
Alison Olcott Marshall*, Craig P. Marshall

University of Kansas, Department of Geology, Lawrence, KS 66045, USA

1. Introduction

The review by Schopf and Kudryavtsev (2012) purports to settle the controversy over the microstructures first identified in the Apex chert twenty-five years ago (Schopf and Packer, 1987). These structures were originally described as microfossils (Schopf and Packer, 1987; Schopf, 1993), but later researchers questioned this identification, claiming that the microstructures did not have a morphology (Brasier et al., 2002; García Ruiz et al., 2003; Brasier et al., 2005, 2011) or mineralogy (Marshall et al., 2011; Olcott Marshall et al., 2012) consistent with life. The review paper addresses all of these studies, and dismisses each as a challenge to the claims of biogenicity (Schopf and Kudryavtsev, 2012). However, our research was not presented accurately, and thus we would maintain that the controversy has not yet been resolved, and that the origin of these microstructures is still unknown. Two facets of our research were misconstrued: (1) the morphology of the hematite pseudofossils we described and (2) the presence of multiple generations of carbonaceous material we described from within the Apex chert samples.

2. Hematite vein pseudofossils

Despite claims to the contrary (Schopf and Kudryavtsev, 2012), we described discrete cylindrical structures, including sinuous (Marshall et al., 2011, Supplementary Fig. 1b, d) and arcuate (Marshall et al., 2011, Fig. 1f) forms. These structures, which Schopf and Kudryavtsev (2012, p. 769) mischaracterize as “rock-transecting planar features” are rock-embedded cylindrical filaments (Marshall et al., 2011, Figs. 1d, 3d), just like the putative microfossils (Schopf and Packer, 1987; Schopf, 1993). Finally, the authors report that our microstructures are much larger than the previously described structures, with a size range of “4–65 μm” (Schopf and Kudryavtsev, 2012, p. 769). However, this is not correct; we reported that our microstructures had a size range of 1–21 μm (Marshall et al., 2011), almost identical to the 0.5–19 μm range originally reported by Schopf (1993). The 4–65 μm range cited in the review is the size of the material interspersed between the opaque microstructures, which we described as a “light material [which] has a coarse block-like texture, with crystal sizes ranging from 4 μm to 65 μm” (Marshall et al., 2011, p. 240). Thus, although the samples we analyzed were not the originally described specimens, but were new samples collected at the same locality, the pseudofossils we described have a morphology and size equivalent to that of the previously described putative microfossils (Schopf and Packer, 1987; Schopf, 1993).

3. Multiple generations of kerogen

Previously, we used Raman spectroscopy to elucidate two separate generations of carbonaceous material in the Apex chert (Olcott Marshall et al., 2012), results that Schopf and Kudryavtsev (2012, p. 769) dismiss, insisting instead that the “Raman spectra do not show evidence of two generations of carbonaceous material”. Our original conclusions were based on the lineshape of the Raman spectra of disseminated disordered sp2 carbonaceous material contained within the Apex chert (Olcott Marshall et al., 2012). These differences can be seen in the representative spectra in Fig. 1A: one spectrum has an increased D band intensity relative to the G band intensity whereas the other spectrum has relatively equal D and G band intensities. Schopf and Kudryavtsev (2012) erroneously interpret these major differences in spectral lineshape as both analytical artifacts and “typical of the spectra of geochemically relatively mature chert-permineralized carbonaceous matter” (Schopf and Kudryavtsev, 2012, p. 769). However, their view that the differences between our two types of spectra are minor and well within the normal variation of one population of carbonaceous matter reveals a misunderstanding of the physical phenomenon underlying Raman spectroscopy and an unawareness of how Raman spectra are properly normalized.

Schopf and Kudryavtsev (2012, p. 769) claim that our previously reported differences in lineshape are “not due to polarization effect; rather…they evidence the orientation of Raman-analyzed kerogens”.

DOI of original article: http://dx.doi.org/10.1016/j.gr.2012.12.005.
* Corresponding author.
E-mail address: olcott@ku.edu (A. Olcott Marshall).
This statement is misleading, as spectroscopically, polarization and orientation are the same thing. All anisotropic crystalline material will display polarization effects. Raman scattering of plane polarized light can result in scattered radiation that is either parallel or perpendicular to the c-axis of anisotropic crystalline solids, which can result in an enhancement of Raman bands depending on c-axis parallel analysis or c-axis perpendicular analysis. Polarized Raman spectra can be achieved by rotating the sample on the stage between analyses, changing its orientation and subsequently the intensity of the Raman bands measured each time. Although the orientation of sp² carbonaceous material with respect to the incident laser beam can have a significant effect on the Raman spectrum in the case of highly ordered graphite, natural graphite, and, as mentioned in Schopf and Kudryavtsev (2012), highly orientated pyrolytic graphite (HOPG) (Katagiri et al., 1988; Wang et al., 1989; Compagnini et al., 1997), this effect is insignificant in disordered sp² carbonaceous materials (Jehlička and Beny, 1992; Wopenka and Pasteris, 1993; Aoya et al., 2010). Nonetheless, as noted in our paper, our experiment controlled for the possibility of polarization/orientation effects: “[t] o examine this orientation effect, multiple measurements were obtained on each sample at different orientations. Repeated measurements for a single spot at different orientations show no spectral variation” (Olcott Marshall et al., 2012, p. 162). Clearly therefore, polarization/orientation effects have not enhanced our D band intensity relative to our G band intensity. In addition to incorrectly dismissing the differences between the intensity of our D and G bands as an analytical artifact, Schopf and Kudryavtsev (2012) normalized our spectra against the height of the G band and simply vertically exaggerating one spectrum to equal the intensity of the other in the carbon rst-order region, Schopf and Kudryavtsev (2012) have increased the signal-to-noise ratio, band intensity, bandwidth, and lineshape of the original spectra, and the resulting spectrum does not resemble the spectral signatures for the crystallinity of that disordered sp² carbonaceous material originally reported (Olcott Marshall et al., 2012) (Fig. 1B). Despite these claims on the contrary, our Raman spectroscopic data reveal that at least two different populations of carbonaceous material are present within the Apex chert. If, as Schopf and Kudryavtsev (2012) claim, these differences are visible in other Precambrian deposits, the deposition of multiple populations of carbonaceous material maybe a wide-spread issue throughout the Precambrian.

References


