

Biogeosciences Discuss., referee comment RC1
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Comment on bg-2021-332

Anonymous Referee #1

Referee comment on "Fossilization of Precambrian microfossils in the Volyn pegmatite, Ukraine" by Gerhard Franz et al., *Biogeosciences Discuss.*,
<https://doi.org/10.5194/bg-2021-332-RC1>, 2022

Comments and revisions for Franz et al. manuscript to *Biogeosciences* – January 2022

GENERAL COMMENTS

This manuscript provides an important contribution to studies of Precambrian fossilization processes, and describes a unique environment for preservation in the continental subsurface. The overall theme of the paper fits well within the context of the journal *Biogeosciences* and would make a valuable addition to the literature in this field. This paper will be well-suited for publication following minor revisions, as discussed below. It is my hope that the authors find these comments constructive and improve the quality of the manuscript and presentation of the research findings.

SPECIFIC COMMENTS

Line 63 – says high N-content is typical for the OM, but Line 33 describes loss of N (and S) due to anaerobic oxidation. Please clarify. Is the N content low from oxidation, but still high enough to be “typical” for OM?

Line 83 – refers to “long cooling history” – is there an estimate on what amount of time is considered “long” (thousands of years? millions?); or at what depth this cooling might have occurred (meters?)

Line 93 – OM is referred to as “highly mature” based on pyrolysis and TEM results. What about these results indicates the OM is highly mature? This sentence could also be moved to the results or discussion section where these findings are covered in more detail.

Line 95 – “partly failed” – how did the Pb analyses partly fail? It is unclear here, please expand.

Line 108 – “sampled in situ from the pegmatites” – how was the kerite (OM) sampled? Is it free from other minerals to be collected by itself? Or did it need to be extracted from the host rock? In other words, were the minerals/crystals collected with OM present (as is the case for beryl in the next sentence, Line 109)? (see comment for Line 122 below).

Line 122 – Similar to above comment, it's unclear how the OM was recovered. Was OM extracted from host rock/minerals using acid digestion? If not, please clarify how the OM (kerite fibers) was isolated. (see also Line 207)

Line 148 – “using a Parr-type hydrothermal digestion vessel” – Has this technique been applied previously to similar samples? If so, please provide citation(s).

Line 162 – “a variable diameter, from 1-2 μm up to c. 80 μm , mostly near c. 15-20 μm .” – This is quite a large range of diameters. Please explain. For example, are these observed diameters considered to be from different fossil taxa? Many (most?) modern cyanobacteria exhibit a more limited range of cellular diameters.

Figure 2 –

1) Are all of these examples of OM considered "kerite"? Or is it only the "fibrous" specimens? Please clarify (in caption or main text).

2) Samples d-f (and underlying "fiber" on b) seem that they could be classified as "filamentous". Is there a reason for the fibrous vs. filamentous identification? If so, please explain in caption and/or main text.

3) Branched fibers (or filaments) as in "2d" should be discussed. Some cyanobacteria (and other microbes?) are known to occasionally exhibit branched morphologies. Please expand on the significance of branched vs. unbranched morphology (in main text).

Line 207 and 208 – “handling” and “preparation” How were the fibers handled for

preparation? Line 122 describes a lack of physical cleaning or preparation -- please clarify.

Line 208 – To my knowledge, "core-mantel" is not a common terminology for microfossil descriptions. Could this be considered a filamentous "sheath" as observed in some cyanobacteria (as mentioned in Line 446 and 479)? Consider rewording (also "mantle" is apparently misspelled here as "mantel").

Line 274 – "anaerobic oxidation" – Citation(s) for this interpretation? Does this imply biomineralization played a role in preservation or degradation? Please expand.

Figure 9 – The elemental distributions of O, S, and N for the botryoidal texture seem to be inverse to other figures (e.g., O and S occur together – possibly indicative of sulfate or other oxidized sulfur?). Please expand.

Line 338 – "thermal overprint" – How is this known to be a thermal overprint? Are there additional indicators for thermal alteration? If so, please explain, or cite relevant literature to help support this interpretation. (See comment for Lines 359 and 360 below.)

Lines 359 and 360 – "These are typical pyrolysis breakdown products of already matured

OM." – Please cite other examples of "typical pyrolysis breakdown products" of mature OM, or explain further how this is known.

Line 365 – “between ~175 and ~200°C” – Likely temperatures based on what? Please explain further or cite relevant examples from the literature.

Line 418 – “Alteration of OM by anaerobic oxidation” – could this not also result from non-biological oxidation? “Anaerobic” typically implies biological activity; please clarify.

Lines 446–448 – “their size and transition to botryoidal and dented structures (Fig. 4) is more consistent with an interpretation as a primary feature.” – It is unclear how the size and transition to botryoidal/dented is consistent with a “primary” (assumed to be “biological”?) feature. Please explain or cite relevant examples.

Lines 459–461 – “the six-sided outline, seen in small and large cavities, cannot be explained by shrinking. There is no reason why a cylindrical body during shrinking should open a central cavity with a regular outline.” – I would tend to agree with this interpretation. It is not entirely necessary, but may help to expand on this point.

e.g., OM shrinking would not likely result in such uniform shapes, and may be related to mineral precipitation or other fossilization processes.

Lines 595 and 596 – “This is not consistent with our observations” – **If the fossils are indeed cyanobacteria, but were not transported from ponds at the surface, how would they be capable of photosynthesizing in the subsurface?**

This seems like an important observation and may indicate a different type of filamentous

microbial population existing in a continental subsurface environment. Are there other possible microbes (e.g., fibrous/filamentous chemotrophic microorganisms) that could help explain this discrepancy?

TECHNICAL CORRECTIONS

Line 25 – omit “own”

Line 36 – omit “also”

Lines 39-40 – suggest changing sentence to read, “The geological environment for growth of the microorganisms and fossilization is assumed to be a geyser system,…”

Line 42 – suggest that the term “caves” should be changed to “large cavities” or something similar. Otherwise, the difference between caves and cavities should be described in the text. Also see other uses of “caves” (Line 609)

Line 43 – suggest changing “prime” to “distinct” or “uncommon” or something similar, in order to differentiate from other descriptions of Precambrian fossils from marine environments.

Line 45 – add “preserved in” after “microorganisms”, and omit “of”. Sentence will then read “... possible habitat for microorganisms **preserved in** the deep biosphere.”

Line 50 – Propose changing “(meta)sediments” to “(meta)sedimentary rocks”, as Precambrian fossils occur almost exclusively in lithified rocks rather than unconsolidated sediments.

Line 51 – omit “also”

Line 51 – provide citations for microbial habitats described from “recent years”

Line 61 – $\delta^{13}\text{C}$ ratios should refer to values less than **negative** (-) 40‰.

Figure 1 – No asterisk (*) on map? There is a black circle where “Volyn” is indicated. Please change in figure or caption to aid reader comprehension.

Line 129 – propose changing “Mappings” to “Maps” throughout (also Lines 340, 449)

Line 147 – spell out “concentrated”; also, what is the percent composition of HNO₃ (e.g., 68%)?

Figure 2 – (a) annotated arrows would be useful to distinguish fibrous vs flaky, and the background materials (e.g., bladed crystal? in “a”)

(c) what is the background composed of (behind or beneath the flakes)? It is unclear from the image alone.

Figure 3 – 1) Add arrows to show pores or central cavity in images.

Line 199 – “surface” Surface of what? The fibers or botryoidal shapes? Please cite the EDS spectra referred to here (e.g., Fig. S1)

Lines 210 and 211 – Change “analyses 6” to “analysis 6”

("analyses 2 & 5; analyses 3 & 4")

Which analyses does this refer to? Something in the Supplementary Info? Not sure which analyses are being discussed.

Lines 212 and 213- "count rate for O decreases systematically from outer rim to center"
Where is this shown? Please refer to figure.

Figure 5 – Line 221 – "central channel" Sometimes this is referred to as the central "cavity". Suggest choosing one description (channel or cavity) to use throughout, in order to avoid reader confusion.

Line 225 – "Fiber" It appears there are multiple fibers? Arrows might be useful here.

"numbers" Numbers are very hard to see in this image. Please enlarge.

Line 241 – "mineral" – which mineral(s)?

Figure 7 – A statement about the white line in this figure may be useful here. Such as, "the white line indicates the outermost rim of the fiber" (similar to dashed line in Fig. 9).

Figure 9 – Lines 316 and 317 “Areas rich in N are poor in O” – This is not immediately obvious (to me) at first glance. Perhaps some arrows would help here.

Figure 10 – Line 325 “absent in this area” – is the area rich in S and N on the left side of the images also epoxy, or is it the interior of the OM flake? It is unclear from the images alone. Please clarify (in BSE image or caption)

Line 365 – omit “a”

Lines 406 and 407 – “it will be done in a companion paper, also with more details on the spherical objects of OM.” – Has this paper already been submitted or will be published? If so, please refer to the paper as “in review” or “in press”. Otherwise this sentence should be omitted, or replaced with something like “more research is needed to clarify the nature (i.e., biological affinity) of the fossils.”

Lines 416 and 417 – “high degree of aromatization, which relates to high thermal maturity.” – There is extensive literature on the relationship of aromatization and thermal maturity. Please cite such studies here.

Line 429 – change “»” to “~”

Lines 438–444 – Are there other examples in the literature re: porosity as degassing features, or cracks as shrinking phenomena? If so, please cite them here.

Lines 482 and 483 – "their Fig. 2" not necessary. It is sufficient to direct reader to Gorlenko et al. (2000).

Line 493 – "anoxic" – Anoxic refers to an environmental parameter. Suggest change to "anaerobic" if referring to biological characteristic.

Line 494 – "Methanogenic bacteria" – Methanogens are typically considered archaea. Change to "Methanogenic archaea" or more broadly "Methanogenic microbes".

Figure 10 – Line 501 – "three morphologically different organisms (fibrous, flaky, and rare...)" – the different textures do not necessarily refer to different organisms. This terminology should be changed; rather than "organisms" it would be more appropriate to say "OM textures".

For example, the flaky OM could possibly be remnants of altered biofilms (as discussed below in Line 509), rather than a distinct microbial population.

Line 511 – "sufficiently low" – How low is "sufficiently low"? Below boiling (i.e., < ~100°C)?

Line 563 – Suggest change from “Anaerobic” to “Anoxic”

Lines 571 and 572 – “whereas silicification, when rapid, helps to preserve their morphological details” – Many studies have documented the role of rapid silicification in microbial fossilization, please cite some of them here. (e.g., Bartley, 1996; Manning-Berg et al., 2019 and refs therein, etc.)

Line 574 – Suggest change from “anaerobic” to “anoxic”

Line 582 – “continental environment” – It may be worth summarizing what the important differences are here, to aid the reader in understanding why these two environments are significantly distinct for fossilization.

Line 599 – “his Fig. 1” not necessary. It is sufficient to direct reader to Zhmur (2003).

Line 602 – insert “continental” or “subsurface” here (before “localities”).

As described above, there are many excellent Precambrian soft tissue fossils preserved from marine environments, but this research is unique in that it comes from a terrestrial region.

Line 604 – Suggest changing “sediments” to “sedimentary rocks”

Line 604 – Suggest changing “more and more” to “growing”

Line 609 – “cave” (twice); Not sure if the term "cave" is appropriate here? Perhaps "large water-filled cavity" is better -- at least to avoid confusion with limestone caves in karst environments. (see comment for Line 42.)