Burilichev[1] D.E., Nikitin[1] A.N., Ivankina[1]T.I., Klima[2] K., Lokaichek[2] T., Pros[2] Z. Study of anisotropy and textures of olivine-bearing mountain rocks at high all-round pressures.

[1]Laboratory of Neutron Physics, United Institute of Nuclear Research (LNF OIYaI), Dubna, Russia

[2]Institute of Structure and Mechanics of Mountain rocks (IRSM), Prague, Czech Republic

key words: [elastic anisotropy, texture, mountain rocks, high pressures]

Precise knowledge on composition and properties of the deep horizons in the earth's crust and mantle is necessary for understanding many geological and geophysical phenomena. These characteristics determine many processes occurring at great depths.

An experimental study of anisotropy of elastic properties at high pressures (from 0.1 to 400 MPa) (Geophysical Institute, Prague) [1] and texture (OIYaI, Dubna) [2] of the mantle xenoliths (SEM1 and ZB1 (Czech Republic)) and dunites (9721 and 9722 (Italy, BQ4 (Albania)) was conducted.

A continuous increasing velocities of longitudinal elastic waves (V_p) with increasing all-round hydrostatic pressure value is observed. The most intensive increase of as maximal as minimal values occurs at the beginning stage of the pressure increase (from 0.1 to 100 MPa). The velocity (V_p) isoline configurations (fig. 1) change, the velocity maximums and minimums shift, but become mostly stable after p=100 MPa. The dunite samples 9721 and 9722 have quite similar velocity isoline distributions in the whole range of applied pressures. The velocity V_p isoline maps for the SEM1 and ZB1 samples at pressure of 0.1 MPa are quite chaotic, but the isolines get more regular perfect shape with pressure increase.

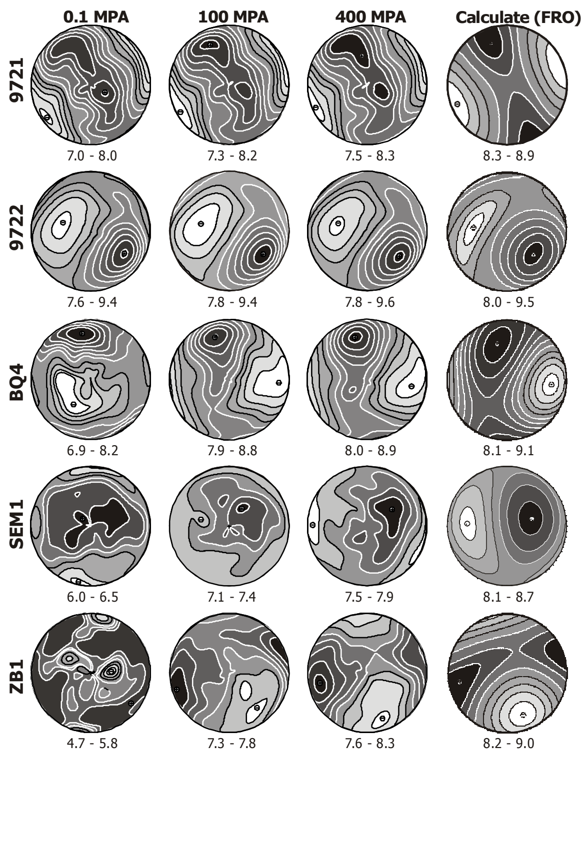

Fig.1. Maps of Vp rate isolines obtained experimentally under various pressure values (0.1, 100 and 400 MPa) and calculated by ODF (orientation distribution functions) for the studied samples.

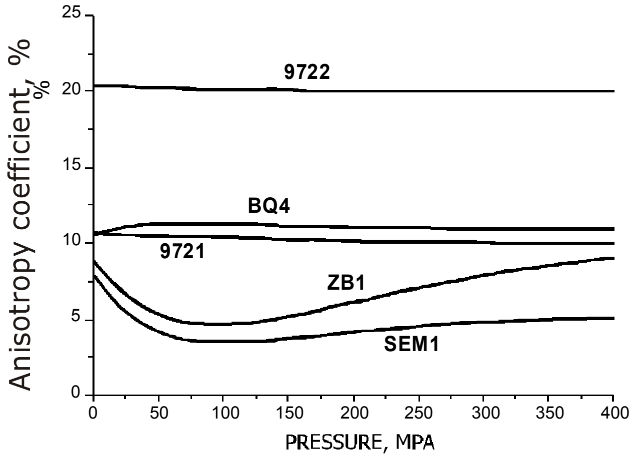

Fig.2. Pole figures for the main crystallographic planes of olivine

The velocity V_p distributions obtained at pressure of 400 MPa for all the samples exhibit a typical picture of maximums and minimums located to each other by angle of 90° and reflect the deformation tensor symmetry.

Behavior of elastic anisotropy (fig. 2) for dunites and xenoliths is different with increasing pressure. The anisotropy coefficient values for dunites (9721, 9722, BQ4) do not change in the whole range of pressures. The samples of xenoliths (SEM1, ZB1) are characterized by decreasing anisotropy at pressures from 0.1 to 100 MPa and its increase at pressures higher than 100 MPa. The reason of that is obviously the changing influence of textures of the oriented pores and microcracks controlling the change of extreme velocity values at different all-round pressures.

Experimental study of olivinite crystallographic textures was conducted at the 7a beam of the IBR-2 reactor (OIYaI) by neutron textural diffractometer SKAT [3]. All the olivine samples are characterized by clearly distinguished crystallographic textures. The experimental pole figures obtained from the neutron diffraction spectra were used for recovering orientation distribution functions (ODF) and calculating the pole figures for the main crystallographic planes (100), (010), and (001) associated with the extreme directions of the elastic wave velocities in the olivine monocrystals (fig. 3). Based on ODF and elastic modules of olivine bearing monocrystals the theoretic modeling of the velocity V_p space distribution for the studied samples was carried out.

The model distributions are very similar to the experimental ones obtained at high pressures (fig. 1). The observed difference as in velocity distributions as in their values are probably due to only one factor being taken into account at Vp distribution modeling – crystallographic texture of the only olivine.

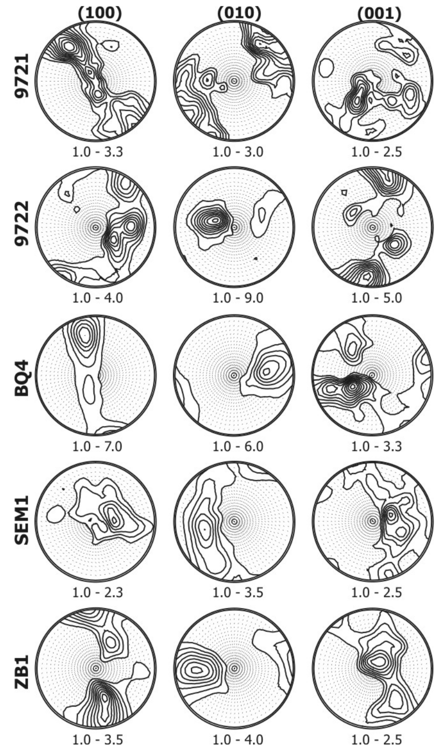

Fig.3. Correlation between the sample elastic anisotropy and the all-round hydrostatic pressure.

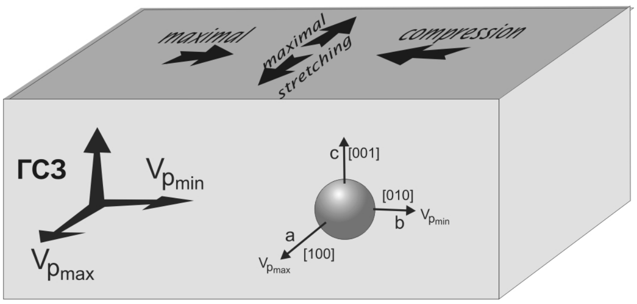

Fig.4. The example of reconstruction of the Earth's lithosphere block being in strained and deformed condition

The major factors defining the type and the character of the olivine crystallographic texture are the conditions of its plastic deformation. Moreover, the active slipping systems and the olivine texture type are mainly determined by temperature and to a less extent by deformation rate. Comparison of textures of experimentally and naturally deformed olivinites allowed us to determine that the texture formation process for the studied samples is the result of high temperature (1300-1600^{o}C) deformation along the slipping system (010)/[100] and corresponds to the depths of the order of magnitude of 100 km and deeper.

Having available experimental data on the character of azimuthal seismic anisotropy for the studied regions, i.e. maximal and minimal velocity directions of P-waves we can consider the natural coordinate system based on these directions. The neutron-graphic textural analysis allows determination of the analogous coordinate systems for the studied samples. It is well known that slipping direction is oriented parallel the axis of maximal stretching, and the slipping planes – perpendicular to the compression axis during plastic deformation of olivine crystals. Thus, it is possible to make reconstruction of the strained-deformed state of the whole lithosphere block (fig. 4) by comparison of the deep seismic sounding data and the results of the studied olivinite textural analysis.

References:

1. T.I. Ivankina, K. Klima, T. Lokaichek, A.N. Nikitin, Z. Pros. Studies of anisotropy of the olivine xenolith by acoustic waves and neutron diffraction // Phizika Zemli. 1999. No. 5. PP. 29-39.
2. A.N. Nnikitin, T.I. Ivankina, D.E. Burilichev, K. Klima, T. Lokaichek, Z. Pros. Anisotropy and texture if the olivine bearing mantle rocks at high pressures // Fizika Zemli. 2001. No.1. PP. 64-78.
3. K. Ullemeyer, P. Spalhoff, J. Heinitz, N.N. Isakov, A.N. Nikitin, K. Weber. The SKAT texture diffractometer at the pulsed reactor IBR-2 at Dubna: experimental layout and first measurements //Nucl. Ins.and Meth. In Phys. Res. 1998. A412. PP. 80-88