Linking plagioclase composition and Instrumental Mass Fractionation (IMF) to correct confidently oxygen isotope composition of plagioclases at the ion microprobe

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The determination of the oxygen isotope composition in plagioclases using an ion microprobe is a challenge due to the compositional zoning and to the mineralogical replacement processes (i.e. albitization) that frequently affect single plagioclase crystals. The establishment of a relation between plagioclase composition and Instrumental Mass Fractionation (IMF) can be useful to correct ion microprobe data obtained from the analysis of plagioclases, especially when the composition of the used standard is not strictly close to the composition of the studied plagioclase. Surprisingly, studies dealing with this problem are rare (Kita et al. 2007; Winpenny and Maclennan, 2014).

To determine this relation, plagioclase standards covering the whole compositional range from albite to anorthite have been selected for our study. Oxygen isotope composition has been determined by fluorination (Table 1) and by ion microprobe analyses. Data have been processed in order to obtain a graph showing the variation of IMF versus anorthite content of plagioclases (Figure 1).

The session was performed between 22 and 25 July 2014 using the CAMECA IMS 1280HR2. The analyses were carried out on eight plagioclase standards of different localities covering a compositional interval from anorthite (An_{95}) to albite (An_{7}) (Table 1).

***Table 1**. Chemical and isotopical composition (determined by fluorination) of the standards used in the study. The standards are classified in the Valentí Masachs Geology Museum (Manresa, Spain) under the reference shown in this table.*

MINERAL	REFERENCE	LOCATIOIN	Ab	An	Or	$^{18}O/^{16}O$
ALBITE	4488	Hybla, Ontario (Canada)	92	7	1	0.00202472
ALBITE	TCWAR 002	Bancroft, Ontario (Canada)	93	6	0	0.00202966
OLIGOCLASE	TCWAR 005	Madawaska, Ontario (Canada)	77	21	2	0.00201523
ANDESINE	TCCLB001	Congo	49	48	3	0.00201944
LABRADORITE	4522	Labrador (Canadà)	44	53	3	0.00202024
LABRADORITE	TCWAR 004	Lake County, Oregon (USA)	34	65	1	0.00202014
BYTOWNITE	TCWAR 006	Beaver Bay, Minnesota (USA)	23	76	1	0.00201894
ANORTHITE	TCEXC001	Miyake Island, Japan	5	95	0	0.00202505

To determine the IMF of the standards at similar conditions only analyses performed at deflector values (LT1X, LT1Y and CAY) ranging from -25 to +75 were used (Figure 1). Due to this restriction one albite, one labradorite and the bytownite were excluded from the results.

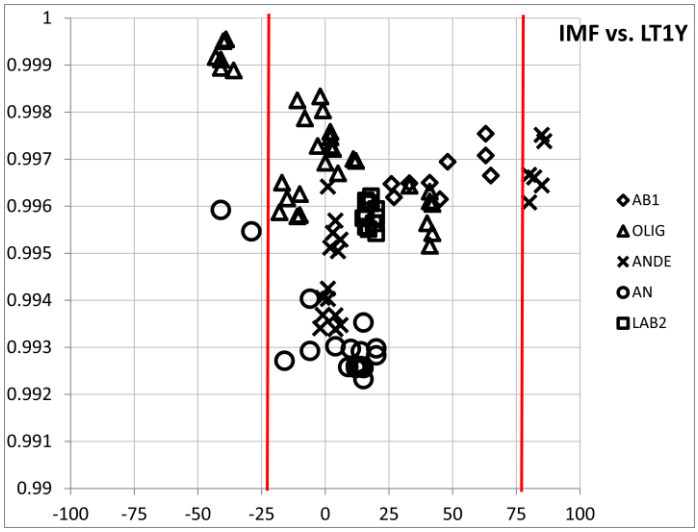

***Figure 1**. Graphic illustrating the interval of the LT1Y deflector used to determine IMF. This process has been also done for LT1X and CAY.*

According to that, the IMF for each standard was calculated as:

$$IMF\ (\alpha\ ratio) = \frac{(^{18}O/^{16}O_{\text{ion probe}})}{(^{18}O/^{16}O_{\text{ fluorination}})}$$

The ratio $^{18}O/^{16}O$ was determined by laser fluorination at the Universidad de Salamanca (Spain). The extreme IMF values were 0.996669 in the An_7 and 0.993176 in the An_{95}. In per mil notation, this range is equivalent to about 3‰ (Figure 2). The Pearson's correlation coefficient ***r*** is **-0.941**, suggesting a high linear correlation between IMF and the plagioclase composition. The best fitting on a line is attained by the following equation:

$$\mathbf{y = -2{\cdot}10^{-07}x^2-2{\cdot}10^{-05}x+0.996,}\ (R^2=0.905),$$

this can be considered as an almost straight line from a practical point of view.

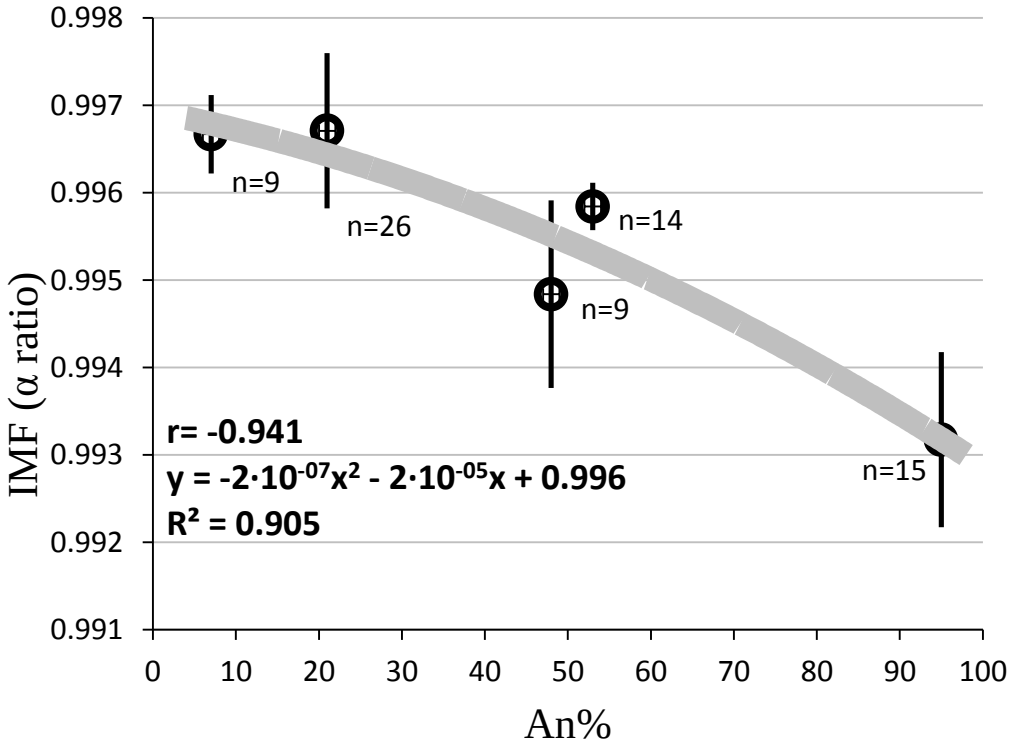

Figure 2*. Proposal of regression line for the plagioclase standards composition and the IMF (α ratio). Error bars represent standard deviation.* ***n*** *is the number of used points for calculation;* ***r*** *is Pearson's lineal correlation coefficient;* ***y*** *is Best fitted equation and* $\boldsymbol{R^2}$ *is best fitting coefficient.*

Currently, the chemical composition (EMPA) and the oxygen-isotope composition (obtained by laser fluorination) of additional plagioclase standards are in process in order to improve the statistics of the correlation and regression between the oxygen-isotope IMF and the plagioclase composition. Subsequently the results will be used to analyse the isotopic composition of primary and albitized granites of the Variscan basement.

References:

Kita, N., Ushikubo, T., Fu, B., Spicuzza, M., Valley, J., 2007. Analytical developments on oxygen three isotope analyses using a new generation ion microprobe IMS-1280. Lunar Planet. Sci. XXXVIII, 1–2.

Winpenny, B., Maclennan, J., 2014. Short Length Scale Oxygen Isotope Heterogeneity in the Icelandic Mantle: Evidence from Plagioclase Compositional Zones. J. Petrol. 55, 2537–2566.