U-Series Dating – David Richards

- Age estimates

"*all ages are model ages*"…

- Growth models

"…*even more so for interpolated ages*"

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Resolution vastly improved through increased efficiency of collection (static collection, improved ionisation efficiency etc)

x1000-10000 reduction in sub-sample size in past 25 years

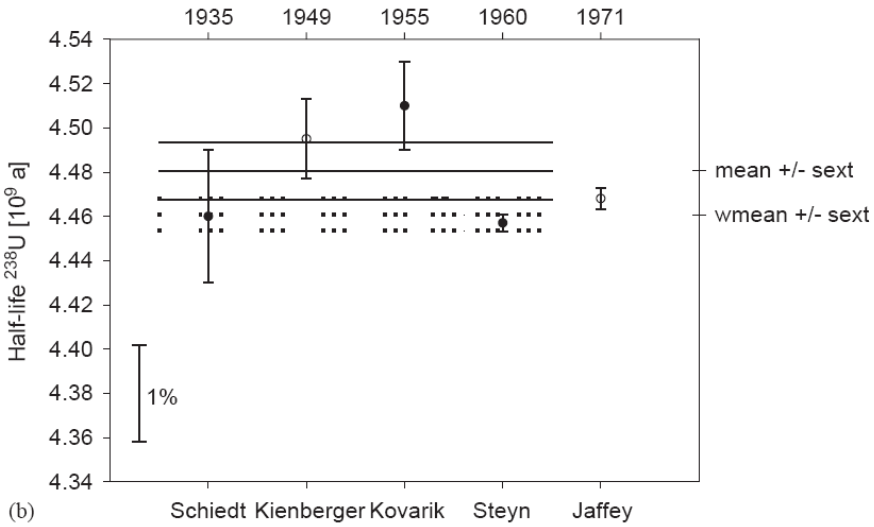
Typical precisions limited to 0.1 to 1 % (95CI), depending primarily on abundance of daughter product

… but this needs unpacking..

Precision related to internal counting statistics, bracketing standard drift, blank correction, but also **half-life uncertainty – we still use Jaffey (1971) value**

New data emerging with higher precision estimates for $t_{1/2}$(^{234}U, ^{230}Th) at 0.01% level but accuracy ultimately limited by

1. ^{238}U half-life determinations (Jaffey et al, 1971)
2. secular equilibrium for ^{238}U-^{234}U-^{230}Th
3. closed system.



There exists reasonable consensus on the values for half-lifes, but their accuracy remains an issue.

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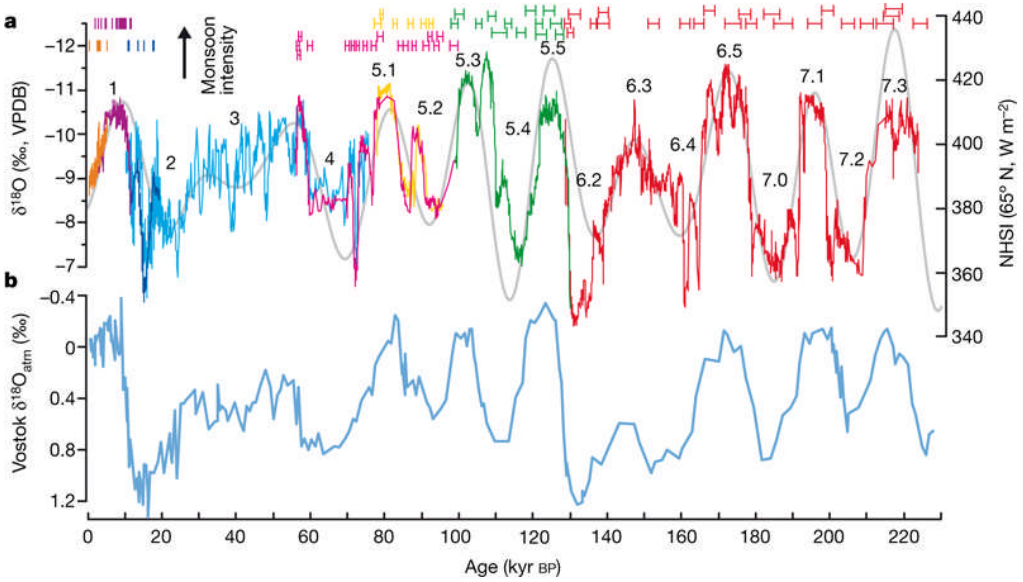
Verification of half-life using orbital data

Cheng et al (Goldschmidt, 2008) employ strategy similar to that of Shackleton et al (1990) in their assessment of the age of the Brunhes/Matuyma reversal and incorrect Ar half-life…

Half-life differences of 0.05% equate to 10 ka difference in age estimate at ~600 ka (~precessional cycle/2). Using new half-lifes, they determine that the speleothem 23 kyr cycle matches that of insolation forcing for > 600 ka.



Above Wang et al, 2008 to 240 ka.

In forthcoming papers, U-Th chronology and orbital chronology match well to greater than 640 ka

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Other chronological concerns: Age estimates

Initial Th-230 (or Pa-231) = 0?

Most use *a priori* estimation, based on either Bulk Earth Th/U ratio, say 3.6 to 3.8, which gives Th-230/Th-232 activity ratio ~ 0.85

Others use ‘more radiogenic’ Th-230/Th-232 activity ratio of 1.7 based on global survey by Kaufman (1993)

Not a problem if Th-232 is low (but how low?) but thorough study is advocated via **isochron methodology (see Hellstrom, 2006, QSR)**

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Chronological concerns: Growth models

Strategies to reduce error

on **predicted** ages between age estimates

Key questions is “how variable is growth rate?”

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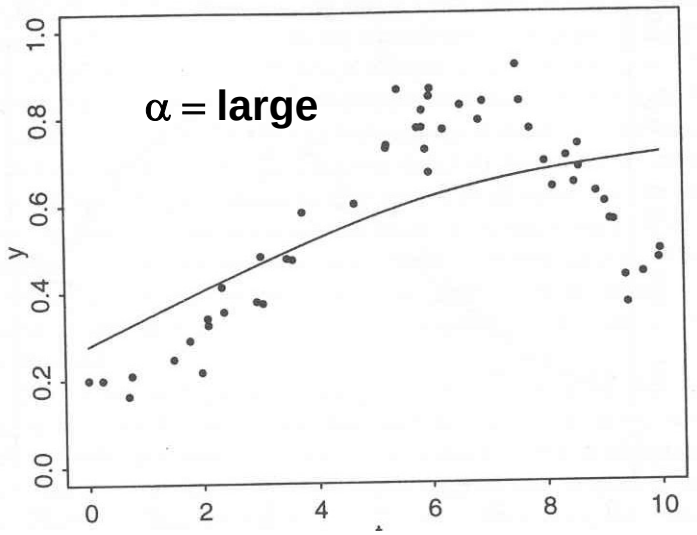
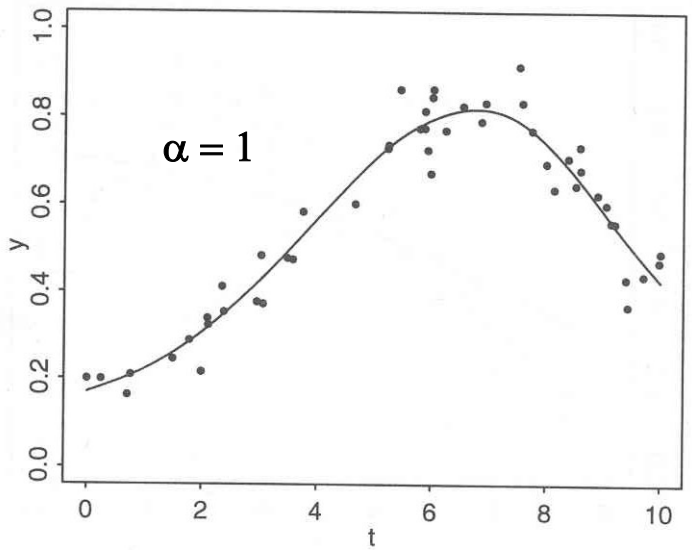
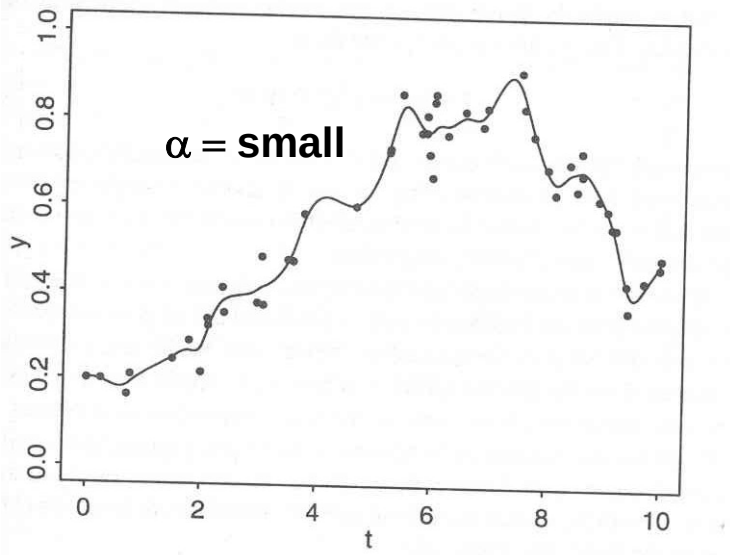


$$S(g) = \sum_{i=1}^{n} \{Y_i - g(t_i)\}^2 + \alpha \int_a^b \{g''(x)\}^2 dx.$$

least squares estimator

roughness penalty, α
or smoothing parameter





Generalised cross validation can be used to 'automatically choose smoothing parameter

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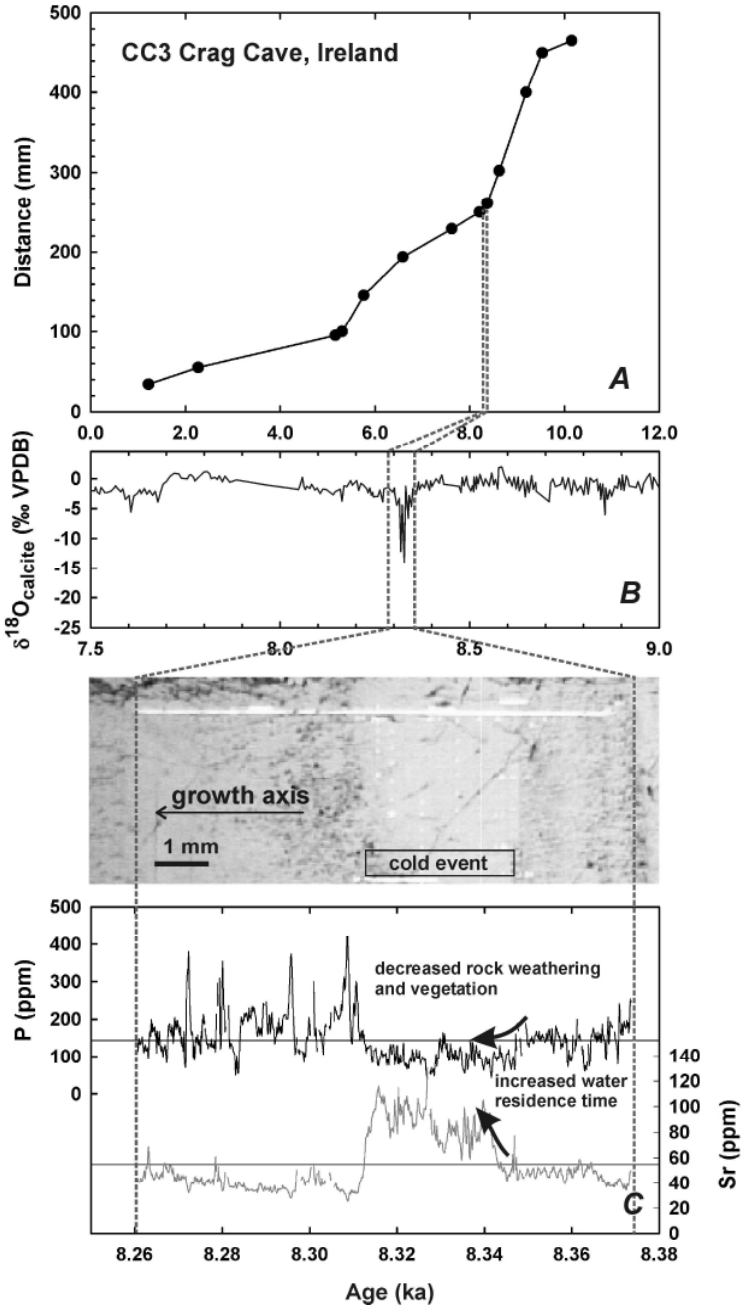

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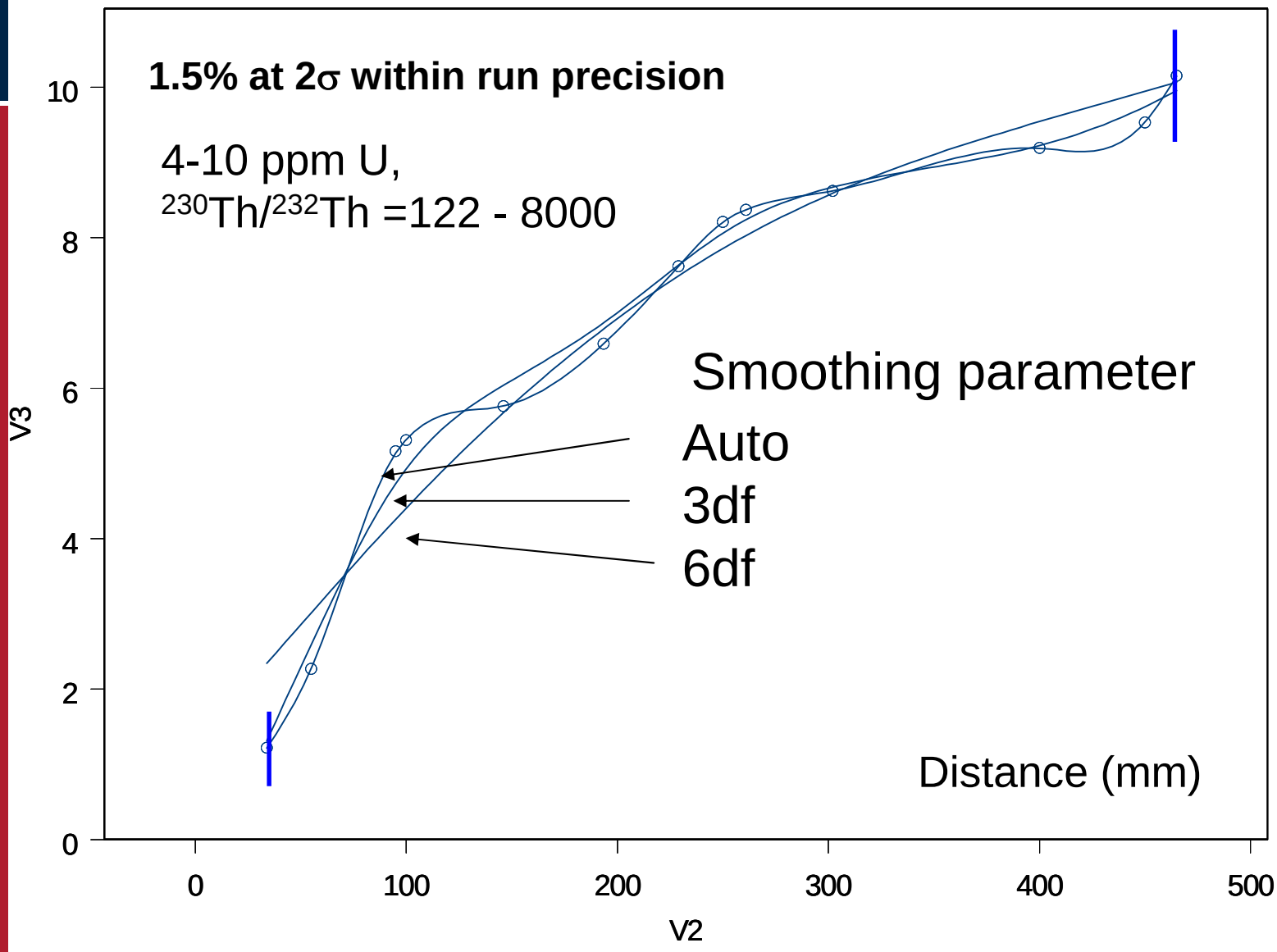

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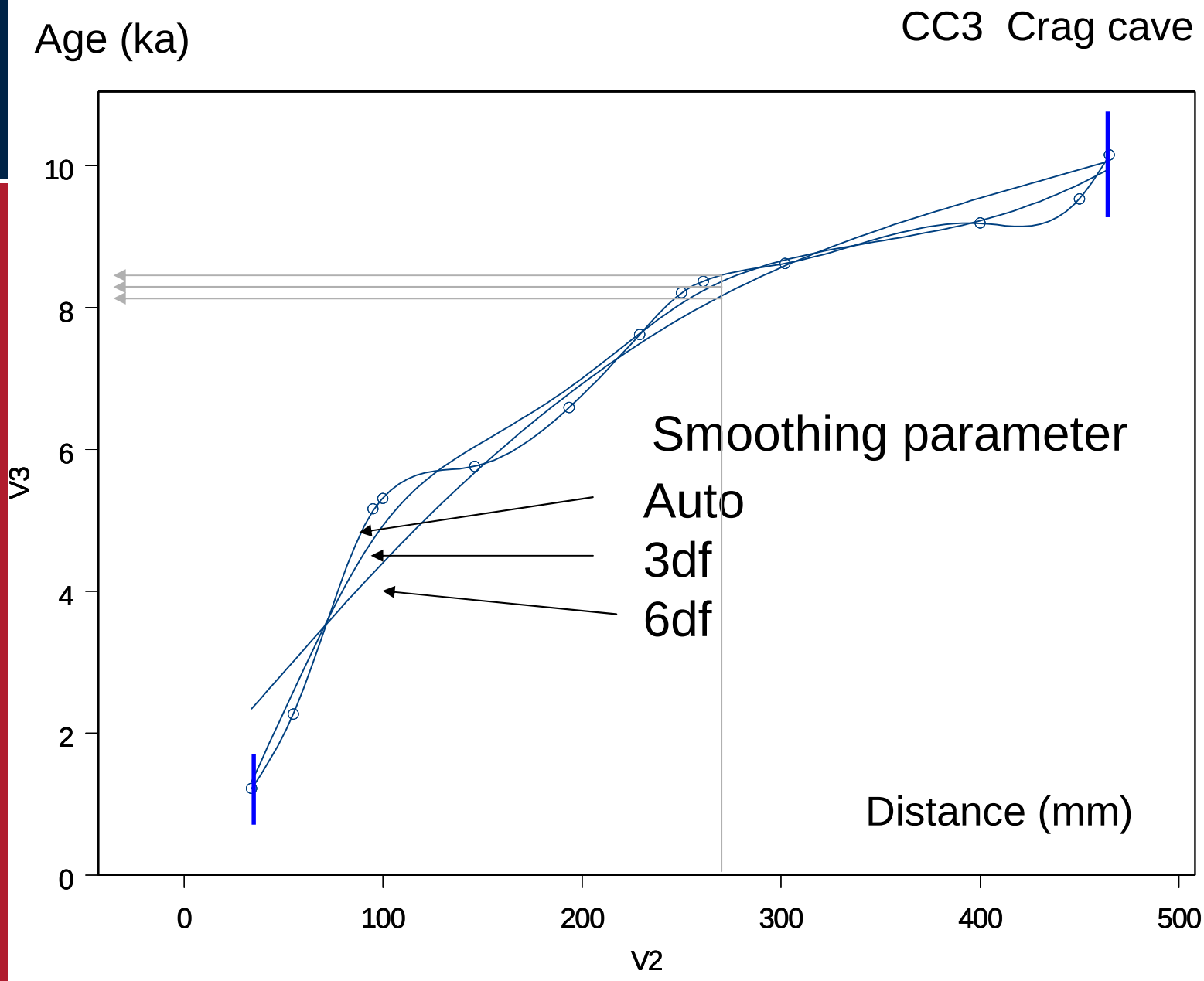

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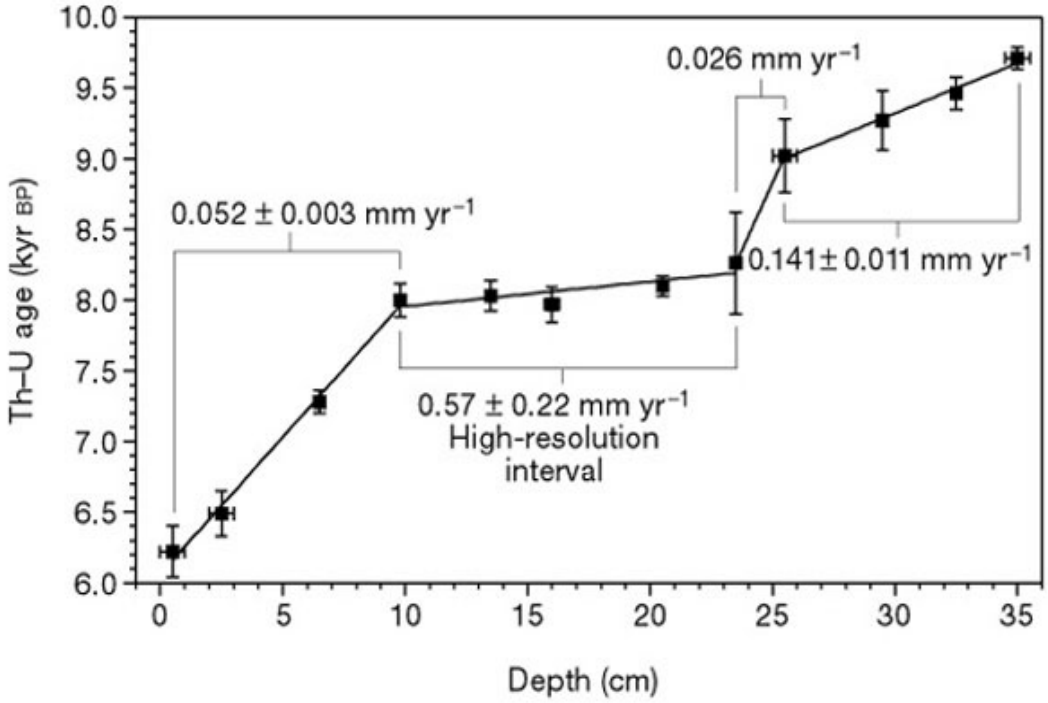
Use of independent evidence to confirm growth model
Oman
Neff et al 2001



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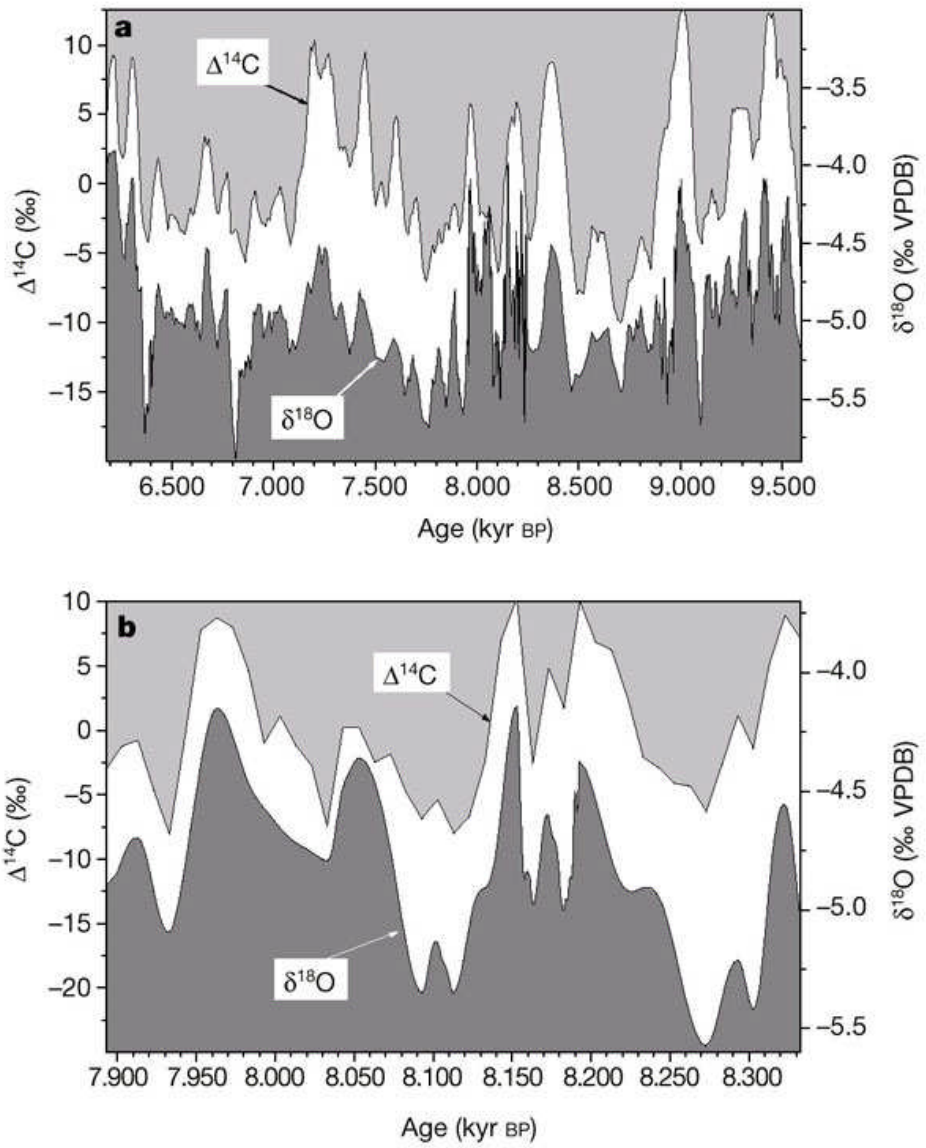

Tuned record from Oman

Neff *et al* 2001

Close correspondence with tree-ring $\Delta^{14}C$ record based on annual bands

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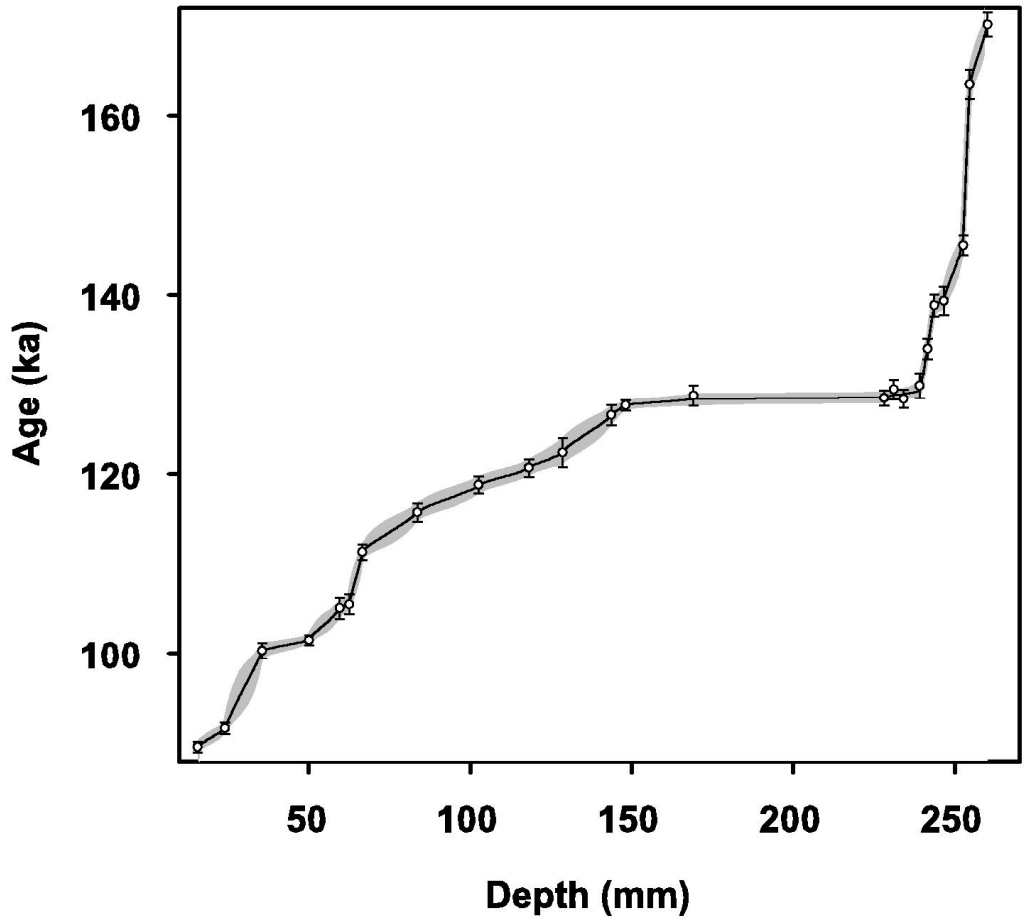
Drysdale et al, GRL, 2005 Corchia Cave and work by Hellstrom (2006)

MCMC using Bayesian framework, assigns prior distribution for $^{230}Th/^{232}Th$ and constrains growth rate to be monotonic and lie within specific but wide constraints.



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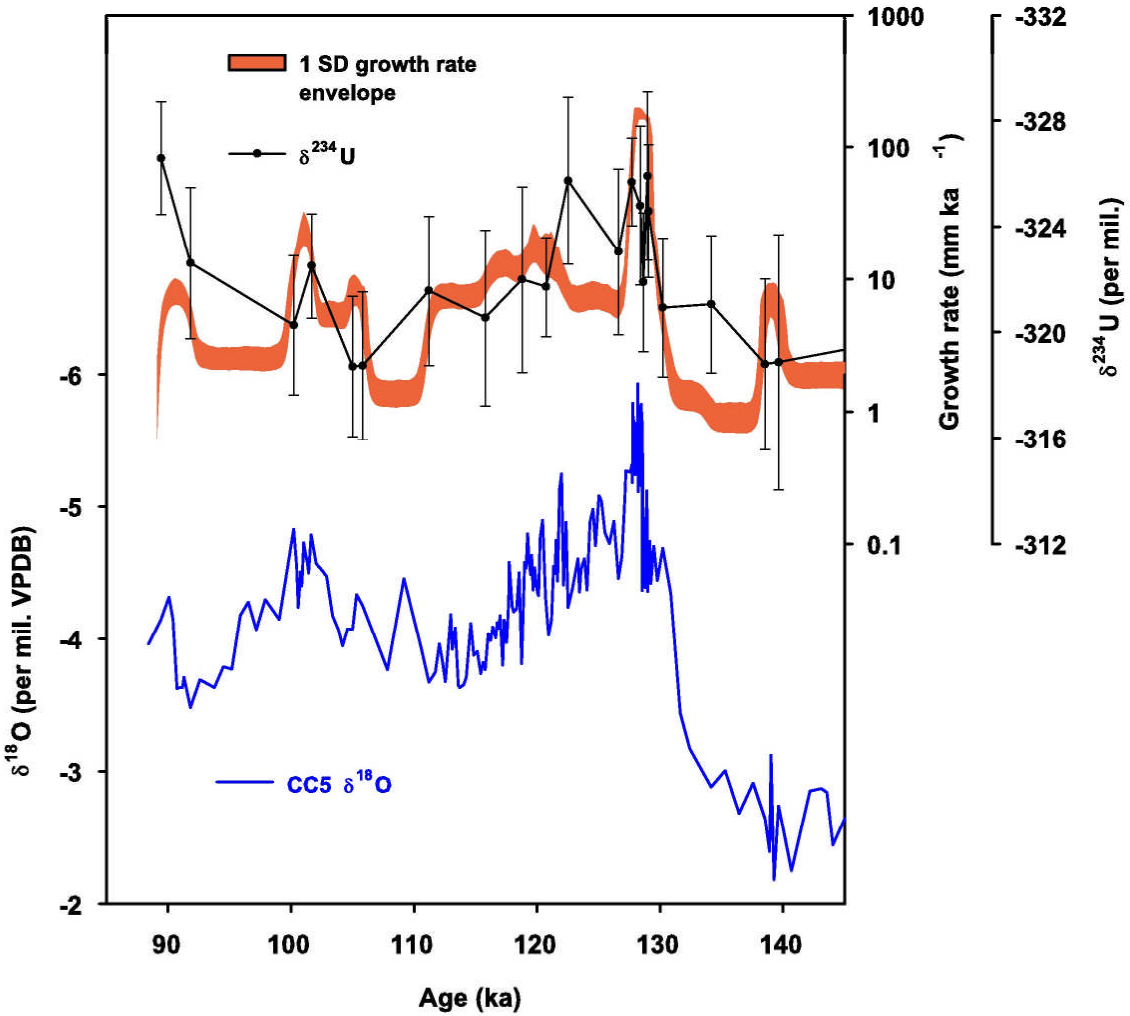
Drysdale et al, GRL, 2005 Corchia Cave



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