

Yixiong Wen, Laiming Zhang, Yalin Li, Katharine W. Huntington, Tianjie Jin, Andrew J. Schauer, and Chengshan Wang, 2022, Late Mesozoic elevation history of the north Taihang Mountains, China: Constraints from clumped isotope geochemistry: GSA Bulletin, <https://doi.org/10.1130/B36364.1>.

Supplemental Material

Figure S1. The near-modern stage I-II soil carbonates (see table 1 in Gile et al., 1966) as pedogenic carbonates formed on the non-gravelly soils (Zamanian et al., 2016) were collected from outcrop and > 40–50 cm below the erosion surface by using tweezers.

Figure S2. Paired plane light (left) and CL images (right) of the Upper Jurassic Tianchihe Formation sample (A/B, ID: 18J3t-4), Lower Cretaceous Wangjiagou Formation sample (C/D, ID: HY-K1-1), and Zuoyun Formation sample (E/F, ID: DT-K1z-7).

Figure S3. (A) Plot of the Age (Ma) versus the $T(\Delta 47)$. (B) $T(\Delta 47)$ versus estimated water $\delta 18O$ for paleosol carbonate nodule in the YH Basin (circle) and marls/ carbonate nodule in the Ordos Basin (square).

Figure S4. The YH basin and low elevation sites for paleoelevation calculation.

Figure S5. The compiled tectonic evolution in the north THM versus estimated paleoelevation (dark rectangle) of the YH Basin (see discussion in main text for detail).

Table S1-1. Clumped isotope raw data.

Table S1-2. Results of clumped isotope analyses.

Table S2. Major and trace element composition of an identified paleosol sediments and mean annual temperature derived from Salinity and TNa

Table S3. Intermediate igneous whole-rock La/Yb from early Cretaceous Taihang mountain range.

Table S4. Intermediate igneous zircons grain Eu* anomaly.

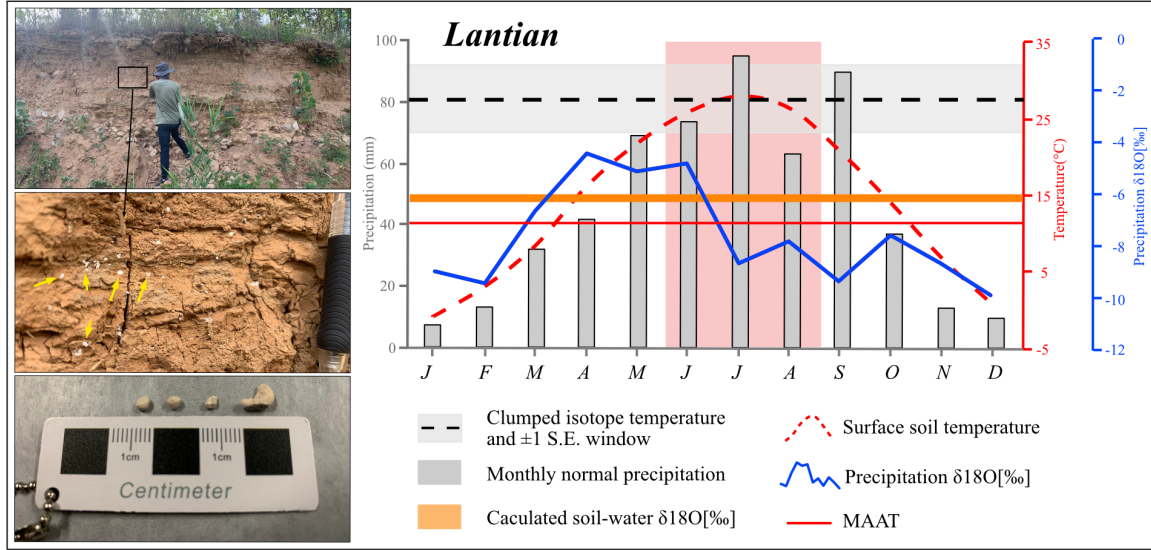


Figure S1. The near-modern stage I-II soil carbonates (see table 1 in Gile et al., 1966) as pedogenic carbonates formed on the non-gravelly soils (Zamanian et al., 2016) were collected from outcrop and > 40-50 cm below the erosion surface by using tweezers. The pedogenic carbonates were collected from Holocene Bahe River T₁ terrace near Lantian County (34°11.9' N; 109°13.8' E) (Fig. 1 in main text), and most likely record an integrated climate signal over several millennia timescale (Lei et al., 1992). To minimal the age uncertain, only the pedogenic carbonates with 1-2 mm in diameter were analyzed. Climate data between 1951 and 2001 from nearby meteorological station of Lantian of south CLP, showing monthly precipitation, soil temperature at 40 cm depth; data source: China Meteorological Data Service Centre (<http://data.cma.cn>). The modern rainfall $\delta^{18}O_p$ at Xian come from Global Network of Isotopes in Precipitation (GNIP; IAEA/WMO, 2006). Reconstructed temperature and soil water $\delta^{18}O_{sw}$ of near-modern pedogenic carbonates show in black dashed line and orange shade, respectively.

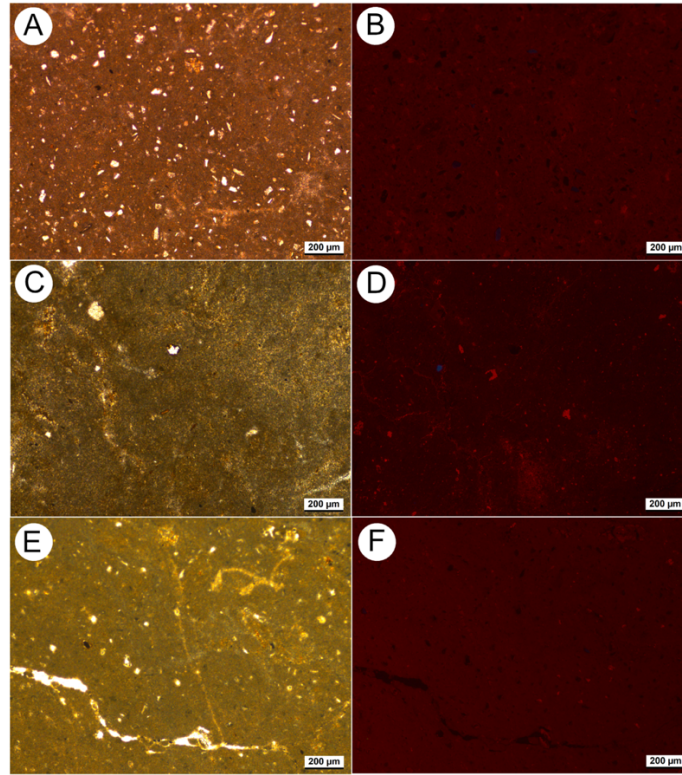


Figure S2. Paired plane light (left) and CL images (right) of the Upper Jurassic Tianchihe Formation sample (A/B, ID: 18J_{3t}-4), Lower Cretaceous Wangjiagou Formation sample (C/D, ID: HY-K₁-1), and Zuoyun Formation sample (E/F, ID: DT-K_{1z}-7). Note dense, homogeneous micrite with detrital grains, homogeneous and dull luminescence of CL.

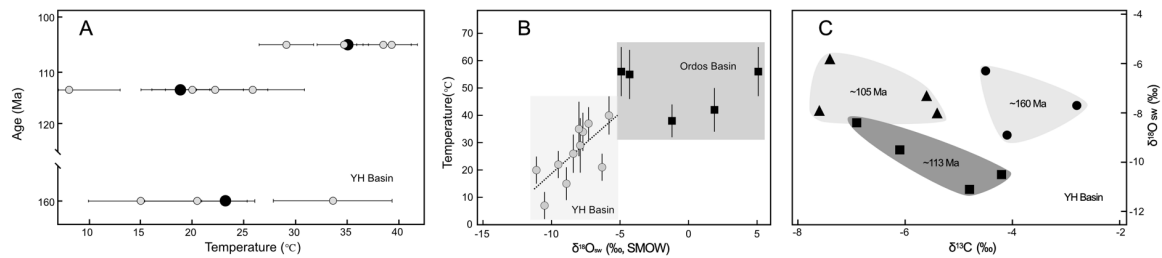


Fig S3 (A) Plot of the Age (Ma) versus the $T(\Delta_{47})$. (B) $T(\Delta_{47})$ versus estimated water $\delta^{18}O$ for paleosol carbonate nodule in the YH Basin (circle) and marls/ carbonate nodule in the Ordos Basin (square). (C) Plot of $\delta^{18}O$ - $\delta^{13}C$ result for paleosol carbonate nodule in each Formation of the YH Basin.

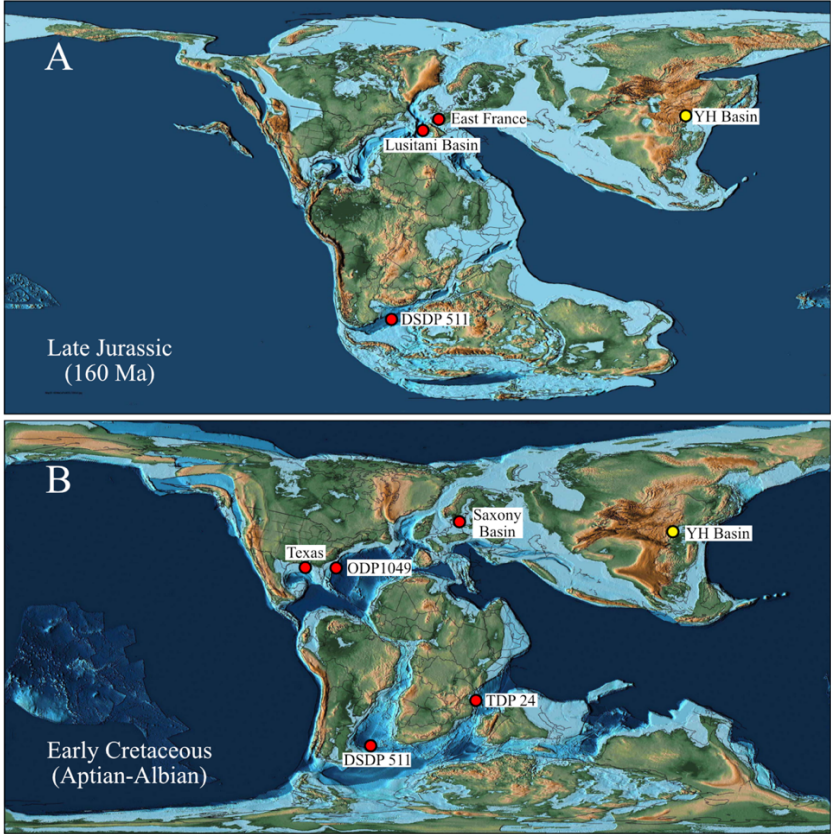


Figure S4. The YH basin and low elevation sites for paleoelevation calculation. The paleogeographic reconstruction is after Scotese (2014a, b). DSDP 511: Vicker et al., 2019; Jenkyns et al., 2012; ODP 1049: Wagner et al., 2008; Saxony: Erbacher et al., 2011; TDP 24: Ando et al., 2015; Texas: Andrzejewski and Tabor, 2020; East France: Dromart et al., 2013; Lusitanian Basin: Myers et al., 2012;

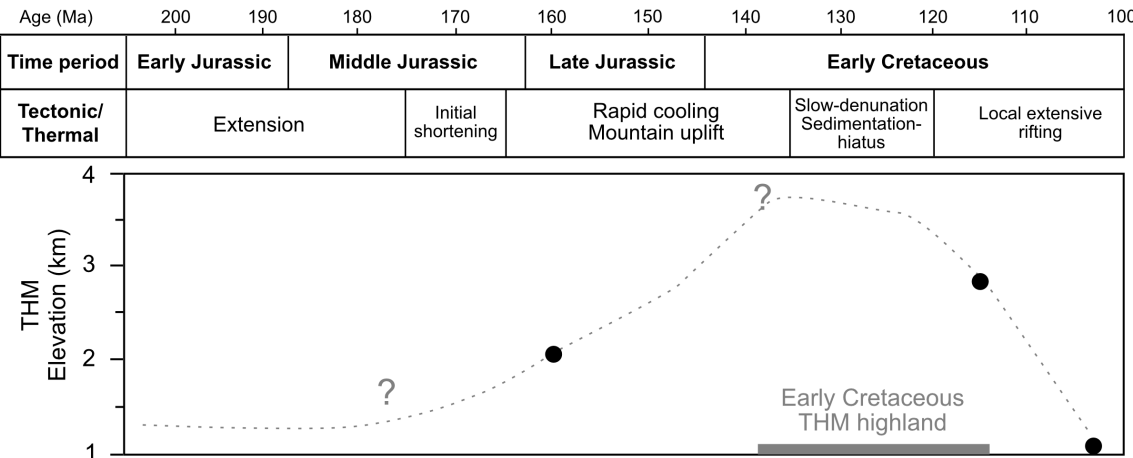


Fig S5 The compiled tectonic evolution in the north THM versus estimated paleoelevation (dark rectangle) of the YH Basin (see discussion in main text for detail).

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Table S1-1 clumped isotope raw data

Date	Sample ID	Mass (mg)	Acid temperature (°C)	d13C vs VPDB (via WG) (permil)	d13C vs VPDB (formal) (permil)	d13C stdev	d18O vs (via WG) (permil)	d18O vs VPDB (formal) (permil)	d18O stdev	d47 vs VPDB (via WG) (permil)	d47 stdev	D47 CDES acid RF2 (permil)	D47 stderr	d48 vs VPDB (via WG) (permil)	d48 stdev	D48 (permil)	D48 stderr	d49 vs VPDB (via WG) (permil)	d49 stdev	D49 (permil)	D49 stderr
2019/3/29	C64	10.127	89.3639	-1.9625	-2.0296	0.00456	-16.448	-15.598	0.00654	-2.5623	0.06356	0.59876	0.00666	-19.916	0.25903	0.08331	0.02783	39.4999	15.2236	51.906	1.6331
2019/3/29	C2	10.46	89.1367	-48.622	-48.913	0.00434	-17.344	-16.49	0.00676	-48.428	0.07202	0.59453	0.00798	-21.765	0.27232	0.20276	0.02894	-1.3428	21.8358	62.0004	2.4481
2019/3/29	ETH3	10.038	90.3348	1.7963	1.7473	0.00388	-2.6952	-1.9123	0.00643	15.413	0.06428	0.72112	0.00661	7.6516	0.2293	0.055	0.02382	75.8354	20.5418	54.8791	2.1234
2019/5/3	coral	6.917	90.8821	-2.128	-2.1959	0.00368	-5.2956	-4.5	0.00749	8.8978	0.05788	0.72724	0.00613	2.3981	0.2883	0.06264	0.03037	104.876	13.8252	93.3043	1.4422
2019/5/20	C64	8.559	90.7861	-1.9655	-2.0326	0.00403	-16.409	-15.646	0.00667	-2.5299	0.06769	0.59354	0.00719	-19.788	0.27052	0.13069	0.02951	42.2672	15.3004	54.6262	1.6319
2019/5/20	coral	7.494	90.9801	-2.008	-2.0753	0.00421	-5.3012	-4.5063	0.00658	8.9859	0.05751	0.70059	0.00589	2.1686	0.25194	-0.1569	0.02681	30.618	14.5566	19.7129	1.5186
2019/5/20	C2	9.785	88.8095	-48.604	-48.895	0.00412	-17.228	-16.468	0.00708	-48.285	0.06092	0.60832	0.00687	-21.639	0.26348	0.09607	0.02877	-27.884	15.7335	33.5081	1.783
2019/5/20	ETH2	9.237	89.4198	-10.035	-10.141	0.00359	-19.176	-18.417	0.00617	-13.38	0.06522	0.2891	0.00696	-25.371	0.25824	0.08244	0.02776	11.0192	13.8745	37.164	1.5004
2019/5/21	coral	7.967	89.4184	-2.0394	-2.1068	0.00412	-5.2879	-4.6058	0.00718	8.9709	0.06325	0.70433	0.00674	2.3068	0.28075	-0.0463	0.02949	20.2898	15.8146	9.4987	1.6495
2019/5/23	ETH3	6.222	89.52	1.7887	1.7397	0.00439	-2.465	-1.8019	0.00759	15.6448	0.05547	0.71828	0.00829	8.0697	0.22117	0.00805	0.03231	67.4694	19.7543	46.2008	2.8865
2019/5/28	C64	6.995	89.4458	-1.9387	-2.0056	0.00446	-16.362	-15.685	0.0073	-2.4481	0.05721	0.60304	0.00593	-19.794	0.24962	0.02997	0.02667	13.3822	17.5468	25.2734	1.8716
2019/5/29	ETH1	7.357	89.5118	2.1456	2.0983	0.00541	-2.9246	-2.2664	0.00676	15.1347	0.05675	0.24105	0.00579	7.0784	0.2675	-0.0556	0.02802	32.567	15.5594	12.5671	1.6084
2019/5/30	C2	7.269	89.7164	-48.609	-48.9	0.0052	-17.175	-16.513	0.00626	-48.255	0.05483	0.58662	0.00614	-21.476	0.21355	0.16182	0.02324	-9.5817	17.701	52.862	1.9947
2019/6/1	ETH4	5.951	89.7938	-10.057	-10.163	0.00389	-19.356	-18.712	0.00679	-13.361	0.05576	0.57783	0.00613	-25.622	0.21111	0.19883	0.02299	27.3834	18.4054	54.362	1.9911
2019/6/4	ETH4	6.164	89.4025	-10.154	-10.261	0.00417	-19.296	-18.678	0.00685	-13.455	0.06134	0.49853	0.00649	-25.545	0.2327	0.15968	0.02495	29.969	19.7924	56.9906	2.1411
2019/6/10	ETH1	9.729	90.3947	2.1109	2.0634	0.00423	-2.8224	-2.1803	0.00763	15.1949	0.06374	0.22599	0.00666	7.2509	0.28316	-0.0891	0.02953	38.3405	10.703	18.0551	1.106
2019/6/12	c2	9.89	89.2246	-48.661	-48.953	0.00536	-16.999	-16.42	0.00705	-48.111	0.0553	0.61407	0.00607	-21.146	0.27434	0.13492	0.02947	-21.929	13.1478	39.4187	1.4725
2019/6/14	eth2	9.397	90.3931	-10.106	-10.212	0.0043	-19.182	-18.623	0.00701	-13.497	0.06124	0.23269	0.00668	-25.318	0.27032	0.14862	0.02892	3.0141	18.3741	29.037	1.9875
2019/6/15	c64	8.431	90.6233	-2.0004	-2.0676	0.00502	-16.186	-15.628	0.00595	-2.3139	0.06971	0.61893	0.00739	-19.302	0.26037	0.17539	0.028	16.6833	13.052	28.3096	1.3916
2019/6/17	eth3	10.002	89.1637	1.768	1.7189	0.00413	-2.3866	-1.7558	0.0071	15.6619	0.06425	0.68552	0.00681	8.2811	0.24413	0.06117	0.02558	42.7728	14.1373	21.8566	1.4601
2019/6/19	coral	9.347	89.9912	-2.0063	-2.0736	0.00466	-5.0744	-4.4634	0.00735	9.2178	0.06402	0.69641	0.00658	2.7457	0.25786	-0.037	0.02695	45.6549	12.6782	34.1174	1.3219
2019/6/20	eth4	8.781	90.2769	-10.06	-10.166	0.00422	-19.47	-18.953	0.00723	-13.523	0.06721	0.52446	0.00737	-25.865	0.23302	0.17438	0.02534	7.2128	17.5665	33.9053	1.9222
2019/6/21	eth1	9.971	90.0413	2.1749	2.1277	0.00415	-2.9589	-2.3381	0.00641	15.0999	0.06968	0.20653	0.00727	6.9681	0.25817	-0.0964	0.02713	48.659	13.1554	28.3881	1.3597
2019/6/24	c2	9.89	88.8382	-48.597	-48.888	0.00403	-17.013	-16.498	0.00719	-48.121	0.06105	0.53582	0.00688	-20.968	0.2733	0.35175	0.03001	2.3978	14.6604	65.2318	1.6607
2019/7/2	ETH1	8.1	89.7594	2.1138	2.0663	0.00422	-2.815	-2.2082	0.0064	15.1779	0.06095	0.18642	0.00654	7.1554	0.2509	-0.1991	0.02635	54.59	19.8	33.9689	2.0581
2019/7/16	ETH1	8.17	89.3734	2.0891	2.0415	0.00351	-2.6387	-2.0473	0.00617	15.35	0.06331	0.20717	0.00664	7.7043	0.25606	-0.0072	0.02677	85.9122	13.3726	64.3282	1.3818
2019/7/17	ETH3	8.093	88.9893	1.7465	1.6973	0.00431	-2.1846	-1.5894	0.00632	15.8704	0.06628	0.69105	0.00688	8.7883	0.21435	0.15947	0.02237	103.18	12.5093	80.6374	1.2918
2019/7/17	ETH4	8.22	88.9607	-10.148	-10.255	0.00442	-19.166	-18.722	0.0061	-13.301	0.06104	0.51888	0.0065	-25.316	0.21196	0.12064	0.02293	6.903	16.9074	33.0388	1.8281
2019/7/23	C2A	7.286	89.6183	-48.717	-49.009	0.00491	-16.928	-16.467	0.00757	-48.076	0.06131	0.64015	0.00676	-20.905	0.23509	0.24434	0.0256	1.6295	18.9575	64.3659	2.1235
2019/7/24	C64	6.226	89.9138	-2.0667	-2.1343	0.00409	-16.111	-15.631	0.00654	-2.3137	0.06464	0.59877	0.00685	-19.062	0.25985	0.27436	0.02826	78.9561	17.6332	91.1982	1.88
2019/7/24	C64	NaN	89.6102	-2.0806	-2.1482	0.00439	-16.095	-15.587	0.00775	-2.3264	0.06719	0.57803	0.00711	-19.142	0.26579	0.16316	0.02895	46.9812	27.2916	58.841	2.9258
2019/7/24	CORAL	6.954	89.7196	-2.1221	-2.1899	0.00411	-4.9483	-4.3803	0.00656	9.2588	0.06388	0.72389	0.00664	3.0625	0.25548	0.02698	0.02693	64.4842	19.1632	52.5938	2.0088
2019/7/24	CORAL	6.15	89.3661	-2.0991	-2.1668	0.00423	-4.9422	-4.3969	0.00653	9.2742	0.0659	0.70599	0.00696	3.1088	0.27567	0.0613	0.02916	59.1519	18.8304	47.2843	1.9626
2019/7/24	C2A	6.077	89.4405	-48.736	-49.028	0.00511	-16.91	-16.412	0.00637	-48.115	0.05279	0.58775	0.00597	-20.693	0.30159	0.42642	0.03277	13.3452	20.6405	76.7974	2.3122
2019/7/24	C2A	7.19	89.1988	-48.739	-49.031	0.00455	-16.905	-16.388	0.00586	-48.136	0.0628	0.55708	0.00702	-20.745	0.24994	0.36057	0.02689	10.7505	23.1365	74.0333	2.5915
2019/7/25	ETH1	6.682	90.852	2.0192	1.9713	0.00436	-2.6785	-2.1251	0.00808	15.2002	0.06223	0.15491	0.00652	8.0626	0.24511	0.42804	0.0261	112.802	21.6442	90.8465	2.237
2019/7/25	C64	7.735	90.5223	-2.0107	-2.078	0.00428	-15.92	-15.398	0.00721	-2.028	0.06862	0.64311	0.00747	-18.53	0.21943	0.43108	0.02374	77.0686	19.8312	88.8066	2.1253
2019/7/29	Coral	6.534	90.3536	-2.0541	-2.1216	0.00471	-5.0831	-4.5141	0.00724	9.1945	0.06822	0.7304	0.00718	3.6188	0.24012	0.8544	0.02499	164.317	19.4319	151.546	2.0265
2019/8/13	c64	7.991	88.8938	-2.0299	-2.0973	0.00462	-16.287	-15.75	0.00691	-2.4395	0.06257	0.62724	0.00663	-19.474	0.26746	0.20408	0.0289	50.2852	21.4469	62.544	2.2875
2019/8/14	c64	7.973	89.5832	-1.8953	-1.962	0.00633	-16.291	-15.753	0.00784	-2.2916	0.05726	0.65524	0.00637	-19.364	0.26956	0.32475	0.02986	66.2156	12.8523	78.5233	1.4019
2019/8/15	C64	7.75	88.9389	-1.9006	-1.9674	0.00393	-16.257	-15.717	0.00753	-2.2962	0.06799	0.61148	0.00711	-19.457	0.23838	0.16355	0.02568	26.0268	18.2688	37.8059	1.9479
2019/8/20	ETH3	8.419	90.2533	1.8418	1.793	0.00408	-2.3091	-1.6894	0.00641	15.7992	0.06801	0.64777	0.007	10.8352	0.6443	2.4388	0.06731	39.164	15.2586	18.087	1.5761
2019/8/22	C64	7.039	90.2635	-1.8757	-1.9423	0.00425	-16.31	-15.765	0.00656	-2.2845	0.05442	0.66587	0.00575	-18.952	0.4602	0.78305	0.04939	57.5859	10.3359	69.8147	1.1021
2019/8/22	C2A	7.061	89.6193	-48.579	-48.87	0.00478	-17.18	-16.64	0.00635	-48.247	0.06344	0.56499	0.00712	-19.457	0.7226	2.233	0.07802	12.2564	12.4761	76.0554	1.3978
2019/8/26	ETH4	7.157	89.6978	-10.092	-10.198	0.00441	-19.382	-18.794	0.00673	-13.453	0.05105	0.5376	0.00551	-25.497	0.2193	0.37382	0.02386	54.2717	11.4819	82.0513	1.2419

Date	Sample ID	Mass (mg)	Acid temperature (°C)	d13C vs VPDB (via WG) (permil)	d13C vs VPDB (formal) (permil)	d13C stdev	d18O vs (via WG) (permil)	d18O vs VPDB (formal) (permil)	d18O stdev	d47 vs VPDB (via WG) (permil)	d47 stdev	D47 CDES acid RF2 (permil)	D47 stderr	d48 vs VPDB (via WG) (permil)	d48 stdev	D48 (permil)	D48 stderr	d49 vs VPDB (via WG) (permil)	d49 stdev	D49 (permil)	D49 stderr
2019/8/27	coral	7.81	90.265	-2.0141	-2.0814	0.00523	-5.1768	-4.5513	0.00581	9.1322	0.05452	0.73043	0.00572	4.1669	0.53146	1.5868	0.05569	44.5352	16.7661	33.2308	1.7483
2019/8/28	C2A	7.479	89.8346	-48.627	-48.918	0.00554	-17.113	-16.502	0.0068	-48.249	0.06134	0.53558	0.00669	-21.166	0.25531	0.35145	0.02776	-8.8252	15.2131	53.5524	1.7044
2019/8/29	ETH2	7.38	90.0452	-10.052	-10.158	0.00329	-19.362	-18.755	0.00704	-13.662	0.057	0.19192	0.00612	-25.406	0.27935	0.43099	0.03055	23.6878	16.4709	50.5782	1.8019
2019/8/30	C64	7.57	90.2774	-1.9308	-1.9977	0.00419	-16.28	-15.662	0.00712	-2.3488	0.05846	0.6112	0.00629	-18.797	0.35424	0.88391	0.03779	32.2993	17.4453	44.2302	1.8606
2019/8/31	LT-4	9.004	89.6563	-7.9998	-8.0959	0.00461	-9.5635	-8.8988	0.00699	-1.2651	0.0649	0.65958	0.00692	-6.0474	0.23694	0.2191	0.02529	48.5765	18.597	52.7452	1.9686
2019/8/31	ETH3	7.364	91.0248	1.8601	1.8114	0.0043	-2.3285	-1.6323	0.00607	15.789	0.06588	0.63392	0.00706	8.5286	0.27623	0.18928	0.02923	98.0034	19.4831	75.7551	2.0234
2019/9/3	coral	7.642	89.9733	-1.9622	-2.0293	0.00457	-5.1948	-4.5065	0.00764	9.1549	0.06079	0.71734	0.00642	2.7399	0.26797	0.20005	0.02818	71.7515	17.0033	60.1361	1.7734
2019/9/6	ETH4	8.258	89.4839	-10.021	-10.126	0.00562	-19.379	-18.739	0.00649	-13.345	0.05207	0.58293	0.00562	-25.716	0.22553	0.15077	0.02469	17.0291	17.3846	43.7458	1.8807
2019/9/6	FX-J3a-1	8.987	89.2341	-2.919	-2.9907	0.00529	-3.9908	-3.2911	0.00658	9.3996	0.06798	0.63427	0.00721	5.1262	0.26532	0.16329	0.02791	130.25	20.3967	116.367	2.1238
2019/9/6	FX-J3a-3	12.408	90.826	-2.0981	-2.1658	0.00455	-6.4883	-5.7982	0.00797	7.6599	0.05629	0.68184	0.00581	-0.0859	0.24213	-0.019	0.02533	58.074	23.5662	49.4775	2.464
2019/9/9	ETH1	6.039	89.0443	2.1491	2.1018	0.00496	-2.9088	-2.2003	0.00681	15.216	0.07317	0.31134	0.00738	7.1116	0.27966	-0.055	0.02925	84.7139	26.5935	63.6665	2.7492
2019/9/10	C2	6.508	89.9094	-48.593	-48.884	0.00448	-17.047	-16.384	0.00666	-48.07	0.05913	0.64572	0.00637	-20.79	0.27043	0.61255	0.02943	61.8882	25.9453	128.529	2.9229
2019/9/20	Corral	7.775	89.0891	-2.0039	-2.0712	0.00392	-5.231	-4.5185	0.00639	9.0718	0.06725	0.71405	0.00691	2.3528	0.26965	-0.1149	0.02844	28.1823	15.0129	17.1553	1.5653
2019/9/22	C2	7.872	91.2275	-48.546	-48.837	0.00713	-17.262	-16.603	0.00584	-48.242	0.0551	0.63845	0.00612	-21.606	0.28613	0.20476	0.0308	17.0429	13.6117	81.2869	1.5257
2019/9/23	ETH2	7.355	89.2697	-10.011	-10.116	0.00461	-19.331	-18.688	0.0076	-13.451	0.06304	0.37169	0.0066	-25.682	0.23551	0.07559	0.02526	-4.6358	14.8972	21.4011	1.6118
2019/9/23	FX-J3a-1	8.677	91.2929	-3.0141	-3.0862	0.00558	-4.2596	-3.5589	0.00673	9.0426	0.07117	0.65431	0.00747	4.3781	0.25826	-0.0423	0.02723	16.0361	14.4513	4.1933	1.5058
2019/9/23	FX-J3a-3	11.558	90.5089	-2.2143	-2.2826	0.00531	-6.7852	-6.0948	0.00772	7.1956	0.06032	0.62992	0.00633	-0.7379	0.27647	-0.0774	0.02903	16.7602	15.3136	9.2199	1.6027
2019/9/24	C64	6.984	90.1377	-1.9311	-1.998	0.00516	-16.386	-15.732	0.0072	-2.448	0.05699	0.62505	0.00608	-19.69	0.23448	0.18319	0.02497	24.0942	15.9834	36.1528	1.7045
2019/9/24	ETH3	7.977	88.9575	1.836	1.7872	0.0051	-2.522	-1.8196	0.00644	15.6243	0.0618	0.71221	0.00652	7.8977	0.22563	-0.0481	0.02376	29.5356	10.2344	9.0904	1.0575
2019/9/26	ETH4	8.34	90.7969	-10.029	-10.135	0.00467	-19.433	-18.788	0.00641	-13.41	0.0615	0.58365	0.00672	-25.733	0.20799	0.23071	0.02211	0.45127	15.3279	26.8544	1.6584
2019/9/27	coral	7.521	90.0178	-1.9802	-2.0473	0.00461	-5.2558	-4.5659	0.00672	9.0638	0.05351	0.70665	0.0056	2.4289	0.28899	0.01104	0.03053	43.0357	14.7862	31.8765	1.5422
2019/9/28	ETH4	7.822	90.2348	-10.057	-10.163	0.0062	-19.406	-18.769	0.00639	-13.415	0.06859	0.57419	0.00746	-25.781	0.24745	0.13113	0.02685	5.4575	11.074	31.9644	1.198
2019/9/29	CJG-J3t-1	24.269	89.2962	-2.5862	-2.6563	0.00589	-16.487	-15.842	0.0076	-3.2366	0.06359	0.55838	0.00675	-19.955	0.24412	0.11774	0.02641	12.6579	19.4584	25.4651	2.077
2019/9/29	SM-J3a-4	9.472	89.0307	-3.5799	-3.6547	0.00491	-12.375	-11.719	0.00652	0.08308	0.06745	0.60637	0.0071	-11.819	0.25135	0.05491	0.02685	11.7131	12.3576	17.0039	1.3168
2019/9/29	ETH1	7.259	90.0075	2.1188	2.0714	0.00439	-2.8895	-2.202	0.00716	15.1605	0.06778	0.26092	0.00712	7.0797	0.26731	-0.1247	0.02813	24.8274	10.9184	4.9333	1.1285
2019/10/1	C2	7.524	89.7814	-48.586	-48.877	0.00431	-17.162	-16.526	0.01179	-48.219	0.05542	0.58803	0.00617	-21.302	0.26016	0.30884	0.02819	4.6077	16.5057	67.8932	1.8799
2019/10/1	YA-J3a-3	8.971	90.5803	3.034	2.9909	0.00425	-3.1741	-2.5103	0.00637	16.0256	0.06508	0.59587	0.00688	6.515	0.27023	-0.1187	0.02855	23.0178	12.4538	2.8177	1.2941
2019/10/1	YA-J3a-4	9.468	89.8632	-12.294	-12.411	0.00385	-13.106	-12.463	0.00726	-9.0822	0.06054	0.62785	0.00637	-13.303	0.21606	0.07084	0.02276	11.359	20.7667	27.1252	2.2234
2019/10/2	ETH2	7.972	90.4123	-10.037	-10.143	0.00417	-19.362	-18.73	0.00675	-13.57	0.05857	0.29108	0.00626	-25.783	0.26028	0.03898	0.02828	-0.3219	16.3439	25.9204	1.7682
2019/10/2	18K1z-9X	7.438	89.5248	-5.401	-5.4846	0.00534	-12.357	-11.713	0.00648	-1.6144	0.0633	0.66535	0.00656	-11.727	0.26913	0.12076	0.02897	42.0514	16.1456	49.3778	1.714
2019/10/2	DT-K1z-7	9.025	89.9842	-7.2207	-7.313	0.00414	-11.411	-10.767	0.00772	-2.3907	0.06624	0.68217	0.0072	-9.8571	0.26427	0.10616	0.02787	21.1838	21.7988	28.2744	2.3134
2019/10/2	HY-k1-2c	8.008	89.9342	-5.85	-5.9357	0.00394	-11.667	-11.023	0.00672	-1.2929	0.05142	0.72372	0.00559	-10.408	0.24285	0.06005	0.02565	12.8608	14.8708	19.0159	1.5859
2019/10/4	C64	7.958	89.2282	-1.923	-1.9899	0.005	-16.24	-15.604	0.00727	-2.2956	0.06949	0.61684	0.00748	-19.348	0.28949	0.23835	0.03107	63.161	13.329	75.3518	1.421
2019/10/4	ETH3	7.294	89.2309	1.8397	1.7909	0.00405	-2.4307	-1.7816	0.00865	15.6852	0.05549	0.66574	0.00572	8.0958	0.27235	-0.0343	0.02861	26.4366	15.1944	5.8652	1.5788
2019/10/6	coral	7.656	90.8872	-1.9992	-2.0664	0.0045	-5.2047	-4.5634	0.00665	9.0978	0.05881	0.70566	0.00621	2.3717	0.26302	-0.1485	0.02763	34.485	19.8972	23.3314	2.0868
2019/10/6	YA-J3a-4	9.557	89.4316	-12.317	-12.434	0.00404	-13.113	-12.478	0.00691	-9.1358	0.06601	0.59692	0.00702	-13.323	0.27531	0.06435	0.02969	15.1132	13.3299	30.9765	1.4274
2019/10/6	18K1z-9X	8.201	89.9845	-5.4001	-5.4837	0.00451	-12.376	-11.847	0.00609	-1.6368	0.0636	0.66065	0.00672	-11.813	0.25057	0.0744	0.02694	22.9417	14.1989	30.1731	1.5075
2019/10/7	ETH4	10.945	90.493	-10.159	-10.266	0.00507	-19.277	-18.646	0.00802	-13.431	0.05685	0.51019	0.0061	-25.42	0.25672	0.23662	0.02751	17.1234	18.2062	43.7714	1.97
2019/10/8	C2	9.04	90.5981	-48.601	-48.892	0.00635	-17.165	-16.534	0.00741	-48.234	0.05678	0.59159	0.00646	-21.489	0.22532	0.12302	0.02403	-26.531	15.4389	34.813	1.7304
2019/10/8	ETH2	9.715	90.6168	-10.043	-10.149	0.0045	-19.306	-18.687	0.00595	-13.522	0.06138	0.28707	0.00661	-25.654	0.237	0.04921	0.02553	-16.203	16.6095	9.5134	1.7971
2019/10/9	C64	8.349	89.6391	-2.0011	-2.0683	0.00397	-16.065	-15.454	0.00621	-2.1803	0.0544	0.63182	0.00584	-19.131	0.24357	0.09703	0.02644	-5.7693	19.3517	5.3531	2.0861
2019/10/9	ETH3	9.994	91.0712	1.817	1.7681	0.00548	-2.3101	-1.7014	0.00739	15.7888	0.06103	0.66666	0.00641	8.3705	0.247	-0.0033	0.02568	26.8054	15.8421	6.006	1.6363
2019/10/10	coral	12.17	88.6396	-1.9226	-1.9895	0.00413	-5.0645	-4.4623	0.00697	9.3289	0.05273	0.72092	0.00561	2.6605	0.24253	-0.1424	0.02524	16.0201	16.8875	4.7053	1.7605
2019/10/10	ETH4	9.176	89.2717	-10.072	-10.178	0.00463	-19.313	-18.727	0.00574	-13.33	0.05893	0.58148	0.00641	-25.691	0.24712	0.03293	0.02683	-0.2937	11.2685	25.8832	1.219
2019/10/11	ETH1	8.041	88.856	2.146	2.0987	0.00545	-2.6426	-2.0507	0.0079	15.4708	0.05674	0.29479	0.00599	7.5546	0.2656	-0.1481	0.02769	34.8654	11.9952	14.2464	1.2395

Date	Sample ID	Mass (mg)	Acid temperature (°C)	d13C vs VPDB (via WG) (permil)	d13C vs VPDB (formal) (permil)	d13C stdev	d18O vs (via WG) (permil)	d18O vs VPDB (formal) (permil)	d18O stdev	d47 vs VPDB (via WG) (permil)	d47 stdev	D47 CDES acid RF2 (permil)	D47 stderr	d48 vs VPDB (via WG) (permil)	d48 stdev	D48 (permil)	D48 stderr	d49 vs VPDB (via WG) (permil)	d49 stdev	D49 (permil)	D49 stderr
2019/10/11	C2	NaN	89.1912	-48.595	-48.886	0.00538	-16.994	-16.422	0.0072	-48.101	0.06482	0.53607	0.00714	-21.16	0.26133	0.11162	0.02797	-23.405	19.1255	37.7677	2.1423
2019/10/12	ETH2	9.323	90.3157	-10.04	-10.146	0.00487	-19.196	-18.627	0.00671	-13.411	0.04874	0.28139	0.00532	-25.43	0.28311	0.0629	0.03137	15.0686	16.2912	41.3658	1.7923
2019/10/12	C64	8.821	90.6969	-1.9364	-2.0033	0.00609	-16.073	-15.506	0.00798	-2.1699	0.06299	0.57539	0.00681	-19.233	0.24093	0.01373	0.02606	4.5509	14.6145	15.7399	1.5575
2019/10/14	ETH3	7.66	90.7094	1.841	1.7922	0.00457	-2.2949	-1.7429	0.00785	15.8638	0.06054	0.71104	0.00634	8.6373	0.25049	0.23059	0.02594	100.69	19.8237	78.3349	2.0476
2019/10/15	Coral	6.9	90.068	-2.0051	-2.0724	0.00444	-4.9506	-4.4072	0.00662	9.3967	0.06205	0.75769	0.00642	3.045	0.25727	0.01335	0.02701	53.683	14.0149	41.7961	1.4608
2019/10/16	ETH4	6.96	89.1103	-10.075	-10.181	0.00598	-19.225	-18.662	0.00801	-13.212	0.06017	0.61948	0.00666	-25.317	0.2284	0.23901	0.02493	26.7686	15.5497	53.4676	1.701
2019/10/17	ETH1	7.87	89.7187	2.1463	2.099	0.00423	-2.6972	-2.1639	0.00623	15.4003	0.05712	0.27836	0.00621	7.4635	0.22579	-0.129	0.02447	35.3763	13.7148	14.8581	1.4758
2019/10/18	ETH2	9.03	90.47	-10.049	-10.155	0.00493	-19.107	-18.548	0.00721	-13.317	0.0551	0.29622	0.00605	-25.303	0.25857	0.00358	0.02805	-11.617	20.2307	13.8122	2.1875
2019/10/21	ETH3	7.39	91.7968	1.8319	1.7831	0.00574	-2.2595	-1.7395	0.00728	15.8901	0.06669	0.70789	0.00708	8.473	0.25323	-0.0035	0.0269	45.5981	17.3444	24.2988	1.8009
2019/10/22	ETH4	6.82	89.3778	-10.093	-10.199	0.00384	-19.375	-18.825	0.00707	-13.419	0.0606	0.57365	0.00659	-25.657	0.25298	0.19449	0.02755	14.9032	12.6735	41.6315	1.3712
2019/10/23	Coral	6.78	90.5581	-1.9845	-2.0517	0.00433	-5.0353	-4.5345	0.00535	9.3342	0.06438	0.76651	0.0066	2.8194	0.24227	-0.0427	0.02543	27.9644	13.6934	16.5198	1.4357
2019/10/24	ETH1	7.638	89.5022	2.1168	2.0693	0.00455	-2.779	-2.272	0.00735	15.2308	0.06368	0.20696	0.0066	7.3742	0.24911	-0.0538	0.02606	81.816	17.2414	60.5825	1.7821
2019/10/25	C2	7.594	89.8499	-48.633	-48.924	0.00469	-17.02	-16.483	0.00652	-48.14	0.05867	0.56665	0.00649	-21.102	0.2572	0.23005	0.02808	0.22364	13.4943	62.9757	1.5287
2019/10/25	CJG-J3t-1	24.116	90.0341	-2.6694	-2.7399	0.00438	-16.327	-15.794	0.0063	-3.1629	0.06133	0.5436	0.00662	-19.655	0.27184	0.10313	0.02918	15.0127	19.3982	27.6013	2.0817
2019/10/25	SM-J3a-4	8.616	89.8201	-3.6637	-3.7389	0.00443	-12.275	-11.752	0.00614	0.11811	0.05925	0.62208	0.00632	-11.359	0.28351	0.31865	0.03016	69.4396	22.7305	74.904	2.4084
2019/10/25	YA-J3a-3	8.852	91.3818	2.9838	2.9405	0.00431	-3.051	-2.5499	0.00548	16.1298	0.05862	0.62702	0.00626	6.7749	0.24586	-0.1073	0.02593	32.9656	21.2448	12.3693	2.1949
2019/10/25	DT-K1z-7	8.969	90.4191	-7.3505	-7.4434	0.00435	-11.202	-10.683	0.0065	-2.33	0.06242	0.64576	0.00686	-9.3689	0.20915	0.17828	0.02206	23.578	13.9713	30.3843	1.4827
2019/10/26	ETH2	6.382	90.3081	-10.084	-10.19	0.00455	-19.21	-18.673	0.00747	-13.507	0.05838	0.22953	0.00632	-25.281	0.26842	0.24804	0.02893	55.4873	16.2965	82.911	1.7624
2019/10/26	HY-k1-2c	7.707	89.8107	-6.0623	-6.1491	0.00454	-11.416	-10.897	0.00557	-1.2583	0.05963	0.70098	0.00646	-9.8547	0.22733	0.11243	0.02421	23.4326	24.6629	29.349	2.615
2019/10/27	C64	7.837	89.4495	-1.9722	-2.0393	0.00347	-16.055	-15.554	0.00619	-2.1255	0.0585	0.65267	0.0062	-19.023	0.25017	0.18876	0.02702	12.3666	13.7227	23.6412	1.4627
2019/10/28	ETH3	8.25	89.3838	1.7851	1.736	0.00617	-2.2606	-1.7752	0.00848	15.8092	0.06308	0.66691	0.00675	8.5721	0.2686	0.09764	0.02834	50.97	14.5415	29.6117	1.5102
2019/10/29	Coral	10.38	89.3744	-2.0251	-2.0925	0.00433	-4.9627	-4.4807	0.00649	9.3416	0.05915	0.73138	0.00621	3.0305	0.26407	0.02212	0.02769	11.6567	12.8243	0.28814	1.3366
2019/10/30	ETH4	6.843	89.7668	-10.124	-10.231	0.0041	-19.145	-18.648	0.00595	-13.263	0.06018	0.50996	0.00657	-25.181	0.24845	0.21236	0.02703	12.7982	12.0179	39.0168	1.3066
2019/10/31	ETH1	8.17	89.6435	2.1136	2.0661	0.00489	-2.7395	-2.2579	0.00714	15.336	0.05665	0.29272	0.0059	7.5015	0.23427	-0.0063	0.02477	68.082	21.094	47.0386	2.1802
2019/11/1	C2	7.81	88.7967	-48.656	-48.947	0.00537	-16.97	-16.486	0.00876	-48.09	0.06784	0.5971	0.00742	-20.904	0.26056	0.32284	0.02737	0.77899	14.9721	63.4848	1.6779
2019/11/2	ETH2	6.938	88.9911	-10.104	-10.21	0.004	-19.198	-18.717	0.00606	-13.461	0.06707	0.29835	0.00723	-25.43	0.23212	0.06327	0.02521	-1.3771	18.1825	24.5642	1.9666
2019/11/4	C64	7.568	88.6566	-1.9883	-2.0555	0.00464	-16.071	-15.587	0.00685	-2.2078	0.06626	0.58747	0.00693	-19.06	0.26388	0.18585	0.02818	31.9492	16.5792	43.4921	1.767
2019/11/5	ETH3	7.3	89.9696	1.7784	1.7293	0.00455	-2.2696	-1.7611	0.00719	15.7733	0.06931	0.64355	0.0072	8.4506	0.27965	-0.0045	0.02918	13.8331	14.9645	-6.7461	1.5455
2019/11/6	Coral	7.543	88.9913	-2.0425	-2.1099	0.00459	-4.9904	-4.4843	0.00579	9.3023	0.06392	0.73769	0.00682	3.0049	0.24994	0.05298	0.02634	57.1509	14.4238	45.3478	1.5035
2019/11/7	ETH4	7.263	87.1177	-10.116	-10.222	0.00436	-19.212	-18.735	0.0072	-13.265	0.06456	0.58561	0.00715	-25.398	0.26833	0.12155	0.02938	-12.424	9.5293	13.2701	1.0364
2019/11/11	ETH1	7.834	89.8429	2.1019	2.0544	0.00532	-2.7548	-2.2415	0.00616	15.2337	0.05806	0.19803	0.0058	7.4032	0.23757	-0.0733	0.02485	54.7168	19.4176	33.9804	2.0068
2019/11/12	ETH2	9.19	90.0377	-10.096	-10.202	0.00386	-19.19	-18.716	0.00675	-13.434	0.06702	0.31338	0.00724	-25.418	0.22393	0.05854	0.02425	0.81954	20.1481	26.7923	2.1792
2019/11/13	C64	11.53	89.7694	-1.9808	-2.0479	0.00389	-16.086	-15.606	0.00675	-2.178	0.0621	0.63609	0.00672	-19.176	0.27371	0.09896	0.02967	16.031	17.6998	27.4198	1.9084
2019/11/18	ETH3	7.86	88.6961	1.7661	1.717	0.00496	-2.1538	-1.6349	0.00672	15.9528	0.06426	0.73098	0.00667	9.0296	0.25648	0.33721	0.02686	146.32	15.1846	122.804	1.5679
2019/11/19	Coral	10.504	89.1138	-2.0249	-2.0923	0.0044	-4.9713	-4.4604	0.00735	9.3772	0.06675	0.78499	0.00715	2.9538	0.26886	-0.0361	0.02841	42.8232	23.552	31.1222	2.455
2019/12/20	ETH3	9.84	88.7955	1.7262	1.6769	0.00522	-2.1821	-1.5794	0.01395	15.8296	0.06393	0.66363	0.00603	8.6076	0.26889	-0.024	0.02762	25.2091	10.001	4.2748	1.0328
2019/11/22	ETH4	8.493	90.1243	-10.135	-10.241	0.00401	-19.216	-18.75	0.00692	-13.297	0.05967	0.57322	0.00644	-25.421	0.2311	0.11308	0.02497	4.1587	14.6211	30.3139	1.5813
2019/11/23	ETH1	7.476	89.0124	2.0726	2.0249	0.00381	-2.6776	-2.1484	0.00636	15.3026	0.06981	0.22107	0.00733	7.6807	0.21877	0.04776	0.02329	69.3384	17.5513	48.1828	1.8556
2019/12/1	ETH2	7.017	90.8821	-10.2	-10.307	0.00401	-19.043	-18.587	0.00743	-13.416	0.0665	0.26932	0.00716	-24.791	0.28456	0.40839	0.03061	82.0066	18.8209	109.87	2.0354
2019/12/1	LT-4	8.763	91.3602	-8.111	-8.2076	0.00478	-9.2836	-8.767	0.00626	-1.0496	0.06338	0.70672	0.00676	-5.5619	0.24073	0.14097	0.02569	31.807	19.059	35.4391	2.0162
2019/12/2	FX-J3a-3	10.923	90.3795	-2.3341	-2.4029	0.00653	-6.3528	-5.8147	0.0077	7.5394	0.06074	0.64627	0.00653	0.2245	0.24971	0.01654	0.02625	35.0394	18.9283	26.5919	1.9898
2019/12/4	C64	7.366	89.3872	-2.1106	-2.1784	0.00543	-15.987	-15.514	0.00828	-2.2432	0.05733	0.5827	0.00596	-18.891	0.27476	0.18711	0.02956	24.4124	17.9831	35.8215	1.9278
2019/12/4	18K1z-9	7.527	89.1921	-5.564	-5.6484	0.00491	-12.114	-11.613	0.00701	-1.5377	0.06561	0.64603	0.00711	-11.286	0.24117	0.07577	0.02557	22.3197	10.2486	29.1699	1.1002
2019/12/4	DT-K1z-7	8.698	91.0681	-7.4898	-7.5834	0.00544	-11.141	-10.633	0.00746	-2.4222	0.05547	0.62137	0.00625	-9.2787	0.2466	0.1433	0.02665	12.6926	19.4549	19.4433	2.088
2019/12/4	HY-k1-2c	7.03	91.1369	-6.1652	-6.2524	0.00621	-11.352	-10.845	0.00816	-1.307	0.05618	0.68094	0.00621	-9.7233	0.23823	0.1182	0.02564	29.586	12.6251	35.5107	1.3385
2019/12/11	Coral	6.359	89.173	-2.1058	-2.1735	0.00503	-5.0705	-4.5	0.00696	9.1377	0.06981	0.71365	0.0074	2.8154	0.24552	0.02454	0.0258	41.2699	20.4033	29.8752	2.1278

Date	Sample ID	Mass (mg)	Acid temperature (°C)	d13C vs VPDB (via WG) (permil)	d13C vs VPDB (formal) (permil)	d13C stdev	d18O vs (via WG) (permil)	d18O vs VPDB (formal) (permil)	d18O stdev	d47 vs VPDB (via WG) (permil)	d47 stdev	D47 CDES acid RF2 (permil)	D47 stderr	d48 vs VPDB (via WG) (permil)	d48 stdev	D48 (permil)	D48 stderr	d49 vs VPDB (via WG) (permil)	d49 stdev	D49 (permil)	D49 stderr
2019/12/12	C2A	7.672	88.6941	-48.721	-49.013	0.00669	-16.983	-16.522	0.0083	-48.174	0.06018	0.58651	0.00672	-21.015	0.2506	0.23542	0.02692	-16.051	18.4955	45.6995	2.0725
2019/12/13	C64	7.37	89.2503	-2.0778	-2.1454	0.00471	-16.057	-15.592	0.00596	-2.2322	0.05668	0.6488	0.00611	-19.092	0.25325	0.12169	0.02724	0.73849	13.9371	11.9943	1.4859
2019/12/18	ETH2	7.036	89.3605	-10.096	-10.202	0.00487	-19.036	-18.615	0.01255	-13.318	0.07272	0.25838	0.00737	-24.926	0.28447	0.25146	0.03067	39.9186	10.8529	66.5713	1.1733
2019/12/18	18J3t-4a	8.678	89.1654	-2.767	-2.8379	0.00724	-12.06	-11.564	0.01684	1.2417	0.06732	0.66529	0.00645	-11.025	0.24798	0.21643	0.02641	42.8545	12.3028	46.7861	1.3248
2019/12/18	DT-K1z-10	9.269	89.5894	-5.342	-5.4253	0.00606	-12.521	-12.03	0.01302	-1.7292	0.06032	0.66202	0.00617	-12.055	0.28906	0.11571	0.03023	17.2962	12.3993	24.7272	1.3163
2019/12/18	HY-k1-2c-1	7.989	89.534	-4.0726	-4.1498	0.00555	-9.0191	-8.4913	0.01473	3.1805	0.06187	0.75322	0.00635	-5.0872	0.27291	0.06672	0.0284	10.0615	14.4236	8.9739	1.5281
2019/12/18	HY-k1-3c	7.189	89.4543	-4.7446	-4.825	0.00502	-12.647	-12.159	0.01434	-1.2368	0.06834	0.71874	0.00662	-12.29	0.22832	0.13201	0.02404	3.735	14.624	10.7198	1.5524
2019/12/18	DT-J3t-2a	9.134	90.3602	-4.0087	-4.0856	0.00618	-9.2881	-8.7636	0.01484	2.9704	0.06288	0.73252	0.00602	-5.6455	0.2405	0.047	0.02548	6.3176	13.3356	5.7156	1.4045
2019/12/19	DT-J3t-2b	8.824	89.3786	-4.3923	-4.471	0.00521	-8.0047	-7.4681	0.01158	3.8909	0.0692	0.69775	0.0067	-3.0274	0.2753	0.09307	0.02869	62.2175	27.8249	59.2435	2.9248
2019/12/19	DT-K1z-15b	8.704	89.8204	-7.4646	-7.5581	0.00466	-11.174	-10.674	0.01327	-2.3867	0.07866	0.6776	0.00764	-9.4655	0.26081	0.02095	0.02779	11.4061	13.6601	18.1889	1.4497
2019/12/21	HY-k1-1a	7.008	89.6319	-6.8194	-6.9098	0.0038	-11.086	-10.596	0.0074	-1.6509	0.06806	0.70474	0.00712	-9.218	0.20089	0.08851	0.02125	11.0356	12.1441	16.9754	1.2877
2019/12/21	DT-J3t-2a	8.425	89.7212	-4.0323	-4.1093	0.00427	-9.1808	-8.6652	0.00791	3.0346	0.06159	0.70622	0.00638	-5.426	0.23584	0.05101	0.02497	7.9086	17.8333	7.1115	1.8785
2019/12/22	HY-k1-2c-1	8.033	89.5786	-4.0908	-4.1681	0.00411	-8.9667	-8.4471	0.01088	3.1867	0.0629	0.71418	0.00654	-0.9334	0.84308	4.1372	0.08911	24.807	13.2351	23.6139	1.3939
2019/12/22	HY-k1-3c	7.538	89.4253	-4.7684	-4.8489	0.0053	-12.547	-12.075	0.01431	-1.1703	0.06085	0.70179	0.00627	-7.8378	0.84062	4.4374	0.0891	16.7312	12.4999	23.6241	1.3264
2019/12/22	HY-k1-1a	7.41	89.5823	-6.821	-6.9114	0.00419	-11.038	-10.546	0.01121	-1.632	0.07162	0.66726	0.00726	-5.4022	0.80499	3.8429	0.08587	9.1124	12.1349	14.9435	1.2935
2019/12/22	18J3t-4a	8.056	88.9719	-2.7707	-2.8416	0.00514	-11.964	-11.485	0.01254	1.4315	0.064	0.7869	0.00676	-7.061	0.60377	4.0301	0.06467	109.572	13.9463	113.543	1.483
2019/12/22	DT-J3t-2a	8.384	88.1408	-2.0987	-2.1664	0.0046	-4.8785	-4.3055	0.01119	9.3358	0.056	0.68292	0.00546	6.3872	0.76337	3.1995	0.08008	20.4214	16.4578	8.8578	1.7152
2019/12/23	ETH4	7.122	89.8101	-10.181	-10.287	0.00472	-19.139	-18.755	0.01234	-13.312	0.06759	0.50936	0.00704	-25.291	0.24494	0.08821	0.02637	-2.5969	12.0559	23.2694	1.3038
2019/12/23	DT-J3t-2b	8.238	89.9058	-4.3609	-4.4395	0.00422	-8.1232	-7.5934	0.00837	3.7969	0.05832	0.69555	0.00611	-3.263	0.24541	0.0947	0.02627	42.0495	11.6916	39.3476	1.2291
2019/12/23	18J3t-4a	8.44	89.8239	-2.7779	-2.8489	0.00432	-11.855	-11.375	0.00866	1.4392	0.06073	0.6621	0.00616	-10.717	0.27111	0.11222	0.02895	10.53	14.0936	13.9307	1.4906
2019/12/23	HY-k1-2c-1	7.768	89.787	-4.0994	-4.1767	0.00357	-8.9385	-8.4196	0.00763	3.2474	0.06104	0.7666	0.00652	-4.7488	0.24658	0.24319	0.02609	44.4407	15.6419	43.1744	1.6468
2019/12/23	HY-k1-3c	6.797	89.5751	-4.7498	-4.8302	0.00447	-12.524	-12.053	0.00723	-1.1377	0.05937	0.69078	0.00646	-12.054	0.24206	0.11824	0.02571	-0.2672	23.9812	6.4439	2.5594
2019/12/25	ETH1	7.84	89.7507	2.0463	1.9985	0.00492	-2.6146	-2.0114	0.01258	15.3241	0.06908	0.19811	0.00695	7.6093	0.28924	-0.1492	0.02996	16.3695	13.9694	-3.838	1.4436
2019/12/26	C2A	7.384	89.3061	-48.716	-49.007	0.00481	-16.903	-16.49	0.01346	-48.094	0.06601	0.58038	0.007	-20.92	0.29054	0.16516	0.03076	-20.626	14.1104	40.6606	1.5892
2019/12/25	LT-4	8.483	89.5133	-8.0958	-8.1923	0.00439	-9.3025	-8.7885	0.00653	-1.079	0.06457	0.67603	0.00697	-5.7655	0.30292	-0.0279	0.03204	2.4302	10.6793	5.9816	1.1293
2019/12/26	DT-J3t-2b	7.384	89.5159	-4.3736	-4.4522	0.00427	-8.0528	-7.517	0.01158	3.8641	0.07528	0.70424	0.00755	-3.1563	0.25503	0.0588	0.02663	11.9801	16.9482	9.2257	1.7816
2019/12/27	ETH2	7.042	89.2136	-10.16	-10.266	0.00435	-19.067	-18.683	0.00744	-13.462	0.06191	0.19272	0.00663	-25.218	0.26413	0.01131	0.02809	-8.6269	18.7925	16.9108	2.0322
2019/12/27	HY-k1-2c	6.621	89.3961	-6.1213	-6.2083	0.00412	-11.258	-10.77	0.00877	-1.1684	0.06699	0.68318	0.00706	-9.5364	0.25252	0.10993	0.02655	12.3538	17.8182	17.9412	1.889
2019/12/28	C64	7.28	91.9341	-2.0439	-2.1113	0.00457	-16.039	-15.615	0.00782	-2.1859	0.06033	0.64293	0.0064	-19.103	0.24532	0.07515	0.02634	1.1829	16.6171	12.3729	1.7716

Reference Materials:

Accepted Values			Temperature (°C)	n	Slope
Name	d13C VPDB (permil)	d18O VPDB (permil)			
C64	-2.05	-15.54	60	9	-0.0003
Coral	-2.14	-4.5	1000	20	-0.0003
C2	-48.93	-16.49	Reference Gases		
ETH1	2.14	-2.18	ref gas name_d47_0 m7_d47_0 std		
ETH2	-10.1	-18.76	t4	0.1091	0.00818
ETH3	1.81	-1.77	t25	NaN	NaN
ETH4	-10.11	-18.82	t60	-0.1285	0.02795
Polly CO2 Reference Gas	-10.3	-6.44	t1000	-0.7788	0.02531

D47 Calibration Type - Carbon Dioxide Equilibrium Scale (CDES) Acid Correction Factor: 0.088

D47 to Temperature equation: $T_{D47_CDES_acid} = \sqrt[4]{(0.0383 * 10^6) / (D47_CDES_acid - 0.258)}$; Petersen et al. G3 2019 - 25 °C Acid Fractionation Factor of 0.088

Table S1-2 Results of clumped isotope analyses

D47 stdev from long-term carbonate standard				0.027						
Date	Sample ID	D47 CDES acid ARF (permil)	D47 1 σ S.E.	D47 sterr (from longer-term standards)	T(D47) (°C) Peterson et al., 2019	T error (standards)	T error (replicates)	$\delta^{13}\text{C}$ (PDB)	$\delta^{18}\text{O}$ (PDB)	$\delta^{18}\text{O}_{\text{sw}}$ (VSMOW)
Tianchihe Fm, Yungang area										
2019/12/18	DT-J3t-2a	0.733	0.006					-4.1	-8.8	
2019/12/21	DT-J3t-2a	0.706	0.006					-4.1	-8.7	
2	Average	0.719	0.013	0.019	15	6	4	-4.1	-8.7	-8.9
2019/12/19	DT-J3t-2b	0.698	0.007					-4.5	-7.5	
2019/12/26	DT-J3t-2b	0.704	0.006					-4.4	-7.6	
2019/12/23	DT-J3t-2b	0.696	0.008					-4.5	-7.5	
3	Average	0.699	0.003	0.016	21	5	1	-4.5	-7.5	-6.3
2019/12/18	18J ₃ t-4	0.665	0.006					-2.8	-11.6	
2019/12/23	18J ₃ t-4	0.662	0.007					-2.8	-11.4	
2	Average	0.664	0.002	0.019	34	7	1	-2.8	-11.5	-7.7
Tianchihe Fm, Yungang area Average:										
N = 7		0.695	0.009	0.010	23	3	3	-3.8	-9.2	-7.6
Zhuangwangpu Group, Hunyuan area										
2019/12/21	HY-K1-1a	0.705	0.007					-6.9	-10.6	
2019/12/22	HY-K1-1a	0.667	0.007					-6.9	-10.5	
2	Average	0.686	0.019	0.019	26	7	7	-6.9	-10.6	-8.4
2019/10/2	HY-K1-2c	0.724	0.006					-5.9	-11.0	
2019/10/26	HY-K1-2c	0.701	0.006					-6.1	-10.9	
2019/12/4	HY-K1-2c	0.681	0.006					-6.3	-10.8	
2019/12/27	HY-K1-2c	0.683	0.007					-6.2	-10.8	
4	Average	0.697	0.010	0.014	22	5	3	-6.1	-10.9	-7.1
2019/12/18	HY-K1-2c-1	0.753	0.006					-4.1	-8.5	
2019/12/22	HY-K1-2c-1	0.714	0.007					-4.2	-8.4	
2019/12/23	HY-K1-2c-1	0.767	0.007					-4.2	-8.4	
3	Average	0.745	0.016	0.016	7	4	5	-4.2	-8.5	-10.6
2019/12/18	HY-K1-3c	0.719	0.007					-4.8	-12.2	
2019/12/22	HY-K1-3c	0.702	0.006					-4.8	-12.1	
2019/12/23	HY-K1-3c	0.691	0.006					-4.8	-12.1	
3	Average	0.704	0.008	0.016	20	5	3	-4.8	-12.1	-11.1
Zhuangwangpu Group, Hunyuan area Average:										
N = 12		0.709	0.008	0.008	18	3	3	-5.5	-10.5	-9.3
Zuoyun Fm, Yungang area										
2019/10/2	DT-K1z-7	0.682	0.007					-7.3	-10.8	
2019/10/25	DT-K1z-7	0.646	0.007					-7.4	-10.7	
2019/12/4	DT-K1z-7	0.621	0.006					-7.6	-10.6	
3	Average	0.650	0.018	0.016	40	6	7	-7.4	-10.7	-5.8
2019/10/2	18K1z-9	0.665	0.007							
2019/10/6	18K1z-9	0.661	0.007					-5.5	-11.8	
2019/12/4	18K1z-9	0.646	0.007					-5.6	-11.6	
3	Average	0.657	0.006	0.016	37	6	2	-5.6	-11.7	-7.3
2019/12/18	DT-K1z-10	0.662	0.006	0.027	35	10	2	-5.4	-12.0	-8
1										
2019/12/19	DT-K1z-15b	0.678	0.008	0.027	29	10	3	-7.6	-10.7	-7.8
1										
Zuoyun Fm, Yungang area Average:										
N = 8		0.658	0.007	0.010	36	4	3	-6.5	-11.3	-7.2

Date	Sample ID	D47 CDES acid ARF (permil)	D47 1 σ S.E.	D47 sterr (from longer-term standards)	T(D47) (°C) Peterson et al., 2019	T error (standards)	T error (replicates)	$\delta^{13}\text{C}$ (PDB)	$\delta^{18}\text{O}$ (PDB)	$\delta^{18}\text{O}_{\text{sw}}$ (VSMOW)
Anding Fm, Shenmu area										
2019/9/29	SM-J3a-4	0.606	0.007					-3.65	-11.72	
2019/10/25	SM-J3a-4	0.622	0.006					-3.74	-11.75	
2	Average	0.614	0.008	0.019	55	9	4	-3.70	-11.74	-4.3
Anding Fm, Yanan-Fuxian area										
2019/9/6	FX-J3a-1	0.634	0.007					-2.99	-3.29	
2019/9/23	FX-J3a-1	0.654	0.007					-3.09	-3.56	
2	Average	0.644	0.010	0.019	42	8	4	-3.04	-3.43	1.9
2019/9/6	FX-J3a-3	0.682	0.006					-2.17	-5.80	
2019/9/23	FX-J3a-3	0.630	0.006					-2.28	-6.09	
2019/12/2	FX-J3a-3	0.646	0.007					-2.40	-5.81	
3	Average	0.653	0.015	0.016	38	6	6	-2.28	-5.90	-1.3
2019/10/1	YA-J3a-4	0.628	0.006					-12.41	-12.46	
2019/10/6	YA-J3a-4	0.597	0.007					-12.43	-12.48	
2	Average	0.612	0.015	0.019	56	9	7	-12.42	-12.47	-4.9
2019/10/1	YA-J3a-3	0.596	0.007					2.99	-2.51	
2019/10/25	YA-J3a-3	0.627	0.006					2.94	-2.55	
2	Average	0.611	0.016	0.019	56	9	7	2.97	-2.53	5.2
Anding Fm, Yanan-Fuxian area Average:										
N = 9		0.633	0.009	0.010	47	4	4	-3.7	-7.2	-0.7
Tianchihe Fm, Chenjiabangou Village										
2019/9/29	CJG-J3t-1	0.558	0.007					-2.66	-15.84	
2019/10/25	CJG-J3t-1	0.544	0.007					-2.74	-15.79	
2	Average	0.551	0.007	0.019	88	12	5	-2.70	-15.82	-3.9
Holocene soil carbonate, Lantian of south Ordos basin										
2019/8/31	LT-4	0.660	0.007					-8.10	-8.90	
2019/12/1	LT-4	0.707	0.007					-8.21	-8.77	
2019/12/25	LT-4	0.676	0.007					-8.19	-8.79	
3	Average	0.681	0.014	0.016	28	6	5	-8.17	-8.82	-6.2

Table S2 major and trace element composition of an identified palsosol sediments and mean annual temperature derived from Salinity and τ_{Na}

Age (Ma)	ID	Depth	SiO ₂ (wt%)	TiO ₂ (wt%)	Al ₂ O ₃ (wt%)	Fe ₂ O ₃ (wt%)	MgO (wt%)	MnO (wt%)	CaO (wt%)	Na ₂ O (wt%)	K ₂ O (wt%)	P ₂ O ₅ (wt%)	Zr (wt%)	τ_{Na}	τ_{Na} -MAT (°C)	SAL	SAL-MAT (°C)
Tianchihe Formation (~160 Ma)	DT-2	10cm, A	62.61	0.98	16.43	6.96	2.18	0.04	0.51	0.24	4.15	0.14	0.04160	/		0.298	11.8
	DT-3	30cm, Bt	62.88	0.69	12.19	5.38	1.34	0.07	5.4	0.21	3.34	0.1	0.02756	/		0.326	11.3
	DT-4	60cm, Bk	48.59	0.67	10.56	4.03	1.42	0.13	14.85	0.18	3.08	0.16	0.03428	-0.312	7	0.344	10.9
	DT-5	90cm, Bk	56.55	0.69	11.31	4.47	1.53	0.08	9.1	0.14	3.17	0.13	0.02628	-0.281	6	0.325	11.3
	DT-6	110cm, Bk	62.99	0.69	11.33	4.5	1.25	0.06	6.17	0.19	3.13	0.07	0.03483	-0.266	6	0.328	11.2
	DT-7	130cm, C	66.62	0.69	12.88	5.32	1.16	0.06	3.64	0.24	3.44	0.07	0.03190	/		0.320	11.4

*negative value of mass transfer coefficient (τ_{Na}) indicate net loss of Na from the regolith (Bk-horizons) relative to the C protolith during the chemical weathering

Table S3 Intermediate igneous whole-rock La/Yb from early Cretaceous Taihang mountain range.

Sample name	Reference	Approx Age	Latitude	Longitude	Location	SiO ₂	MgO	La	Yb	Rb	Sr	Rb/Sr	La/Ybn	Z	Error		
															high	low	Average
XSM04-H	Sun et al, 2015	134	36°45′	114°	Handan	58.9	2.1	40.2	1.8	70.1	849.3	0.08	15.35	58.5	12.1	9.0	10.6
XSM05-H	Sun et al, 2015	134	36°45′	114°	Handan	61.7	1.2	35.6	1.9	65.8	792.6	0.08	13.01	55.0	11.7	8.7	10.2
KSC06-H	Sun et al, 2015	134	36°45′	114°	Handan	61.5	1.5	42.2	1.7	56.5	742.3	0.08	17.05	60.8	12.4	9.3	10.8
BLS09-H	Sun et al, 2015	134	36°45′	114°	Handan	60.6	2.2	25.6	1.6	66.0	573.8	0.11	11.21	51.9	11.3	8.4	9.8
KSC10-H	Sun et al, 2015	134	36°45′	114°	Handan	63.8	1.0	26.4	2.0	40.7	347	0.12	9.06	47.3	10.8	8.0	9.4
XSM1249-H	Sun et al, 2015	134	36°45′	114°	Handan	62.5	1.5	26.0	1.9	35.1	709.2	0.05	9.25	47.8	10.8	8.0	9.4
DZP1250-H	Sun et al, 2015	134	36°45′	114°	Handan	59.1	1.3	27.6	1.8	79.2	596.2	0.13	10.53	50.5	11.1	8.3	9.7
HS02-H1	Sun et al, 2015	135	36°45′	114°20′	Hongshan	57.6	3.1	28.1	1.7	104.8	922.8	0.11	10.96	51.4	11.2	8.3	9.8
HS04-H1	Sun et al, 2015	135	36°45′	114°20′	Hongshan	61.2	1.1	31.3	1.9	139.2	2041.6	0.07	11.32	52.1	11.3	8.4	9.9
HS04-H3	Sun et al, 2015	135	36°45′	114°20′	Hongshan	63.5	0.9	40.7	1.7	129.0	650.3	0.20	16.46	60.0	12.3	9.2	10.7
HS05-H2	Sun et al, 2015	135	36°45′	114°20′	Hongshan	63.3	0.4	30.4	1.5	124.1	779.8	0.16	13.43	55.7	11.8	8.8	10.3
HS08-H	Sun et al, 2015	135	36°45′	114°20′	Hongshan	62.8	0.8	44.7	2.1	101.8	876.5	0.12	14.33	57.1	11.9	8.9	10.4
HS09-H	Sun et al, 2015	135	36°45′	114°20′	Hongshan	61.0	0.7	35.2	1.9	93.3	1222.8	0.08	12.44	54.1	11.6	8.6	10.1
Hs1257-H	Sun et al, 2015	135	36°45′	114°20′	Hongshan	62.8	0.5	28.2	1.2	150.6	1570.5	0.10	15.55	58.8	12.1	9.1	10.6
Hs1279-H	Sun et al, 2015	135	36°45′	114°20′	Hongshan	62.9	0.5	23.6	1.0	177.5	1091.7	0.16	15.85	59.2	12.2	9.1	10.6
16FS01-1	Kang et al., 2021	132	40°30′	116°40′	Fangshan	59.5	2.5	53.0	1.6	77.2	1285.3	0.06	22.23	66.4	13.0	9.8	11.4
16FS01-2	Kang et al., 2021	132	40°30′	116°40′	Fangshan	59.9	2.8	48.7	1.8	80.6	1198.6	0.07	18.28	62.3	12.5	9.4	11.0
16FS01-3	Kang et al., 2021	132	40°30′	116°40′	Fangshan	60.5	2.5	51.3	1.7	83.3	1204.6	0.07	20.26	64.4	12.8	9.6	11.2
16FS01-4	Kang et al., 2021	132	40°30′	116°40′	Fangshan	61.6	2.4	56.2	2.0	88.5	1129	0.08	19.58	63.7	12.7	9.5	11.1
16FS01-5	Kang et al., 2021	132	40°30′	116°40′	Fangshan	60.2	2.6	45.3	1.7	85.3	1184.8	0.07	18.65	62.7	12.6	9.4	11.0
16FS02-1	Kang et al., 2021	128	40°30′	116°40′	Fangshan	63.6	1.9	63.3	1.3	68.2	1110.3	0.06	33.60	75.2	14.1	10.6	12.4
16FS02-3	Kang et al., 2021	128	40°30′	116°40′	Fangshan	64.3	2.0	51.2	1.4	79.6	1032.9	0.08	25.39	69.2	13.4	10.1	11.7
16FS02-4	Kang et al., 2021	128	40°30′	116°40′	Fangshan	63.0	1.9	41.5	1.0	76.2	1202.6	0.06	27.37	70.8	13.6	10.2	11.9
16FS04-1	Kang et al., 2021	134	40°30′	116°40′	Fangshan	63.9	2.0	39.7	1.1	74.2	1163	0.06	25.44	69.3	13.4	10.1	11.7
16FS04-2	Kang et al., 2021	134	40°30′	116°40′	Fangshan	63.0	2.1	44.2	1.1	70.9	1242.7	0.06	26.34	70.0	13.5	10.1	11.8
16FS05-1	Kang et al., 2021	132	40°30′	116°40′	Fangshan	60.3	2.0	48.5	1.9	58.5	1146.1	0.05	17.34	61.1	12.4	9.3	10.8
16FS05-2	Kang et al., 2021	132	40°30′	116°40′	Fangshan	61.1	1.9	49.4	1.8	64.0	1114.4	0.06	18.96	63.0	12.6	9.5	11.1
LY-21/1	Xue et al., 2021	128	39°15′	114°50′	Laiyuan	62.0	2.0	20.8	0.8	80.3	1251	0.06	18.60	62.6	12.6	9.4	11.0
LY-37/1-2	Xue et al., 2021	128	39°15′	114°50′	Laiyuan	65.2	1.4	29.5	1.7	40.6	783.1	0.05	12.06	53.4	11.5	8.5	10.0
LY-20/1	Xue et al., 2021	128	39°15′	114°50′	Laiyuan	58.8	2.7	19.3	1.3	88.3	919.3	0.10	10.08	49.6	11.0	8.2	9.6
LY-22/1	Xue et al., 2021	128	39°15′	114°50′	Laiyuan	59.0	3.3	35.8	1.8	136.0	889	0.15	13.36	55.6	11.7	8.8	10.3
LY-22/2	Xue et al., 2021	128	39°15′	114°50′	Laiyuan	58.0	3.4	35.4	1.9	129.0	936	0.14	12.53	54.2	11.6	8.6	10.1
LY-42/2	Xue et al., 2021	132	39°15′	114°50′	Laiyuan	55.0	3.7	33.7	1.3	53.0	879	0.06	17.21	61.0	12.4	9.3	10.8

QS35-7	Li et al., 2019	125	na	na	south part	65.1	1.1	32.7	1.6	61.8	712	0.09	13.97	56.5	11.9	8.8	10.4
ZJZ-1-3	Yang et al., 2018	126	39°16′	114°51′	Mujicun	59.8	2.3	39.9	1.0	69.0	1319	0.05	27.11	70.6	13.5	10.2	11.9
ZJZ-1-5	Yang et al., 2018	126	39°16′	114°51′	Mujicun	61.3	2.2	37.7	0.9	77.0	1239	0.06	28.46	71.7	13.7	10.3	12.0
27-1	Huo et al., 2016	130	35°50′	110°30′	south part	60.1	1.4	37.8	2.4	101.0	910	0.11	10.66	50.8	11.2	8.3	9.7
26-1	Huo et al., 2016	130	35°50′	110°30′	south part	62.7	1.4	38.5	1.7	56.7	1171	0.05	15.30	58.5	12.1	9.0	10.6
25-1	Huo et al., 2016	130	35°50′	110°30′	south part	65.0	1.1	44.8	1.7	67.9	1191	0.06	17.80	61.7	12.5	9.3	10.9
B2595-1A	Jiang et al, 2020	125	36°48′	114°7′	Wuan	63.7	1.4	33.9	1.7	98.6	600	0.16	13.47	55.8	11.8	8.8	10.3
B2595-1C	Jiang et al, 2020	125	36°48′	114°7′	Wuan	63.4	1.6	31.7	1.6	110.0	491	0.22	13.38	55.6	11.8	8.8	10.3
B6001	Jiang et al, 2020	125	36°48′	114°7′	Wuan	59.8	1.8	27.5	1.7	60.8	586	0.10	10.80	51.1	11.2	8.3	9.8
B6004	Jiang et al, 2020	125	36°48′	114°7′	Wuan	59.9	2.4	27.2	1.8	55.0	620	0.09	10.15	49.7	11.1	8.2	9.6
B6026	Jiang et al, 2020	125	36°48′	114°7′	Wuan	58.6	1.9	27.5	2.1	40.7	833	0.05	8.81	46.7	10.7	7.9	9.3
B6026-1a	Jiang et al, 2020	125	36°48′	114°7′	Wuan	57.0	2.2	32.1	2.3	58.6	690	0.08	9.56	48.5	10.9	8.1	9.5
B6029	Jiang et al, 2020	125	36°48′	114°7′	Wuan	60.2	1.3	27.0	1.8	64.9	491	0.13	9.97	49.4	11.0	8.2	9.6
B6029-1	Jiang et al, 2020	125	36°48′	114°7′	Wuan	59.6	1.5	25.5	2.0	66.0	506	0.13	8.84	46.8	10.7	7.9	9.3
B6280	Jiang et al, 2020	125	36°48′	114°7′	Wuan	61.5	1.2	32.0	2.1	69.3	508	0.14	10.50	50.5	11.1	8.3	9.7
B6298-1	Jiang et al, 2020	125	36°48′	114°7′	Wuan	60.5	1.9	33.5	1.8	55.2	805	0.07	12.44	54.1	11.6	8.6	10.1
B6390	Jiang et al, 2020	125	36°48′	114°7′	Wuan	58.5	2.6	30.8	2.1	45.5	363	0.13	9.92	49.2	11.0	8.1	9.6
B6475	Jiang et al, 2020	125	36°48′	114°7′	Wuan	60.6	1.7	30.3	2.5	54.8	455	0.12	8.14	45.0	10.5	7.7	9.1
B6692	Jiang et al, 2020	125	36°48′	114°7′	Wuan	58.2	2.6	30.2	1.9	78.9	615	0.13	10.97	51.4	11.2	8.4	9.8
PM3-3B1	Jiang et al, 2020	125	36°48′	114°7′	Wuan	60.2	2.6	31.9	2.0	80.9	351	0.23	11.11	51.7	11.3	8.4	9.8
PM3-3B2	Jiang et al, 2020	125	36°48′	114°7′	Wuan	60.2	3.4	26.4	1.9	39.5	342	0.12	9.44	48.2	10.9	8.0	9.5
B6391	Jiang et al, 2020	125	36°48′	114°7′	Wuan	61.3	1.5	35.5	1.8	34.5	271	0.13	13.47	55.8	11.8	8.8	10.3
B6595	Jiang et al, 2020	125	36°48′	114°7′	Wuan	58.8	2.1	31.8	2.1	66.1	642	0.10	10.49	50.4	11.1	8.3	9.7
B6032	Jiang et al, 2020	125	36°48′	114°7′	Wuan	60.1	1.4	24.8	2.0	49.0	378	0.13	8.55	46.1	10.6	7.8	9.2
B6288-2	Jiang et al, 2020	136	36°48′	114°7′	Wuan	64.0	1.2	35.9	2.6	41.4	616	0.07	9.53	48.4	10.9	8.1	9.5
B6018	Jiang et al, 2020	136	36°48′	114°7′	Wuan	62.7	1.4	20.4	2.0	76.0	385	0.20	7.03	41.9	10.1	7.4	8.8
B6029-1	Jiang et al, 2020	136	36°48′	114°7′	Wuan	62.3	1.6	22.7	1.9	47.6	315	0.15	8.25	45.3	10.5	7.8	9.1
B6071-2	Jiang et al, 2020	136	36°48′	114°7′	Wuan	64.7	1.1	34.7	1.9	106.0	499	0.21	12.61	54.3	11.6	8.6	10.1
B6072	Jiang et al, 2020	136	36°48′	114°7′	Wuan	61.2	1.6	31.5	2.2	100.0	752	0.13	9.82	49.0	11.0	8.1	9.5
B6073-1	Jiang et al, 2020	136	36°48′	114°7′	Wuan	59.7	1.9	33.2	2.0	93.3	778	0.12	11.28	52.0	11.3	8.4	9.9
B6077	Jiang et al, 2020	136	36°48′	114°7′	Wuan	51.7	3.8	20.5	1.9	37.3	459	0.08	7.37	42.9	10.2	7.5	8.9
B6007	Jiang et al, 2020	136	36°48′	114°7′	Wuan	61.0	1.1	21.3	1.7	38.0	372	0.10	8.36	45.6	10.6	7.8	9.2
B6875a	Jiang et al, 2020	136	36°48′	114°7′	Wuan	56.1	1.0	36.8	2.3	23.1	323	0.07	10.78	51.0	11.2	8.3	9.8
B6920	Jiang et al, 2020	136	36°48′	114°7′	Wuan	57.4	2.1	33.7	2.1	18.9	320	0.06	10.95	51.4	11.2	8.3	9.8
PM3-5b14	Jiang et al, 2020	136	36°48′	114°7′	Wuan	57.3	2.1	28.3	1.9	44.4	373	0.12	10.07	49.6	11.0	8.2	9.6
KS0816-2	Jiang et al, 2020	136	36°48′	114°7′	Wuan	61.3	1.6	37.1	2.1	101.0	774	0.13	11.83	53.0	11.4	8.5	10.0
TW2832	Jiang et al, 2020	124	36°48′	114°7′	Wuan	60.6	3.4	27.7	1.4	44.4	902	0.05	13.35	55.6	11.7	8.8	10.2

PM3-5b1a	Jiang et al, 2020	136	36°48′	114°7′	Wuan	57.5	1.3	21.6	1.9	55.7	317	0.18	7.60	43.6	10.3	7.6	9.0
PM3-5b4c	Jiang et al, 2020	136	36°48′	114°7′	Wuan	59.0	1.2	34.5	2.4	47.0	383	0.12	9.68	48.7	10.9	8.1	9.5
PM3-5b7b	Jiang et al, 2020	136	36°48′	114°7′	Wuan	56.8	1.1	28.4	2.0	53.7	381	0.14	9.70	48.8	10.9	8.1	9.5
B6393	Jiang et al, 2020	136	36°48′	114°7′	Wuan	56.5	1.4	28.2	2.4	58.9	411	0.14	8.05	44.8	10.5	7.7	9.1
B6969	Jiang et al, 2020	136	36°48′	114°7′	Wuan	58.7	1.4	31.7	2.0	61.0	597	0.10	10.56	50.6	11.2	8.3	9.7
07FS09	Sun et al., 2010	130	40°30′	116°40′	Fangshan	63.2	1.7	44.6	1.7	68.4	1074	0.06	18.25	62.2	12.5	9.4	11.0
08FS02	Sun et al., 2010	134	40°30′	116°40′	Fangshan	61.6	2.5	53.5	1.7	79.9	1150	0.07	21.76	66.0	13.0	9.8	11.4
08FS10	Sun et al., 2010	132	40°30′	116°40′	Fangshan	63.2	2.1	56.6	1.3	77.4	1186	0.07	30.76	73.3	13.9	10.5	12.2
LY038-2	Zhang et al., 2016	128	39°20′	114°55′	Wanganzhen	65.7	1.7	31.3	1.4	57.7	616	0.09	15.53	58.8	12.1	9.1	10.6
LY036-3	Zhang et al., 2016	128	39°20′	114°55′	Wanganzhen	65.2	1.1	41.4	1.1	53.6	373	0.14	25.54	69.4	13.4	10.1	11.7
LY083-2	Zhang et al., 2016	130	39°20′	114°55′	Wanganzhen	67.1	1.8	43.4	1.3	33.2	460	0.07	23.59	67.7	13.2	9.9	11.6
ly038-1	Zhang et al., 2016	128	39°20′	114°55′	Wanganzhen	57.8	3.6	47.7	1.8	33.0	522	0.06	17.7	61.6	12.5	9.3	10.9
LY038-1	Zhang et al., 2016	128	39°20′	114°55′	Wanganzhen	61.6	2.2	37.1	1.6	65.4	821	0.08	15.45	58.7	12.1	9.1	10.6
ly027-1	Zhang et al., 2016	128	39°20′	114°55′	Wanganzhen	62.9	2.8	51.0	1.8	30.6	539	0.06	18.93	63.0	12.6	9.5	11.0
ly039-2	Zhang et al., 2016	128	39°20′	114°55′	Wanganzhen	62.5	2.5	66.9	1.9	54.1	395	0.14	23.54	67.6	13.2	9.9	11.5
ly025-3	Zhang et al., 2016	128	39°20′	114°55′	Wanganzhen	64.1	2.5	52.3	1.3	45.0	394	0.11	27.54	71.0	13.6	10.2	11.9
LY026-2	Zhang et al., 2016	128	39°20′	114°55′	Wanganzhen	68.8	1.4	35.2	1.0	59.4	689	0.09	24.39	68.4	13.3	10.0	11.6
LY026-1A	Zhang et al., 2016	128	39°20′	114°55′	Wanganzhen	68.8	1.2	33.4	1.0	67.6	587	0.12	23.61	67.7	13.2	9.9	11.6
MP1/1	He et al., 2014	130	38°44′	114°8′	Mapeng	63.8	2.3	38.1	1.7	101.0	445	0.23	14.88	57.9	12.0	9.0	10.5
ZKS002-8-1	Chu et al., 2021	129	36°55′	114°20′	Hongshan	60.9	1.9	22.8	2.2	48.1	475	0.10	7.07	42.1	10.1	7.5	8.8
ZKSS002-8-2	Chu et al., 2021	129	36°55′	114°20′	Hongshan	61.1	1.8	24.7	2.4	53.9	487	0.11	7.05	42.0	10.1	7.4	8.8
ZKS002-11-2	Chu et al., 2021	129	36°55′	114°20′	Hongshan	62.1	1.1	16.4	1.6	124.0	715	0.17	7.01	41.9	10.1	7.4	8.8
WA1271-H	Sun et al., 2019	130	36°45′	114°20′	Hongshan	59.2	3.8	29.4	1.6	46.8	937.7	0.05	12.78	54.6	11.6	8.7	10.1
BLS-ZK01-4	Sun et al., 2019	130	36°45′	114°20′	Hongshan	57.3	2.5	26.3	1.6	61.7	697.2	0.09	11.08	51.6	11.3	8.4	9.8
BLS-ZK01-5	Sun et al., 2019	130	36°45′	114°20′	Hongshan	59.0	2.1	28.8	1.7	59.2	676.7	0.09	11.63	52.6	11.4	8.5	9.9
BLS-ZK01-6	Sun et al., 2019	130	36°45′	114°20′	Hongshan	59.2	2.0	31.5	1.7	58.1	585.7	0.10	12.90	54.8	11.7	8.7	10.2
BLS-ZK01-7	Sun et al., 2019	130	36°45′	114°20′	Hongshan	58.2	2.2	32.0	1.7	60.3	388.5	0.16	12.57	54.3	11.6	8.6	10.1
BLS-ZK01-8	Sun et al., 2019	130	36°45′	114°20′	Hongshan	59.0	2.3	32.4	1.7	67.9	437.9	0.16	12.88	54.8	11.7	8.7	10.2
BLS-ZK01-13	Sun et al., 2019	130	36°45′	114°20′	Hongshan	57.2	2.2	23.6	1.9	26.3	489.2	0.05	8.36	45.6	10.6	7.8	9.2
BLS-ZK01-17	Sun et al., 2019	130	36°45′	114°20′	Hongshan	55.5	3.9	32.3	1.9	26.2	339.9	0.08	11.42	52.2	11.4	8.4	9.9
BLS-ZK01-19	Sun et al., 2019	130	36°45′	114°20′	Hongshan	59.3	3.0	28.5	2.0	22.0	269.3	0.08	9.72	48.8	10.9	8.1	9.5
BLS-ZK01-20	Sun et al., 2019	130	36°45′	114°20′	Hongshan	58.6	2.3	23.6	1.6	88.5	628.7	0.14	9.77	48.9	11.0	8.1	9.5
BLS-ZK01-21	Sun et al., 2019	130	36°45′	114°20′	Hongshan	57.0	2.6	17.7	1.8	77.6	576.9	0.13	6.87	41.4	10.1	7.4	8.7
BLS-ZK01-22	Sun et al., 2019	130	36°45′	114°20′	Hongshan	55.5	2.1	28.6	1.9	93.4	613.7	0.15	10.34	50.1	11.1	8.2	9.7
HS02-H1	Sun et al., 2019	134	36°45′	114°20′	Hongshan	57.6	3.1	28.1	1.7	104.8	922.8	0.11	10.96	51.4	11.2	8.3	9.8
HS04-H1	Sun et al., 2019	134	36°45′	114°20′	Hongshan	61.2	1.1	31.3	1.9	139.2	2041.6	0.07	11.32	52.1	11.3	8.4	9.9
SX108-6	Wang et al., 2017	127	35°50′	111°50′	Laoshan	57.3	1.4	28.1	2.2	139.0	706	0.20	8.68	46.4	10.7	7.9	9.3

DK-11	Xi et al., 2021	126	36°40′	113°40′	Fushan	57.6	3.8	20.7	1.3	45.0	713	0.06	10.82	51.1	11.2	8.3	9.8
DK-13	Xi et al., 2021	126	36°40′	113°40′	Fushan	60.8	2.8	30.7	1.6	47.0	985	0.05	13.12	55.2	11.7	8.7	10.2
B7240	Cui et al., 2022	129	36°40′	113°40′	Fushan	58.6	2.9	27.4	1.7	45.0	806	0.06	11.15	51.7	11.3	8.4	9.8
B8809	Cui et al., 2022	122	36°40′	113°40′	Fushan	57.7	3.1	33.3	2.0	53.3	806	0.07	11.44	52.3	11.4	8.4	9.9
B7228-2	Cui et al., 2022	122	36°40′	113°40′	Fushan	58.1	3.4	32.9	1.9	47.9	795	0.06	11.50	52.4	11.4	8.4	9.9
fs1881	Cui et al., 2022	122	36°40′	113°40′	Fushan	61.2	3.7	30.8	1.5	38.5	674	0.06	13.85	56.3	11.8	8.8	10.3
P33-1	Wang et al., 2013	126	na	na	Pingshun	56.21	2.8	22.8	1.78	42	776	0.05	8.70	46.5	10.7	7.9	9.3
P34-1	Wang et al., 2013	126	na	na	Pingshun	59.45	2.7	22.4	1.51	51	734	0.07	10.08	49.6	11.0	8.2	9.6
P39-1	Wang et al., 2013	126	na	na	Pingshun	57.96	3.0	22.5	1.66	44.4	770	0.06	9.21	47.7	10.8	8.0	9.4
20HD-69	Peng et al., 2004	126	36°30′	113°45′	Dongzhi	56.88	3.1	31.9	1.78	45	755	0.06	12.17	53.6	11.5	8.6	10.0
ZJS02	Ying et al., 2007	127	37°57′	110°59′	Zijinshan	58.2	1.6	41.3	2.18	118	1607	0.07	12.87	54.8	11.7	8.7	10.2
03ZJS13	Ying et al., 2007	127	37°57′	110°59′	Zijinshan	55	2.5	35.9	2.04	99.5	1702	0.06	11.96	53.2	11.5	8.5	10.0
RFS-24	Si et al., 2015	131	35°50′	111°33′	Fushan	57.39	1.1	53.7	3.06	111	1270	0.09	11.92	53.2	11.5	8.5	10.0
RFS-27	Si et al., 2015	131	35°50′	111°33′	Fushan	57.17	1.2	50.3	2.86	99.9	1299	0.08	11.95	53.2	11.5	8.5	10.0
HD14-17	Yang et al., 2017	129	35°53′	111°40′	Ertashan	62.15	1.1	26	1.7	72.2	1193	0.06	10.39	50.2	11.1	8.2	9.7

Data filtering follows the principle of Chapman et al (2020)

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Table S4 intermediate igneous zircons grain Eu* anomaly.

Sample	Reference	Age (Ma)	La_ppm	Sm_ppm	Eu_ppm	Gd_ppm	Th_ppm	U_ppm	Th/U	Eu/Eu*	Z (km)	Z min	Z max
HS02-N-01	Sun et al., 2015	134.5	0.050	3.69	0.91	19.3	916	1146	0.8	0.330	52.3	45.9	58.6
HS02-N-02		134.5	0.016	4.06	1	18.7	862	1072	0.8	0.351	54.0	47.5	60.6
HS02-N-03		134.5	0.170	10.60	2.63	44	3637	2583	1.4	0.372	55.8	49.1	62.6
HS02-N-04		134.5	0.120	9.13	1.48	38.3	1165	1406	0.8	0.242	44.9	39.3	50.4
HS02-N-05		134.5	0.240	12.00	2.31	50.5	1670	1673	1.0	0.287	48.7	42.7	54.6
HS02-N-06		134.5	0.011	2.87	0.6	17.7	1457	1358	1.1	0.257	46.2	40.5	51.8
HS02-N-07		134.5	0.170	31.00	8.8	162	4858	2767	1.8	0.380	56.5	49.7	63.3
HS02-N-08		134.5	0.250	17.90	3.08	49.1	656	701	0.9	0.318	51.2	45.0	57.5
HS02-N-09		134.5	0.150	8.39	1.83	31.6	1445	2091	0.7	0.344	53.4	47.0	59.9
HS02-N-10		134.5	0.030	2.89	1.05	14.9	858	1422	0.6	0.489	65.7	57.9	73.5
HS02-N-11		134.5	0.057	8.05	1.94	34.2	1143	1632	0.7	0.357	54.6	48.0	61.2
HS02-N-12		134.5	0.047	5.37	1.58	26.7	933	1261	0.7	0.403	58.5	51.5	65.5
HS02-N-13		134.5	0.022	5.40	1.11	19	2503	1936	1.3	0.335	52.7	46.3	59.1
D55-04	Li et al., 2014	134	0.27	5.62	1.44	23.04	153	100	1.5	0.387	57.1	50.2	63.9
D55-05		134	0.56	4.81	1.03	19.41	120	110	1.1	0.326	51.9	45.6	58.2
D55-12		134	0.97	5.79	1.02	18.57	87	104	0.8	0.301	49.8	43.8	55.9
D55-13		134	0.99	4.5	0.85	16.85	123	116	1.1	0.298	49.6	43.6	55.7
D55-14		134	0.41	10.27	1.91	39.79	145	125	1.2	0.289	48.8	42.9	54.8
D55-16		134	0.18	12.39	2.52	39.56	145	102	1.4	0.348	53.8	47.3	60.3
D55-17		134	0.09	7.42	1.44	26.35	107	94	1.1	0.315	51.0	44.8	57.2
D55-19		134	0.05	3.97	0.83	17.74	92	104	0.9	0.302	50.0	43.9	56.0
D55-20		134	0.44	7.91	2.83	30.53	163	188	0.9	0.557	71.4	63.0	79.8
D55-21		134	0.11	8.04	3.17	34.44	325	162	2.0	0.582	73.5	64.9	82.2
D55-22		134	0.34	6.72	2.61	28.2	242	125	1.9	0.580	73.3	64.7	81.9
D55-23		134	0.12	8.59	1.21	29.21	141	154	0.9	0.234	44.2	38.7	49.6
D55-25		134	0.58	7.22	1.66	27.09	161	155	1.0	0.363	55.1	48.4	61.7
D55-24		134	0.27	20.37	3.31	71.68	648	299	2.2	0.265	46.8	41.1	52.5
D55-26		134	0.02	5.14	0.88	20.82	131	127	1.0	0.260	46.4	40.7	52.1
D55-29		134	0.18	2.73	0.45	10.84	84	132	0.6	0.253	45.8	40.2	51.4
D55-30		134	0.09	14.31	2.5	51.4	320	168	1.9	0.282	48.2	42.3	54.1
D55-38		134	0.1	7.15	1.63	30.44	104	103	1.0	0.338	52.9	46.5	59.3
D55-39		134	0.02	4.05	0.59	17.32	93	103	0.9	0.215	42.6	37.4	47.9
D55-40		134	0.67	11.37	2.41	36.37	125	96	1.3	0.362	55.0	48.4	61.6
D55-41		134	0.03	9.47	3.48	39.28	363	135	2.7	0.552	70.9	62.6	79.3

D55-42	134	0.02	4.93	1.05	19.42	83	91	0.9	0.328	52.1	45.8	58.4	
D55-44	134	0.21	42.27	15.05	123.91	284	139	2.1	0.636	78.0	68.9	87.2	
D55-47	134	0.27	4.91	1.37	18.32	74	91	0.8	0.442	61.7	54.3	69.0	
D55-48	134	0.11	4.58	0.64	20.12	88	134	0.7	0.204	41.7	36.5	46.8	
D55-51	134	0.06	5.27	0.9	22.96	136	125	1.1	0.250	45.6	40.0	51.2	
D55-52	134	0.2	12.23	2.81	46.17	166	124	1.3	0.362	54.9	48.3	61.6	
D55-56	134	0.16	3.72	0.74	17.27	76	81	0.9	0.282	48.3	42.4	54.2	
D55-34	134	0.07	7.04	2.32	31.91	256	134	1.9	0.473	64.3	56.7	72.0	
D55-08	134	0.32	6.7	1.33	28.14	188	140	1.3	0.296	49.4	43.4	55.5	
D55-57	134	0.36	35.16	13.05	105.01	341	163	2.1	0.657	79.8	70.4	89.1	
D55-07	134	0.07	6.29	1.72	27.98	109	117	0.9	0.396	57.9	50.9	64.8	
D55-02	134	0.03	3.92	0.53	16.32	104	102	1.0	0.203	41.6	36.4	46.7	
D55-60	134	0.51	7.23	1.09	27.92	256	322	0.8	0.235	44.2	38.8	49.7	
D55-58	134	0.25	7.8	1.49	29.64	230	365	0.6	0.300	49.7	43.7	55.8	
4	133	0.27	5.62	1.44	23	153	99.5	1.5	0.387	57.1	50.2	64.0	
5	133	0.56	4.81	1.03	19.4	120	110	1.1	0.326	51.9	45.6	58.2	
12	133	0.97	5.79	1.02	18.6	86.8	104	0.8	0.300	49.8	43.7	55.9	
13	133	0.99	4.5	0.85	16.9	125	116	1.1	0.298	49.6	43.5	55.6	
14	133	0.41	10.3	1.91	39.8	145	125	1.2	0.288	48.8	42.8	54.7	
16	133	0.18	12.4	2.52	39.6	145	102	1.4	0.348	53.8	47.3	60.3	
17	133	0.09	7.42	1.44	26.4	7	94.3	0.1	0.315	51.0	44.8	57.2	
19	133	0.05	3.97	0.83	17.7	121	108	1.1	0.303	50.0	43.9	56.1	
20	133	0.44	7.91	2.83	30.5	163	188	0.9	0.557	71.4	63.0	79.8	
21	133	0.11	8.04	3.17	34.4	325	162	2.0	0.583	73.6	64.9	82.2	
22	133	0.34	6.72	2.61	28.2	242	125	1.9	0.580	73.3	64.7	81.9	
23	133	0.12	8.59	1.21	29.2	141	154	0.9	0.234	44.2	38.7	49.6	
25	133	0.58	7.22	1.66	27.1	161	155	1.0	0.363	55.0	48.4	61.7	
24	133	0.27	20.4	3.61	71.7	648	299	2.2	0.289	48.8	42.8	54.8	
26	133	0.02	5.14	0.88	20.8	131	127	1.0	0.260	46.4	40.7	52.1	
29	133	0.18	2.73	0.45	10.8	84.1	132	0.6	0.253	45.8	40.2	51.5	
30	Song et al.,2015	133	0.09	14.3	2.5	51.4	320	168	1.9	0.282	48.2	42.3	54.1
38		133	0.1	7.15	1.63	30.4	104	103	1.0	0.338	53.0	46.6	59.4
40		133	0.67	11.4	2.41	36.4	125	95.6	1.3	0.362	55.0	48.3	61.6
41		133	0.03	9.47	3.48	39.3	363	135	2.7	0.551	70.9	62.6	79.3
42		133	0.02	4.93	1.05	19.4	82.6	90.9	0.9	0.328	52.1	45.8	58.5
44		133	0.21	42.3	15.1	124	284	139	2.0	0.637	78.2	69.0	87.3
47		133	0.27	4.91	1.37	18.3	74.5	90.7	0.8	0.442	61.7	54.3	69.1

48	133	0.11	4.58	0.64	20.1	na	na	na	0.204	41.7	36.5	46.8	
51	133	0.06	5.27	0.9	23	136	125	1.1	0.250	45.5	39.9	51.1	
52	133	0.2	12.2	2.81	46.2	166	124	1.3	0.362	55.0	48.3	61.6	
56	133	0.16	3.72	0.74	17.3	76.3	80.5	0.9	0.282	48.2	42.4	54.1	
34	133	0.07	7.04	2.32	31.9	256	134	1.9	0.473	64.4	56.7	72.0	
8	133	0.32	6.7	1.33	28.1	188	140	1.3	0.296	49.5	43.4	55.5	
57	133	0.36	35.2	13.1	105	341	163	2.1	0.659	80.0	70.6	89.3	
7	133	0.07	6.29	1.72	28	109	117	0.9	0.396	57.9	50.9	64.8	
2	133	0.03	3.92	0.53	16.3	104	102	1.0	0.203	41.6	36.4	46.7	
60	133	0.51	7.23	1.09	27.9	256	322	0.8	0.235	44.3	38.8	49.7	
58	133	0.25	7.8	1.49	29.6	230	365	0.6	0.300	49.7	43.7	55.8	
HS06-1	134.1	0.03	2.2	0.54	10.53	471	436	1.1	0.343	53.4	46.9	59.8	
HS06-2	134.1	0.01	2.45	0.53	10.64	445	411	1.1	0.317	51.2	45.0	57.4	
HS06-3	134.1	0.13	6.09	1.52	24.7	1910	1009	1.9	0.379	56.4	49.6	63.2	
HS06-4	134.1	0.07	5.07	0.87	21.05	597	534	1.1	0.257	46.2	40.5	51.8	
HS06-5	134.1	0.14	6.76	1.31	27.76	865	640	1.4	0.292	49.1	43.1	55.1	
HS06-6	134.1	0.09	1.75	0.48	8.85	551	599	0.9	0.373	55.9	49.2	62.6	
HS06-7	134.1	0	1.5	0.32	8.74	690	487	1.4	0.270	47.2	41.5	53.0	
HS06-9	Sun et al., 2019	134.1	0.13	8.1	1.65	28.65	337	269	1.3	0.331	52.4	46.0	58.7
HS06-10		134.1	0.09	4.83	1.01	18.34	776	812	1.0	0.328	52.1	45.8	58.4
HS06-11		134.1	0.03	1.65	0.66	8.98	444	545	0.8	0.524	68.6	60.5	76.8
HS06-12		134.1	0.04	3.69	0.77	14.88	796	468	1.7	0.318	51.2	45.0	57.5
HS06-13		134.1	0.03	4.51	1.08	18.34	593	628	0.9	0.363	55.1	48.4	61.7
HS06-14		134.1	0.03	3.01	0.85	14.26	477	482	1.0	0.397	57.9	50.9	64.8
HS06-15		134.1	0.02	3.16	0.81	13.75	500	648	0.8	0.376	56.1	49.4	62.9
HS06-16		134.1	0	3	0.63	10.03	1307	750	1.7	0.351	54.1	47.5	60.6

Data filtering following the principle of Tang et al (2021)

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