Metallophore Extractable Rare Earth Element in Piedmont Soils

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Introduction

Rare earth elements (REEs), or lanthanides, are essential components in various technological products (magnets, lasers, etc). We sought an environmental signature for the action of bacterial lanthanide metallophores (lanthanophores) in soil by examining the relative extractability of soil REEs using various acids and chelators. Four compounds potentially simulating a lanthanophore were chosen for extractions: diethylenetriaminepentaacetic acid (DTPA), desferrioxamine B (DFOB), citrate and oxalate. Each molecule was chosen to examine the effects of denticity and functional group on REE extraction to approximate the structure and environmental signature of a lanthanophore.

Questions

- Do chelators have unique fractionation patterns in soil based on denticity and functional groups?
- Can patterns be distinguished with quantitative measures?

Fractionation Patterns Reveal Differences in Extractants

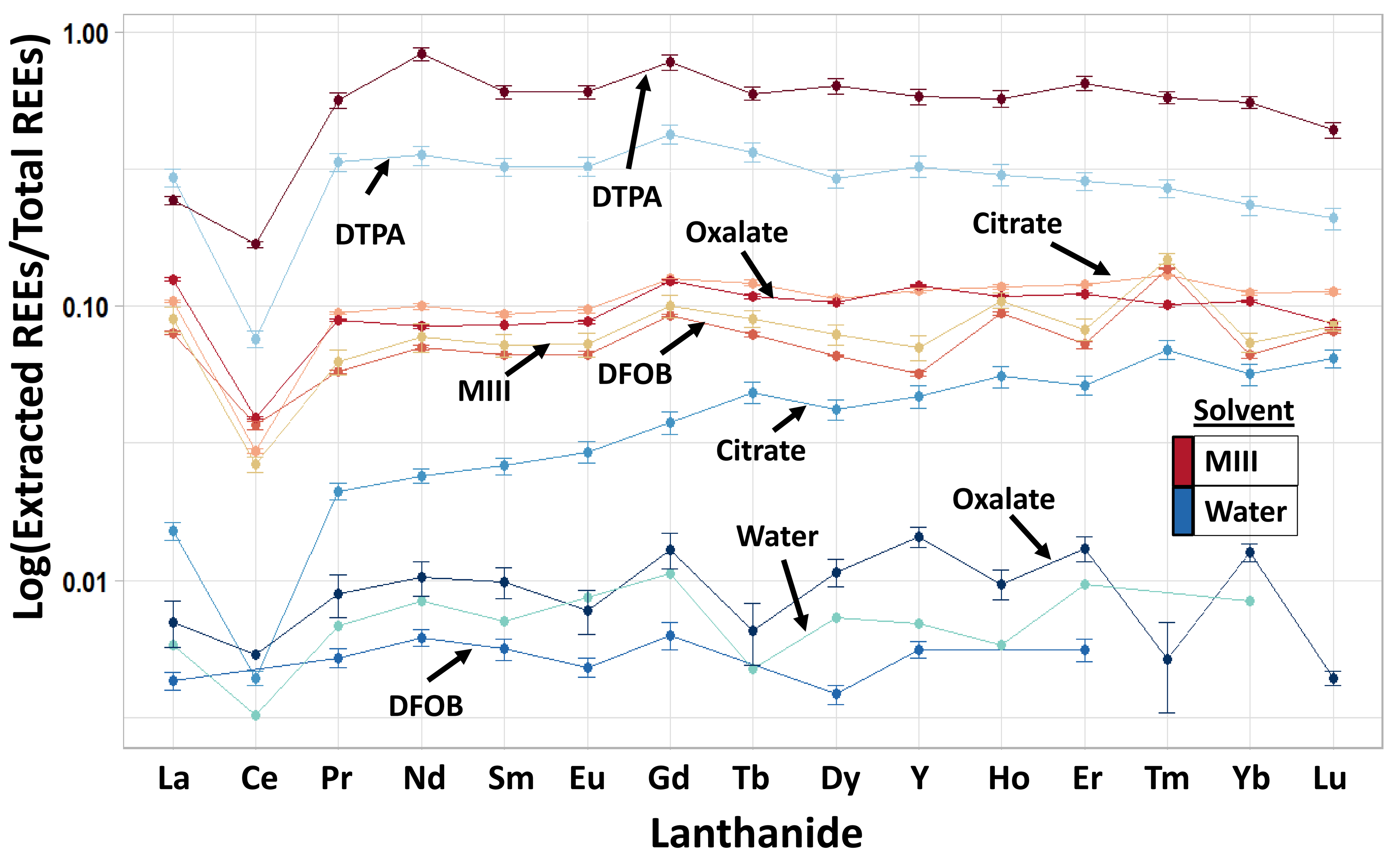


Fig. 1
DTPA+Mehlich III extracts nearly all available REEs. MIII extracts hold similar patterns and extraction potential. Increasing denticity increases extraction. Carboxylate groups are better than hydroxamate groups at extraction.

La/Lu Displays Differences in Extractants

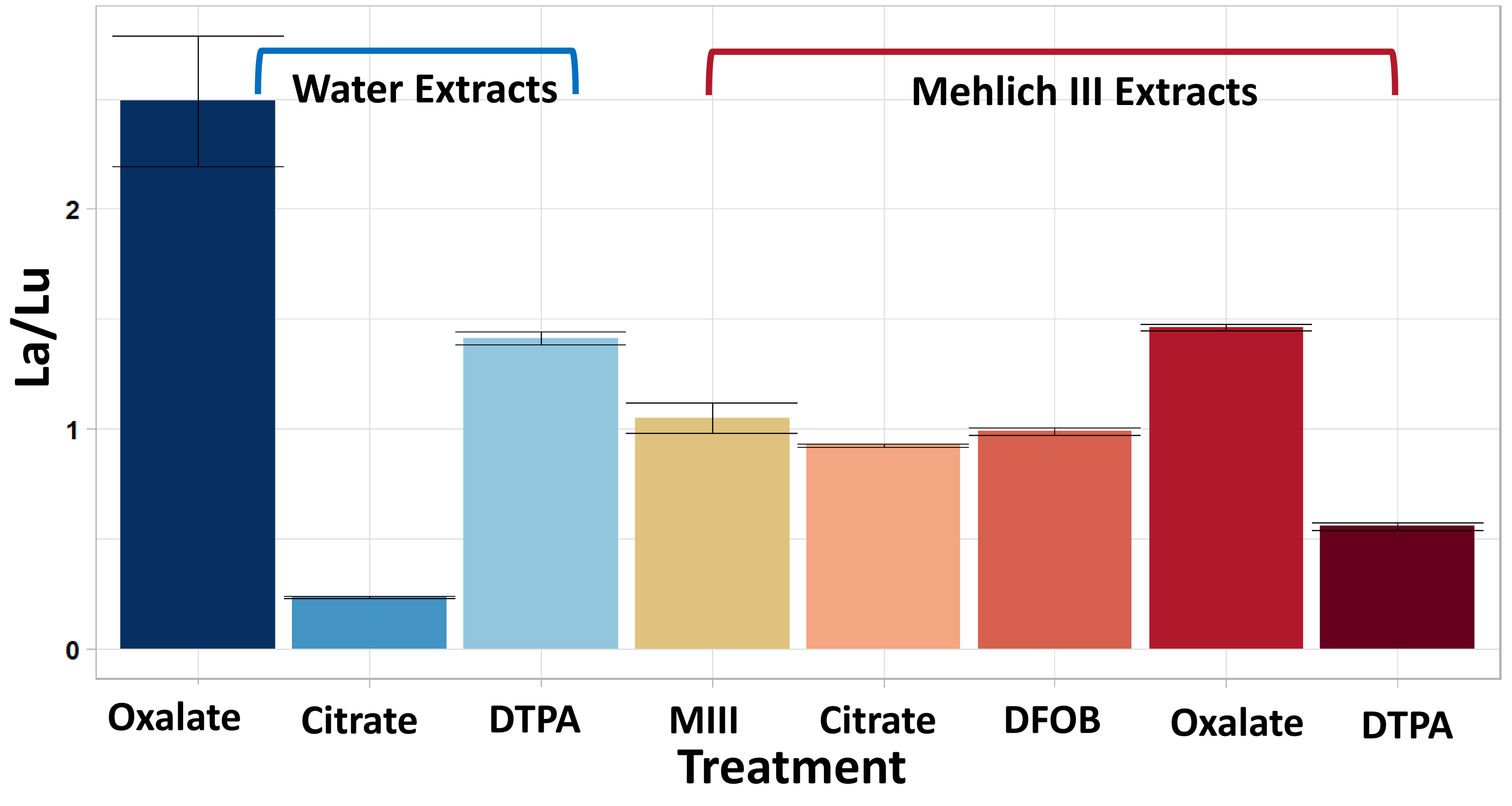
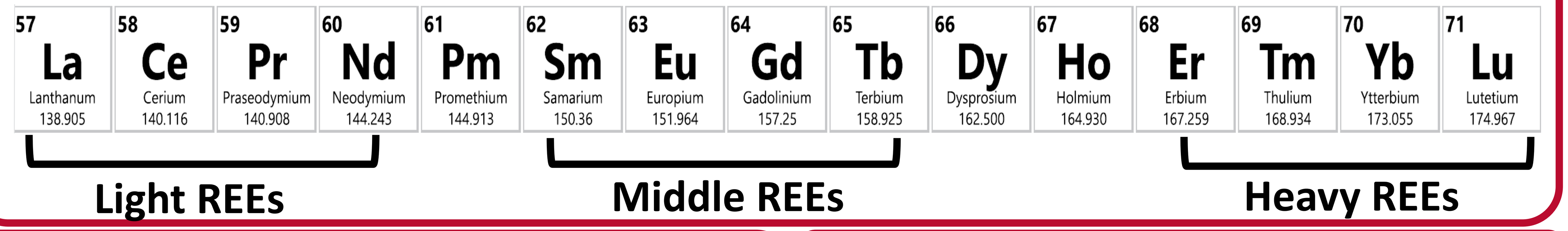


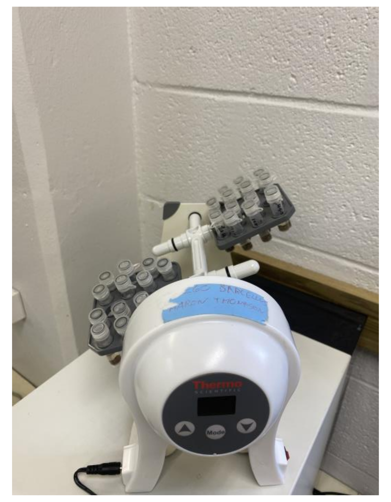
Fig. 3
La and Lu represent the light and heavy REEs respectively. With MIII as a solvent we see even extraction of REEs. Water extracts show greater ligand bias for different REEs



Methods

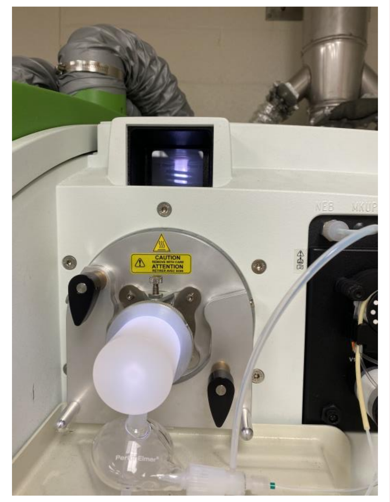
Soils were collected from the Calhoun Critical Zone Observatory

Samples were shaken with extractants for 30 minutes

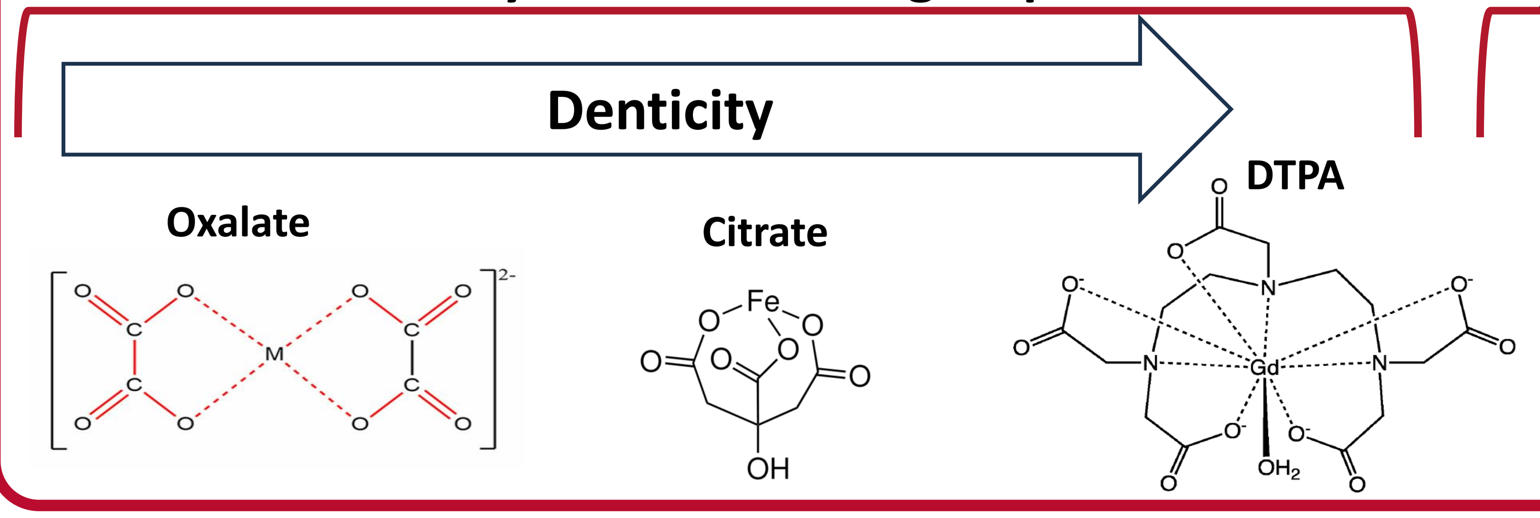


Samples were centrifuged at 14000 rpm for 14 minutes

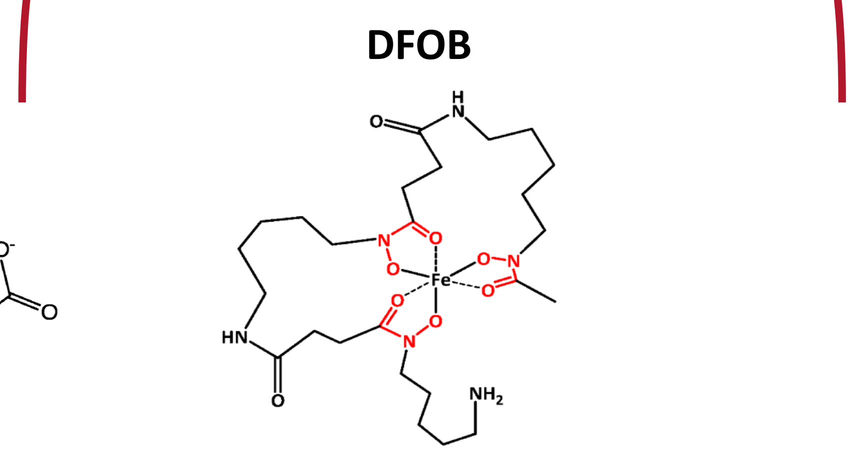
Supernatants were diluted and analyzed with an ICP-MS



Carboxylate functional groups



Hydroxamate functional groups



Y:Ho Ratio Quantifies Signature Differences

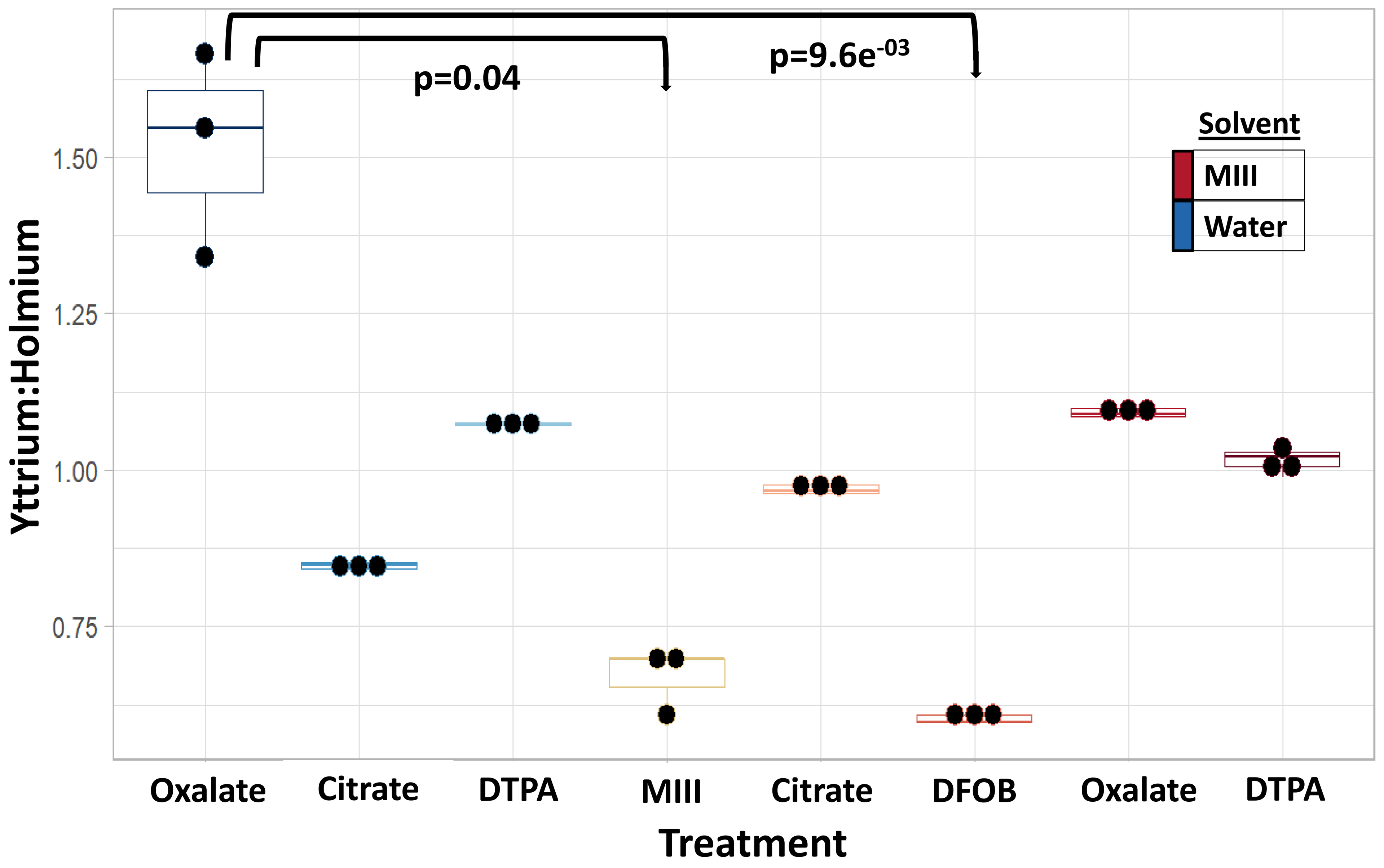


Fig. 2
Y:Ho ratios quantitatively demonstrate differences in fractionation patterns. Oxalate is different from MIII and DFOB+MIII by this metric

Conclusions

- Environmental signatures of extractants are distinct
- DFOB patterns reflect their solvent, indicating their poor REE affinity
- Increasing denticity increases REE extraction
- Carboxylate functional groups are more effective than hydroxamate groups at REE extraction
- Atypical anomalies may better reflect the differences between fractionation patterns

Acknowledgments

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