Supplemental Material for:

Lease, R.O., Houseknecht, D.W., and Kylander-Clark, A.R.C., 2022, Quantifying large-scale continental shelf margin growth and dynamics across middle Cretaceous Arctic Alaska with detrital zircon U-Pb dating: *Geology*, volume 50, <https://doi.org/10.1130/G49118.1>

Zircon U-Pb Methods and Data

Twenty sandstone samples and one volcanic ash sample were collected from selected intervals of exploration well cores (Table S1) warehoused at the U.S. Geological Survey (USGS) Core Research Center, Alaska Geological Materials Center, and Armstrong Oil and Gas. Seven sandstone samples were collected from outcrops during fieldwork. Zircon mineral separation was performed by GeoSep Services using standard crushing, magnetic, and heavy liquid procedures. Random, representative splits of detrital zircon grains were mounted for sandstone samples, whereas pristine zircon grains were handpicked for the volcanic ash sample. Grains were mounted in epoxy and sanded and polished for analysis by laser-ablation inductively coupled plasma mass spectrometry (LA-ICPMS).

LA-ICPMS analyses were performed at the University of California, Santa Barbara using a Photon Machines Analyte 193-nm excimer laser and Nu Instruments Plasma HR MC-ICPMS using standard methodology (Kylander-Clark et al., 2013). Analyses targeted the cores of randomly selected detrital zircon grains that were free of cracks and inclusions using a spot size of 15 μm and repetition rate of 4 Hz. The 91500 reference zircon was used as the primary standard and GJ1, Plesovice, and Peixe were used as secondary standards to monitor data accuracy. Data reduction was performed using the Iolite software (Paton et al., 2010) and age calculations were performed using Isoplot (Ludwig, 2012). We report isotope ratio uncertainties for individual grains that include analytical and systematic components according to Horstwood et al. (2016). We report ^{207}Pb -corrected $^{238}\text{U}/^{206}\text{Pb}$ ages (Ludwig, 2012). For interpretation, $^{238}\text{U}/^{206}\text{Pb}$ ages are used for <1400 Ma ages, whereas $^{207}\text{Pb}/^{206}\text{Pb}$ ages are used for >1400 Ma ages. Grains older than 600 Ma with >15% discordance or >5% reverse discordance were excluded. 6700 grains were analyzed in total (Lease et al., 2022; Data S1-S4; Figs. S1-S2). 100-565 grains were analyzed per sample with increasing numbers of analyses for better resolution of minor, young grain populations in some samples.

A maximum depositional age (MDA) was calculated for each sample according to the youngest grain cluster at 2σ method (YGC 2σ ; Coutts et al., 2019) and is the weighted mean of the youngest three or more dates that overlap within 2σ age uncertainty (Figs. S3-S6, Table S1). A few young grains excluded from the weighted mean calculation for 10 samples are labelled on Figs. S3-S6 as having poor age overlap and/or low isotope ratio concordance. We report weighted mean age uncertainties “ S_{total} ” according to Horstwood et al. (2016) that include analytical and systematic components (long-term excess variance of the validation materials, ratio uncertainty of the primary reference material used for normalization, and decay constant uncertainties).

Compilation of zircon U-Pb ages from potential Chukotka and Brooks Range sediment sources in Figure 3 of this manuscript includes the following datasets: (Miller et al., 2006, 2008, 2010; Amato et al., 2009, 2015; Tuchkova et al., 2011; Till et al., 2014; Gottlieb et al., 2014; Johnson et al., 2016, 2019; Strauss et al., 2017, 2019; Hoiland et al., 2018; Colpron et al., 2019; Akinin et al., 2020).

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Captions

Table S1. Summary of sample information and detrital zircon U-Pb maximum depositional ages.

Fig. S1. Probability density functions of detrital zircon U-Pb ages from individual Torok-Nanushuk shelf margin samples.

Fig. S2. Probability density functions of detrital zircon U-Pb ages from individual Ninuluk transgressive sandstone, Juniper-Arctic Creek basin-floor fan, and Nanushuk upper topset samples

Fig. S3-S4. Ranked date plot of youngest detrital zircon U-Pb grains from individual Torok-Nanushuk shelf margin samples. Weighted mean date used for estimation of maximum depositional age.

Fig. S5. Ranked date plot of youngest detrital zircon U-Pb grains from individual Ninuluk transgressive sandstone and Nanushuk upper topset samples. Weighted mean date used for estimation of maximum depositional age.

Fig. S6. Ranked date plot of youngest detrital zircon U-Pb grains from individual Juniper-Arctic Creek basin-floor fan samples. Weighted mean date used for estimation of maximum depositional age.

Data S1. Zircon U-Pb data for Torok-Nanushuk shelf margin samples

Data S2. Zircon U-Pb data for Ninuluk transgressive sandstone samples

Data S3. Zircon U-Pb data for Juniper-Arctic Creek basin-floor fan samples

Data S4. Zircon U-Pb data for Nanushuk upper topset samples

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Table S1: Sample summary

Site	Name: well / outcrop	Latitude	Longitude	sampled depth range (ft)	relationship to top lap surface (ft)	DZ MDA weighted mean date (Ma)	2 σ analytical error (Ma)	2 σ S _{total} error (Ma)	mswd	probability	n (grains)
Torok-Nanushuk shelf margin											
C	Crackerjack #1	71.4188	-165.5415	4400-4590	1100' above	114.7	1.7	2.2	0.36	0.78	4
T	Tunalik Test #1	70.2060	-161.0692	5552-5562	800' above	111.8	0.9	1.7	0.82	0.62	13
P	Peard Test #1	70.7157	-159.0007	3034-3038	500' below	109.6	1.2	1.8	1.01	0.39	4
So	South Meade Test #1	70.6150	-156.8899	3015-3020	500' below	109.1	1.3	1.9	0.91	0.46	5
To	Topagoruk Test #1	70.6250	-155.8933	2087-2097	60' above	107.5	0.8	1.6	1.50	0.14	10
S	Square Lake Test #1	69.5667	-153.3000	3874-3905	0 (coincident)	105.4	1.4	1.9	1.20	0.29	3
E	East Simpson Test #2	70.9785	-154.6738	2386-2401	1200' above	104.5	1.0	1.6	1.90	0.07	7
I	Inigok Test #1	70.0049	-153.0992	5000-5010	1000' below	104.5	1.1	1.7	1.50	0.19	5
U	Umiat Test #11	69.4081	-152.0994	2835-2850	200' above	103.6	1.3	1.8	0.53	0.66	4
G	Gubik Test #2	69.4194	-151.4572	4323-4350	40' above	99.4	1.3	1.8	0.64	0.59	4
Q	Qugruk #8	70.3128	-150.7238	4226-4228	0 (coincident)	99.3	1.0	1.6	1.80	0.13	5
Ka	Kalubik #2	70.4849	-150.3061	4951-5027	700' below	97.9	1.0	1.6	1.00	0.40	5
Cd	Colville Delta #3	70.4373	-150.3294	5127-5154	1000' below	97.8	1.1	1.6	1.20	0.29	5
K	Kuparuk Unit #1	69.2972	-150.8305	5529-5545	500' above	97.6	0.7	1.4	1.60	0.10	11
Nanushuk upper topset											
U	Umiat Test #11	69.4081	-152.0994	2214-2215.5	-	98.2	0.7	1.4	1.40	0.14	14
U	Umiat Test #11	69.4081	-152.0994	2225-2227	-	98.2	0.5	1.3	0.76	0.92	63
U	Umiat Test #11	69.4081	-152.0994	^2227.5	-	98.4	0.4	1.3	1.20	0.20	28
U	Umiat Test #11	69.4081	-152.0994	2233-2235	-	98.4	0.7	1.4	1.40	0.14	13
Juniper-Arctic Creek basin-floor fan											
J3	Juniper-base	69.3919	-146.4059	-	-	97.6	0.6	1.3	0.42	0.89	8
J2	Juniper-middle	69.3794	-146.7178	-	-	96.7	0.8	1.5	0.34	0.71	3
J1	Juniper-top	69.3861	-146.6184	-	-	95.5	0.7	1.4	0.98	0.40	4
A3	Arctic Creek-base	69.5241	-144.6123	-	-	98.4	0.8	1.5	1.02	0.38	4
A2	Arctic Creek-middle	69.5386	-144.6538	-	-	96.0	0.8	1.4	0.44	0.64	3
A1	Arctic Creek-top	69.5477	-144.6615	-	-	95.6	0.8	1.5	0.77	0.46	3
Ninuluk transgressive sandstone											
G	Gubik Test #2	69.4194	-151.4572	3105-3125	-	95.4	0.6	1.3	1.14	0.33	10
U	Umiat Test #11	69.4081	-152.0994	2048-2060	-	95.0	1.0	1.6	2.40	0.05	5
S	Square Lake	69.5667	-153.3000	1637-1664	-	95.4	0.5	1.3	0.80	0.76	29
N	*Ninuluk Bluff	69.1288	-153.2850	-	-	95.1	0.5	1.3	1.12	0.31	26

NOTES

*118-136 meters of Lepain et al. (2009) Ninuluk Bluff section

^volcanic ash

mswd: mean square of the weighted deviates

S_{total}: analytical and systematic error

Figure S1 Lease et al.

Figure S2 Lease et al.

Figure S3

Lease et al.

South Meade Test #1 3015-3020'
 mean = $109.1 \pm 1.3/1.9$ Ma
 MSWD = 0.91; probability = 0.46

Topagoruk Test #1 2087-2097'
 mean = $107.5 \pm 0.8/1.6$ Ma
 MSWD = 1.5, probability = 0.14

Square Lake Test #1 3874-3905'
 mean = $105.4 \pm 1.4/1.9$ Ma
 MSWD = 1.2, probability = 0.29

Crackerjack #1 4400-4590'
 mean = $114.7 \pm 1.7/2.2$ Ma
 MSWD = 0.36, probability = 0.78

Tunalik Test #1 5552-5562'
 mean = $111.8 \pm 0.9/1.7$ Ma
 MSWD = 0.82, probability = 0.62

Peard Test #1 3034-3038'
 mean = $109.6 \pm 1.2/1.8$ Ma
 MSWD = 1.01, probability = 0.39

Figure S5

Lease et al.

Figure S6

Lease et al.