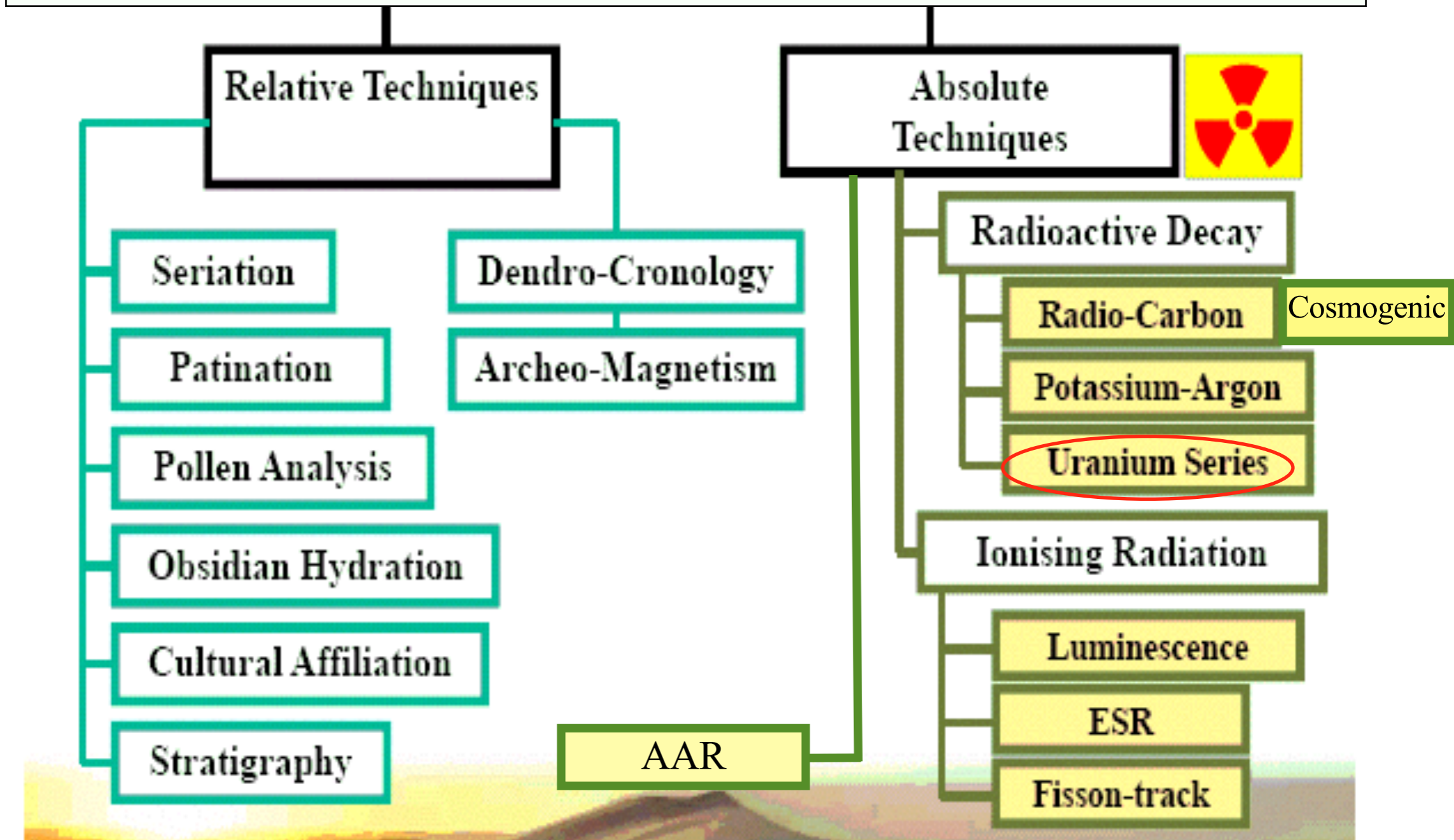


Advanced Analytical Methods in Bioarchaeology

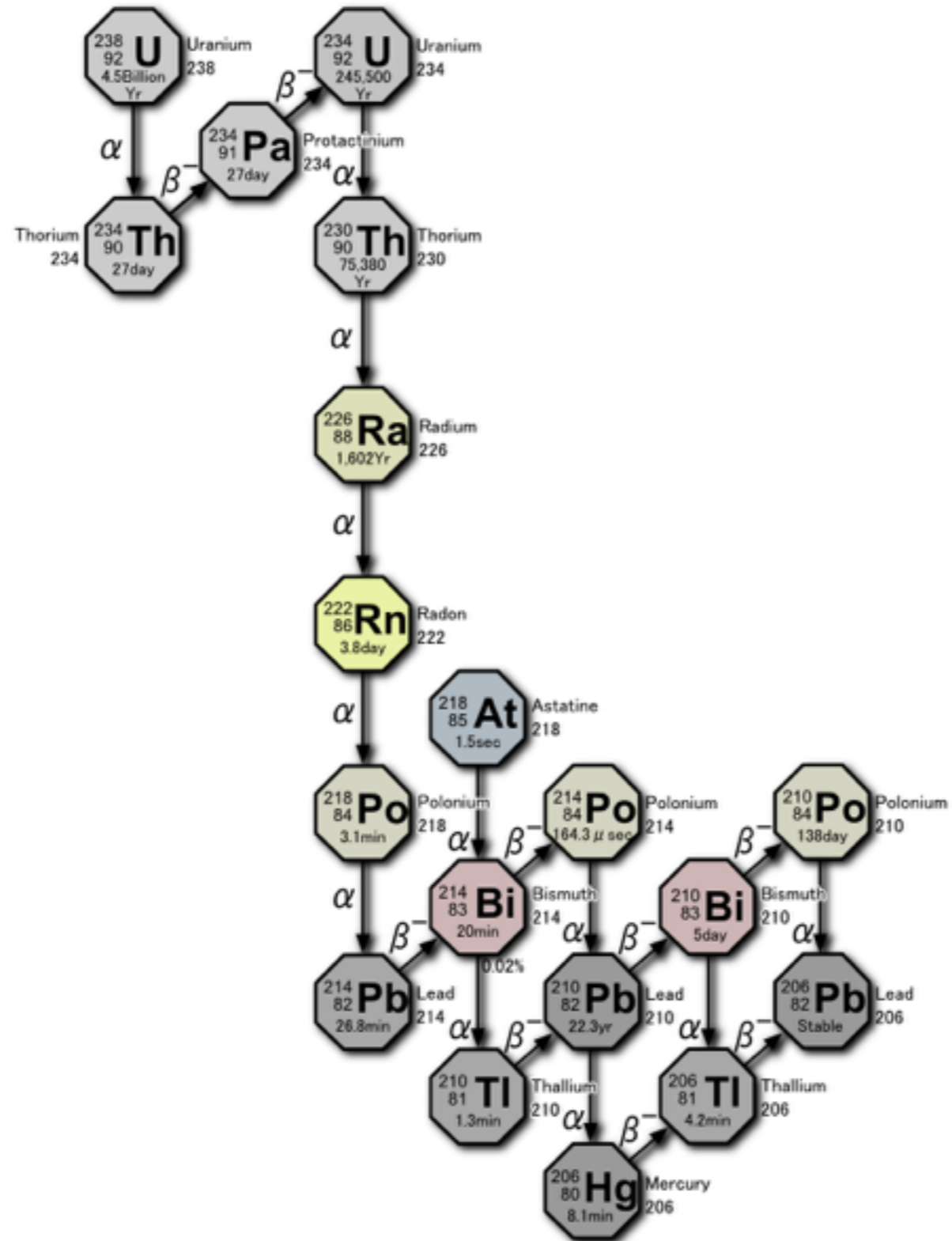
Claudio Tuniz

Uranium series

Dating Techniques



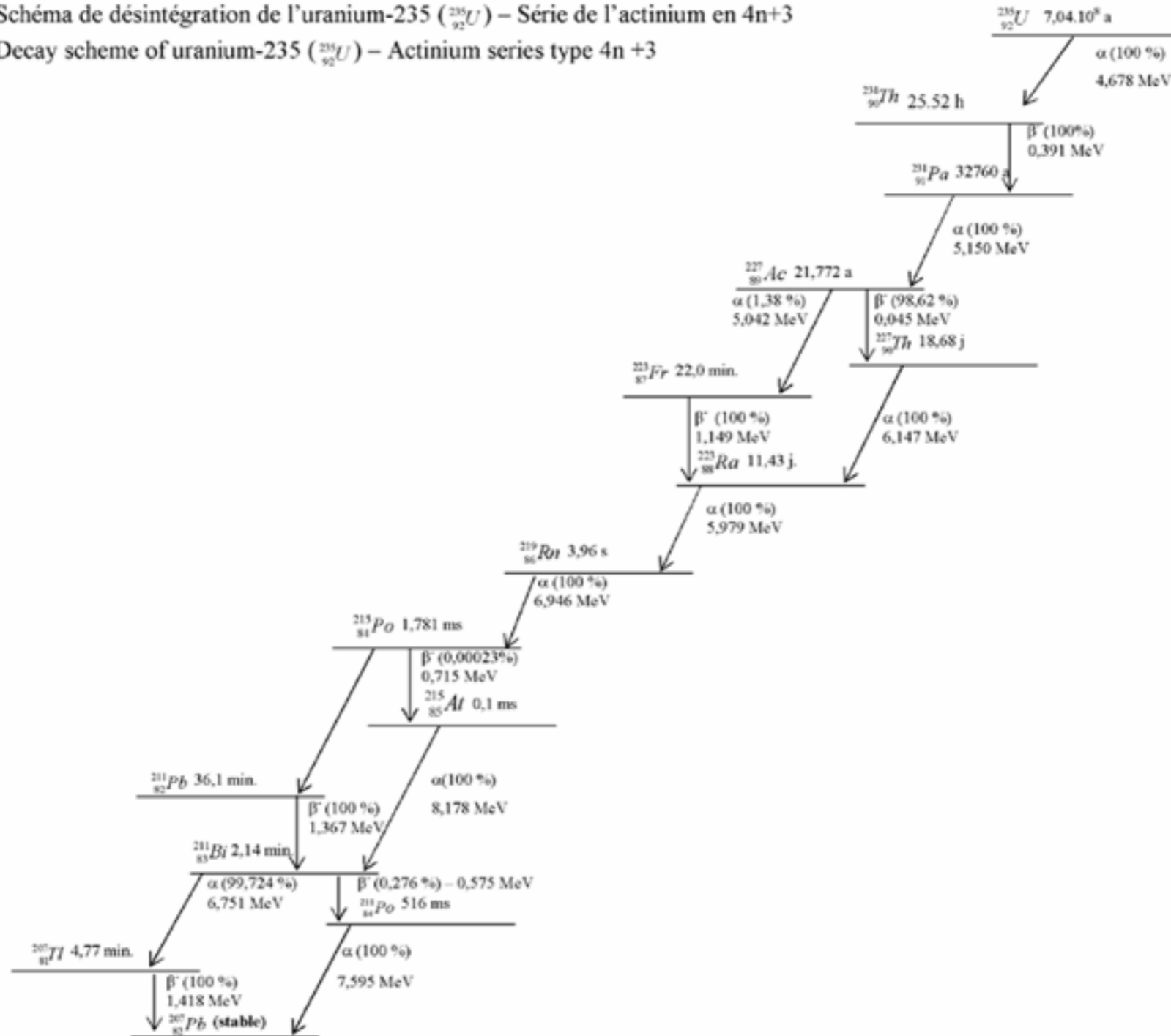
Decay uranium-238



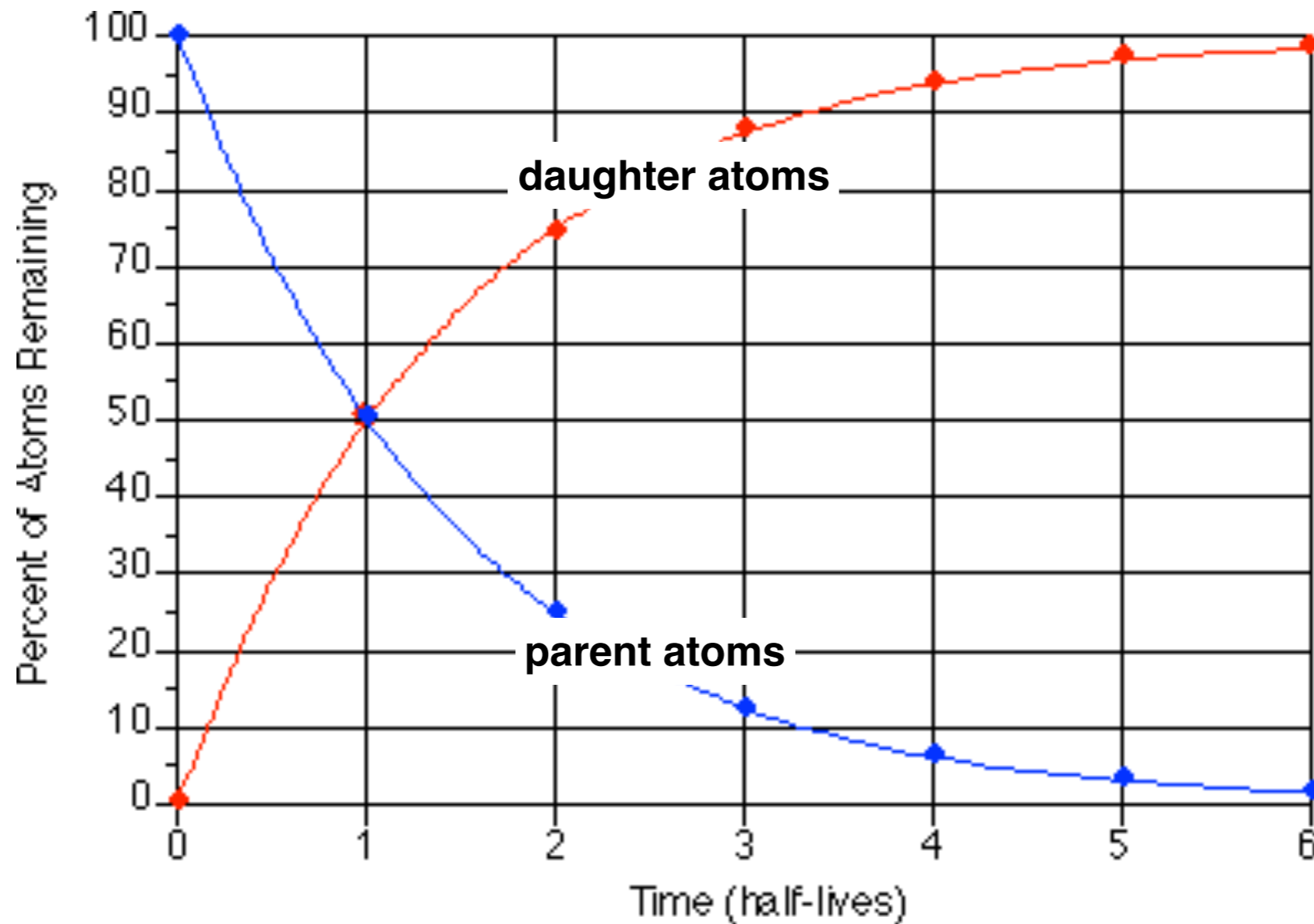
Decay uranium-235

Schéma de désintégration de l'uranium-235 (^{235}U) – Série de l'actinium en $4n+3$

Decay scheme of uranium-235 (^{235}U) – Actinium series type $4n+3$



Law of radioactivity



Uranium-Lead dating

$$N_{206} = N_{238} (e^{\lambda_8 t} - 1)$$

$$N_{207} = N_{235} (e^{\lambda_5 t} - 1)$$

$$N_{207} / N_{206} = N_{235} (e^{\lambda_5 t} - 1) / N_{238} (e^{\lambda_8 t} - 1)$$

$$N_{206} / N_{207} = 0.0072 (e^{\lambda_5 t} - 1) / (e^{\lambda_8 t} - 1)$$

Only the two lead isotopes need to be measured to evaluate the age (**Uranium-Lead** dating)

Uranium - Thorium dating

- U water soluble, Th water insoluble
- Natural waters contain traces of U but are free of Th
- Minerals precipitated from water (speleothems, shells, corals, etc.) contain U but no Th
- $^{230}\text{Th}/^{234}\text{U}$ are zero at time of mineral formation ($t=0$)
- After parent isotopes incorporated into mineral, they start to decay and isotope of decay chain grow towards secular equilibrium (ratio = 1)

Measurement

- alpha spectrometry (until late 1980s)

➔ dating range 350 ka

- gamma spectrometry
 - ❖ non-destructive
 - low efficiency

Measurement

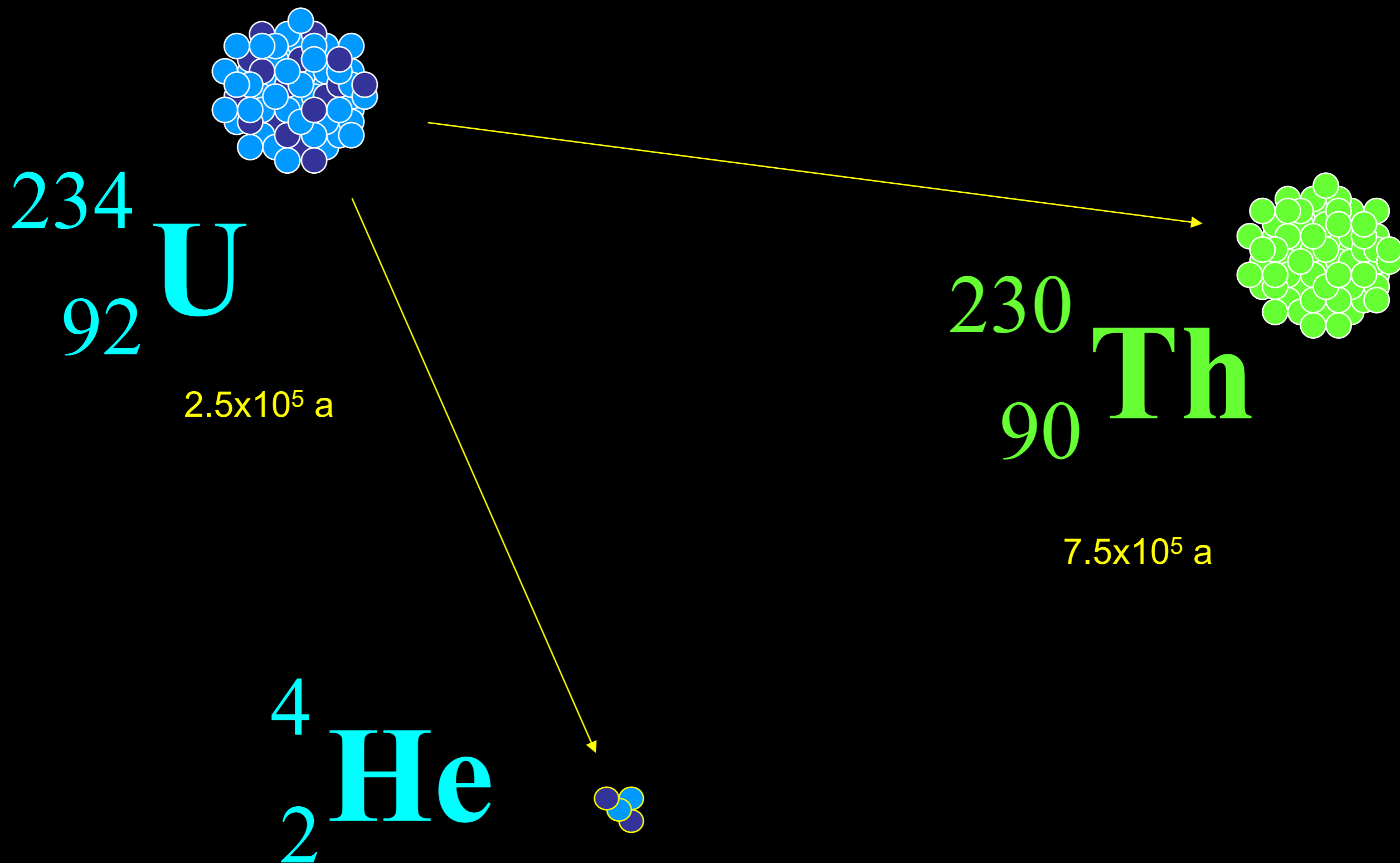
- Thermal ionisation mass spectrometry (TIMS)
 - ➔ ^{238}U , ^{230}Th
 - ❖ More precise and efficient than decay counting
 - ➔ dating range 500 ka
 - ➔ smaller samples can be analysed

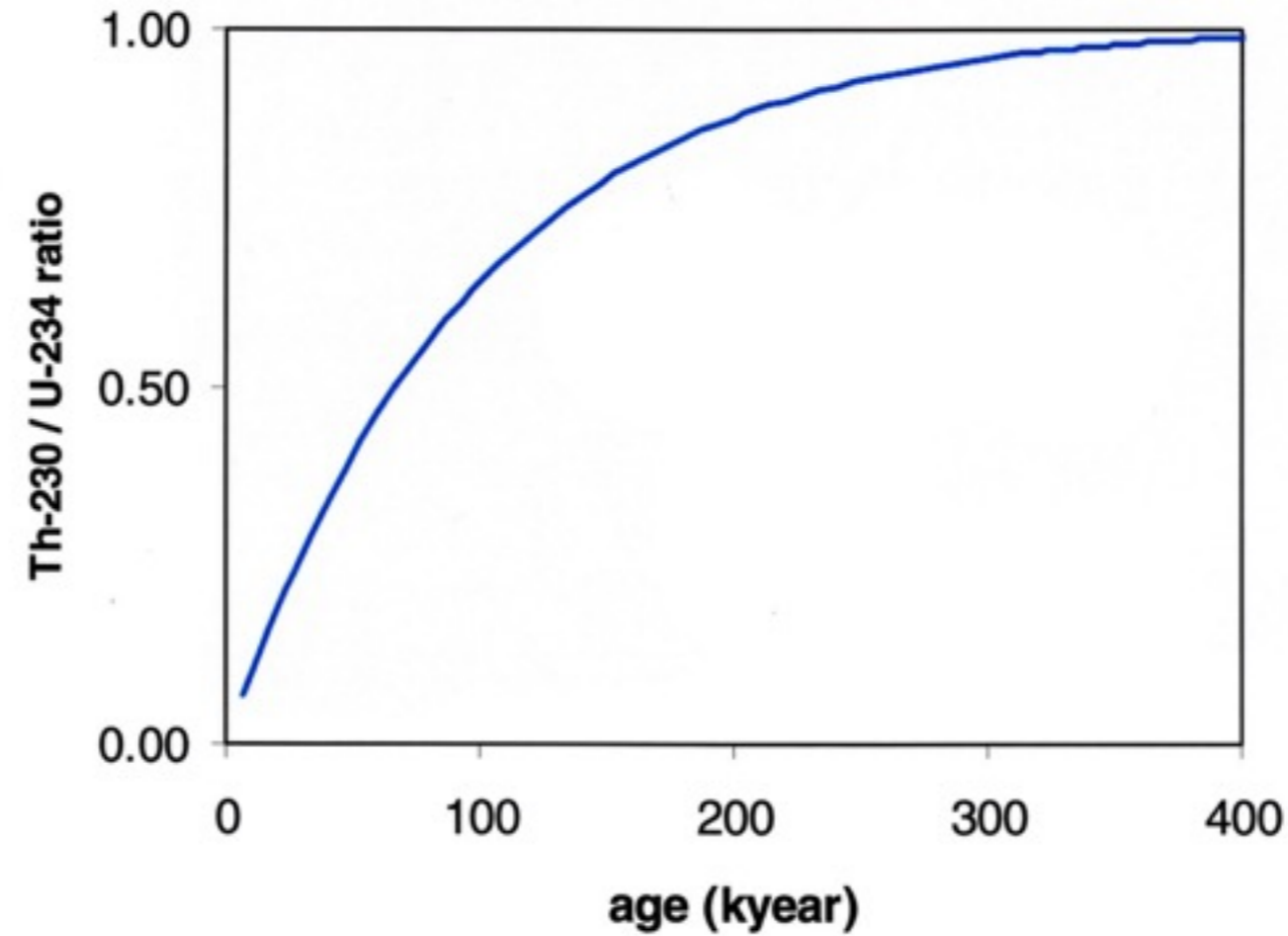
Measurement

- Laser ablation inductively coupled mass spectrometry LA ICP-MS
- ➔ in situ analysis of ^{238}U , ^{234}U in bones and teeth

U–Pb dating of fossil enamel from the Swartkrans Pleistocene hominid site, South Africa

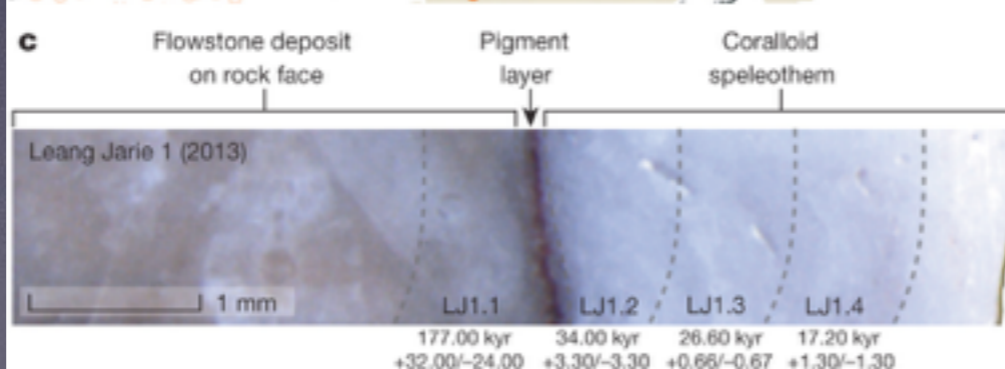
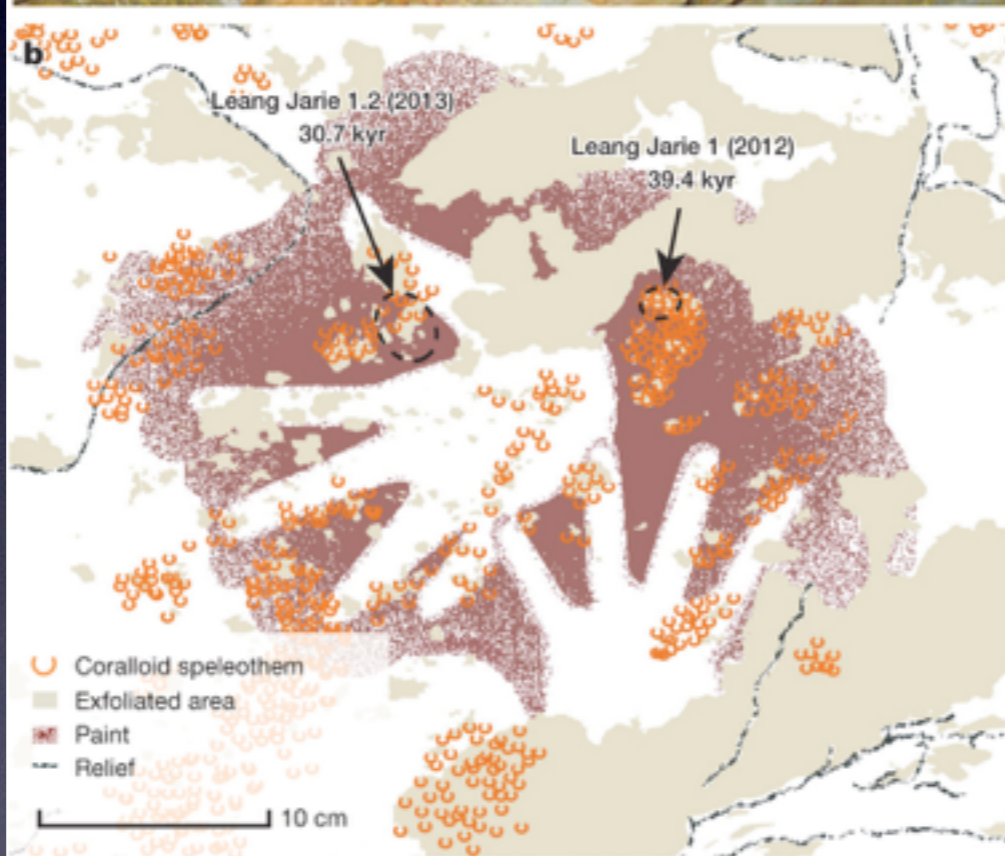
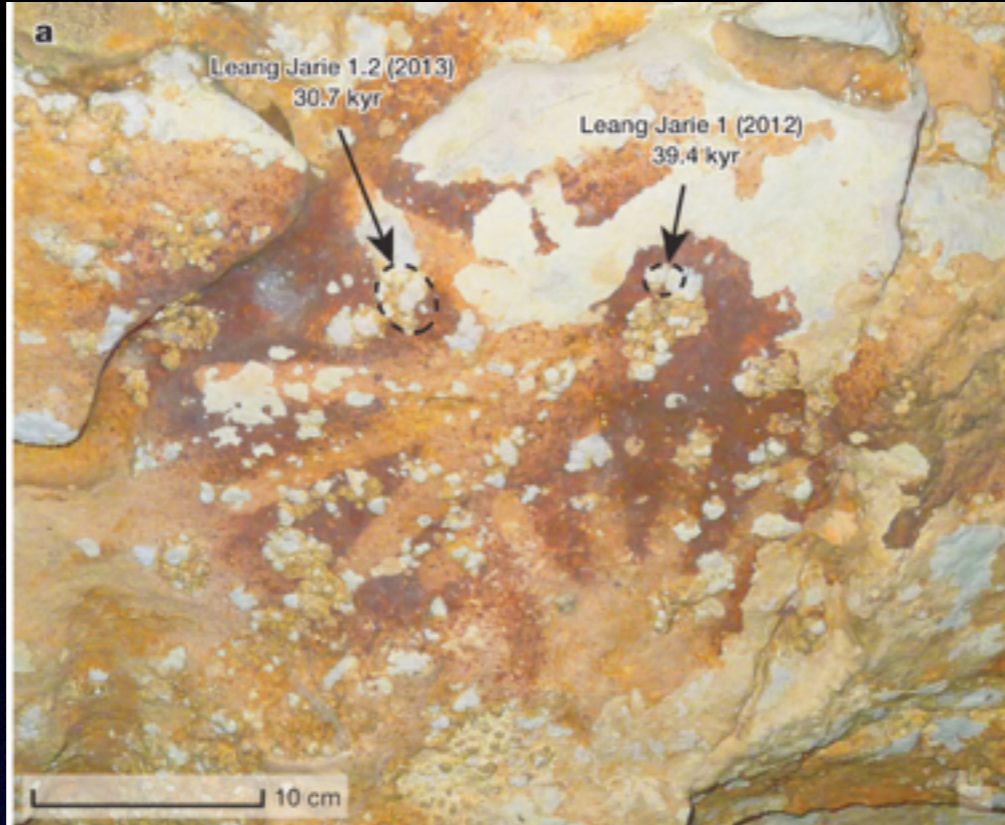
- “early uptake” (EU): U is acquired post-mortem during the decay of the organic fraction present in bone material and that subsequently its decay products remained in the host apatite until today (i.e., closed-system behavior).
- uptake is supposed to be instantaneous



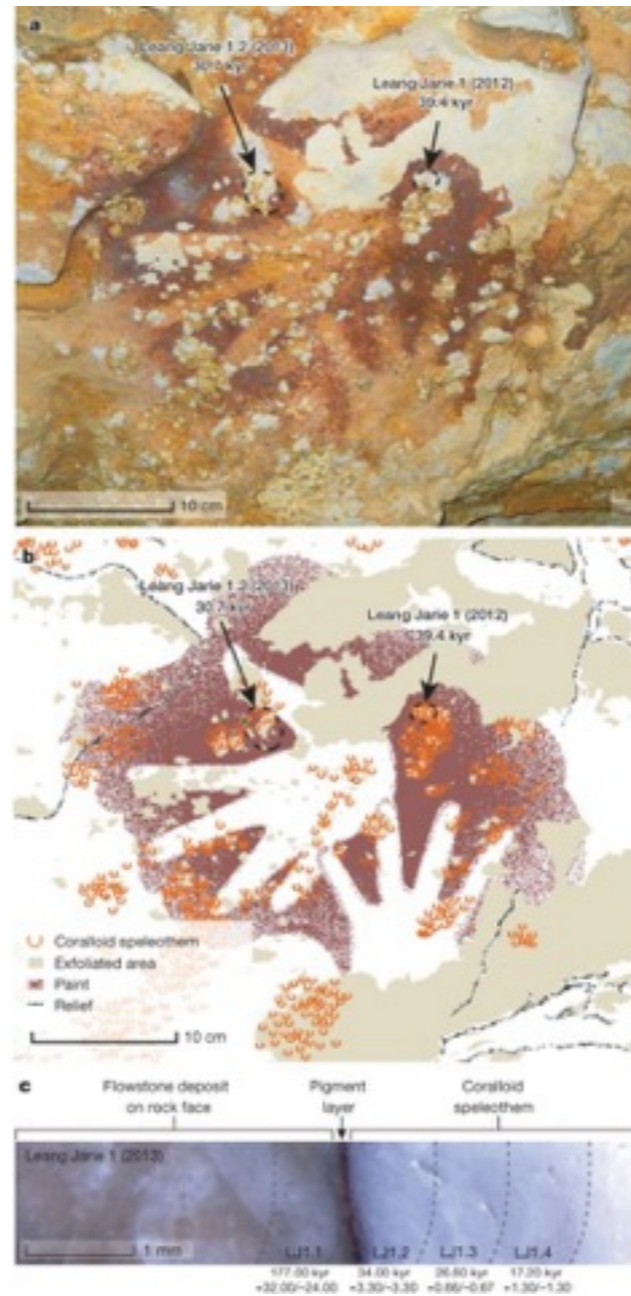


$$^{230}\text{Th} = ^{234}\text{U} (1 - e^{-\lambda_{230}t})$$

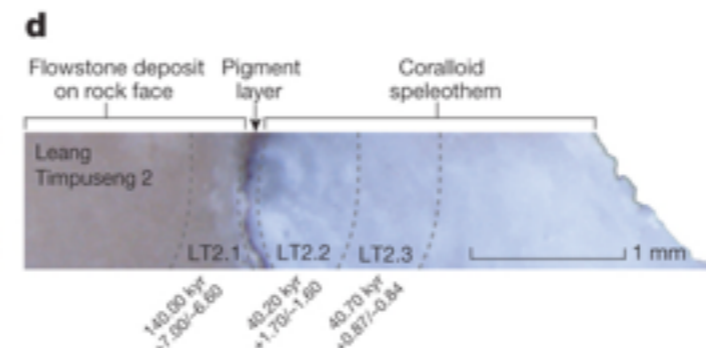
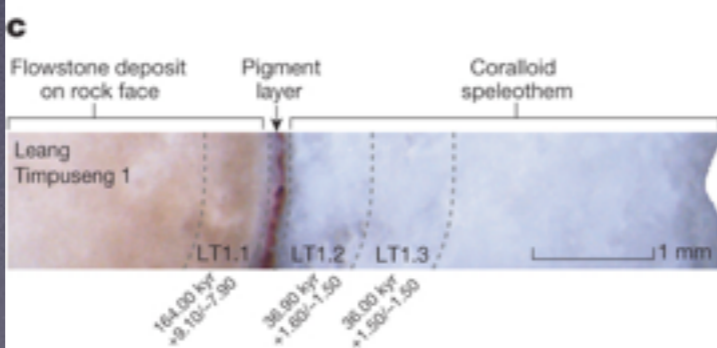
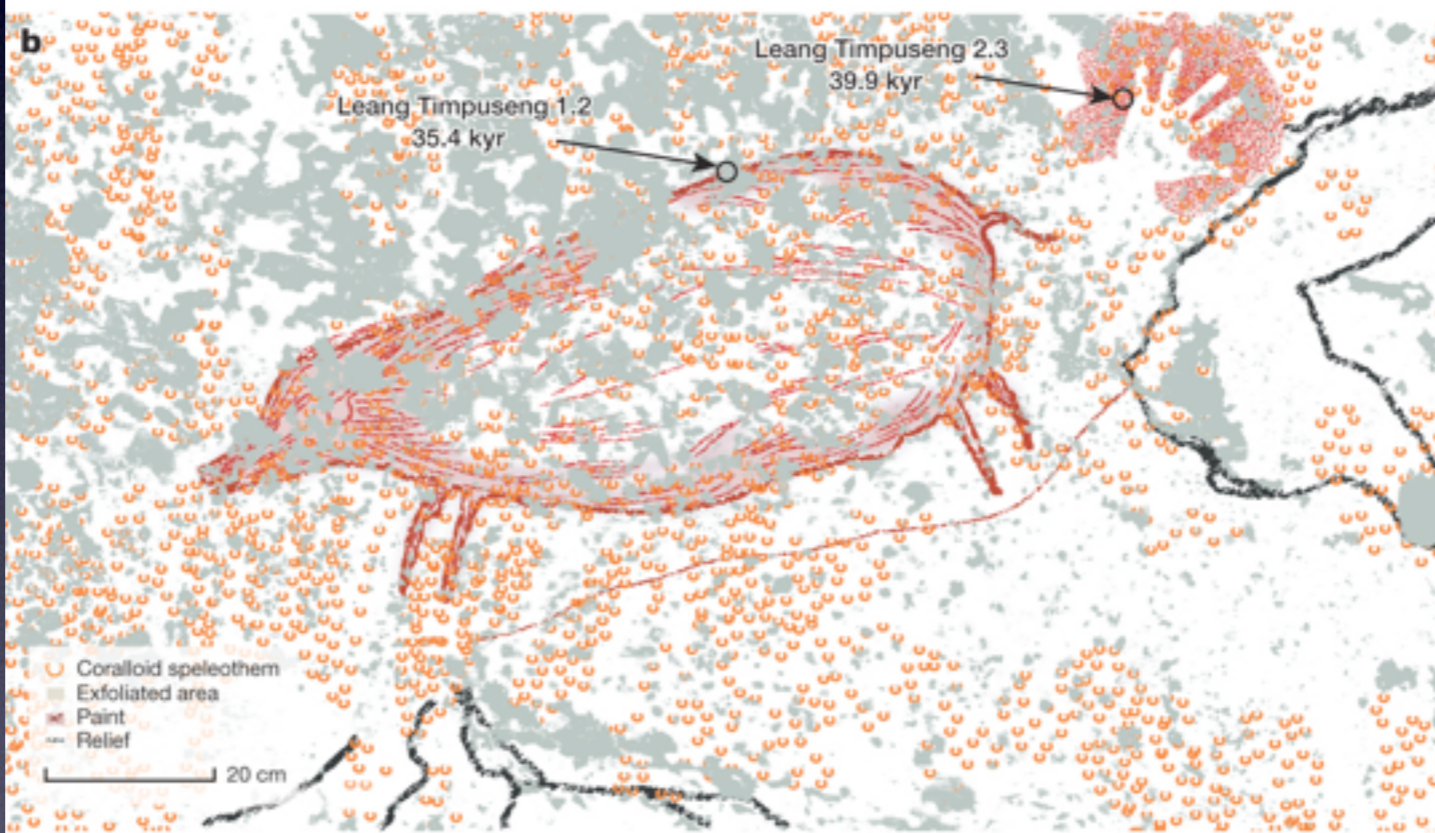
Age range < 350 ka alpha counting
Age range < 500 ka TIMS



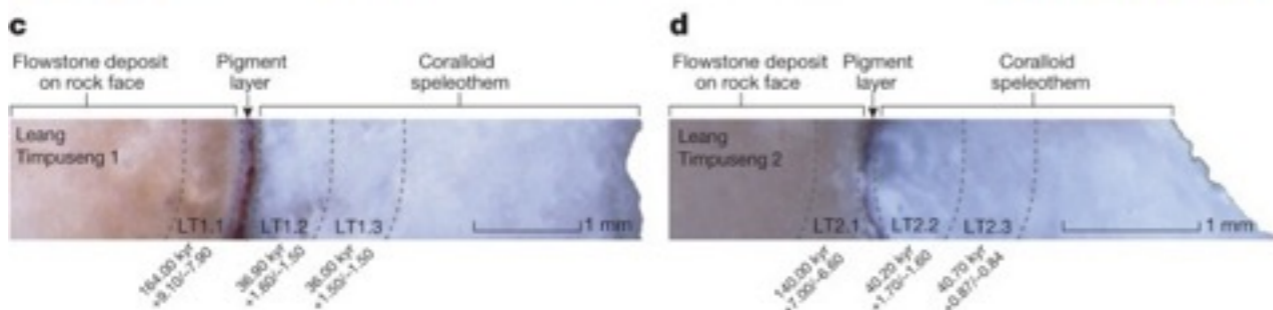
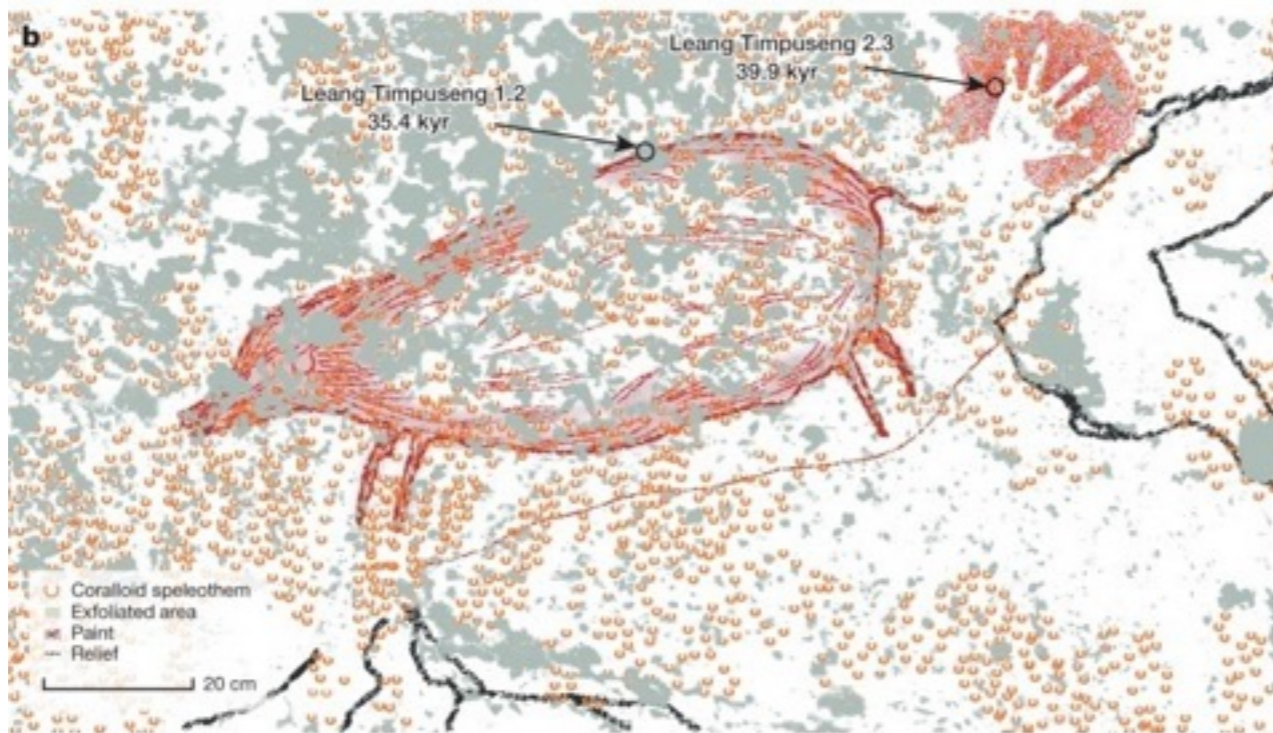
Dated rock art from Leang Jarie.



M Aubert *et al.* *Nature* **514**, 223-227 (2014) doi:10.1038/nature13422



Dated rock art from Leang Timpuseng.



nature