PECULIARITIES OF TRANSFORMATIONS OF PLAGIOCLASE AND AMFIBOLE OF DIFFERENT COMPOSITIONS IN SHOCK WAVES (by results of experiments)

Sazonova L.V.(Petrol. Dep. MSU), **Miljavskiy V.V., Borodina T.I., Sokolov S.N.** (IHED AIHT RAS)
saz@geol.msu.ru;

Key words: shock waves, amphibole, plagioclase, isotropization, maskelynite

The impact transformations in Pl–Amf schist with Grt (35% Pl, 60% Amf, and 5% Grt) from the Southern Urals (sample 1) and Cpx–Amf–Pl schist (20% clinopyroxene, 30% Amf, and 50% Pl) from the Anabar Shield (sample 2) has been studied using of recovery assemblies of planar geometry. The assemblies were loaded by impact of Al plates up to pressures 26, 36 and 52 GPa. In the sample, the peak pressure was achieved after several reverberations of the waves between the walls of the steel sample container.

The pristine rocks of samples 1 and 2 were metamorphosed to the amphibolite and granulite facies, respectively, and both of the rocks contain Pl as one of their major rock-forming minerals, along with Amf of different compositions.

Our research was centered on the comparison of the behavior in shock waves of minerals of the same groups (plagioclase and amphibole groups), i.e., having similar structures but different compositions.

Results

Plagioclase (Pl). The original Pl of sample 2 has a more calcic composition ($An_{45\text{-}48}$) than in sample 1 ($An_{30\text{-}31}$). The Pl in sample 2 is extensively isotropized already under a pressure of 26 GPa. At 26 GPa, Pl in sample 2 acquires undulatory and block extinction, and the amount of isotropic grains is not great. Using X-ray diffraction analysis of this mineral, we determined that its isotropization proceeds in two stages: (i) *thin crushing of the material* on a microscopic scale (coherent-scattering domains in Pl are 1–2 nm in size in the shock-metamorphosed rocks and >100 nm in the pristine rocks) at a pressure of 26 GPa; (ii) amorphization of the mineral at pressures of 36 and 52 GPa. The Na concentration in the amorphous Pl phase statistically significantly decreases compared to that in the original Pl, and this element migrates from the crystalline structure of this mineral. The results of our experiments confirm the conclusion drawn from experiments with single Pl crystals [1]: the more calcic composition of Pl, the more rapid its isotropization. At the same time, intense Pl isotropization in the polymineralic rock of sample 2 takes place at a lower pressure (26 GPa) that in the experiments [1] with single Pl crystals (27–30.5 GPa), perhaps, due to differences in the character of the traveling of shock waves through mono- and polymineralic rocks.

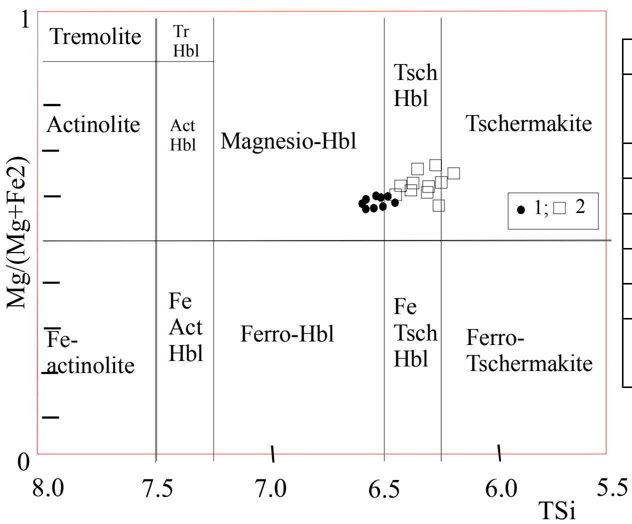

Fig.1. Amf composition (in compliance with the systematics [2]) of (*1*) the Pl–Amf schist with Grt (sample 1) and (*2*) pyroxene–Amf–Pl schist (sample 2).

	sample 1	Sample 2
Some peculiarities of composition of initial Amf		
Fe/(Fe+Mg)	0,47	0,40-0,46
F%	0,00-0,16	0,41-0,93
K_2O%	0,24-0,27	1,38-1,77
Al_2O_3%	13,87-14,07	12,53-13,78
TiO_2	1,08-1,28	2,08-2,52
The content in the rock	60%	30%

Amphibole (Amf). The pristine Amf of sample 2 is hornblende that is richer in Ca, F, and Ti than hornblende of sample 1 (table, fig. 1).

Under shock pressures of 26 and 36 GPa, Amf in both rocks typically acquires numerous cracks. The cracks are mostly open, and some of them are parallel to crystallographic directions in the mineral (fig. 2). As the shock pressure increases, the number of cracks within a unit area increases.

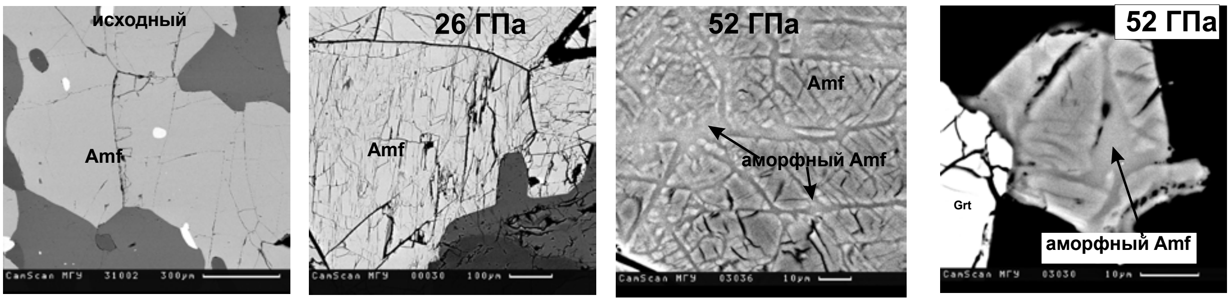

Fig.2. Amf in samples of Pl–Amf schist with Grt (sample 1) before and after shock loading under a pressure of 26 and 52 GPa.

Sample 1. Under a pressure of 52 GPa, Amf in sample 1 becomes partly amorphous as a result of melting along numerous cracks (fig. 2). The cracks widen toward grain margins, and their network simultaneously becomes thicker. Unmelted Amf fragments become rounded and acquire corroded outlines. The number of amorphized Amf grains reaches ~20%.

Compared with the FeO concentration in the pristine Amf, those in Amf grains shock-loaded at 26, 36, and 52 GPa and in grains amorphized at 52 GPa statistically significantly decrease, and this decrease is more significant in the amorphized grains. The decrease in the Fe concentration is explained by the migration of this component from Amf. The iron removed from this mineral is partly accommodated in Pl and partly oxidizes and produces newly formed oxide, which sometimes occurs as fine dust along cracks in Amf.

According to X-ray diffraction data, the unit cell volume of Amf shock-loaded at 36 GPa decreases by approximately 0.2% compared to the original unit cell volume; and at a pressure of 52 GPa, the unit cell volume of Amf increases by approximately 0.8% compared to the original one.

Sample 2. No traces of phase transformations or component migration were detected in this sample. According to X-ray diffraction data, the unit cell volume of Amf from sample 2 that was shock-loaded at 36 GPa increased by 0.2% compared with the original one. A load at 52 GPa notably increases the unit cell volume of Amf (by 1.3% relative to the original one).

Conclusions

1. Increase in the concentrations of F, Ti, and K in Amf and a decrease in the Na concentration in Pl stabilize these minerals under higher shock pressures.

2. Already on hard stages of transformation in Pl and Amf migration of some elements is fixed.

3. Shock - wave loading on Amf of different structure in some cases leads to opposite changes of the sizes of an elementary cell of this mineral that can be caused by qualitative distinctions in character shock - metamorphism transformations.

4. The isotropization of Pl in experiments with the stepwise shock loading of polymineralic rocks begins at lower pressures than in analogous experiments with monomineralic samples.

4. Under relatively low pressures, Pl isotropization is caused by its fragmentation on a microscopic scale and is associated with the origin of maskelynite, a typical mineral of meteorites and astroblemes. At higher pressures, Pl isotropization is related to amorphization by means of melting.

The studying is made up at support of the program of Presidium of RAS " Researches of matter in extreme conditions " and of the grant Russian Foundation for Basic Research 03-05-64496

References

1. *Stöffler D.,* et al. Shock metamorphism and petrography of the Shergotty achondrite // Geochimica et Cosmochimica Acta. 1985. V.50. PP. 889-903.
2. *Leake B., Wooley A., Arps C.* et al. Nomenclature of amphiboles; report of subcommittee on amphiboles of the International Mineralogical Association, commission on new minerals and mineral names // Canad. Mineralogist. 1997. V.35 (1). PP. 219-246.

Electronic Scientific Information Journal "Herald of the Department of Earth Sciences RAS" № 1(24)'2006
ISSN 1819 – 6586
Informational Bulletin of the Annual Seminar of Experimental Mineralogy, Petrology and Geochemistry – 2006
URL: http://www.scgis.ru/russian/cp1251/h_dgggms/1-2006/informbul-1_2006/planet-11e.pdf

Published on July, 1, 2006