

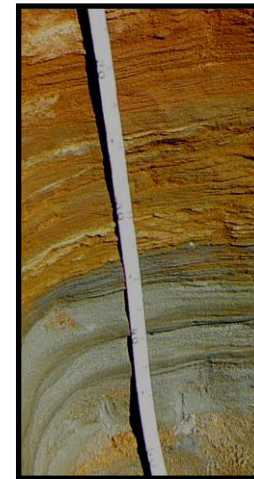
Transformation of arsenic-bearing particulate matter and associated impacts on bioaccessibility

Jon Chorover, Ph.D.

Professor, Department of Environmental Science

Associate Dean for Research, College of Agriculture, Life and Environmental Sciences

The University of Arizona

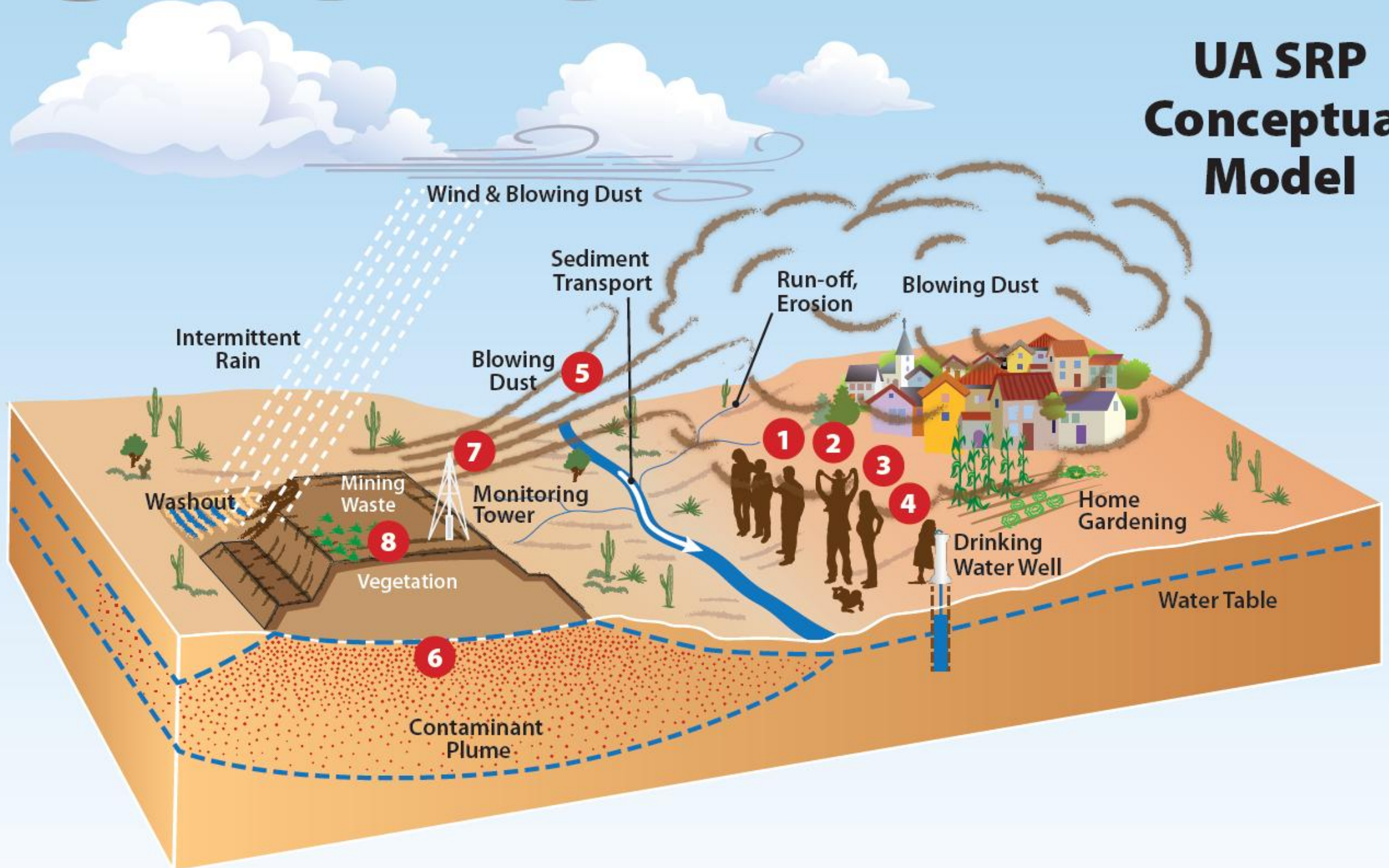


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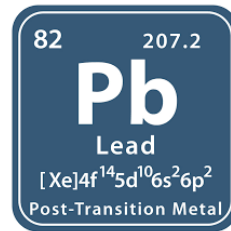
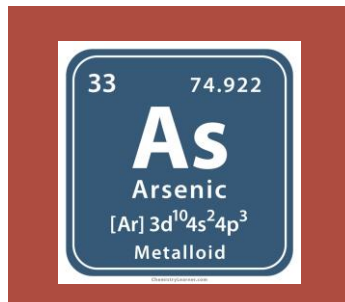


Superfund
Research Center

UA SRP Conceptual Model



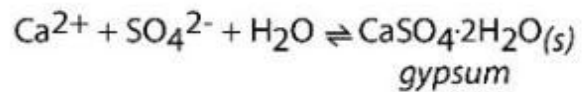
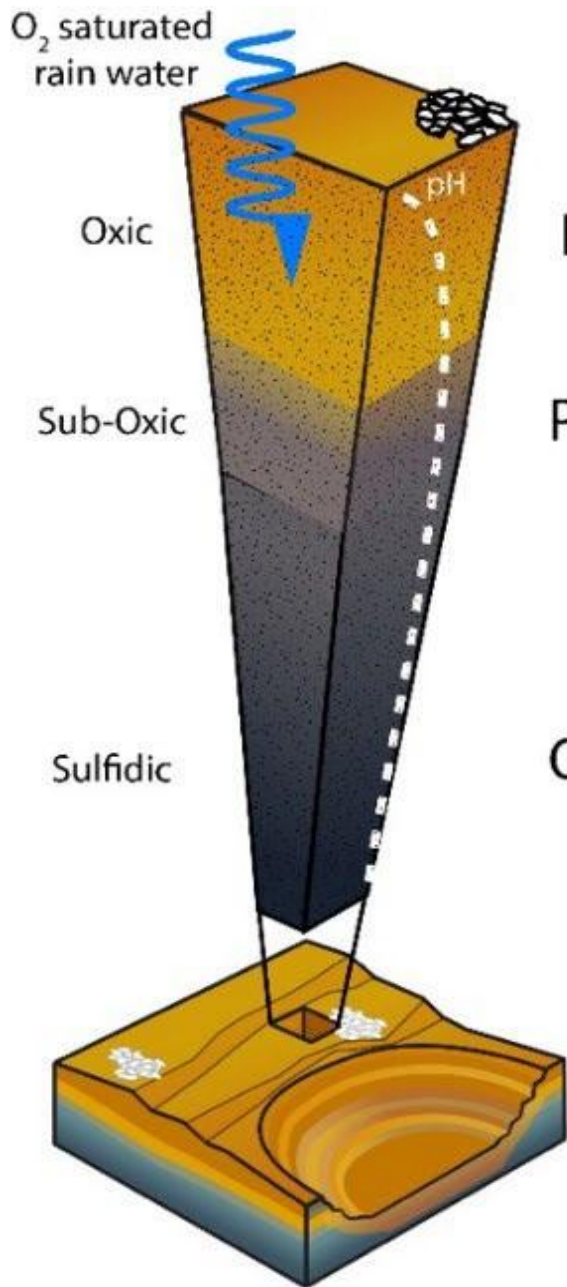
Legacy mine tailings in the western US



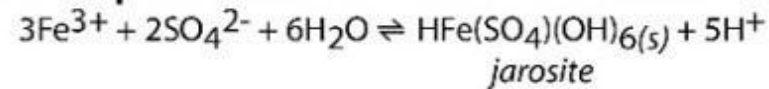
Mining waste material, particularly from sulfide ores, is enriched in toxic metal(loid)s.

Arsenic is a human toxicant and carcinogen (#1 on the ATSDR substance priority list). **Lead** is #2 on ATSDR SPL.

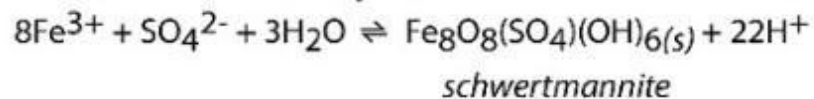
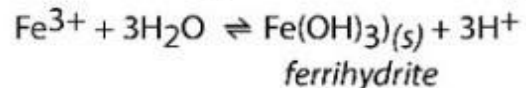
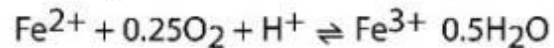
Wind dispersion of tailings leads to significant human health risk (ingestion and inhalation of contaminated dusts).



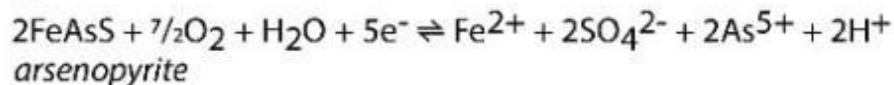
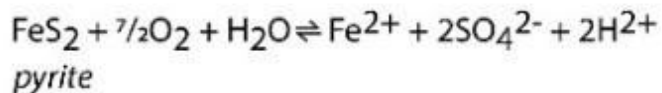
Precipitation of Ferric sulfate



Precipitation of Ferric solids

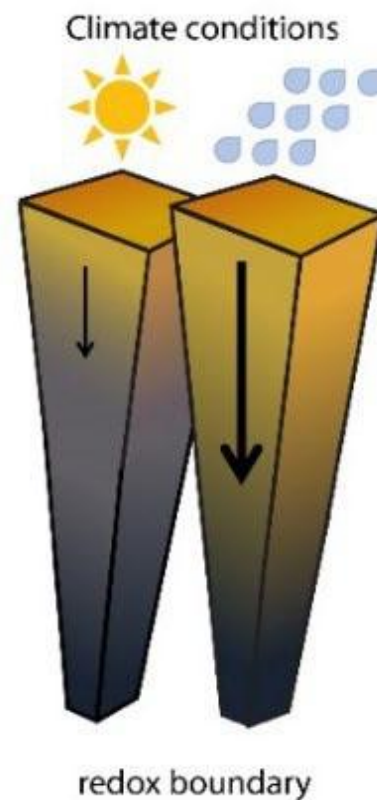


Oxidation of sulfides



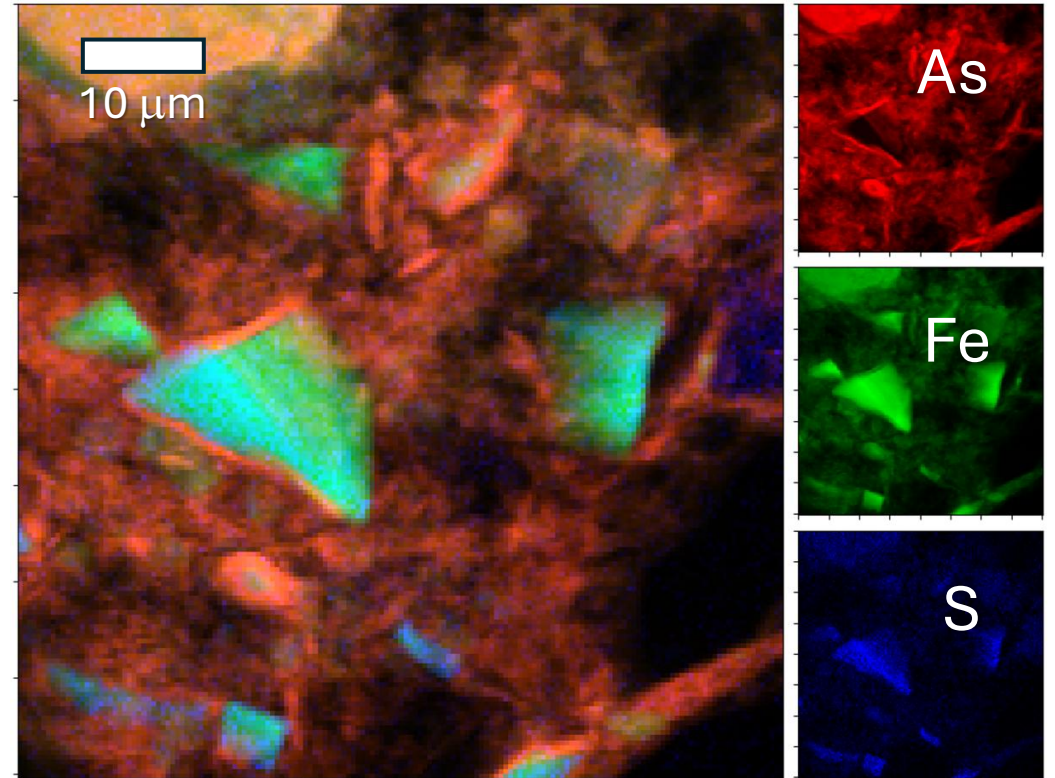
Specifics depend on the amount of H₂O and O₂ fluxing through (*climate*)

Driving Reactions at Mine Tailing



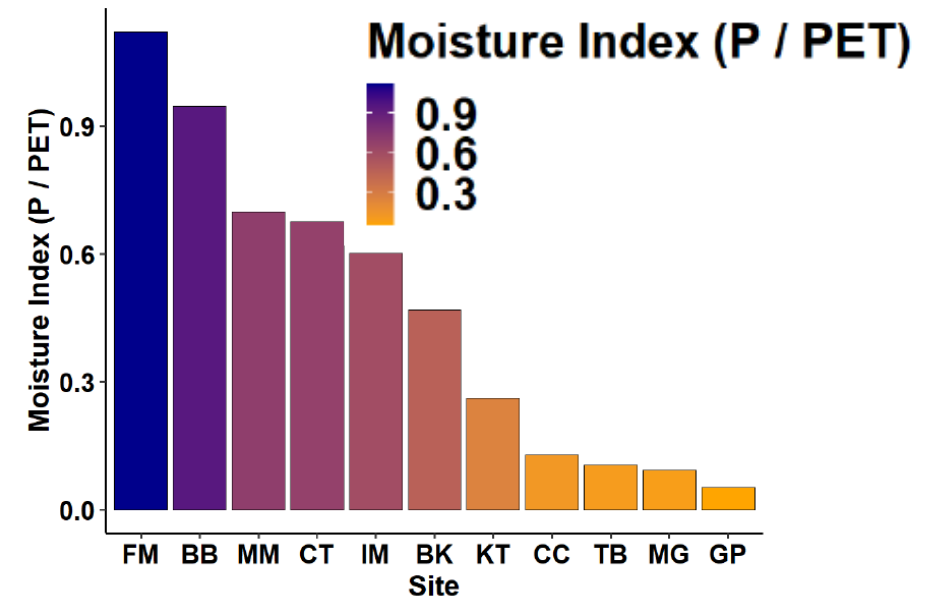
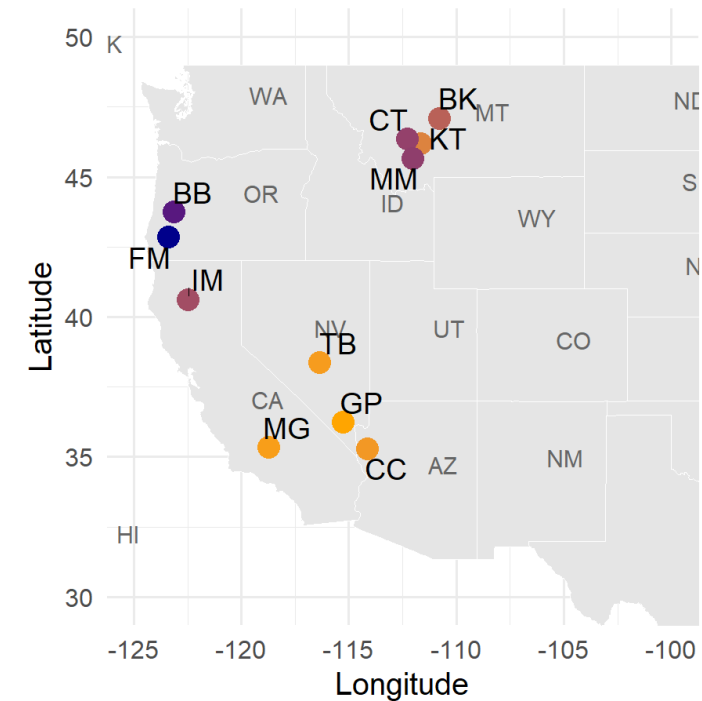
Key research questions and hypotheses

- How **bioaccessible** is the arsenic (As) in mine tailings particulate matter (mt-PM)?
- How does environmental weathering affect the **molecular speciation** of As in mt-PM?
- Is As molecular speciation predictive of its bioaccessibility in gastrointestinal fluid?



Research Approach

- Sampled a climate sequence of arsenic-containing mt-PM across the western U.S. to assess the impacts of climate on weathering of the mine tailings profile and arsenic molecular speciation.
- Quantified the relative contribution of various As molecular species to the total mt-PM pool (using X-ray absorption spectroscopy, XANES and EXAFS).
- Measured the bioaccessibility of the various mt-PM species using IVBA and in vivo methods to simulate gastric and intestinal conditions.



Weathering profiles across the climosequence



Decreasing Aridity
(increasing moisture)

$$MI = \frac{P}{PET}$$



 0.05



 0.09



 0.10




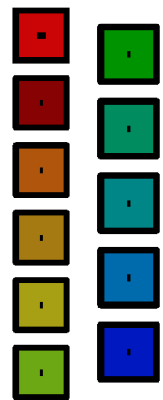
 0.13



 0.26




 0.47




 0.60



 0.68



 0.70

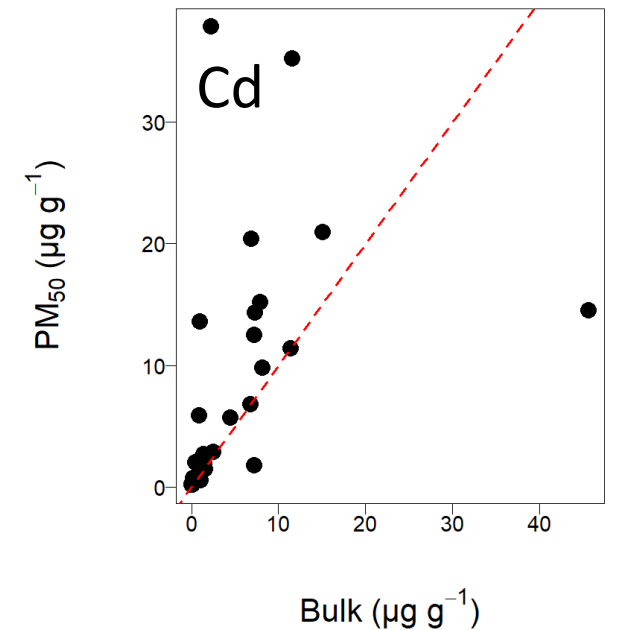
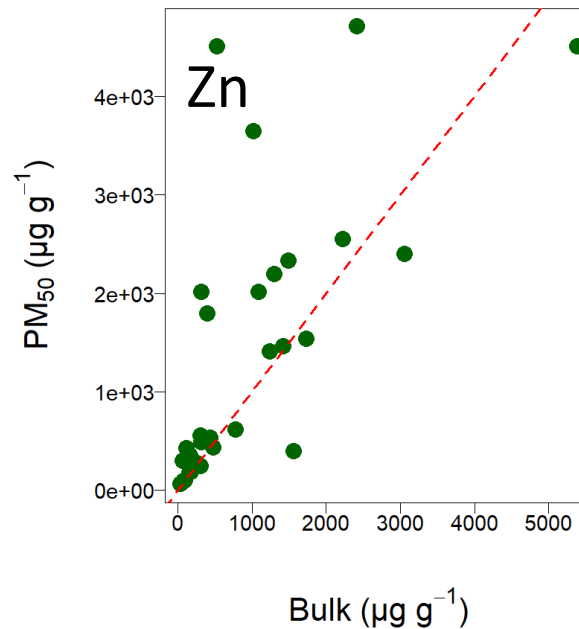
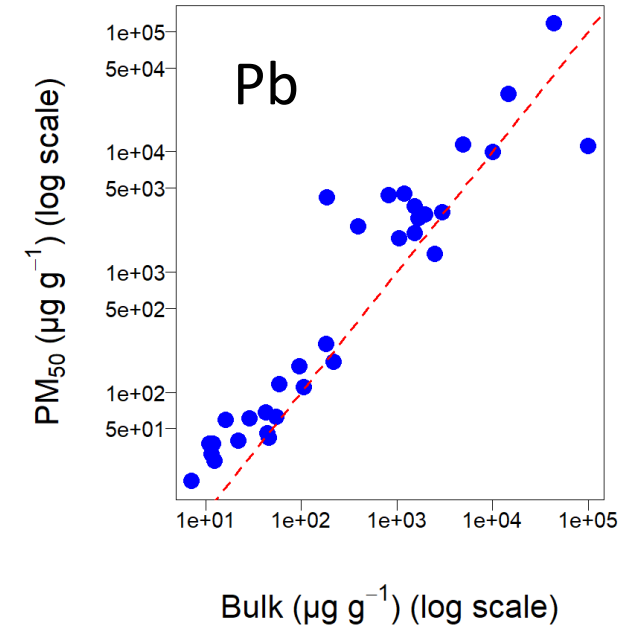
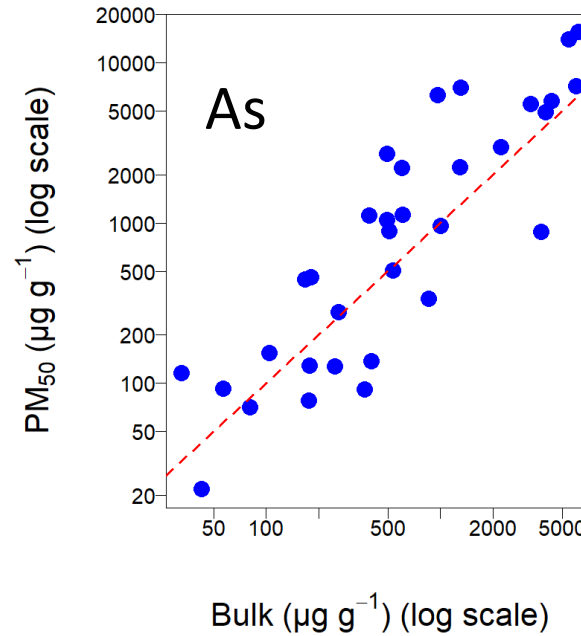


 0.95



 1.12

Modest increase in toxic metal(loid) concentration with decrease in particle size from bulk to PM₅₀



Ma'in Alghzawi
SRC Ph.D. graduate
Now at JUST

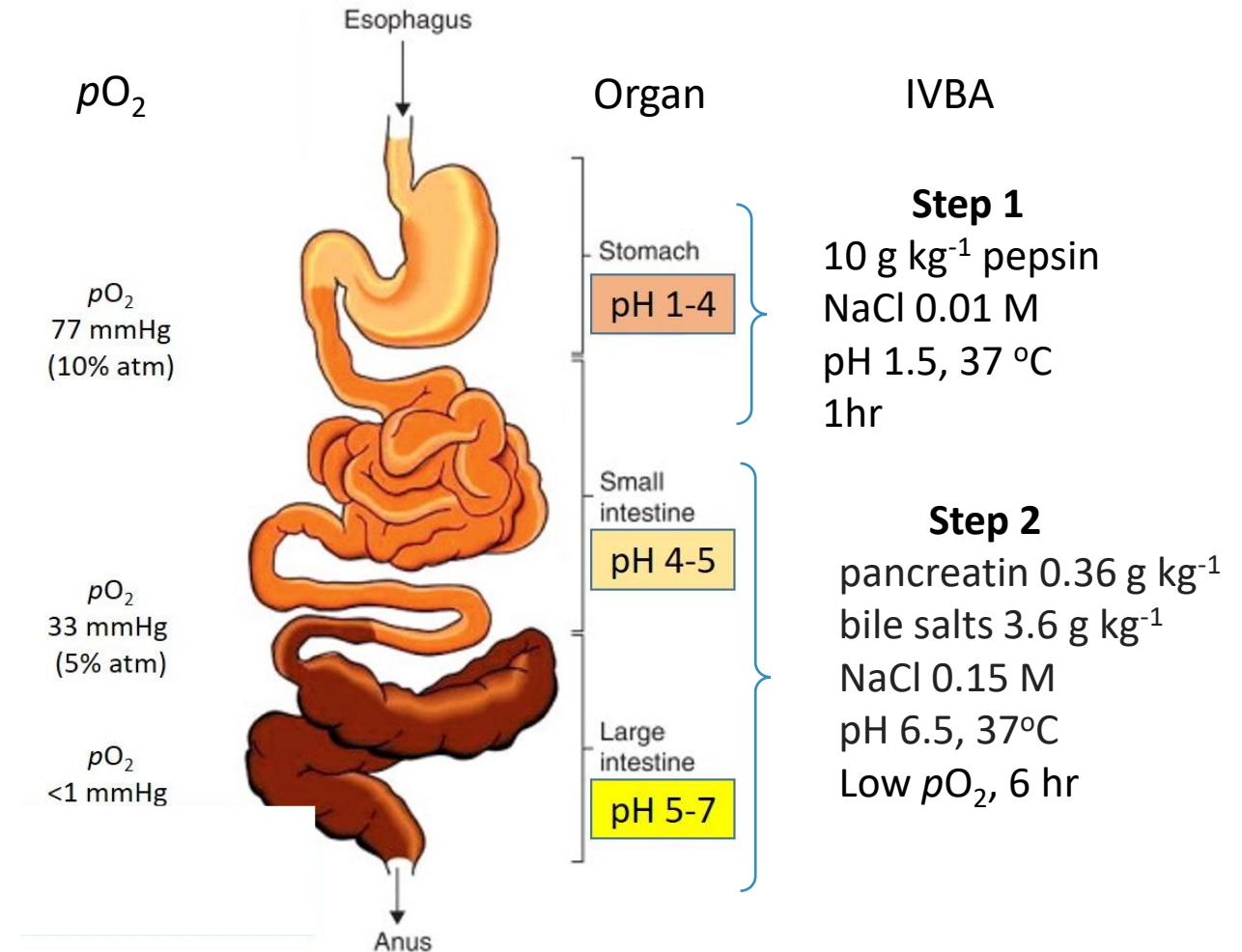
In vitro bioassay for % bioaccessibility

Use synthetic body fluids to elucidate operationally defined % BAc

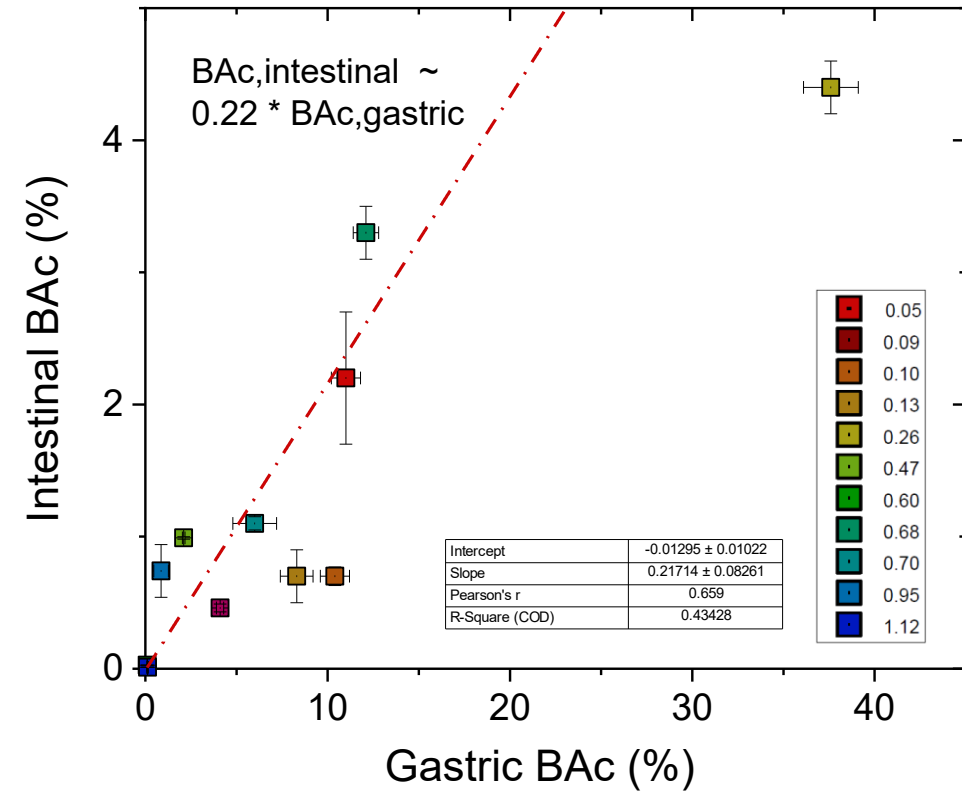
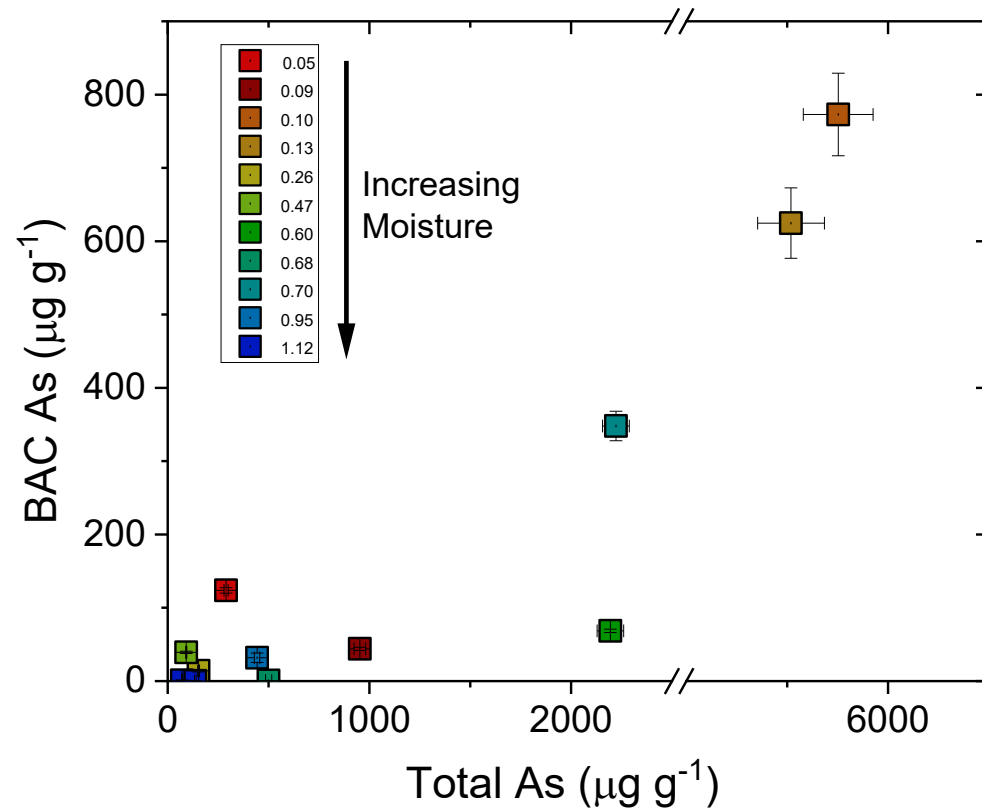


Synthetic Gastric + Intestinal Fluids

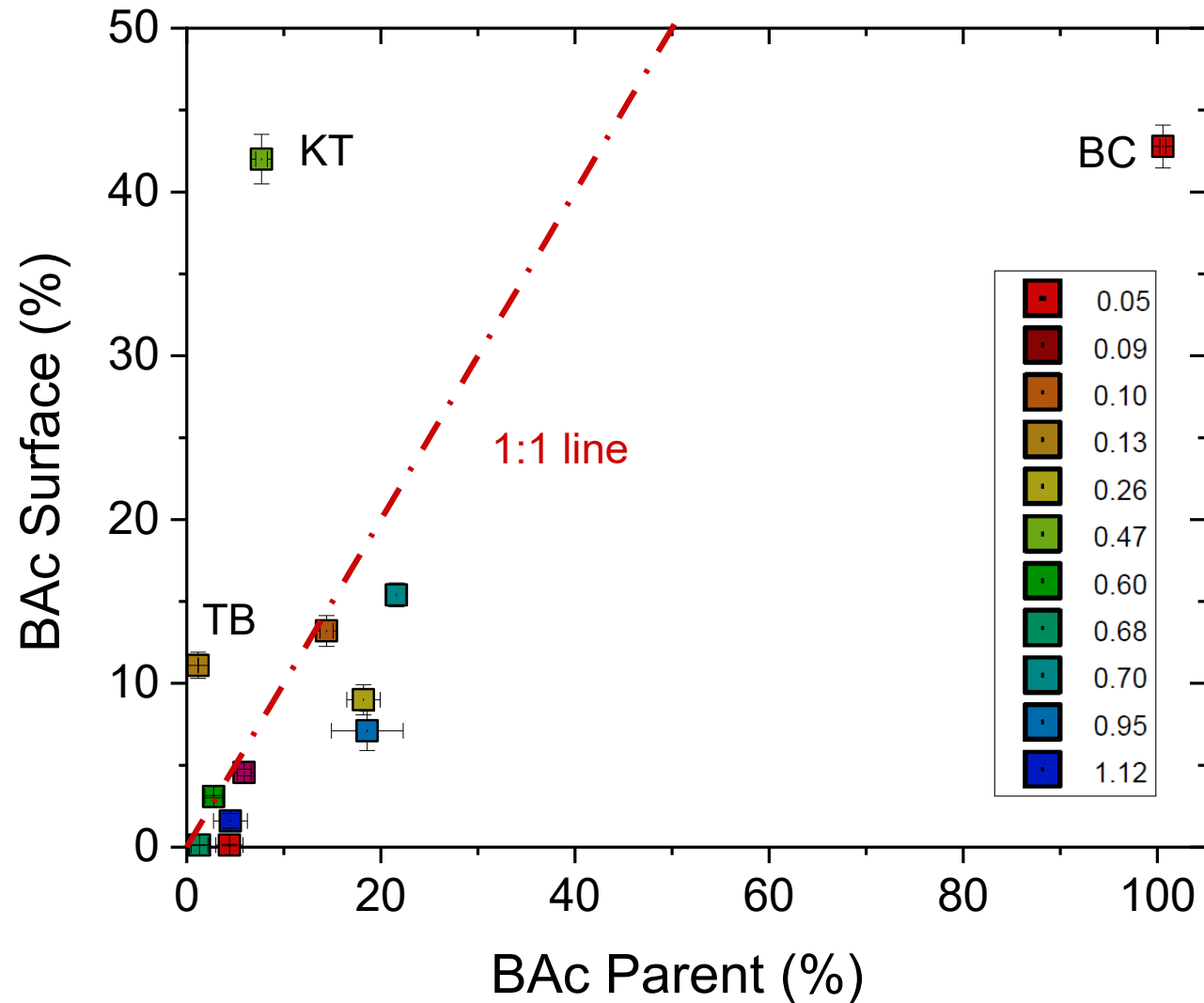
$$As \%BAC = \left(\frac{\text{in vitro } As}{\text{total } As} \right) \times 100$$



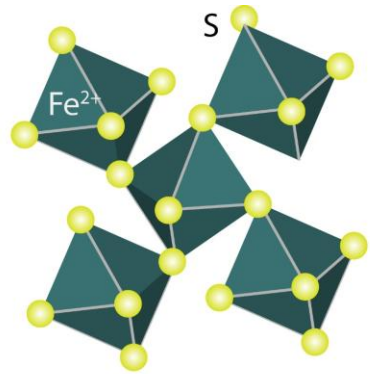
Gastrointestinal bioaccessibility of PM_{50} (*Surface Tailings*)



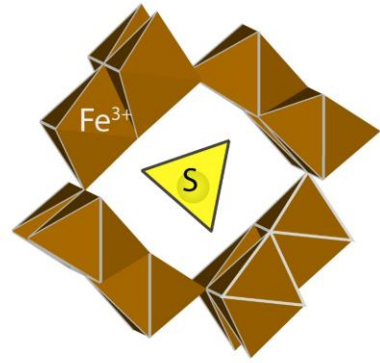
Gastric bioaccessibility of surface relative to parent (PM₅₀)



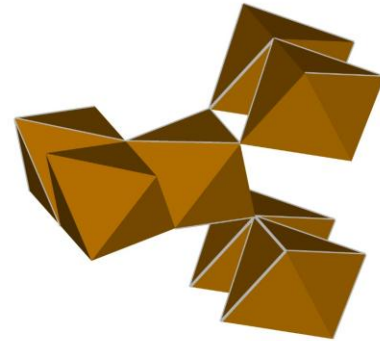
Dominant host minerals and As species in mt-PM



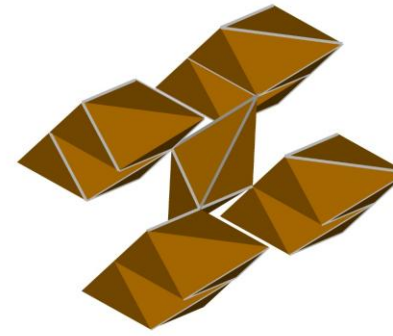
Pyrite



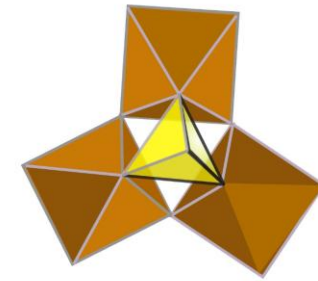
Schwertmannite



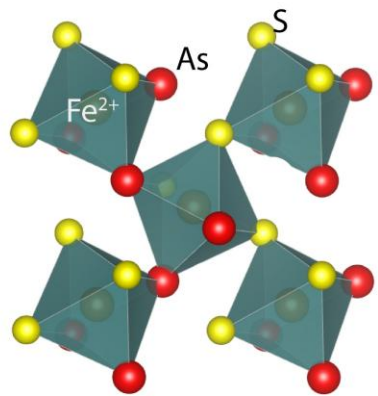
Goethite



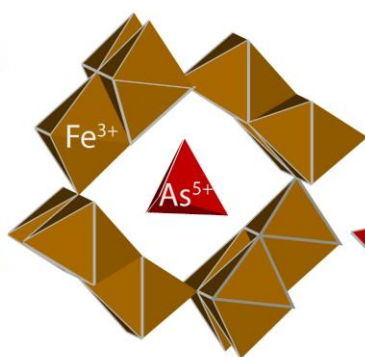
Ferrihydrite



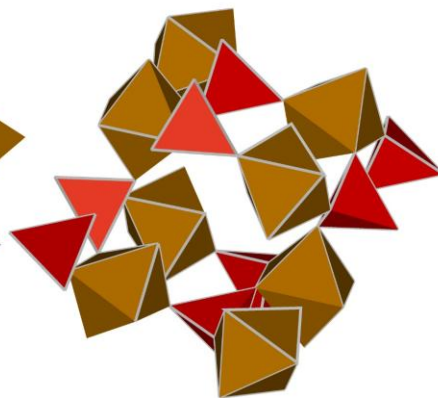
Jarosite



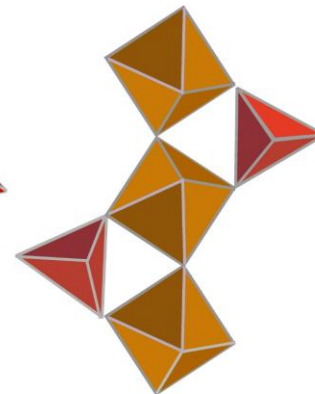
Arsenopyrite



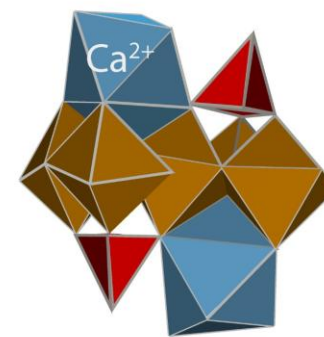
As-Schwertmannite



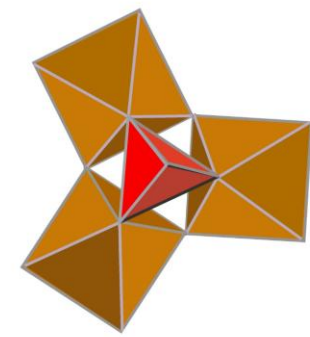
Scorodite



As-Ferrihydrite

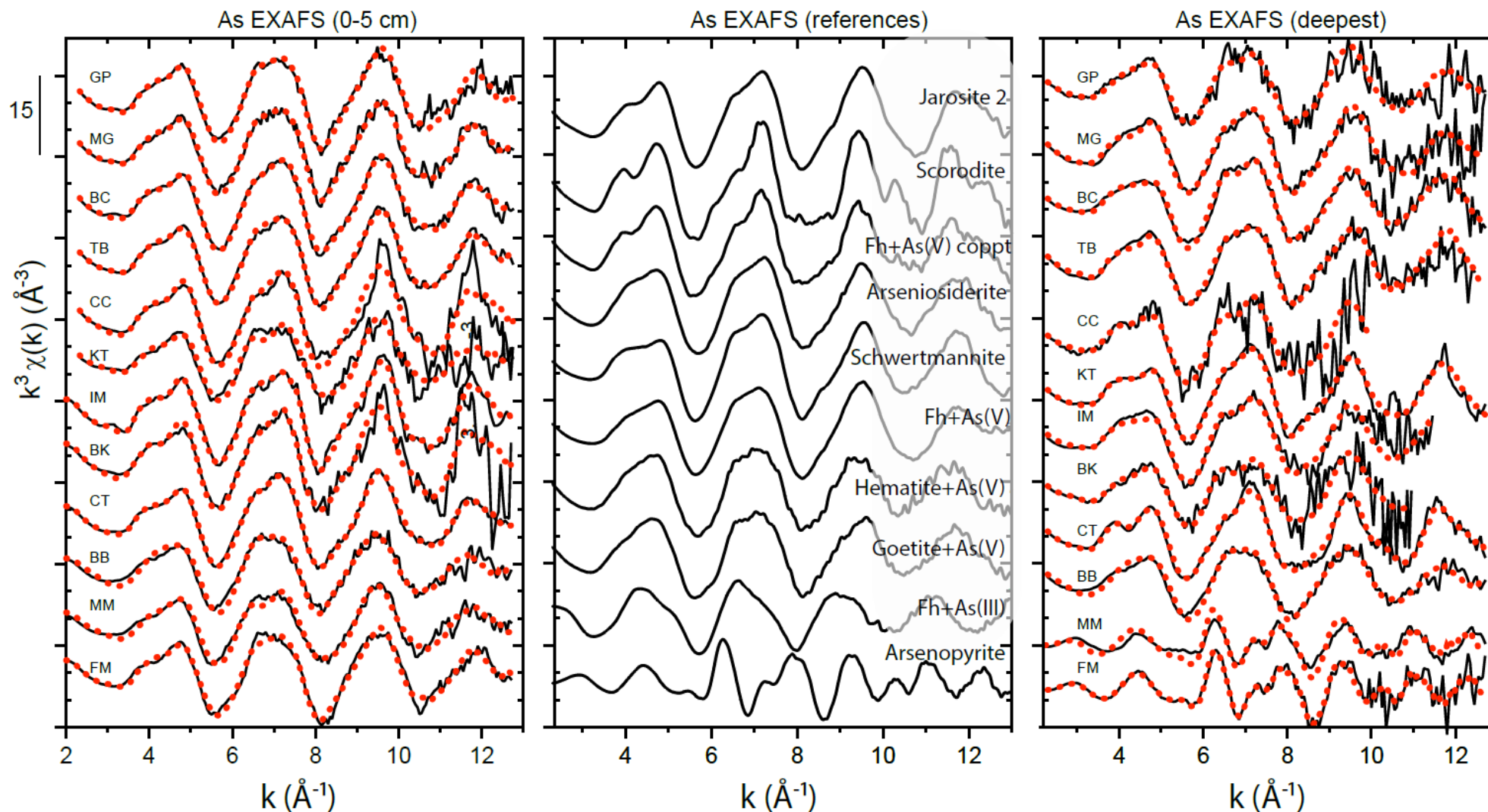


Arseniosiderite



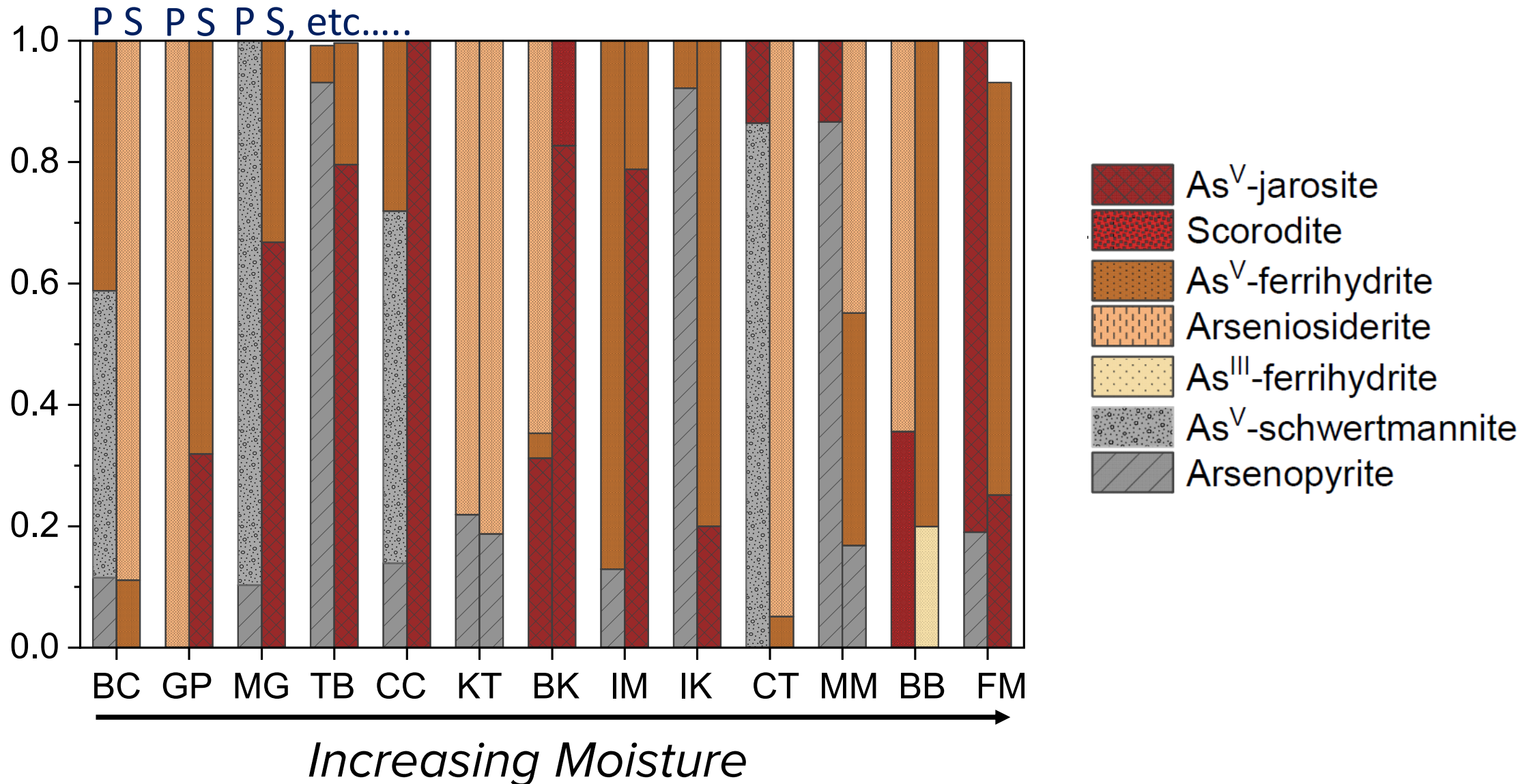
As-Jarosite

As K-edge EXAFS spectra of mt-PM and references

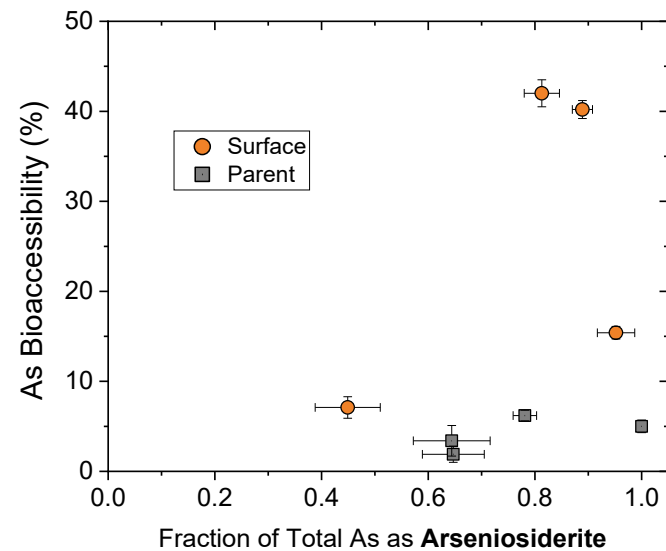
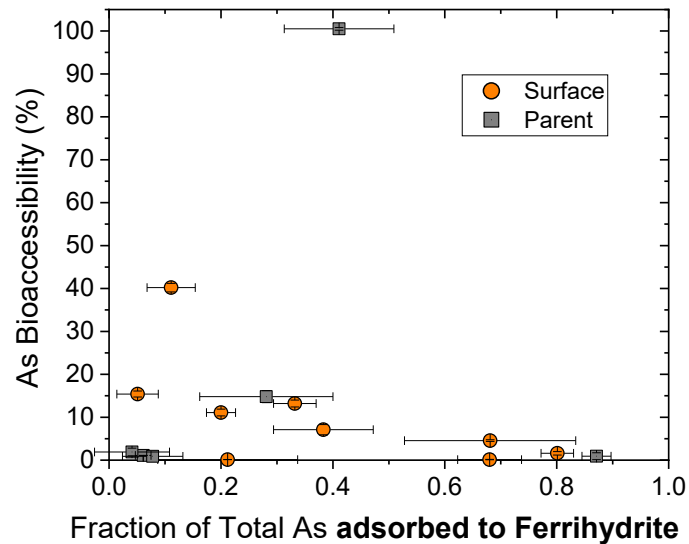
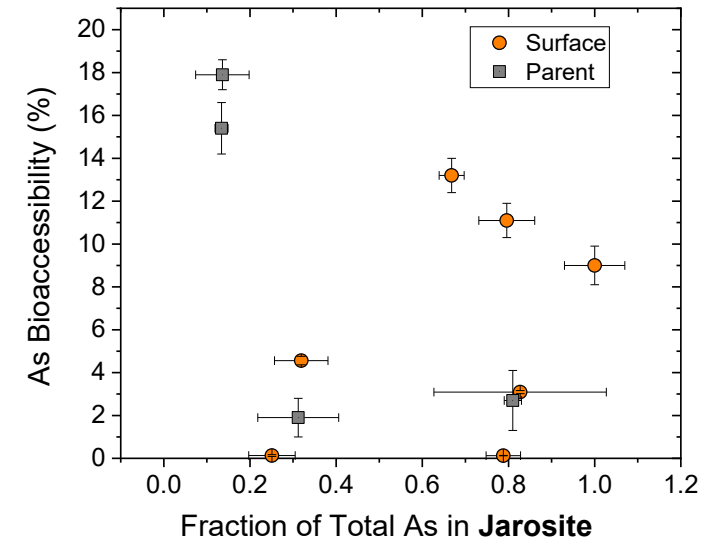
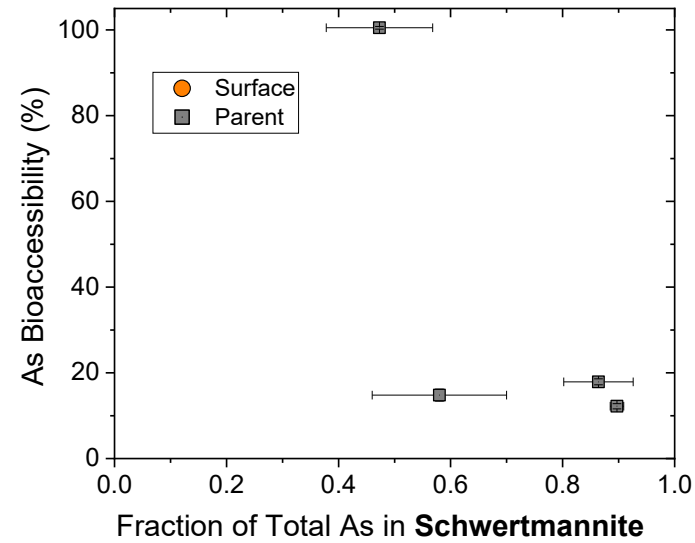
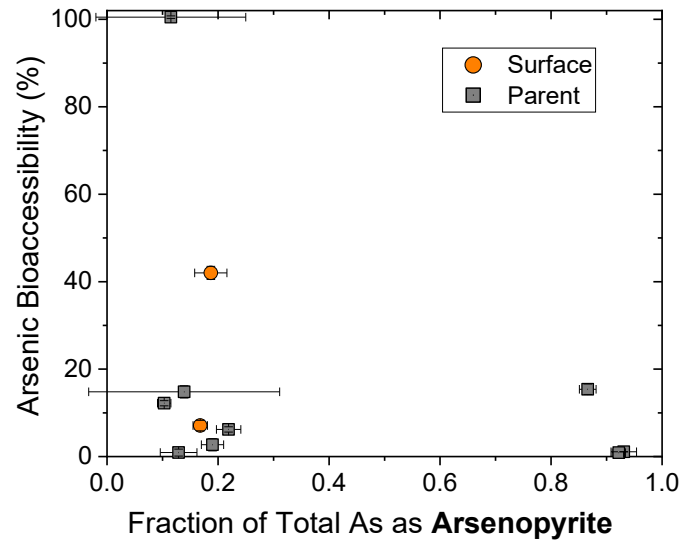


Dr. Rob Root
Research
Professor

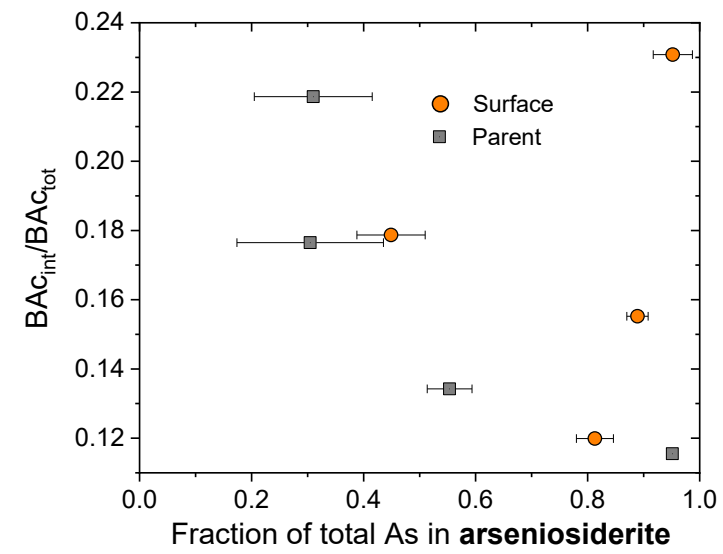
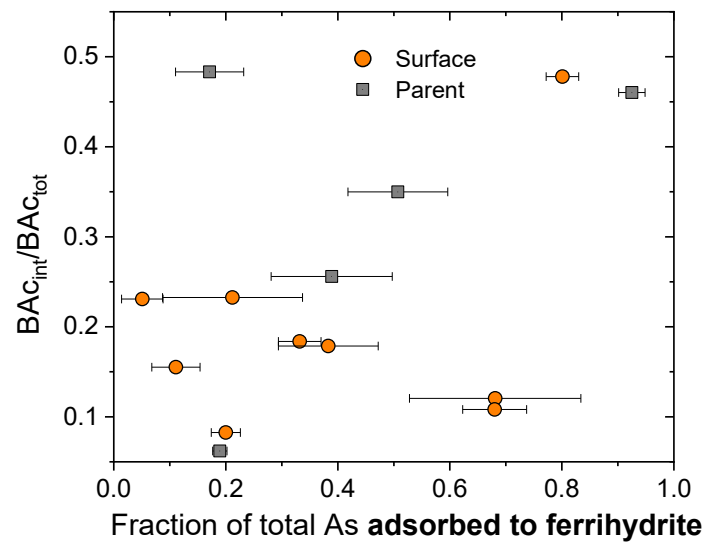
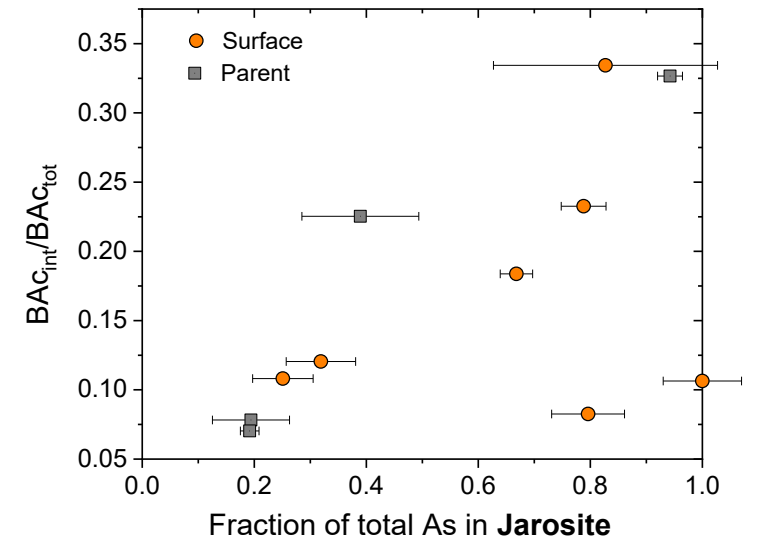
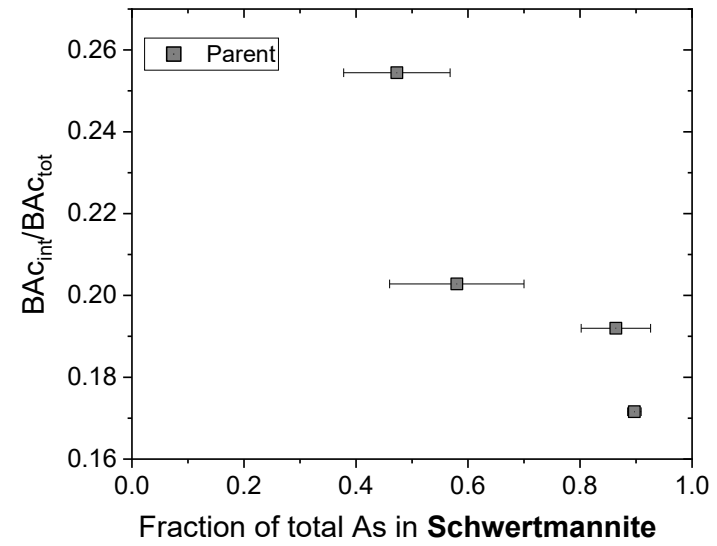
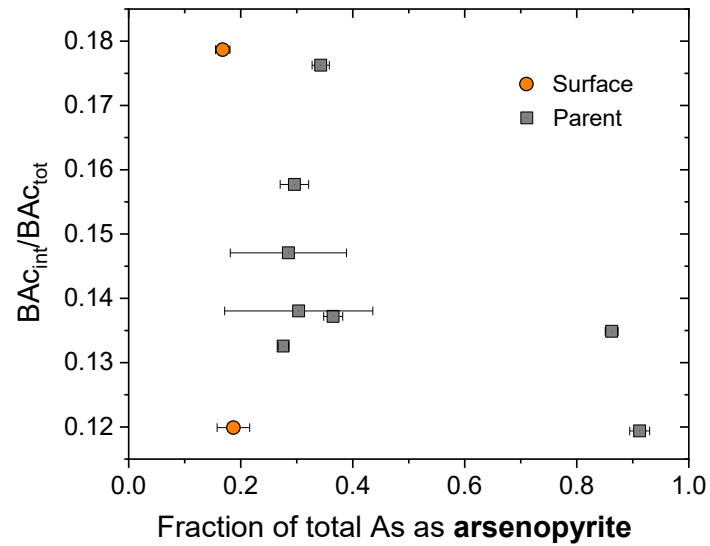
As molecular speciation change from parent to surface



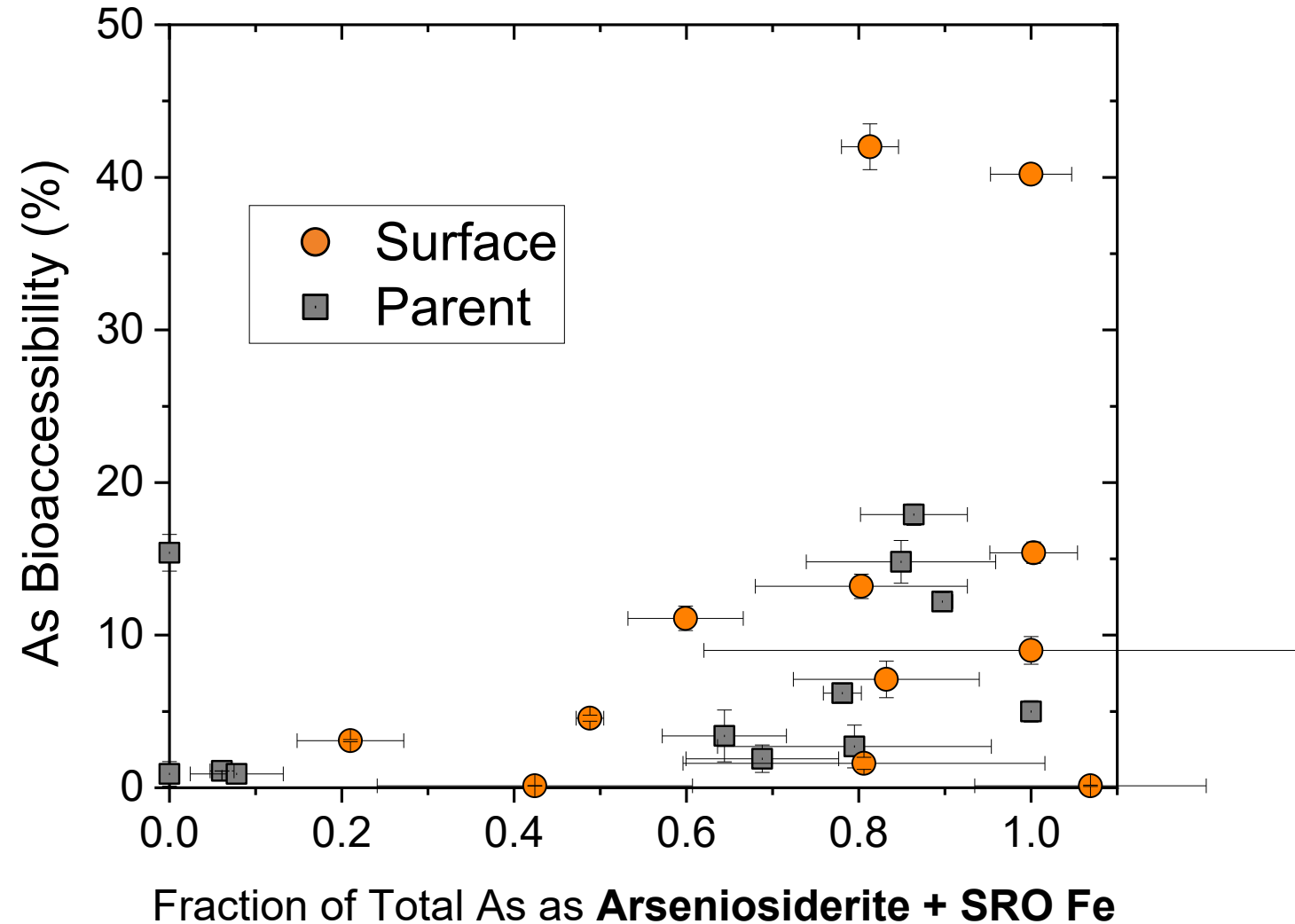
Relation of mt-PM As species composition to bioaccessibility



Intestinal BAc as a fraction of the Total BAc



Gastric As bioaccessibility is a function of both Arseniosiderite and SRO-Fe contributions



Mouse model (*in vivo*) experiment methods

**Treatment groups (n = 3 per group),
Germ Free and Wild Type (male):**

As(V)-jarosite, As(V)-ferrihydrite,
arsenopyrite, arseniosiderite,
negative control

Equivalent As dose of 40 μg As per
treated mouse

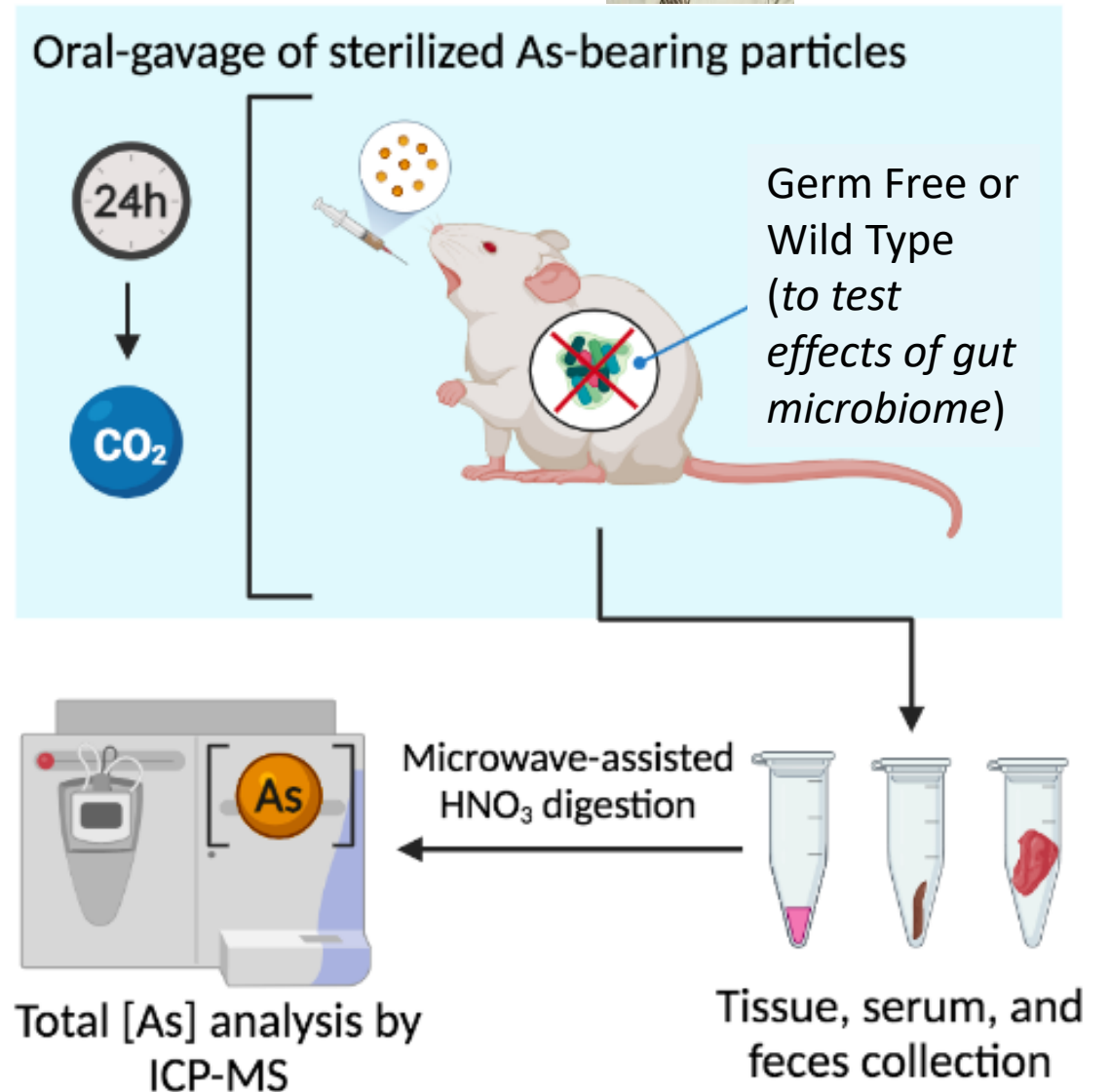
As bearing particles sterilized by
gamma irradiation (Sandia Nat'l Lab,
NM)



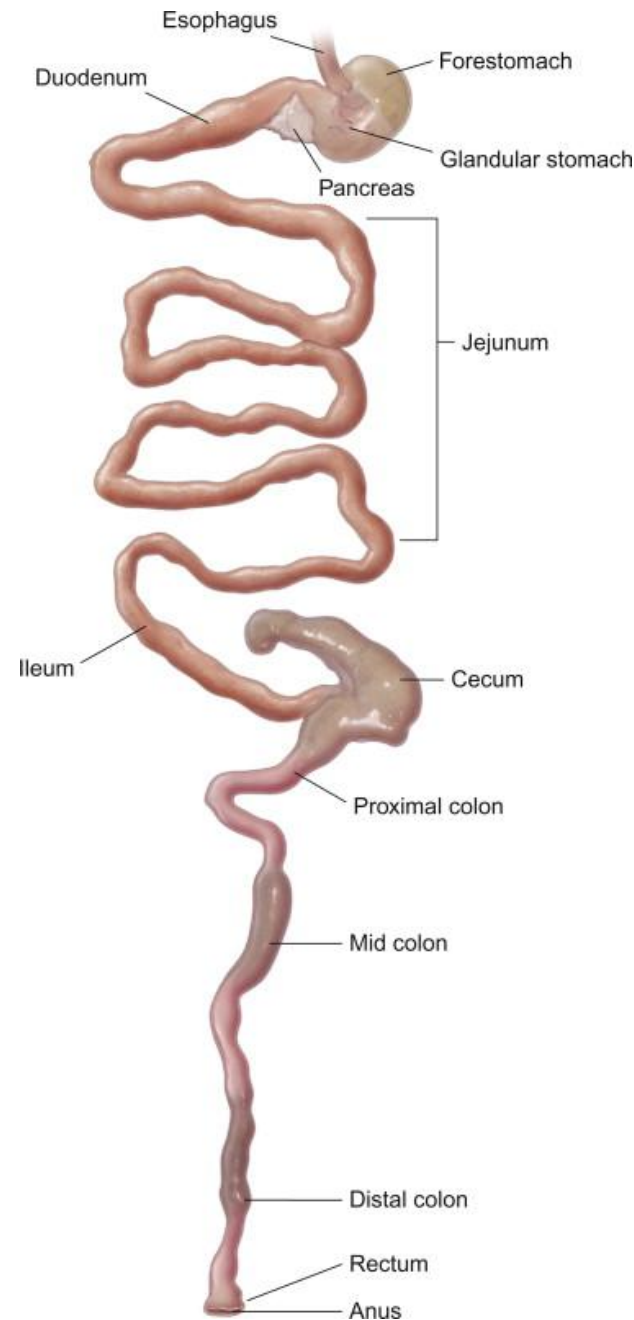
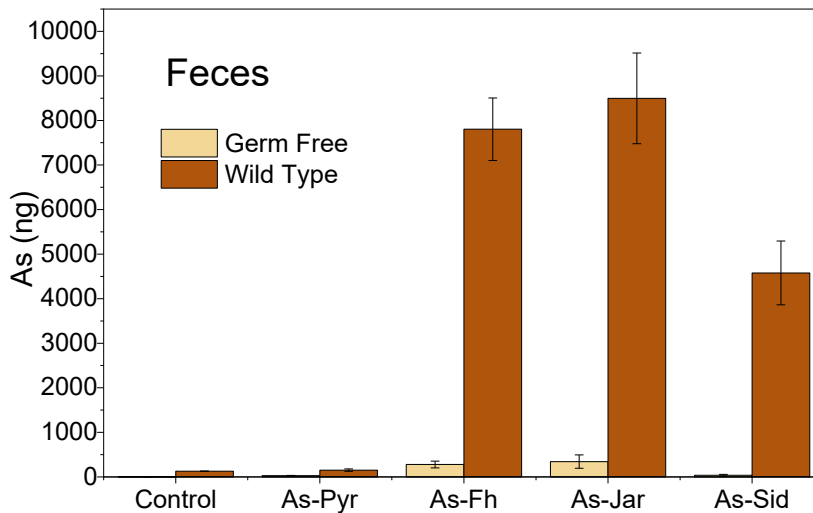
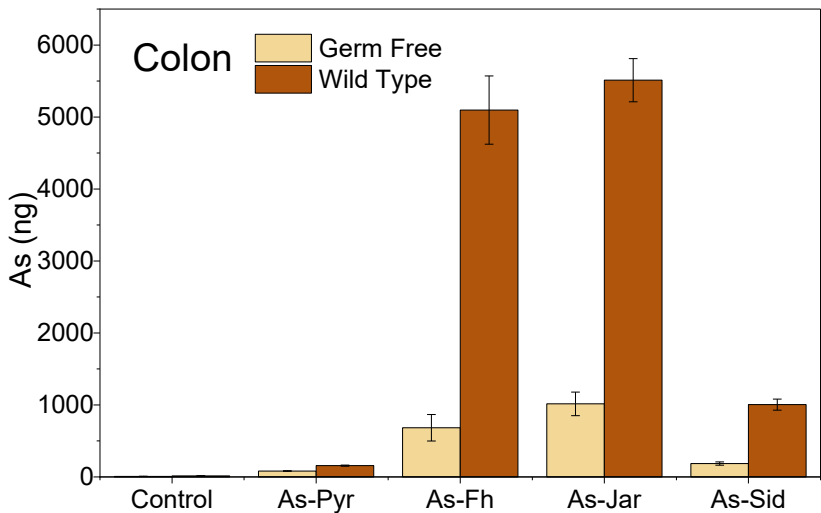
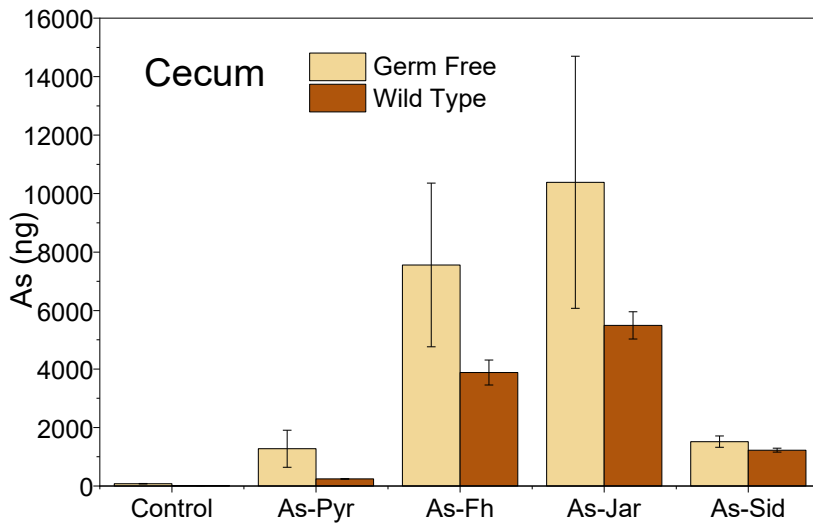
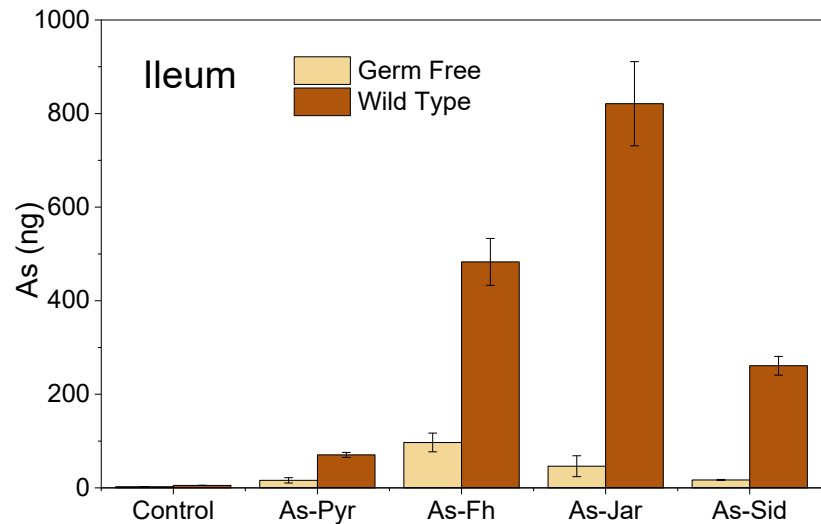
Kendra
Bonsey,
Graduate
Student



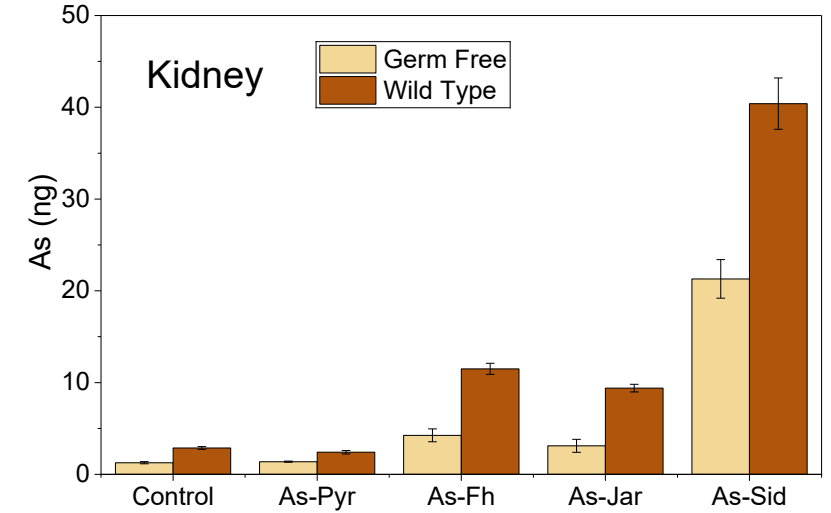
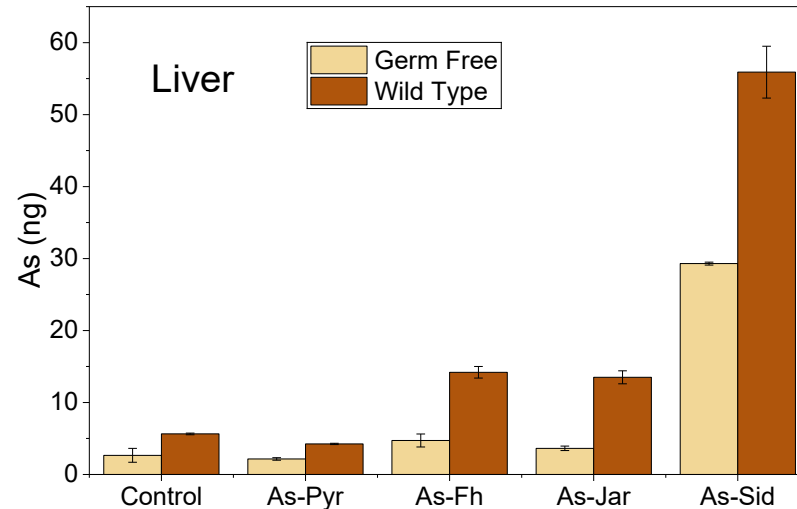
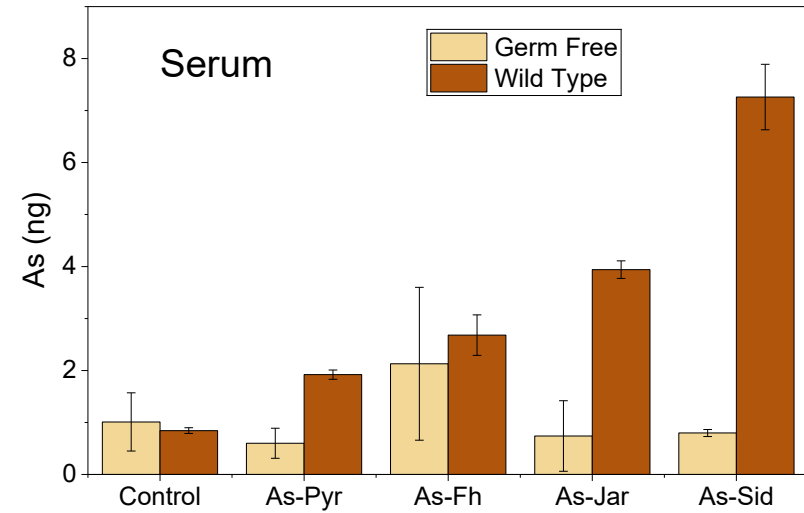
Dr. Pawel Kiela
UA College of
Medicine



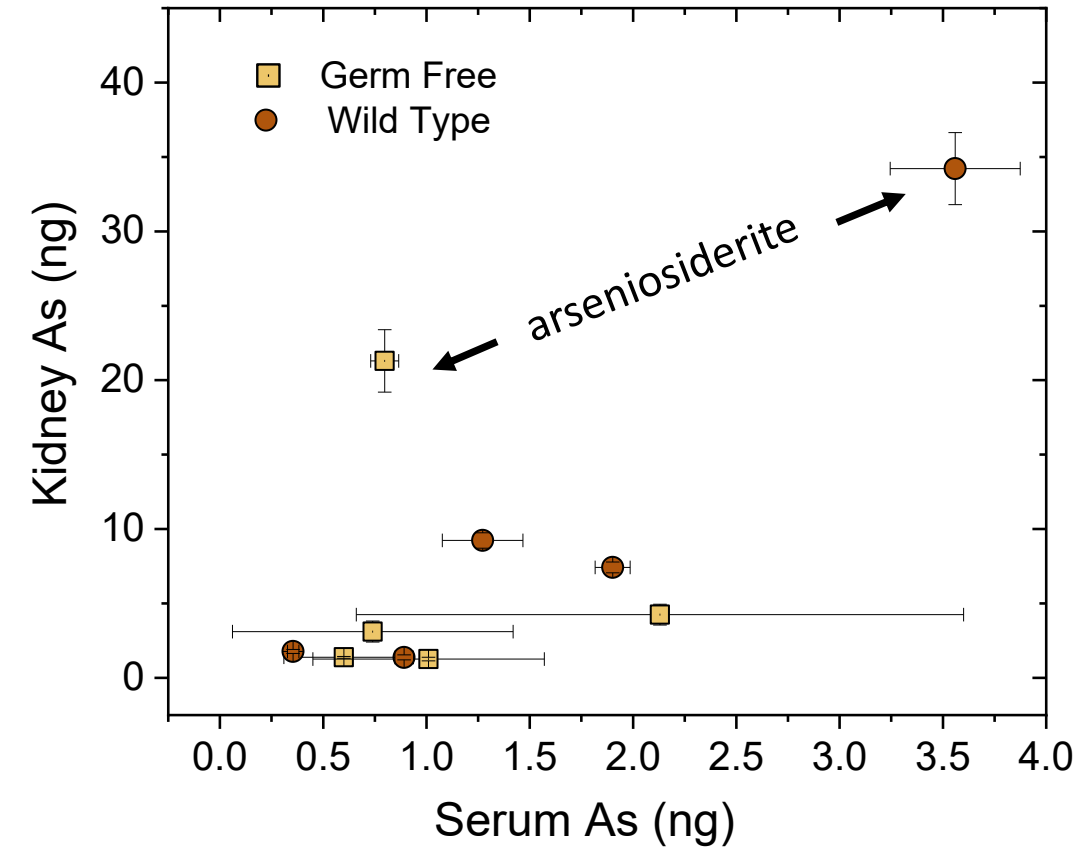
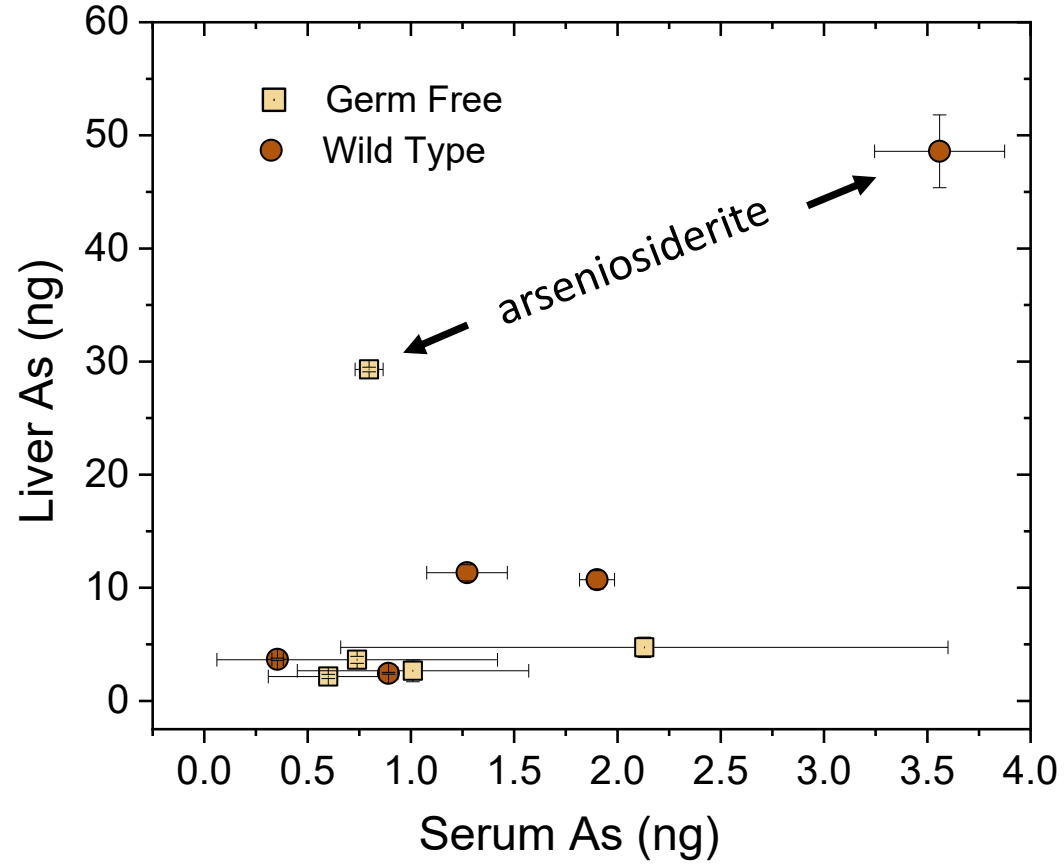
Arsenic recovery in GI tract



Arsenic recovery in serum, liver and kidney



Serum correlation with liver and kidney



Conclusions

- The arsenic-bearing weathering products that form in mine tailings exhibit a wide range in bioaccessibility.
- Total arsenic concentration is not an accurate predictor of ingestion risk for mt-PM (*particle size and species effects*).
- Molecular speciation exerts a strong control on bioaccessibility measured *in vitro* and bioavailability measured *in vivo*.
- The molecular form of toxic metal(loid) constituents of mine tailings should be considered in risk assessments of such sites.



National Institute of
Environmental Health Sciences

Grant #2 P42ES004940
University of Arizona
Superfund Research Center



Acknowledgements