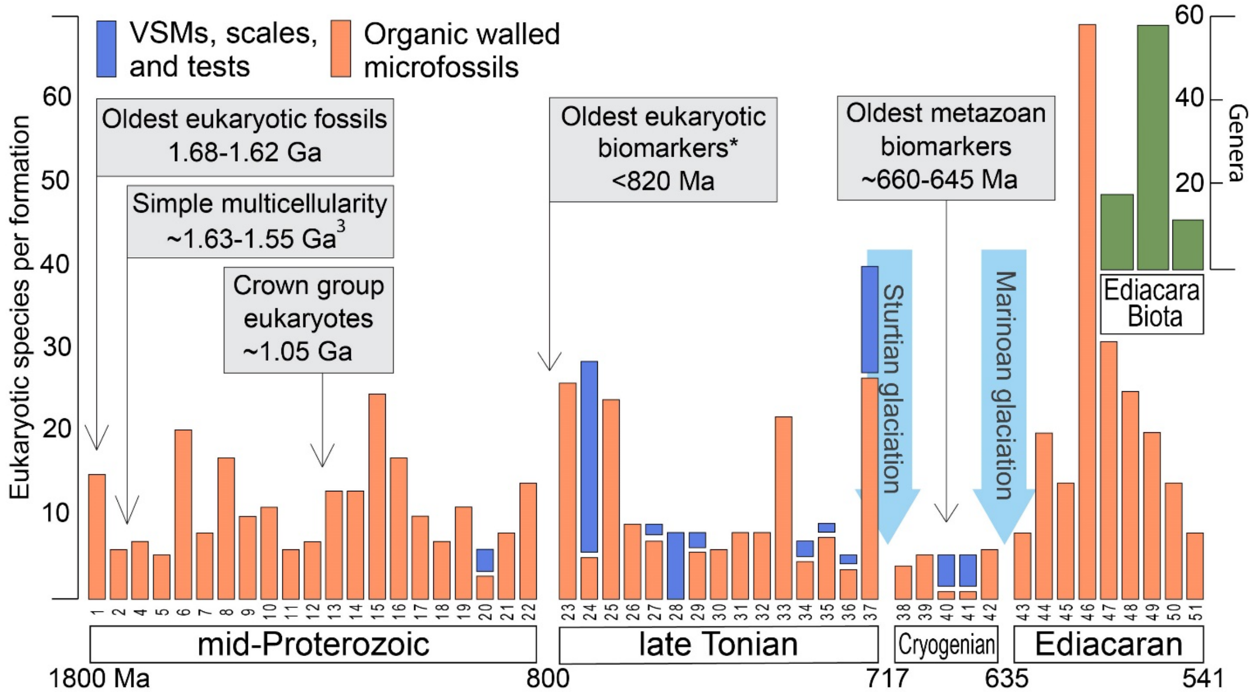
Supplementary Information:

Figure S1. Annotated version of Figure 1 and accompanying table. References for evolutionary milestones are listed at the bottom of the table.

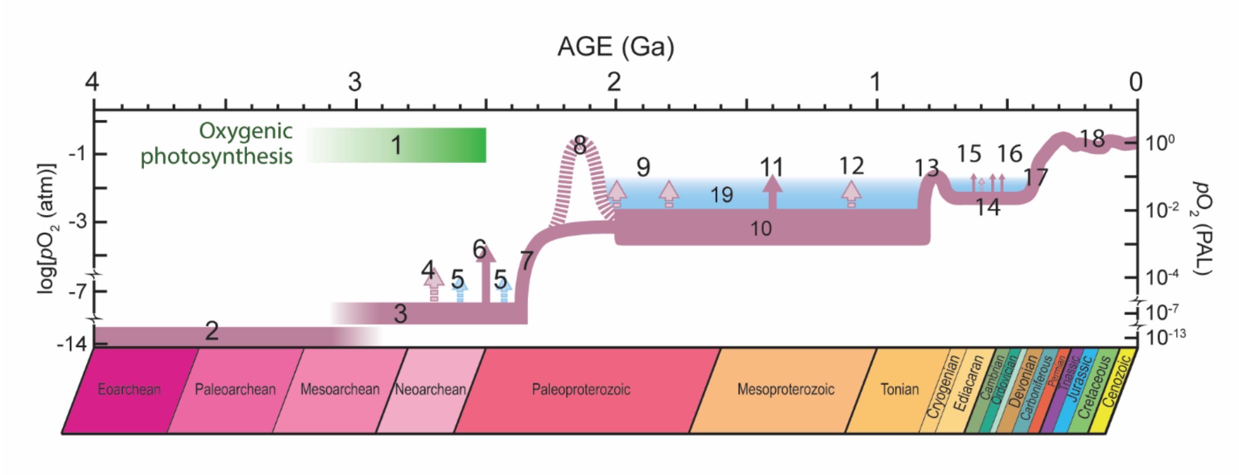


No.	Formation or Group	Approximate Age (Ma)	Eukaryotic Diversity	Primary References
1	Changzhougou Formation	1650	15	Lamb et al., 2009; Zhang, 1997
2	Chengcheng Formation	1650	6	Miao et al., 2019
3	Tuanshanzi Formation	1630	3	Qu et al., 2018
4	Ruyang Group	1645	7	Yin et al., 2005; Agić et al., 2017
5	Gaoyuzhuang Formation	1560	5	Shi et al., 2017
6	Beidajian Formation	1500	20	Agić et al., 2017
7	Roper Group	1455	8	Javaux et al., 2004; Javaux and Knoll, 2017
8	Kaltasy Formation	1435	17	Sergeev et al., 2016
9	Thule Supergroup	1135	10	Samuelsson et al., 1999
10	Atar/El Mariti Group	1100	11	Beghin et al., 2017
11	Nonesuch Shale	1095	6	Strother et al., 2011
12	Olenek Uplift	1050	7	Stanevich et al., 2009
13	Torridonian Succession	1025	13	Battison and Brasier, 2012; Strother et al., 2012
14	Lakhanda Group	1025	13	Jankauskas, 1989
15	Shaler Group	~1000	25	Loron and Moczydłowska, 2018
16	Tongjiazhuang Formation	~1000	17	Li et al., 2019

17	Mbuji-Mayi Supergroup	975	10	Baludikay et al., 2016
18	Halkal / Hulkal Formation	895	7	Sharma and Shukla, 2012; Maithy and Babu, 1996
19	Liulaobei Formation	850	11	Tang et al., 2013
20	Huainan Group	850	6	Xiao et al., 2014a
21	Basinal Assemblage of Little Dal Group	>820	8	Hofmann, 1985
22	Wynniatt Formation	>810	14	Hofmann and Rainbird, 1994; Butterfield and Rainbird, 1998
23	Alinya Formation	800	26	Zang, 1995; Riedman and Porter, 2016
24	Fifteenmile Group	800	28	Allison and Hilgert, 1986; Allison and Awramik, 1989; Cohen and Knoll, 2012
25	Svanbergfjellet Formation	800	24	Butterfield et al., 1994
26	Hunnberg Formation	790	9	Knoll, 1984
27	Chichikan Formation	785	9	Sergeev and Schopf, 2010
28	Urucum Formation	766	8	Morais et al., 2017
29	Draken Formation	765	8	Knoll et al., 1991
30	Backlundtoppen Formation	765	6	Knoll et al., 1989
31	Batsfjord Formation	760	8	Vidal and Siedlecka, 1983
32	Visingsö Group (Lower and Middle)	760	8	Vidal, 1976
33	Visingsö Group (upper)	750	22	Loren and Moczydłowska, 2018; Vidal, 1976
34	Rysso Formation	745	7	Knoll and Calder, 1983
35	Uinta Mountain Group	740	9	Dehler et al., 2010
36	Pahrump Group, Death Valley	740	5	Corsetti et al., 2003
37	Chuar Group	740	39	Vidal and Ford, 1985; Nagy et al., 2007; Porter et al., 2003; Porter, 2016
38	Areyonga Formation	660	4	Riedman et al., 2014
39	Aralka Formation	660	5	Riedman et al., 2014
40	Rasthof Formation	660	5	Bosak et al., 2011a; Dalton et al., 2013
41	Tayshir Formation	660	5	Bosak et al., 2011b
42	Tapley Hill Formation	650	6	Riedman et al., 2014
43	Lantian Formation	<635	8	Xunlai et al., 1999; Yuan et al., 2001
44	Ura Formation	<635	20	Sergeev et al., 2011
45	Parsha Formation	<635	14	Golubkova et al., 2010
46	Doushantuo Formation	635-580	69	Xiao et al., 2002; Xiao et al., 2004; Xiao et al., 2014b
47	Dey-Dey Formation-Officer Basin	580-560	31	Grey, 2005
48	Dey-Dey Formation-Amadaeus Basin	580-560	25	Zang and Walter, 1992
49	Kelt'ma Assemblage	580-552	20	Vorob'eva et al., 2009
50	Redkino Suite	550	14	Burzin et al., 1996

51	Nama Group	550	8	Germs et al., 1986; Cohen et al., 2009
	Oldest eukaryotic microfossils	1680-1620		Knoll and Nowak, 2017; Javaux and Lepot, 2018
	Simple multicellularity	1630-1550		Zhu et al., 2016
	Crown group eukaryotes	1.05		Butterfield, 2000; Gibson et al., 2017; but see also Bengtson et al., 2017
	Oldest eukaryotic biomarkers	~800		Brocks et al., 2017
	Oldest metazoan biomarkers	~660-645		Love et al., 2009; Love and Summons, 2015

Figure S2. Annotated version of Figure 3 with accompanying table.



No.	Explanation	References
1	The evolution of oxygenic photosynthesis occurred prior to the end of the Archaean.	Planavsky et al., 2014a; Satkoski et al., 2015
2	Prior to the evolution of oxygenic photosynthesis, O_2 production restricted to photolytic reactions in the upper atmosphere involving CO_2 and H_2O.	Kasting and Walker, 1981
3	After the evolution of oxygenic photosynthesis, dynamic models suggest system stability ~10^{-7} PAL.	Pavlov and Kasting, 2002; Goldblatt et al., 2006
4	Possible 'whiff' of O_2 or oxygen oasis suggested from Jeerinah Formation, Western Australia.	Scott et al., 2011
5	Hypothetical oscillations predicted to accompany the GOE transition because of low buffering capacity of the system nearing conditions that favored change in steady state.	
6	Confident 'whiff' of O_2 prior to the GOE recorded in the Mt. McRae Shale, Western Australia.	Anbar et al., 2007
7	'Great Oxidation Event' dated to ~2.33 Ga by the disappearance of non-mass-dependent fractionation of sulfur observed in pyrite.	Luo et al., 2016
8	Potential O_2 'overshoot' suggested by interpretation of the Lomagundi Event (~200 Myr interval of extremely ^{13}C enriched carbonate rocks) as the product of enhanced burial of oxygenic-photosynthetically derived organic carbon; significant uncertainty surrounds this interpretation, including the possibility that O_2 gained passed only transiently through the atmosphere and accumulated rather as elevated oxidant availability in the oceans (e.g., sulfate). Also poorly known are the controls on declining O_2/oxidants at the end of the Lomagundi Event.	Bekker and Holland, 2012; cf., Krissansen-Totton et al., 2015; Blättler et al., 2018; Ossa Ossa et al., 2018
9	Potential transient oxygenation events in the later	Planavsky et al., 2018; Mänd et al., 2020

	Paleoproterozoic (after the falling limb of the Lomagundi carbon isotope excursion at ~2.0 and 1.8 Ga)	
10	Low atmospheric O_2 levels (0.1-1% PAL based on the $\delta^{53}Cr$ record in iron formations and shales) characterized the bulk of the mid-Proterozoic.	Planavsky et al., 2014b; Cole et al., 2016
11	Multiple lines of evidence point to a transient increase in O_2 ~1.4 Ga.	Zhang et al., 2016; Liu et al., 2016; Hardisty et al., 2017; Yang et al., 2017; Diamond et al., 2018
12	The $\delta^{53}Cr$ record of carbonates suggests the possibility of transient oxygenation ~1.1 Ga.	Gilleaudeau et al., 2016
13	The $\delta^{53}Cr$ record of iron formations, iron stones, and organic rich shales shows significant fractionations beginning ~800 Ma, indicating the onset of oxidative Cr cycling in terrestrial weathering environments.	Planavsky et al., 2014; Cole et al., 2016
14	Multiple lines of evidence indicate that widespread anoxic conditions persisted through the bulk of the late Neoproterozoic and early Palaeozoic.	Sperling et al., 2015; Wallace et al., 2017
15	Transient spikes in redox-sensitive trace metal concentrations in the Doushantuo Formation indicate transient reductions in spatial extent of anoxic marine conditions.	Sahoo et al., 2016; Shi et al., 2018
16	Multiple studies have suggested oxygenation in the Middle Cambrian (~521 Ma) on the basis of various proxies applied to strata of south China, other work has shown a subsequent continuation of widespread anoxia, indicating that this event was likely transient if genuine.	Chen et al., 2015; Jin et al., 2017; Li et al., 2017
17	A stepwise increase to near modern pO_2 is suggested to have accompanied the rise of vascular land plants; multiple lines of evidence support this notion.	Dahl et al., 2010; Lenton et al., 2016; Wallace et al., 2017
18	Remainder of pO_2 curve adapted from GEOCARBSULF, which is based on the $\delta^{13}C$ record of marine carbonates.	Berner, 2006: Schachat et al., 2018
19	Some model predictions suggest a lack of stability in the pO_2 range consistent with the $\delta^{53}Cr$ record and instead argue for higher (1-10% PAL) pO_2 throughout the mid-Proterozoic.	Daines et al., 2017

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