



Uran-Thorium Datierung

Axel Berger

Institut für Ur- und Frühgeschichte
Universität zu Köln

Seminar: Datierungsmethoden
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PD Dr. Daniel Richter



Gliederung

① Grundlagen und Methode

② Probleme und Fehlerursachen

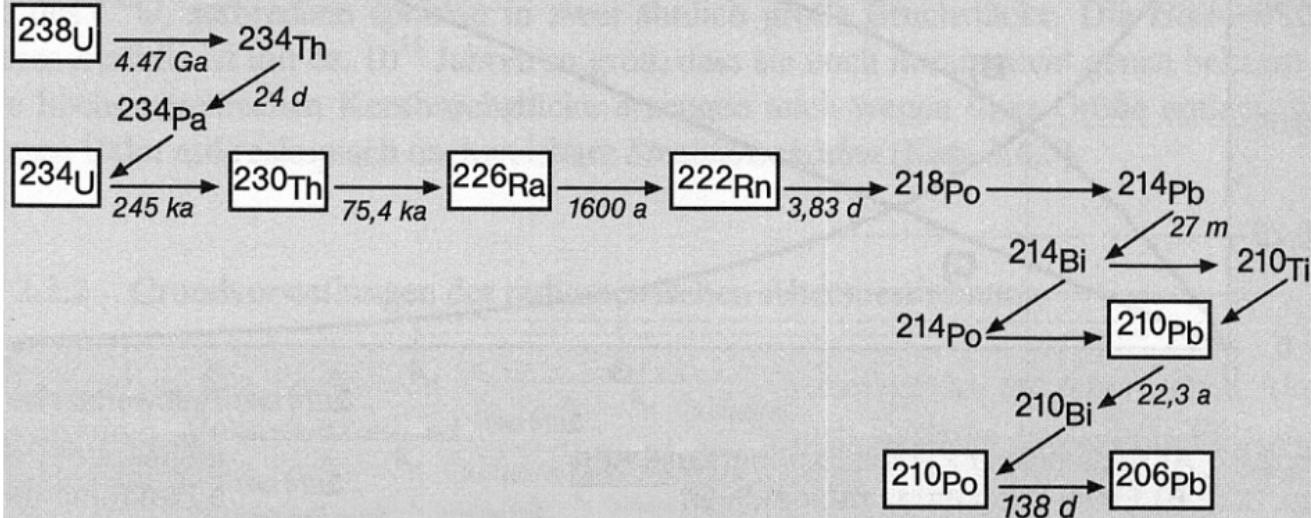
③ Anwendungen

④ Résumé



Die ^{238}U / ^{206}Pb Zerfallsreihe

U	Pa	Th	Ac	Ra	Fr	Rn	As	Po	Bi	Pb	Ti
92	91	90	89	88	87	86	85	84	83	82	81

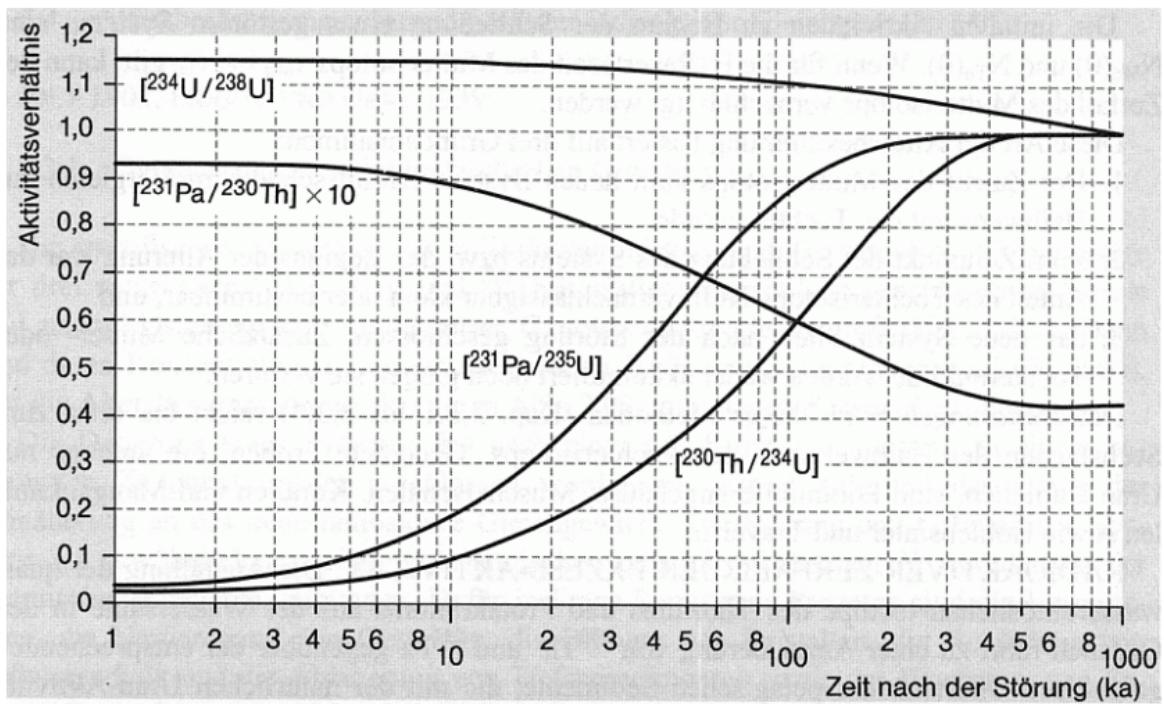




Die Zerfallsreihe in der Nuklidkarte

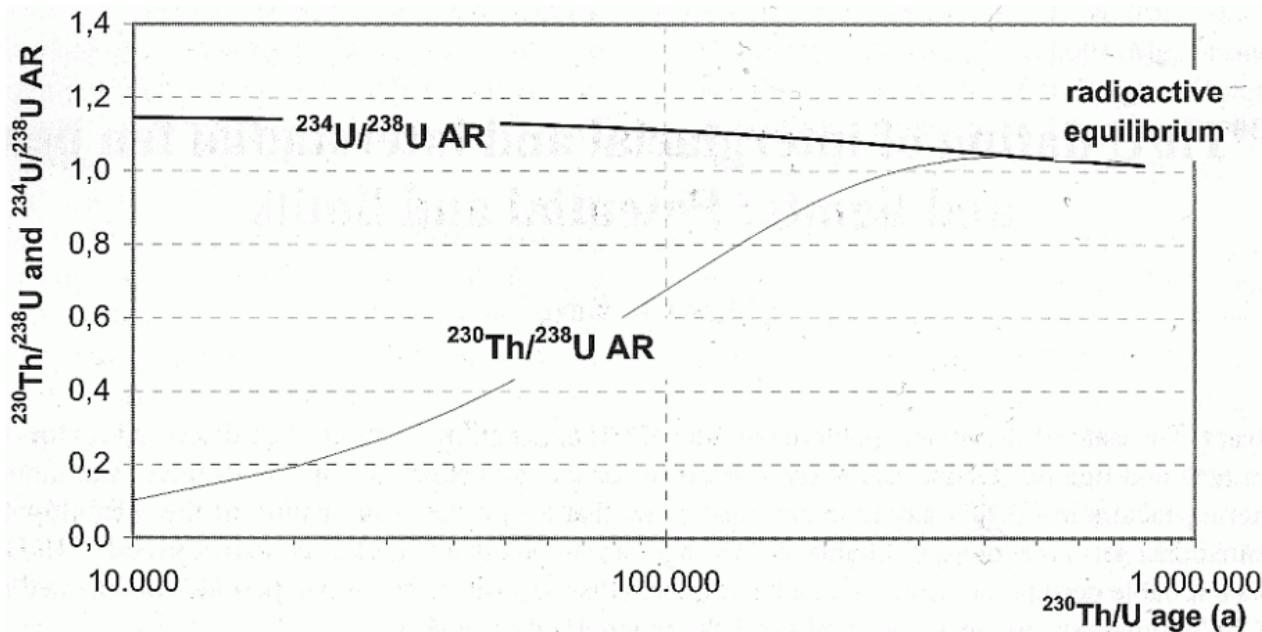
	547...)	$\sigma_f \sim 900$	g; $\sigma \sim 160 + ?$	g; $\sigma_f \sim 2700$	g; $\sigma_f \sim 2600$	$\sigma \sim 180; \sigma_f \sim 0,020$	g; $\sigma_f \sim 2100$	$\sigma \sim 32 + 19; \sigma_f < 1$	ly...;
	U 232 68,9 a	$U 2331,592 \cdot 10^5 a$	U 234 0,0055	U 235 0,7200	U 236 120 ns	U 237 2,342 \cdot 10^7 a 6,75 d	U 238 270 ns 99,2745	U 238 4,468 \cdot 10^9 a 270 ns	ly...;
	α ; 5,320; 5,262... Ne 24; γ (58; 129...); e^- σ ; 73; σ_f ; 74	α ; 4,824; 4,783... Ne 25; γ (42; 97...); e^- σ ; 47; σ_f ; 530	$2,455 \cdot 10^5 a$ α ; 4,775; 4,723...; sf Mg 28; Ne; γ (53; 121...) e^- ; 96; σ_f ; < 0,005	26 m ly (0,07) e^-	$7,038 \cdot 10^8 a$ α ; 4,398...; sf Ne; γ 186... σ ; 95; σ_f ; 588	α ; 4,494; 4,445... sf; γ (49; 113...) e^- ; σ ; 5,1	β^- ; 0,2... γ 60; 208... e^- σ ~ 100; σ_f ; < 0,35	α ; 4,198...; sf ly 2514; 1879... sf β^- ; γ (50...); e^- σ ; 2,7; σ_f ; 3,10 ⁻⁶	β^- γ 75 2
00	Pa 231 $3,276 \cdot 10^4 a$ α ; 5,014; 4,952; 5,028...; Ne 24; F 23? γ 27; 300; 303...; e^- σ ; 200; σ_f ; < 0,020	Pa 232 1,31 d β^- ; 0,3; 1,3...; e^- 969; 894; 150...; e^- σ ; 460; σ_f ; 700	Pa 233 27,0 d β^- ; 0,3; 0,6... 312; 300; 341...; e^- σ ; 20+19; σ_f ; < 0,1	Pa 234 1,17 m β^- ; 2,3... γ (1001; 767...) ly (74...); e^- σ ; < 500	Pa 235 6,70 h β^- ; 0,5; 1,2... γ 131; 881; 883...; e^- σ ; < 5000	Pa 236 24,2 m β^- ; 1,4... γ 128 - 659 m	Pa 237 9,1 m β^- ; 2,0; 3,1... γ 642; 687; 1763...; g β sf ?	Pa 237 8,7 m β^- ; 1,4; 2,3... γ 854; 865; 529; 541...	F
5...	Th 230 $7,54 \cdot 10^4 a$ α ; 4,687; 4,621... γ (68; 144...); e^- Ne 24; σ ; 23,4 σ_f ; < 0,0005	Th 231 25,5 h β^- ; 0,3; 0,4... 26; 84... e^-	Th 232 100 $1,405 \cdot 10^{10} a$ α ; 4,013; 3,950...; sf γ (64...); e^- σ ; 7,37; σ_f ; 0,000003	Th 233 22,3 m β^- ; 1,2... γ 87; 29; 459...; e^- σ ; 1500; σ_f ; 15	Th 234 24,10 d β^- ; 0,2... γ 63; 92; 93... e^- ; m σ ; 1,8; σ_f ; < 0,01	Th 235 7,1 m β^- ; 1,4... γ 417; 727; 696...	Th 236 37,5 m β^- ; 1,0... γ 111; (647; 196...)	T	
	Ac 229	Ac 230	Ac 231	Ac 232	Ac 233	Ac 234			

Entwicklung der Aktivitätsverhältnisse





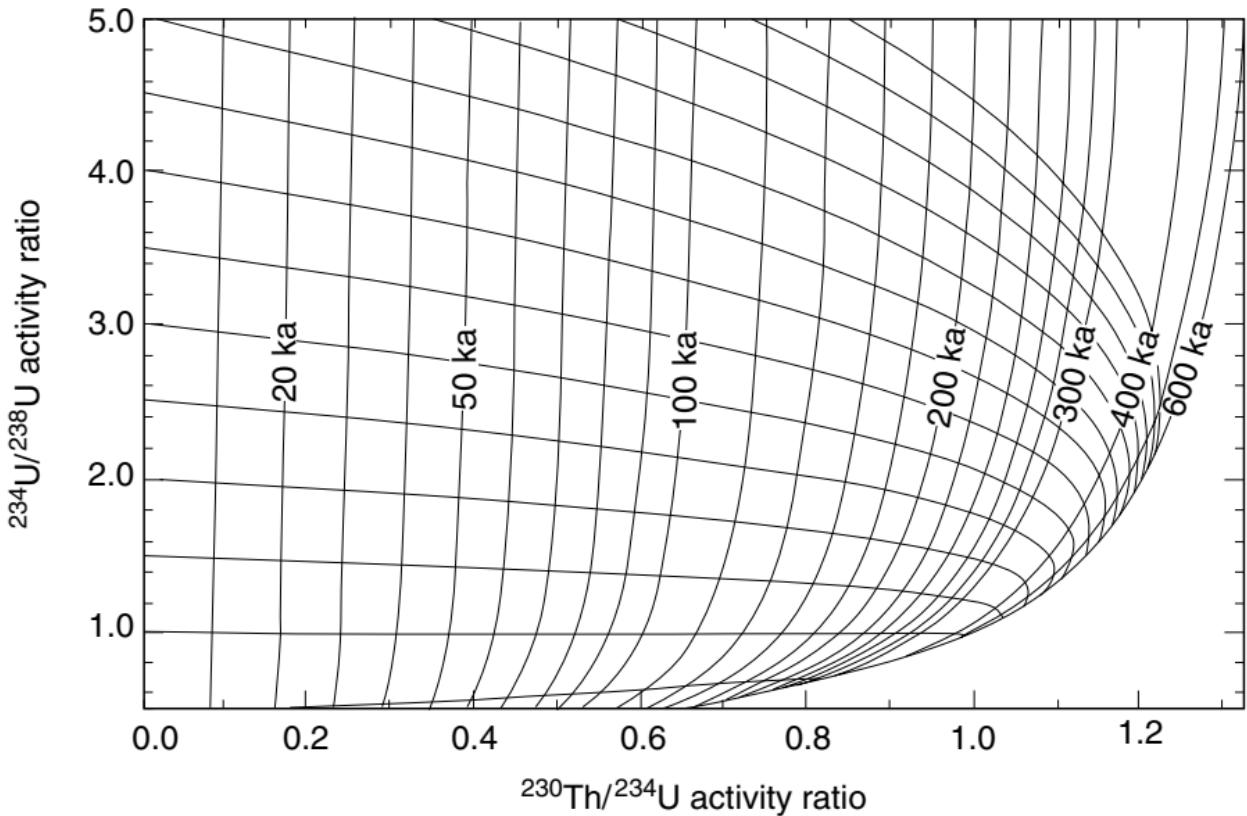
Entwicklung der Aktivitätsverhältnisse



$$\left[\frac{^{230}\text{Th}}{^{238}\text{U}} \right] = (1 - e^{-\lambda_{230} \cdot t}) + \left(\frac{^{234}\text{U}}{^{238}\text{U}} - 1 \right) \cdot \frac{\lambda_{230}}{\lambda_{230} - \lambda_{234}} \cdot (1 - e^{-(\lambda_{230} - \lambda_{234}) \cdot t})$$



Entwicklungslien im U/U – Th/U – Diagramm

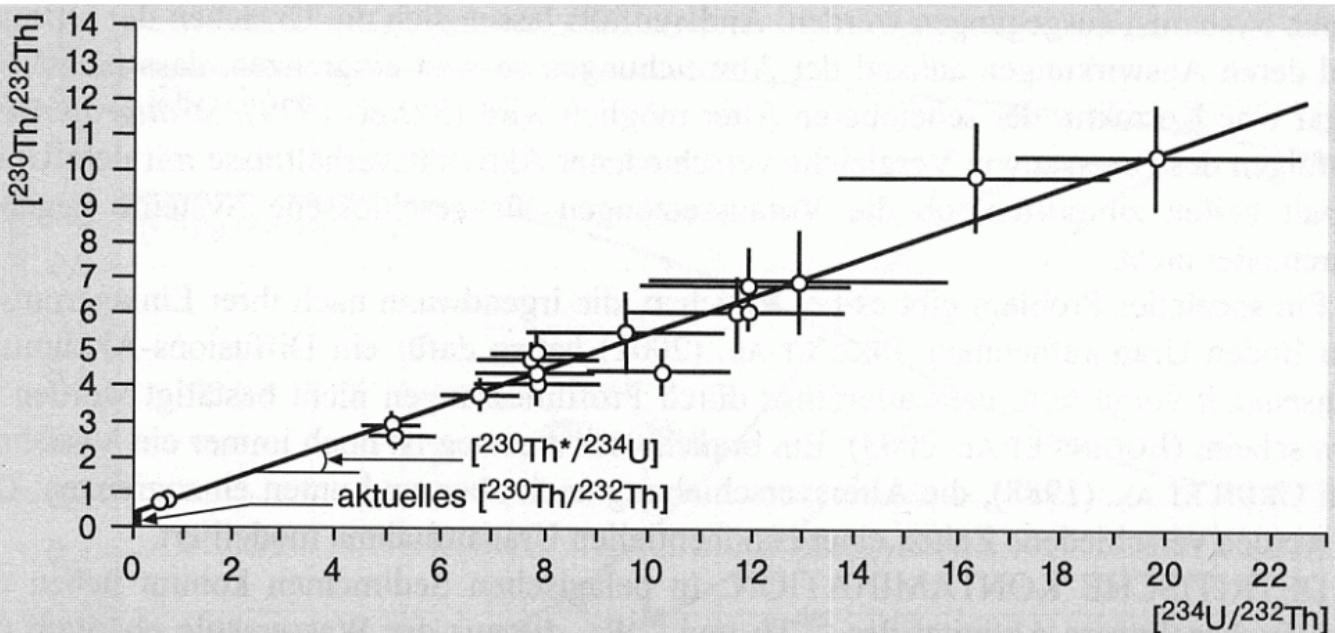




Uran und Thorium im Periodensystem

Periodensystem		
232.0381 230 232 $\approx 5 \cdot 10^{-4}$ ≈ 100 232(α) $1.4 \cdot 10^{10}$ a	231.03588 231 234 ≈ 100 $\approx 10^{-9}$ 231(α, γ) $3.3 \cdot 10^4$ a	238.02891 234 235 238 0.005 0.72 99.275 238(α) $4.5 \cdot 10^9$ a
90 Th 6.307 11.72 Thorium	91 Pa 15.37 Protactinium	92 U 6.194 18.97 Uran
1750	1554	1132.3

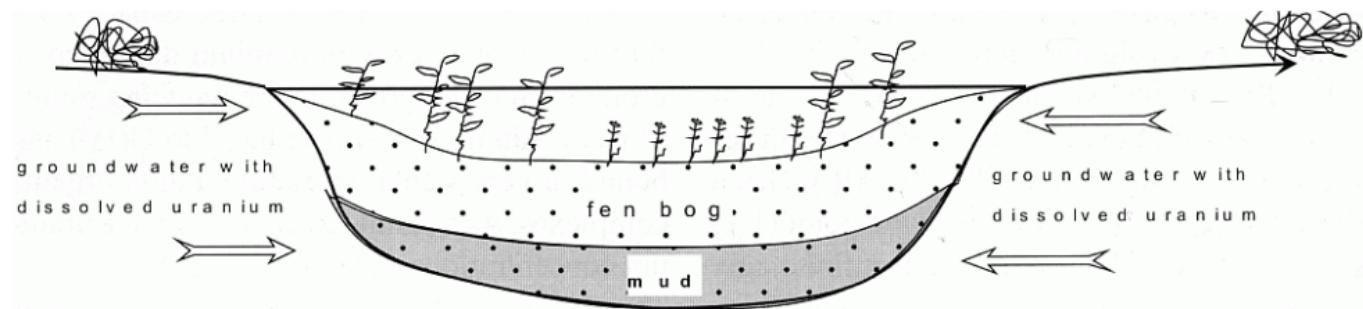
Korrektur der Verunreinigung mithilfe der Rosholt-Geraden



Die Steigung der Rosholt-Geraden entspricht dem Verhältnis des radiogenen Anteils von ^{230}Th zum Mutternuklid ^{234}U [Ge05, 96].

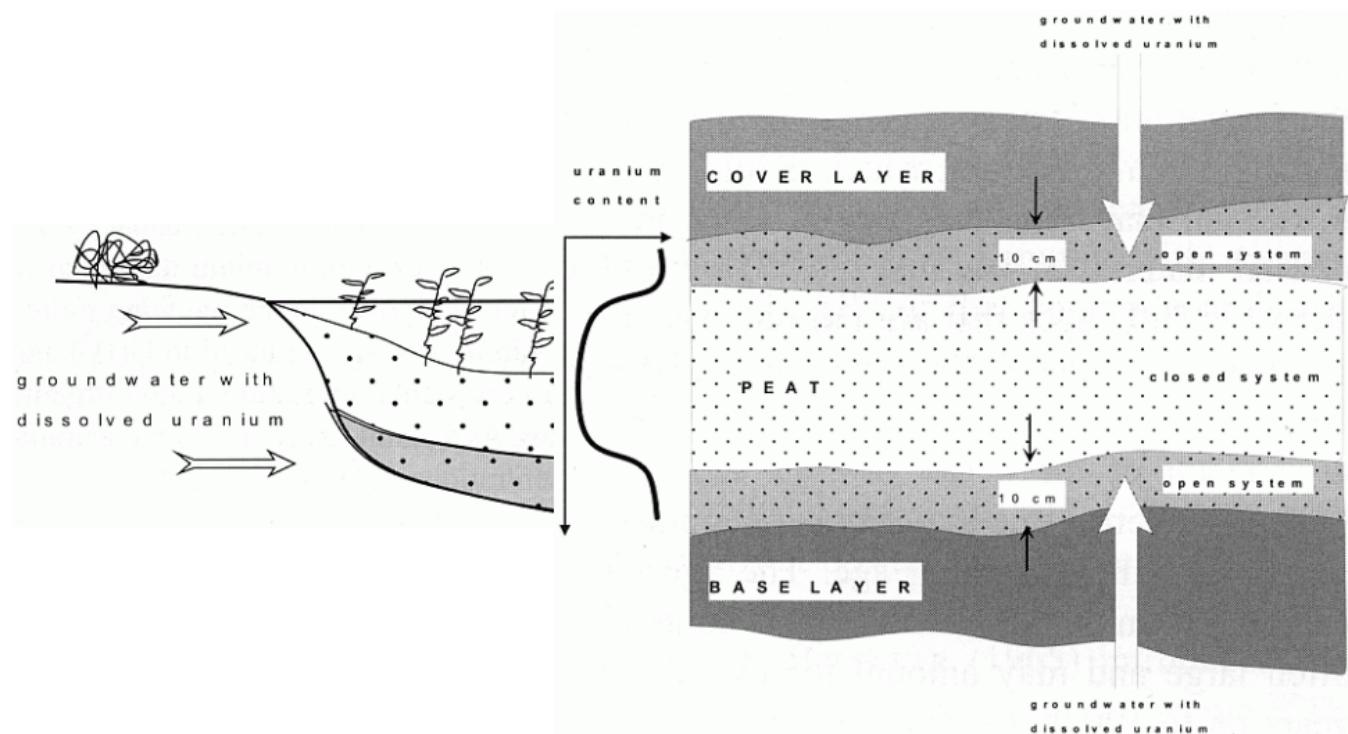


Ein Niedermoor als teiloffenes verunreinigtes System





Ein Niedermoor als teiloffenes verunreinigtes System

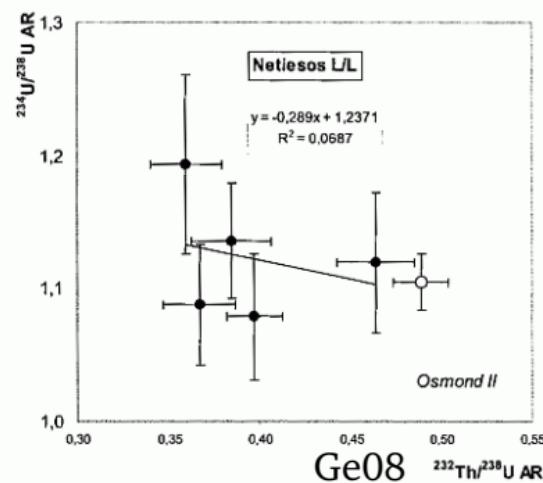
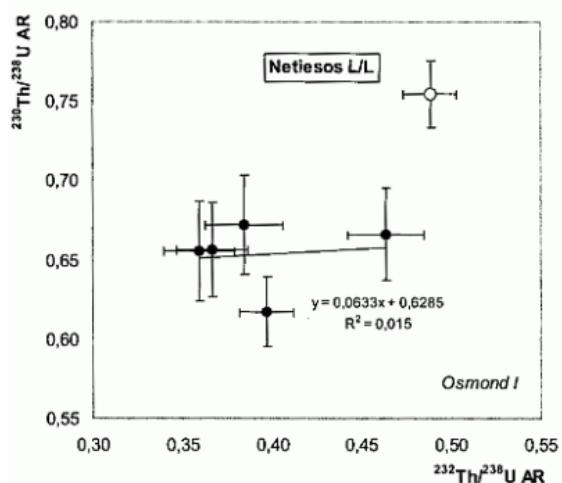
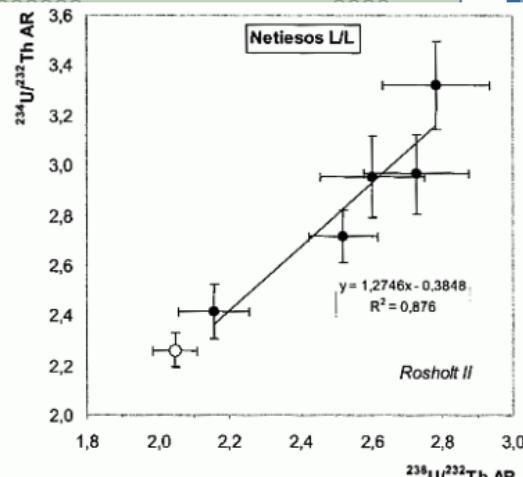
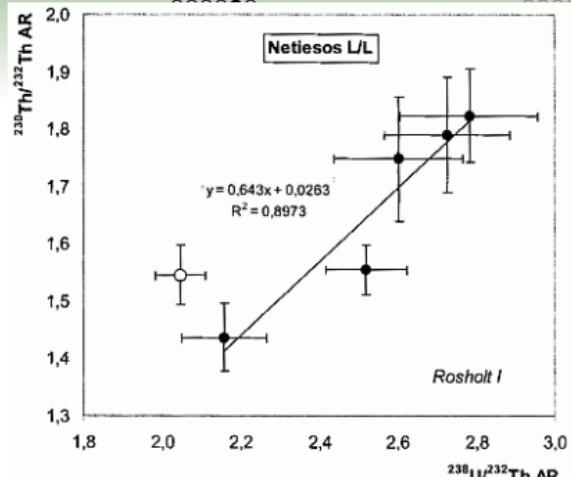




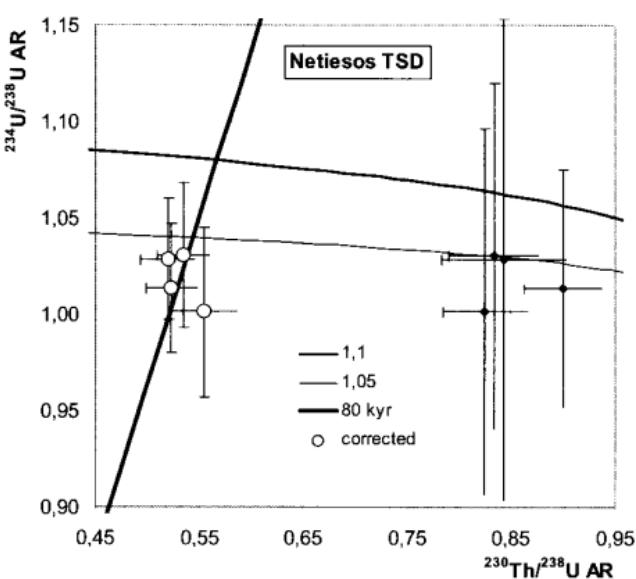
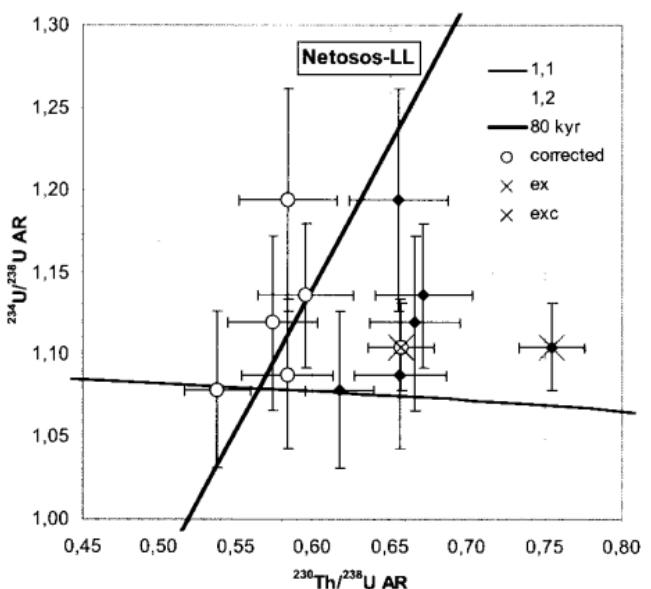
Die Meßwerte der Torfproben

No.	name	depth (cm)	ash (%)	$^{238}\text{U} \pm 2\sigma$ (dpm/g)	$^{230}\text{Th}/^{238}\text{U} \pm 2\sigma$	$^{234}\text{U}/^{238}\text{U} \pm 2\sigma$	$^{230}\text{Th}/^{232}\text{Th} \pm 2\sigma$
5133	L-1	30-35	50.4	0.537 ± 0.011	0.655 ± 0.032	1.194 ± 0.068	1.824 ± 0.081
5134	L-2	35-40	51.9	0.572 ± 0.018	0.617 ± 0.022	1.079 ± 0.047	1.555 ± 0.043
5135	L-3	40-45	49.7	0.494 ± 0.017	0.666 ± 0.029	1.119 ± 0.053	1.437 ± 0.059
5136	L-4	45-50	49.3	0.728 ± 0.022	0.657 ± 0.030	1.088 ± 0.046	1.790 ± 0.100
5137	L-5	50-55	47.3	0.640 ± 0.018	0.672 ± 0.031	1.136 ± 0.044	1.748 ± 0.107
5138	L-6	55-60	45.8	0.477 ± 0.008	0.755 ± 0.021	1.105 ± 0.026	1.545 ± 0.053
5129	T-2	35-40	51.9	1.582 ± 0.049	0.825 ± 0.032	1.001 ± 0.044	1.584 ± 0.075
5130	T-3	40-45	49.7	1.446 ± 0.034	0.900 ± 0.025	1.014 ± 0.033	1.240 ± 0.026
5131	T-4	45-50	49.3	2.009 ± 0.052	0.833 ± 0.025	1.030 ± 0.038	1.448 ± 0.036
5132	T-5	50-55	47.3	1.786 ± 0.039	0.843 ± 0.026	1.029 ± 0.032	1.352 ± 0.043

Korrektur

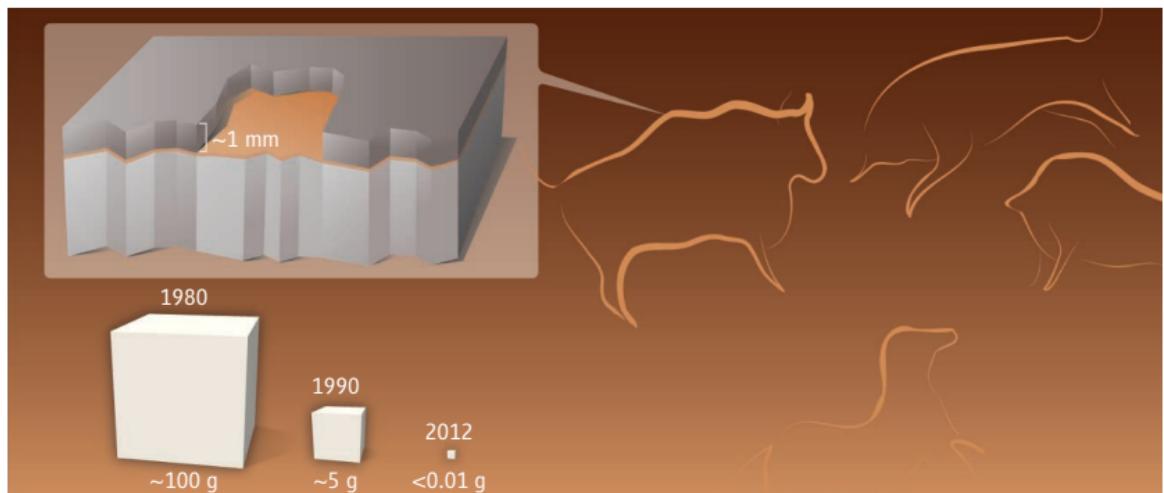
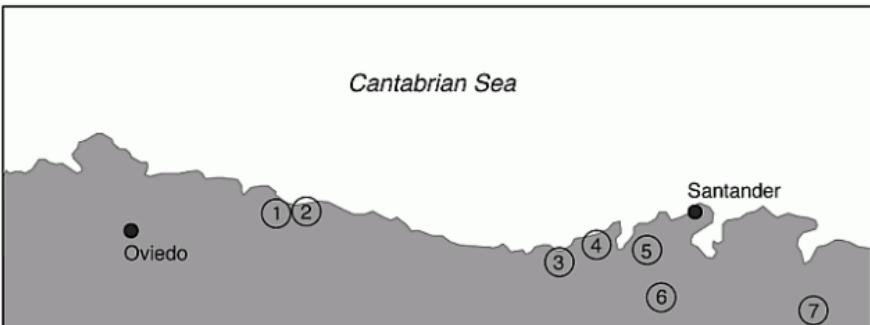


Das korrigierte Ergebnis



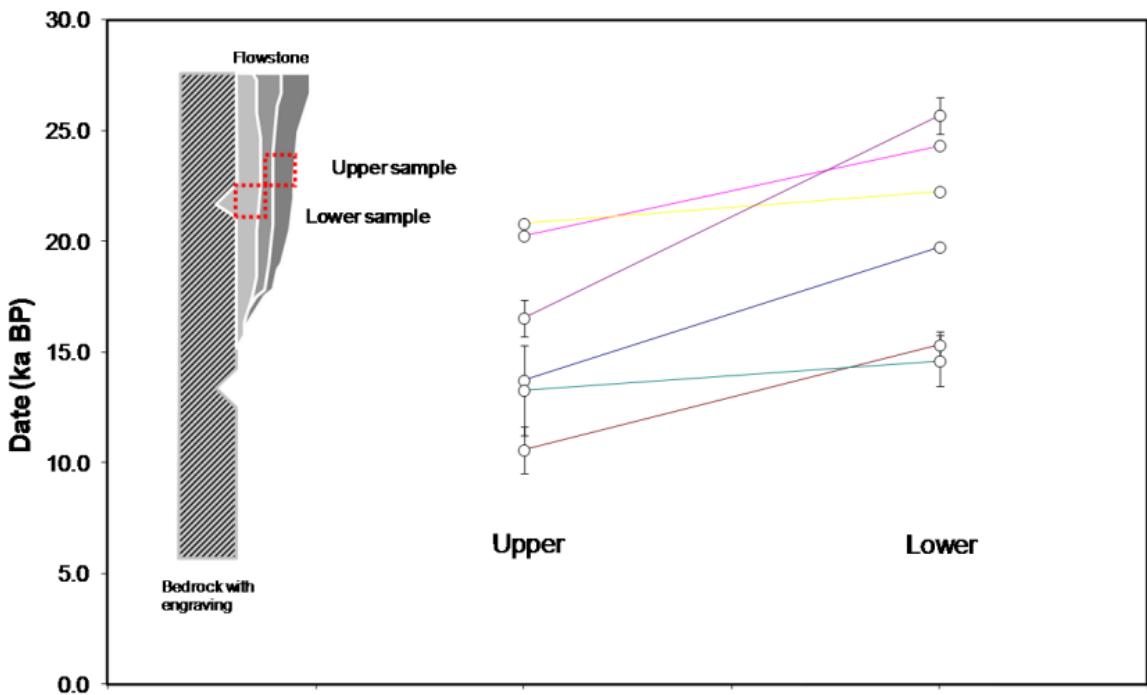


Datierung von Höhlenkunst mit Kalzitschichten



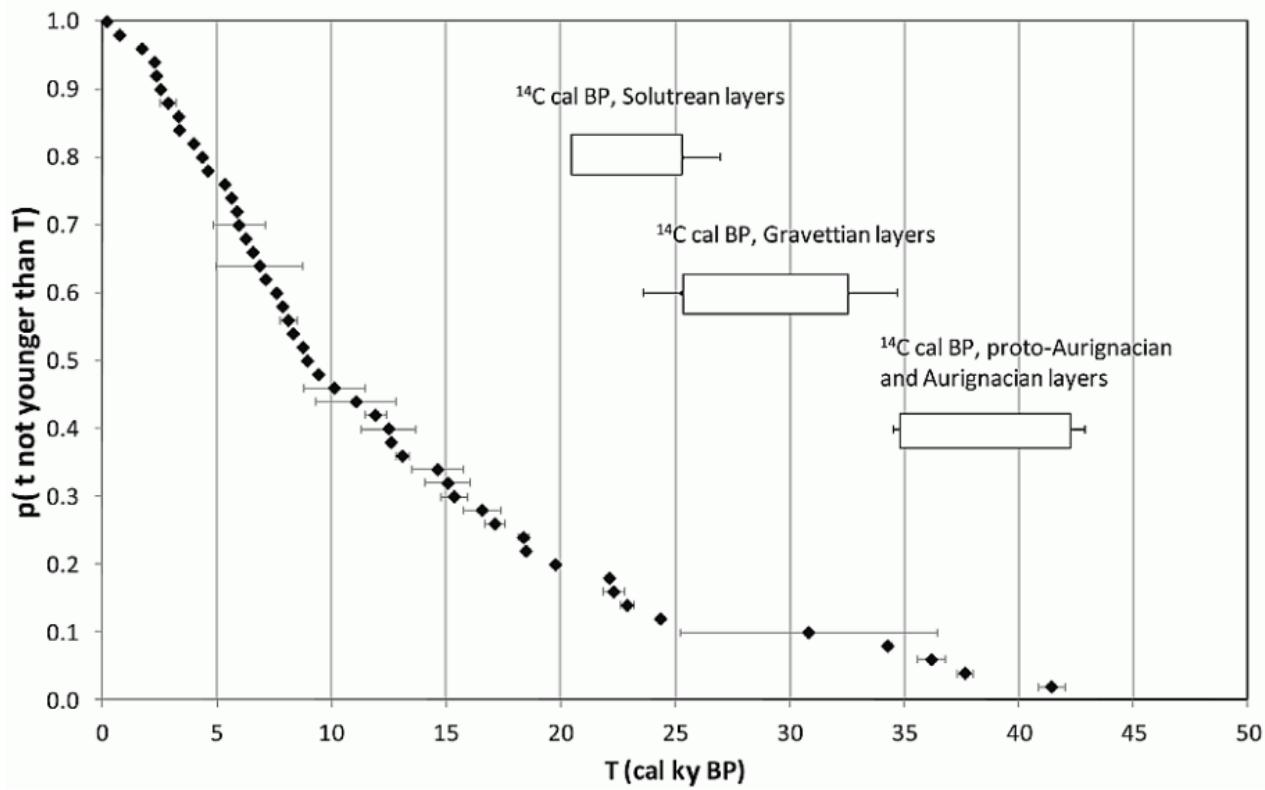


Plausibilitätskontrolle an dicken Schichten



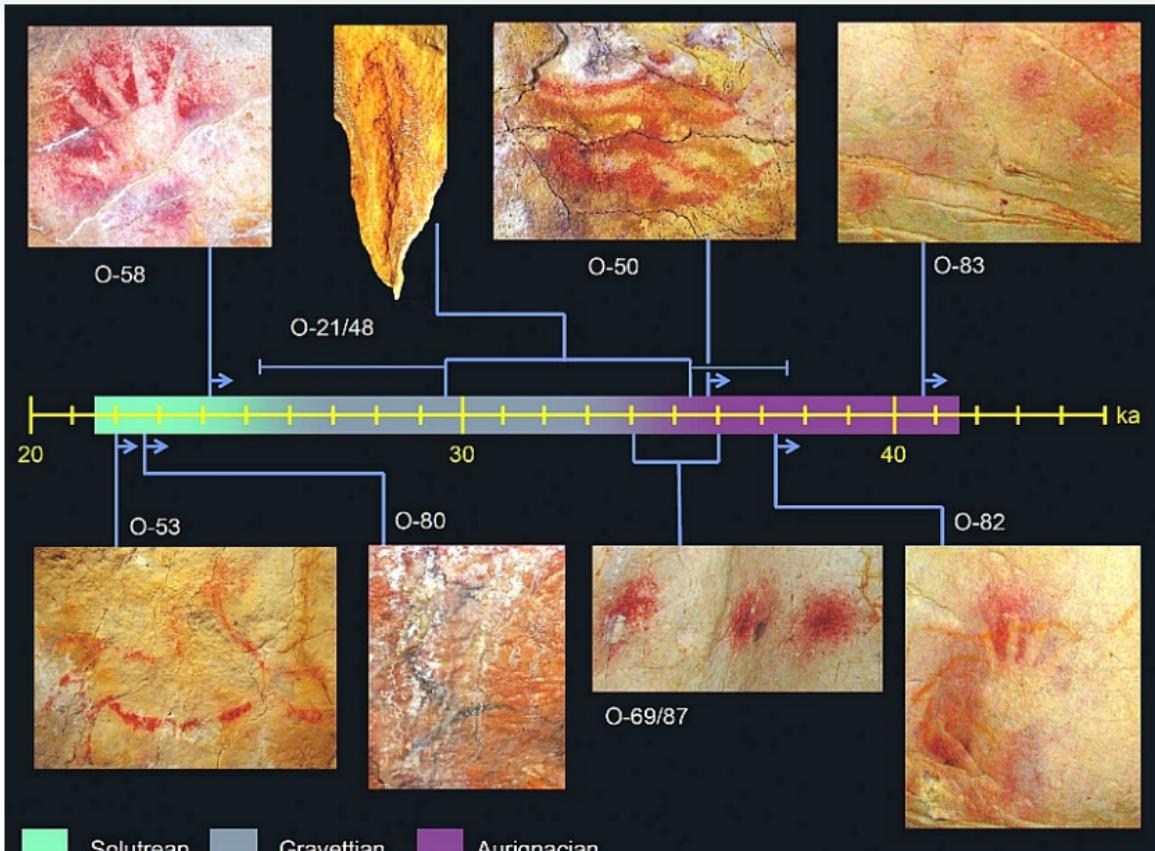


Altersverteilung der 50 gemessenen Proben



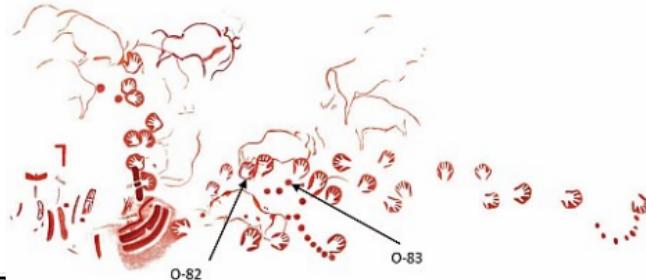


Beispiele datierter Felskunst



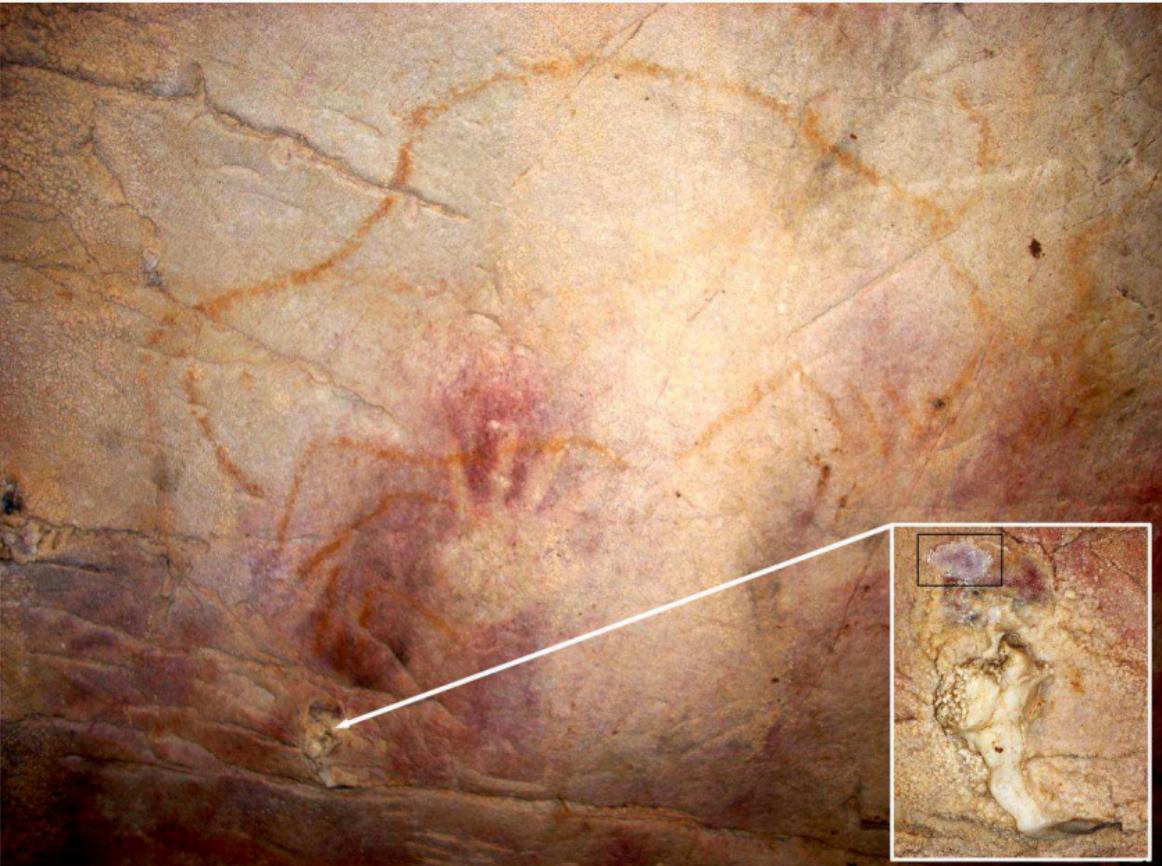


Die beiden ältesten Proben aus der El-Castillo-Höhle





Die beiden ältesten Proben aus der El-Castillo-Höhle





Die beiden ältesten Proben aus der El-Castillo-Höhle



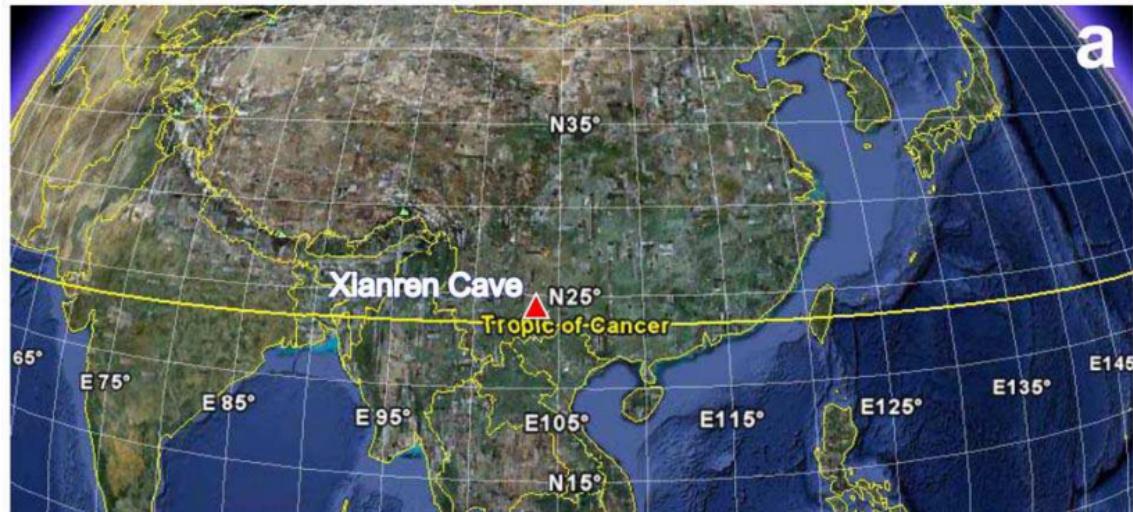


Auswahl der Ergebnisse

Sample BIG-UTh-	Site	Description	$^{230}\text{Th}/^{238}\text{U}$	$^{234}\text{U}/^{238}\text{U}$	$^{230}\text{Th}/^{232}\text{Th}$	Uncorrected age (ky)	Corrected age (ky)
<i>Minimum ages</i>							
O-53	Altamira	Overlays red spotted outline horse of <i>Techo de los Políicos</i> chamber	0.2884 ± 0.0013	1.5471 ± 0.0026	107.07 ± 0.20	22.26 ± 0.11	22.11 ± 0.13
O-80	El Castillo	Overlays black outline drawing of indeterminate animal of corridor of <i>Techo de las Manos</i>	0.7879 ± 0.0047	3.9828 ± 0.0073	30.01 ± 0.15	23.43 ± 0.16	22.88 ± 0.27
O-58	El Castillo	Overlays red stippled negative hand stencil of <i>Techo de las Manos</i>	0.5272 ± 0.0020	2.5774 ± 0.0049	222.70 ± 0.49	24.42 ± 0.11	24.34 ± 0.12
O-21	Tito Bustillo	Red pigment associated with anthropomorphic figure of <i>Galería de los Antropomorfos</i>	0.6252 ± 0.0031	1.8038 ± 0.0037	2.17 ± 0.01	44.94 ± 0.29	30.8 ± 5.6 $29.65 \pm 0.55^*$
O-69	El Castillo	Large red disk of <i>Galería de los Discos</i>	0.7512 ± 0.0029	2.7072 ± 0.0051	788.2 ± 5.5	34.28 ± 0.17	34.25 ± 0.17
O-50	Altamira	Large red claviform-like symbol of <i>Techo de los Políicos</i>	0.4933 ± 0.0024	1.6594 ± 0.0030	17.473 ± 0.068	37.60 ± 0.23	36.16 ± 0.61
O-82	El Castillo	Sample overlays red negative hand stencil, and underlies yellow outline bison of <i>Panel de las Manos</i>	0.5112 ± 0.0029	1.6970 ± 0.0035	48.81 ± 0.49	38.15 ± 0.27	37.63 ± 0.34
O-83	El Castillo	Overlays large red stippled disk of <i>Panel de las Manos</i>	0.3573 ± 0.0022	1.1048 ± 0.0020	28.64 ± 0.29	42.38 ± 0.33	41.40 ± 0.57
<i>Maximum ages</i>							
O-87	El Castillo	Underlies large red disk of <i>Galería de los Discos</i> (same panel as O-69)	0.7969 ± 0.0038	2.7432 ± 0.0051	61.24 ± 0.61	36.11 ± 0.21	35.72 ± 0.26
O-48	Tito Bustillo	Underlies red anthropomorphic figure of <i>Galería de los Antropomorfos</i> (see also O-21)	0.5281 ± 0.0038	1.6895 ± 0.0042	7.260 ± 0.047	39.85 ± 0.36	36.2 ± 1.5 35.54 ± 0.39^t



Die Xianrenhöhle in Südchina



b

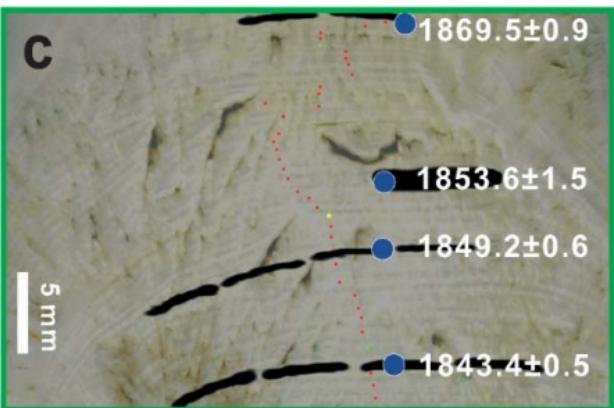
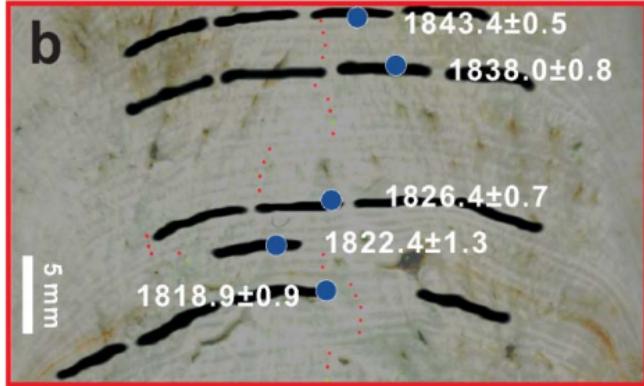
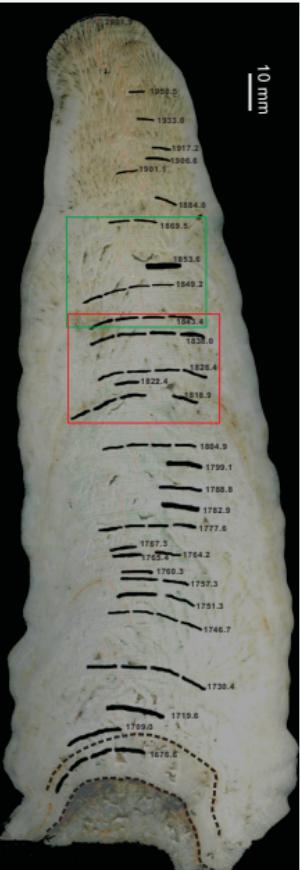
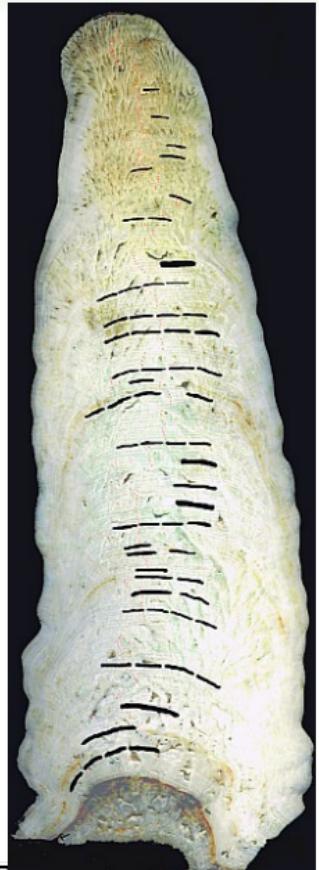


Source: Google Earth

Sh13

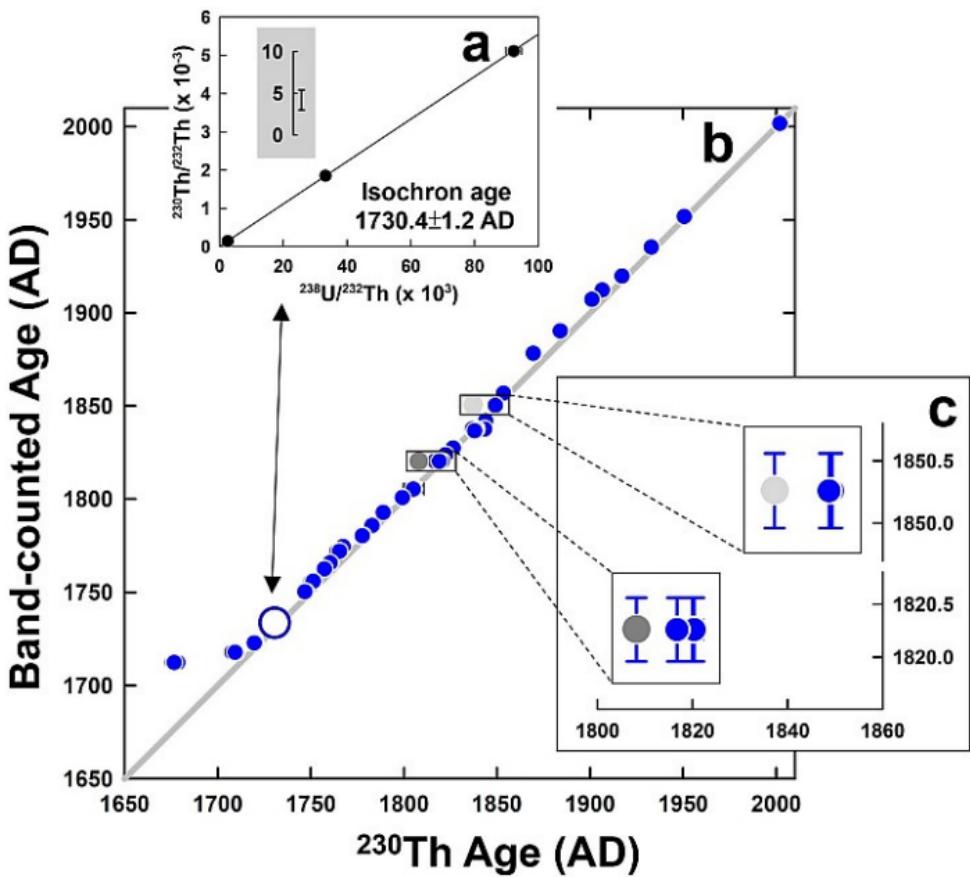


Der gebänderte Stalagmit



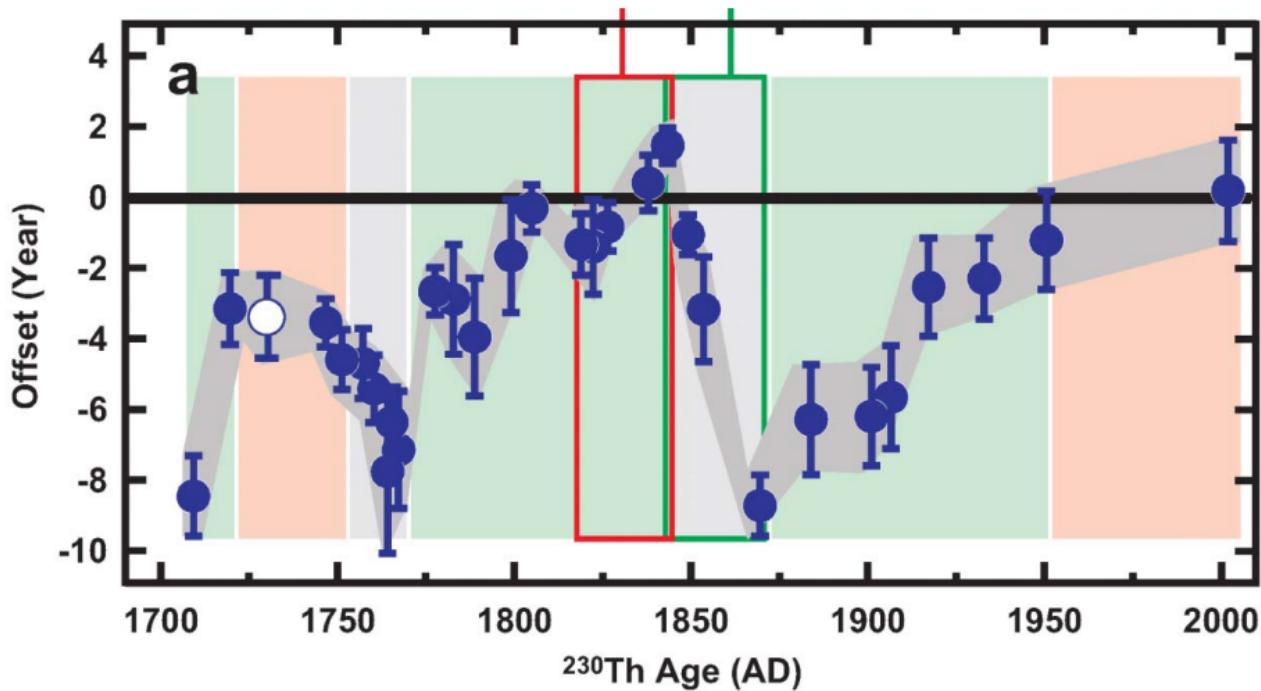


Die Verteilung der Meßwerte





Das Ergebnis





Résumé

Reliability	Material	Closed system?	Contaminated?
Reliable	Unaltered coral	Closed	Clean
	Clean speleothem		Clean
	Volcanic rocks		—
	Dirty speleothem		Contaminated
Possibly reliable	Ferruginous concretions	Possibly closed	Contaminated
	Tufa		Contaminated
	Mollusc shells		Contaminated
	Phosphates		Contaminated
Generally unreliable	Diagenetically altered corals	Open	Clean
	Bone		?
	Evaporites		Contaminated
	Caliche		Contaminated
	Stromatolites		Contaminated
	Peat and wood		?

Unter idealen Bedingungen ist die Genauigkeit des Verfahrens deutlich besser als $\pm 1\%$. Es wird deshalb häufig zur Kalibration anderer Methoden verwendet, vor allem ^{14}C jenseits der Dendrogrenze.

Grundlagen
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Probleme
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Anwendungen
oooooooooooo

Résumé
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Handout und Literatur

Vielen Dank

Das Handout und Literatur liegen auf:
www.axel.berger-odenthal.de/work/Referat/



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