Deducing the depth of origin of granulite xenoliths from zircon-rutile thermometry: A case study from Tanzania

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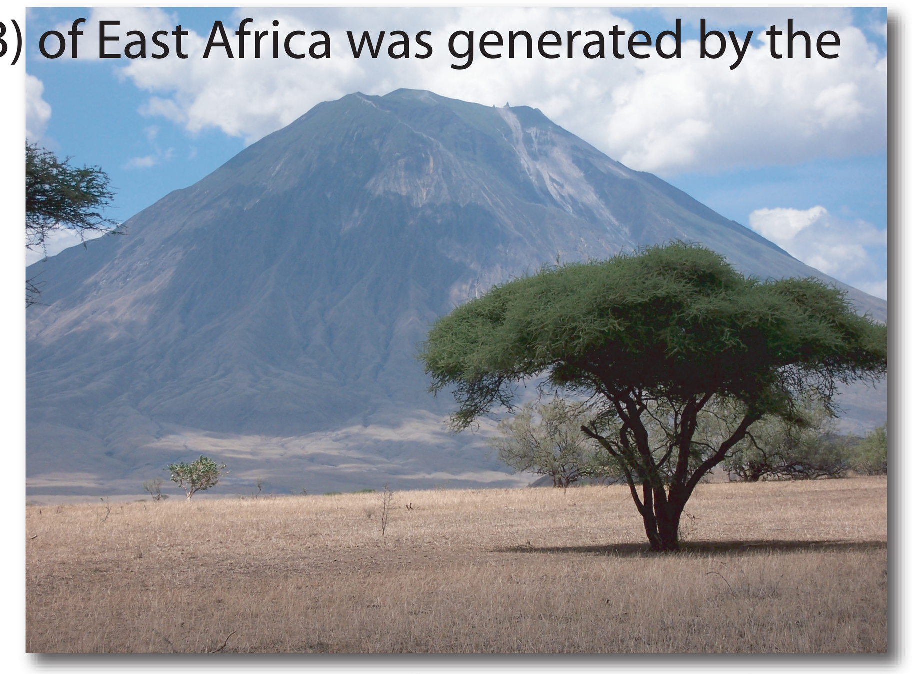
THE BIG PICTURE

The Mozambique Fold Belt (MFB) of East Africa was generated by the Pan-African Orogeny



We want to better understand the evolution of the MFB and the chronology of the geologic events of the Pan-African, so samples from the MFB must be analyzed

Before analyzing the samples from MFB, we must first constrain their origin (present-day upper or lower crust)

THE PROBLEM

How to determine depth of origin of high-grade crustal xenoliths carried in Rift-basalts.

METHODS

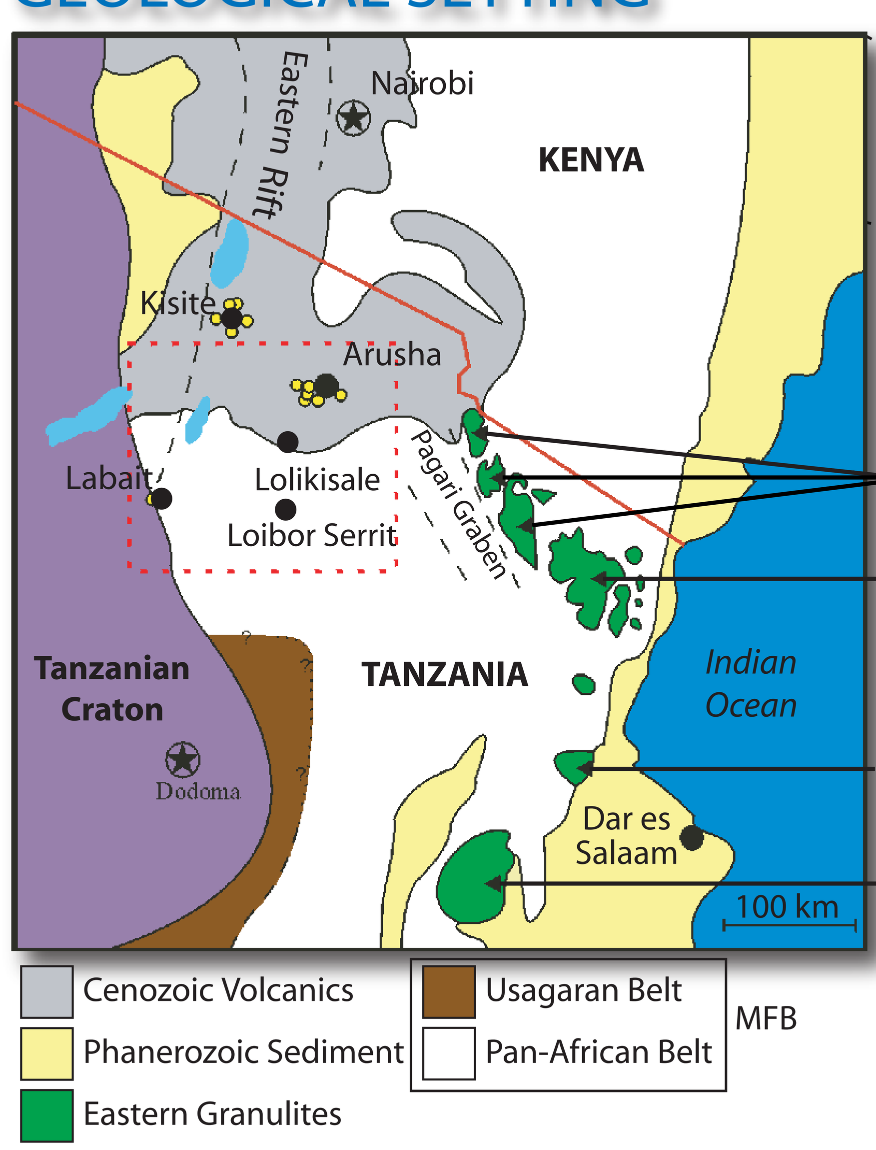
Temperatures of samples containing coexisting zircon and rutile can be calculated using the Zr-in-rutile and Ti-in-zircon thermometers developed by Watson et al. (2006).

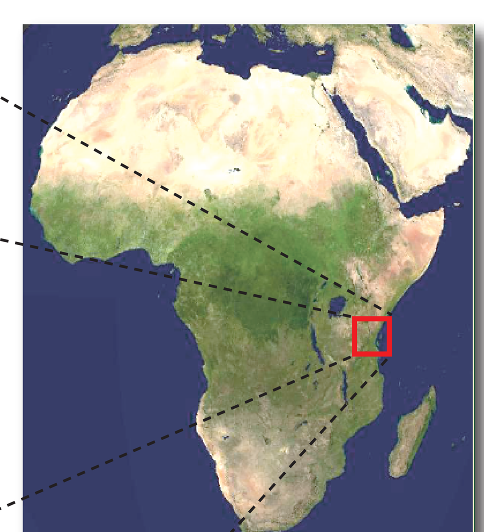
Histories can be deduced based on the difference in temperature recorded by the zircon and rutile :

- If zircon T's > rutile T's → slow cooling
- If zircon T's ≈ rutile T's → fast cooling

Granulites from the present-day lower crust should experience slow cooling.
Granulites from the present-day upper crust that experience uplift during the final phase of the orogeny should have cooled at a faster rate.

GEOLOGICAL SETTING

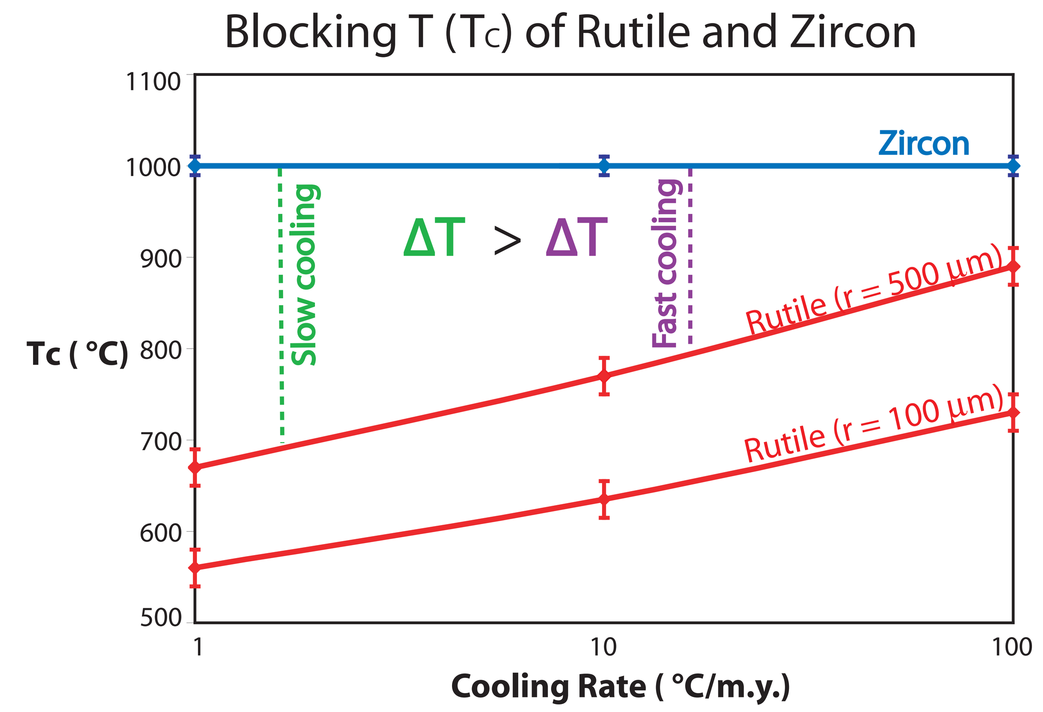




Xenoliths:
Labait
Kisite

Surface Samples:
Loibor Serrit
Lolikisale

WHY WILL ZIRCON AND RUTILE RECORD DIFFERENT TEMPERATURES?

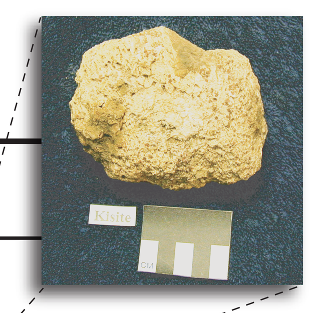


Blocking temperature (Tc): a function of both cooling rate and grain size.

Cooling rates decrease → Blocking T's decrease → More Zr diffuses out of rutile → Rutile will record lower temperatures.

Zircon will retain most Ti (Ti diffusion is very slow) and record the temperature at which it crystallize.

SAMPLES



Sample	Locality
Xenoliths	
Mafic garnet-orthopyroxene granulite	Labait
Garnet-biotite orthogneiss	Kisite
Mafic garnet-orthopyroxene granulite	Kisite
Surface Samples	
Graphite schist	Loibor Serrit
Garnet amphibolite	Lolikisale

ANALYTICAL TECHNIQUES

Electron Probe Microanalyzer:
- Zr in rutile and BSE images

Laser Ablation-Inductively Coupled Plasma-Mass Spectrometer:
- Ti in zircon
- Challenging due to small size of zircons

Cathodoluminescence (CL) Petrography Techniques:
- Image zoning in zircons

ACKNOWLEDGEMENTS

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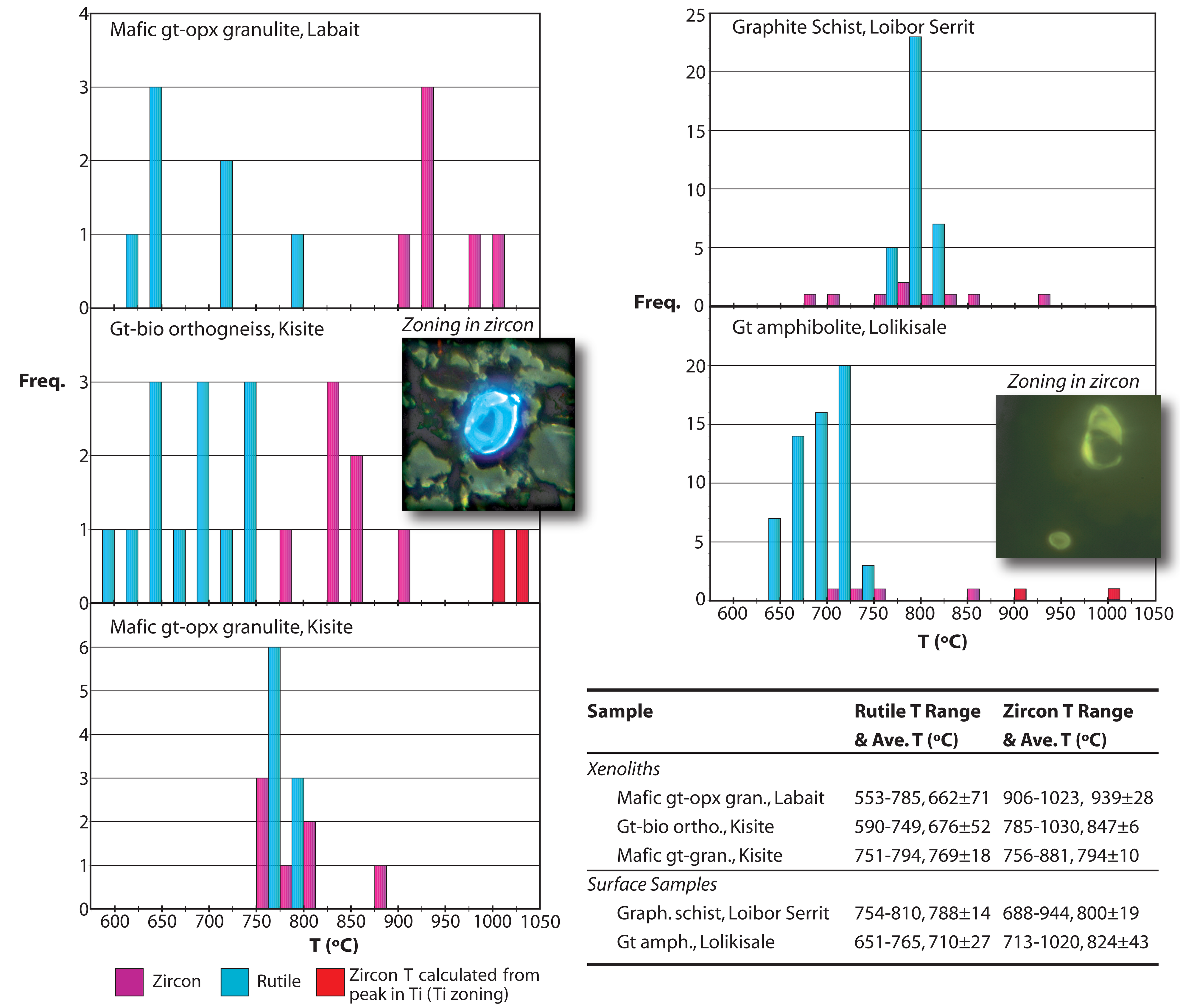
REFERENCES

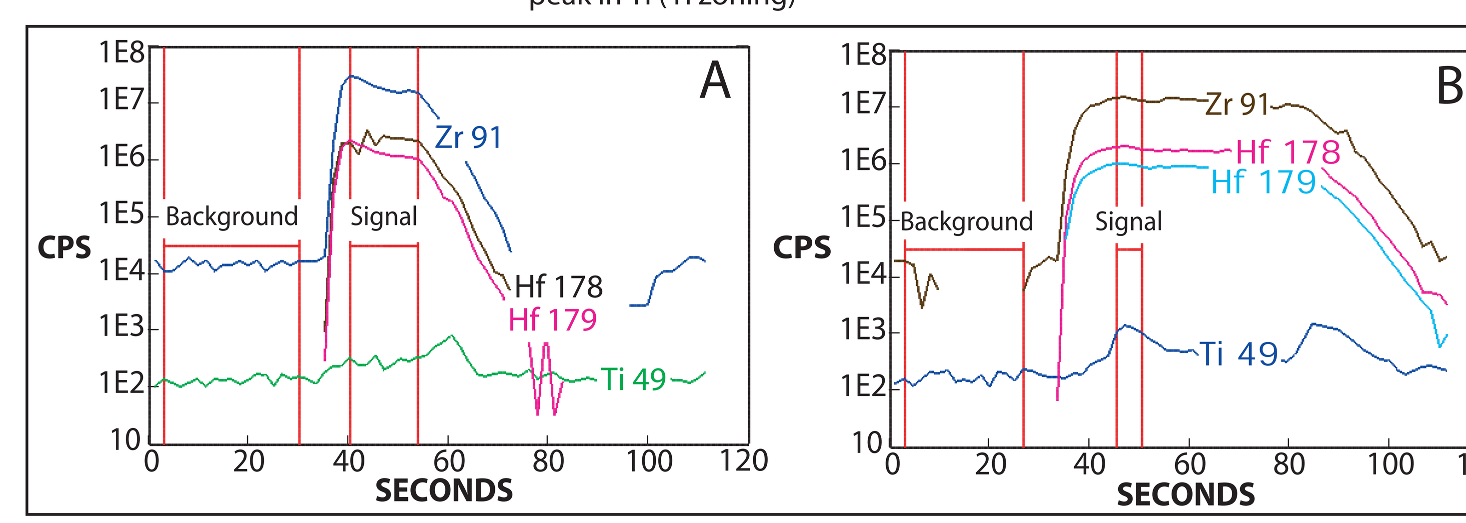
Watson EB, Wark DA, Thomas JB (2006) Crystallization thermometers for zircon and rutile. *Contrib Mineral Petrol* 151(4):413.

RESULTS

TEMPERATURES RETURNED BY RUTILE AND ZIRCON



Sample	Rutile T Range & Ave. T (°C)	Zircon T Range & Ave. T (°C)
Xenoliths		
Mafic gt-opx gran., Labait	553-785, 662±71	906-1023, 939±28
Gt-bio ortho., Kisite	590-749, 676±52	785-1030, 847±6
Mafic gt-gran., Kisite	751-794, 769±18	756-881, 794±10
Surface Samples		
Graph. schist, Loibor Serrit	754-810, 788±14	688-944, 800±19
Gt amph., Lolikisale	651-765, 710±27	713-1020, 824±43



A.) Time-resolved spectrum of a zircon analysis from the mafic gt-opx granulite from Kisite. Ti concentration = 12 ppm.
B.) Time-resolved spectrum of a zircon analysis from the garnet-biotite orthogneiss xenolith from Kisite. Ti 49 peak concentration = 114 ppm.

CONCLUSIONS

2 crustal xenoliths return zircon T's > rutile T's
Cooled slowly and isobarically in the present-day lower crust

1 crustal xenolith returns zircon T's = rutile T's
Cooled relatively quickly as it was uplifted during the final stages of the orogeny

Surface samples return zircon T's ≈ rutile T's
Large range in zircon T's due to Ti zoning and possible multiple populations (detrial vs. metamorphic)