating thin felsic layers having hornblendite rims with normal amphibolites; ii) alternating layers of similar mineralogy but different hornblende-feldspar ratios; iii) Alternating layers of different mineralogy but always of a mafic type. The iii) banding presents as the most significant feature an alternance of hornblende-feldspar (pyroxene-epidote)-bearing layers with garnet-horneblende-(pyroxene-quartz)-bearing layers. While the first two bandings are most likely the product of an early metamorphic differentiation (see for istance BOWES and PARK [1966]; GHALY [1969]), the origin of the third is not so easily understood. It could be, like the others, the product of a metamorphic segregation or be a pre-metamorphic either sedimentary or igneous feature. In this paper the origin of the iii) banding, and consequently of the concordant amphibolites themselves, will be studied.

GEOCHEMISTRY OF THE AMPHIBOLITES

The chemical analyses for major elements and the modal analyses for the amphibolites considerer in this work have been reported by RIVALENTI and ROSSI [1970]. In Table 1 are reported,

TABLE 1 - *Minor and trace elements and Niggli numbe*

	Horneblende - plagioclase (-pyroxe				
Sample	57731	57849	58821	73518	7382
MnO	0.226	0.180	0.205	0.196	0.20
Ti	5990	2220	5815	5390	6230
V	300	258	250	265	235
Co	42	40	39	39	33
Ni	145	72	40	85	96
Cr	312	322	135	750	205
si	102.79	105.14	116.39	101.14	101.22
ti	1.61	0.60	1.69	1.46	1.69
al	19.28	19.46	20.38	20.20	18.97
fm	44.74	49.89	49.03	47.40	47.92
c	31.43	24.51	24.46	27.83	27.25
alk	4.54	6.14	6.13	4.57	5.86
k	0.17	0.04	0.07	0.08	0.13
mg	0.57	0.61	0.57	0.61	0.54
f **)	23.68	25.16	27.61	23.30	27.49

				Garnet-bea	
Sample	75910 *)	57748 *)	57794	73517	7351
MnO	0.213	0.215	0.228	0.278	0.28
Ti	3000	8090	21580	14390	15530
V	265	300	375	160	640
Co	43	48	53	33	51
Ni	124	127	18	14	17
Cr	410	297	74	61	83
si	105.00	94.14	121.35	131.36	109.48
ti	0.82	2.07	6.79	4.61	4.49
al	17.19	17.86	18.62	18.50	17.03
fm	48.08	52.37	54.92	51.66	54.48
c	30.12	27.20	23.86	25.90	24.50
alk	4.61	2.57	2.59	3.94	3.99
k	0.06	0.10	0.04	0.08	0.13
mg	0.54	0.61	0.20	0.29	0.34
f **)	25.66	23.57	52.07	45.16	42.38

$$**)\ f = 100 \frac{FeO + Fe_2O_3 + MnO}{MgO + CaO + FeO + Fe_2O_3 + MnO}$$

*) Samples 75910 and 57748 will be considered together with the horneblende - pla clase amphibolites in diagrams and statistical calculations (see text for explanati

the amphibolites (MnO = percent; other elements = ppm)

epidote) - bearing amphibolites						
73841	57821	57872	73858	75839	75895	75904
0.173	0.185	0.203	0.194	0.175	0.180	0.219
6230	4017	4196	1680	4196	3957	3600
299	210	275	280	320	293	165
38	53	45	55	59	38	25
104	235	131	86	87	90	162
180	740	275	320	210	230	297
110.28	97.88	106.61	114.14	108.24	115.98	164.91
1.78	1.03	1.16	0.48	1.18	1.15	1.31
20.00	15.73	19.31	20.06	21.00	19.59	26.73
44.90	52.82	46.70	45.48	47.40	46.16	39.05
28.15	27.74	30.03	31.30	25.39	29.11	25.86
6.95	3.72	3.97	3.15	6.21	5.14	8.36
0.11	0.20	0.05	0.10	0.05	0.08	0.30
0.51	0.64	0.51	0.59	0.53	0.49	0.47
28.39	22.07	26.64	23.06	28.92	29.48	30.12

amphibolites						
73520	73846	73863	75815	75833	75838	
0.235	0.243	0.310	0.178	0.232	0.157	
5995	5515	11150	2700	4860	5156	
430	280	25	215	290	255	
36	32	27	40	32	32	
52	37	5	82	56	36	
140	58	63	165	110	128	
112.25	142.39	147.53	126.56	136.85	192.63	
1.75	1.82	3.84	0.83	1.57	2.08	
19.63	22.06	19.96	23.98	23.86	28.55	
51.77	49.87	58.61	44.12	48.11	40.09	
23.39	21.47	20.01	27.29	22.50	22.52	
5.21	6.60	1.42	4.61	5.54	8.84	
0.07	0.08	0.23	0.18	0.10	0.07	
0.37	0.41	0.25	0.52	0.44	0.43	
40.24	38.52	54.39	28.39	37.17	33.78	

therefore, only some minor and trace elements determinations and Niggli numbers. The samples have been devided into two categories: a) those belonging to the hornblende-plagioclase(-pyroxene-epidote) bands; b) those belonging to the garnet-bearing bands and having garnet as a main constituent. Nevertheless, as garnet was also formed during the last period of metamorphism, the samples have been plotted on a ACF diagram (Fig. 1) for the almandine-amphibolites facies (TURNER and VERHOOGEN [1960], p. 549) to test if garnet is bonded to a pre-existing composition of whatever origin it might be. It can be seen that all but two (75910 and 57748) the garnet-bearing samples plot in the field in which

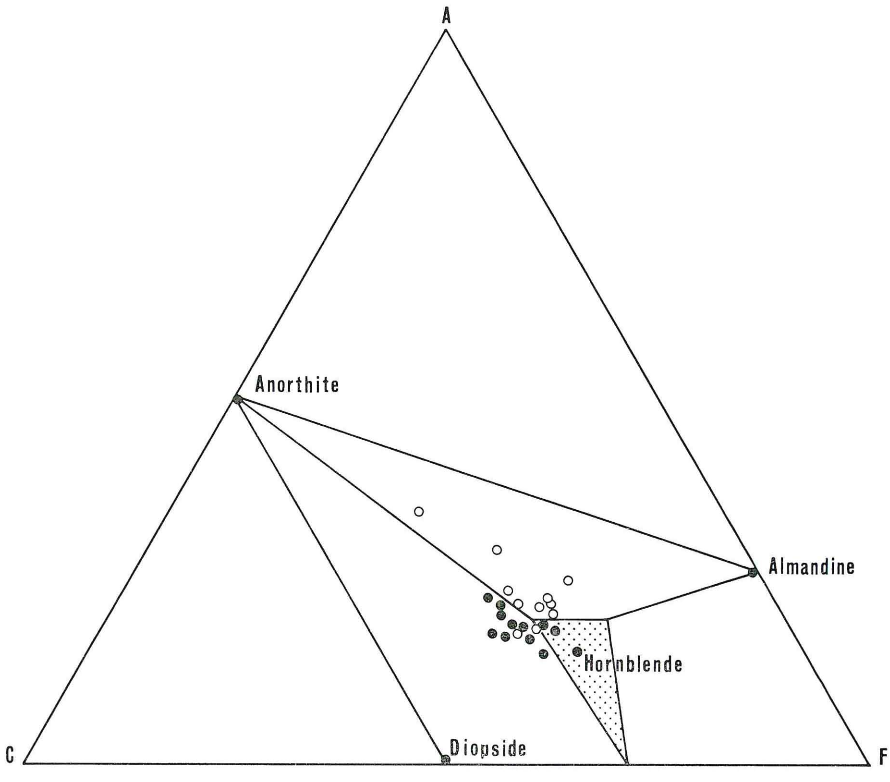

Fig. 1 - ACF diagram for the almandine-amphibolite facies. Circles = garnet-bearing amphibolites; dots = horneblende-plagioclase(-pyroxene-epidote)-bearing amphibolites. It can be seen how all the garnet-bearing samples, except two (75910 and 57748), plot in the ga-ho-an field. In the following diagrams the two samples of garnet-bearing amphibolite plotting in the an-cp-ho field will be considered together with the non-garnetiferous samples (see text for explanation).

the presence of this mineral is expected and garnet is therefore related only to the bulk composition of the rock (De Waard [1965, 1967]). The other two samples plot in the an-cp-ho field; therefore, their garnet can be assumed to derive from mineralogical transformations during the metamorphism and for this reason they will be considered together with the nongarnetiferous samples.

A simple glance at the chemical analyses reveals that the garnet-bearing amphibolites are richer in Si, iron, Ti and Mn and lower in Ca and Mg than others. As generally the element contents spread much within the two groups, a comparison of the geochemical trends is of much more interest than a simple comparison of the averages in investigating eventual systematic differences. The geochemical trends have been statistically tested for correlation coefficient r and significance t_r test. Moreover, tests have been made to discover if the trends between the garnet-bearing group and the normal amphibolite group are significantly different, Student's t test (t_c) being used. The results of the statistical analyses for the correlation between all the samples together, for the garnet-bearing group, for the normal amphibolite group and the comparison between the two groups are reported in Table 2. In the same Table the average values for the considered variables are also reported. The following points can be made:

i) when all the samples are considered together, many variation trends which are normally assumed ad indicators of igneous origin are present: for example the positive correlations *si-al, si-alk, mg*-Ni, *mg*-Cr, MnO-Ti, MnO-*total* Fe etc. and the negative correlations *si-c, si-mg, mg-ti, mg-f, mg*-Ti etc. (see for istance Evans and Leake [1960]; Leake [1964]; Rivalenti [1966]; Van De Kamp [1968]).

ii) If a graphic plot is made for the considered variables, from an igneous point of wiew it can be seen how generally the garnet-bearing amphibolites behave as a later differentiate in respect to the normal amphibolites. As an example there has been reported (Fig. 2) the *mg-c* diagram.

iii) When the behaviour of the two groups is considered separately, the following cases can occur: a) the two groups have a similar behaviour (correlation coefficient r significant or not significant for both; $t_c < 1.96$; for istance *si-al*); b) one group has a significant correlation and the other has not, but t_c is lower than 1.96, which should indicate that the different behaviour is only apparent, e.g.

TABLE 2 - *Statistical calculations* (a group = *horneblende - plagioclase amphibolites;* b group = *garnet-bearing amphibolites*).

x	y	*samples*	n	$\overline{x}$	$\overline{y}$	r_{xy}	t_r	t'_r	t_c	t'_c
si	*al*	all samples	23	120.19	20.35	0.83	6.90	2.08		
si	*al*	a group	14	110.27	19.70	0.89	6.90	2.18	0.63	1.96
si	*al*	b group	9	135.60	21.35	0.81	3.61	2.36		
si	*fm*	all samples	23	120.19	48.50	−0.34	1.68	2.08		
si	*fm*	a group	14	110.28	47.28	−0.80	4.62	2.18	0.89	1.96
si	*fm*	b group	9	135.60	50.40	−0.57	1.84	2.36		
si	*c*	all samples	23	120.19	26.17	−0.56	3.11	2.08		
si	*c*	a group	14	110.28	27.88	−0.23	0.80	2.18	0.43	1.96
si	*c*	b group	9	135.60	23.49	−0.42	1.22	2.36		
si	*alk*	all samples	23	120.19	4.99	0.47	2.41	2.08		
si	*alk*	a group	14	110.28	5.14	0.68	3.19	2.18	0.32	1.96
si	*alk*	b group	9	135.60	4.75	0.58	1.88	2.36		
si	*mg*	all samples	23	120.19	0.48	−0.47	2.44	2.08		
si	*mg*	a group	14	110.28	0.56	−0.63	2.81	2.18	1.91	1.96
si	*mg*	b group	9	135.60	0.36	0.22	0.61	2.36		
mg	*c*	all samples	23	0.48	26.17	0.61	3.52	2.08		
mg	*c*	a group	14	0.56	27.88	−0.06	0.21	2.18	0.67	1.96
mg	*c*	b group	9	0.36	23.49	0.27	0.75	2.36		
mg	*alk*	all samples	23	0.48	4.99	0.21	0.96	2.08		
mg	*alk*	a group	14	0.56	5.14	−0.60	2.61	2.18	3.01	1.96
mg	*alk*	b group	9	0.36	4.75	0.68	2.47	2.36		
mg	*ti*	all samples	23	0.48	1.99	−0.83	6.92	2.08		
mg	*ti*	a group	14	0.56	1.29	−0.10	0.34	2.18	2.81	1.96
mg	*ti*	b group	9	0.36	3.09	−0.91	5.79	2.36		
mg	*f*	all samples	23	0.48	32.05	−0.98	20.85	2.08		
mg	*f*	a group	14	0.56	26.08	−0.89	6.66	2.18	1.25	1.96
mg	*f*	b group	9	0.36	41.34	−0.97	10.02	2.36		
f	*alk*	all samples	23	32.05	4.99	−0.27	1.27	2.08		
f	*alk*	a group	14	26.08	5.14	0.78	4.36	2.18	3.99	1.96
f	*alk*	b group	9	41.34	4.75	−0.75	3.00	2.36		

mg	Ni	all samples	23	0.48	61	0.46	2.36	2.08		
mg	Ni	a group	14	0.56	104	—0.08	0.28	2.18	2.49	1.96
mg	Ni	b group	9	0.36	27	0.83	3.91	2.36		
mg	Cr	all samples	23	0.48	242	0.49	2.57	2.08		
mg	Cr	a group	14	0.56	335	—0.03	0.10	2.18	1.71	1.96
mg	Cr	b group	9	0.36	98	0.69	2.49	2.36		
mg	Ti	all samples	23	0.48	6586	—0.18	0.81	2.08		
mg	Ti	a group	14	0.56	4615	0.22	0.80	2.18	3.73	1.96
mg	Ti	b group	9	0.36	9653	—0.93	6.75	2.36		
MnO	Ti	all samples	23	0.213	6586	0.63	3.67	2.08		
MnO	Ti	a group	14	0.198	4615	0.23	0.81	2.18	1.00	1.96
MnO	Ti	b group	9	0.238	9653	0.63	2.14	2.36		
MnO	Total Fe	all samples	23	0.213	13.95	0.73	4.92	2.08		
MnO	Total Fe	a group	14	0.198	12.20	—0.29	1.04	2.18	2.95	1.96
MnO	Total Fe	b group	9	0.238	17.77	0.83	4.00	2.36		
V	Total Fe	all samples	23	278	13.95	—0.09	0.43	2.08		
V	Total Fe	a group	14	265	12.20	0.62	2.77	2.18	1.66	1.96
V	Total Fe	b group	9	297	17.77	—0.11	0.29	2.36		
Total Fe	Ti	all samples	23	13.95	6586	0.77	5.46	2.08		
Total Fe	Ti	a group	14	12.20	4615	0.33	1.22	2.18	1.67	1.96
Total Fe	Ti	b group	9	17.77	9653	0.83	3.96	2.36		
Ti	Ni	all samples	23	6586	83	—0.66	4.02	2.08		
Ti	Ni	a group	14	4615	113	0.05	0.16	2.18	2.13	1.96
Ti	Ni	b group	9	9653	35	—0.78	3.25	2.36		
Ti	Cr	all samples	23	6586	242	—0.61	3.52	2.08		
Ti	Cr	a group	14	4615	335	—0.22	0.80	2.18	1.20	1.96
Ti	Cr	b group	9	9653	98	—0.68	2.48	2.36		
Ni	Cr	all samples	23	83	242	0.83	6.84	2.08		
Ni	Cr	a group	14	113	335	0.55	2.30	2.18	0.68	1.96
Ni	Cr	b group	9	35	98	0.75	2.99	2.36		

$\overline{x}, \overline{y}$ = mean values of the variables. n = number of samples. r_{xy} = correlation coefficient.
t_r = Student's test for r_{xy}. t'_r = tabular (5% probability of error). t_c = test of comparison.
a group - b group. t'_r = tabular (5% probability of error).

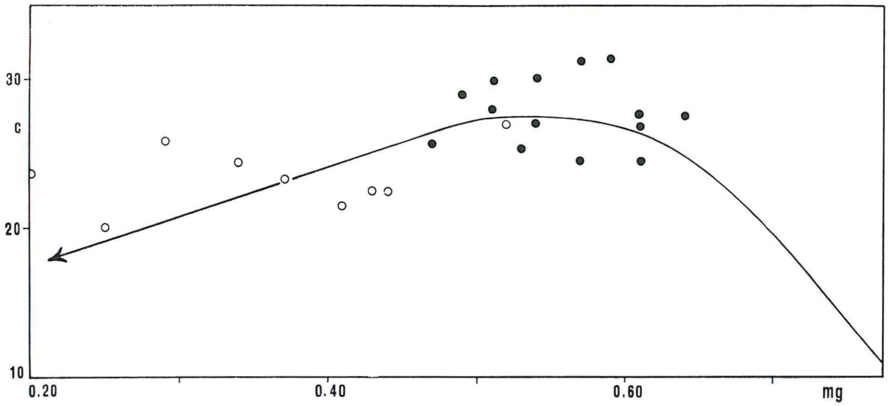

Fig. 2 - *mg-c* plot. The line with an arrow indicates the igneous trend of variation (LEAKE, 1964). The garnet-bearing samples behave as later differentiates. Symbols as in Fig. 1.

due to the low number of samples (for instance *si-alk*); c) the two groups have an opposite behaviour but significant in both ($t_c > 1.96$); this is the case of *mg-alk* and *f-alk* (Figs. 3 and 4); d) the groups have a significantly different behaviour ($t_c > 1.96$) but only one has a significant correlation (for istance *mg-ti*).

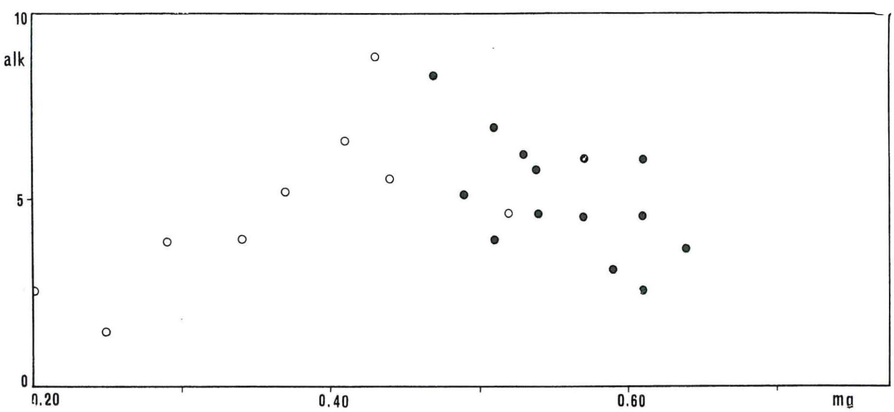

Fig. 3 - *mg-alk* plot. The two groups of amphibolites have an opposite trend. Symbols as in Fig. 1.

iv) The correlation among all the samples depends on the following cases: a) both groups have a significant and similar trend of variation and thus the total correlation is significant; b) only one

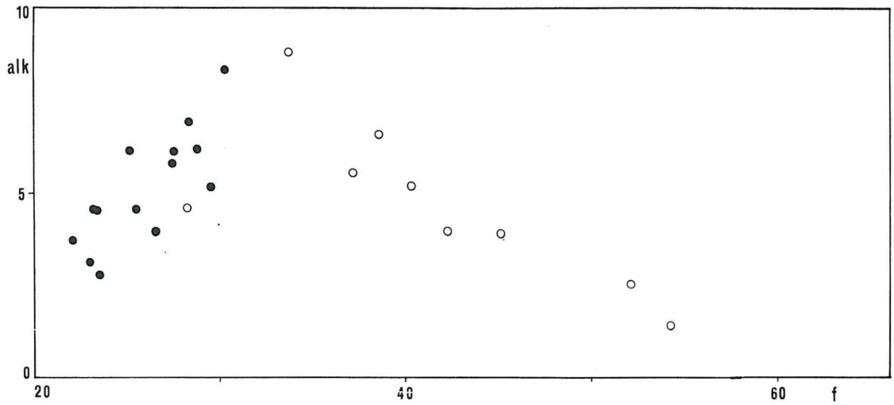

Fig. 4 - *f-alk* plot. The two groups of amphibolites have an opposite trend. Symbols as in Fig. 1.

group has a significant correlation while the other does not, but the total correlation is significant; c) both groups have a non-significant correlation but the total correlation is significant and therefore essentially due to a correlation between the two groups.

v) The garnet-bearing samples, when plotted in a AFM diagram are strongly shifted taward the F corner, showing a high iron-enrichment in respect to the others (Fig. 5).

Discussion

In the preceding paragraph it has been shown that many trends are of an igneous-like type. To investigate if this represents the real origin of the amphibolites (and of their banding) or if it is only apparent, it is worth considering those plots where the garnet-bearing group and the normal amphibolite group have an opposite behaviour, i.e. those cases in which the two groups have significant r but of opposite sign and $t_c > 1.96$: they are the *mg-alk* and *f-alk* plots. The garnet-bearing group has a trend of variation contrary to the expected in a normal differentiation. The elements involved are the following. A decreasing *alk* at decreasing *mg* is necessarily due to a decrease in Na + K or an increase of one or all of the elements which are at the denominator (Al, iron, Mg, Ca, Na, K). It can easily be seen how the element which influences the parameters more is iron (very high in the garnet-bearing group), which appears at the denominator in both. A strong Fe enrichment in respect to Mg can cause from one hand a diminution of *mg* and from the other hand a diminution of *alk*, accounting for the positive correlation. Moreover the garnet-bearing amphibolites have an higher *si* (and SiO_2) content in respect to the normal amphibolites. Thus, being *al* strictly correlated to *si*, a relative enrichment in Al in respect to the

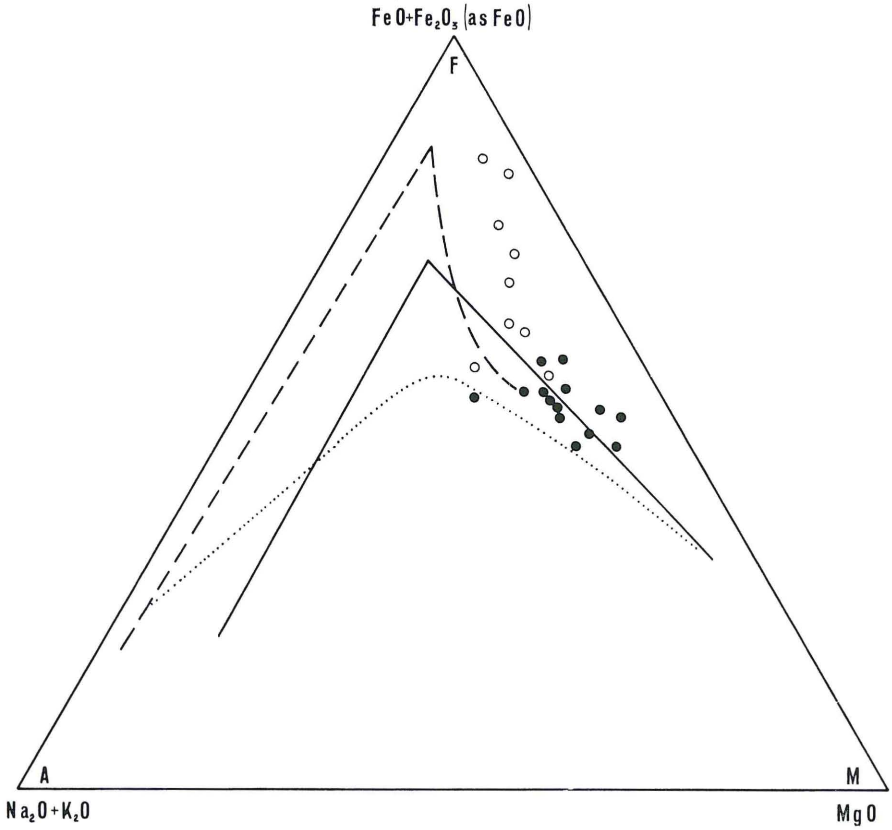

Fig. 5 - AFM diagram. The garnet-bearing amphibolites (circles) are shifted towards the F corner, showing a marked iron enrichment in respect to the normal amphibolites (dots). The differentiation lines for Skaergaard (dashes) and for tholeiitic (solid line) and alkalic (dotted line) suites of Hawaii (MacDonald and Katsura, 1964) are reported.

other oxides has to be admitted. Ca on the contrary is depleted, as it can be inferred from the relations *si-c*. Owing to the lack of correlation between *alk* and *si*, most probably Na and K do not follow a definite trend of variation. The strong iron enrichment of the garnet-bearing amphibolites is confirmed by the negative variation between f and *alk*. Summarizing, this group in respect to the normal amphibolites is characterized by an enrichment in Fe and Si (Ti, Mn), while also Al is enriched in respect to the other elements, which was not easily visible from the simple chemical analyses. In the light of the variations stated above, the following possibilities for the origin of the banding can be considered.

Igneous origin. - As the normal amphibolite bands often follow trends typical for an igneous differentiation, an igneous origin can be assumed for them and the garnet-bearing layers should be logically considered as differentiates of the same magma. The actual banded structure of the amphibolites leads to search for their premetamorphic correspondent among the layered igneous complexes. The one which is most similar is the Skaergaard complex, where the rocks show a marked iron-enrichment fractionation trend (WAGER and DEER [1939]; WAGER [1960]). As it is well known a basaltic magma can fractionate with SiO_2 enrichment and constancy or slight decrease in iron under high oxygen pressure, while a lower oxygen pressure causes an iron enrichment without increase in silica (KUNO [1965]; OSBORN [1969]) as it happens at Skaergaard. In the present case the garnet-bearing amphibolites, besides iron, are also enriched in silica and Al, not fitting therefore with the differentiation schemes above reported and suggesting that an igneous origin is not very likely for them, in spite of the several igneous trends they present.

Sedimentary origin. - The chemistry of the garnet-bearing amphibolites is only consistent with an alteration process giving an enrichment in Fe, Si and Al and a depletion of the other major elements. These elements, as is well known, can concentrate in hydrolyzates under the action of various factors, such as ionic potential, PH, redox potential etc. together with other elements such as Ti, Mn. The alteration can have occurred on pre-existing rocks either igneous (basalt flows or mafic tuffs) or sedimentary (the possibility that sedimentary rocks have igneous-like trends has been discussed by RIVALENTI and SIGHINOLFI [1969]) now representing the normal amphibolite bands. It is worth noting that garnetiferous amphibolites have also been related to a process of weathering by KANISAWA [1969] to account for their chemistry.

Metamorphic origin. - As far as I know a metamorphic segregation process normally leads from one side to the formation of felsic bands and from the other side to the formation of restites, more or less depleted in salic elements and enriched in mafics, as for instance in the cases described by BOWES and PARK [1966], GHALY [1969]. The present case clearly does not fit with such a mechanism, as, to account for the composition of the garnet-bearing bands, is should be required that either iron and silica concentrate together or Mg and Ca migrate. Nevertheless, though at the moment no satisfactory metamorphic explanation can be given, the intervention of a peculiar segregation process, occurring under particular oxygen and water pressure, cannot yet be excluded. On the other hand segregation phenomena certainly occurred, such as the formation of felsic bands contoured by hornblendite rims (RIVALENTI and ROSSI, 1970).

CONCLUSIONS

The many igneous-like trends present when all the samples are considered together might lead to the conclusion that the amphibolites are meta-igneous rocks. In this respect the garnet-bearing bands behave as later differentiates in respect to the normal amphibolite bands. Nevertheless in the preceding pages it has been shown that the garnet-bearing bands are not likely to be considered as igneous differentiates from the same magma giving the normal amphibolites, but that most likely they have been formed either by an alteration process occurring in a sedimentary environment or by a metamorphic segregation whose mechanism, however, remains unknown. If therefore an igneous process can be excluded as responsible for the banding, the meaning of the igneous-like variation trends has still to be discussed. Holding a sedimentary (or metamorphic) hypothesis good for the formation of the garnetiferous amphibolites, their trends are also considered consequent of the same process and all those plots where the total correlation is due to a correlation between the two amphibolite groups or at least to the high correlation of the garnet-bearing samples (as *mg*-Ni, *mg*-Ti, MnO-total Fe etc.) can no longer be considered as indicators of an ignous origin, but only as simulating such a parentage. Not many indications can therefore be achieved on the first origin of the amphibolites.

Nevertheless, as igneous trends are also present within the normal amphibolite group, possibly the pre-metamorphic formation was constituted by igneous rocks (basalt flows or igneous tuffs) which were partially transformed either in a pre-metamorphic period (sedimentary alteration) or during the metamorphism (metamorphic segregation).

APPENDIX

Chemical analytical methods. - Major elements determination methods have been reported by RIVALENTI and ROSSI [1970].

V, Co, Ni and Cr have been determined by emission optical spectroscopy by a Hilger & Watts E. 742 spectrograph. The methods have been published by SIGHINOLFI [1966, 1968].

Statistical analysis. - The correlation coefficient has been determined by the formula:

$$r_{xy} = \frac{Sxy}{\sqrt{Sx^2 \; Sy^2}}$$

(MILLER and KAHN [1962]; SCOSSIROLI [1962])
x and y = the variables; $Sxy = \Sigma\,(\bar{x}\bar{y} - xy)$; $Sx^2 = \Sigma\,(\bar{x} - x)^2$; $Sy^2 = \Sigma\,(\bar{y} - y)^2$.

Student's t test has been calculated to test if r is significantly different from zero by the following formula:

$$t_r = n \sqrt{\frac{n - 2}{1 - \mathrm{r}^2}}$$

To test whether the correlation coefficient for the two groups of amphibolite is significantly different, the following t test has been used:

$$t_c = \frac{z_A - z_B}{\sqrt{\dfrac{1}{n_A - 3} + \dfrac{1}{n_B - 3}}}$$

(SCOSSIROLI [1962])
A and B = the two series; n = number of samples in each series, and

$$z = \frac{1}{2}\,[\log_e (1 + r) - \log_e (1 - r)]$$

A 5% level of probability of error has been chosen in both t tests.

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Note - The present work had already been sent to the Editor when the author was informed that a study on similar amphibolites, but cropping out in an area 50 Km SSE of Frederishåb, had been carried out by KALBEEK and LEAKE [1970]. These Authors consider as possible that the garnet-bearing amphibolites are later differentiates of the basaltic magma giving the amphibolite complex; nevertheless they do not exclude that a metamorphic segregation or a sedimentary process, though different from the one proposed in this work, has lead to the actual banded structure and compositional differences.

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