Commonwealth Environment Research Facilities
Marine and Tropical Sciences Research Facility

Impacts and Achievements of the MTSRF

Copy of abstract and presentation given at the
2010 Annual Conference of the
Marine and Tropical Sciences Research Facility (MTSRF)
http://www.rrrc.org.au/news/2010_conference.html

Showcasing the Australian Government's investment in the MTSRF for improved sustainability of the North Queensland region, and Australia

18-20 May 2010
Pullman Reef Hotel & Casino
Cairns, North Queensland

Reef & Rainforest RESEARCH CENTRE

Australian Government
Department of the Environment, Water, Heritage and the Arts

Abstract

MTSRF Project Number 1.1.4

Improving the accuracy and precision of TIMS U-series ages of modern corals and application to coral death assemblages from the inshore region of the Great Barrier Reef, Australia

Tara R. Clark*[1,2], Jian-xin Zhao[2], George Roff[3], Yue-xing Feng[2], Terry Done[4], John M. Pandolfi[3]
[1]School of Earth Sciences, University of Queensland, Brisbane; [2]Radiogenic Isotope Facility, Centre for Microscopy and Microanalysis, University of Queensland, Brisbane; [3]ARC Centre of Excellence in Coral Reef Studies, Centre for Marine Studies, University of Queensland, Brisbane; [4]Australian Institute of Marine Science, Townsville

In order to understand the timing and nature of historical mortality events and changes in community structure in inshore reef coral communities, accurate chronologies are essential. While Uranium-series dating has proven to be a reliable method for dating carbonates >1,000 years old, less attention has been paid to dating young modern corals <200 years old, especially those affected by post-mortem terrestrial sediment contamination typical of inshore reefs. The main limiting factor in obtaining precise and accurate Uranium-series ages of modern corals is the ability to constrain and correct for initial or non-radiogenic ^{230}Th. To date, thermal ionisation mass spectrometry (TIMS) Uranium-series dating of 61 samples collected from living and non-living *Porites* spp. from three near shore regions of the GBR has been performed to spatially constrain initial $^{230}Th/^{232}Th$ ($^{230}Th/^{232}Th_0$) variability. The results of this study demonstrate that accurate U-series ages cannot be achieved where single non-radiogenic ($^{230}Th/^{232}Th_0$) values are used for correction interchangeably for samples taken from different hydrological settings and for both living and dead *Porites*. As Th in non-living corals is derived from both a soluble component in seawater and terrestrial sediment contamination through post-mortem infiltration, we propose the use of a specific correction value calculated based on ^{232}Th levels for individual samples to account for both components. Furthermore, we have also developed a vigorous cleaning procedure to reduce the level of infiltrated sediment adhering to the non-living coral skeleton. Using both methods we are able to achieve precise and accurate U-series ages (up to ±1 year) for corals less than 200 years old. Here we present preliminary results from the U-series dating of coral death assemblages where the sedimentary record has revealed unprecedented shifts in coral community structure since European settlement of northern Australia around 1850 AD.

MTSRF Project 1.1.4

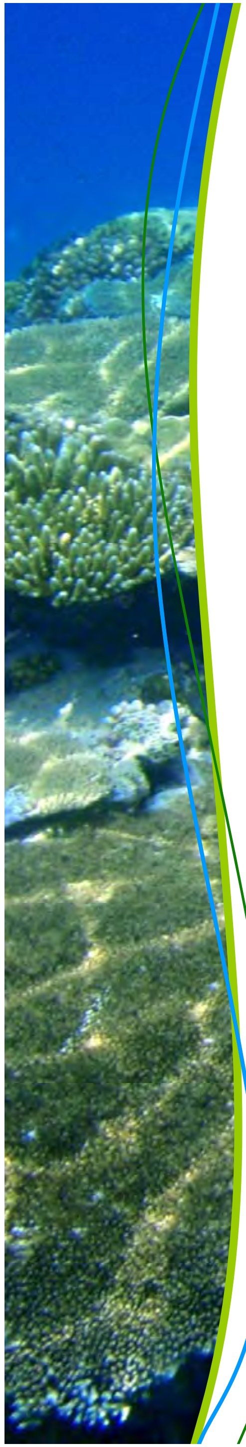
Improving the accuracy and precision of TIMS U-series ages of modern corals from the Great Barrier Reef, Australia

T.R. Clark, J-x. Zhao, G. Roff, Y. Feng,
T. Done & J.M. Pandolfi

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Reef & Rainforest RESEARCH CENTRE

Australian Government
Department of the Environment, Water, Heritage and the Arts



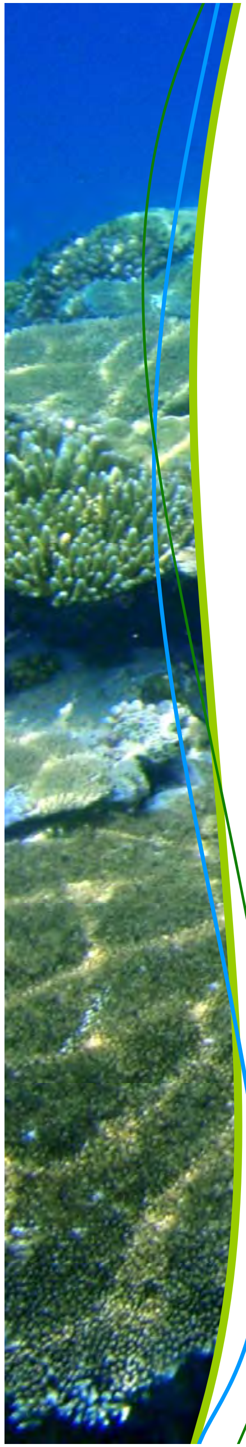
U/Th dating of inshore corals

- Problematic
  - Adjacent to continental shelf
  - Terrigenous sediment wedge
  - Subject to re-suspension of fine sediments
  - Routinely exposed to flood plumes

- High initial non-radiogenic Th ($^{230}Th_0$)
  - U/Th age older than the ‘true’ age of the sample
  - Inaccurate age estimates especially for young corals (<200yrs)

- Large uncertainty associated with assumed bulk Earth value

- $^{230}Th_0$ in GBR massive *Porites* colonies unknown



Aims

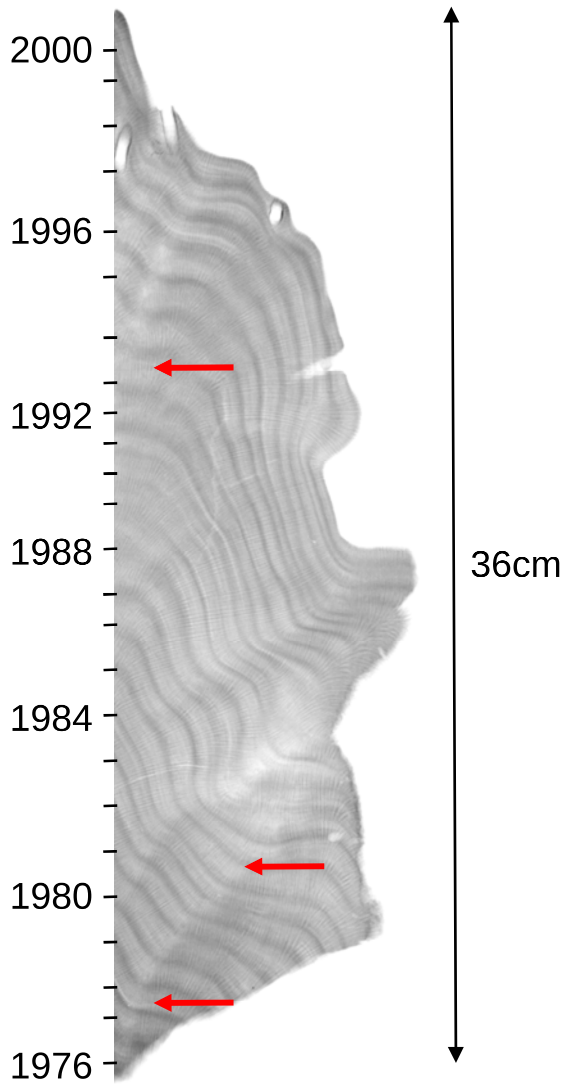
- To determine the spatial and temporal variability of $^{230}Th_0$ in living *Porites*
- Compare $^{230}Th_0$ values with international studies
- Determine whether $^{230}Th_0$ values from live *Porites* can be used as a suitable correction value for dead *Porites*
- Further remove ^{232}Th using a new cleaning procedure


www.fraps.com
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2010 Cnes/Spot Image
Image © 2010 TerraMetrics
Image © 2010 DigitalGlobe
Google

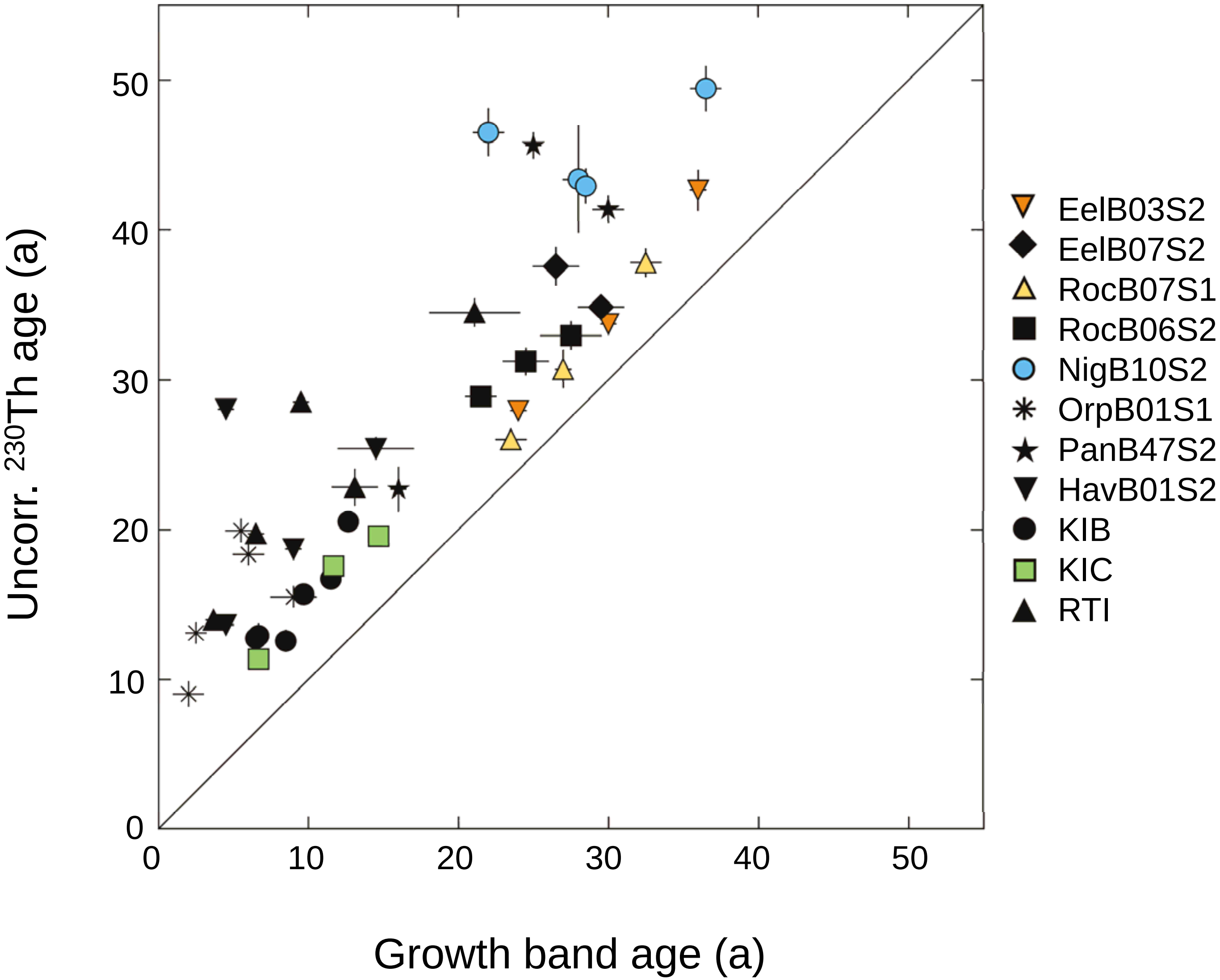
Sampling

- Annual density bands identified from X-rays
  - 41 samples taken from live *Porites* of known age
  - 17 samples from dead *Porites*

- Chemistry & TIMS U-series dating performed at Radiogenic Isotope Facility, University of Queensland



$^{230}Th_0$ in inshore *Porites*



$^{230}Th_0$ calculation

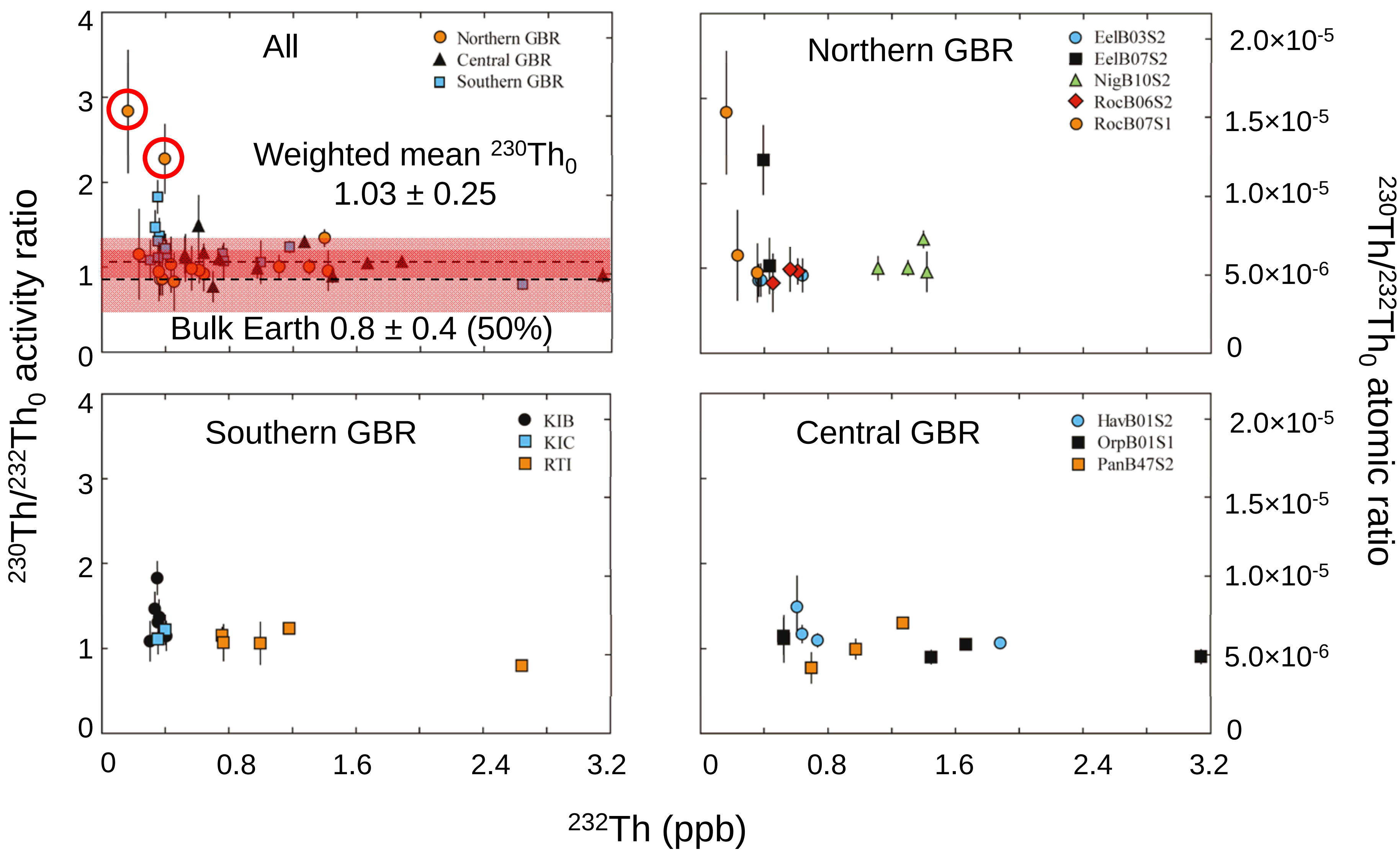
Using the revised equation from Zhao et al. (2009):

$$T_0 \approx \left(\frac{1}{\lambda_{230}}\right)\left(\frac{^{230}\mathrm{Th}}{^{234}\mathrm{U}}\right)_0 \approx \left(\left(\frac{1}{\lambda_{230}}\right)\left(\frac{\mathrm{Th}}{\mathrm{U}}\right)_0\left(\frac{\lambda_{232}}{\lambda_{238}}\right)\left(\frac{^{230}\mathrm{Th}}{^{232}\mathrm{Th}}\right)_0\right) \Big/ \left(\frac{^{234}\mathrm{U}}{^{238}\mathrm{U}}\right)_0$$

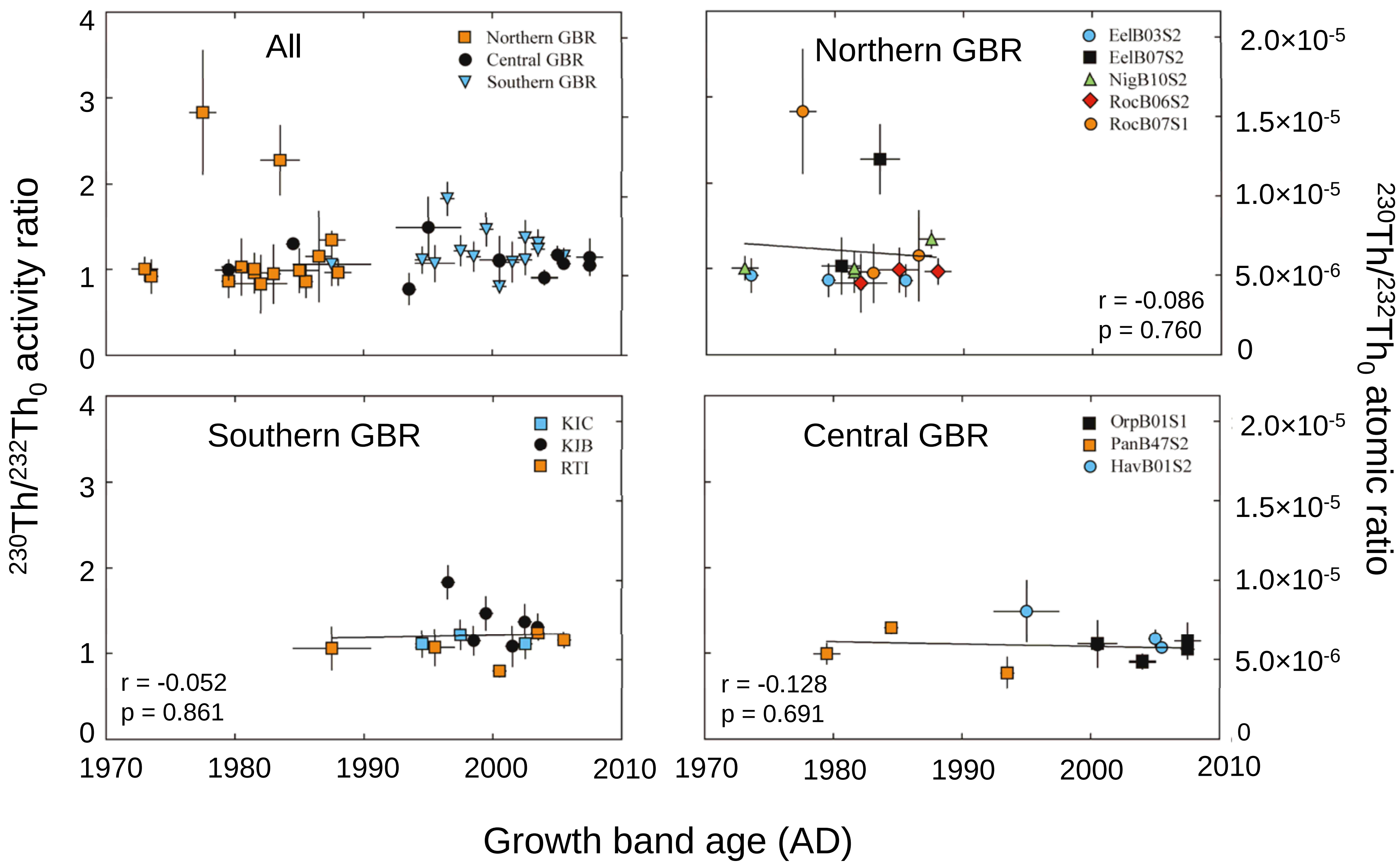
Solving for $^{230}Th/^{232}Th_0$:

$$\left(\frac{^{230}\mathrm{Th}}{^{232}\mathrm{Th}}\right)_0 = \left(T_{uncorr} - T_{abs}\right)\left(\frac{^{234}\mathrm{U}}{^{238}\mathrm{U}}\right)_0\left(\frac{\mathrm{U}}{\mathrm{Th}}\right)_0 \Big/ \left(\frac{\lambda_{232}}{\lambda_{230} \times \lambda_{238}}\right)$$

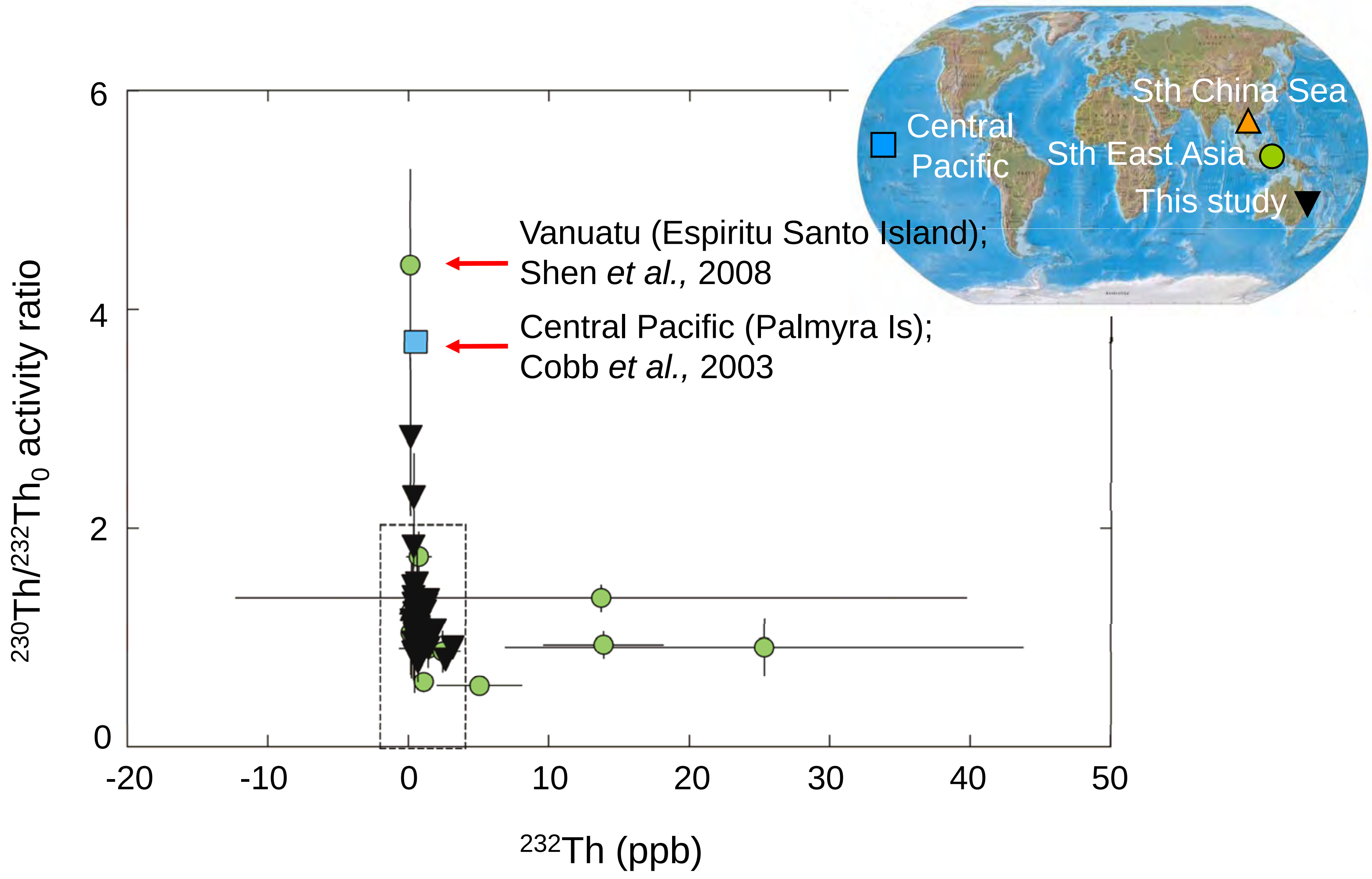
Spatial variability of $^{230}Th_0$



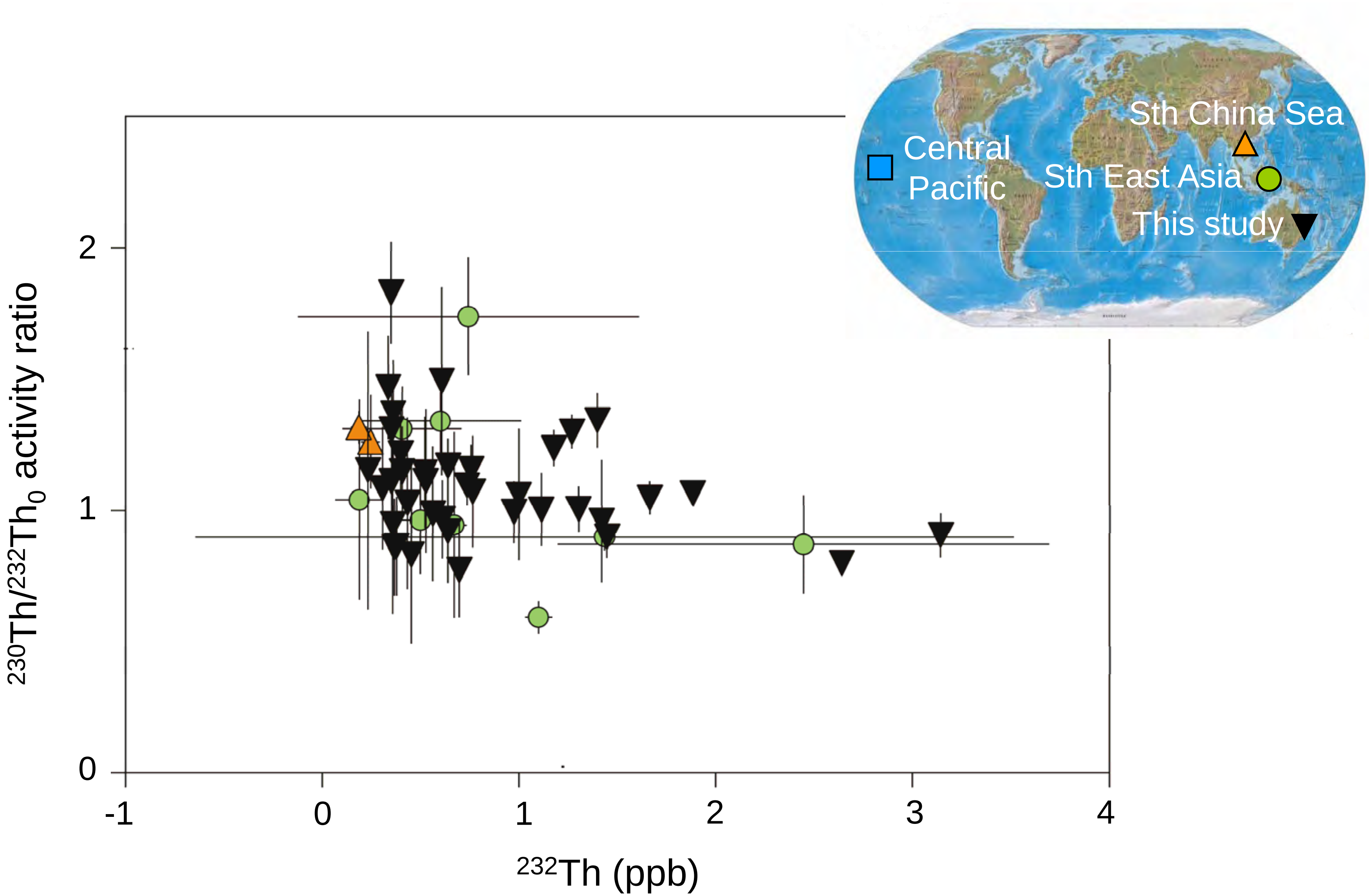
Temporal variability of $^{230}Th_0$



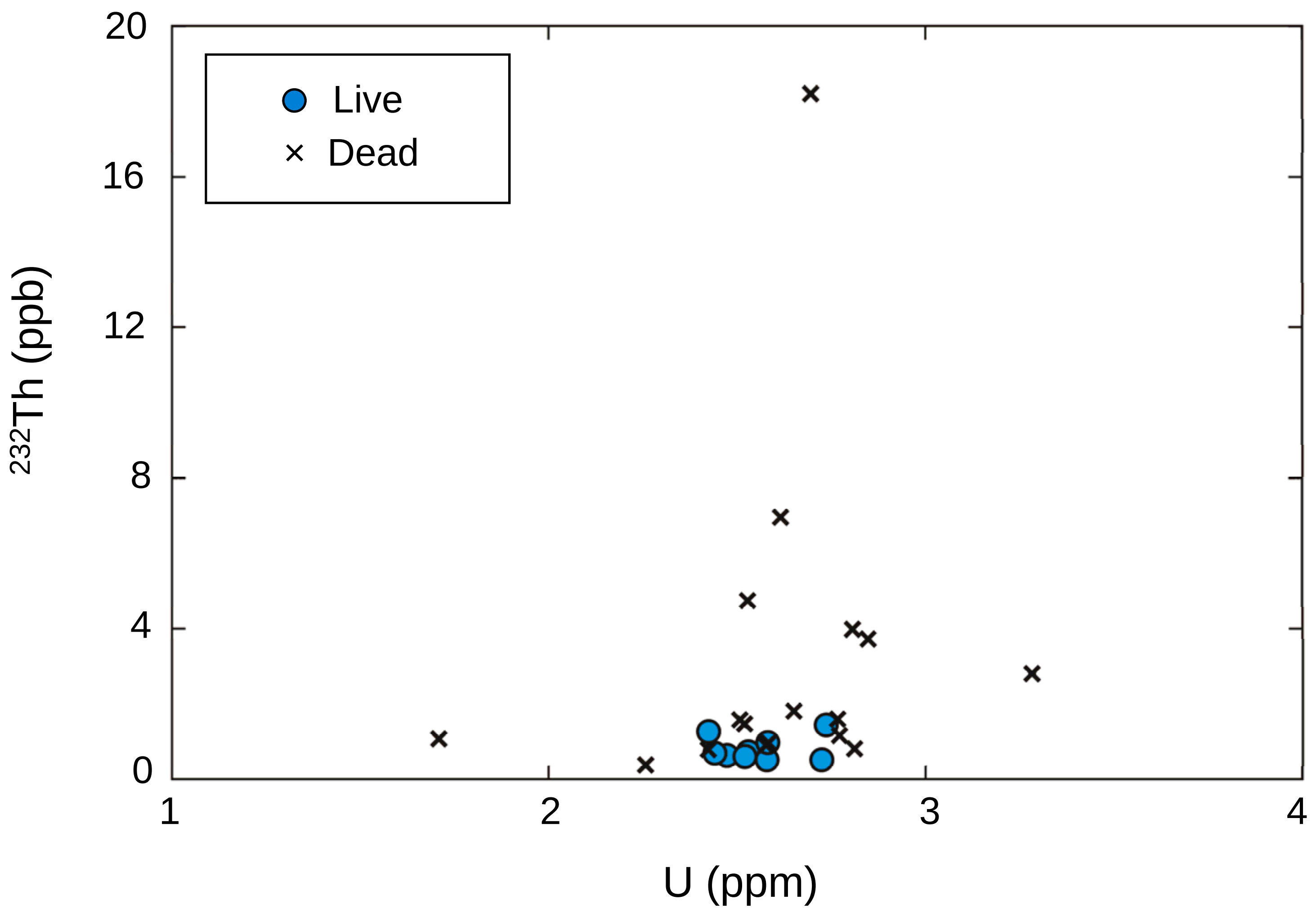
International $^{230}Th_0$ values



International $^{230}Th_0$ values



Live v. dead
(Palm Islands, central GBR)



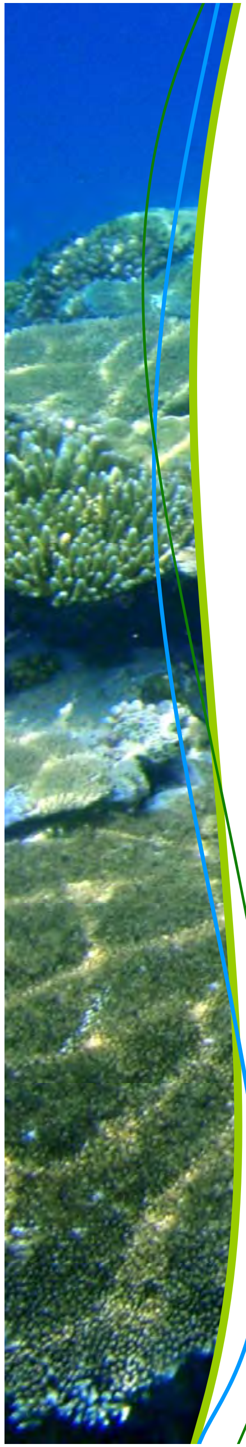
Live v. dead
(Palm Islands, central GBR)

Material	Live coral	Dead coral	Burdekin R. sediments
U (ppm)	2.42 – 2.75 (av. 2.59)	2.26 – 3.28 (av. 2.67)	3.21 ± 0.64
^{232}Th (ppb)	0.52 – 1.88 (av. 0.95)	0.38 – 18.20 (av. 3.25)	15,470 ± 2,940
$(^{230}Th/^{232}Th)_{meas}$	1.20 – 3.50 (av. 2.08)	0.85 – 5.34 (av. 2.33)	0.65 ± 0.10
$(^{230}Th/^{232}Th)_0$	1.08 ± 0.19	? (≤ 0.85)	0.65 ± 0.10

Live

Dead

Burdekin River



Two-component correction

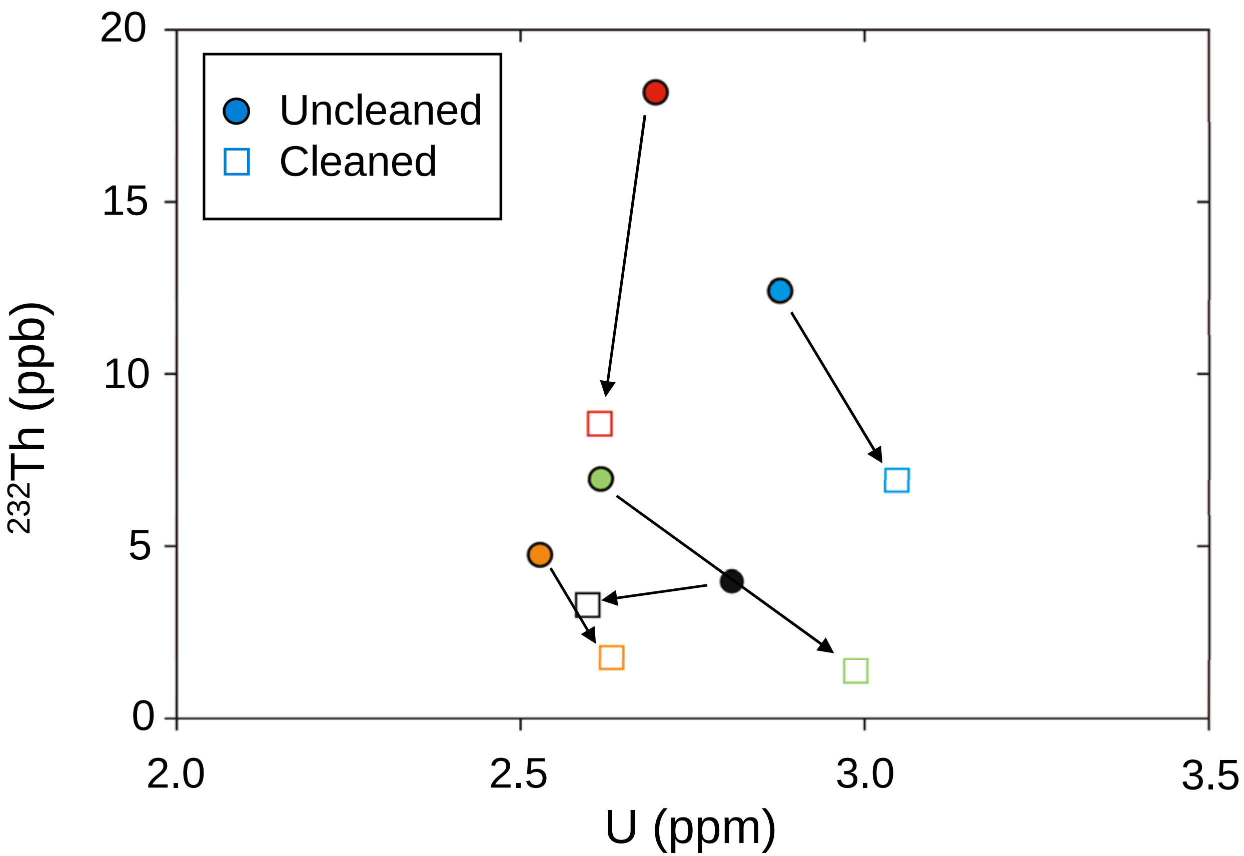
?

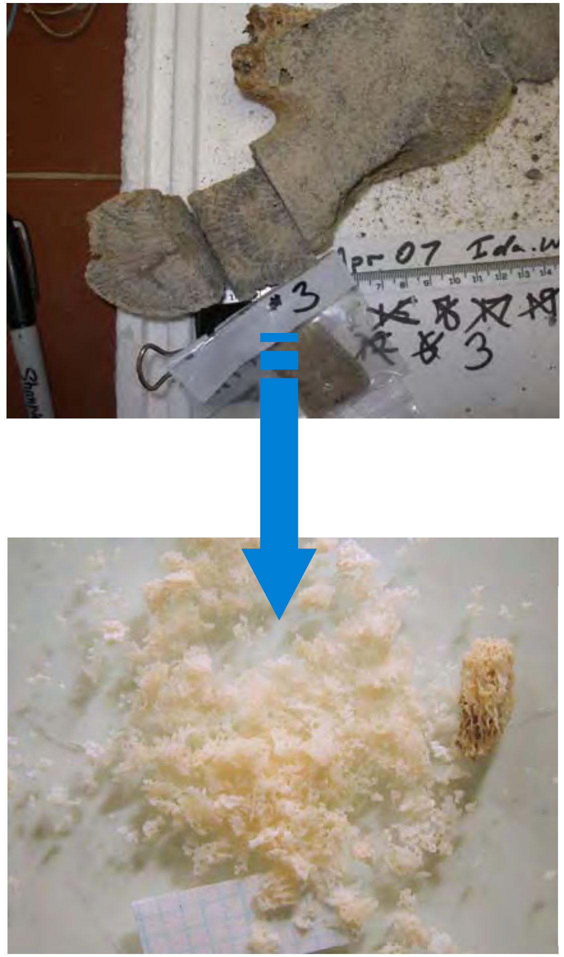
Proportion $^{230}Th_0$ detrital (measured in sediments)

$$\left(\frac{^{230}Th}{^{232}Th}\right)_{mix} = \left(\left(\frac{^{232}Th_{live}}{^{232}Th_{dead}}\right) \times \left(\frac{^{230}Th}{^{232}Th}\right)_{live}\right) + \left(\left(\frac{^{232}Th_{dead} - {}^{232}Th_{live}}{^{232}Th_{dead}}\right) \times \left(\frac{^{230}Th}{^{232}Th}\right)_{sed}\right)$$

Proportion $^{230}Th_0$ hydrogenous (measured in live corals)

Cleaning





Two-component correction

Sample name	Corr. ^{230}Th age (yr)	±2σ	
1- uncleaned	11	12	×4
1- cleaned	13	3	
2- uncleaned	79	9	×2.3
2- cleaned	71	4	
3- uncleaned	136	29	×1.9
3- cleaned	114	15	
4- uncleaned	266	19	×1.9
4- cleaned	258	10	

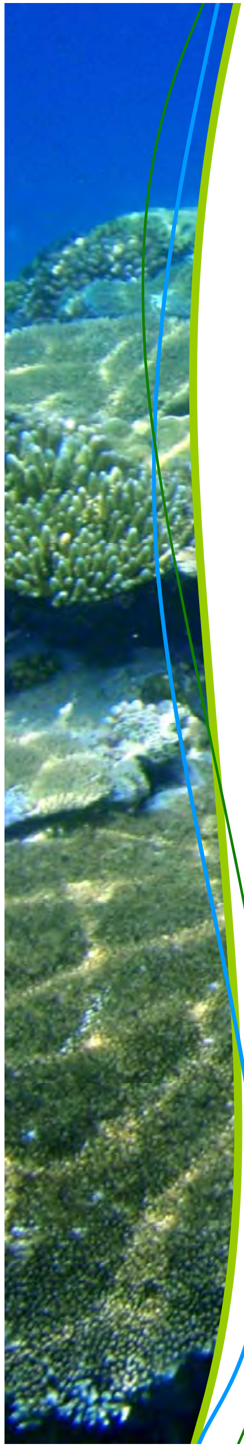
Overview

- $^{230}Th_0$ in live corals
  - $^{230}Th/^{232}Th_0$ ≥ bulk Earth value
  - Spatial variability of $^{230}Th_0$ & ^{232}Th
  - High intra-colony variability (temporal variability)
  - Reflect international values from continental shelf settings
  - Weighted mean $^{230}Th/^{232}Th_0$ for GBR *Porites* = 1.03 ± 0.25

- Live versus dead corals
  - ↑ ^{232}Th in dead corals
  - Additional source of $^{230}Th_0$ incorporated post-mortem (sediment?)
  - Two component correction required for non-living corals (<200yrs)

- New cleaning procedure
  - Reduces ^{232}Th with little addition or loss of U

Two component correction + rigorous cleaning = precise and accurate U/Th ages



Acknowledgements

Janice Lough & Eric Matson, AIMS

Australian Government Department of the Environment, Water, Heritage and the Arts

Marine and Tropical Science Research Facility (MTSRF)

Radiogenic Isotope Facility, Centre for Microscopy and Microanalysis, University of Queensland

Great Barrier Reef Marine Park Authority (GBRMPA)

Orpheus Island Research Station (OIRS)

Thankyou

Tara Clark
School of Earth Sciences,
University of Queensland
Brisbane, Australia

E-mail: t.clark1@uq.edu.au


Stone Is. 1915


Stone Is. 1994

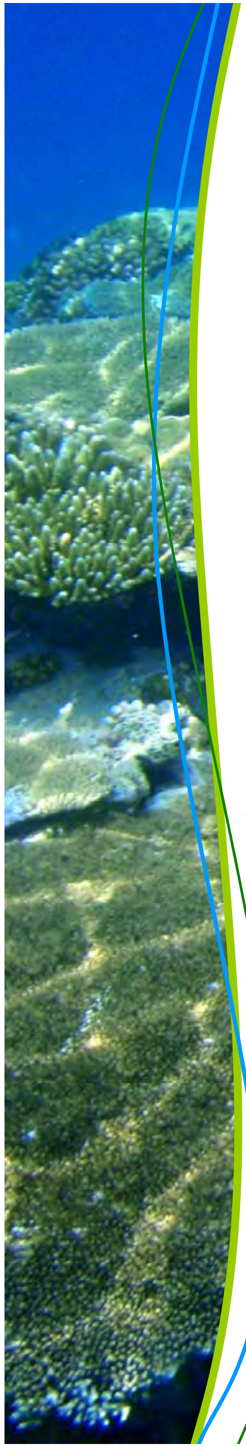
$^{230}Th_0$ equation

Using the revised equation from Zhao et al. (2009):

$$T_0 \approx \left(\frac{1}{\lambda_{230}}\right)\left(\frac{^{230}\text{Th}}{^{234}\text{U}}\right)_0 \approx \left(\left(\frac{1}{\lambda_{230}}\right)\left(\frac{\text{Th}}{\text{U}}\right)_0\left(\frac{\lambda_{232}}{\lambda_{238}}\right)\left(\frac{^{230}\text{Th}}{^{232}\text{Th}}\right)_0\right)\Bigg/\left(\frac{^{234}\text{U}}{^{238}\text{U}}\right)_0$$

Solving for $^{230}Th/^{232}Th_0$:

$$\left(\frac{^{230}\text{Th}}{^{232}\text{Th}}\right)_0 = \left(T_{uncorr} - T_{abs}\right)\left(\frac{^{234}\text{U}}{^{238}\text{U}}\right)_0\left(\frac{\text{U}}{\text{Th}}\right)_0\Bigg/\left(\frac{\lambda_{232}}{\lambda_{230}\times\lambda_{238}}\right)$$



$^{230}Th_0$ equation: error calculation

To calculate the total error, the above U-series equation can be simplified into the following function (f):

$$f = V_1 \times V_2 \times V_3$$

where variables V_1 = $\left(T_{uncorr} - T_{abs}\right)$, V_2 = $\left(\frac{^{234}U}{^{238}U}\right)_0$ and V_3 = $\left(\frac{U}{Th}\right)_0$

$\left(\frac{\lambda_{232}}{\lambda_{230} \times \lambda_{238}}\right)$ is a constant and can be ignored.

The total relative error can then be calculated for the simplified function using the rule for the propagation of errors of precision:

$$\Delta f = f\sqrt{\left(\left(\frac{\Delta V_1}{V_1}\right)^2 + \left(\frac{\Delta V_2}{V_2}\right)^2 + \left(\frac{\Delta V_3}{V_3}\right)^2\right)}$$

where

$$\left(\frac{\Delta V_1}{V_1}\right)^2 = \left(\frac{\sqrt{\left(\left(\Delta T_{uncorr}\right)^2 + \left(\Delta T_{abs}\right)^2\right)}}{\left(T_{uncorr} - T_{abs}\right)}\right)^2$$