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Supplemental Material

TABLE S1. MAXIMUM DEPOSITIONAL AGES

TABLE S2. LU-HF ISOTOPIC DATA

TABLE S3. APATITE FISSION TRACK DATA

TABLE S4. APATITE (U-TH)/HE DATA FOR SAMPLE FC-AC17-7

TABLE S5. APATITE FISSION TRACK DPAR

TABLE S6. MODELING PARAMETERS FOR QTQT MODELS

TABLE S7. APATITE FISSION TRACK LENGTHS

Figure S1.

Figure S2.

Figure S3.

TABLE S1. MAXIMUM DEPOSITIONAL AGES

Sample	TuffZirc routine	Weighted mean	Unmix routine	Youngest graphical peak
FC-HC18-1	77.40 +0.40 -0.60	77.46 ± 0.49	77.16 ± 0.22	77
FC-HC18-2	76.35 +0.31 -0.41	76.48 ± 0.31	76.15 ± 0.19	76

TABLE S2. LU-HF ISOTOPIC DATA

Order	Sample	(¹⁷⁶ Yb + ¹⁷⁶ Lu)/ ¹⁷⁶ Hf (%)	Volts Hf	¹⁷⁶ Hf/ ¹⁷⁷ Hf	± (1s)	¹⁷⁶ Lu/ ¹⁷⁷ Hf	¹⁷⁶ Hf/ ¹⁷⁷ Hf (T)	E-Hf (0)	E-Hf (0) ± (1s)	E-Hf (T)	Age (Ma)
0	F_CCC18- 3-18	40.30198393	5.80230096	0.282558068	2.23064E- 05	0.002767209	0.282554184	-8.024886297	0.788809969	-6.495568587	75.12765544
0	F_CCC18- 3-42	37.90508199	5.197501475	0.282506049	2.40616E- 05	0.002439784	0.282502603	-9.864433129	0.850881164	-8.309446456	75.59986828
0	F_CCC18- 3-48	31.15417969	6.022529945	0.282502994	2.29552E- 05	0.002006514	0.28250017	-9.9724508	0.811753621	-8.401618834	75.32290265
0	F_CCC18- 3-57	45.09501958	4.895713564	0.282127476	2.28137E- 05	0.002689292	0.282123637	-23.25172572	0.806752108	-21.69511149	76.40111735
0	F_CCC18- 3-55	28.32125291	3.426935692	0.282477481	2.32448E- 05	0.001745757	0.282456852	-10.87464208	0.821996085	2.43965413	629.2131878
0	F_CCC18- 3-59	21.47725709	4.855087112	0.282100047	2.5748E- 05	0.001483438	0.282059604	-24.2216983	0.910514248	6.763607111	1440.713553
0	F_CCC18- 3-50	10.03321979	4.566834574	0.281913552	2.01934E- 05	0.000678921	0.281892353	-30.81661246	0.714091203	5.554918014	1646.871311
0	F_CCC18- 3-37	38.45831127	5.02239474	0.282376391	3.93206E- 05	0.002456821	0.282294694	-14.44945313	1.390475729	22.26043507	1752.135274
0	F_CCC18- 3-38	27.65486455	5.67704196	0.282486004	2.72988E- 05	0.001847009	0.282425862	-10.57325621	0.965353864	26.09055981	1716.291536
0	F_CCC18- 3-15	25.9800294	4.386185105	0.282019667	2.37976E- 05	0.001700945	0.281966357	-27.06413066	0.841543021	8.321151392	1652.94314
0	F_CCC18- 3-39	13.5557398	4.267176891	0.282034945	2.19291E- 05	0.000957132	0.282009281	-26.523845	0.77546747	4.442260413	1417.272333
0	F_CCC18- 3-49	15.47788887	4.612890732	0.281988589	2.68772E- 05	0.001050205	0.281973408	-28.16313378	0.950446519	-11.54476787	768.6876167
0	SF-MF-2- 6	18.08985041	3.69249224	0.282554536	2.15742E- 05	0.001305801	0.282552702	-8.149786032	0.762920486	-6.546476462	75.19620651
0	SF-MF-2- 14	20.80577996	4.558070416	0.282549989	1.90957E- 05	0.001497334	0.282547898	-8.310601482	0.675272489	-6.726320661	74.74908684
0	SF-MF-2- 15	16.69410069	4.381986386	0.282568511	2.66596E- 05	0.001305359	0.282566695	-7.655610542	0.942752865	-6.067701256	74.46969727
0	SF-MF-2- 28	18.84280446	4.042319092	0.282566661	2.28651E- 05	0.001357628	0.282564727	-7.721012258	0.808569661	-6.097221597	76.274941
0	SF-MF-2- 32	27.92192726	2.898686835	0.282468991	3.1168E- 05	0.001650054	0.282466604	-11.17488998	1.102180359	-9.542132958	77.42577956
0	SF-MF-2- 20	13.51307287	4.085843099	0.282522441	2.73939E- 05	0.000976812	0.282521074	-9.28474754	0.968716743	-7.670678088	74.94578848
0	SF-MF-2- 22	10.24368658	4.257285397	0.282558584	2.52467E- 05	0.000766375	0.282557513	-8.006662382	0.892787587	-6.385446817	74.78502504

0	SF-MF-2-30	47.79144733	2.577339378	0.282575898	2.33048E-05	0.002461378	0.282572492	-7.394379086	0.824116717	-5.871561979	74.06880493
0	SF-MF-2-34	23.05157279	4.267467447	0.28250598	2.56751E-05	0.00157242	0.282503775	-9.866874511	0.907937028	-8.280679781	75.02701606
0	SF-MF-2-38	21.12015455	3.927909753	0.282647072	3.13044E-05	0.001609365	0.282644719	-4.877470383	1.107003008	-3.223553968	78.27668492
0	SF-MF-2-9	18.39487654	2.877939377	0.282508891	2.58669E-05	0.001189352	0.282484352	-9.763911849	0.914719519	13.91724023	1093.852687
0	SF-MF-2-37	145.9523021	3.284393582	0.282330991	3.3561E-05	0.009335504	0.282140675	-16.05492151	1.186802771	1.441072834	1080.943728
0	SF-MF-2-39	18.61625906	4.452701659	0.2825132	2.29444E-05	0.001324498	0.28250281	-9.611544632	0.811374298	-0.65894175	418.5239406
0	SF-MF-2-5	14.58483	4.343103646	0.282552102	2.92456E-05	0.001075379	0.282529465	-8.235862553	1.034198076	16.01561612	1115.805738
0	SMITH SF-RJ-1-53	34.71328206	4.669013176	0.282505561	2.72647E-05	0.002181729	0.282502634	-9.881692132	0.964147689	-8.392771522	71.79599002
0	SMITH SF-RJ-1-51	33.87665296	4.369661228	0.282469732	2.59811E-05	0.002263348	0.282466627	-11.14869236	0.91875981	-9.630318048	73.4157624
0	SMITH SF-RJ-1-24	36.15632657	4.272646086	0.282514617	2.9628E-05	0.00257397	0.282511061	-9.561418207	1.047723052	-8.046994203	73.94556631
0	SMITH SF-RJ-1-29	26.21949984	4.997056113	0.282459235	2.4143E-05	0.001743574	0.282456784	-11.51988854	0.853756899	-9.937965779	75.24032497
0	SMITH SF-RJ-1-5	24.30134181	3.983372047	0.282436205	3.1303E-05	0.001651621	0.282433901	-12.33427191	1.106954083	-10.75961621	74.6857475
0	SMITH SF-RJ-1-43	28.32213695	3.583664575	0.282459645	2.40341E-05	0.002031887	0.282456849	-11.50539036	0.849906898	-9.971020371	73.64717004
0	SMITH SF-RJ-1-13	27.59706868	4.06778766	0.2824838	3.07923E-05	0.001859328	0.282481247	-10.65120284	1.088893694	-9.111823504	73.47892098
0	SMITH SF-RJ-1-20	27.35341586	4.210359126	0.282482612	2.17428E-05	0.001868038	0.282480085	-10.69322388	0.768880402	-9.176717578	72.40823543
0	SMITH SF-RJ-1-48	33.40950817	2.041252076	0.282259404	2.56379E-05	0.002286968	0.282256254	-18.58642215	0.906621799	-17.06388668	73.73120504
0	SMITH SF-RJ-1-21	47.07513583	5.689091249	0.28245698	1.59121E-05	0.002614864	0.282453389	-11.59962418	0.562693049	-10.09652781	73.50606542

0	SMITH SF-RJ-1- 40	29.43364938	5.588404731	0.282497514	1.98059E- 05	0.0019253	0.282494893	-10.16625466	0.700387663	-8.643342492	72.84125683
0	SMITH SF-RJ-1- 30	10.64266796	3.662109081	0.281896101	2.96123E- 05	0.000814946	0.281869302	-31.43373132	1.047165224	6.71840404	1733.050021
0	SMITH SF-RJ-1-2	15.80930393	4.582118631	0.281991196	2.30255E- 05	0.001048072	0.281963222	-28.0709439	0.814242268	2.661588434	1410.853869
0	SMITH SF-RJ-1- 15	34.38462489	4.363022133	0.282376966	3.03577E- 05	0.002038519	0.282361719	-14.42914096	1.073526679	-6.087182296	399.1032038
0	SMITH SF-RJ-1- 41	13.86936115	3.312777765	0.282578302	2.51275E- 05	0.00102299	0.282574264	-7.309385046	0.888572976	-2.764136124	210.9729322
0	SMITH SF-RJ-1- 18	14.75309039	3.720080748	0.2822985	2.50255E- 05	0.000887794	0.282279996	-17.20389103	0.884966611	6.923585959	1104.888178
0	SMITH SF-RJ-1- 45	20.54246414	5.300556709	0.282160037	3.07504E- 05	0.001336884	0.282124223	-22.10030078	1.087412806	8.49047965	1415.986796

TABLE S3. APATITE FISSION TRACK DATA

Sample	Unit /Locality	Type	No. of crystals	Spontaneous		Induced		P(χ^2) (%)	Dosimeter		Age Pooled (Ma $\pm$ 1 σ)	Age Central (Ma $\pm$ 1 σ)	Long. ($^{\circ}$ W)	Lat. ($^{\circ}$ N)	Elevation (m a.s.l.)
				ps	Ns	pi	Ni		pd	Nd					
FC-AC17-7	Fort Crittenden	Apatite	20	4.24E+05	191	2.75E+06	1240	16.71	1.30E+06	2460	34.08 $\pm$ 4.34	34.10 $\pm$ 4.35	110.77013 $^{\circ}$	31.68848	5065
FC-AC18-2B	Fort Crittenden	Apatite	19	2.92E+05	99	2.52E+06	856	16.37	1.36E+06	4702	26.86 $\pm$ 3.92	26.86 $\pm$ 3.92	110.767617	31.690067	5073
MW18-3	Late Cretaceous Intrusion, Mt. Wrightson	Apatite	17	9.54E+05	302	5.85E+06	1852	42.4	1.40E+06	4702	38.98 $\pm$ 4.59	41.92 $\pm$ 5.74	110.863626	31.69680504	2055.666
MW18-4	Late Cretaceous Intrusion, Mt. Wrightson	Apatite	19	9.68E+05	223	5.45E+06	1257	52	1.32E+06	4702	39.91 $\pm$ 4.93	44.94 $\pm$ 6.72	110.87065	31.70885	1800.135

Note: ps—spontaneous track density, Ns—number of spontaneous tracks, pi—induced track density; Ni—number of induced tracks ; pd—dosimeter track density; Nd—number of dosimeter tracks; P(χ^2)— χ^2 probability; m a.s.l.: meters above sea level. Error is 1 σ , calculated using the zeta calibration method (Hurford et al., 1983) with zeta of 354.7 $\pm$ 11.7 for apatite.

TABLE S4. APATITE (U-TH)/HE DATA FOR SAMPLE FC-AC17-7

Aliquot name	4He (pmol)	4He (pmol $\pm$ 1 σ)	4He (pmol $\pm$ 1 σ)	U (ng)	U (ng $\pm$ 1 σ)	Th (ng)	Th (ng $\pm$ 1 σ)	Sm (ng)	Sm (ng $\pm$ 1 σ)	Th/U (atomic)	Raw age (Ma)	Raw age (Ma $\pm$ 1 σ)	Ft 238U	Ft 235U
18A576_FC-AC17-7_Ap1	0.085796687	0.00030015	0.34984	0.362179	0.00521	1.84484	0.0263	2.5257	0.03894	5.22552	19.808	0.2095	0.794	0.766
18A577_FC-AC17-7_Ap2	0.091336261	0.000289137	0.31656	0.290605	0.00415	1.97836	0.0281	3.1895	0.04805	6.98387	22.163	0.2367	0.786	0.756
18A578_FC-AC17-7_Ap3	0.065063492	0.000214285	0.32935	0.275393	0.00397	1.70557	0.0244	3.1067	0.04698	6.35346	17.64	0.1882	0.775	0.743
18A579_FC-AC17-7_Ap4	0.094844762	0.000310994	0.3279	0.353382	0.00506	2.41624	0.0345	3.1054	0.04687	7.0144	18.897	0.2032	0.798	0.770
18A580_FC-AC17-7_Ap5	0.041178923	0.000153308	0.3723	0.16948	0.00241	1.03366	0.0147	1.7187	0.02601	6.25679	18.316	0.1965	0.806	0.779
18A581_FC-AC17-7_Ap6	0.062782546	0.000243542	0.38791	0.251802	0.00363	1.47004	0.0209	2.1965	0.03355	5.98912	19.293	0.2081	0.771	0.739

Note: FT—alpha-ejection correction (see methods section and references therein); 1s err anal.—one-sigma analytical precision; eU—equivalent uranium concentration ($U + 0.235 \times Th$); m a.s.l. - meters above sea level. W.A.: Weighted Average.

TABLE S4. APATITE (U-TH)/HE DATA (CONTINUED)

Ft 232Th	Ft 147Sm	Rs (um)	Corrected age (Ma)	1s err anal. (Ma)	ppm eU w/ Sm (Ca)	ppm U (morph)	ppm Th (morph)	ppm Sm (morph)	nmol 4He/g (morph)	mass ap (μg)	Long. (°W)	Lat. (°N)	Elev. (m a.s.l.)
0.766	0.934	70.60	25.43	0.27	89.49	49.44	251.86	344.80	11.71	7.32E-06	110.77013	31.688	1525
0.756	0.932	67.68	28.85	0.31	97.50	48.78	332.06	535.36	15.33	5.96E-06			
0.743	0.928	64.07	23.31	0.25	91.17	44.47	275.44	501.72	10.51	6.19E-06			
0.770	0.936	72.06	24.19	0.26	98.15	43.98	300.74	386.51	11.80	8.03E-06			
0.779	0.938	75.33	23.16	0.25	44.57	42.11	256.85	427.09	10.23	4.02E-06			
0.739	0.927	62.83	25.64	0.28	96.73	54.97	320.92	479.52	13.71	4.58E-06			

Note: FT—alpha-ejection correction (see methods section and references therein); 1s err anal.—one-sigma analytical precision; eU—equivalent uranium concentration ($U + 0.235 \times Th$); m a.s.l. - meters above sea level. W.A.: Weighted Average.

TABLE S5. APATITE FISSION TRACK DPAR

Induced		Dpar	Age (Ma)	Age error
pi	Ni			
4	35	1.68	25.31	13.371
9	53	1.73	37.58	13.569
10	49	1.67	45.14	15.688
8	59	1.72	30.02	11.328
7	43	1.63	36.03	14.702
7	72	1.79	21.54	8.54
14	125	2.04	24.81	7.01
10	68	1.85	32.56	11.046
7	45	1.61	34.43	14.007
18	88	1.84	45.24	11.738
11	98	1.85	24.86	7.922
12	120	2.04	22.16	6.723
12	44	1.92	60.25	19.658
8	33	1.91	53.58	21.143
10	54	1.87	40.97	14.129
7	26	1.7	59.48	25.355
10	71	1.78	31.18	10.551
11	55	1.81	44.24	14.638
8	66	1.68	26.85	10.065
8	36	1.83	49.13	19.23

TABLE S6. MODELING PARAMETERS FOR QTQT MODELS

AHe data	Number of aliquotes modeled	Data source
Fort Crittenden Formation	6 (Ap 1, 2, 3, 4, 5,6)	Table S4
AFT data	Data modeled	Data source
Fort Crittenden Formation	ages, lengths, dpar	Table S3
Data treatment, uncertainties, and other constraints		
Treatment: Each apatite analysis was modeled independently but simultaneously for each sample.		
Lengths are C-axis corrected		
Etching: 5.5. molar nitric acid		
compositional data from Dpar		
System and model specific parameters		
AHe model: Flowers et al. (2009)		
FT annealing model: Ketcham et al. (2007)		
FT c-axis projection: yes		
Statistical fitting criteria: Default QTQt values		
MCMC Parameters: Burn-in = 1,000,000 - or between 100,000,000		

TABLE S7. APATITE FISSION TRACK
LENGTHS SAMPLE FC-AC17-7

Length	Angle to C-axis	Dpar
12	39	1.68
8.27	74	1.73
16.32	81	1.67
13.8	46	1.72
13.06	41	1.63
9.64	14	1.79
10.69	6	2.04
12.24	74	1.85
13.72	52	1.61
11.74	72	1.84
8.48	48	1.85
10.99	36	2.04
13.59	47	1.92
11.11	71	1.91
10.82	31	1.87
9.49	76	1.7
12.35	29	1.78
12.24	62	1.81
8.34	58	1.68
8.43	58	1.83
13.55	35	1.58
14.72	54	1.73
12.85	75	1.92
12.05	59	1.46
9.65	51	1.96
10.82	27	1.49
9.78	11	1.55
9.47	80	1.8
11.62	74	1.65
11.62	70	1.72
9.92	81	1.52
10.52	52	1.69
9.14	54	1.65
9.88	45	1.69
16.08	79	1.63
10.24	48	1.58
13.68	65	1.47
10.88	10	1.75
12.12	56	1.17
12.3	60	2.11
9.59	74	1.82
12.88	73	2.17

12.37	34	1.78
10.88	47	1.69
12.52	51	1.44
12.37	53	1.39
11.82	51	1.41
9.55	51	1.79
9.31	39	1.17
8.5	42	2.11
9.41	24	1.82
6.53	73	2.17
11.44	75	1.78
12.83	29	1.69
12.9	47	1.44
13.28	64	1.39
13.42	51	1.41
11.94	45	1.44
15.38	62	1.39