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Program of the mantle thermometers and barometers: usage for reconstructions and calibration of PT methods

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Program description

Original monomineral thermobarometers for mantle peridotites for clinopyroxene, garnet, chromite and ilmenites for the mantle peridotites were statistically calibrated on the PT estimates for mantle peridotites [*Ashchepkov et al.*, 2010] were tested using the mineral phases obtained in high pressure experiments with the natural peridotites (380 runs) [*Brey et al.*,1990; 2008 etc] and eclogites (240 runs)[*Dasgupta et al.*, 2006 etc]. In the original program of that written on FORTRAN are assembled the most reliable methods of mineral thermometers (45) and barometers (36) and oxybarometers (5), including original monomineral and methods [*Ashchepkov,* 2003 *Ashchepkov et al.*, 2008; 2009; 2010; 2011] for the mantle peridotites bases on the compositions of on clinopyroxene, garnet, chromite and ilmenite. Program reads the text files, which converted from Excel. Original data include standard silicate compositions for 12 components in standard order. The text file includes 15 columns of 8 symbols. The first is file name which is the same for all the minerals in the association. The second is indicator symbol for phases. E- enstatite, D - diopside, O-olivine, S-spinel, G- garnet, I –ilmenite, A- amphibole, F – phlogopite, P-plagioclase, L- liquid, R- bulk rock. Then follow oxides: SiO2, TiO2, Al2O3, Cr2O3, FeO, MnO, MgO, CaO, Na2O, K2O, NiO, V2O3 written with 2–3 decimals. The last column may contain description of the mineral or association up to 64 symbols. Monomineral methods use calculated values for Fe#Ol or Fe#Cpx. The input from console includes file name (8 symbols) (A8), then amount of PT pairs of numbers thermometers and barometers (2I2) and one for FO2 method. Program allows input of the iteration numbers (to 25 by default). It allow to choose whether to use the calculated Fe^{3+} for the minerals and also. It is possible also to put fixed values of T and P (default 1000^{o}C and 40 kbar)

The program is reading mineral compositions detecting them by mineral indexes till name of the association are the same and start the estimations of PT values when read different names. They are going to the dispatcher points sending to the thermometers and barometers according to the input numbers. It is performing calculation for each pair till the difference of the temperatures is higher 1^{o} or less then iteration number made then goes to next pair. The values of calculates pairs are writing in the matrix. It is writing in new line when the new association starts.

The results of the calculations of pairs (to 15) PT of the parameters in any combination are writing in the matrix of data in the CSV format together with the compositions of minerals or their formula coefficients. The calculated Fe#Ol for coexisting olivine for each mineral are written also as well as Cr# and Fe^{3+} for chromites and Fe^{3+} for Cpx. The description is writing before the results of the calculations. The CSV (comma separated values) files are easily converting to Excel or Grapher or may be used for the statistical programs.

Special variety of programs works with the data files of the experimental PT values and data of the minerals in runs [*Dasgupta et al.*, 2006; *Brey et al.,* 1990, 2008 etc] reading PT parameters and writing them together with the calculated values and compositions of the minerals. This allows to make the correlations of compositions of minerals and PT values of the experimental runs and results of the approximations and to find the difference between the P and T difference and their dependence from mineral, liquid or even starting rock compositions.

Applications

Recently new version of the peridotite- pyroxenites Cpx barometer [*Ashchepkov et al.*, 2003-2011] was obtained using about 300 experimental runs for basalts and peridotites and pyroxenites.

This universal barometer [*Ashchepkov et al.*, 2011] reveals rather good calibration and agreement with the most reliable methods of mantle thermobarometry [*Brey and Kohler, 1990*; *Krogh,* 1988; *Nimis and Taylor,* 2000; *McGregor*, 1974; *O'Neill and Wood,* 1979; *Taylor et al.*, 1998; *O'Neill and Wall*, 1987] (Fig.1-3,5).

The new improvements of the garnet barometer [*Ashchepkov et al.*, 2008; 2010] give much better coincidence for the experimental systems [*Brey, G.P. and Kohler, 1990; Brey et al.,* 2009] and garnet bearing peridotitic mantle xenoliths as well as garnets from diamond inclusions *[Logvinova et al*., 2005; *Sobolev et al.,* 1984] and from diamond associations [*Grutter et al.,* 2006; *Sobolev et al*., 1984] (Fig.3). Comparison with the diagram based on the experimental data show that most of the pressures in the natural associations are overestimating the experimental values for the same Cr/(Cr+Al) values (Fig.4) [*Turkin and Sobole*v, 2009].

A newly modified version of the programs includes the methods for the T and P estimates according to the precise data for olivine [*Sobolev et al.,* 2009*; De Hoog,* 2010]. They single grain temperatures for olivine show a good correlation with the pyroxene estimates (*Ashchepkov et al.,* 2010).

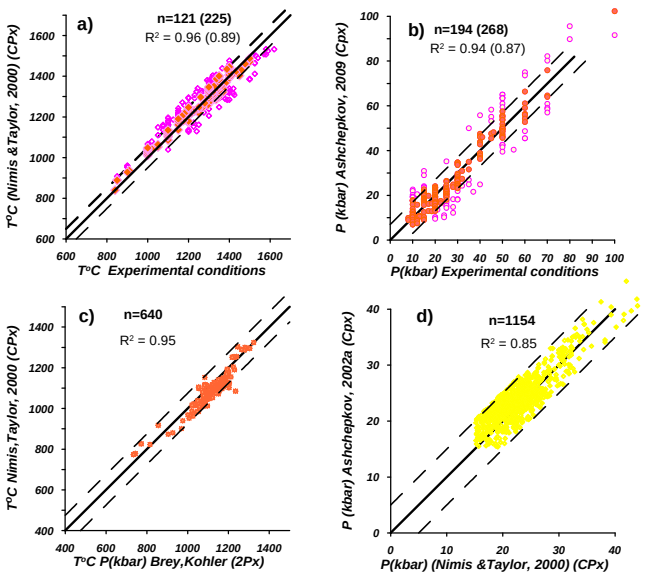

Fig. 1. Correlation of the determinations of the from the universal equation of clinopyroxene barometer [*Ashchepkov,* 2011] according to the experimental data (b) in the peridotite system and the comparison of estimations according to this equation and Cr-Tchermakite barometer [*Nimis and Taylor,* 2000] (d).

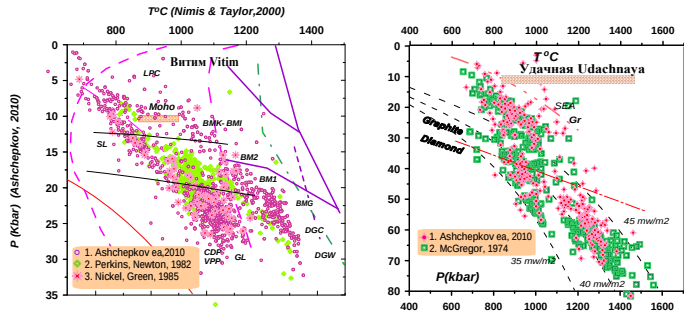

Fig. 2. Estimations of (temperature and) of pressure with the universal version of clinopyroxene barometer [*Ashchepkov,* 2011] in the comparison with the estimations according to orthopyroxene methods (see legend) for the xenoliths from basalts from the Vitim plateau (a) and for the xenoliths from Udachnaya pipe [*Boyd et al .,* 1997; *Ionov et al.*, 2010].

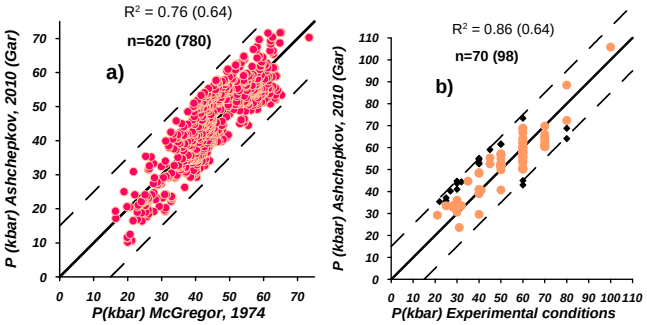

Fig. 3. Correlations dependences between: a) values of pressure, determined according to [*McGregor*, 1974] and the equation garnet barometer with the corrections. (b). Correlations between the estimations from the equations of garnet barometer and experimental data.

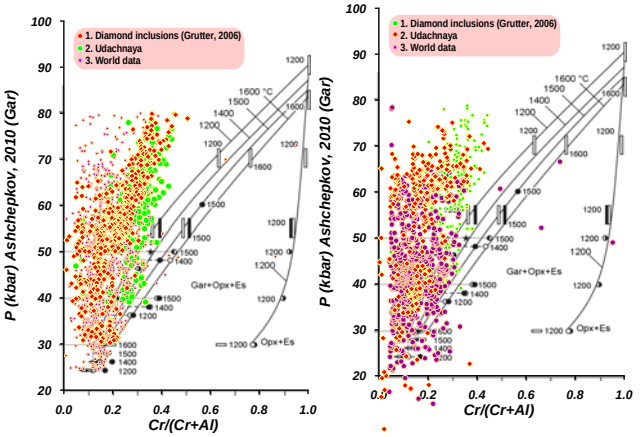

Fig. 4 The diagram Cr/Cr+Al - P (kbar) [*Turkin and Sobole*v, 2009] according to experimental data and values calculated for natural garnets a) by garnet barometer and b0 according to Opx. Data from : 1- Udachnaya [Boyd, et al ., 1997; *Ashchepkov et al*., 2010; *Pokhilenko et al*., 1999; Sobolev , 1977]; 2. Diamond associations [*Grutter et al.*, 2006; *Sobolev et al.*, 1984; *Logvinova et al.*, 2005]; 3. Worldwide kimberlites [*Sobolev,* 1977; *Burgess and Harte*, 2004; *Simon et al* ., 2007 etc].

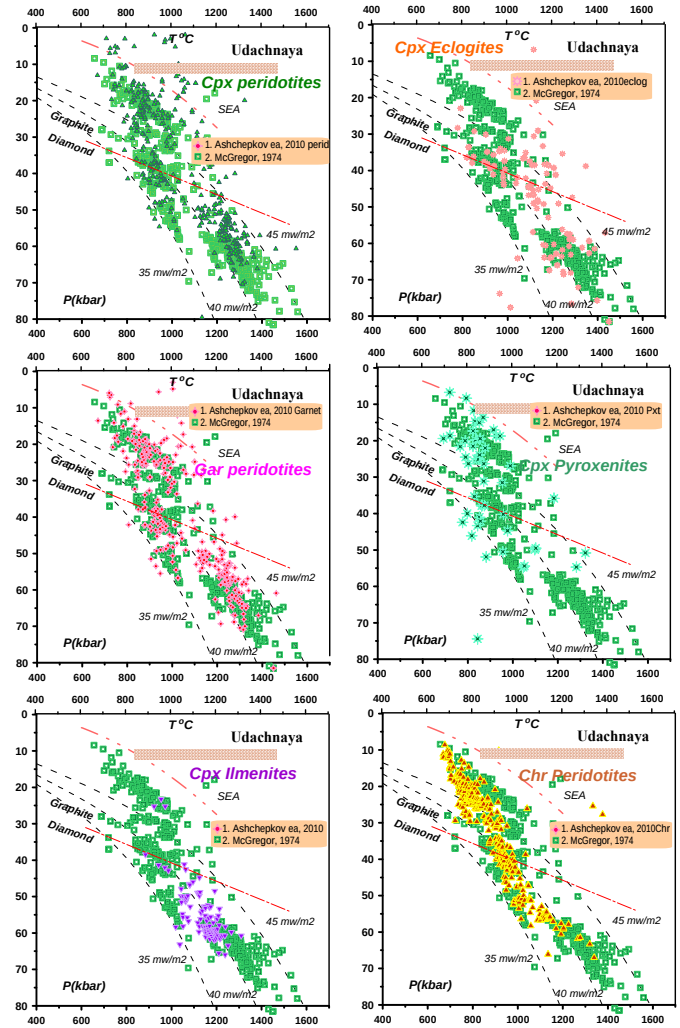

Fig.5. PT estimates obtained modified singe grain thermobarometers [*Ashchepkov et al.*, 2010; 2011; *Krogh*, 1988; *Nimis and Taylor*, 2000; *McGregor*, 1974; *O'Neil and Wood*, 1979; Taylor et al., 1998; *O'Neil and Wall*, 1987] in comparison with those Opx- based method [*Brey and Kohler*, 1990 – *McGregor,* 1974].

For the works with Grapher software the calculated values of pressures are writing together with the Fe# or any other parameters including trace components in other column and distances between the objects. This allows obtaining rather detail pictures for the mantle beneath Daldyn field (Fig.6). Different minerals and their monomineral thermobarometric methods give similar inclination of the mantle layers toward the east. The comparison of the data obtained for India by W. Griffin shows the more detail layering then represented in their paper [*Griffin et al.*, 2009].

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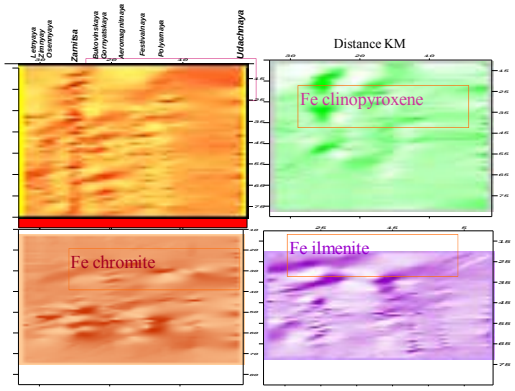

Fig.6. The cross -sections of the Daldyn field in Yakutia. From Zarnitsa to Udachnaya pipe, data from [*Ashchepkov et al.*, 2010].

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