**The palaeolatitudinal distribution of the Ediacaran macrobiota**

***Supplementary Information***

**Methods**

In compiling our dataset, we took several decisions to ensure effective comparison of taxa and morphogroups, and their relationship to palaeolatitude over geological time, as detailed below.

***Selection of time-bins***

We opted to use time-bins of regular intervals through the late Ediacaran to avoid imposing the widely cited tripartite Avalon-White Sea-Nama division of biotic assemblages onto the dataset because of the temporal overlap they have. Time-bins also permitted standardisation of the data, since there was wide variation in error bars surrounding available radiometric dates (see Supp. File 2). 10 Myr intervals were chosen since grouping at a coarser scale would reduce resolution of patterns in the data, while many sites are insufficiently well-dated to permit examination of the data at a finer scale. We treated fossils in the >581 Ma and 580–571 Ma time-bins separately, but we have plotted them together on the maps in the manuscript both because there are few sites in these time-bins, and because most >581 Ma sites have poor age constraints.

Where possible, we used age constraints with error bars of <5 Myrs to date fossil-bearing portions of the stratigraphy (favouring U-Pb ages obtained from zircons), ensuring that our dating errors are smaller than the time-bins. We then used the stated date to calibrate our dataset (e.g. for a date of 571±3.5 Myrs, we took the age of the dated horizon to be 571 Ma, with beds above that horizon considered to be <571 Ma, and those below >571 Ma). For sites without radiometric dating constraints (e.g. the Ediacara Member of the Rawnsley Quartzite in South Australia), we followed accepted practice in the literature (in that case, the suggestion that the Ediacara Member is of a similar age to the White Sea biota of Russia, putting the site within the 560–551 Ma time-bin).

***Selection of taxa***

We only considered macroscopic taxa of Ediacaran age, to enable direct comparison with previous work. Microfossil taxa (including for example *Protolagena, Ramatubulus* and *Yangtzitubus*, Liu et al., 2008; *Waltheria, Titanotheca* and *Soldadotubulus*, Gaucher & Sprechmann, 1999; and Doushantuo microfossils), and microbial mat fabrics/impressions, were not included because they were not the focus of this study. Data from new publications were not added to the database after March 2021.

Simple discoidal fossils (such as *Aspidella, Beltanella, Eoporpita, Hiemalora* and *Inaria*) were excluded, since they have either been confirmed as, or are suspected to be, the holdfast structures of frondose taxa or microbial colonies, rather than being discrete organisms (Gehling et al., 2000; Grazhdankin and Gerdes, 2007; Serezhnikova, 2013; Burzynski et al., 2017). Impressions widely interpreted as trace fossils (such as *Epibaion*; Ivantsov, 2013) or taphomorphs (such as *Ivesheadia* and other Ivesheadiomorphs; Liu et al., 2011), were also excluded (though see *Trace Fossils* below).

We compiled a list of all previously described Ediacaran taxa fulfilling these criteria, and their location data, via a comprehensive literature review. We considered taxa at a generic level (as opposed to species) to minimise biases that may be introduced by the over-splitting of taxa, and for consistency with previous data compilations. Visual assessment of figured holotype specimens was used to exclude a small number of dubiofossils from consideration (such as *Elasenia, Papillionata* and *Vendella*). We have followed published synonymisation of taxa wherever possible (this includes suggested synonymisation proposed in the *Atlas of Ediacaran macrofossil taxa* in Fedonkin et al., 2007). The full list of taxa included in our study, and their assignment to various morphogroups and ‘Types’, is presented in the accompanying Supplementary File 2. Below we highlight a few key groupings, explaining our rationale for presenting them in this way, and stating the taxa they comprise.

***Classification of taxa***

*Morphogroups*

To assess potential patterns in the palaeolatitudinal distribution of taxa, we followed previous authors in considering taxa to belong within established ‘morphogroups’ (see Erwin et al., 2011; Laflamme et al., 2013; Grazhdankin, 2014). These morphogroups group taxa of a similar grade, although some may reflect clades (Dececchi et al., 2017). Erwin et al. (2011) divided the Ediacaran macrobiota into Rangeomorpha, Erniettomorpha, Dickinsoniomorpha, Arboreomorpha, Triradialomorpha, Kimberellamorpha, Bilateralomorpha, Tetraradialomorpha, Pentaradialomorpha, Sponges and Valid Problematica. Grazhdankin (2014) alternatively split the biota into eight taxonomic groups, which were then grouped into three major clades: Vendobionta (Rangeomorphs, Dickinsoniomorphs, Petalonamae and Palaeopascichnids), Frondomorpha, and Eumetazoa (Tribrachiomorphs, Bilateralomorphs and Psammocorals). There is considerable overlap between some of the groups in these two schemes, but there are also important differences, with some rare morphotypes not included in the latter scheme.

We here follow the Erwin et al. (2011) classification scheme because it encompasses a greater range of taxa and makes fewer assumptions about phylogenetic relationships between groups. In addition to the Erwin et al. (2011) morphogroups, we have added Tubular, Algal, Protist, Complex discoidal (for non-holdfast discoidal taxa that do not fall into other groups, e.g. *Eoandromeda*, *Hallidaya*, *Kuckaraukia*, *Persimedusites* and *Suvorovella*), and Cnidarian groups, to which taxa were assigned on the basis of either their gross morphology, or their interpretation in the published literature. Taxa that could not be assigned to any of these morphogroups were assigned to a Miscellaneous group. The morphogroups considered in this study are therefore:

* Algae
* Arboreomorpha
* Bilateralomorpha
* Cnidarians
* Dickinsoniomorpha
* Complex discoidal
* Erniettomorpha
* Kimberellamorpha
* Miscellaneous
* Pentaradialomorpha
* Protists
* Rangeomorpha
* Sponges
* Tetraradialomorpha
* Triradialomorpha
* Tubular

We note that our inclusion of a taxon within a pre-existing morphogroup with a phylogenetically informative name (e.g. ‘Sponges’), in line with previous compilations, does not necessarily mean that we consider the evidence in support of that designation to be conclusive. We also note that here, and for the ‘Types’ below, the terminology we use encompasses a mixture of morphological, phylogenetic, and ecological groupings. Given the current state of Ediacaran palaeobiological understanding, whereby the field has more confidence in the phylogenetic placement of some taxa than others, this is unfortunately unavoidable. In seeking to track evolutionary patterns through time, we would ideally prefer to assess phylogenetic groupings of taxa. However, as so few taxa can be confidently assigned to such groupings at present, we feel using morphological groupings is currently the best available approach.

*Problematic taxa*

Several genera are subject to ongoing debate regarding their morphological characters or the morphogroup to which they belong. These taxa require further study and possible future revision of the groupings to which they are assigned here, and include:

* *Attenborites (Miscellaneous*). Droser et al. (2020) suggest that this inferred pelagic organism could have been related to ctenophores, cnidarians, or something else. Given this uncertainty, even though a metazoan affinity is considered likely, we place it within the Miscellaneous grouping here.
* *Gibbavasis (Miscellaneous).* Exhibiting distinct pore-shaped depressions within a seemingly rigid framework, *Gibbavasis* has been considered a poriferan-grade organism capable of filter feeding (Vaziri et al., 2018). However, spicules are absent (as for all proposed late Ediacaran sponges), and therefore secure interpretation of *Gibbavasis* as a sponge is not possible. We have therefore grouped it within the Miscellaneous group.
* *Nenoxites (Tubular).* *Nenoxites* has been considered as a trace fossil (Seilacher et al., 2005; Rogov et al., 2012), and alternatively as a tubular body fossil (Brasier et al., 2013; Ivantsov, 2018; Luo and Miao, 2020). This study follows the most recent interpretation of the genus as a tubular body fossil, but we recognise that this discussion is far from resolved.
* *Podolimirus (Dickinsoniomorpha).* Most specimens of *Podolimirus* are fragmentary, apart from those presented in Dzik and Martyshyn (2015). Although rare, this taxon has been included in the dataset as a valid body fossil within the Dickinsoniomorpha group.

*Types*

In order to investigate broad trends within the data, and to undertake statistical tests with sufficient sample numbers, the taxa were grouped into eight ‘Types’, as detailed in Supplementary Table 1. Bilateral Type fossils are those with bilateral symmetry, which we consider to be the most likely candidates for true bilaterian taxa. Radial Type fossils include all forms of radial symmetry. Frondomorph Type fossils include all frondose organisms (here incorporating Rangeomorphs and Arboreomorphs, rather than following the use of this term by Grazhdankin, 2014). Note that despite some Erniettomorphs (e.g. *Swartpuntia*) being ‘frondose’, we have not included Erniettomorph taxa within the Frondomorph Type, since not all of them bear a frondose gross morphology. Aside from the Algal and Protist Types, our groupings here largely reflect morphological groups. The Bilateral group is the only other grouping here that could potentially have phylogenetic weight, but we cannot exclude the possibility that some taxa in our Tubular Type may also ultimately be recognised as bilaterian metazoans (e.g. *Cloudina* as interpreted by Schiffbauer et al., 2020; Yang et al., 2020).

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| **Types** | **Morphogroups included** |
| Algal | Algae |
| Bilateral | Bilateralomorpha; Dickinsoniomorpha; Kimberellamorpha |
| Radial | Complex discoidal; Pentaradialomorpha; Tetraradialomorpha; Triradialomorpha |
| Frondomorph | Arboreomorpha; Rangeomorpha |
| Erniettomorph | Erniettomorpha |
| Protist | Protists |
| Tubular | Tubular |
| Miscellaneous | Miscellaneous; Cnidarians; Sponges |

**Supplementary Table 1:** The morphogroups included in each Type grouping.

There is much debate within the literature over the morphology and phylogenetic placement of *Dickinsonia*. Sprigg (1947) originally described it as possibly a cnidarian or a worm. Since then, further studies have produced multiple competing *Dickinsonia* interpretations, with recent work largely converging on it being bilaterian (Gold et al., 2015; Evans et al., 2017), placozoan (Sperling and Vinther, 2010), or a member of the Proarticulata (Ivantsov et al., 2020). Much of this debate surrounds the question of whether *Dickinsonia* originally possessed bilateral symmetry (as observed in many South Australian specimens of *D. costata* for example), or a glide plane of symmetry (e.g. Ivantsov et al., 2020). Other dickinsoniomorph taxa clearly show a glide plane that is unlikely to be taphonomic in origin (e.g. *Yorgia* and *Andiva*), but such a symmetry state is not necessarily incompatible with a bilaterian affinity. Although there remains debate regarding the composition of the Dickinsoniomorpha group (e.g. Dunn et al., 2018), assuming that this morphogroup is robust, and that *Dickinsonia costata* is a representative taxon for the group (we appreciate that this assumption is also contentious), we follow Gold et al. (2015) in considering *Dickinsonia*, and therefore Dickinsoniomorphs, within our Bilateral Type.

*Biomineralising taxa*

Taxa are grouped by body composition as being: CaCO3 biomineralised; SiO2 biomineralised; organic template; agglutinated; or soft-bodied, following Selly et al. (2020). Biomineralised taxa are thought to have possessed a biomineralised (calcium carbonate, calcium phosphate, or silica) hard shell or external structures. ‘Organic template’ taxa are inferred to have possessed non-mineralised walls made of organic biomolecules (e.g. collagen) that provided some degree of external structural integrity. Taxa assigned to the biomineralised, organic template and agglutinated groupings are listed in Supplementary Table 2, alongside all soft-bodied tubes (see Figure 5).

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| **Group** | **Taxa included** |
| Complex discoidal, CaCO3 biomineralised | *Suvorovella* |
| Bilateralomorpha, CaCO3 biomineralised | *Namacalathus* |
| Tubular, CaCO3 biomineralised | *Cambrotubulus, Cloudina, Multiconotubus, Sinotubulites* |
| Tubular, SiO­2 biomineralised | *Anulitubus, Coniculus, Fistula* |
| Cnidarian, organic template | *Paraconularia* |
| Tubular, organic template | *Conotubus, Convolutubus, Corumbella, Costatubus, Gaojiashania, Saarina, Shaanxilithes, Zuunia* |
| Sponges, organic template | *Coronacollina* |
| Protist, agglutinated | *Orbisiana, Palaeopascichnus* |
| Tubular, agglutinated | *Archaeichnium* |
| Tubular, soft bodied | *Annulatubus, Aulozoon, Calyptrina, Funisia, Nenoxites, Plexus, Protoconites, Sabellidites, Sekwitubulus, Sinospongia, Somatohelix, Wutubus* |

**Supplementary Table 2:** All genera categorised into biomineralised (CaCO3 or SiO2), organic template, or soft-bodied tubular groupings.

There has been recent debate over whether *Cloudina* was originally biomineralised, or whether it instead possessed an organic template (Yang et al., 2020). We have followed the classic biomineralised interpretation here. Meanwhile, *Namapoikia* has recently been re-interpreted as a microbial structure (Mehra et al., 2020) rather than a sponge (Wood et al., 2002), and in light of this new data *Namapoikia* is excluded from our analysis. There is also debate over whether *Suvorovella* and *Coronacollina* had organic or biomineralised skeletons. We have followed the biomineralised interpretation discussed in Wood et al. (2017) for *Suvorovella*. The original description of *Coronacollina* leaves open both possibilities, and we have assigned it to the organic template group here, on the basis that primary biominerals have not yet been observed (Clites et al., 2012).

*Trace fossils*

Perhaps the most compelling evidence for late Ediacaran bilaterian metazoans comes from trace fossils, and so we have incorporated the latitudinal distribution of reported bilaterian ichnotaxa into our analysis. Since we cannot be sure whether the full spectrum of ichnodiversity was created by one taxon or many, we have taken a conservative approach of simply grouping multiple ichnotaxa as one data point, with bilaterian trace fossils being either present (regardless of the number of ichnogenera) or absent at each body fossil locality within a given time-bin. Ichnogenera commonly considered to record the activity of bilaterians included within this study include *Helminthoidichnites*, *Archaeonassa*, and *Lamonte* (see also Jensen et al., 2006). Metazoan trace fossils from the ~565–560 Ma Mistaken Point and Fermeuse Formations of Newfoundland are not included, since they are not considered to have been produced by bilaterian organisms (Liu et al., 2010; Menon et al., 2013; Liu and McIlroy, 2015). The presence of trace fossils is factored into our dendrogram analysis.

***Environmental data within the database***

To test whether observed trends in the data may result from differences in water depth or environment, rather than palaeolatitude, we collated published information on the broad-scale bathymetry and sedimentation regime of each fossil locality. Individual localities often record multiple fossil-bearing facies. Considerable variability also exists in terms of how well individual localities have been environmentally constrained, and in the strength of evidence in support of their specific depositional settings. We therefore divided the sites simply as lacustrine, or shallow or deep marine (with the slope break taken as the boundary, i.e. nearshore or offshore), and carbonate or siliciclastic dominated (Figure 6; Supp. Fig. 2).

*Assumptions with environment and age*

Since there is little consistency at different localities in the magnitude of errors surrounding radiometric dates, the number and quality of available dates, or the level of detail to which facies at individual localities have been characterised, we have had to make several decisions regarding assignment of individual localities to time-bins, environmental categories, and lithologies. The references that guided our thinking, as well as notes explaining our decisions, can be found in Supplementary File 2 under the ‘*Localities*’ tab, and in the reference list below. In each case, our interpretations focus on the units or beds within which the fossils are found.

***Sampling biases***

To interpret palaeolatitudinal data, our plots group northern and southern latitudes together by their palaeolatitude (n.b. very few palaeocontinents are considered to have occupied high northern latitudes during the late Ediacaran in Neoproterozoic plate reconstructions). Grouping in this way ensures that palaeolatitude, rather than global position (i.e. palaeogeography), is the focus of the analyses. Latitudes were separated into 20° bins for graphical plots.

Sources of bias in species-diversity datasets include variation in outcrop volume, research intensity for each locality, and ease of sample collection/study (Allison and Briggs, 1993). To determine whether visual signals from the plotted maps may simply reflect the palaeolatitudinal distribution of fossil sites, we employed the following tests:

* Chi-squared tests performed in *R* (Version 3.6.1) within *RStudio* (Version 1.2.5019; RStudio Team, 2019) determined whether visual signals seen in the maps are statistically significant. These tests are intended to account for sampling variation, but can only indicate whether a signal is significant or not, rather than identifying the cause of the signal. To perform the chi-squared tests, the data were split into two 45° latitudinal bands (corresponding to high and low palaeolatitudes), and for each group studied the data were divided into those within a given category, and those outside it. To avoid false positives from performing multiple tests on a single dataset we used the Bonferroni correction at a 5% significance level. If the *p*-value falls below this corrected significance level, then a result is deemed significant. Weakly-significant signals were defined between a 5–10% significance level, also using the Bonferroni correction.
* Kruskal-Wallis tests were performed in *R* to determine whether taxonomic distribution through time correlates with locality distribution through time. These tests can only state whether a signal is significant, rather than identifying the cause. The number of localities and number of taxa were compared for each of the two 45° latitudinal bands (low and high latitude), to determine whether they follow the same distribution. A 5% significance level was taken.

**Supplementary Results**

The results described in this section refer to the distribution of Ediacaran macrofossils on the Scotese (2001) (SCO01) palaeogeographic reconstruction, and comparison to the distribution on the Merdith et al. (2021) (MER21) reconstruction described in the main text. The distribution of fossil-bearing localities in the two reconstructions varies most notably in the positioning of the Laurentia-Siberia-Baltica palaeocontinental cluster (Supp. Fig. 1).

*Overall diversity through time*

The distribution of fossil Types through time in the SCO01 reconstruction (Supp. Fig. 13 initially appears similar to that in the MER21 reconstruction, with the two localities in the oldest pre-581 Ma time-bin (the Lantian Formation and Kimberley) both positioned at low palaeolatitudes (< 45º), but further from the Equator. In the next 10 Myr interval, three localities (the Nadaleen Formation, Finnmark and Newfoundland) are present at high palaeolatitudes (> 45º), so a global distribution for Frondomorphs cannot be assessed, but assuming protistan taxa in the pre-581 Ma time-bin persisted in the low latitude regions, that group can be inferred to exhibit a global distribution by this point. The diversification between 560–551 Ma, and subsequent apparent dip in generic diversity in the final 10 Myr of the Ediacaran Period, appears to occur similarly in both latitudinal bands (Supp. Figs 13 inset; 14), albeit weakly or not significantly.

A Kruskal-Wallis test of whether the distribution in taxon diversity significantly differs from the distribution of localities across 20° palaeolatitudinal bands, with the null hypothesis being that they follow the same distribution, revealed a significant signal (*KW test*, *p* = 0.009; Supp. Table 3; Supp. Fig. 18b).

Kruskal-Wallis tests to assess whether the distribution of diversity is significantly identical to the number of localities through time reveal weakly-significant signals at high palaeolatitudes (*KW test*, *p* = 0.094; Supp. Table 3), and non-significant signals at low palaeolatitudes (*KW test*, *p* = 0.141; Supp. Table 3). Non-significant signals are observed between low and high palaeolatitude taxa (*KW test*, *p* = 0.754, Supp. Table 3) and low and high palaeolatitude localities (*KW test*, *p* = 1, Supp. Table 3). These signals are similar to those observed in the MER21 reconstruction (Table 1).

The overall diversity (of all macrobiota across the entire late Ediacaran) and the number of localities across latitudes are both higher at low palaeolatitudes than at high palaeolatitudes (Supp. Fig. 18b). When the data are normalised to sampling intensity, no significant difference is recovered (Supp. Fig. 20a), so, as on the MER21 reconstruction (Supp. Fig. 9a), the apparent difference between low and high palaeolatitudes cannot be visually differentiated from a flat overall latitudinal distribution of taxa during the Ediacaran.

Contrary to the MER21 reconstruction, the distribution of Frondomorph taxa does not exhibit a statistically significant signal when compared with non-Frondomorph taxa between high and low palaeolatitudes (*χ2*(1, *N =* 214) = 2.935, *p* = 0.087; Supp. Table 3), whilst Algal taxa show a statistically significant difference (*χ2*(1, *N =* 214) = 6.954, *p* = 0.008; Supp. Table 3). The distribution of Tubular taxa is not statistically significant (*χ2*(1, *N =* 214) = 4.704, *p* = 0.030; Supp. Table 3), as on the MER21 reconstruction. Sampling for Radial taxa on the SCO01 reconstruction permits a valid test, indicating no significant difference (*χ2*(1, *N =* 214) = 0.159, *p* = 0.691; Supp. Table 3), whilst other Types remain too poorly sampled to perform valid chi-squared tests. The Bonferroni corrected *p*-value for 5% significance is 0.006 for the chi-squared tests performed for taxa on the SCO01 reconstruction (Supp. Table 3).

*Bilateral Taxa*

Body fossils of Bilateral-Type taxa, and trace fossils interpreted to have been produced by bilaterian taxa, occur globally in the SCO01 reconstruction (Bilateralomorpha, Dickinsoniomorpha and Kimberellamorpha; Supp. Figs 18a,c, 21). A chi-squared test comparing Bilateral taxa against non-bilateral taxa at low and high palaeolatitudes is non-significant (*χ2*(1, *N =* 214) = 0.825, *p* = 0.364; Supp. Table 3). Therefore, the apparent latitudinal restriction of Bilateral taxa resolved in the MER21 reconstruction is not observed in the SCO01 reconstruction (Supp. Fig. 18).

*Biomineralisers and Tubular fossils*

The distribution of both tubular and biomineralising organisms in the SCO01 reconstruction is global, spanning equatorial to almost polar palaeolatitudes (Supp. Fig. 19), as similarly observed in the MER21 reconstruction. The distribution of taxa by body composition (biomineralising, organic template and soft-bodied; Supp. Fig. 19b–d) shows no significant latitudinal signal distinguishable from the sampling density, with the diversity of taxa roughly following the distribution of fossil localities (Supp. Fig. 20d–f). The biomineralising organism distribution is predominantly dictated by tubular component organisms. Whereas a chi-squared test comparing biomineralising and organic template taxa with soft-bodied and agglutinating taxa (i.e. non-biomineralising and non-organic-template taxa), at low and high palaeolatitudes confirms no significant signal, as in the MER21 reconstruction (*χ2*(1, *N =* 214) = 3.277, *p* = 0.070; Supp. Table 3), a chi-squared test between soft-bodied taxa (non-algal) and non-soft-bodied taxa at low and high palaeolatitudes (performed to distinguish the difference between algal taxa and non-algal soft-bodied taxa) is significant (*χ2*(1, *N =* 214) = 7.590, *p* = 0.006). This result is likely a reflection of the significant Algal signal, since soft-bodied (algal) taxa dominate over the lower diversity groups also included in the comparison group, which contains all non-soft-bodied taxa and algal taxa (soft-bodied (algal), biomineralising, organic template and agglutinating). The algal signal is likely to be heavily driven by diverse populations of constituent taxa in South China. These comparisons are made across the entire late Ediacaran.

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| Test type | Comparison | Chi-squared | *p*-value |
| Kruskal-Wallis | Low latitude localities—Low latitude taxa | 2.164 | 0.141 |
| Kruskal-Wallis | High latitude localities—High latitude taxa | 2.810 | **0.094** |
| Kruskal-Wallis | Low latitude taxa—High latitude taxa | 0.098 | 0.754 |
| Kruskal-Wallis | Low latitude localities—High latitude localities | 0 | 1 |
| Kruskal-Wallis | Overall taxa—Localities (20° bands) | 6.818 | **0.009** |
| Chi-squared | Algal—Non-algal | 6.954 | **0.008** |
| Chi-squared | Bilateral—Non-bilateral | 0.825 | 0.364 |
| Chi-squared | Frondomorph—Non-frondomorph | 2.935 | 0.087 |
| Chi-squared | Radial—Non-radial | 0.159 | 0.691 |
| Chi-squared | Tubular—Non-tubular | 4.704 | 0.030 |
| Chi-squared | Soft-bodied—Non-soft-bodied | 7.590 | **0.006** |
| Chi-squared | Biomineralising and Organic Template—Soft and Agglutinating | 3.277 | 0.070 |
| Chi-squared | Miscellaneous—Non-miscellaneous (control) | 1.380 | 0.240 |

**Supplementary Table 3:** Key statistical results from the SCO01 reconstruction. Significant and weakly-significant *p*-value results in bold. Significant and weakly-significant *p*-values for Kruskal-Wallis tests are below 0.05 and between 0.05–0.10, respectively. Significant and weakly-significant *p*-values for chi-squared tests on Types are corrected to 0.006 and 0.013 using the Bonferroni correction, respectively.

**Supplementary Figures**

Diagram

Description automatically generated

**Supplementary Figure 1:** Precambrian cratons, and the locations of Ediacaran fossil localities included in this study (in italic), plotted on: (**a**) the modern global map (cratons shaded), (**b**) the projected MER21 reconstruction at 555 Ma, and; (**c**) the projected SCO01 reconstruction at 555 Ma.

Map

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**Supplementary Figure 2:** (**a–b**) Maps showing the distribution of depositional environments for Ediacaran fossil localities on the MER21 and SCO01 reconstructions, respectively. (**c–d**) Maps showing the distribution of lithologies of Ediacaran fossil localities on both MER21 and SCO01 reconstructions, respectively. Black arrows indicate the palaeo-location in cases where two sites are so closely spaced that their symbols have been moved for clarity.

Chart, line chart

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**Supplementary Figure 3:** Overall generic diversity of Ediacaran macrobiota (orange) and corresponding variation in locality density (blue) through late Ediacaran time. A significant Kruskal-Wallis result (*p*-value = 0.047, Table 1) suggests that the distribution of sampled localities cannot fully describe the distribution of genera through time.

Chart

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**Supplementary Figure 4:** Stacked area chart representing the overall diversity of Ediacaran macrobiota genera through the late Ediacaran, arranged by ‘Type’. Note the late appearance of Bilateral and Erniettomorph Types in the 560–551 Ma time-bin.

Chart

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**Supplementary Figure 5:** Stacked area chart representing the overall diversity of Ediacaran macrobiota genera through the late Ediacaran, arranged by Morphogroup. Note the substantial increase in morphogroup diversity after 560 Ma.

Chart, line chart

Description automatically generated

**Supplementary Figure 6:** Variation in generic diversity at low (yellow) and high (orange) palaeolatitudes through late Ediacaran time, normalised against locality density, on the MER21 reconstruction. ‘Normalised taxa’ axis scale is equivalent to that used for taxonomic diversity in Figure 2. There are notably more taxa at low palaeolatitudes in the 560–551 Ma time-bin than would be expected from locality coverage alone, and fewer taxa at low palaeolatitudes than would be expected in the 550–539 Ma time bin.

Diagram

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**Supplementary Figure 7:** Distribution of Morphogroups on the MER21 reconstruction, with each locality presented as a pie chart centred on the locality (black arrows indicate the palaeo-location where necessary), and each map plotted with palaeocontinents positioned as estimated at the mid-point of each time-bin (Precambrian craton shapes are colour coded for each bin). Pie chart scaling represents the number of genera within each Morphogroup, with the circle area being equivalent to the total number of genera at each locality.

Chart

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**Supplementary Figure 8:** Stacked area chart representing the overall variation in Ediacaran macrobiota generic diversity by Morphogroup at (**a**) low and (**b**) high palaeolatitudes through time, on the MER21 reconstruction.

Chart, line chart

Description automatically generated

**Supplementary Figure 9:** The latitudinal generic diversity variation of various Ediacaran macrofossil groups across the late Ediacaran (i.e. >581–539 Ma), normalised against locality density, on the MER21 reconstruction. The ‘normalised taxa’ axis values are equivalent to those used for taxon diversity in Figures 4 and 5. All Bilateral taxa included in (**b**) are found between 560–539 Ma, and all CaCO3 biomineralising and organic template taxa (**d–e**) are found between 550–539 Ma. Bilateral taxa (b) produce a weakly-significant chi-squared result when compared to non-bilateral taxa at low and high latitudes (*p*-value = 0.013, Table 1), whereas the trends shown by other groups are non-significant.

Chart, line chart

Description automatically generated

**Supplementary Figure 10:** The palaeolatitudinal diversity distribution of Bilateral Type taxa on the MER21 reconstruction. (**a**)Stacked area chart revealing how Bilateral taxa are distributed across palaeolatitudes across all time-bins, compared with the distribution of Ediacaran fossil sites across the late Ediacaran (blue). (**b–c**) Graphs comparing the distribution of Ediacaran fossil sites in the corresponding time-bin (blue) to the distribution of (b) Bilateral taxa found between 560–551 Ma, and (c) Bilateral taxa found between 550–539 Ma. (**d–e**) Graphs of Bilateral taxon distribution normalised against locality density. The ‘normalised taxa’ axes are equivalent to those used for taxon diversity in (b–c). The sample sizes of Bilateral taxa in individual time-bins are not sufficient to perform valid chi-squared tests.

Chart, line chart

Description automatically generated

**Supplementary Figure 11:** The palaeolatitudinal diversity distribution of the three individual Bilateral morphogroups on the MER21 reconstruction, across the late Ediacaran (i.e. >581–539 Ma). (**a–c**) Graphs comparing the distribution of Ediacaran fossil sites (blue) to the distribution of (a) Bilateralomorpha, (b) Dickinsoniomorpha, and (c) Kimberellamorpha. (**d–f**) Graphs normalised against locality density. All taxa included here are found between 560–539 Ma. The ‘normalised taxa’ axes are equivalent to those used for taxon diversity in (a–c). The sample sizes of these morphogroups are not sufficient to perform valid chi-squared tests.

Chart, line chart

Description automatically generated

**Supplementary Figure 12:** The distribution of Ediacaran fossil sites relative to the distribution of tubular organisms on the MER21 reconstruction, across the late Ediacaran (i.e. >581–539 Ma). (**a–c**) Comparisons between the distribution of Ediacaran fossil sites (blue) and the distribution of (a) CaCO3 biomineralising tubes, (b) organic template tubes, and (c) soft bodied tubes (see also Figure 5). (**d–f**) Graphical plots normalised against locality density. All CaCO3 biomineralising and organic template tubes included in (a–b, d–e) are found between 550–539 Ma. The ‘normalised taxa’ axes are equivalent to those used for taxon diversity in (a–c). The sample sizes of these groups are not sufficient to perform valid chi-squared tests.

Map

Description automatically generated

**Supplementary Figure 13:** Distribution of Ediacaran macrobiota Fossil Types on the SCO01 reconstruction, with each locality presented as a pie chart centred on its locality (black arrows indicate the palaeo-location where it has been necessary to move pie charts to avoid overlap), and with each map plotted with palaeocontinents positioned as estimated at the mid-point of each time-bin (Precambrian craton shapes are colour coded for each bin). Pie charts are scaled to represent the number of genera within each Type, with the circle area being equivalent to the total number of genera at each locality. **Inset**: graph comparing the distribution of Ediacaran fossil sites within two palaeolatitudinal bands to the distribution of taxa throughout the late Ediacaran (a weakly-significant Kruskal-Wallis result is observed when comparing high palaeolatitude taxa against high palaeolatitude localities, *p*-value = 0.094, Supp. Table 3).

Chart, line chart

Description automatically generated

**Supplementary Figure 14:** Graph illustrating the overall generic diversity of the Ediacaran macrobiota at high and low palaeolatitudes (orange and yellow lines, respectively) through time, normalised against locality density, on the SCO01 reconstruction. The ‘normalised taxa’ axis scale is equivalent to that used for taxon diversity in Supplementary Figure 13.

Chart

Description automatically generated

**Supplementary Figure 15:** Stacked area chart representing Ediacaran macrobiota generic diversity variation by Type at (**a**) low and (**b**) high palaeolatitudes through time, on the SCO01 reconstruction.

Diagram

Description automatically generated

**Supplementary Figure 16:** Morphogroups presented as pie charts centred over their locality (black arrows indicate the palaeo-location where necessary) at the mid-point of each time-bin on the SCO01 reconstruction (Precambrian craton shapes coloured for each bin). The pie charts on all plots represent the number of genera within each morphogroup, and the circle area represents the total number of genera at each locality.

Chart

Description automatically generated

**Supplementary Figure 17:** Stacked area chart representing Ediacaran macrobiota generic diversity variation by Morphogroup at (**a**) low and (**b**) high palaeolatitudes through time, on the SCO01 reconstruction.

Diagram

Description automatically generated

**Supplementary Figure 18:** The global distribution of Bilateral Type fossils on the SCO01 reconstruction. (**a**) Bilateral body and trace fossils presented as pie charts featuring the relative proportion of constituent morphogroups centred over the locality at which they are found at 555 Ma. The area of the circles represents the number of genera at each locality. The distribution appears more global on this reconstruction than on the MER21 reconstruction. Note that we have considered trace fossils as one data point, and so the true diversity of bilateral organisms represented by documented traces is not reflected by these plots. (**b–d**) Graphs comparing the distribution of Ediacaran fossil sites across the late Ediacaran (i.e. >581–539 Ma) (blue) to the distribution of (b) all taxa, (c) Bilateral taxa, and (d) non-bilateral taxa. All Bilateral taxa included in (c) are found between 560–539 Ma. None of the distributions in plots (b–d) show a statistically significant difference between high and low latitudes.

Diagram

Description automatically generated

**Supplementary Figure 19:** The global distribution of biomineralising and tubular Ediacaran taxa on the SCO01 reconstruction. (**a**)Tubular fossils and all other biomineralising fossils (faint circles), with pie charts of only biomineralising organisms overlain (solid circles), centred over the locality at which they are found at 545 Ma (black arrows indicate the palaeo-location where necessary). The area of the circles is proportional to the number of relevant genera at each locality. A global distribution is observed for both tubular and biomineralising organisms. Biomineralising organisms are dominated by tubular taxa, and are often found along with non-biomineralising tubular organisms. (**b–d)** Graphs comparing the distribution of Ediacaran fossil sites across the late Ediacaran (i.e. >581–539 Ma) (blue) to the distribution of: (b) CaCO3 biomineralising taxa; (c) organic template taxa; and (d) soft bodied taxa. This latter group has a significant chi-squared result when compared with non-soft bodied taxa at low and high latitudes (*p*-value = 0.006, Supp. Table 3). All CaCO3 biomineralising and organic template taxa (b–c) are found between 550–539 Ma.

Chart, line chart

Description automatically generated

**Supplementary Figure 20:** Variation in the palaeolatitudinal generic diversity of selected groups, normalised against locality density across the late Ediacaran (i.e. >581–539 Ma), on the SCO01 reconstruction. All Bilateral taxa included in (**b**) are found between 560–539 Ma, and all CaCO3 biomineralising and organic template taxa (**d–e**) are found between 550–539 Ma. The ‘normalised taxa’ axes are equivalent to those used for taxon diversity in Supplementary Figures 18 and 19.

Chart, line chart

Description automatically generated

**Supplementary Figure 21:** The palaeolatitudinal diversity distribution of the three individual ‘Bilateral Type’ morphogroups on the SCO01 reconstruction, across the late Ediacaran (i.e. >581–539 Ma). (**a–c**) Graphs comparing the distribution of Ediacaran fossil sites (blue) to the distribution of (a) Bilateralomorpha, (b) Dickinsoniomorpha, and (c) Kimberellamorpha. (**d–f**)Graphs normalised against locality density. All taxa included here are found between 560–539 Ma. The ‘normalised taxa’ axes are equivalent to those used for taxon diversity in (a–c). The sample sizes of these morphogroups are not sufficient to perform valid chi-squared tests.

Chart, line chart

Description automatically generated

**Supplementary Figure 22:** Comparison of the palaeolatitudinal distribution of Ediacaran fossil localities with the distribution of tubular organisms on the SCO01 reconstruction, across the late Ediacaran (i.e. >581–539 Ma). (**a–c**) Graphs comparing the distribution of Ediacaran fossil sites (blue) to the distribution of (a) CaCO3 biomineralising tubes, (b) organic template tubes, and (c) soft bodied tubes. (**d–f**) Graphs normalised against locality density. All CaCO3 biomineralising and organic template tubes included in (a–b, d–e) are found between 550–539 Ma. The ‘normalised taxa’ axes are equivalent to those used for taxon diversity in (a–c). The sample sizes of these groups are not sufficient to perform valid chi-squared tests.

Diagram

Description automatically generated**Supplementary Figure 23:** Alternative dendrograms featuring localities with >3, >4, >5 and >6 taxa, with or without the inclusion of data for the presence/absence of bilaterian trace fossils. The corresponding cophenetic correlation coefficients (CPCC) are also presented. The nodes vary with even small changes to the data, suggesting limited support for these trees. Incorporation of data from sites with fewer taxa increases mixing of “traditional” (Waggoner, 2003) assemblages. The most consistent trends as judged by CPCC occur when sites with few taxa are excluded, but such plots necessarily include fewer localities. The inclusion of the presence/absence of bilaterian traces improves the CPCC, and so traces were included for our main analysis (Figure 6).

**Supplementary File 2 contents**

Our database contains base data, plotted data (graphical and maps), and analysis data. Plotted data and analysis data are derived from the base data, using formulae in Excel. These data and corresponding Excel formulae are presented in the following worksheets within Supplementary File 2:

***Data - Taxa*** – Dataset of all genera along with their Morphogroup, Location, Age, Body Composition, Type, Palaeolatitude on both MER21 and SCO01 reconstructions, and References.

***Data - Localities*** – Dataset of all Localities along with their Age, Palaeolatitude on both MER21 and SCO01 reconstructions, Environment, Lithology, and References.

***Plots - Temporal Data*** – Data extracted from the two datasetsto study trends through time:

* *Overall diversity through time* provides the number of localities and number of taxa in each 10 Myr time-bin, used for Supp. Fig. 3.
* *Diversity through time in 45° palaeolatitudinal bands* provides the number of localities and taxa in both low and high palaeolatitudes for both MER21 and SCO01 reconstructions, in each 10 Ma time-bin, used for Figure 2 inset and Supp. Fig. 13 inset.
* *Normalised taxon diversity for locality density through time in 45° palaeolatitudinal bands*, taxon data normalised to account for varying locality density through time, used for Supp. Figs 6 and 14.
* *Type and Morphogroup data through time* provides the number of each taxon Type/morphogroup in each 10 Ma time-bin, used for Figure 3 and Supp. Figs 4, 5, 8, 15 and 17.

***Plots - Palaeolatitudinal Data*** – Data extracted from the two datasets to study trends across palaeolatitude on both the MER21 and SCO01 reconstructions:

* *Diversity in 20° palaeolatitudinal bands* provides the number of Taxa (total and grouped for Bilateral and body composition plots) in each 20° palaeolatitudinal band, used for Figures 4, 5 and Supp. Figs 10–12 (MER21) and Supp. Figs 18, 19, 21 and 22 (SCO01).
* *Normalised diversity for locality density*, taxon data normalised to account for varying locality density across 20° palaeolatitudinal bands, used for Supp. Figs 9–12 (MER21) and Supp. Figs 19–22 (SCO01).

***R - All Data*** – Data extracted from the two datasets to perform statistical analyses in R:

* *Overall diversity through time* provides the number of localities and number of taxa in each 10 Ma time-bin, used for Kruskal-Wallis tests “Localities—Taxa”.
* *Diversity through time in 45° palaeolatitudinal bands* provides the number of localities and taxa in both low and high latitudes for both MER21 and SCO01 reconstructions, in each 10 Ma time-bin, used for Kruskal-Wallis tests “Low latitude localities—Low latitude taxa”; “High latitude localities—High latitude taxa”; “Low latitude taxa—High latitude taxa” and “Low latitude localities—High latitude localities”.
* *Taxa and locality counts in 20° palaeolatitudinal bands* provides the number of taxa and localities in each 20° latitudinal band, used for Kruskal-Wallis test “Overall taxa—Localities (20° bands)”.
* *Type and body composition counts in 45° palaeolatitudinal bands* provides localities and taxa (overall, Types and body composition) across low and high latitudes, used for chi-squared tests in both MER21 and SCO01 “Algal—Non-algal”; “Bilateral—Non-bilateral”; “Frondomorph—Non-frondomorph”; “Radial—Non-radial” (SCO01 only); “Tubular—Non-tubular”; “Soft-bodied—Non-soft-bodied”; “Biomineralising and Organic Template—Soft and Agglutinating” and “Miscellaneous—Non-misc. (control)”.

***Maps - >571 Ma*** – Data extracted from the dataset to plot the maps with all Types and morphogroups in the two oldest time-bins (>581 Ma in red), up to 571 Ma, used for Figure 2, Supp. Figs 7, 13 and 16.

***Maps - 570–561 Ma*** – Data extracted from the dataset to plot the maps with all Types and morphogroups between 570–561 Ma, used for Figure 2, Supp. Figs 7, 13 and 16.

***Maps - 560–551 Ma*** – Data extracted from the dataset to plot the maps with all Types and morphogroups between 560–551 Ma, used for Figure 2, Supp. Figs 7, 13 and 16.

***Maps - 550–539 Ma*** – Data extracted from the dataset to plot the maps with all Types and morphogroups between 550–539 Ma, used for Figure 2, Supp. Figs 7, 13 and 16.

***Maps – Bilateral&Biomineraliser*** – Data extracted from the dataset to plot the maps for Bilateral morphogroups and Biomineralising morphogroups and Tubular taxa, used for Figures 4, 5, Supp. Figs 18, 19.

***Coordinates*** – Coordinates of all localities at the mid-point of the four youngest time-bins used to plot the map data and determine latitudinal bands.

**Supplementary File 3 contents**

Code for all chi-squared and Kruskal-Wallis tests. Data exported to run these tests can be found in Supplementary File 2 (*R - All Data*).

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