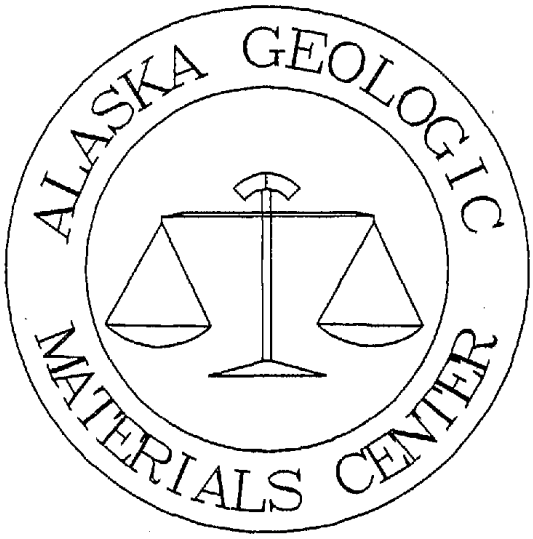
Apatite fission track data from the Paul G. Benedum Nulato Unit No. 1 well.



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Apatite fission track data from Nulato Unit #1 well, western Alaska

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The following fission track data sheets summarize apatite fission track age and track length data from the Nulato Unit #1 well in tabular format. The study was part of a Ph.D. Dissertation on the thermal history of the Yukon-Koyukuk Basin and Borderlands. Samples were composited over ~500' intervals from washed ditch cuttings and consited of up to 20 teaspoons, one each 30 feet, until sufficient material was obtained (generally 0.5-1.0 kg). Apatite grains were separated using conventional grinding and mineral extraction techniques. Yields were poor to very poor and the data by itself is of marginal quality. Finished slides, residual materials and unprocessed samples (odd numbers) are stored at the Geologic Materials Center- Eagle River, Alaska.

To reveal spontaneous fission tracks apatite grains were mounted in epoxy resin on glass slides, ground and polished to expose internal surfaces, then etched in 5N Nitric acid for 18-20 seconds. To detect induced fission fragments escaping apatite grains during irradiation Uranium-free muscovite external detectors were attatched to each grain-mount. After irradiation the mica detectors were etched for 18-25 minutes in concentrated hydrofluoric acid to reveal induced fission tracks. Neutron irradiations, performed at the Australian Atomic Energy Commissions HIFAR reactor, were subsidized by a grant to the La Trobe University Fission Track Research Group.

Using facilities of the Fission Track Research Group, La Trobe University, Australia fission tracks were counted and measured at 1250x in transmitted light using a dry 80x objective. Ages were determined using the zeta-calibrated external detector method and appropriately modified fission track age equation (e.g. Hurford and Green, 1982, 1983). Errors, reported as 1-sigma, were calculated using the techniques of Green (1981). Fully-etched and horizontal confined fission tracks were measured using a projection tube and calibrated digitizing pad. Track length data is given in Table 1 (errors are 2-sigma).

The program 'Mactrack', developed by the Melbourne fission track community, was used for age calculations and formatting of the data sheets below. The following page explains categories given on individual age data sheets.

Sample Status

Number	Depth (m)	Status
NU1	76	Unprocessed
NU2	381	Apatite fission track age and length data
NU3	686	Unprocessed
NU4	991	Apatite fission track age data only
NU5	1295	Unprocessed
NU6	1600	No apatite in sample, thus no age or length data
NU7	1905	Unprocessed
NU8	2210	Apatite fission track age and length data
NU9	2515	Unprocessed
NU10	2819	Apatite fission track age data only
NU11	3124	Unprocessed
NU12	3429	Apatite fission track age and length data

Selected References

Green, P.F., 1981, A new look at statistics in fission track dating. Nuclear Tracks, v. 5, p. 77-86.

Hurford, A.J. and Green, P.F., 1982, A users' guide to fission track dating: Earth and Planetary Sci. Letters, v. 59, p. 343-354.

Hurford, A.J. and Green, P.F., 1983, The zeta age calibration of fission-track dating: Chemical Geology (Isotope Geoscience Section), v. 1, p. 285-317.

Sample Number MINERAL DATED ELEVATION (depth ft./m)- AREA
La Trobe University I.D. NUMBER; All samples analyzed by John M. Murphy (JM)

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)

No. - Apatite grain number for this sample
Ns - Number of spontaneous tracks counted on mineral surface
Ni - Number of spontaneous tracks counted on mica detector surface
Na - Number of counting areas, whose area is given below; used to determine U(ppm)
RATIO - Ratio of Ns/Ni
U(ppm) - Uranium concentration in the mineral grain; ppm- parts per million
RHOs - Spontaneous track density
RHOi - Induced track density (ends of tracks escaping apatite surface counted on mica)
F.T.AGE (Ma) - Single grain age with a 1-sigma error

	519	1627		37.7	1.102E+06	3.453E+06

Area of basic unit = counting area of individual grid squares (squares/cm2); used in calculating (U)ppm, RHOs and RHOi and RHOD

CHI SQUARED = statistical test to deterimine if single grain ages form a single population (Galbraith, 1981). >5% is a **PASS**, < 5% is a **FAIL**; **PASS*** means MEAN AGE is reported because there were less than 5 grains

P(chi squared) = less than 5% means non-poissanian distribution so MEAN AGE is reported

CORRELATION COEFFICIENT = 0.926 Linear regression of single grain ages

VARIANCE OF SQR(Ns) = 2.234059 Currently unused statistic

VARIANCE OF SQR(Ni) = 8.658181 Currently unused statistic

Ns/Ni = 0.319 ± 0.016 Ratio used in calculating POOLED AGE. Mean of sum of Ns/Ni (i.e. 519/1627). For single population

MEAN RATIO = 0.356 ± 0.029 Ratio used in calculating MEAN AGE. Average Ns/Ni ratio of all single grains. For mixed populations

POOLED AGE = 66.6 ± 4.0 Ma — Calculated using total spontaneous (N_S) and induced (N_i) track counts in the ratio Ns/Ni. Underlined if PASS

MEAN AGE = 74.2 ± 6.4 Ma — Calulated using N_S/N_i ratios of individual grains (i.e. MEAN RATIO). Underlined if FAIL

Ages calculated using a zeta of 350 ± 10 for SRM612 glass (see Appendix A)

RHO D = (tracks/cm2); ND = number of tracks counted on mica detector adjacent to dosimetry glass NBS-SRM612; used in determining RHO D.

* Mean age reported due to low (U)ppm, <5; or low numbers of grains, <5.

NU2 APATITE -1,000' TO -1,500' (average -381m) NULATO WELL

IRRADIATION LU160-10; COUNTED BY: JM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	9	46	10	0.196	25.6	9.990E+05	5.106E+06	88.7± 32.4
2	1	5	25	0.200	1.1	4.440E+04	2.220E+05	90.6± 99.3
3	0	1	6	0.000	0.9	0.000E+00	1.850E+05	0.0± 0.0
4	9	56	12	0.161	26.0	8.325E+05	5.180E+06	72.9± 26.3
5	1	12	4	0.083	16.7	2.775E+05	3.330E+06	37.9± 39.5
6	2	5	10	0.400	2.8	2.220E+05	5.550E+05	180.0±150.7
7	15	65	15	0.231	24.2	1.110E+06	4.810E+06	104.5± 30.1
8	0	3	9	0.000	1.9	0.000E+00	3.700E+05	0.0± 0.0
9	3	31	10	0.097	17.3	3.330E+05	3.441E+06	44.0± 26.6
10	2	17	14	0.118	6.8	1.586E+05	1.348E+06	53.5± 40.0
11	0	0	16	0.000	0.0	0.000E+00	0.000E+00	0.0± 0.0
12	40	259	16	0.154	90.3	2.775E+06	1.797E+07	70.1± 12.1
13	13	45	12	0.289	20.9	1.202E+06	4.162E+06	130.5± 41.3
	95	545			19.1	6.632E+05	3.805E+06	

Area of basic unit = 9.009E-07 cm-2

CHI SQUARED = 7.792746 WITH 12 DEGREES OF FREEDOM; **PASS**
P(chi squared) = 80.1 %
CORRELATION COEFFICIENT = 0.979
VARIANCE OF SQR(Ns) = 3.461296
VARIANCE OF SQR(Ni) = 17.92451

Ns/Ni = 0.174 ± 0.019
MEAN RATIO = 0.148 ± 0.033

POOLED AGE = 79.1 ± 9.1 Ma
MEAN AGE = 67.3 ± 15.1 Ma

Ages calculated using a zeta of 350 ± 10 for SRM612 glass
RHO D = 2.608E+06cm-2; ND = 5868

NU4 APATITE -3000' TO -3500' (average -991m) NULATO WELL

IRRADIATION LU160-11; COUNTED BY: JM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	21	220	25	0.095	49.1	9.324E+05	9.768E+06	43.4± 10.0
2	4	39	16	0.103	13.6	2.775E+05	2.706E+06	46.6± 24.5
3	1	5	49	0.200	0.6	2.265E+04	1.133E+05	90.6± 99.3
4	0	4	49	0.000	0.5	0.000E+00	9.061E+04	0.0± 0.0
5	1	2	40	0.500	0.3	2.775E+04	5.550E+04	224.3±274.7
6	0	2	40	0.000	0.3	0.000E+00	5.550E+04	0.0± 0.0
7	2	6	64	0.333	0.5	3.469E+04	1.041E+05	150.4±122.9
8	27	92	40	0.293	12.8	7.492E+05	2.553E+06	132.6± 29.3
	56	370			6.4	1.924E+05	1.272E+06	

Area of basic unit = 9.009E-07 cm-2

CHI SQUARED = 17.22372 WITH 7 DEGREES OF FREEDOM; **FAIL**
P(chi squared) = 1.6 %
CORRELATION COEFFICIENT = 0.815
VARIANCE OF SQR(Ns) = 3.878117
VARIANCE OF SQR(Ni) = 24.02362

Ns/Ni = 0.151 ± 0.022
MEAN RATIO = 0.191 ± 0.062

POOLED AGE = 68.7 ± 10.1 Ma
MEAN AGE = 86.4 ± 28.3 Ma

Ages calculated using a zeta of 350 ± 10 for SRM612 glass
RHO D = 2.608E+06cm-2; ND = 5868

NU8 APATITE -7000' TO -7500' (average -2210m) NULATO WELL

IRRADIATION LU160-13; COUNTED BY: JM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	1	7	5	0.143	7.8	2.220E+05	1.554E+06	64.9± 69.4
2	1	3	5	0.333	3.3	2.220E+05	6.660E+05	150.4±173.7
3	22	33	16	0.667	11.5	1.526E+06	2.289E+06	297.3± 82.4*
4	0	1	4	0.000	1.4	0.000E+00	2.775E+05	0.0± 0.0
5	0	5	16	0.000	1.7	0.000E+00	3.469E+05	0.0± 0.0
6	1	9	40	0.111	1.3	2.775E+04	2.498E+05	50.5± 53.3
7	6	60	8	0.100	41.8	8.325E+05	8.325E+06	45.5± 19.5
8	0	0	32	0.000	0.0	0.000E+00	0.000E+00	0.0± 0.0
9	0	1	9	0.000	0.6	0.000E+00	1.233E+05	0.0± 0.0
10	9	86	30	0.105	16.0	3.330E+05	3.182E+06	47.6± 16.7
11	6	11	9	0.545	6.8	7.400E+05	1.357E+06	244.3±124.2*
12	29	49	12	0.592	22.8	2.682E+06	4.532E+06	264.6± 62.5*
13	2	35	16	0.057	12.2	1.388E+05	2.428E+06	26.0± 18.9
14	0	0	8	0.000	0.0	0.000E+00	0.000E+00	0.0± 0.0
15	3	10	25	0.300	2.2	1.332E+05	4.440E+05	135.5± 89.3
	80	310			7.4	3.779E+05	1.464E+06	

Area of basic unit = 9.009E-07 cm-2

CHI SQUARED = 48.83725 WITH 14 DEGREES OF FREEDOM; **FAIL**
P(chi squared) = 0.0 %
CORRELATION COEFFICIENT = 0.564
VARIANCE OF SQR(Ns) = 2.943743
VARIANCE OF SQR(Ni) = 8.373639

Ns/Ni = 0.258 ± 0.032
MEAN RATIO = 0.197 ± 0.061

POOLED AGE = 116.7 ± 15.1 Ma
MEAN AGE = 89.2 ± 27.6 Ma

Ages calculated using a zeta of 350 ± 10 for SRM612 glass
RHO D = 2.608E+06cm-2; ND = 5868

*- Anomalous single-grain age reported here, but not in recalculated age NU8R (next page). The stratigraphic age of the deposit is Cretaceous and because paleotemperatures exceeded 225°C (from VR) after that time these fission track ages are impossibly old.

NU8R APATITE -7000' TO -7500' (average -2210m) NULATO WELL **(Recaculated from NU8)**

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	1	7	5	0.143	7.8	2.220E+05	1.554E+06	64.9± 69.4
2	1	3	5	0.333	3.3	2.220E+05	6.660E+05	150.4±173.7
3	0	1	4	0.000	1.4	0.000E+00	2.775E+05	0.0± 0.0
4	0	5	16	0.000	1.7	0.000E+00	3.469E+05	0.0± 0.0
5	1	9	40	0.111	1.3	2.775E+04	2.498E+05	50.5± 53.3
6	6	60	8	0.100	41.8	8.325E+05	8.325E+06	45.5± 19.5
7	0	0	32	0.000	0.0	0.000E+00	0.000E+00	0.0± 0.0
8	0	1	9	0.000	0.6	0.000E+00	1.233E+05	0.0± 0.0
9	9	86	30	0.105	16.0	3.330E+05	3.182E+06	47.6± 16.7
10	2	35	16	0.057	12.2	1.388E+05	2.428E+06	26.0± 18.9
11	0	0	8	0.000	0.0	0.000E+00	0.000E+00	0.0± 0.0
12	3	10	25	0.300	2.2	1.332E+05	4.440E+05	135.5± 89.3
	23	217			6.1	1.289E+05	1.217E+06	

Area of basic unit = 9.009E-07 cm-2

CHI SQUARED = 5.416492 WITH 11 DEGREES OF FREEDOM; **PASS**
P(chi squared) = 90.9 %
CORRELATION COEFFICIENT = 0.959
VARIANCE OF SQR(Ns) = 1.072261
VARIANCE OF SQR(Ni) = 8.953177

Ns/Ni = 0.106 ± 0.023
MEAN RATIO = 0.096 ± 0.033

POOLED AGE = 48.2 ± 10.7 Ma
MEAN AGE = 43.6 ± 15.3 Ma

Ages calculated using a zeta of 350 ± 10 for SRM612 glass
RHO D = 2.608E+06cm-2; ND = 5868

NU10 APATITE 9000-9500' (average -2819m) NULATO WELL

IRRADIATION LU107-1; COUNTED BY: JM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	2	17	16	0.118	6.6	1.388E+05	1.179E+06	48.0± 35.9
	2	17			6.6	1.388E+05	1.179E+06	

Area of basic unit = 9.009E-07 cm-2

CHI SQUARED = 0 WITH 0 DEGREES OF FREEDOM; **PASS**
P(chi squared) = 100.0 %
CORRELATION COEFFICIENT = 0.000
VARIANCE OF SQR(Ns) = 0
VARIANCE OF SQR(Ni) = 0

Ns/Ni = 0.118 ± 0.088
MEAN RATIO = 0.118 ± 0.000

POOLED AGE = 48.0 ± 35.9 Ma
MEAN AGE = 48.0 ± 1.5 Ma

Ages calculated using a zeta of 350 ± 10 for SRM612 glass
RHO D = 2.338E+06cm-2; ND = 8424

NU12 APATITE 11,000-11,500' (average -3429m) NULATO WELL

IRRADIATION LU107-2; COUNTED BY: JM

No.	Ns	Ni	Na	RATIO	U(ppm)	RHOs	RHOi	F.T.AGE(Ma)
1	17	58	40	0.293	9.0	4.718E+05	1.610E+06	118.8± 33.0
2	0	1	40	0.000	0.2	0.000E+00	2.775E+04	0.0± 0.0
3	12	72	12	0.167	37.3	1.110E+06	6.660E+06	67.8± 21.3
4	0	0	10	0.000	0.0	0.000E+00	0.000E+00	0.0± 0.0
5	0	2	24	0.000	0.5	0.000E+00	9.250E+04	0.0± 0.0
6	1	5	50	0.200	0.6	2.220E+04	1.110E+05	81.3± 89.1
7	0	3	16	0.000	1.2	0.000E+00	2.081E+05	0.0± 0.0
8	1	3	20	0.333	0.9	5.550E+04	1.665E+05	135.0±155.9
9	1	13	25	0.077	3.2	4.440E+04	5.772E+05	31.4± 32.6
10	0	0	9	0.000	0.0	0.000E+00	0.000E+00	0.0± 0.0
11	1	11	9	0.091	7.6	1.233E+05	1.357E+06	37.1± 38.8
12	7	25	9	0.280	17.3	8.633E+05	3.083E+06	113.6± 48.7
13	8	52	60	0.154	5.4	1.480E+05	9.620E+05	62.6± 23.9
14	0	3	21	0.000	0.9	0.000E+00	1.586E+05	0.0± 0.0
15	1	7	25	0.143	1.7	4.440E+04	3.108E+05	58.2± 62.2
16	0	4	12	0.000	2.1	0.000E+00	3.700E+05	0.0± 0.0
	49	259			4.2	1.424E+05	7.526E+05	

Area of basic unit = 9.009E-07 cm-2

CHI SQUARED = 7.972058 WITH 15 DEGREES OF FREEDOM; **PASS**
P(chi squared) = 92.5 %
CORRELATION COEFFICIENT = 0.936
VARIANCE OF SQR(Ns) = 1.907443
VARIANCE OF SQR(Ni) = 6.963639

Ns/Ni = 0.189 ± 0.029
MEAN RATIO = 0.109 ± 0.030

POOLED AGE = 76.9 ± 12.2 Ma
MEAN AGE = 44.3 ± 12.2 Ma; low uramium

Ages calculated using a zeta of 350 ± 10 for SRM612 glass
RHO D = 2.338E+06cm-2; ND = 8424

Table 1. Confined track length data for samples from Nulato Benedum Well.

Sample #	No. Tracks			Track	Length	Class	Interval	(microns)					Mean Track	Error of	S.D. of Mean
	Total	(6 - 7)	(7 - 8)	(8 - 9)	(9 - 10)	(10 - 11)	(11 - 12)	(12 - 13)	(13 - 14)	(14 - 15)	(15 - 16)	(16 - 17)	Length (microns)	Measurement	(2-Sigma)
NU2	17	1	0	0	0	1	0	2	3	1	7	2	14.12	na	2.62
N4	0														
N8	5	0	1	0	0	1	1	1	0	1	0	0	9.92	0.93	3.72
NU10	0														
NU12	4	0	0	0	0	0	1	0	1	1	0	1	13.16	0.91	1.82