

The C and O isotopes in calcites from aillikites and carbonatites of the Beloziminsky and Tomtor massifs (Siberia, Russia)

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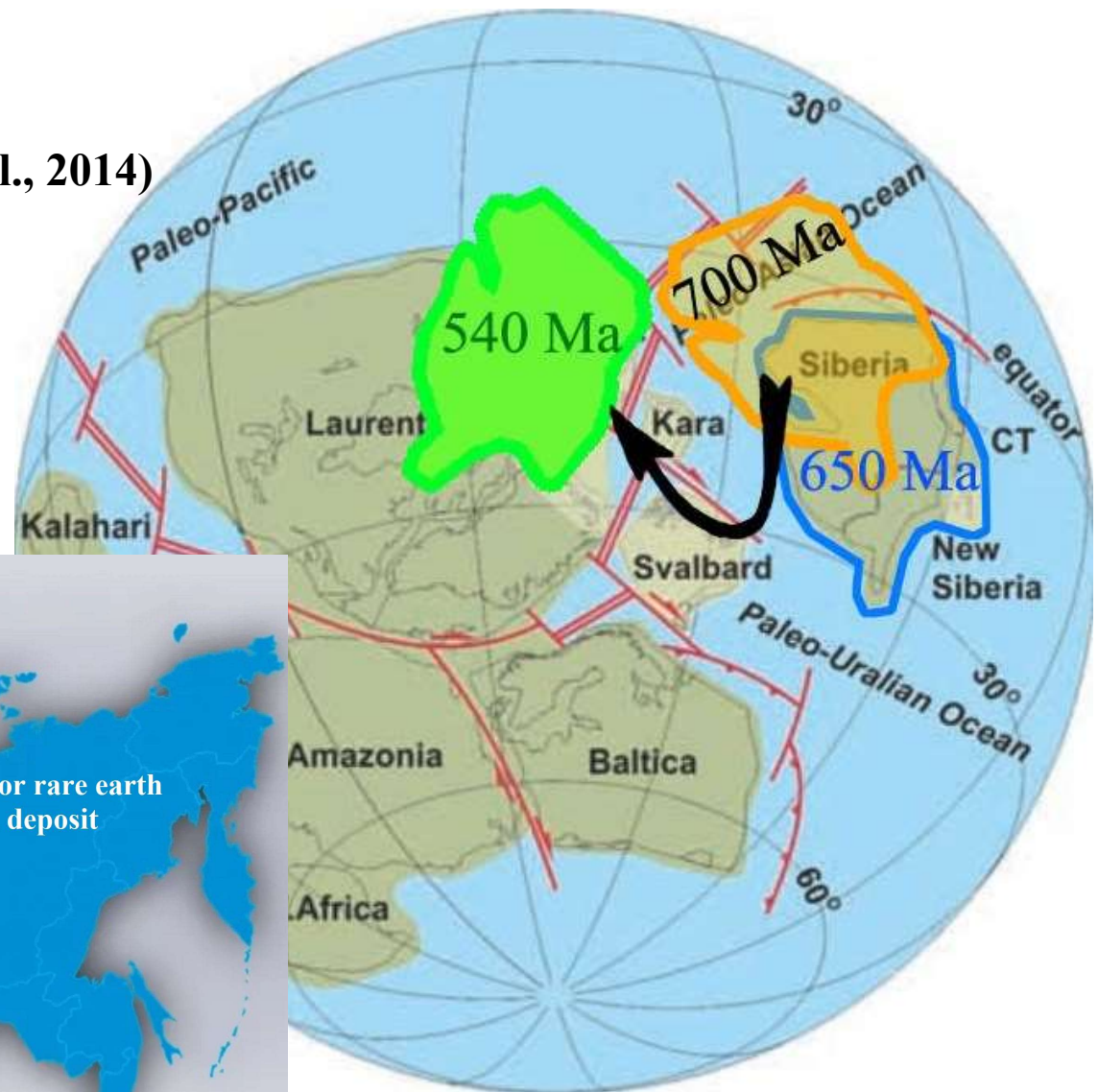
Introduction

The modern progress of human civilization is closely related to critical and strategic metals, the list of which is indicated for different countries in documents (US Department of Energy, 2011; British Geological Survey, 2012; European Commission, 2014). One of the sources of REE + Nb + Ti - metals are deposits associated with carbonatites. The number of known carbonatites exceeds 500, but not every one of them is associated with an economically attractive deposit. The total reserve of such carbonatite deposits depends on the scale of the original source, the concentration of ore contents at the magmatic, hydrothermal, supergene stages (Smith et al., 2016). In the evolutionary sequence of these ore-forming processes, according to (Chakhmouradian, A., Wall, F., 2012), the accumulation of REE in carbonatites usually occurs at the final stages of evolution, which are characterized by a decrease in temperature. In this regard, the question arises whether it is possible to use the temperature-dependent C-O isotopic C-O and Ar-Ar systems for predictive assessment of the intensity the final stages and, accordingly, the likely formation of the deposit.



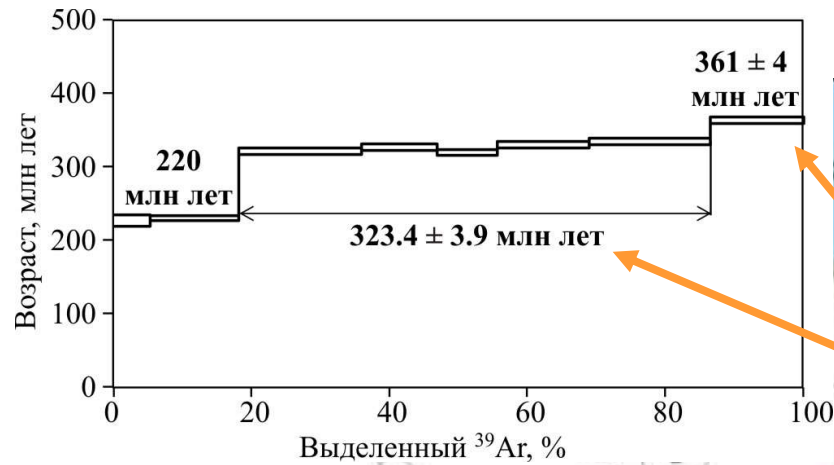
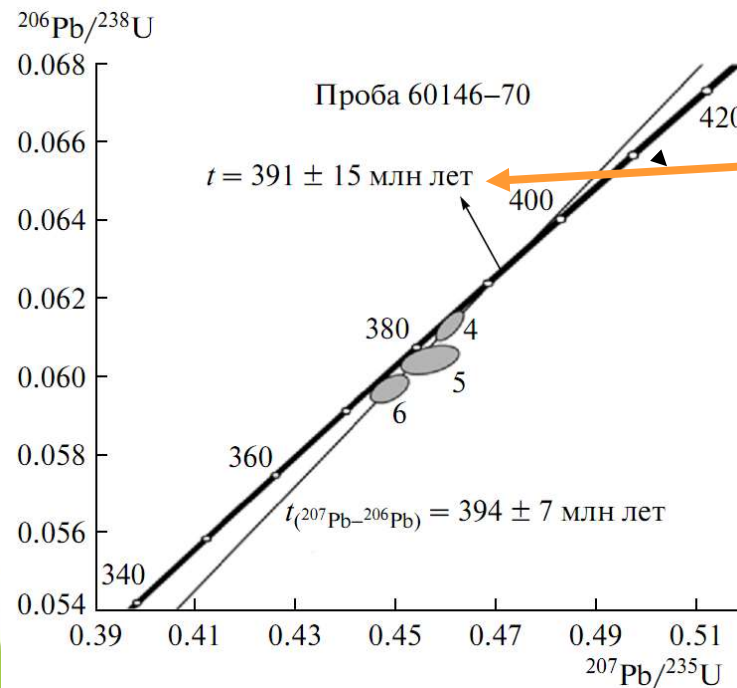
For this purpose, a comparison was made of the parameters of the isotopic C-O and Ar-Ar systems for the Beloziminsky carbonatite complex and the Tomtor complex. The latter is known to be the largest deposit of Nb and REE. ...

At the Tomtor complex, zircon from syenites is 701-675 Ma. (Vladikin et al., 2014)

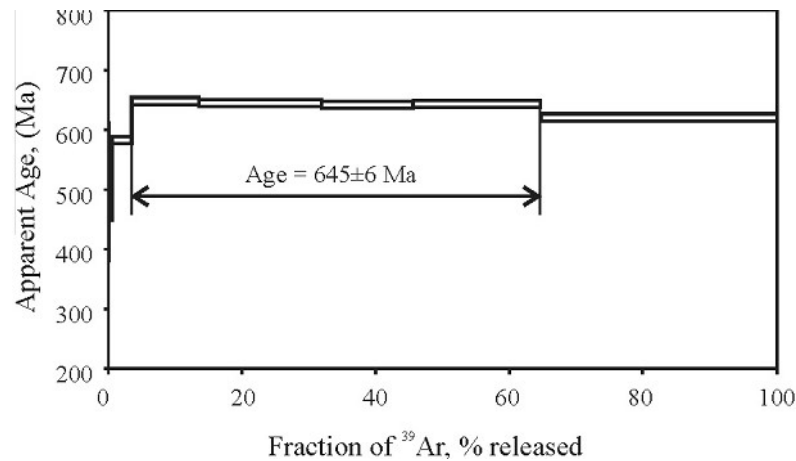


For the Beloziminsky carbonatite complex: 1) for nepheline syenite, 643 $\pm$ 4 were obtained; 648 $\pm$ 10 Ma (Yarmolyuk et al. 2008); 2) after phlogopite from carbonatites 645 $\pm$ 6 Ma (Doroshkevich, 2016).

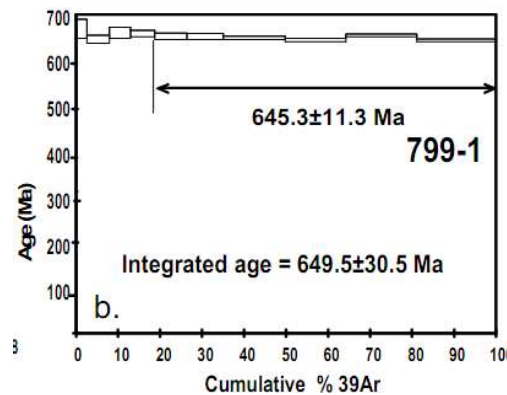
During the drift of the Siberian continent, the Tomtor complex experienced several endogenous impulses: 391 Ma (Vladykin et al., 2014), 361 and 323.4 Ma (Dobretsov et al., 2020).



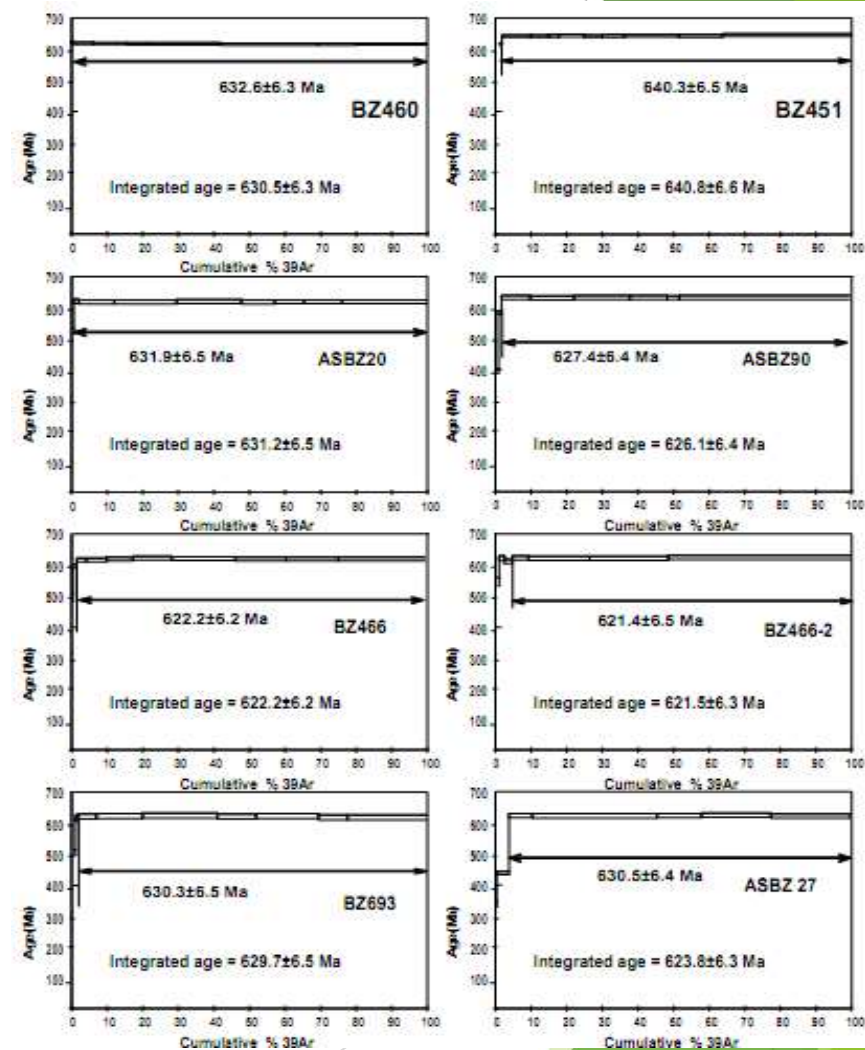
The spectra of ^{40}Ar - ^{39}Ar diagrams of micas from carbonatites of the Beloziminsky complex reveal an age of 645 Ma. The age plateau is even. The age of phlogopite from the aillikites varies from 640 to 621 Ma. The closing temperature of the K-Ar isotope system is 300-400°C. Consequently, there was no significant endogenous event younger than ~ 645-620 Ma.



Doroshkevich et al., 2016



The Yuzhnaya pipe (YuP)



Results for the $^{40}\text{Ar}/^{39}\text{Ar}$ dating of lamprophyre dykes and stocks inside the Beloziminsky massif (Ashchepkov et al., 2020)

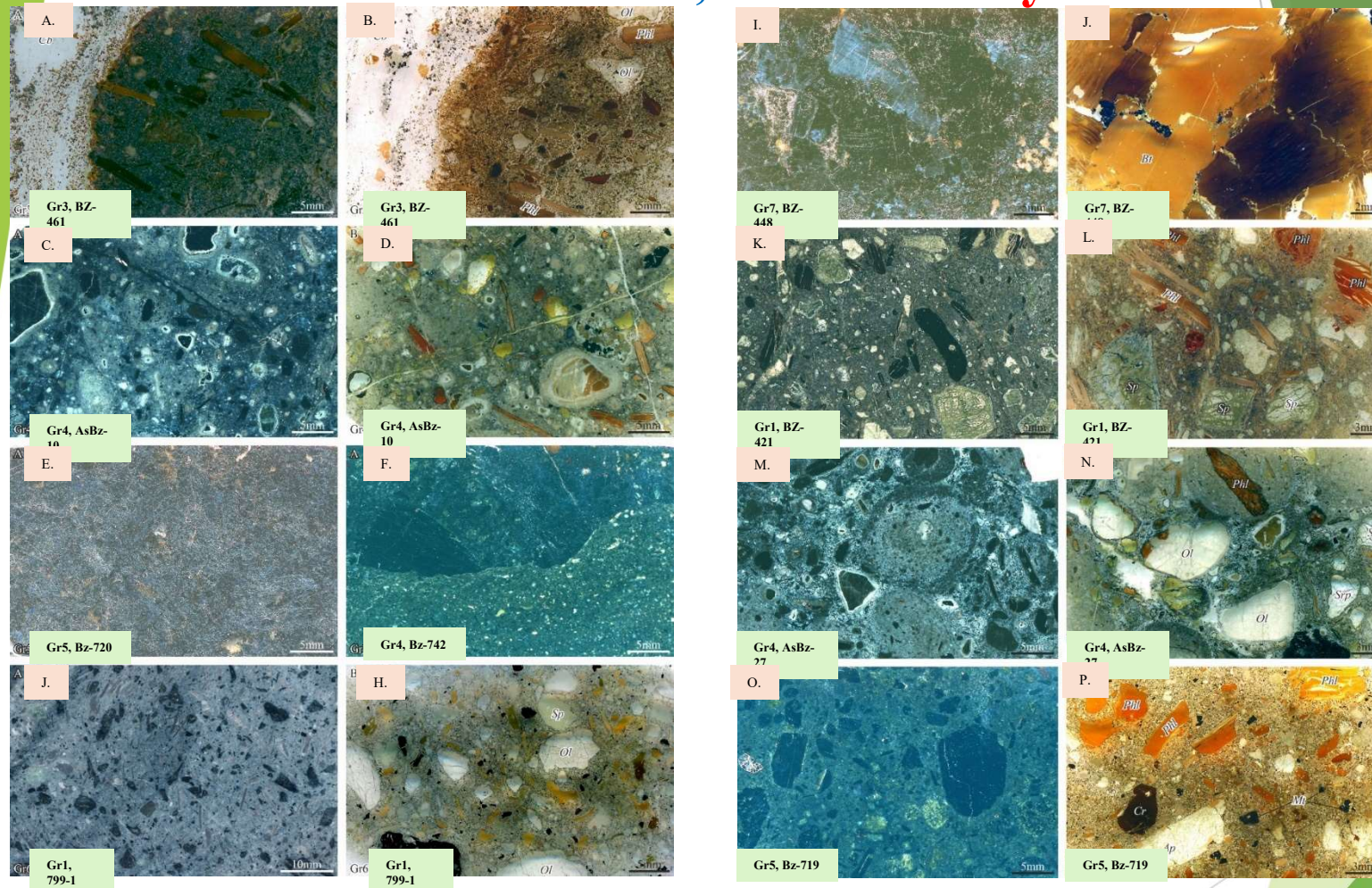
Beloziminsky carbonatite complex: Contact of carbonatite and aillikite

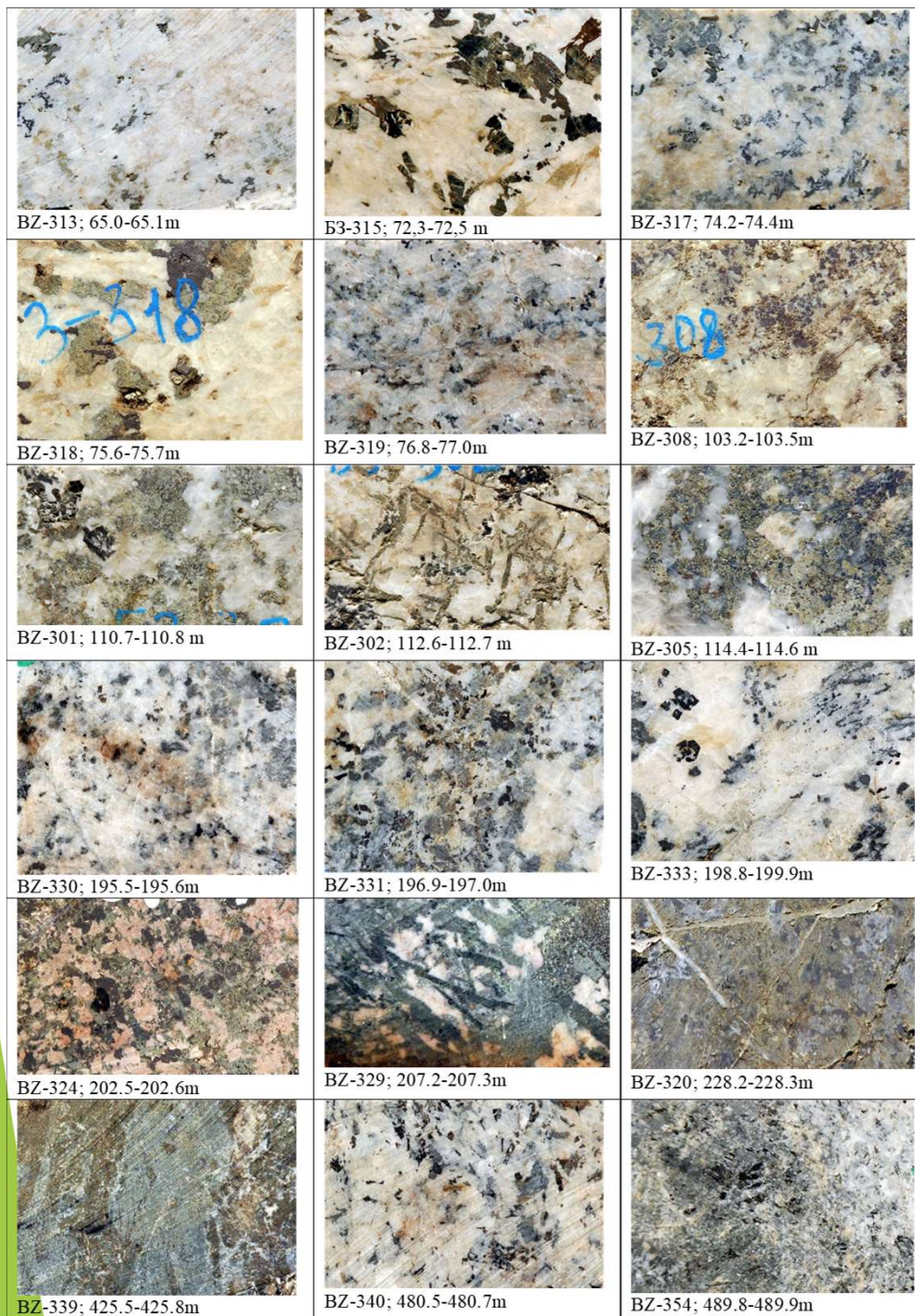
According to geochronological data, aillikites in the Beloziminsky complex are younger than carbonatites. The interaction of aillikite and carbonatite, shown in the figure, can be interpreted differently.



Scanned image of the cut sample from YuP (a).

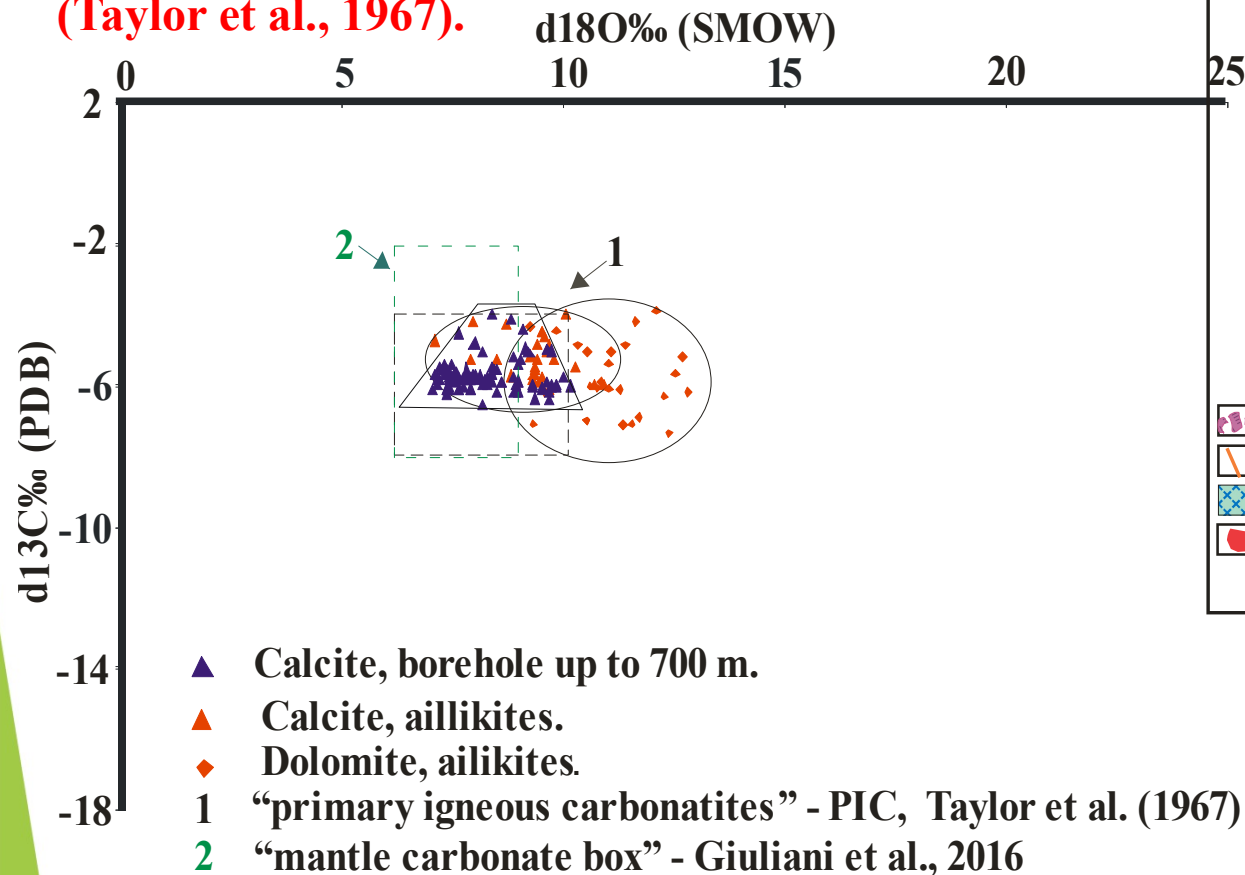
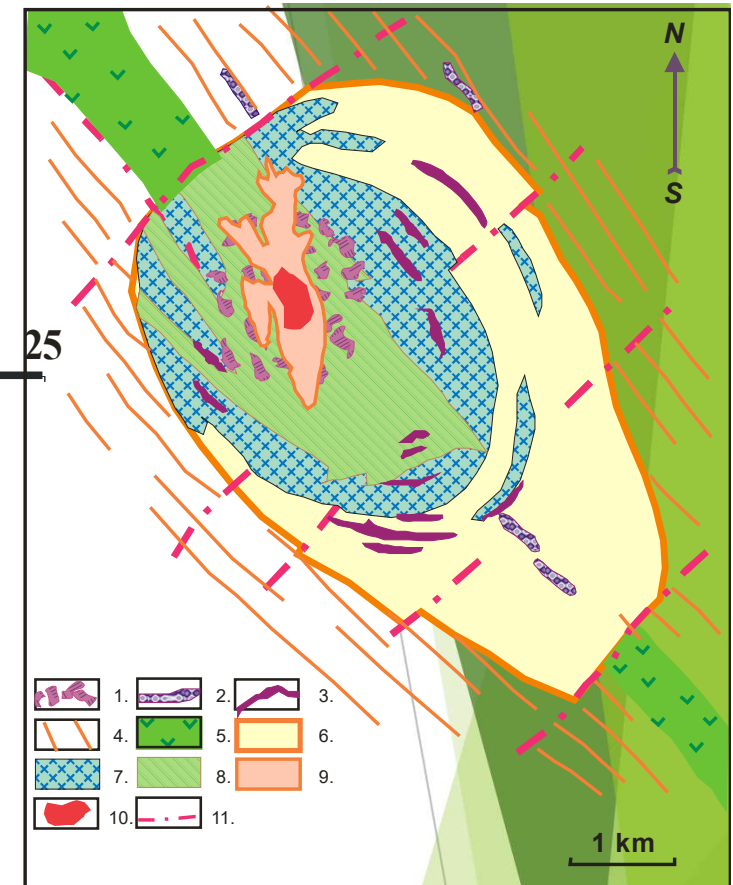
aillikite breccia rocks from, Beloziminsky massif



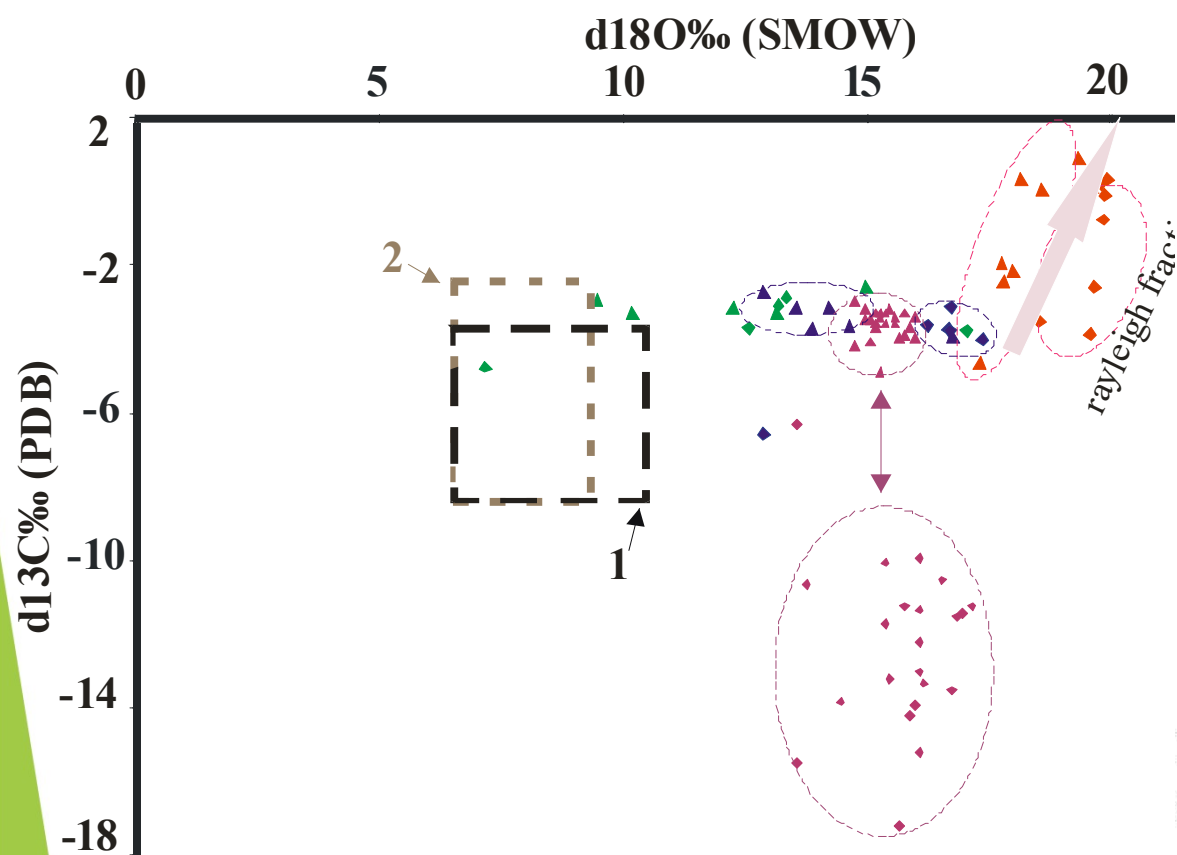


**Scanned images of the
carbonatite
samples from
Beloziminsky massif**

Along with the study of K-Ar isotopic the system carried out studies of isotopes C and O in carbonates from the well. C and O isotopes of calcites are distributed in mostly within the PIC (Taylor et al., 1967).



The C and O isotopes in carbonates from the **BOREHOLES** of carbonatites of the Tomtor complex showed a wide scatter. The C and O isotopes of calcites and dolomites are located at a considerable distance from the PIC (Taylor et al., 1967).



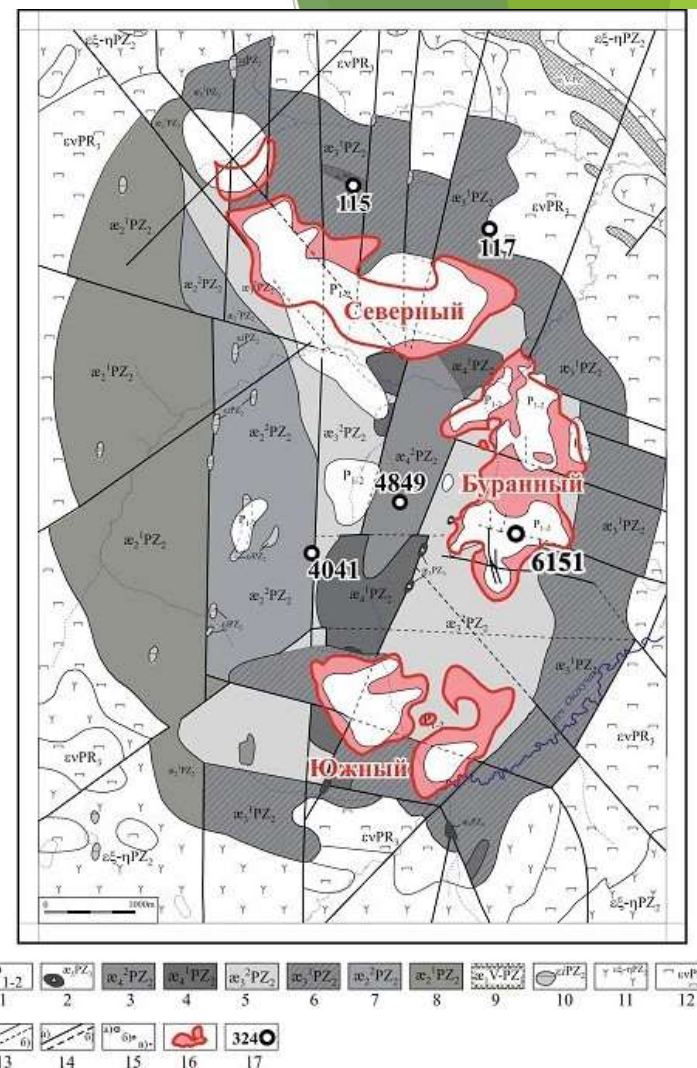
1 - “primary igneous carbonatites” - Taylor et al. (1967)

2 - “mantle carbonate box” - Giuliani et al., 2016

▲ - calcite, ◆ - dolomite, borehole 6151

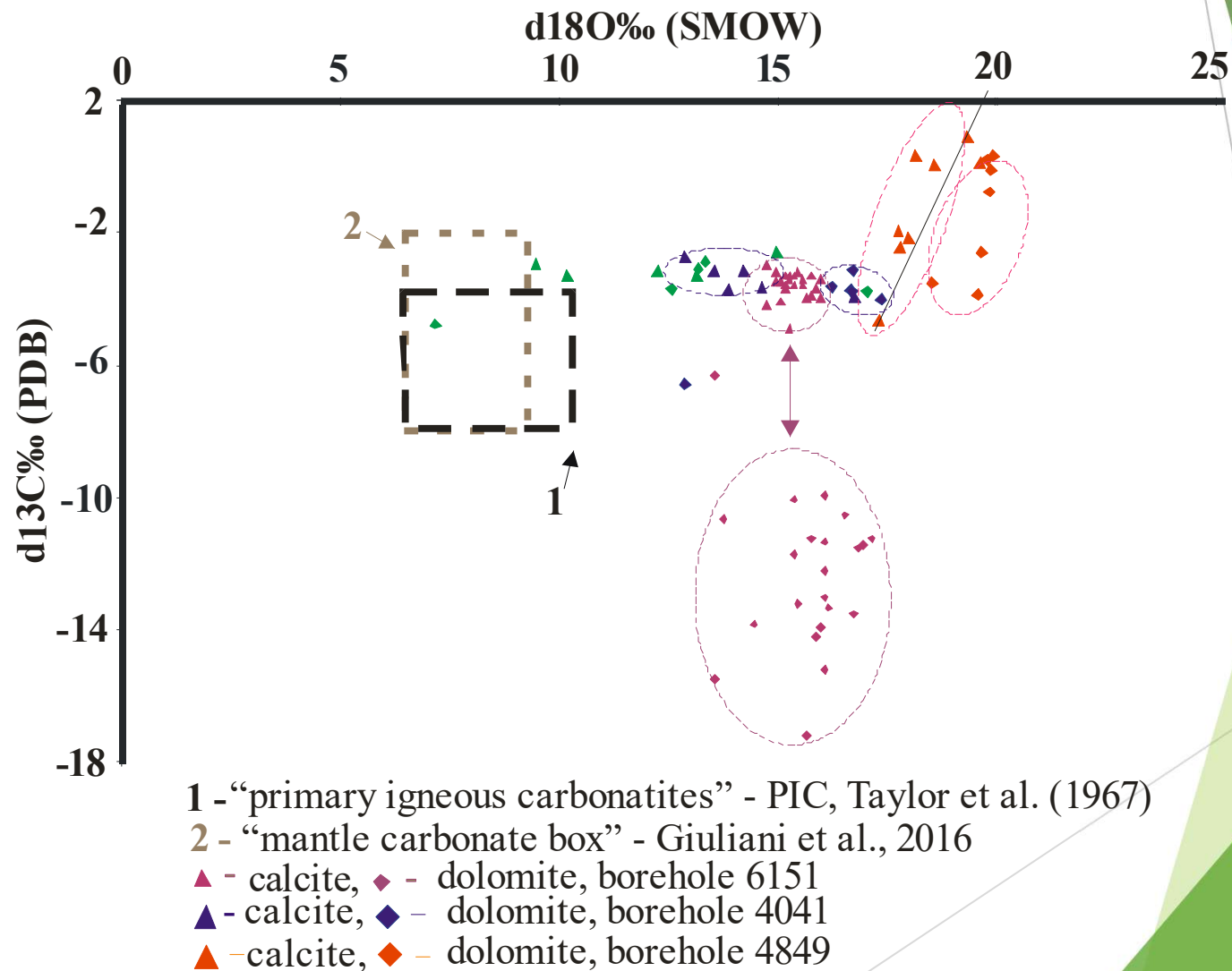
▲ - calcite, ◆ - dolomite, borehole 4041

▲ - calcite, ◆ - dolomite, borehole 4849



Schematic geological map of the central part of the Tomtor complex with the position of the discussed boreholes, designations are presented in Lazareva et al., 2015

Each borehole is characterized by an individual trend: the trend of well 4041 is horizontal with a slight negative slope, the trend of well 4849 is due to Rayleigh fractionation, the trend of the deepest well 6151 was formed under the influence of the interaction of carbonates with low-temperature fluids and with clear signs of the participation of organic matter .



Conclusions

The multistage nature of endogenous impulses in a carbonatite deposit is accompanied by hydrothermal and metasomatic processes that lead to dissolution-recrystallization of carbonates, and ultimately contributes to the concentration of ore matter.