APPENDIX I. COLLECTING LOCALITIES AND STRATIGRAPHIC HORIZONS IN KANSAS AND NEW MEXICO.

KANSAS

Oread cycle, Shawnee Group (Virgilian age) - Waverly Quarry section, with exposures of Heebner Shale and Plattsmouth Limestone

Location: quarry 3 km northeast of the town of Waverly, Coffey Co., Kansas. Section measured by authors.

Stratigraphic horizons: middle and upper parts of Oread cycle, with exposures of the top 0.5 m of the cycle-center platy, phosphatic, black shales (Heebner Shale) and 5 m of regressive Plattsmouth Limestone.

Samples: taken from black and gray shales in top 25 cm of Heebner Shale and shale interbeds at 2.5 m and 4.7 m above base of Plattsmouth.

Stanton cycle, Lansing Group (Missourian age) - Kill Creek section, with exposures of Captain Creek Limestone, Eudora Shale, and Stoner Limestone (in ascending order).

Location: Along Route K-10, just east of Kill Creek crossing, near DeSoto, Johnson Co., Kansas. Strata are exposed in road cuts on both sides of the highway over a distance of about a half-mile. Section measured by authors; also illustrated in Watney et al. (1991).

Stratigraphic horizons: most of the Stanton cycle, with top of tidal-dominated shoal marine strata of Vilas Shale, overlain by 2.5 m of transgressive Captain Creek Limestone, 0.75 to 2.3 m of cycle-center black and gray shales, containing fossil-rich zone at base and phosphate nodule-rich zone at 1 m above base, and 3.5 m of regressive Stoner Limestone.

Samples: taken from shale interbed 25 cm below top of Captain Creek Limestone, from base to 0.8 m above base in Eudora Shale, and 80 cm above base of Stoner Limestone.

Wyandotte cycle, Kansas City Group (Missourian age) - Holliday Drive section, with exposures of Frisbee Limestone, Quindaro black shale, and Argentine Limestone.

Location: Along Holliday Drive interchange of Interstate route I-435, on south bank of Kansas River in northwestern Kansas City, Kansas. Section located on west side of interchange along the ramp joining southward lanes of Interstate I-435 with Holliday Drive. Section illustrated in Watney et al. (1985; 1991).

Stratigraphic horizons: most of the Wyandotte cycle, with 2 m of transgressive Frisbee Limestone, 0.3 m of cycle-center gray shales of Quindaro Shale, and 7 m of regressive Argentine Limestone

Samples: taken from Quindaro Shale

Iola cycle, Kansas City Group (Missourian age) - Holliday Drive section, with exposures of Chanute Shale, Paola Limestone, Muncie Creek black shale, Raytown Limestone, and Lane Shale.

Location: Along Holliday Drive interchange of Interstate route I-435, on south bank of Kansas River in northwestern Kansas City, Kansas. Section located on west side of interchange along the ramp joining southward lanes of Interstate I-435 with Holliday Drive. Section illustrated in Watney et al. (1985; 1991).

Stratigraphic horizons: all of the Iola cycle, with 1 m of transgressive mudstone in top of Chanute Shale, 0.3 m of transgressive Paola Limestone, 1.1 m of cycle-center platey, black shales of Muncie Creek Shale, 3 m of regressive Raytown Limestone, 14 m of regressive, shoal water Lane Shale.

Samples: taken from base and top of Muncie Creek Shale, from shale interbed 20 cm above base of Raytown Limestone, and from 0.5 and 1.0 m above base of Lane Shale.

Cherryvale cycle, Kansas City Group (Missourian age) - Raytown section, with exposures of Fontana Shale, Block Limestone, and Wea Shale.

Location: Along 63rd St. interchange (Raytown exit) of Interstate route I-435, in southeastern Kansas City, Missouri. Section located on south side of 63rd St. at interchange and on both sides of Interstate I-435 south of interchange. Section illustrated in unpublished report by L. Watney and J. French of the Kansas Geological Survey.

Stratigraphic horizons: all of the Cherryvale cycle, with 0.5 m of transgressive mudstone in top of Fontana Shale, 0.5 m of transgressive limestone bed in lower part of Block Limestone, 0.6 m of cycle-center gray shales of middle part of Block Limestone, 0.4 m of regressive limestone bed in upper part of Block Limestone, and 5 m+ of regressive, shoal water Wea Shale.

Samples: taken from top of Fontana Shale, from middle shale of Block Limestone, and from top limestone bed of Block Limestone.

Dennis cycle, Kansas City Group (Missourian age) - Raytown section, with exposures of Galesburg Shale, Stark Shale, Winterset Limestone, and Fontana Shale.

Location: Along 63rd St. interchange (Raytown exit) of Interstate route I-435, in southeastern Kansas City, Missouri. Section located on south side of 63rd St. at interchange and on both sides of Interstate I-435 south of interchange. Section illustrated in unpublished report by L. Watney and J. French of the Kansas Geological Survey.

Stratigraphic horizons: all of the Dennis cycle, with 0.2 m of transgressive mudstone in top of Galesburg Shale, 1.5 m of cycle-center platey, black shales of Stark Shale, 11 m of regressive Winterset Limestone bed, and 1.5 m of regressive, shoal water Fontana Shale.

Samples: taken from top of Stark Shale, from shale interbeds at 0.4 m and 1.5 m above base of Winterset Limestone.

Swope cycle, Kansas City Group (Missourian age) - Raytown section, with exposures of Elm Branch Shale, Middle Creek Limestone, Hushpuckney Shale, and Bethany Falls Limestone.

Location: Along 63rd St. interchange (Raytown exit) of Interstate route I-435, in southeastern Kansas City, Missouri. Section located on south side of 63rd St. at interchange and on both sides of Interstate I-435 south of interchange.Section illustrated in unpublished report by L. Watney and J. French of the Kansas Geological Survey.

Stratigraphic horizons: all of the Swope cycle, with 0.7 m of transgressive mudstone and limestone in Elm Branch Shale, 0.4 m of transgressive Middle Creek Limestone, 1.4 m of cycle-center platey, black shales of Hushpuckney Shale, 6 m of regressive Bethany Falls Limestone.

Samples: taken from top of Elm Branch Shale and from upper part of Hushpuckney Shale.

NEW MEXICO

Upper Jemez Springs cycle, Madera Formation (Virgilian age) - Jemez Springs section, with exposures of Jemez Springs Member of Madera Formation.

Location: east wall of San Diego Canyon on Rt. 4, near Jemez Springs State Monument on north side of town of Jemez Springs, in Jemez Mountains 80 km north of

Albuquerque, New Mexico. Samples collected from head of small gully high on hillside above highway, just north of Church Canyon tributary of San Diego Canyon. Section illustrated in Sutherland and Harlow (1967) and in unpublished notes of B. Kues, Univ. of New Mexico.

Stratigraphic horizons: all of Upper Jemez Springs cycle, with exposures of 1.0 m of transgressive brown mudstone, 0.3 m of transgressive limestone, 2.3 m of cycle-center gray shale, and 1.6 m of regressive limestone.

Samples: taken from base, middle, and upper levels in cycle-center gray shale.

Lower Jemez Springs cycle, Madera Formation (Virgilian age) - Jemez Springs section, with exposures of Jemez Springs Member of Madera Formation.

Location: east wall of San Diego Canyon on Rt. 4, near Jemez Springs State Monument on north side of town of Jemez Springs, in Jemez Mountains 80 km north of Albuquerque, New Mexico. Samples collected from head of small gully high on hillside above highway, just north of Church Canyon tributary of San Diego Canyon. Section illustrated in Sutherland and Harlow (1967) and in unpublished notes of B. Kues, Univ. of New Mexico.

Stratigraphic horizons: all of Lower Jemez Springs cycle, with exposures of 2.5 m of transgressive limestone, 8 m of cycle-center interbeds of gray shale and limestone, and 1.0 m of regressive limestone.

Samples: taken from lower, middle, and upper levels in cycle-center shale and limestone unit.

Upper Jemez Springs cycle, Madera Formation (Virgilian age) - Hot Spring section, with exposures of Jemez Springs Member of Madera Formation.

Location: west wall of San Diego Canyon beside Rt. 4, near the main hot springs, 2 km north of Battleship Rock and 8 km north of town of Jemez Springs, in the northeast end of San Diego Canyon, in Jemez Mountains 80 km north of Albuquerque, New Mexico. Samples collected from small gully near highway level. Section measured by authors during field work.

Stratigraphic horizons: all of Upper Jemez Springs cycle, with exposures of 2.5 m of transgressive brown siltstone, 2.0 m of transgressive sandstone, 2.0 m of cycle-center gray mudstone, and 4.8 m of regressive shale and limestone.

Samples: taken from shale interbeds in regressive limestone.

Sol se Mete cycle, Wild Cow Formation (Missourian age) - Chilili Road quarry, with exposures of Sol se Mete Member of Wild Cow Formation.

Location: quarry on northeast side of Chilili Road (Route 10), 2 km south of town of Escabosa, 5 km north of town of Chilili, and 27 km south of town of Tijeras, on interstate route I-40, in the high areas of the Manzano Mountains, 40 km southeast of Albuquerque, New Mexico. Section measured by authors; general section illustrated by Myers (1988).

Stratigraphic horizons: most of the Sol se Mete cycle, with exposures of 2.2 m of regressive interbedded shale and limestone and 5.5 m of regressive limestone.

Samples: taken from interbedded shale and limestone unit.

APPENDIX II

Stable isotopic compositions of brachiopod shells (in ‰ vs. PDB) from Kansas and New Mexico. SP = specimen. LC = luminescent character of sampled area of brachiopod shells (key at end of appendix). Letter next to interval (INT) represents the fossil depth zone for that interval (M = myalinid zone, F = fusulinid zone, A = ammonoid zone, G = gondolellid zone).

INT (cm)	GENUS	SP[1]	$\delta^{13}C$ (‰)	$\delta^{18}O$ (‰)	LC
OREAD CYCLE, KANSAS					
470F	*Com*[2]	a	4.74	-1.81	NL
		b	4.58	-1.28	NL-SP
		c	5.37	-1.41	NL-SP
	Cru	a	3.47	-1.52	NL-SP
		b	3.64	-1.44	NL-ST
		c	3.42	-1.63	NL-SP
	Neo	a	3.40	-1.62	NL-ST
		b	3.99	-1.34	NL
		b1	3.83	-1.34	NL
		c	3.63	-1.62	NL-SP
460F	*Com*	a	5.37	-1.34	NL
		b	5.13	-1.30	NL-SP
		c	4.65	-1.57	NL-SP
		d	5.16	-1.48	NL
		e	4.63	-1.63	NL
		f	4.66	-2.12	NL
	Neo	a	3.36	-1.72	NL
		a1	3.84	-2.00	NL
		b1	3.87	-1.66	NL
		c	3.47	-2.15	NL
		c1	3.67	-1.96	NL
	Neoph.	a	4.37	-1.49	NL
250F	*Com*	a	4.04	-1.33	NL
		b	4.84	-1.36	NL
		c	5.36	-1.08	NL
	Neo	a	3.77	-1.67	NL
		a1	3.93	-1.26	NL
		b	3.43	-1.80	NL-SP
		c	3.58	-1.38	NL
-5A	*Com*	a	4.43	-0.77	NL
		b	4.82	-1.03	NL
		c	4.51	-1.45	NL
	Neo	a	4.96	-1.26	NL
		b	4.38	-1.37	NL-ST
		b1	4.52	-1.00	NL-SP
		c	4.65	-0.90	NL-SP
-23A	*Cru*	a	2.58	-0.88	NL-SP
STANTON CYCLE (NW), KANSAS					
310F	*Com*	a	3.39	-1.43	NL
		a1	3.57	-1.20	NL
		b	3.39	-1.41	NL
		b1	3.25	-1.30	NL
		c	4.66	-1.48	NL
	Neo	a	2.71	-2.63	NL-vFL
		b	2.77	-1.99	NL-vFL
		c	2.54	-2.03	NL
85A	*Cru*	a	2.84	-1.46	DL
		b	3.52	-2.22	NL-SP
		c	3.07	-2.33	NL
23A	*Cru*	a	3.32	-2.06	NL-SP
13A	*Com*	a	3.70	-1.50	NL
		b	4.49	-1.60	NL

INT (cm)	GENUS	SP[1]	$\delta^{13}C$ (‰)	$\delta^{18}O$ (‰)	LC
		c	4.03	-1.62	NL
	Cru	a	3.35	-2.12	NL
		b	3.21	-1.83	NL
	Neo	a	3.36	-1.92	NL
		b	3.71	-1.23	NL
-30F	*Com*	a	4.76	-1.58	NL
		a1	4.66	-1.33	NL
	Neo	a	3.51	-1.43	NL
		b	3.29	-2.06	NL
		c	3.07	-2.41	NL
STANTON CYCLE (SW), KANSAS					
105	*Cru*	a	*3.26*[3]	*-2.14*[3]	BL+NL
45	*Cru*	a	*2.34*	*-4.53*	BL
25A	*Cru*	a	2.90	-1.67	NL+L
		b	3.23	-1.73	NL-SP
		c	2.60	-2.00	L+NL
5A	*Com*	a	5.53	-1.66	NL
		b	5.39	-1.75	NL-SP
		c	4.96	-1.55	NL
	Cru	a	5.39	-1.17	NL
	Neo	a	4.41	-1.72	NL
		b	3.84	-1.85	NL+L
-28F	*Com*	a	5.16	-1.71	NL-SP
		b	5.26	-1.67	NL-SP
	Neo	a	3.42	-1.91	NL
		a1	3.22	-2.02	NL
		b	3.05	-2.08	NL
		c	2.95	-2.22	NL
		c1	3.10	-2.12	NL
WYANDOTTE CYCLE, KANSAS					
0A	*Com*	a	4.40	-2.03	NL
		b	4.42	-1.90	NL
		c	4.35	-2.29	NL
	Neo	a	3.52	-1.66	NL
		b	3.70	-1.67	NL
		c	3.75	-1.70	NL
		c1	3.47	-1.86	NL
IOLA CYCLE, KANSAS					
127F	*Com*	a	4.47	-1.89	NL
		b	4.55	-1.90	NL
		c	4.48	-1.67	NL
		c1	4.54	-2.08	NL
	Cru	a	2.67	-1.31	NL
	Neo	a	4.03	-1.78	NL
		b	3.13	-1.61	NL
		b1	3.43	-2.21	NL
		c	2.89	-1.98	NL
CHERRYVALE CYCLE, KANSAS					
100F	*Com*	a	3.48	-2.55	NL
		b	3.49	-2.75	NL

(Cont.)

INT (cm)	GENUS	SP[1]	$\delta^{13}C$ (‰)	$\delta^{18}O$ (‰)	LC
		c	3.01	-3.69	NL
		d	2.57	-3.22	NL
		e	2.96	-2.73	NL
	Cru	a	3.26	-2.59	NL
		b	3.37	-2.12	NL
		c	2.85	-2.28	NL
	Hystric	a	3.24	-2.38	NL
		b	3.09	-2.41	NL
		c	2.84	-2.38	NL
85F	*Com*	a	4.67	-2.06	NL
		b	5.12	-2.09	NL
		c	4.98	-1.97	NL+DL ST
		d	5.46	-1.70	NL
		d1	5.04	-2.02	NL
	Cru	a	3.65	-2.32	NL-ST
		b	3.46	-1.84	NL
		c	3.69	-2.26	NL
		d	3.75	-2.21	NL
		e	3.56	-2.61	NL
		f	3.79	-1.87	NL
58F	*Cru*	a	3.45	-2.20	NL
		b	3.75	-2.00	NL
		c	3.54	-2.34	NL
-13M	*Com*	a	3.78	-2.18	NL
		b	3.73	-1.38	NL
		c	3.14	-1.99	NL
	Neo	a	3.16	-1.92	NL
		a1	3.41	-1.86	NL
		b	2.80	-2.54	NL

DENNIS CYCLE, KANSAS

INT (cm)	GENUS	SP[1]	$\delta^{13}C$ (‰)	$\delta^{18}O$ (‰)	LC
152F	*Com*	a	4.11	-1.89	NL
		b	3.03	-2.09	NL
		b1	4.13	-2.40	NL
		b2	3.78	-1.86	NL
		c	4.14	-2.37	NL
	Cru	a	3.40	-1.95	NL-SP
		b	2.93	-2.34	NL
		c	*1.50*	*-6.24*	L
	Neo	a	2.97	-2.43	NL
		b	2.99	-2.14	NL
		c	2.79	-2.13	NL
42F	*Com*	a	4.11	-1.85	NL
		b	4.42	-1.60	NL
		c	4.43	-1.42	NL
	Cru	a	*1.28*	*-6.77*	L
		b	*1.10*	*-7.08*	L
		c	2.98	-1.90	NL
		d	3.19	-2.33	NL-SP
	Neo	a	2.96	-1.98	NL
		a1	3.36	-1.53	NL
		b	3.21	-2.24	NL
		c1	3.22	-2.14	NL
-10A	*Neo*	a	4.97	-1.79	NL

SWOPE CYCLE, KANSAS

INT (cm)	GENUS	SP[1]	$\delta^{13}C$ (‰)	$\delta^{18}O$ (‰)	LC
138A	*Com*	a	2.63	-2.24	NL
		a1	2.68	-1.99	NL
		a2	3.87	-2.07	NL
		b	4.20	-1.17	NL
		b1	4.06	-1.94	NL
		c	4.62	-1.72	NL
	Cru	a	2.84	-2.31	NL+L
		b	2.35	-2.76	NL
		c	2.47	-1.91	NL
		d	*1.23*	*-4.40*	L
	Neo	a	1.96	-2.20	NL
		a1	2.16	-2.25	NL
130A	*Cru*	a	*1.35*	*-4.80*	L
		b	2.76	-2.27	NL
		c	2.43	-2.29	NL
100G	*Cru*	a	2.67	-2.33	NL-SP
		b	2.98	-2.20	NL-ST
		c	2.40	-2.43	NL
		d	2.47	-2.62	NL-ST
		e	3.12	-2.07	NL-BD
-43F	*Com*	a	3.61	-1.53	NL+L
		b	3.52	-1.72	NL-SP
		c	3.53	-1.72	NL

UPPER JEMEZ SPRINGS CYCLE (HOT SPRINGS SECTION), NEW MEXICO

INT (cm)	GENUS	SP[1]	$\delta^{13}C$ (‰)	$\delta^{18}O$ (‰)	LC
1130	*Com*	a1	4.29	-3.82	NL
	Neo	a	3.62	-3.58	NL
		b	2.96	-3.89	NL
1000	*Com*	a	3.81	-3.59	NL-ST
		b	4.89	-2.66	NL
		b1	4.52	-3.24	NL
		c	*3.13*	*-4.67*	NL-ST
	Cru	a	2.33	-3.85	NL-SP
		a1	2.28	-4.04	NL-SP
	Neo	a	3.66	-3.66	NL
		b	3.42	-3.15	NL
		c	3.42	-3.85	NL
900	*Com*	a	4.40	-2.71	NL-SP
		b	4.55	-3.03	NL
		c	4.60	-3.30	NL
	Cru	a	2.69	-4.49	NL-ST
		b	2.90	-4.17	NL+L
		c	3.08	-3.75	NL-ST
	Neo	a	3.49	-3.28	NL
		b	4.43	-2.64	NL
		c	3.40	-2.85	NL
		c1	3.25	-2.85	NL
800	*Com*	a	4.68	-2.79	NL-ST
		b	4.05	-2.64	NL
		c	*2.74*	*-3.65*	NL-ST
		d	*1.92*	*-4.17*	NL-ST
	Neo	a	3.97	-2.89	NL
		b	3.63	-2.46	NL
		c	2.95	-2.95	NL
500	*Derbyia*	a	3.16	-2.64	NL-SP
		b	*3.61*	*-4.15*	NL-BR
		c	*3.37*	*-7.07*	BR

UPPER JEMEZ SPRINGS CYCLE (JEMEZ SPRINGS SECTION), NEW MEXICO

INT (cm)	GENUS	SP[1]	$\delta^{13}C$ (‰)	$\delta^{18}O$ (‰)	LC
180	*Com*	a	3.95	-3.64	NL-BD
		b	3.68	-3.79	NL-SP
		c	4.47	-3.64	NL
	Cru	a	*1.51*	*-3.80*	DL
100	*Com*	a	3.79	-4.39	NL
		b	2.65	-3.92	NL
		c	*2.36*	*-4.78*	NL-SP
		c1	*1.57*	*-5.25*	BR
	Cru	a	2.24	-4.16	NL

(Cont.)

INT (cm)	GENUS	SP[1]	$\delta^{13}C$ (‰)	$\delta^{18}O$ (‰)	LC
	Derbyia	a	*-0.20*	*-3.95*	BR-NL
	Hystric	a	*0.83*	*-4.06*	NL-L
		a1	*-1.65*	*-6.88*	BR
	Neo	a	3.53	-3.56	NL-BD
		a1	4.03	-3.59	NL-BD
		b	3.10	-4.04	NL
		b1	3.37	-3.60	NL
		b2	3.65	-3.58	NL
		c	*2.40*	*-4.52*	NL-SP
10	*Com*	a	4.31	-3.58	NL+LMF
		b	3.80	-4.10	NL-SP
		c	4.41	-3.51	NL-SP
		d	*2.79*	*-3.06*	FL-BR
		d1	*3.70*	*-3.84*	FL-BR
		e	*-1.11*	*-5.57*	BR
		e1	*1.04*	*-3.85*	FL
		e2	*1.59*	*-4.93*	NL-ST
	Derbyia	a	*-0.55*	*-4.66*	BR
		a1	*-0.20*	*-6.44*	FL-ST
	Neo	a	*2.44*	*-5.26*	vFL-SP
		b	2.57	-3.63	FL-ST
		c	3.70	-2.12	NL-SP
		d	3.35	-3.35	NL
		d1	3.27	-3.14	NL
		d2	3.30	-3.40	NL
LOWER JEMEZ SPRINGS CYCLE, NEW MEXICO					
600	*Com*	a	3.92	-3.45	NL
350	*Derbyia*	a	2.31	-3.90	NL-SP
	Neo	a	2.81	-3.90	NL
		a1	2.40	-3.72	NL
		b	2.77	-3.68	NL-SP
		c	2.69	-3.97	NL
250	*Com*	a	3.12	-3.80	NL
		b	2.38	-3.87	NL
	Derbyia	a	1.72	-3.93	NL
	Neo	a	2.34	-3.58	NL
		b	2.21	-4.73	NL
		b1	2.92	-3.97	NL
		c	2.66	-4.08	NL
WILD COW FM., NEW MEXICO					
100	*Com*	a	4.84	-3.05	NL
10	*Com*	a	4.17	-3.17	NL
		b	4.67	-2.57	NL
		c	4.70	-3.63	NL
	Neo	a	3.31	-3.32	NL-SP
		b	3.96	-3.85	NL
		b1	4.41	-3.01	NL
		c	3.43	-4.03	NL
LOWER SALESVILLE CYCLE, TEXAS					
-380	*Cru*		3.51	-3.05	
			3.95	-2.21	
			4.01	-2.41	
	Com		5.26	-2.05	
			4.78	-2.24	
			3.24	-2.47	
	Neo		3.62	-2.19	
			3.55	-2.42	
			3.48	-2.12	
-480	*Cru*		3.69	-2.28	
			3.61	-2.55	
			3.90	-2.21	
	Com		4.79	-1.95	
			5.11	-2.15	
	Neo		4.46	-1.88	
			3.16	-1.49	
-580	*Cru*		3.83	-2.58	
			4.11	-2.22	
			3.18	-2.75	
	Com		5.20	-1.92	
			5.48	-2.32	
-680	*Cru*		3.82	-2.64	
			4.02	-2.44	
-880	*Cru*		4.20	-2.18	
	Com		4.79	-1.71	
			5.15	-2.07	
			4.82	-2.02	
	Neo		3.64	-2.17	
			4.35	-1.92	

Key:

DEGREE:
- BL = bright luminescence
- L = luminescence
- FL = faint luminescence
- vFL = very faint luminescence
- NL = completely non-luminescent

FEATURES:
- ST = luminescent streaks, usually on the order of 100 μ long
- SP = luminescent specks
- MF = microfractures
- BD = luminescent bands

Footnotes:

[1] each shell is given a different letter; multiple analyses of the same shell are denoted a1, a2, etc.

[2] *Cru* = Crurithyris, *Com* = Composita, *Neo* = Neospirifer, *Neophyr* = *Neophyricodothyris*, *Hystric* = *Hystriculina*

[3] Isotopic values in italics do not meet criteria for non-luminescence and are not included in calculation of mean values and isotope stratigraphy.

APPENDIX III. AVERAGE ISOTOPIC COMPOSITIONS OF INDIVIDUAL BRACHIOPOD SPECIMENS FROM DIFFERENT FOSSIL DEPTH ZONES IN KANSAS.

Cycle	Species	$\delta^{18}O$ ±2standard error ‰ (N) Myalinid	Fusulinid	Ammonoid	Gondolellid
Oread	*Composita*		-1.48 ±0.16 (12)	-1.08 ±0.40 (3)	
	Crurithyris		-1.53 ±0.12 (3)	-0.88 (1)	
	Neospirifer		-1.65 ±0.16 (9)	-1.12 ±0.22 (3)	
Stanton	*Composita*		-1.50 ±0.14 (6)	-1.61 ±0.08 (6)	
	Crurithyris			-1.86 ±0.22 (10)	
	Neospirifer		-2.09 ±0.22 (9)	-1.68 ±0.32 (4)	
Wyandotte	*Composita*			-2.07 ±0.24 (3)	
	Neospirifer			-1.70 ±0.08 (3)	
Iola	*Composita*		-1.89 ±0.02 (3)		
	Crurithyris		-1.31 (1)		
	Neospirifer		-1.89 ±0.12 (3)		
Cherryvale	*Composita*	-1.85 ±0.48 (3)	-2.55 ±0.21 (9)		
	Crurithyris		-2.22 ±0.02 (12)		
	Neospirifer	-2.22 (0.55) (2)			
Dennis	*Composita*		-1.88 ±0.28 (6)		
	Crurithyris		-2.13 ±0.24 (4)		
	Neospirifer		-2.14 ±0.18 (6)	-1.79 (1)	
Swope	*Composita*		-1.66 ±0.12 (3)	-1.79 ±0.32 (3)	
	Crurithyris			-2.31 ±0.26 (5)	-2.33 ±0.18 (5)
	Neospirifer			-2.23(1)	

Cycle	Species	$\delta^{13}C$ ±2standard error ‰ (N) Myalinid	Fusulinid	Ammonoid	Gondolellid
Oread	*Composita*		4.88 ±0.24 (12)	4.59 ±0.24 (3)	
	Crurithyris		3.51 ±0.14 (3)	2.58 (1)	
	Neospirifer		3.65 ±0.13 (9)	4.69 ±0.30 (3)	
Stanton	*Composita*		4.43 ±0.69 (6)	4.68 ±0.60 (6)	
	Crurithyris			3.34 ±0.49 (10)	
	Neospirifer		3.03 ±0.21 (9)	3.83 ±0.44 (4)	
Wyandotte	*Composita*			4.39 ±0.05 (3)	
	Neospirifer			3.61 ±0.10 (3)	
Iola	*Composita*		4.51 ±0.05 (3)		
	Crurithyris		2.67 (1)		
	Neospirifer		3.40 ±0.67 (3)		
Cherryvale	*Composita*	3.55 ±0.42 (3)	3.95 ±0.70 (9)		
	Crurithyris		3.51 ±0.16 (12)		
	Neospirifer	3.05 (0.49) (2)			
Dennis	*Composita*		4.14 ±0.23 (6)		
	Crurithyris		3.14 ±0.22 (4)		
	Neospirifer		3.05 ±0.14 (6)	4.97 (1)	
Swope	*Composita*		3.55 ±0.06 (3)	3.94 ±0.92 (3)	
	Crurithyris			2.57 ±0.20 (5)	2.73±0.28 (5)
	Neospirifer			2.06	

* Isotopic values are reported in PDB. When only two shells are analyzed, the difference between values is shown in parentheses. N = number of shells.