Li, M., et al., 2021, Phanerozoic variation in dolomite abundance linked to oceanic anoxia: Geology, v. 49, https://doi.org/10.1130/G48502.1

SUPPLEMENTAL MATERIAL

Phanerozoic variation in dolomite abundance linked to oceanic anoxia

A literature search was performed using Google Scholar with a search term such as “Early Triassic carbonate”, and then the literature was compiled based on the result. On average, ~300 search items are required to collect ~50 study sections, because most collected sections lack lithological logs or well-constrained age by biostratigraphy and/or chemostratigraphy. For a certain region/basin, up to 5 sections were collected to minimize the effect from sample bias.

The time bins are referred to 2019 international chronostratigraphic chart with a temporal resolution of Epoch for most intervals. Some epochs with much longer durations (e.g., Early/Late Carboniferous and Early/Late Cretaceous) were divided into two bins to improve the temporal resolution. The average duration of the 34 time bins is 15.8 ± 7.4 Myr (million years).

The statistical analysis to yield Phanerozoic dolomite abundance was performed by R program (version 3.3.1). The code performing the resampling process with 10,000 iterations is attached as follows:

```
####Phanerozoic dolostone####`
dolodata = read.csv("C:\\Users\\DAI Xu\\Desktop\\dolodata.csv",header =
TRUE)
a = nrow(dolodata)
x = rep(NA, a)
doloab = function(n){
for (i in 1:a){
   if(dolodata$timecode[i] == n){
      x[i] = i
   }
}
x = na.omit(x)
bindata = dolodata[x,]
b = nrow(bindata)
meanab = rep(NA, 10000)
for (j in 1:10000){
c = sample(b,size = 45, replace = F)
```

```
subdata = bindata[c,]
meanab[j] = mean(subdata$abundance)
}
hist(meanab)
c(mean(meanab),quantile(meanab,0.025),quantile(meanab,0.975))
}
doloresult = matrix (NA,34,3)
for (k in 1:34){
  doloresult[k,] = doloab(k)
}
write.table(doloresult, file = "C:\\Users\\DAI Xu\\Desktop\\doloresult.txt")
```

Before the correlation analysis of dolomite abundance, genus richness, and the rate of change of $\delta^{34}S$, these three variables were tested to justify whether they follow the normal distribution. Here, frequency and the Shapiro-Wilk test were performed by using SPSS software (SPSS version 22.0, SPSS) (Figs. S1-S6). The test results show that $\delta^{34}S$ data shows a good pattern of normal distribution (Figs. S1-S2), dolomite abundance and genus richness show near normal distributions (Figs. S3-S6).

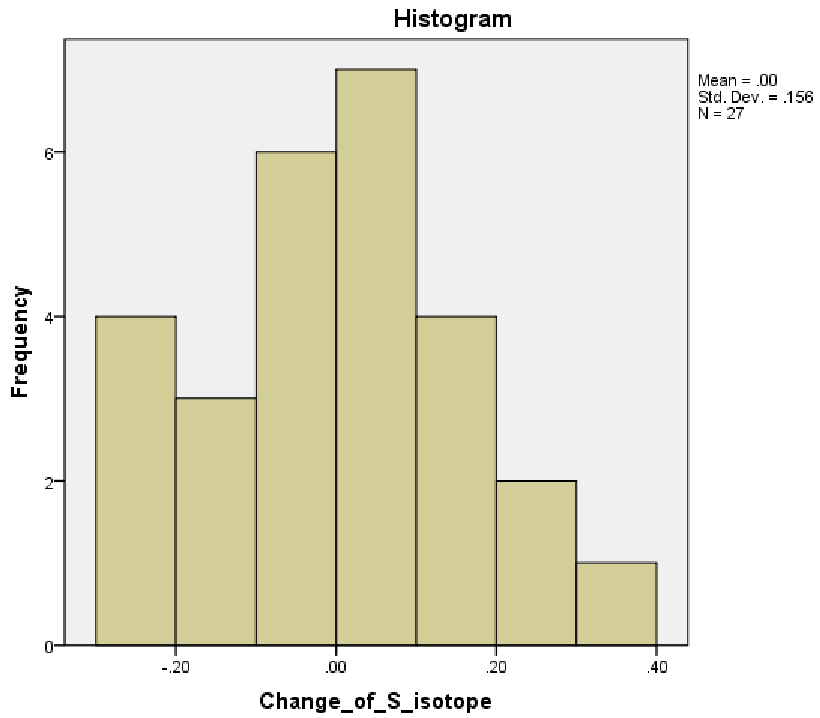

Figure S1. The frequency distribution of rate of change of $\delta^{34}S$ showing a pattern of normal distribution with Asymp. Sig (2-tailed) being of 0.664 calculated from Shapiro-Wilk Test.

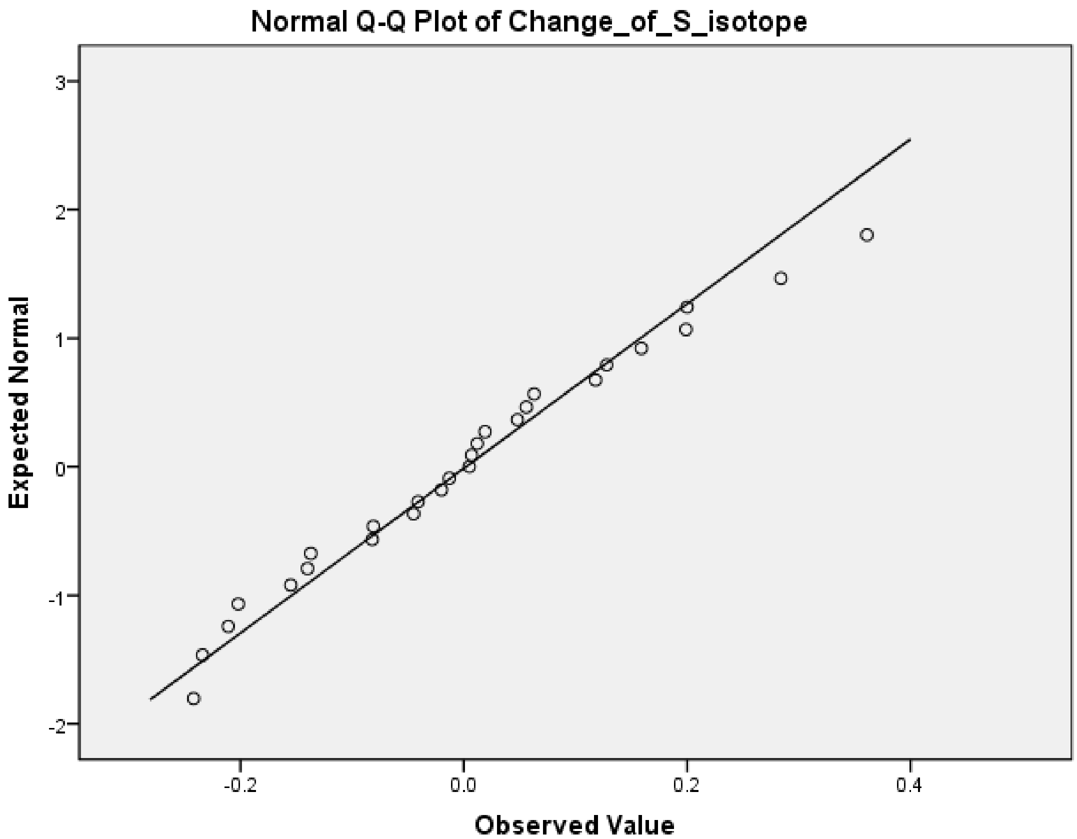

Figure S2. The normal Q-Q plot of rates of change in $\delta^{34}S$ showing most data are in good agreement with regression line with few deviated from the regression line.

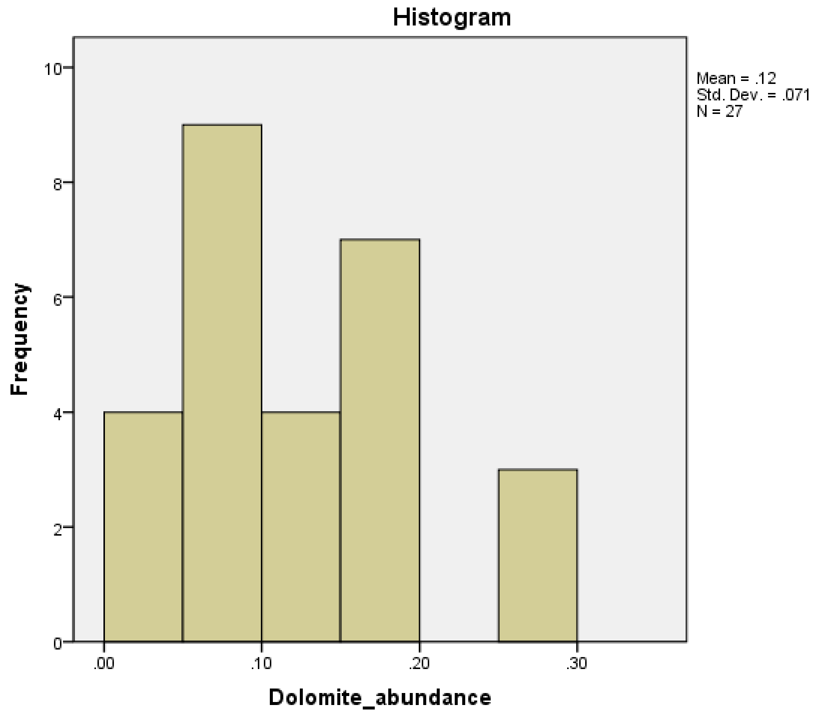

Figure S3. The frequency distribution of Phanerozoic dolomite abundance showing near-normal distribution pattern with Asymp. Sig (2-tailed) being of 0.01 calculated from Shapiro-Wilk Test.

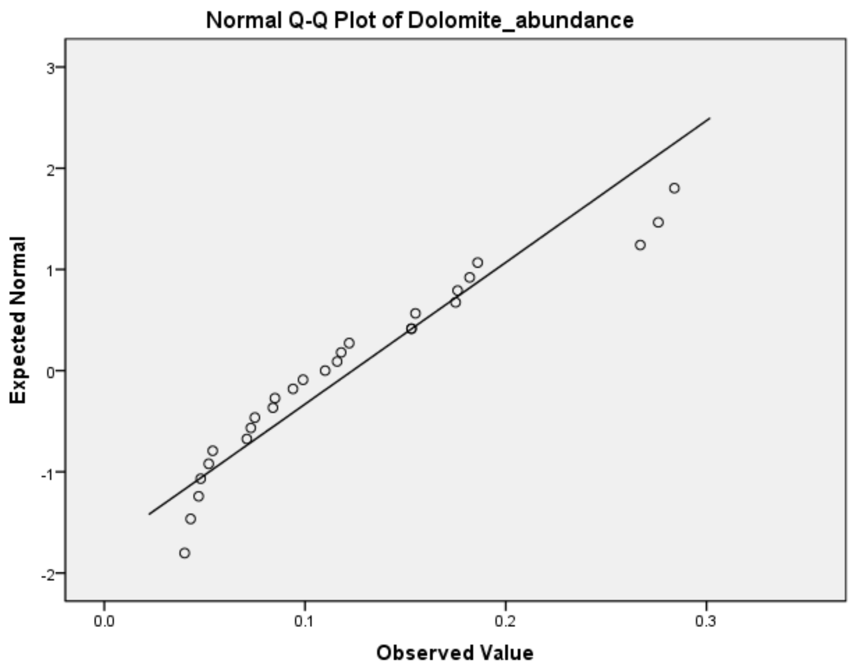

Figure S4. The normal Q-Q plot of Phanerozoic dolomite abundance showing most data are in agreement with the regression line, but with a few deviated from the trend line.

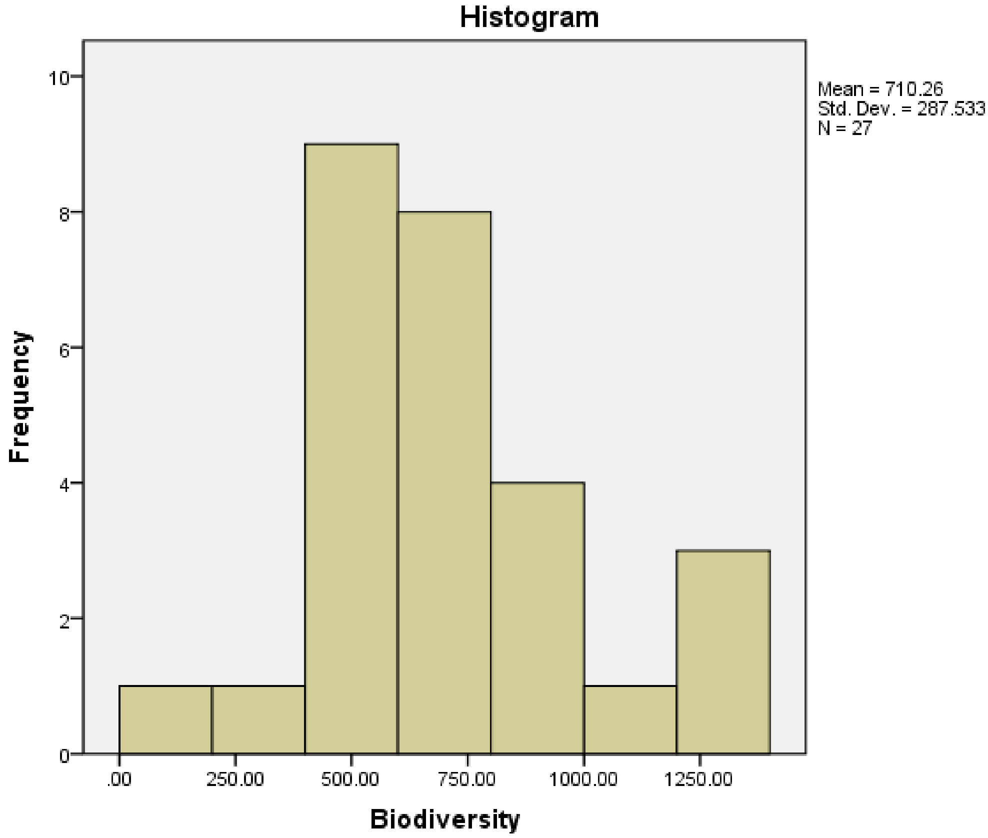

Figure S5. The frequency distribution of biodiversity (genus richness of marine benthic invertebrates) showing a pattern of normal distribution with Asymp. Sig (2-tailed) being of 0.237 calculated from Shapiro-Wilk Test.

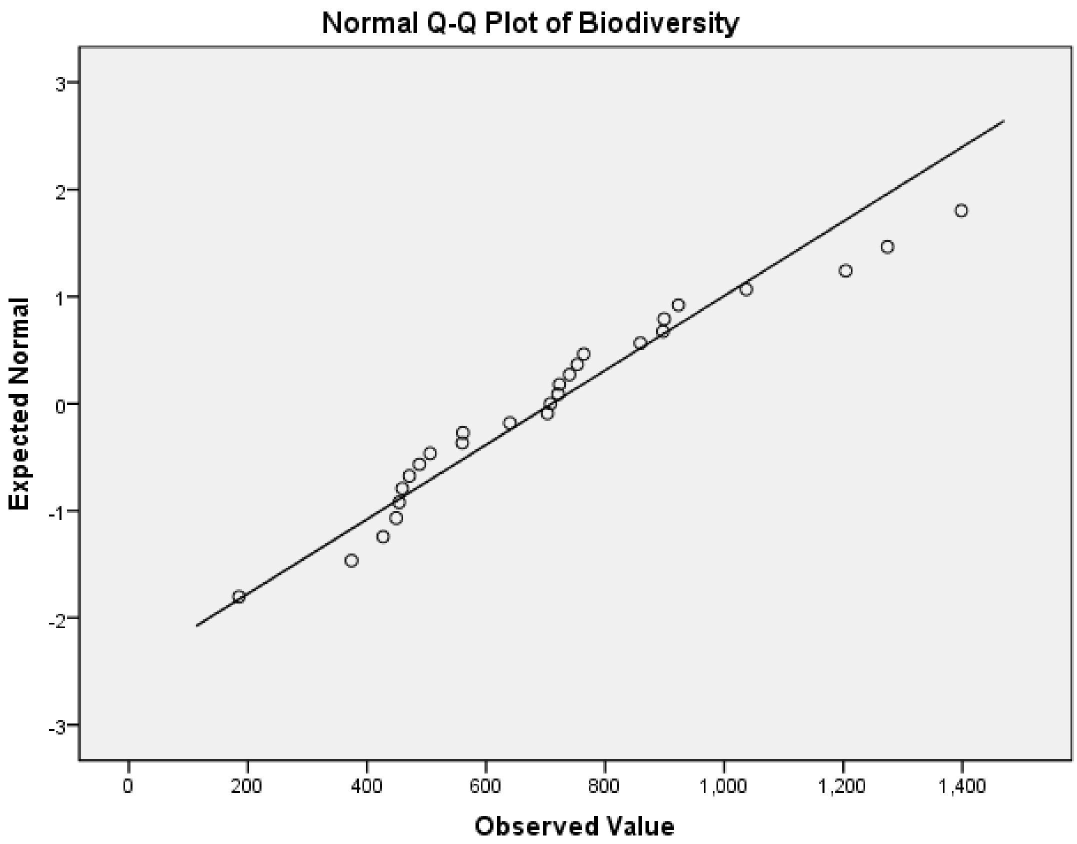

Figure S6. The normal Q-Q plot of Phanerozoic biodiversity (genus richness of marine benthic invertebrates) showing most data lie on the regression line with few deviated from it.

Table S1. Number of sections and countries for each time bin.

Time bin	Number of Sections	Number of countries represented
Terreneuvian	53	12
Series2	63	9
Series3	55	16
Furongian	51	17
Early Ordovician	51	15
Middle Ordovician	53	8
Late Ordovician	59	13
Llandovery	54	11
Wenlock	54	14
Ludlow-Pridoli	66	17
Early Devonian	60	16
Middle Devonian	55	12
Late Devonian	62	13
Tournaisian-Visean	67	16
Serpukhovian	115	15
Bashkirian		12
Moscovian-Gzhelian	55	11
Cisuralian	56	12
Guadalupian	52	13
Lopingian	50	17
Early Triassic	61	14
Middle Triassic	61	15
Late Triassic	57	19
Early Jurassic	61	20
Middle Jurassic	53	21
Late Jurassic	58	21
Berriasian-Barremian	52	19
Aptian-Albian	59	19
Cenomanian-Coniacian	75	20
Santonian-Maastrichtian	51	18
Paleocene	72	20
Eocene	87	21
Oligocene	52	20
Miocene	55	12

Table S2. Sulfur isotope composition in Phanerozoic marine carbonate (from Kampschulte and Strauss, 2004, Prokoph et al., 2008, Hannisdal and Peters, 2011).

Time bin	**Age (Ma)**	**δ^{34}S (‰)**	**Rate of change of δ^{34}S (‰ Myr^{-})**
Series 3	498.9	32.638	-0.217
	494.65	31.714	-0.152
Furongian	490.4	31.067	-0.138
	483.45	30.107	-0.242
Lower Ordovician	475.2	28.112	-0.199
	467.9	26.658	-0.083
	462.45	26.205	-0.544
Middle Ordovician	459.95	24.846	-0.099
	456.25	24.477	-0.009
	451.75	24.434	0.112
Upper Ordovician	446.85	24.984	0.282
	441.35	26.536	0.524
Llandovery	437.5	28.553	-0.124
Wenlock	432.1	27.884	-0.137
Ludlow	425.55	26.987	-0.057
Pridoli	420.8	26.714	-0.411
	417.35	25.297	-0.311
	413.6	24.131	-0.711
	409.1	20.93	-0.280
	402.25	19.01	0.089
Lower Devonian	394.65	19.687	0.159
Middle Devonian	388.55	20.655	0.159
	379.9	22.031	-0.047
Upper Devonian	366.85	21.423	-0.115
Tournaisian	353.6	19.902	-0.175
	344	18.222	-0.317
Visean	336.5	15.848	-0.113
Serpukhovian	325.55	14.609	0.018
	314.9	14.8	-0.222
	309.85	13.678	-0.148
Moscovian	307.25	13.294	-0.380
Kasimovian	305.75	12.724	-0.038
Gzhelian	302	12.581	0.015

	289.5	12.768	0.028
Cisuralian	275.3	13.168	0.098
Guadalupian	265.5	14.133	0.284
Lopingian	255.7	16.916	0.361
Lower Triassic	248	19.698	0.199
Middle Triassic	241	21.091	-0.041
	232.5	20.74	-0.162
	222.25	19.083	-0.077
Upper Triassic	208.05	17.993	-0.008
	198.05	17.911	-0.073
	193.05	17.544	0.001
	186.3	17.548	0.017
Lower Jurassic	179.3	17.668	0.004
	173.6	17.689	-0.068
	169.65	17.42	-0.086
Middle Jurassic	166.2	17.124	-0.157
	162.95	16.615	-0.102
	158.45	16.154	-0.031
	153.25	15.993	0.063
Upper Jurassic	148.15	16.315	0.061
Berriasian	142.85	16.637	0.077
	138.3	16.986	0.031
Valanginian	133.2	17.144	0.041
Barrermian	127.5	17.375	-0.127
Aptian	118.5	16.236	-0.027
Albian	105.8	15.898	0.262
Cenomanian	96.55	18.324	0.064
Turonian	91.4	18.652	-0.089
Coniacian	87.55	18.31	-0.109
Santonian	84.65	17.993	0.078
Campanian	77.05	18.589	0.029
Maastrichtian	68.05	18.852	-0.050
	63.6	18.626	-0.150
Paleocene	58.75	17.898	0.246
	52.2	19.512	0.361
	44.5	22.295	-0.004
Eocene	38.8	22.271	-0.062

	35.55	22.069	-0.071
	31.15	21.757	-0.019
Oligocene	25.715	21.653	0.033
	21.73	21.785	0.027
	18.2	21.879	0.028
	14.81	21.974	0.060
	12.629	22.104	-0.011
Miocene	9.427	22.067	-2.341

Table S3. Dolomite abundance, rate of change of $\delta^{34}S$ and genus richness of marine benthic invertebrates for each time bin in the Phanerozoic. Dolomite abundance data are from Data Repository File DR1, sulfur isotope data are from Table DR2, and fossil data are from the Paleobiology Database (PBDB; https://paleobiodb.org).

Time bin	**Dolomite abundance**	**Rate of change of $\delta^{34}S$ (‰ Myr^{-})**	**Genus richness**
Terreneuvian	0.4097		39
Series2	0.2127		271
Series3	0.1669	-0.217	24
Furongian	0.1750	-0.145	3
Early Ordovician	0.1794	-0.220	350
Middle Ordovician	0.0523	-0.242	471
Late Ordovician	0.1553	0.128	703
Llandovery	0.2759	0.200	454
Wenlock	0.1527	-0.137	561
Ludlow-Pridoli	0.0538	-0.234	506
Early Devonian	0.0728	-0.211	859
Middle Devonian	0.0942	0.159	923
Late Devonian	0.1759	-0.081	560
Tournaisian-Visean	0.1159	-0.202	708
Serpukhovian	0.0476	0.018	509
Bashkirian	0.0506		
Moscovian-Gzhelian	0.0838	-0.155	449
Cisuralian	0.1100	0.063	740
Guadalupian	0.1525	0.284	897

Lopingian	0.2839	0.361	753
Early Triassic	0.2666	0.199	185
Middle Triassic	0.1863	-0.041	488
Late Triassic	0.1815	-0.082	723
Early Jurassic	0.1224	-0.013	374
Middle Jurassic	0.0400	-0.100	459
Late Jurassic	0.0715	-0.002	764
Berriasian-Barremian	0.0850	0.005	427
Aptian-Albian	0.0750	0.118	899
Cenomanian-Coniacian	0.0478	-0.045	640
Santonian-Maastrichtian	0.0472	0.019	1037
Paleocene	0.1755	0.048	721
Eocene	0.0993	0.056	1398
Oligocene	0.0430	0.007	1204
Miocene	0.1182	0.012	1274

REFERENCES

Hannisdal, B., and Peters, S.E., 2011, Phanerozoic Earth system evolution and marine biodiversity: science, v. 334, p. 1121–1124, https://doi.org/10.1126/science.1210695.

Kampschulte, A., and Strauss, H., 2004, The sulfur isotopic evolution of Phanerozoic seawater based on the analysis of structurally substituted sulfate in carbonates: Chemical Geology, v. 204, p. 255–286, https://doi.org/10.1016/j.chemgeo.2003.11.013

Prokoph, A., Shields, G.A., and Veizer, J., 2008, Compilation and time-series analysis of a marine carbonate $\delta^{18}O$, $\delta^{13}C$, $^{87}Sr/^{86}Sr$ and $\delta^{34}S$ database through Earth history: Earth-Science Reviews, v. 87, p. 113–133, https://doi.org/10.1016/j.earscirev.2007.12.003