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Supplemental Material

Supplemental Data Set 1. Organic carbon isotopes from the first round of sampling in the Muchanggou section.

Supplemental Data Set 2. Elemental data from the second round of sampling in the Muchanggou section.

Supplemental Text

1. Carbon isotope mass balance calculations

   Table S1. Carbon reservoirs in the present day

2. Numerical simulation of the global carbon cycle

   Figure S1. Simulated atmospheric pCO_2 and inorganic- and organic-carbon isotopic composition in sediments in response to volcanic outgassing of ~5.1 × 10^{13} t of CO_2 over 500 ky.

   Figure S2. Simulated atmospheric pCO_2 and inorganic- and organic-carbon isotopic composition in sediments in response to volcanic outgassing of ~5.1 × 10^{13} t of CO_2 over 50 ky.

   Table S2. Parameters used for the carbon isotope mass balance model

1. Carbon isotope mass balance calculations

The exchangeable carbon stored in a reservoir consists of inorganic and organic carbon with a residence time of ~10^5 years (Dickens et al., 1995). The isotopic composition of the total exchangeable carbon reservoir can be calculated by the mass balance Equation (1):

$$(M_T)(\delta^{13}C_T) = (M_O)(\delta^{13}C_O) + (M_I)(\delta^{13}C_I) \quad (1)$$

where M_T, M_O, M_I, $\delta^{13}C_T$, $\delta^{13}C_O$, $\delta^{13}C_I$ represent the mass and $\delta^{13}C$ values of carbon in the total, organic and inorganic exchangeable carbon reservoirs, respectively.

The mass of carbon required for a particular negative shift of $\delta^{13}C$ in the exchangeable carbon reservoir caused by volcanic outgassing can be estimated by the following Equation (2):

$$(M_T + M_V)(\delta^{13}C_{T'}) = (M_V)(\delta^{13}C_V) + (M_T)(\delta^{13}C_T) \quad (2)$$

where M_T, $\delta^{13}C_T$, are defined as above, M_V and $\delta^{13}C_V$ represent the mass and $\delta^{13}C$ values of carbon from the volcanic outgassing, and $\delta^{13}C_{T'}$ is the $\delta^{13}C$ value in the total exchangeable carbon reservoir after mixing.

Assuming that the observed negative shift of ~1‰ in $\delta^{13}C_{org}$ is contributed by CO_2 released from volcanic eruptions, and that the mass and isotopic composition of carbon reservoirs during the Late Ordovician were similar to the present day (Table S1), a −1‰ shift in $\delta^{13}C$ of the exchangeable carbon reservoir requires ~8.7×10^{13} t of volcanic CO_2 with a $\delta^{13}C$ value of −5‰.

Table S1. Carbon reservoirs in the present day

Reservoir	Total mass C (10^5 g)	$\delta^{13}C$ (VPDB, ‰)	Data source
Inorganic	30500	0	Dickens et al., 1995
Organic	3500	-25	Dickens et al., 1995
Total exchangeable	34000	-2.57	Dickens et al., 1995
Volcanic outgassing		-5	Deines, 2002

2. Numerical simulation of the global carbon cycle

The mass balance model of global carbon cycle used for numerical simulation is taken from Kump and Arthur (1999). Here, we provide a brief description of the model, which is described in detail in Kump and Arthur (1999). The change in amount of inorganic carbon in the ocean and atmosphere (M_I) over timescales of thousands of years is defined as:

$$\frac{dM_I}{dt} = F_W + F_V - (F_{b,org} + F_{b,carb}) \quad (1)$$

where F_W and F_V are the input carbon fluxes from weathering and metamorphism or volcanism, and $F_{b,org}$ and $F_{b,carb}$ represent the output carbon fluxes from organic matter and carbonate mineral deposition, respectively.

Since the changes in the carbon isotopic composition of the ocean carbon reservoir are reflected in the isotopic composition of carbonate sediments, the isotope mass balance equation can be defined as:

$$\frac{dM_I\delta^{13}C_{carb}}{dt} = F_W\delta^{13}C_W + F_V\delta^{13}C_V - F_{b,carb}\delta^{13}C_{carb} - F_{b,org}(\delta^{13}C_{carb} + \Delta_B) \quad (2)$$

where $\delta^{13}C_{carb}$, $\delta^{13}C_W$ and $\delta^{13}C_V$ are the δ^{13}C values in carbonate sediments, riverine input from weathering and metamorphism/volcanism, and Δ_B represents the isotopic difference between the organic matter and carbonate deposited from the ocean.

The expression for Δ_B relative to pCO$_2$ is defined as:

$$\Delta_B = \left(\frac{(159.5[PO_4]+38.39}{0.034pCO_2}\right) - 33 \ (3)$$

where [PO$_4$] is dissolved phosphate concentration with a value of 0.25 μmol/kg.

Initial parameters used to simulate the Late Ordovician carbon cycle were taken from Kump and Arthur (1999) and Longman et al. (2021) (Table S2). In the model, the initial organic carbon isotopic composition in marine sediments depends on the inorganic carbon isotopic compositions and atmospheric CO_2 levels. The initial $\delta^{13}C_{carb}$ in the model is set to 0.78‰ (Kump and Arthur, 1999), which is generally consistent with the inorganic carbon isotopic compositions in carbonates prior to the Katian volcanism in South China ($\delta^{13}C_{carb} \approx 0$ at ~447 Ma, Saltzman and Thomas, 2012). Although the Late Ordovician atmosphere may have had extremely high CO_2 levels (>4000 ppmv, Royer, 2006), recent proxy data suggest that it may vary between 300 and 800 ppmv (Witkowski et al., 2018). Owing to this uncertainty, we use a moderate atmospheric CO_2 concentration (1000 ppmv), a value that has recently been used to model changes in the global carbon cycle induced by large-scale volcanism in the Late Ordovician (Longman et al., 2021). After inserting these two parameters, the initial $\delta^{13}C_{org}$ value of the sediment in the model is −29.9‰ at steady state, which is consistent with the measured organic isotopes (~–30‰) prior to the volcanism in the Muchanggou section (Fig. 2, Table S2).

To simulate the negative shift of organic carbon isotopes induced by volcanic outgassing, we add a perturbation that increases volcanic CO_2 delivery with duration of 500 ky. The results show that a shift of approximately −1‰ in $\delta^{13}C_{org}$ in sediments at steady-state would require ~5.1×10^{13} t of volcanic CO_2 (Fig. S1). The values of organic carbon isotopes under steady-state depend on the total mass of CO_2 released by volcanoes, independent of the duration. However, the duration can affect the maximum negative shift of organic carbon isotopes in marine sediments. To assess this effect, we set the duration of perturbation to 50 ky. The results show that although CO_2 can cause a maximum negative shift of −2‰ in organic carbon isotopes, there is a rapid return to steady-state within 500 ky (Fig. S2). Therefore, the long-term −1‰ shift in $\delta^{13}C_{org}$ observed in the Muchanggou section would require ~5.1×10^{13} t of volcanic CO_2.

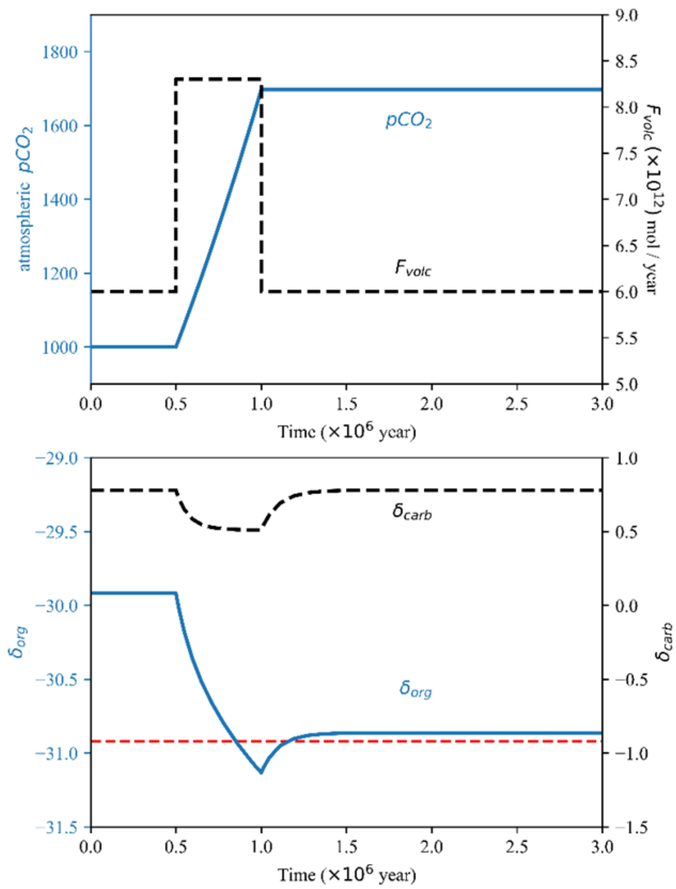

Fig. S1 Simulated atmospheric pCO_2 and inorganic- and organic-carbon isotopic composition in sediments in response to volcanic outgassing of ~5.1 × 10^{13} t of CO_2 over 500 ky. The red dashed line represents a negative shift of 1‰ in the initial $\delta^{13}C_{org}$.

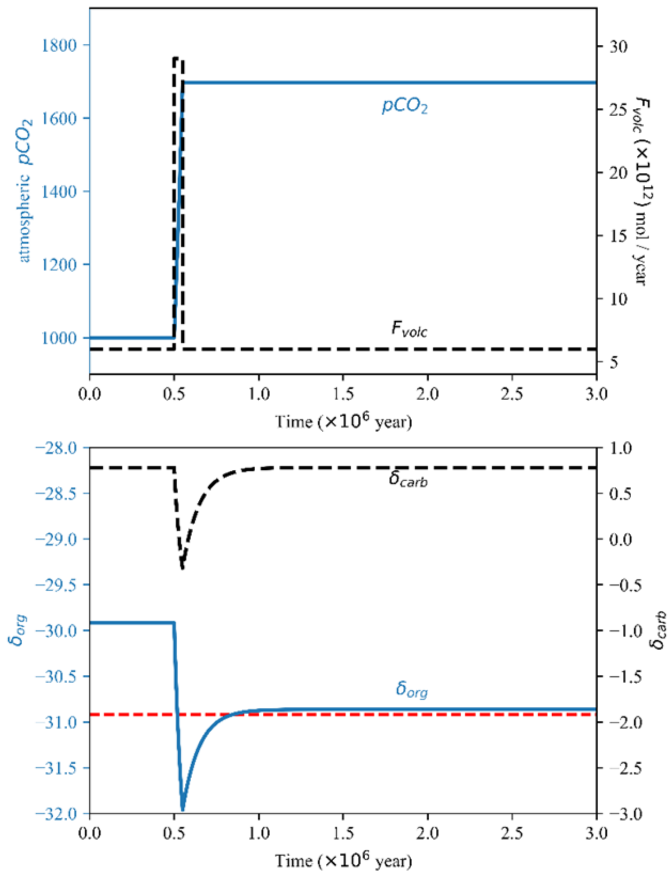

Fig. S2 Simulated atmospheric pCO_2 and inorganic- and organic-carbon isotopic composition in sediments in response to volcanic outgassing of ~5.1 × 10^{13} t of CO_2 over 50 ky. The red dashed line represents a negative shift of 1‰ in the initial $\delta^{13}C_{org}$.

Table S2. Parameters used for the carbon isotope mass balance model

Parameters	Late Ordovician	Data source
F_W (mol/year)	4.4×10^{13}	Kump and Arthur, 1999
F_V (mol/year)	0.6×10^{13}	Kump and Arthur, 1999
$F_{b,org}$ (mol/year)	1.0×10^{13}	Kump and Arthur, 1999
$F_{b,carb}$ (mol/year)	4.0×10^{13}	Kump and Arthur, 1999
$\delta^{13}C_{carb}$ (‰)	0.78	Kump and Arthur, 1999
$\delta^{13}C_W$ (‰)	-5.4	Kump and Arthur, 1999
$\delta^{13}C_V$ (‰)	-5	Deines, 2002
pCO_2 (ppmv)	1000	Longman et al., 2021
Initial modeled steady-state $\delta^{13}C_{org}$ (‰)	-29.9	

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Data Set 1. Organic carbon isotopes from the first round of sampling in the Muchanggou section

Sample	**Lithology**	**Formation**	**Height m**	**Graptolite zone**	**$\delta^{13}C_{org}$(VPDB) ‰**
CSM1	Black shale	Wufeng	2.9	*D. complexus*	-29.31
CSM7	Black shale	Wufeng	3.7	*D. complexus*	-28.76
CSM8	Black shale	Wufeng	4.0	*D. complexus*	-28.29
CSM9	Black shale	Wufeng	4.1	*D. complexus*	-30.06
CSM10	Black shale	Wufeng	4.4	*D. complexus*	-30.08
CSM11	Black shale	Wufeng	4.7	*D. complexus*	-30.19
CSM12	Black shale	Wufeng	5.0	*D. complexus*	-30.09
CSM13	Black shale	Wufeng	5.3	*P. pacificus* (Lower subzone)	-30.10
CSM14	Black shale	Wufeng	5.6	*P. pacificus* (Lower subzone)	-30.19
CSM15	Black shale	Wufeng	5.9	*P. pacificus* (Lower subzone)	-30.10
CSM16	Black shale	Wufeng	6.2	*P. pacificus* (Lower subzone)	-29.97
CSM17	Black shale	Wufeng	6.5	*P. pacificus* (Lower subzone)	-29.91
CSM18	Black shale	Wufeng	6.8	*P. pacificus* (Lower subzone)	-30.00
CSM19	Black shale	Wufeng	7.1	*P. pacificus* (Lower subzone)	-30.05
CSM20	Siliceous shale	Wufeng	7.4	*P. pacificus* (Lower subzone)	-30.01
CSM21	Siliceous shale	Wufeng	7.7	*P. pacificus* (Lower subzone)	-29.87
CSM22	Siliceous shale	Wufeng	8.0	*P. pacificus* (Lower subzone)	-30.02
CSM23	Siliceous shale	Wufeng	8.3	*P. pacificus* (Lower subzone)	-29.91
CSM24	Siliceous shale	Wufeng	8.5	*P. pacificus* (Lower subzone)	-29.44
CSM25	Siliceous shale	Wufeng	8.7	*P. pacificus* (Lower subzone)	-29.71
CSM26	Siliceous shale	Wufeng	8.9	*P. pacificus* (Lower subzone)	-30.36
CSM28	Siliceous shale	Wufeng	9.0	*P. pacificus* (Lower subzone)	-29.79
CSM29	Siliceous shale	Wufeng	9.1	*P. pacificus* (Lower subzone)	-30.02
CSM31	Siliceous shale	Wufeng	9.3	*P. pacificus* (Lower subzone)	-29.97
CSM32	Siliceous shale	Wufeng	9.5	*P. pacificus* (Lower subzone)	-30.43
CSM33	Siliceous shale	Wufeng	9.6	*P. pacificus* (Lower subzone)	-30.40
CSM34	Muddy chert	Wufeng	9.8	*P. pacificus* (Lower subzone)	-30.73
CSM35	Muddy chert	Wufeng	10.0	*P. pacificus* (Lower subzone)	-30.33
CSM37	Muddy chert	Wufeng	10.2	*P. pacificus* (Lower subzone)	-30.72
CSM38	Muddy chert	Wufeng	10.4	*P. pacificus* (Lower subzone)	-30.60
CSM40	Muddy chert	Wufeng	10.6	*P. pacificus* (Lower subzone)	-30.65
CSM41	Muddy chert	Wufeng	10.8	*P. pacificus* (Lower subzone)	-30.45
CSM42	Siliceous shale	Wufeng	10.9	*P. pacificus* (Lower subzone)	-30.60
CSM43	Siliceous shale	Wufeng	11.1	*P. pacificus* (Lower subzone)	-30.25
CSM44	Siliceous shale	Wufeng	11.2	*P. pacificus* (Lower subzone)	-30.53
CSM45	Siliceous shale	Wufeng	11.3	*P. pacificus* (Lower subzone)	-30.43
CSM47	Siliceous shale	Wufeng	11.5	*P. pacificus* (Lower subzone)	-30.68
CSM48	Siliceous shale	Wufeng	11.6	*P. pacificus* (Lower subzone)	-30.32
CSM49	Siliceous shale	Wufeng	11.8	*P. pacificus* (Lower subzone)	-30.67
CSM50	Siliceous shale	Wufeng	11.9	*P. pacificus* (Lower subzone)	-30.72
CSM52	Siliceous shale	Wufeng	12.0	*P. pacificus* (Lower subzone)	-30.04
CSM53	Siliceous shale	Wufeng	12.1	*P. pacificus* (Lower subzone)	-30.66

CSM54	Siliceous shale	Wufeng	12.2	*P. pacificus* (Lower subzone)	-30.67
CSM56	Siliceous shale	Wufeng	12.3	*P. pacificus* (Lower subzone)	-30.64
CSM57	Siliceous shale	Wufeng	12.5	*T. typicus*	-30.70
CSM58	Siliceous shale	Wufeng	12.7	*T. typicus*	-30.62
CSM59	Siliceous shale	Wufeng	12.9	*T. typicus*	-30.74
CSM60	Siliceous shale	Wufeng	13.1	*T. typicus*	-29.69
CSM61	Siliceous shale	Wufeng	13.3	*T. typicus*	-30.53
CSM62	Siliceous shale	Wufeng	13.5	*T. typicus*	-30.52
CSM64	Siliceous shale	Wufeng	13.6	*T. typicus*	-30.41
CSM65	Siliceous shale	Wufeng	13.7	*T. typicus*	-30.36
CSM67	Siliceous shale	Wufeng	13.8	*T. typicus*	-30.36
CSM68	Siliceous shale	Wufeng	13.9	*D. mirus*	-30.28
CSM69	Siliceous shale	Wufeng	14.0	*D. mirus*	-30.25
CSM70	Siliceous shale	Wufeng	14.1	*D. mirus*	-30.23
CSM71	Siliceous shale	Wufeng	14.2	*D. mirus*	-30.14
CSM72	Siliceous shale	Wufeng	14.3	*D. mirus*	-30.06
CSM73	Argillaceous limestone	Kuanyinqiao	14.5	*M. extraordinarius*	-30.03
CSM74	Argillaceous limestone	Kuanyinqiao	14.6	*M. extraordinarius*	-30.08
CSM75	Argillaceous limestone	Kuanyinqiao	14.7	*M. extraordinarius*	-30.05
CSM76	Argillaceous limestone	Kuanyinqiao	14.8	*M. extraordinarius*	-30.05
CSM77	Argillaceous limestone	Kuanyinqiao	14.9	*M. extraordinarius*	-29.77
CSM78	Argillaceous limestone	Kuanyinqiao	15.0	*M. extraordinarius*	-29.65
CSM79	Argillaceous limestone	Kuanyinqiao	15.1	*M. extraordinarius*	-30.17
CSM80	Argillaceous limestone	Kuanyinqiao	15.2	*M. extraordinarius*	-30.42
CSM81	Argillaceous limestone	Kuanyinqiao	15.3	*M. extraordinarius*	-30.51
CSM82	Black shale	Lungmachi	15.5	*M. persculptus*	-30.53
CSM83	Black shale	Lungmachi	15.7	*M. persculptus*	-30.59
CSM84	Black shale	Lungmachi	15.8	*M. persculptus*	-30.46
CSM85	Black shale	Lungmachi	15.9	*M. persculptus*	-30.51
CSM86	Black shale	Lungmachi	16.1	*M. persculptus*	-30.51
CSM87	Black shale	Lungmachi	16.3	*M. persculptus*	-30.49
CSM88	Black shale	Lungmachi	16.5	*M. persculptus*	-30.55
CSM89	Black shale	Lungmachi	16.7	*M. persculptus*	-30.57
CSM90	Black shale	Lungmachi	17.0	*A. ascensus*	-30.51
CSM91	Black shale	Lungmachi	17.4	*A. ascensus*	-30.56
CSM92	Black shale	Lungmachi	17.6	*P. acuminatus*	-30.51
CSM93	Black shale	Lungmachi	17.9	*Cy. vesiculosus*	-30.55
CSM94	Black shale	Lungmachi	18.1	*Cy. vesiculosus*	-30.56
CSM95	Black shale	Lungmachi	18.3	*Cy. vesiculosus*	-29.95
CSM96	Black shale	Lungmachi	18.5	*Cy. vesiculosus*	-30.25
CSM97	Black shale	Lungmachi	18.7	*Cy. vesiculosus*	-30.34
CSM99	Black shale	Lungmachi	18.9	*Cy. vesiculosus*	-30.08
CSM100	Black shale	Lungmachi	19.3	*Cy. vesiculosus*	-29.71
CSM101	Black shale	Lungmachi	19.5	*Cy. vesiculosus*	-29.72
CSM102	Black shale	Lungmachi	19.8	*Co. cyphus*	-30.19

Data Set 2. Elemental data from the second round of sampling in the Muchanggou section

Sample	Lithology	Formation	Height m	Graptolite zone	TOC %	TS %	Al_2O_3 %	Hg ppb	Hg/TOC ppb/%	Hg/TS ppb/%	Hg/Al_2O_3 ppb/%
MG-01	Limestone	Linxiang	0.50		0.36	0.31	10.82	85.8	238.2	276.6	7.9
MG-02	Limestone	Linxiang	1.10		0.37	0.36	11.96	100.6	272.0	279.6	8.4
MG-03	Mudstone	Wufeng	1.60		0.86	0.73	11.75	149.5	173.8	204.8	12.7
MG-04	Black shale	Wufeng	2.50	*D. complexus*	2.05	0.59	14.80	107.5	52.4	182.2	7.3
MG-05	Black shale	Wufeng	3.40	*D. complexus*	1.55	0.77	15.30	234.4	151.3	304.5	15.3
MG-06	Black shale	Wufeng	4.40	*D. complexus*	2.81	0.30	9.07	88.3	31.4	294.5	9.7
MG-07	Black shale	Wufeng	5.40	*P. pacificus* (Lower subzone)	2.64	0.44	14.63	115.1	43.6	261.5	7.9
MG-08	Black shale	Wufeng	6.20	*P. pacificus* (Lower subzone)	2.26	0.49	12.41	170.5	75.4	347.9	13.7
MG-09	Black shale	Wufeng	7.00	*P. pacificus* (Lower subzone)	3.33	0.22	6.80	71.8	21.5	326.2	10.5
MG-10	Siliceous shale	Wufeng	7.50	*P. pacificus* (Lower subzone)	3.52	0.17	7.63	95.6	27.2	562.2	12.5
MG-11	Volcanic ash	Wufeng	7.70	*P. pacificus* (Lower subzone)	0.31	12.70	15.62	682.5	2201.6	53.7	43.7
MG-12	Siliceous shale	Wufeng	7.80	*P. pacificus* (Lower subzone)	2.79	0.13	8.58	27.4	9.8	210.7	3.2
MG-13	Siliceous shale	Wufeng	7.90	*P. pacificus* (Lower subzone)	2.37	0.13	5.17	57.2	24.1	439.6	11.1
MG-14	Siliceous shale	Wufeng	8.10	*P. pacificus* (Lower subzone)	2.81	0.13	7.03	51.5	18.3	396.4	7.3
MG-15	Volcanic ash	Wufeng	8.10	*P. pacificus* (Lower subzone)	0.53	3.54	22.73	353.7	667.4	99.9	15.6
MG-16	Siliceous shale	Wufeng	8.20	*P. pacificus* (Lower subzone)	3.56	0.07	12.53	73.1	20.5	1043.7	5.8
MG-17	Siliceous shale	Wufeng	8.30	*P. pacificus* (Lower subzone)	3.58	0.13	8.93	59.9	16.7	460.6	6.7
MG-18	Volcanic ash	Wufeng	8.35	*P. pacificus* (Lower subzone)	0.96	1.01	26.24	167.9	174.9	166.2	6.4
MG-19	Siliceous shale	Wufeng	8.40	*P. pacificus* (Lower subzone)	3.41	0.34	9.34	101.3	29.7	298.0	10.9
MG-20	Siliceous shale	Wufeng	8.50	*P. pacificus* (Lower subzone)	4.19	0.32	12.41	95.3	22.7	297.7	7.7
MG-21	Siliceous shale	Wufeng	8.60	*P. pacificus* (Lower subzone)	3.70	0.17	9.02	89.1	24.1	524.0	9.9
MG-22	Volcanic ash	Wufeng	8.65	*P. pacificus* (Lower subzone)	1.08	1.12	26.45	198.5	183.8	177.3	7.5
MG-22-1	Siliceous shale	Wufeng	8.65	*P. pacificus* (Lower subzone)	3.88	0.22	20.97	72.9	18.8	331.5	3.5
MG-23	Siliceous shale	Wufeng	8.70	*P. pacificus* (Lower subzone)	3.56	0.10	8.21	30.5	8.6	305.3	3.7
MG-24	Siliceous shale	Wufeng	8.80	*P. pacificus* (Lower subzone)	3.92	0.07	7.12	84.8	21.6	1211.7	11.9

MG-25	Volcanic ash	Wufeng	8.82	*P. pacificus* (Lower subzone)	2.33	0.83	20.42	253.0	108.6	304.9	12.4
MG-25-1	Siliceous shale	Wufeng	8.82	*P. pacificus* (Lower subzone)	4.89	0.11	17.99	83.7	17.1	761.2	4.7
MG-26	Siliceous shale	Wufeng	8.83	*P. pacificus* (Lower subzone)	2.94	0.12	6.52	174.1	59.2	1450.7	26.7
MG-27	Siliceous shale	Wufeng	8.84	*P. pacificus* (Lower subzone)	2.68	0.09	7.32	127.1	47.4	1412.5	17.4
MG-28	Volcanic ash	Wufeng	8.85	*P. pacificus* (Lower subzone)	0.56	0.59	24.20	175.3	313.1	297.1	7.2
MG-29	Siliceous shale	Wufeng	8.90	*P. pacificus* (Lower subzone)	3.57	0.19	6.94	331.4	92.8	1744.1	47.7
MG-30	Siliceous shale	Wufeng	9.00	*P. pacificus* (Lower subzone)	3.48	0.32	8.97	122.8	35.3	383.8	13.7
MG-31	Siliceous shale	Wufeng	9.10	*P. pacificus* (Lower subzone)	3.96	0.36	9.79	142.0	35.9	394.4	14.5
MG-32	Volcanic ash	Wufeng	9.20	*P. pacificus* (Lower subzone)	0.54	11.60	17.40	710.7	1316.1	61.3	40.9
MG-33	Siliceous shale	Wufeng	9.25	*P. pacificus* (Lower subzone)	3.47	0.28	9.92	116.9	33.7	417.3	11.8
MG-34	Siliceous shale	Wufeng	9.35	*P. pacificus* (Lower subzone)	3.64	0.25	11.17	96.9	26.6	387.5	8.7
MG-35	Volcanic ash	Wufeng	9.40	*P. pacificus* (Lower subzone)	1.16	2.38	24.03	310.5	267.6	130.4	12.9
MG-35-1	Siliceous shale	Wufeng	9.40	*P. pacificus* (Lower subzone)	3.80	0.34	11.06	70.7	18.6	208.0	6.4
MG-36	Siliceous shale	Wufeng	9.45	*P. pacificus* (Lower subzone)	5.40	0.25	14.43	122.8	22.7	491.1	8.5
MG-37	Siliceous shale	Wufeng	9.55	*P. pacificus* (Lower subzone)	3.76	0.14	7.58	100.6	26.8	718.7	13.3
MG-38	Volcanic ash	Wufeng	9.62	*P. pacificus* (Lower subzone)	0.96	9.13	18.19	474.2	493.9	51.9	26.1
MG-39	Muddy chert	Wufeng	9.70	*P. pacificus* (Lower subzone)	4.35	0.20	9.33	119.0	27.3	594.8	12.7
MG-40	Muddy chert	Wufeng	9.80	*P. pacificus* (Lower subzone)	4.83	0.20	5.90	112.3	23.3	561.6	19.1
MG-41	Volcanic ash	Wufeng	9.82	*P. pacificus* (Lower subzone)	0.95	8.61	18.72	451.6	475.4	52.5	24.1
MG-42	Muddy chert	Wufeng	9.90	*P. pacificus* (Lower subzone)	3.09	0.18	3.36	30.9	10.0	171.8	9.2
MG-43	Volcanic ash	Wufeng	10.00	*P. pacificus* (Lower subzone)	0.61	10.20	17.94	411.8	675.1	40.4	23.0
MG-44	Muddy chert	Wufeng	10.05	*P. pacificus* (Lower subzone)	3.19	0.37	5.94	130.1	40.8	351.6	21.9
MG-45	Muddy chert	Wufeng	10.10	*P. pacificus* (Lower subzone)	4.17	0.42	7.54	128.8	30.9	306.6	17.1
MG-46	Volcanic ash	Wufeng	10.20	*P. pacificus* (Lower subzone)	3.12	3.46	15.89	305.8	98.0	88.4	19.2
MG-47	Muddy chert	Wufeng	10.25	*P. pacificus* (Lower subzone)	3.85	0.10	4.67	35.1	9.1	351.4	7.5
MG-48	Volcanic ash	Wufeng	10.30	*P. pacificus* (Lower subzone)	1.12	2.00	22.70	443.3	395.8	221.6	19.5
MG-49	Muddy chert	Wufeng	10.40	*P. pacificus* (Lower subzone)	1.89	0.47	2.78	127.4	67.4	271.1	45.8
MG-50	Muddy chert	Wufeng	10.70	*P. pacificus* (Lower subzone)	3.73	0.32	4.15	152.6	40.9	476.8	36.8

MG-51	Siliceous shale	Wufeng	10.90	*P. pacificus* (Lower subzone)	6.23	0.28	8.72	107.6	17.3	384.1	12.3
MG-52	Volcanic ash	Wufeng	11.00	*P. pacificus* (Lower subzone)	0.82	8.39	23.16	555.8	677.8	66.2	24.0
MG-53	Siliceous shale	Wufeng	11.10	*P. pacificus* (Lower subzone)	3.55	0.15	4.06	193.5	54.5	1289.7	47.6
MG-54	Siliceous shale	Wufeng	11.30	*P. pacificus* (Lower subzone)	5.19	0.34	4.27	259.5	50.0	763.3	60.8
MG-55	Siliceous shale	Wufeng	11.40	*P. pacificus* (Lower subzone)	4.94	0.06	8.53	129.0	26.1	2150.1	15.1
MG-56	Volcanic ash	Wufeng	11.45	*P. pacificus* (Lower subzone)	0.77	17.20	9.48	1620.5	2104.5	94.2	170.9
MG-57	Siliceous shale	Wufeng	11.50	*P. pacificus* (Lower subzone)	4.14	0.05	7.33	81.3	19.6	1627.0	11.1
MG-58	Siliceous shale	Wufeng	11.70	*P. pacificus* (Lower subzone)	3.14	0.04	3.17	53.8	17.1	1344.1	17.0
MG-59	Volcanic ash	Wufeng	11.80	*P. pacificus* (Lower subzone)	0.98	0.07	26.34	156.4	159.6	2234.6	5.9
MG-60	Siliceous shale	Wufeng	11.90	*P. pacificus* (Lower subzone)	3.75	0.04	5.44	62.6	16.7	1566.2	11.5
MG-61	Siliceous shale	Wufeng	12.10	*P. pacificus* (Lower subzone)	3.74	0.05	4.36	70.9	18.9	1417.2	16.2
MG-62	Siliceous shale	Wufeng	12.30	*P. pacificus* (Lower subzone)	4.91	0.05	7.51	106.3	21.7	2126.9	14.2
MG-63	Volcanic ash	Wufeng	12.35	*P. pacificus* (Lower subzone)	0.56	1.13	23.52	434.6	776.1	384.6	18.5
MG-64	Siliceous shale	Wufeng	12.40	*T. typicus*	5.52	0.05	10.43	127.6	23.1	2552.9	12.2
MG-65	Siliceous shale	Wufeng	12.70	*T. typicus*	4.44	0.27	5.61	92.3	20.8	341.9	16.5
MG-66	Siliceous shale	Wufeng	13.00	*T. typicus*	5.38	0.10	8.53	152.3	28.3	1522.6	17.8
MG-67	Siliceous shale	Wufeng	13.30	*T. typicus*	6.14	0.06	8.32	146.9	23.9	2447.5	17.7
MG-68	Volcanic ash	Wufeng	13.50	*T. typicus*	0.56	1.36	27.85	403.9	721.2	297.0	14.5
MG-69	Siliceous shale	Wufeng	13.60	*T. typicus*	5.09	0.13	6.80	123.6	24.3	951.1	18.2
MG-70	Siliceous shale	Wufeng	13.80	*T. typicus*	7.99	0.09	11.73	249.1	31.2	2767.8	21.2
MG-71	Siliceous shale	Wufeng	13.90	*D. mirus*	5.05	0.15	5.07	117.0	23.2	780.2	23.1
MG-72	Siliceous shale	Wufeng	14.10	*D. mirus*	5.95	0.35	5.91	124.6	20.9	356.0	21.1
MG-73	Siliceous shale	Wufeng	14.30	*D. mirus*	7.56	1.24	7.53	212.8	28.1	171.6	28.3
MG-74	Argillaceous limestone	Kuanyinqiao	14.50	*M. extraordinarius*	6.14	0.09	3.68	104.1	17.0	1156.5	28.3
MG-75	Argillaceous limestone	Kuanyinqiao	14.70	*M. extraordinarius*	5.43	0.07	2.44	24.2	4.5	345.8	9.9
MG-76	Argillaceous limestone	Kuanyinqiao	14.90	*M. extraordinarius*	5.25	0.09	3.15	66.2	12.6	735.1	21.0
MG-77	Argillaceous limestone	Kuanyinqiao	15.20	*M. extraordinarius*	6.52	0.33	6.31	130.2	20.0	394.6	20.7
MG-78	Black shale	Lungmachi	15.40	*M. persculptus*	8.16	0.36	11.90	293.1	35.9	814.1	24.6

MG-79	Black shale	Lungmachi	15.70	*M. persculptus*	6.08	0.78	9.59	186.4	30.7	238.9	19.4
MG-80	Black shale	Lungmachi	15.90	*M. persculptus*	5.47	0.44	6.81	133.1	24.3	302.4	19.5
MG-81	Black shale	Lungmachi	16.20	*M. persculptus*	5.04	4.96	6.84	503.0	99.8	101.4	73.5
MG-82	Black shale	Lungmachi	16.50	*M. persculptus*	5.46	0.49	7.55	172.2	31.5	351.3	22.8
MG-83	Black shale	Lungmachi	16.90	*M. persculptus*	5.58	0.46	8.35	176.3	31.6	383.3	21.1
MG-84	Black shale	Lungmachi	17.00	*A. ascensus*	5.97	0.49	8.43	178.5	29.9	364.3	21.2
MG-85	Black shale	Lungmachi	17.30	*A. ascensus*	5.66	0.60	7.88	215.6	38.1	359.4	27.4
MG-86	Black shale	Lungmachi	17.60	*P. acuminatus*	5.48	0.49	6.30	173.5	31.7	354.1	27.5
MG-87	Black shale	Lungmachi	17.80	*P. acuminatus*	5.32	0.58	7.48	157.1	29.5	270.8	21.0
MG-88	Black shale	Lungmachi	18.00	*Cy. vesiculosus*	5.31	0.52	8.12	146.1	27.5	281.0	18.0
MG-89	Black shale	Lungmachi	18.20	*Cy. vesiculosus*	5.88	2.04	10.79	217.8	37.0	106.8	20.2
MG-90	Black shale	Lungmachi	18.50	*Cy. vesiculosus*	6.66	0.05	10.37	199.2	29.9	3983.0	19.2
MG-91	Black shale	Lungmachi	18.80	*Cy. vesiculosus*	3.95	0.04	12.25	267.2	67.6	6679.1	21.8
MG-92	Black shale	Lungmachi	19.00	*Cy. vesiculosus*	3.32	0.03	12.30	218.5	65.8	7281.9	17.8
MG-93	Black shale	Lungmachi	19.40	*Cy. vesiculosus*	3.05	0.03	12.07	259.5	85.1	8650.4	21.5
MG-94	Black shale	Lungmachi	19.60	*Co. cyphus*	3.14	0.03	14.21	226.2	72.0	7539.2	15.9
MG-95	Black shale	Lungmachi	19.80	*Co. cyphus*	3.57	0.09	12.28	283.2	79.3	3146.2	23.1
MG-96	Black shale	Lungmachi	20.10	*Co. cyphus*	3.47	0.05	11.63	225.5	65.0	4509.2	19.4
MG-97	Black shale	Lungmachi	20.40	*Co. cyphus*	1.90	0.02	13.78	294.2	154.9	14711.0	21.3
MG-98	Black shale	Lungmachi	20.60	*D. triangulatus* ?	3.06	0.05	11.92	226.0	73.9	4520.7	19.0
MG-99	Black shale	Lungmachi	20.80	*D. triangulatus* ?	3.45	0.03	11.23	216.3	62.7	7210.8	19.3
MG-100	Black shale	Lungmachi	21.00	*D. triangulatus* ?	3.48	0.04	11.36	228.9	65.8	5721.7	20.2
MG-101	Black shale	Lungmachi	21.20	*D. triangulatus* ?	2.82	0.03	11.03	204.8	72.6	6825.1	18.6