

**Supplemental Table DR1.** Selected case studies documenting recurrent ichnofaunas recording the activity of epifaunal and shallow-tier infaunal organisms in matgrounds in the absence of a well-developed mixed layer.

Age	Stratigraphic unit and location	Trace-fossil composition	Architectural designs	Depositional environment	References
Ediacaran	Gametrail Formation (western Canada)	<i>Helminthoidichnites tenuis</i>	Simple horizontal trails	Continental slope	MacNaughton et al. (2000)
Ediacaran	Blueflower Formation (western Canada)	<i>Archaeonassa fossulata</i> , <i>Helminthoidichnites tenuis</i> , <i>Helminthopsis hieroglyphica</i> , <i>Helminthopsis?</i> isp., <i>Palaeophycus tubularis</i> , <i>Planolites montanus</i> , <i>Torrowangea rosei</i>	Simple horizontal trails, Passively filled horizontal burrows, Actively filled (massive) horizontal burrows, Smooth bilobate trails and burrows	Continental slope	Narbonne & Hofmann (1987); Narbonne & Aitken (1990); MacNaughton et al. (2000)
Ediacaran	Upper Miette (western Canada)	<i>Archaeonassa</i> isp., <i>Cochlichnus</i> isp., <i>Helminthoidichnites tenuis</i> , <i>Helminthopsis abeli</i> , <i>Helminthopsis</i> isp., <i>Palaeophycus</i> isp.	Simple horizontal trails, Passively filled horizontal burrows	Relatively deep marine	Young (1972); Hofmann & Mountjoy (2010)
Ediacaran	Wyman Formation (western United States)	<i>Helminthoidichnites tenuis</i>	Simple horizontal trails	Subtidal	Corsetti & Hagadorn (2003)
Ediacaran	Hoedberg Formation (South Africa)	<i>Helminthoidichnites tenuis</i>	Simple horizontal trails	Offshore	Buatois et al. (2007); Almond et al. (2008)
Ediacaran	Dabis and Zaris formations (Namibia)	<i>Helminthoidichnites tenuis</i>	Simple horizontal trails	Nearshore to offshore	Jensen & Runnegar (2005)
Ediacaran	Vingerbreek Member, Nudauas Formation (Namibia)	<i>Archaeonassa</i> isp., <i>Helminthoidichnites tenuis</i>	Simple horizontal trails	Nearshore to offshore	Jensen & Runnegar (2005)

Ediacaran	Shibantan Member, Dengying Formation (Yangtze Platform, China)	<i>Helminthoidichnites tenuis</i> , <i>Palaeophycus</i> isp., <i>Torrowangea rosei</i>	Simple horizontal trails, Passively filled horizontal burrows, Actively filled (massive) horizontal burrows	Offshore	Weber et al. (2007)
Ediacaran	Coomb Volcanic Formation (Wales)	<i>Helminthopsis</i> isp.	Simple horizontal trails	Shallow-marine volcanoclastic	Cope (1977, 1983); Cope & Bevins (1993)
Ediacaran	Kanilov Formation (Ukraine)	<i>Helminthoidichnites tenuis</i>	Simple horizontal trails	Nearshore to offshore	Palij et al. (1974, 1979, 1983)
Ediacaran	Brzegi Shale Formation (southern Poland)	<i>Helminthoidichnites tenuis</i>	Simple horizontal trails	Nearshore to offshore	Kowalski (1986)
Ediacaran	Lublin Formation (southeastern Poland)	<i>Helminthopsis</i> isp., <i>Palaeophycus</i> isp., <i>Torrowangea rosei</i> , <i>Torrowangea</i> isp.	Simple horizontal trails, Passively filled horizontal burrows, Actively filled (massive) horizontal burrows	Tidal flats to shelf	Pacześna (1985, 1986, 1996)
Ediacaran	Ediacara Member, Rawnsley Quartzite (southern Australia)	<i>Archaeonassa fossulata</i> , <i>Gordia marina</i> , <i>Helminthoidichnites tenuis</i> , <i>Helminthopsis tenuis</i> , <i>Radulichnus</i> isp., Dickinsoniid resting traces	Simple horizontal trails, Oval-shaped impressions	Shoreface to upper offshore	Glaessner (1969); Jenkins (1995); Gehling (1999, 2000); Seilacher et al. (2005); Droser et al. (1999, 2005)
Cambrian	Lake Oesa Member, St. Piran Formation, Gog Group (western Canada)	<i>Diplichnites</i> isp., <i>Dimorphichnus</i> isp., <i>Helminthoidichnites</i> isp., <i>Helminthopsis</i> isp., <i>Rusophycus carbonarius</i>	Actively filled (massive) horizontal burrows, Trackways and scratch marks, Scratched bilobate trails and burrows	Sand, mixed and mud flat	Desjardins et al. (2010)
Cambrian	Puncovisana Formation (Northwest)	<i>Circulichnus montanus</i> , <i>Cochlichnus</i>	Simple horizontal trails, Passively filled	Deep-marine turbidite system	Buatois & Mángano (2003)

	Argentina)	<i>anguineus</i> , <i>Didymaulichnus lyelli</i> , <i>Diplichnites</i> isp., <i>Helminthoidichnites tenuis</i> , <i>Helminthopsis abeli</i> , <i>Helminthopsis tenuis</i> , <i>Oldhamia antiqua</i> , <i>Oldhamia curvata</i> , <i>Oldhamia flabellata</i> , <i>Oldhamia radiata</i> , <i>Palaeophycus tubularis</i>	horizontal burrows, Circular trails, Surface-coverage branching burrows, Trackways and scratch marks, Smooth bilobate trails and burrows		
Cambrian	Puncovisana Formation (Northwest Argentina)	<i>Archaeonassa fossulata</i> , <i>Asaphoidichnus trifidus</i> , <i>Cochlichnus anguineus</i> , <i>Diplichnites</i> isp., <i>Helminthopsis tenuis</i> , <i>Helminthoidichnites tenuis</i> , <i>Multina</i> isp., <i>Oldhamia alata</i> , <i>Oldhamia geniculata</i> , <i>Palaeophycus tubularis</i> , <i>Pilichnus cf. dichotomus</i> , <i>Psammichnites saltensis</i> , <i>Tasmanadia cachii</i> , <i>Treptichnus pollardi</i> , <i>Volkichnium volki</i>	Simple horizontal trails, Passively filled horizontal burrows, Galleries, Horizontal to oblique branching burrows, Surface-coverage branching burrows, Radial branching structures, Trackways and scratch marks, Meniscate bilobate trails	Lower offshore to offshore transition	Buatois & Mángano (2004)
Cambrian	Ingtá Formation, Simple Sequence 5 (western Canada)	<i>Cochlichnus anguineus</i> , <i>Diplopodichnus biformis</i> , <i>Helminthoidichnites tenuis</i> , <i>Planolites montanus</i> , <i>Saerichnites</i> isp., <i>Treptichnus coronatum</i> , <i>Treptichnus pedum</i>	Simple horizontal trails, Actively filled (massive) horizontal burrows, Horizontal to oblique branching burrows, Smooth bilobate trails and burrows	Lower shoreface to lower offshore	MacNaughton & Narbonne (1999)
Cambrian	Blow Me Down Brook Formation (eastern Canada)	<i>Gordia marina</i> , <i>Oldhamia antiqua</i> , <i>Oldhamia curvata</i> , <i>Oldhamia radiata</i> , <i>Palaeophycus</i> isp	Surface-coverage branching burrows, Simple horizontal trails, Passively filled horizontal burrows	Deep-marine turbidite system	Lindholm & Casey (1989, 1990)
Cambrian	Besonderheid Formation (South Africa)	<i>Oldhamia geniculata</i>	Surface-coverage branching burrows	Shelf to distal prodelta	Seilacher et al. (2005); Buatois et al.

					(2007); Almond et al. (2008)
Cambrian	Upper Phosphate unit, Zhongyicun Member, Zhijiaqing Formation (Yangtze Platform, China)	<i>Didymaulichnus miettensis</i> , <i>Didymaulichnus</i> isp., <i>Radulichnus</i> isp., <i>Rusophycus avalonensis</i> , <i>Rusophycus</i> isp.	Radular marks, Scratched bilobate trails and burrows, Smooth bilobate trails and burrows	Subtidal to intertidal	Jiang et al. (1982); Crimes & Jiang (1986); Li & Yang (1988); Luo et al. (1994); Li et al. (1997); Zhu (1997); Dornbos et al. (2004); Weber et al. (2007)
Carboniferous	Tonganoxie Sandstone (Kansas, central United States)	<i>Dendroidichnites irregulare</i> , <i>Diplichnites gouldi</i> , <i>Diplopodichnus biformis</i> , <i>Kouphichnium</i> isp., <i>Mirandaichnium famatinense</i> , <i>Stiaria intermedia</i> , <i>Tonganoxichnus buildexensis</i> , <i>Stiallia pilosa</i> , <i>Tonganoxichnus ottawensis</i> , <i>Gordia indianaensis</i> , <i>Helminthoidichnites tenuis</i> , <i>Helminthopsis hieroglyphica</i> , <i>Circulichnus montanus</i> , <i>Treptichnus bifurcus</i> , <i>Treptichnus pollardi</i>	Simple horizontal trails, Circular trails, Horizontal to oblique branching burrows, Trackways and scratch marks, Smooth bilobate trails and burrows	Fluvio-estuarine tidal flats	Buatois et al. (1997, 1998); Mángano et al. (1997)
Carboniferous	Mansfield Formation (Indiana, central-east United States)	<i>Cochlichnus anguineus</i> , <i>Gordia indianaensis</i> , <i>Maculichnina</i> isp., <i>Palaeophycus</i> isp., <i>Pterichnus tardigradus</i> , <i>Tonganoxichnus buildexensis</i> , <i>Treptichnus bifurcus</i> , <i>Umfolozia</i> isp.	Simple horizontal trails, Passively filled horizontal burrows, Horizontal to oblique branching burrows, Trackways and scratch marks	Fluvio-estuarine tidal flats	Archer and Maples (1984); Mángano et al. (2001)
Carboniferous	Keota Sandstone Member, McAlester Formation (Oklahoma, south-central	cf. <i>Cochluchnus</i> isp., <i>Diplichnites gouldi</i> , <i>Diplopodichnus biformis</i> , <i>Gordia marina</i> , <i>Paleohelcura tridactyla</i> , <i>Tonganoxichnus</i>	Simple horizontal trails, Horizontal to oblique branching burrows, Trackways and	Fluvio-estuarine tidal flats	Lucas et al. (2004)

	United States)	<i>buildensis</i> , <i>Treptichnus bifurcus</i>	scratch marks, Smooth bilobate trails and burrows		
Carboniferous	Pottsville Formation (Alabama, southern United States)	<i>Arborichnus repetitia</i> , <i>Cochlichnus</i> isp., <i>Diplichnites gouldi</i> , <i>Kouphichnium</i> isp., <i>Palaeophycus</i> isp., <i>Selenichnites</i> isp., <i>Treptichnus bifurcus</i>	Simple horizontal trails, Horizontal to oblique branching burrows, Trackways and scratch marks	Fluvio- estuarine tidal flats	Rindsberg (1990); Lucas and Lerner (2005); Buta et al. (2005)
Permian	Mafra Formation, Itarare Group (southern Brazil)	<i>Diplichnites gouldi</i> , <i>Diplopodichnus biformis</i>	Trackways and scratch marks, Smooth bilobate trails and burrows	Glacial lake	Balistieri et al., (2002, 2003); Netto et al. (2009)

Examples include deposits from Ediacaran-Cambrian shallow- to deep-marine environments, Carboniferous fluvioestuarine environments, and Permian glacial lakes. Original ichnotaxonomic assignments have been checked and reassessed for each case. Only invertebrate trace fossils are mentioned. Architectural designs refer to basic morphologic types. Degree of bioturbation is 0 in almost all cases, and structures indicative of the presence of microbial mats are common. Many case studies of recurrent ichnofaunas dominated by trilobite trace fossils with well-preserved scratch marks may be used to compile a separate list, revealing the nature of firm substrates close to or at the sediment surface in Cambrian-Ordovician deposits (see Droser et al., 2004 for a summary). Similar conditions in the Early Triassic are illustrated by shallow-marine ichnofaunas in the Montney (Zonneveld et al., 2010) and Toad (MacNaughton and Zonneveld, 2010) formations of western Canada.