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MIGRATION MECHANISM TO FORM HIGH_PRESSURE POLYMORPHOUS MODIFIKATIONS OF MINERALS UNDER THE ACTION OF SHOCK WAVES

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Abstract

Shock loading of the rock in laboratory-scale experiments by spherical converging shock waves [1, 2] allowed us to observe formation of ringwoodite, i.e. polymorphous form of the olivine composition having the structure of spinel, as well as of the high-density modification of the pyroxene composition ("pyroxene"). These minerals occur at the solid-phase stage of rock alteration (prior to melting initiation) under shock-thermal decomposition of ferromagnesian alumosilicates, i.e. garnet, biotite, and amphibole. In addition to these high-density minerals, the structurelessed residue of the initial mineral is also observed to present in shock-thermal aggregation. The feature of composition of newly formed phases is the admixture chemical components, which is non characteristic for these high-density phases, as well as for the structurelessed residue of the initial mineral. These are aluminium, titanium, sometimes potassium, calcium, and manganese in ringwoodite and "pyroxene", as well as potassium, sodium, and calcium – in the structurelessed residue.

1. Introduction

High-density phases appear within 25 – 40 GPa and the beginning of neocrystallization depends on the type of the crystal lattice in the initial mineral. If the rock simultaneously has two of above initial minerals, then the shock-thermal aggregation is formed only on one them being dominant in the rock [2].

Retained shape of grains in the initial mineral, when the shock-thermal aggregation is formed, confirms the formation of high-density phases at the solid-phase stage of the substance transformation.

1.1 Chemical composition of newly formed phases

Elements being admixtures in the newly formed phases have the two-way origin (Table. 1 – 3). First, these are remains of initial minerals substance, i.e. aluminium and titanium in ringwoodite after biotite; aluminium, titanium, sodium, potassium, and calcium in ringwoodite after amphibole; aluminium, titanium, sodium, and calcium in ringwoodite after garnet. Second, these are components that migrated due to shock-wave loading from minerals of enclosing rocks – i.e. sodium and potassium in the apobiotite residue, which came from plagioclase present in the rock and sodium and potassium in apogarnet residue, which came from biotite and plagioclase of the rock matrix, etc. Widely developed migration of chemical components under shock-wave loading of growing intensity and their redistribution into surrounding minerals was stated in our previous publications [3].

1.2 Conclusions

The newly formed high-pressure phases are distinguished from similar minerals occurring in the course of martensite phase transitions (e.g. when ringwoodite occurs after olivine) or due to crystallization from melt. This allows us to suggest the crucially new mechanism of mineral phase's formation in the high-intensity shock waves.

Table 1 Formation of ringwoodite after biotite (experiment)

Compo-nents,%	Initial biotite	Ringwoodite			Spinel	Apobiotite residue
SiO_2	36.99	32.84	30.54	29.13	0.41	52.17
TiO_2	2.01	0.43	0.27	0.50	0.48	1.07
Al_2O_3	21.12	8.53	8.92	14.17	60.01	20.98
FeO	22.04	28.78	35.54	34.49	20.82	12.45
MgO	8.46	28.97	24.29	21.12	14.54	3.86
CaO	–	–	–	0.12	–	1.76
Na_2O	–	–	–	–	–	1.80
K_2O	9.06	0.12	0.09	0.31	–	5.59

Table 2 Formation of ringwoodite after garnet (experiment)

Compo-nents,%	Initial garnet	Ringwoodite			Apog arnet resi due
SiO_2	37.89	34.23	29.86	28.36	61.40
TiO_2	–	–	–	–	–
Al_2O_3	21.26	1.77	13.20	13.43	15.80
FeO	29.28	48.97	39.86	37.19	16.20
MnO	1.57	1.66	1.31	0.34	–
MgO	5.32	12.55	15.22	20.19	1.49
CaO	4.68	0.71	0.55	–	2.82
Na_2O	–	–	–	–	0.40
K_2O	–	0.10	–	–	1.00

Table 3 Formation of ringwoodite after amphibole (experiment)

Compo-nents,%	Initial amphibo le	Ringwoodite		Apoamp hibol residue
SiO_2	41.61	33.26	26.67	50.74
TiO_2	0.29	–	–	–
Al_2O_3	16.37	2.81	17.17	15.05
FeO	20.72	41.74	33.18	15.39
MnO	0.39	0.50	0.34	0.31
MgO	5.93	20.52	20.83	4.41
CaO	11.47	0.56	0.68	7.44
Na_2O	0.91	–	–	0.37
K_2O	0.42	–	–	0.28

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