

# Significant variability in the $\delta^{44/40}\text{Ca}$ of global carbonatites: implications for carbonate recycling, magma differentiation and source-mantle mineralogy

Anupam Banerjee ([anupam.gg.2006@gmail.com](mailto:anupam.gg.2006@gmail.com))<sup>1</sup>, Ramananda Chakrabarti<sup>1</sup> and Antonio Simonetti<sup>2</sup>

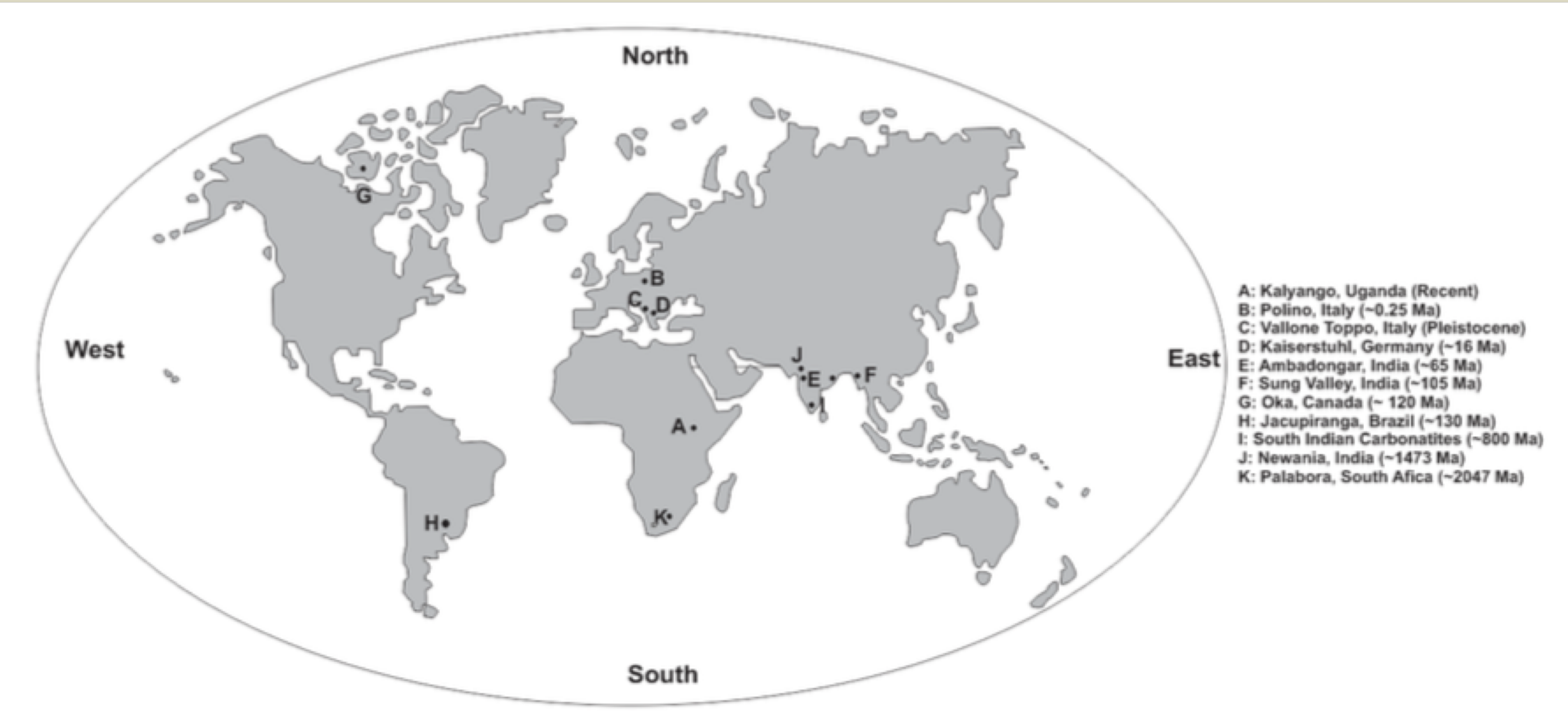
<sup>1</sup>Centre for Earth Sciences, Indian Institute of Science, Bangalore, India

<sup>2</sup> Department of Civil and Environmental Engineering and Earth Sciences, University of Notre Dame, USA

## Introduction

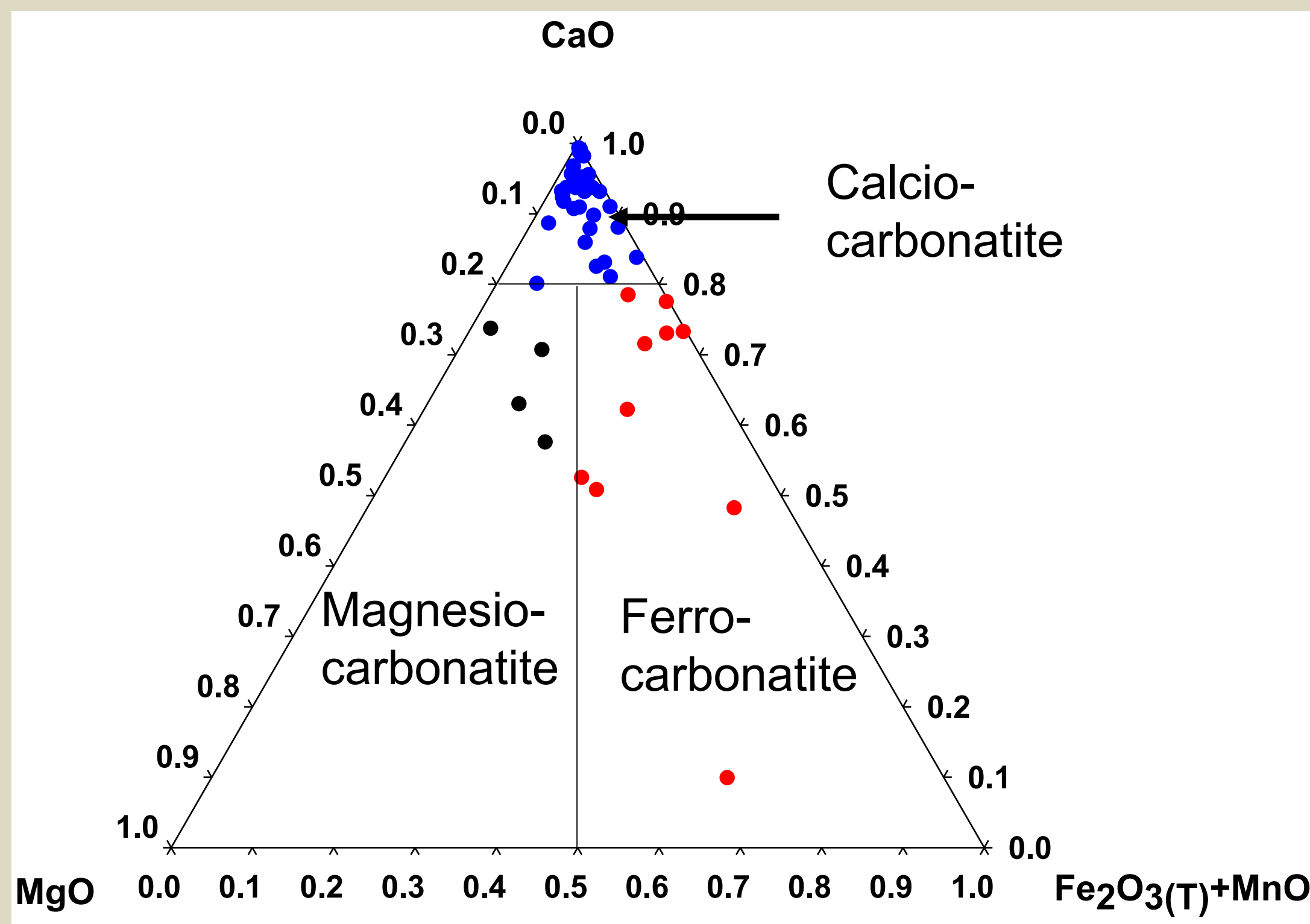
Stable Ca isotopic compositions ( $\delta^{44/40}\text{Ca}_{\text{SRM915a}}$ ) of crustal carbonates are typically lighter (typically 0.2 ‰ or lower, [Huang et al., 2011](#); [DePaolo, 2004](#)) than the bulk silicate Earth (BSE) or upper mantle compositions (0.94-1.05 ‰) ([Huang et al., 2010](#), [Kang et al., 2017](#), [DePaolo, 2004](#)). Carbonatites are unique igneous rocks with more than 50% modal carbonate minerals. Hence, these unique igneous rocks provides ideal opportunity to study the role of recycled carbonates in their mantle sources. In this study, we report major, trace element concentrations and Ca-Sr isotopic compositions of WR-carbonatites of different ages (from the Precambrian to recent) and exposed in different geographical locations of the world to understand their origin as well as explaining the reason of variability of  $\delta^{44/40}\text{Ca}$  in such unique igneous rock types.

## Sampling of carbonatites: location and ages



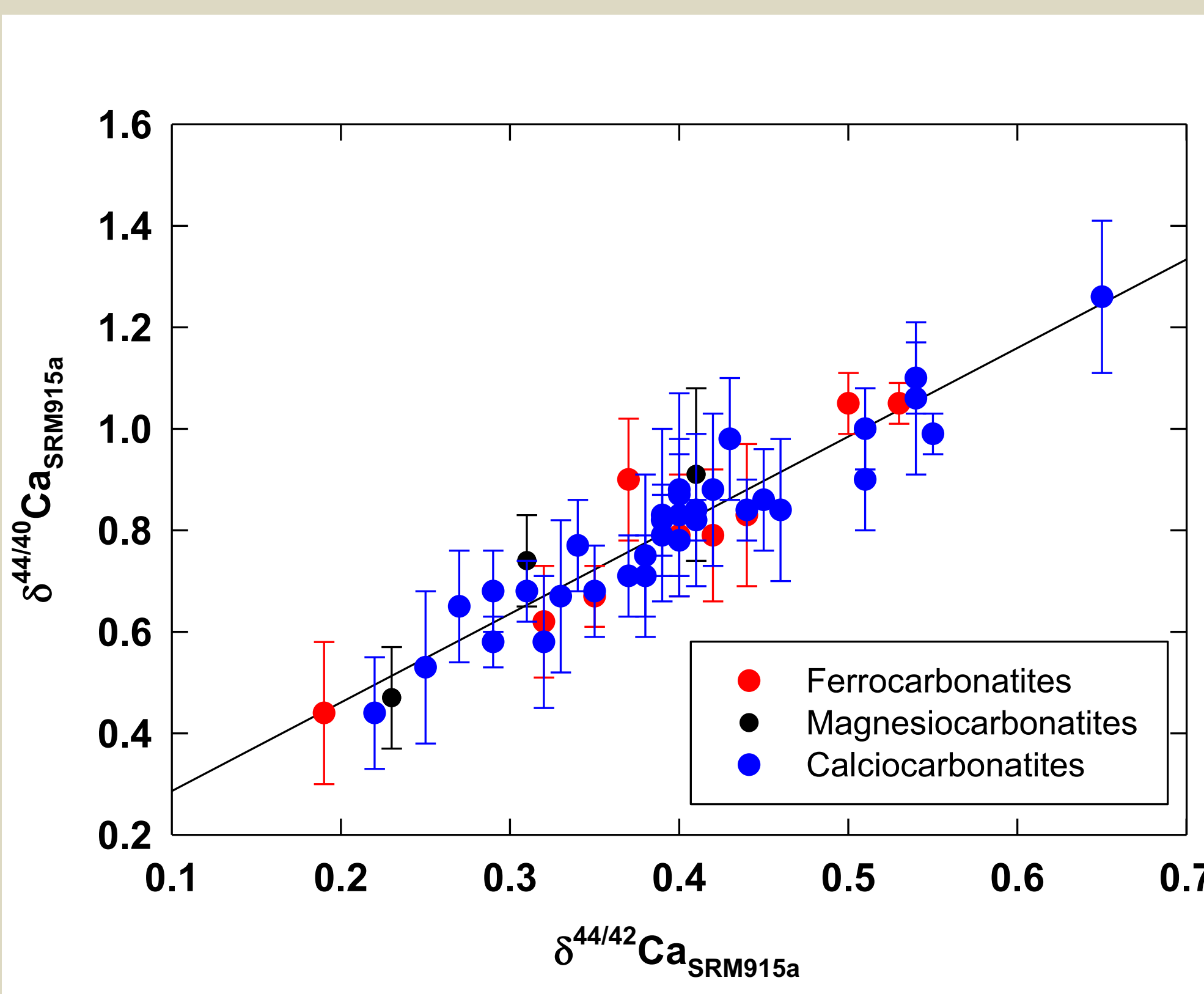
**Figure 1.** Geographic locations of the carbonatites ( $n = 46$ ) analysed in the present study with their eruption ages.

## Classification of carbonatites



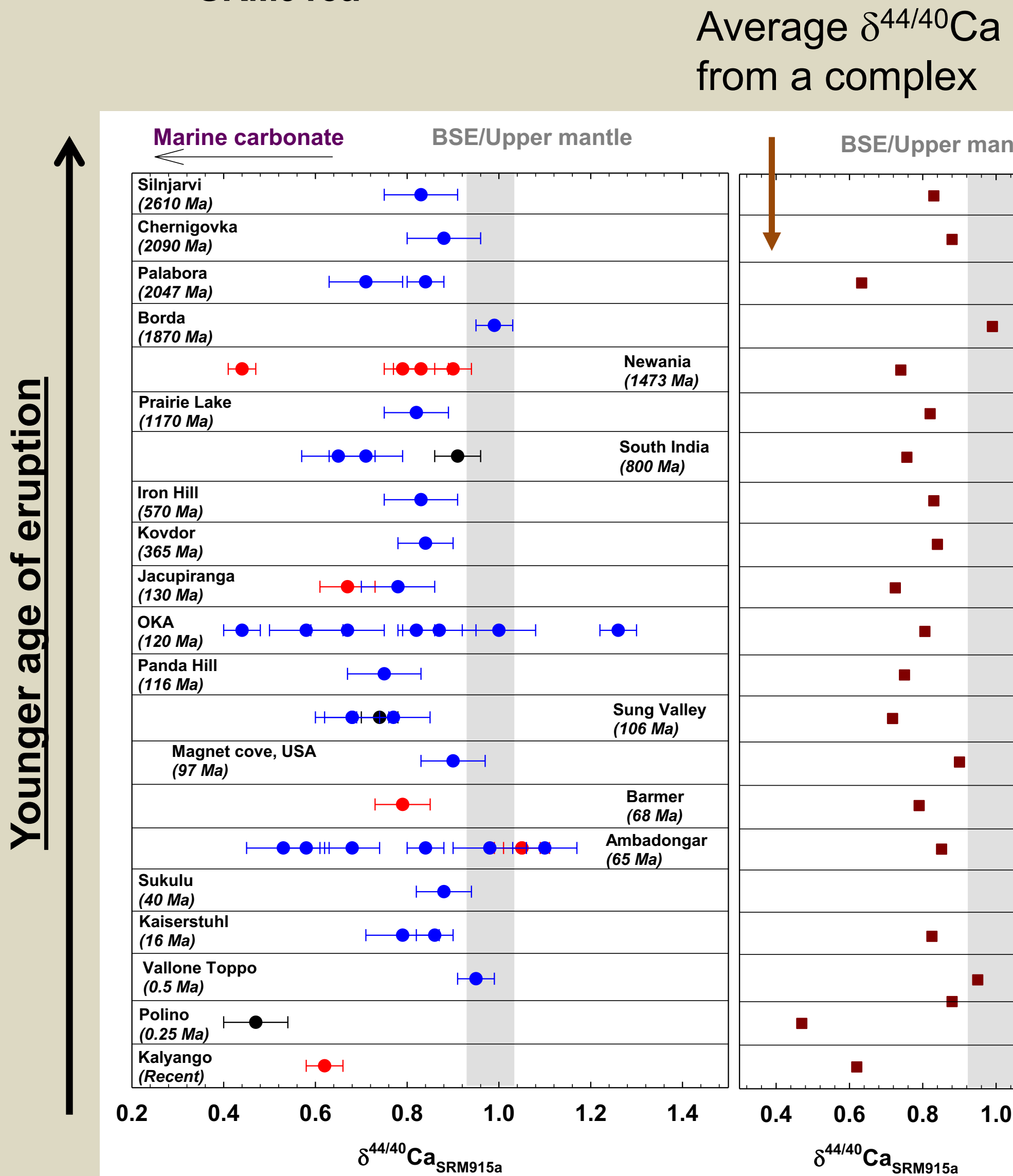
**Figure 2.** Most of the studied global carbonatites analysed are calcio-carbonatites while few carbonatites plot in the ferro-carbonatite and magnesio-carbonatite domains.

## Mass-dependent isotopic fractionation



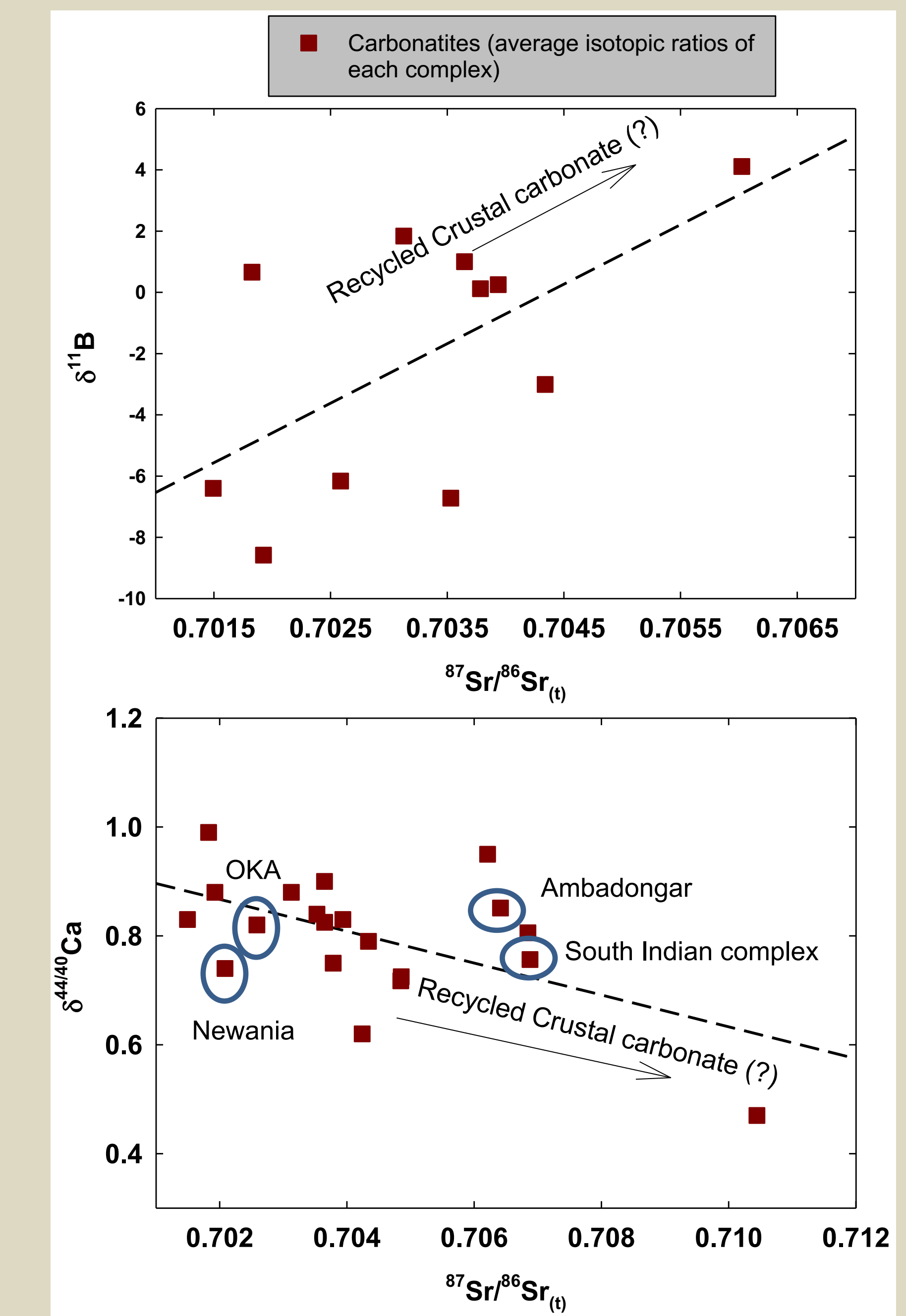
**Figure 3.** Plot of  $\delta^{44/40}\text{Ca}$  versus  $\delta^{44/42}\text{Ca}$  of global WR carbonatites. All the carbonatites plot on the theoretical mass dependant fractionation line. External precision for  $\delta^{44/40}\text{Ca}$  is better than 0.08 ‰ ([Mondal and Chakrabarti, 2018](#)).

## $\delta^{44/40}\text{Ca}_{\text{SRM915a}}$ of global carbonatites



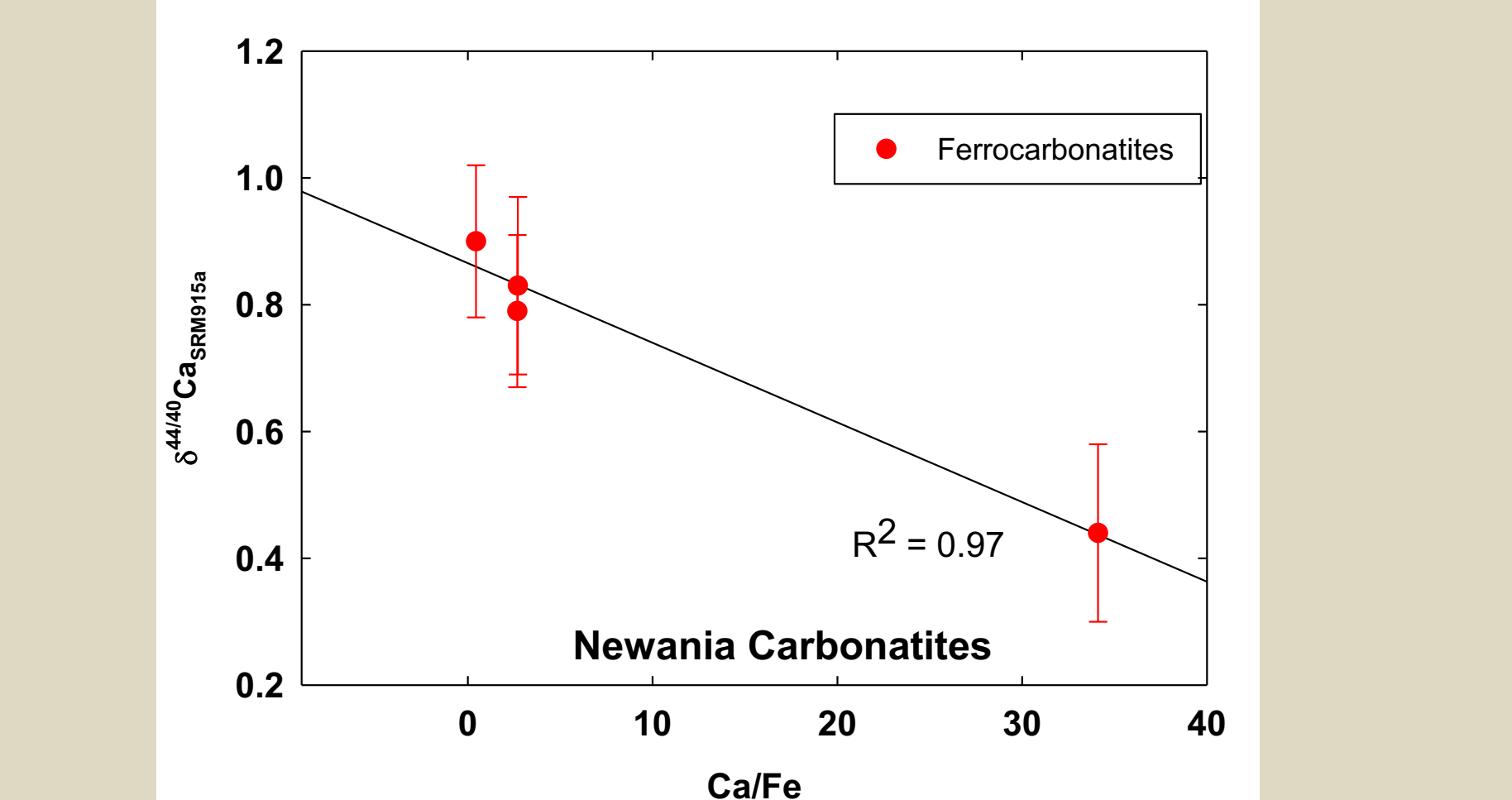
**Figure 4.** (a) Plot of  $\delta^{44/40}\text{Ca}$  (0.35-1.26 ‰,  $n = 46$ ) of global carbonatites. No apparent variation in  $\delta^{44/40}\text{Ca}$  has been observed with their corresponding eruption ages.

## $\delta^{44/40}\text{Ca}$ , $\delta^{11}\text{B}$ and $^{87}\text{Sr}/^{86}\text{Sr}_{(t)}$ of global carbonatites



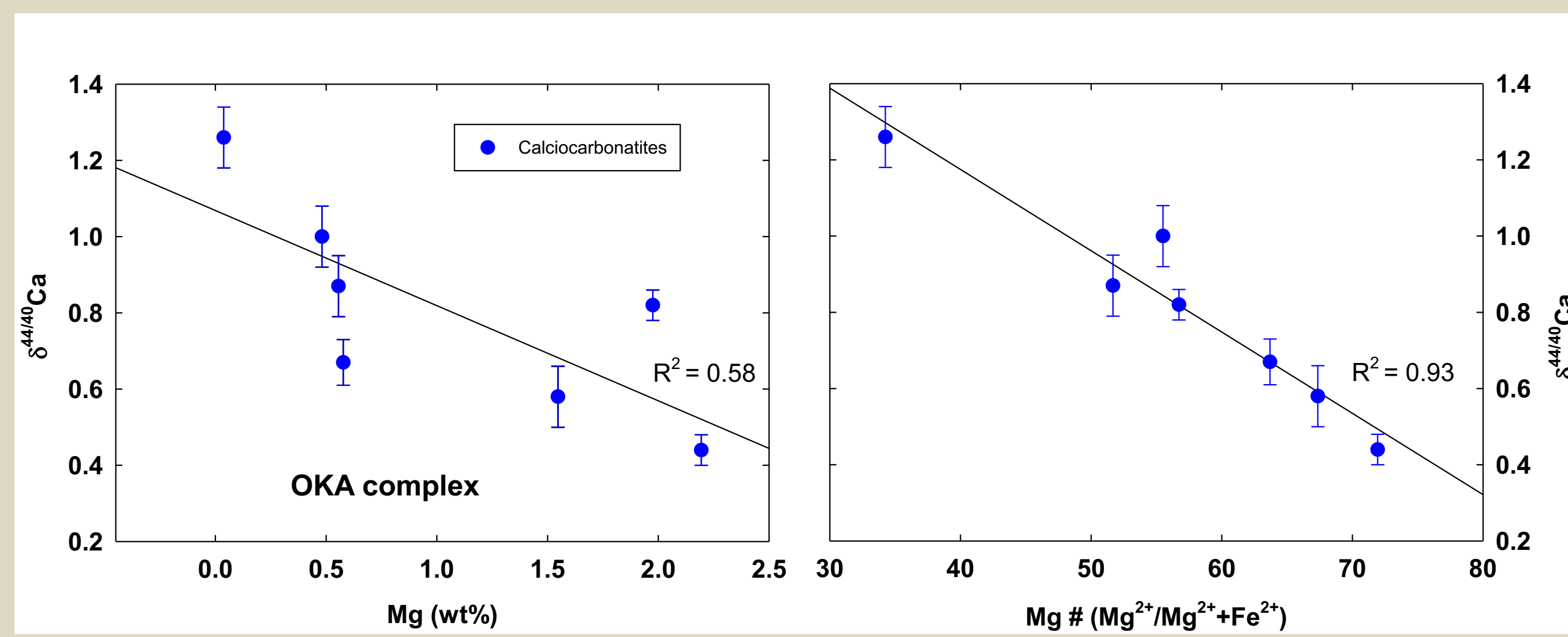
**Figure 5.** Plot of  $^{87}\text{Sr}/^{86}\text{Sr}_{(t)}$  versus  $\delta^{11}\text{B}$  (top panel) and  $\delta^{44/40}\text{Ca}$  of whole rock carbonatites from multiple carbonatite complexes. Average values are plotted for carbonatites complexes reporting multiple whole rock analyses. B isotopic compositions ( $n = 17$ ) are reported in [Hulett et al., 2016](#).

## Newania carbonatite complex



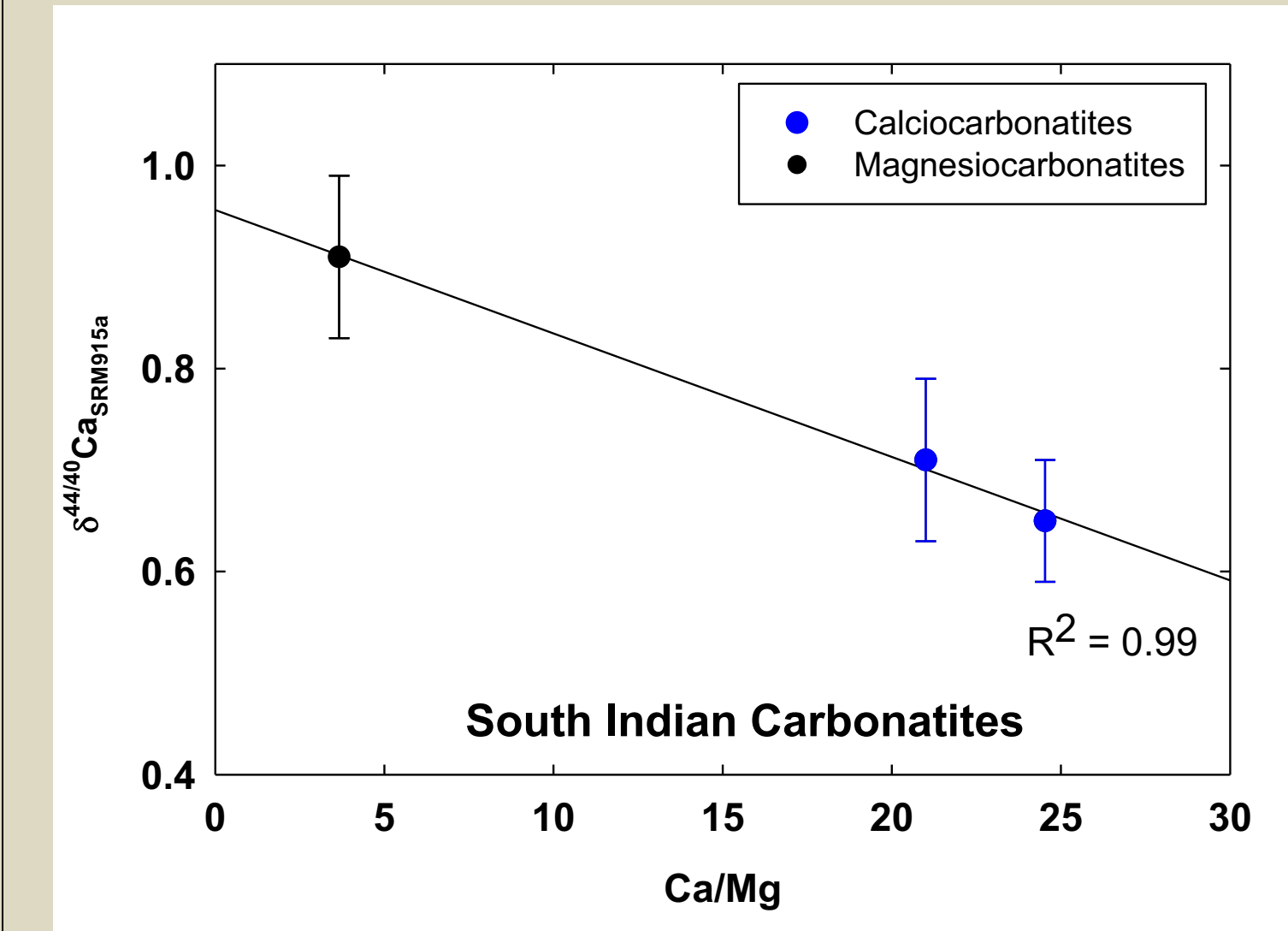
**Figure 6.**  $\delta^{44/40}\text{Ca}$  of Newania carbonatites ( $n = 4$ ) varies with Ca/Fe content. This could indicate that  $\delta^{44/40}\text{Ca}$  of carbonatites can vary with **mineralogical compositions**.

## OKA carbonatite complex, Canada (~120 Ma)



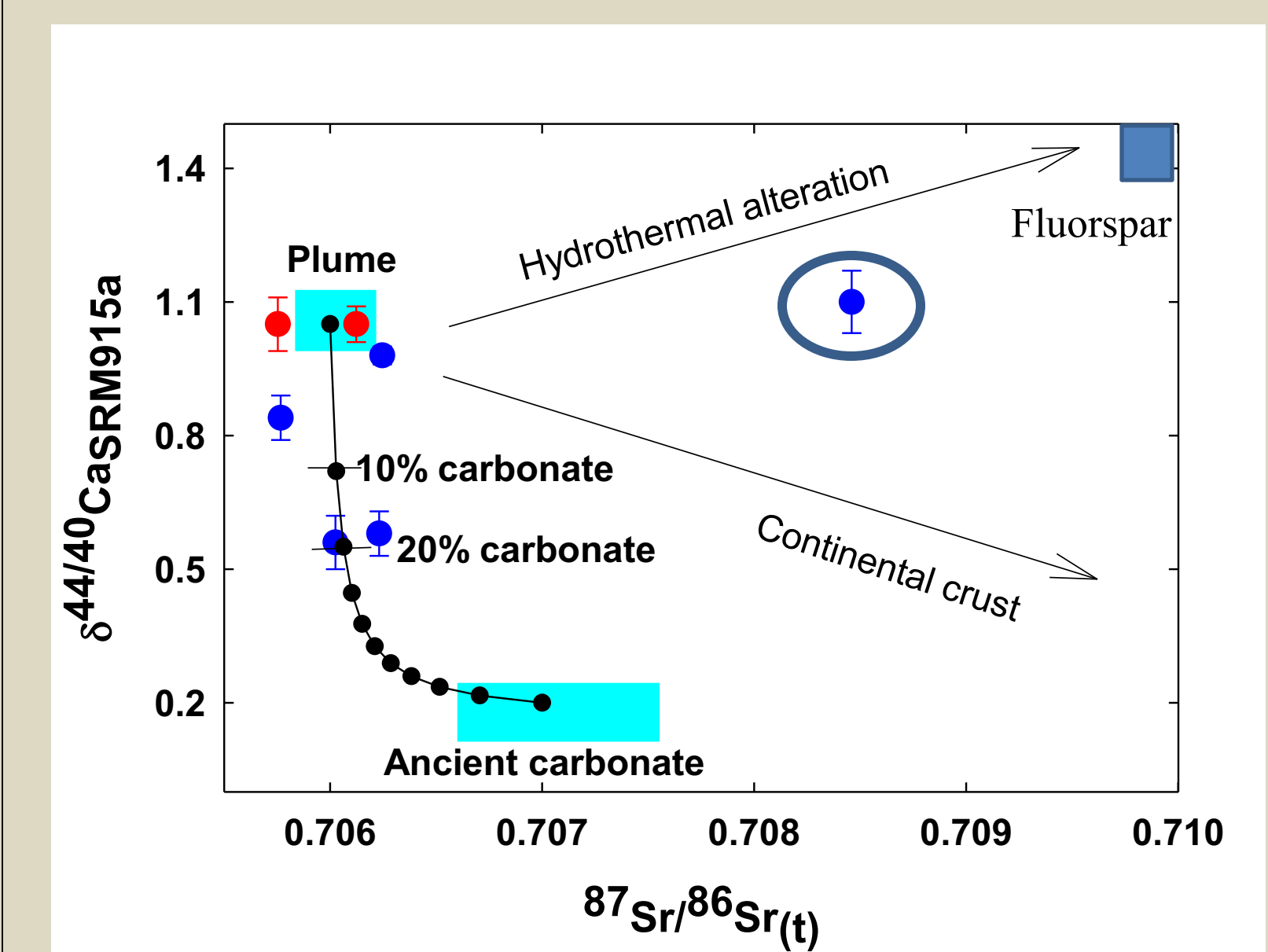
**Figure 7.**  $\delta^{44/40}\text{Ca}$  of carbonatites ( $n = 7$ ) from the OKA complex shows strong correlation with their Mg concentration and Mg #, thus indicating  $\delta^{44/40}\text{Ca}$  can vary depending on the **nature and degree of differentiation of the magma**

## South Indian Carbonatites (~800 Ma)



**Figure 8.**  $\delta^{44/40}\text{Ca}$  of carbonatites from the South Indian occurrences ( $n = 3$ ) shows strong correlation with their corresponding Ca/Mg ratios, which apparently indicates that  $\delta^{44/40}\text{Ca}$  of these carbonatites might be a function of their **mineralogical compositions**

## Ambadongar carbonatite complex, India (~65 Ma)



**Figure 9.** Large range of  $\delta^{44/40}\text{Ca}$  values of carbonatites ( $n = 6$ ) from the Ambadongar complex, India and their co-variation with  $^{87}\text{Sr}/^{86}\text{Sr}_{(t)}$  can be explained by **role of recycled carbonates** in the Reunion plume source. One carbonatite ( $n = 1$ ) shows effect of **hydrothermal alteration**

## Conclusions

(1) No variability of  $\delta^{44/40}\text{Ca}$  of global carbonatites with their age of eruption. (2) Variability in  $\delta^{44/40}\text{Ca}$  of carbonatites from a particular complex can vary as a result of (i) *presence of isotopically lighter ancient subducted carbonates in the mantle-source regions*, (2) *degree of differentiation of magma* and (3) *mineralogical compositions*. Hence, a comprehensive study of carbonatites from a particular complex is required to explain the variability in  $\delta^{44/40}\text{Ca}$  of these rocks