Apatite fission track analysis by laser-ablation: A novel fast grain mapping approach using the map interrogation tool 'Monocle'

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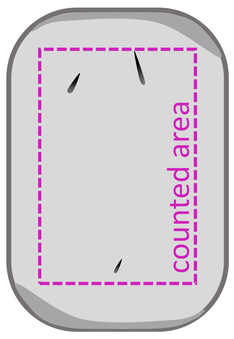
1 LASER SPOT ANALYSIS ISSUES

Apatite

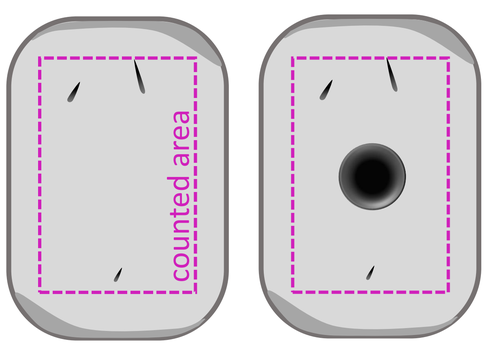


Mica

External Detector Method

- identical areas counted on apatite and mirror image in mica
- zonation and/or inclusion detected
- Spatial and depth-weighted U-heterogeneity taken into account or avoided (i.e. inclusions)

Laser spot



Laser spot analysis

- spot area ≠ counted area
- Hence U heterogeneity may not be accounted for
- U/Ca from spot may not be representative of that of the entire counted area

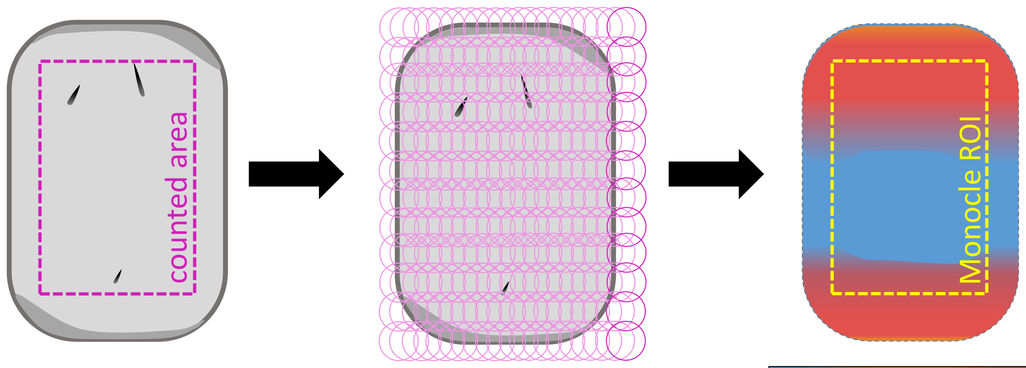
MAIN APPLICATION: Potential U-zoning cannot be detected by the spontaneous track density in young and/or low U apatites

2 MAPPING APPROACH

- Apatites are mounted in epoxy resin, ground, polished and etched to reveal spontaneous fission tracks. Fission tracks are counted under an Axio imager.Z1m (Zeiss) using TrackWorks (Autoscan).
- A Photon Machines Analyte Excite 193 nm ArF Excimer LA system coupled to an Agilent 7900 Q-ICPMS has been used to map the grains.
- Data are reduced in Iolite 2.5[1] using the Trace_Element_FTD and VisualAgeUcomPbine DRSs. Elemental regions of interest (i.e. counted areas) are drawn in Monocle[2]. Mean value of elements and ratios over the ROI are summarised in an exportable table from Monocle.

raster of spots

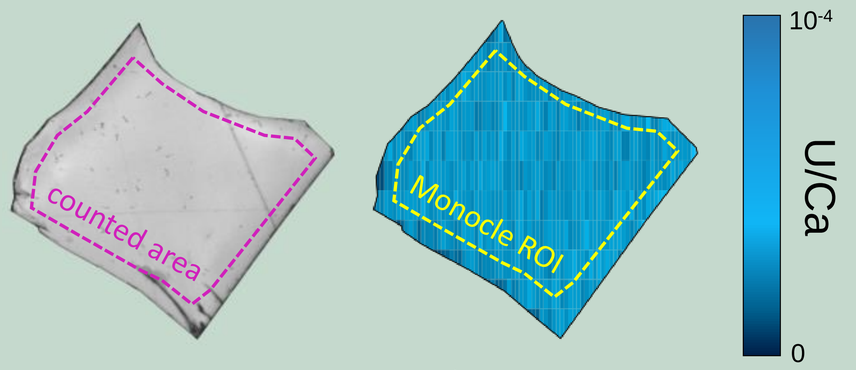
Monocle map



LA-Q-ICPMS settings:	
fluence	2.56 J.cm^{-2}
repetition rate	53 Hz
energy set point	2.7 mJ
scan speed	25 µm.s^{-1}
background	7 s
sampling mode	raster employing a 18 µm circle
raster depth	2 µm
isotopes analysed	^{43}Ca, ^{55}Mn, ^{88}Sr, ^{139}La, ^{140}Ce, ^{147}Sm, ^{153}Eu, ^{157}Gd, ^{175}Lu, $^{206, 207, 208}$Pb, ^{232}Th, ^{238}U
standards	NIST612, Durango (AFT), Madagascar (U-Pb)
apatite (used as unknowns)	McClure Mt (U-Pb); Durango, Fish Canyon Tuff, Paros, Sutlej (India) and Astor (Pakistan) valleys (AFT)

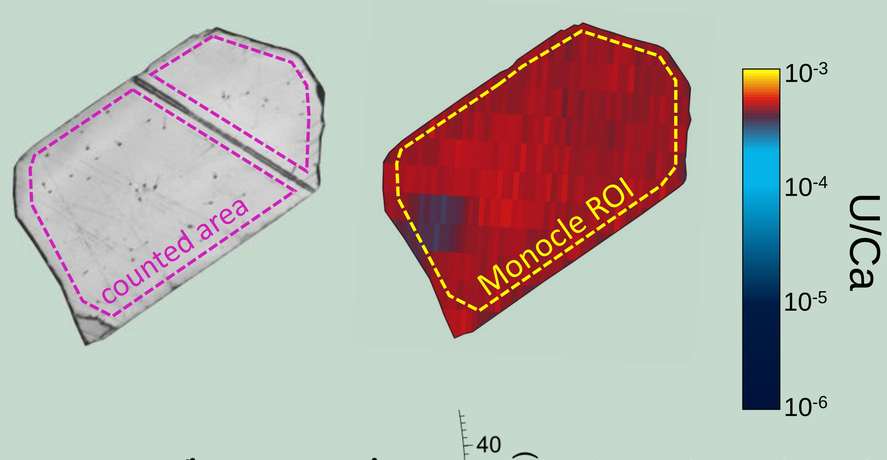
3 PRELIMINARY RESULTS

Durango (U-homogeneous; accepted age 31.4 ± 0.5 Ma[3])



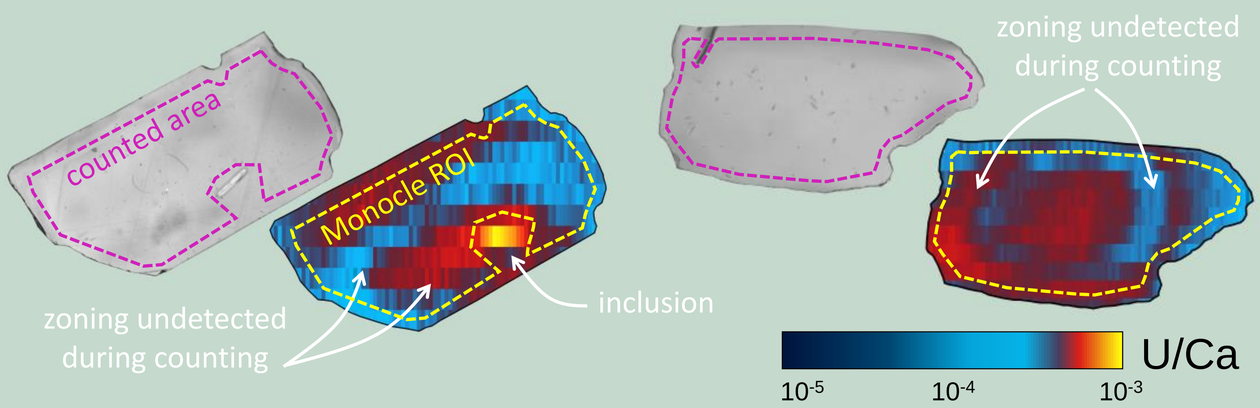
Durango apatite, n=41 shards
Central age= 31.3 ± 2 Ma
Pooled age= 31.8 ± 2 Ma
Dispersion= 0
P(X^2)=1
U-Pb age (same session) = 30.3 ± 1.7 Ma

Fish Canyon Tuff (U-heterogeneous; accepted age 27.8 ± 0.5 Ma[3])



FCT apatite, n=31 grains
Central age= 28.3 ± 1 Ma
Pooled age= 27.6 ± 1 Ma
Dispersion= 17%
P(X^2)=0
U-Pb age (same session)= 30.9 ± 2.4 Ma

Paros (U-heterogeneous; accepted age 12.7 ± 2.8 – 10.5 ± 2.0 Ma[4])



FCT apatite, n=76 grains
Central age= 9.9 ± 0.5 Ma
Pooled age= 10.4 ± 0.6 Ma
Dispersion= 0%
P(X^2)=1
U-Pb age (same session)= 12.0 ± 2.2 Ma

4 ADVANTAGES

- Irradiation free (!) and remove potential mismatches between FT-counted area and laser spot
- Method takes into account intra single-grain U-variation for a better representation of grain's heterogeneity, ideally suited for young and/or low U apatites
- Elemental region of interests can be easily defined using Monocle (i.e. to avoid inclusions, etc…)
- Combine multiple dating (AFT and U-Pb), and trace + REE analysis for provenance studies

[1] Paton, C. et al., (2011). *J. Anal. At. spectrum., v.26, p. 2508-2518*
[2] Petrus, J. et al., (2017). *Chemical Geology, v.463, p. 76-93*
[3] Hurford, A. J. (2018). *Fission-Track Thermochronology and its Application to Geology, chapitre 1, p. 3-23*
[4] Brichau, S. et al., (2006). *Earth and Planetary Science Letters, v. 241, p. 293-306*

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