# 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

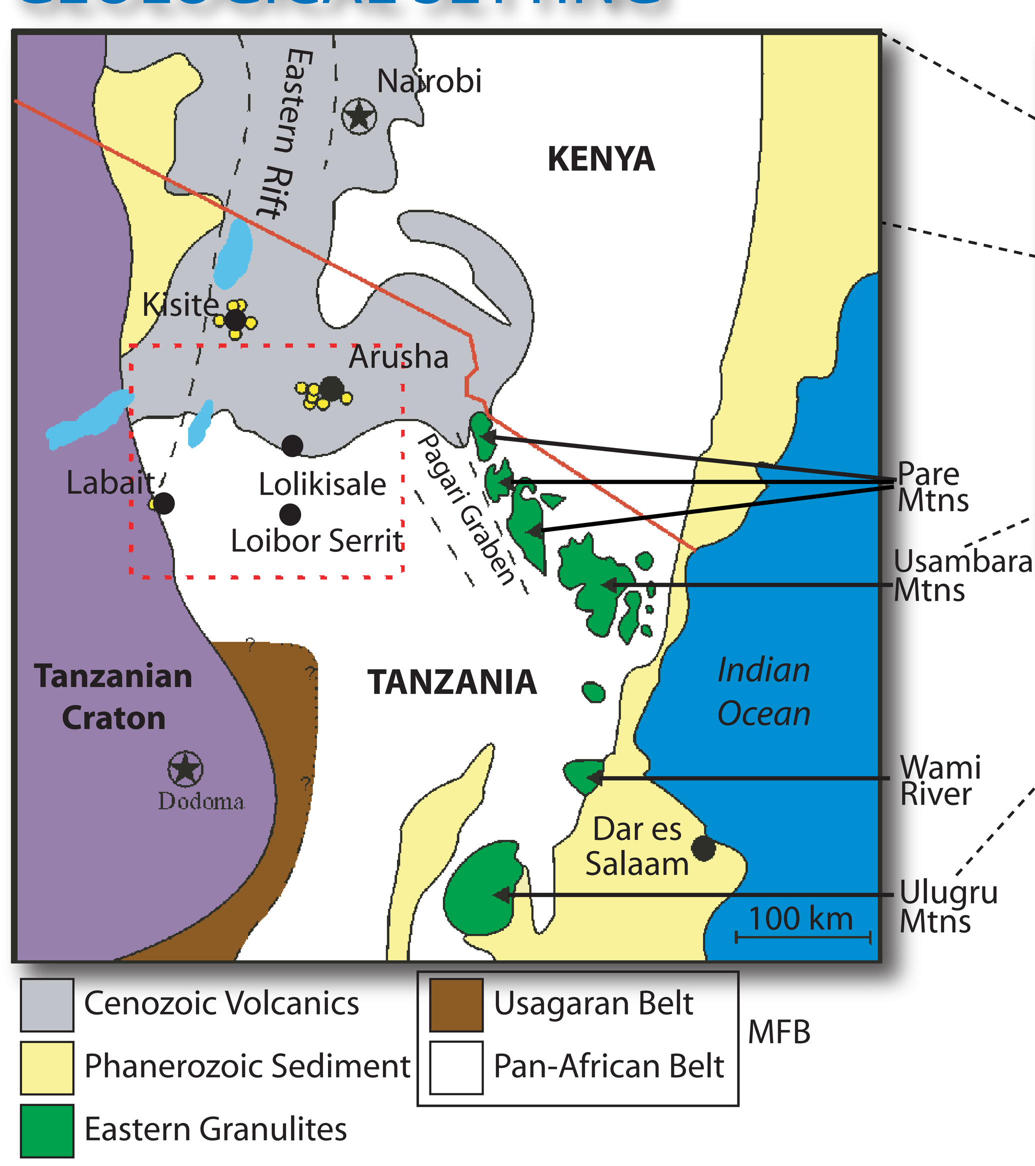
Temperatures of samples containing coexisting zircon and rutile can be calculated using the Zr-in-rutile and Ti-in-zircon thermometers developed by Watson et al. (2006).

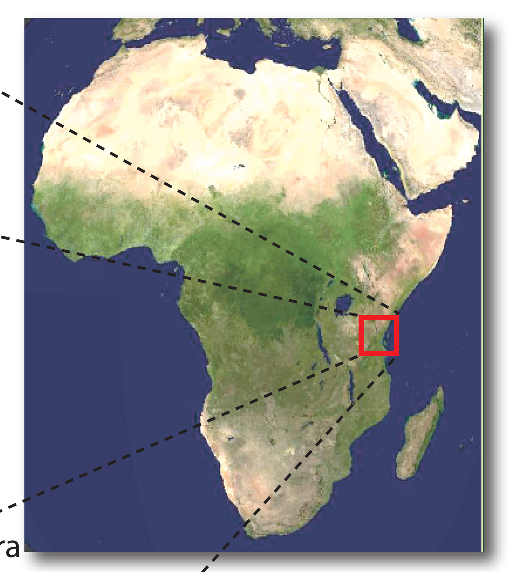
Histories can be deduced based on the difference in temperature recorded by the zircon and rutile :

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



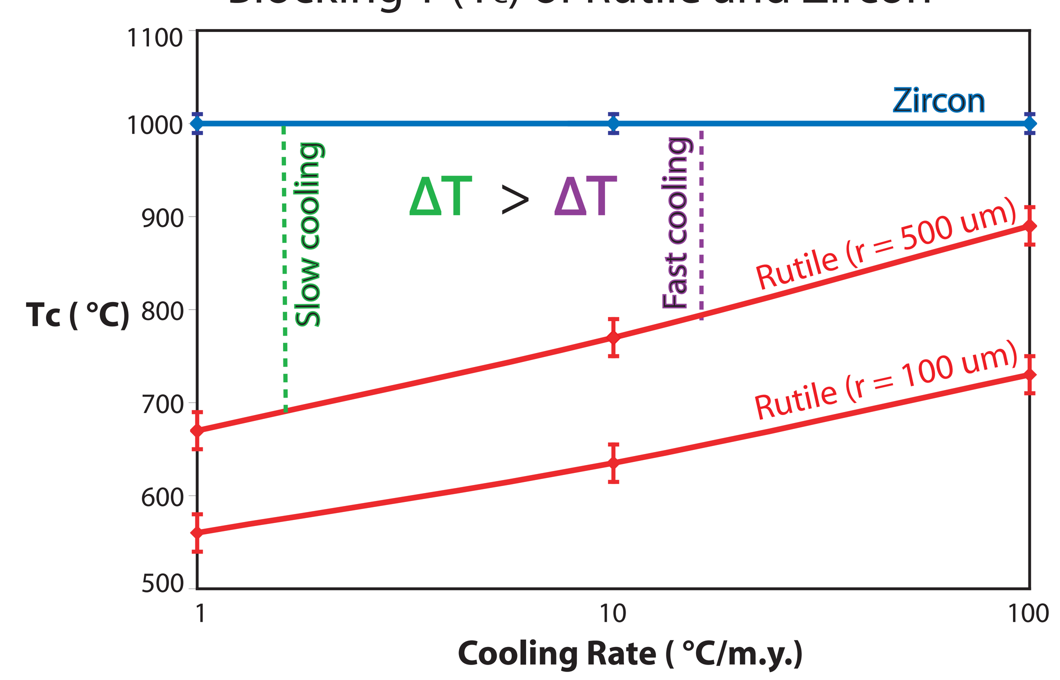



**Xenoliths:**
Labait
Kisite

**Surface Samples:**
Loibor Serrit
Lolikisale

## WHY WILL ZIRCON AND RUTILE RECORD DIFFERENT TEMPERATURES?

Blocking T (Tc) of Rutile and Zircon

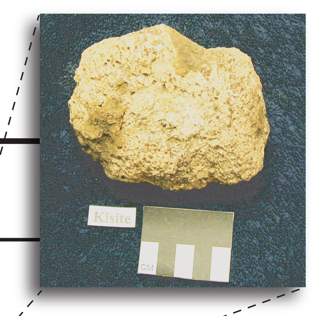



**Blocking temperature (Tc):** a function of both cooling rate and grain size.

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 graunlite | 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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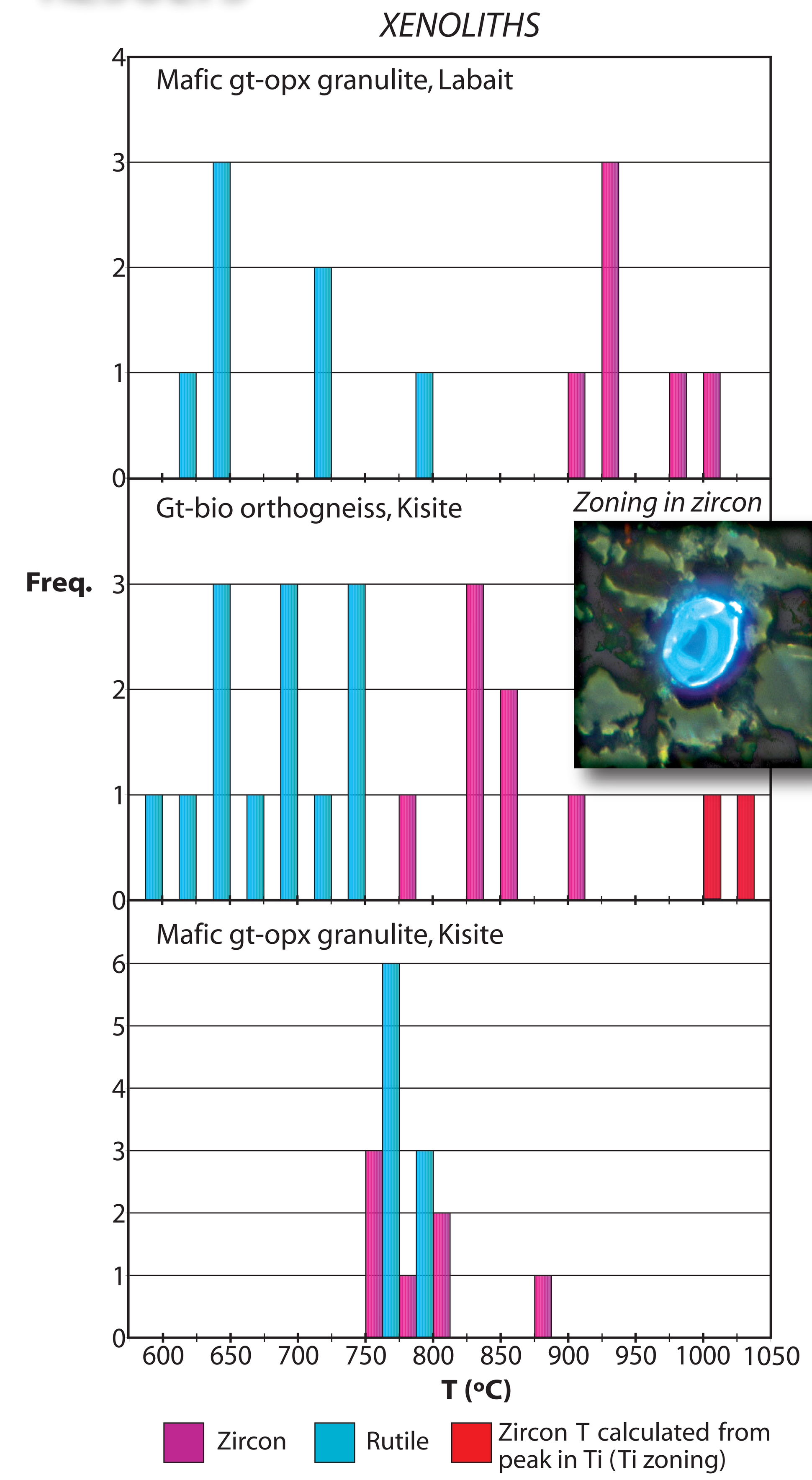
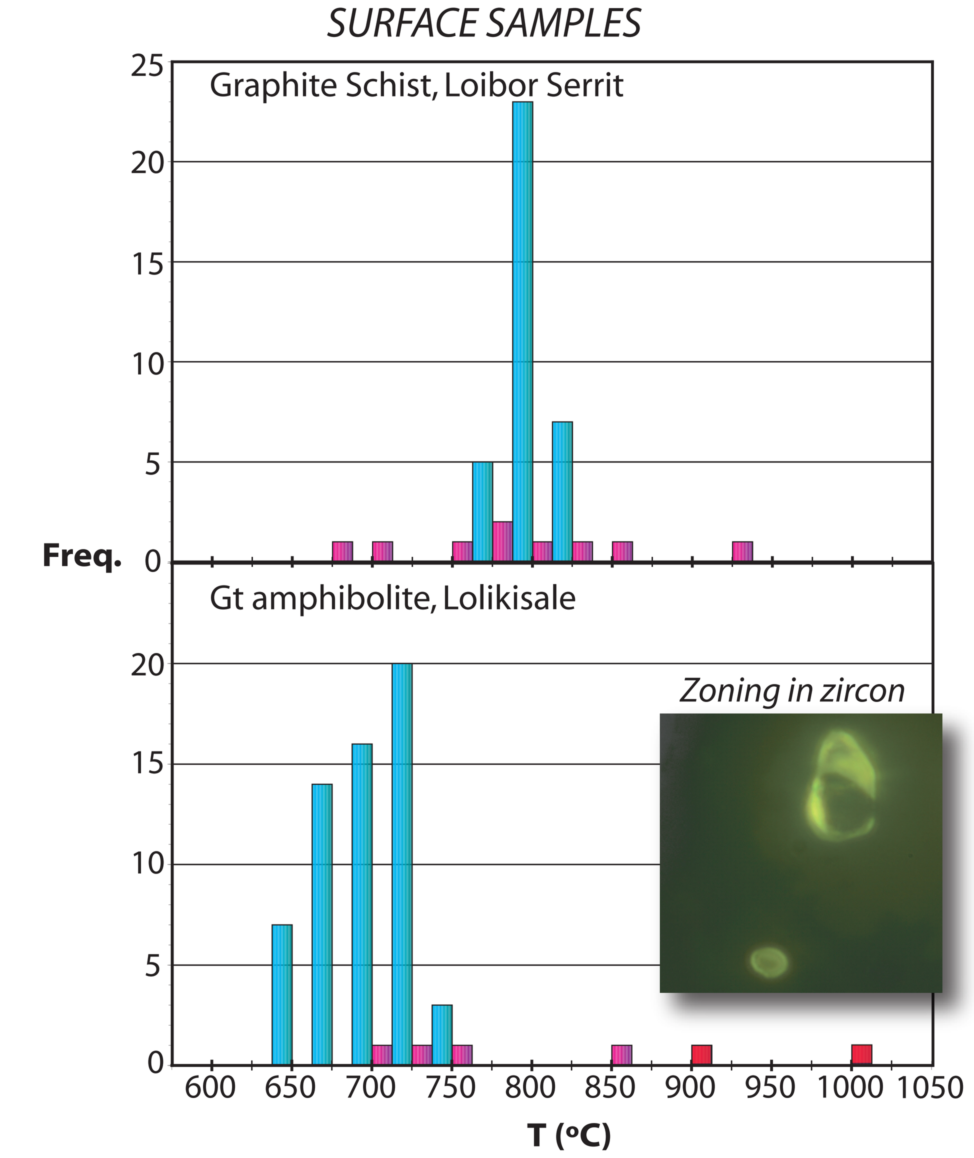
## REFERENCES

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

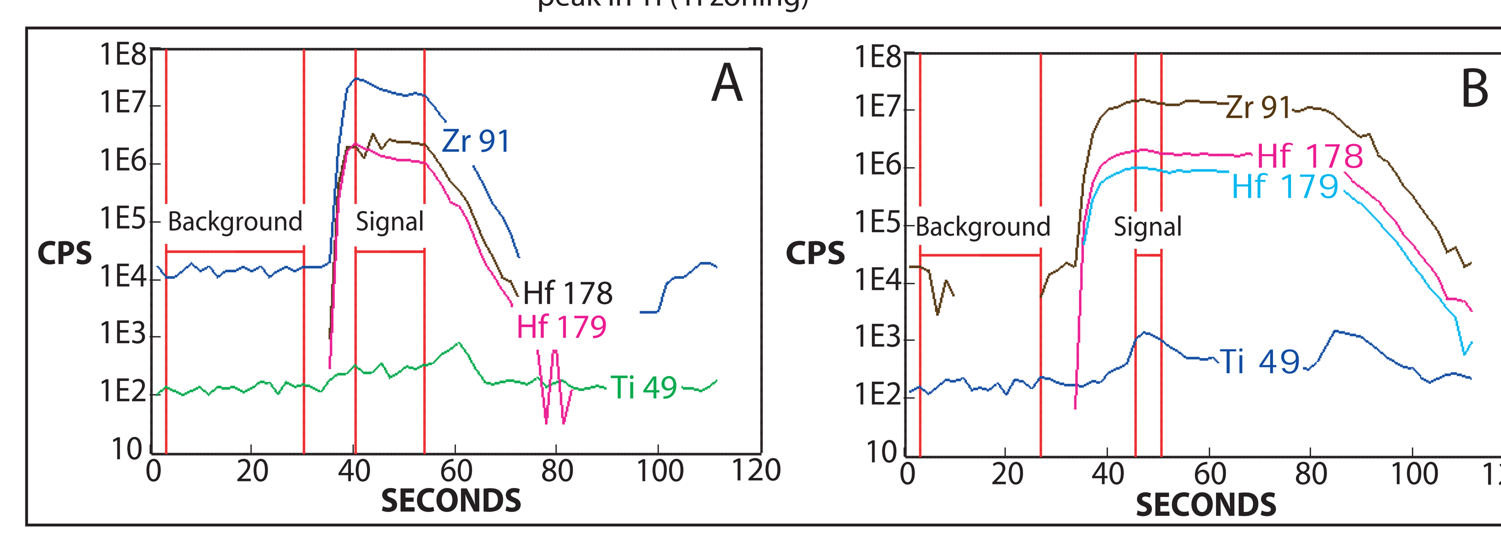
## RESULTS

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
Slowly cooled granulites should show different T's from Ti-in-zircon vs. Zr-in-rutile thermometers

1 crustal xenolith returns zircon T's = rutile T's
Quickly cooled granulites should show relatively similar T's

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