Cosmogenic burial dating complications due to non-steady erosion and complex exposure histories

Presented by Tebogo Makhubela

Explicit treatment of inheritance in dating depositional surfaces using in situ ^{10}Be and ^{26}Al

Robert S. Anderson
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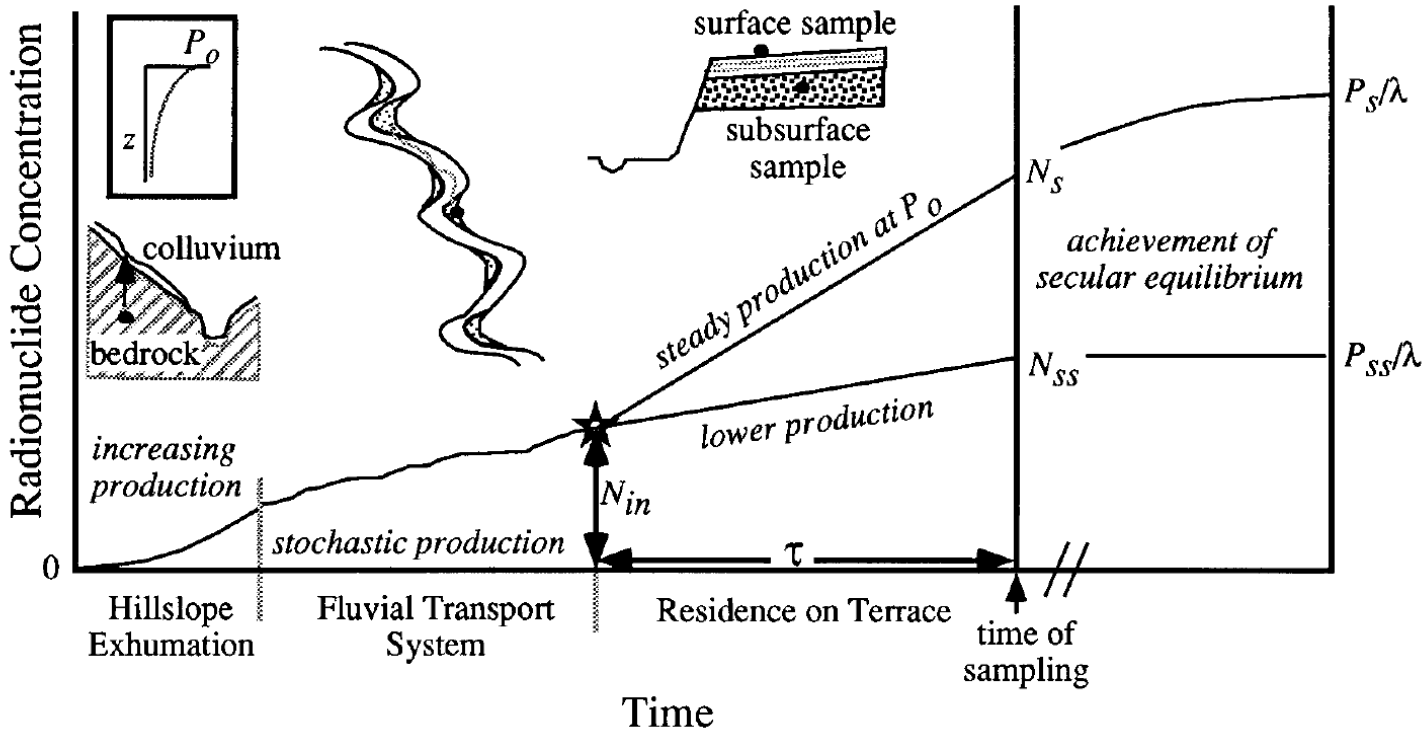
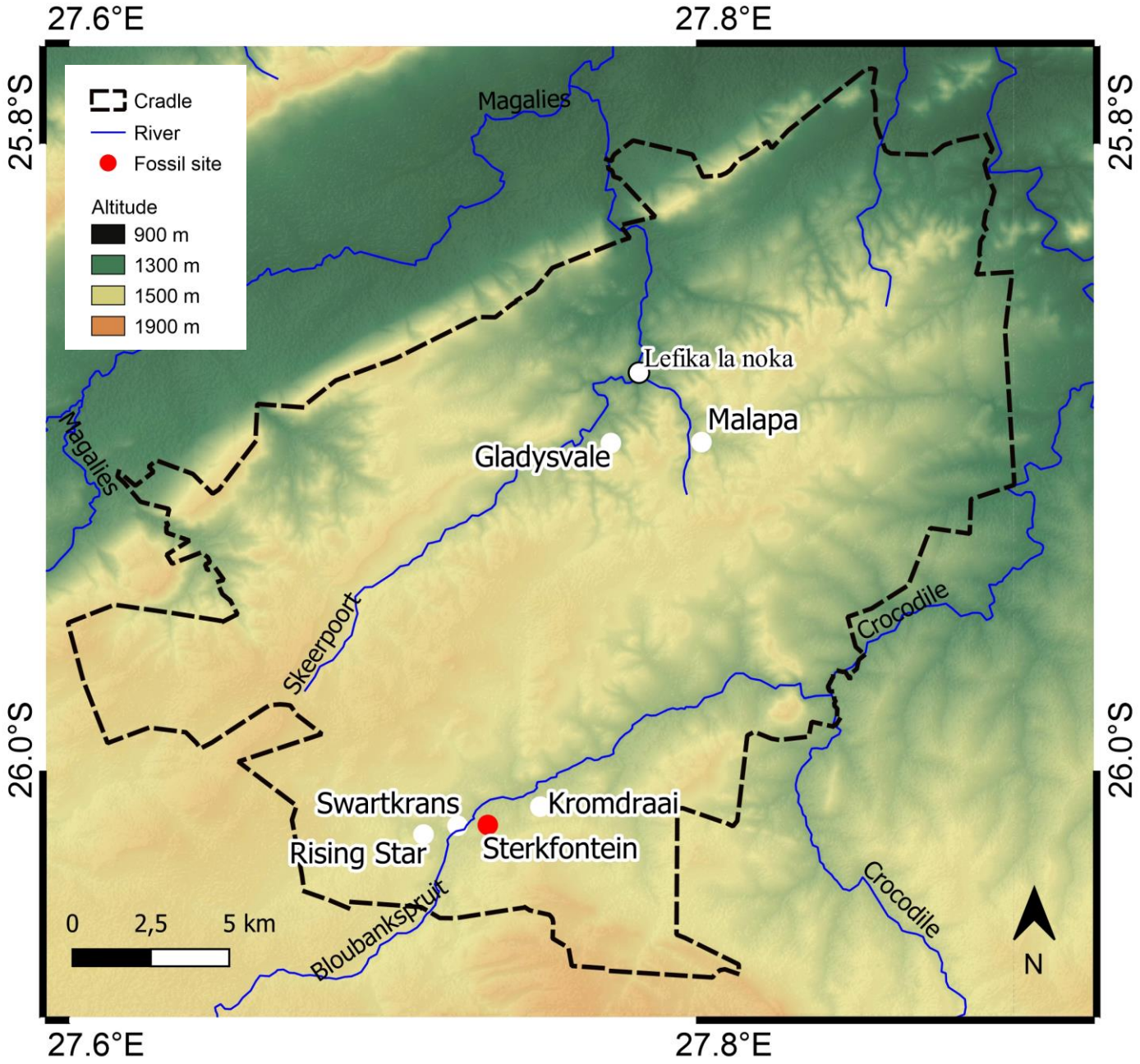
Gregory S. Dick

Department of Earth Sciences and Institute for Tectonics, University of California, Santa Cruz, California 95064

Geology; January 1996; v. 24; no. 1; p. 47–51; 3 figures; 1 table.



Site 1:
Sterkfontein Cave



Sterkfontein Cave cosmogenic burial dating

Science
AAAS

Lower Pliocene Hominid Remains from Sterkfontein
T. C. Partridge *et al.*
Science **300**, 607 (2003);
DOI: 10.1126/science.1081651

T. C. Partridge,[1]* D. E. Granger,[2] M. W. Caffee,[3] R. J. Clarke[4]

Cosmogenic aluminum-26 and beryllium-10 burial dates of low-lying fossiliferous breccia in the caves at Sterkfontein, South Africa, show that associated hominid fossils accumulated in the Lower Pliocene. These dates indicate that the skeleton StW 573 and newly discovered specimens from Jacovec Cavern have much the same age: approximately 4 million years. These specimens are thus of an age similar to *Australopithecus anamensis* from East Africa.

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Journal of Human Evolution
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Re-appraisal of the stratigraphy and determination of new U-Pb dates for the Sterkfontein hominin site, South Africa

Robyn Pickering[a,b,*], Jan D. Kramers[a,c,d]

ELSEVIER
Contents lists available at ScienceDirect
Quaternary Geochronology
journal homepage: www.elsevier.com/locate/quageo

Research Paper

U–Pb dating of calcite–aragonite layers in speleothems from hominin sites in South Africa by MC-ICP-MS

Robyn Pickering[a,b,*], Jan D. Kramers[a,c,d], Tim Partridge[c,1], Janos Kodolanyi[a], Thomas Pettke[a]

Science
AAAS

U-Pb Isotopic Age of the StW 573 Hominid from Sterkfontein, South Africa
Joanne Walker *et al.*
Science **314**, 1592 (2006);
DOI: 10.1126/science.1132916

Joanne Walker,[1] Robert A. Cliff,[1]* Alfred G. Latham[2]

Sterkfontein cave, South Africa, has yielded an australopith skeleton, StW 573, whose completeness has excited great interest in paleoanthropology. StW 573, or "Little Foot," was found 25 meters below the surface in the Silberberg Grotto. ^{238}U-^{206}Pb measurements on speleothems immediately above and below the fossil remains, corrected for initial ^{234}U disequilibrium, yield ages of 2.17 ± 0.17 million years ago (Ma) and $2.24^{+0.09}_{-0.07}$ Ma, respectively, indicating an age for StW 573 of close to 2.2 Ma. This age is in contrast to an age of ~3.3 Ma suggested by magnetochronology and ages of ~4 Ma based on ^{10}Be and ^{26}Al, but it is compatible with a faunal age range of 4 to 2 Ma.

Sterkfontein Cave cosmogenic burial dating

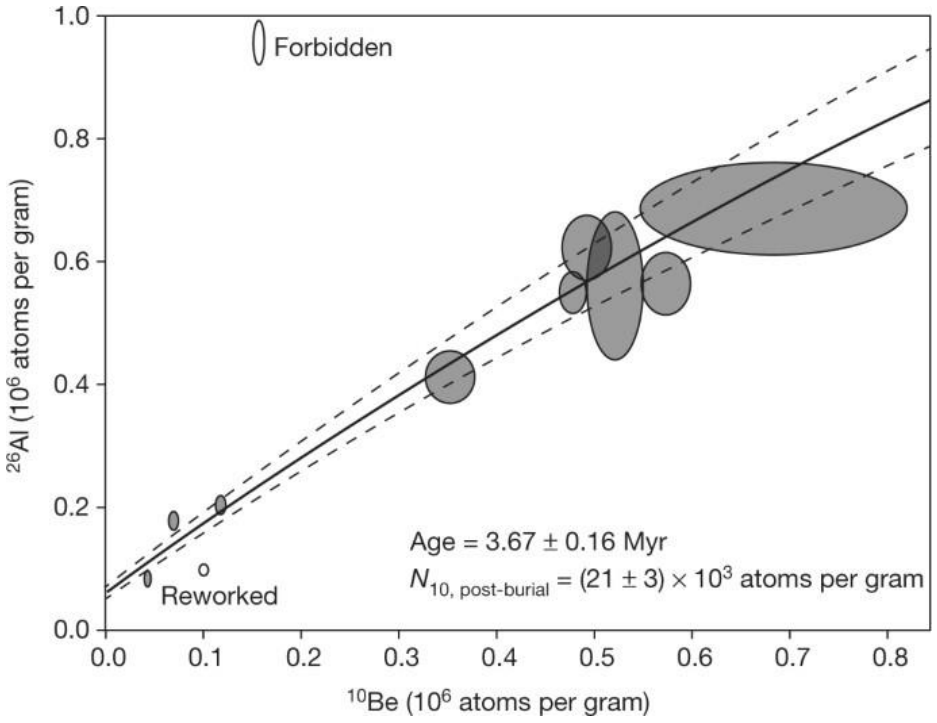
Letter | Published: 01 April 2015

New cosmogenic burial ages for Sterkfontein Member 2 *Australopithecus* and Member 5 Oldowan

Darryl E. Granger, Ryan J. Gibbon, Kathleen Kuman, Ronald J. Clarke, Laurent Bruxelles & Marc W. Caffee

Nature **522**, 85–88 (2015) | Cite this article

nature



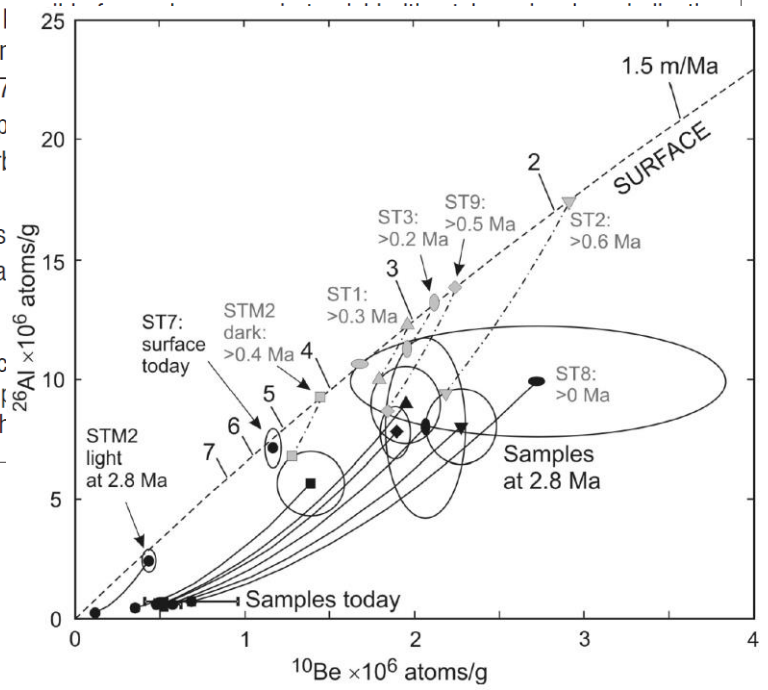
South African Journal of Science
120 years

The age of fossil StW573 ('Little Foot'): An alternative interpretation of ^{26}Al/^{10}Be burial data

Following the publication (Granger DE et al., Nature 2015;522:85–88) of an ^{26}Al/^{10}Be burial isochron age of 3.67±0.16 Ma for the sediments encasing hominin fossil StW573 ('Little Foot'), we consider data on chert samples presented in that publication to explore alternative age interpretations. ^{10}Be and ^{26}Al concentrations determined on individual chert fragments within the sediments were calculated back in time, and data from one of these fragments point to a maximum age of 2.8 Ma for the sediment package and therefore also for the fossil. An alternative hypothesis is explored, which involves re-deposition and mixing of sediment that had previously collected over time in an upper chamber, which has since been eroded. We show that it is
an apparent age much older thar
scenario for deposition of StW57
the Silberberg Grotto and an upp
trap, but it could also have disturl
sediment to be washed into the
younger age for the fossil, consis
not in contradiction to available fa

Significance:

- Data on chert samples taken c
than the 3.67 Ma originally re
inconsistency and to reopen th

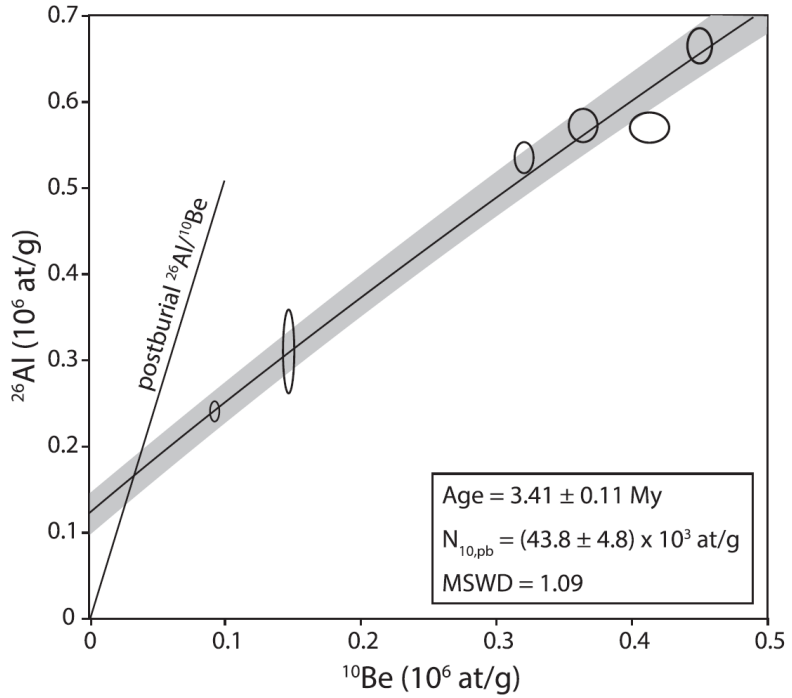


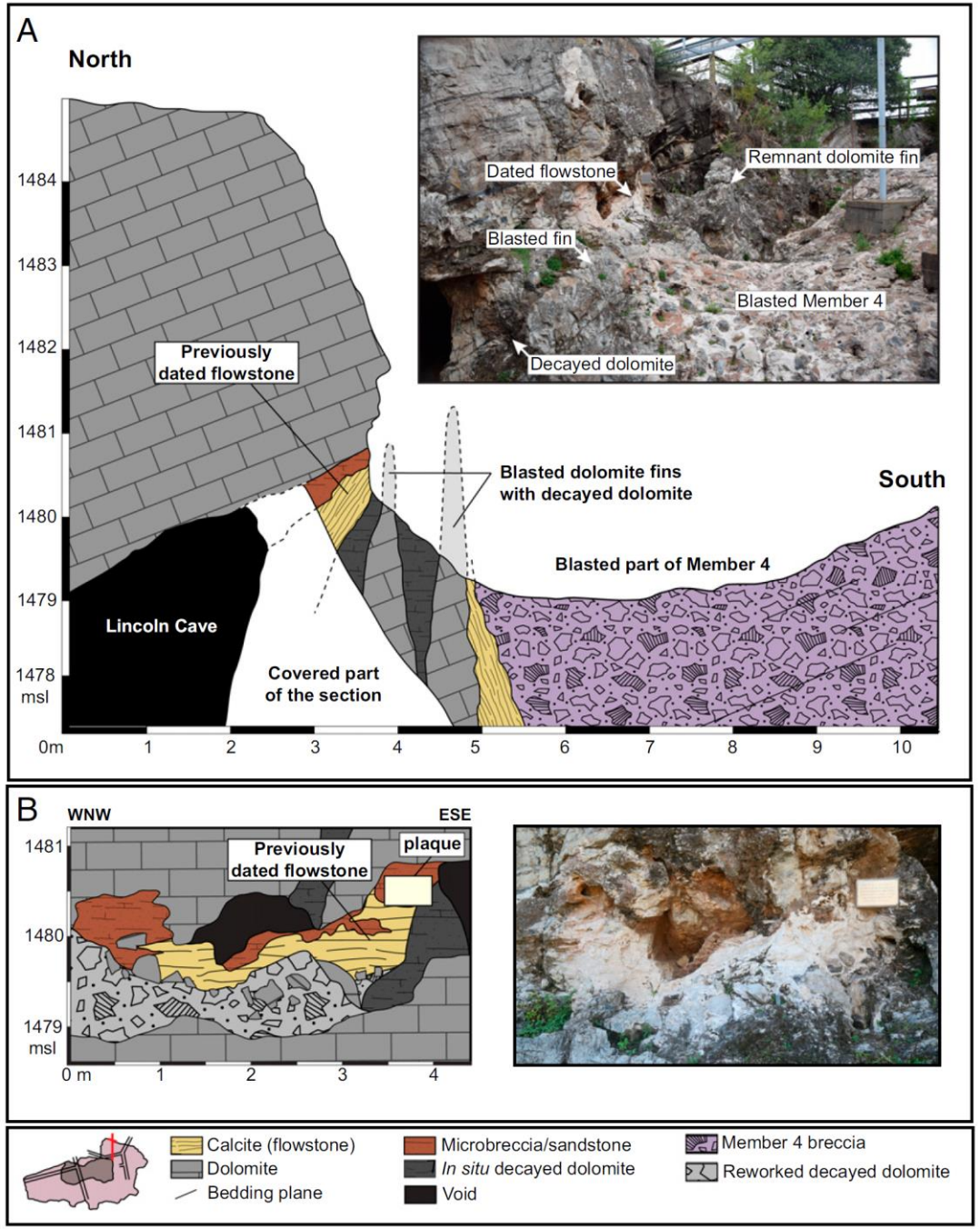
Sterkfontein Cave cosmogenic burial dating

PNAS RESEARCH ARTICLE | EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES ANTHROPOLOGY OPEN ACCESS

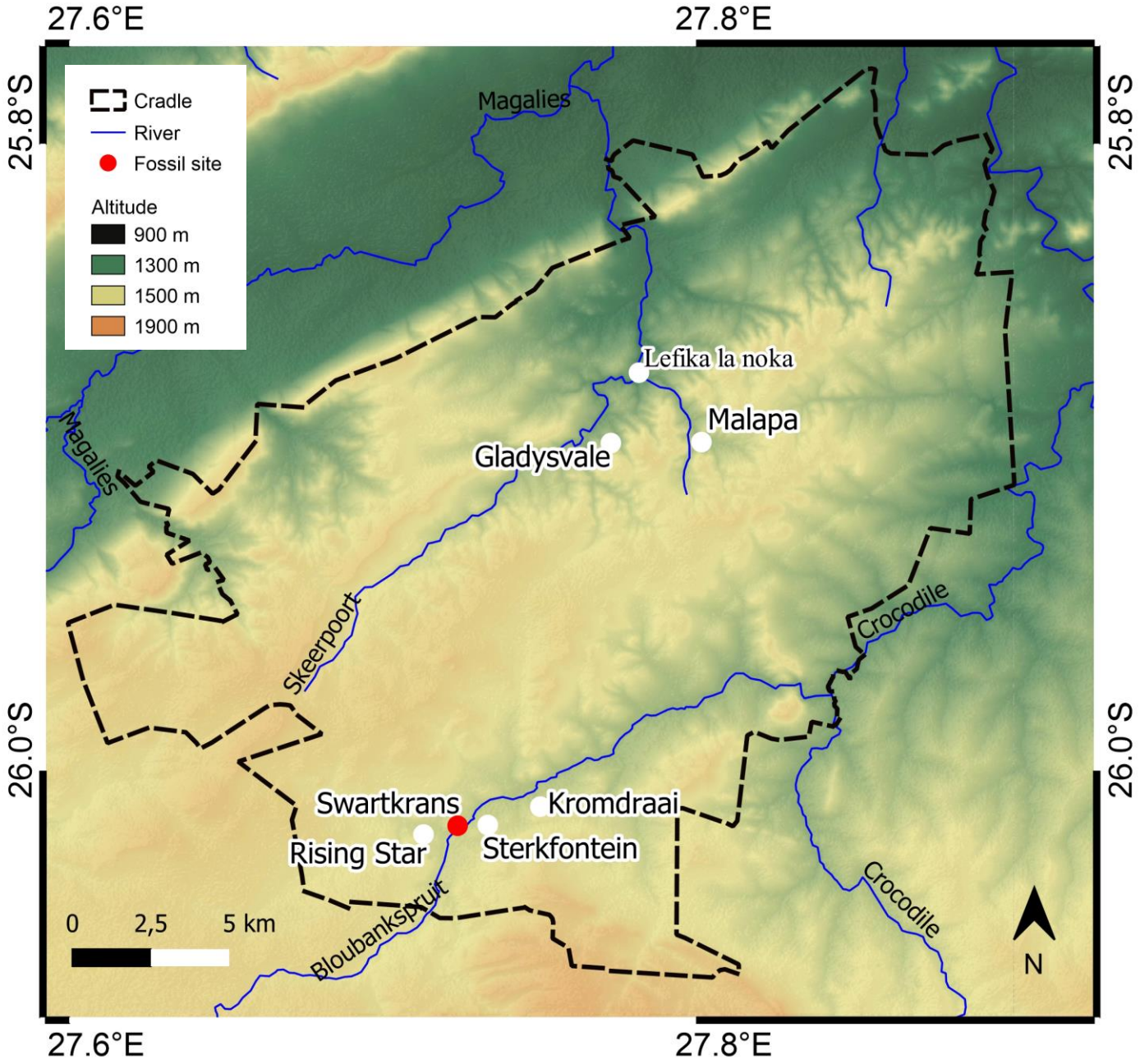
Cosmogenic nuclide dating of *Australopithecus* at Sterkfontein, South Africa

Darryl E. Granger[a,1], Dominic Stratford[b], Laurent Bruxelles[b,c], Ryan J. Gibbon[d], Ronald J. Clarke[e,2], and Kathleen Kuman[b,2]





Site 2:
Swartkrans Cave



Swartkrans Cave cosmogenic burial dating

Quaternary Geochronology 24 (2014) 10–15

Contents lists available at ScienceDirect

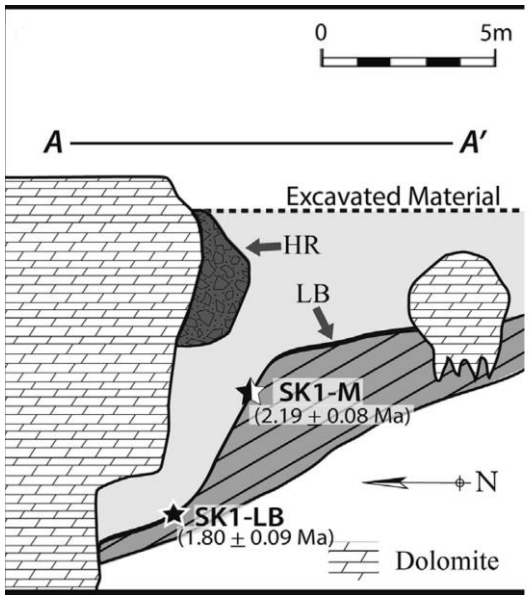
Quaternary Geochronology

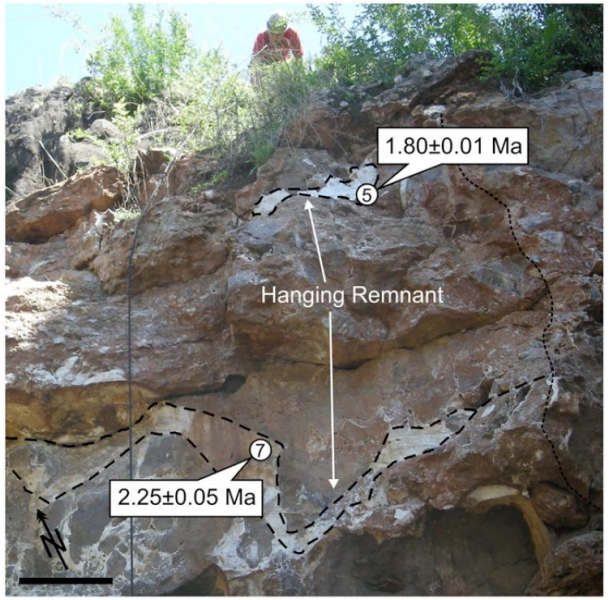
journal homepage: www.elsevier.com/locate/quageo

Research paper

Cosmogenic nuclide burial dating of hominin-bearing Pleistocene cave deposits at Swartkrans, South Africa

Ryan J. Gibbon [a, *], Travis Rayne Pickering [b, c, d], Morris B. Sutton [e], Jason L. Heaton [c, d, f], Kathleen Kuman [c, e], Ron J. Clarke [c], C.K. Brain [d], Darryl E. Granger [g]





Pickering et al. (2011), EPSL

Journal of Human Evolution 156 (2021) 103000

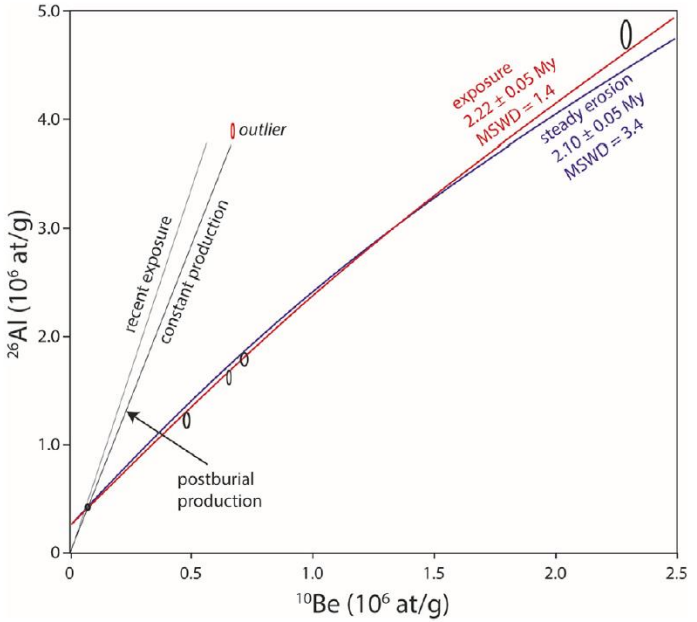
Contents lists available at ScienceDirect

Journal of Human Evolution

journal homepage: www.elsevier.com/locate/jhevol

A new absolute date from Swartkrans Cave for the oldest occurrences of *Paranthropus robustus* and Oldowan stone tools in South Africa

Kathleen Kuman [a, *], Darryl E. Granger [b, **], Ryan J. Gibbon [c], Travis Rayne Pickering [d, e], Matthew V. Caruana [f], Laurent Bruxelles [a, g, h], Ronald J. Clarke [e], Jason L. Heaton [e, i], Dominic Stratford [a], C.K. Brain [j]



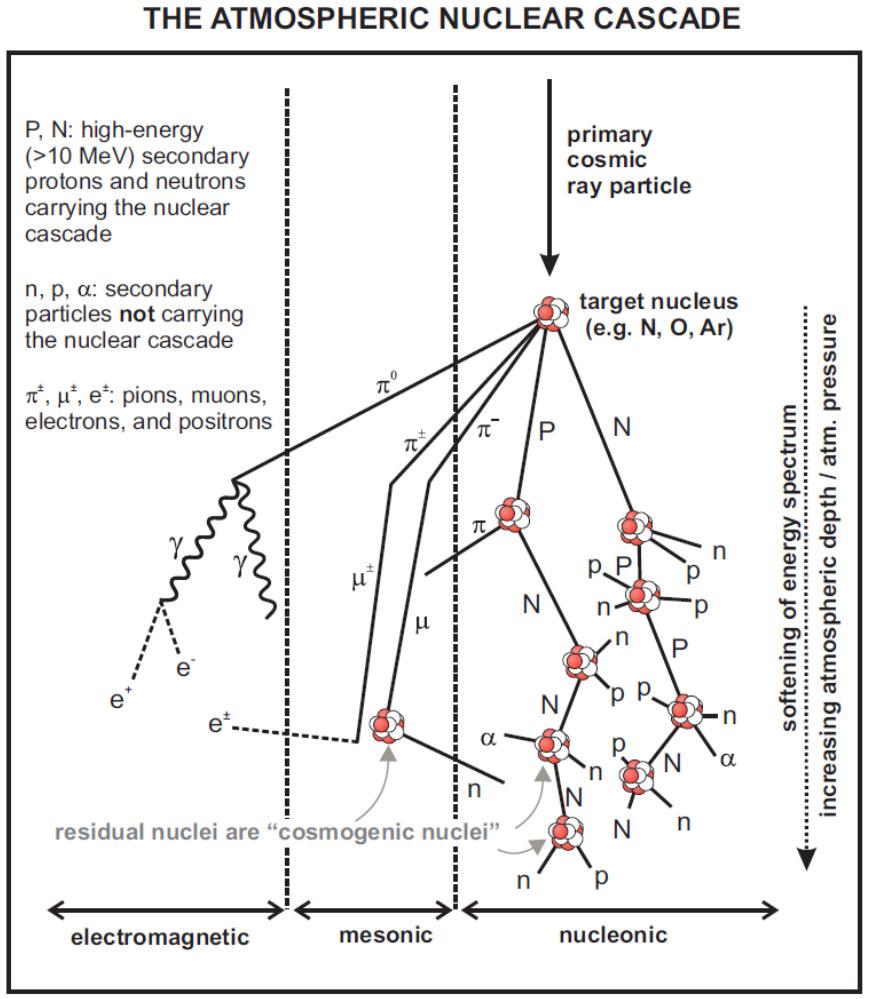
What is causing the issues?

The basics of $^{26}Al/^{10}Be$ burial dating

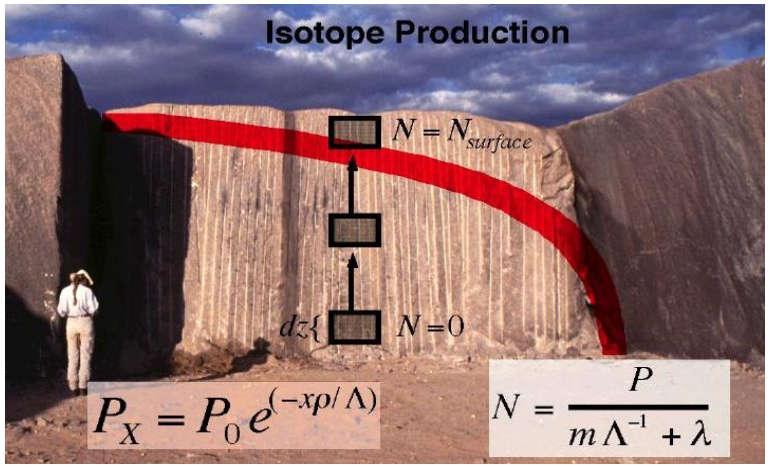
Produced in quartz at

- a "known" rate over time: ~ 5 (Be) and ~ 35 (Al) atoms g^{-1} yr^{-1}
- "known" relationships to (1) altitude, (2) latitude, and (3) sample depth
- have long half-lives: 1.387 ± 0.012 Ma for ^{10}Be and 708 ± 17 ka for ^{26}Al

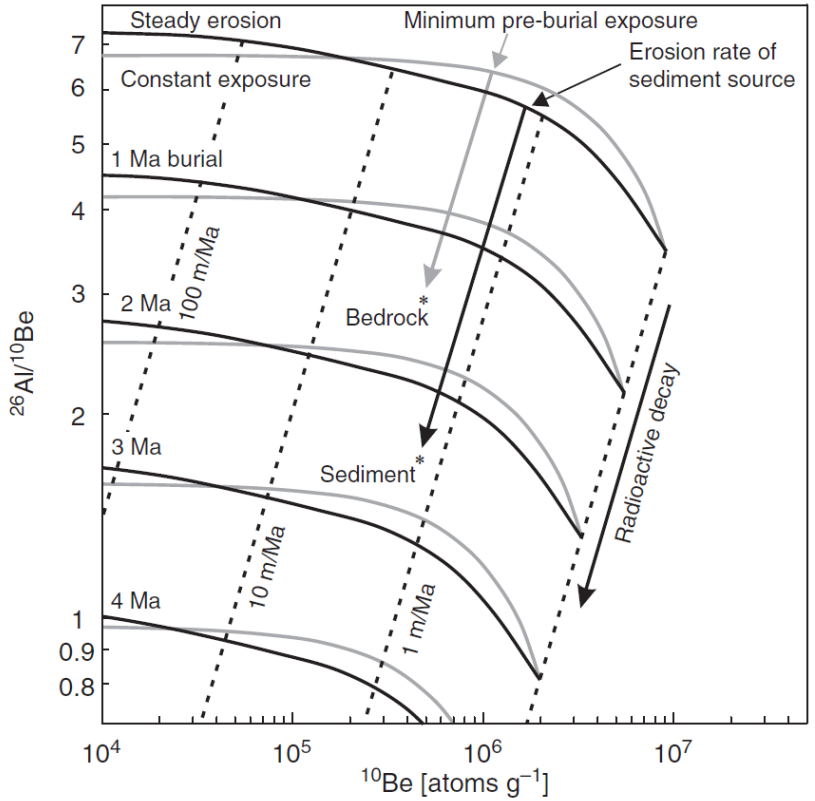
$^{26}Al/^{10}Be$ surface production ratio always assumed to be 6.75



Dunai and Lifton, 2014, *Elements*.



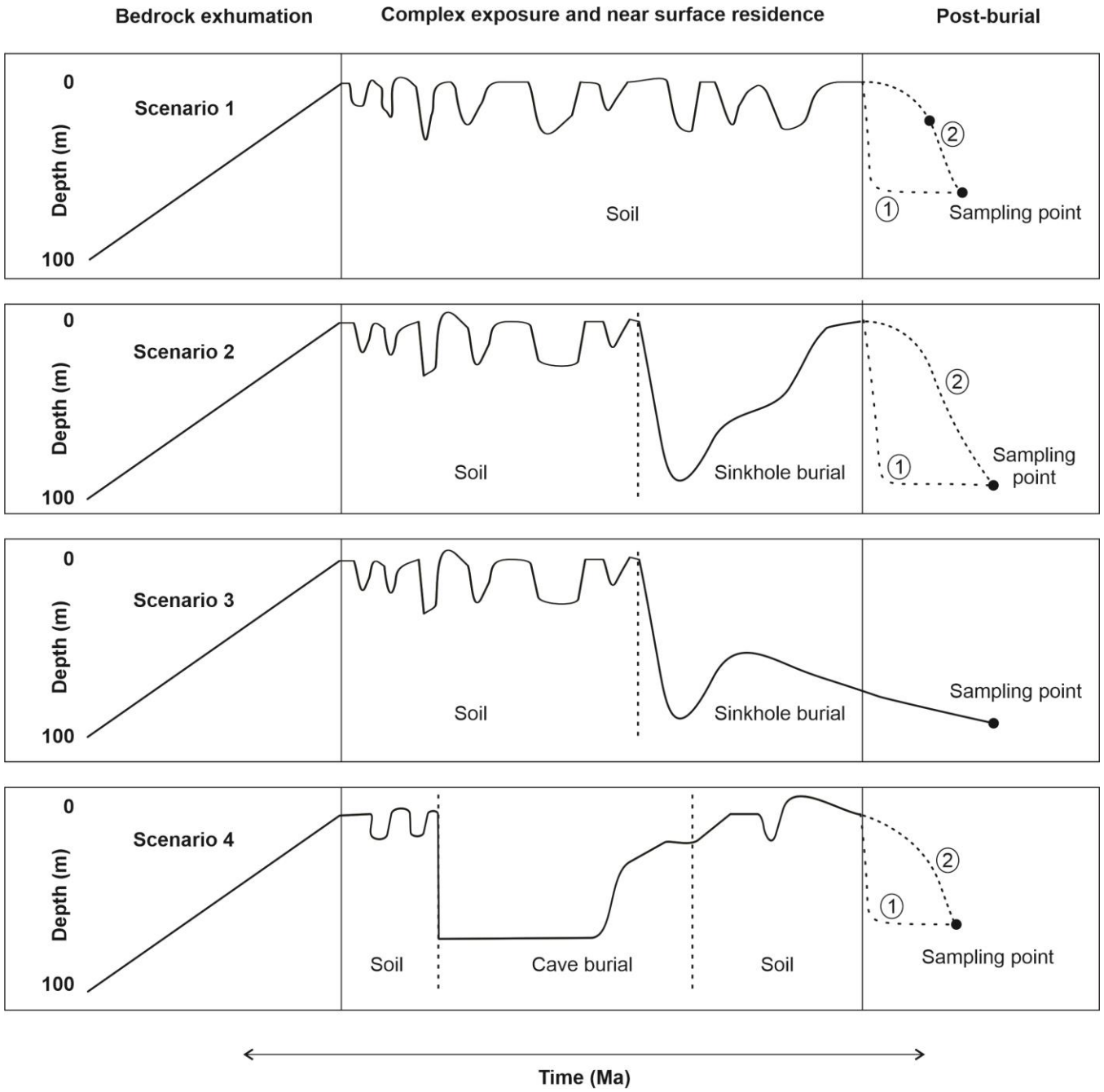
Bierman & Nichols, 2004, *Annu. Rev. Earth Planet. Sci.*



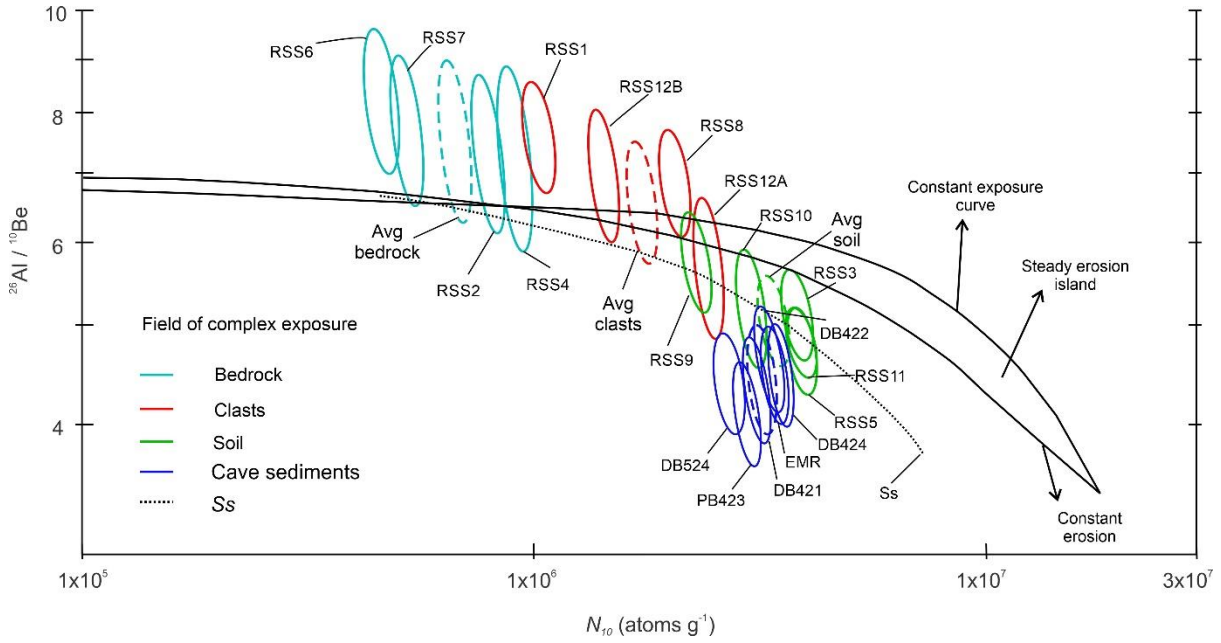
Dunai, 2010, *Cosmogenic Nuclides*.

What leads to complex exposure histories in the Cradle?

- Soil thicknesses vary greatly (0 cm to 70 cm) in short distances. Average soil thickness = 30 cm.
- Effective on trapping sediments and prolonging their near-surface residence times.



Complex exposure histories above the Rising Star Cave



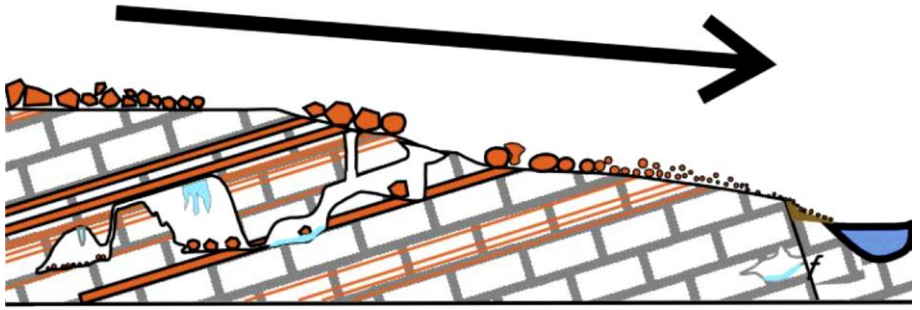
EARTH SURFACE PROCESSES AND LANDFORMS
Earth Surf. Process. Landforms (2019)

Published online in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/esp.4723

Effects of long soil surface residence times on apparent cosmogenic nuclide denudation rates and burial ages in the Cradle of Humankind, South Africa

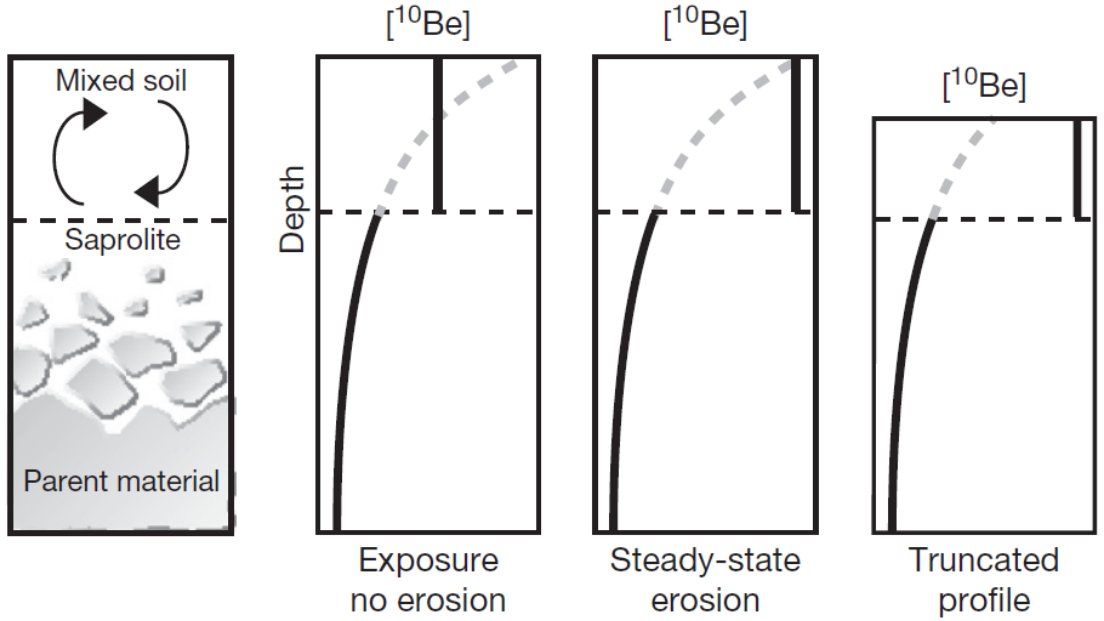
T.V. Makhubela,[1*] J.D. Kramers,[1] D. Scherler,[2,3] H. Wittmann,[2] P.H.G.M. Dirks[4,5] and S.R. Winkler[6]

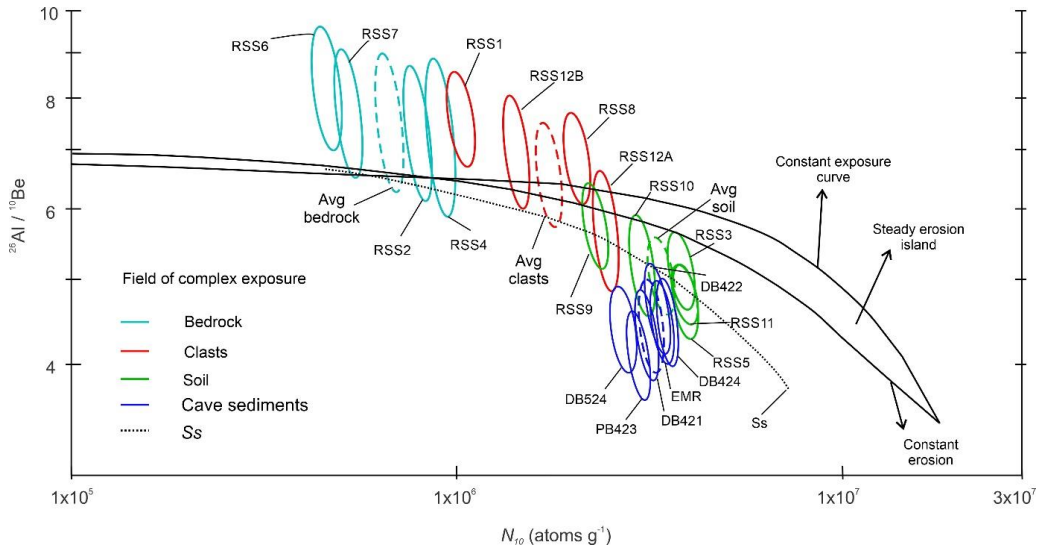
- Soil samples: average ^{26}Al/^{10}Be ratio (5.12 ± 0.27) lower than the surface production ratio of 6.75, suggesting complex exposure histories.
- Apparent ^{10}Be denudation rates of soil: 2-3 times lower than bedrock denudation rates.
- Prolonged surface residence time up to 1.5 Ma in vertically mixed soils of thickness up to 3m thick due to irregular karst surface and features.



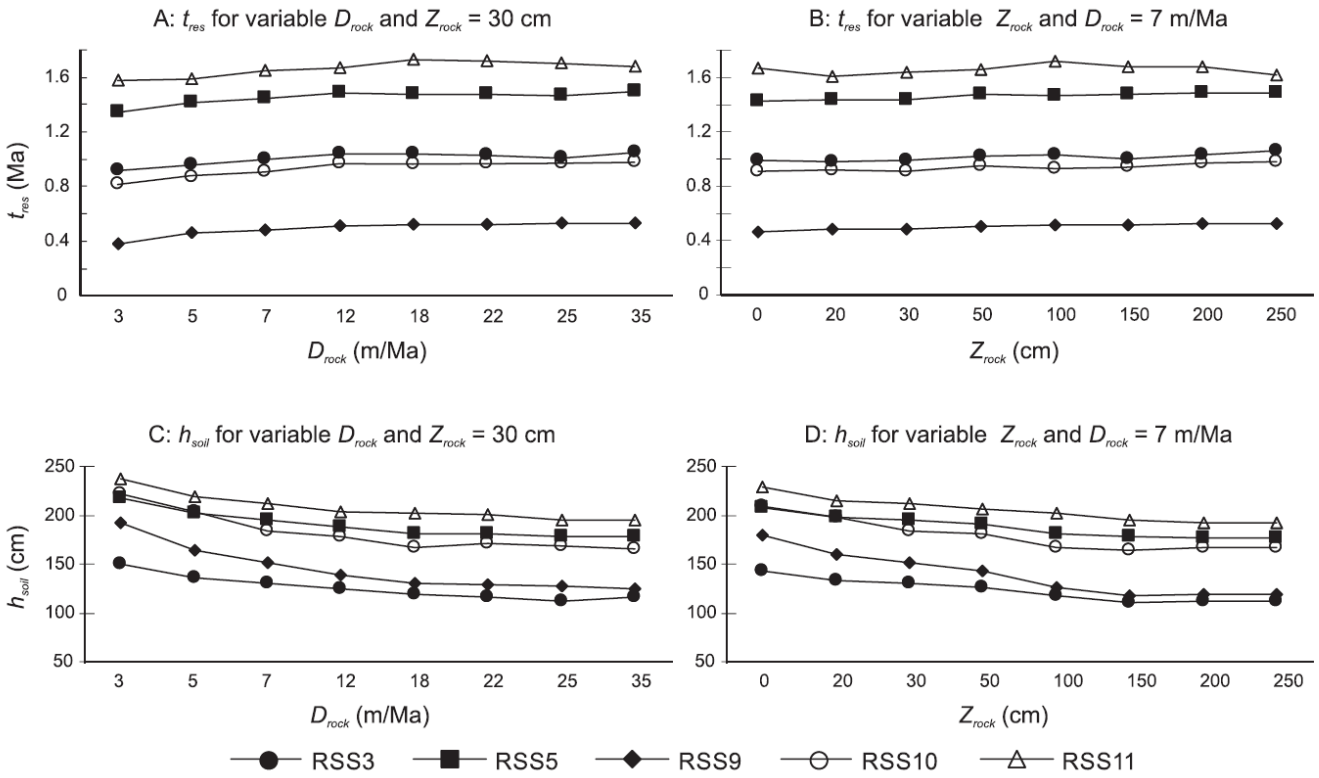
- Burial ages of cave sediment samples might be overestimated if pre-burial ^{26}Al/^{10}Be ratio of 6.75 is used.

Complex exposure histories above the Rising Star Cave

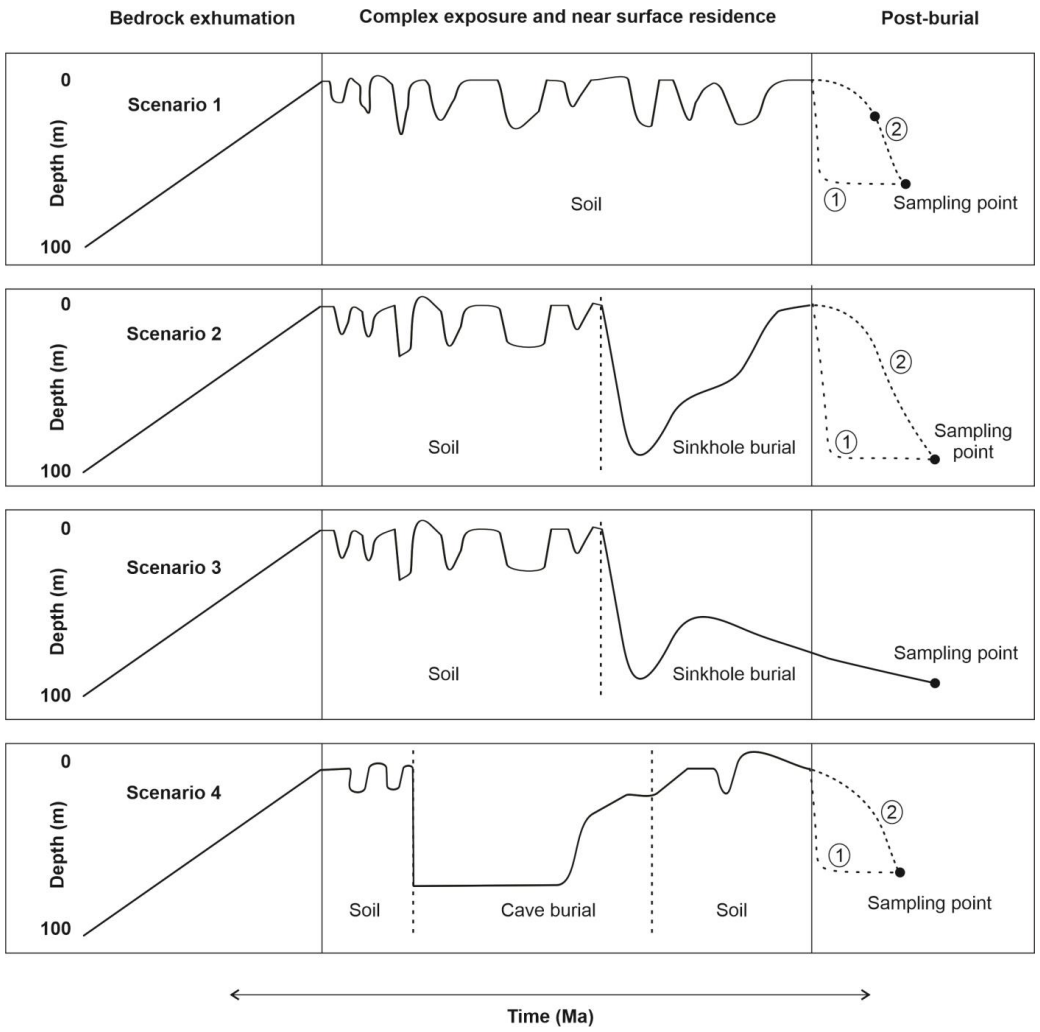




Only h_{soil} *(soil thickness)* has up to 30% higher values for very low bedrock denudation rates (D_{rock}) and for soil formation at very shallow levels (Z_{rock}).



Attempt to resolve complications with burial dating in Cradle caves



Quaternary Geochronology 51 (2019) 110–119

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journal homepage: www.elsevier.com/locate/quageo

Time-integrating cosmogenic nuclide inventories under the influence of variable erosion, exposure, and sediment mixing

Mads Faurschou Knudsen*, David Lundbek Egholm, John D. Jansen

Quaternary Geochronology 74 (2023) 101420

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journal homepage: www.elsevier.com/locate/quageo

P–PINI: A cosmogenic nuclide burial dating method for landscapes undergoing non-steady erosion

Jesper Nørgaard [a,*], John D. Jansen [b], Stephanie Neuhuber [c], Zsófia Ruszkiczay-Rüdiger [d], Mads Faurschou Knudsen [a]

The end.
Questions/comments?

Thank you for listening.