Hinkley Community Meeting

April 25, 2019

AGENDA

- Cr(VI) background study status
- Cr(VI) background study report review
- Chromium in rocks, minerals, and groundwater
- Conclusions

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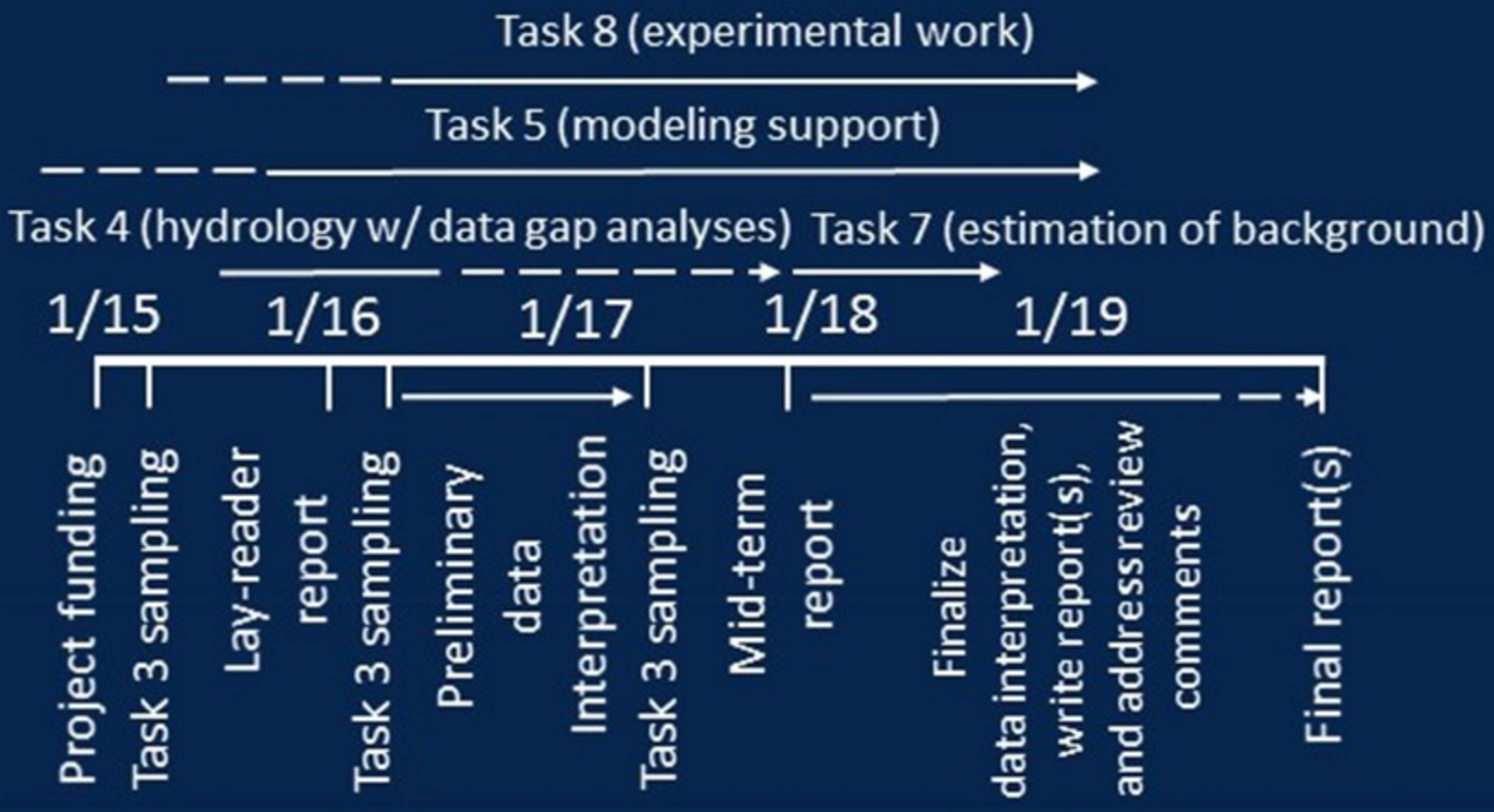
Simplified timeline



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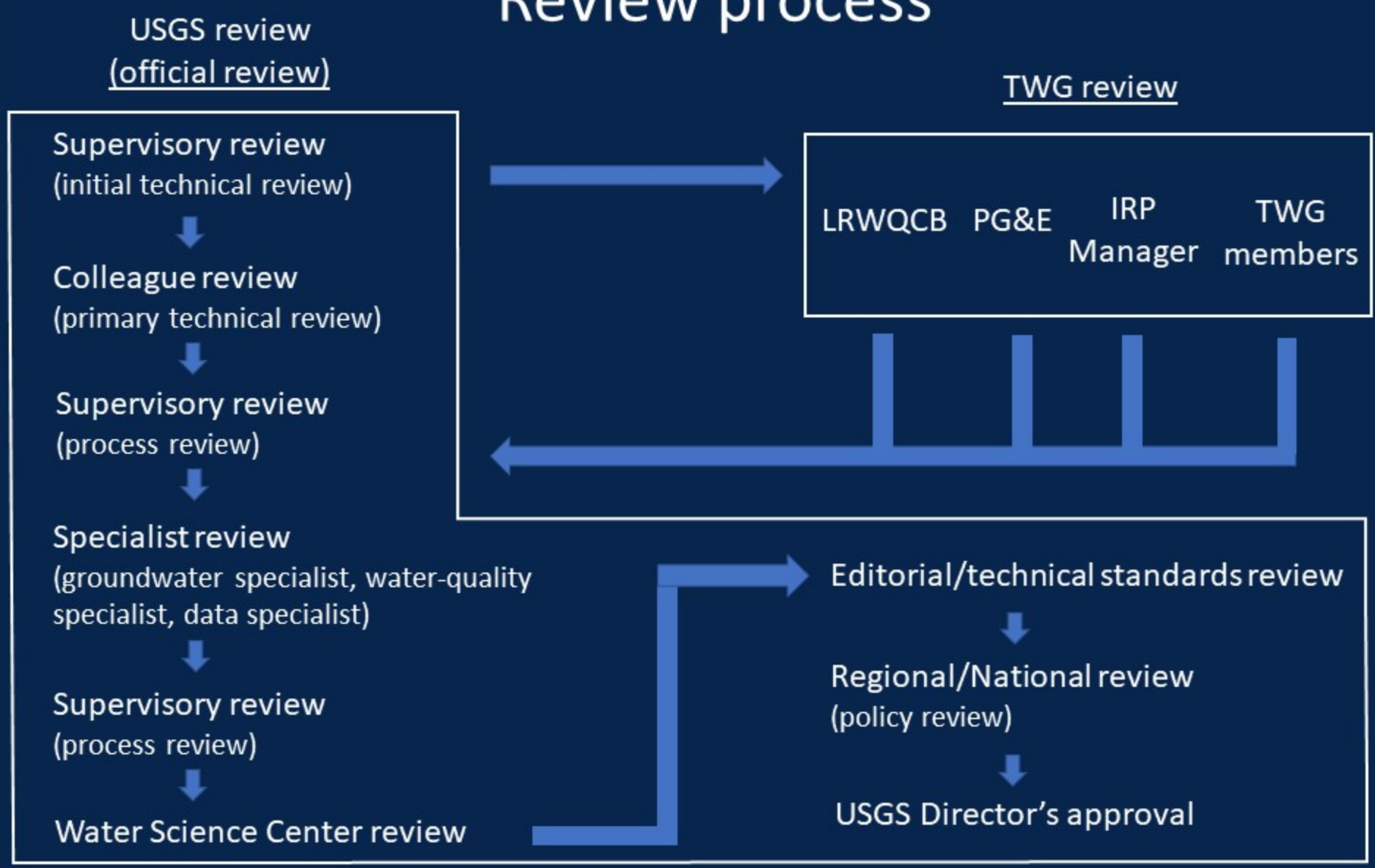
Review process



USGS review process was last reviewed by The National Academy of Sciences in 2017

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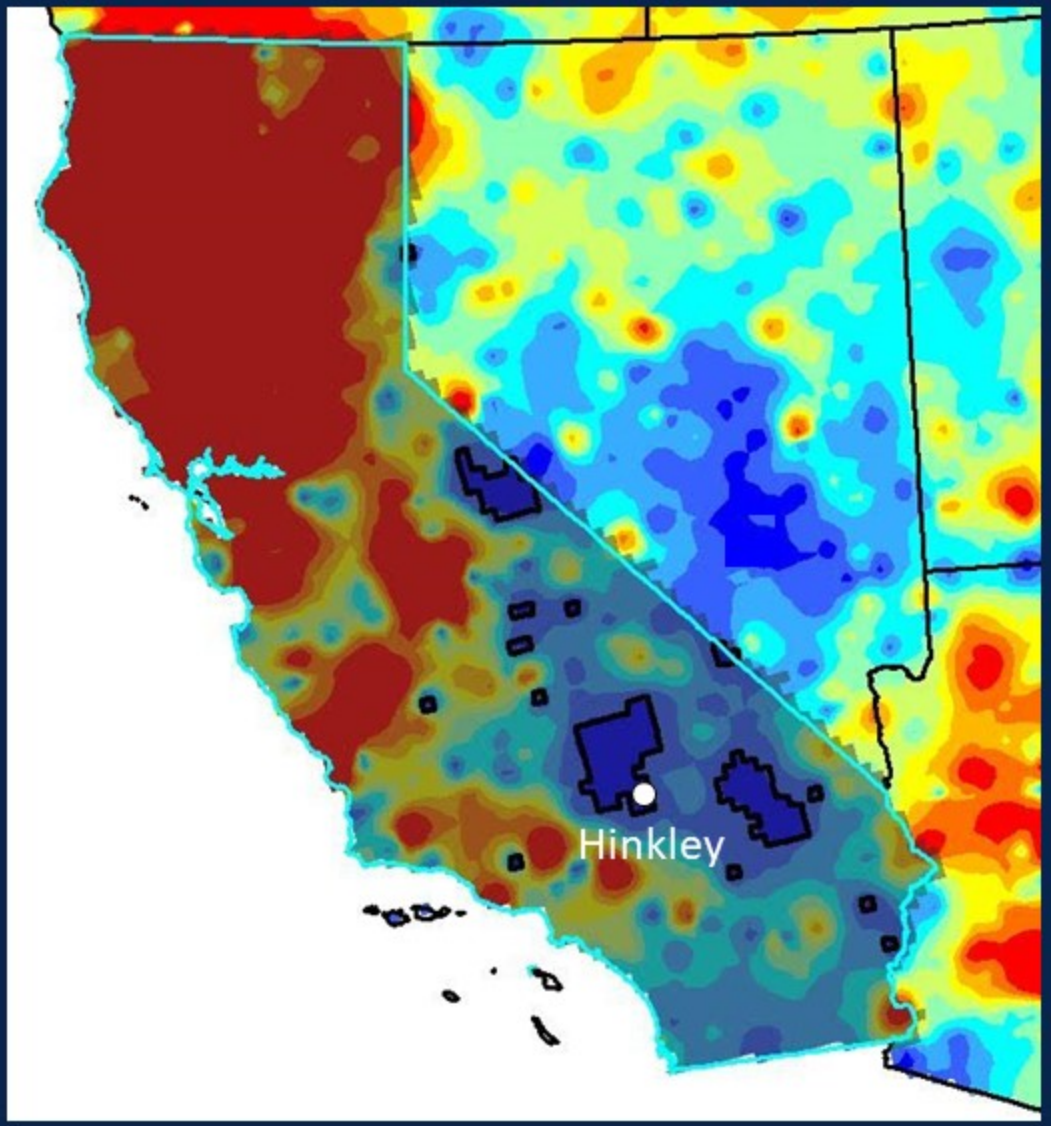
Chromium concentrations in soils in California



Percentile

Milligrams per kilogram (mg/kg)

90 - 100 — 55 to 2,580

0 - 10 — <1 to 10

Low-resolution data
(1,600 square mile sample grid with 40 mile by 40 mile resolution)

Only 4 percent of California has Chromium concentrations in soils as low as the Hinkley area

From: Smith and others, 2014. USGS Open File Report 2014-1082
http://pubs.usgs.gov/of/2014/1082/pdf/ofr-2014-1082.pdf

Modified from Smith et al., 2014

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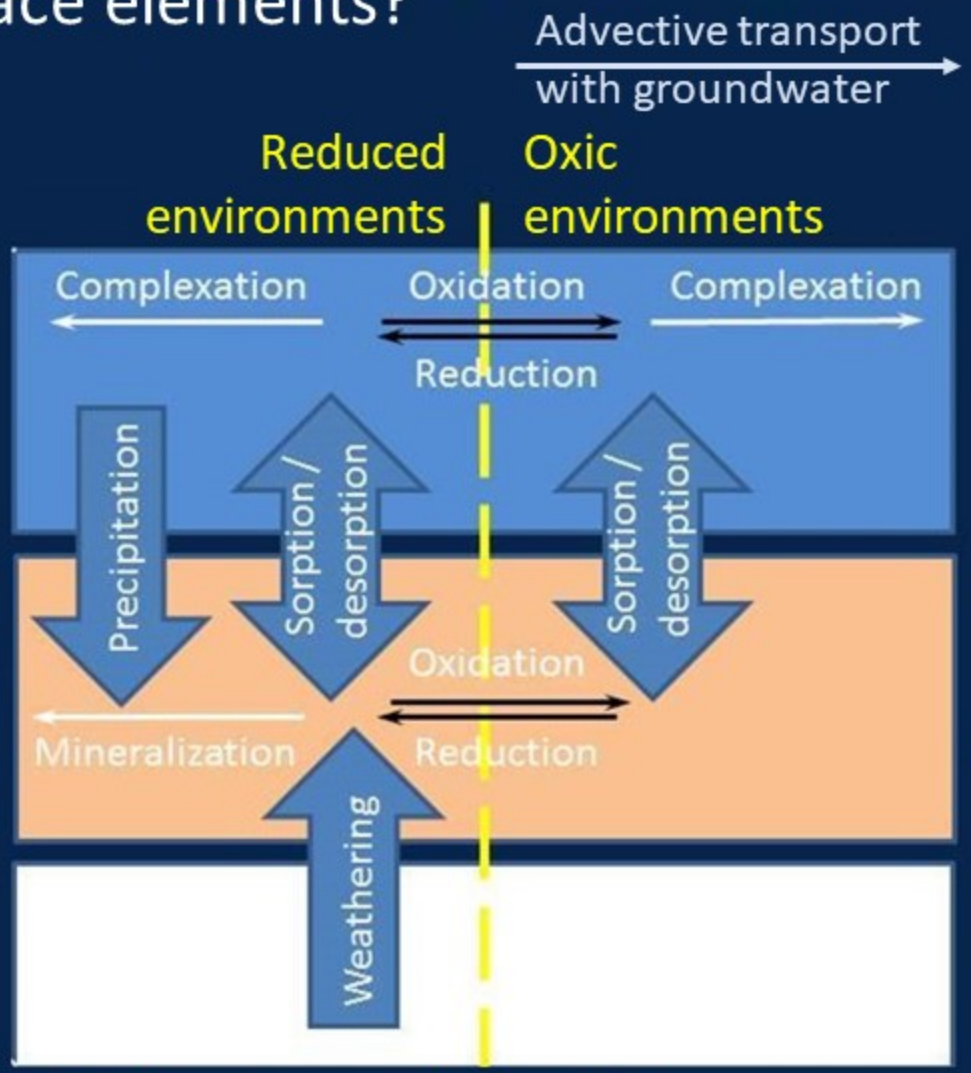
SSA Question 6: Is there an excess of Cr(VI) with respect to trace elements?



Water samples
(pH, redox, saturation indexes GW age/contact time)

Sequential extractions, Raman and XANES spectroscopy
(Multiple operationally-defined fractions)

Handheld and laboratory XRF, ICP-MS, SEM
(Mineralogy by density and particle-size)

Optical microscopy

Modified from: Scancar and Milacac, 2014

Framework for understanding the occurrence and behavior of Cr(VI) and other trace elements at the basin-wide and mineral grain scales

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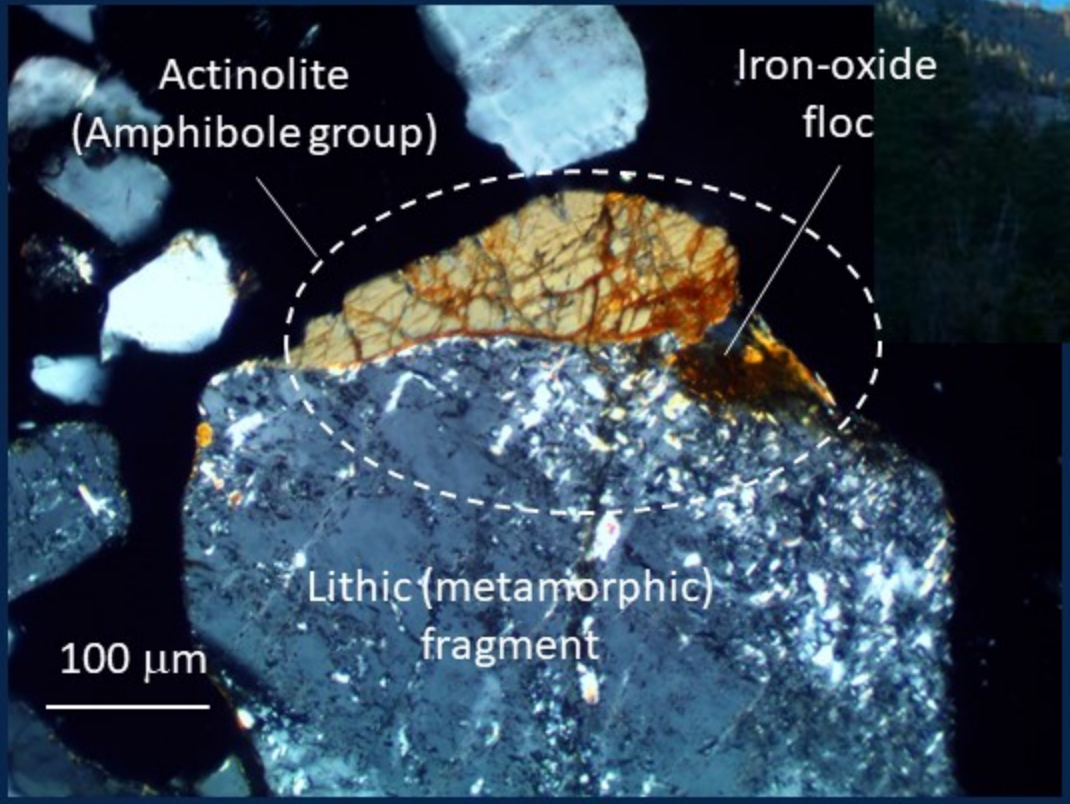
Actinolite, Older Mojave River alluvium

Trace mineral (less than 1 percent)



Chromium concentrations range from 900 to 4,010 milligrams per kilogram

BG-005 at 106 to 109 ft blsd

Cr_{solid} ranges from 10 to 23 mg/kg

Cr(VI) concentrations in water from well BG-005A

1.4 to 2.2 micrograms per liter

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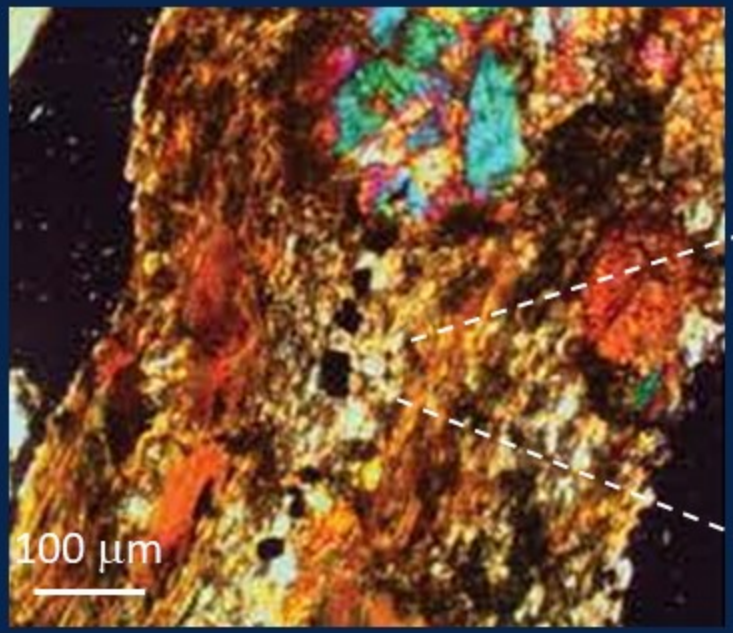
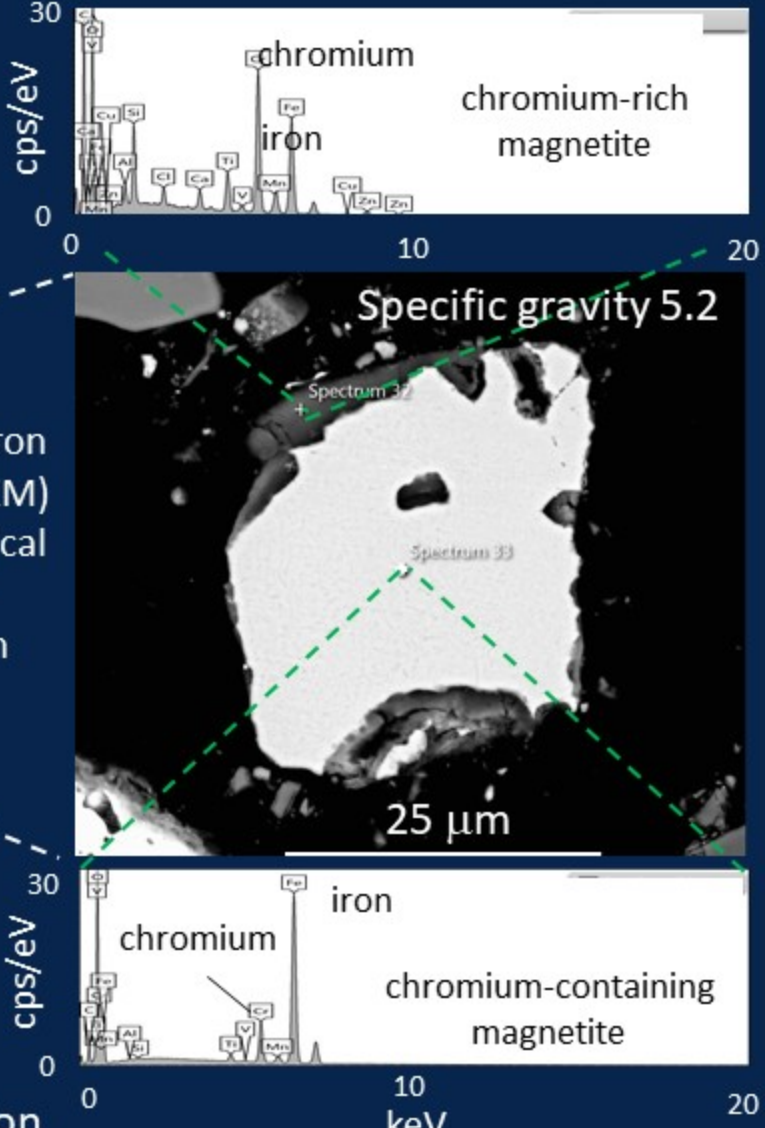
Magnetite, Mojave River alluvium

Small opaque crystals,
finely-disseminated within host rock



Scanning electron microscope (SEM) image of a typical magnetite mineral grain with EDS



- Most abundant chromium-containing mineral in recent Mojave River alluvium:
  - Cr_{solid} 7 to 12 mg/kg
  - Cr(VI) commonly less than 1.5 µg/L
- Present in low abundance, isolated by density separation
- Resistant to weathering. Chromite within the magnetite mineral group was not detected in Hinkley or Water Valleys

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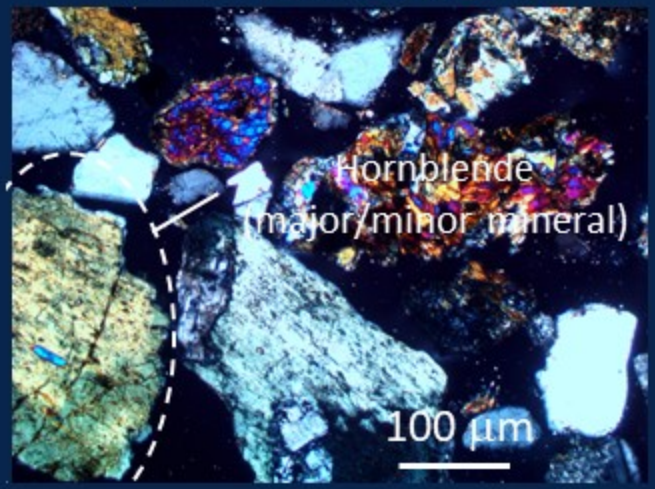
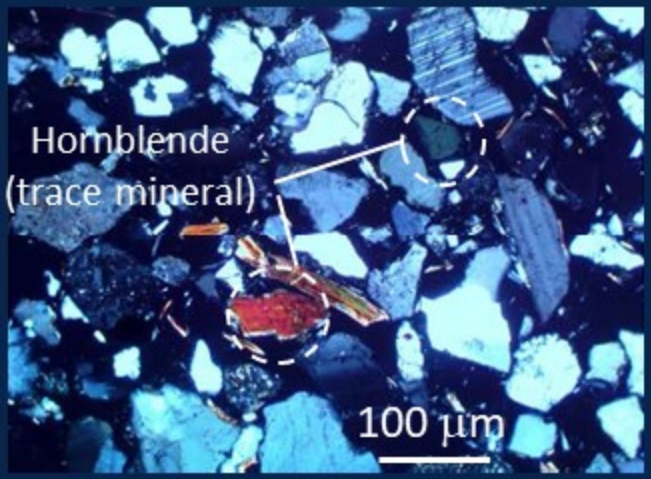
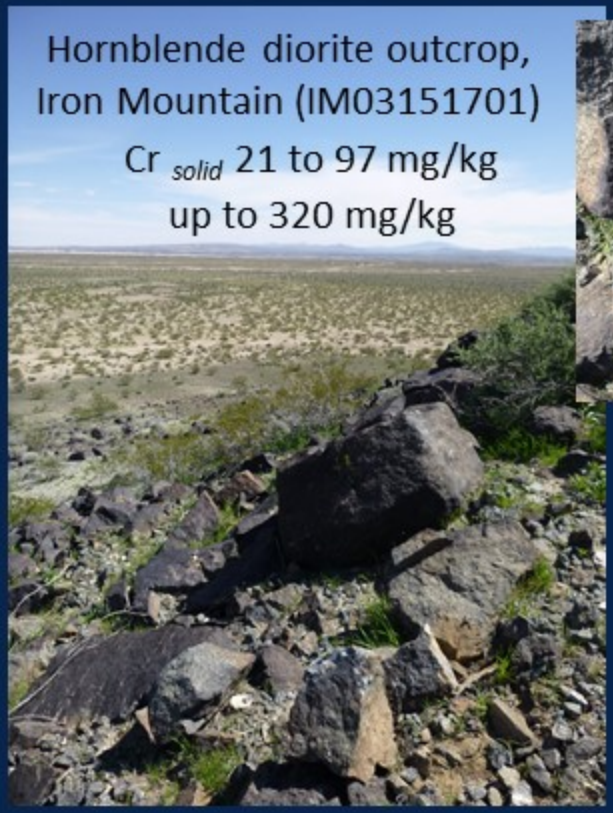
Hornblende, locally-derived alluvium

Alluviated stream channel,
Iron Mountain
Cr $_{solid}$ 190 to 210 mg/kg





Hornblende diorite outcrop,
Iron Mountain (IM03151701)
Cr $_{solid}$ 21 to 97 mg/kg
up to 320 mg/kg



Weathered
hornblende diorite
core material

- MW-165 in the "western finger"
  Cr $_{solid}$ 325 to 622 mg/kg
  Cr(VI) 0.99 to 1.2 µg/L
- MW-153S in the "western finger"
  Cr $_{solid}$ 61 to 250 mg/kg
  Cr(VI) 3.3 µg/L
- MW-159 93-100 ft blsd "western excavation site"
  Cr $_{solid}$ 9 to 16 mg/kg Cr(VI) 6.0 to 6.6 micrograms per liter

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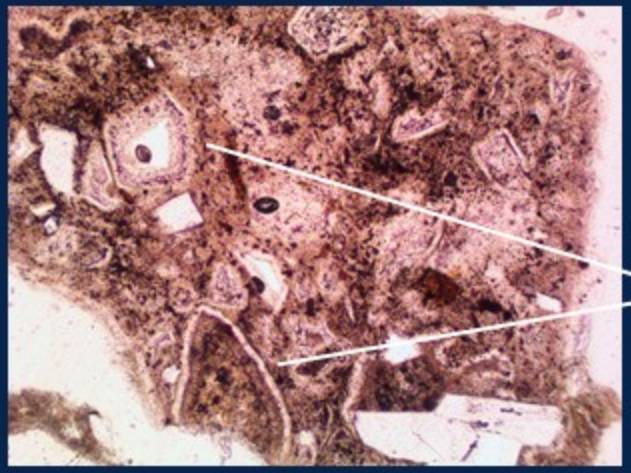
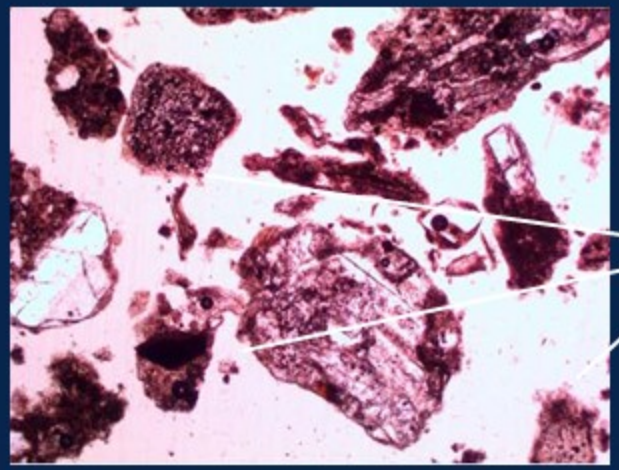
Mineral weathering and Miocene age deposits



MW-193 (Water Valley)
76 – 81.5 ft blsd
Cr_{solid} 6.7 to 22 mg/kg

Weathering rinds

MW-193S1
Cr(VI) 4.0 to 4.3 µg/L



MW-203 (Western subarea)
108 – 115 ft blsd
Cr_{solid} 20 to 44 mg/kg

Oxide accumulation

MW-203D
Cr(VI) 5.4 to 8.9 µg/L

- Miocene age deposits underlie parts of the western subarea. Locally-derived alluvium in Water Valley has been in part eroded from these materials
- 5 to 20 million years old and mineral grains are weathered
- Groundwater is often highly alkaline and water is some wells was recharged as much as 10,000 years ago

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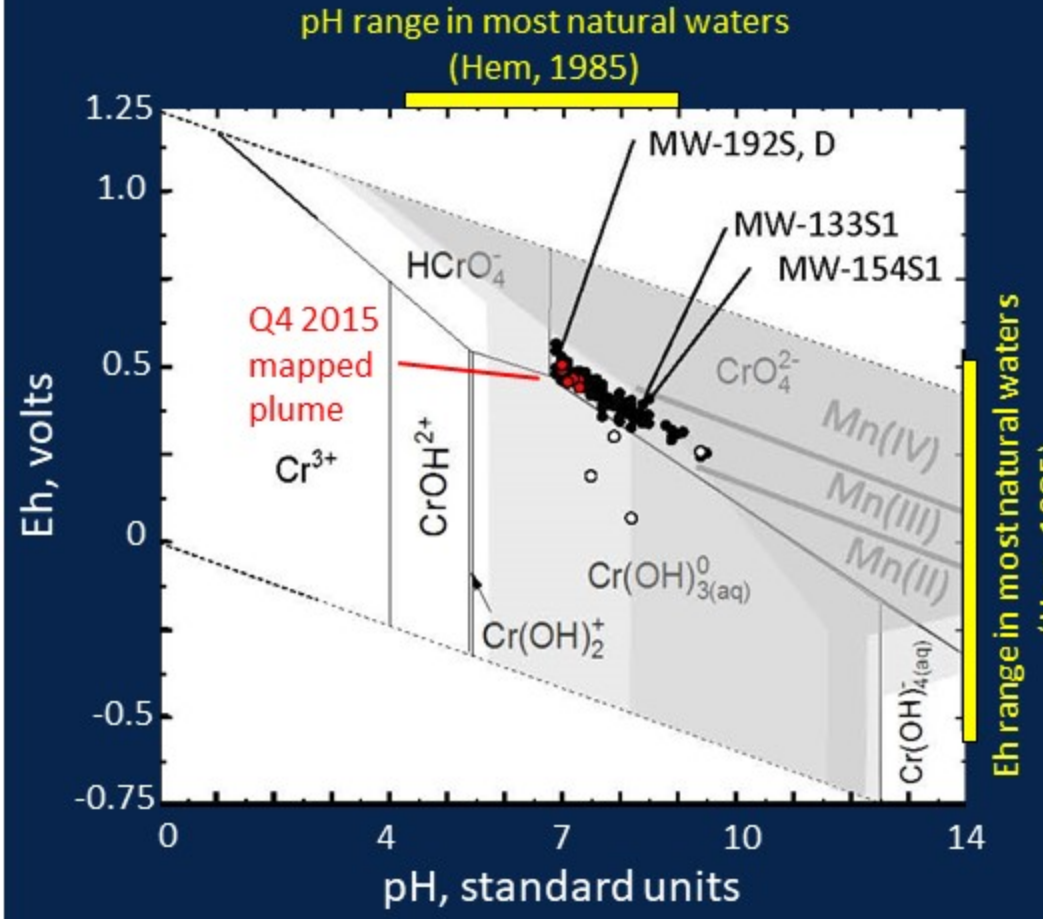
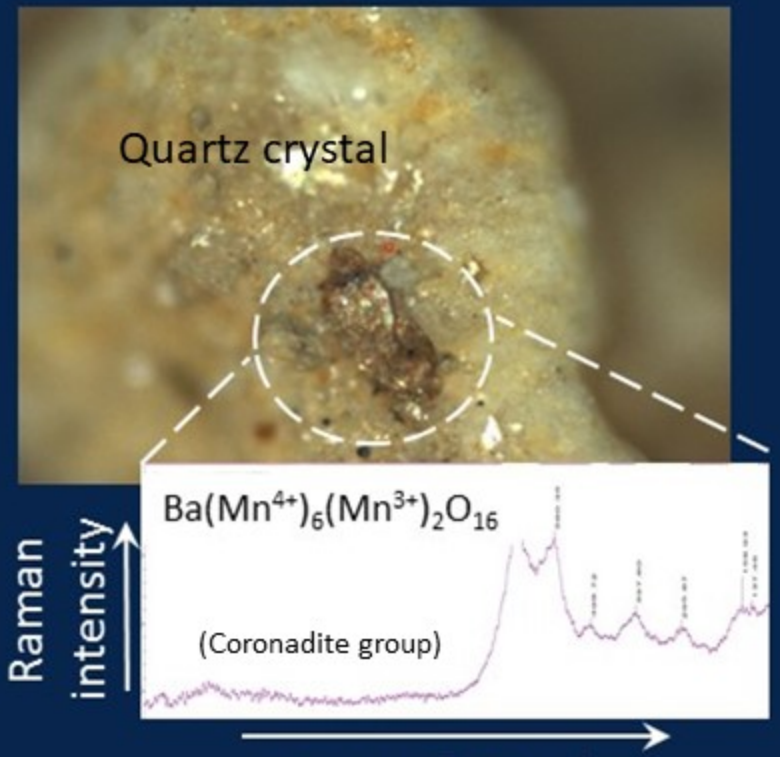
Manganese oxides, oxidation of Cr(III) to Cr(VI)



Manganese oxides drive oxidation of Cr(III) to Cr(VI)

Most Cr(VI) in water in redox-equilibrium with Mn(III) oxide coatings on the surfaces of mineral grains



BG-005 104 to 115.5 ft blsd

Cr_{solid} ranges from 8 to 23 mg/kg

Cr(VI) BG-005A ranges from 1.4 to 2.2 µg/L

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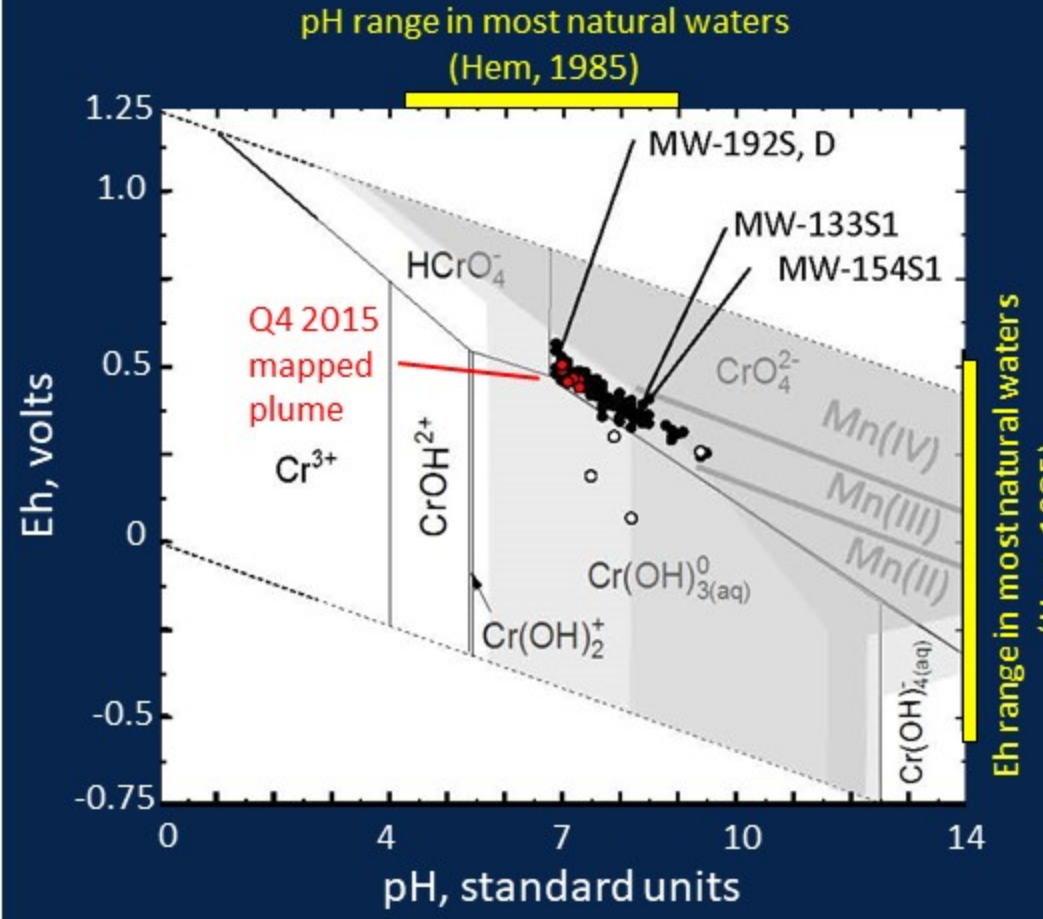
Manganese oxides, oxidation of Cr(III) to Cr(VI)



Visually-abundant oxide coatings near lithologic contact,

MW-121 at 112.4 ft blsd

Cr_{solid} ranges from 58 to 118 mg/kg

MW-121D Cr(VI) 3.9 µg/L

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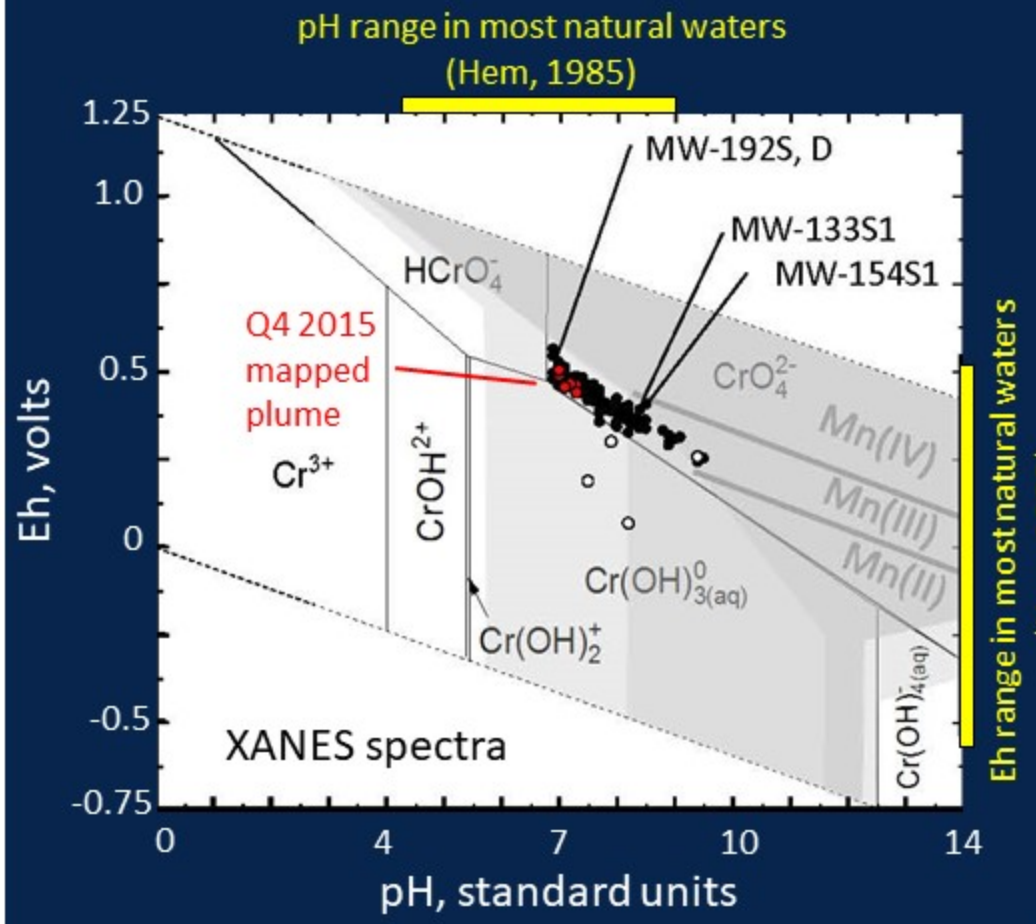
Manganese oxides, oxidation of Cr(III) to Cr(VI)

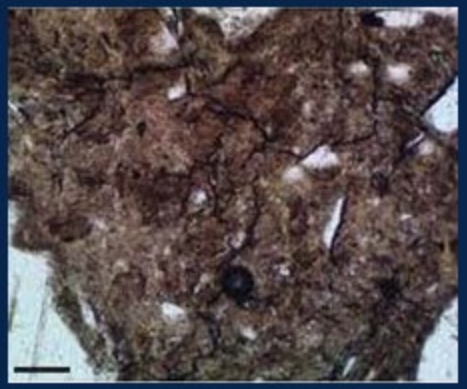


Water from wells within "brown clay" materials have higher Eh and are within the Mn(VI) stability field

MW-154 72 to 77 ft blsd

Cr_{solid} ranges from 82 to 94 mg/kg

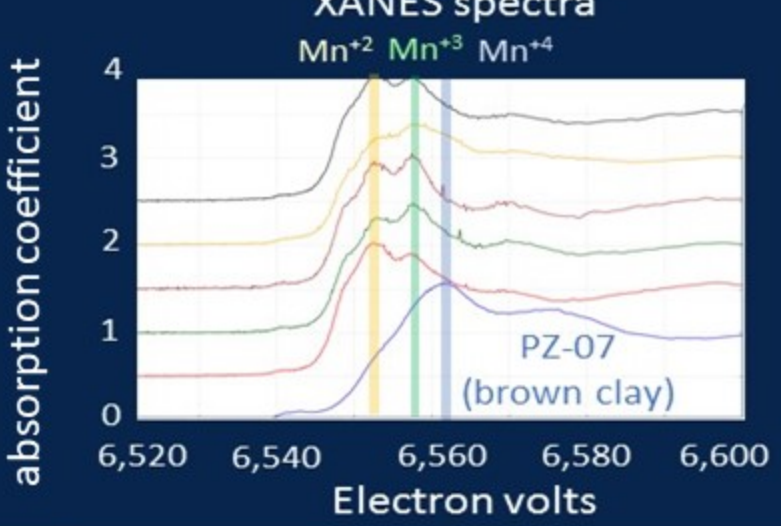
MW-154S1 Cr(VI) 9.8 to 11 µg/L



Manganese-oxides (dark nodules, dendritic structures) within clay-mineral Miocene age matrix

Cr(VI) porewater 1.1 µg/L

(highly alkaline pH 9.4, low specific conductance)



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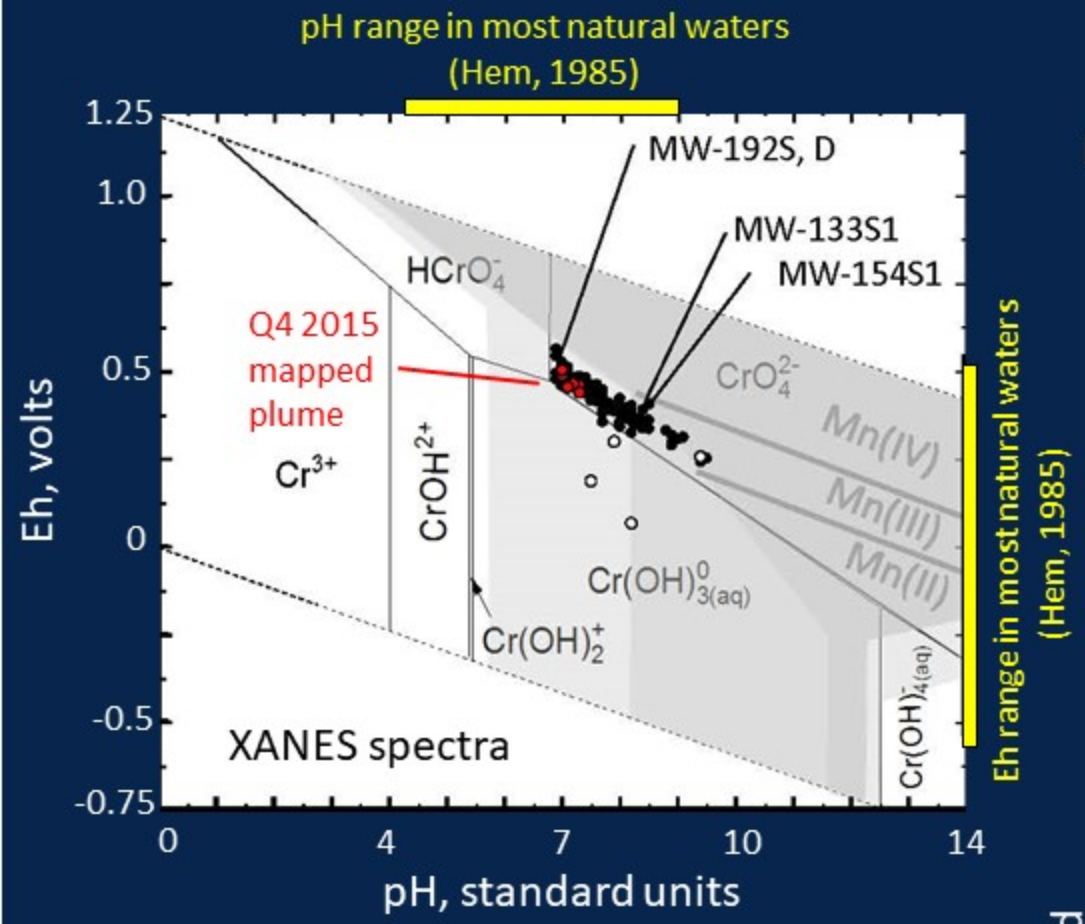
Manganese oxides, oxidation of Cr(III) to Cr(VI)



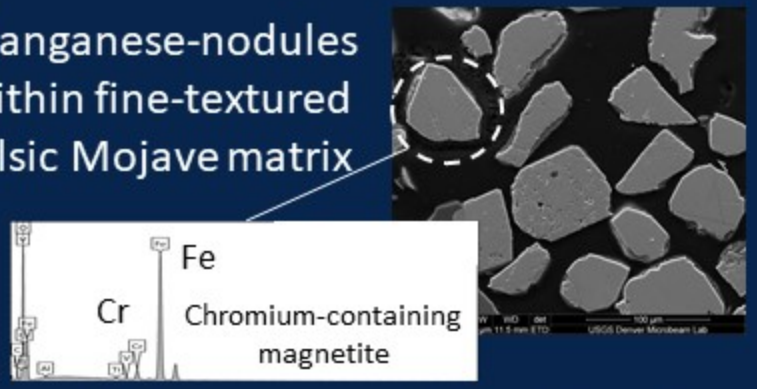
Water from wells within "brown clay" materials have higher Eh and are within the Mn(VI) stability field

MW-192 3 samples

Cr_{solid} ranges from 16 to 30 mg/kg

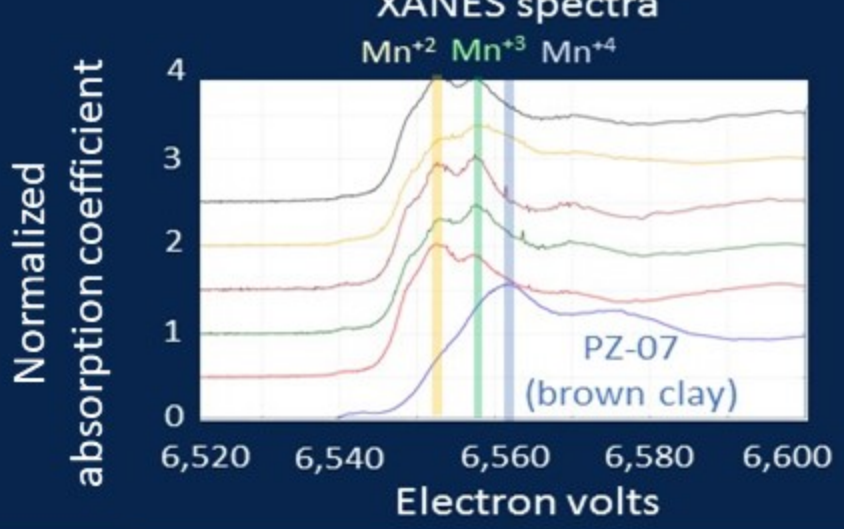
MW-192S and D, Cr(VI) 3.5 to 3.9 µg/L

Manganese-nodules within fine-textured felsic Mojave matrix



Cr(VI) porewater 0.7 to 3.3 µg/L

(alkaline pH 7.9-8.1, low specific conductance)



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Draft manuscript is almost done

- All we had to do was *listen* to the concerns of the stakeholders and community
- Everything in the report is traceable to a number, a measurement, or a piece of data

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