

**Supplementary Material for**  
**Late Paleozoic tectonic evolution of the Paleo-Asian Ocean in the northern Alxa Block (NW China)**

Rongsong Tian<sup>1</sup>, Guoai Xie<sup>1\*</sup>, Wenbin Zhu<sup>1\*</sup>, Jin Zhang<sup>2</sup>, Beihang Zhang<sup>2</sup>, Heng Zhao<sup>2</sup>, Shuang Gao<sup>1</sup>, Tian Li<sup>1</sup>

\* Corresponding author. Email: [njuxie@nju.edu.cn](mailto:njuxie@nju.edu.cn) (G.-A. Xie)  
[zwb@nju.edu.cn](mailto:zwb@nju.edu.cn) (W.-B. Zhu)

Supplementary Materials include:

**Supplementary text:** LA-ICP-MS Zircon U–Pb dating and whole-rock major and trace element Analytical methods

**Table S1:** LA-ICP-MS zircon U–Pb and Hf isotopic dating results

**Table S2:** whole-rock major and trace element and Sr-Nd isotopic compositions of volcanic rocks

**Table S3:** References for geochronological data in Langshan (Fig. 2).

**Supplementary figure:** Cumulative probability curves of measured crystallization ages for detrital zircons grains relative to the depositional age of samples from the Permian Dahongshan Formation.

**LA-ICP-MS zircon U–Pb dating :** The samples were prepared for U–Pb dating after photographing under reflected and transmitted lights. Cathodoluminescence (CL) imaging was carried out at Langfang Sincerity Geological Service Co., Ltd, Hebei Province, China, to identify the internal structures and to select target points for U–Pb isotopic analyses. In situ zircon U–Pb dating were carried out at the State Key Laboratory for Mineral Deposits Research, Nanjing University, using an Agilent 7500a ICP–MS (Inductively Coupled Plasma–Mass Spectrometry) attached to a Geolas 213 nm laser ablation system with an in–house sample cell. Detailed analytical procedures are similar to those described by Griffin et al. (2004) and Jackson et al. (2004). U–Pb fractionation was corrected using zircon standard GEMOC GJ–1 (<sup>207</sup>Pb/<sup>206</sup>Pb age of 608.5±1.5 Ma, Jackson et al., 2004) and accuracy was controlled using zircon standards 91500 (<sup>207</sup>Pb/<sup>206</sup>Pb age of 1065.4±0.6 Ma, Wiedenbeck et al., 1995) and Mud Tank (intercept age of 732±5 Ma). All analyses were carried out using a beam with a spot size of 32µm and a repetition rate of 5 Hz. Zircon U–Pb Concordia and weighted average ages diagrams were made using Isoplot (version 3.23; Ludwig, 2003).

**Whole-rock major and trace element and Sr-Nd isotopes of the Permian volcanic rocks:** 12 samples were used to analyze major and trace components at the ALS Laboratory Group, Guangzhou, China. Major elements were measured by X-ray fluorescence spectrometry (XRF), using fused lithium tetraborate glass pellets. Generally, major and trace-elements analytical precision is higher than 2% and 5%, respectively. Detailed analytical procedures can be found in Dai et al. (2017). 6 samples were used to analyze Sr-Nd isotopic compositions. Sr-Nd isotopes were analyzed using ID-TIMS (Finnigan MAT Triton TI) at the State Key Laboratory for Mineral

Deposits Research, Nanjing University (NJU). Chemical separation procedures can be found in [Pu et al. \(2005\)](#), with relative standard deviation (RSD) lower than  $5 \times 10^{-6}$ . Mass fractionation was corrected assuming  $^{86}\text{Sr}/^{88}\text{Sr} = 0.1194$ . Mass fractionation of Nd isotopes was corrected assuming  $^{146}\text{Nd}/^{144}\text{Nd} = 0.7219$ . The  $\epsilon\text{Nd}(t)$  values were calculated based on the Nd isotopic compositions of  $^{143}\text{Nd}/^{144}\text{Nd}$  (CHUR) = 0.512638 and  $^{147}\text{Sm}/^{144}\text{Nd}$  (CHUR) = 0.1967.

## References

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**Table S1. LA-ICP-MS zircon U–Pb isotopic dating results from Nuergong-Langshan Zone.**

Sample	Th		U(p)		Ratio								Age (Ma)			
	(pm)	(pm)	Th/U		$^{207}\text{Pb}/^{206}\text{Pb}$	1 $\sigma$	$^{207}\text{Pb}/^{235}\text{U}$	1 $\sigma$	$^{206}\text{Pb}/^{238}\text{U}$	1 $\sigma$	$^{207}\text{Pb}/^{206}\text{Pb}$	1 $\sigma$	$^{207}\text{Pb}/^{235}\text{U}$	1 $\sigma$	$^{206}\text{Pb}/^{238}\text{U}$	1 $\sigma$
<b>19A01 (Dacite)</b>	<b>Lat. N41°10' 51" , Long. E106°20' 19"</b>															
19A01-1	96	203	0.47	0.05643	0.00094	0.55209	0.00971	0.07097	0.00087	469	19	446	6	442	5	
19A01-2	172	277	0.62	0.11966	0.00771	0.77661	0.04839	0.04707	0.00077	1951	118	584	28	297	5	
19A01-3	154	271	0.57	0.05049	0.00101	0.29072	0.00598	0.04176	0.00052	218	26	259	5	264	3	
19A01-4	123	192	0.64	0.05166	0.00123	0.29704	0.00719	0.0417	0.00053	270	33	264	6	263	3	
19A01-5	146	270	0.54	0.05103	0.00143	0.29318	0.00835	0.04168	0.00051	242	43	261	7	263	3	
19A01-6	81	176	0.46	0.05546	0.00131	0.54028	0.01304	0.07066	0.00088	431	32	439	9	440	5	
19A01-7	126	223	0.57	0.05514	0.00118	0.53892	0.01178	0.07089	0.0009	418	27	438	8	442	5	
19A01-8	102	222	0.46	0.05564	0.0011	0.54802	0.01124	0.07145	0.00089	438	25	444	7	445	5	
19A01-9	91	182	0.50	0.05288	0.00207	0.30119	0.01168	0.04131	0.00061	324	61	267	9	261	4	
19A01-10	66	132	0.50	0.05534	0.00109	0.54768	0.01117	0.07179	0.0009	426	24	443	7	447	5	
19A01-11	97	389	0.25	0.05544	0.00116	0.54059	0.01158	0.07073	0.00089	430	26	439	8	441	5	
19A01-12	88	183	0.48	0.05544	0.00098	0.54392	0.01003	0.07117	0.00088	430	21	441	7	443	5	

19A01-13	64	144	0.45	0.05584	0.0017	0.54816	0.01668	0.07121	0.00097	446	43	444	11	443	6
19A01-14	85	165	0.52	0.05615	0.00102	0.54857	0.01041	0.07087	0.00088	458	22	444	7	441	5
19A01-15	106	190	0.56	0.05593	0.00115	0.55094	0.0117	0.07145	0.0009	450	26	446	8	445	5
19A01-16	236	841	0.28	0.05598	0.00098	0.54853	0.01006	0.07107	0.00088	452	20	444	7	443	5
19A01-17	87	207	0.42	0.05489	0.00124	0.53576	0.01242	0.07079	0.00087	408	30	436	8	441	5
19A01-18	82	315	0.26	0.05568	0.00083	0.548	0.00872	0.07139	0.00087	440	17	444	6	445	5
19A01-19	242	1301	0.19	0.05586	0.00066	0.54733	0.00726	0.07108	0.00085	447	13	443	5	443	5
19A01-20	402	445	0.90	0.05056	0.00089	0.29267	0.00537	0.04199	0.00052	221	21	261	4	265	3
19A01-21	95	188	0.51	0.05623	0.00102	0.55098	0.01043	0.07108	0.00088	461	21	446	7	443	5
19A01-22	81	238	0.34	0.05717	0.00096	0.55886	0.00985	0.0709	0.00087	498	19	451	6	442	5
19A01-23	98	212	0.46	0.05606	0.00092	0.54722	0.00943	0.07081	0.00087	455	19	443	6	441	5
19A01-24	169	276	0.61	0.05521	0.00114	0.54074	0.01147	0.07104	0.0009	421	26	439	8	442	5
19A01-25	106	200	0.53	0.05508	0.00166	0.53347	0.01462	0.07024	0.00087	416	69	434	10	438	5
19A01-26	118	271	0.44	0.05629	0.00091	0.55007	0.00937	0.07088	0.00087	464	18	445	6	441	5
19A01-27	134	306	0.44	0.05542	0.00085	0.54208	0.00883	0.07095	0.00086	429	17	440	6	442	5

**TLS18-22 (Andesite) Lat. N40 35' 33" , Long. E106 22' 06"**

TLS18-22-1	114	268	0.42	0.05377	0.00178	0.31838	0.01138	0.04295	0.00113	361	76	281	9	271	7
TLS18-22-2	77	190	0.41	0.05321	0.00204	0.31621	0.01277	0.04311	0.00116	338	89	279	10	272	7
TLS18-22-3	284	370	0.77	0.05316	0.00166	0.31472	0.01074	0.04295	0.00112	336	72	278	8	271	7
TLS18-22-4	159	249	0.64	0.05273	0.00197	0.31243	0.01235	0.04298	0.00115	317	87	276	10	271	7
TLS18-22-5	150	233	0.65	0.04996	0.00187	0.2968	0.0118	0.04309	0.00115	193	89	264	9	272	7
TLS18-22-6	113	177	0.64	0.05267	0.00284	0.30685	0.01671	0.04226	0.00122	315	126	272	13	267	8
TLS18-22-7	63	146	0.43	0.05236	0.00303	0.30948	0.01798	0.04288	0.00127	301	135	274	14	271	8
TLS18-22-8	104	238	0.44	0.05342	0.00195	0.31576	0.01225	0.04287	0.00115	347	85	279	9	271	7
TLS18-22-9	91	215	0.42	0.05061	0.00329	0.29945	0.01768	0.04291	0.00117	223	149	266	14	271	7
TLS18-22-10	123	229	0.54	0.05339	0.00195	0.31727	0.01233	0.0431	0.00116	345	85	280	10	272	7
TLS18-22-11	101	97	1.04	0.05348	0.00284	0.24885	0.01336	0.03375	0.00099	349	123	226	11	214	6
TLS18-22-12	81	190	0.43	0.05095	0.00214	0.29894	0.0132	0.04255	0.00115	239	99	266	10	269	7
TLS18-22-13	67	171	0.39	0.05266	0.00213	0.30948	0.0131	0.04263	0.00117	314	94	274	10	269	7
TLS18-22-14	152	294	0.52	0.05154	0.0019	0.30427	0.01197	0.04282	0.00115	265	87	270	9	270	7
TLS18-22-15	212	298	0.71	0.05307	0.002	0.31535	0.01262	0.0431	0.00117	332	88	278	10	272	7
TLS18-22-16	112	211	0.53	0.05179	0.00418	0.30299	0.02286	0.04243	0.0012	276	185	269	18	268	7
TLS18-22-17	97	169	0.57	0.0807	0.00227	2.22119	0.07082	0.19964	0.0053	1214	57	1188	22	1173	28
TLS18-22-18	65	156	0.42	0.05163	0.00245	0.30388	0.01497	0.04269	0.00118	269	111	269	12	269	7
TLS18-22-19	137	221	0.62	0.05539	0.00222	0.32849	0.01384	0.04301	0.00119	428	92	288	11	271	7
TLS18-22-20	81	166	0.49	0.05182	0.00215	0.30671	0.0134	0.04292	0.00118	277	97	272	10	271	7
TLS18-22-21	79	181	0.43	0.05175	0.00193	0.31063	0.01236	0.04354	0.00119	274	88	275	10	275	7
TLS18-22-22	86	120	0.72	0.05177	0.0026	0.30302	0.01555	0.04246	0.00123	275	118	269	12	268	8
TLS18-22-23	102	172	0.59	0.05154	0.00265	0.29975	0.01571	0.04218	0.00123	265	121	266	12	266	8
TLS18-22-24	97	215	0.45	0.05452	0.00763	0.31939	0.04341	0.04249	0.002	393	317	281	33	268	12
TLS18-22-25	146	240	0.61	0.05161	0.00182	0.30178	0.01151	0.04241	0.00115	268	83	268	9	268	7
TLS18-22-26	89	196	0.45	0.05111	0.00213	0.3021	0.01327	0.04287	0.00119	246	98	268	10	271	7
TLS18-22-27	40	238	0.17	0.07055	0.00199	1.44375	0.04649	0.14843	0.00397	944	59	907	19	892	22

TLS18-22-28	139	235	0.59	0.05022	0.00257	0.29706	0.01557	0.04291	0.00124	205	119	264	12	271	8
TLS18-22-29	141	243	0.58	0.051	0.00213	0.2989	0.01317	0.04251	0.00118	241	99	266	10	268	7
TLS18-22-30	126	277	0.45	0.05161	0.00477	0.30587	0.02665	0.04299	0.00133	268	212	271	21	271	8

**19A12 (Rhyolite) Lat. N40 01' 31" , Long. E105 11' 39"**

19A12-1	110	123	0.89	0.0553	0.00258	0.32829	0.01513	0.04306	0.00071	424	73	288	12	272	4
19A12-2	195	239	0.81	0.05274	0.00159	0.31184	0.00953	0.04289	0.00059	318	45	276	7	271	4
19A12-3	358	254	1.41	0.05204	0.00104	0.31174	0.00655	0.04345	0.00057	287	25	276	5	274	4
19A12-4	188	216	0.87	0.05177	0.00132	0.31102	0.00809	0.04357	0.00059	275	35	275	6	275	4
19A12-5	153	130	1.17	0.168	0.00208	11.01619	0.15793	0.47565	0.0061	2538	11	2525	13	2508	27
19A12-6	215	218	0.99	0.0525	0.00146	0.31179	0.0088	0.04308	0.0006	307	39	276	7	272	4
19A12-7	219	182	1.20	0.05323	0.00163	0.31539	0.00976	0.04298	0.00061	339	44	278	8	271	4
19A12-8	136	131	1.03	0.05224	0.00134	0.31119	0.00816	0.04321	0.00059	296	35	275	6	273	4
19A12-9	335	171	1.96	0.05386	0.00173	0.37844	0.01218	0.05097	0.00074	365	46	326	9	320	5
19A12-10	150	143	1.05	0.05339	0.00181	0.31731	0.01077	0.04311	0.00063	345	50	280	8	272	4
19A12-11	172	157	1.09	0.05145	0.00117	0.30967	0.00724	0.04366	0.00058	261	30	274	6	275	4
19A12-12	292	241	1.21	0.05248	0.00101	0.34681	0.00699	0.04793	0.00062	306	24	302	5	302	4
19A12-13	297	256	1.16	0.05254	0.00153	0.31069	0.00913	0.0429	0.00059	309	42	275	7	271	4
19A12-14	175	172	1.02	0.05296	0.00155	0.3161	0.00935	0.04329	0.00061	327	42	279	7	273	4
19A12-15	184	182	1.01	0.05326	0.00151	0.31443	0.00901	0.04282	0.00059	340	40	278	7	270	4
19A12-16	76	112	0.67	0.07202	0.0014	1.72603	0.03527	0.17383	0.00231	987	21	1018	13	1033	13
19A12-17	131	164	0.80	0.05346	0.00168	0.31609	0.00996	0.04289	0.00061	348	46	279	8	271	4
19A12-18	254	251	1.01	0.05135	0.00111	0.30607	0.00686	0.04323	0.00056	257	29	271	5	273	3
19A12-19	139	206	0.68	0.05208	0.00141	0.31026	0.0085	0.04321	0.00059	289	38	274	7	273	4
19A12-20	134	155	0.87	0.05284	0.00229	0.31169	0.0134	0.04278	0.00068	322	69	275	10	270	4
19A12-21	167	158	1.06	0.05239	0.00143	0.31476	0.00866	0.04358	0.0006	302	38	278	7	275	4
19A12-22	320	284	1.13	0.05205	0.00144	0.30862	0.00868	0.04301	0.00058	288	40	273	7	271	4
19A12-23	712	371	1.92	0.04997	0.00093	0.30524	0.00596	0.04431	0.00057	194	23	270	5	279	4
19A12-24	370	187	1.98	0.05163	0.00115	0.31078	0.00715	0.04366	0.00058	269	29	275	6	275	4
19A12-25	243	257	0.94	0.0507	0.00546	0.29699	0.03132	0.04249	0.00117	227	186	264	25	268	7
19A12-26	1248	636	1.96	0.05179	0.00099	0.31283	0.00624	0.04381	0.00057	276	23	276	5	276	4
19A12-27	206	350	0.59	0.05225	0.00096	0.34906	0.00674	0.04845	0.00062	296	22	304	5	305	4
19A12-28	197	156	1.27	0.04942	0.00181	0.29783	0.01088	0.04371	0.00064	168	58	265	9	276	4

**TLS18-20 (Granitic mylonite) Lat. N40 42' 54" , Long. E106 22' 12"**

TLS18-20-1	304	315	0.97	0.05243	0.00165	0.31419	0.01102	0.04347	0.00118	304	73	277	9	274	7
TLS18-20-2	522	798	0.65	0.05045	0.00133	0.30519	0.00942	0.04388	0.00117	216	62	270	7	277	7
TLS18-20-3	307	506	0.61	0.05232	0.00159	0.31108	0.01065	0.04313	0.00116	299	71	275	8	272	7
TLS18-20-4	443	485	0.91	0.05441	0.00165	0.32108	0.01094	0.0428	0.00115	388	70	283	8	270	7
TLS18-20-5	522	580	0.90	0.05318	0.00151	0.31585	0.01024	0.04308	0.00115	336	66	279	8	272	7
TLS18-20-6	290	413	0.70	0.05137	0.00248	0.30281	0.01506	0.04275	0.00123	257	113	269	12	270	8
TLS18-20-7	197	261	0.75	0.05345	0.00187	0.31534	0.012	0.0428	0.00117	348	81	278	9	270	7
TLS18-20-8	455	656	0.69	0.05329	0.0017	0.31561	0.01118	0.04296	0.00116	341	74	279	9	271	7
TLS18-20-9	333	376	0.89	0.05205	0.00161	0.307	0.0106	0.04278	0.00115	288	72	272	8	270	7

TLS18-20-10	445	871	0.51	0.05184	0.00136	0.30583	0.00942	0.04279	0.00114	278	61	271	7	270	7
TLS18-20-12	519	827	0.63	0.05295	0.0014	0.31605	0.00974	0.0433	0.00115	327	61	279	8	273	7
TLS18-20-13	161	161	1.00	0.05294	0.00188	0.32177	0.01234	0.04409	0.00121	326	83	283	9	278	7
TLS18-20-14	416	484	0.86	0.05341	0.00171	0.31625	0.01122	0.04295	0.00116	346	74	279	9	271	7
TLS18-20-15	357	322	1.11	0.05235	0.00168	0.31355	0.01117	0.04345	0.00117	301	75	277	9	274	7
TLS18-20-16	304	352	0.86	0.05228	0.00236	0.31099	0.01456	0.04315	0.00122	298	106	275	11	272	8
TLS18-20-17	128	109	1.17	0.0517	0.003	0.30737	0.01797	0.04313	0.0013	272	135	272	14	272	8
TLS18-20-18	284	323	0.88	0.05278	0.00173	0.31452	0.01134	0.04323	0.00117	319	76	278	9	273	7

**TLS18-21 (Undeformed diorite veins) Lat. N40 44' 20" , Long. E106 21' 57"**

TLS18-21-1	243	371	0.65	0.05658	0.00822	0.30152	0.04248	0.03866	0.00186	474	293	268	33	245	12
TLS18-21-2	558	2626	0.21	0.05125	0.00133	0.31623	0.00975	0.04477	0.00119	252	61	279	8	282	7
TLS18-21-3	179	179	1.00	0.05733	0.00184	0.62973	0.02246	0.07969	0.00216	504	72	496	14	494	13
TLS18-21-4	278	290	0.96	0.05415	0.00203	0.29669	0.01187	0.03974	0.00104	377	86	264	9	251	6
TLS18-21-5	237	164	1.44	0.0561	0.00187	0.57827	0.02129	0.07479	0.00203	456	76	463	14	465	12
TLS18-21-6	704	1856	0.38	0.05413	0.00152	0.35159	0.01134	0.04713	0.00126	376	65	306	9	297	8
TLS18-21-7	92	97	0.94	0.0524	0.00251	0.28664	0.01442	0.03968	0.00111	303	112	256	11	251	7
TLS18-21-8	287	404	0.71	0.05291	0.00162	0.33415	0.01146	0.04582	0.00123	325	71	293	9	289	8
TLS18-21-9	722	616	1.17	0.0537	0.00162	0.32268	0.01092	0.0436	0.00116	358	70	284	8	275	7
TLS18-21-10	156	289	0.54	0.05449	0.00187	0.34096	0.01278	0.0454	0.00122	391	79	298	10	286	8
TLS18-21-11	564	420	1.34	0.05231	0.00206	0.29014	0.01203	0.04023	0.00106	299	92	259	9	254	7
TLS18-21-12	306	354	0.87	0.05292	0.00153	0.28869	0.00931	0.03957	0.00103	325	67	258	7	250	6
TLS18-21-13	54	56	0.95	0.16147	0.00402	12.61392	0.37185	0.5668	0.01502	2471	43	2651	28	2895	62
TLS18-21-14	71	72	0.98	0.1656	0.0041	11.07561	0.3243	0.48526	0.01281	2514	43	2530	27	2550	56
TLS18-21-15	522	1992	0.26	0.0521	0.00129	0.38486	0.01126	0.05359	0.0014	290	58	331	8	337	9
TLS18-21-16	122	120	1.01	0.05055	0.00435	0.27931	0.02404	0.04008	0.00131	220	196	250	19	253	8
TLS18-21-17	530	2044	0.26	0.05237	0.0013	0.36128	0.01056	0.05005	0.0013	302	58	313	8	315	8
TLS18-21-18	122	181	0.68	0.06373	0.0107	0.31521	0.05199	0.03587	0.00113	733	375	278	40	227	7
TLS18-21-19	173	220	0.79	0.05466	0.00263	0.2999	0.01476	0.0398	0.00112	398	111	266	12	252	7
TLS18-21-20	425	269	1.58	0.05126	0.0035	0.283	0.01957	0.04004	0.00122	253	158	253	15	253	8
TLS18-21-21	180	529	0.34	0.06187	0.00171	0.79223	0.0246	0.09289	0.00241	670	61	592	14	573	14
TLS18-21-22	416	522	0.80	0.04759	0.00366	0.25498	0.0195	0.03886	0.00124	78	174	231	16	246	8
TLS18-21-23	560	762	0.74	0.06568	0.00182	0.48513	0.01507	0.05358	0.00139	796	59	402	10	336	9
TLS18-21-24	288	341	0.84	0.05392	0.0018	0.37678	0.01356	0.05068	0.00133	368	77	325	10	319	8
TLS18-21-25	130	153	0.85	0.05379	0.00208	0.39298	0.01589	0.05299	0.00142	362	89	337	12	333	9
TLS18-21-26	126	94	1.34	0.05004	0.00343	0.27504	0.0189	0.03987	0.00126	197	157	247	15	252	8
TLS18-21-27	98	125	0.78	0.05459	0.0024	0.41375	0.01879	0.05497	0.00149	395	101	352	13	345	9
TLS18-21-28	576	720	0.80	0.05362	0.00162	0.31881	0.01051	0.04312	0.00111	355	70	281	8	272	7
TLS18-21-29	90	141	0.64	0.05243	0.00278	0.28709	0.01573	0.03972	0.00114	304	124	256	12	251	7
TLS18-21-30	617	832	0.74	0.05475	0.0016	0.32071	0.01026	0.04248	0.00109	402	67	282	8	268	7
TLS18-21-31	43	33	1.31	0.05661	0.00581	0.32293	0.03263	0.04136	0.00141	476	234	284	25	261	9
TLS18-21-32	75	49	1.54	0.0456	0.00453	0.27545	0.02722	0.0438	0.00135	-23	204	247	22	276	8
TLS18-21-33	131	197	0.66	0.05103	0.00182	0.26042	0.00997	0.03702	0.001	242	80	235	8	234	6
TLS18-21-34	310	1775	0.17	0.05097	0.00146	0.29777	0.00932	0.04236	0.00108	239	68	265	7	267	7

TLS18-21-35	230	72	3.18	0.05242	0.00293	0.2848	0.01617	0.03941	0.00118	304	131	254	13	249	7
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**TLS18-23 (Granitic mylonite) Lat. N40 39' 12" , Long. E106 17' 24"**

TLS18-23-1	289	151	1.91	0.05237	0.00207	0.31003	0.01295	0.04294	0.00119	302	92	274	10	271	7
TLS18-23-2	208	336	0.62	0.05178	0.00164	0.31002	0.01089	0.04343	0.00117	276	74	274	8	274	7
TLS18-23-3	349	382	0.91	0.0514	0.00367	0.31326	0.02224	0.04421	0.00142	259	165	277	17	279	9
TLS18-23-4	466	716	0.65	0.05158	0.0018	0.30542	0.01157	0.04295	0.00117	267	82	271	9	271	7
TLS18-23-5	535	952	0.56	0.05321	0.00158	0.31574	0.01053	0.04304	0.00115	338	69	279	8	272	7
TLS18-23-6	218	254	0.86	0.05094	0.00177	0.31042	0.01172	0.0442	0.0012	238	82	275	9	279	7
TLS18-23-7	242	194	1.25	0.05217	0.00298	0.30756	0.01777	0.04277	0.00128	293	133	272	14	270	8
TLS18-23-8	82	69	1.18	0.05418	0.00338	0.31834	0.0201	0.04262	0.00125	379	144	281	15	269	8
TLS18-23-9	85	105	0.81	0.05188	0.00267	0.30726	0.01615	0.04296	0.00125	280	121	272	13	271	8
TLS18-23-10	168	149	1.12	0.05269	0.00234	0.31308	0.01452	0.04311	0.00119	315	104	277	11	272	7
TLS18-23-11	182	158	1.15	0.05305	0.00212	0.31454	0.01326	0.04301	0.00119	331	93	278	10	271	7
TLS18-23-12	596	886	0.67	0.05267	0.00163	0.31073	0.01066	0.04279	0.00114	315	72	275	8	270	7
TLS18-23-13	79	140	0.57	0.05141	0.00209	0.30413	0.01328	0.04291	0.00118	259	96	270	10	271	7
TLS18-23-14	177	215	0.82	0.05252	0.0017	0.3101	0.01095	0.04282	0.0011	308	75	274	8	270	7
TLS18-23-15	128	118	1.09	0.05477	0.00482	0.32595	0.0284	0.04317	0.0014	403	202	286	22	272	9
TLS18-23-16	94	52	1.81	0.05398	0.00319	0.32067	0.01917	0.04309	0.00131	370	137	282	15	272	8

**19A03 (Sandstone) Lat. N40 57' 45" , Long. E106 43' 54"**

19A03-1	147	331	0.44	0.11214	0.00258	4.61326	0.09079	0.29837	0.00358	1834	43	1752	16	1683	18
19A03-2	96	321	0.30	0.06719	0.00365	1.29158	0.06887	0.13943	0.0026	844	80	842	31	841	15
19A03-3	54	94	0.57	0.08473	0.00171	2.61323	0.05328	0.22371	0.00279	1309	21	1304	15	1301	15
19A03-4	55	88	0.63	0.08457	0.00135	2.6105	0.04296	0.22389	0.00264	1306	15	1304	12	1302	14
19A03-5	61	97	0.63	0.08499	0.00125	2.62748	0.04033	0.22422	0.00261	1315	14	1308	11	1304	14
19A03-6	0	0	1.18	0.08805	0.175	3.04389	5.96675	0.25073	0.13561	1384	2821	1419	1498	1442	699
19A03-7	268	145	1.85	0.05238	0.00247	0.31573	0.01462	0.04372	0.00068	302	77	279	11	276	4
19A03-8	59	131	0.45	0.08639	0.00115	2.82316	0.03971	0.23702	0.00273	1347	12	1362	11	1371	14
19A03-9	101	74	1.37	0.05132	0.01137	0.32835	0.07111	0.04641	0.00241	255	346	288	54	292	15
19A03-10	34	87	0.39	0.12227	0.00162	6.10261	0.08633	0.36199	0.00423	1990	11	1991	12	1992	20
19A03-11	163	88	1.85	0.0528	0.0121	0.32323	0.07236	0.0444	0.00241	320	360	284		280	15
19A03-12	73	133	0.55	0.09577	0.00399	3.21567	0.13189	0.24352	0.00444	1543	50	1461	32	1405	23
19A03-13	81	47	1.73	0.05314	0.00311	0.36634	0.0211	0.04999	0.00086	335	99	317	16	314	5
19A03-14	64	98	0.65	0.0853	0.0013	2.65957	0.04254	0.22612	0.0027	1322	15	1317	12	1314	14
19A03-15	186	203	0.92	0.10874	0.00156	4.72822	0.0718	0.31535	0.00376	1778	13	1772	13	1767	18
19A03-16	89	224	0.40	0.16269	0.00211	10.50514	0.14816	0.4683	0.00555	2484	11	2480	13	2476	24
19A03-17	103	60	1.72	0.05276	0.00226	0.35582	0.01505	0.04891	0.00074	318	68	309	11	308	5
19A03-18	102	68	1.50	0.0497	0.01514	0.29534	0.08799	0.0431	0.00302	181	417	263	69	272	19
19A03-19	89	142	0.62	0.05243	0.00177	0.32777	0.01102	0.04534	0.00063	304	51	288	8	286	4
19A03-20	161	113	1.42	0.05213	0.00203	0.33529	0.01297	0.04665	0.00067	291	62	294	10	294	4
19A03-21	201	251	0.80	0.0538	0.00282	0.31007	0.01598	0.0418	0.0007	363	86	274	12	264	4
19A03-22	134	162	0.83	0.05246	0.00523	0.32265	0.03145	0.04461	0.00116	306	173	284	24	281	7
19A03-23	200	121	1.65	0.05264	0.00258	0.36115	0.01744	0.04976	0.0008	313	80	313	13	313	5

19A03-24	89	143	0.62	0.08566	0.00131	2.72564	0.04484	0.2308	0.00283	1331	15	1335	12	1339	15
19A03-25	187	202	0.93	0.05512	0.00461	0.17053	0.01395	0.02244	0.00051	417	143	160	12	143	3
19A03-26	28	24	1.18	0.05236	0.00845	0.34271	0.0541	0.04748	0.00187	301	279	299	41	299	12
19A03-27	215	271	0.79	0.11412	0.0016	5.22827	0.08088	0.33231	0.00406	1866	13	1857	13	1850	20
19A03-28	72	110	0.66	0.08571	0.00139	2.76691	0.04829	0.23416	0.00293	1332	16	1347	13	1356	15
19A03-29	53	36	1.46	0.05446	0.00318	0.37889	0.02196	0.05047	0.00081	390	101	326	16	317	5
19A03-30	164	126	1.30	0.05453	0.00675	0.3394	0.04104	0.04515	0.00142	393	214	297	31	285	9
19A03-31	58	98	0.59	0.08661	0.00134	2.7601	0.04555	0.23114	0.00287	1352	15	1345	12	1340	15
19A03-32	76	174	0.43	0.08738	0.00116	2.97204	0.04306	0.2467	0.00299	1369	13	1400	11	1421	15
19A03-33	167	101	1.66	0.05175	0.00748	0.33431	0.04726	0.04685	0.00166	274	253	293	36	295	10
19A03-34	45	99	0.46	0.09611	0.0014	3.6002	0.05637	0.27171	0.00335	1550	14	1550	12	1549	17
19A03-35	102	73	1.39	0.05193	0.00176	0.34867	0.01182	0.0487	0.00066	282	53	304	9	307	4
19A03-36	74	111	0.67	0.08645	0.00125	2.69706	0.04192	0.2263	0.00278	1348	14	1328	12	1315	15
19A03-37	67	98	0.68	0.08668	0.00122	2.85771	0.04355	0.23914	0.00293	1353	13	1371	11	1382	15
19A03-38	194	106	1.83	0.05272	0.00393	0.32299	0.02359	0.04444	0.00092	317	128	284	18	280	6
19A03-39	69	97	0.71	0.086	0.00126	2.71697	0.0427	0.22915	0.00282	1338	14	1333	12	1330	15
19A03-40	87	121	0.72	0.09045	0.00133	3.0671	0.04848	0.24595	0.00304	1435	14	1425	12	1418	16
19A03-41	88	66	1.34	0.05293	0.00356	0.35789	0.02363	0.04904	0.00096	326	115	311	18	309	6
19A03-42	192	110	1.74	0.05298	0.00221	0.36316	0.01502	0.04972	0.00076	328	66	315	11	313	5
19A03-43	65	98	0.67	0.08658	0.00126	2.75042	0.04324	0.23042	0.00284	1351	14	1342	12	1337	15
19A03-44	72	84	0.85	0.09406	0.00609	2.86415	0.17566	0.22086	0.00459	1509	126	1373	46	1286	24
19A03-45	130	146	0.89	0.05171	0.00123	0.29386	0.00709	0.04122	0.00053	273	32	262	6	260	3
19A03-46	84	119	0.70	0.08239	0.00261	2.51799	0.07297	0.22166	0.00283	1255	63	1277	21	1291	15
19A03-47	157	103	1.53	0.05183	0.00366	0.34575	0.024	0.04839	0.00097	278	122	302	18	305	6
19A03-48	304	142	2.13	0.05266	0.00281	0.34956	0.01834	0.04815	0.00082	314	88	304	14	303	5
19A03-49	56	105	0.54	0.08711	0.00131	2.77764	0.04484	0.23129	0.00286	1363	15	1350	12	1341	15
19A03-50	74	109	0.68	0.08723	0.00152	2.78475	0.05107	0.23157	0.00296	1366	17	1351	14	1343	15
19A03-51	79	105	0.75	0.09962	0.00143	3.85902	0.06002	0.281	0.00347	1617	13	1605	13	1596	17
19A03-52	47	83	0.57	0.08781	0.00137	2.79321	0.04666	0.23075	0.00288	1378	15	1354	12	1338	15
19A03-53	125	77	1.62	0.05351	0.00186	0.37619	0.01299	0.05099	0.00073	350	52	324	10	321	4
19A03-54	102	122	0.83	0.05532	0.00187	0.5223	0.01767	0.06849	0.00097	425	50	427	12	427	6
19A03-55	112	155	0.72	0.08613	0.00126	2.71424	0.04298	0.22858	0.00282	1341	14	1332	12	1327	15
19A03-56	346	235	1.47	0.05296	0.00223	0.35274	0.0147	0.04831	0.00074	327	67	307	11	304	5
19A03-57	215	98	2.19	0.05262	0.00478	0.35564	0.03167	0.04902	0.00118	312	158	309	24	309	7
19A03-58	165	93	1.78	0.06686	0.00913	0.41637	0.0563	0.04517	0.00086	833	301	353	40	285	5
19A03-59	85	125	0.68	0.08935	0.00147	2.96868	0.05202	0.24101	0.00305	1412	16	1400	13	1392	16
19A03-60	410	360	1.14	0.05656	0.00239	0.35725	0.01491	0.04582	0.00071	474	65	310	11	289	4
19A03-61	181	123	1.46	0.05578	0.00228	0.35599	0.01442	0.04629	0.00071	444	63	309	11	292	4
19A03-62	134	95	1.41	0.05277	0.00263	0.3499	0.01724	0.0481	0.00077	319	83	305	13	303	5
19A03-63	98	71	1.39	0.07197	0.01052	0.40671	0.05857	0.04098	0.00103	985	317	347	42	259	6
19A03-64	67	146	0.46	0.08769	0.00135	2.97475	0.04938	0.24609	0.00307	1376	15	1401	13	1418	16
19A03-65	96	142	0.68	0.08663	0.00135	2.74997	0.04529	0.23026	0.00285	1352	15	1342	12	1336	15
19A03-66	42	55	0.76	0.08991	0.00193	3.02462	0.06631	0.24402	0.00327	1424	22	1414	17	1408	17
19A03-67	13	408	0.03	0.05569	0.00079	0.60608	0.00927	0.07894	0.00095	440	16	481	6	490	6

19A03-68	97	204	0.48	0.16161	0.0019	10.43583	0.13743	0.46837	0.00561	2473	10	2474	12	2476	25
19A03-69	37	69	0.54	0.09902	0.00867	3.76962	0.32291	0.27614	0.00939	1606	109	1586	69	1572	47
19A03-70	189	89	2.12	0.05952	0.00566	0.38066	0.0357	0.04639	0.00073	586	214	328	26	292	5
19A03-71	66	96	0.68	0.0861	0.00137	2.69818	0.04561	0.2273	0.00284	1340	16	1328	13	1320	15
19A03-72	74	114	0.65	0.08609	0.0013	2.71586	0.04383	0.22883	0.00283	1340	15	1333	12	1328	15
19A03-73	115	73	1.58	0.05245	0.00286	0.34453	0.01876	0.04764	0.00068	305	98	301	14	300	4
19A03-74	203	126	1.61	0.05318	0.00202	0.33308	0.01252	0.04543	0.00067	336	58	292	10	286	4
19A03-75	126	91	1.39	0.05364	0.01069	0.31701	0.06165	0.04287	0.00208	356	327	280	48	271	13
19A03-76	220	305	0.72	0.09881	0.00316	3.47483	0.10121	0.25504	0.00334	1602	61	1522	23	1464	17
19A03-77	267	173	1.55	0.05114	0.00404	0.31956	0.02474	0.04532	0.00098	247	136	282	19	286	6
19A03-78	98	65	1.51	0.05291	0.00454	0.36042	0.03028	0.04941	0.00115	325	149	313	23	311	7
19A03-79	61	335	0.18	0.10704	0.00407	4.60307	0.17381	0.31193	0.00577	1750	42	1750	31	1750	28
19A03-80	71	108	0.66	0.08645	0.00133	2.69204	0.04449	0.22588	0.00283	1348	15	1326	12	1313	15
19A03-81	474	170	2.79	0.05522	0.00149	0.38506	0.01048	0.05058	0.00068	421	37	331	8	318	4
19A03-82	70	106	0.66	0.08803	0.00303	2.77132	0.09501	0.22836	0.00373	1383	41	1348	26	1326	20
19A03-83	274	174	1.57	0.05296	0.00171	0.33537	0.01084	0.04593	0.00064	327	48	294	8	289	4
19A03-84	251	146	1.72	0.05129	0.0079	0.32542	0.049	0.04603	0.00173	254	266	286	38	290	11
19A03-85	183	91	2.02	0.05596	0.00912	0.39212	0.0624	0.05083	0.00209	451	281	336	46	320	13
19A03-86	109	70	1.57	0.05248	0.00596	0.3498	0.03935	0.04834	0.00078	306	260	305	30	304	5
19A03-87	71	94	0.75		0.00249	2.78344	0.07992	0.23112	0.00347	1368	33	1351	21	1340	18
19A03-88	254	147	1.73	0.05223	0.00296	0.33808	0.0189	0.04695	0.00083	295	95	296	14	296	5
19A03-90	37	67	0.54	0.14116	0.00425	8.24192	0.22062	0.42347	0.00582	2241	53	2258	24	2276	26
19A03-91	73	108	0.68	0.0901	0.00136	2.92089	0.04814	0.23516	0.00298	1428	15	1387	12	1361	16
19A03-92	247	240	1.03	0.0553	0.00127	0.37452	0.00884	0.04913	0.00065	424	30	323	7	309	4
19A03-93	234	245	0.95	0.05545	0.0038	0.36775	0.02472	0.04811	0.00098	430	114	318	18	303	6
19A03-94	146	162	0.90	0.12556	0.00194	5.23336	0.08811	0.30237	0.00388	2037	14	1858	14	1703	19
19A03-95	228	145	1.56	0.05722	0.0081	0.36321	0.05026	0.04605	0.00161	500	245	315	37	290	10
19A03-96	75	64	1.16	0.07002	0.00754	0.4979	0.05285	0.05158	0.00094	929	231	410	36	324	6
19A03-97	60	98	0.61	0.0848	0.00139	2.72603	0.04847	0.23321	0.00301	1311	17	1336	13	1351	16
19A03-98	83	139	0.60	0.08893	0.00151	2.95074	0.05396	0.24072	0.00313	1403	17	1395	14	1390	16
19A03-99	68	133	0.51	0.09004	0.00184	3.03501	0.06498	0.24453	0.00332	1426	21	1416	16	1410	17

**19A04 (Sandstone) Lat. N40 57' 46" , Long. E106 43' 54"**

19A04-1	58	41	1.40	0.16911	0.00223	11.39856	0.16416	0.48892	0.00602	2549	11	2556	13	2566	26
19A04-2	12	12	1.07	0.15308	0.00506	9.93314	0.33072	0.47068	0.00872	2381	32	2429	31	2487	38
19A04-3	71	200	0.35	0.1483	0.00184	8.33331	0.11399	0.4076	0.0049	2326	10	2268	12	2204	22
19A04-4	137	120	1.14	0.15441	0.0047	9.42537	0.28805	0.44277	0.00803	2395	28	2380	28	2363	36
19A04-5	31	199	0.15	0.11788	0.00144	5.82576	0.07843	0.35847	0.00426	1924	11	1950	12	1975	20
19A04-6	252	745	0.34	0.05648	0.00076	0.56542	0.00823	0.07261	0.00086	471	15	455	5	452	5
19A04-7	36	113	0.32	0.12844	0.00286	6.55331	0.12039	0.37004	0.00468	2077	40	2053	16	2030	22
19A04-8	42	55	0.75	0.1713	0.00465	10.65214	0.25095	0.45101	0.00607	2570	46	2493	22	2400	27
19A04-9	15	58	0.26	0.12087	0.00169	5.91526	0.08879	0.35498	0.00431	1969	12	1963	13	1958	21
19A04-10	37	73	0.51	0.11626	0.00161	5.5807	0.08316	0.34817	0.00421	1899	12	1913	13	1926	20
19A04-11	53	102	0.52	0.11586	0.0016	5.42538	0.0806	0.33967	0.00409	1893	12	1889	13	1885	20



19A04-12	125	155	0.81	0.11469	0.00155	5.37081	0.07809	0.33968	0.00406	1875	12	1880	12	1885	20
19A04-13	36	53	0.68	0.11703	0.00175	5.65614	0.08964	0.35056	0.00429	1911	13	1925	14	1937	20
19A04-14	38	45	0.83	0.0559	0.00307	0.38838	0.02107	0.0504	0.00083	448	91	333	15	317	5
19A04-15	55	149	0.37	0.1148	0.00163	5.35594	0.08116	0.33842	0.00406	1877	13	1878	13	1879	20
19A04-16	79	200	0.39	0.11863	0.00285	5.52859	0.11169	0.33801	0.00438	1936	44	1905	17	1877	21
19A04-17	119	98	1.21	0.05409	0.00407	0.37294	0.02745	0.05001	0.00106	375	128	322	20	315	7
19A04-18	82	141	0.58	0.11807	0.00253	5.56364	0.09854	0.34177	0.00413	1927	39	1910	15	1895	20
19A04-19	179	103	1.73	0.10849	0.00174	4.54238	0.07656	0.3037	0.00379	1774	15	1739	14	1710	19
19A04-20	68	141	0.48	0.11968	0.00155	5.69734	0.08019	0.34531	0.00412	1951	11	1931	12	1912	20
19A04-22	135	177	0.77	0.11368	0.00174	5.18595	0.08411	0.3309	0.0041	1859	14	1850	14	1843	20
19A04-23	236	198	1.19	0.16587	0.00212	10.90993	0.15254	0.47711	0.0057	2516	11	2515	13	2515	25
19A04-24	89	247	0.36	0.11664	0.00168	5.49316	0.08477	0.34162	0.00417	1905	13	1900	13	1894	20
19A04-25	147	85	1.73	0.09862	0.00146	3.75741	0.05935	0.27636	0.00337	1598	14	1584	13	1573	17
19A04-26	87	102	0.85	0.05551	0.00152	0.50731	0.01391	0.06629	0.00088	433	38	417	9	414	5
19A04-27	86	114	0.76	0.15675	0.00257	9.76616	0.1688	0.45193	0.00581	2421	14	2413	16	2404	26
19A04-28	171	195	0.88	0.12351	0.00191	6.32116	0.10375	0.37124	0.0046	2008	14	2021	14	2035	22
19A04-29	79	83	0.96	0.16728	0.00262	10.94112	0.18216	0.47442	0.00598	2531	13	2518	15	2503	26
19A04-30	45	56	0.80	0.15312	0.00315	9.07943	0.19258	0.43011	0.00603	2381	18	2346	19	2306	27
19A04-31	72	93	0.78	0.11457	0.00158	5.31626	0.07964	0.3366	0.00412	1873	12	1871	13	1870	20
19A04-32	50	128	0.39	0.11951	0.00165	5.78499	0.08679	0.35114	0.00431	1949	12	1944	13	1940	21
19A04-33	16	145	0.11	0.10338	0.00202	4.26806	0.08628	0.29949	0.00387	1686	19	1687	17	1689	19
19A04-34	939	745	1.26	0.05229	0.00087	0.31215	0.00548	0.04331	0.00053	298	20	276	4	273	3
19A04-35	41	158	0.26	0.12168	0.00405	5.86938	0.19476	0.34991	0.00617	1981	35	1957	29	1934	29
19A04-36	148	235	0.63	0.11987	0.00163	5.82175	0.08649	0.35232	0.00432	1954	12	1950	13	1946	21
19A04-37	329	321	1.03	0.05388	0.00113	0.39484	0.0085	0.05316	0.00068	366	26	338	6	334	4
19A04-38	136	109	1.26	0.16399	0.00227	10.7542	0.16308	0.47572	0.0059	2497	12	2502	14	2509	26
19A04-39	258	309	0.83	0.05306	0.0011	0.37155	0.00798	0.0508	0.00065	331	26	321	6	319	4
19A04-40	84	238	0.35	0.16123	0.00529	10.09653	0.33264	0.45426	0.00875	2469	31	2444	30	2414	39
19A04-41	13	49	0.26	-0.02216	0.0033	-0.93029	0.13859	0.30455	0.00412	-248	93	-2704	2019	1714	20
19A04-42	64	120	0.54	0.11882	0.00189	5.72771	0.0979	0.34969	0.00444	1939	15	1936	15	1933	21
19A04-43	243	142	1.71	0.12017	0.00179	5.87602	0.09507	0.3547	0.00443	1959	13	1958	14	1957	21
19A04-44	213	226	0.94	0.053	0.00132	0.37245	0.00947	0.05098	0.00067	329	34	321	7	321	4
19A04-45	214	281	0.76	0.11542	0.00176	5.37505	0.08902	0.3378	0.00423	1886	14	1881	14	1876	20
19A04-46	145	195	0.75	0.14537	0.00182	6.88344	0.09833	0.34346	0.00431	2292	11	2097	13	1903	21
19A04-47	57	84	0.68	0.16046	0.00205	10.25297	0.1485	0.46349	0.00585	2461	11	2458	13	2455	26
19A04-48	86	95	0.91	0.15729	0.00199	9.86643	0.14206	0.45501	0.00573	2427	11	2422	13	2417	25
19A04-49	33	208	0.16	0.11869	0.00147	5.71239	0.08089	0.34911	0.00436	1937	11	1933	12	1930	21
19A04-50	93	58	1.60	0.12216	0.00176	6.19495	0.09874	0.36784	0.00473	1988	13	2004	14	2019	22
19A04-51	562	775	0.72	0.12706	0.00575	0.75543	0.03216	0.04312	0.00066	2058	82	571	19	272	4
19A04-52	465	295	1.58	0.16618	0.00206	10.856	0.15456	0.47386	0.00593	2520	11	2511	13	2500	26
19A04-53	100	153	0.66	0.11806	0.00154	5.61377	0.08289	0.3449	0.00434	1927	12	1918	13	1910	21
19A04-54	72	45	1.61	0.16399	0.00233	10.97591	0.17357	0.48549	0.00629	2497	12	2521	15	2551	27
19A04-55	117	158	0.74	0.13523	0.00178	7.32857	0.10929	0.3931	0.00496	2167	12	2152	13	2137	23
19A04-56	479	455	1.05	0.05437	0.00086	0.37836	0.00651	0.05048	0.00064	386	18	326	5	317	4

19A04-57	148	132	1.13	0.12673	0.00189	6.32058	0.104	0.36176	0.00468	2053	13	2021	14	1991	22
19A04-58	4	93	0.04	0.15365	0.00239	10.01641	0.17054	0.47287	0.00619	2387	14	2436	16	2496	27
19A04-59	58	64	0.91	0.05663	0.00405	0.42146	0.02954	0.05398	0.00114	477	118	357	21	339	7
19A04-60	2	52	0.04	0.1187	0.0021	5.63597	0.10664	0.3444	0.00463	1937	16	1922	16	1908	22
19A04-61	16	370	0.04	0.29834	0.00355	28.88954	0.40017	0.70236	0.00884	3462	10	3450	14	3430	33
19A04-62	173	154	1.12	0.0541	0.00179	0.41222	0.01371	0.05527	0.0008	375	49	350	10	347	5
19A04-63	112	146	0.76	0.12378	0.00156	6.29961	0.091	0.36913	0.00466	2011	11	2018	13	2025	22
19A04-64	118	61	1.94	0.16397	0.00219	10.60456	0.16025	0.46908	0.00605	2497	11	2489	14	2480	27
19A04-65	137	220	0.62	0.05616	0.00181	0.33932	0.01095	0.04382	0.00063	459	46	297	8	276	4
19A04-66	120	118	1.02	0.16009	0.00202	10.30114	0.14958	0.46669	0.00593	2457	11	2462	13	2469	26
19A04-67	21	24	0.85	0.12536	0.00231	6.46674	0.12662	0.37414	0.0052	2034	17	2041	17	2049	24
19A04-68	35	41	0.84	0.11884	0.00193	5.75902	0.10153	0.35148	0.00469	1939	15	1940	15	1942	22
19A04-69	37	47	0.79	0.05477	0.00207	0.38877	0.01462	0.05148	0.0008	403	56	333	11	324	5
19A04-70	59	30	2.00	0.15374	0.00268	9.38833	0.17592	0.44289	0.00617	2388	15	2377	17	2364	28
19A04-71	7	11	0.69	0.1705	0.00331	11.47115	0.23621	0.48796	0.00716	2563	17	2562	19	2562	31
19A04-72	78	72	1.09	0.0543	0.00296	0.40845	0.02194	0.05455	0.00098	384	88	348	16	342	6
19A04-73	240	342	0.70	0.15176	0.00211	7.67566	0.12042	0.36681	0.00474	2366	12	2194	14	2014	22
19A04-74	22	20	1.09	0.12751	0.00232	6.67742	0.13004	0.37981	0.00526	2064	17	2070	17	2075	25
19A04-75	108	105	1.02	0.1278	0.00187	6.51034	0.1066	0.36947	0.00481	2068	13	2047	14	2027	23
19A04-76	70	68	1.02	0.05483	0.00181	0.38535	0.01281	0.05097	0.00075	405	48	331	9	320	5

\*The data marked in red is discordant.

**Table S2: whole-rock major and trace element compositions of volcanic rocks**

Sample	19A01-1	19A01-2	19A01-3	19A12-1	19A12-2	TLS18-22-1	TLS18-22-2	TLS18-22-3	TLS18-22-4	TLS18-22-5	TLS18-22-6	TLS18-22-7
Rock type	Dacite		Andesite	Rhyolite		Dacite				Andesite		
SiO <sub>2</sub>	59.79	63.91	63.80	75.91	73.35	66.42	66.87	65.79	68.37	56.65	56.93	56.78
TiO <sub>2</sub>	0.83	0.48	0.65	0.08	0.17	0.36	0.38	0.44	0.35	0.81	0.81	0.83
Al <sub>2</sub> O <sub>3</sub>	15.54	14.97	15.20	13.02	13.81	15.58	15.33	15.95	15.40	16.48	16.36	16.82
Fe <sub>2</sub> O <sub>3</sub> <sup>T</sup>	4.99	3.57	4.30	1.55	2.48	3.87	4.14	4.46	3.70	8.35	7.95	6.11
MnO	0.08	0.07	0.08	0.04	0.06	0.05	0.06	0.06	0.05	0.09	0.09	0.07
MgO	2.05	1.67	2.10	0.03	0.14	1.55	1.60	1.76	1.48	2.80	2.66	2.93
CaO	4.36	2.87	2.09	0.40	0.47	2.69	2.63	2.72	2.25	5.16	5.07	6.08
Na <sub>2</sub> O	4.21	5.31	5.12	5.28	4.87	2.22	2.10	2.18	1.96	3.62	3.56	3.46
K <sub>2</sub> O	2.70	3.53	3.25	3.18	4.25	3.39	3.15	3.15	3.30	1.12	1.21	2.08
P <sub>2</sub> O <sub>5</sub>	0.29	0.15	0.22	0.01	0.03	0.12	0.11	0.13	0.11	0.23	0.24	0.24
Total	94.84	96.53	96.81	99.50	99.63	96.25	96.37	96.64	96.97	95.31	94.88	95.40
L.O.I.	4.96	3.16	2.23	0.53	0.54	3.51	3.45	3.51	3.29	4.81	5.03	4.59
σ	2.84	3.74	3.37	2.17	2.74	1.34	1.15	1.25	1.09	1.65	1.63	2.23
A/CNK	0.87	0.84	0.96	1.01	1.02	1.27	1.31	1.33	1.41	0.99	1.00	0.88
A/NK	1.58	1.19	1.27	1.07	1.09	2.13	2.23	2.28	2.26	2.30	2.28	2.12
Trace element (ppm)												
Ba	624	1240	983	229	1370	1200.0	1100.0	1080.0	1090.0	703.0	772.0	881.0
Rb	102.0	102.0	92.7	85.1	114.5	102.00	99.20	98.50	108.5	27.7	28.40	42.40
Sr	427	309	380	30.4	58.9	479.0	432.0	447.0	404.00	669.00	665.0	820.0
Ta	0.6	0.8	0.7	0.9	0.8	0.6	0.6	0.5	0.60	0.50	0.5	0.5
Nb	11.2	11.7	11.5	16.3	15.3	6.80	7.10	7.00	6.80	7.30	7.20	7.60
Hf	6.1	5.9	5.9	6.9	7.5	5.20	5.20	4.90	5.00	4.00	3.90	4.00
Zr	269	253	256	280	337	194.00	197.00	194.00	184.00	151.00	150.00	156.00
Y	26.1	24.7	25.6	36.4	33.1	14.80	14.90	15.1	14.3	19.4	19.0	17.5
Th	11.50	13.15	13.05	16.90	14.35	7.50	7.65	7.25	7.76	4.53	4.46	4.61
U	2.87	3.23	3.16	3.54	3.16	2.4	2.4	2.3	2.3	1.5	1.4	1.5

Cr	20	20	20	<10	<10	90	100	90	90	90	90	130
V	65	55	56	<5	<5	50	69	72	64	163	162	155
Ga	19.9	17.3	19.0	17.7	17.3	18.7	19.3	19.7	19.4	19.7	19.7	20.4
Sr/Y	16.4	12.5	14.8	0.8	1.8	32.4	29.0	29.6	28.3	34.5	35.0	46.9

REE(ppm)

La	38.1	40.2	41.7	52.9	49.5	30.70	31.30	31.00	30.80	27.70	27.30	27.90
Ce	78.5	82.1	83.2	110.5	102.5	58.5	58.7	59.8	58.00	55.20	54.6	56.6
Pr	8.75	8.85	8.96	12.35	11.25	6.5	6.7	6.7	6.40	6.61	6.6	6.7
Nd	33.4	32.3	33.2	44.3	40.8	22.50	24.00	23.10	22.60	25.70	25.50	25.80
Sm	6.89	6.10	6.82	8.63	8.01	3.73	3.89	3.91	3.75	4.88	4.79	4.65
Eu	1.77	1.54	1.49	0.25	0.92	0.96	1.03	0.97	0.98	1.22	1.28	1.32
Gd	5.60	5.12	5.46	6.59	5.67	3.0	3.1	3.2	3.0	4.4	4.0	4.2
Tb	0.83	0.75	0.83	1.05	0.96	0.44	0.46	0.45	0.44	0.60	0.59	0.62
Dy	4.65	4.25	4.73	6.32	5.64	2.64	2.86	2.69	2.54	3.52	3.55	3.39
Ho	0.94	0.86	0.91	1.35	1.18	0.5	0.6	0.6	0.5	0.7	0.7	0.7
Er	2.65	2.47	2.65	3.89	3.47	1.6	1.6	1.7	1.5	2.0	2.1	1.8
Tm	0.39	0.39	0.41	0.62	0.53	0.24	0.24	0.25	0.24	0.29	0.31	0.27
Yb	2.50	2.50	2.61	3.88	3.29	1.60	1.59	1.65	1.58	1.80	1.88	1.72
Lu	0.39	0.38	0.40	0.64	0.56	0.26	0.25	0.25	0.24	0.27	0.28	0.26
LREE	167.41	171.09	175.3	228.93	212.98	122.89	125.61	125.44	122.53	121.31	120.04	122.94
HREE	17.95	16.72	18	24.34	21.3	10.31	10.67	10.73	10.04	13.57	13.45	12.98
ΣREE	185.36	187.81	193.3	253.27	234.28	133.2	136.28	136.17	132.57	134.88	133.49	135.92
LREE/HRE	9.3	10.2	9.7	9.4	10.0	11.9	11.8	11.7	12.2	8.9	8.9	9.5
(La/Yb)N	10.93	11.53	11.46	9.78	10.79	13.76	14.12	13.48	13.98	11.04	10.42	11.64
δEu	0.84	0.82	0.72	0.10	0.40	0.85	0.88	0.81	0.87	0.79	0.87	0.89

**Table S2: whole-rock Sr-Nd isotopic compositions of volcanic rocks**

Sample	t/Ma	<sup>87</sup> Rb/ <sup>86</sup> Sr	<sup>87</sup> Sr/ <sup>86</sup> Sr	±2σ	( <sup>87</sup> Sr/ <sup>86</sup> Sr) <sub>i</sub>	<sup>147</sup> Sm/ <sup>144</sup> Nd	<sup>143</sup> Nd/ <sup>144</sup> Nd	±2σ	ε <sub>Nd</sub> (t)
Aguimiao andesite									
TLS18-22-5	270	0.119809	0.708933	0.000010	0.708473	0.008152	0.511869	0.000008	-8.51
TLS18-22-6	270	0.123576	0.708971	0.000010	0.708497	0.006994	0.511853	0.000006	-8.78
TLS18-22-7	270	0.149620	0.709062	0.000012	0.708487	0.001595	0.511817	0.000008	-9.30
Aguimiao dacite									
TLS18-22-2	270	0.664454	0.710590	0.000014	0.708038	0.004476	0.511847	0.000016	-8.81
TLS18-22-3	270	0.637626	0.710427	0.000012	0.707978	0.002602	0.511897	0.000014	-7.76
TLS18-22-4	270	0.777115	0.710857	0.000010	0.707872	0.001964	0.511852	0.000010	-8.62

$$(^{87}\text{Sr}/^{86}\text{Sr})_i = (^{87}\text{Sr}/^{86}\text{Sr}) - (^{87}\text{Rb}/^{86}\text{Sr}) \times (e^{\lambda t} - 1); \lambda_{\text{Rb-Sr}} = 0.0142 \text{ Ga}^{-1};$$

$$\epsilon_{\text{Nd}}(t) = 10000 \times \left\{ \left[ \frac{(^{143}\text{Nd}/^{144}\text{Nd})_s - (^{147}\text{Sm}/^{144}\text{Nd})_s \times (e^{\lambda t} - 1)}{(^{143}\text{Nd}/^{144}\text{Nd})_{\text{CHUR},0} - (^{147}\text{Sm}/^{144}\text{Nd})_{\text{CHUR}} \times (e^{\lambda t} - 1)} \right] - 1 \right\};$$

$$(^{147}\text{Sm}/^{144}\text{Nd})_s \text{ and } (^{143}\text{Nd}/^{144}\text{Nd})_s \text{ are values of analysed sample; } (^{147}\text{Sm}/^{144}\text{Nd})_{\text{CHUR}} = 0.1967 \text{ and } (^{143}\text{Nd}/^{144}\text{Nd})_{\text{CHUR},0} = 0.512638;$$

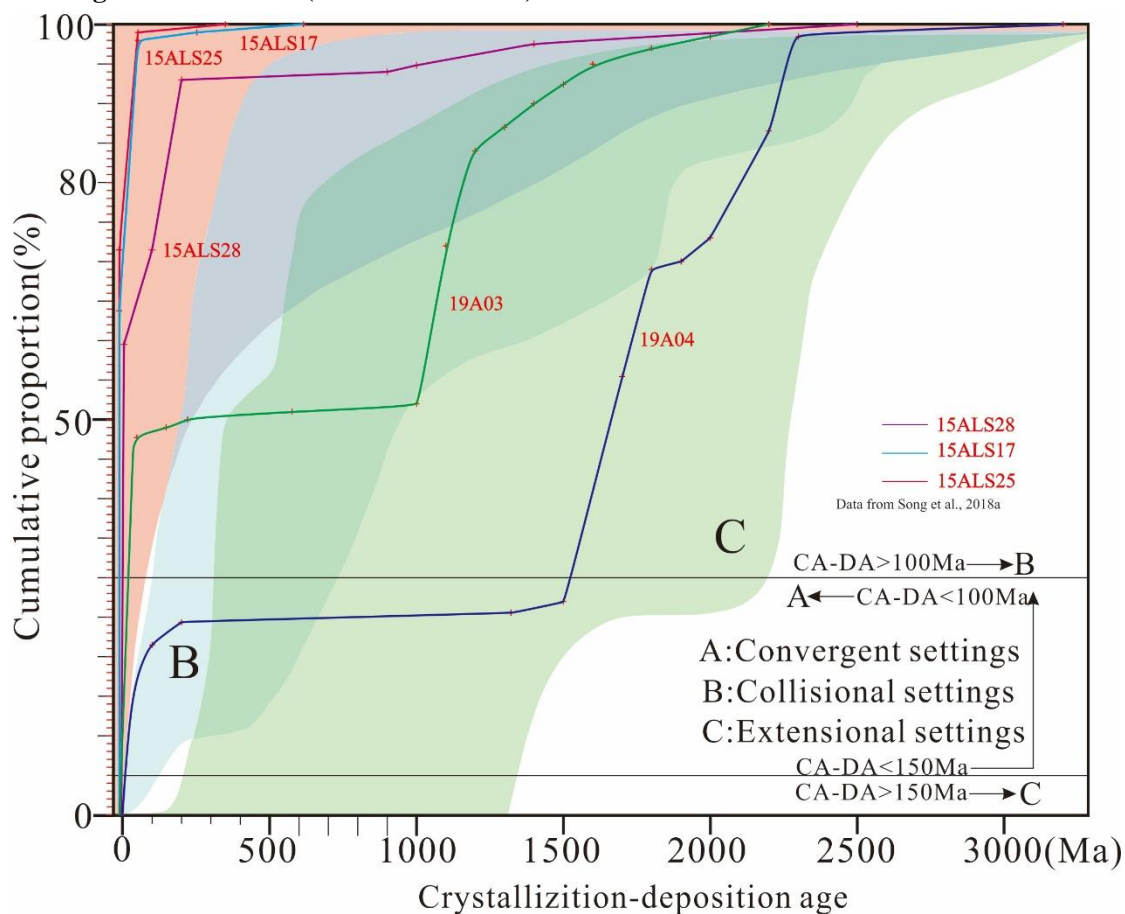
$$(^{147}\text{Sm}/^{144}\text{Nd})_{\text{DM}} = 0.2135 \text{ and } (^{143}\text{Nd}/^{144}\text{Nd})_{\text{DM}} = 0.51315; (^{147}\text{Sm}/^{144}\text{Nd})_c = 0.118; \lambda_{\text{Sm-Nd}} = 0.00654 \text{ Ga}^{-1}.$$

**Table S3: References of geochronological data in Langshan zone**

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**Supplementary figure: Cumulative probability curves of measured crystallization ages for**

**detrital zircons grains relative to the depositional age of samples from the Permian Dahongshan Formation (19A03 and 19A04).**



We use 265 Ma as the depositional age of the Permian strata in Langshan (adjacent to our study region) based on the zircon U - Pb ages of the interlayer volcanic rocks (Guo et al., 2017). Two samples from the Dahongshan Formation plot into the convergent setting (19A03) and collisional setting (19A04). Associating with the detrital zircon age spectrum, lithology, and terrestrial plant fossils in this Formation, we argue that the Dahongshan Formation was most likely deposited in a retroarc foreland basin. The Permian samples from the western Alxa Block (Song et al., 2018a) plot into the convergent setting, probably in a forearc basin.

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