

Supplementary Materials for
**Complex carbonaceous matter in Tissint martian meteorites give insights into
the diversity of organic geochemistry on Mars**

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Sci. Adv. **9**, eadd6439 (2023)
DOI: 10.1126/sciadv.add6439

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Figs. S1 to S9

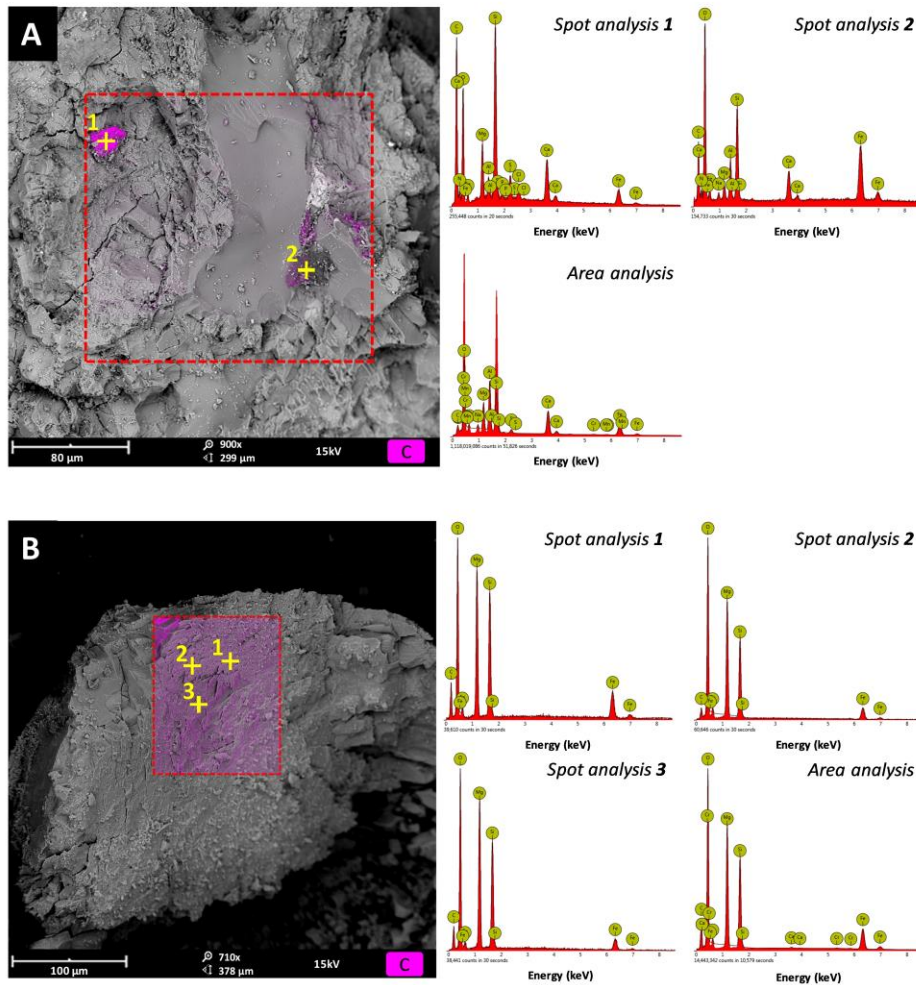


Figure S1. Backscattered electron images including carbon (C) mapping of (A) the fresh broken surface of the Tissint meteorite and (B) the broken intern face of an olivine macrocrystal extracted from Tissint meteorite. Some spot EDX-analyses were also performed (yellow cross).

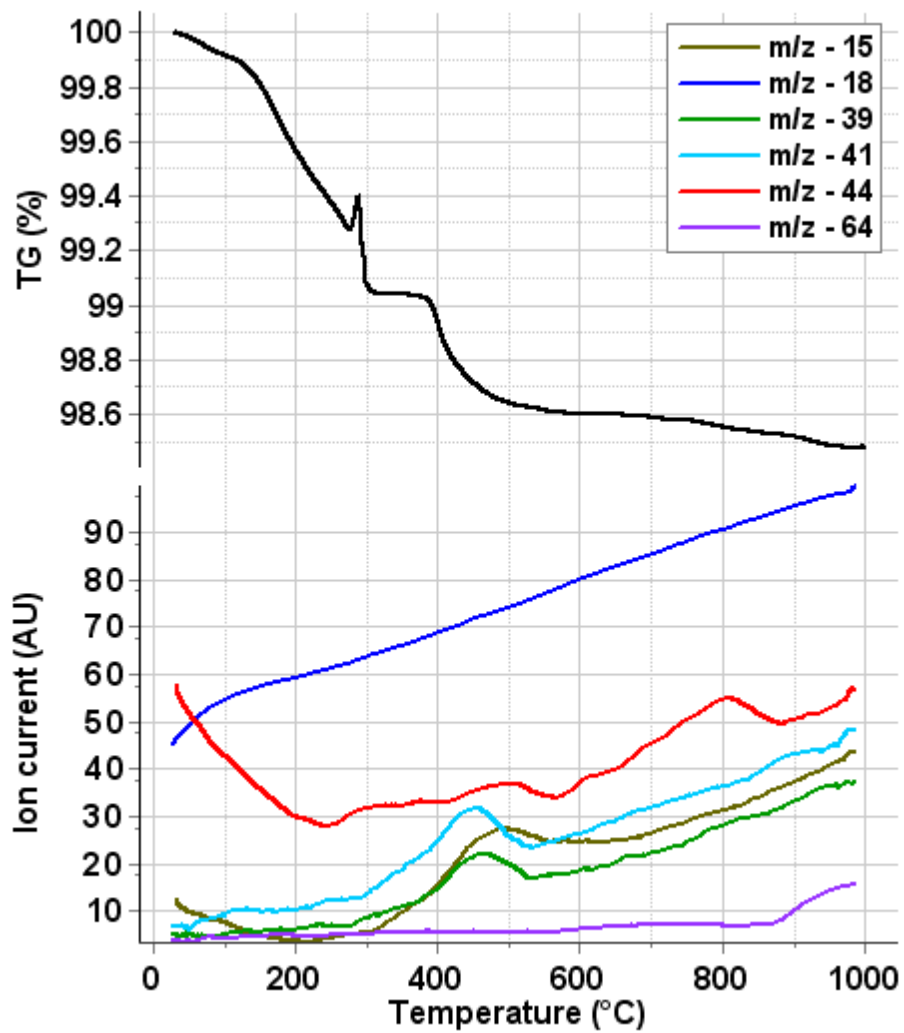


Figure S2. MSEGA analysis of Tissint. Mass loss (TG – upper black curve) and the formation profile of the main volatiles (lower half of the figure) detected.

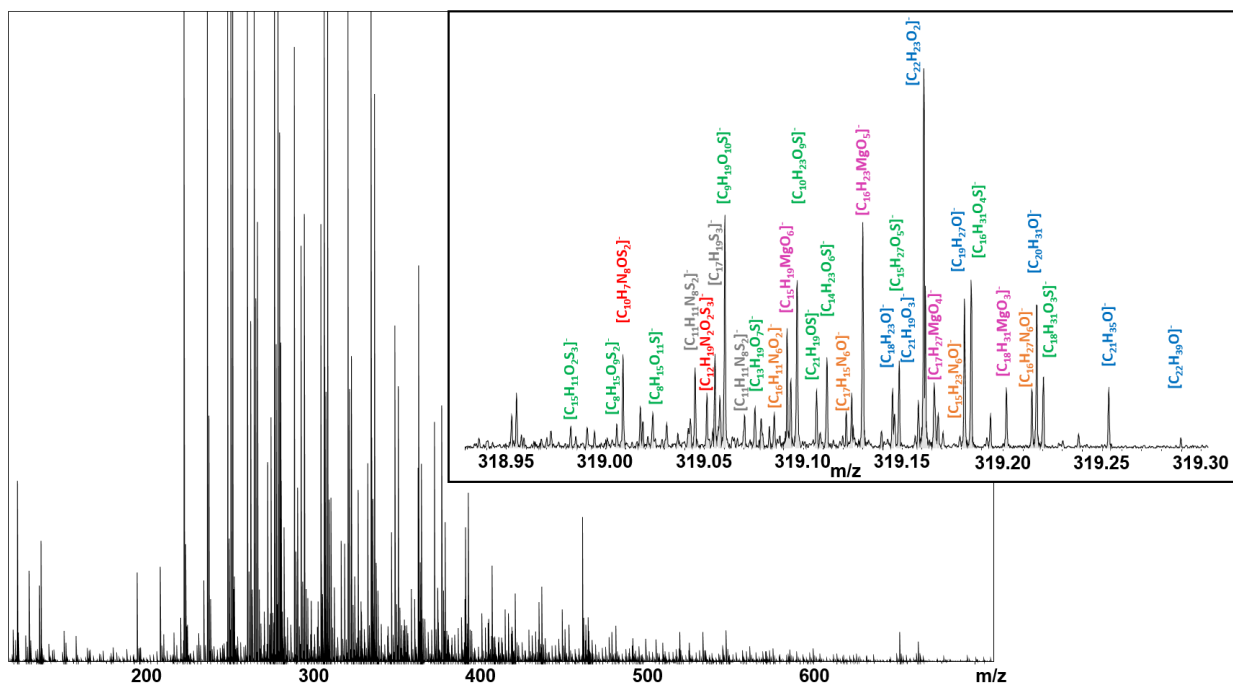


Figure S3. Representative ESI(-)-FTICR-spectrum of the methanol extract of a Tissint fragment. We observe a full spectrum with multiple signals in each nominal mass. In detail the nominal mass 319 counting more than 70 signals exemplary annotated in the CHNOSMg-space (colour code as used in the manuscript for the CHO (blue), CHNO (orange), CHOS (green), CHNOS (red) and CHOMg (pink)).

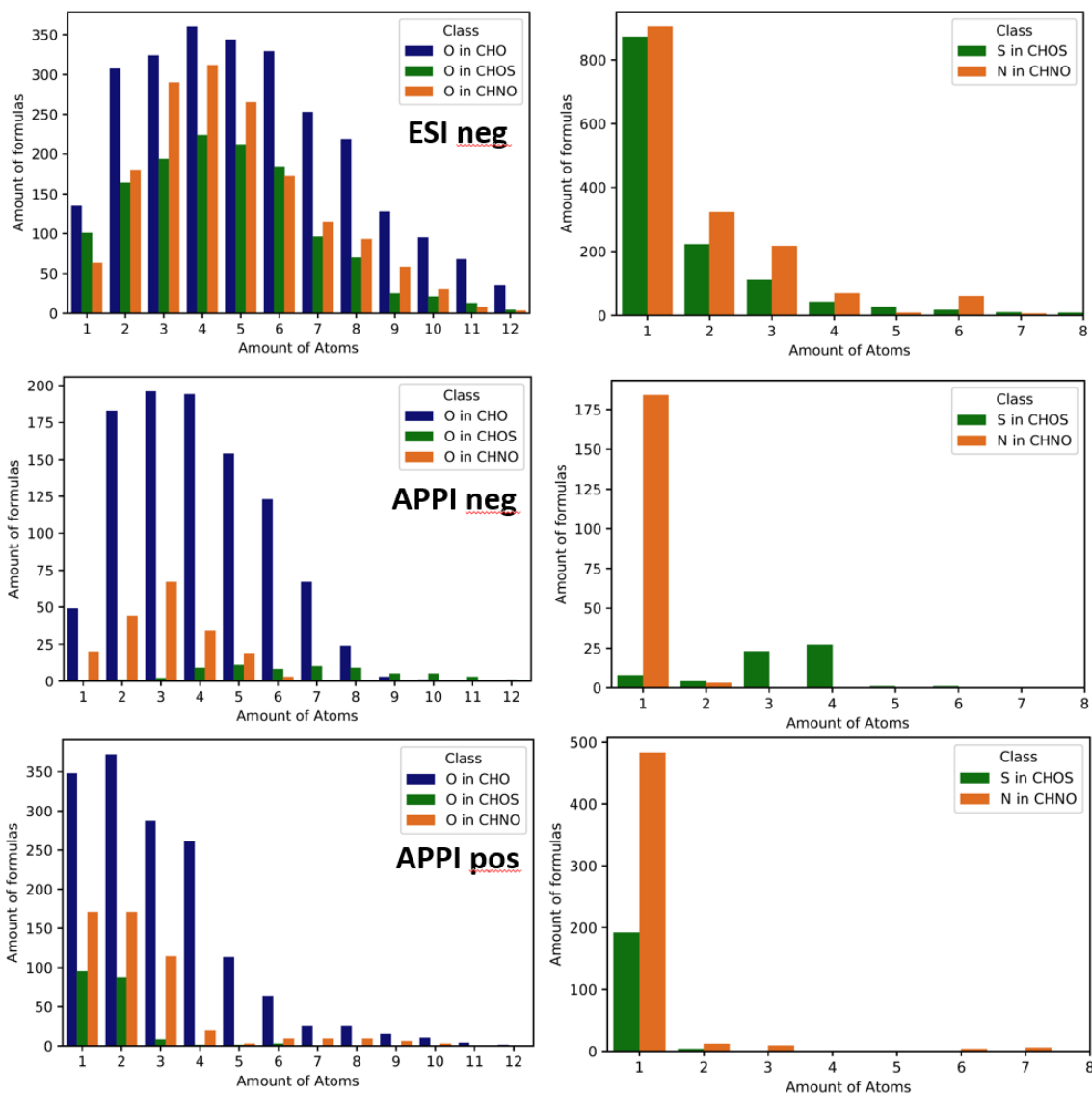


Figure S4. Oxygen and heteroatom (S, N) abundance in the compound's formula obtained from the various ionization methods used with FTICR-MS analysis when analyzing Tissint whole methanol extract. The polarity of the observed CHO (blue), CHNO (orange) and CHOS (green) molecular ions is decreasing from ESI(-) to APPI(-) and APPI(+) enabling us with this approach to cover a wide range of carbon oxidation state in describing molecular diversity in Tissint. Also, electrospray ionization presents much more oxygenated compounds having multiple nitrogen and sulfur atoms in the molecular formula, compared to APPI where most abundant CHNO and CHOS have mainly one N or S.

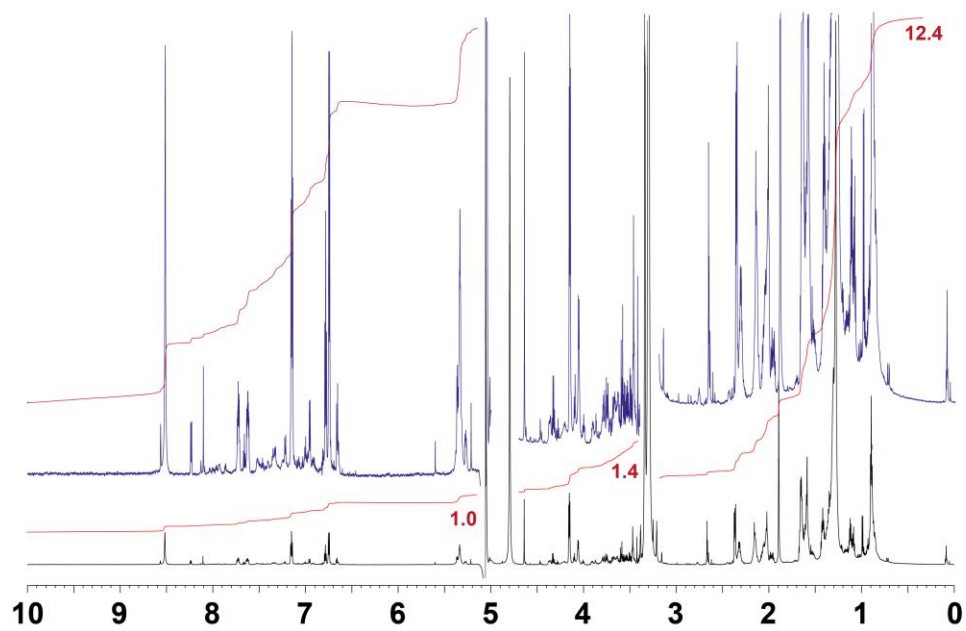


Figure S5. ¹H NMR spectrum (800 MHz, CD₃OD) of Tissint methanolic extract.

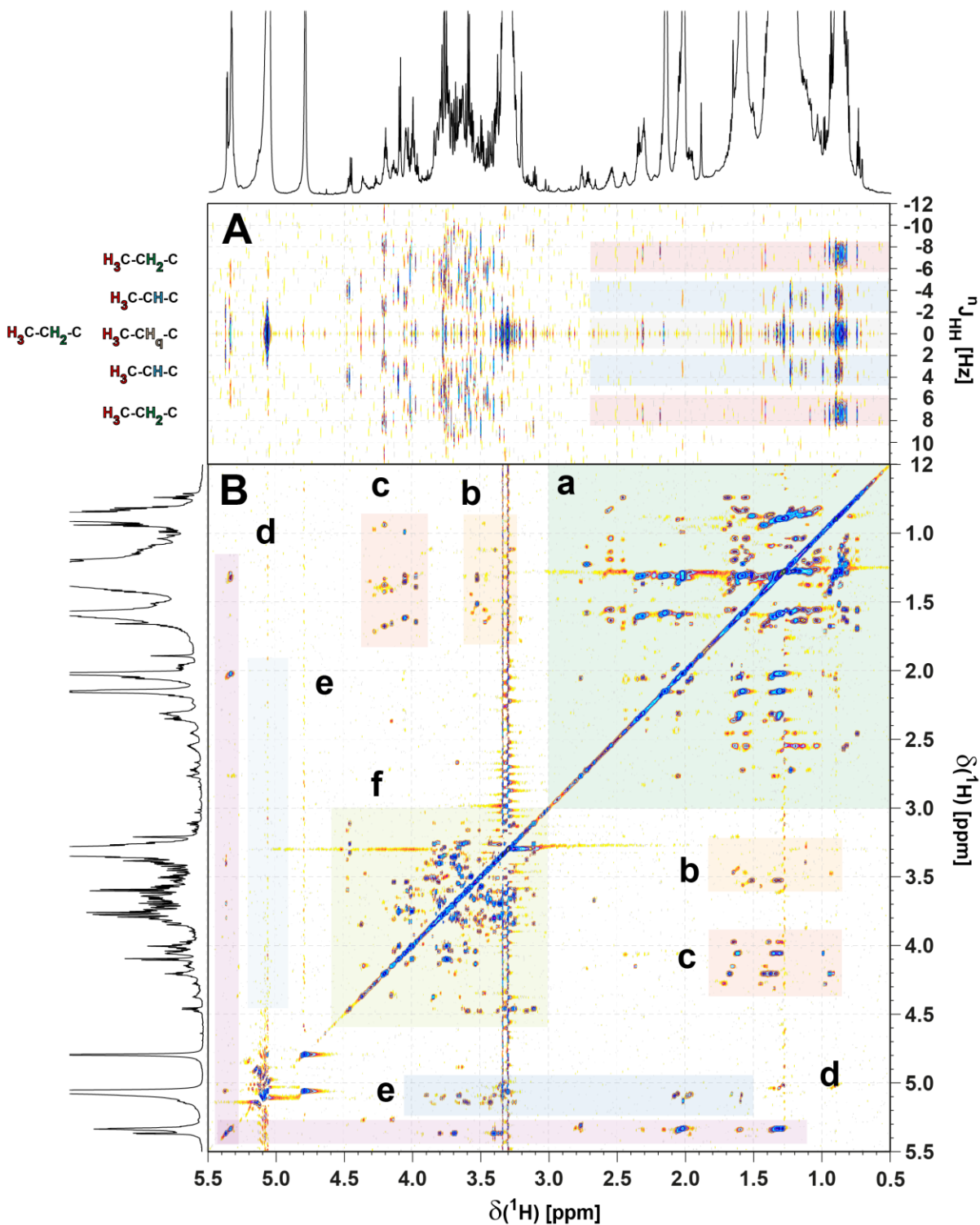


Figure. S6. ^1H , ^1H JRES and ^1H , ^1H TOCSY NMR spectrum (800 MHz, CD_3OD) of Tissint methanolic extract. Cross peaks indicating (panel A) --- $\text{C}-\text{CH}_n-\text{CH}_n-\text{C}$ -, $\text{HOOC}-\text{C}\alpha\text{H}_n-\text{C}\beta\text{H}_n-\text{C}\gamma\text{H}_n-\text{C}\delta\text{H}_n$ -, $-\text{C}-\text{CH}_n-\text{CH}_n-\text{CH}_3$, (panel B) $-\text{C}-\text{O}-\text{CH}_n-\text{CH}_n-\text{C}$ -, $\text{HO}-\text{CH}_n-\text{CH}_n-\text{C}$ -, (panel C) $-\text{C}-(\text{C}=\text{O})-\text{O}-\text{CH}_n-\text{CH}_n-\text{CH}_n$ -, (panel D) $-\text{OCH}_n-\text{OCH}_n$ -, (panel E) $=\text{CH}-\text{CH}_n-\text{CH}_n-\text{O}$ - and $=\text{CH}-\text{CH}_n-\text{CH}_n$ - units (cf. text).

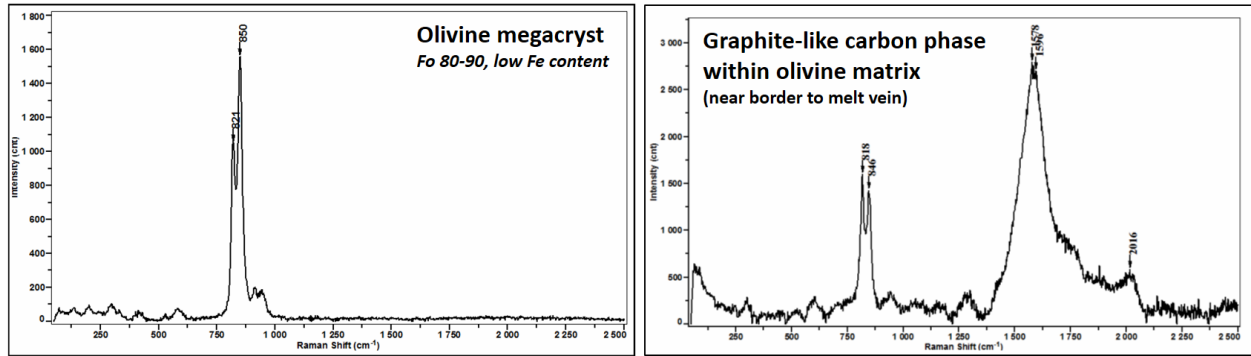


Figure S7. Raman spectroscopy of the olivine macrocryst matrix and in a zone near a melt vein showing the presence of carbon phases such as graphite.

Relative abundance

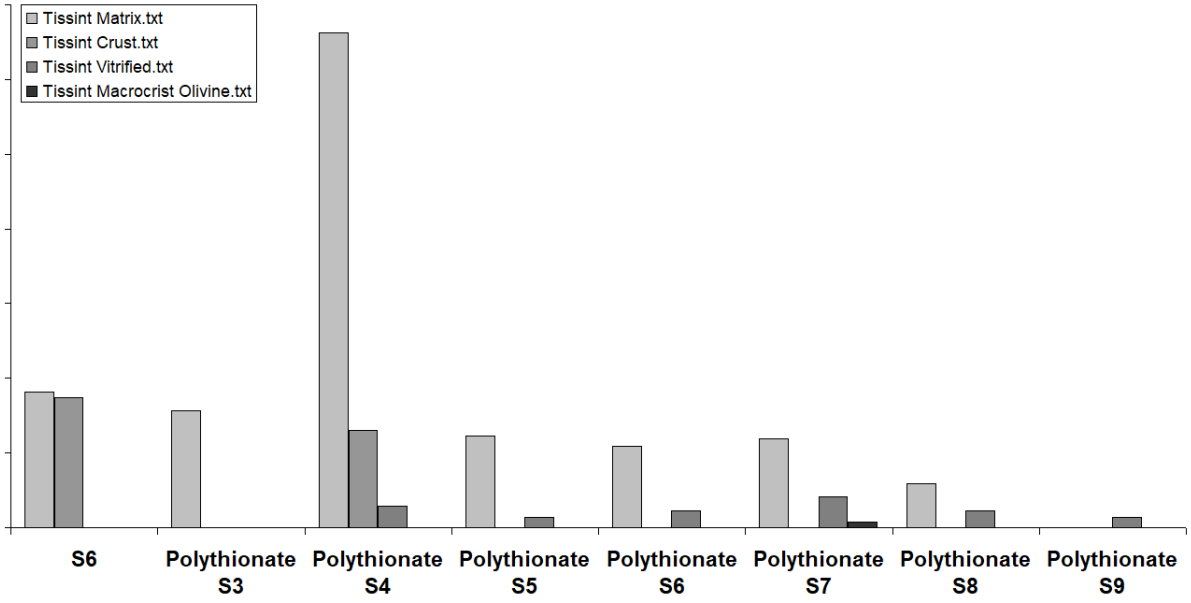


Figure S8 Polysulfur species in the different TISSINT mineral fractions.

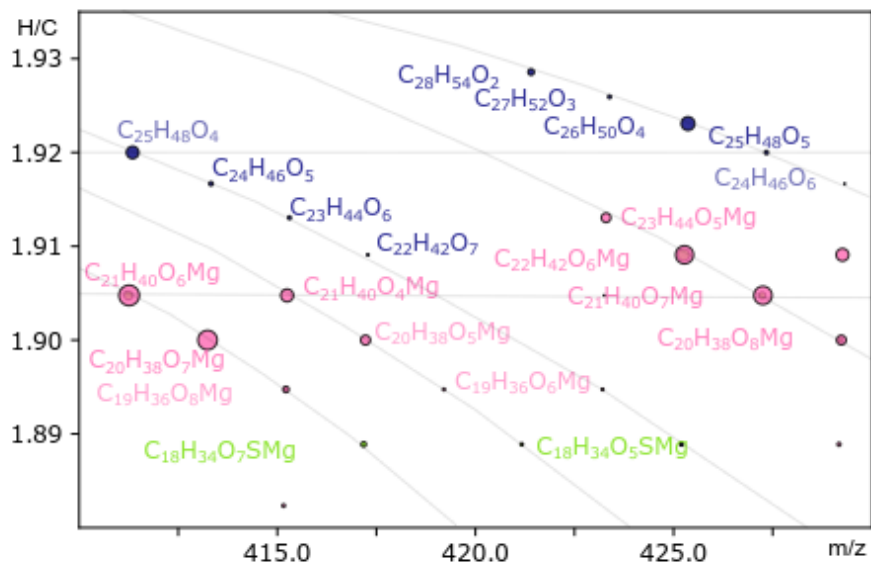


Figure S9: Detail in the van Krevelen representation of the ESI(-)-FTIRC-MS data showing the relative abundances and homologous chemical series of CHO (blue), CHOMg (pink) and CHOSMg (light green)