

Carbon and Hydrogen isotopic distributions in soluble polycyclic aromatic hydrocarbons in the Cold Bokkeveld meteorite

ALEX MESHOULAM¹, DR. AMY E HOFMANN² AND JOHN EILER¹

¹California Institute of Technology

²Jet Propulsion Laboratory, California Institute of Technology

Polycyclic aromatic hydrocarbons (PAHs) are abundant in nebulae, planetary atmospheres and meteorites, considered as one of the most abundant forms of C in the galaxy. These compounds can form at high temperatures (i.e., $T > 1000\text{K}$) in circumstellar environments, in cold molecular clouds and the interstellar medium ($\sim 10\text{--}50\text{K}$), via thermal and/or aqueous processes on carbonaceous planetesimals (100s K). Different reaction mechanisms have been suggested to dominate these different formation environments of PAHs. Therefore, constraining the mechanisms by which PAHs in meteorites were synthesized could inform understanding of the formation conditions and processes those meteorites have experienced.

In this work, we report the $\delta^{13}\text{C}$, δD and $\Delta^{2x13}\text{C}$ values of three PAHs (phenanthrene, fluoranthene and pyrene) extracted from the soluble organic matter of Cold Bokkeveld (CB) a carbonaceous chondrite. These meteorites are considered to be among the oldest materials in our solar system and therefore PAHs found on them may record the formation and evolution of organic matter in our solar system. Positive clumped isotopologue anomalies (i.e. $\Delta^{2x13}\text{C}$) of the three and four-ring PAHs extracted from Murchison and Ryugu¹ were previously interpreted as evidence that some fraction of PAHs on those bodies formed in cold ($< 50\text{K}$) environments.

The $\delta^{13}\text{C}_{\text{VPDB}}$ and $\delta\text{D}_{\text{VSMOW}}$ values of the CB PAHs are similar to the values measured for other CM chondrites and show similar relationships to molecular size and identity². However, unlike Murchison and Ryugu, in CB all the $\Delta^{2x13}\text{C}$ values of these three PAHs are $\approx 0\text{‰}$ providing no evidence that PAHs formed by cold chemistry mechanisms were preserved. We will discuss specific reaction mechanisms and conditions that could explain the measured $\delta^{13}\text{C}$, $\Delta^{2x13}\text{C}$ values.

References

1. Zeichner, S. S. *et al.* Polycyclic aromatic hydrocarbons in samples of Ryugu formed in the interstellar medium. *Science (80-.)*. **382**, 1411–1416 (2023).
2. Naraoka, H., Shimoyama, A. & Harada, K. Isotopic evidence from an Antarctic carbonaceous chondrite for two reaction pathways of extraterrestrial PAH formation. *Earth Planet. Sci. Lett.* **184**, 1–7 (2000).