

ESTIMATIONS ON THE CONDITIONS OF FORMING THE ENRICHED PRIMARY MELTS IN RIFT ZONE NEAR HOT SPOT BOUVET

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The west end of the South – West Indian Ridge consists of the two segments of rift interrupted by the fracture zone Bouvet. The north segment is called the Spiess Ridge and is 2 million years old. The south segment is the ancient one. The hot spot Bouvet have formed about 2 million years ago [1]. And the influence of the hot spot significantly changed the character of magmatism in this region. The melts in these regions are geochemical analogous and are determined as enriched tholeiites. But besides the enriched types there are also typically depleted tholeiites in this region. The question concerning the influence of the hot spot Bouvet on the conditions of melting of the primary melts is one of the supreme by this day.

We have received the parameters for anhydrous phase equilibriums under the pressure conditions of 1 kbar and volatility of O₂ appropriate for buffers QFM and Ni – NiO (method of Khvorov et al., 2004) [2]. For these purposes we have used 6 glasses from the basalts of Spiess Ridge (table 1). The less precise results were found for systems with greater pressures and for systems saturated with water.

To verify our model for basaltic systems we have used the glass 61-002-110 (table1), synthesized by Yang [3] under the conditions of temperature being 1160°C in equilibrium with olivine (Fo₇₉), plagioclase (An₆₄) and calcic clinopyroxene (Mg# = 82). In our model the equilibrium for this glass and these phases (olivine (Fo₇₇), plagioclase (An₆₇₋₆₅) and clinopyroxene (mg#=81)) we have obtained under the temperature 1155 ± 2 °C.

Table 1.

The composition of glasses from the basalts of Spiess Ridge

Sample	Baker, Eggler, 1987	12/12	15/27k	13/11	15/19	T4	10/19	Yang et al, 1996
SiO ₂	59.20	56.35	51.93	51.56	50.51	52.02	50.85	50.40
TiO ₂	1.23	2.59	2.86	2.80	2.63	2.29	1.87	1.84
Al ₂ O ₃	14.60	13.52	14.46	14.29	14.53	14.51	14.47	14.70
FeO	8.61	12.41	12.19	12.36	11.88	10.62	10.94	10.30
MnO	0.22	0.25	0.01	0.27	0.19	0.17	0.16	nd
MgO	2.74	2.58	4.55	4.88	5.78	5.67	6.90	6.96
CaO	5.82	6.10	9.09	9.01	9.95	10.20	11.25	11.70
Na ₂ O	3.70	3.81	3.46	3.67	3.43	3.60	3.06	2.90
K ₂ O	2.75	1.72	0.95	0.77	0.73	0.59	0.33	0.17
P ₂ O ₅	0.32	0.67	0.50	0.39	0.37	0.33	0.17	0.18
Mg#	0.36	0.27	0.40	0.42	0.47	0.49	0.53	0.55

To verify our model for andesitic systems we have used the glass 1086 (table 1), synthesized by Baker and Eggler [4] under the temperature 1106 °C in equilibrium with olivine (Fo₆₄), plagioclase (An₅₃) and calcic clinopyroxene (Mg# = 69). In our model the under the temperature 1120 ± 2 °C this glass was in equilibrium only with plagioclase. When the temperature decreased to 1100 °C we had obtained the equilibrium for following phases: glass 1086, plagioclase (An₅₂₋₅₀), olivine (Fo₆₇), clinopyroxene (Mg# = 71), pigeonite (Mg# = 75) and Ti-magnetite. So our model could not restore the experimental results.

The sample 10/19 was picked from the magma flow. It is vesicular aphyric basalt with few grains of plagioclase. The glass 10/19 (table 1) is one of the less primitive (Mg# = 0.53) glasses found in this region. Near the liquidus under the temperature of 1185 °C this glass is in equilibrium simultaneously

with olivine (Fo₈₂₋₈₀) and plagioclase (An₆₉₋₆₇). The first liquid phase in this system is olivine. The crystallization of calcic clinopyroxene begins about 1170°C.

Table 2.

Phase equilibrium for glasses from the basalts of Spiess Ridge under the pressure of 1 kbar

Sample	T, °C	phases
10/19	1185	lq,pl(82),ol(81)
	1170	lq,pl,ol,aug
T4	1165	lq,pl(81),ol(78)
	1155	lq,pl,ol,aug
15/19	1155	lq,pl(81),ol(78)
	1145	lq,pl,ol,aug
13/11	1150	lq,pl(80),ol(74)
	1130	lq,pl,ol,aug
15/27k	1145	lq,pl(80),ol(76)
	1130	lq,pl,ol,aug
12/12	1100	lq,pl(79),ol(58),aug(65)
	1095	lq,pl,ol,aug,pig
	1080	lq,pl,aug

The melt 10/19 is saturated with water under the temperature 1080°C and pressure about 1 kbar. Olivine and probably magnetite are stable as liquid phases under the pressures up to 4-5 kbar. Then under the greater the liquid phase is calcic clinopyroxene.

The samples T4, 15/19, 13/11 and 15/27k were get from aphiric basalts with few grains of plagioclase. The chemical compositions of their glasses (Mg# = 0.4-0.5) are the most abundant for all magmas dragged in the region of Spiess Ridge. Under the temperatures 1145 – 1165 °C these glasses are in equilibrium simultaneously with olivine (Fo₇₉₋₇₃), plagioclase (An₆₄₋₆₀) and probably Ti-magnetite. The calcic clinopyroxene becomes the liquid phase 10-20 °C later. Plagioclase is a stable liquid phase under the pressures 7-9 kbar. Then calcic clinopyroxene takes its place. For example, the glass T4 is in equilibrium simultaneously with plagioclase and calcic clinopyroxene under the conditions of 8.5 kbar and 1230 °C. The glasses 13/11 and 15/27k are in equilibrium simultaneously with calcic clinopyroxene and garnet under the conditions 27-32 kbar and 1380-1420 °C.

These melts are saturated with water under the temperature about 1050 °C and pressure 1 kbar. Olivine and Ti-magnetite are the stable liquid phases up to 2-3 kbar, and then on their place we obtain calcic clinopyroxene.

The sample 12/12 is from the flow of basalts from the caldera of Spiess Ridge. It is a vesicular aphiric andesite. The glass 12/12 has low contents of MgO (Mg# = 0.27) and high contents of P₂O₅ and Na₂O. It is in equilibrium with olivine (Fo₅₉₋₅₇), plagioclase (An₅₃₋₅₁), clinopyroxene (Mg# = 0.65) and probably Ti-magnetite under the temperature about 1100 °C.

Conclusions

1. The glasses of the Spiess Ridge form an uninterrupted significantly differentiated set varying in composition from basalts to andesites. The temperatures of the anhydrous liquidus (1 kbar) for this set subsequently decrease from 1200 to 1100 °C.

2. The composition of the most glasses is suitable for the equilibrium liquid – olivine – plagioclase (1 kbar). Plagioclase is stable as liquid phase from 7 to 9 kbar. As the pressure increases the only one liquid phase is clinopyroxene and from 27-32 kbar the liquid phase is garnet. In anhydrous conditions we have not received equilibrium with olivine and clinopyroxene as stable phases. When the system is saturated with water there is equilibrium for these two phases. In this case olivine is stable only from

4-5 to 2 kbar. Thus, we conclude that magmas of the Spiess Ridge have been formed by the processes of crystal differentiation of water saturated melt.

3. Natural phenocrysts of plagioclase are An_{60-91} . We have obtained the most calcic plagioclase (An_{69-67}) in the equilibrium with one of the basaltic melts. Natural plagioclases with the greater values of CaO were formed in conditions of greater pressures. The most evolved plagioclase (An_{53-51}) is in equilibrium with andesitic melts. The more evolved phenocrysts are not suitable for the equilibrium.

4. The forming of the set of basaltic melts has taken its place in the pressure conditions from 1 to 5 kbar during the crystal differentiation of anhydrous melt.

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