In situ EMPA and SIMS investigation of mineral geochemistry of mantle xenoliths from Cerro Nemby (25°24' S, 57°32' W), Paraguay

(https://doi.org/10.5880/fidgeo.2022.038)

Mattia Bonazzi[1], Alberto Zanetti[1], Roberto Margutti[2], Maurizio Mazzucchelli[3], Riccardo Vannucci[2]

1. *Istituto di Geoscienze – C.N.R. U.O.S. of Pavia, Italy Country*
2. *Dipartimento di Scienze della Terra e dell'Ambiente, Università di Pavia, Pavia, Italyffiliation2, City, Country*
3. Dipartimento di Scienze Chimiche e Geologiche, Università degli Studi di Modena e Reggio Emilia, Modena, Italy

1. Licence

2. Citation

When using the data please cite:

Bonazzi, Mattia; Zanetti, Alberto; Margutti, Roberto; Mazzucchelli, Maurizio; Vannucci, Riccardo (2023): In situ EMPA and SIMS investigation of mineral geochemistry of mantle xenoliths from Cerro Nemby (25°24' S, 57°32' W), Paraguay. GFZ Data Services. https://doi.org/10.5880/fidgeo.2022.038

The data are supplementary material to:
Please add citation and DOI of the key paper/s

Table of contents

3. Data Description

3.1. Sampling method

Mantle xenoliths are hosted in lavas localized in the Nemby area (25°24' S, 57°32' W; Asunciòn-Sapucai-Villarrica graben, ASV, central Paraguay: Fig.1), where a small melanephelinitite plug (Cerro Nemby), with elliptical topography (800 x 500 m, about 100 m above the plain), contains very abundant mantle xenoliths (10-15% by volume of the plug) together with crustal xenoliths (Comin-Chiaramonti et al., 2001).

According to Le Bas (1987), lavas consist of nephelinite and subordinately of ankaratrite (CIPW Ab < 5 wt% e Ne > 20 wt%).

The average size of the mantle xenoliths (10-12 cm, max 45 cm, i.e. the largest observed in ASV) and the compositional range (lherzolite to dunite to pyroxenite) make these xenoliths particularly suitable for a study regarding metasomatic processe(s) affecting the Sub-Continental Lithospheric Mantle of central Paraguay.

The dunite results to be the most abundant xenolith type in such lavas. In-situ geochemical characterization was performed on silicates and glasses from very fresh xenoliths, which document a large variety of rock types. Five samples were investigated, namely: i) dunite 3209; ii) spinel harzburgite 3284; iii) spinel lherzolite 3293; iv) olivine websterite 3253 and v) olivine clinopyroxenite 3270. The analyses were directly carried out on thin petrographic sections (30 µm thick) of the selected samples.

Figure 1: Localization of the area of study, and position of Cerro Nemby, from which the mantle xenoliths were collected.

Dunite (3209) consists mainly of Ol (93 Vol.%), Cpx (5 Vol.%) and Spl (2 Vol.%). Olivine crystal has large size (up to 6 mm), whereas cpx and spl crystals are relative smaller size (1 and 3 mm, respectively). All olivine crystals show diffuse fractures and fluid inclusions. Larger olivine are also characterized by kink band. Inside the fractures of the olivine are filled by the olivine (Ol II) neoblasts. Clinopyroxene (cpx I) shows a “spongy” texture. We found clear evidence of embayed boundaries in the Spl crystals. The presence of melt pockets with neoblast of olivine (Ol II), euhedral clinopyroxene (cpx II) and rare spinel and phlogopite.

Spinel Lherzolite (3293) consists of Ol, Cpx, Opx and Spl. It shows protogranular texture, all crystals show millimeter sized. Large olivine has commonly fluid inclusion and fractures, these crystals show mostly wavy extinction and kink-band deformation. Opx and cpx have anhedral shape with spongy texture. Fluid inclusion trails are common in pyroxenes. Spinel crystal (up to 3mm) are interstitial showing embayed boundaries. We observed the presence of melt veins with small neoblast of olivine among the grain boundaries.

Spinel harzburgite (3284) consists of ol, opx, cpx and spl with protogranular texture. Olivine is present in two generations. Primary olivine (Ol I) appears as large crystals strongly fractured and deformed. It is common observed glass associated with primary olivine, which fill fracture or is present in pockets. Secondary olivine (Ol II) is locally present as melted pocket. It results weakly deformed and shows small size. Opx has large crystal with inclusions of secondary olivine. Cpx is present as primary (cpx I) and secondary (cpx II). Primary clinopyroxene has "spongy" texture whereas secondary clinopyroxene appears in the melted pockets. Spl shows resorbed rims.

Olivine websterite (3253) consists of opx, ol, cpx and spl. Opx has large fractured crystal with size up to 6 mm and are fully filled of many inclusions (fluid, spinel and secondary olivine). Opx has commonly exsolution of clinopyroxene. The presence of two olivine generations (ol I and ol II). Primary olivine is strongly fractured and strongly deformed (kink band) whereas secondary olivine has smaller size (< 2 mm). Cpx shows "spongy" texture with size up to 2 mm. Spinel appears as interstitial and inclusion.

Olivine clinopyroxenite (3270) is large vein that crosscut the peridotite (dunite). It consists of cpx, ol, opx and spl with coarse-grained size (up to 8 mm). Clinopyroxene contains inclusions of olivine, opx, spinel, oxides and fluid. Among Clinopyroxenes (cpx I), there is the presence of melted pockets with neoblast of clinopyroxene (cpx II). Olivine (ol I) shows large grain with kink band. Instead, the secondary olivine shows small neoblast in contact with the peridotite indicating the reaction between pyroxenite vein and host dunite. There are few opx crystals with lobate boundaries, which result strongly replaced by glass or reacted with cpx.

3.2. Analytical procedure

3.2.1. Electron microprobe

Major element analyses on olivine, clinopyroxene, spinel, apatite and glass were performed at the Dipartimento di Scienze della Terra, University of Modena using an ARL-SEMQ electron microprobe in wavelength-dispersive (WDS) mode. The analytical conditions were an accelerating potential of 15 kV with a beam current of 20 nA, and a focused spot size of about 4 µm. Natural silicate minerals and metallic Ni were used as standards. Counts were converted to weight percent (wt%) oxides using the PROBE software by J.J. Donovan (Advanced Microbeam 4217 °C, Kings Graces Road, Vienna, OH 44473, USA). Data accuracy is estimated to be 2-6%.

3.2.2. SIMS

In-situ trace elements analyses were carried out on clinopyroxenes, phlogopite (crystal and melted), plagioclase, K-feldspar using a Cameca IMS 4f ion microprobe located at CNR-IGG, Pavia, Italy. Analysis was performed on minerals placed on petrographic thin sections. Grains were selected on the basis of the absence of fractures and inclusions. Potassium, Sc, Ti, V, Cr, Rb, Sr, Y, Zr, Nb, Ba, La, Ce, Nd, Sm, Eu, Gd, Dy, Er and Yb concentrations were determined during the analytical runs. All the petrographic sections were platinum coated (Pt layer thickness ~400 Å) and sputtered with a 12.5-kV accelerated $^{16}O^-$ primary beam at ~9.5 nA current intensity. The ion beam was focus on the target surface to get 10–15 µm spot size. The analytical runs involved 10 cycles, with an overall 20-200 s counting time for the masses of unknown trace elements. ^{30}Si was used as internal standard, with 20 s counting time. REE and other trace elements of clinopyroxene were determined following the peak-stripping procedures described in by Bottazzi et al. (1994). Natural and synthetic samples were used as external standards. Accuracy and precision resulted better than ±10% at ppm concentration level.

4. File description

4.1. File inventory

The zipped folder “2022-038_Bonazzi-et-al_Data” contains all data files displayed as tables in Excel format and tab delimited txt files and the “2022-038_Bonazzi-et-al_Data-Description” as a pdf file.

- 2022-038_Bonazzi-et-al_Table1_Lithology_nemby.xlsx: mineralogical and textural information of the studied samples
- 2022-038_Bonazzi-et-al_Table2_EMPA_data.xlsx: List of EMPA major element chemical analyses expressed as oxide (wt%) and cation for formula units.
- 2022-038_Bonazzi-et-al_Table3_SIMS_data: List of SIMS trace element analysis.

4.1.1. 2022-038_Bonazzi-et-al_Table1_Lithology

Column header	**unit**	**Description**
Sample		Sample name
Lithology		Type of rocks
texture		Description of texture
Ol%	Vol.%	Amount of mineral
Opx%	Vol.%	Amount of mineral
Cpx%	Vol.%	Amount of mineral
Spl	Vol.%	Amount of mineral

4.1.2. 2022-038_Bonazzi-et-al_Table2_EMPA-data

Column header	unit	Description
Sample type		Type of rocks
session		Name of analytical sessions
section		Name of sections
grain		Name of analysis
Oxide Wt%		unit
SiO_2	Wt%	Content of element (expressed in oxide wt%)
TiO2	Wt%	Content of element (expressed in oxide wt%)
Al_2O_3	Wt%	Content of element (expressed in oxide wt%)
Cr_2O_3	Wt%	Content of element (expressed in oxide wt%)
FeOT	Wt%	Content of element (expressed in oxide wt%)
MnO	Wt%	Content of element (expressed in oxide wt%)
MgO	Wt%	Content of element (expressed in oxide wt%)
CaO	Wt%	Content of element (expressed in oxide wt%)
Na_2O	Wt%	Content of element (expressed in oxide wt%)
K_2O	Wt%	Content of element (expressed in oxide wt%)
total	Wt%	Sum of all element (wt%)
Oxygen atomic number		Number of oxygen used to recalculate the cation in the atomic formula
A.p.fu		title
Si		Number of cations for formula unit
Ti		Number of cations for formula unit
Al		Number of cations for formula unit
Cr		Number of cations for formula unit
Fe		Number of cations for formula unit
Mn		Number of cations for formula unit
Mg		Number of cations for formula unit
Ca		Number of cations for formula unit
Na		Number of cations for formula unit
K		Number of cations for formula unit
cations		Sum of all cations

4.1.3. 2022-038_Bonazzi-et-al_Table3_SIMS-data

Column header	unit	Description
Sample type		Type of rocks
session		Name of analytical sessions
section		Name of sections
phase		Name of analysed phase
SiO_2	Wt%	Internal standard
K	ppm	Concentration of trace element
Sc	ppm	Concentration of trace element
Ti	ppm	Concentration of trace element
V	ppm	Concentration of trace element
Cr	ppm	Concentration of trace element
Rb	ppm	Concentration of trace element
Sr	ppm	Concentration of trace element
Y	ppm	Concentration of trace element
Zr	ppm	Concentration of trace element
Nb	ppm	Concentration of trace element
Ba	ppm	Concentration of trace element
La	ppm	Concentration of trace element
Ce	ppm	Concentration of trace element
Nd	ppm	Concentration of trace element
Sm	ppm	Concentration of trace element
Eu	ppm	Concentration of trace element
Gd	ppm	Concentration of trace element
Dy	ppm	Concentration of trace element
Er	ppm	Concentration of trace element
Yb	ppm	Concentration of trace element

5. References

Bottazzi P., Ottolini L., Vannucci R., Zanetti A. (1994). An accurate procedure for the quantification of Rare Earth Elements in silicates. In: Secondary Ion Mass Spectrometry, SIMS IX proceedings, edited by A. Benninghoven, Y. Nihei, R. Shimizu, H. W. Werner, John Wiley & Sons Ltd, pp. 927-930.

Comin-Chiaramonti P., Princivalle F., Girardi V.A.V., Gomes C.B., Laurora A. and Zanetti A. (2001). Mantle xenoliths from Nemby, Eastern Paraguay: 0-Sr-Nd isotopes, trace elements and crystal chemistry of hosted clinopyroxenes. Per. Mineral. (2001), 70, 2, 205-230

Le Bas, M. J. (1987). Nephelinites and carbonatites. Geological Society, London, Special Publications, 30(1), 53-83.