Potential for gas leakage along fracture conduits within the prospective national CO_2 Storage Test Site, Teapot Dome (NPR-3), Wyoming

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U.S. Department of the Interior
U.S. Geological Survey

Teapot Dome

- What is it?
  - Series of stacked oil and gas reservoirs
  - Found on the basis of hydrocarbon seeps
  - Is also known as NPR-3
  - Operated by RMOTC for DOE
- Importance for CCS community
  - Potential to be a national CO_2 storage test center
  - CO_2 is being brought to the adjacent field (Salt Creek)
  - Need to conduct baseline studies (which are underway)

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USGS Studies at Teapot

- Broadly stated, the USGS is using geochemical evidence to assess fluid communication within individual reservoirs, between reservoirs, and between reservoirs and the surface.
- Two major parts of the study:
  - Hydrocarbon geochemistry (See poster today)
  - **Are the calcite-lined fractures sites of active seepage?**

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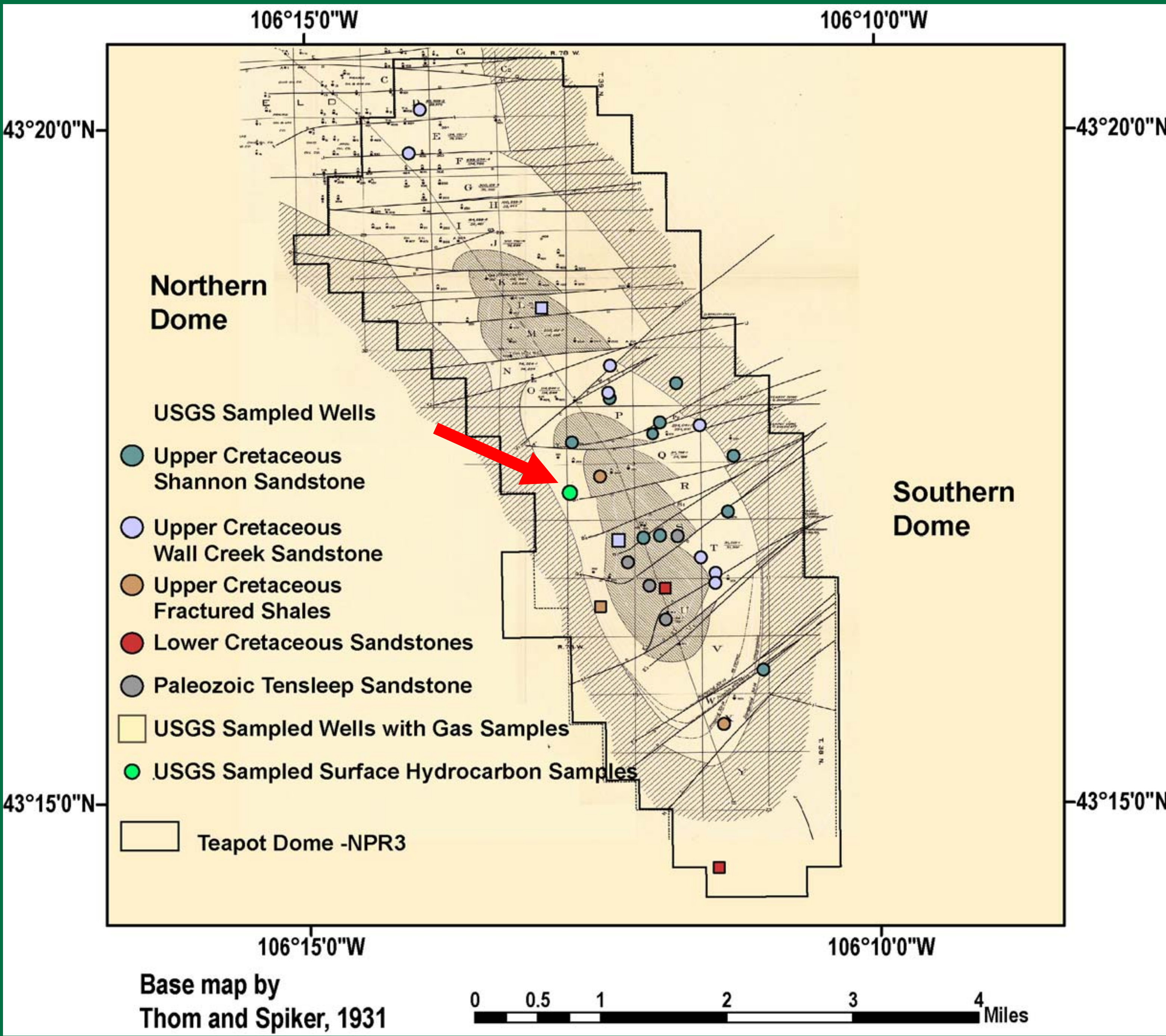
106°15'0"W
106°10'0"W
43°20'0"N
43°15'0"N
Northern Dome
Southern Dome
USGS Sampled Wells
Upper Cretaceous Shannon Sandstone
Upper Cretaceous Wall Creek Sandstone
Upper Cretaceous Fractured Shales
Lower Cretaceous Sandstones
Paleozoic Tensleep Sandstone
USGS Sampled Wells with Gas Samples
USGS Sampled Surface Hydrocarbon Samples
Teapot Dome -NPR3
Base map by
Thom and Spiker, 1931
0
0.5
1
2
3
4
Miles

Period	Formation		Litho logy	Thick-ness (feet)	Depth (feet)	Produc-tive
Upper Cretaceous	Steele			195		
		Sussex		30		□
				290	225	
		Shannon		120	515	■
				1355	635	▣
	Niobrara Shale			450	1990	▣
	Carlisle Shale			240	2440	□
	Frontier	1st Wall Creek		160	2680	□
				245	2840	
		2nd Wall Creek		65	3085	■
				175	3150	
		3rd Wall Creek		5	3325	▣
				265	3330	

Rocky Mountain Oilfield Testing Center (RMOTC), Casper Wyoming

Currently productive	■
Productive in past	▣
Potentially productive	□


~15 cm

Key Questions

- What is the paragenesis of the fractures and cements?
- When were the hydrocarbons emplaced within the fractures?
- Is there active seepage in these fractures?

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Preliminary Study

- In this preliminary study, we were looking for evidence that could be used to constrain the timing and conditions of the hydrocarbon emplacement.
  - Are there multiple fracture events?
  - Are there multiple cementation events?
  - Fluid inclusion evidence
  - Geochemical clues from the ozokerite

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~15 cm


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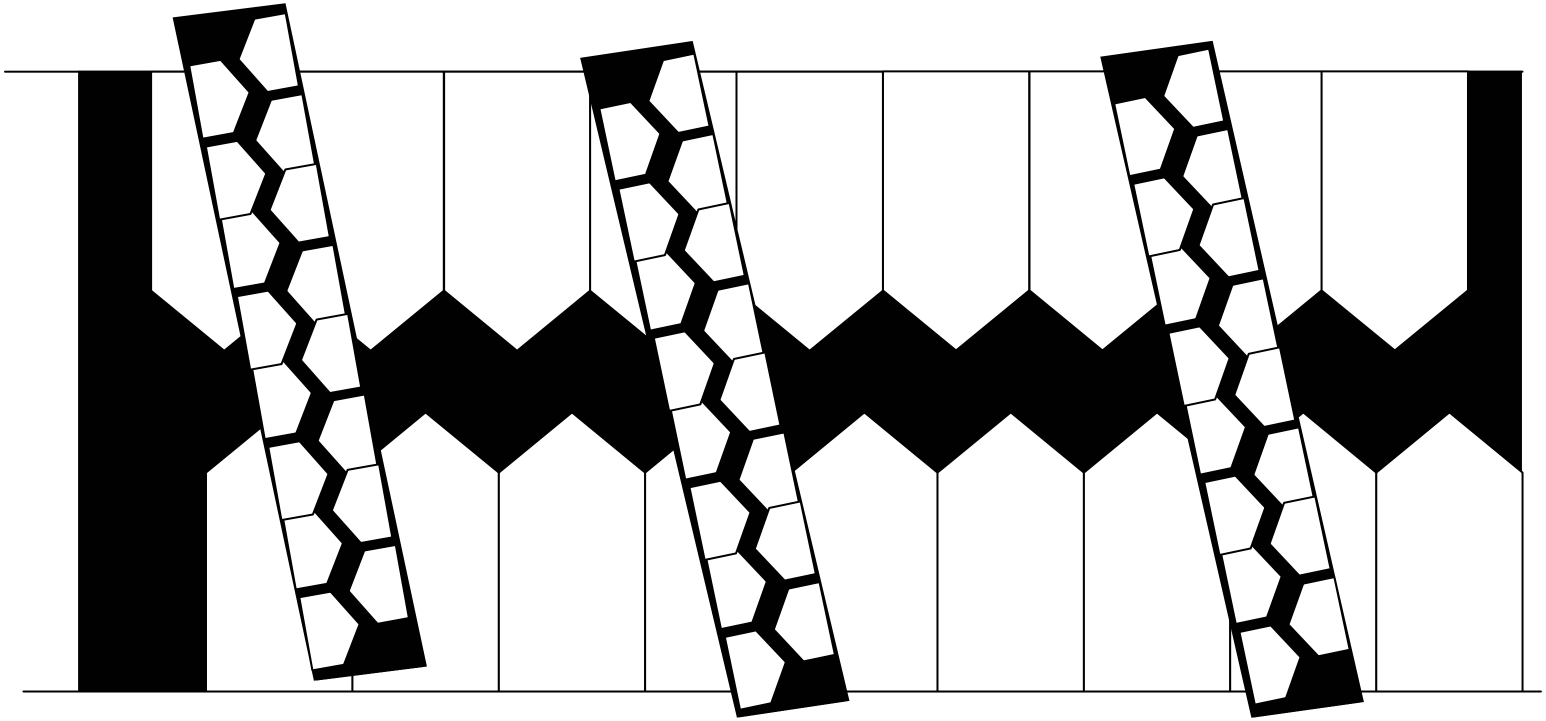

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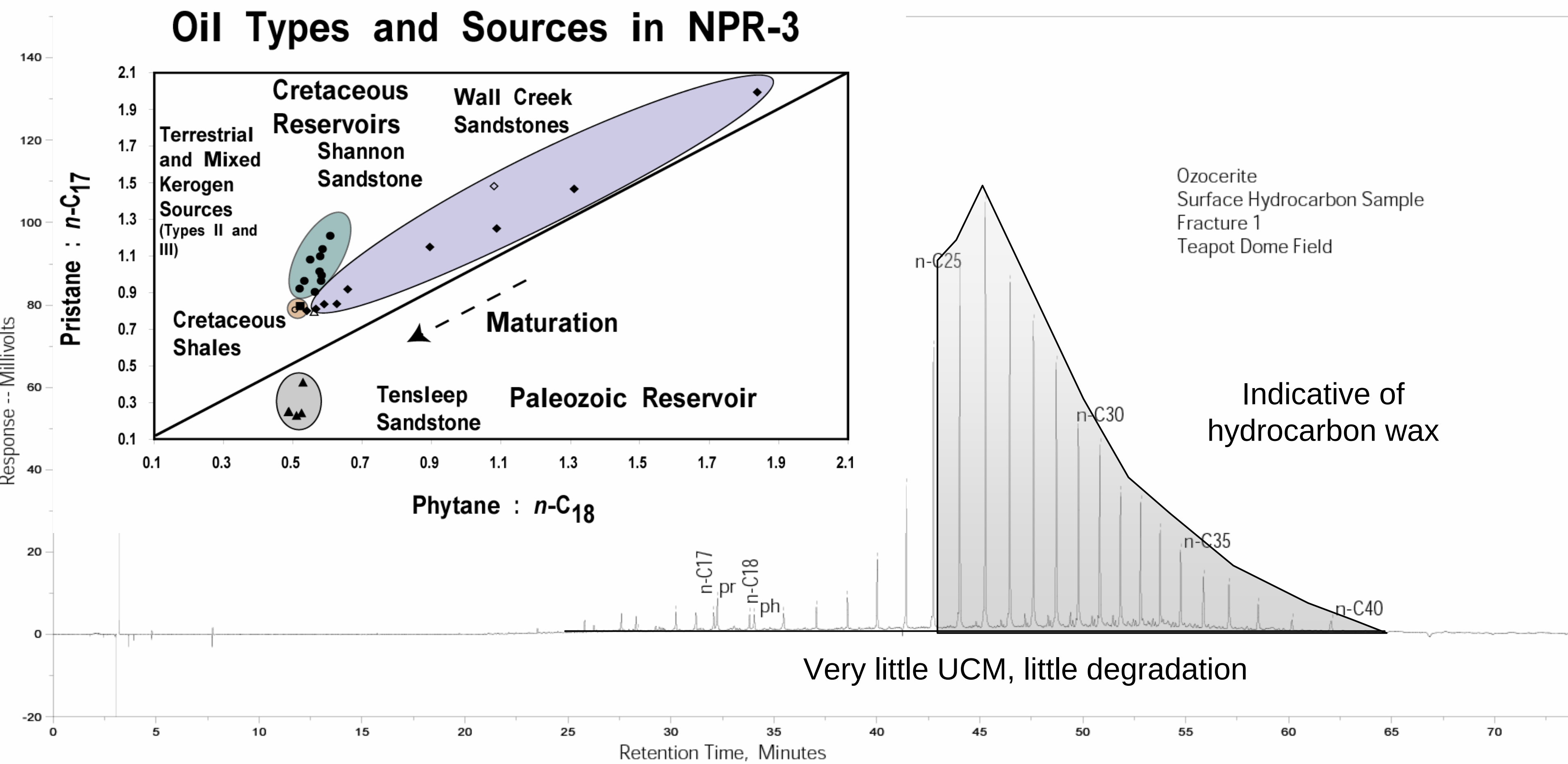
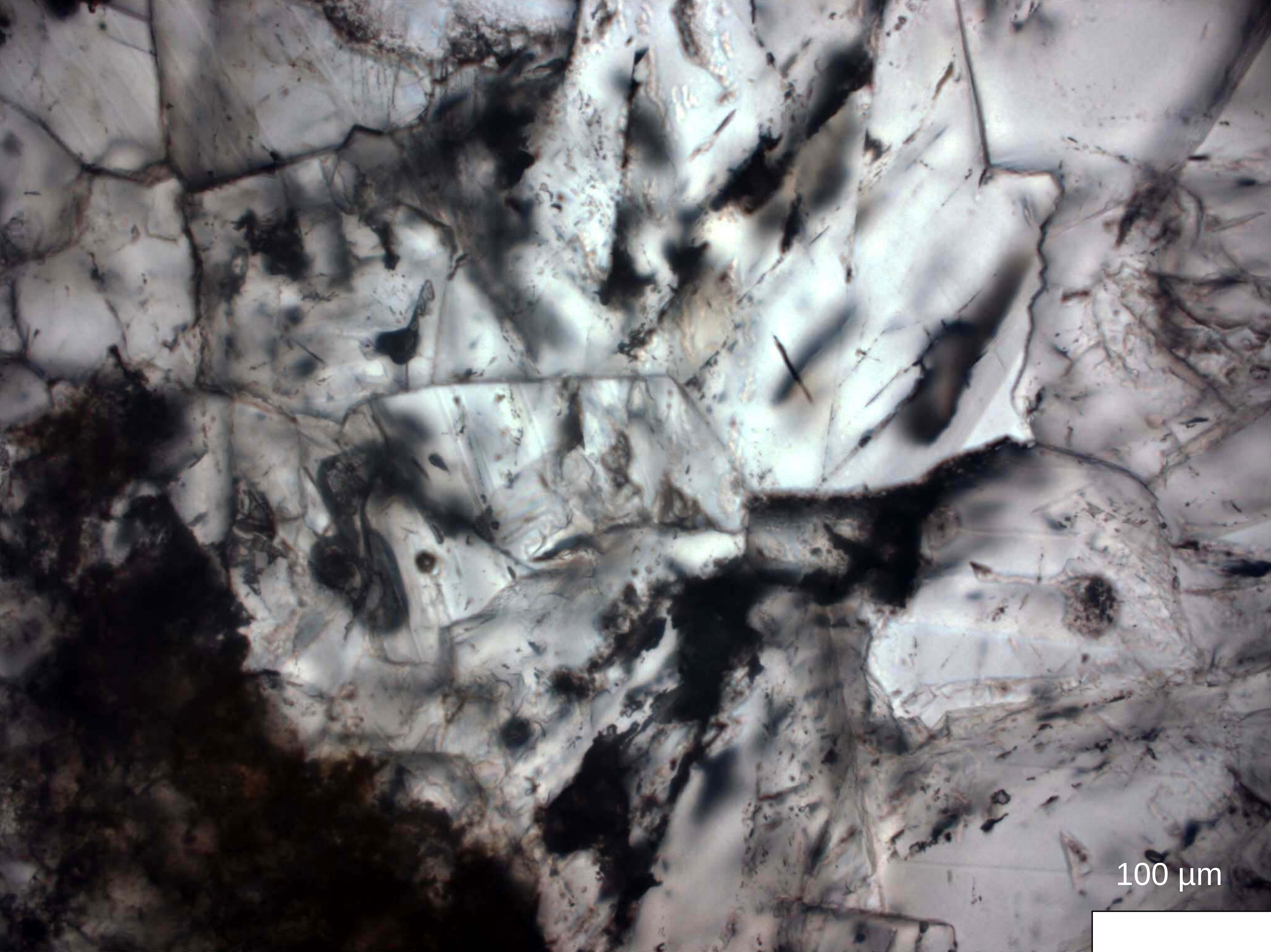
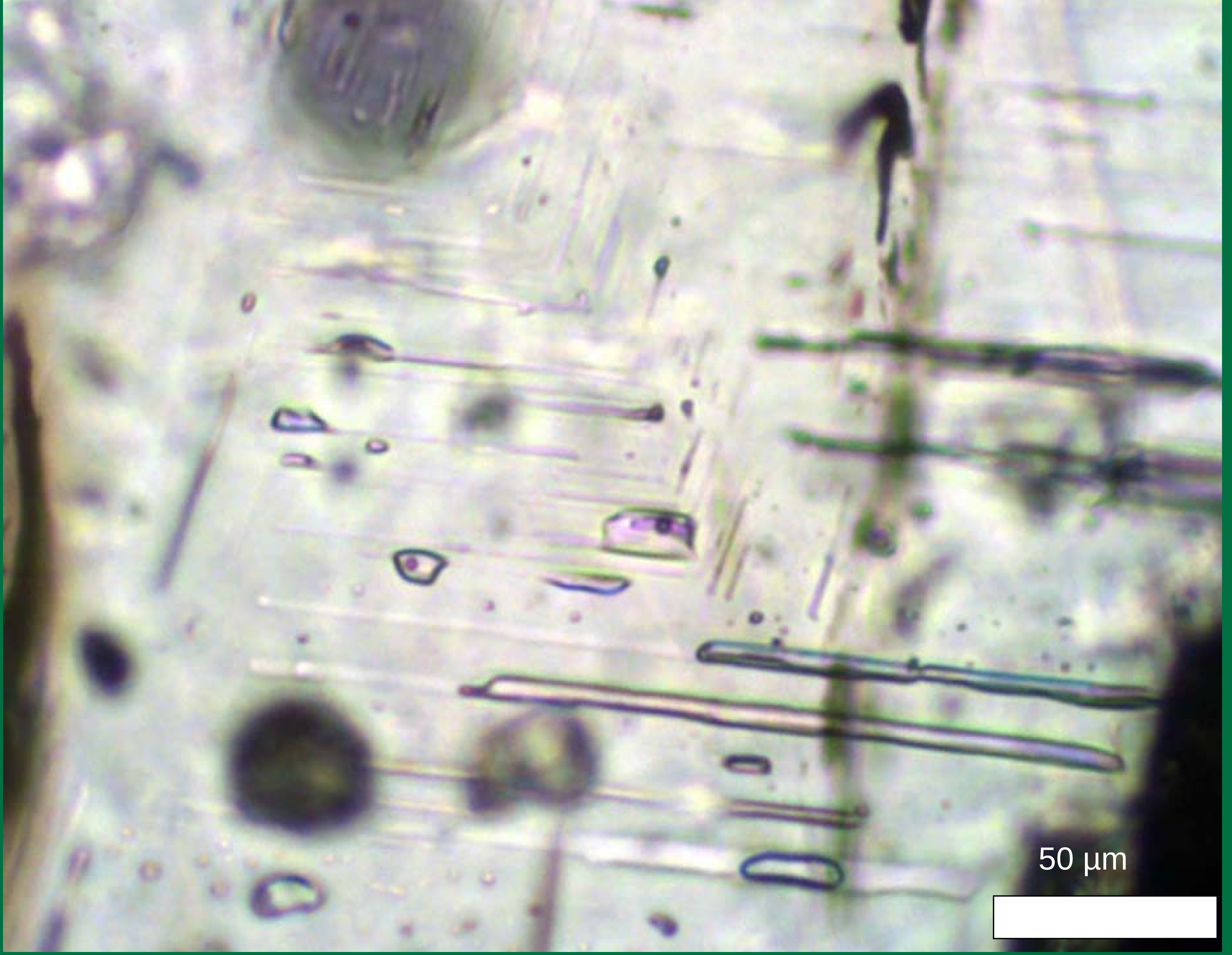


Figure 36: Ozocerite gas chromatogram, Surface Hydrocarbon Sample, Fracture 1, Teapot Dome field.
Selected peak indentifications: n-Cx, normal alkanes where X is the carbon number; pr, pristane; ph, phytane.


100 µm


100 µm


50 µm


50 µm


66°C
66°C
65°C
64°C
50 µm

Thermal data

- Fluid inclusion homogenization temperatures indicate that hydrocarbons were present in the fractures at ~64°C.
- Reported temperatures of the Shannon and Second Wall Creek oils are ~15°C and ~45°C respectively.
- The Shannon reservoir is currently between 120 to 180 meters deep, and the Second Wall Creek is between 850 to 950 meters deep.
- The high wax content of the ozokerite and the GC data suggest a Shannon source.
- Therefore, assuming a thermal gradient similar to the modern, then the parent oil was likely emplaced when the Shannon was significantly deeper (~1.5-2 km) than present.

Conclusions

- There is potential to determine the fluid history of these fractures.
- Based on the homogenization temperatures of the fluid inclusions, the oil in the fractures was emplaced at greater depth and not at the surface.
- The ozokerite has not been significantly degraded.
- The source of the oil was likely from the Shannon
- There is no evidence for active seepage from the fractures
- The Shannon source suggests that the ozokerite and fluid inclusion evidence may represent a highly localized Steele Shale fluid system rather than a more extensive multi-horizon fluid-flow system.

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Possible Future Work

- Compare observed fracture history to published fracture models and timing of structural events to further constrain paragenesis.
- Fluid inclusion petrography and analyses
  - Fluid inclusion petrography to determine timing of fluid migration events
  - Microthermometry of hydrocarbon and aqueous inclusions
  - Crush-GC or crush-leach-GC of hydrocarbon inclusions
  - Raman of aqueous and/or HC fluid inclusions.
- Analyses of calcite generations
  - CL work on calcite, how many generations of calcite can be identified?
  - Stable Isotopic analyses of the individual generations of calcite cements to help determine source of fluids
  - Microprobe analyses for trace elements in the calcite to help determine source fluids.

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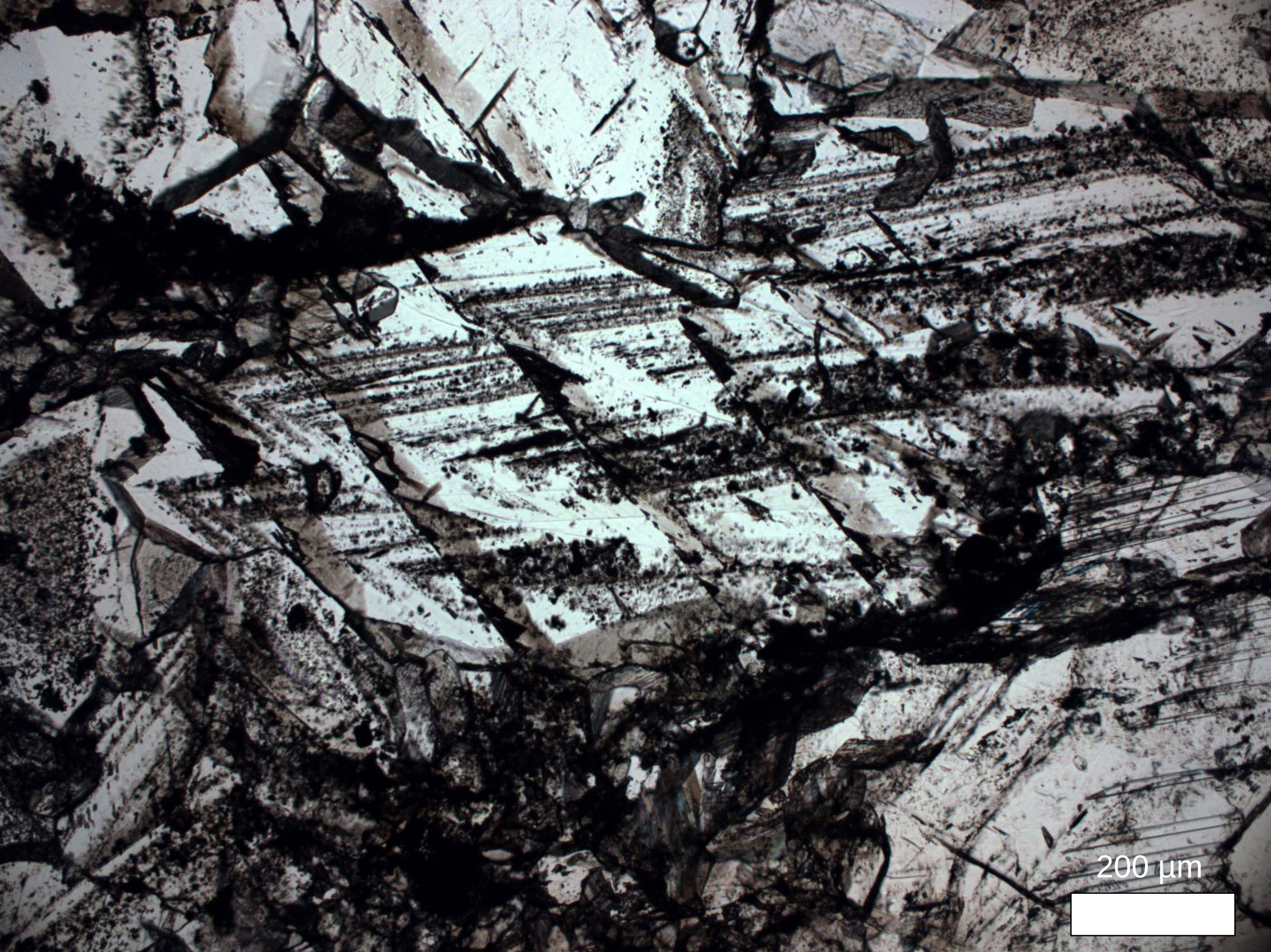
200 µm

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