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Supplementary Information

1. Tables S1 – S4
2. Figures S1 – S2
3. References

1. Tables

Table S1 – Compilation of apparent *n*-alkane-precipitation fractionation factors used to infer the δD of precipitation.

Source/Location	Plant Species	$\alpha_{C29\text{-}precip}$
Chikaraishi & Naraoka (2003)[a]		
Tokyo, Japan	*Quercus acutissima*	0.892
"	*Camellia sasanqua*	0.870
"	*Chamaecyparis obtusa*	0.887
"	*Pinus thunbergii*	0.873
Ogasawara, Japan	*Albizia julibrissin*	0.914
Gunma, Japan	*Benthamidia japonica*	0.896
Gunma, Japan	*Acer carpinifolium*	0.921
Gunma, Japan	*Acer argutum*	0.937
Gunma, Japan	*Phrogmites communis*	0.845
Gunma, Japan	*Benthamidia japonica*	0.883
Gunma, Japan	*Prunus jamasakura*	0.869
Gunma, Japan	*Acer carpinifolium*	0.893
Gunma, Japan	*Acer argutum*	0.933
Gunma, Japan	*Taraxacum offcinale*	0.899
Gunma, Japan	*Plantago asiatica*	0.874
Gunma, Japan	*Artemisia princeps*	0.897
Gunma, Japan	*Acer palmatum*	0.882
Gunma, Japan	*Quercus mongolica*	0.864
Gunma, Japan	*Quercus dentata*	0.859
Gunma, Japan	*Cryptomeria japonica*	0.898
Gunma, Japan	*Cryptomeria japonica*	0.885
Thailand	*Manihot utilissima*	0.902
Bi et al. (2005)[b]		
Guangzhou, China	*Euphorbia pulcherrima Willd.*	0.833
"	*Codiaeum variegatum (L.)*	0.878
"	*Ficus altissima Bl.*	0.867
"	*Ficus microcarpa Linn. f.*	0.852
"	*Osmanthus fragrans Lour.*	0.858
"	*Kigelia africana (am.) Benth.*	0.875
"	*Syzygium cumini (L.) Skeels*	0.872
"	*Swietenia mahagoni (L.) Jacq.*	0.862
"	*Pistia stratiotes*	0.872
"	*Caryota mitis Lour.*	0.835
"	*Cinnamomum burmanni (Nees) Bl.*	0.825
"	*Araucaria cunninghamii Sweet*	0.926

Table S1 – continued.

Source/Location	Plant Species	$\alpha_{C29\text{-}precip}$
Bi et al. (2005)[b]		
Guangzhou, China	*Alternanthera dentata 'Rubiginosa'*	0.828
"	*Alternanthera versicolor Regel*	0.822
"	*Alternanthera bettzickiana (Regel) Nichols.*	0.824
"	*Holmskioldia sanguinea Retz.*	0.827
Sachse et al. (2006)[b]		
Holzmaar, Germany	*Betula pendula*	0.884
Castigliano, Italy	*Quercus robur*	0.877
Lago Grande di Monticchio, Italy	*Fagus sylvatica*	0.893
Lago di Massachiucoli, Italy	*Alnus incana*	0.862
"	*Quercus cerris*	0.862
"	*Quercus variabilis*	0.855
Lago di Mezzano, Italy	*Carpinus betulus*	0.888
"	*Quercus petraea*	0.879
Luosto, Finland	*Betula pendula*	0.930
Pääjarvi, Finland	*Betula pendula*	0.924
Tunturilampi, Finland	*Betula pendula*	0.909
Kiuvajärvi, Finland	*Betula pendula*	0.894
Syrjänalunen, Finland	*Myrte*	0.846
Liu et al. (2006)[b]		
Ertuokeqi, China	*Citibetica kom*	0.887
"	*Asparagus oYcinalis*	0.888
"	*Oxytropis aciphylla*	0.891
"	*Caragana stenophylla*	0.921
Yanan, China	*Artemisia scoparia*	0.914
"	*Vitex negundo*	0.911
"	*Sviciifolia hance*	0.942
"	*Dracocephalum moldavica*	0.887
Yanchi, China	*Peganum harmala*	0.893
Yijun, China	*Lespedeza davurica*	0.919
Yingchuan, China	*Oxytropis aciphylla*	0.890
Huanglong, China	*Pinus tabulaeformis*	0.915
"	*Pinus tabulaeformis*	0.914
	Average	**0.883**
	±1σ	**0.030**

[a] $\alpha_{C29\text{-}precip}$ values calculated from this reference are relative to the δD of Tokyo rainfall, Haruna lake water and rain in Thailand collected and reported in the same reference.

[b] $\alpha_{C29\text{-}precip}$ values calculated relative to mean annual precipitation δD estimated from the OIPC at www.waterisotopes.org (Bowen and Revenaugh, 2003).

Table S2 – Hydrogen isotopic composition of standards determined by offline pyrolysis and dual-inlet IRMS (dual-inlet), conventional GC-IRMS (conventional), and size-corrected GC-IRMS (small-peak). The isotopic difference between normal GC-IRMS and the accepted value (Δ_{C-A}) and small- vs. normal-peak GC-IRMS (Δ_{S-C}) indicate the accuracy of both measurements.

	dual-inlet (a)		conventional GC-IRMS (b)				small-peak GC-IRMS (c)			
n -alkane	δD	±1σ	δD	±1σ	Δ_{C-A}	±1σ	δD	±1σ	Δ_{S-C}	±1σ
16	-76.7	1.7	-78	3.5	-1.6	3.9	-81	4.4	-2.5	5.2
17	-142.4	1.7	-145	2.8	-2.7	3.2	-146	2	-0.4	2.9
18	-53.8	2.1	-57	3.1	-3.3	3.7	-57	3.2	0.3	4
19	-118	2	-122	2.3	-3.6	3.1	-127	3.6	-5.2	4
20	-52.6	0.8	-51	3.8	2.1	3.9	-45	6.9	5.8	7.7
21	-214.7	2	-212	2.9	2.3	3.5	-216	7	-3.6	7.4
22	-62.8	1.6	-59	2.2	3.7	2.7	-63	7.4	-4.1	7.6
23	-48.8	1.4	-44	2.2	4.7	2.6	-49	8.2	-4.6	8.3
24	-53	1.6	-52	3.1	1.4	3.5	-55	6	-3.6	6.4
25	-254.7	1.6	-255	1.6	-0.2	2.3	-257	7.4	-2.4	7.6
26	-54.9	1.5	-59	2.4	-4.1	2.8	-63	10	-4.4	10.1
27	-227.3	2	-225	3	2.3	3.6	-223	8	2	8.6
28	-49	1.5	-51	2.7	-2.3	3	-48	13.6	3.8	13.8
29	-179.3	2.7	-180	2.3	-0.6	3.5	-179	7.1	1	7.3
30	-46.3	2.1	-44	2.5	1.9	3.3	-40	8.2	3.9	8.4
mean					*0.01*				*-0.92*	
rmse					*2.84*				*3.69*	

(a) Determined by Arndt Schimmelmann, Indiana U. (http://geology.indiana.edu/schimmelmann/)

(b) n=16

(c) n=5

Table S3 – Soil water, lake water and precipitation isotope compositions calculated from calcite and *n*-alkane isotope measurements. Oxygen isotope values for Dingqinghu and Niubao Formations are from Rowley and Currie (2006), Wudaoling values are unpublished (D.B. Rowley, unpublished data) and M. Fenghuoshan data are from Cyr et al. (2005).

Formation	Sample	Material	$\delta^{13}C_{cc}$ (‰ VPDB)	$\delta^{18}O_{cc}$ (‰ VPDB)	$\delta^{18}O_{cc}$ (‰ VSMOW)	Temp.[a] (°C)	± 1σ	$\alpha_{cc\text{-}H2O}$[b]	± 1σ	$\delta^{18}O_{water}$ (‰ VSMOW)	± 1σ[c]	δD_{C29} (‰ VSMOW)	δD_{water} (‰ VSMOW)	± 1σ[d]	$\delta^{18}O_{precip.}$ (‰ VSMOW)	$\delta D_{precip.}$ (‰ VSMOW)
Dingqinghu	292A	lake sed.	0.3	-5.2	25.6	10	10	1.0323	0.0025	-6.5	2.4					
Dingqinghu	292C	lake sed.	-0.7	-4.3	26.5	10	10	1.0323	0.0025	-5.6	2.4					
Dingqinghu	292D	lake sed.	-0.5	-7.2	23.5	10	10	1.0323	0.0025	-8.5	2.4					
Dingqinghu	296	lake sed.	-1.0	-9.2	21.4	10	10	1.0323	0.0025	-10.5	2.4					
Dingqinghu	297	lake sed.	-5.9	-1.3	29.6	10	10	1.0323	0.0025	-2.6	2.5					
Dingqinghu	297B	lake sed.	-1.5	-4.8	26.0	10	10	1.0323	0.0025	-6.1	2.4					
Dingqinghu	298A	lake sed.	-2.5	-6.1	24.7	10	10	1.0323	0.0025	-7.4	2.4					
Dingqinghu	298B	lake sed.	0.0	-7.1	23.6	10	10	1.0323	0.0025	-8.4	2.4					
Dingqinghu	298C	lake sed.	1.7	-5.3	25.4	10	10	1.0323	0.0025	-6.6	2.4					
Dingqinghu	299A	lake sed.	2.5	-6.7	24.0	10	10	1.0323	0.0025	-8.0	2.4	-236	-135	29	-19.5	-146
Dingqinghu	299B	lake sed.	-6.7	-14.6	15.8	10	10	1.0323	0.0025	-15.9	2.4					
Dingqinghu	299C	lake sed.	-8.3	-0.4	30.5	10	10	1.0323	0.0025	-1.7	2.5	-219	-115	33	-17.6	-131
Dingqinghu	300A	lake sed.	-0.3	-5.1	25.7	10	10	1.0323	0.0025	-6.4	2.4					
Dingqinghu	300B	lake sed.	0.9	-4.3	26.4	10	10	1.0323	0.0025	-5.7	2.4					
Dingqinghu	301	lake sed.	0.5	-8.9	21.7	10	10	1.0323	0.0025	-10.2	2.4	-230	-128	30	-18.2	-136
									mean ± s.d.	*-7.3 ±3.4*		*-228.1 ±8.9*	*-125.8 ±10*		*-18.4 ±1*	*-137.5 ±7.8*
U. Niubao	305B	paleosol	-7.9	-17.7	12.7	10	10	1.0323	0.0025	-19.0	2.4					
U. Niubao	305D	paleosol	-7.8	-17.6	12.7	10	10	1.0323	0.0025	-18.9	2.4					
U. Niubao	305G	paleosol	-7.8	-17.5	12.9	10	10	1.0323	0.0025	-18.8	2.4					
U. Niubao	305I	paleosol	-7.9	-17.3	13.1	10	10	1.0323	0.0025	-18.6	2.4					
U. Niubao	305J	paleosol	-8.2	-17.8	12.6	10	10	1.0323	0.0025	-19.1	2.4					
U. Niubao	305L	paleosol	-8.0	-16.8	13.6	10	10	1.0323	0.0025	-18.1	2.4					
U. Niubao	305O	paleosol	-7.5	-17.3	13.1	10	10	1.0323	0.0025	-18.6	2.4					
U. Niubao	305P	paleosol	-7.4	-17.4	13.0	10	10	1.0323	0.0025	-18.7	2.4					
U. Niubao	305Q	paleosol	-7.5	-18.0	12.4	10	10	1.0323	0.0025	-19.3	2.4					
U. Niubao	305R	paleosol	-7.5	-17.4	13.0	10	10	1.0323	0.0025	-18.7	2.4					
U. Niubao	305S	paleosol	-7.3	-17.6	12.8	10	10	1.0323	0.0025	-18.9	2.4					
U. Niubao	305T	paleosol	-7.3	-17.5	12.8	10	10	1.0323	0.0025	-18.8	2.4					
					12.9 ±0.3				*mean ± s.d.*	*-18.8 ±0.3*						

Table S3 – continued.

Formation	Sample	Material	$\delta^{13}C_{cc}$ (‰ VPDB)	$\delta^{18}O_{cc}$ (‰ VPDB)	$\delta^{18}O_{cc}$ (‰ VSMOW)	Temp. (°C)	± 1σ[a]	$\alpha_{cc\text{-}H2O}$	± 1σ[a]	$\delta^{18}O_{water}$ (‰ VSMOW)	± 1σ[a]	δD_{C29} (‰ VSMOW)	δD_{water} (‰ VSMOW)	± 1σ[b]	$\delta^{18}O_{precip.}$ (‰ VSMOW)	$\delta D_{precip.}$ (‰ VSMOW)	
M. Niubao	307	lake sed.	-7.8	-15.9	14.5	10	10	1.0323	0.0025	-17.2	2.4						
M. Niubao	308	lake sed.	-7.5	-16.2	14.2	10	10	1.0323	0.0025	-17.5	2.4						
M. Niubao	309	lake sed.	-7.4	-16.4	14.0	10	10	1.0323	0.0025	-17.7	2.4						
M. Niubao	310	lake sed.	-6.7	-15.5	15.0	10	10	1.0323	0.0025	-16.8	2.4						
M. Niubao	316	lake sed.	-4.4	-13.8	16.7	10	10	1.0323	0.0025	-15.1	2.4	-198	-91	29	-15.1	-91	e
M. Niubao	318A	lake sed.	-1.5	-3.2	27.6	10	10	1.0323	0.0025	-4.5	2.4						
M. Niubao	318B	lake sed.	-1.8	-3.3	27.6	10	10	1.0323	0.0025	-4.6	2.4						
M. Niubao	320	lake sed.										-205	-99	31			
M. Niubao	326	lake sed.	-1.6	-5.2	25.6	10	10	1.0323	0.0025	-6.5	2.4						
M. Niubao	327	lake sed.	-1.9	-13.6	16.9	10	10	1.0323	0.0025	-14.9	2.4	-198	-92	31	-14.9	-92	e
M. Niubao	328	lake sed.	-0.5	-5.2	25.5	10	10	1.0323	0.0025	-6.6	2.4						
M. Niubao	329	lake sed.	-3.1	-6.1	24.6	10	10	1.0323	0.0025	-7.4	2.4						
M. Niubao	330A	lake sed.	-1.6	-4.8	26.0	10	10	1.0323	0.0025	-6.1	2.4						
M. Niubao	330B	lake sed.	-1.8	-5.2	25.6	10	10	1.0323	0.0025	-6.5	2.4						
M. Niubao	330C	lake sed.	-1.3	-5.0	25.8	10	10	1.0323	0.0025	-6.3	2.4	-217	-114	30	-16.8	-124	
									mean ± s.d.	*-10.6 ±5.5*		*-204.4 ±9.2*	*-99 ±10.4*		*-15.6 ±1*	*-102.4 ±18.8*	
Wudaoling	156A	lake sed.	2.2	-8.0	22.7	10	10	1.0323	0.0025	-9.3	2.4						
Wudaoling	156B	lake sed.	2.1	-8.1	22.6	10	10	1.0323	0.0025	-9.4	2.4	-201	-96	31	-13.8	-100	
Wudaoling	156D	lake sed.										-200	-94	31			
Wudaoling	157	lake sed.	3.4	-5.2	25.6	10	10	1.0323	0.0025	-6.5	2.4	-198	-92	31	-13.7	-100	
Wudaoling	158A	lake sed.										-203	-97	31			
Wudaoling	158C	lake sed.	2.3	-7.4	23.3	10	10	1.0323	0.0025	-8.7	2.4	-204	-98	31	-14.2	-104	
									mean ± s.d.	*-8.5 ±1.4*		*-201.3 ±2.2*	*-95.5 ±2.5*		*-13.9 ±0.3*	*-101.2 ±2.4*	

Table S3 – continued.

Formation	Sample	Material	$\delta^{13}C_{cc}$ (‰ VPDB)	$\delta^{18}O_{cc}$ (‰ VPDB)	$\delta^{18}O_{cc}$ (‰ VSMOW)	Temp. (°C)	± 1σ[a]	$\alpha_{cc\text{-}H2O}$	± 1σ[a]	$\delta^{18}O_{water}$ (‰ VSMOW)	± 1σ[a]	δD_{C29} (‰ VSMOW)	δD_{water} (‰ VSMOW)	± 1σ[b]	$\delta^{18}O_{precip.}$ (‰ VSMOW)	$\delta D_{precip.}$ (‰ VSMOW)
M. Fenghuoshan	27	lake sed.	-3.1	-11.6	19.0	22.5	7.5	1.0293	0.0017	-10.0	1.6					
M. Fenghuoshan	29	lake sed.	-3.6	-11.2	19.4	22.5	7.5	1.0293	0.0017	-9.7	1.6					
M. Fenghuoshan	030A	lake sed.	-4.6	-10.7	19.9	22.5	7.5	1.0293	0.0017	-9.2	1.6					
M. Fenghuoshan	030B	lake sed.	-4.4	-10.5	20.1	22.5	7.5	1.0293	0.0017	-9.0	1.6					
M. Fenghuoshan	030C	lake sed.	-4.6	-10.7	19.9	22.5	7.5	1.0293	0.0017	-9.2	1.6					
M. Fenghuoshan	31	lake sed.	-5.6	-11.3	19.2	22.5	7.5	1.0293	0.0017	-9.8	1.6					
M. Fenghuoshan	031A	lake sed.	-4.5	-10.5	20.1	22.5	7.5	1.0293	0.0017	-9.0	1.6					
M. Fenghuoshan	032A	lake sed.	-3.5	-11.2	19.4	22.5	7.5	1.0293	0.0017	-9.6	1.6					
M. Fenghuoshan	032B	lake sed.	-4.2	-11.2	19.4	22.5	7.5	1.0293	0.0017	-9.7	1.6					
M. Fenghuoshan	032C	lake sed.	-3.5	-11.7	18.8	22.5	7.5	1.0293	0.0017	-10.2	1.6					
M. Fenghuoshan	033A	lake sed.	-3.1	-11.0	19.6	22.5	7.5	1.0293	0.0017	-9.4	1.6					
M. Fenghuoshan	033B	lake sed.	-3.0	-11.0	19.5	22.5	7.5	1.0293	0.0017	-9.5	1.6					
M. Fenghuoshan	033C	lake sed.	-4.5	-10.9	19.6	22.5	7.5	1.0293	0.0017	-9.4	1.6					
M. Fenghuoshan	34	lake sed.	-2.6	-11.1	19.5	22.5	7.5	1.0293	0.0017	-9.5	1.6					
M. Fenghuoshan	35	lake sed.	-3.5	-10.8	19.8	22.5	7.5	1.0293	0.0017	-9.3	1.6					
M. Fenghuoshan	36	lake sed.	-3.3	-11.1	19.5	22.5	7.5	1.0293	0.0017	-9.6	1.6					
M. Fenghuoshan	37	lake sed.	-2.3	-11.0	19.6	22.5	7.5	1.0293	0.0017	-9.5	1.6					
M. Fenghuoshan	049A	lake sed.	-6.2	-10.3	20.3	22.5	7.5	1.0293	0.0017	-8.7	1.6					
M. Fenghuoshan	049B	lake sed.	-5.8	-10.7	19.9	22.5	7.5	1.0293	0.0017	-9.1	1.6					
M. Fenghuoshan	049D	lake sed.	-4.7	-11.3	19.3	22.5	7.5	1.0293	0.0017	-9.8	1.6					
M. Fenghuoshan	050A	lake sed.	-3.4	-11.5	19.1	22.5	7.5	1.0293	0.0017	-10.0	1.6					
M. Fenghuoshan	050C	lake sed.	-4.0	-11.7	18.9	22.5	7.5	1.0293	0.0017	-10.1	1.6					
M. Fenghuoshan	052B	lake sed.	-5.4	-11.3	19.3	22.5	7.5	1.0293	0.0017	-9.7	1.6					
M. Fenghuoshan	54	lake sed.	-2.2	-11.1	19.4	22.5	7.5	1.0293	0.0017	-9.6	1.6					
M. Fenghuoshan	131A	lake sed.	-5.7	-10.7	19.9	22.5	7.5	1.0293	0.0017	-9.2	1.6					
M. Fenghuoshan	135A	lake sed.	-5.9	-11.1	19.5	22.5	7.5	1.0293	0.0017	-9.5	1.6					
M. Fenghuoshan	135B	lake sed.	-5.8	-11.0	19.5	22.5	7.5	1.0293	0.0017	-9.5	1.6					
M. Fenghuoshan	137	lake sed.	-5.3	-11.2	19.4	22.5	7.5	1.0293	0.0017	-9.7	1.6					
M. Fenghuoshan	138	lake sed.	-5.3	-11.0	19.6	22.5	7.5	1.0293	0.0017	-9.4	1.6					
M. Fenghuoshan	139	lake sed.	-6.4	-11.0	19.6	22.5	7.5	1.0293	0.0017	-9.5	1.6					
M. Fenghuoshan	140	lake sed.	-6.2	-11.1	19.4	22.5	7.5	1.0293	0.0017	-9.6	1.6					
M. Fenghuoshan	140A	lake sed.	-6.6	-11.2	19.4	22.5	7.5	1.0293	0.0017	-9.6	1.6					
M. Fenghuoshan	141	lake sed.	-7.1	-11.2	19.4	22.5	7.5	1.0293	0.0017	-9.7	1.6					
M. Fenghuoshan	143	lake sed.	-6.0	-11.3	19.3	22.5	7.5	1.0293	0.0017	-9.8	1.6					
M. Fenghuoshan	143A	lake sed.	-6.2	-11.3	19.2	22.5	7.5	1.0293	0.0017	-9.8	1.6					
M. Fenghuoshan	143B	lake sed.	-6.0	-11.4	19.1	22.5	7.5	1.0293	0.0017	-9.9	1.6					
M. Fenghuoshan	144	lake sed.	-5.0	-11.6	19.0	22.5	7.5	1.0293	0.0017	-10.1	1.6					
M. Fenghuoshan	145	lake sed.	-3.7	-11.7	18.9	22.5	7.5	1.0293	0.0017	-10.1	1.6					
M. Fenghuoshan	146	lake sed.	-4.3	-11.4	19.1	22.5	7.5	1.0293	0.0017	-9.9	1.6					
									mean ± s.d.	*-9.6 ±0.3*						

a - value and range from primary data source

b - calculated using Friedman & O'Neil (1977)

c - includes 0.1 ‰ analytical uncertainty and temperature uncertainty

d - includes analytical and apparent fractionation factor uncertainties

e - Sample plots above the GMWL, $\delta^{18}O_{water}$ and δD_{water} value used for precipitation

Table S4 – Paleoelevations calculated from the difference between high and low-elevation $\delta^{18}O_{precip}$. Values for M. Niubao, Dingqinghu and Wudaoling samples are from paired $\delta^{18}O$-δD analyses while $\delta^{18}O_{water}$ values from calcite were taken to represent $\delta^{18}O_{precip}$ for the U. Niubao and M. Fenghuoshan samples. Low-elevation precipitation for a southern moisture source (S. moisture) are from the Miocene Siwaliks while a northern moisture source (N. moisture) is estimated as +2 ‰ relative to the southern source based upon the modern difference and paleoisotope data from the Qaidam and Linxia Basins (Dettman, et al., 2003; Graham, et al., 2005; Rieser, et al., 2008). Values for Eocene low-elevation precipitation used to calculate elevations for the U. Niubao, M. Niubao and M. Fenghuoshan samples have been increased by +0.7 ‰ to account for Eocene-Miocene changes in seawater $\delta^{18}O$ values (Billups and Schrag, 2003). Elevations for a southern isotope-elevation relationship (S. δ-z gradient) were calculated using the theoretical model described in the text while the northern isotope-elevation relationship (N. δ-z gradient) is based upon a quadratic fit to modern precipitation ($\Delta\delta^{18}O = -1.11 \cdot 10^{-7} z^2 - 3.29 \cdot 10^{-4} z$). Model uncertainties reflect uncertainty in the initial airmass relative humidity and temperature (section 1.2) while data uncertainties reflect the uncertainty in the paleoisotopic water composition (Table S3).

		S. moisture, S. δ-z gradient			N. moisture, S. δ-z gradient			N. moisture, N. δ-z gradient	
Formation	**Sample**	**elev. (m)**	**2σ model**	**2σ data**	**elev. (m)**	**2σ model**	**2σ data**	**elev. (m)**	**2σ data**
Dingqinghu	299A	4920	±1800	+1260 / –2040					
Dingqinghu	299C	4500	±1690	+1520 / –2790					
Dingqinghu	301	4630	±1720	+1370 / –2330					
	mean±2σ	**4680±430**							
U. Niubao	305B	4650	±1730	+940 / –1320					
U. Niubao	305D	4640	±1730	+940 / –1320					
U. Niubao	305G	4610	±1720	+950 / –1340					
U. Niubao	305I	4570	±1710	+960 / –1360					
U. Niubao	305J	4670	±1730	+930 / –1310					
U. Niubao	305L	4440	±1670	+1000 / –1420					
U. Niubao	305O	4550	±1700	+960 / –1370					
U. Niubao	305P	4590	±1710	+960 / –1350					
U. Niubao	305Q	4720	±1750	+920 / –1290					
U. Niubao	305R	4580	±1710	+960 / –1350					
U. Niubao	305S	4640	±1720	+940 / –1330					
U. Niubao	305T	4620	±1720	+950 / –1330					
	mean±2σ	**4610±140**							
M. Niubao	316	3640	±1440	+1750 / –3420					
M. Niubao	327	3580	±1420	+1780 / –3500					
M. Niubao	330C	4100	±1580	+1570 / –2890					
	mean±2σ	**3770±570**							

Table S4 – continued.

		S. moisture, S. δ-z gradient			N. moisture, S. δ-z gradient			N. moisture, N. δ-z gradient	
Formation	**Sample**	**elev. (m)**	**2σ model**	**2σ data**	**elev. (m)**	**2σ model**	**2σ data**	**elev. (m)**	**2σ data**
Wudaoling	156B	3430	±1370	+1870 / –3800	4030	±1550	+1620 / –3060	7720	+3190 / –5240
Wudaoling	157	3410	±1360	+1880 / –3850	4010	±1550	+1640 / –3100	7690	+3220 / –5330
Wudaoling	158C	3590	±1420	+1800 / –3580	4160	±1590	+1570 / –2900	7960	+3130 / –4940
	mean±2σ	**3480±190**			**4060±160**			**7790±290**	
M. Fenghuoshan	27	1650	±720	+1370 / –1970	2550	±1060	+1120 / –1550	5230	+1880 / –2680
M. Fenghuoshan	29	1460	±640	+1420 / –2060	2400	±1010	+1160 / –1620	4970	+1940 / –2870
M. Fenghuoshan	030A	1200	±540	+1490 / –2180	2190	±930	+1220 / –1710	4640	+2020 / –3180
M. Fenghuoshan	030B	1090	±490	+1530 / –2220	2100	±900	+1240 / –1750	4490	+2060 / –3360
M. Fenghuoshan	030C	1210	±540	+1490 / –2170	2200	±930	+1220 / –1710	4640	+2020 / –3170
M. Fenghuoshan	31	1530	±670	+1400 / –2030	2450	±1030	+1150 / –1600	5060	+1920 / –2800
M. Fenghuoshan	031A	1100	±500	+1520 / –2220	2110	±900	+1240 / –1750	4500	+2050 / –3340
M. Fenghuoshan	032A	1450	±640	+1420 / –2070	2390	±1000	+1170 / –1620	4960	+1940 / –2880
M. Fenghuoshan	032B	1460	±640	+1420 / –2060	2400	±1010	+1160 / –1620	4980	+1940 / –2860
M. Fenghuoshan	032C	1740	±750	+1340 / –1930	2620	±1090	+1100 / –1520	5350	+1860 / –2600
M. Fenghuoshan	033A	1340	±590	+1460 / –2120	2300	±970	+1190 / –1660	4820	+1980 / –3000
M. Fenghuoshan	033B	1370	±610	+1450 / –2100	2330	±980	+1180 / –1650	4860	+1970 / –2960
M. Fenghuoshan	033C	1320	±590	+1460 / –2120	2290	±970	+1190 / –1670	4800	+1980 / –3020
M. Fenghuoshan	34	1380	±610	+1440 / –2100	2340	±980	+1180 / –1650	4880	+1960 / –2950
M. Fenghuoshan	35	1260	±560	+1480 / –2150	2240	±950	+1210 / –1690	4710	+2000 / –3110
M. Fenghuoshan	36	1410	±620	+1430 / –2090	2360	±990	+1170 / –1640	4910	+1950 / –2920
M. Fenghuoshan	37	1360	±600	+1450 / –2110	2320	±980	+1190 / –1660	4840	+1970 / –2980
M. Fenghuoshan	049A	940	±430	+1570 / –2270	1990	±850	+1280 / –1810	4290	+2110 / –3660
M. Fenghuoshan	049B	1170	±520	+1500 / –2190	2170	±920	+1230 / –1720	4590	+2030 / –3230
M. Fenghuoshan	049D	1500	±660	+1410 / –2040	2440	±1020	+1150 / –1600	5040	+1920 / –2820
M. Fenghuoshan	050A	1610	±700	+1380 / –1990	2520	±1050	+1130 / –1570	5170	+1890 / –2720
M. Fenghuoshan	050C	1700	±740	+1350 / –1940	2600	±1080	+1110 / –1540	5300	+1870 / –2630
M. Fenghuoshan	052B	1490	±660	+1410 / –2050	2430	±1020	+1160 / –1610	5020	+1930 / –2830
M. Fenghuoshan	54	1430	±630	+1430 / –2080	2370	±1000	+1170 / –1630	4930	+1950 / –2900
M. Fenghuoshan	131A	1200	±540	+1490 / –2180	2190	±930	+1220 / –1710	4640	+2020 / –3180
M. Fenghuoshan	135A	1390	±610	+1440 / –2100	2340	±990	+1180 / –1640	4880	+1960 / –2940
M. Fenghuoshan	135B	1380	±610	+1440 / –2100	2330	±980	+1180 / –1650	4870	+1960 / –2960

Table S4 – continued.

		S. moisture, S. δ-z gradient			**N. moisture, S. δ-z gradient**			**N. moisture, N. δ-z gradient**	
Formation	**Sample**	**elev. (m)**	**2σ model**	**2σ data**	**elev. (m)**	**2σ model**	**2σ data**	**elev. (m)**	**2σ data**
M. Fenghuoshan	137	1470	±650	+1420 / –2060	2410	±1010	+1160 / –1620	4990	+1940 / –2860
M. Fenghuoshan	138	1340	±590	+1460 / –2120	2300	±970	+1190 / –1660	4810	+1980 / –3010
M. Fenghuoshan	139	1350	±600	+1450 / –2110	2310	±980	+1190 / –1660	4830	+1970 / –2990
M. Fenghuoshan	140	1430	±630	+1430 / –2080	2380	±1000	+1170 / –1630	4940	+1950 / –2900
M. Fenghuoshan	140A	1440	±640	+1430 / –2070	2390	±1000	+1170 / –1630	4950	+1940 / –2890
M. Fenghuoshan	141	1470	±650	+1420 / –2060	2410	±1010	+1160 / –1610	4990	+1930 / –2850
M. Fenghuoshan	143	1500	±660	+1410 / –2040	2440	±1020	+1150 / –1600	5040	+1920 / –2820
M. Fenghuoshan	143A	1530	±670	+1400 / –2030	2460	±1030	+1150 / –1590	5070	+1920 / –2790
M. Fenghuoshan	143B	1580	±690	+1390 / –2010	2490	±1040	+1140 / –1580	5130	+1900 / –2750
M. Fenghuoshan	144	1670	±730	+1360 / –1960	2570	±1070	+1120 / –1550	5250	+1880 / –2660
M. Fenghuoshan	145	1700	±740	+1350 / –1940	2600	±1080	+1110 / –1540	5300	+1870 / –2630
M. Fenghuoshan	146	1580	±690	+1390 / –2000	2500	±1040	+1140 / –1580	5140	+1900 / –2740
	mean±2σ	**1420±360**			**2370±290**			**4920±470**	

2. Figures

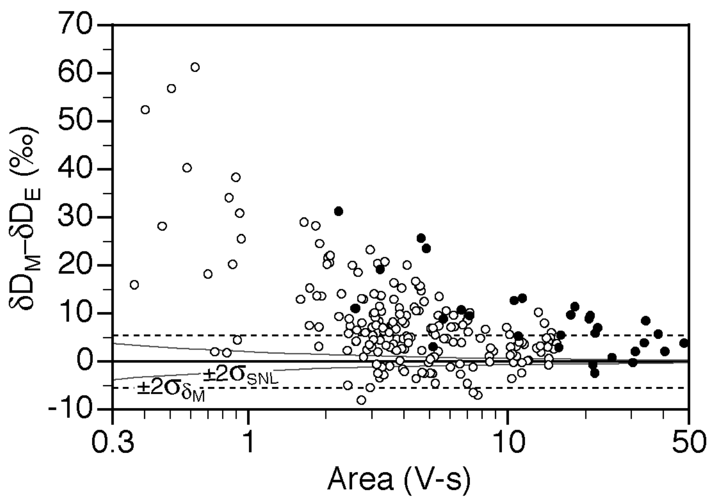

Figure S1 – Measured minus expected values for isotopic standards (○) and samples (•) as a function of chromatogram peak area. Dashed lines are the average 2σ of measurements at normal peak sizes while gray lines are the maximum possible precision calculated from shot-noise levels (Merritt and Hayes, 1994).

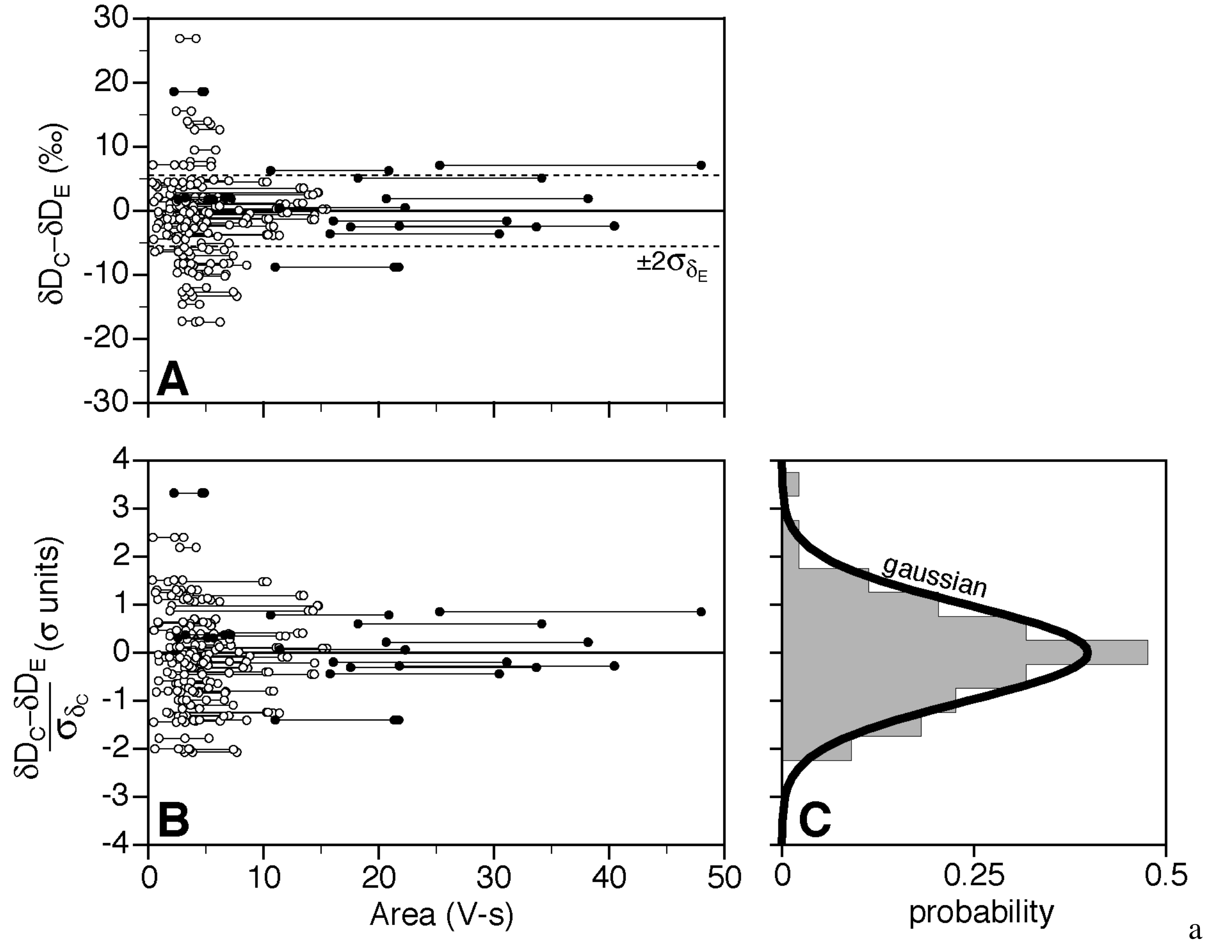

Figure S2 –Variability of blank-corrected δD values for standards (○) and samples (●). Panel A shows the differences of size-corrected values (δD_C) from the expected value (δD_E, determined at peak sizes greater than 20 V-s). Horizontal lines connect groups of replicate measurements used for regression and calculation of intercept values. Dashed lines are the average 2σ of measurements at normal peak sizes. Panel B plots the differences in the upper panel normalized by the uncertainty in the intercept value for each replicate group. The histogram (C) illustrates the frequency distribution of these values compared to that expected for a Gaussian distribution of zero mean and unit standard deviation.

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