Description of Supplementary Files

File Name: Supplementary Information
Description: Supplementary Notes, Supplementary Figures, Supplementary Tables and Supplementary References

File Name: Peer Review File
Supplementary Note 1 | The middle Ediacaran MRBs

The first appearance of widespread MRBs in middle Ediacaran successions is of particular importance. Typical examples include the Rainstorm Member of Johnnie Formation in the Death Valley region of western USA, the upper Doushantuo Formation in South China, the Krol B interval of the Lesser Himalaya, northern India, the Chenchinskaya and Alyanchskaya formations in southeast Siberia, Russia, the Tikhfist Formation in Morocco, and the Lubudi Formation in central Africa. In this study, we examined the MRBs of the Johnnie Formation, the Doushantuo Formation, and the Krol Group.

The pink limestones of the Rainstorm Member (Johnnie Formation) in the Death Valley region rest above the Johnnie oolite and consist of microcrystalline limestone with siltstone and fine-grained sandstone interbeds. They were deposited from shallow subtidal to deep subtidal environments. Ooids, stromatolites, and crystal fans are observed in some of the sections such as in the northern Mesquite Mountains and southern Nopah Range. Carbon isotope analyses have been conducted multiple times for the Rainstorm Member in this region and the data show negative δ¹³C values down to −12‰, which were correlated with the Shuram excursion. Our carbon isotope analyses of the pink limestones from the northern Mesquite Mountains have δ¹³C values of −9.5‰ to −12‰ (Supplementary Table 1 and Fig. 7), consistent with previous studies. The unusually low δ¹³C values (down to −12‰) from the pink limestones raised concerns about diagenetic alteration of primary carbon isotope signature, but the consistent spatial and temporal δ¹³C pattern and the well-preserved radial fabrics in ooids, stromatolites and crystal fans suggest an overall preservation of primary features.

The pink-red dolostones of the upper Doushantuo Formation in South China is exemplified by the sections in the Yangtze Gorges area. The thinly bedded dolostones are interbedded with shale laminae and are composed of micritic or microcrystalline dolomite suggestive of
deposition from deep subtidal environments below fair-weather wave base. Carbon isotope analyses reveal $\delta^{13}C$ values of $-6\%o$ to $-9\%o$ (Supplementary Table 1 and Fig. 6), which is consistent with the upper Doushantuo negative $\delta^{13}C$ excursion documented from the region$^{135}$. The upper Doushantuo $\delta^{13}C$ excursion has also been correlated to the Shuram excursion$^{141, 142}$.

The red beds of the Krol B interval in the Lesser Himalaya, northern India are present in all of the five synclines examined$^{68, 143}$. They are composed of red siltstone, shale and micritic dolostone. The presence of some gypsum pseudomorphs in proximal sections led to the interpretation of intertidal to supratidal environments$^{143}$, but our new observations indicate that at least in the distal sections such as in Solan and Korgai synclines, they were likely deposited below the fair-weather wave base. Carbon isotopes of the red dolostones in Krol B vary from $-2\%o$ to $-12\%o$ $^{136}$, but overall the negative $\delta^{13}C$ shift is apparent at correlative intervals throughout the Krol platform, which has also been correlated with the Shuram excursion$^{136}$.

Field and petrographic observations show that the middle Ediacaran MRBs share similar attributes with those of the Triassic and Cretaceous MRBs examined in this study: they are all composed of fine-grained carbonates and shales and have almost no organic matter content or organic-rich interbeds; their red colour is homogenous and does not show patchy staining suggestive of oxidation from reduced iron. Their bulk rock Fe$_2$O$_3$ contents are identical ($\leq1\%$ in carbonates and 1–6% in shales). Petrographic and SEM observations reveal no framboidal or euhedral pyrite precursors. Therefore, we believe that the middle Ediacaran MRBs had the same origin as those of the Triassic and Cretaceous MRBs.

Supplementary Note 2 | Compilation of Phanerozoic MRBs

We document a total of five global MRB intervals from the Phanerozoic, including Cambrian, Late Devonian, Early Triassic, Jurassic and Cretaceous episodes (Supplementary Table 2). Marine red beds are also found in Early Silurian (Telychian) successions in many places including Europe, North America$^{144, 145}$ and South China$^{146}$, but they are mostly found
distributed around uplifted “old lands” and consist predominately of red sandstone, siltstone and shales without carbonates. The iron source of these Silurian red beds are thought to be of detrital origin. Therefore, we think that these red beds may have been formed differently from the five intervals we have described. However, if future studies indicate that they were formed by similar processes like the ones in Cretaceous and Triassic, the Telychian red beds could be another representative Phanerozoic MRB.

Most of the Phanerozoic MRBs slightly postdate oceanic anoxic events (OAEs), but in a few cases red beds are also found within the interval of oceanic anoxia. One of the examples is the thin red beds within OAE2 in New Zealand. Further study may reveal if this type of red beds records episodic oxidation within a broad anoxic event or a local phenomenon.

Red-pink carbonates of MRBs all have δ13C values that are lower than temporally adjacent strata, creating “negative” δ13C excursions (Figs. 2c and 3; Supplementary Figs. 3–7). This is conceivable because oxidation of reduced iron from anoxic waters would inevitably involve oxidation of organic carbon and incorporation of 13C-depleted HCO3− during carbonate precipitation, adding 13C-depleted carbon to carbonate. This process may have resulted in negative δ13C shifts in the range of −0.5‰ to −2‰, as seen in the Phanerozoic MRBs (Figs. 2c and 3; Supplementary Figs. 3–5). The negative δ13C excursion associated with the middle Ediacaran MRB, or the Shuram δ13C excursion, however, has a magnitude of ≥ 12‰. While 13C-depleted carbon from oxidation of organic carbon and 13C-depleted HCO3− certainly made contributions to the Shuram excursion, the amount of oxidants and reduced carbon source required for the Shuram excursion is enormous and has been highly debated.

**Supplementary Note 3 | Debates on the origin of the Shuram δ13C excursion**

The negative δ13C excursion associated with the middle Ediacaran MRB, or the Shuram excursion, has a magnitude of ≥ 12‰ (ranging from ≥ 4‰ to ≤ −8‰) and a duration of ≥ 5 million years (Myr). The large magnitude and long duration of this δ13C excursion make it difficult to interpret using the Phanerozoic carbon cycle models. Early interpretations invoked the upwelling of 13C-depleted deep water, but the enormous...
amount of $^{13}$C-depleted carbon required for accommodating a $>5$ Myr $\delta^{13}$C excursion with a magnitude of $\geq 12\%_o$ is difficult to reconcile. This led to the proposal of a large oceanic dissolved organic carbon (DOC) pool (100–1000 times that of the modern ocean DOC) and perhaps a relatively smaller (than modern) dissolved inorganic carbon pool that was more susceptible to carbon isotope changes\textsuperscript{149}. Evidence supporting a large DOC pool came from the decoupled carbonate and organic carbon isotopes prior to and across the Shuram excursion\textsuperscript{152, 157}. This hypothesis, however, is challenged by the equally large amount of oxidants required for remineralizing the large DOC pool\textsuperscript{148}. Even with the oxidant budget available in the modern surface environments (including atmosphere and ocean) and with an unlimited organic carbon source, it is difficult to support a $12\%_o$ negative $\delta^{13}$C excursion for more than 3 Myr\textsuperscript{148}. In addition, more recent paired carbonate-organic carbon isotope analyses documented decoupled–coupled $\delta^{13}$C\textsubscript{carb}–$\delta^{13}$C\textsubscript{org} patterns from multiple intervals of Ediacaran-Cambrian strata\textsuperscript{158, 159, 160}, suggesting that even if a large DOC existed in the Precambrian ocean, it was not large enough to buffer the organic carbon isotopes and the evolution of the DOC reservoir was not unidirectional\textsuperscript{159, 161}.

The shortage of $^{13}$C-depleted carbon source or oxidants required for the Shuram excursion led to alternative meteoric\textsuperscript{162, 163} and burial\textsuperscript{164} diagenetic interpretations. However, both meteoric and burial diagenesis have difficulties of explaining the globally consistent $\delta^{13}$C excursion across different continents (sedimentary basins) with varying burial history. In addition, most if not all Shuram-age negative $\delta^{13}$C values are produced in transgressive units above an unconformity where influence from meteoric water should be relatively less significant. The preservation of primary sedimentary structures and fabrics such as crystal fans, radial fabrics of ooids, and microbial laminae in stratigraphic units that host the Shuram excursion also argue against complete recrystallization of carbonate minerals and resetting of isotope signature through burial diagenesis.

A more recent hypothesis invokes authigenic carbonate precipitation in porewater as a possible origin of the Shuram excursion\textsuperscript{165}. Due to anoxic bottom waters, authigenic carbonate precipitation in porewaters in Precambrian oceans may have been much more pervasive than in the modern ocean and might be a major $^{13}$C-depleted carbon flux. This has
two implications: (1) the cutoff or decline in the global flux of authigenic carbonate would result in a negative $\delta^{13}C$ excursion and (2) the addition of authigenic carbonate into primary marine carbonate would result in localized/regional $\delta^{13}C$ shift. This hypothesis explains some of the spatial variations of the Shuram excursion such as the large isotope gradients and local isotope extremes documented from the Doushantuo Formation in South China, but it cannot explain a global $\delta^{13}C$ excursion with minimum values down to $\leq -12‰$ because even a complete cutoff of the authigenic carbonate flux would not result in ocean seawater $\delta^{13}C$ values lower than the riverine (or average crust) $\delta^{13}C$ value of ca. $-5‰$, unless additional evidence confirm that the Shuram excursion is not globally synchronous.

The debate on the origin of the Shuram excursion (and its correlatives) will continue until better constraints on its magnitude, duration, and spatial variations can be achieved, and our findings by no means solve this debate. However, the coincidence of the Phanerozoic-like, middle Ediacaran MRB and the Shuram excursion does confirm that (1) similar to the negative $\delta^{13}C$ shift associated with the Phanerozoic MRBs, oxidation of organic carbon and incorporation of $^{13}C$-depleted HCO$_3^-$ from anoxic waters during carbonate precipitation likely contributed to the Shuram excursion, (2) the larger magnitude of the Shuram excursion may be related to the longer period of anoxia prior to the middle Ediacaran MRB, during which more $^{13}C$-depleted carbon may have accumulated through remineralization of organic matter, and (3) iron reduction (using iron oxides as electron acceptors) may have contributed, at least locally, to the heterogeneity of the Shuram excursion.
Supplementary Figure 1 | Marine red bed occurrences in the Phanerozoic and Ediacaran. Data are based on Supplementary Table 2.

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Supplementary Figure 2 | Banded Iron Formation occurrences in the Archean and Proterozoic. Data are based on Supplementary Table 2.
Supplementary Figure 3 | Carbonate $\delta^{13}C$ curve from the Late Cretaceous strata in Chuangde, Tibet, China.
Supplementary Figure 4 | Carbonate δ\textsuperscript{13}C curve from the Spathian (Early Triassic) in Mingtang, South China.
Supplementary Figure 5 | Carbonate δ¹³C curve from the Famennian (Late Devonian) strata in Baisha, South China.
Supplementary Figure 6 | Carbonate $\delta^{13}C$ curves from the middle Ediacaran in Shijiahe, South China.
Supplementary Figure 7 | Carbonate δ\textsuperscript{13}C curves from the middle Ediacaran in northern Mesquite Mountains, United States.
| Age (Ma) | Period      | Stage      | Sample No. | Sample position (m) | δ13C (%o) | δ18O (%o) | FeO (%o) | Fe3+/%(%) | Fe3+/Fe2+ | Type         |
|----------|-------------|------------|------------|---------------------|------------|------------|----------|-----------|-----------|--------------|
| ~83      | Cretaceous  | Campanian  | CD001      | 0                   | -0.38      | -13.03     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD002      | 1.5                 | -0.4       | -12.31     | 0.53     |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD003      | 3.6                 | -0.67      | -13.43     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD004      | 3.6                 | -0.67      | -13.42     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD005      | 5.1                 | 0.03       | -13.2      |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD006      | 6.5                 | 0.69       | -13        | 5.2      |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD007      | 7.7                 | 0.37       | -13.27     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD008      | 8.9                 | -0.86      | -15.87     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD009      | 9.9                 | 0          | -14.43     | 9.23     |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD010      | 10.6                | 0.13       | -11.99     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD011      | 11.4                | 0.48       | -12.17     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD012      | 12.4                | 0.15       | -12.22     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD013      | 14.3                | 0.25       | -11.86     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD014      | 15.2                | 0.46       | -11.9      | 6.1      |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD015      | 16.2                | 0.5        | -11.96     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD016      | 16.7                | 0.21       | -12.4      |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD017      | 16.7                | 0.17       | -12.41     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD018      | 18.1                | 0.67       | -12.55     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD019      | 19                  | 0.23       | -11.81     | 2.26     |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD020      | 20.1                | 0.77       | -11.77     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD021      | 21.3                | 0.91       | -11.95     |          |           |           | red mudstone |
| ~83      | Cretaceous  | Campanian  | CD022      | 22.4                | 1.1        | -11.73     |          |           |           | grey mudstone |
| ~83      | Cretaceous  | Campanian  | CD023      | 23.4                | 1.35       | -11.67     | 4.15     |           |           | grey mudstone |
| ~83      | Cretaceous  | Campanian  | CD024      | 24.8                | 1.49       | -11.65     |          |           |           | grey mudstone |
| ~83      | Cretaceous  | Campanian  | CD025      | 25.8                | 1.55       | -11.7      |          |           |           | grey mudstone |
| ~83      | Cretaceous  | Campanian  | CD026      | 26.7                | 1.53       | -11.79     | 1.32     |           |           | grey mudstone |
| ~83      | Cretaceous  | Campanian  | CD027      | 26.7                | 1.54       | -11.79     |          |           |           | grey mudstone |
| ~83      | Cretaceous  | Campanian  | CD028      | 27.8                | 1.63       | -11.7      |          |           |           | grey mudstone |
| ~83      | Cretaceous  | Campanian  | CD029      | 28.8                | 1.65       | -11.67     | 1.83     |           |           | grey mudstone |
| ~83      | Cretaceous  | Campanian  | CD030      | 29.9                | 1.61       | -11.76     |          |           |           | grey mudstone |
| ~83      | Cretaceous  | Campanian  | CD031      | 31                  | 1.43       | -11.91     | 0.63     |           |           | grey mudstone |
| ~83      | Cretaceous  | Campanian  | CD032      | 32.1                | 1.14       | -11.91     | 0.7      |           |           | grey mudstone |
| ~83      | Cretaceous  | Campanian  | CD033      | 33.1                | 0.7        | -11.93     |          |           |           | grey mudstone |
| ~248     | Triassic    | Spathian   | TL001      | 11.25               | -1.75      | -9.69      | 0.41     | 0.14      | 0.14      | 1.03         | grey limestone |
| ~248     | Triassic    | Spathian   | TL002      | 11.55               | -2.32      | -12.24     | 0.32     | 0.14      | 0.09      | 0.62         | grey limestone |
| ~248     | Triassic    | Spathian   | TL003      | 11.95               | -1.65      | -10.33     | 0.4      | 0.16      | 0.12      | 0.72         | grey limestone |
| ~248     | Triassic    | Spathian   | TL004      | 12.15               | -1.2       | -10.16     | 0.54     | 0.25      | 0.13      | 0.51         | grey limestone |

Supplementary Table 1 | Carbon and oxygen isotope values of carbonate and iron geochemical data in marine red beds, banded iron formations, and adjacent rocks.
| Triassic Spathian TL005 12.55 | -1.46 | -10.75 | 0.45 | 0.21 | 0.1 | 0.48 | grey limestone |
|-----------------------------|-------|--------|------|------|-----|-----|----------------|
| Triassic Spathian TL006 13.4 | -1.16 | -10.64 | 0.59 | 0.22 | 0.2 | 0.91 | grey limestone |
| Triassic Spathian TL007 13.8 | 0.02 | -11.03 | 0.68 | 0.25 | 0.23 | 0.9 | grey limestone |
| Triassic Spathian TL008 14.4 | 0.63 | -10.57 | 0.66 | 0.3 | 0.16 | 0.55 | grey limestone |
| Triassic Spathian TL009 14.6 | 3.14 | 1.78 | 0.42 | 0.24 | grey limestone |
| Triassic Spathian TL010 14.9 | 0.72 | -12.48 | 2.62 | 1.2 | 0.65 | 0.54 | grey limestone |
| Triassic Spathian TL011 15.02 | 1.76 | -12.35 | 3.42 | 1.98 | 0.41 | 0.2 | grey limestone |
| Triassic Spathian TL012 16.22 | -0.45 | -13.01 | 10.19 | 2.9 | 4.24 | 1.46 | grey limestone |
| Triassic Spathian TL013 18.62 | -0.1 | -11.52 | 1.03 | 0.29 | 0.43 | 1.49 | red limestone |
| Triassic Spathian TL014 18.62 | -0.09 | -11.54 | 0.79 | 0.12 | 0.43 | 3.53 | red limestone |
| Triassic Spathian TL015 19.02 | -0.12 | -11.71 | 0.93 | 0.15 | 0.51 | 3.4 | red limestone |
| Triassic Spathian TL016 19.54 | -0.44 | -12.12 | 0.53 | 0.11 | 0.26 | 2.44 | red limestone |
| Triassic Spathian TL017 20.28 | -0.46 | -11.74 | 0.56 | 0.11 | 0.28 | 2.56 | red limestone |
| Triassic Spathian TL018 21.38 | -0.18 | -12.11 | 0.76 | 0.16 | 0.37 | 2.25 | red limestone |
| Triassic Spathian TL019 21.68 | 0.06 | -12.09 | 1.07 | 0.21 | 0.54 | 2.62 | red limestone |
| Triassic Spathian TL020 21.98 | 0.19 | -11.89 | 1.11 | 0.2 | 0.57 | 2.81 | red limestone |
| Triassic Spathian TL021 22.48 | 0.27 | -12.15 | 0.55 | 0.21 | 0.18 | 0.83 | grey limestone |
| Triassic Spathian TL022 23.33 | 0.35 | -12.24 | 0.6 | 0.26 | 0.16 | 0.61 | grey limestone |
| Triassic Spathian TL023 23.63 | 1.52 | -12.5 | 0.77 | 0.31 | 0.5 | 1.61 | grey limestone |
| Triassic Spathian TL024 24.33 | 0.26 | -12.66 | 1.17 | 0.44 | 0.82 | 1.85 | grey limestone |
| Triassic Spathian TL025 24.73 | 0.02 | -12.68 | 0.59 | 0.24 | 0.29 | 1.23 | grey limestone |
| Triassic Spathian TL026 25.13 | 2.36 | -11.62 | 0.76 | 0.33 | 0.19 | 0.58 | grey limestone |
| Triassic Spathian TL027 26.63 | 0.18 | -12.71 | 0.75 | 0.31 | 0.57 | 1.82 | grey limestone |
| Triassic Spathian GD001 0.4 | 0.33 | 0.14 | 0.09 | 0.06 | grey limestone |
| Triassic Spathian GD002 1.3 | 2.34 | 0.95 | 0.69 | 0.72 | grey limestone |
| Triassic Spathian GD003 3.8 | 0.56 | 0.26 | 0.13 | 0.48 | grey limestone |
| Triassic Spathian GD004 4.9 | 0.73 | 0.37 | 0.14 | 0.39 | grey limestone |
| Triassic Spathian GD005 6.1 | 2.71 | 1.44 | 0.45 | 0.31 | grey limestone |
| Triassic Spathian GD006 8 | 0.08 | 0.05 | 0.01 | 0.19 | grey limestone |
| Triassic Spathian GD007 9.7 | 0.17 | 0.11 | 0.01 | 0.11 | grey limestone |
| Triassic Spathian GD008 12.4 | 0.35 | 0.22 | 0.02 | 0.1 | grey limestone |
| Triassic Spathian GD009 14.2 | 1.27 | 0.3 | 0.59 | 0.79 | grey limestone |
| Triassic Spathian GD010 39 | 2.41 | 1.17 | 0.51 | 0.44 | grey limestone |
| Triassic Spathian GD011 40.3 | 2.96 | 1.17 | 0.91 | 0.78 | grey limestone |
| Triassic Spathian GD012 41 | 4.81 | 1.2 | 2.17 | 1.81 | red limestone |
| Triassic Spathian GD013 41.5 | 2.96 | 0.82 | 1.26 | 1.54 | red limestone |
| Triassic Spathian GD014 43 | 3.51 | 0.87 | 1.59 | 1.82 | red limestone |
| Triassic Spathian GD015 44 | 0.12 | 0.02 | 0.06 | 2.51 | red limestone |
| Triassic Spathian GD016 45.1 | 2.43 | 0.88 | 0.82 | 0.92 | red limestone |
| Triassic Spathian GD017 45.9 | 2.92 | 0.66 | 1.38 | 2.08 | red limestone |
| Triassic Spathian GD018 46.2 | 2.12 | 0.47 | 1.02 | 2.16 | red limestone |
| Triassic Spathian GD019 47 | 2.71 | 0.64 | 1.26 | 1.99 | red limestone |
| Trilobite | Limestone Type | GD020 | 47.4 | 1.73 | 0.44 | 0.78 | 1.79 | red limestone |
|----------|----------------|-------|------|------|------|------|------|----------------|
| Trilobite | Limestone Type | GD021 | 48   | 0.35 | 0.16 | 0.08 | 0.53 | red limestone |
| Trilobite | Limestone Type | GD022 | 48.9 | 2.69 | 0.61 | 1.27 | 2.08 | red limestone |
| Trilobite | Limestone Type | GD023 | 49.8 | 1.84 | 0.44 | 0.86 | 1.96 | red limestone |
| Trilobite | Limestone Type | GD024 | 50.3 | 2.36 | 0.54 | 1.11 | 2.08 | red limestone |
| Trilobite | Limestone Type | GD025 | 51.3 | 1.58 | 0.39 | 0.71 | 1.8  | red limestone |
| Trilobite | Limestone Type | GD026 | 52.5 | 1.43 | 0.34 | 0.66 | 1.96 | red limestone |
| Trilobite | Limestone Type | GD027 | 53.3 | 1.01 | 0.19 | 0.52 | 2.72 | red limestone |
| Trilobite | Limestone Type | GD028 | 53.7 | 1.31 | 0.36 | 0.56 | 1.56 | red limestone |
| Trilobite | Limestone Type | GD029 | 54.15| 0.41 | 0.09 | 0.19 | 2.08 | red limestone |
| Trilobite | Limestone Type | GD030 | 54.95| 1.66 | 0.48 | 0.68 | 1.43 | red limestone |
| Trilobite | Limestone Type | GD031 | 55.75| 1.73 | 0.42 | 0.79 | 1.9  | red limestone |
| Trilobite | Limestone Type | GD032 | 56.35| 0.22 | 0.1  | 0.06 | 0.56 | red limestone |
| Trilobite | Limestone Type | GD033 | 57.55| 1.7  | 0.51 | 0.69 | 1.36 | red limestone |
| Trilobite | Limestone Type | GD034 | 60.6 | 0.08 | 0.03 | 0.02 | 0.76 | grey limestone |
| Trilobite | Limestone Type | GD035 | 64.3 | 0.06 | 0.02 | 0.02 | 0.84 | grey limestone |
| Trilobite | Limestone Type | GD036 | 66.3 | 0.28 | 0.1  | 0.1  | 0.96 | grey limestone |
| Trilobite | Limestone Type | GD037 | 67.6 | 0.38 | 0.2  | 0.07 | 0.34 | grey limestone |
| Trilobite | Limestone Type | GD038 | 68.4 | 0.14 | 0.04 | 0.06 | 1.5  | grey limestone |
| Trilobite | Limestone Type | MT001 | 14.4 | 1.77 | -5.32|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT002 | 15.5 | 1.57 | -9.96|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT003 | 15.5 | 1.57 | -10.32|     |      | light grey dolomite |
| Trilobite | Limestone Type | MT004 | 16.3 | 1.85 | -5.6 |      |      | light grey dolomite |
| Trilobite | Limestone Type | MT005 | 17.8 | 1.81 | -6.26|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT006 | 18.6 | 1.98 | -7.24|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT007 | 21   | 1.61 | -8.12|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT008 | 22   | 1.6  | -8.07|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT009 | 22.5 | 1.56 | -7.47|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT010 | 23.3 | 0.67 | -8.77|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT011 | 24.5 | 1.7  | -7.6 |      |      | light grey dolomite |
| Trilobite | Limestone Type | MT012 | 25.7 | 1.67 | -8.09|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT013 | 26.8 | 2.57 | -4.34|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT014 | 32   | 1.91 | -4.52|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT015 | 34.8 | 1.95 | -5.77|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT016 | 39   | 2.36 | -4.44|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT017 | 42   | 2    | -4.9 |      |      | light grey dolomite |
| Trilobite | Limestone Type | MT018 | 44   | 2.05 | -9.03|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT019 | 47.2 | 2.11 | -5.45|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT020 | 50.6 | 3.11 | -4.73|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT021 | 53.5 | 2.06 | -4.95|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT022 | 55.8 | 2.04 | -5.69|      |      | light grey dolomite |
| Trilobite | Limestone Type | MT023 | 57.2 | 1.33 | -3.93|      |      | grey limestone  |
| Age   | Horizon | Locality | Lithology       | B-values |
|-------|---------|----------|-----------------|----------|
| Triassic | Spathian | MT024    | 57.6            | 1.45     | -3.45   | grey limestone |
| Triassic | Spathian | MT025    | 51.8            | 0.59     | -7      | grey limestone |
| Triassic | Spathian | MT026    | 59.1            | 0.81     | -7.56   | grey limestone |
| Triassic | Spathian | MT027    | 58.4            | 0.71     | -7.81   | grey limestone |
| Triassic | Spathian | MT028    | 58.7            | 0.14     | -10.69  | grey limestone |
| Triassic | Spathian | MT029    | 60.0            | -0.12    | -10.91  | grey limestone |
| Triassic | Spathian | MT030    | 60.4            | 0.75     | -5.63   | grey limestone |
| Triassic | Spathian | MT031    | 60.8            | -0.37    | -8.15   | grey limestone |
| Triassic | Spathian | MT032    | 61.3            | 0.44     | -3.71   | grey limestone |
| Triassic | Spathian | MT033    | 61.3            | 0.44     | -3.52   | grey limestone |
| Triassic | Spathian | MT034    | 61.8            | 0.28     | -4.29   | grey limestone |
| Triassic | Spathian | MT035    | 62.0            | 0.24     | -4.33   | grey limestone |
| Triassic | Spathian | MT036    | 62.4            | -0.65    | -8.71   | red limestone |
| Triassic | Spathian | MT037    | 64.2            | 0.16     | -5.34   | red limestone |
| Triassic | Spathian | MT038    | 64.6            | -0.01    | -6.49   | red limestone |
| Triassic | Spathian | MT039    | 65.0            | 0.02     | -6.16   | red limestone |
| Triassic | Spathian | MT040    | 65.5            | -0.05    | -5.96   | red limestone |
| Triassic | Spathian | MT041    | 65.8            | -0.03    | -5.88   | red limestone |
| Triassic | Spathian | MT042    | 66.4            | -0.56    | -6.69   | red limestone |
| Triassic | Spathian | MT043    | 68.0            | 0.01     | -4.41   | red limestone |
| Triassic | Spathian | MT044    | 70.5            | -0.64    | -6.49   | red limestone |
| Triassic | Spathian | MT045    | 72.0            | -0.2     | -5.03   | red limestone |
| Triassic | Spathian | MT046    | 74.5            | 0.1      | -3.57   | red limestone |
| Triassic | Spathian | MT047    | 74.5            | 0.09     | -3.56   | red limestone |
| Triassic | Spathian | MT048    | 75.5            | -1.06    | -8.12   | red limestone |
| Triassic | Spathian | MT049    | 76.0            | -0.79    | -8.2    | red limestone |
| Triassic | Spathian | MT050    | 76.5            | -0.78    | -5.79   | red limestone |
| Triassic | Spathian | MT051    | 77.4            | -0.81    | -6.46   | red limestone |
| Triassic | Spathian | MT052    | 78.3            | -0.58    | -4.77   | red limestone |
| Triassic | Spathian | MT053    | 79.4            | -1.25    | -6.89   | red limestone |
| Triassic | Spathian | MT054    | 80.0            | -0.19    | -3.91   | red limestone |
| Triassic | Spathian | MT055    | 82.0            | -0.27    | -4.45   | red limestone |
| Triassic | Spathian | MT056    | 82.2            | -0.29    | -4.43   | red limestone |
| Triassic | Spathian | MT057    | 82.5            | -0.39    | -4.85   | red limestone |
| Triassic | Spathian | MT058    | 84.0            | -0.44    | -5.24   | red limestone |
| Triassic | Spathian | MT059    | 85.0            | 0.38     | -4.78   | red limestone |
| Triassic | Spathian | MT060    | 85.5            | -0.18    | -5.69   | grey limestone |
| Triassic | Spathian | MT061    | 86.0            | 0.63     | -4.04   | grey limestone |
| Triassic | Spathian | MT062    | 86.8            | 0.83     | -5.57   | grey limestone |
| Triassic | Spathian | MT063    | 87.8            | 0.04     | -5.11   | grey limestone |
| Triassic | Spathian | MT064    | 90.0            | 0.04     | -5.49   | grey limestone |
| Triassic | Spathian | MT065    | 90.4            | 0.06     | -5.58   | grey limestone |
| Traps | Stage | Depth | V.Poro | V.Gas | Rock Type |
|-------|-------|-------|--------|-------|-----------|
| 248   | Triassic | Spathian | MT066 | 92.4 | 0.72 | -4.72 | grey limestone |
| 248   | Triassic | Spathian | MT067 | 93.6 | 0.62 | -2.23 | grey limestone |
| 248   | Triassic | Spathian | MT068 | 94.3 | 0.71 | -2.17 | grey limestone |
| 248   | Triassic | Spathian | MT069 | 95   | 0.97 | -2.95 | grey limestone |
| 248   | Triassic | Spathian | MT070 | 96.8 | 1.17 | -2.37 | grey limestone |
| 248   | Triassic | Spathian | MT071 | 97.5 | 1.16 | -3.47 | grey limestone |
| 248   | Triassic | Spathian | MT072 | 98   | 1.14 | -3.35 | grey limestone |
| 248   | Triassic | Spathian | MT073 | 99   | 1.77 | -2.02 | grey limestone |
| 248   | Triassic | Spathian | MT074 | 100.4| 1.8  | -2.92 | grey limestone |
| 248   | Triassic | Spathian | MT075 | 102.3| 2.68 | -1.93 | grey limestone |
| 370   | Devonian | Famennian | BS001 | 118  | 1.89 | -5.71 | grey limestone |
| 370   | Devonian | Famennian | BS002 | 120  | 2    | -6.56 | 2.81 | grey limestone |
| 370   | Devonian | Famennian | BS003 | 122  | 1.3  | -4.95 | grey limestone |
| 370   | Devonian | Famennian | BS004 | 124  | 1.44 | -5.48 | grey limestone |
| 370   | Devonian | Famennian | BS005 | 126  | 1.33 | -5.93 | red limestone |
| 370   | Devonian | Famennian | BS006 | 128  | 1.17 | -6   | red limestone |
| 370   | Devonian | Famennian | BS007 | 130  | 1.35 | -5.78 | red limestone |
| 370   | Devonian | Famennian | BS008 | 130  | 1.34 | -5.9  | red limestone |
| 370   | Devonian | Famennian | BS009 | 132  | 1.55 | -5.61 | 0.3  | red limestone |
| 370   | Devonian | Famennian | BS010 | 133  | 1.51 | -5.68 | red limestone |
| 370   | Devonian | Famennian | BS011 | 134  | 1.65 | -5.87 | red limestone |
| 370   | Devonian | Famennian | BS012 | 135  | 1.55 | -5.87 | 0.86 | red limestone |
| 370   | Devonian | Famennian | BS013 | 136  | 0.98 | -6.06 | red limestone |
| 370   | Devonian | Famennian | BS014 | 136  | 1.58 | -6.26 | red limestone |
| 370   | Devonian | Famennian | BS015 | 137  | 1.69 | -6.25 | red limestone |
| 370   | Devonian | Famennian | BS016 | 139  | 1.75 | -4.59 | red limestone |
| 370   | Devonian | Famennian | BS017 | 140  | 1.37 | -8.81 | 0.3  | red limestone |
| 370   | Devonian | Famennian | BS018 | 142  | 1.98 | -6.36 | red limestone |
| 370   | Devonian | Famennian | BS019 | 144  | 1.98 | -6.48 | red limestone |
| 370   | Devonian | Famennian | BS020 | 145.5| 2.21 | -5.92 | red limestone |
| 370   | Devonian | Famennian | BS021 | 147.5| 2.05 | -6.08 | red limestone |
| 370   | Devonian | Famennian | BS022 | 149.5| 1.96 | -6.64 | 0.65 | red limestone |
| 370   | Devonian | Famennian | BS023 | 151.5| 1.9  | -6.39 | grey limestone |
| 370   | Devonian | Famennian | BS024 | 156.5| 1.95 | -6.49 | grey limestone |
| 370   | Devonian | Famennian | BS025 | 161  | 1.73 | -6.15 | grey limestone |
| 370   | Devonian | Famennian | BS026 | 163  | 1.97 | -6.9 | 0.31 | grey limestone |
| 370   | Devonian | Famennian | BS027 | 163  | 2.01 | -6.82 | grey limestone |
| 370   | Devonian | Famennian | BS028 | 167.5| 2.09 | -6.5  | grey limestone |
| 370   | Devonian | Famennian | BS029 | 169.5| 2.49 | -6.4  | grey limestone |
| 370   | Devonian | Famennian | BS030 | 173  | 2.17 | -5.69 | grey limestone |
| 370   | Devonian | Famennian | BS031 | 175  | 2.18 | -6.25 | grey limestone |
| 370   | Devonian | Famennian | BS032 | 179  | 2.2  | -5.69 | grey limestone |
| Age   | Stage | Locality | RSm   | SiO2 | K2O  | Na2O | MgO | CaO  | FeO  |
|-------|-------|----------|-------|------|------|------|-----|------|------|
| ~370  | Devonian | Famennian | BS033 | 182  | 2.59 | -5.42|      |      |      |
| ~370  | Devonian | Famennian | BS034 | 185  | 2.46 | -5.5 |      |      |      |
| ~370  | Devonian | Famennian | BS035 | 188  | 2.41 | -4.98|      |      |      |
| ~358  | Ediacaran |            | NM001 | 64.8 | -9.83| -10.09|      |      |      |
| ~358  | Ediacaran |            | NM002 | 61   | -9.7 | -10.2 |      |      |      |
| ~358  | Ediacaran |            | NM003 | 59.5 | -10.1| -8.63 |      |      |      |
| ~358  | Ediacaran |            | NM004 | 58.5 | -9.73| -6.65 |      |      |      |
| ~358  | Ediacaran |            | NM005 | 57   | -9.72| -9.06 |      |      |      |
| ~358  | Ediacaran |            | NM006 | 56   | -10.06| -8.61 |      |      |      |
| ~358  | Ediacaran |            | NM007 | 55   | -9.52| -7.58 |      |      |      |
| ~358  | Ediacaran |            | NM008 | 53.5 | -9.76| -9.73 |      |      |      |
| ~358  | Ediacaran |            | NM009 | 50   | -10.32| -9.56 |      |      |      |
| ~358  | Ediacaran |            | NM010 | 49   | -10.31| -9.09 |      |      |      |
| ~358  | Ediacaran |            | NM011 | 46   | -10.54| -9.09 |      |      |      |
| ~358  | Ediacaran |            | NM012 | 45   | -10.38| -10.35|      |      |      |
| ~358  | Ediacaran |            | NM013 | 43   | -10.63| -7.65 |      |      |      |
| ~358  | Ediacaran |            | NM014 | 42   | -10.53| -7.71 |      |      |      |
| ~358  | Ediacaran |            | NM015 | 41   | -10.78| -8.3 |      |      |      |
| ~358  | Ediacaran |            | NM016 | 40   | -10.42| -7.73 |      |      |      |
| ~358  | Ediacaran |            | NM017 | 39.5 | -10.78| -7.72 |      |      |      |
| ~358  | Ediacaran |            | NM018 | 38   | -10.88| -8.34 |      |      |      |
| ~358  | Ediacaran |            | NM019 | 37   | -11.09| -6.68 |      |      |      |
| ~358  | Ediacaran |            | NM020 | 36   | -12.12| -7.75 |      |      |      |
| ~358  | Ediacaran |            | NM021 | 35   | -10.67| -7.95 |      |      |      |
| ~358  | Ediacaran |            | NM022 | 34   | -10.15| -8.35 |      |      |      |
| ~358  | Ediacaran |            | NM023 | 33.5 | -10.44| -8.61 |      |      |      |
| ~358  | Ediacaran |            | NM024 | 33.5 | -10.55| -8.12 |      |      |      |
| ~358  | Ediacaran |            | NM025 | 32.5 | -10.82| -6.07 |      |      |      |
| ~358  | Ediacaran |            | NM026 | 31.5 | -11.92| -8.11 |      |      |      |
| ~358  | Ediacaran |            | NM027 | 30.3 | -11.99| -8.09 |      |      |      |
| ~358  | Ediacaran |            | NM028 | 29.5 | -11.94| -8.26 |      |      |      |
| ~358  | Ediacaran |            | NM029 | 28.5 | -11.84| -10.92|      |      |      |
| ~358  | Ediacaran |            | NM030 | 21   | -10.24| -10.92|      |      |      |
| ~358  | Ediacaran |            | NM031 | 17   | -10.23| -8.17 |      |      |      |
| ~358  | Ediacaran |            | NM032 | 16.5 | -10.92| -7.51 |      |      |      |
| ~358  | Ediacaran |            | NM033 | 16   | -10.87| -8.82 |      |      |      |
| ~358  | Ediacaran |            | NM034 | 15.5 | -8.94 | -7.72 |      |      |      |
| ~358  | Ediacaran |            | NM035 | 2.4  | -6.1 | -8.14 |      |      |      |
| ~358  | Ediacaran |            | NM036 | 2.1  | -5.36| -7.58 |      |      |      |
| ~358  | Ediacaran |            | NM037 | 1.8  | -5.12| -8.25 |      |      |      |
| ~358  | Ediacaran |            | NM038 | 1.5  | -5.26| -8.34 |      |      |      |
| ~358  | Ediacaran |            | NM039 | 1.2  | -5.1| -9.97 |      |      |      |

Notes: BS033-035: grey limestone, NM001-039: red dolomite, NM040: oolitic dolomite.
| Age  | Sample   | Depth (m) | X-ray (μm) | Rock Type               |
|------|----------|-----------|------------|-------------------------|
| 580  | Ediacaran| 0.8       | -4.47      | oolitic dolomite         |
| 580  | Ediacaran| 0.8       | -4.49      | oolitic dolomite         |
| 580  | Ediacaran| 0.5       | -4.63      | oolitic dolomite         |
| 580  | Ediacaran| 0.3       | -4.96      | oolitic dolomite         |
| 580  | Ediacaran| 0       | -4.55      | oolitic dolomite         |
| 580  | Ediacaran| 0.5       | -0.69      | light grey dolomite      |
| 580  | Ediacaran| 1         | 0.22       | light grey dolomite      |
| 580  | Ediacaran| 1.1       | -0.53      | light grey dolomite      |
| 580  | Ediacaran| 1.7       | 0.9        | light grey dolomite      |
| 580  | Ediacaran| 1.9       | 0.17       | light grey dolomite      |
| 580  | Ediacaran| 2         | 0.34       | light grey dolomite      |
| 580  | Ediacaran| 2.2       | 0.8        | light grey dolomite      |
| 580  | Ediacaran| 2.5       | 0.95       | light grey dolomite      |
| 580  | Ediacaran| 2.8       | 0.92       | light grey dolomite      |
| 580  | Ediacaran| 2.9       | 0.16       | light grey dolomite      |
| 580  | Ediacaran| 3         | 0.31       | light grey dolomite      |
| 580  | Ediacaran| 3.2       | 2.1        | light grey dolomite      |
| 580  | Ediacaran| 3.6       | 1.84       | light grey dolomite      |
| 580  | Ediacaran| 4         | 2.43       | light grey dolomite      |
| 580  | Ediacaran| 4.4       | 2.22       | light grey dolomite      |
| 580  | Ediacaran| 4.8       | 2.82       | light grey dolomite      |
| 580  | Ediacaran| 5.2       | 2.36       | light grey dolomite      |
| 580  | Ediacaran| 5.5       | 2.83       | light grey dolomite      |
| 580  | Ediacaran| 5.7       | 2.79       | light grey dolomite      |
| 580  | Ediacaran| 5.9       | 2.61       | light grey dolomite      |
| 580  | Ediacaran| 5.9       | 2.62       | light grey dolomite      |
| 580  | Ediacaran| 6.7       | 2.63       | light grey dolomite      |
| 580  | Ediacaran| 11        | -7.64      | red dolomite             |
| 580  | Ediacaran| 11.8      | -7.38      | red dolomite             |
| 580  | Ediacaran| 13        | -7.38      | red dolomite             |
| 580  | Ediacaran| 13.8      | -7.48      | red dolomite             |
| 580  | Ediacaran| 14.6      | -7.7       | red dolomite             |
| 580  | Ediacaran| 15.3      | -8.09      | red dolomite             |
| 580  | Ediacaran| 16.2      | -8.78      | red dolomite             |
| 580  | Ediacaran| 17.1      | -8.36      | red dolomite             |
| 580  | Ediacaran| 18        | -8.01      | red dolomite             |
| 580  | Ediacaran| 18.8      | -9.03      | red dolomite             |
| 580  | Ediacaran| 19.8      | -8.65      | red dolomite             |
| 580  | Ediacaran| 22.4      | -8.45      | grey limestone           |
| 580  | Ediacaran| 22.8      | -8.32      | grey limestone           |
| 580  | Ediacaran| 23        | -6.69      | grey limestone           |
| 580  | Ediacaran| 23.2      | -8.14      | grey limestone           |
| Age  | Formation | Site | Age (ky) | Width (mm) | Length (mm) | Thickness (mm) | Rock Type |
|------|-----------|------|----------|------------|-------------|----------------|-----------|
| 580  | Ediacaran  | SJH038 | 23.6     | -7.8       | -7.13       | 3.19           | grey limestone |
| 580  | Ediacaran  | SJH039 | 23.8     | -8.23      | -9.31       | grey limestone |
| 580  | Ediacaran  | SJH040 | 24.5     | -7.49      | -7.42       | grey limestone |
| 580  | Ediacaran  | SJH041 | 25.1     | -6.76      | -9.28       | grey limestone |
| 580  | Ediacaran  | SJH042 | 25.7     | -7.9       | -8.94       | grey limestone |
| 580  | Ediacaran  | SJH043 | 26.2     | -7.48      | -8.16       | grey limestone |
| 580  | Ediacaran  | SJH044 | 26.8     | -7.84      | -8.17       | grey limestone |
| 580  | Ediacaran  | SJH045 | 27.5     | -8.02      | -8.06       | grey limestone |
| 580  | Ediacaran  | SJH046 | 28       | -7.38      | -7.38       | grey limestone |
| 580  | Ediacaran  | SJH047 | 28.2     | -7.78      | -8.54       | grey limestone |
| 580  | Ediacaran  | SJH048 | 28.5     | -7.49      | -8.49       | grey limestone |
| 580  | Ediacaran  | SJH049 | 28.8     | -7.8       | -3.11       | grey limestone |
| 750  | Tonian     | SYB001 | 4        | -6.01      | -23.13      | 10.02          | marble    |
| 750  | Tonian     | SYB002 | 12       | -6.5       | -22.89      | marble         |
| 750  | Tonian     | SYB003 | 19.5     | -6.31      | -22.93      | marble         |
| 750  | Tonian     | SYB004 | 21       | -5.76      | -22.3       | 5.65           | marble    |
| 750  | Tonian     | SYB005 | 28       | -6.81      | -21.79      | marble         |
| 750  | Tonian     | SYB006 | 36       | -11.06     | -19.28      | 22.45          | banded iron formation |
| 750  | Tonian     | SYB007 | 43.6     | -8.62      | -19.73      | 8.06           | marble    |
| 750  | Tonian     | SYB008 | 52.5     | -11.94     | -19.22      | 1.67           | marble    |
| 750  | Tonian     | SYB009 | 55       | -8.31      | -17.97      | 9.17           | marble    |
| 750  | Tonian     | SYB010 | 57.5     | -6.52      | -24.16      | marble         |
| 750  | Tonian     | SYB011 | 60.6     | -5.83      | -24.96      | 1.67           | marble    |
| 750  | Tonian     | SYB012 | 63.5     | -6.41      | -24.52      | marble         |
| 750  | Tonian     | SYB013 | 67.5     | -4.78      | -16.45      | marble         |
| 750  | Tonian     | SYB014 | 71.5     | -4.72      | -16.29      | marble         |
| 750  | Tonian     | SYB015 | 77       | -3.78      | -11.41      | 4.72           | marble    |
| 750  | Tonian     | SYB016 | 83.5     | -1.86      | -13.86      | marble         |
| 2500 | Siderian   | KJG001 | 170      | -2.98      | -19.65      | 14.4           | calcareous schist |
| 2500 | Siderian   | KJG002 | 160      | -3.06      | -19.8       | calcareous schist |
| 2500 | Siderian   | KJG003 | 150      | -3.46      | -10.86      | calcareous schist |
| 2500 | Siderian   | KJG004 | 145      | 0.13       | -5.21       | 16.23          | calcareous schist |
| 2500 | Siderian   | KJG005 | 140      | -3.03      | -19.85      | calcareous schist |
| 2500 | Siderian   | KJG006 | 130      | -5.37      | -9.37       | banded iron formation |
| 2500 | Siderian   | KJG007 | 128      | -2.62      | -7.88       | banded iron formation |
| 2500 | Siderian   | KJG008 | 126      | -4.43      | -8.48       | banded iron formation |
| 2500 | Siderian   | KJG009 | 122      | -5.32      | -8.39       | 23.81          | banded iron formation |
| 2500 | Siderian   | KJG010 | 120      | -3.83      | -8.66       | banded iron formation |
| 2500 | Siderian   | KJG011 | 118      | -3.68      | -18.48      | banded iron formation |
| 2500 | Siderian   | KJG012 | 118      | -3.68      | -18.47      | 41.98          | banded iron formation |
| 2500 | Siderian   | KJG013 | 116      | -3.94      | -8.56       | banded iron formation |

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| Sample ID | Location | Age | Type | Description |
|-----------|----------|-----|------|-------------|
| Siderian KJG014 | 114 | -4.06 | 17.14 | banded iron formation |
| Siderian KJG015 | 108 | -3.45 | 16.91 | banded iron formation |
| Siderian KJG016 | 107 | -3.69 | 16.93 | 41.92 | banded iron formation |
| Siderian KJG017 | 106 | -3.58 | 16.67 | banded iron formation |
| Siderian KJG018 | 104.5 | -1.39 | 8.33 | banded iron formation |
| Siderian KJG019 | 102.5 | -3.39 | 9.66 | 37.02 | banded iron formation |
| Siderian KJG020 | 101 | -3.58 | 17.47 | banded iron formation |
| Siderian KJG021 | 100.3 | -3.42 | 16.88 | banded iron formation |
| Siderian KJG022 | 100.3 | -3.32 | 16.81 | banded iron formation |
| Siderian KJG023 | 100.3 | -3.67 | 17.25 | 30.02 | banded iron formation |
| Siderian KJG024 | 99.8 | -2.02 | 18.59 | calcareous schist |
| Siderian KJG025 | 99.3 | -2.21 | 16.81 | calcareous schist |
| Siderian KJG026 | 99.3 | -2.5 | 16.93 | calcareous schist |
| Siderian KJG027 | 99 | -1.98 | 16.46 | calcareous schist |
| Siderian KJG028 | 98.8 | -2.05 | 18.52 | 18.05 | calcareous schist |
| Siderian KJG029 | 98.8 | -1.97 | 18.59 | calcareous schist |
| Siderian KJG030 | 98.8 | -1.81 | 18.32 | calcareous schist |
| Siderian KJG031 | 80 | -1.9 | 19.81 | calcareous schist |
| Siderian KJG032 | 77 | -2.08 | 19.64 | calcareous schist |
| Siderian KJG033 | 77 | -1.94 | 19.72 | calcareous schist |
| Siderian KJG034 | 65 | -1.27 | 19.64 | 18.77 | calcareous schist |
| Siderian KJG035 | 60 | -1.46 | 19.12 | calcareous schist |
| Siderian KJG036 | 50 | -2.15 | 19.19 | calcareous schist |
| Siderian KJG037 | 40 | -1.72 | 19.76 | 17.68 | calcareous schist |
### Supplementary Table 2 | MRBs and BIFss in the Phanerozoic and Precambrian.

| Age (Ma) | Period/Stage | Formation | Lithology | Thickness (m) | Locations | References of MRB and BIF | Paleolatitude | References of Paleolatitude |
|----------|--------------|-----------|-----------|---------------|-----------|--------------------------|---------------|-----------------------------|
| 70       | Maastrichtian| claystone | 10        | ODP-Leg 149-Site 899, North Atlantic | 1         | N0-30                    | 2             |                             |
| 70       | Maastrichtian| claystone | 10        | ODP-Leg 171B-Site 1049C, North Atlantic | 1         | N0-30                    | 2             |                             |
| 70       | Maastrichtian| limestone | 20        | ODP-Leg 207-Site 1258, South Atlantic | 1         | S0-30                    | 2             |                             |
| 80       | Campanian    |          |           |               |            | Globally distribution    | 3             | N30-60                      | 2             |
| 80       | Campanian    |          |           |               |            | Globally distribution    | 3             | N0-30                       | 2             |
| 80       | Campanian    |          |           |               |            | Globally distribution    | 3             | S0-30                       | 2             |
| 80       | Campanian    |          |           |               |            | Globally distribution    | 3             | S10-60                      | 2             |
| 80       | Campanian    | Chuangde Formation | shale, limestone | 25 | Gyangze Chuangde section, Tibet | 4 | S0-30 | 2 |
| 83       | Santonian-Lower Campanian | Chuangde Formation | limestone, shale | 30 | Chuangde section, Tibet | This study | S0-30 | 2 |
| 83.6-66  | Campanian-Maastrichtian | claystone | 23 | ODP-Leg 171B-Site 1050, North Atlantic | 1 | N0-30 | 2 |
| 83.6-66  | Campanian-Maastrichtian | limestone, claystone | 30-80 | South Atlantic | 5 | S10-60 | 2 |
| 83.6-66  | Campanian-Maastrichtian | limestone, claystone | 0.7-150 | Pacific | 5 | S0-30 | 2 |
| 83.6-66  | Campanian-Maastrichtian | claystone | 13-115 | Indian Ocean | 5 | S10-60 | 2 |
| 83.6-70  | Campanian-early Maastrichtian | Chuangde Formation | limestone, shale | 125 | Tianbu section, Tibet | 6 | S0-30 | 2 |
| 84-72.1  | upper Santonian-Campanian | limestone, shale | 10-600 | Tethys | 5 | S0-30 | 2 |
| 84       | late Santonian | Dicarinella asymetrica zone | limestone | 5 | Çavuşdere section, Turkey | 7 | N0-30 | 2 |
| 84       | late Santonian | Dicarinella asymetrica zone | limestone | 7 | Doğrumentüel section, Turkey | 7 | N0-30 | 2 |
| 84       | late Santonian | Dicarinella asymetrica zone | limestone | 6 | Sammaçavuş section, Turkey | 7 | N0-30 | 2 |
| 84       | late Santonian | Dicarinella asymetrica zone | limestone | 3 | Muğumu section, Turkey | 7 | N0-30 | 2 |
| 84       | late Santonian | Dicarinella asymetrica zone | limestone | 9 | Gölünük-Sünnet section, Turkey | 7 | N0-30 | 2 |
| 84       | late Santonian | Dicarinella asymetrica zone | limestone | 13 | İsmailler section, Turkey | 7 | N0-30 | 2 |
| 89.8-83.6 | Coniacian-Santonian | limestone | 42 | ODP-Leg 192-Site 1183, Indian Ocean | 1 | S10-60 | 2 |
| Time         | Event                        | Location                     | Depth (m) | Site/Section          | Latitude  | Longitude | Age       | References                              |
|--------------|------------------------------|------------------------------|-----------|-----------------------|-----------|-----------|-----------|------------------------------------------|
| 93.5-65      | Turonian-early Paleocene     | Scaglia Rossa                | 260       | Bottaccione section, Italy | N0-30    | 2         |
| 93.9-66      | Turonian-Maastrichtian       | clayslate                    | 30-60     | North Atlantic        | N0-30    | 2         |
| 93.9-83.6    | Turonian-Santonian           | clayslate                    | 45        | ODP-Leg 210-Site 1276, North Atlantic | N0-30    | 2         |
| 93.9-86.3    | Turonian-Coniacian           | clayslate                    | 19        | ODP-Leg 171B-Site 1050, North Atlantic | N0-30    | 2         |
| 95-86.3      | Late Cenomanian-Coniacian    | clayslate                    | 10-20     | New Zealand           | S0-90    | 2         |
| 95-90        | Late Cenomanian, middle Turonian | Solde Formation, limestone | 35        | Boreal realm          | N0-30-60 | 2         |
| 97-95        | Cenomanian                   | Mazak Formation, shale       |           | Outer Western Carpathians, Czech | N0-30-60 | 2         |
| 93           | Turonian                     | Helvetotrunca helvetica Zone | mudstone  | Buchberg, Switzerland | N0-30    | 2         |
| 95           | Late Cenomanian              | Whetenella arche osovica Zone | shale     | Çavuşdere section, Turkey | N0-30    | 2         |
| 95           | Late Cenomanian              | Whetenella arche osovica Zone | shale     | Göynük-Sünnet section, Turkey | N0-30    | 2         |
| 95           | Late Cenomanian              | Whetenella arche osovica Zone | shale     | İsmailler section, Turkey | N0-30    | 2         |
| 100-88       | Cenomanian-Turonian          | Botita-Botita Formation, shale | 120       | Audia Nappe, Romania  | N0-30-60 | 2         |
| 100-88       | Cenomanian-Turonian          | Carnu-Siclau Formation, shale | 60        | Tarcau Nappe, Romania | N0-30-60 | 2         |
| 100-88       | Cenomanian-Turonian          | claystone                    | 19.5      | DSDP-Leg 11-Site 105, Atlantic Ocean | N0-30-60 | 2         |
| 101-95       | Late Albian-Cenomanian       | Skalski Marl Member, mudstone, shale | Pieniny Klippen Basin, Poland | N0-30-60 | 2         |
| 101-99       | Late Albian                  | Ustree Buste Schiefer, shale | 8         | Rhenodanubian Flysch, Austria | N0-30-60 | 2         |
| 101-99       | Late Albian                  | Red Chalk Formation, chalk   | 3         | East Carpathians, Romania | N0-30-60 | 2         |
| 105          | Mid-Cretaceous               | limestone                    | 8         | Zanskar Himalaya, India | S0-30    | 2         |
| 105          | Mid-Cretaceous               | Globally distribution        | 3         | N0-30-60 | 2         |
| 105          | Mid-Cretaceous               | Globally distribution        | 3         | S0-30    | 2         |
| 105          | Late Albian                  | Biticinella breggio nus Zone | shale     | Samaçavuş section, Turkey | N0-30    | 2         |
| 105          | Late Albian                  | Biticinella breggio nus Zone | shale     | Mudurnu section, Turkey | N0-30    | 2         |
| 108-100      | Albian                       | Red Chalk Formation, chalk   | 9         | Northeastern England  | N0-30-60 | 2         |
| Sample ID | Geologic Age | Sample Type | Depth (m) | Location | Horizon | Site Number | Location Type |
|-----------|--------------|-------------|-----------|----------|----------|-------------|---------------|
| 110       | Albian       | claystone   | 10 m      | ODP-Leg 171B-Site 1049C, North Atlantic | 1 | N0-30 | 2 |
| 110       | Albian       | claystone   | 65 m      | ODP-Leg 159-Site 962, South Atlantic | 1 | S30-60 | 2 |
| 113-93.9  | Albian-Cenomanian | claystone | 13 m      | ODP-Leg 171B-Site 1050, North Atlantic | 1 | N0-30 | 2 |
| 113       | late Aptian-early Albian | Puratiscocollis euh eumansensis Zone | mudstone | 10 m | North Atlantic | 12 | N0-30 | 2 |
| 115       | late Aptian  | Planomalina cheviensis Zone | limestone | 3 m | Sınmetgili section, Turkey | 7 | N0-30 | 2 |
| 115       | late Aptian  | Planomalina cheviensis Zone | limestone | 15 m | Değirmençil section, Turkey | 7 | N0-30 | 2 |
| 115       | late Aptian  | Planomalina cheviensis Zone | limestone | 1 m | Mudumu section, Turkey | 7 | N0-30 | 2 |
| 115       | late Aptian  | Globigerinelloides algerianus Zone | limestone | 4 m | Sınmetgili section, Turkey | 7 | N0-30 | 2 |
| 116-112   | Aptian       | Schrambach Formation | limestone | North Calcareous Alps, Austria | 9 | N30-60 | 2 |
| 116-112   | Aptian       | Mudovevskiya Formation | mudstone | Caucasus | 9 | N60-90 | 2 |
| 118-108   | Aptian-Albian | claystone | Atlantic | 9 | N0-30 | 2 |
| 118-108   | Aptian-Albian | claystone | Atlantic | 9 | S0-30 | 2 |
| 118-108   | Aptian-Albian | claystone | Atlantic | 9 | S30-60 | 2 |
| 120       | early Aptian  | Leupoldina cabri Zone | shale | 3 m | Samsaçavuş section, Turkey | 7 | N0-30 | 2 |
| 120       | Aptian       | claystone   | 10 m      | ODP-Leg 171B-Site 1049C, North Atlantic | 1 | N0-30 | 2 |
| 120       | Aptian       | claystone   | 5 m       | ODP-Leg 192-Site 1187, Indian Ocean | 1 | S30-60 | 2 |
| 125-100   | Aptian and Albian | Mamea Fuzoidi | limestone, claystone | ~30 m | Piobbico Core, Italy | 9 | N0-30 | 2 |
| 125-100.5 | Aptian-Albian | claystone   | 78 m      | ODP-Leg 198-Site 1213, Pacific Ocean | 5 | N0-30 | 2 |
| 125-100.5 | Aptian-Albian | claystone   | 60 m      | ODP-Leg 198-Site 1214, Pacific Ocean | 5 | S0-30 | 2 |
| 125-100.5 | Aptian-Albian | claystone   | 22 m      | ODP-Leg 192-Site 1184, Indian Ocean | 1 | S30-60 | 2 |
| 125-100.5 | Aptian-Albian | claystone   | 3.3 m     | DSDP-Leg 41-Site 367, Atlantic Ocean | 1 | N0-30 | 2 |
| 133       | late Valanginian-early Hauterivian | Rosso Ammonitico | limestone | 5 m | Trento Plateau, Italy | 13 | N0-30 | 2 |
|   |                     |       |       |                     |       |
|---|---------------------|-------|-------|---------------------|-------|
| 150| Tithonian           | limestone | 15 m  | Subbetic Cordillera, Spain | 14    |
| 163.5-145 | Oxfordian-Tithonian   | limestone | 9-13 m | Betic Cordillera, Spain | 15    |
| 165 | middle Callovian    | Dalichai Formation | limestone | east Alborz, Iran | 16    |
| 165 | Callovian           | Tabanos Formation | limestone, mudstone | Neaquén Basin, Argentina | 17    |
| 166.1-139 | Callovian-late Berriasian | Rosso Ammonitico | limestone | Monte Inci, Sicily | 18    |
| 166.1-145 | Callovian-Tithonian | Ammonitico Rosso Veronese | limestone | Trento Plateau, Italy | 19    |
| 169-145 | late Bajocian-Tithonian | Rosso Ammonitico Veronese | limestone | Verona, Italy | 20    |
| 169-145 | late Bajocian-Tithonian | Rosso Ammonitico Inferiore | limestone | Asiago, Italy | 20    |
| 168.3 | late Bajocian      | Dalichai Formation | limestone | east Alborz, Iran | 16    |
| 170.3-145 | Bajocian-Tithonian | Rosso Ammonitico Veronese | limestone | Northeastern Italy | 21    |
| 170.3-145 | Bajocian-Tithonian | Rosso Ammonitico Veronese | limestone | Luznic Lake area, Slovenia | 22    |
| ~170 | Bajocian            | Rosso Ammonitico Veronese | limestone | Triglav Lake Valley, Slovenia | 22    |
| ~170 | Bajocian            | shale |       | Central Japan | 23    |
| 174.1-145 | late Toarcian-Tithonian | Rosso Ammonitico Veronese | limestone | Julian Alps, Slovenia | 22    |
| 174.1-145 | late Toarcian-Tithonian | Rosso Ammonitico | limestone | Western Sicily, Italy | 24    |
| 174.1-157 | Toarcian-Oxfordian | Rosso Ammonitico | limestone | MonteKameta, Sicily | 25    |
| 175-163.5 | late Toarcian-Callovian | Rosso Ammonitico | limestone | Ankara, Turkey | 26    |
| 175 | late Toarcian      | Polymorphum Zone | limestone | Izmirloz, Spain | 27    |
| 175 | late Toarcian      | Rosso Ammonitico | limestone | ValdMIRBlia, Italy | 28    |
| 175 | Toarcian           | Rosso Ammonitico | limestone | Ticino, Switzerland | 29    |
| Age         | Location                      | Formation                                | Rock Type      | Thickness | Location Details | N0-30 | Notes          |
|-------------|-------------------------------|------------------------------------------|----------------|-----------|------------------|-------|----------------|
| 182.7-170   | Toarcian-Aalenian             | Rosso Ammonitico                          | limestone      | 35 m      | Ionian Basin, Greece | 30, 31 | N0-30 | 2              |
| 182.7-170   | Toarcian-Aalenian             | Rosso Ammonitico                          | limestone      | 30 m      | Ionian Basin, Greece | 32    | N0-30 | 2              |
| ~189        | Pliensbachian                 | Lower Senkoy Formation                    | limestone, mudstone | ~18 m    | Senkoy, Turkey     | 33    | N0-30 | 2              |
| ~189        | Pliensbachian                 | Lower Senkoy Formation                    | limestone, mudstone | ~22 m    | Gokdere, Turkey     | 33    | N0-30 | 2              |
| 189         | early Pliensbachian           | Ammonitico Rosso                          | limestone      |           | Anatolia, Turkey    | 34    | N0-30 | 2              |
| 195         | Sinemurian                    | Ammonitico Rosso                          | limestone      | ~18 m    | Montecatini, Italy  | 35    | N0-30 | 2              |
| 195         | Sinemurian                    | Ammonitico Rosso                          | limestone, mudstone | ~26 m    | La Spezia, Italy    | 35    | N0-30 | 2              |
| 199-185     | late Hettangian-early Pliensbachian | Ammonitico Rosso         | limestone      |           | Transdanubian Central Range, Hungary | 36    | N0-30 | 2              |
| 199-185     | Hettangian-Pliensbachian      | Putnitzke Limestone Formation            | limestone      | ~20 m    | Transdanubian Central Range, Hungary | 37    | N0-30 | 2              |
| 199-185     | Hettangian-Pliensbachian      | Lower Senkoy Formation                   | limestone      | ~20 m    | Canayurdu, Turkey   | 33    | N0-30 | 2              |
| 199-185     | Hettangian-Pliensbachian      | Lower Senkoy Formation                   | limestone      | ~29 m    | Tersun, Turkey      | 33    | N0-30 | 2              |
| 199-185     | Hettangian-Pliensbachian      | Lower Senkoy Formation                   | limestone      | ~60 m    | Kirkil, Turkey      | 33    | N0-30 | 2              |
| 199-185     | Hettangian-Pliensbachian      | Lower Senkoy Formation                   | limestone      | ~50 m    | Duragiza, Turkey    | 33    | N0-30 | 2              |
| 199         | Hettangian                    | Ammonitico Rosso                          | limestone      |           | Transdanubian Central Range, Hungary | 38    | N0-30 | 2              |
| ~248        | Olenekian                     | Nanlinghu Formation                      | limestone, mudstone | 20 m     | Chaohu, South China | This study | N0-30 | 2              |
| ~248        | Spathian                      | Jialingjiang Formation                    | limestone      | 16 m     | Wulong, South China | This study | S0-30 | 2              |
| ~248        | Spathian                      | Luelou Formation                         | limestone      | 15 m     | Lalaichau, South China | This study | S0-30 | 2              |
| ~248        | Spathian                      | Luelou Formation                         | limestone      | 15 m     | Guindao, South China | This study | S0-30 | 2              |
| ~248        | Spathian                      | Luelou Formation                         | limestone      | 15 m     | Mingqiang, South China | This study | S0-30 | 2              |
| ~248        | Spathian                      | Luelou Formation                         | limestone      | 2 m      | Bianyang, South China | This study | S0-30 | 2              |
| ~248        | Spathian                      | Luelou Formation                         | limestone      | 2 m      | Qingyan, South China | This study | S0-30 | 2              |
| ~248        | Spathian                      | Jialingjiang Formation                    | limestone      | 2 m      | Zanyi, South China  | This study | S0-30 | 2              |
| ~248        | Spathian                      | Kangshu Formation                        | limestone, shale | 10 m   | Tulong, Tibet     | This study | S30-60 | 2              |
| ~248        | Spathian                      | Kangshu Formation                        | limestone      | 9 m      | Yalai, Tibet      | This study | S30-60 | 2              |
| Stage | Period | Formation | Superspecies | Location | Thickness | Reference |
|-------|--------|-----------|--------------|----------|-----------|-----------|
| -248  | Spathian | Neospathodus homeri Zone | claystone | 2 m | Aichi Prefecture, Japan | 39 | N0-30 | 2 |
| -248  | Spathian | Moenkopi Formation | limestone, shale | < 1 m | California, USA | This study | N0-30 | 2 |
| -370  | Famenian | Lower Three Forks Formation | limestone | 33 m | Montana and Wyoming, USA | 40 | S0-30 | 2 |
| -370  | Famenian | Upper Shetianshao Formation | limestone | 4.3 m | Baqi, South China | 41 | N0-30 | 2 |
| -370  | Famenian | Wuzishan Formation | limestone | 66 m | Baisha, South China | This study | N0-30 | 2 |
| -370  | Famenian | Wuzishan Formation | limestone | 12 m | Lengshuihe, South China | This study | N0-30 | 2 |
| -370  | Famenian | Nullara Limestone | limestone | 5.5 m | Canning basin, Western Australia | 42 | S0-30 | 2 |
| -370  | Famenian | Marginifer Zone, Trachytera Zone | limestone | 1.5 m | Einenberg, Germany | 43 | N0-30 | 2 |
| -370  | Frasnian-Famenian | limestone | 2 m | Vogelsberg, Germany | 44 | N0-30 | 2 |
| -370  | Famenian | Cheiloceras beds | limestone | 2 m | Casey Falls, Western Australia | 45 | S0-30 | 2 |
| -370  | Famenian | Cheiloceras beds | limestone | 2 m | McWhat Ridge, Western Australia | 45 | S0-30 | 2 |
| -370  | Famenian | Sulcifer Formation | limestone | 20-120 m | Central Kazakhstan | 46 | N30-60 | 2 |
| 372-370 | Frasnian-Famenian | Coumiac carbonate | limestone | 10 m | Coumiac, France | 47 | S0-30 | 2 |
| 494   | Jiangshangian | Wilbens Limestone | limestone | 4 m | White Creek, Texas, USA | 48 | S0-30 | 2 |
| 494   | Jiangshangian | Wilbens Limestone | limestone | 33 m | Lion Mountain, Texas, USA | 48 | S0-30 | 2 |
| -506  | Stage 5 | Oknekk Formation | limestone | | North-Central Siberia | 49 | S0-30 | 2 |
| -509  | Stage 5 | Mautou Formation | mudstone, shale | | Shandong, North China | 50 | N30-60 | 2 |
| -509  | Stage 5 | Kork Formation | limestone, mudstone | 17 m | Southeast Turkey | 51 | S30-60 | 2 |
| -509  | Stage 5 | upper Cal Tepe Formation | limestone | 47 m | Southwestern Turkey | 52 | S30-60 | 2 |
| -509  | Stage 5 | upper Lancara Formation | limestone | | Cantabrian, Spain | 53 | S30-60 | 2 |
| -509  | Stage 5 | Lancara Formation | limestone | | Spain | 54 | S30-60 | 2 |
| -509  | Stage 5 | upper Cal Tepe Formation | limestone | | Southwestern Turkey | 54 | S30-60 | 2 |
| -510  | Stage 4 | middle Montejinni Limestone | limestone, mudstone | | Northern Territory, Australia | 55 | S0-30 | 2 |
| Stage  | Formation | Location | Age | Interval | Description |
|--------|-----------|----------|-----|----------|-------------|
| 3      | Wilkawillina Limestone | Flinders Ranges, South Australia | 56 | S0-30 | 2 |
| 3      | Salauny Gis Formation | Zavkhan Basin, Mongolia | 57 | S0-30 | 2 |
| 3      | Little Hollow Formation | Nova Scotia, Canada | 58 | N0-30 | 2 |
| 3 | early Atdabanian | Ulatkan-Kyryy-Taas, Siberian | 59 | S0-30 | 2 |
| 3 | Tommotian | Zhurinskii Mys, Siberian | 59 | S0-30 | 2 |
| 3 | Tommotian | Dvortsy, Siberian | 59 | S0-30 | 2 |
| 3 | early Tommotian | Sukhurikha River, Siberian | 59 | S0-30 | 2 |
| 2 | Member 4 of Chapel Island Formation | Dantzic Cove, Newfoundland, Canada | 60, 61 | S0-30 | 2 |
| 2 | Member 4 of Chapel Island Formation | Dantzic Cove, Newfoundland, Canada | 62 | S0-30 | 2 |
| 2 | Member 4 of Chapel Island Formation | Fortune North, Newfoundland, Canada | 62 | S0-30 | 2 |
| 2 | Member 4 of Chapel Island Formation | Fortune North, Newfoundland, Canada | 63 | S0-30 | 2 |
| 2 | Tikhfist Formation | Anti-Atlas, Morocco | 64 | S10-60 | 65 |
| 2 | Johnnie Formation | northern Spring Mountains, USA | 66 | S10-60 | 65 |
| 2 | Johnnie Formation | Resting Spring Range, USA | 66 | S10-60 | 65 |
| 2 | Johnnie Formation | southern Nopah Range, USA | 66, 67 | S10-60 | 65 |
| 2 | Johnnie Formation | Johnson Canyon, USA | 66 | S10-60 | 65 |
| 2 | Johnnie Formation | Old Dad Mountains, USA | 66 | S10-60 | 65 |
| 2 | Johnnie Formation | northern Mesquite Mountains, USA | 66 | S10-60 | 65 |
| 2 | Johnnie Formation | Lesser Himalaya, India | 68 | S0-30 | 65 |
| 2 | Krol B (or Jarashi Formation) | Zhauna, Siberian | 69 | S0-30 | 65 |
| 2 | Chenchinskaya Formation | Zhauna, Siberian | 70 | S0-30 | 65 |
| 2 | Alyanchskaya Formation | Bol'shoy Patom, Siberian | 69 | S0-30 | 65 |
| 2 | Lubadi Formation | Lubadi and Lukafu, Congo | 70 | S0-30 | 65 |
| 2 | Doushantuo | Yichang, South China | 68 | S0-30 | 65 |
| Age     | Location          | Formation          | Type       | Age Range | Error | Latitude | Longitude | Notes                                      |
|---------|-------------------|--------------------|------------|-----------|-------|----------|-----------|--------------------------------------------|
| 780 ±660 | Tonian            | Braemar Ironstone  | limestone  | South Australia | 71    | N0-30    | 65        |                                            |
| 767 ±15 | Tonian            | Erin BIF           | limestone  | Erin basin, Tuva     | 72    | N30-60   | 65        |                                            |
| >717 ±3 | Tonian            | Pocatello Formation| limestone  | Idaho, North America | 73    | S0-30    | 65        |                                            |
| 730     | Tonian            | Fulu Formation     | limestone  | Sanjiang, South China | This study | N30-60   | 65        |                                            |
| 730     | Tonian            | Fulu Formation     | limestone  | Zhongjiajiang, South China | 74    | N30-60   | 65        |                                            |
| 730     | Tonian            | Fulu Formation     | limestone  | Lanyang, South China | 74    | N30-60   | 65        |                                            |
| 730     | Tonian            | Fulu Formation     | limestone  | Jiujiang, South China | 74    | N30-60   | 65        |                                            |
| 730     | Tonian            | Fulu Formation     | limestone  | Changshao, South China | 74    | N30-60   | 65        |                                            |
| 730     | Tonian            | Fulu Formation     | limestone  | Longjia, South China | 75    | N30-60   | 65        |                                            |
| 730     | Tonian            | Fulu Formation     | limestone  | Lijiapo, South China | 74    | N30-60   | 65        |                                            |
| 730     | Tonian            | Fulu Formation     | limestone  | Tandonduk River, Canada | 75    | N0-30    | 65        |                                            |
| 730     | Tonian            | Fulu Formation     | limestone  | Backbone Range, Canada | 75    | N0-30    | 65        |                                            |
| 730     | Tonian            | Fulu Formation     | limestone  | Thundercloud Range, Canada | 75    | N0-30    | 65        |                                            |
| 730     | Tonian            | Santa Cruz Formation| limestone  | Unacum, Brazil | 76    | S10-60   | 65        |                                            |
| 730     | Tonian            | Santa Cruz Formation| limestone  | Unacum, Brazil | 77    | S10-60   | 65        |                                            |
| 731 ± 4 | Tonian            | Wadi Karem BIF     | limestone  | Eastern Desert, Egypt | 78    | S0-30    | 65        |                                            |
| 734 ± 7 | Tonian            | Wadi El Dabbah BIF | limestone  | Eastern Desert, Egypt | 78    | S0-30    | 65        |                                            |
| >750    | Tonian            | Chuos Formation    | limestone  | Owambo Basin, Namibia | 79    | S0-30    | 65        |                                            |
| 1738.5 ± 0.5 | Statherian      | Cleopatra Rhyolite | limestone  | central Arizona, USA | 80    | N30-60   | 81        |                                            |
| 1874 ± 9 | Orosirian        | Vulcan Iron Formation, Menominee Group | limestone  | Great Lake, North America | 82, 83 | N30-60   | 81        |                                            |
| 1877.8 ± 1.3 | Orosirian      | Sokoman Iron Formation | limestone  | Labrador Trough, North America | 84    | N30-60   | 81        |                                            |
| 1878 ± 2 | Orosirian        | Gunflint Iron Formation, Animikie Group | limestone  | Lake Superior, North America | 85    | N30-60   | 81        |                                            |
| 1880    | Orosirian        | Sokoman Iron Formation | limestone  | Labrador Trough, North America | 86    | N30-60   | 81        |                                            |
| 1891± 8 | Orosirian        | Frere Formation    | limestone  | Earahedy Basin, Western Australia | 87, 88 | N30-60   | 81        |                                            |
| 1910 ± 10  | Orosirian       | Fence River Formation, Menominee Group | limestone  | Lake Superior, North America | 85    | N30-60   | 81        |                                            |
| Age     | Setting           | Formation/Group            | Location                   | Depth (m) | Basement      | Latitude     | Longitude    | Reference |
|---------|------------------|-----------------------------|----------------------------|-----------|---------------|--------------|--------------|-----------|
| 1914 ± 120 | Orosirian        | Morar Formation, Gwalior Group | Gwalior basin, India       | 600       | Gwalior basin | S0-30        | 90           | 89        |
| 2460 ± 5 | Siderian         | Griquatown BIF, Kuruman BIF, Ghaap Group | Transvaal basin, South Africa | 250       | Transvaal basin | S0-30        | 81           | 91, 92, 93, 94 |
| ~2460   | Siderian         | Caud Formation              | Minas Gerais, Brazil      | 350       | Minas Gerais  | S0-30        | 81           | 95, 96    |
| 2480 ± 6 | Siderian         | Penge BIF, Chuisiespoort Group | Transvaal basin, South Africa | 600       | Western Australia | S0-30        | 81           | 9, 93, 94 |
| 2481 ± 4 | Siderian         | Brockman Iron Formation     | Minas Gerais, Brazil      | 140       | Minas Gerais  | S0-30        | 81           | 97, 98, 99, 100 |
| 2533 ± 11 | Neoarchean       | Anshan Group                | Dongchongling, North China | 140       | Dongchongling | S0-30        | 81           | 101       |
| 2534 ± 8 | Neoarchean       | Luoxian Group               | Miyun, North China        | 161       | Miyun, North China | S0-30        | 81           | 103, 104, 105 |
| 2545 ± 7 | Neoarchean       | Xinghe Group                | Guyang, North China       | 500       | Guyang, North China | S0-30        | 81           | 105       |
| 2549 ± 7 | Neoarchean       | Proto BIF, Nanga Formation  | Prieska, South Africa     | 30        | Prieska, South Africa | S0-30        | 81           | 106       |
| ~2550   | Neoarchean       | Haiziyan Formation          | Luliang, North China      | 38        | Luliang, North China | S0-30        | 81           | 102       |
| ~2550   | Neoarchean       | Yuanjiacun Formation        | Wutai, North China        | 500       | Wutai, North China | S0-30        | 81           | 102       |
| ~2550   | Neoarchean       | Rio Das Velhas Supergroup   | Minas Gerais, Brazil      | 200       | Minas Gerais  | S0-30        | 81           | 96        |
| 2554 ± 10 | Neoarchean       | Kolar Group                 | Kolar, India              | 140       | Kolar, India  | S0-30        | 81           | 107, 108  |
| 2555 ± 7 | Neoarchean       | Jiaping Group               | Jiaping, North China      | 150       | Jiaping, North China | S0-30        | 81           | 110       |
| 2629 ± 4 | Neoarchean       | Wittenoom Formation         | Western Australia         | 150       | Western Australia | S0-30        | 81           | 97, 98, 99, 100, 111, 112 |
| 2677 ± 2 | Neoarchean       | Chitradurga Group           | Chitradurga, India        | 150       | Chitradurga, India | S0-30        | 81           | 108, 114  |
| 2691 ± 9 | Neoarchean       | Koolyanobbing Greenstone Belt | Western Australia         | 200       | Western Australia | S0-30        | 81           | 115, 116, 117, 118 |
| 2718 ± 6 | Neoarchean       | Bababudan Group             | Kamatuka, India           | 150       | Kamatuka, India | S0-30        | 81           | 114, 119  |
| 2731 ± 2 | Neoarchean       | North Spirit Lake greenstone belt | Northwestern Ontario, Canada | 200       | Northwestern Ontario, Canada | S0-30        | 81           | 120       |
| 2747 ± 1 | Neoarchean       | Carajás BIF                 | Carajás, Brazil           | 250       | Carajás, Brazil | S0-30        | 81           | 121       |
| 2847 ± 4 | Neoarchean       | Illilarsup Quqqa BIF        | Disko Bay, West Greenland | 400       | Disko Bay, West Greenland | S0-30        | 81           | 122       |
| 2914 ± 8 | Neoarchean       | West Rand Group             | Witwatersrand basin, South Africa | minor       | Witwatersrand basin, South Africa | S0-30        | 81           | 123       |
| 2990 ± 7 | Neoarchean       | Mosquito Creek Formation    | Western Australia         | 250       | Western Australia | S0-30        | 81           | 124       |
| 3014 ± 13 | Neoarchean       | Western Gneiss Terrain      | Western Australia         | 250       | Western Australia | S0-30        | 81           | 125       |
| 3112 ± 6 | Neoarchean       | Cleaverville                | Western Australia         | 250       | Western Australia | S0-30        | 81           | 124, 126  |
| Age (Ma ± Uncertainty) | Eon | Supracrustal Belt | Formation | Rock Type | Location | Latitude | Longitude | Reference | Notes |
|-----------------------|-----|------------------|-----------|-----------|----------|----------|-----------|-----------|-------|
| 3235 ± 3              | Paleoproterozoic | Nimmingarra Iron Formation | ironstone | 50 m | Western Australia | 100, 127 | S30-60° | 113 |
| 3243 ± 4              | Paleoproterozoic | Jaspilite BIF | ironstone | 40 m | Barberton, South Africa | 100, 128 | S60-90° | 113 |
| 3298 ± 7              | Paleoproterozoic | Sardar Group | ironstone | | Karnataka, India | 114, 129 | S30-60° | 113 |
| 3506.8 ± 2.3          | Paleoproterozoic | Iron Ore Group | ironstone | 120 m | Singhbhum, India | 130 | S30-60° | 113 |
| 3689 ± 5              | Early Archean | Isua Supracrustal Belt | ironstone | 5 m | Nuuk, West Greenland | 131, 132 | S30-60° | 113 |
| 3802 ± 12             | Early Archean | Nuvvuagittuq Supracrustal Belt | ironstone | 35 m | Quebec, Canada | 133 | S30-60° | 113 |
| 3850                  | Early Archean | Itsaq Gneiss Complex | ironstone | 20 m | Akilia, West Greenland | 134 | S30-60° | 113 |
### Supplementary Table 3 | Carbon isotope data used in Figure 2c.

| Age (Ma) | Era       | Period     | Stage          | Strata unite          | Section                | Region     | References |
|----------|-----------|------------|----------------|-----------------------|------------------------|------------|------------|
| 84       | Mesozoic  | Cretaceous | Campanian      | Chuangde Formation    | Chuangde                | Tibet      | This study |
| 94       | Mesozoic  | Cretaceous | Turonian       | Red beds              | Buchberg                | Austria    | 10         |
| 94       | Mesozoic  | Cretaceous | Turonian       | Scaglia Rossa Formation | Gubbio                | Italy      | 167        |
| 94       | Mesozoic  | Cretaceous | Turonian       | Scaglia Rossa Formation | Gubbio                | Italy      | 168        |
| 94       | Mesozoic  | Cretaceous | Turonian       | Red beds              | Buchberg                | Austria    | 169        |
| 94       | Mesozoic  | Cretaceous | Turonian       | Red beds              | English Chalk           | UK         | 170        |
| 113      | Mesozoic  | Cretaceous | Aptian         | Scisti a Fucosidi Formation | Gorge a Cerbara | Italy      | 171        |
| 113      | Mesozoic  | Cretaceous | Aptian         | Red beds              | Yenicesihlar            | Turkey     | 172        |
| 152      | Mesozoic  | Jurassic   | Tithonian      | Rosso Ammonitico      | Monte Inici             | Sicily     | 18         |
| 157      | Mesozoic  | Jurassic   | Oxfordian-Kim meridgian | Rosso Ammonitico      | Monte Inici             | Sicily     | 18         |
| 168      | Mesozoic  | Jurassic   | Bajocian-Bathonian | Rosso Ammonitico      | Puerto Escano           | Spain      | 173        |
| 199      | Mesozoic  | Jurassic   | Hettangian-Sinemurian | Ammonitico Rosso      | Montecatini             | Italy      | 35         |
| 199      | Mesozoic  | Jurassic   | Hettangian-Sinemurian | Moltrasio Formation and Sedrina Limestone | Pozzo Glaciale | Italy      | 174        |
| 248      | Mesozoic  | Triassic   | Spalthian      | Luolou Formation      | Mingtang                | South China | This study |
| 370      | Paleozoic | Devonian   | Famennian      | Wuzhishan Formation   | Baisha                  | South China | This study |
| 509      | Paleozoic | Cambrian   | Stage 5        | La Tanque Formation   | Ferrals-les-Montagnes   | South France | 175        |
| 520      | Paleozoic | Cambrian   | Tommotian      | Pestrotsvet Formation | Dvortsy                 | Siberian   | 176        |
| 580      | Neoproterozoic | Ediacarian | Doushantuo Formation | Shijiahe              | South China             | This study |
| 580      | Neoproterozoic | Ediacarian | Johnnie Formation | North Mesquite Mountains | USA       | This study |
| 730      | Neoproterozoic | Tonian | Fula Formation | Sangyuan             | South China             | This study |
| 730      | Neoproterozoic | Tonian | Santa Cruz Formation | Uruum District         | Brazil                | 76         |
| 1900     | Paleoproterozoic | Orosirian | Gunflint Iron Formation | Thunder Bay            | Canada                | 177        |
| 2460     | Paleoproterozoic | Siderian | Kuruman Iron Formation | Adelaide Pomfret       | South Africa           | 178        |
| 2500     | Nearchean  | Siderian   | Baizhiyan Formation | Kangjiagou            | North China            | This study |
| 2500     | Nearchean  | Siderian   | Brockman Iron Formation | Hamersley Range       | Western Australia      | 111        |
| 2600     | Nearchean  | Siderian   | Mount Sylvia Iron Formation | Hamersley Range       | Western Australia      | 179        |
| 3000     | Mesarchean | Siderian   | Swaziland Sequence | Barberton Mountain Land | South Africa            | 180        |
| 3800     | Eoarchean  | Siderian   | Isua Supracrustal Belt | South Asia          | Greenland              | 181        |
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