

CHEMICAL PECULIARITIES OF TRANSFORMATION OF GARNET IN SHOCK WAVES (BY RESULTS OF EXPERIMENTS)

Kozlov E.A.*, Sazonova L.V.***, Beljatinskaja I.V.**

* Russian Federal Nuclear Center – E.I.Zababakhin Research Institute of Technical Physics, Russia
kozlov@gdd.ch70.chel.su

**M.V. Lomonosov Moscow State University, Russia
saz@geol.msu.ru

The study of impactites has shown that shock wave effects on target rocks are both, physical and chemical. Natural post-impact variations in mineral chemistry over the area of the astroblemes make it difficult to interpret shock-induced chemical changes. In order to understand these chemical effects in garnet, we have performed laboratory shock-loading experiments on garnet containing samples. We used a spherically convergent shock loading technique [1]. One advantage of this technique is that the peak pressure at the shock front increases as the shock progresses towards the center of the sample. A single experiment covers a wide range of pressures, from ~20 GPa to >100 GPa. We performed experiments as follows: Spherical sample, 51 mm diameter was prepared from garnet containing schist. The sample was enclosed in 6 mm-thick austenitic stainless steel half shells and hermetically sealed by vacuum welding (10^{-5} torr). The explosive was initiated simultaneously over its external surface by a spherical initiation system [1]. After the experiment, the sample was allowed to cool to room temperature and was cut by a diamond disk. The polished diametral sections were used for the analyses reported here.

The sample was examined on a CamScan-4DV scanning electron microscope, quantitative analyses were conducted on a Link AN 10 000 analytical set at 15 kV accelerating voltage, $1.2 \cdot 10^{-9}$ A current, and an angle of X-ray radiation collection of 30° ; the excitation area of X-ray radiation was approximately 3 μm in diameter. The elemental analyses were accurate to $\pm 2\%$ at concentrations of >10 wt %, to $\pm 5\%$ at concentrations from 5 to 10% wt %, and to $\pm 10\%$ at concentrations from 1 to 5%.

For convenience in describing our results, we divide the sample into four major zones, each corresponding to a range of pressures, as observed on the polished diametral sections.

Zone I - zone of jointing of garnet, has a thickness from 9 up to 11 mm. Initial shock pressures in this region ranged from 20 to 27 GPa. Aside from the presence of a great amount of fractures, SEM images of this zone do not appear to differ from unshocked material.

Zone II, 2-3 mm in thickness. Initial shock pressures in this zone increase to ~ 27-37 GPa at its inner boundary. This is the zone of extensive transformation of garnet. The aggregate of new phases are observed in veinlets tracing fractures in garnet. The width of such veinlets varies from a microns up to hundreds micron. An amount and width of veinlets grow to inner boundary of this zone. At the end of this zone the aggregate of new phases develops on garnet grains as a continuous net and the garnet already is preserved only as fragments among new phases.

Zone III, \approx 2-3 mm in thickness. Calculated initial shock pressures in this zone increase to ~ 37-58 GPa. Garnet grain boundaries often become very diffuse. Partial melting of garnet is observed in this zone.

Central **Zone IV** ranges from 9 to 12 mm in diameter. This is the zone of complete melting of all minerals. Calculated initial shock pressures in this region exceed 60 GPa. The boundary between zones III and IV is gradual; the width of the transition region is slightly more than 100 μm .

Changes in the chemical composition of garnet

The special interest calls occurrence in II zone aggregates of newly formed minerals (fig.1, 2). The aggregates consist of "olivine"- , "pyroxene"- , "garnet"- phases and spinel (whose composition is close to hercynite) submerged in a glass. By their skeletal crystal form and glass, cementing them, these phases crystallized from a melt originating on garnet. The STA developing at 20 GPa consist of very thin veinlets tracing fractures. These veinlets may possibly be adiabatic shear bands. The process of garnet transformation in II zone develops irregular. The new phases formation is inspected by smallest fractures. The irregular of development of melting and crystallization is bound with a high velocity of process and heterogeneity of a medium at loading by a shockwave. As a result a disequilibrium of substance and its considerable local heatings take place. Melting and crystallization of garnet in fractures take place, probably, on isentropes. The detail chemical analysis new minerals allows to discover "spinel-", "pyroxene-" "olivine"- and "garnet" - phase. The chemical analysis of the "garnet" phase are re-counted on the formula of garnet and differs from containing almandine garnet. The new

garnet phase has pyrope composition. The chemical analysis of «olivine» phase is re-counted on the formula of olivine, but differ from this mineral by presence of alumina (up to 13 %). Phase of the same composition developing on biotite was found out in one of earlier investigated experimental specimen and identified by a method of Raman spectroscopy [2,3], as ringwoodite (γ -spinel). The “olivine” phase frequently develops around spinel, and sharp boundaries between spinel and this phase miss, that guesses presence of a solid solution between spinel and this phase that is an indirect proof that the “olivine” phase is ringwoodite, which is isostructural mineral to spinel. The composition of the “pyroxene” phase is re-counted on the formula perovxene well, but the content of alumina in this phase till 15-17 of % keeps us to guess, that in this case we deal or with silica- perovscite, or with majorite.

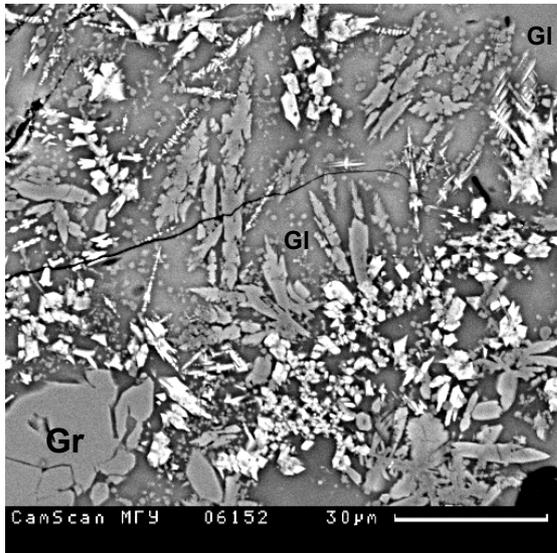


Fig.1. Aggregate of new phase on garnet: white-“olivine”- phase; grey – “pyroxene” – phase; small rash – spinel; GI – glass. Gr – relict garnet.

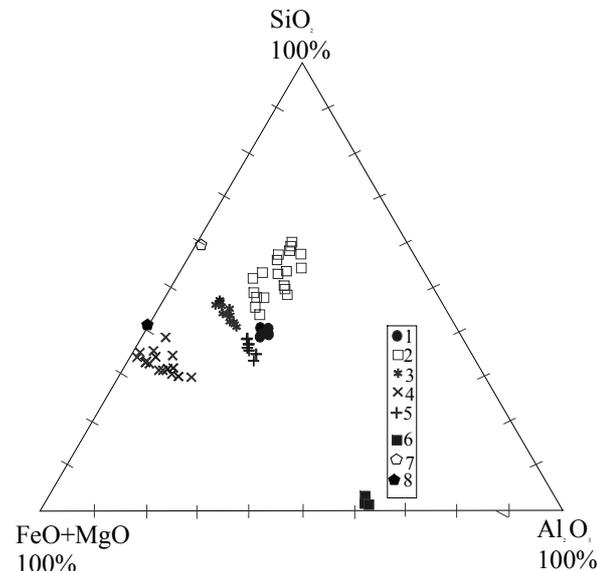


Fig.2. Compositions of initial garnet and relict of not changed garnet (1) and newly formed of phases: glasses (2); “pyroxene”- phase (3); “olivine”-phase (4); garnet (5); spinel (6). Theoretical compositions of minerals: pyroxene (7); olivine (8).

References

1. Kozlov, E.A., 1999, Metals, Minerals and Meteorites Research in Spherical Shock-Isentropic Recovery Experiments: Polymorphous and Phase Transitions, Spall and Shear Fractures, Physicochemical Transformations // (Review): Proceedings International Conference, V Zababakhin Scientific Talks, September 21-25, 1998, Snezhinsk, Russia, Russian Federal Nuclear Center – Research Institute Of Technical Physics, Part II. PP. 413 – 424.
2. Kozlov, E.A., Sazonova, L.V., Fel'dman, V.I., Dubrovinskaya, N.A., Dubrovinsky, L.S., 2002, Formation of ringwoodite in high-explosive experiments on muscovite-biotite-quartz states // Bayerisches Forschungsinstitut für Experimentelle Geochemie und Geophysik Universität Bayreuth, Annual Report / Jahresbericht. PP. 100-101.
3. Kozlov, E.A., Sazonova, L.V., Fel'dman, V.I., Dubrovinskaya, N.A., and Dubrovinsky, L.S., 2003, Formation of ringwoodite during shock-wave loading of two-mica quartz schist: experimental data // Doklady Earth Sciences, V.390. N. 4. PP. 571-573.