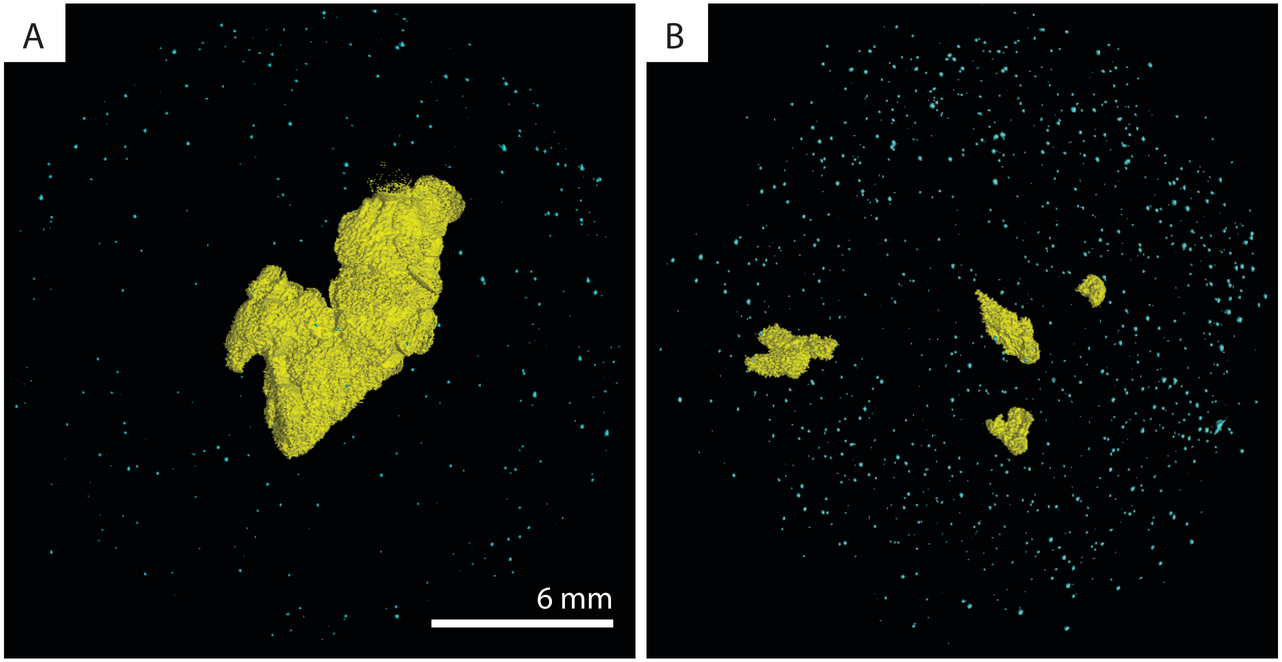
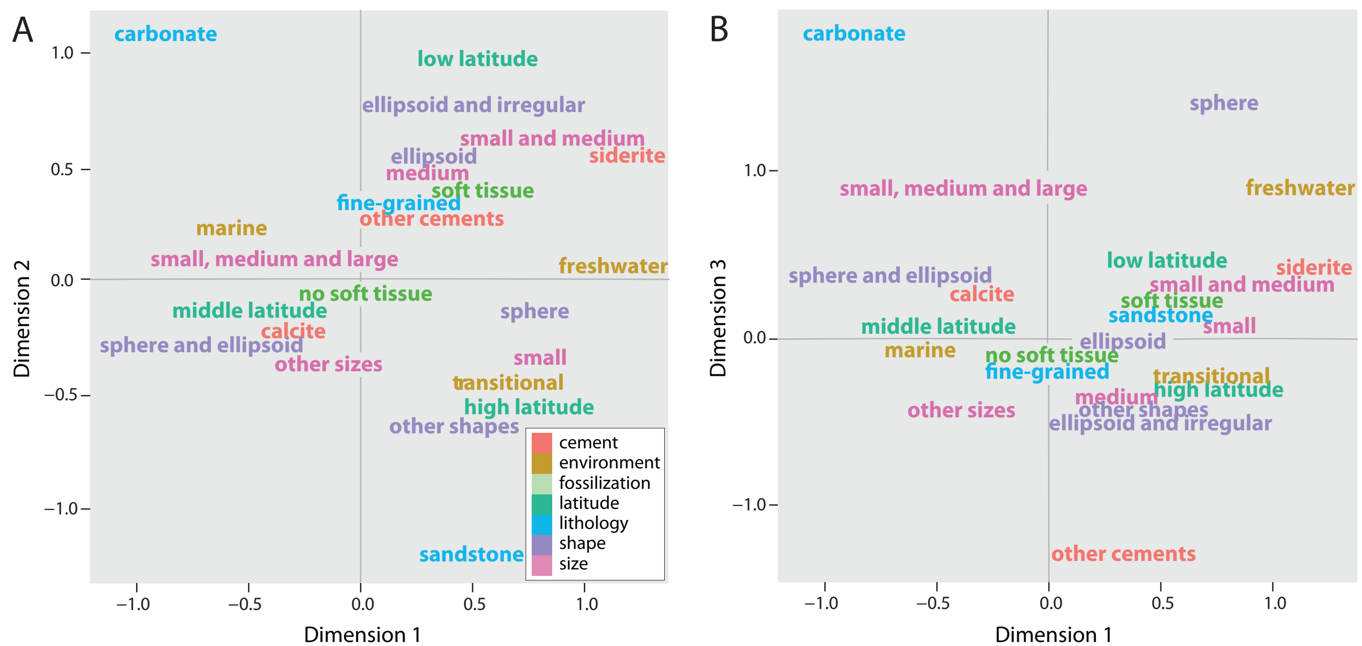


SUPPLEMENTARY FIGURE 1—3D CT scan reconstruction of mineral precipitation experiments. Yellow is remaining fish tissue, blue is glass beads cemented together by authigenic mineral precipitation. Scale bar refers to both. A) Fine grained glass beads. B) Medium grained glass beads.



SUPPLEMENTARY FIGURE 2—The distribution of variable states along each Dimension. The states of each variable that contribute meaningfully to the Dimensions are plotted to show how the variables are positioned. A) Dimension 1 vs Dimension 2. B) Dimension 1 vs. Dimension 3.

Supplementary Table 1. Data Used in Analyses

Formation	Age	Variable state†												References
		latitude	cement	pyrite	size	shape	environment	lithology	soft tissue preservation*	$\delta^{13}C$	$\delta^{13}C$ trend	$\delta^{18}O$	$\delta^{18}O$ trend	
Doushantuo	Ediacaran	3	3	1	2	4	3	2	1	?	?	?	?	Zhu et al., 2005; Dong et al., 2008
Lion Mountain sandstone	Cambrian	1	2	0	4	2	2	3	0	1	2 (0)	2 (0)	2 (0)	McBride, 1988
Upper Cambrian beds, St Tudwal's Peninsula	Cambrian	3	2	?	4	3	2	2	0	?	?	?	?	Raiswell, 1971
Rastrites Shale	Silurian	1	2	1	5	1	3	2	0	2	1	2 (0)	3 (1)	Morad and Eshete, 1990; Mozley and Burns, 1993
Wenlock Series	Silurian	2	2	1	3	1	1	2	1	?	?	?	?	Briggs et al., 1996; Orr et al., 2000; Sutton, 2001
Kellwasser beds	Devonian	3	2	?	2	?	3	2	0	?	?	?	?	Becker et al., 2004; Meyer-Berthaud et al., 2004
Geneseo Formation	Devonian	2	2	1	5	3	3	2	0	0	3 (1)	2 (0)	1	Dix and Mullins, 1987; Wilson and Brett, 2013
Windom Member	Devonian	2	2	1	5	3	3	2	0	0	0 (1)	2 (0)	2 (0)	Dix and Mullins, 1987; Wilson and Brett, 2013

Formation	Age	Variable state†												References
		latitude	cement	pyrite	size	shape	environment	lithology	soft tissue preservation*	$\delta^{13}C$	$\delta^{13}C$ trend	$\delta^{18}O$	$\delta^{18}O$ trend	
Butternut Member	Devonian	2	2	1	5	3	3	3 (2)	0	0	1	2 (0)	0 (1)	Dix and Mullins, 1987; Wilson and Brett, 2013
Chittenango Member	Devonian	2	2	1	5	3	3	2	0	0	0 (1)	2 (0)	0	Dix and Mullins, 1987; Wilson and Brett, 2013
Union Springs Member	Devonian	2	2	1	5	3	3	2	0	0	1	2 (0)	2 (0)	Dix and Mullins, 1987; Wilson and Brett, 2013
Ivy Point Member	Devonian	2	2	1	5	3	3	3	0	1	1	2 (0)	2 (1)	Dix and Mullins, 1987; Wilson and Brett, 2013
Kettle Point Formation	Devonian	1	2	1	4	3	3	2	0	0	3 (1)	2 (0)	1	Coniglio and Cameron, 1990
Woodford Shale	Devonian	1	2	1	4	4	3	2	1	?	?	?	?	Feldmann and Schweitzer, 2010
Gogo Formation	Devonian	1	2	0	2	5	3	2	1	0	?	2	?	Long and Trinajstic, 2010
English Coal Measures-other cement	Carboniferous	1	3	1	?	1	3	2	0	0	1 (?)	2 (0)	?	Coleman et al., 1993; Wilson and Almond, 2001
English Coal Measures-siderite	Carboniferous	1	1	1	?	2	2	2	0	1 (0)	?	2 (0)	?	Coleman et al., 1993; Wilson and Almond, 2001
Hepworth sequence	Carboniferous	1	1	1	3	2	3	2	0	1	?	?	?	Pearson, 1979

Formation	Age	Variable state†												References
		latitude	cement	pyrite	size	shape	environment	lithology	soft tissue preservation*	$\delta^{13}C$	$\delta^{13}C$ trend	$\delta^{18}O$	$\delta^{18}O$ trend	
Upper Cattletown Formation	Carboniferous	1	2	1	2	2	?	1	0	?	?	?	?	Dickson and Barber, 1976
Francis Creek Shale, Mazon Creek Braidwood	Carboniferous	1	1	1	2	5	1	2	1	2	2 (0)	2 (0)	2 (0)	Woodland and Stenstrom, 1979; Baird et al., 1985a; Baird et al., 1985b; Baird et al., 1986
Francis Creek Shale, Mazon Creek Essex	Carboniferous	1	1	1	2	5	2	2	1	1	1	2 (0)	1	Woodland and Stenstrom, 1979; Baird et al., 1985a; Baird et al., 1985b; Baird et al., 1986
Montceau les Mines	Carboniferous	2	1	1	1	2	2	2	1	?	?	?	?1	Rolfe et al., 1982; Charbonnier et al., 2008
Dugger Formation	Carboniferous	1	1	1	5	?	2	2	0	?	?	?	?	Maples, 1986
Iowa equivalent to Francis creek Shale,	Carboniferous	1	1	1	3	5	1	2	0	?	?	?	?	Archer et al., 1995
Orzesze beds	Carboniferous	1	1	1	3	2	1	?	1	?	?	?	?	Filipiak and Krawczynski, 1996
Dwyka and Ecca groups	Permian	3	2	1	4	3	1	2	0	0	3 (1)	1	1	Abdala et al., 2006; Herbert and Compton, 2007

Formation	Age	Variable state†												References
		latitude	cement	pyrite	size	shape	environment	lithology	soft tissue preservation*	$\delta^{13}C$	$\delta^{13}C$ trend	$\delta^{18}O$	$\delta^{18}O$ trend	
Helongshan Formation	Triassic	2	2	1	3	2	3	2	0	?	?	?	?	Tong et al., 2006; Shuangying et al., 2007
Chanares Formation	Triassic	3	2	0	4	2	1	2	0	?	?	?	?	Rogers et al., 2001
Weser Formation equivalent	Triassic	2	2	1	1	4	1	2	0	?	?	?	?	Dzik, 2008; Bodzioch and Kowal-Linka, 2012
Chinle Formation	Triassic	1	2	?	3	?	1	2	0	?	?	?	?	Fiorillo et al., 2000
Katberg Formation	Triassic	3	2	0	3	4	2	3	0	?	?	?	?	Johnson, 1989
Ollach Sandstone Member, Bearreraig Formation	Jurassic	2	2	0	4	4	3	3	0	0	?	2 (0)	?	Wilkinson, 1991
Udairn Shale Member, Bearreraig Formation	Jurassic	2	2	0	4	4	3	2	0	2	?	2 (0)	?	Wilkinson, 1991

Formation	Age	Variable state†												References
		latitude	cement	pyrite	size	shape	environment	lithology	soft tissue preservation*	$\delta^{13}C$	$\delta^{13}C$ trend	$\delta^{18}O$	$\delta^{18}O$ trend	
Holm Sandstone Member, Bearreraig Formation	Jurassic	2	2	0	4	3	3	3	0	2	?	2 (0)	?	Wilkinson, 1991
Birchi nodular bed	Jurassic	2	3	1	4	2	3	2	0	0	2 (0)	2 (0)	2 (0)	Marshall, 1982
Jurassic marine sediments, Cordillero de Domekyo	Jurassic	2	2	?	5	3	3	1	1	?	?	?	?	Arratia and Schultze, 1999
Valtos sandstone	Jurassic	2	2	0	4	3	2	3	0	2	0 (1)	1	0 (1)	Wilkonson, 1993
Jet Rock	Jurassic	2	2	1	4	3	3	2	0	2	2 (0)	2 (0)	2 (0)	Coleman and Raiswell, 1981; Coleman, 1993; Coleman and Raiswell, 1995
Kimmeridge Clay	Jurassic	2	3	1	4	5	2	2	0	0	1	2 (0)	1	Irwin, 1980; Astin and Scotchman, 1988; Scotchman, 1991
La Voulte-sur-Rhône	Jurassic	3	3	1	3	5	3	2	1	?	?	?	?	Wilby et al., 1996; Fischer, 2003; Charbonnier et al., 2007

Formation	Age	Variable state†												References
		latitude	cement	pyrite	size	shape	environment	lithology	soft tissue preservation*	$\delta^{13}C$	$\delta^{13}C$ trend	$\delta^{18}O$	$\delta^{18}O$ trend	
Sysola Formation	Jurassic	3	1	0	?	?	2	2	0	0	?	1	?	Vetoshkina, 2006
Oxfordian black shales, Chile	Jurassic	2	2	0	5	2	3	2	1	?	?	?	?	Schultze, 1989
Oxford Clay	Jurassic	2	2	1	4	4	3	2	0	2	3 (1)	2 (0)	1	Hudson, 1978
Upper Bajocian beds, Polish Jura	Jurassic	3	2	1	2	3	3	2	0	0	3 (1)	2 (0)	1	Zatoń and Marynowski, 2006
Shelikof and Lonesome formations	Jurassic	3	2	1	?	?	3	2	0	?	?	?	?	Blome, 1984
The Coinstone Type 1 nodules	Jurassic	2	2	1	4	5	3	2	0	0	3 (1)	2 (0)	1	Hesselbo and Palmer, 1992
The Coinstone Type 2 nodules	Jurassic	2	2	1	4	4	3	2	0	0	3 (1)	2 (0)	1	Hesselbo and Palmer, 1992
The Coinstone Type 3 nodules	Jurassic	2	2	0	4	2	3	2	0	0	3 (1)	2 (0)	1	Hesselbo and Palmer, 1992
Carlile shale	Cretaceous	3	3	1	4	2	3	2	0	2	3 (1)	1	2	Coniglio et al., 2000

Formation	Age	Variable state†												References
		latitude	cement	pyrite	size	shape	environment	lithology	soft tissue preservation*	$\delta^{13}C$	$\delta^{13}C$ trend	$\delta^{18}O$	$\delta^{18}O$ trend	
Cardium Formation	Cretaceous	3	1	1	?	?	3	2	0	2	3 (1)	1	1	Machemer and Hutcheon, 1988
Cretaceous black shales	Cretaceous	2	1	0	1	3	3	2	0	0	?	2 (0)	?	Tasse and Hesse, 1984
Gammon Shale	Cretaceous	3	3	1	2	2	?	2	0	2	2 (0)	2 (0)	2 (0)	Gautier, 1982
Cretaceous black shales, Magdalena Valley	Cretaceous	1	2	0	5	3	3	2	0	?	?	?	?	Weeks, 1953; Weeks, 1957
Santa Marta Formation	Cretaceous	3	2	1	4	4	2	3	0	0	?	2 (0)	?	Pirrie and Marshall, 1991
Lopez de Bertodano	Cretaceous	3	2	1	4	3	2	2	0	0	?	2 (0)	?	Pirrie and Marshall, 1991
Mishash	Cretaceous	2	2	0	4	3	3	3	0	0	1	2 (0)	1	Sass and Kolodny, 1972
Bearpaw shale	Cretaceous	2	3	1	5	5	3	2	0	?	?	?	?	Feldmann et al., 1977; Cameron, 1995
Maungataniwha sandstone	Cretaceous	3	2	1	4	2	2	3	0	?	?	?	?	Crampton and Moore, 1990

Formation	Age	Variable state†												References
		latitude	cement	pyrite	size	shape	environment	lithology	soft tissue preservation*	$\delta^{13}C$	$\delta^{13}C$ trend	$\delta^{18}O$	$\delta^{18}O$ trend	
Fox Hill	Cretaceous	3	3	1	?	4	2	3	0	0	?	2 (0)	?	Waagé, 1964; Carpenter et al., 1988
Peace River Formation	Cretaceous	3	1	1	?	4	2	3	0	2	0 (1)	1	0 (1)	Bloch, 1990
Krasnojarkovskaja 1	Cretaceous	2	1	0	?	?	2	2	0	?	?	?	?	Alabushev, 1995
Krasnojarkovskaja 2	Cretaceous	2	2	0	?	?	2	2	0	?	?	?	?	Alabushev, 1995
Romualdo Member, Santana Formation	Cretaceous	2	2	0	2	3	2	2	1	?	?	?	?	Mabesoone and Tinoco, 1973
Aptian beds, Shilovka	Cretaceous	3	1	?	1	?	3	?	1	?	?	?	?	Larisa and Harry, 2005
Pierre shale	Cretaceous	3	3	?	4	5	3	2	0	?	?	?	?	Bishop, 1981
Turonian marls and limestones	Cretaceous	1	2	0	?	2	3	1	0	0	3 (1)	2 (0)	3 (1)	El Albani et al., 2001
Otway and Strzelecki groups	Cretaceous	3	2	0	5	1	1	3	0	2	1	1	3	Gregory et al., 1989; Martin, 2009

Formation	Age	Variable state†												References
		latitude	cement	pyrite	size	shape	environment	lithology	soft tissue preservation*	$\delta^{13}C$	$\delta^{13}C$ trend	$\delta^{18}O$	$\delta^{18}O$ trend	
Otway and Strzelecki groups	Cretaceous	3	1	0	5	1	1	3	0	?	?	1	?	Gregory et al., 1989; Martin, 2009
Cretaceous Marine Sediments, Zululand	Cretaceous	3	2	0	2	4	3	2	0	?	?	?	?	Kennedy and Klinger, 2009
London Clay	Paleogene	2	2	1	2	2	3	2	0	2	1	2 (0)	0 (1)	Huggett, 1994; Huggett, 1995; Huggett et al., 2000
Sakamena Group	Paleogene	3	?	?	2	4	2	3	0	?	?	?	?	Olsen, 1984
Moeraki Formation	Paleogene	3	2	1	4	1	2	2	0	2	1	2 (0)	2 (0)	Thyne and Boles, 1989
Rio Foyel Formation	Paleogene	2	2	?	3	4	3	2	0	?	?	?	?	Crawford, 2008
Huitrera Formation	Paleogene	3	?	?	1	2	1	3	1	?	?	?	?	Báez and Pugener, 2003
Alamenca Formation	Paleogene	2	2	1	?	?	3	2	0	?	?	?	?	Feldmann et al., 1997
Sediment, Calico Mountains	Neogene	2	2	0	1	4	1	2	1	0	2 (0)	2 (0)	3 (1)	Degens et al., 1962

Formation	Age	Variable state†												References
		latitude	cement	pyrite	size	shape	environment	lithology	soft tissue preservation*	$\delta^{13}C$	$\delta^{13}C$ trend	$\delta^{18}O$	$\delta^{18}O$ trend	
Tapaliza Formation	Neogene	1	2	?	4	?	3	3	0	?	?	?	?	Coates et al., 2004
Membrillo Formation	Neogene	1	?	?	?	4	2	2	0	?	?	?	?	Coates al., 2004
Yaviza Formation	Neogene	1	?	?	4	4	2	3	0	?	?	?	?	Coates et al., 2004
Chucunaque Formation	Neogene	1	2	?	?	5	2	2	0	?	?	?	?	Coates et al., 2004
Pliocene layers, La Serra Quarry	Neogene	2	2	0	?	5	3	3	0	?	?	?	?	Garassino et al., 2012
Monterey	Neogene	2	3	1	4	2	3	2	0	2	1	2 (0)	1	Burns and Baker, 1987
Barstow Formation	Neogene	2	2	1	1	?	1	2	1	1	2 (0)	1	2 (0)	Allison and Bassett, 1954; Park, 1995; Park and Downing, 2001
Upper Sisquoc Formation	Neogene	2	3	1	5	?	3	2	0	1	2 (0)	2 (0)	1	Henderson et al., 1984
Sediments, Loch Sunart	Quaternary	3	3	0	1	4	1	2	0	?	?	?	?	Brown and Farrow, 1978
Sediments, Norfolk Coast	Quaternary	2	3	1	1	4	2	3	0	0	?	?	?	Pye, 1984; Pye et al., 1990; Allison and Pye, 1994

Formation	Age	Variable state†												References
		latitude	cement	pyrite	size	shape	environment	lithology	soft tissue preservation*	$\delta^{13}C$	$\delta^{13}C$ trend	$\delta^{18}O$	$\delta^{18}O$ trend	
Sediments, West Haven	Quaternary	2	2	0	3	5	2	3	1	0	2 (0)	2 (0)	2 (0)	Waage et al., 2001

* Soft tissue preservation was used as a supplemental variable in the MCA and a response variable in regression analyses.

† Variable states for regression analyses are listed in parentheses where they differ from those used in the MCA.

SUPPLEMENTARY TABLE 1—Data used in multiple correspondence (MCA) and regression analyses. For key to variable states see Supplementary Table 2.

Supplementary Table 2. Key to Variable States

	0	1	2	3	4	5	?
Latitude (at time of deposition)		Low latitudes (−30º to 30º)	Middle latitudes (−60º to −30º, 30º to 60º)	High latitudes (−90º to 90º, −60º to 60º)			Unknown
Cement composition		Siderite	Calcite	Other			Unknown
Pyrite	Absent	Present					Unknown
Concretion size		Small (<10 cm)	Medium (10–50 cm)	Small and medium concretions	Other size combinations	Small, medium and large (>50 cm)	Unknown
Concretion shape		Spherical	Elliptical	Spherical and elliptical	Other shape combinations	Elliptical and irregular	Unknown
Environment		Freshwater	Transitional	Marine			Unknown
Host lithology		Carbonate	Fine-grained	Sand			Unknown
δ^{13}C trend (from center to edge)	No trend	Decreasing	Constant	Increasing			Unknown
δ^{13}C trend (from center to edge) [†]	Constant	Non-constant					
δ^{18}O trend (from center to edge)	No trend	Decreasing	Constant	Increasing			Unknown
δ^{18}O trend (from center to edge) [†]	Constant	Non-constant					

	0	1	2	3	4	5	?
$\delta^{13}C$ (PDB)	Negative values	Positive values	Both negative and positive values				Unknown
$\delta^{18}O$ (SMOW)	Small values (<10)	Large values (>10)	Small and large values				Unknown
Soft tissue preservation	Absent	Present					Unknown

† Variable states used exclusively for regression analyses

SUPPLEMENTARY TABLE 2—Key to variable states for multiple correspondence (MCA) and regression analyses.

Supplementary Table 3. Data from Decay Experiments

	Seawater (0.1 g)			Seawater (0.2 g)				Seawater (0.3 g)			Fine beads (0.2 g)				Medium beads (0.2 g)				Coarse beads (0.2 g)		
Day	1	2	3	1	2	3	4	1	2	3	1	2	3	4	1	2	3	4	1	2	3
1	11.60	14.07	13.54	12.27	15.85	16.17	14.49	18.01	19.43	18.93	2.99	3.46	0.69	3.70	2.82	2.32	2.22	2.60	9.59	9.88	11.61
3	38.47	40.62	43.56	42.87	56.73	60.84	59.29	68.69	72.89	90.71	1.17	1.07	0.29	1.52	1.83	1.87	1.86	1.62	18.60	19.25	22.19
6	59.43	48.91	59.38	105.88	90.61	109.88	129.22	190.33	182.19	178.16	1.00	0.93	0.37	1.11	11.60	7.69	12.57	6.84	29.47	33.49	41.03
8	98.19	79.61	103.54	161.85	127.55	188.76	199.63	185.36	207.82	178.56	1.77	1.80	0.69	3.79	26.97	24.49	43.82	38.76	55.14	48.60	72.98
9	129.71	111.84	143.00	198.48	181.50	254.05	232.03	244.05	X	187.43	3.58	3.53	1.66	9.31	51.92	49.60	59.61	61.50	74.07	78.40	90.38
14	135.09	123.15	147.26	198.22	152.50	161.21	131.85	158.14	128.11	145.05	6.76	8.05	5.14	22.09	88.85	84.61	109.78	84.86	97.42	105.40	127.31
15	153.08	136.14		190.73	160.16	171.91		169.39	148.59		11.37	12.79		32.99	105.80	102.96		141.86	109.42	109.70	
16	88.80	74.08		98.15	73.96	82.48		73.27	68.68		7.61	8.74		35.09	65.35	63.03		168.39	65.36	64.80	
17	125.78	105.89		129.74	111.79	116.67		104.30	77.04		15.27	17.52		62.88	99.04	95.29		197.27	100.90	103.80	
18	64.13	57.15		60.48	58.74	54.68		60.18	48.94		9.71	10.11		35.16	49.95	X		88.02	51.35	51.85	
20	53.43	47.70		39.28	45.70	37.27		42.24	36.50		10.26	10.42		20.40	48.02	30.87		63.54	50.20	49.15	
24	52.49	56.12		42.43	38.01	26.67		30.55	29.59		14.88	17.36		15.45	58.83			46.01	64.83	60.08	
27	27.15	55.17		23.16	24.74	18.02		19.89	21.73		12.57	17.04		10.90	52.21			34.25	62.42	50.91	
29	44.67	68.91			28.29	22.90		4.47	3.97			24.73		13.42				37.46		63.64	
31	35.40	55.32			22.23	20.57		3.93	3.29			25.33		10.75				31.82		57.99	

SUPPLEMENTARY TABLE 3—Data from decay experiments. Values represent milliliters of carbon dioxide produced per hour per gram of fish. X = no data recorded. Underline indicates when replicates were terminated; those terminated after 27 days were CT scanned to investigate mineral precipitation.

Supplementary References

ABDALA, F., CISNEROS, J.C., and SMITH, R.M.H., 2006, Faunal aggregation in the Early Triassic Karoo basin: earliest evidence of shelter sharing behavior among tatrapods?: PALAIOS, v. 21, p. 507–512, doi: 10.2110/palo.2005.P06-001R.

ALABUSHEV, A., 1995, Sedimentary formations of the Cretaceous Sakhalin Basin (Far East Asia): Geologische Rundschau, v. 84, p. 237–244, doi: 10.1007/bf00260437.

ALLISON, P.A., and PYE, K., 1994, Early diagenetic mineralization and fossil preservation in modern carbonate concretions: PALAIOS, v. 9, p. 561–575.

ALLISON, R.P., and BASSETT, A.M., 1954, Nonmarine Miocene Arthropods from California: Science, v. 120, p. 228–229.

ARCHER, A.W., KUECHER, G.J., and KVALE, E.P., 1995, The role of tidal-velocity asymmetries in the deposition of silty tidal rhythmites (Carboniferous, eastern Interior Coal Basin, U.S.A.): Journal of Sedimentary Research, v. 65, p. 408–416, doi: 10.1306/d42680d6-2b26-11d7-8648000102c1865d.

ARRATIA, G., and SCHULTZE, H.-P., 1999, Mesozoic fishes from Chile: Mesozoic fishes, v. 2, p. 565–593.

ASTIN, T.R., and SCOTCHMAN, I.C., 1988, The diagenetic history of some septarian concretions from the Kimmeridge Clay, England: Sedimentology, v. 35, p. 349–368, doi: 10.1111/j.1365-3091.1988.tb00952.x.

BAÉZ, A.M., and PUGENER, L.A., 2003, Ontogeny of a new Palaeogene pipid frog from southern South America and xenopodinomorph evolution: Zoological Journal of the Linnean Society, v. 139, p. 439–476, doi: 10.1046/j.1096-3642.2003.00085.x.

BAIRD, G.C., SHABICA, C.W., ANDERSON, J.L., and RICHARDSON, E.S., JR., 1985, Biota of a Pennsylvanian muddy coast: habitats within the Mazonian delta complex, Northeast Illinois: Journal of Paleontology, v. 59, p. 253–281.

BAIRD, G.C., SROKA, S.D., SHABICA, C.W., BEARD, T.L., SCOTT, A.C., and BROADHURST, F.M., 1985, Mazon Creek-Type fossil assemblages in the U.S. Midcontinent Pennsylvanian: their recurrent character and palaeoenvironmental significance [and discussion]: Philosophical Transactions of the Royal Society of London. B, Biological Sciences, v. 311, p. 87–99, doi: 10.1098/rstb.1985.0141.

BAIRD, G.C., SROKA, S.D., SHABICA, C.W., and KUECHER, G.J., 1986, Taphonomy of Middle Pennsylvanian Mazon Creek area fossil localities, Northeast Illinois: significance of exceptional fossil preservation in syngenetic concretions: PALAIOS, v. 1, p. 271–285.

BECKER, R., JANSEN, U., PLODOWSKI, G., SCHINDLER, E., ABOUSSALAM, Z., and WEDDIGE, K., 2004, Devonian litho-and biostratigraphy of the Dra Valley area–an overview, Devonian Neritic-Pelagic Correlation and Events in the Dra Valley (Western Anti-Atlas, Morocco). Subcommission on Devonian Stratigraphy. International Meeting on Stratigraphy, Rabat, p. 3–18.

BISHOP, G.A., 1981, Occurrence and fossilization of the Dakoticancer Assemblage, Upper Cretaceous Pierre Shale, South Dakota: Communities of the Past, v. 13, p. 383–413.

BLOCH, J., 1990, Stable isotopic composition of authigenic carbonates from the Albian Harmon Member (Peace River Formation); evidence of early diagenetic processes: Bulletin of Canadian Petroleum Geology, v. 38, p. 39–52.

BLOME, C.D., 1984, Middle Jurassic (Callovian) Radiolarians from carbonate concretions, Alaska and Oregon: Micropaleontology, v. 30, p. 343–389.

BODZIOCH, A., and KOWAL-LINKA, M., 2012, Unraveling the origin of the Late Triassic multitaxic bone accumulation at Krasiejów (S Poland) by diagenetic analysis: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 346–347, p. 25–36, doi: 10.1016/j.palaeo.2012.05.015.

BRIGGS, D.E.G., SIVETER, D.J., and SIVETER, D.J., 1996, Soft-bodied fossils from a Silurian volcaniclastic deposit: Nature, p. 248–250, doi: 10.1038/382248a0.

BROWN, B.J., and FARROW, G.E., 1978, Recent dolomitic concretions of crustacean burrow origin from Loch Sunart, west coast of Scotland: Journal of Sedimentary Research, v. 48, p. 825–833, doi: 10.1306/212f757c-2b24-11d7-8648000102c1865d.

BURNS, S.J., and BAKER, P.A., 1987, A geochemical study of dolomite in the Monterey Formation, California: Journal of Sedimentary Research, v. 57, p. 128–139, doi: 10.1306/212f8ac6-2b24-11d7-8648000102c1865d.

CAMERON, J.T., 1995, Origin of concretion-hosted shell clusters in the Late Cretaceous Bearpaw Formation, Southern Alberta, Canada: PALAIOS, v. 10, p. 408–423.

CARPENTER, S.J., ERICKSON, J.M., LOHMANN, K.C., and OWEN, M.R., 1988, Diagenesis of fossiliferous concretions from the Upper Cretaceous Fox Hills Formation, North Dakota: Journal of Sedimentary Research, v. 58, p. 706–723, doi: 10.1306/212f8e27-2b24-11d7-8648000102c1865d.

CHARBONNIER, S., VANNIER, J., GAILLARD, C., BOURSEAU, J.-P., and HANTZPERGUE, P., 2007, The La Voulte Lagerstätte (Callovian): Evidence for a deep water setting from sponge and crinoid communities: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 250, p. 216–236, doi: 10.1016/j.palaeo.2007.03.013.

CHARBONNIER, S., VANNIER, J., GALTIER, J., PERRIER, V., CHABARD, D., and SOTTY, D., 2008, Diversity and paleoenvironment of the flora From the nodules of the Montceau-Les-Mines biota (Late Carboniferous, France): PALAIOS, v. 23, p. 210–222, doi: 10.2110/palo.2006.p06-078r.

COATES, A.G., COLLINS, L.S., AUBRY, M.-P., and BERGGREN, W.A., 2004, The Geology of the Darien, Panama, and the late Miocene-Pliocene collision of the Panama arc with northwestern South America: Geological Society of America Bulletin, v. 116, p. 1327–1344, doi: 10.1130/b25275.1.

COLEMAN, M.L., 1993, Microbial processes: Controls on the shape and composition of carbonate concretions: Marine Geology, v. 113, p. 127–140, doi: 10.1016/0025-3227(93)90154-n.

COLEMAN, M.L., and RAISWELL, R., 1981, Carbon, oxygen and sulphur isotope variations in concretions from the Upper Lias of N.E. England: Geochimica et Cosmochimica Acta, v. 45, p. 329–340, doi: 10.1016/0016-7037(81)90243-x.

COLEMAN, M.L., and RAISWELL, R., 1995, Source of carbonate and origin of zonation in pyritiferous carbonate concretions: evaluation of a dynamic model: American Journal of Science, v. 295.

COLEMAN, M.L., RAISWELL, R., BROWN, A., CURTIS, C.D., APLIN, A.C., ORTOLEVA, P.J., GRUSZCZYNSKI, M., LYONS, T., LOVLEY, D.R., and EGLINTON, G., 1993, Microbial mineralization of organic matter: mechanisms of self-organization and inferred rates of precipitation of diagenetic minerals [and discussion]: Philosophical Transactions of the Royal Society of London. Series A: Physical and Engineering Sciences, v. 344, p. 69–87, doi: 10.1098/rsta.1993.0076.

CONIGLIO, M., and CAMERON, J.S., 1990, Early diagenesis in a potential oil shale; evidence from calcite concretions in the Upper Devonian Kettle Point Formation, southwestern Ontario: Bulletin of Canadian Petroleum Geology, v. 38, p. 64–77.

CONIGLIO, M., MYROW, P., and WHITE, T., 2000, Stable carbon and oxygen isotope evidence of Cretaceous sea-level fluctuations recorded in septarian concretions from Pueblo, Colorado, U.S.A: Journal of Sedimentary Research, v. 70, p. 700–714, doi: 10.1306/2dc40931-0e47-11d7-8643000102c1865d.

CRAMPTON, J.S., and MOORE, P.R., 1990, Environment of deposition of the Maungataniwha Sandstone (Late Cretaceous), Te Hoe River area, western Hawke's Bay, New Zealand: New Zealand Journal of Geology and Geophysics, v. 33, p. 333–348, doi: 10.1080/00288306.1990.10425691.

CRAWFORD, R.S., 2008, A new species of fossil homolid crab (Decapoda: Brachyura) from the Río Foyel formation (Paleogene), Río Negro province, Argentina: Journal Information, v. 82.

DEGENS, E.T., PIERCE, W.D., and CHILINGAR, G.V., 1962, Origin of petroleum-bearing fresh-water concretions of Miocene age: AAPG Bulletin, v. 46, p. 1522–1525.

DICKSON, J.A.D., and BARBER, C., 1976, Petrography, chemistry and origin of early diagenetic concretions in the Lower Carboniferous of the Isle of Man: Sedimentology, v. 23, p. 189–211, doi: 10.1111/j.1365-3091.1976.tb00046.x.

DIX, G.R., and MULLINS, H.T., 1987, Shallow, subsurface growth and burial alteration of Middle Devonian calcite concretions: Journal of Sedimentary Research, v. 57, p. 140–152, doi: 10.1306/212f8acb-2b24-11d7-8648000102c1865d.

DONG, J., ZHANG, S., JIANG, G., ZHAO, Q., LI, H., SHI, X., and LIU, J., 2008, Early diagenetic growth of carbonate concretions in the upper Doushantuo Formation in South China and their significance for the assessment of hydrocarbon source rock: Science in China Series D: Earth Sciences, v. 51, p. 1330–1339, doi: 10.1007/s11430-008-0107-3.

DZIK, J., 2008, Gill structure and relationships of the Triassic cycloid crustaceans: Journal of Morphology, v. 269, p. 1501–1519, doi: 10.1002/jmor.10663.

EL ALBANI, A., VACHARD, D., KUHNT, W., and THUROW, J., 2001, The role of diagenetic carbonate concretions in the preservation of the original sedimentary record: Sedimentology, v. 48, p. 875-886, doi: 10.1046/j.1365-3091.2001.00398.x.

FELDMANN, R.M., BISHOP, G.A., and KAMMER, T.W., 1977, Macrurous Decapods from the Bearpaw Shale (Cretaceous: Campanian) of Northeastern Montana: Journal of Paleontology, v. 51, p. 1161–1180.

FELDMANN, R.M., RODRIGUEZ, M.F., MARTINEZ, G.A., and AGUIRRE-URRETA, M., 1997, Costacopluma salamanca New Species (Decapoda, Retroplumidae) from the Salamanca Formation (Danian) of Patagonia, Argentina: Journal of Paleontology, v. 71, p. 125–130.

FELDMANN, R.M., and SCHWEITZER, C.E., 2010, The Oldest Shrimp (Devonian: Famennian) and Remarkable Preservation of Soft Tissue: Journal of Crustacean Biology, v. 30, p. 629–635, doi: 10.1651/09-3268.1.

FILIPIAK, P., and KRAWCZYNSKI, W., 1996, Westphalian xiphosurans (Chelicerata) from the Upper Silesia Coal Basin of Sosnowiec, Poland: Acta Palaeontologica Polonica, v. 41, p. 413–425.

FIORILLO, A.R., PADIAN, K., and MUSIKASINTHORN, C., 2000, Taphonomy and depositional setting of the Placerias Quarry (Chinle Formation: Late Triassic, Arizona): PALAIOS, v. 15, p. 373–386.

FISCHER, J.-C., 2003, Remarkable invertebrates from the Lower Callovian of la Voulte-sur-Rhone (Ardeche, France): Annales de Paleontologie, v. 89, p. 223–252, doi: 10.1016/j.annpal.2003.09.001.

GARASSINO, A., PASINI, G., DE ANGELI, A., CHARBONNIER, S., FAMIANI, F., BALDANZA, A., and BIZZARRI, R., 2012, The decapod community from the Early Pliocene (Zanclean) of "La Serra" quarry (San Miniato, Pisa, Toscana, central Italy): sedimentology, systematics, and palaeoenvironmental implications: Annales de Paleontologie, v. 98, p. 1–61, doi: 10.1016/j.annpal.2012.02.001.

GAUTIER, D.L., 1982, Siderite concretions; indicators of early diagenesis in the Gammon Shale (Cretaceous): Journal of Sedimentary Research, v. 52, p. 859–871, doi: 10.1306/212f8076-2b24-11d7-8648000102c1865d.

GREGORY, R.T., DOUTHITT, C.B., DUDDY, I.R., RICH, P.V., and RICH, T.H., 1989, Oxygen isotopic composition of carbonate concretions from the lower Cretaceous of Victoria, Australia: implications for the evolution of meteoric waters on the Australian continent in a paleopolar environment: Earth and Planetary Science Letters, v. 92, p. 27–42, doi: 10.1016/0012-821x(89)90018-6.

HENDERSON, N.C., CRAWFORD, G.A., DUNHAM, J.B., and OSBORNE, R.H., 1984, Relationship of diagenetic dolomite to depositional facies in diatomaceous strata, Upper Sisquoc Fm., Casmalia Hills, Santa Barbara Co., California, *in* Garrison, R.E., Kastner, M., and Zenger, D.H., eds., Dolomites of the Monterey Formation and Other Organic-rich Units: SEPM Pacific Section Special Publication, p. 119–140.

HERBERT, C.T., and COMPTON, J.S., 2007, Depositional environments of the lower Permian Dwyka diamictite and Prince Albert shale inferred from the geochemistry of early diagenetic concretions, southwest Karoo Basin, South Africa: Sedimentary Geology, v. 194, p. 263–277, doi: 10.1016/j.sedgeo.2006.06.008.

HESSELBO, S.P., and PALMER, T.J., 1992, Reworked early diagenetic concretions and the bioerosional origin of a regional discontinuity within British Jurassic marine mudstones: Sedimentology, v. 39, p. 1045–1065, doi: 10.1111/j.1365-3091.1992.tb01996.x.

HUDSON, J.D., 1978, Concretions, isotopes, and the diagenetic history of the Oxford Clay (Jurassic) of central England: Sedimentology, v. 25, p. 339–370, doi: 10.1111/j.1365-3091.1978.tb00317.x.

HUGGETT, J.M., 1994, Diagenesis of mudrocks and concretions from the London Clay Formation in the London Basin: Clay Minerals, v. 29, p. 693–707.

HUGGETT, J.M., 1995, Carbonate concretions from the London Clay Formation (early Eocene), southern England: Tertiary Research, v. 15, p. 175–190.

HUGGETT, J.M., GALE, A.S., AND EVANS, S., 2000, Carbonate concretions from the London Clay (Ypresian, Eocene) of southern England and the exceptional preservation of wood-boring communities: Journal of the Geological Society, v. 157, p. 187-200, doi: 10.1144/jgs.157.1.187.

IRWIN, H., 1980, Early diagenetic carbonate precipitation and pore fluid migration in the Kimmeridge Clay of Dorset, England: Sedimentology, v. 27, p. 577-591, doi: 10.1111/j.1365-3091.1980.tb01648.x.

JOHNSON, M.R., 1989, Paleogeographic significance of oriented calcareous concretions in the Triassic Katberg Formation, South Africa: Journal of Sedimentary Research, v. 59, p. 1008–1010, doi: 10.1306/212f90d9-2b24-11d7-8648000102c1865d.

KENNEDY, W.J., and KLINGER, H.C., 2009, Hiatus concretions and hardground horizons in the Cretaceous of Zululand (South Africa)

LARISA, D., and HARRY, M., 2005, The original composition of the gladius in the Aptian plesioteuhtid Nesisoteuthis, Central Russia, based on its ultrastructure: 2nd International symposium—Coleoid cephalopods through time, p. 50–53.

LONG, J.A., and TRINAJSTIC, K., 2010, The Late Devonian Gogo Formation Lägerstatte of Western Australia: exceptional early vertebrate preservation and diversity: Annual Review of Earth and Planetary Sciences, v. 38, p. 255–279, doi: doi:10.1146/annurev-earth-040809-152416.

MABESOONE, J., and TINOCO, I., 1973, Palaeoecology of the Aptian Santana Formation (northeastern Brazil): Palaeogeography, Palaeoclimatology, Palaeoecology, v. 14, p. 97–118.

MACHEMER, S.D., and HUTCHEON, I.D., 1988, Geochemistry of early carbonate cements in the Cardium Formation, central Alberta: Journal of Sedimentary Research, v. 58, p. 136–147, doi: 10.1306/212f8d37-2b24-11d7-8648000102c1865d.

MAPLES, C.G., 1986, Enhanced paleoecological and paleoenvironmental interpretations result from analysis of early diagenetic concretions in Pennsylvanian shales: PALAIOS, v. 1, p. 512–516.

MARSHALL, J.D., 1982, Isotopic composition of displacive fibrous calcite veins; reversals in pore-water composition trends during burial diagenesis: Journal of Sedimentary Research, v. 52, p. 615–630, doi: 10.1306/212f7fb3-2b24-11d7-8648000102c1865d.

MARTIN, A.J., 2009, Dinosaur burrows in the Otway Group (Albian) of Victoria, Australia, and their relation to Cretaceous polar environments: Cretaceous Research, v. 30, p. 1223–1237, doi: 10.1016/j.cretres.2009.06.003.

MCBRIDE, E.F., 1988, Contrasting diagenetic histories of concretions and host rock, Lion Mountain Sandstone (Cambrian), Texas: Geological Society of America Bulletin, v. 100, p. 1803-1810, doi: 10.1130/0016-7606(1988)100<1803:cdhoca>2.3.co;2.

MEYER-BERTHAUD, B., RÜCKLIN, M., SORIA, A., BELKA, Z., AND LARDEAUX, H., 2004, Frasnian plants from the Dra Valley, southern Anti-Atlas, Morocco: Geological Magazine, v. 141, p. 675–686, doi: 10.1017/s0016756804009665.

MORAD, S., and ESHETE, M., 1990, Petrology, chemistry and diagenesis of calcite concretions in Silurian shales from central Sweden: Sedimentary Geology, v. 66, p. 113-134, doi: 10.1016/0037-0738(90)90010-q.

MOZLEY, P.S., and BURNS, S.J., 1993, Oxygen and carbon isotopic composition of marine carbonate concretions; an overview: Journal of Sedimentary Research, v. 63, p. 73–83, doi: 10.1306/d4267a91-2b26-11d7-8648000102c1865d.

OLSEN, P.E., 1984, The skull and pectoral girdle of the parasemionotid fish *Watsonulus eugnathoides* from the Early Triassic Sakamena Group of Madagascar, with comments on the relationships of the holostean fishes: Journal of Vertebrate Paleontology, v. 4, p. 481–499.

ORR, P.J., BRIGGS, D.E.G., SIVETER, D.J., and SIVETER, D.J., 2000, Three-dimensional preservation of a non-biomineralized arthropod in concretions in Silurian volcaniclastic rocks from Herefordshire, England: Journal of the Geological Society, v. 157, p. 173–186, doi: 10.1144/jgs.157.1.173.

PARK, L.E., 1995, Geochemical and paleoenvironmental analysis of lacustrine arthropod-bearing concretions of the Barstow Formation, Southern California: PALAIOS, v. 10, p. 44–57.

PARK, L.E., and DOWNING, K.F., 2001, Paleoecology of an exceptionally preserved arthropod fauna from lake deposits of the Miocene Barstow Formation, Southern California, U.S.A: PALAIOS, v. 16, p. 175–184, doi: 10.1669/0883-1351(2001)016<0175:poaepa>2.0.co;2.

PEARSON, M.J., 1979, Geochemistry of the Hepworth Carboniferous sediment sequence and origin of the diagenetic iron minerals and concretions: Geochimica et Cosmochimica Acta, v. 43, p. 927–941, doi: 10.1016/0016-7037(79)90230-8.

PIRRIE, D., and MARSHALL, J.D., 1991, Field relationships and stable isotope geochemistry of concretions from James Ross Island, Antarctica: Sedimentary Geology, v. 71, p. 137–150, doi: 10.1016/0037-0738(91)90098-x.

PYE, K., 1984, SEM analysis of siderite cements in intertidal marsh sediments, Norfolk, England: Marine Geology, v. 56, p. 1–12, doi: 10.1016/0025-3227(84)90002-1.

PYE, K., DICKSON, J.A.D., SCHIAVON, N., COLEMAN, M.L., and COX, M., 1990, Formation of siderite-Mg-calcite-iron sulphide concretions in intertidal marsh and sandflat sediments, north Norfolk, England: Sedimentology, v. 37, p. 325–343, doi: 10.1111/j.1365-3091.1990.tb00962.x.

RAISWELL, R., 1971, The growth of Cambrian and Liassic concretions: Sedimentology, v. 17, p. 147–171, doi: 10.1111/j.1365-3091.1971.tb01773.x.

ROGERS, R.R., ARCUCCI, A.B., ABDALA, F., SERENO, P.C., FORSTER, C.A., and MAY, C.L., 2001, Paleoenvironment and taphonomy of the Chanares Formation tetrapod assemblage (Middle Triassic), Northwestern Argentina: spectacular preservation in volcanogenic concretions: PALAIOS, v. 16, p. 461–481, doi: 10.1669/0883-1351(2001)016<0461:patotc>2.0.co;2.

ROLFE, W.D.I., SCHRAM, F.R., PACAUD, G., SOTTY, D., and SECRETAN, S., 1982, A Remarkable Stephanian Biota from Montceau-les-Mines, France: Journal of Paleontology, v. 56, p. 426–428.

SASS, E., and KOLODNY, Y., 1972, Stable isotopes, chemistry and petrology of carbonate concretions (Mishash formation, Israel): Chemical Geology, v. 10, p. 261-286, doi: 10.1016/0009-2541(72)90022-8.

SCHULTZE, H.-P., 1989, Three-dimensional muscle preservation in Jurassic fishes of Chile: Andean Geology, v. 16, p. 183–215.

Scotchman, I.C., 1991, The geochemistry of concretions from the Kimmeridge Clay Formation of southern and eastern England: Sedimentology, v. 38, p. 79–106, doi: 10.1111/j.1365-3091.1991.tb01856.x.

Shuangying, L., Jinnan, T., Kongyan, L., Fanjian, W., and Yangyang, H., 2007, The Lower Triassic cyclic deposition in Chaohu, Anhui Province, China: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 252, p. 188–199, doi: 10.1016/j.palaeo.2006.11.043.

Sutton, M.D., 2001, A three-dimensionally preserved fossil polychaete worm from the Silurian of Herefordshire, England: Proceedings of the Royal Society of London. Series B: Biological Sciences, v. 268, p. 2355–2363, doi: 10.1098/rspb.2001.1788.

Tasse, N., and Hesse, R., 1984, Origin and significance of complex authigenic carbonates in Cretaceous black shales of the Western Alps: Journal of Sedimentary Research, v. 54, p. 1012–1027, doi: 10.1306/212f8553-2b24-11d7-8648000102c1865d.

Thyne, G.D., and Boles, J.R., 1989, Isotopic evidence for origin of the Moeraki septarian concretions, New Zealand: Journal of Sedimentary Research, v. 59, p. 272–279, doi: 10.1306/212f8f6c-2b24-11d7-8648000102c1865d.

Tong, J., Zhou, X., Erwin, D.H., Zuo, J., and Zhao, L., 2006, Fossil fishes from the Lower Triassic of Majiashan, Chaohu, Anhui Province, China: Journal of Paleontology, v. 80, p. 146–161, doi: 10.1666/0022-3360(2006)080[0146:ffftlt]2.0.co;2.

Vetoshkina, O., 2006, Siderite biomorphic structures in Jurassic sediments of the Nizhnyaya Vychegda Depression, northern Russian plate: Doklady Earth Sciences, v. 407, p. 236–240, doi: 10.1134/s1028334x06020188.

Waagé, K.M., 1964, Origin of repeated fossiliferous concretion layers in the Fox Hills Formation, *in* Merriam, D.F., ed., Symposium on cyclic sedimentation: Kansas Geological Survey, Bulletin 169, p. 541–563.

Waage, K.M., MacClintock, C., and Hickey, L.J., 2001, Post-glacial Fossils from Long Island Sound off West Haven, Connecticut: Postilla, Peabody Museum of Natural History, v. 225, p. 1–25.

Weeks, L.G., 1953, Environment and mode of origin and facies relationships of carbonate concretions in shales: Journal of Sedimentary Research, v. 23, p. 162-173.

Weeks, L.G., 1957, Origin of carbonate concretions in shales, Magdalena Valley, Colombia: Geological Society of America Bulletin, v. 68, p. 95–102, doi: 10.1130/0016-7606(1957)68[95:ooccis]2.0.co;2.

Wilby, P.R., Briggs, D.E.G., and Riou, B., 1996, Mineralization of soft-bodied invertebrates in a Jurassic metalliferous deposit: Geology, v. 24, p. 847–850, doi: 10.1130/0091-7613(1996)024<0847:mosbii>2.3.co;2.

Wilkinson, M., 1991, The concretions of the Bearreraig Sandstone Formation: geometry and geochemistry: Sedimentology, v. 38, p. 899–912, doi: 10.1111/j.1365-3091.1991.tb01878.x.

Wilkinson, M., 1993, Concretions of the Valtos Sandstone Formation of Skye: geochemical indicators of palaeo-hydrology: Journal of the Geological Society, v. 150, p. 57–66, doi: 10.1144/gsjgs.150.1.0057.

Wilson, D.D., and Brett, C.E., 2013, Concretions as sources of exceptional preservation, and decay as a source of concretions: Examples from the Middle Devonian of New York: PALAIOS, v. 28, p. 305–316.

WILSON, H.M., and ALMOND, J.E., 2001, New euthycarcinoids and an enigmatic arthropod from the British Coal Measures: Palaeontology, v. 44, p. 143–156, doi: 10.1111/1475-4983.00174.

WOODLAND, B.G., and STENSTROM, R.C., 1979, The occurrence and origin of siderite concretions in the Francis Creek shale (Pennsylvanian) of northeastern Illinois. In NITECKI, M.H. Mazon Creek fossils, papers presented at symposium, Ann Arbor, Michigan, May 1978, p. 69-103. Academic Press, New York.

ZATOŃ, M., and MARYNOWSKI, L., 2006, Ammonite fauna from uppermost Bajocian (Middle Jurassic) calcitic concretions from the Polish Jura—biogeographical and taphonomical implications: Geobios, v. 39, p. 426–442, doi: 10.1016/j.geobios.2005.02.001.

ZHU, M., BABCOCK, L.E., and STEINER, M., 2005, Fossilization modes in the Chengjiang Lagerstätte (Cambrian of China): testing the roles of organic preservation and diagenetic alteration in exceptional preservation: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 220, p. 31–46, doi: 10.1016/j.palaeo.2003.03.001.