SUPPLEMENTAL ITEMS

For Witkosky and Wernicke, Subsidence history of the Ediacaran Johnnie Formation and related strata of southwest Laurentia: implications for the age and duration of the Shuram isotopic excursion and animal evolution

Figure S1: (A) and (B) Annotated Google Earth images of Johnnie Wash

Figure S2: Carbon and oxygen isotope ratios versus stratigraphic height and cross plots for each individual carbonate interval (16 total)

Figure S3: Chemostratigraphic comparisons of Johnnie Formation with Huqf Supergroup below Shuram excursion (8 plots)

Figure S4: Subsidence plot $Y(t)$, assuming no Pahrump substrate and density variation of +/-5%

Figure S5: Subsidence plot $Y(t)$, assuming no Pahrump substrate, intermediate density, and variable characteristic time τ

Figure S6: Subsidence plot $Y(S)$, assuming intermediate sediment grain density and Pahrump substrate

Table S1: Carbon and oxygen isotopic samples and data

Table S2: Age estimates of pre-541 Ma strata, assuming hypothetical Pahrump substrate

Supplemental text: Lithostratigraphic unit descriptions for Mt. Schader section

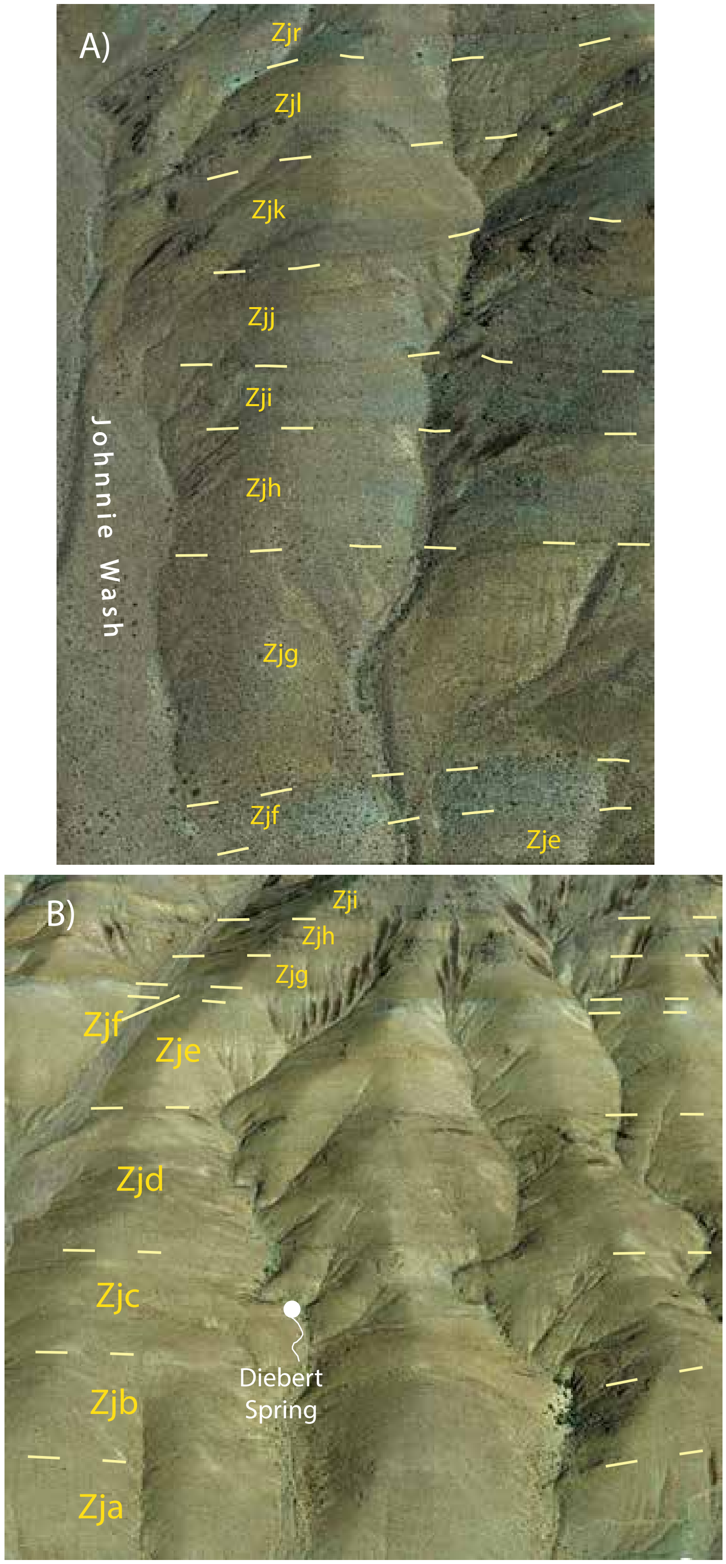
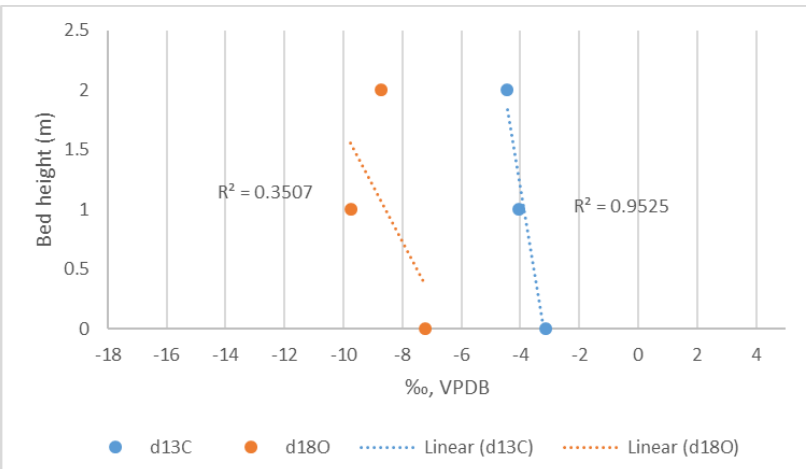


Figure S1: (A) Google Earth image looking c. 60° down-dip to the east along section B - B′ in Figure 3, showing traces of mapped unit boundaries (dashed lines) for units E through L and the Rainstorm Member, using unit designations from the Appendix. Width of view at level of Zji is c. 400 m. (B) Google Earth image looking ca. 40° down-dip to the east along section A - A′ in Figure 3, showing traces of mapped unit boundaries for units A through I. Width of view at unit D/E boundary is c. 1200 m.

Zjr (j69-71)



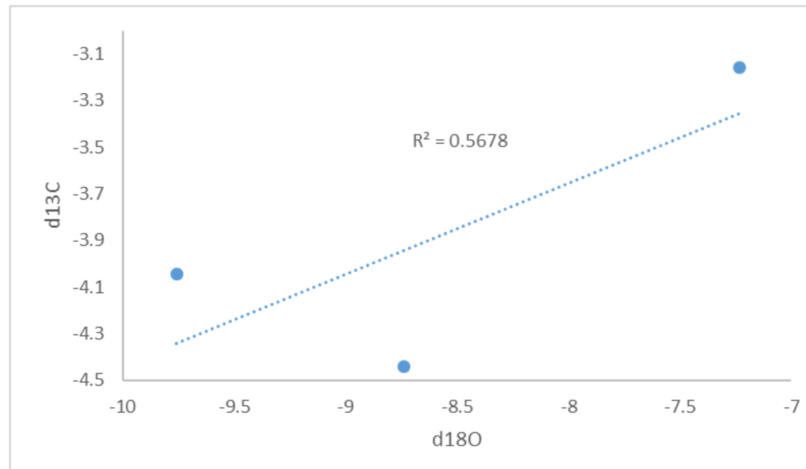
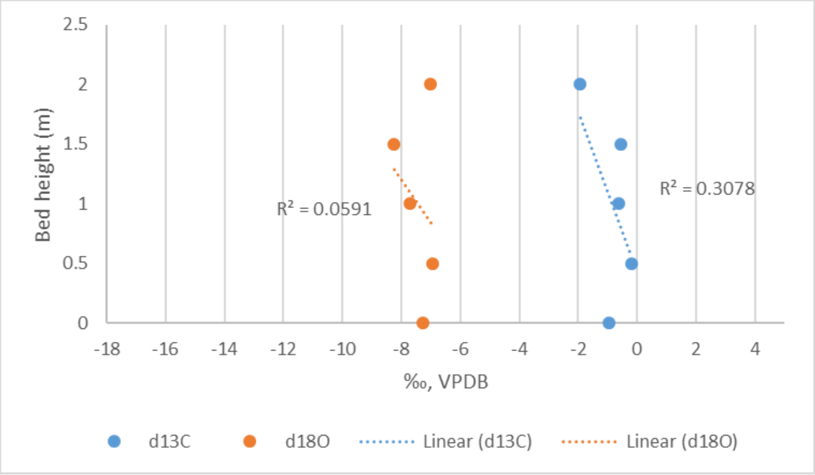
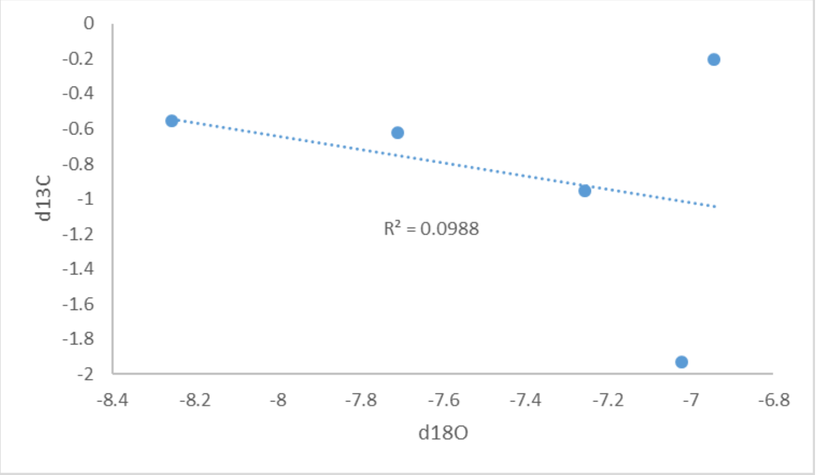


Figure S3: Plots of $\delta^{13}C$ and $\delta^{18}O$ versus stratigraphic position with side-by-side cross plots of $\delta^{18}O$ versus $\delta^{13}C$, for each individual carbonate interval designated in Figure 10 of the main text.

Zjl (j64-68)

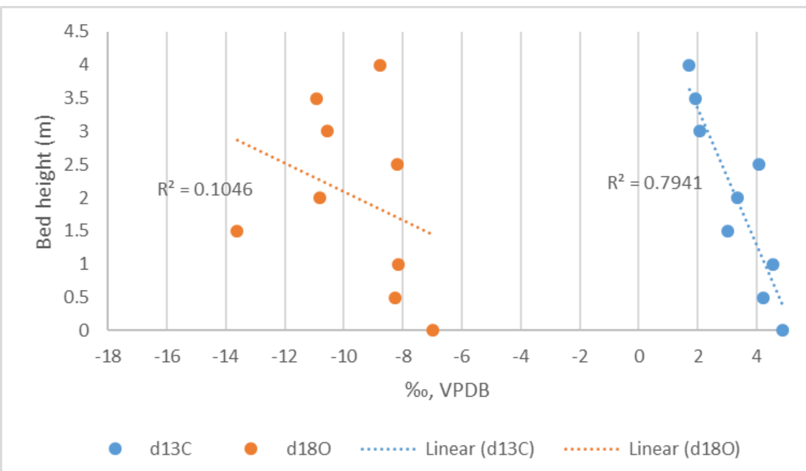


Bed height (m)
2.5
2
1.5
1
0.5
0
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
2
4
‰, VPDB
R² = 0.0591
R² = 0.3078
d13C
d18O
Linear (d13C)
Linear (d18O)

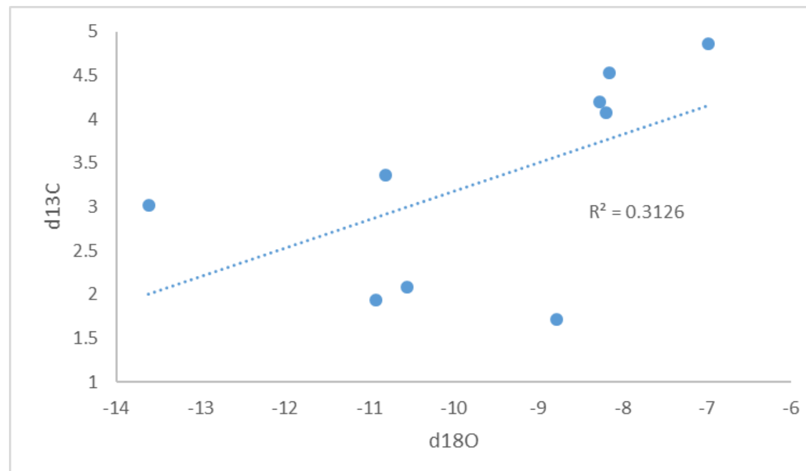


d13C
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
-2
-8.4
-8.2
-8
-7.8
-7.6
-7.4
-7.2
-7
-6.8
d18O
R² = 0.0988

Zjk2 (j55-63)

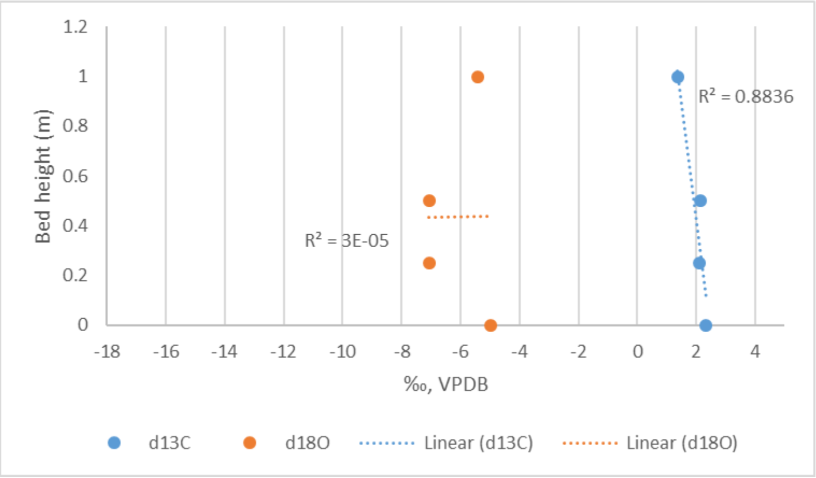


4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Bed height (m)
R² = 0.1046
R² = 0.7941
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
2
4
‰, VPDB
d13C
d18O
Linear (d13C)
Linear (d18O)

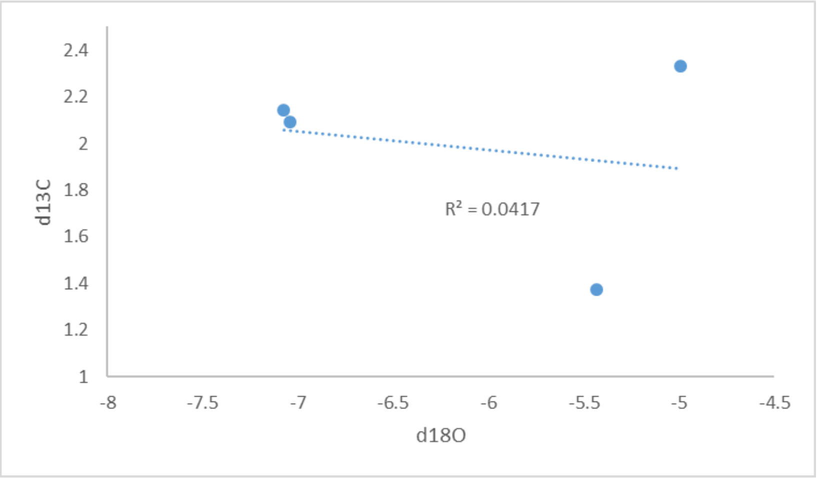


5
4.5
4
3.5
3
2.5
2
1.5
1
d13C
R² = 0.3126
-14
-13
-12
-11
-10
-9
-8
-7
-6
d18O

Zjk1 (j51-54)

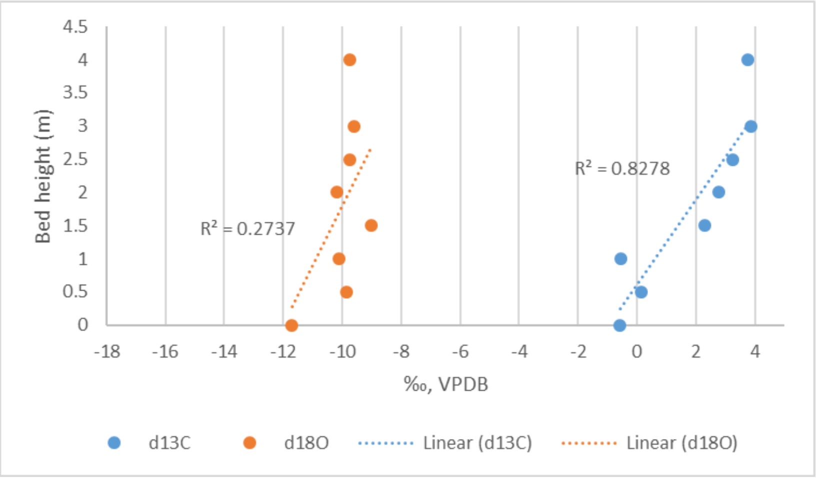


1.2
1
0.8
0.6
0.4
0.2
0
Bed height (m)
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
2
4
‰, VPDB
R² = 0.8836
R² = 3E-05
d13C
d18O
Linear (d13C)
Linear (d18O)

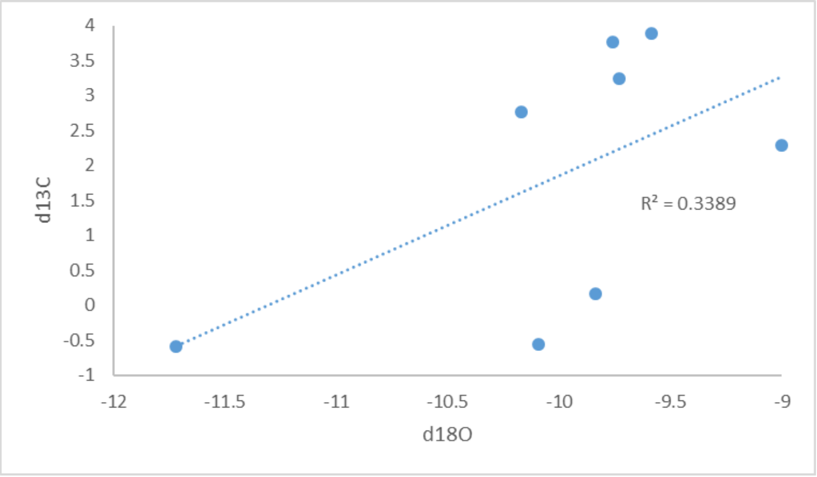


2.4
2.2
2
1.8
1.6
1.4
1.2
1
d13C
-8
-7.5
-7
-6.5
-6
-5.5
-5
-4.5
d18O
R² = 0.0417

Zjj2 (j43-50)

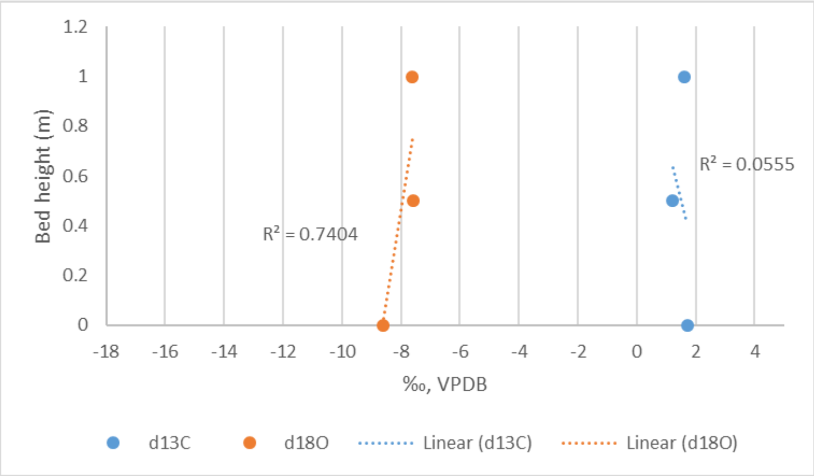


4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Bed height (m)
R² = 0.2737
R² = 0.8278
-18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4
‰, VPDB
d13C
d18O
Linear (d13C)
Linear (d18O)

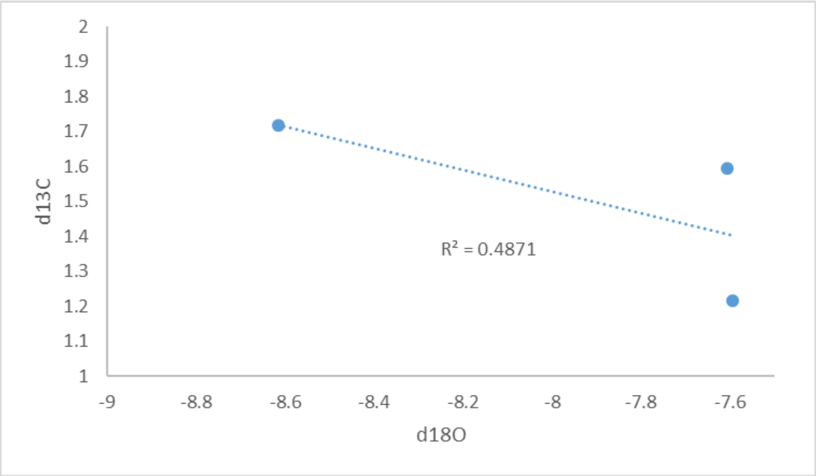


4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
d13C
R² = 0.3389
-12 -11.5 -11 -10.5 -10 -9.5 -9
d18O

Zjj1 (j40-42)

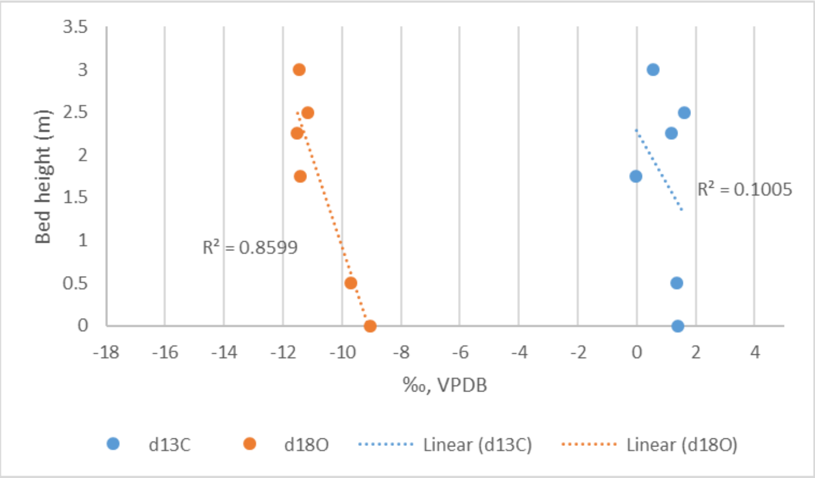


Bed height (m)
1.2
1
0.8
0.6
0.4
0.2
0
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
2
4
‰, VPDB
R² = 0.7404
R² = 0.0555
d13C
d18O
Linear (d13C)
Linear (d18O)

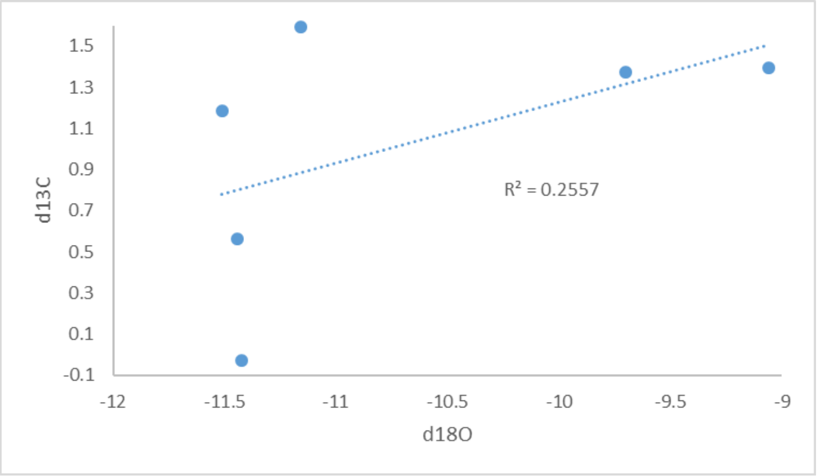


d13C
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
-9
-8.8
-8.6
-8.4
-8.2
-8
-7.8
-7.6
d18O
R² = 0.4871

Zji2 (j34-39)

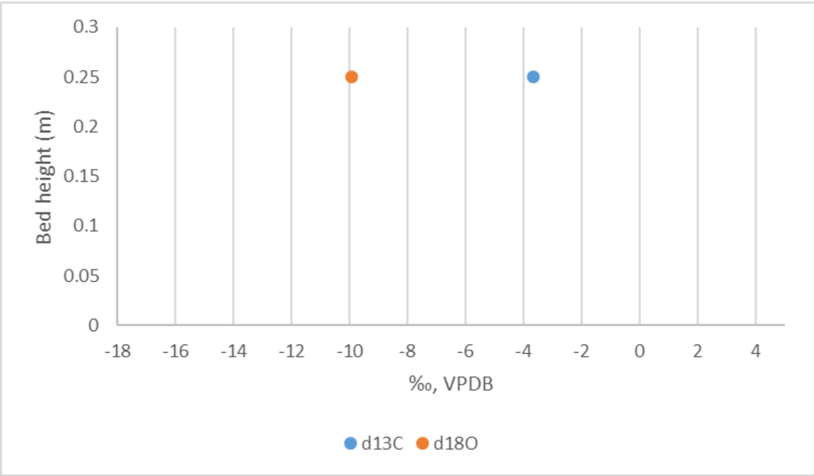


Bed height (m)
3.5
3
2.5
2
1.5
1
0.5
0
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
2
4
‰, VPDB
R² = 0.8599
R² = 0.1005
d13C
d18O
Linear (d13C)
Linear (d18O)

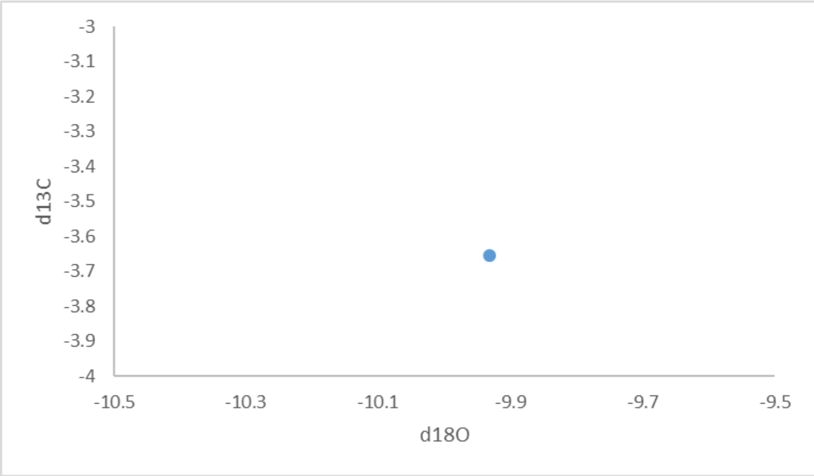


d13C
1.5
1.3
1.1
0.9
0.7
0.5
0.3
0.1
-0.1
-12
-11.5
-11
-10.5
-10
-9.5
-9
d18O
R² = 0.2557

Zji1 (j33)

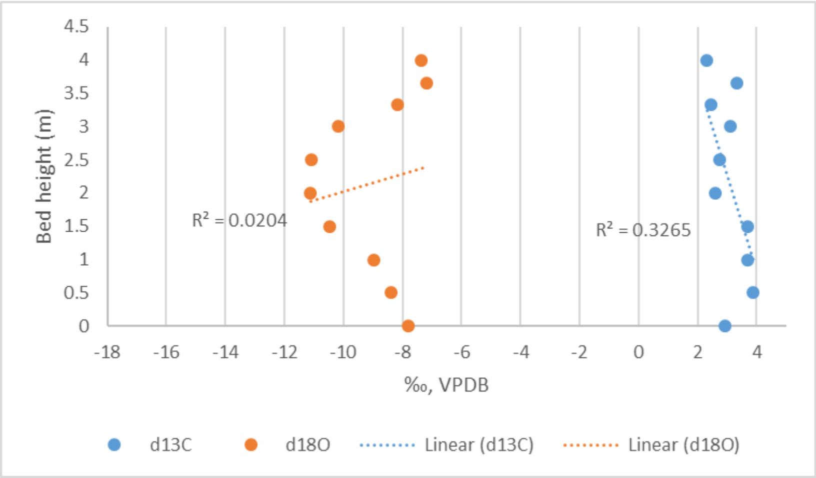


Bed height (m)
0.3
0.25
0.2
0.15
0.1
0.05
0
-18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4
‰, VPDB
d13C d18O

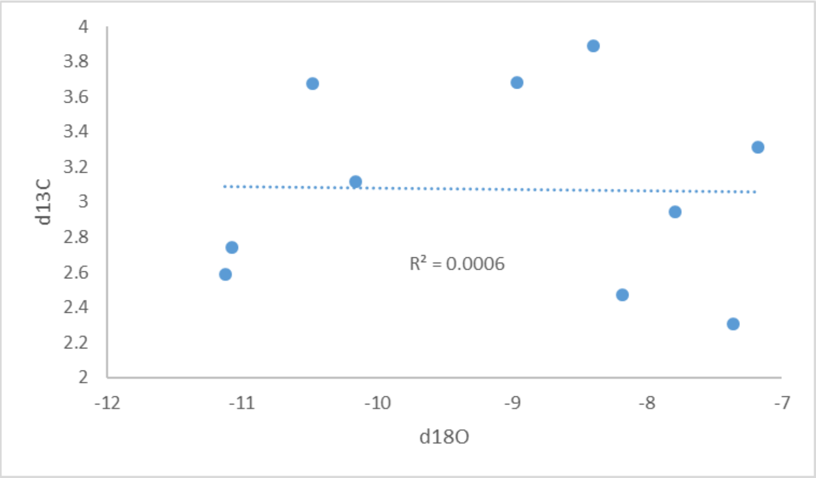


d13C
-3
-3.1
-3.2
-3.3
-3.4
-3.5
-3.6
-3.7
-3.8
-3.9
-4
-10.5 -10.3 -10.1 -9.9 -9.7 -9.5
d18O

Zjh6 (j23-32)

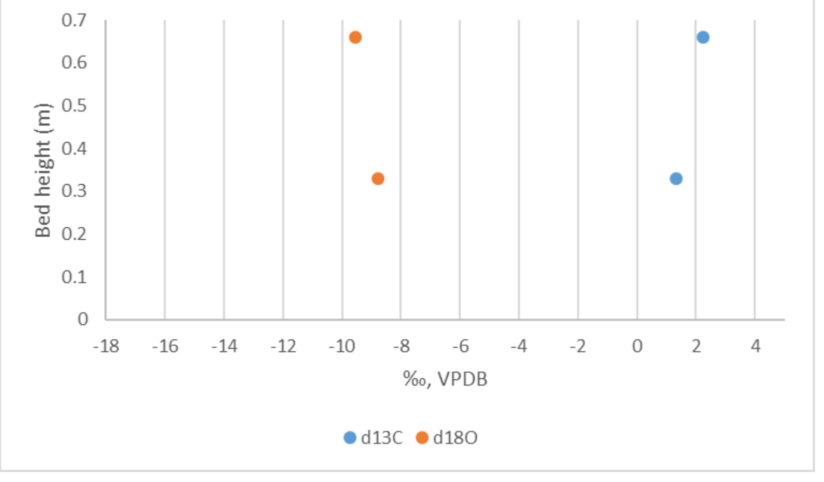


Bed height (m)
‰, VPDB
R² = 0.0204
R² = 0.3265
d13C
d18O
Linear (d13C)
Linear (d18O)

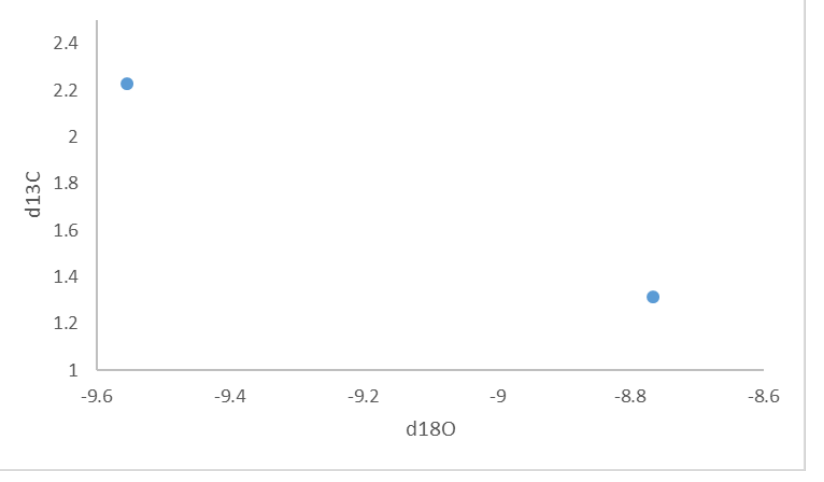


d13C
d18O
R² = 0.0006

Zjh5 (j21-22)

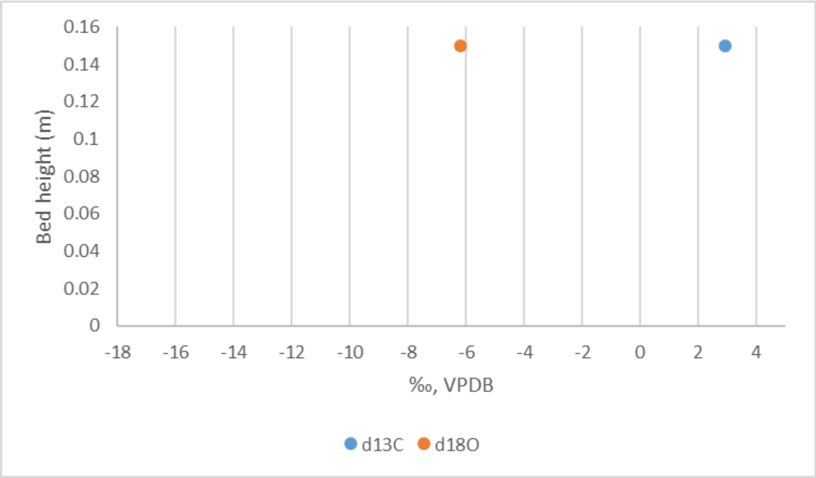


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Bed height (m)
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
2
4
‰, VPDB
d13C
d18O

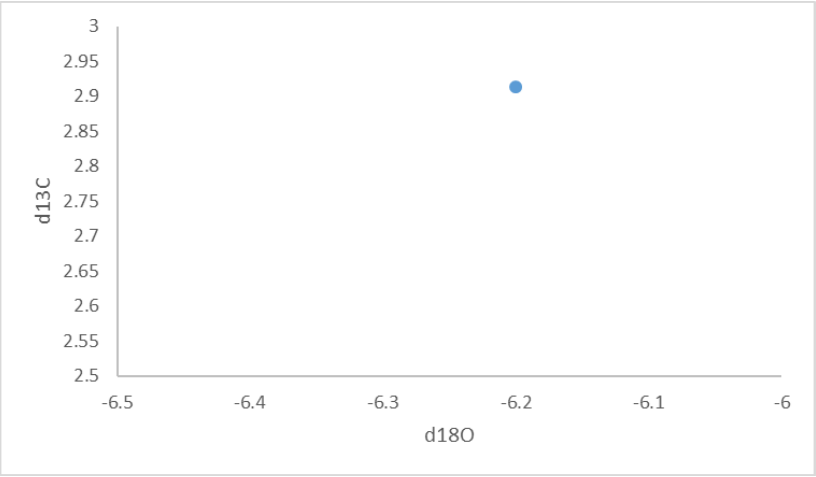


2.4
2.2
2
1.8
1.6
1.4
1.2
1
d13C
-9.6
-9.4
-9.2
-9
-8.8
-8.6
d18O

Zjh4 (j20)

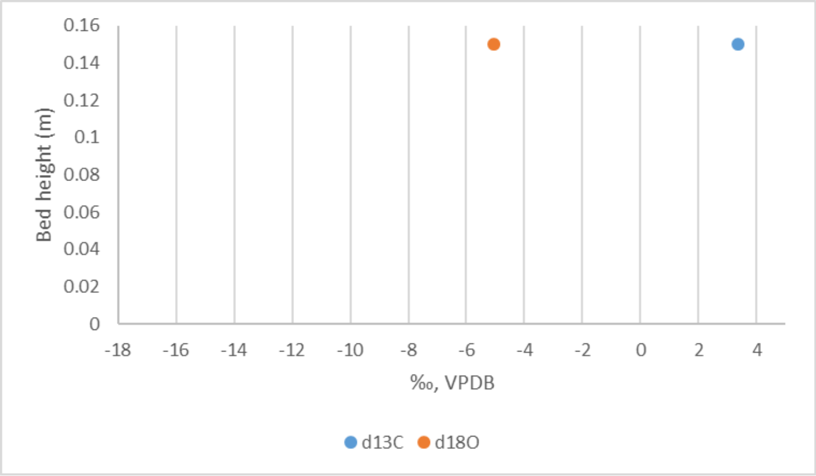


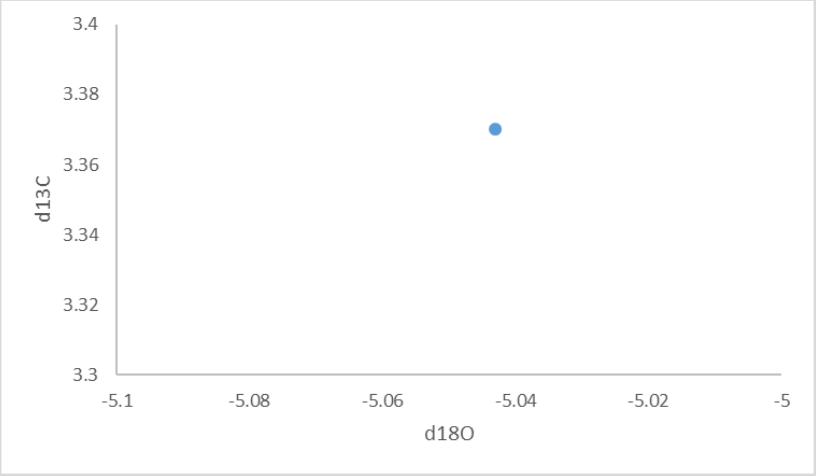
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Bed height (m)
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
2
4
‰, VPDB
d13C
d18O



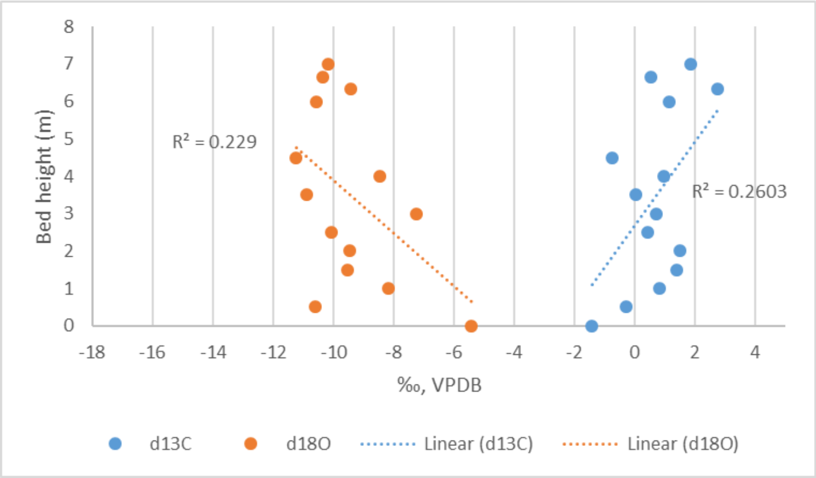
3
2.95
2.9
2.85
2.8
2.75
2.7
2.65
2.6
2.55
2.5
d13C
-6.5
-6.4
-6.3
-6.2
-6.1
-6
d18O

Zjh3 (j19)

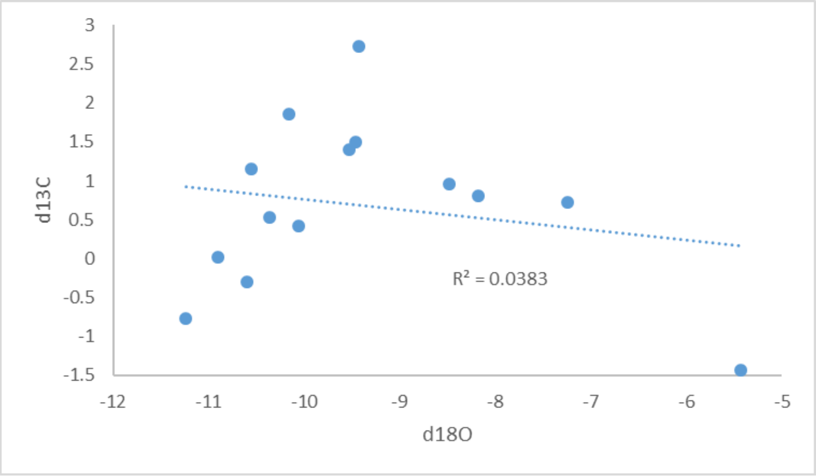

0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Bed height (m)
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
2
4
‰, VPDB
d13C
d18O


3.4
3.38
3.36
3.34
3.32
3.3
d13C
-5.1
-5.08
-5.06
-5.04
-5.02
-5
d18O

Zjh2 (j5-18)

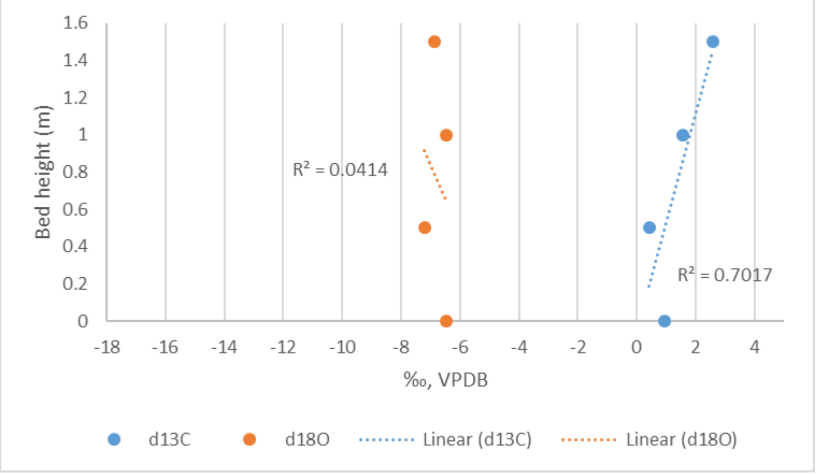


Bed height (m)
8
7
6
5
4
3
2
1
0
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
2
4
‰, VPDB
R² = 0.229
R² = 0.2603
d13C
d18O
Linear (d13C)
Linear (d18O)

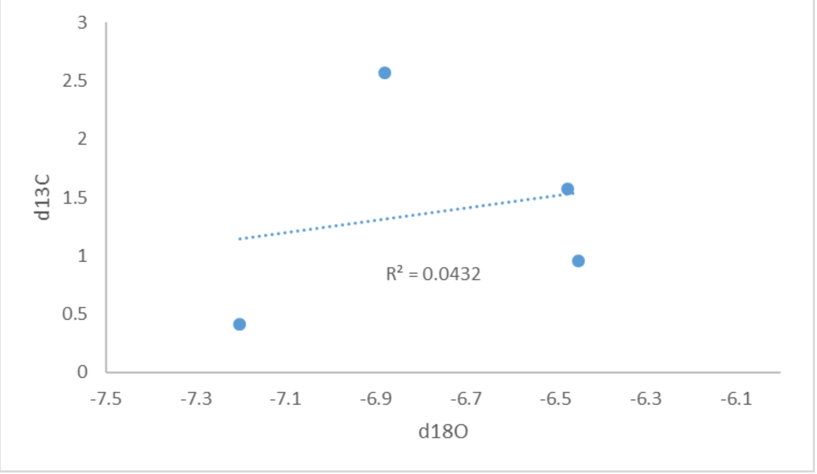


d13C
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-12
-11
-10
-9
-8
-7
-6
-5
d18O
R² = 0.0383

Zjh1 (j(1-4)

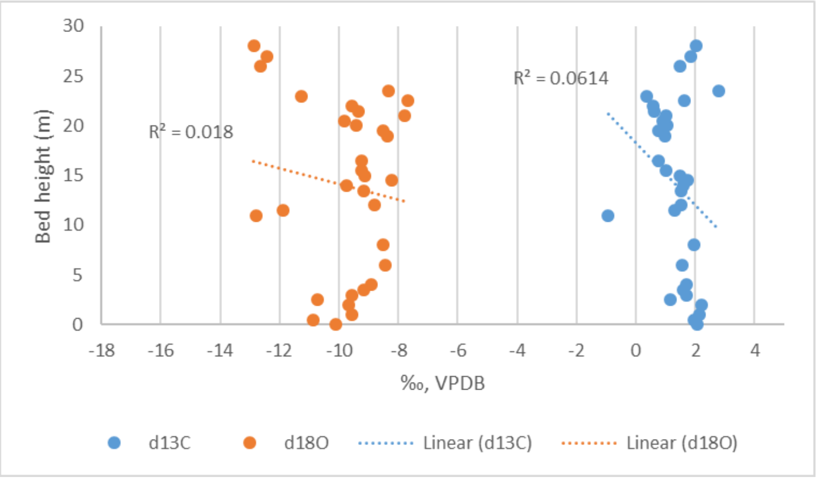


1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Bed height (m)
R² = 0.0414
R² = 0.7017
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
2
4
‰, VPDB
d13C
d18O
Linear (d13C)
Linear (d18O)

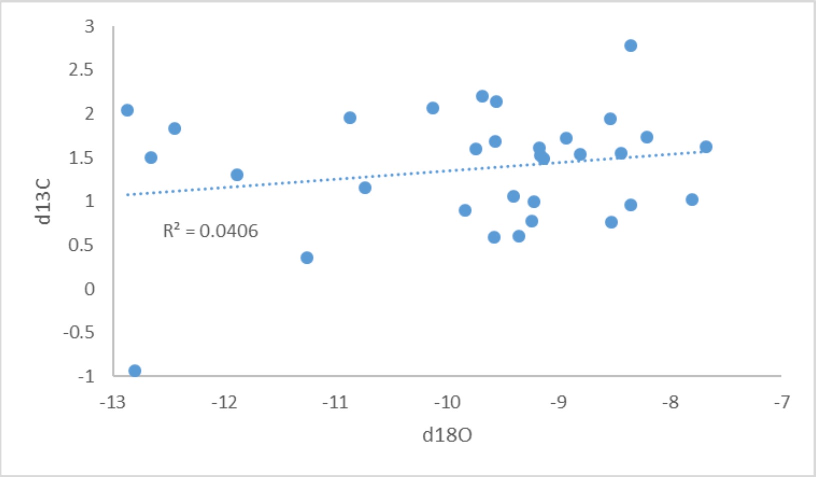


3
2.5
2
1.5
1
0.5
0
d13C
R² = 0.0432
-7.5
-7.3
-7.1
-6.9
-6.7
-6.5
-6.3
-6.1
d18O

Zjf (j76-107)

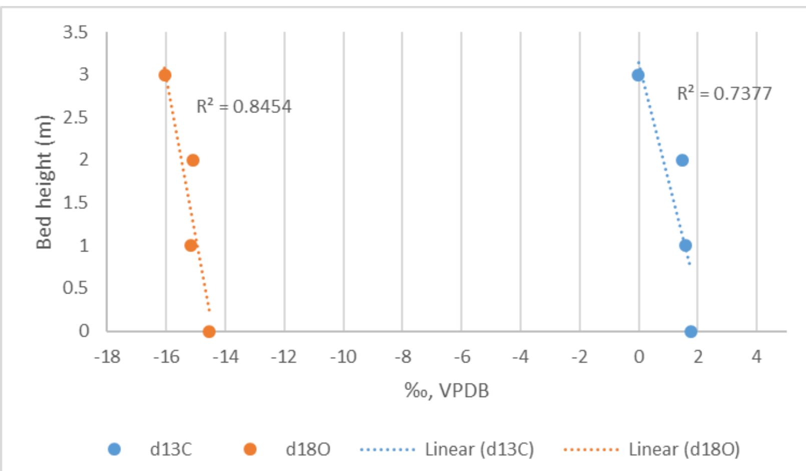


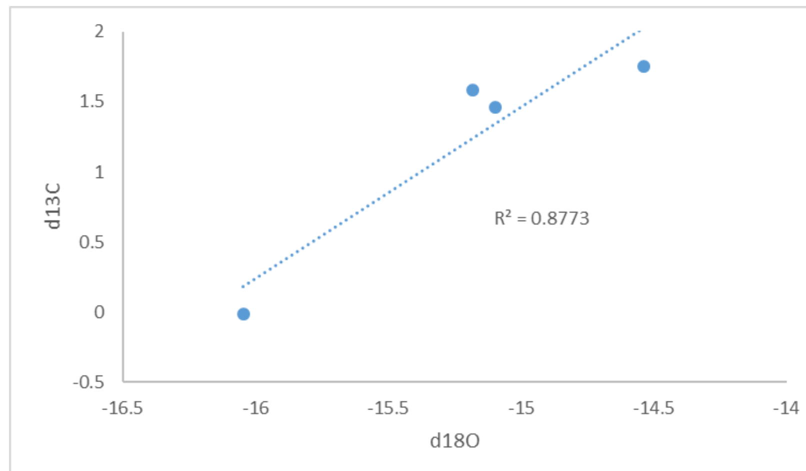
Bed height (m)
‰, VPDB
R^2 = 0.018
R^2 = 0.0614
d13C
d18O
Linear (d13C)
Linear (d18O)



d13C
d18O
R^2 = 0.0406

Zjc (j72-75)


3.5
3
2.5
2
1.5
1
0.5
0
Bed height (m)
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
2
4
‰, VPDB
R² = 0.8454
R² = 0.7377
d13C
d18O
Linear (d13C)
Linear (d18O)


2
1.5
1
0.5
0
-0.5
d13C
-16.5
-16
-15.5
-15
-14.5
-14
d18O
R² = 0.8773

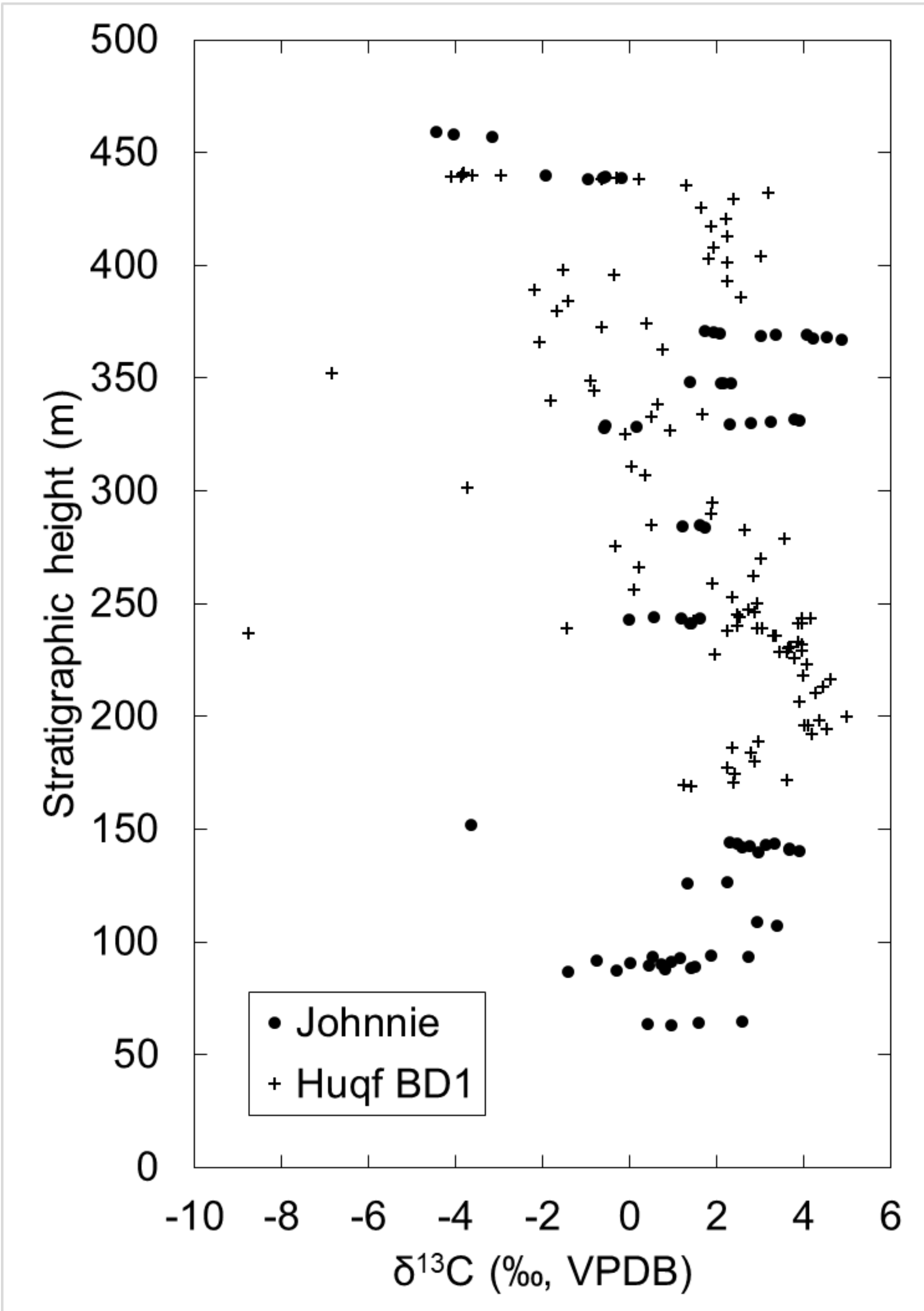
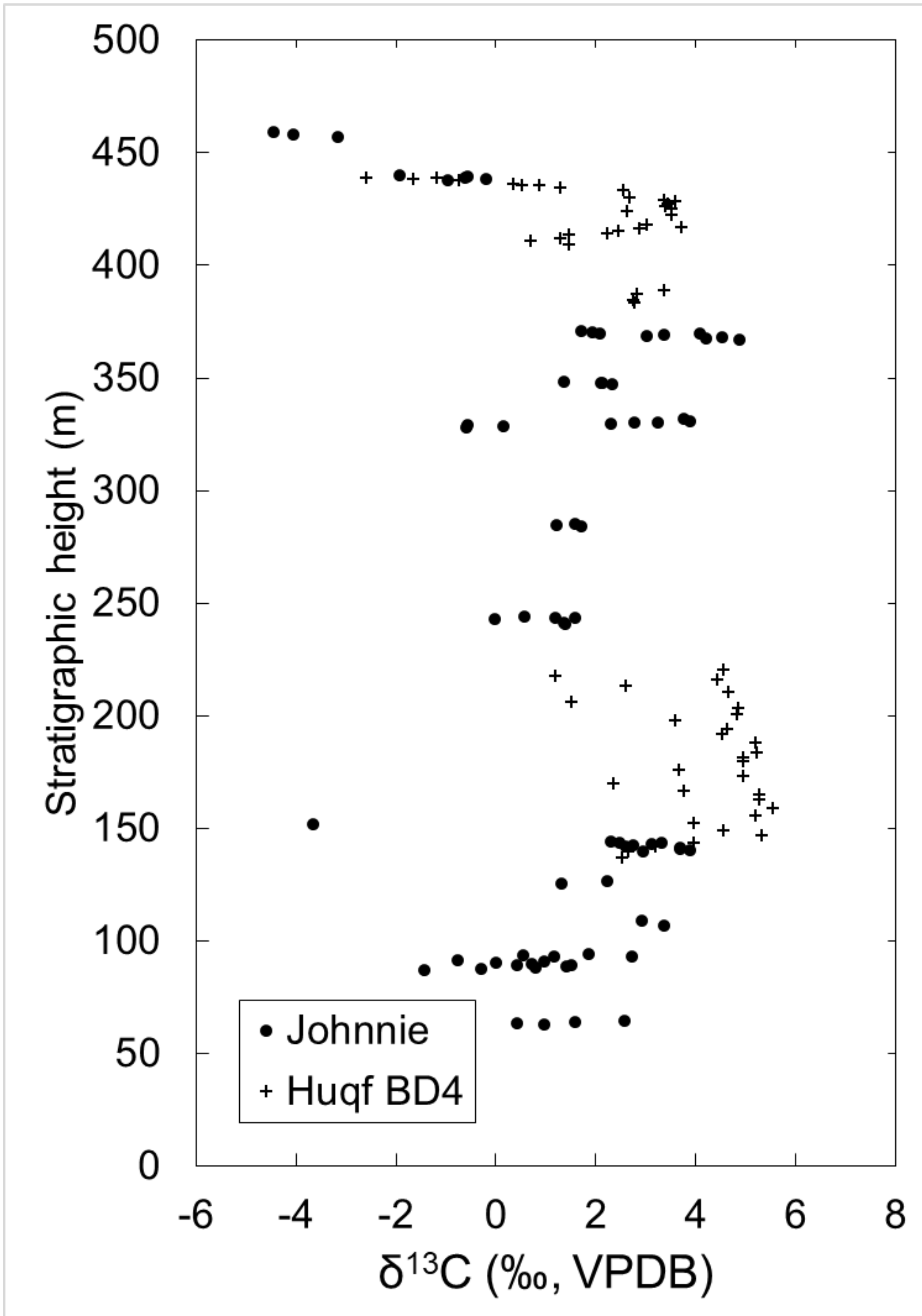
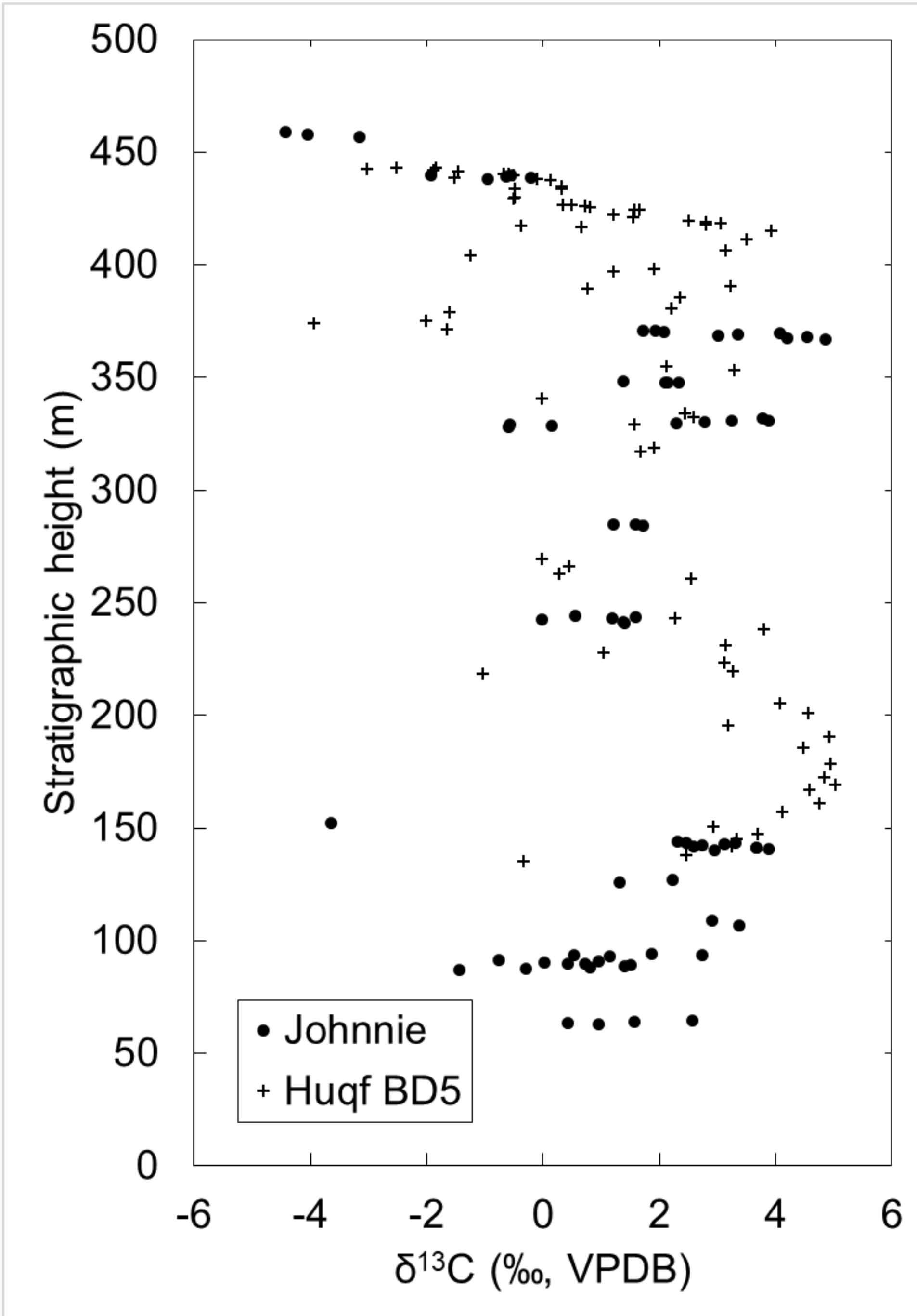


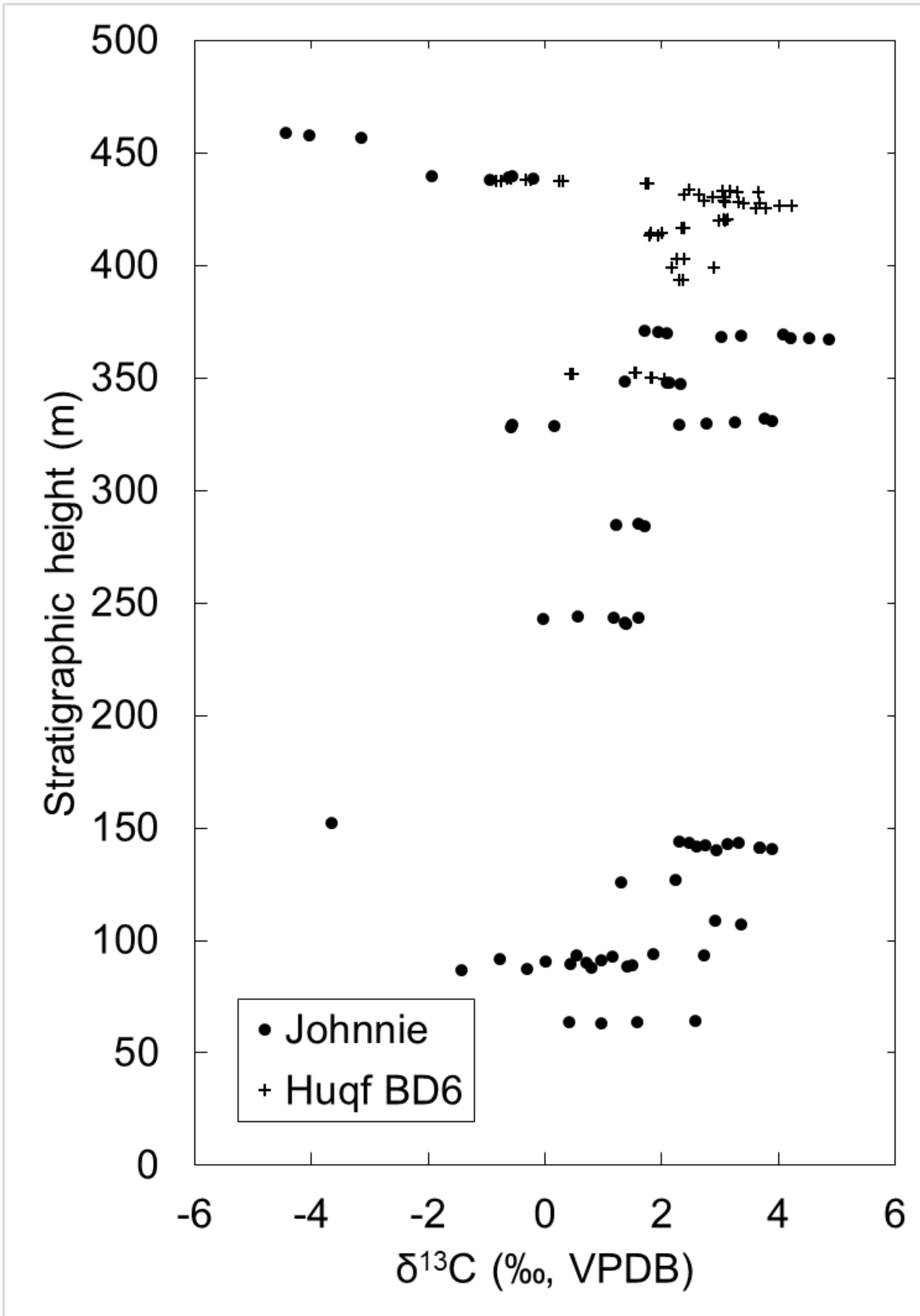
Figure S3: Chemostratigraphic profiles comparing carbon isotopic data from the Johnnie Formation from unit H through the lowermost Rainstorm Member (ending at the top of the oolite marker bed, Figure 7) with profiles from the Buah Dome (BD1, BD4, BD5, BD6); Khufai Dome (KDW); and Mukhaibah Dome (MD5, MD6, MDE) areas of Oman (Osburn et al., 2015). Vertical axis shows measured stratigraphic height, from the Mt. Schader section, in all profiles.

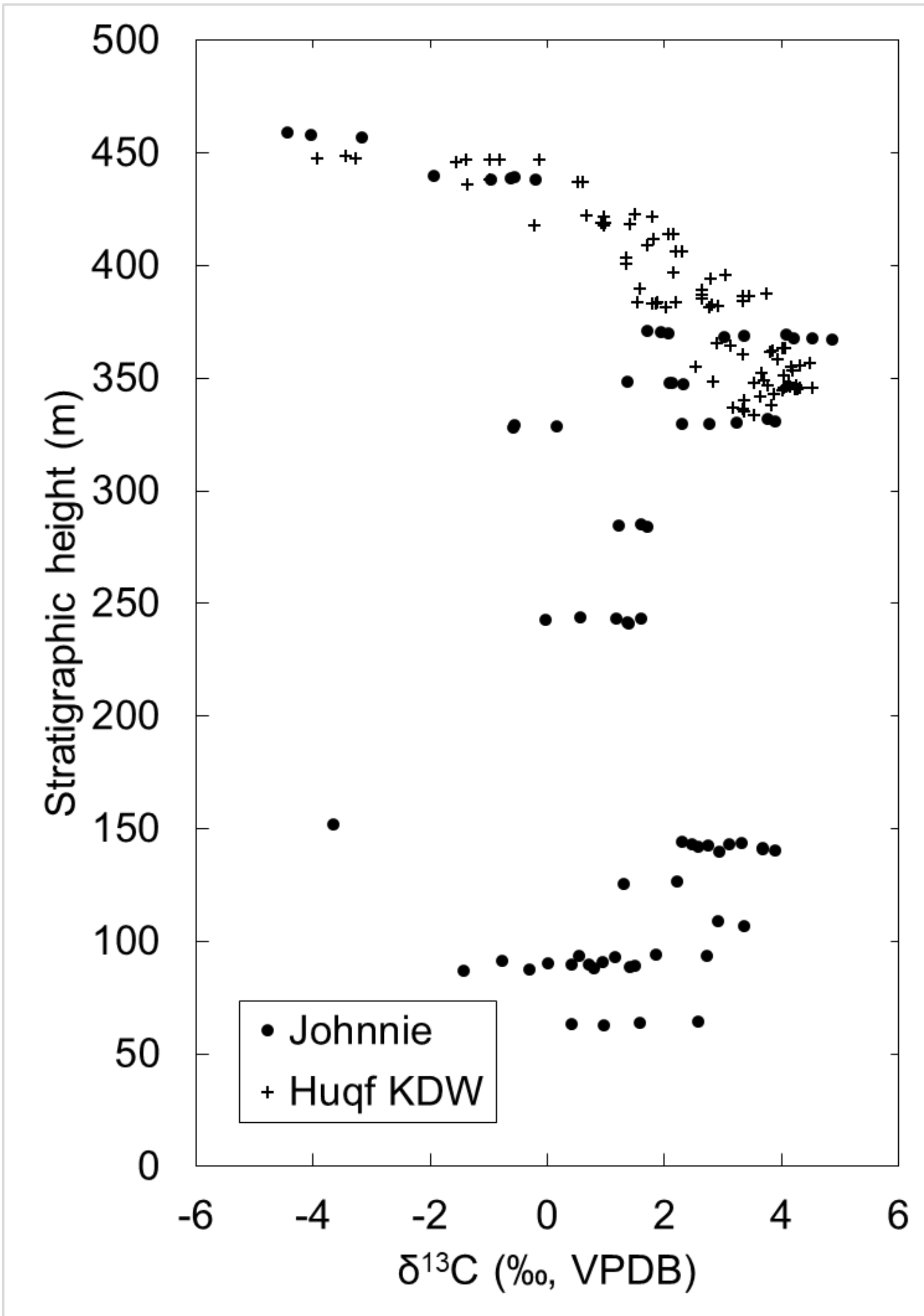


500
450
400
350
300
250
200
150
100
50
0
Stratigraphic height (m)
-6
-4
-2
0
2
4
6
8
δ13C (‰, VPDB)
Johnnie
Huqf BD4

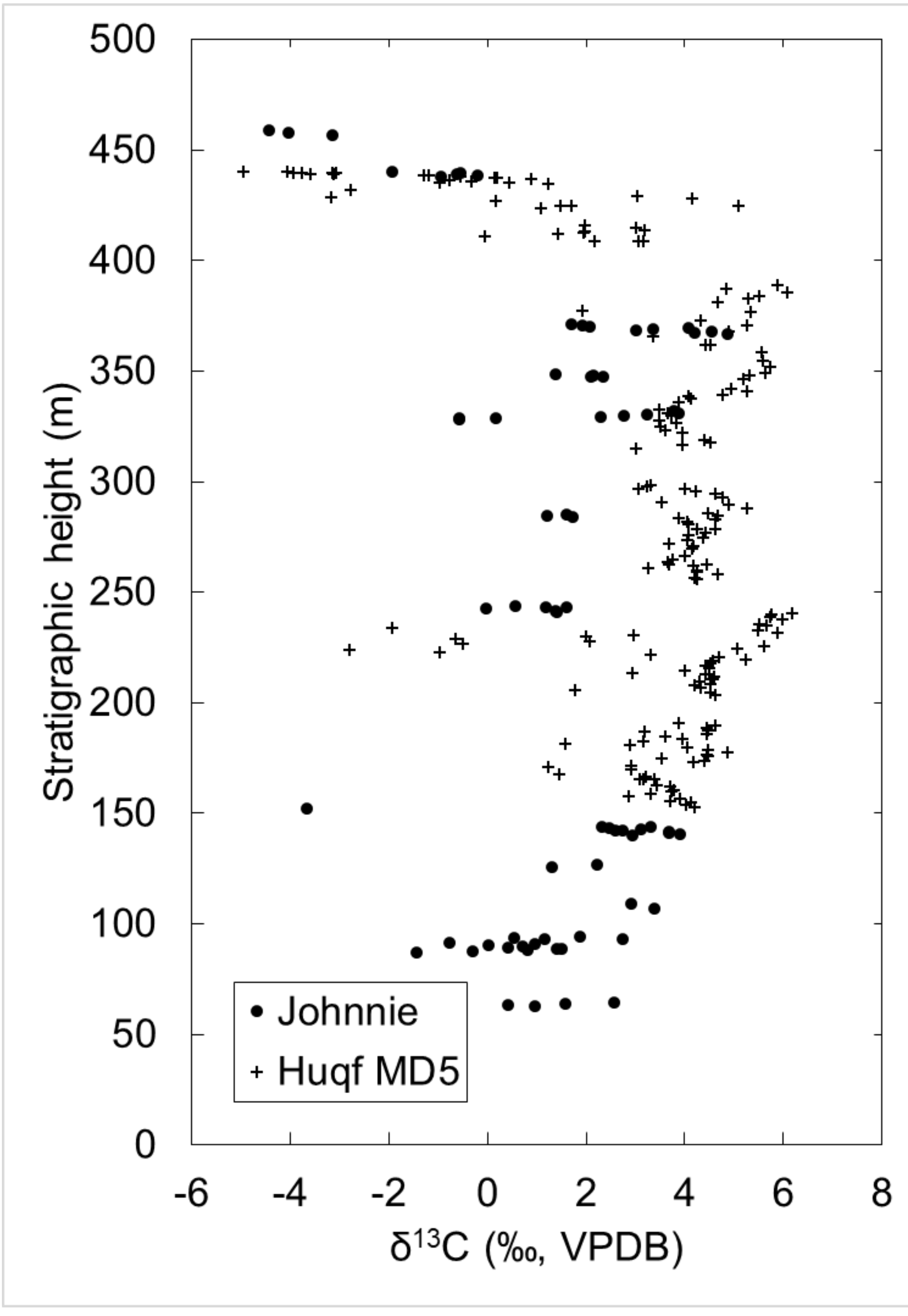


500
450
400
350
300
250
200
150
100
50
0
Stratigraphic height (m)
-6
-4
-2
0
2
4
6
δ13C (‰, VPDB)
Johnnie
Huqf BD5

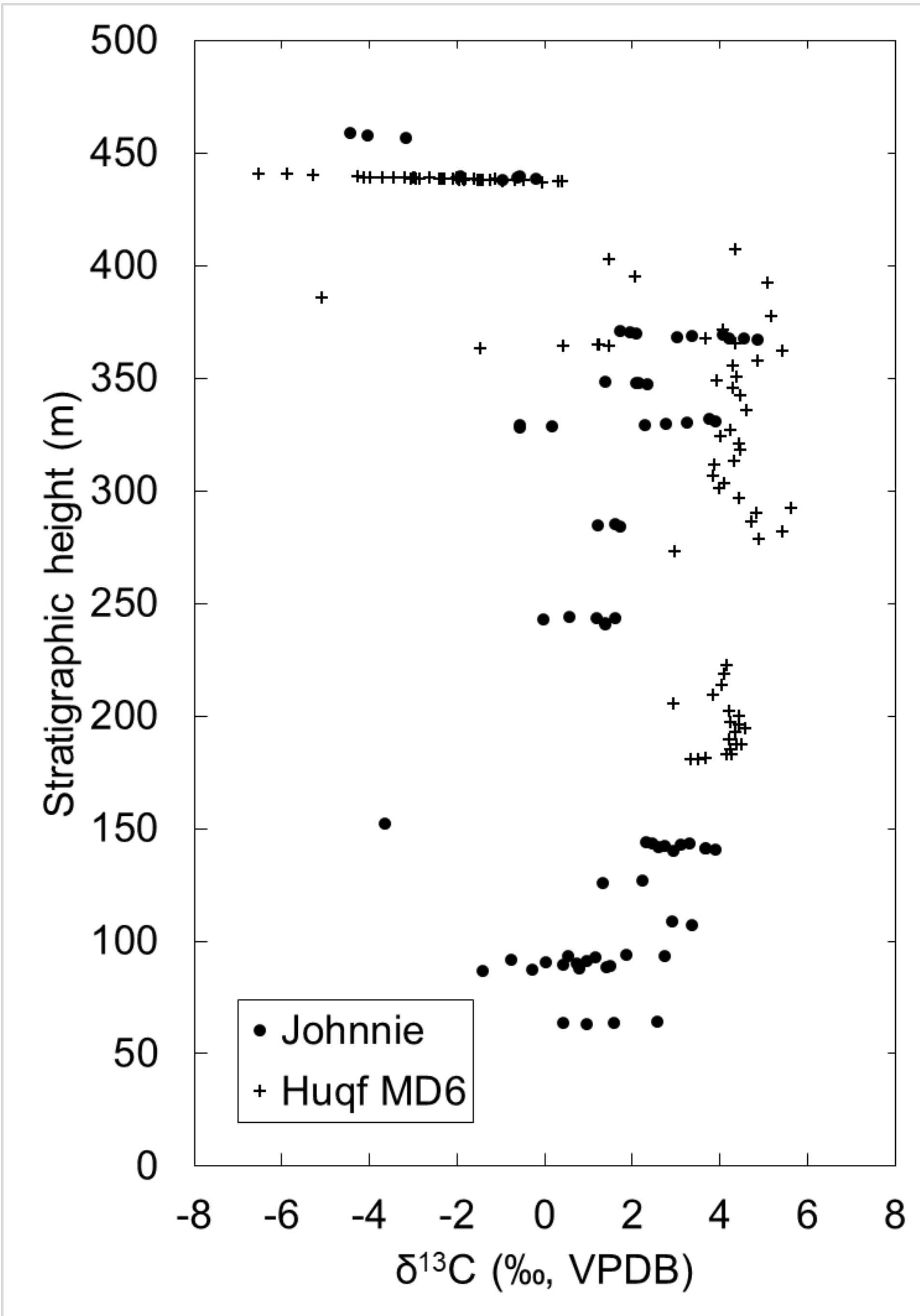

Stratigraphic height (m)
δ13C (‰, VPDB)
500
450
400
350
300
250
200
150
100
50
0
-6
-4
-2
0
2
4
6
Johnnie
Huqf BD6



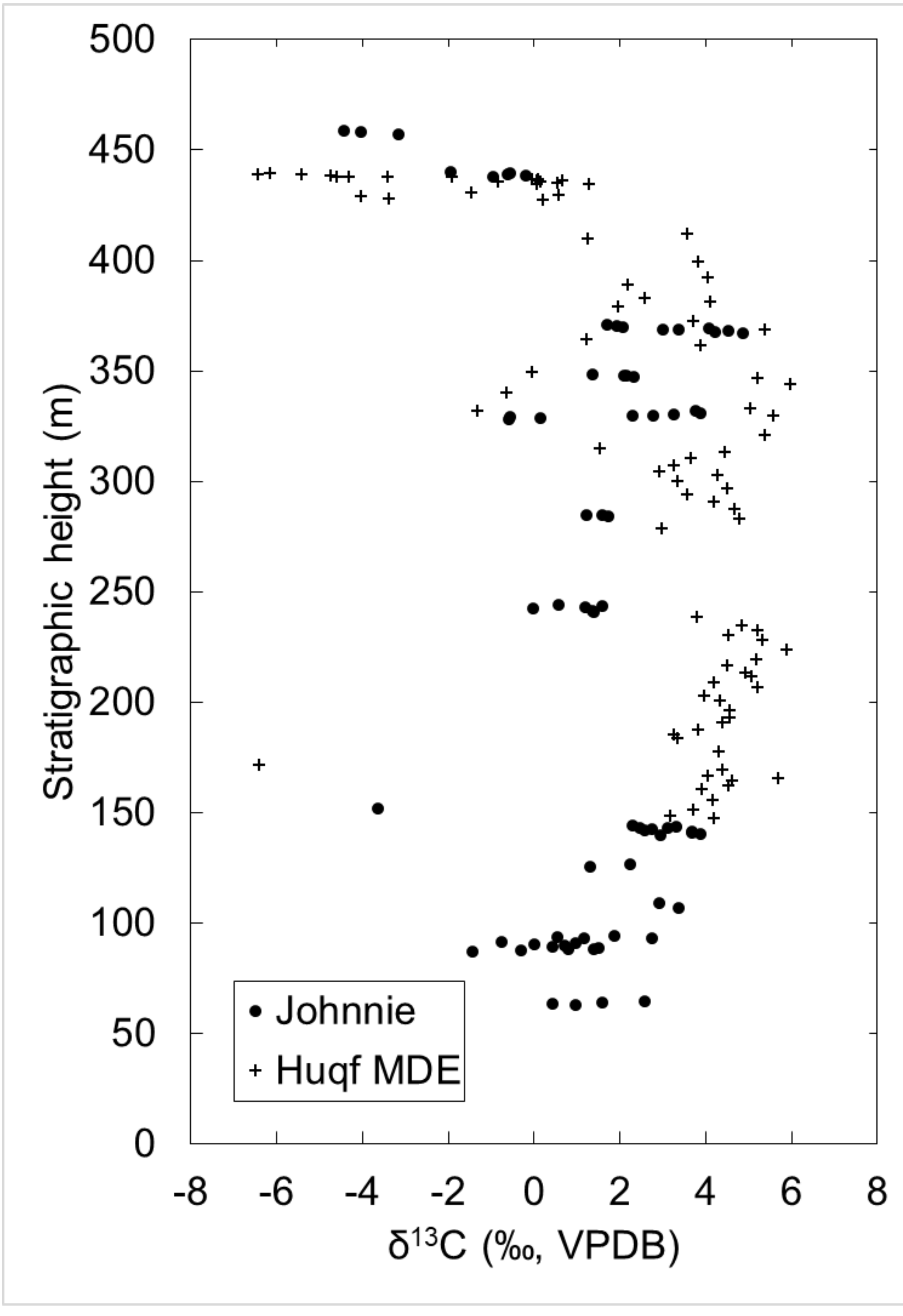
500
450
400
350
300
250
200
150
100
50
0
Stratigraphic height (m)
-6
-4
-2
0
2
4
6
δ13C (‰, VPDB)
Johnnie
Huqf KDW



500
450
400
350
300
250
200
150
100
50
0
Stratigraphic height (m)
-6
-4
-2
0
2
4
6
8
δ13C (‰, VPDB)
Johnnie
Huqf MD5



Stratigraphic height (m)
δ13C (‰, VPDB)
Johnnie
Huqf MD6



Stratigraphic height (m)
δ13C (‰, VPDB)
Johnnie
Huqf MDE
500
450
400
350
300
250
200
150
100
50
0
-8
-6
-4
-2
0
2
4
6
8

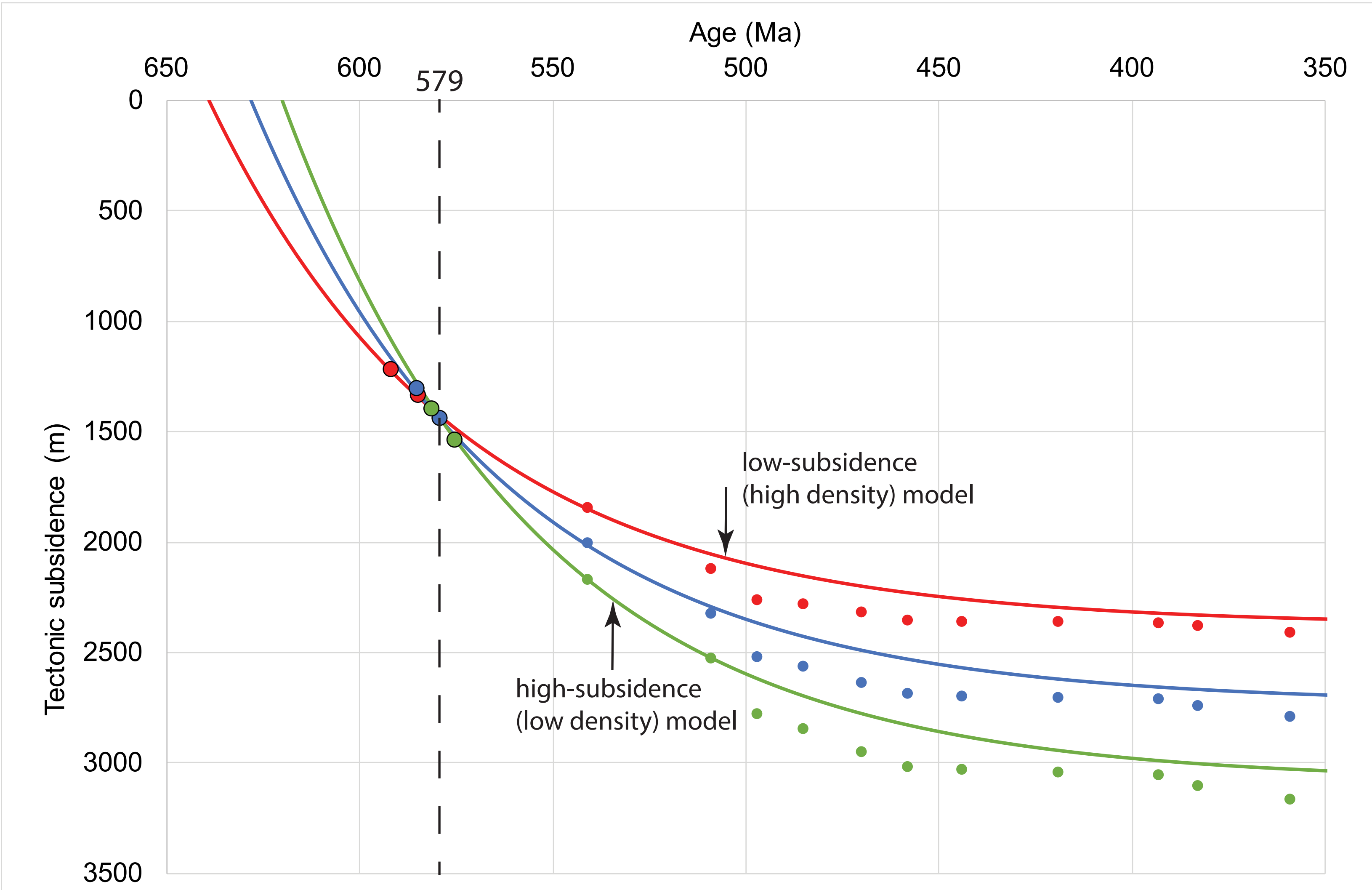


Figure S4: Plot showing tectonic subsidence data and models as a function of age (small points and curves, respectively), showing the effect of varying sediment grain density on estimates for the age and duration of the Shuram excursion (large points). Red: high-density; blue: intermediate density; green: low density.

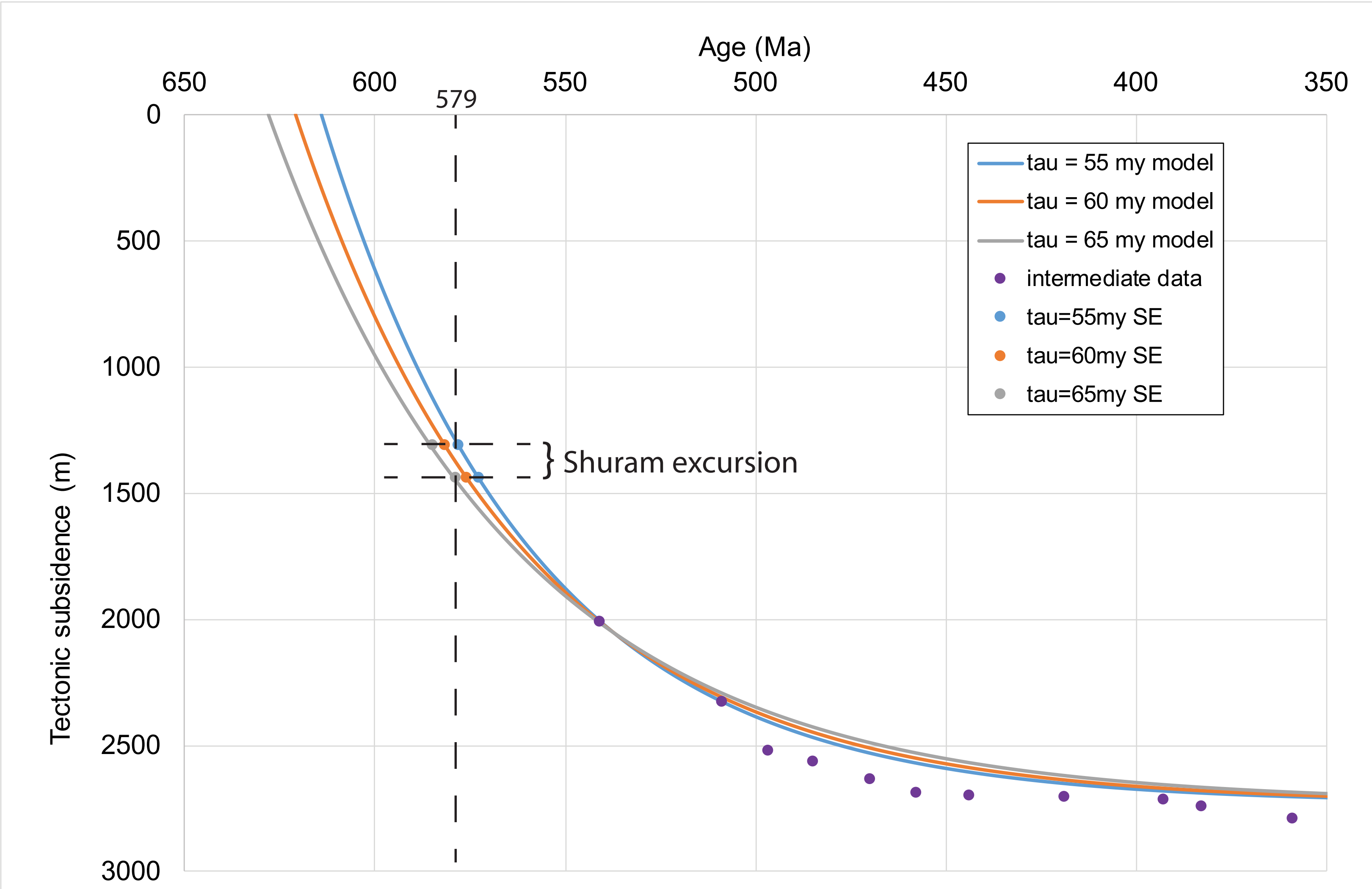


Figure S5: Plot showing tectonic subsidence data and models as a function of age (points and curves, respectively), showing the effect of varying the exponential time constant τ. Models are fit to the 541 Ma data point and assume intermediate sediment grain density.

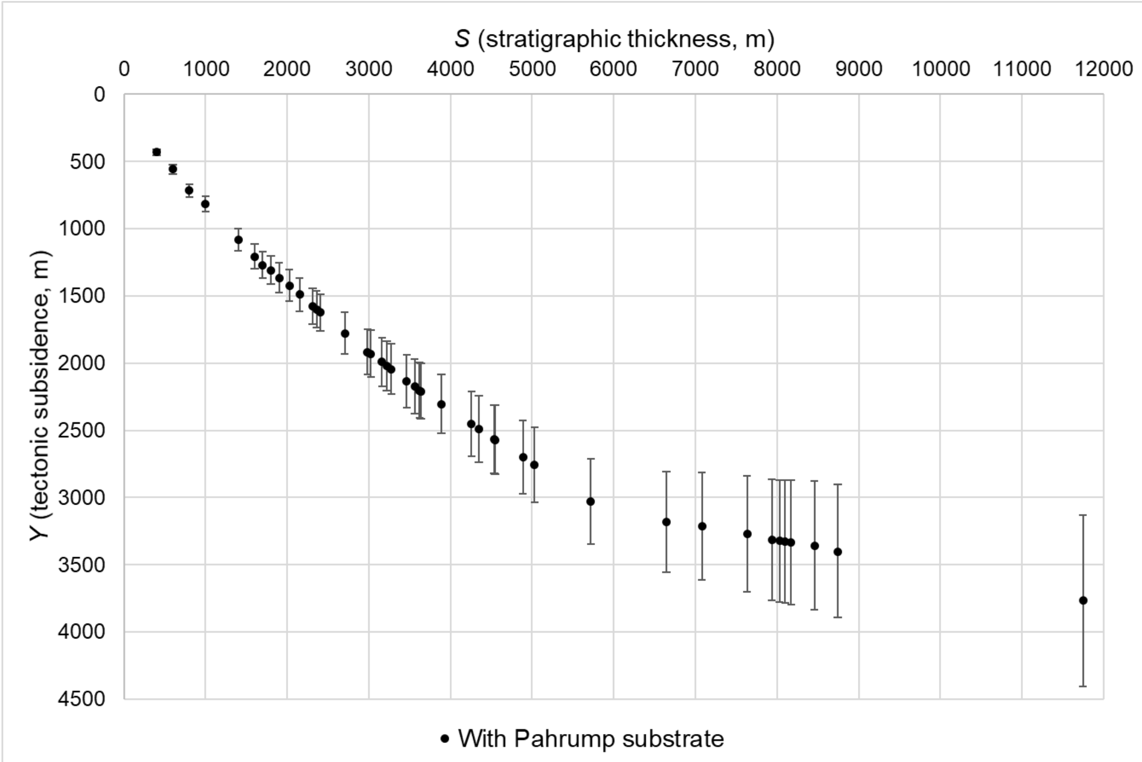


Figure S6: Plot showing calculated tectonic subsidence *Y* as a function of observed stratigraphic thickness *S* for the backstripping and delithification model that includes a hypothetical Pahrump Group substrate below the lowest exposed Johnnie Formation strata (unit A) in the Spring Mountains section. Error bars show range of estimates of *Y* produced by a ±5 % variation in sediment grain density.

FIGURE CAPTIONS

Figure S1: (A) Google Earth image looking c. 60° down-dip to the east along section B - B’ in Figure 3, showing traces of mapped unit boundaries (dashed lines) for units E through L and the Rainstorm Member, using unit designations from the Appendix. Width of view at level of Zji is c. 400 m. (B) Google Earth image looking c. 40° down-dip to the east along section A - A’ in Figure 3, showing traces of mapped unit boundaries for units A through I. Width of view at unit D/E boundary is c. 1200 m.

Figure S2: Plots of $\delta^{13}C$ and $\delta^{18}O$ versus stratigraphic position with side-by-side cross plots of $\delta^{18}O$ versus $\delta^{13}C$, for each individual carbonate interval designated in Figure 10 of the main text.

Figure S3: Chemostratigraphic profiles comparing carbon isotopic data from the Johnnie Formation from unit H through the lowermost Rainstorm Member (ending at the top of the oolite marker bed, Figure 7) with profiles from the Buah Dome (BD1, BD4, BD5, BD6); Khufai Dome (KDW); and Mukhaibah Dome (MD5, MD6, MDE) areas of Oman (Osburn et al., 2015). Vertical axis shows measured stratigraphic height, from the Mt. Schader section, in all profiles.

Figure S4: Plot showing tectonic subsidence data and models as a function of age (small points and curves, respectively), showing the effect of varying sediment grain density on estimates for the age and duration of the Shuram excursion (large points). Red: high-density; blue: intermediate density; green: low density.

Figure S5: Plot showing tectonic subsidence data and models as a function of age (points and curves, respectively), showing the effect of varying the exponential time constant τ. Models are fit to the 541 Ma data point and assume intermediate sediment grain density.

Figure S6: Plot showing calculated tectonic subsidence *Y* as a function of observed stratigraphic thickness *S* for the backstripping and delithification model that includes a hypothetical Pahrump Group substrate below the lowest exposed Johnnie Formation strata (unit A) in the Spring Mountains section. Error bars show range of estimates of *Y* produced by a ±5 % variation in sediment grain density.

TABLES

Table S1: Chemostratigraphy results

Unit	Sample	Stratigraphic position (m)	Bed position (m)	$\delta^{13}C$ (‰, VPDB)	$\delta^{18}O$ (‰, VPDB)	Notes
Zjc collection site* located at 36°30'35.05" N, 116°00'58.55" W (within rectangle labeled “Locality A” in Figure 2A)						
Zjc	J72	-	0.00	1.8	-14.5	
	J73	-	1.00	1.6	-15.2	
	J74	-	2.00	1.5	-15.1	
	J75	-	3.00	0.0	-16.0	

Zjf collected along a transect beginning at 36°28'53.96" N, 116°01'30.13" W; ending at 36°28'53.79" N, 116°01'28.97" W (at the beginning of cross section line B-B' in Figure 3: Johnnie Wash geologic map)						
Zjf	J76	-	0.00	2.1	-10.1	
	J77	-	0.50	2.0	-10.9	
	J78	-	1.00	2.1	-9.6	
	J79	-	2.00	2.2	-9.7	
	J80	-	2.50	1.2	-10.7	
	J81	-	3.00	1.7	-9.6	
	J82	-	3.50	1.6	-9.2	
	J83	-	4.00	1.7	-8.9	
	J84	-	6.00	1.6	-8.4	
	J85	-	8.00	1.9	-8.5	
	J86	-	11.00	-0.9	-12.8	
	J87	-	11.50	1.3	-11.9	
	J88	-	12.00	1.5	-8.8	
	J89	-	13.50	1.5	-9.2	
	J90	-	14.00	1.6	-9.7	
	J91	-	14.50	1.7	-8.2	
	J92	-	15.00	1.5	-9.1	
	J93	-	15.50	1.0	-9.2	

	J94	-	16.50	0.8	-9.2	
	J95	-	19.00	1.0	-8.4	
	J96	-	19.50	0.8	-8.5	
	J97	-	20.00	1.1	-9.4	
	J98	-	20.50	0.9	-9.8	
	J99	-	21.00	1.0	-7.8	
	J100	-	21.50	0.6	-9.4	
	J101	-	22.00	0.6	-9.6	
	J102	-	22.50	1.6	-7.7	
	J103	-	23.00	0.4	-11.3	
	J104	-	23.50	2.8	-8.4	
	J105	-	26.00	1.5	-12.7	
	J106	-	27.00	1.8	-12.4	
	J107	-	28.00	2.0	-12.9	
Transect a-a’ in Figure 6: Mt. Schader geologic map (begins at 36°27'31.70" N, 116°05'43.38" W; ends at 36°27'30.30" N, 116°05'33.92" W)						
Zjh	J1	63.00	0.00	1.0	-6.5	
	J2	63.50	0.50	0.4	-7.2	
	J3	64.00	1.00	1.6	-6.5	
	J4	64.50	1.50	2.6	-6.9	

	J5	87.00	0.00	-1.4	-5.4	
	J6	87.50	0.50	-0.3	-10.6	
	J7	88.00	1.00	0.8	-8.2	
	J8	88.50	1.50	1.4	-9.5	
	J9	89.00	2.00	1.5	-9.5	
	J10	89.50	2.50	0.4	-10.1	
	J11	90.00	3.00	0.7	-7.2	
	J12	90.50	3.50	0.0	-10.9	
	J13	91.00	4.00	1.0	-8.5	
	J14	91.50	4.50	-0.8	-11.2	
	J15	93.00	6.00	1.2	-10.6	
	J16	93.33	6.33	2.7	-9.4	
	J17	93.66	6.66	0.5	-10.4	
	J18	94.00	7.00	1.9	-10.2	
	J19	107.00	-	3.4	-5.0	
	J20	109.00	-	2.9	-6.2	
	J21	125.75	-	1.3	-8.8	
	J22	126.75	-	2.2	-9.6	
	J23	140.00	0.00	2.9	-7.8	
	J24	140.50	0.50	3.9	-8.4	

	J25	141.00	1.00	3.7	-9.0	
	J26	141.50	1.50	3.7	-10.5	
	J27	142.00	2.00	2.6	-11.1	
	J28	142.50	2.50	2.7	-11.1	
	J29	143.00	3.00	3.1	-10.2	
	J30	143.33	3.33	2.5	-8.2	
	J31	143.66	3.66	3.3	-7.2	
	J32	144.00	4.00	2.3	-7.4	
Transect b-b' in Figure 6: Mt. Schader geologic map (begins at 36°27'18.37" N, 116°05'39.60" W; ends at 36°27'17.54" N, 116°05'33.18" W)						
Zji	J33	152.00	-	-3.7	-9.9	
	J34	241.00	0.00	1.4	-9.1	
	J35	241.50	0.50	1.4	-9.7	
	J36	242.75	1.75	0.0	-11.4	
	J37	243.25	2.25	1.2	-11.5	
	J38	243.50	2.50	1.6	-11.2	
	J39	244.00	3.00	0.6	-11.4	
Transect c-c' in Figure 6: Mt. Schader geologic map (begins at 36°26'50.85" N, 116°05'53.02" W; ends at 36°26'45.94" N, 116°05'46.85" W)						
Zjj	J40	284.00	0.00	1.7	-8.6	
	J41	284.50	0.50	1.2	-7.6	

	J42	285.00	1.00	1.6	-7.6	
	J43	328.00	0.00	-0.6	-11.7	
	J44	328.50	0.50	0.2	-9.8	
	J45	329.00	1.00	-0.6	-10.1	
	J46	329.50	1.50	2.3	-9.0	
	J47	330.00	2.00	2.8	-10.2	
	J48	330.50	2.50	3.2	-9.7	
	J49	331.00	3.00	3.9	-9.6	
	J50	332.00	4.00	3.8	-9.8	
Zjk	J51	347.50	0.00	2.3	-5.0	
	J52	347.75	0.25	2.1	-7.0	
	J53	348.00	0.50	2.1	-7.1	
	J54	348.50	1.00	1.4	-5.4	
	J55	367.00	0.00	4.9	-7.0	
	J56	367.50	0.50	4.2	-8.3	
	J57	368.00	1.00	4.5	-8.2	
	J58	368.50	1.50	3.0	-13.6	
	J59	369.00	2.00	3.4	-10.8	
	J60	369.50	2.50	4.1	-8.2	
	J61	370.00	3.00	2.1	-10.6	

	J62	370.50	3.50	1.9	-10.9	
	J63	371.00	4.00	1.7	-8.8	
Transect d-d' in Figure 6: Mt. Schader geologic map (begins at 36°27'28.71" N, 116°05'16.42" W; ends at 36°27'24.47" N, 116°05'10.44" W)						
Zjl	J64	438.00	0.00	-1.0	-7.3	
	J65	438.50	0.50	-0.2	-6.9	
	J66	439.00	1.00	-0.6	-7.7	
	J67	439.50	1.50	-0.6	-8.3	
	J68	440.00	2.00	-1.9	-7.0	
Zjr	J69	457.00	0.00	-3.2	-7.2	Johnnie oolite
	J70	458.00	1.00	-4.0	-9.8	
	J71	459.00	2.00	-4.4	-8.7	
*All locations recorded using GPS with the WGS84 coordinate system						

Table S2: All ages modeled using hypothetical Pahrump Group substrate										
		Model ages (Ma)								
		τ = 55 my			τ = 60 my			τ = 65 my		
Unit	Age (Ma)	Min	Int	Max	Min	Int	Max	Min	Int	Max
MzPzco	~243	-	-	-	-	-	-	-	-	-
Ddg	359	-	-	-	-	-	-	-	-	-

Dn	383	-	-	-	-	-	-	-	-	-
Dl	393	342	327	288	324	307	265	306	288	242
Sl	419	364	349	310	348	332	289	331	314	268
Oes	444	378	365	318	363	349	298	348	333	278
Oe	458	393	379	332	380	364	313	366	350	294
Op1	470	436	429	413	427	419	401	417	409	390
O€n1	485	468	460	440	461	452	431	454	445	422
€bk1	497	481	470	442	475	464	433	470	457	424
€c1	509	513	507	492	511	504	488	508	501	483
€Zwc1	541	541	541	541	541	541	541	541	541	541
Zse	-	545	546	547	546	546	548	546	547	548
Zsd	-	554	556	560	556	558	561	557	559	563
Zsc	-	554	556	560	556	558	562	557	559	563
Zsb	-	559	562	566	561	563	568	562	565	571
Zsa	-	561	564	569	563	566	571	565	568	574
Zjr2	-	569	572	579	571	575	582	574	578	585
Zjr1	-	573	577	584	576	580	588	579	584	592
Zjl	-	574	577	584	577	581	588	580	584	592
Zjk	-	575	579	586	578	582	590	581	586	594
Zjj	-	577	581	588	580	584	592	583	588	596

Zji	-	580	585	592	584	589	597	587	592	602
Zjh	-	581	586	594	585	590	598	588	594	603
Zjg	-	582	587	595	586	591	600	590	595	605
Zjf	-	584	589	598	588	594	603	592	598	608
Zje	-	585	590	598	589	594	603	593	599	608
Zjd	-	590	595	604	594	600	609	598	605	615
Zjc2	-	594	600	609	599	605	616	604	611	622
Zjc1	-	595	601	610	600	606	617	605	612	623
Zjb	-	596	602	611	601	607	618	606	613	624
Zja	-	598	604	614	603	610	621	609	616	627
Zjt	-	600	606	616	605	612	623	611	618	630
Zkpw	635	602	608	618	607	614	625	613	620	632
Zkpth	-	603	609	620	609	615	627	614	622	634
Zkpmg	-	604	610	621	610	617	628	615	623	635
Zkpsmp	-	605	612	622	611	618	630	617	625	637
Zkpls	-	608	615	626	615	622	634	621	629	641
Zbs	-	614	621	633	621	628	641	627	636	649
Zhs	<787	616	623	635	623	631	643	630	638	652
Ycs2	>1087	619	627	638	626	634	647	633	642	656
Ycs1	-	621	629	641	629	637	650	636	645	659

(base)	-	628	637	649	636	645	659	644	654	669

SUPPLEMENTAL TEXT

Lithologic descriptions regarding the Mt. Schader stratigraphic section for the Ediacaran Johnnie Formation, Montgomery Mountains, Nevada

Thickness of stratigraphic units were measured with a Jacob's staff and recorded to the nearest 1/4 or 1/3 of a meter. Care was taken to avoid structural complexities (i.e. by moving to locations where faults and/or folds are not present). Color names and numerical designations were recorded using a Geological Society of America Rock Color Chart with genuine Munsell® color chips. Grain sizes were recorded using an American/Canadian Stratigraphic reference card. Bed thicknesses use the following general designations: thin, <20 centimeters; medium, >20 centimeters; and thick, >50 centimeters. Total thickness of section measured is 538 meters for the Johnnie Formation, and 54 meters for the Stirling Quartzite (grand total of 592 meters).

Locality 1 (section 4, d-d')

Northeast part of Montgomery Mountains, measured about 3 kilometers west/southwest of Mt. Schader, starting at UTM zone 11S 0581729 m E 4035133 m N, and ending at UTM zone 11S 0581879 m E 4035004 m N.

Stirling Quartzite (incomplete):

Zsa member (incomplete):

Meters

48. Breccia and conglomerate. Breccia and conglomerate are very pale orange (10YR 8/2); weather to dark yellowish orange (10YR 6/6) and grayish black (N2); grains are poorly sorted coarse sand, pebbles, gravel; massive bedding; irregular cliff-forming protrusions; slickenlines on slickensided surfaces. Samples 20BW15 (590 m breccia) and 21BW15 (591 m). Incomplete measurement of bed.

4

47. Massive orthoquartzite. Orthoquartzite is pinkish gray (5YR 8/1); weathers to moderate yellowish orange (10YR 7/6); medium-coarse well-sorted grains; massive bedding with conjugate fractures; some cliff-forming protrusions on mostly recessive slopes. Sample 19BW15 (583 m-orthoquartzite).

14

46. Dolomitic sandstone. Dolomitic sandstone is grayish orange pink (5YR 7/2); weathers to grayish brown (5YR 3/2); fine-grained; laminated medium beds; trough cross strata; resistant cliff-forming unit.

8

45. Orthoquartzite and carbonate cemented sandstone. Orthoquartzite is very pale orange (10YR 8/2); weathers to dark yellowish orange (10YR 6/6); fine- to medium-grained; thick bedded; some laminations with fractures both along laminations and sub-orthogonal to laminations; channel fill with normal grading near base. Carbonate cemented sandstone is pale reddish brown (10R 5/4); weathers to olive black (5Y 2/1); fine-grained; medium-thick bedded; sometimes laminated.

28

Total of incomplete Zs member 54

Total of incomplete Stirling Quartzite 54

Johnnie Formation (incomplete):

Zjr member:

44. Sandstone and siltstone in ball-and-pillow structure, and dolostone. Ball-and-pillow structure is 1-2 m thick; light brown (5YR 6.4); weathers to dusky yellowish brown (10YR 2/2); sandstone is fine- to medium-grained; siltstone casted around sandstone. Other sandstone is pale red (5R 6/2); weathers to dark yellowish orange (10YR 6/6); fine-grained; medium bedded. Siltstone is typical VSS with additional new hue of pale red (5R 6/2); weathers to light greenish gray (5GY 8/1); speckled by 1 mm hematite grains; laminated. Dolostone is medium light gray (N6); weathers to yellowish orange (10YR 6/6) and light brown (5YR 6/4). Base of dolomitic sandstone is moderate yellowish brown (10YR 5/4); weathers to dusky yellowish brown (10YR 2/2) medium grains; some south-dipping foresets.

4

43. VSS and calcite-cemented sandstone. VSS as previous. Sandy limestone is pale red (10R 6/2); weathers to pale reddish brown (10R 5/4); very fine-grained; thin lenses of flaser beds.

8

42. Limestone breccia and sucrosic limestone. Limestone breccia is light gray (N7); weathers to light olive gray (5Y 5/2). Sucrosic limestone is pale red (10R 6/2); weathers to pale reddish brown (10R 5/4). Sandy

limestone and calcite cemented sandstone with laminated thin interbeds of sucrosic limestone; recessive, slope-forming unit.

24

41. Mixed siltstone and carbonate-rich sandstone. Siltstone as VSS; finely laminated. Sandstone is pale red (10R 6/2); weathers to dark yellowish brown (10YR 4/2); fine-grained, thin- to medium-bedded. Siltstone and sandstone form recessive slope-forming unit.

18

40. Argillite and limestone. Argillite is medium dark gray (N4); weathers to medium gray (N5); very fine mica, phyllitic texture. Limestone is laminated, as in unit 38.

5

39. Folded limestone. Same as liver limestone (38): pale reddish brown (10R 5/4); weathers to grayish red (10R 4/2); varnish is very dusky red (10R 2/2); folded top to west, pitted dissolution surfaces.

1

38. Liver limestone. Limestone is pale reddish brown (10R 5/4); weathers to grayish red (10R 4/2). Fine-grained with interspersed quartz grains; thinly to medium bedded, massive to laminated beds; occasional brecciation near top.

11.5

37. Carbonate-rich sandstone. Sandstone is grayish red (10R 4/2); weathers to pale reddish brown (10R 5/4) and dark yellowish orange (10YR 6/6) and various similar hues; fine-medium grains**;** thinly bedded and finely laminated with rare north-dipping foresets.

7.5

36. Dolomitic oolite; "Johnnie Oolite". Oolite is pale yellowish brown (10YR 6/2); weathers to grayish orange (10YR 7/4); very coarse-grained.

2

35. VSS. VSS is finely laminated, occasionally phyllitic, with rare N-dipping foresets and occasional quartz veins.

17

Total of Zjr member 98

Zjl member (combine with Zjl from section 3):

34. Laminated dolostone. Dolostone is pale yellowish brown (10YR 6/2); weathers to moderate yellowish brown (10YR 6/4); thick, laminated beds.

2

33. VSS and dolomitic sandstone (incomplete). VSS as previous. Dolomitic sandstone is medium gray (N5); weathers to moderate yellowish orange (10YR 5/6); fine-grained. Beds are massive with varnish of dark gray (N3).

6

Locality 1 (section 3, c-c')

Northeast part of Montgomery Mountains, measured about 3 kilometers west/southwest of Mt. Schader, starting at UTM zone 11S 0580829 m E 4033958 m N (approximate), and ending at UTM zone 11S 0580984 m E 4033808 m N.

Meters

Johnnie Formation (incomplete):

Zjl member (combine with Zjl from section 4):

32. Orthoquartzite and siltstone (VSS) as in 31. Sample 18BW15 (430 m), medium-grained orthoquartzite (incomplete).

36

31. Orthoquartzite and minor siltstone. Light brownish gray (5YR 6/1); weathers to moderate brown (5YR 4/4) and grayish black (N2); siltstone is fine-medium grained; thin-thick parallel beds with some hummocky cross-strata.

12

30. Siltstone and fine sandstone with minor orthoquartzite. Siltstone and fine sandstone, as VSS, are variegated; bluish white (5B 4/1) weathers to

blackish red (5R 2/2) and green (undocumented), thin beds. Orthoquartzite is medium light gray (N6); weathers to moderate reddish brown (10R 4/6).

13

Total of Zjl member 69

Zjk member:

29. Dolostone with chert. Dolostone is medium gray (N5); weathers to light olive gray (5Y 5/2) and medium yellowish brown (10YR 6/4). Dolostone is medium bedded with chert in lower third of section. Chert is medium light gray (N6); weathers to grayish black (N2). Hummocky cross-stratified mounds with anastomosing laminations in middle of section. Samples J63 (371 m), J62 (370.5 m), J61 (370), J60 (369.5), J59 (369), J58 (368.5), J57 (368), J56 (367.5), and J55 (367).

4

28. Siltstone and orthoquartzite, mainly parallel bedded.

18

27. Dolostone. Medium gray (N5); weathers to moderate olive brown (5Y 4/4) and moderate yellowish brown (10YR 5/4). Medium bedded with basal sandy dolostone. Samples J54 (349 m), J53 (348.5 m), J52 (348 m), and J51 (347.5 m).

2

26. Siltstone and orthoquartzite. Siltstone is typical variegates sandstone and siltstone, bluish white (5B 4/1) and blackish red (5R 2/2) and green (undocumented color), thinly bedded with thin beds or orthoquartzite. Orthoquartzite is medium light gray (N6); weathers to moderate reddish brown (10R 4/6), ripple laminations.

15

Total of Zjk member 39

Zjj member (combine with Zjj from section 2):

25. Dolostone and sandy dolostone. Dolostone is medium-dark gray (N4); weathers to olive gray (5Y 4/1); medium-thick bedded; some hummocky cross-stratified structures. Sandy dolostone is medium gray (N6-N8); weathers medium yellowish brown (10 YR 5/4); medium-thick beds with pure dolostone blebs and no chert. Samples J50 (332 m), J49 (331.5 m),

J48 (331 m), J47 (330.5 m), J46 (330 m), J45 (329.5 m), J44 (329 m), and J43 (328.5 m).

5

24. Orthoquartzite and Siltstone. 2-4 m thick orthoquartzite and siltstone beds in rhythmic sets every 5 m. Siltstone coarsens upward into top (final) orthoquartzite bed.

23

23. Siltstone and sandstone. Siltstone is variegated (variegated sandstone and siltstone=VSS); mainly bluish white (5B 4/1); weathers to blackish red (5R 2/2); also typically green (undocumented color); thinly bedded. Sandstone is orthoquartzite; medium light gray (N6); weathers to moderate reddish brown (10R 4/6); minor in abundance.

19

22. Dolomitic sandstone marker bed. Light olive gray (5Y 6/1); weathers to moderate brown (5YR 4/6); fine to medium sand; some hummocky cross stratification (HCS). Samples J42 (285 m), J41 (284.5 m), and J40 (284 m).

1

21. (combine with unit 21 in section 2) Orthoquartzite, sandstone and siltstone. Orthoquartzite is medium light gray (N6); weathers to moderate reddish brown (10R 4/6); fine sand; thickly bedded. Sandstone and

siltstone are variegated (VSS); “both “green-brown” and “lt. blue-red” shades of variegation present in VSS”-green color undocumented; bluish white (5B 4/1); weathers to blackish red (5R 2/2); fine sand; thinly bedded; some hummocky cross stratification (HCS).

27

Locality 1 (section 2, b-b')

Northeast part of Montgomery Mountains, measured about 3 kilometers west/southwest of Mt. Schader, starting at UTM zone 11S 0581155 m E 4034809 m N, and ending at UTM zone 11S 0581315 m E 4034785 m N.

Meters

Johnnie Formation (incomplete):

Zjj member (combine with Zjj in section 3):

21. (combine with unit 21 in section 3) Orthoquartzite, sandstone and siltstone. Orthoquartzite is medium light gray (N6); weathers to moderate reddish brown (10R 4/6); fine sand; thickly bedded. Sandstone and siltstone are variegated (VSS); "typical green fine sand of VSS"-green color undocumented; thinly bedded. Samples 17-BW-15 (247 m-sandstone) and 16-BW-15 (246.5 m-siltstone).

13

Total of Zjj member 88

Zji member (also see Zji from section 1):

20. Dolomitic sandstone. Medium gray (N5); weathers to pale reddish-brown (10R 5/4) and moderate yellowish-brown (10YR 5/4); fine to medium sand; medium bedded. Hummocky cross stratification (HCS), with an east-west trend in one well-exposed hummock. Samples J39 (244 m), J38 (243.5 m), J37 (243.25 m), J36 (242.75), J35 (241.5 m), J34 (241 m), and 15-BW-15 (242 m-dolomitic sandstone).

3

19. Orthoquartzite and siltstone. Orthoquartzite is medium light gray (N6); weathers to moderate reddish brown (10R 4/6); fine sand; thickly bedded. Siltstone has some sandstone (~25%) and is variegated (VSS); mainly bluish white (5B 4/1); weathers to blackish red (5R 2/2); fine sand; medium bedded. Orthoquartzite and siltstone occur in relative abundances of 75%/25% (respectively) throughout this section. Hummocky cross stratification is very prominent at ~190 m (most sandstone beds involved) and good hummocks in cross section at ~184 m; sandstone is more commonly medium-grained and micaceous at ~210 m; conspicuous thickly bedded intervals in 5-10 m cycles begin at ~215 m and continue through ~240 m. Sample 14-BW-15 (210.5 m-orthoquartzite; light purplish gray (5P 8/1); weathers to dark yellowish brown (10YR 4/4) and dusky yellowish brown (10YR 2/2); medium sand; thickly bedded).

Thickness is approximate; contact is covered in talus; bed surfaces in the float contain asymmetric ripples.

63

18. Orthoquartzite and siltstone. Orthoquartzite is grayish red (5R 4/2); weathers to very dusky red (10R 2/2); fine to medium sand (borderline); bedding thickness unknown. Siltstone is variegated (VSS); mainly blush white (5B 4/1); weathers to blackish red (5R 2/2); thinly bedded. Siltstone occurs in decimeter partings on ~30-70 cm sandstone beds.

14

17. Sandstone (dolomitic at the base of this unit) and siltstone. Sandstone can be light bluish gray (Munsell code unknown), grayish red purple (5RP 4/2) where carbonate-poor, and light brown (5YR 5/6) where carbonate-rich; weathers to moderate yellowish brown (10YR 5/4) where carbonate-poor, and moderate/light brown (5YR 4/6) where carbonate-rich; fine to medium sand; medium to thickly bedded. Siltstone is variegated (VSS); mainly bluish white (5B 4/1); weathers to blackish red (5R 2/2); thinly bedded. Carbonate cement occurs in lowest 2-3 sand beds; some hummocks observed, mainly parallel laminations. Sample J33 (152 m).

20

Locality 1 (section 1, a-a')

Northeast part of Montgomery Mountains, measured about 3 kilometers west/southwest of Mt. Schader, starting at UTM zone 11S 0581057 m E 4035219 m N, and ending at UTM zone 11S 0581293 m E 4035178 m N.

Meters

Johnnie Formation (incomplete):

Zji member (also see Zji from section 2):

16. Orthoquartzite and siltstone. Orthoquartzite is light gray (N7); weathers to brownish black (5YR 2/1); fine to medium sand; thin to medium bedded, mainly low angle hummocky cross stratification and parallel lamination. Siltstone is variegated (VSS); mainly medium to light bluish gray (5B 6/1), moderate red (5R 4/3 or 5R 5/4?), grayish orange pink (5YR 7/2), and grayish orange (10YR 7/4); weathers to light greenish gray (5GY 8/1), and brownish gray (5YR 4/1); laminated to massive. At the bottom, mainly low angle hummock cross stratification and parallel lamination; at the top, unit forms uniform, fairly steep hillsides and is predominantly parallel bedded with some hummocky cross stratification. Sample 13-BW-15 (198 m-coarse orthoquartzite from highest thick bed).

Note: unit 16 is omitted because for section 2, we restart at the base of the Zji member and repeat the same stratigraphy.

(58)

Total of Zji member 100

Zjh member:

15. Dolostone; medium gray (N5) and dark gray (N3); weathers to moderate yellow brown (10YR 5/4) and medium gray (N5); fine-grained to sucrosic; thickly bedded. Some evidence of hummocky cross stratification, but not as pronounced as in lower carbonate. "Colors vary; reddish gray top and bottom from alteration; more conspicuous here than in most markers." Samples J32 (144 m), J31 (143.66 m), J30 (143.33 m), J29 (143 m), J28 (142.5 m), J27 (142 m), J26 (141.5 m), J25 (141 m), J24 (140.5 m), and J23 (140 m).

5

14. Sandstone and siltstone. Sandstone is medium light gray (N6); weathers to brownish gray (5YR 4/1); fine sand; thin to medium bedded. Siltstone is variegated (VSS); mainly medium to light bluish gray (5B 6/1), moderate red (5R 4/3 or 5R 5/4?), grayish orange pink (5YR 7/2),

and grayish orange (10YR 7/4); weathers to light greenish gray (5GY 8/1), and brownish gray (5YR 4/1); laminated to massive. Mainly parallel bedding.

12.25

13. Sandy limestone; medium reddish brown (10R 4/6) and moderate yellowish brown (10YR 5/4); weathers to moderate brown (10YR 5/4); fine sand; medium bedded. No well-developed lamination or internal structure. Samples J22 (126.75 m), and J21 (125.75 m).

1

12. Very fine sandstone (vfs) and siltstone. Very fine sandstone is medium light gray (N6); weathers to dusky yellowish brown (10YR 2/2); thinly bedded. Siltstone has several “modes”: brown and light green (Munsell codes unknown); pale red and light green (Munsell codes unknown). Photo of light green and red vfs at ~118 m.

14.75

11. Sandstone with minor carbonate (carbonate occurs in two separate decimeter-scale beds). Sandstone is light bluish gray (5B 7/1); weathers to grayish orange (10YR 7/4) or light brown (5YR 5/6); fine sand; thinly to medium bedded. Carbonate is grayish red (5R 4/2); weathers to grayish red (10R 4/2); fine sand; thinly to medium bedded. Overall, this unit forms a resistant interval; mostly parallel bedded with some cross stratification; intense hummocky cross stratification (HCS); hummocks are apparently

cross-stratified with decimeter-scale "mounds" similar to unit 9 carbonates. Samples J20 (109 m; moderate yellowish brown (10YR 5/4); weathers to moderate brown (5YR 5/4)), and J19 (107 m).

7

10. Very fine/fine sandstone and siltstone. Very fine/fine sandstone is pale yellowish brown (10YR 6/2); weathers to dark yellowish brown (10YR 4/2); thinly bedded. Siltstone is variegated (VSS); mainly light bluish gray (5B 6/1), moderate red (5R 4/3 or 5R 5/4?), grayish orange pink (5YR 7/2), and grayish orange (10YR 7/4); weathers to light greenish gray (5GY 8/1), and brownish gray (5YR 4/1); laminated to massive. Photo of "brown-light green VSS" at ~96 m.

10

9. Stromatolitic dolostone; light olive gray (N4 or 5Y 6/1) or grayish red (10R 4/2); weathers to light olive gray (N5) or moderate yellowish brown (10YR 5/4); "macroscopically, unit tends to whether brown, lesser olive gray"; fine-grained/very fine-grained to micritic; medium to thickly bedded. Dolostone is laminated with variably steep-sided mound structures ~0.5-1 m across (three photos at ~89 m and ~92 m). Truncations of mounds observed at bedding interfaces. Samples J18 (94 m), J17 (93.66 m), J16 (93.33 m), J15 (93 m), J14 (91.5 m), J13 (91 m), J12 (90.5 m), J11 (90 m), J10 (89.5 m), J9 (89 m), J8 (88.5 m), J7 (88 m), J6 (87.5 m), and J5 (87 m).

7

8. Sandstone; thin to medium beds are medium light gray (N6), and weather to medium dark gray (N4) or moderate yellowish brown (10YR 6/4); basal bed is light greenish gray (5GY 6/1), and weathers to dark greenish gray (5GY 4/1); fine to medium sand. Inconspicuous orthoquartzites, sandstone, and variegated sandstones and siltstones (VSS) occur near the top of this unit; near the bottom, sands are thinly bedded with no/minor cross stratification (not orthoquartzite, somewhat friable and porous in places).

18.5

7. Very fine sandstone and siltstone. Very fine sandstone is light purplish blue (5PB 8/1), or “white”; weathers to dark reddish brown (10R 4/4); thinly to medium bedded. Siltstone is variegated (VSS); mainly light bluish gray (5B 6/1), moderate red (5R 4/3 or 5R 5/4?), grayish orange pink (5YR 7/2), and grayish orange (10YR 7/4); weathers to light greenish gray (5GY 8/1), and brownish gray (5YR 4/1); laminated.

4

6. Dolostone; dark gray (N3); weathers to moderate yellowish brown (10YR 5/4); fine-grained; medium bedded with laminations and thin (~1-2 cm) siliceous stringers; some dispersed quartz grains; complex structures; disruptions in laminations. Samples J4 (64.5 m), J3 (64 m), J2 (63.5 m), and J1 (63 m).

1.5

5. Very fine sandstone and siltstone. Very fine sandstone is light purplish blue (5PB 8/1), or “white”; weathers to dark reddish brown (10R 4/4); thinly to medium bedded; interbeds are massively textured, with a fair degree of induration. Siltstone is variegated (VSS); mainly light bluish gray (5B 6/1), moderate red (5R 4/3 or 5R 5/4?), grayish orange pink (5YR 7/2), and grayish orange (10YR 7/4); weathers to light greenish gray (5GY 8/1), and brownish gray (5YR 4/1); laminated. Overall, this is a recessive, slope-forming unit.

17.5

4. Orthoquartzite and very fine sandstone/siltstone. Orthoquartzite is medium light gray (N6); weathers to medium gray (N5); fine to medium sand; thickly bedded at base, medium to thinly bedded higher in unit; heavy desert varnish and cross-stratified higher in unit; silty “caps” on sandstone beds have abundant grooves/tool-markings, and small current ripples. Very fine sandstone/siltstone can be moderate red/grayish red (5R 4/3), light brown (5YR 5/6), or medium light bluish gray (5B 6/1); weathers to moderate red/grayish red (5R 4/3), moderate brown (5YR 4/4), or light greenish gray (5GY 8/1) and darker hues. Generally, orthoquartzite is resistant, while very fine sandstone is recessive.

6.5

Total of Zjh member 105

Zjg member (incomplete)

3. Interstratified variegated sandstone and siltstone (VSS), and orthoquartzite. Siltstone has various hues and is “patchy” or “pinstriped”; hues include medium light bluish gray (5B 6/1), grayish orange pink (5YR 7/2), and grayish orange (10YR 7/4); weathers to brownish gray (5YR 4/1), light greenish gray (5GY 8/1), and darker hues. Sandstone is moderate red to grayish red (5R 4/3); weathers to moderate red/grayish red (5R 4/3); fine-grained. VSS is interstratified on the cm-scale. Orthoquartzite is medium gray (N6); weathers to medium dark gray (N4); thinly to medium bedded; 0.5 m foresets with steeply truncated laminatiosn observed near base at ~16 m. VSS is generally recessive and slope-forming unit; orthoquartzite beds are resistant.

22

2. Orthoquartzite; medium light gray (N6); weathers to medium dark gray (N4); thinly bedded. Thickness of this unit is certainly >2 m because there is a minor break in section (due to poor exposure).

2

1. Interstratified variegated sandstone and siltstone (VSS), and orthoquartzite. Sandstone is light brown (5YR 5/6); weathers to moderate brown (5YR 4/4); medium to fine sand; thinly to medium bedded. Siltstone is medium to light bluish gray (5B 6/1); weathers to light greenish gray (5GY 8/1) and darker hues; laminated to massive. Orthoquartzite is medium gray (N6); weathers to medium dark gray (N4); medium sand; thin to medium parallel bedding, with low-angle trough cross stratification observed at ~3 m.

15

Total of incomplete Zjg member 39

Total of incomplete Johnnie Formation 538