High Sensitivity Mapping of Melt Inclusions in Miocene Zircons of Central Anatolian Volcanic Province (CAVP), Cappadocia, Turkey

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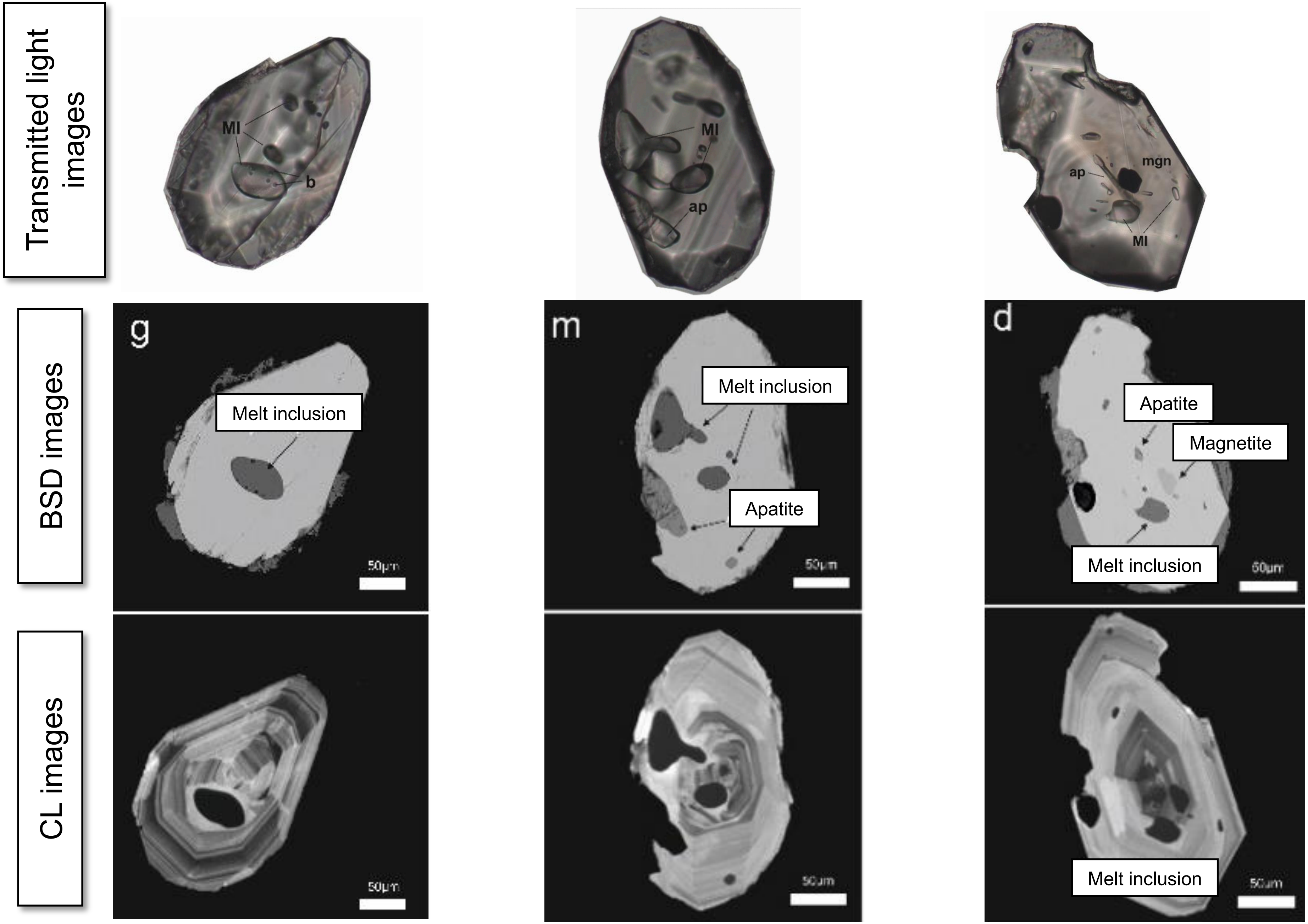
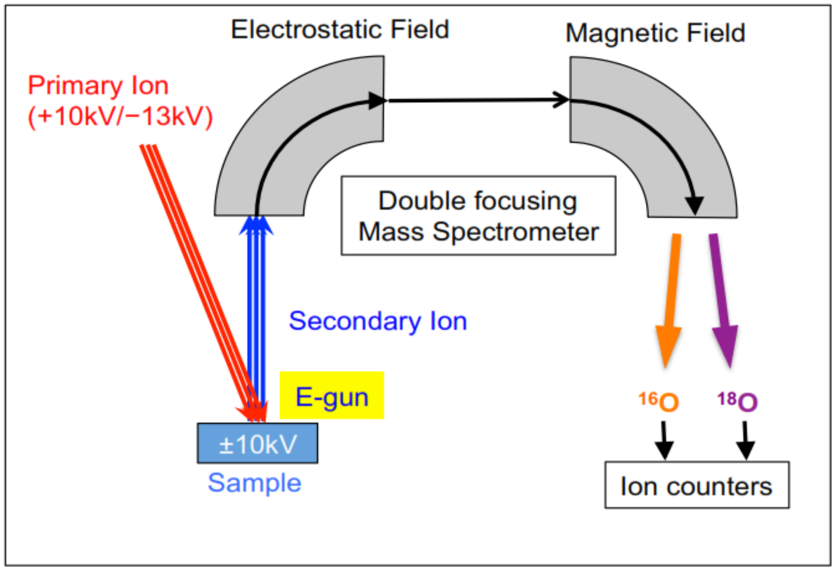
Characterization of melt inclusion

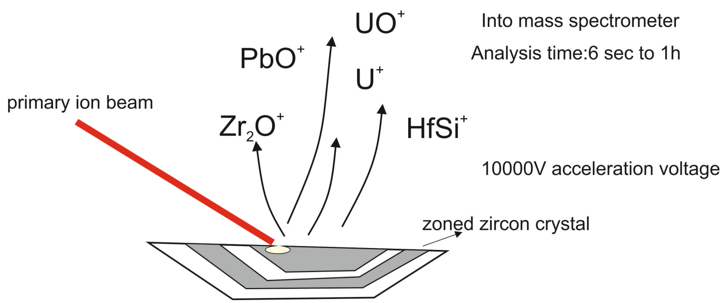


Analytical Methods

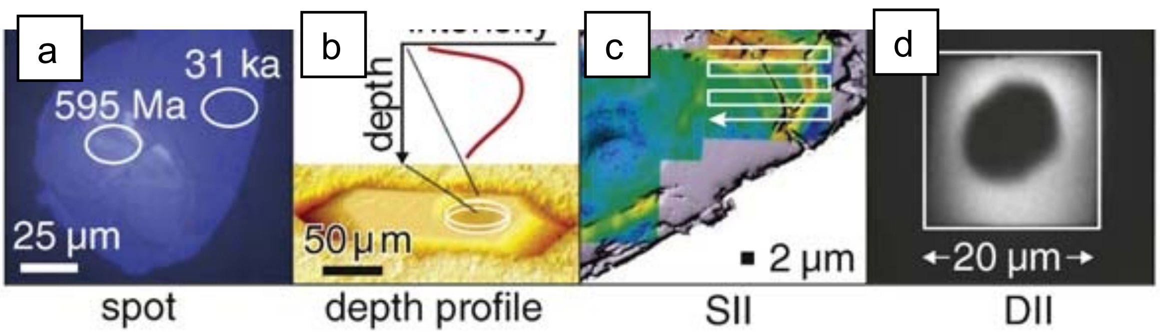
<u>Secondary Ion Mass Spectrometry (SIMS)</u>

- Trace element determination of zircon and melt inclusion by conventional spot analysis
- High sensitivity ion image mapping of melt inclusion smaller than 20 μm



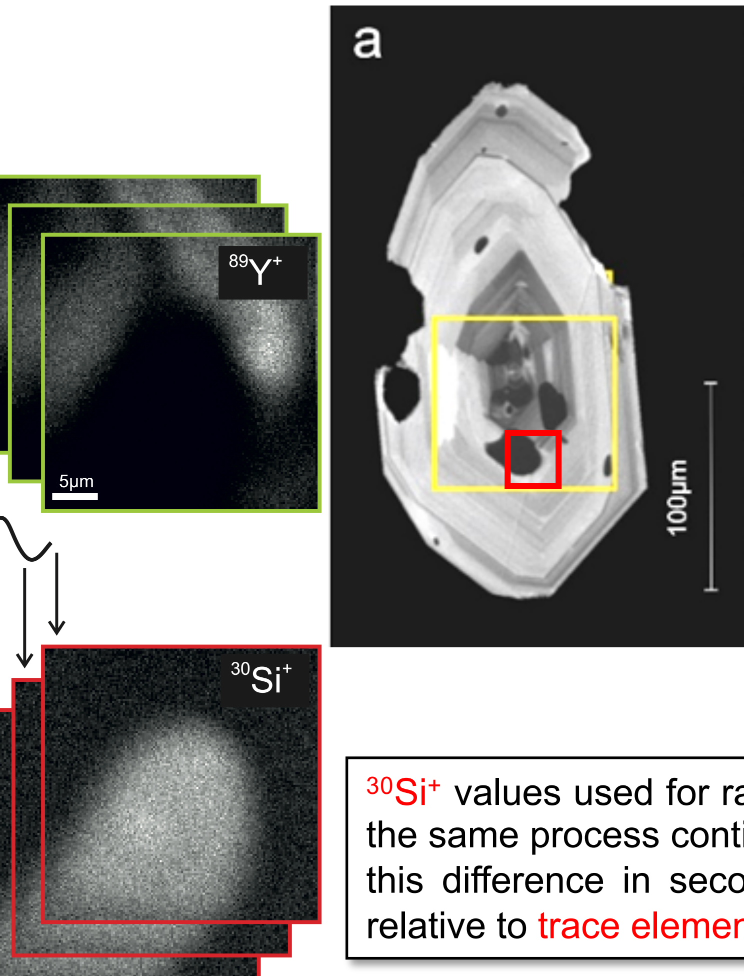


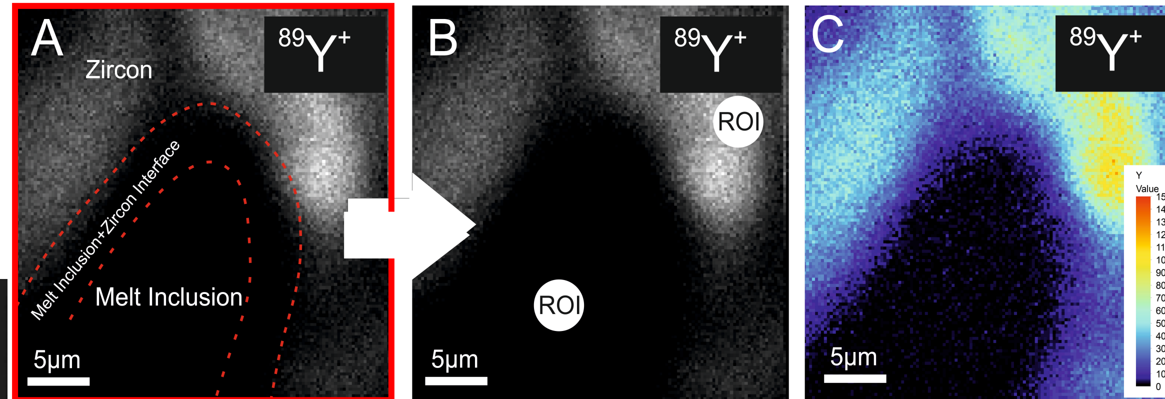
Schematic sketch illustrating the conventional technique for zircon mounting and mass spectrometer analysis (modified after Schmitt, 2015).



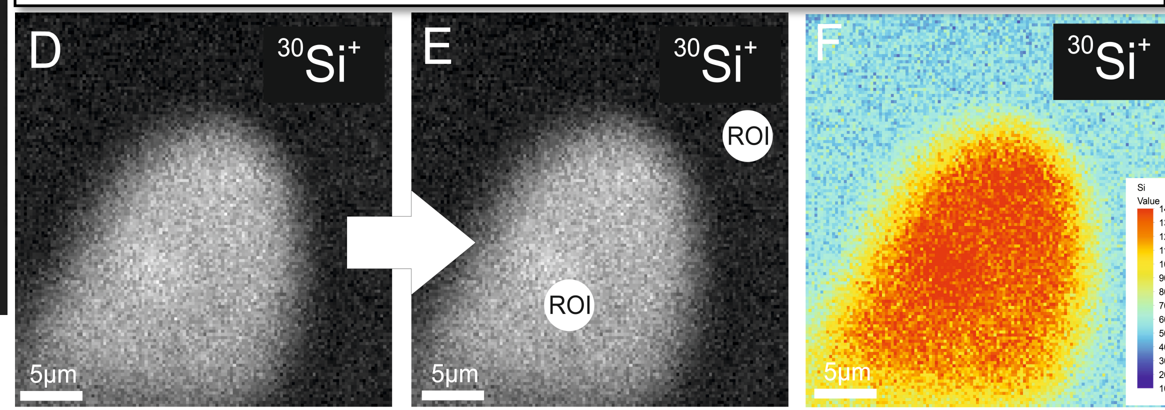
- 128x128 pixel image files containing raw intensities,
- Accumulation as single ion images by WINImage© processing program of Cameca-HR-IMS,
- Binary images containing grayscale values as raw intensities processed by ImageJ© .

Image processing for identification and quantification of melt inclusions



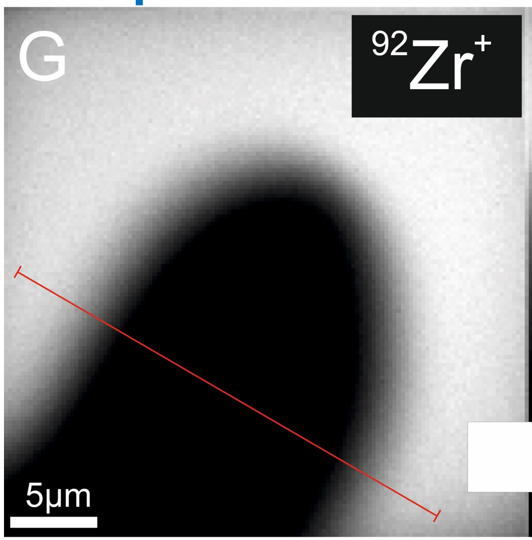


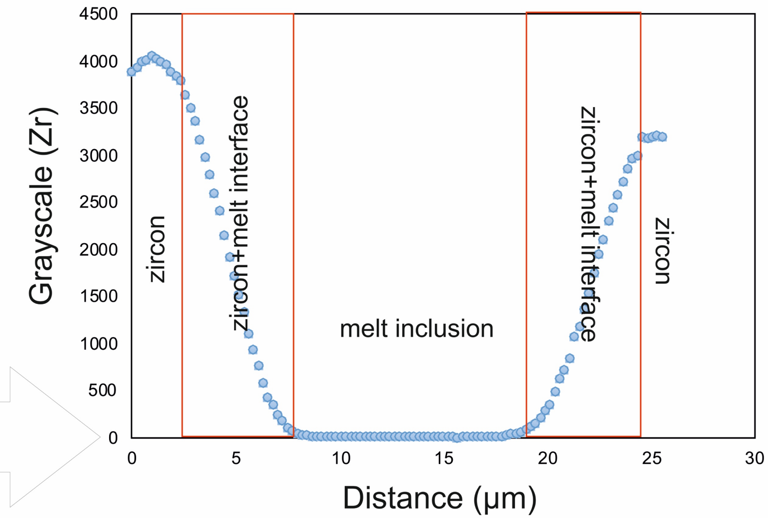
Raw intensity values from each accumulated images are calculated according to the selected region of interests (ROI; B) for both zircons and melt inclusions. Same procedure is applied to each trace elements.



$^{30}Si^+$ values used for rationing with the trace element species, are also calculated based on the same process continuously for each melt inclusion in the image processing. We attribute this difference in secondary ion yield to the systematic suppression of molecular $^{30}SiO^+$ relative to trace element species within the rastered area due to offset energy distributions.

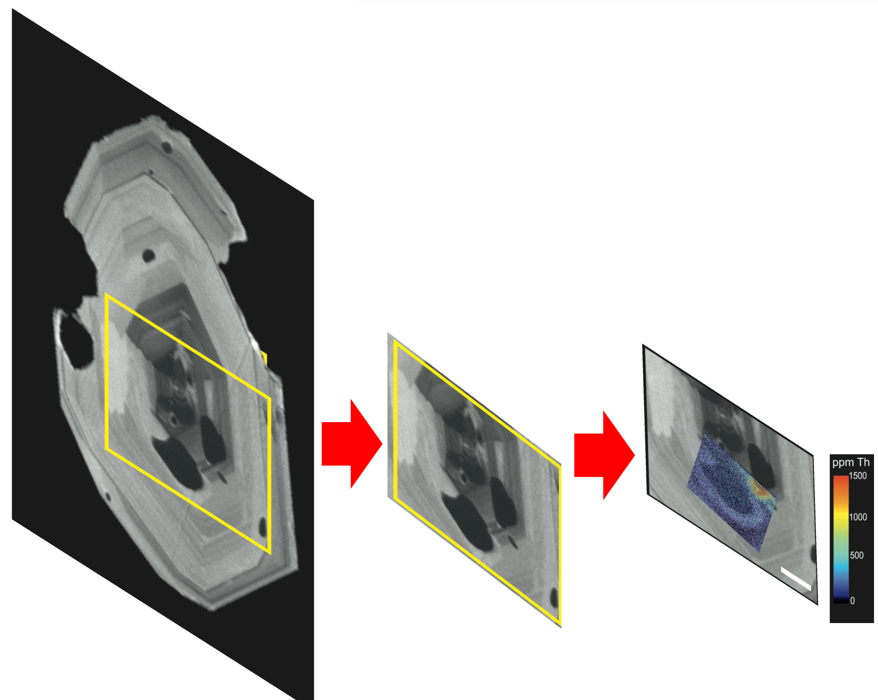
Image processing for identification and quantification of melt inclusions

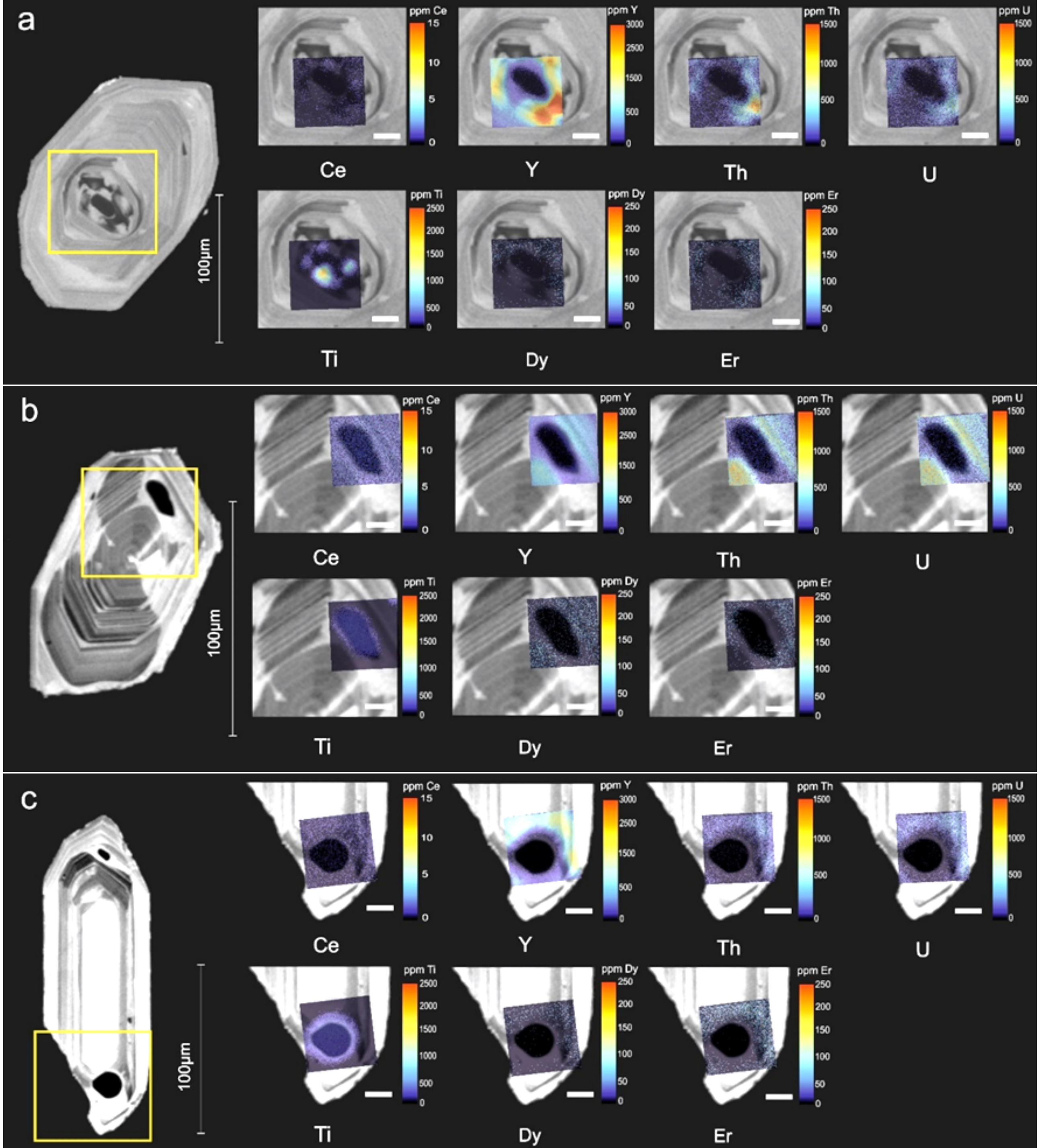




128x128 pixel grayscale images containing raw density data are imported into the ARCGIS©. Each element image was converted to a color coded scale expressing appropriate value ranges, and the data obtained on the same trace element for each zircon in different units was reduced to the same indicator values.

Before deciding where to draw ROI, we plot a line profile thorough the raster image of $^{92}Zr^+$ which includes both zircon and melt. Then from this line profile we can generate a graph that shows the exact location of melt inclusion, zircon and zircon+melt inclusion interface. The graph drawn according to the gray scale value of $^{92}Zr^+$ to distance (µm) also shows the approximate size of the melt and thickness of the interface.

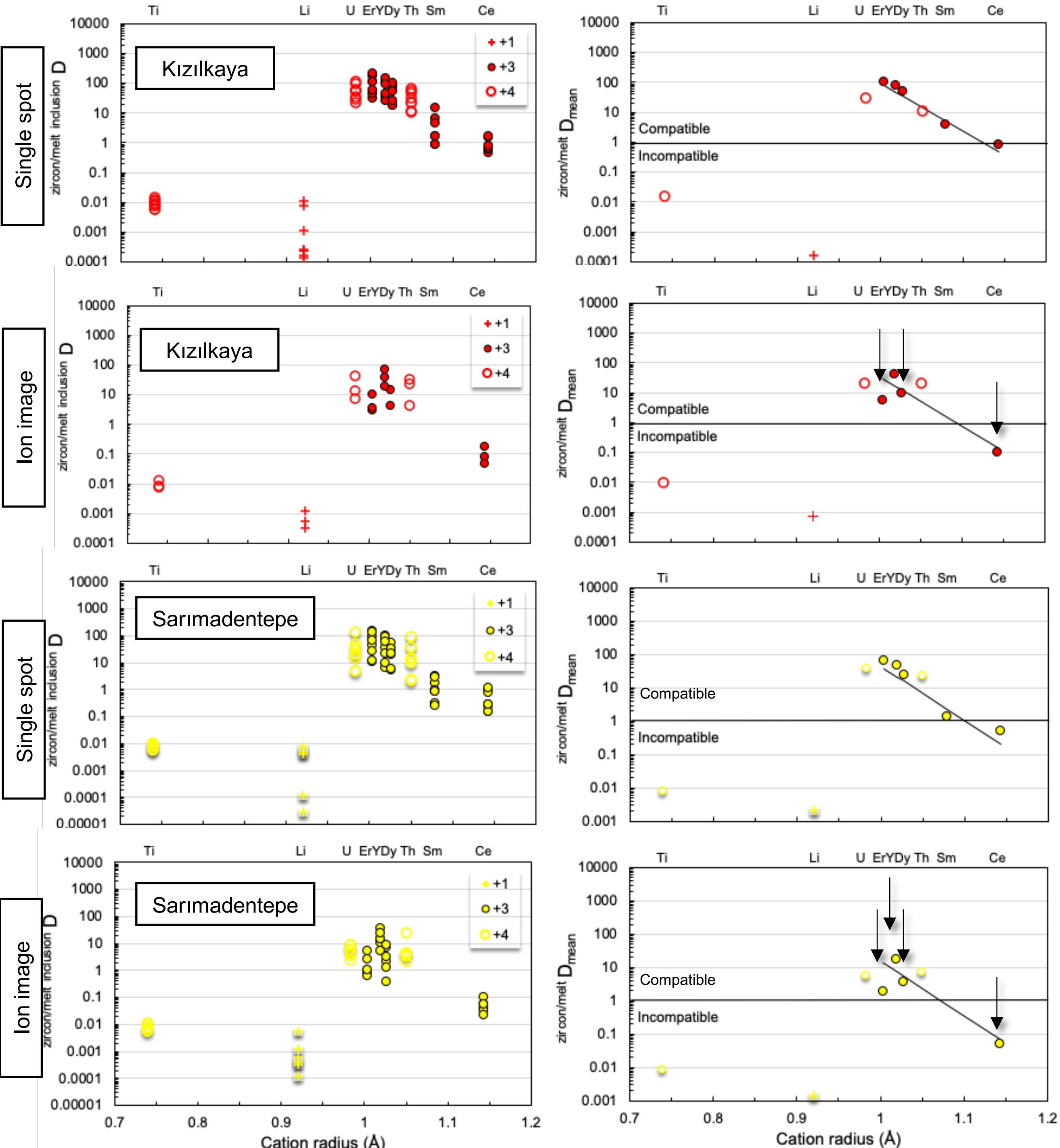




Y-rich areas of dark CL zonings (~ 2500-3000 ppm)

Th and U concentrations show high values in regions with high Y ion images (Th= ~ 1000 ppm; U= ~ 500 ppm), while ion images of Dy, Er and Ce elements do not present any pattern development due to zoning.

The dark CL zone, which developed immediately after the melt inclusion of the zircon showing sector zoning in the same unit, offers high values in terms of Y (<1000 ppm) and the elements of U, Th (~ 1000 ppm) follow the same zoning pattern.



The partition coefficient values calculated for the zircon/melt inclusion pairs of single spot and ion image analysis show a parabolic form in the plotted graph of the cationic group in a zircon crystal lattice structure against the ionic radius.

$$D_i = D_o \exp \frac{-4\pi E\,[\frac{r_o}{2}(r_i - r_o)^2 + \frac{1}{3}(r_i - r_o)^3]}{RT}$$

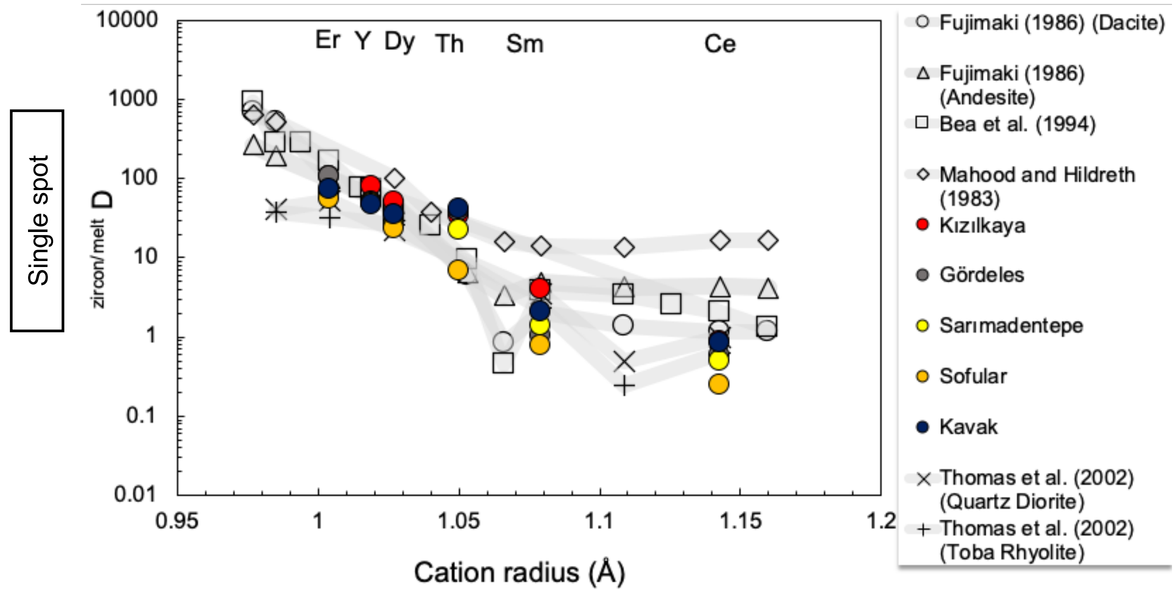
Brice (1975) ve Blundy ve Wood (1994)

r_i ve r_o ($r_o = r_{zr} = 0.84$ Å) Shannon (1976),
T: Ti in zircon temperature,
For D_0 values, partition coefficient of the melt inclusion of the zircons for each unit used,
(E) was used as 2003 kb (Thomas et al., 2002).

The maximum in the parabola defines the optimum cation size that fits the partition included (Onuma et al., 1968) and usually represents the cation near the size of the main cation subjected to displacement.

Values with ionic radii that can be replaced by Zr^{4+} in the zircon cage structure are expressed by the elements Y, Er and Dy.

Overview of conclusion



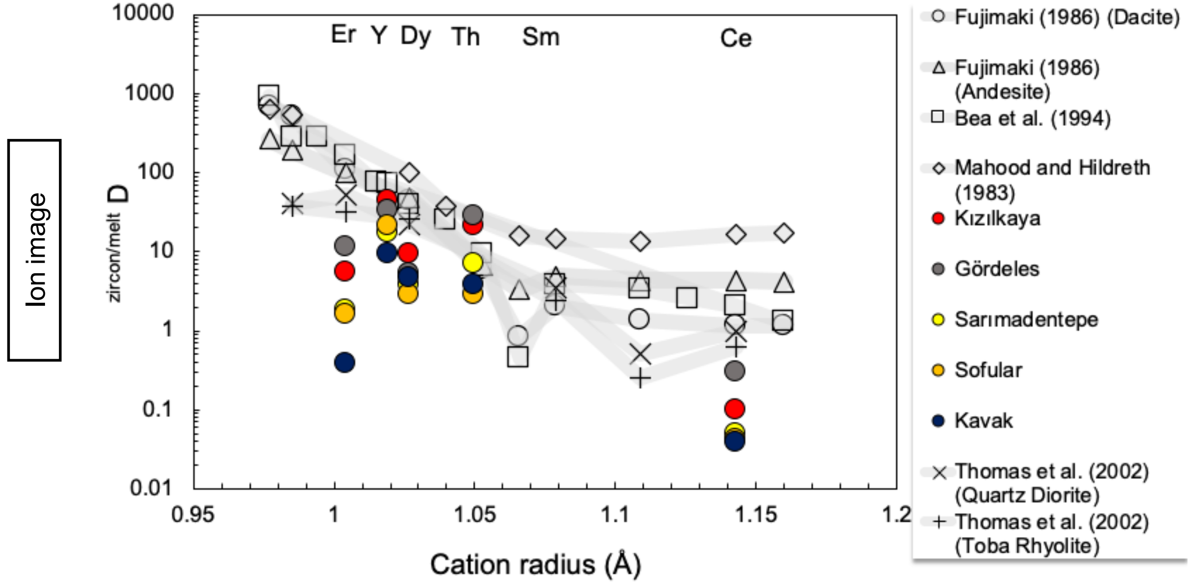
Graph showing the comparison of the mean D values of the elements with the previously published data as a result of the zircon/melt inclusion pairs of the ignimbrites in the study area.

- There is a significant increase in the partition coefficient values of ignimbrites in the study area calculated according to the melt inclusion trace element composition in the zircons compared to the increasing atomic number (decreasing ionic radius).

- The partition coefficient values of LREE elements show a flat separation pattern in previous studies. However, the partition between the mineral-melt inclusion show decreasing more in the form of a concave parabolic curve.

- The differences observed in the partition pattern develop independently of the ionic radius and attribute this difference to the impurities affecting the mineral/melt partitioning in these studies and therefore to the method of analysis used.

Overview of conclusion



Graph showing the comparison of the mean D values of the elements with the previously published data as a result of the zircon/melt inclusion pairs of the ignimbrites in the study area.

- The partition coefficient values were calculated for the zircon/melt inclusion pairs for both ion image single spot analyze techniques. In particular, it has been observed that the values calculated according to ion image analysis are slightly lower which can be attributed to image quantification process.
- Difference between spot and ion image analysis on the basis of partitioning might be affected by selection of region of interest which has also strong influence on avoiding the impurities.
- It is also observed that differences in partitioning is higher in low concentration elements like Er, Dy, Y, Ce than high concentration elements like Th, U in zircon.