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Investigation of Karasburg and Muonionalusta Meteorites

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2019 Scot Forge Company Metallography Internship

2020 BS Materials Science and Engineering at University of Wisconsin-Madison

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Presentation Outline

Meteorite Basics

Featuring the Muonionalusta Meteorite

Metallographic Preparation

Mounting

Thermosetting compression mounting with Buehler EpoMetTM G mounting compound

Metallographic Preparation

1. Planarizing – Global Abrasive Solutions 180 grit SiC paper
2. Fine Grinding – Global Abrasive Solutions 320 grit SiC paper
3. Coarse Polishing – Advanced Abrasives Aqua-Pol 9 um diamond suspension
4. Fine Polishing – Advanced Abrasives Aqua-Pol 3 um diamond suspension
5. Vibratory Polishing – Advanced Abrasives Premasol 0.06 um colloidal silica

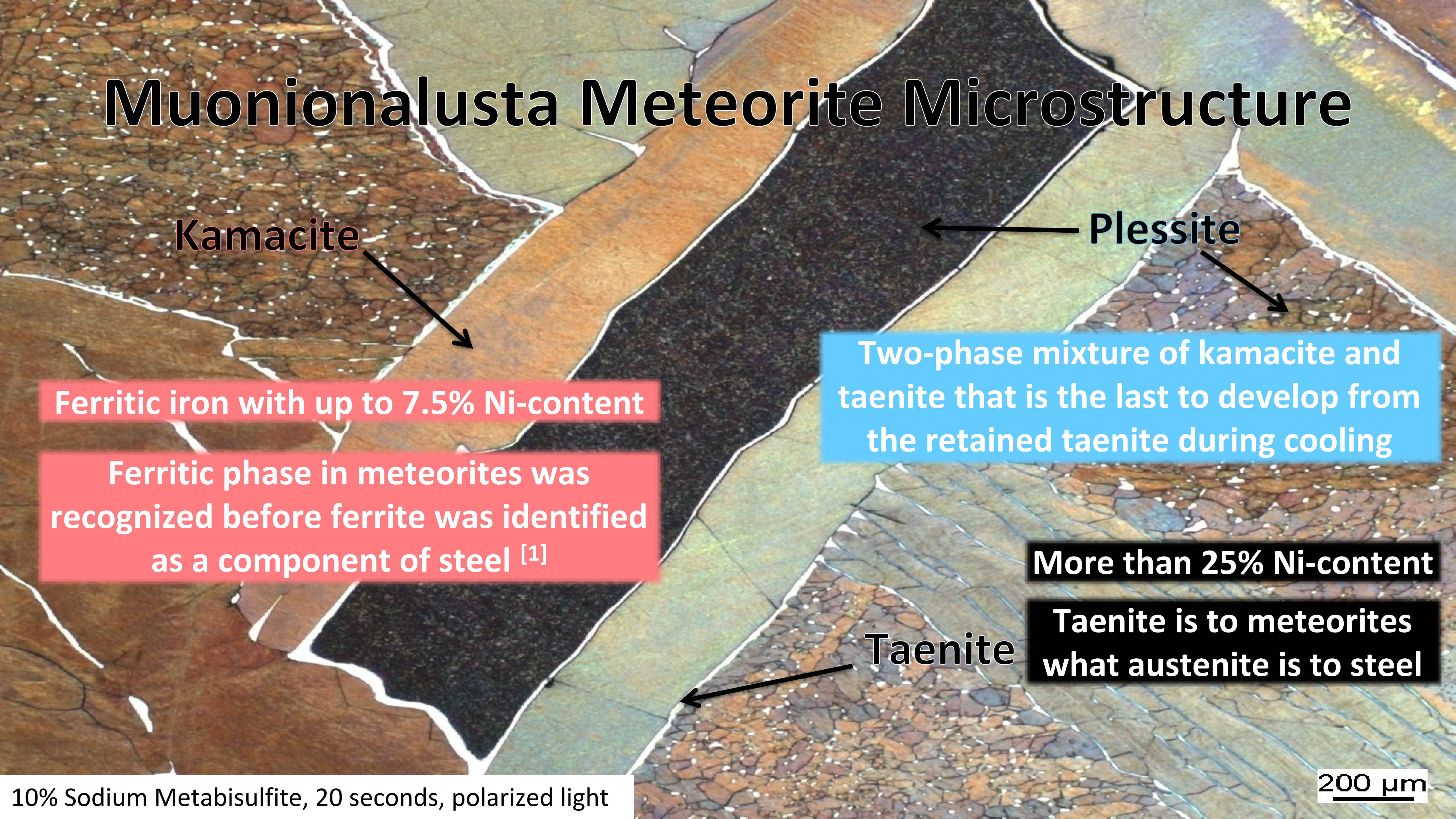
Etching [2], [3]

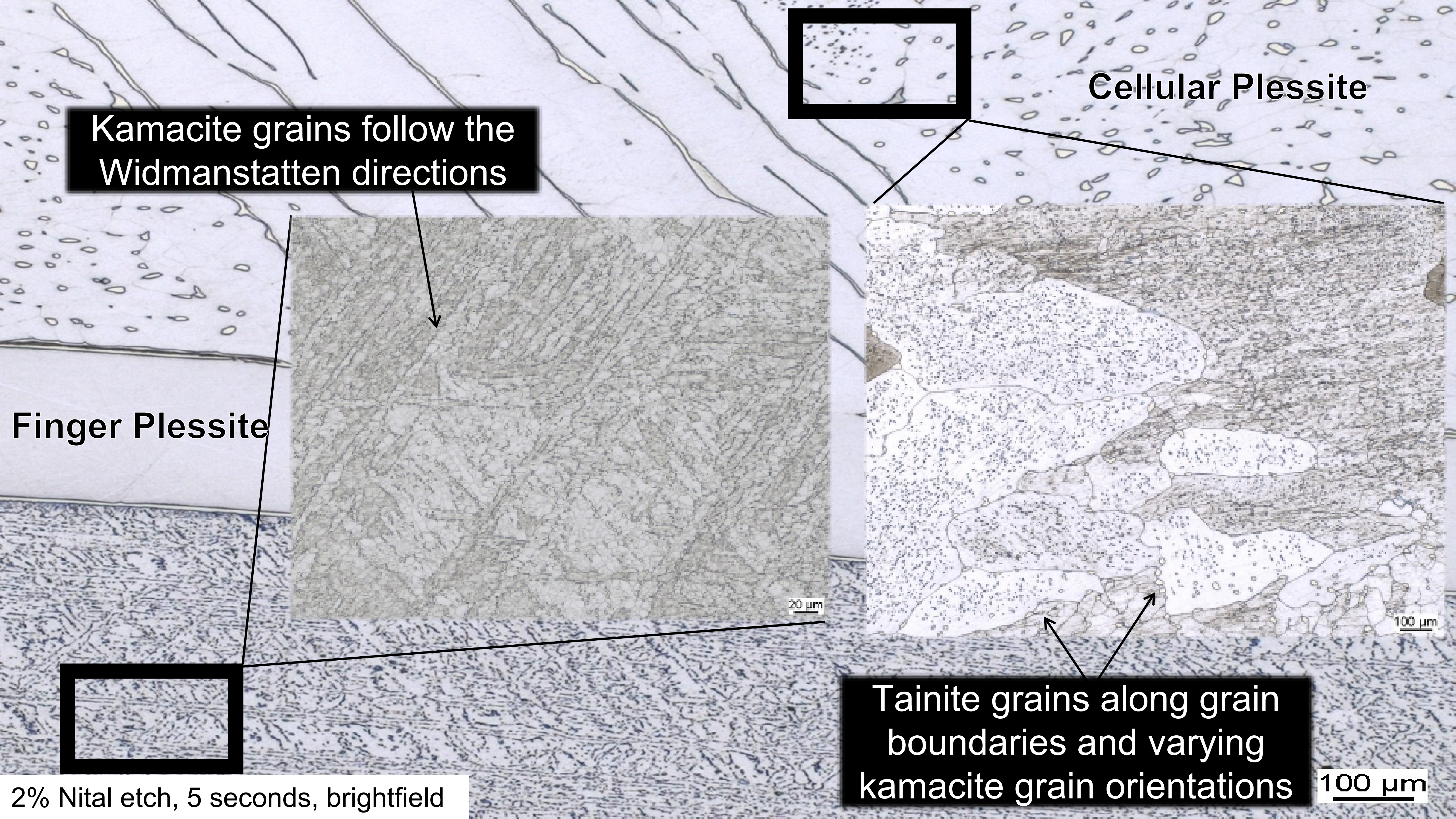
2% Nital – 98 mL ethyl alcohol and 2 mL nitric acid

4% Picral – 100 mL ethyl alcohol and 4 g picric acid

10% Sodium Metabisulfite – 90 mL water and 10 g sodium metabisulfite

Muonionalusta Meteorite Microstructure



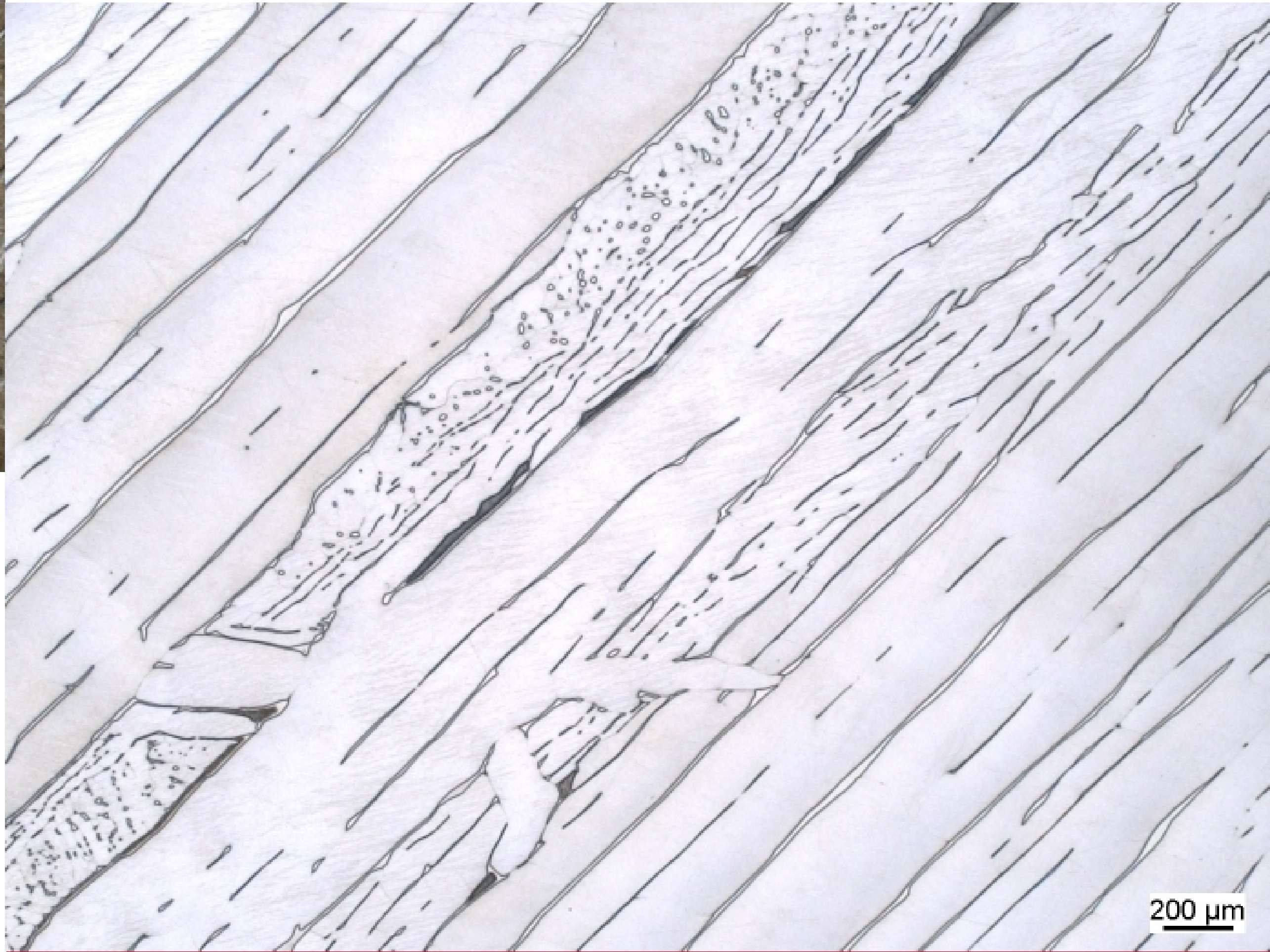

Kamacite grains follow the Widmanstatten directions
Cellular Plessite
Finger Plessite
20 µm
100 µm
Tainite grains along grain boundaries and varying kamacite grain orientations
2% Nital etch, 5 seconds, brightfield
100 µm

2% Nital Etch

Reveals Neumann Bands
Colors Kamacite preferentially

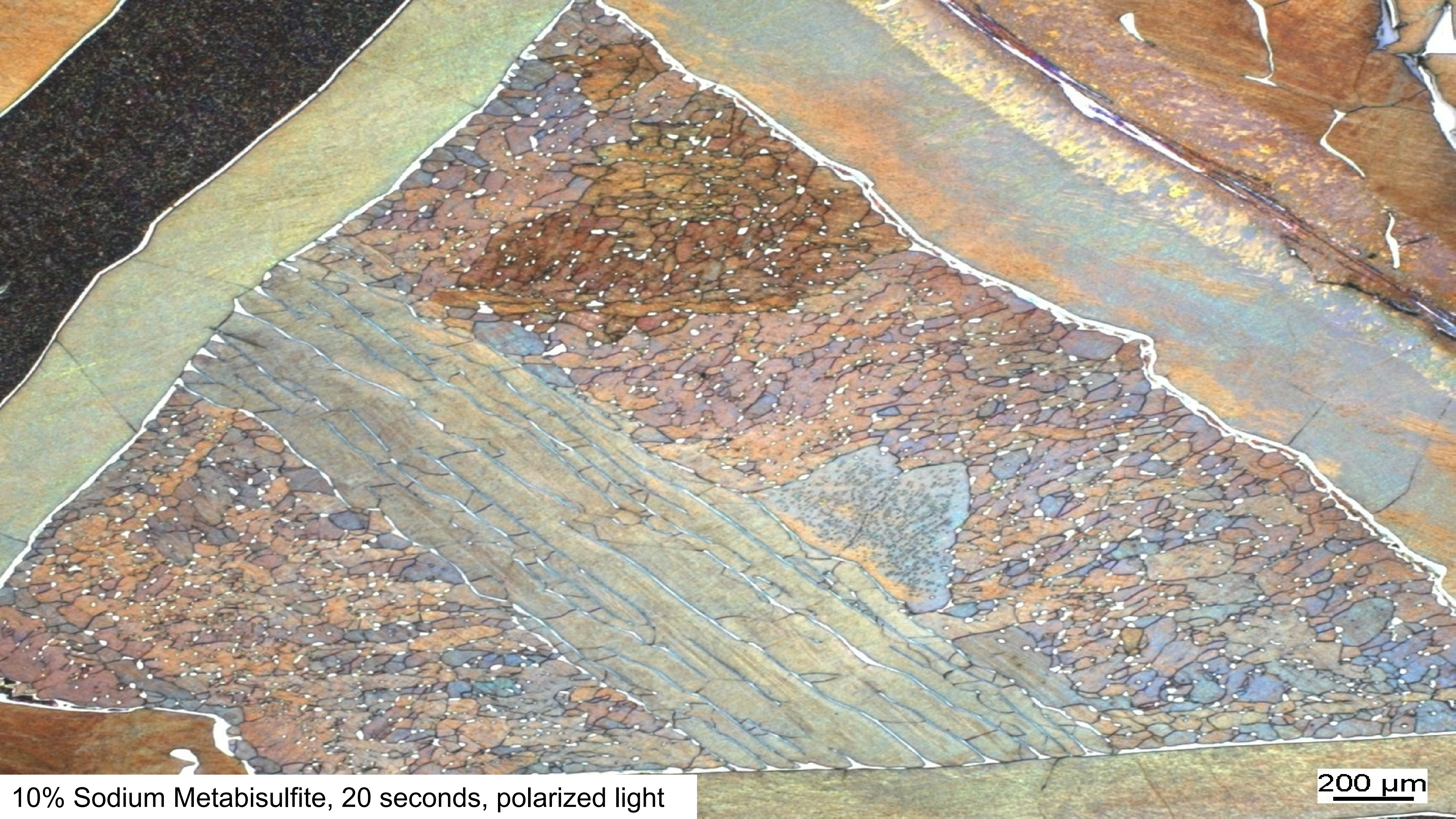
4% Picral Etch

Does NOT reveal Neumann Bands
Does NOT color Kamacite preferentially



Meteoritic Inclusions

- Schreibersite (Karasburg)
  - A phosphorous-rich and irregularly shaped inclusion that becomes visible when the bulk composition of a meteorite reaches 0.06% P
  - Appears as a yellow precipitate with a micro-hardness of 800-950 HV
  - It is extremely brittle; so much so that micro-indentations will typically cause cracking to form within the inclusion
- Troilite (Gibeon)
  - A sulfur-rich inclusion that is bronze-colored and is irregularly shaped
  - It has a micro-hardness of 220-280 HV



10% Sodium Metabisulfite, 20 seconds, polarized light

Karasburg Meteorite

Gibeon Meteorite History

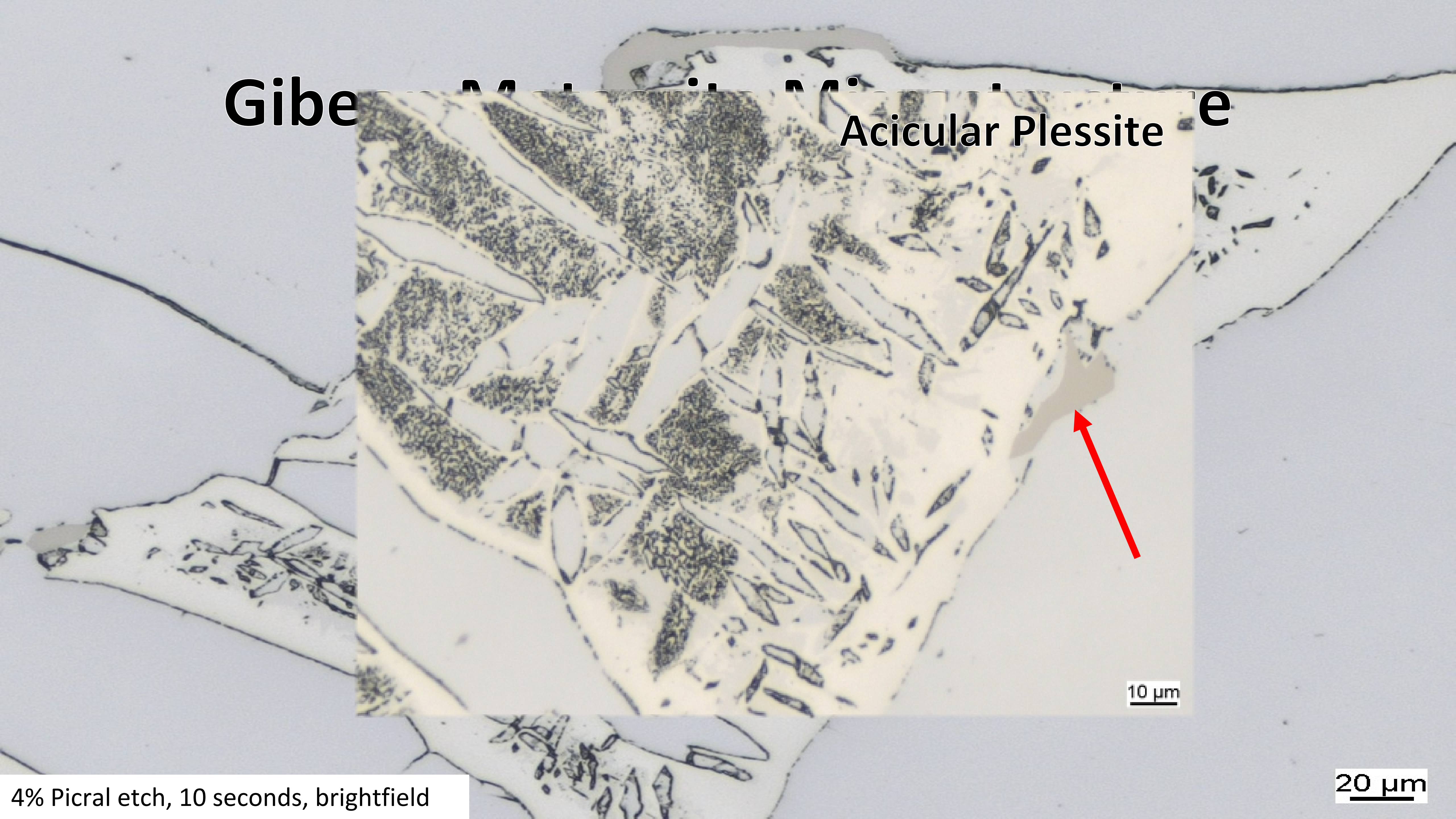
- First discovered in 1838 by Captain J.E. Alexander
- Many other masses have been located at cattle farms throughout the area
- Gibeon meteorites have been found as far as 143 miles away from the impact site

Gibeon Characteristics

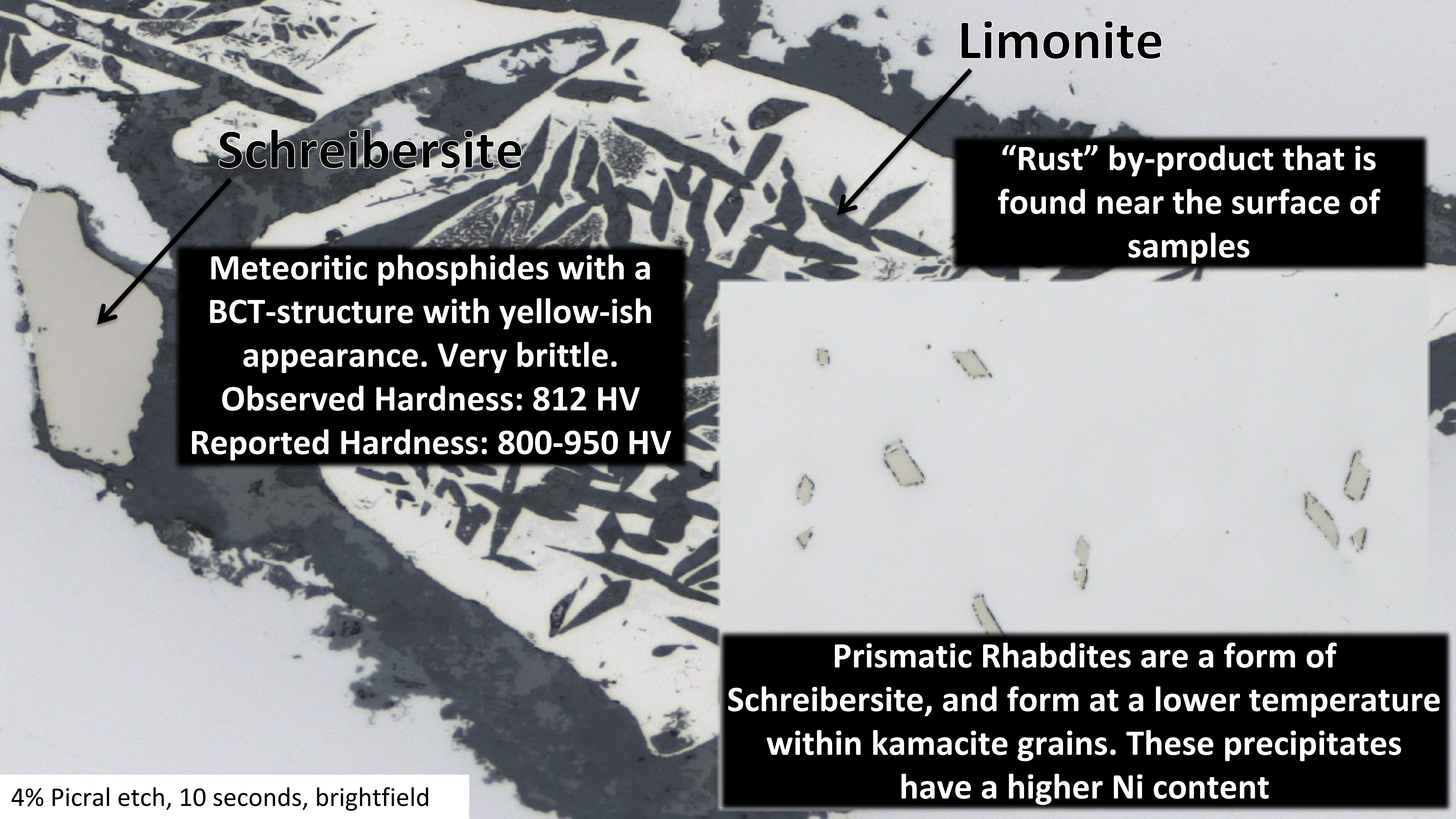
- Chemical analysis (in wt. %):

Ni	Co	P
7.93	0.41	0.04

- Microhardness:
  - Kamacite: 170 ± 20 HV
- Kamacite width: 300 ± 50 μm – Fine Octahedrite
  - Famous for Widmanstatten pattern
- Primarily features kamacite, taenite, plessite, and troilite
- Does NOT feature schreibersite



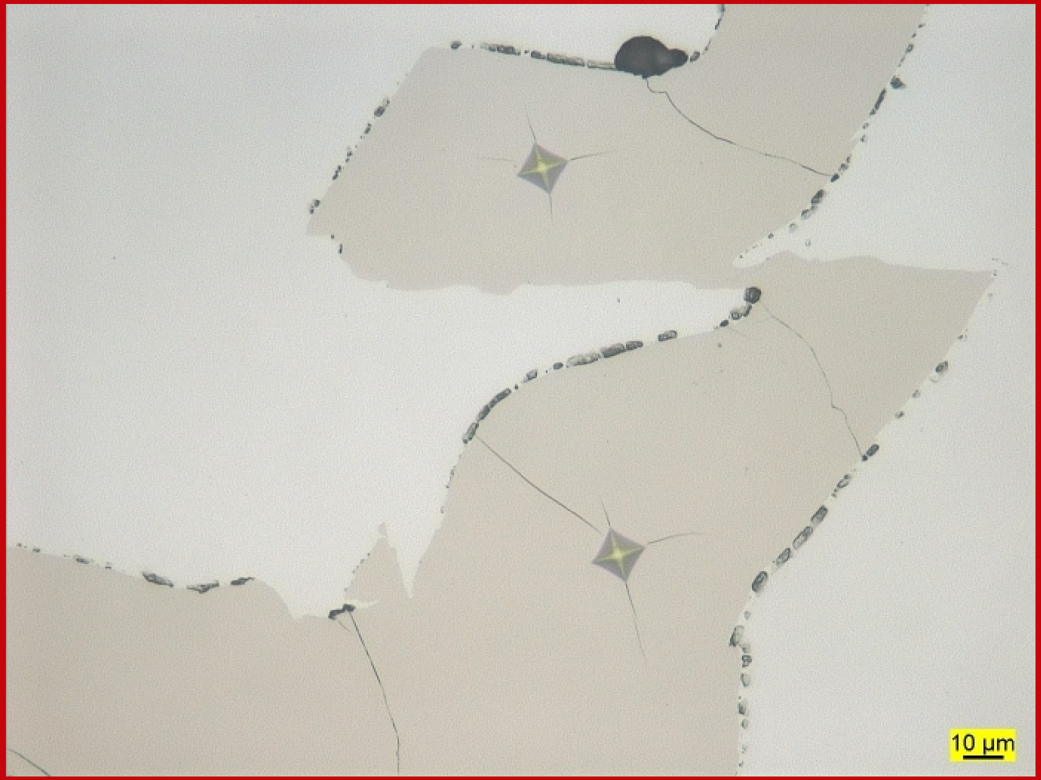
4% Picral etch, 10 seconds, brightfield

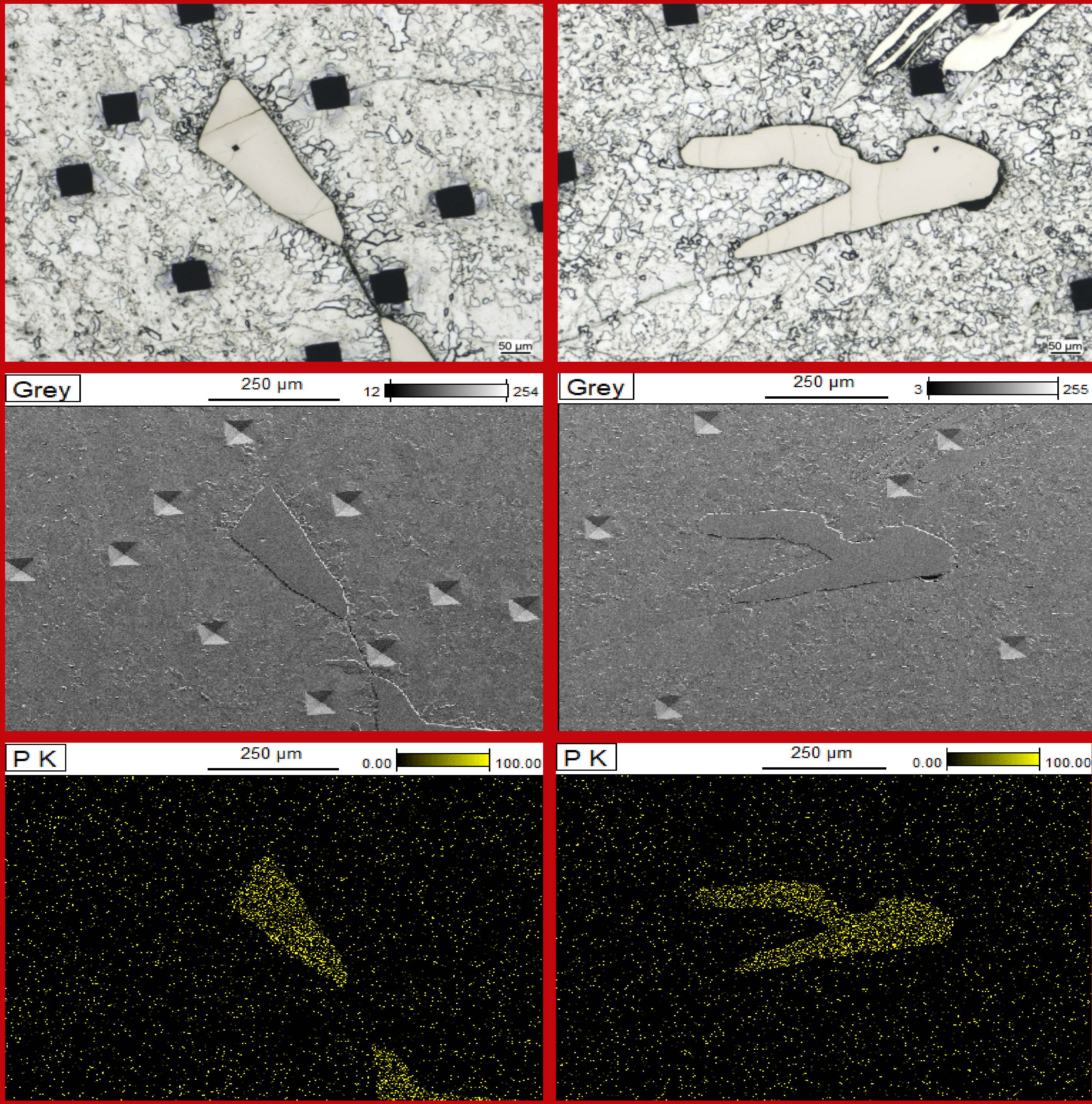


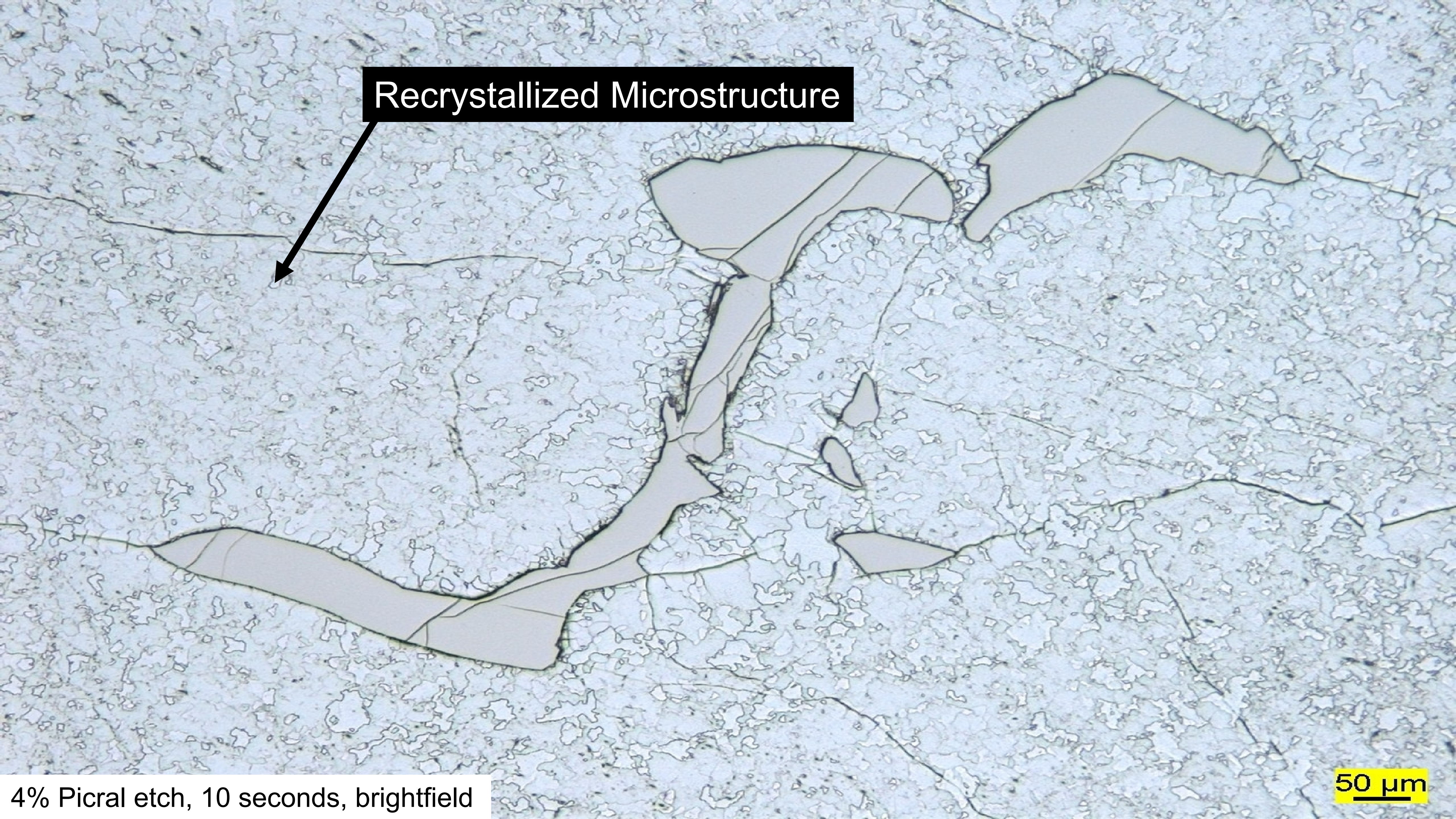
4% Picral etch, 10 seconds, brightfield

Schreibersite (wt. %)

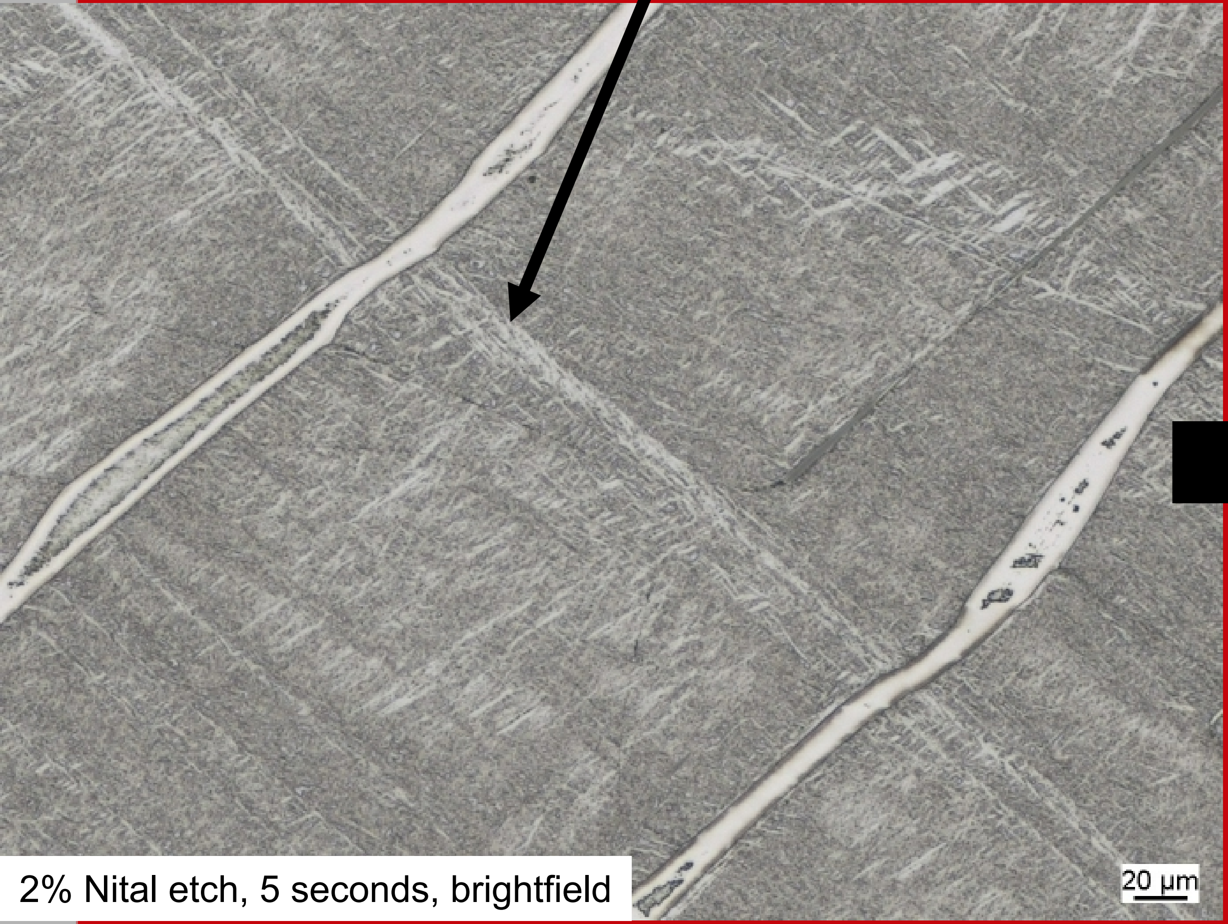
Ni	P
41.05	12.51





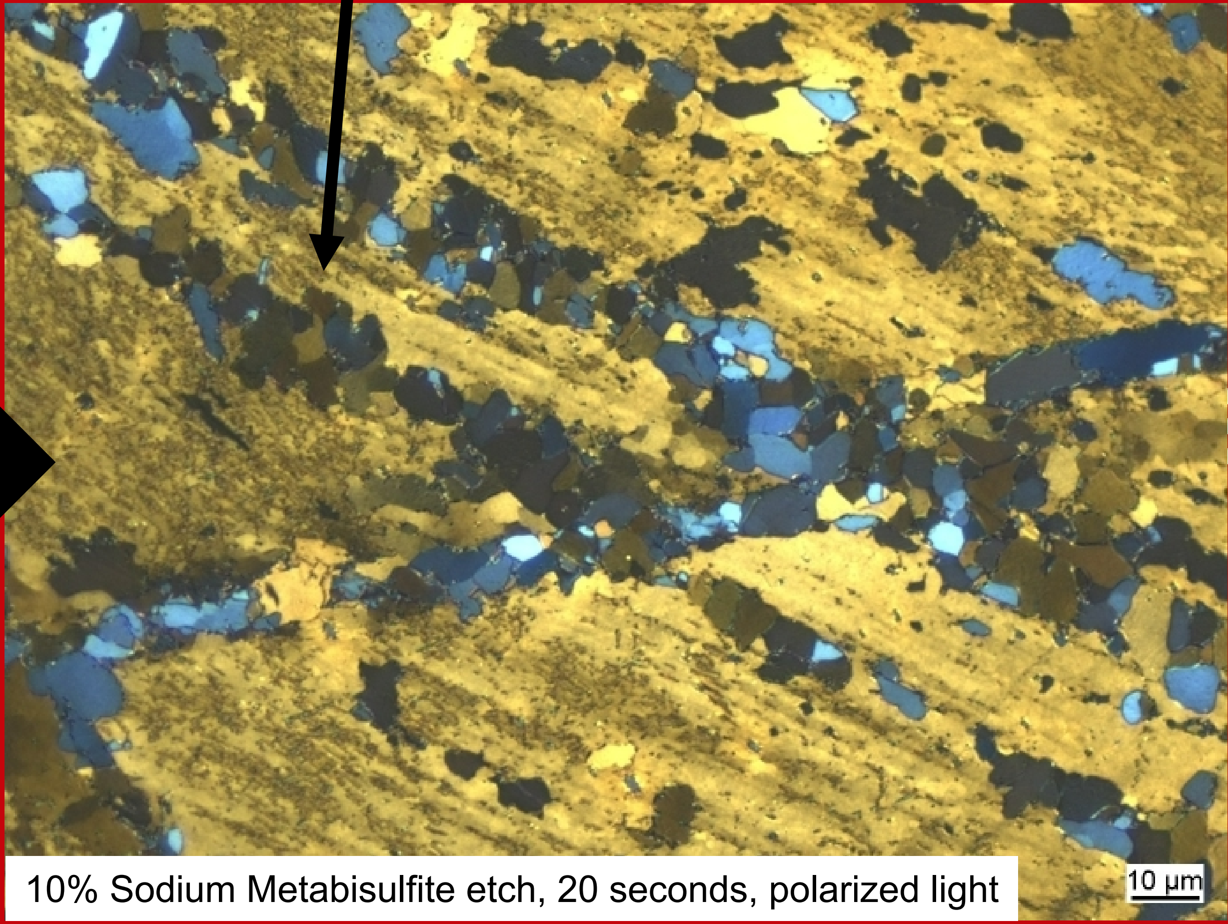

Recrystallized Microstructure
4% Picral etch, 10 seconds, brightfield
50 µm

Neumann Band

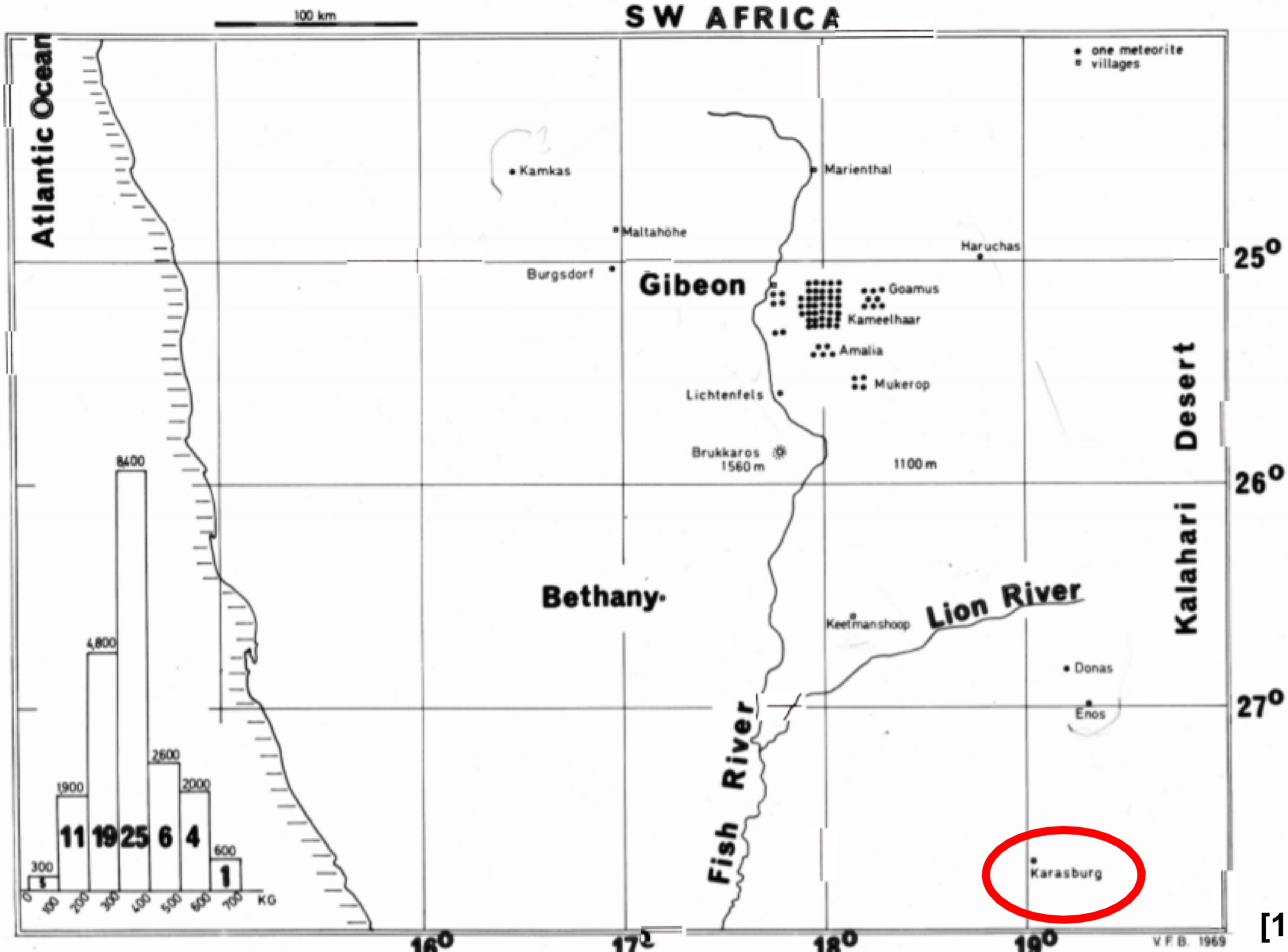


2% Nital etch, 5 seconds, brightfield

Annealed Neumann Bands



10% Sodium Metabisulfite etch, 20 seconds, polarized light


SW AFRICA
100 km
Atlantic Ocean
one meteorite
villages
Kamkas
Marienthal
Maltahöhe
Haruchas
Burgsdorf
Gibeon
Goamus
Kameelhaar
Amalia
Mukerop
Lichtenfels
Brukkaros
1560 m
1100 m
Kalahari Desert
25°
26°
27°
Bethany
Keetmanshoop
Lion River
Donas
Enos
Fish River
Karasburg
8400
4800
2600
2000
1900
600
300
11
19
25
6
4
1
0 100 200 300 400 500 600 700 KG
16°
17°
18°
19°
V.F.B. 1969

[1]

Meteorite Comparison

Gibeon

- Troilite
- Not reheated

Ni (wt. %)	P (wt. %)
7.93	0.04

Meteorite X

- Schreibersite
- Reheated

Ni (wt. %)	P (wt. %)
8.55	0.20

Karasburg

- Schreibersite
- Reheated

Ni (wt. %)	P (wt. %)
8.7	0.23

Conclusions

- The following features were evaluated…
  - Meteoritic Inclusions
  - Microstructure (signs of reheating, recrystallization)
  - Meteorite Chemistry
  - Gibeon/Karasburg Geography
- Based on the evaluated information, this meteorite can most accurately be classified as a Karasburg meteorite

10% Sodium Metabisulfite, 20 seconds, polarized light

Meteorite References

- [1] Buchwald, Vagn Fabritius. *Handbook of Iron Meteorites. Their HISTORY, DISTRIBUTION, Composition and Structure: Iron METEORITES: ABAKAN-MEJILLONES*. University of California Press, 1975.

- [2] Vander Voort, George. “Metallography of Iron Meteorites.” *Vander Voort*, Feb. 2001, www.georgevandervoort.com/metallography-of-iron-meteorites/.

- [3] Vander Voort, George. “A Note on Metallographic Techniques for Iron Meteorites.” *Materials Characterization*, vol. 29, no. 2, 1992, pp. 223–241., doi:10.1016/1044-5803(92)90117-z.

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