Tribometamorphism and tribometamorphic products

Трибометаморфизъм и трибометаморфни продукти

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Introduction

Regional metamorphism develops in different manners due to tectonic deformation which controls a spatial anisotropy of the thermodynamic parameters: temperature, pressure and fluids. A specific local type of regional metamorphism is tribometamorphism.

Tribometamorphism designates the recrystallization of rocks caused by the friction between rock layers due to tectonic processes in local shear zones. Tribometamorphic products are new metamorphic rocks formed through recrystallization of minerals under the local conditions prevailing in the tribozones.

Location of the tribozones

The tectonic processes in the Earth's crust control dislocations and different deformations of the layers like folding, thrusting, initiation and evolution of shear zones, and destruction of the minerals. During the deformation a great number of shear zones with different dimensions are formed. They are situated: *i)* at the lithological contacts between rock layers with different rheological properties (density, hardness, elasticity, plasticity) and usually they occupy the anticlinal/synclinal flanks; *ii)* at the surfaces of thrusts; *iii)* on the faults crossing the layers. In some cases secondary surfaces of dislocation and friction are forming along thrusts or into minerals due to splitting of rock or mineral substance.

Processes in the tribozones

Friction due to layers movements along shear zones leads to cataclasis, mylonitization, and in deeper zones to recrystallization of minerals. Friction also has an effect on the intracrystalline levels: *i)* interlaminar movements between microlayers; *ii)* between minerals during interlamination sliding when some minerals disintegrate rapidly while the more resistant ones (*e.g.* garnets) only rotate; *iii)* internal translation of crystal lattice of quartz, graphite, calcite and others. It is well known by tribochemistry the successive steps for genesis of a new mineral phase in the friction zones, proceed through elastic and plastic deformation of minerals, appearance of lattice defects in the crystal up to completely decomposition of minerals getting to molecular and atomic rang and dehydratation (Heinicke, 1984). Due to the mechanical-chemical (or tribochemical) processes the temperature, pressure and chemical activation of components increase resulting in a new mineral product beginning with nucleation. Nuclei grow to form crystal grains. The steps involved in nucleation and subsequent grain growth are activated by thermal energy.

Triboreactions are favored by the velocity and duration of friction between the plates, the resistance of the material, the degree of unevenness (ruggedness) of gliding surface, the presence of solid hard rolling beds or minerals (Hedba, Chichinadze, 1989). The cumulated effect of triboprocesses occasionally could generate very high temperature and pressure inside the tribozones. The high concentration of energy into narrow space more over with high velocity of friction could determine a temporary "explosion" of temperature and during a second or microsecond the temperature could increase till 1000 °C. Under these conditions new high thermobaric mineral assemblages also containing microdiamonds could form. At the same time the country rocks, out of the tribozones, consist of minerals crystallized under lower temperature and pressure which are not in equilibrium with those from the tribozone. In this way the mineral assemblages from the tribozone and country rocks are synchronous but heterofacial (Kozhoukharova, 2008).

Tribometamorphic products

The mineral composition of tribometamorphic products corresponds to chemical features of the substance medium as well to the thermobaric conditions of the tribozones.

Garnet lherzolites from the Eastern Rhodopes are ultrabasic metamorphic rocks consisting of garnet, enstatite, diopside, olivine and spinel. They form thin

(1–2 cm) parallel stripes only into peripheral zones of serpentinite bodies at the contact with host gneisses. The high Al-content both in ortho- and clinopyroxenes from the garnet lherzolites is indicative for high pressure conditions (Kozhoukharova, 1996). The temperature/pressure conditions of the garnet lherzolite zones are T – 800 °C/P – 10–15 kbar. The background regional metamorphism of the country rocks is typical medium pressure amphibolite facies: T – 480–540 °C/P – 4–5 kbar (Kozhoukharova, 1999). Usually the bands have a zonal structure. Theirs innermost zones are built of garnet, followed by strips consisting mainly of enstatite, diopside, olivine and spinel. A transitional zone of cryptocrystalline talc-chlorite aggregate occurs between the new high minerals and the serpentine. The myrmekite-like symplectites are built up of: *i)* diopside and spinel; *ii)* diopside, enstatite and spinel; *iii)* diopside, spinel and magnetite; *iv)* diopside and actinolite. They are typical reaction products indicative for a rapid recrystallization. Similar layered metaperidotites are also found in North Greece at Kimi village where micro diamonds have been described (Mposkos, Kostopolous, 2001).

Eclogites (Kozhoukharova, 1980) are basic metamorphic rocks built by garnet, omphacite and rutile. They form thin bands or small lens-like bodies among amphibolites. Specific features are the structures of decomposition of the omphacite to an aggregate of albite-oligoclase and diopside, followed by amphibolitization. Decomposition of omphacite and the replacement by amphibole starts after the cessation of the tectonic movements and the restoration of the equilibrium between the tribozone and the host rocks.

Tribomicaschists appear in the zones of friction from gneisses and granitogneisses where the feldspars are disintegrated to very fine-grained material enriched in silicon and aluminium together with chemical changes in presence of water. Increase of temperature and pressure triggered the recrystallization of white mica. The nuclei grow to form crystals of white mica often enriched in phengite molecule, an indicator for higher pressure. The flakes of white mica are orientated parallel to surfaces of rock plates in the zone, forming very thin layers of mica with a clear foliation. The surfaces covered by micaschists favoured the gliding movements of rock plates and in this case schists act like a lubricant.

Calc-silicate rocks (metamorphic skarns, erlans) form thin (1–5 cm) layers into marbles and calcareous schists. They are very firm and dense, white to grey-white fine-grained rocks, with thin lenticular texture, consisting of garnet, pyroxene, scapolite, rutile, calcite, quartz.

Conclusion

The main features of the tribometamorphism are:

– the tribometamorphism takes place in local shear zones of friction;

– transformation of the rocks in the tribozones pass in two stages: deconstruction (deformation and disintegration of the rocks to fine ground mass) and construction (nuclear recrystallization and growth of the crystals);

– the thermobaric parameters of metamorphism (temperature and pressure) only in the narrow space of the tribozones increase sometimes to extremely high values;

– the tribometamorphic products are synchronous but heterofacial to the country rocks.

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