

## Supplementary Data Set

Text  
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References

### Criteria used to infer primary mineralogy

The following criteria are used to infer the primary mineralogy of fossilized skeletons (shells, tests, sclerites, spicules, teeth, etc.) and abiotic precipitates (oids, marine synsedimentary cements):

- (1) Detection of original element concentrations either from fluid inclusions in precipitates or from skeletal material (magnesium – for low- or high-Mg calcite; strontium – for aragonite).
- (2) Preservation of specific skeletal fabrics either in calcite or in phosphate minerals' and silica replicas (e.g., foliated and prismatic microstructure – low Mg-calcite; microgranular microstructure – high-Mg calcite; nacreous and lamello-fibrillar microstructures – aragonite).
- (3) Relative quality of preservation of different precipitates in the same sample: fabric preserved – low-Mg calcite; fabric preserved and spar-filled molds with microdolomite – high-Mg calcite; coarse spar mosaic-filled molds, generally irregularly cross-cutting original structure – aragonite.
- (4) Epitaxial synsedimentary marine cements developing in optical continuity with skeletal elements (skeletons only): bladed equant calcite – low-Mg calcite; fibrous calcite – high Mg-calcite; botryoids of acicular crystals – aragonite.
- (5) Phylogenetic application of skeletal mineralogies in extant groups to their probable fossil relatives.
- (6) Relative stable isotope composition ( $\delta^{13}\text{C}$ ,  $\delta^{18}\text{O}$ ) of different precipitates in the same sample with less altered signatures characterizing low-Mg calcite fabrics.

Table 1. Inferred primary mineralogy of taxa listed on Figure 1 (Distribution of major skeletal taxa and carbonate abiotic precipitates (oids and synsedimentary marine cements) from the Upper Ediacaran to Middle Ordovician). FAD – first appearance datum: E – Upper Ediacaran, IND – lower Nemakit-Daldynian, uND – upper Nemakit-Daldynian, IT – lower Tommotian, mT – middle Tommotian, uT – upper Tommotian, IA – lower Atdabanian, uA – upper Atdabanian, B – Botoman, MC – Middle Cambrian (Cambrian Series 3), UC – Upper Cambrian (Furongian), LO – Lower Ordovician, MO – Middle Ordovician; A – aragonite, HMC – high Mg-calcite, LMC – low Mg-calcite, P – phosphate.

Taxon	FAD	Inferred mineralogy	Criteria	Comments and references
<i>Cloudina</i> -group	E	HMC	2-4	(S1-S3)
<i>Namapoikia</i>	E	A	3	(S4)
<i>Namacalathus</i> -gr.	E	HMC	2-4	(S3, S5)
<i>Sinotubilites</i>	E	A	2	(S6)
Chaetognatha	IND	P	2, 3	including protoconodonts (S7, S8); FAD (S9)
Anabaritida	IND	A	2, 3	(S10, S11); FAD (S9)
Orthothecimorpha	uND	A	2, 3	(S12, S13); FAD (S9)

Helcionelliformes	uND	A	2, 3	(S14-S18); FAD (S9)
Paragastropoda	uND	A	2, 3	(S14-S17); FAD (S9)~
Coelosclerophora	uND	A	2, 3	including chancelloriids (S16-S20); FAD (S9)
Renalcida	IND	HMC	2, 3	(S21), herein; FAD (S22)
Cambroclavida	IT	A		(S16, S23); FAD (S24)
Tommotiida	IT	P	2, 3	(S25); FAD (S9)
Linguliformea	IT	P	2, 5	(S26, S27); FAD (S9)
Hyolithelmintida	IT	P	2, 3	(S28, S29); FAD (S9)
Paracarinachitidae	IT	A	2, 3	(S30)
Conulariida	IT	P	2, 3	including hexangulaconulariids (S31, S32)
Rostroconchia	IT	A	2, 3	(S17, S33, S34); FAD (S9)
Bivalvia	IT	A	2, 3	(S14, S35-S37)
Archaeocyatha	IT	HMC	1-6	(S21, S38, S39), herein; FAD (S40)
Cribrycyatha	mT	HMC	2, 3	herein; FAD (S40)
Hyolithomorpha	IT	?		FAD (S40)
Coleoloida	IT	A	2, 3	(S41); FAD (S40)
Obbolellata	mT	HMC	2, 3, 5	(S42, S43)
Calcarea	mT	HMC	2, 3, 5	(S21, S44); FAD (S39)
Khasaktiidae	mT	HMC	1-4, 6	(S38, S45)
Radiocyatha	mT	A	3, 4	(S46); FAD (S40)
Tabulaconida	B	A	1-4, 6	modular species only (S44, S47, S48)
Mobergellidae	uT	P	2, 3	(S49); FAD (S40)
Hydroconozoa	uT	LMC	1-4, 6	(S38, S39, S50)
Stenothecoida	lA	LMC	2, 3	(S42); FAD (S40)
Trilobita	lA	LMC	1-4, 6	(S21, S51-S54); FAD (S40)
Agmata	B	LMC	2, 3	(S21); FAD (S55)
Ostracoda	LO	LMC	2, 3, 5	(S56, S57); FAD (S58)
Rhynchonellata	lA	LMC	2, 3, 5, 6	(S42, S59)
Kutorginata	uT	LMC	2, 3	not shown on Fig. 1 (S59)
Echinodermata	uA	HMC	1-5	(S21, S60); FAD (S40)
Palaeoscolecida	uA	P	2, 3	(S61-S63); FAD (S40)
Tannuolinidae	uA	P	2, 3	(S64); FAD (S24)
Byroniida	uA	P	2, 3	(S65); FAD (S16)
Tardypolipoda	uA	P	2, 3	<i>Microdyction</i> and other Cambrian sclerite-bearing lobopodians (S66); FAD (S40)
Conodontata	MC	P	2, 5	(S7)
Bryozoa	LO	LMC	2, 3, 5	(S67-S69); FAD (S70)
Stromatoporata	MO	LMC	2, 3	(S71); FAD (S72)
Tabulata	LO	LMC	2, 3	(S73); FAD (S74)
Rugosa	MO	LMC	2, 3	(S73); FAD (S74)
Cephalopoda	UC	HMC?	5	(S75-S77)
Polyplacophora	UC	HMC?	5	(S78, S79); FAD (S80)

Table 2. Inferred primary mineralogy of ooids indicated on Figure 1 (Distribution of major skeletal taxa and carbonate abiotic precipitates (ooids and synsedimentary marine cements) from the Upper Ediacaran to Middle Ordovician). E – Ediacaran, ND – Nemakit-Daldynian, T – Tommotian, 1A – lower Attabanian, uA – upper Attabanian, B – Botoman, Tn – Toyonian; A – aragonite, HMC – high Mg-calcite, LMC – low Mg-calcite.

<b>Formation; locality; paleocontinent</b>	<b>Age</b>	<b>Inferred mineralogy</b>	<b>Criteria</b>	<b>Comments and references</b>
Biri Formation; Norway; Baltica	E	A	3	(S81)
Islay Limestone, Kingston Peak Formation; Scotland, UK; Avalonia	E	A	3	(S82)
Virgin Spring Limestone; California, USA; Laurentia	E	A	3	(S83)
Trezena Formation; South Australia; Eastern Gondwana	E	A	3	(S84)
Wonoka Formation; South Australia; Eastern Gondwana	E	A	3	(S82)
Série Lie de Vin; Anti-Atlas, Morocco; Western Gondwana	T	A, HMC	3	(S82); age (S85)
Parachilna Formation; South Australia; Eastern Gondwana	T	A, HMC	3	(S82)
Lower Wilkawillina Limestone; South Australia; Eastern Gondwana	1A	LMC	3	(S82)
lower Churan Member, Pestrotsvet Formation; southern Yakutia, Russia; Siberia	1A	LMC	3	(S86)
upper Churan Member, Pestrotsvet Formation; southern Yakutia, Russia; Siberia	uA	HMC	3	(S86)
Salaany Gol Formation; western Mongolia; Zavkhan terrane	A	A, HMC	3	(S46)
Amouslek Formation; Anti-Atlas, Morocco; Western Gondwana	uA	A	3	(S82); age (S87)
upper Wood Canyon Formation; California, USA; Laurentia	uA-B	HMC/A(?)	3	(S88)

unnamed formation; Ellsworth Mountains, West Antarctica; Eastern Gondwana	B	A	3	(S89); age (S90)
erratics; South Shetland Islands, Antarctica; Eastern Gondwana	B	A	3	(S90)
Punta Manna Member; Nebida Formation; Sardinia, Italy; Western Gondwana	B	A	3	(S91)
Mural Limestone; British Columbia, Canada; Laurentia	B	HMC	3	(S92); age (S93)
Forteau Formation; Labrador-Newfoundland, Canada; Laurentia	B	A, HMC	3	(S21); age (S93)
Shady Dolomite; Virginia, USA; Laurentia	B	HMC	3	(S94); age (S95)
Lastours Formation; Montagne Noire, France; Western Gondwana	B	HMC	3	(S96)
Burj Formation; Jordan; Western Gondwana	Tn	HMC	3	(S97)
Ledger Formation; Pennsylvania, USA; Laurentia	Tn?	HMC	3	(S98)
Port au Port Group; Newfoundland, Canada; Laurentia	MC- UC	HMC, A, LMC	3, 4	LMC ooids were not indicated in (S99) but some of them show optical continuity with nuclei of trilobite fragments

Table 3. Inferred primary mineralogy of synsedimentary marine cements indicated on Figure 1 (Distribution of major skeletal taxa and carbonate abiotic precipitates (ooids and synsedimentary marine cements) from the Upper Ediacaran to Middle Ordovician). E – Ediacaran, ND – Nemakit-Daldynian, T – Tommotian, A – Atdabanian, uA – upper Atdabanian, B – Botoman, MC – Middle Cambrian (Cambrian Series 3), UC – Upper Cambrian (Furongian), UO – Upper Ordovician; A – aragonite, HMC – high Mg-calcite, LMC – low Mg-calcite.

<b>Formation; locality; paleocontinent</b>	<b>Age</b>	<b>Inferred mineralogy</b>	<b>Criteria</b>	<b>Comments and references</b>
Biri Formation; Norway; Baltica	E	A	3	(S81)
Islay Limestone, Kingston Peak Formation; Scotland, UK; Avalonia	E	A	3	(S82)
Virgin Spring Limestone; California, USA; Laurentia	E	A	3	(S83)
Trezena Formation; South	E	A	3	(S84)

Australia; Eastern Gondwana				
Wonoka Formation; South Australia; Eastern Gondwana	E	A	3	(S82)
Série Lie de Vin; Anti-Atlas, Morocco; Western Gondwana	T	A	3	(S82); age (S85)
Parachilna Formation; South Australia; Eastern Gondwana	T	A	3	(S82)
Isit' Member, Pestrotsvet Formation; southern Yakutia, Russia; Siberia	T	HMC	3	(S39)
Negyurchene Biohermal and Oy-Muran Reef massives; southern Yakutia, Russia; Siberia	A	A	3	aragonite botryoids are cited as calcified alga <i>Zaganolomia</i> in (S100)
Salaany Gol Formation; western Mongolia; Zavkhan terrane	A	A, HMC	3	(S46)
Amouslek Formation; Anti-Atlas, Morocco; Western Gondwana	uA	A	3	(S82); age (S87)
Upper Wilkawillina Limestone; South Australia; Eastern Gondwana	uA	A, HMC	1, 3	(S101)
Mural Limestone; British Columbia, Canada; Laurentia	B	A, HMC	3	(S102); age (S93)
Sekwi Formation; Yukon Territory, Canada; Laurentia	B	A, HMC	3	(S103); age (S93)
Forteau Formation; Labrador-Newfoundland, Canada; Laurentia	B	A, HMC	3	(S21); age (S95)
March Point Formation; Newfoundland, Canada; Laurentia	MC	A	3	(S104)
Mila Formation; Iran; Western Gondwana	UC	LMC	3	(S105)
Wilberns Formation; Texas, USA; Laurentia	UC	LMC	1, 3	(S106)
Effna Formation; Virginia, USA; Laurentia	UO	LMC	3, 6	(S107)

Table 4. Stratigraphic distribution and location of carbonate flat-pebble conglomerates in Cambrian and Lower Ordovician. B – Botoman, Tn – Toyonian, LMC – lower Middle Cambrian (Cambrian Series 3), uMC – upper Middle Cambrian (Cambrian Series 3), UC – Upper Cambrian (Furongian), LO – Lower Ordovician.

Formation; locality; paleocontinent	Age	Comments and references
Sellick Hill Formation; South Australia; Eastern Gondwana	B	(S108); age (S109)
Agaleva Formation; Krasnoyarsk Region, Russia;	B	cited as calcareous

Siberia		breccia in ( <i>S110</i> )
Barylay Formation; Yakutia, Russia; Siberia	Tn	AZ, pers. Observation
Zaledeevo Formation; Krasnoyarsk Region, Russia; Siberia	IMC	cited as calcareous breccia in ( <i>S110</i> )
Litvintsevo Formation; Krasnoyarsk Region, Russia; Siberia	IMC	cited as calcareous breccia in ( <i>S110</i> )
Dereskir Formation; Yakutia, Russia; Siberia	IMC	cited as calcareous breccia in ( <i>S110</i> )
Elanskoe Formation; Yakutia, Russia; Siberia	IMC	cited as calcareous breccia in ( <i>S110</i> )
Zonda Formation; Argentine Precordillera; Occidentalia terrane	MC	( <i>S111</i> )
La Laja Formation; Argentine Precordillera; Occidentalia terrane	MC	( <i>S112</i> )
Jubilee Formation; British Columbia, Canada; Laurentia	MC	( <i>S113</i> )
upper Wheeler Formation; Utah, USA; Laurentia	MC	( <i>S114</i> )
Marjum Formation; Utah, USA; Laurentia	MC	( <i>S114</i> )
Tangha Formation; Yakutia, Russia; Siberia	uMC	cited as calcareous breccia in ( <i>S110</i> )
Ust'botoma Formation; Yakutia, Russia; Siberia	uMC	cited as calcareous breccia in ( <i>S110</i> )
Ust'brus Formation; Krasnoyarsk Region, Russia; Siberia	uMC	cited as calcareous breccia in ( <i>S110</i> )
Labazny Formation; Krasnoyarsk Region, Russia; Siberia	uMC	cited as calcareous breccia in ( <i>S110</i> )
North China; Eastern Gondwana	MC-UC	( <i>S115</i> )
Mila Formation; Iran; Western Gondwana	UC	( <i>S105</i> )
Port au Port Group; Newfoundland, Canada; Laurentia	MC-UC	( <i>S116</i> )
Whipple Cave Formation; Nevada, USA; Laurentia	UC	( <i>S117</i> )
Shingle Limestone; Nevada, USA; Laurentia	UC	( <i>S118</i> )
Maynardville Limestone, Conasauga Group; Tennessee, USA; Laurentia	UC	( <i>S119</i> )
Survey Peak Formation; Alberta, Canada; Laurentia	UC	( <i>S120</i> )
Nolichucky Formation; Virginia, USA; Laurentia	UC	( <i>S121</i> )
Morgan Creek Limestone, Wilberns Formation; Texas, USA; Laurentia	UC	( <i>S122</i> )
Dotsero Formation; Colorado, USA; Laurentia	UC	( <i>S123</i> )
Snowy Range Formation (=Galatin Formation); Wyoming-Montana, USA; Laurentia	UC	( <i>S124</i> )
Deadwood Formation; Dacota, USA; Laurentia	UC	( <i>S125</i> )
Pilgrim Formation; Wyoming-Montana, USA; Laurentia	UC	( <i>S126</i> ); age ( <i>S127</i> )
Bison Creek Formation; Alberta, Canada; Laurentia	UC	( <i>S128</i> )
Waterflow Formation; Alberta, Canada; Laurentia	UC	( <i>S129</i> )
Nopah Formation; California, USA; Laurentia	UC	( <i>S130</i> )
Conococheague Limestone; Maryland, USA;	UC	( <i>S130</i> )

Laurentia		
Machinchang Formation; Malaysia; Eastern Gondwana	UC	(S131)
Fenshan Formation; Jilin, China; Eastern Gondwana	UC	(S132)
Shabakty Formation; southern Kazakhstan; Kazakhstan	UC	(S133)
Mort Member, Ninmaroo Formation; Queensland, Australia; Eastern Gondwana	UC	(S134)
Arrinthunga Formation; Northern Territory, Australia; Eastern Gondwana	UC	(S135)
Chopko Formation; Krasnoyarsk Region, Russia; Siberia	UC	(S136)
Chukuka Formation; Yakutia, Russia; Siberia	UC	cited as calcareous breccia in (S110)
Eyra Formation; Yakutia, Russia; Siberia	UC	cited as calcareous breccia in (S110)
Diringde Reef Massif; Yakutia, Russia; Siberia	UC	cited as calcareous breccia in (S110)
Orakta Formation; Krasnoyarsk Region, Russia; Siberia	UC	cited as calcareous breccia in (S110)
Kulyumbe Formation; Krasnoyarsk Region, Russia; Siberia	UC	cited as calcareous breccia in (S110)
Oldondo Formation; Yakutia, Russia; Siberia	LO	(S110)
Fillmore Formation; Utah, USA; Laurentia	LO	(S137)
House Limestone; Nevada, USA; Laurentia	LO	(S117)
St George Group; Newfoundland, Canada; Laurentia	LO	(S138)
Wahwah Limestone; Utah, USA; Laurentia	LO	(S118)
Volkhov Stage; Leningrad Region, Russia; Baltica	LO	(S139)
Dumugol Formation; South Korea; Eastern Gondwana	LO	(S140)
Mungok Formation; South Korea; Eastern Gondwana	LO	(S141)

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