# Mineral phases in silica sand samples from the Maydena Sands Property

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## EXECUTIVE SUMMARY

- This investigation was initiated to search for mineral phases that would contribute phosphorous (P), boron (B) and and lithium (Li) to samples from the Maydena Sands property.
- The search for these phases was done by making polished thin sections of the samples and examining these first on the Petrographic Microscope and then on the Scannng Electron Microscope which was used to produce semi-quantitative analyses of any phases found
- The phases found in the thin sections are described in APPENDIX A, which is the first mini-report prepared on the project.
- As no rutile was found in any of the thin sections, polished grain mounts were made of silica sand samples that had undergone mineral processing using an electrostatic separator to remove the conductive material in the samples and produce a concentrate that would be "free" of any conductive phases (eg, rutile) that were present in the samples
- The silica sand samples examined were
  - -the raw but sieved head sample
  - - the conductive fraction
  - -the non-conductive fraction

•As with the polished thin sections, the grain mounts were first examined on the Petrographic Microscope and then on the Scannng Electron Microscope which was used to produce semi-quantitative analyses of any phases found

•The phases found in the polished grain mounts are described in APPENDIX B, which is the second mini-report on the project.

•A significant number of apatite grains (the host for P) were found within quartz grains in both the thin sections as well as all of the processed samples

-the apatite generally occurs as small (~ 1µm) grains within the quartz and often in clusters; the largest apatite grain (~8µm) was found in a quartz grain in the non-conductive fraction

•Other minerals that also occurred within quartz grains in the thin sections include barite, calcite, wollastonite (a single grain) and pyrite.

•Within the matrix of the thin section samples are galena (2 grains), ilmenite (1 grain), iron oxides (numerous grains), and cassiterite (1 grain)

•Also in the matrix of the thin sections are a number of different alloys, including those of Fe-V-Ti-Ni and Ti

-it is suspected that these alloys may have been introduced to the samples during preparation of the thin sections

• The mineral phases in the Head sample include apatite (in quartz grains) and pyrite (also in the quartz grains) as rutile, ilmenite, native iron overgrown by tin, iron oxides, chalcopyrite and lead carbonate, all in the matrix to the quartz grains

- The mineral phases in the Conductive Fraction include apatite in quartz grains as well as numerous rutile and zircon grains together with a few ilmenite grains, a grain of Pb, and a grain of pentlandite, all in the matrix to the quartz
- The only impurities observed in the Non-Conductive Fraction include two apatite grains within the quartz and an iron oxide phase in the matrix
- The Non-Conductive Fraction assays 100 ppm $TiO_2$

    -although no rutile or ilmenite was observed in the grain mount of this fraction, it is concluded that one or both of these phases are present in this fraction

    -a thin section or a grain mount represents a very small sample and so the few grains of a TiO2-bearing phase required to account for the 100 ppm $TiO_2$ in an assay-sized sample may not be present in a single thin section
- Similarly, although no tourmaline was observed in any of the samples investigated, it has previously been reported in other samples

    -it is therefore concluded that the Boron reported in the assayed samples is contributed by tourmaline
- No lithium-bearing phases were observed in any of the samples examined

    -this author is unable to suggest which phase(s) might be contributing Li to the assayed samples

    -however, tourmaline contains up to 2% Li2O, so it is possible that the Li is contributed by the same phase that contributes boron

# APPENDIX A

Mineral phases in thin sections of silica sand samples

# Mineral phases in thin sections of silica samples from the Maydena Sands Property

Mini report by

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*April 3, 2011*

# Executive Summary

- The following observations are based on examination of polished thin sections prepared from samples supplied by Gerhard Krummei using the Scanning Electron Microscope (SEM)
- The primary objective of this thin section examination was to find the hosts for boron (B) and phosphorous (P) that are both detrimental to the quality of the silica
- Although a significant number of apatite (the host for P) grains were observed no tourmaline or any other possible host for boron was observed
- Other phases observed in the samples include barite, pyrite, carbonates, galena, and a range of native metals and alloys

# Phases Identified by SEM

- Silica (the host)
- Apatite
- Barite
- Wollastonite
- Ilmenite
- Pyrite
- Cassiterite
- Galena
- Various alloys including native Fe, Fe-V-Ti-Ni, Fe-Ni-Cr, and Ti metal
- Iron oxides

# Distribution of Phases (1)

- All minerals and alloys are very irregularly distributed in the samples
- Most of the silica is free of all mineral/alloy inclusions
- Each of the mineral species/alloys occur in clusters and/or domains

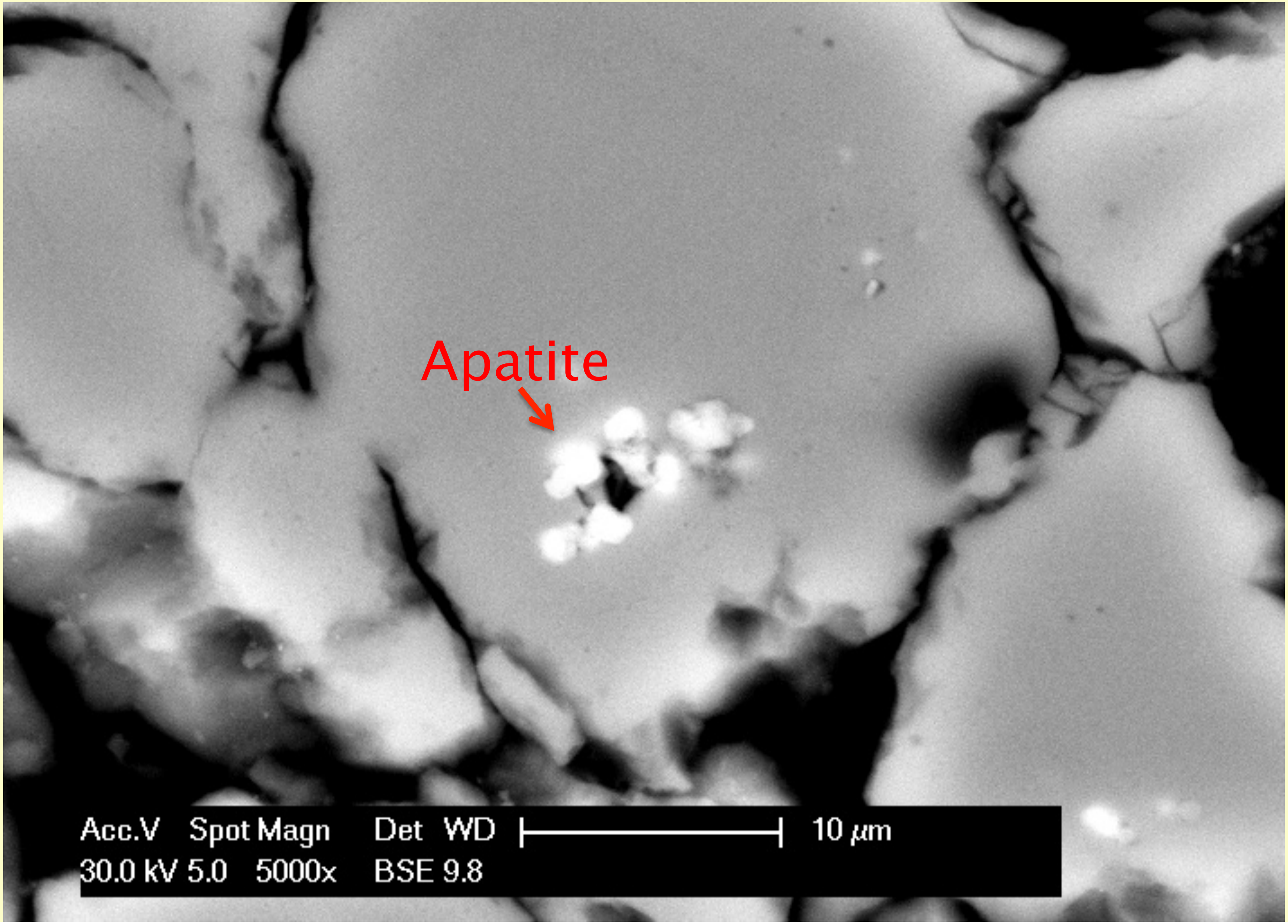
# Distribution of Phases

- As individual phases or clusters of grains within the silica host (apatite, ilmenite, wollastonite)
- As trails of grains along crystal growth planes or fractures in primary crystal grains that have since been pseudomorphed by silica (pyrite and barite)
- Between grains that have been pseudomorphed by silica (most of the alloys, iron oxides)
- Almost always occur together in domains within the silica

# Apatite

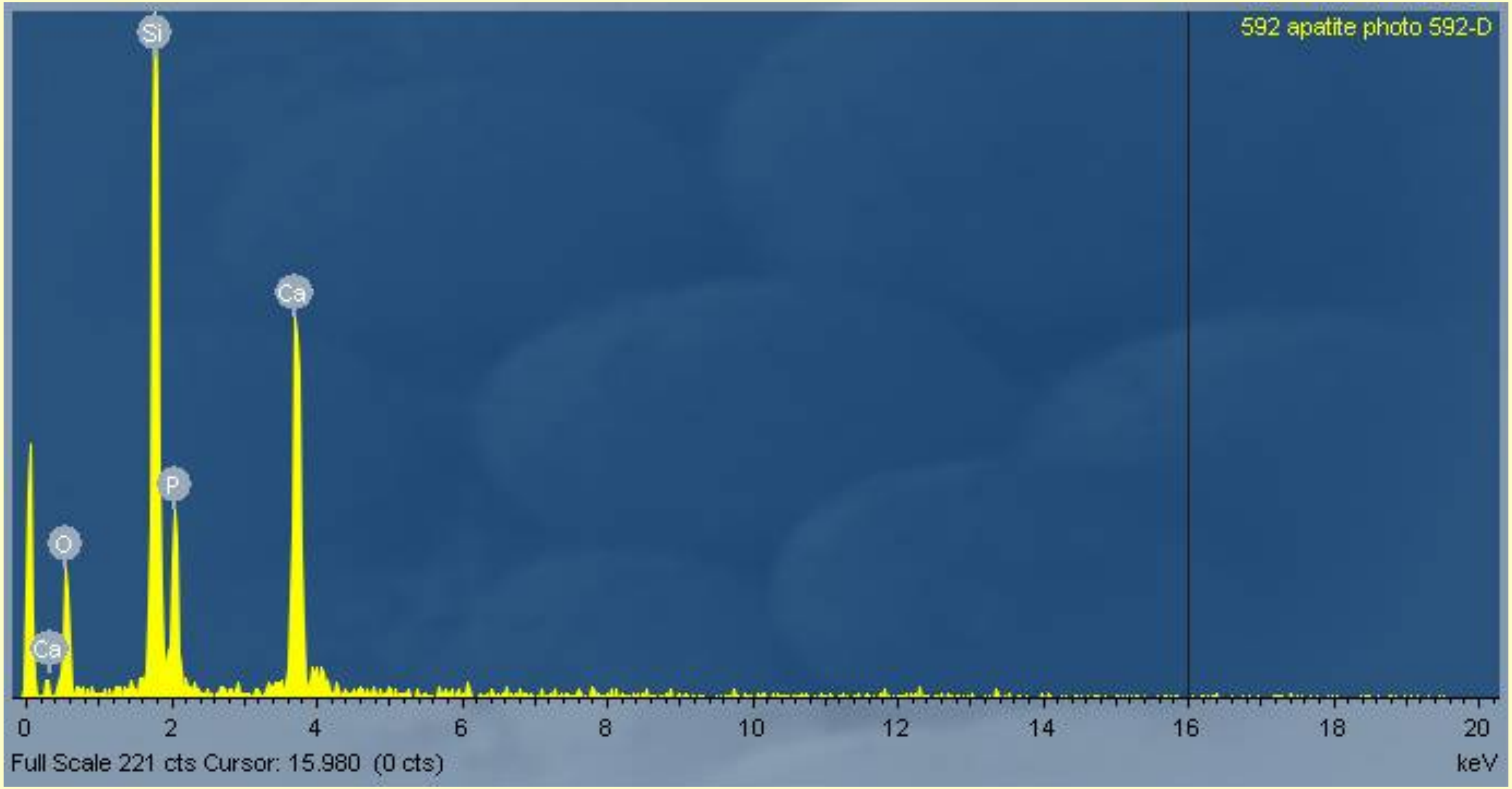
- Most of the silica is free of apatite
- The apatite may occur in tight clusters, disseminated in a section of a thin section, or in small groups
- Individual apatite grains are about a micron across and occur within the silica grains
- Large areas of the polished thin sections are completely free of apatite

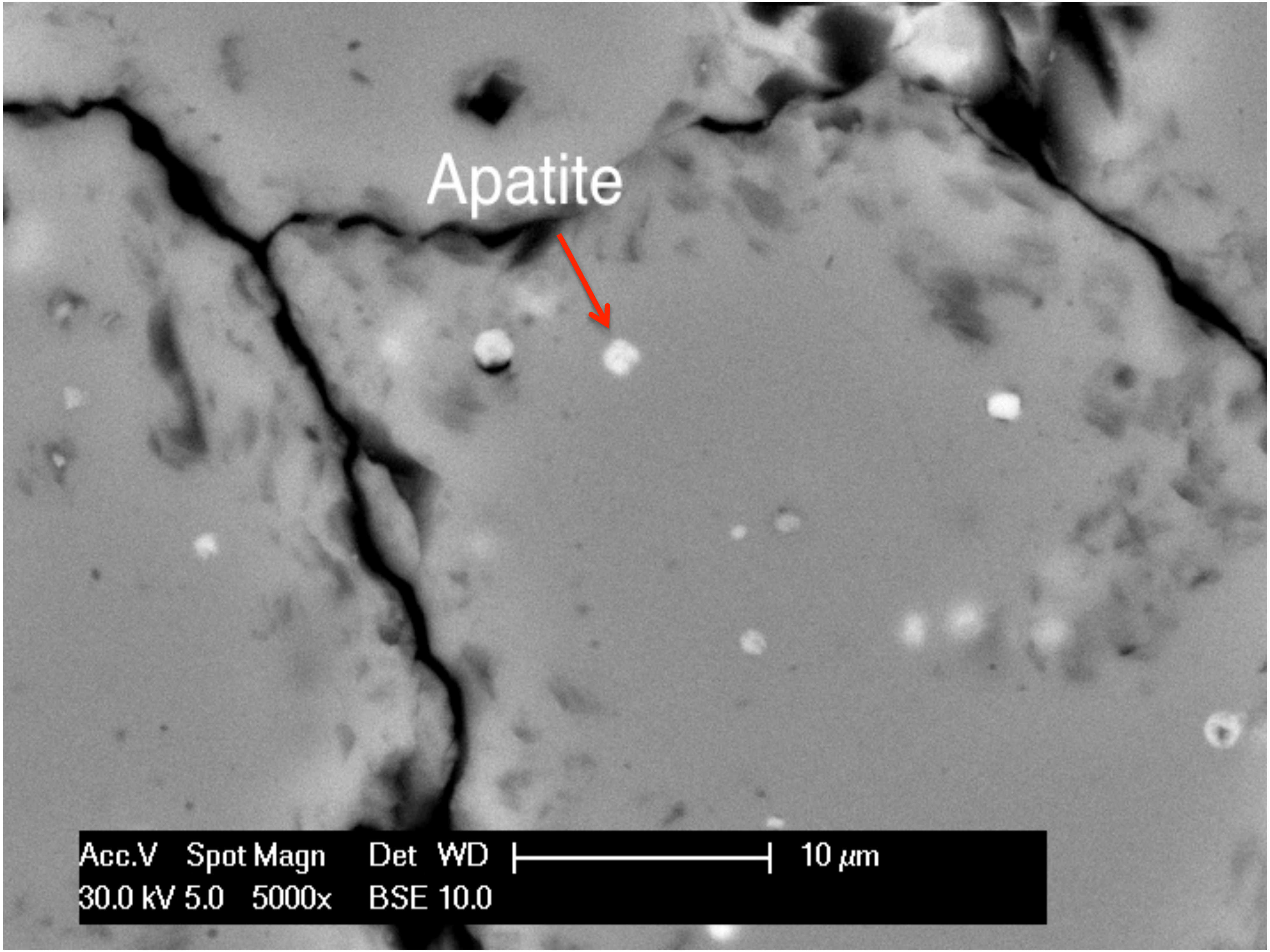
# Apatite in clusters



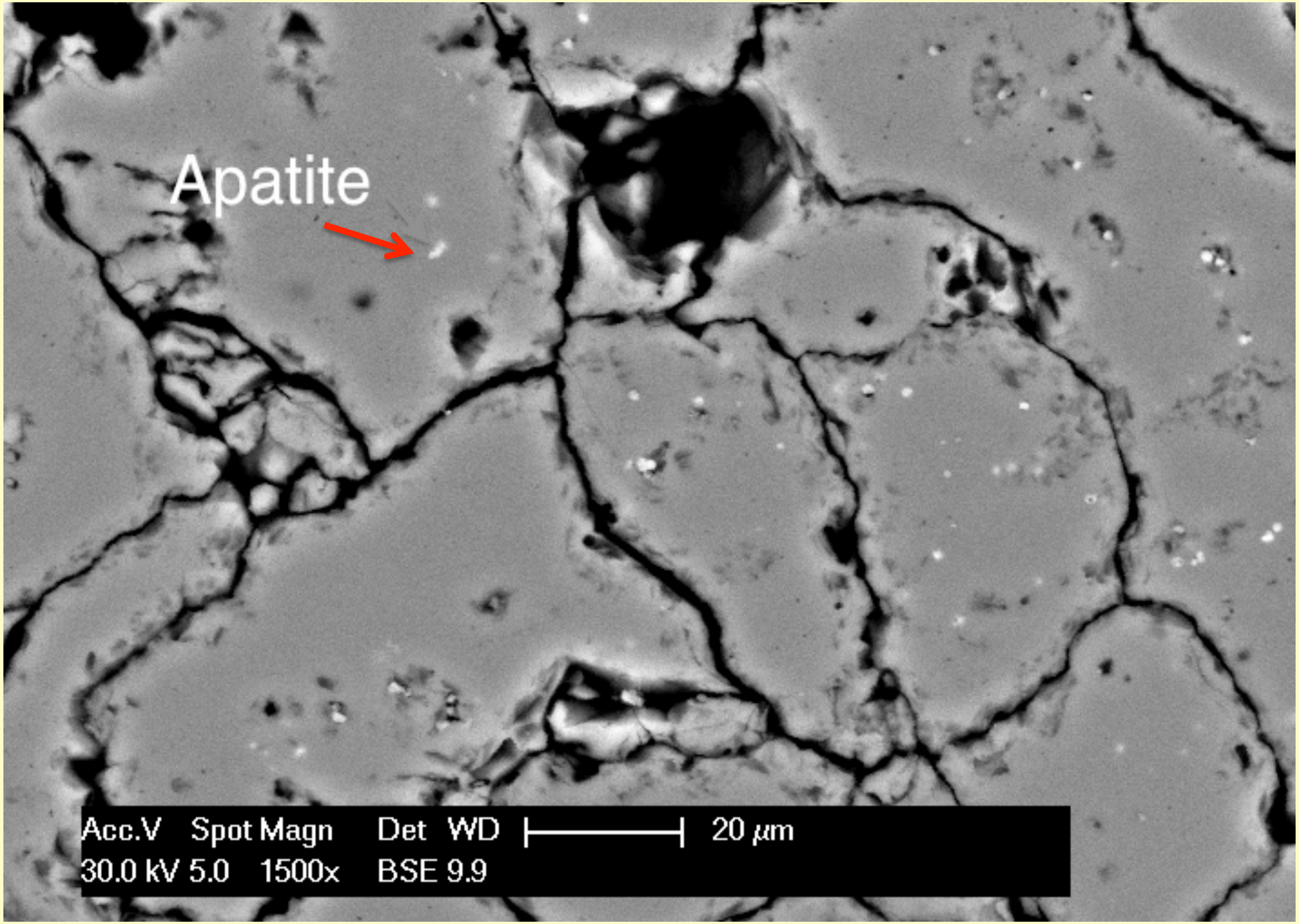
## Apatite spectrum

Because of the small size of the apatite, the beam picks up the host silica as well as the apatite




Apatite
Acc.V Spot Magn Det WD
30.0 kV 5.0 5000x BSE 10.0
10 μm

All the white grains are apatite



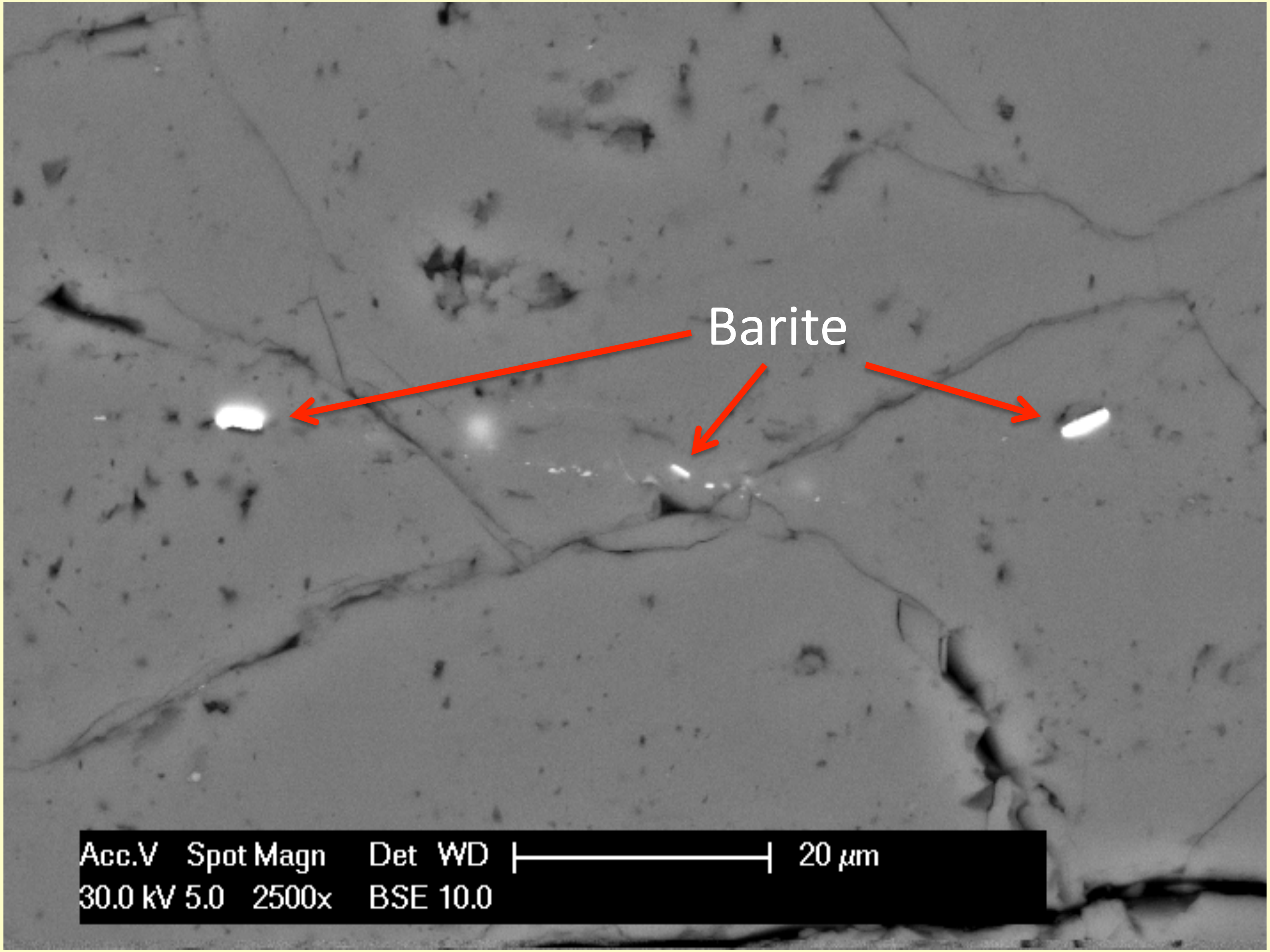
# Boron Hosts

- It was assumed that the most likely host for boron would be tourmaline
- Although a very thorough search for “exotic” phases in the silica was conducted,  no possible hosts for boron, including tourmaline
- However, this does not rule out the possibility that tourmaline is more randomly distributed in the samples than, say, apatite, and that although present in the samples, none were sampled by the thin sections

# Barite

- Although only observed in one thin section, barite occurs in trails
- As most individual barite grains are very small (< 1 micron), it was not possible to get an analysis free of the background silica
- In addition to Ba, Sr is also present in the barite

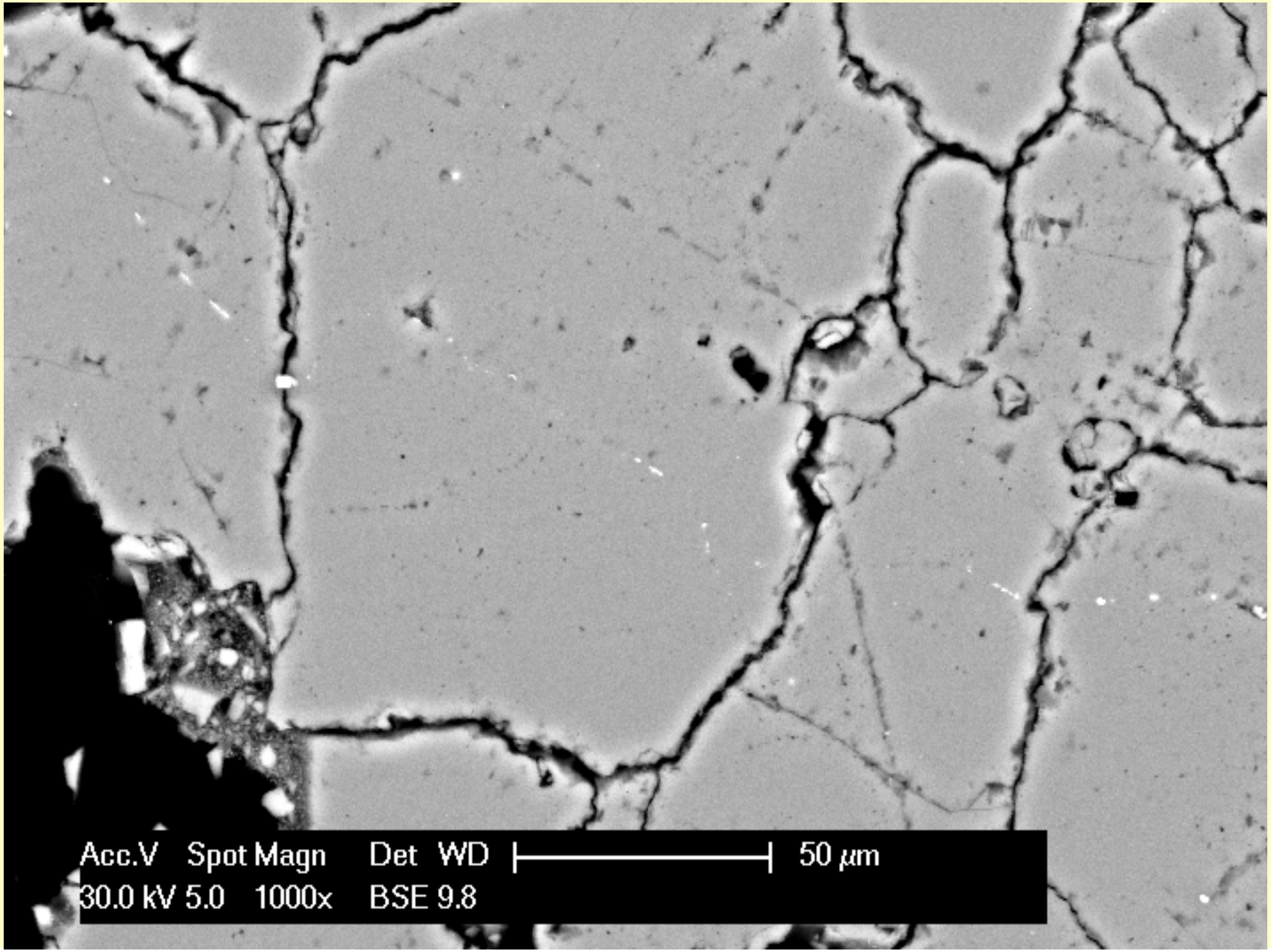
# Trail of Barite in Silica



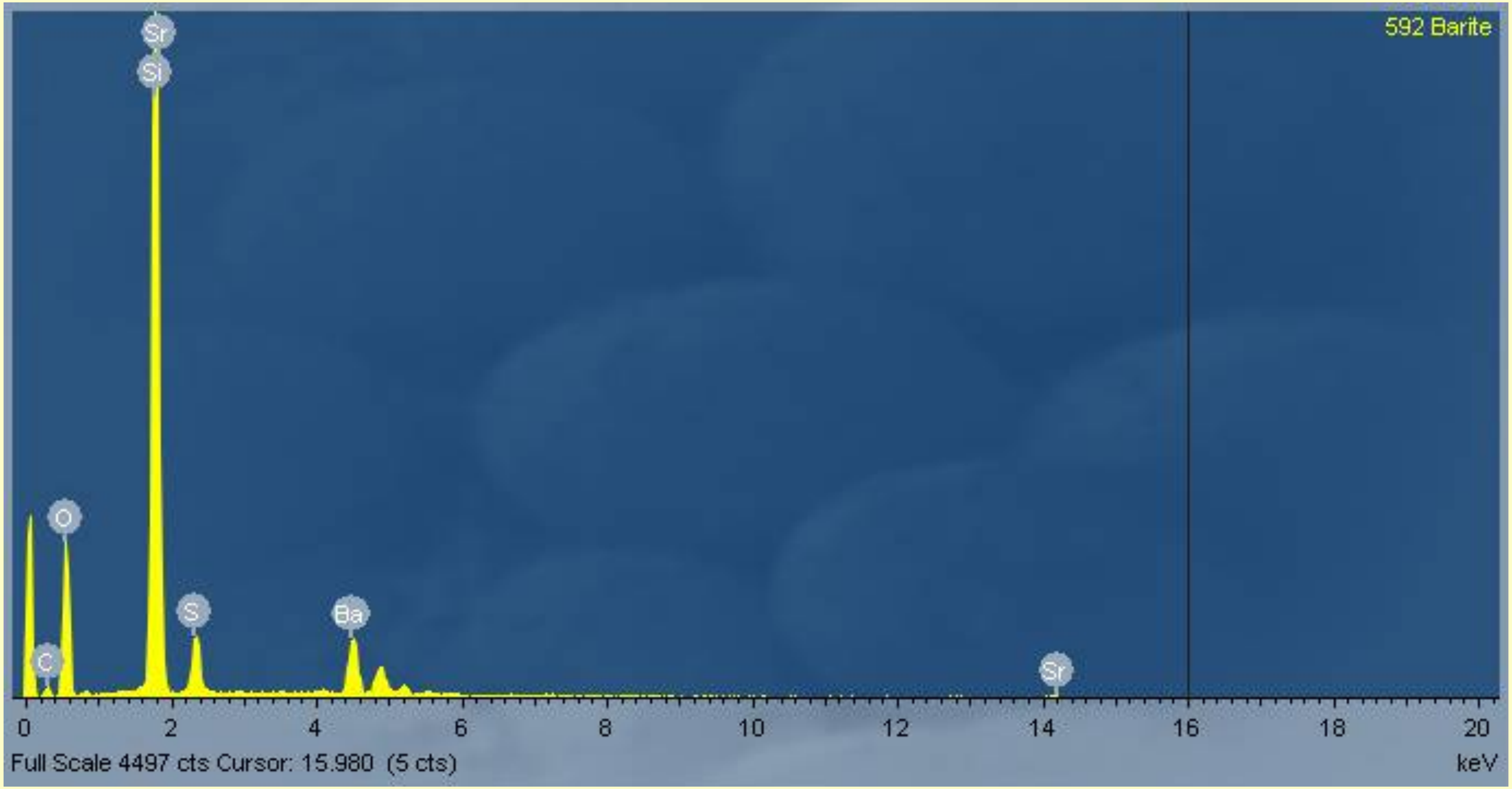
## Trail of Barite in Silica

All white phase are barite hosted by silica

The barite was emplaced along fractures/grain boundaries in minerals which were pseudomorphed by silica



Barite Spectrum*
The barite contains some Sr but no Si



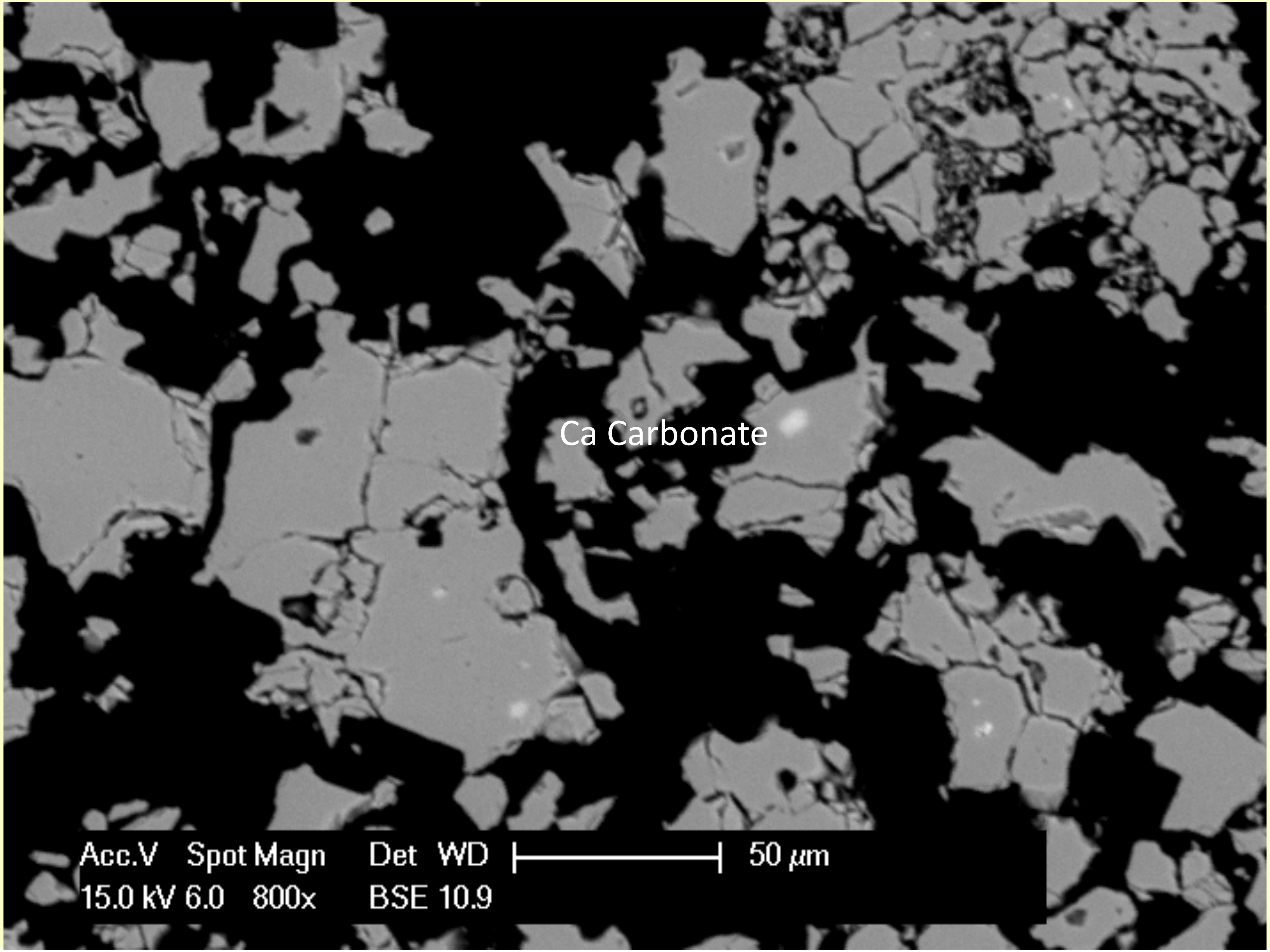

•Although the Sr peak lies on top of the “Si” peak, there is no Si in the mineral because there Is no higher energy Si peak

# Ca Carbonate

- All of the Ca carbonate grains occur within silica grains
- Presumably, the carbonates represent the remnants of much large carbonate grains that were replaced by the silica

## Calcium Carbonate

All white grains with the silica grains are Ca carbonate

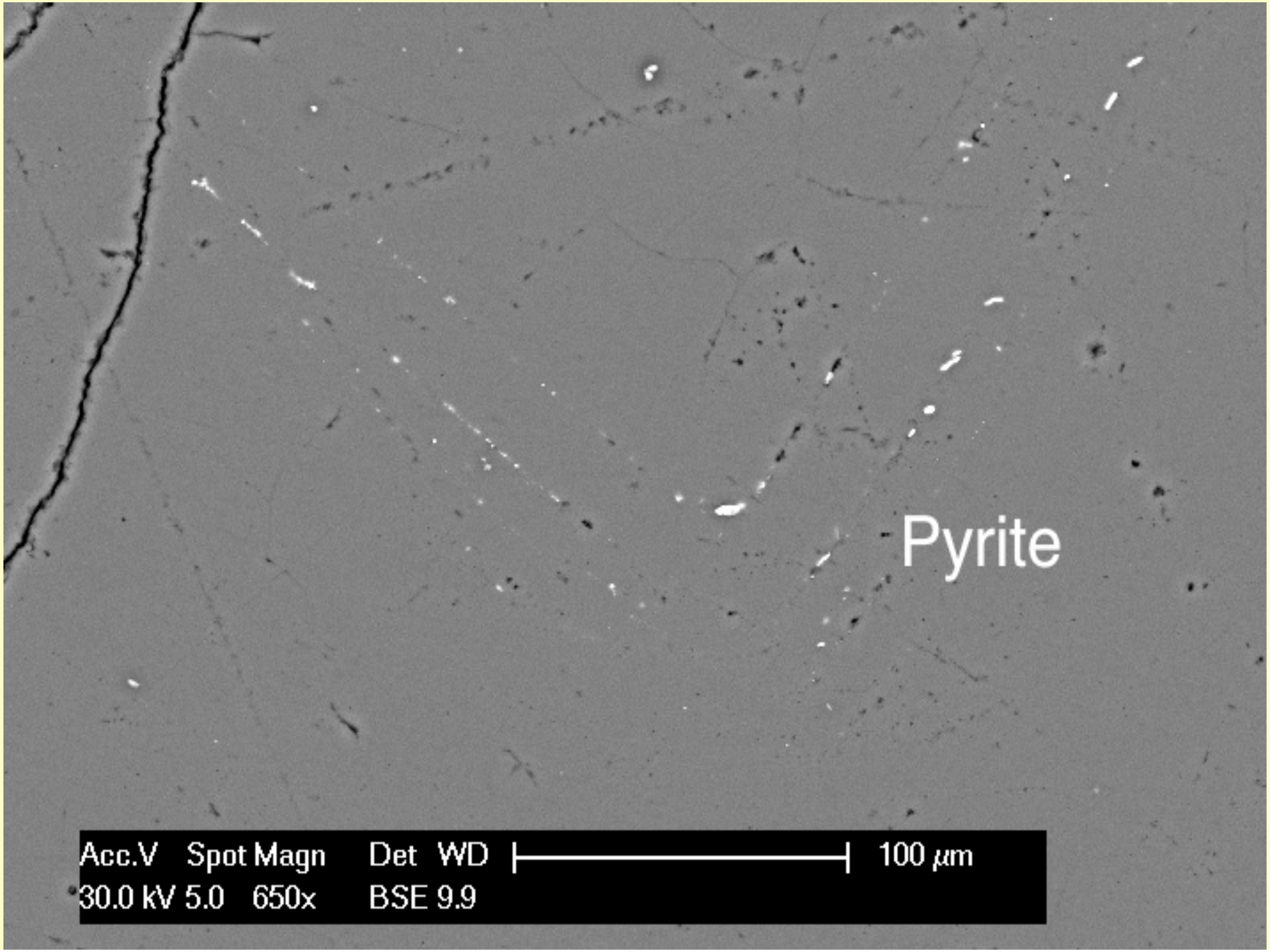


# Pyrite

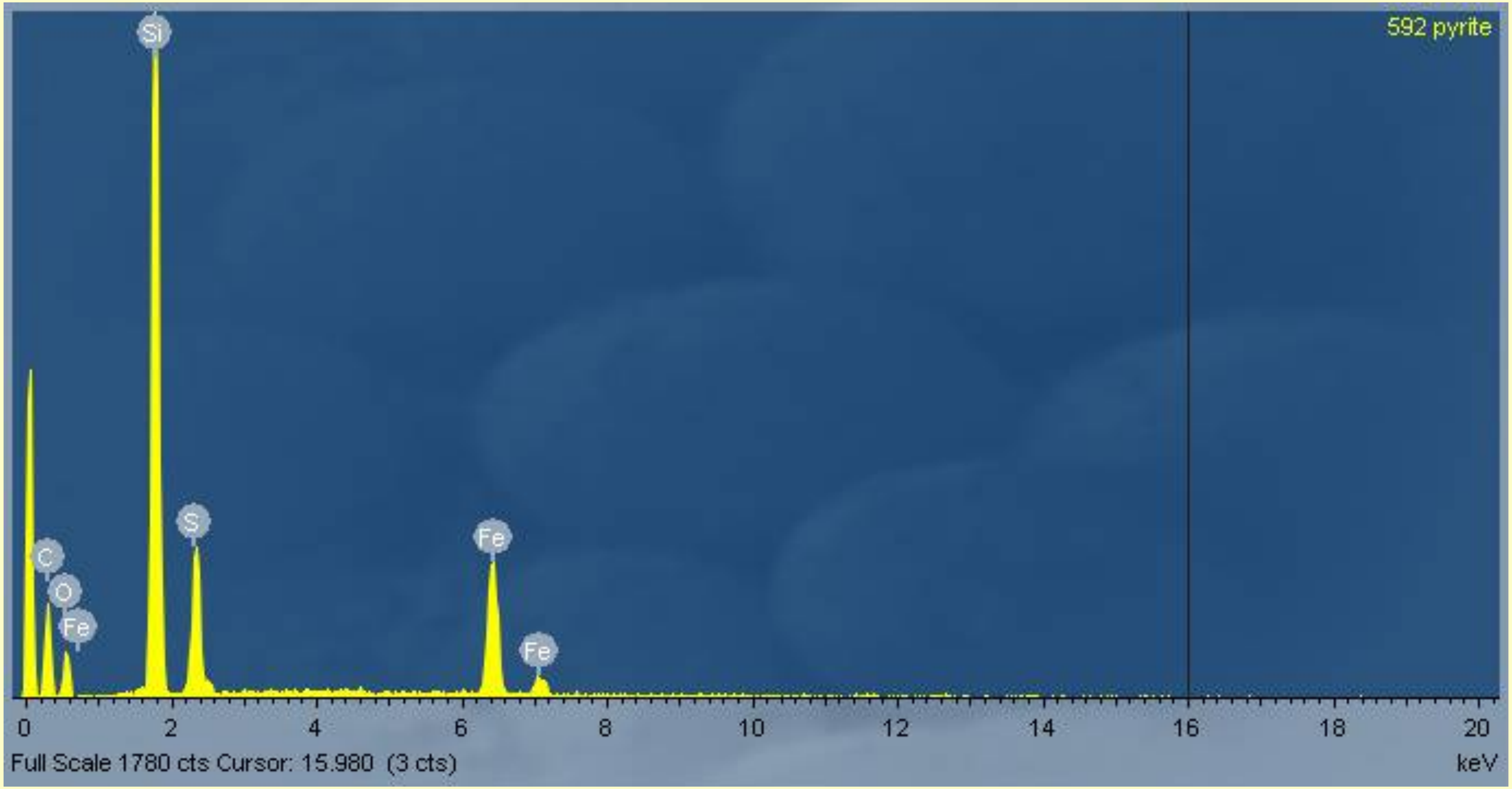
- Small grains of pyrite occur as individual grains within the silica
- Pyrite also occurs along well defined trails
- In the latter case, it is probable that the pyrite was deposited along growth planes in a mineral that was subsequently replaced by the silica

Trails of pyrite in silica

Was the pyrite deposited along the edges of crystals pseudomorphed by silica??



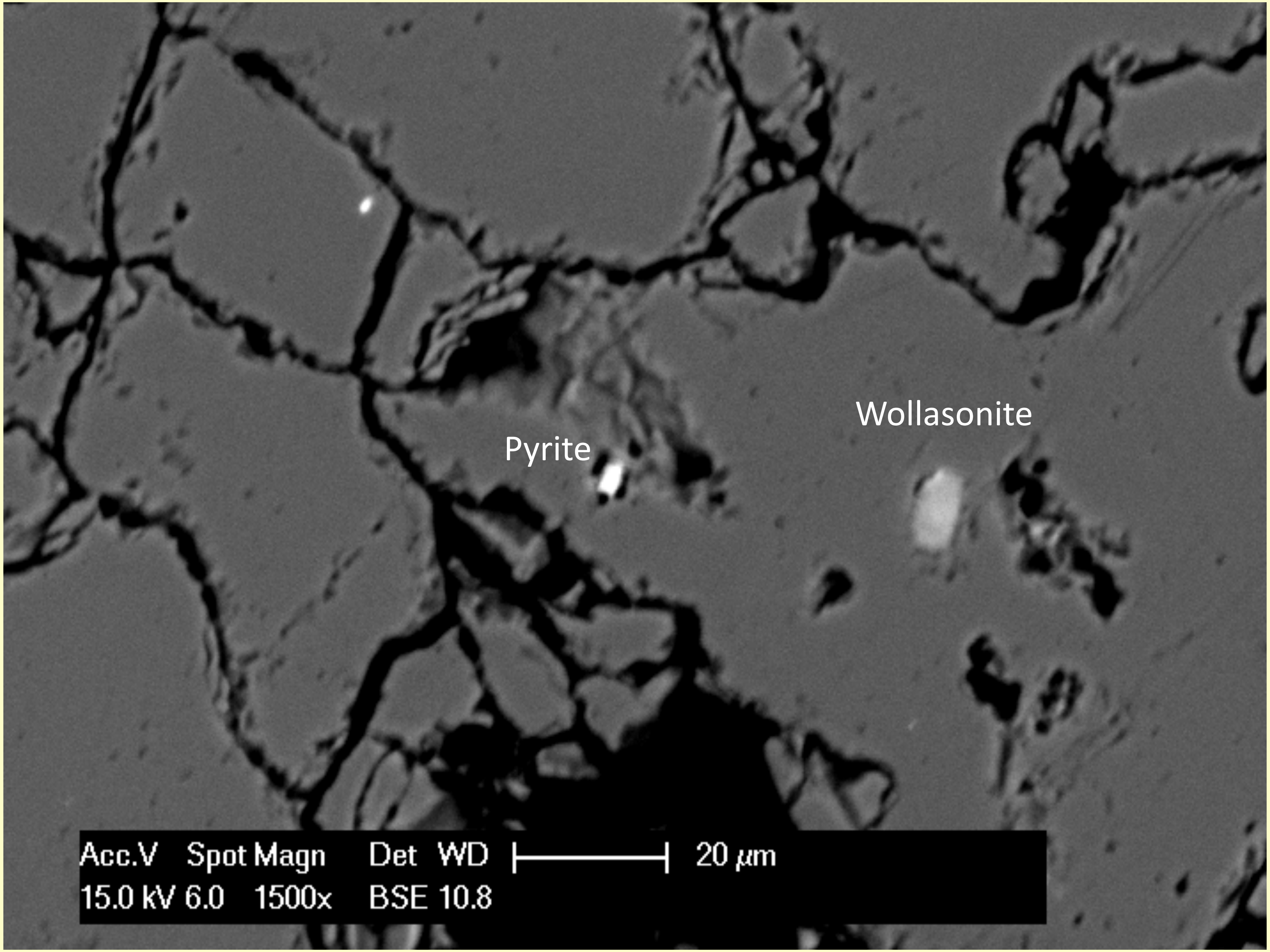
Spectrum of pyrite in silica*



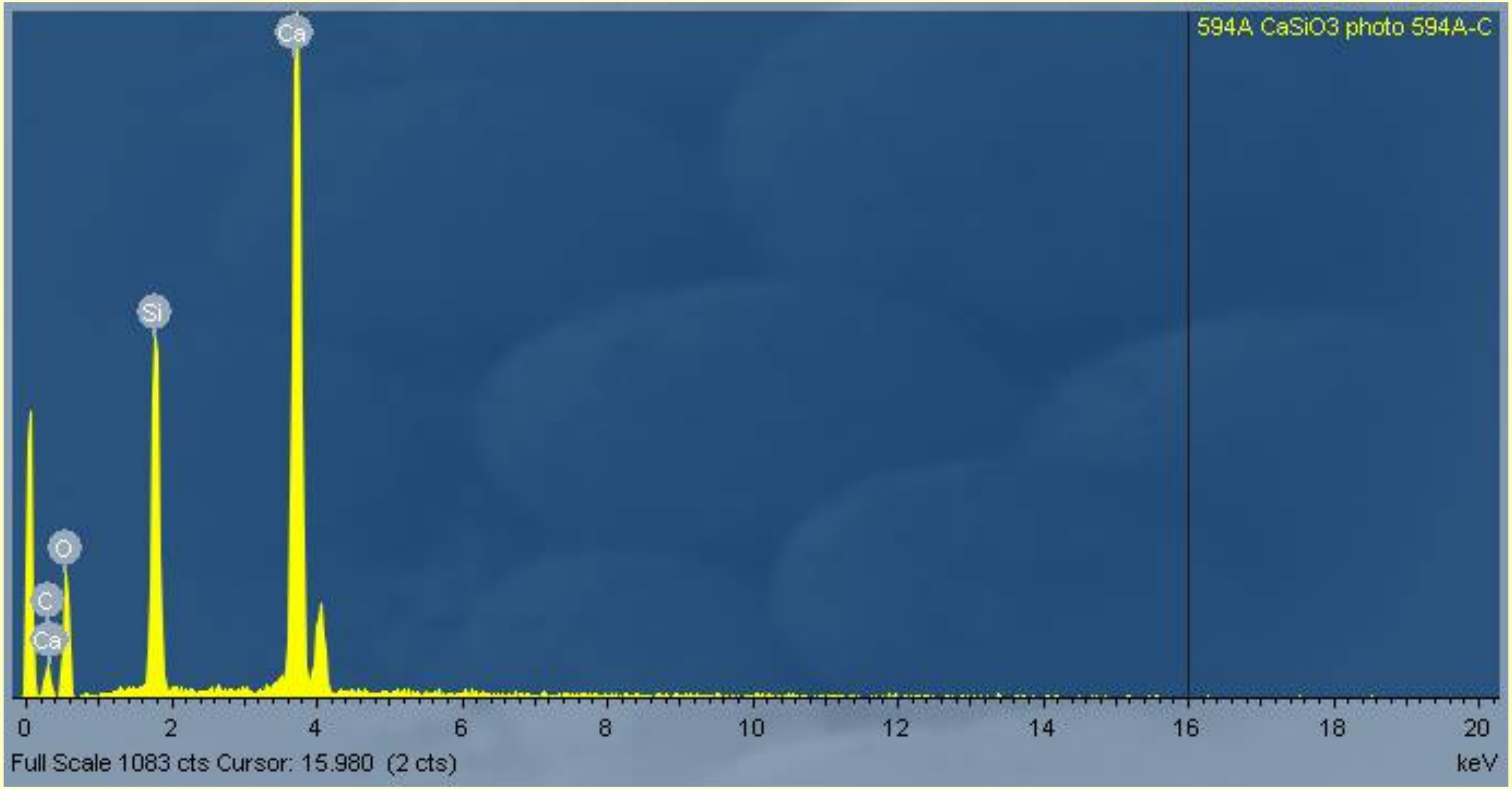

•The Si peak is present because of the small size of the pyrite

Wollastonite

Also present are two grains of pyrite



# Spectrum of Wollastonite



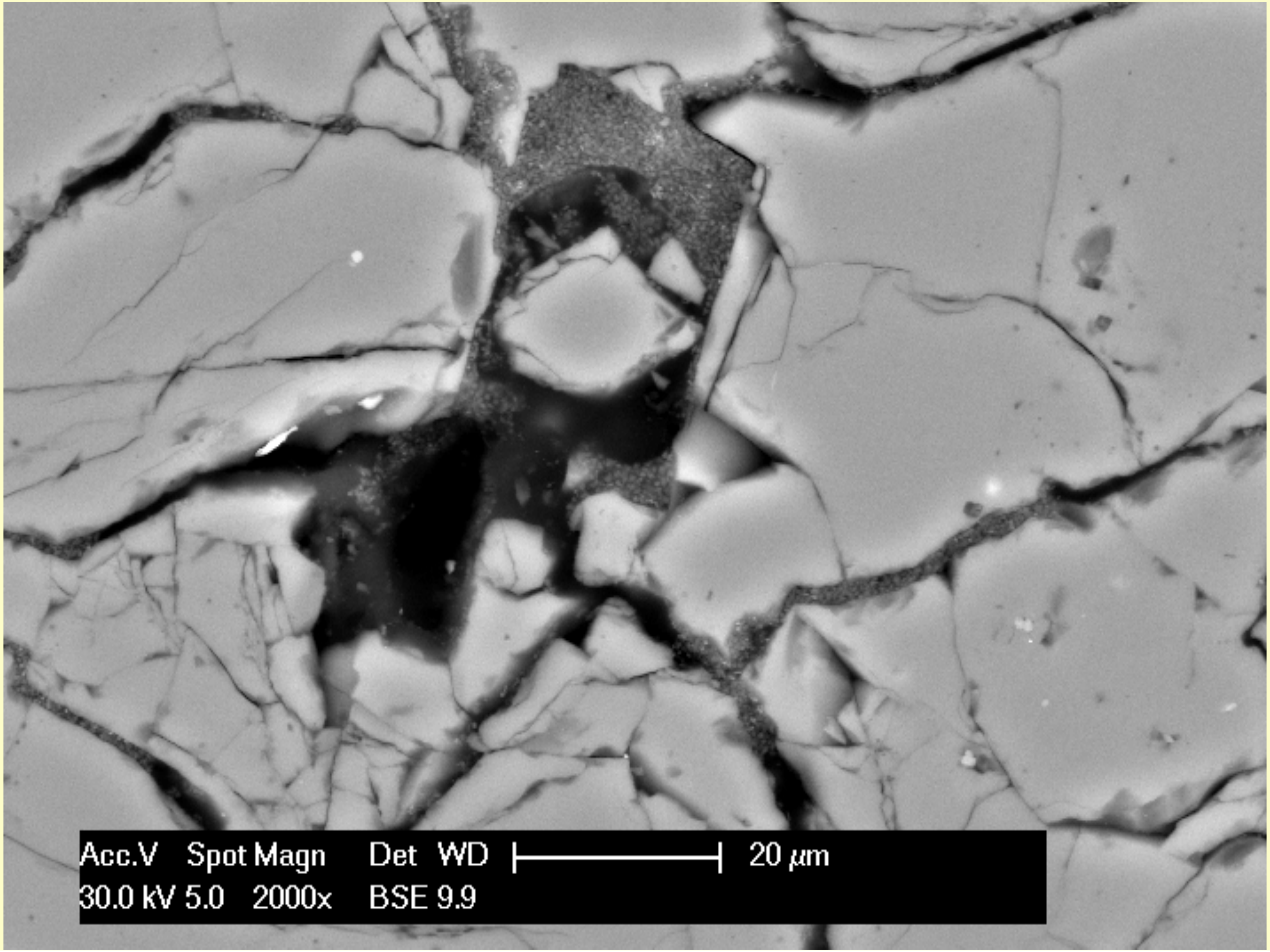
# Alloys

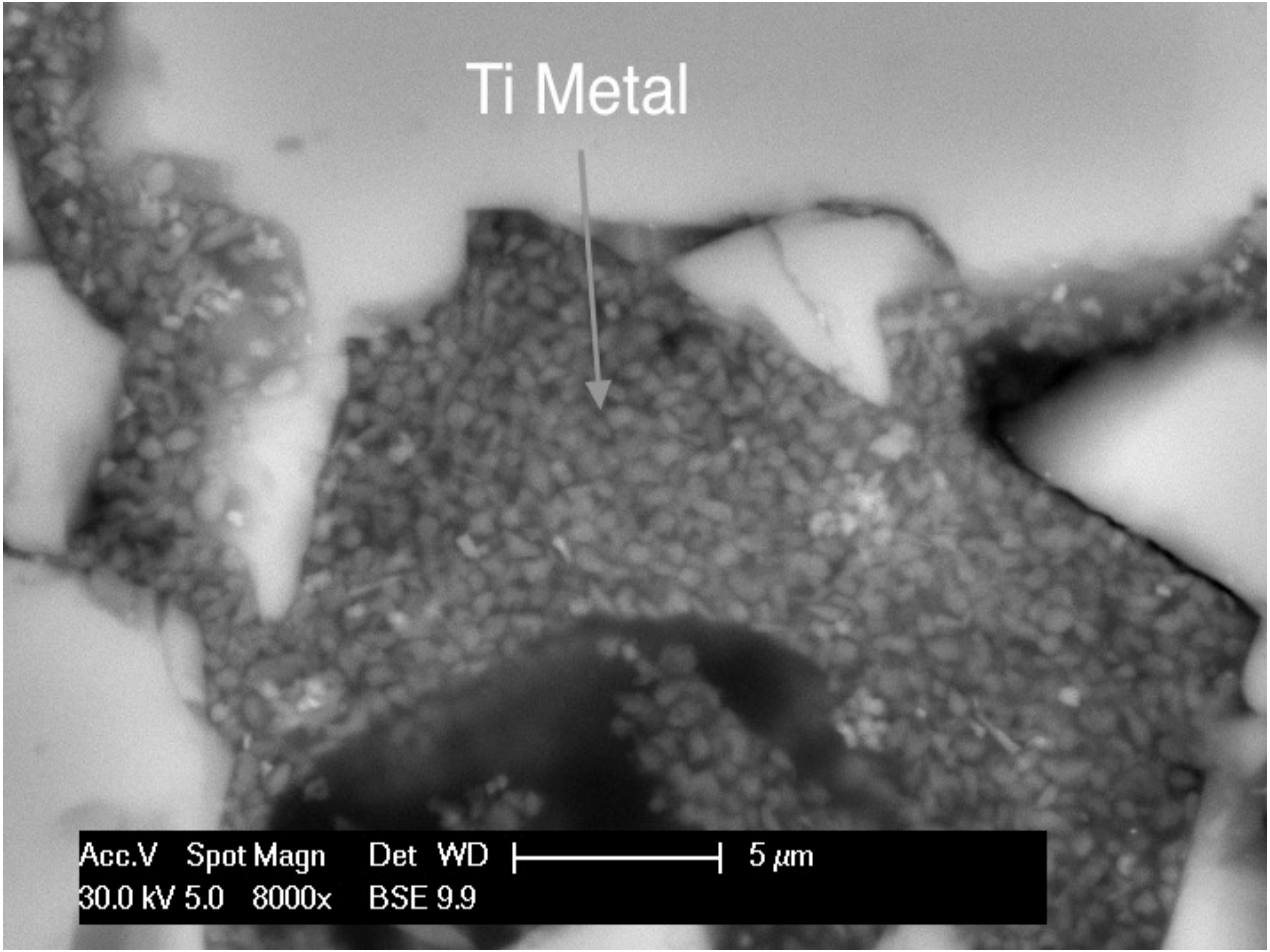
- A number of alloys were found in the samples
- Although it is possible that the phases are contaminants, it is difficult to see how and when they became incorporated into the samples
- Alloy phases observed include
    - Native Fe
    - Fe-V-Ti-Ni
    - Ti metal
    - Fe-Ni-Cr

# Titanium Metal

- Several thin sections contain small, tightly packed  grains of titanium metal contained in a silica host
- The titanium metal-silica mixture has very much the appearance of having been "squirted" into a silica framework
- The origin of the titanium metal is a complete mystery-however, it was definitely not added during preparation of the thin sections

# Titanium metal hosted in silica





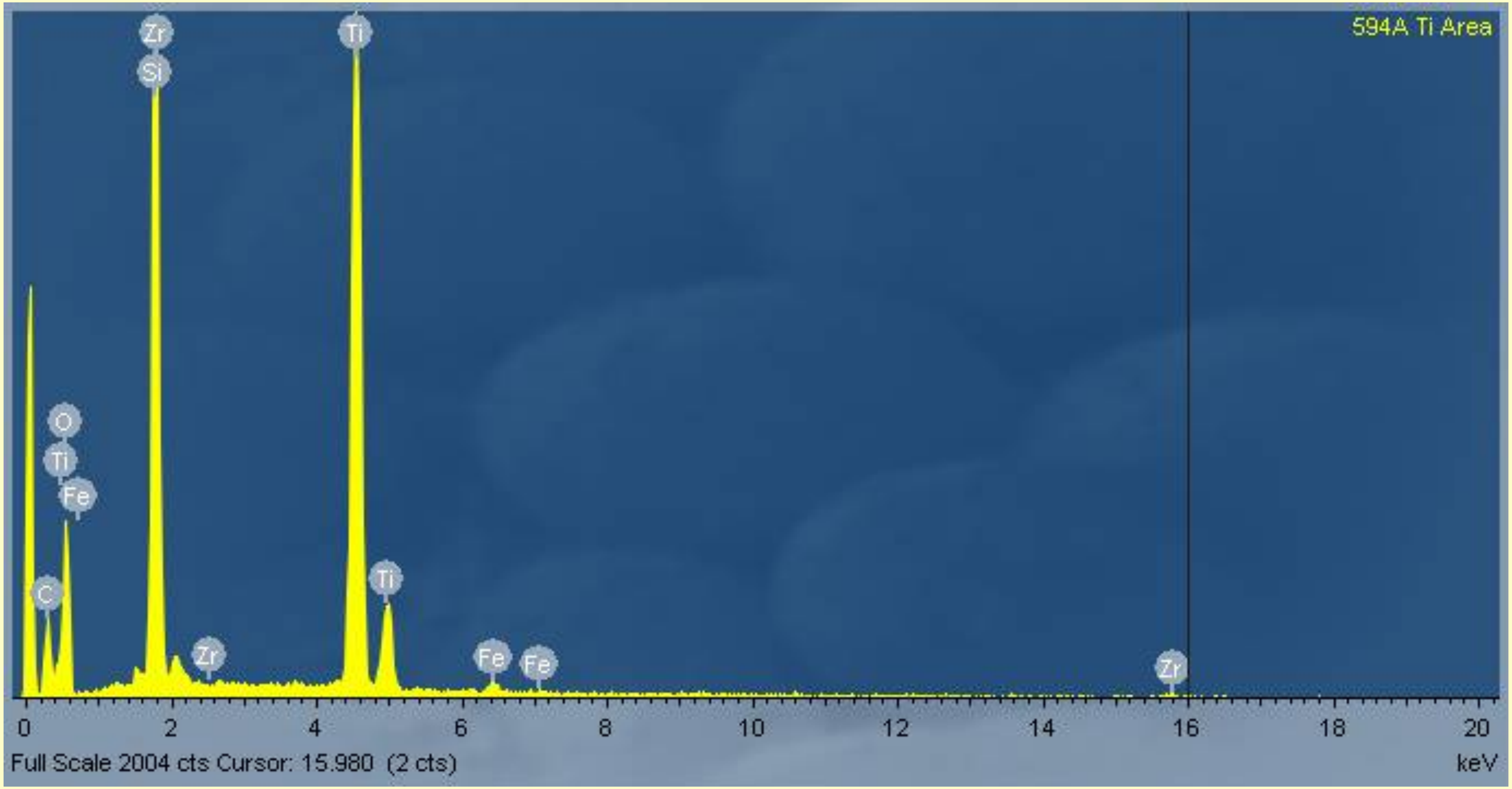
Ti Metal
Acc.V Spot Magn Det WD 5 μm
30.0 kV 5.0 8000x BSE 9.9

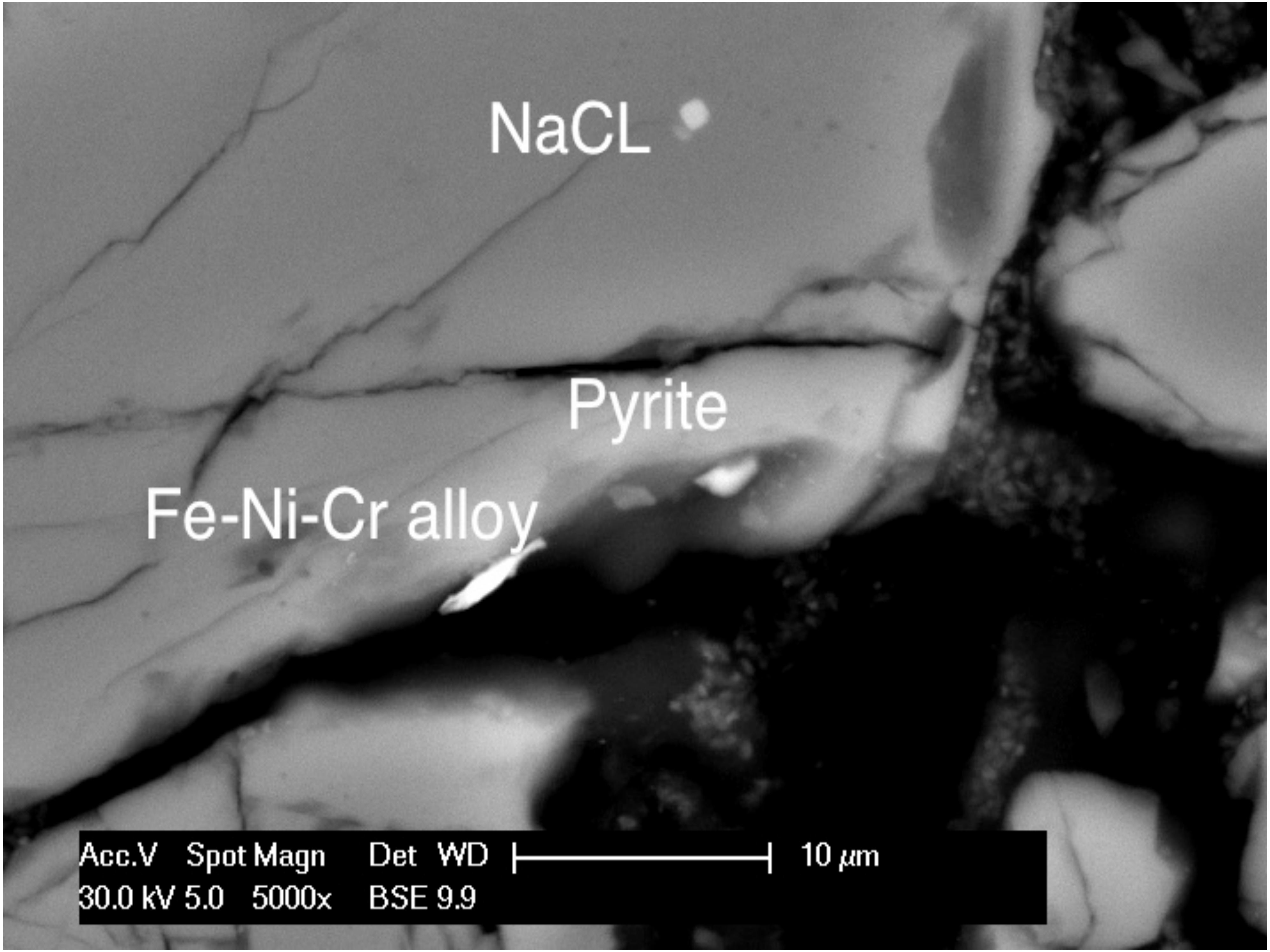
## Spectrum of Ti area

Because of their very small grain size, it is not possible to get a clean analysis of the Ti metal

Rather, the spectra includes the host silica

There is no Zr in the sample-the Zr peak at 1.8 keV overlaps on the Si peak at that position

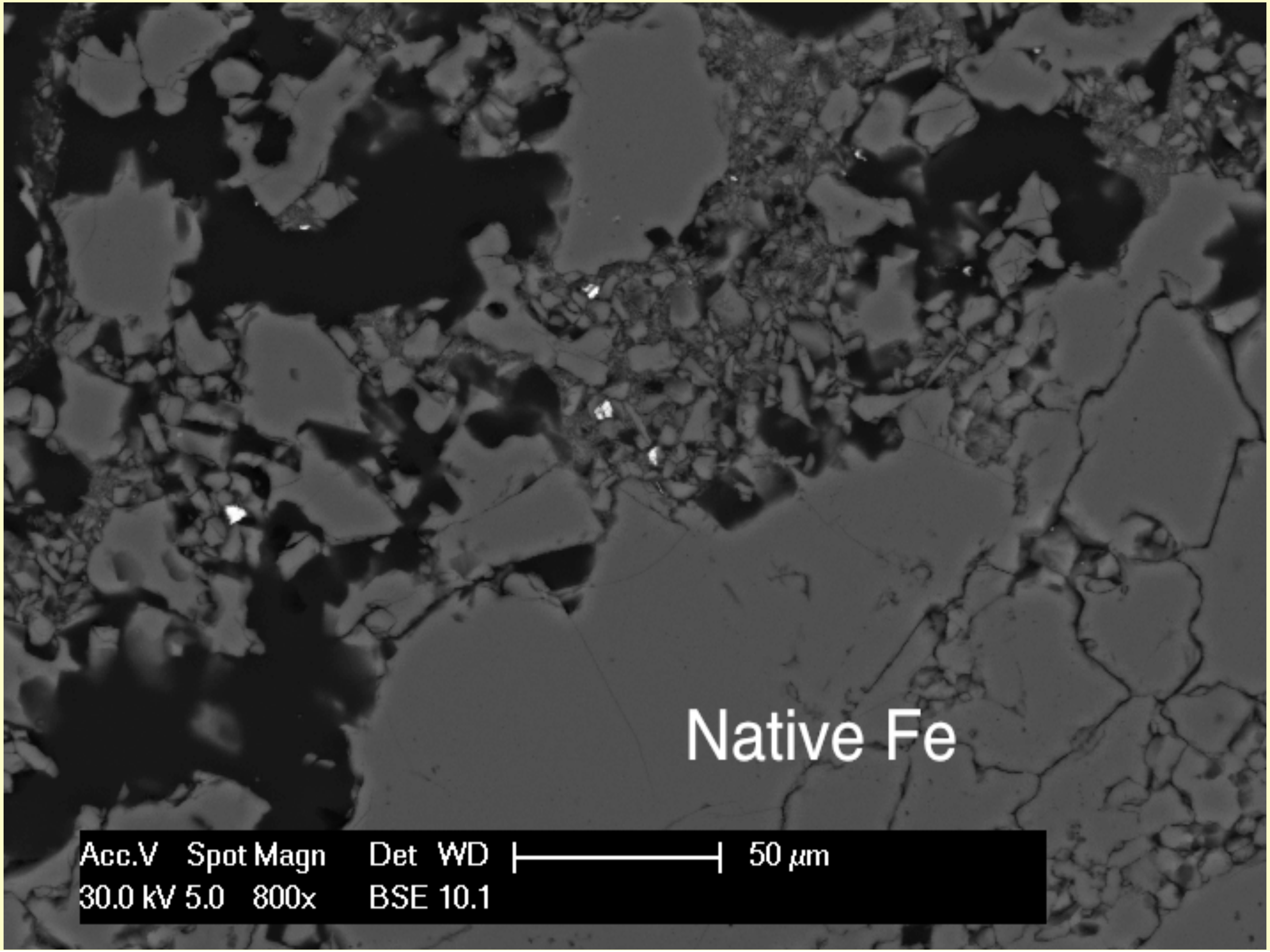



NaCL
Pyrite
Fe-Ni-Cr alloy
Acc.V Spot Magn Det WD
30.0 kV 5.0 5000x BSE 9.9
10 μm

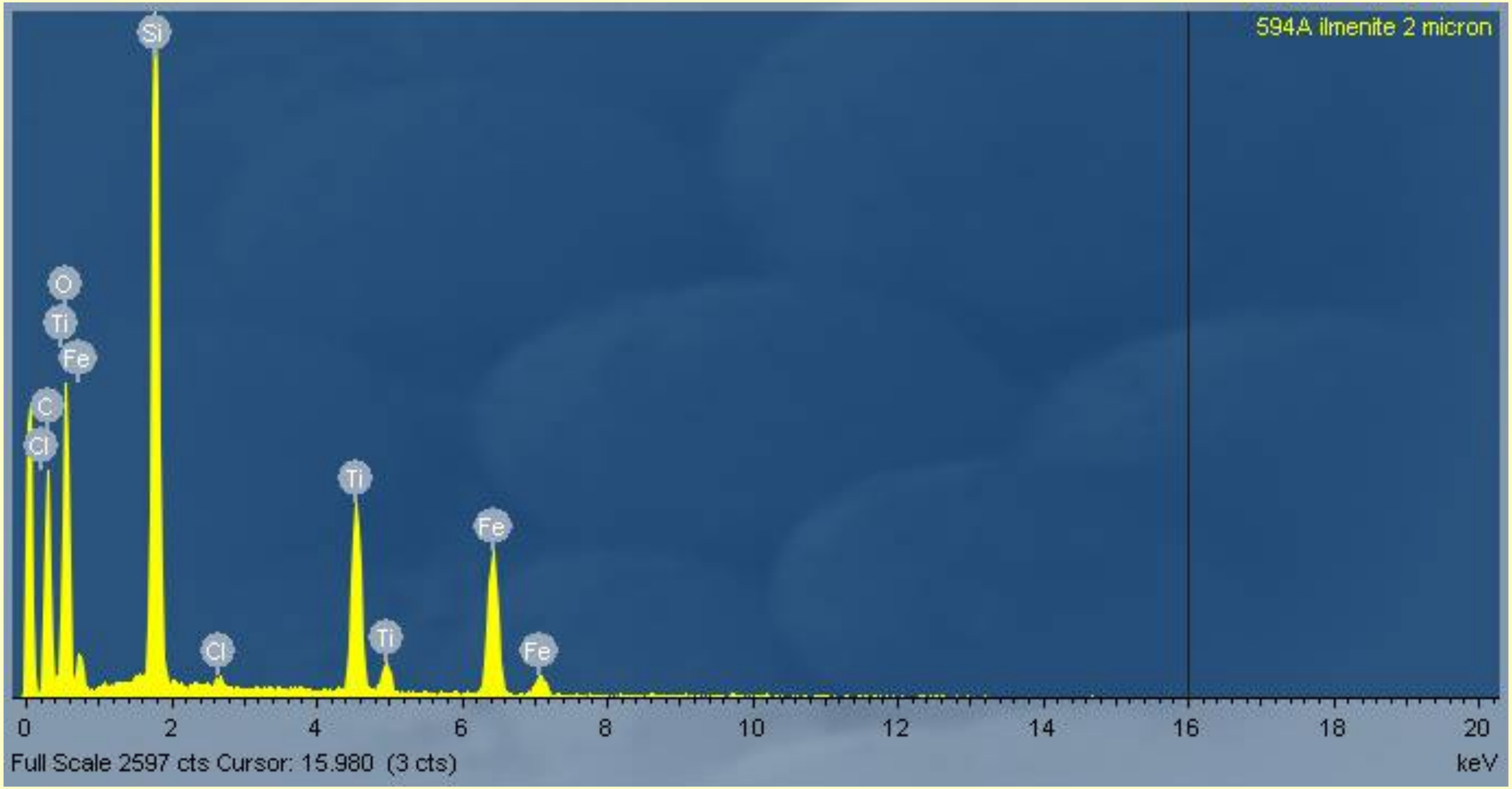
All the bright white grains are native iron

As native iron should oxidize rapidly in the near surface environment, these grains may not be indigenous to the samples

However, there is no obvious explanation as to their presence



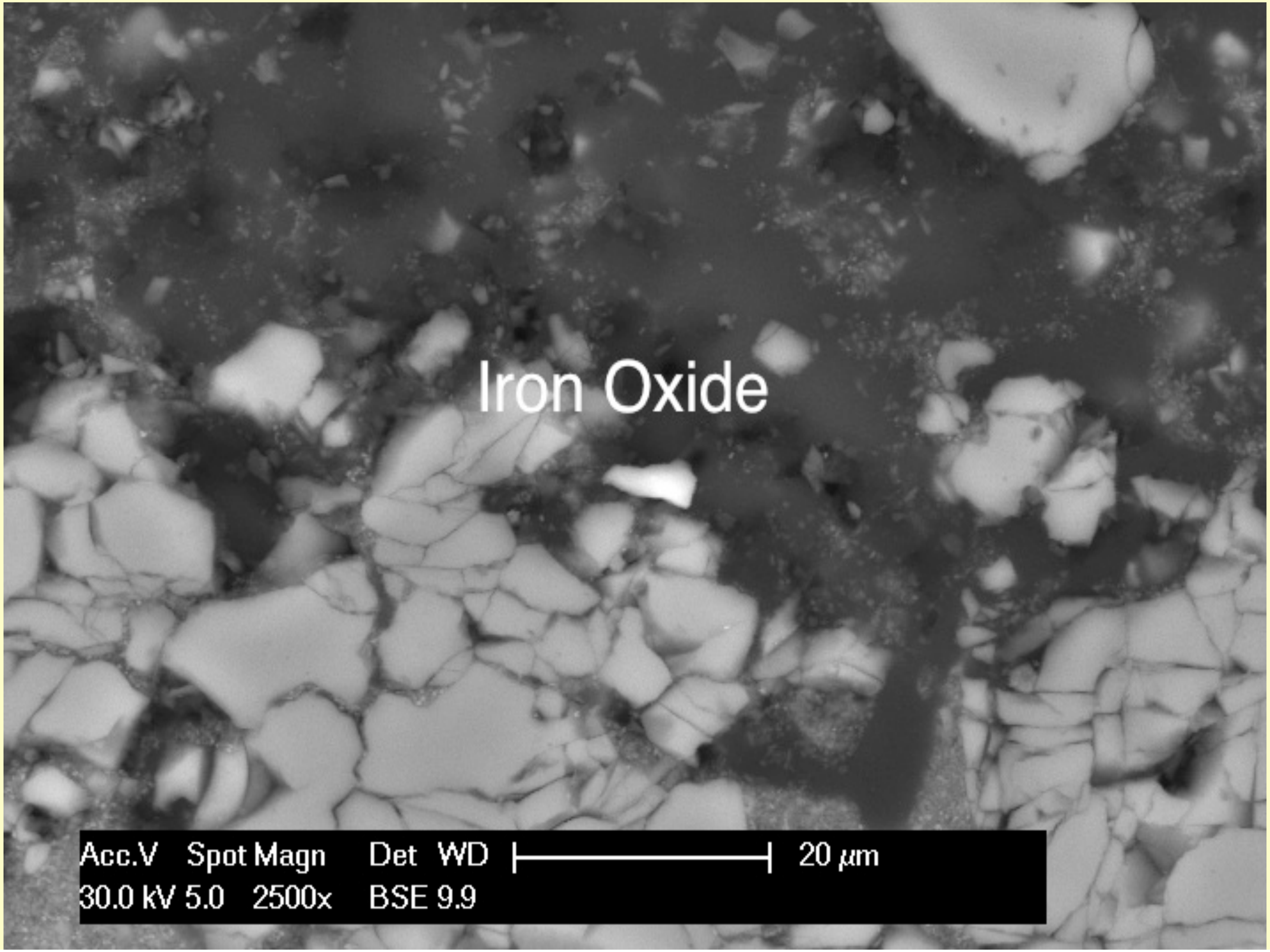
# Spectrum of Ilmenite



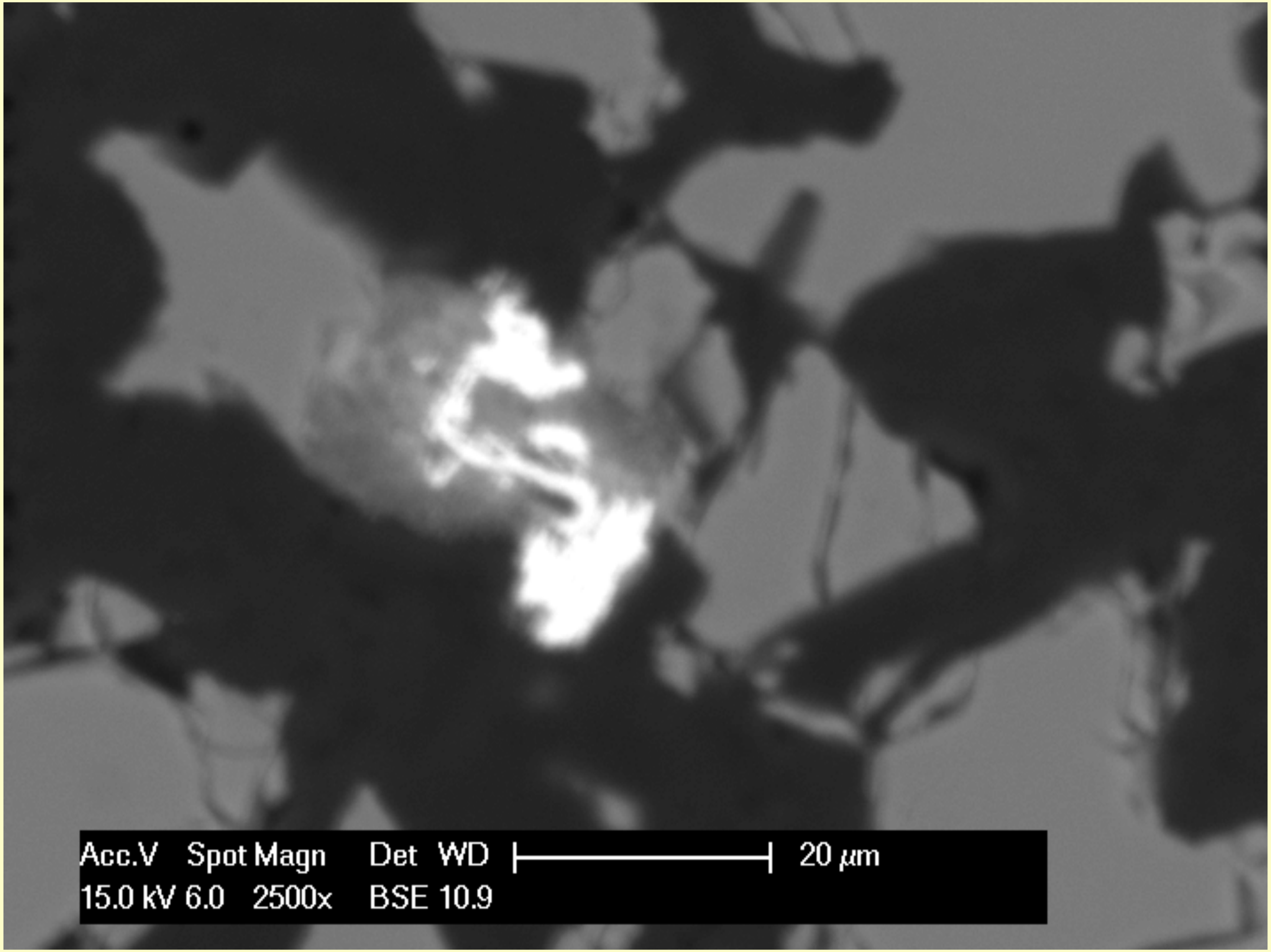
# Iron Oxides

- A number of iron oxide grains were observed
- While some are in the silica matrix (and therefore could be exoctic), others are ingrown with the silica

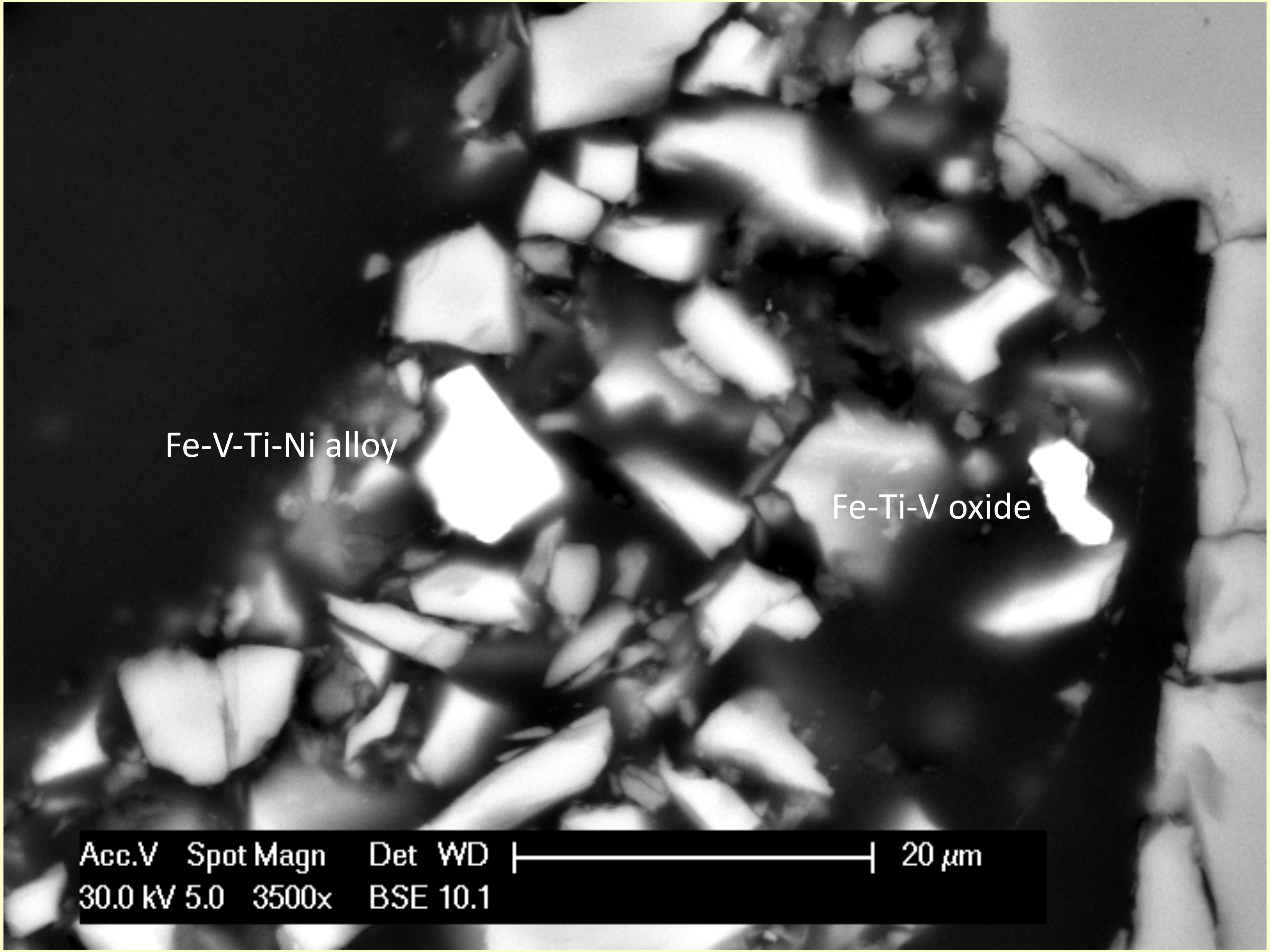
# Grain of iron oxide



# Iron oxide intergrown with the silica



An Fe-V-Ti-Ni alloy and an Fe-Ti-(V) oxide.  The oxide phase is probably ilmenite



## Galena and Cassiterite

- Several grains of galena were observed, but no photos taken
- A single grain of cassiterite was observed, but no photo taken

# Mineral Processing

- Because of their very small size and location within the silica, mechanical removal of the apatite, barite and pyrite would be very difficult

# APPENDIX B

Mineral phases in polished grain mounts of silica sand samples subjected to mineral processing

# Mineral phases in silica samples subjected to mineral dressing from the Maydena Sands Property

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*November 10, 2011*

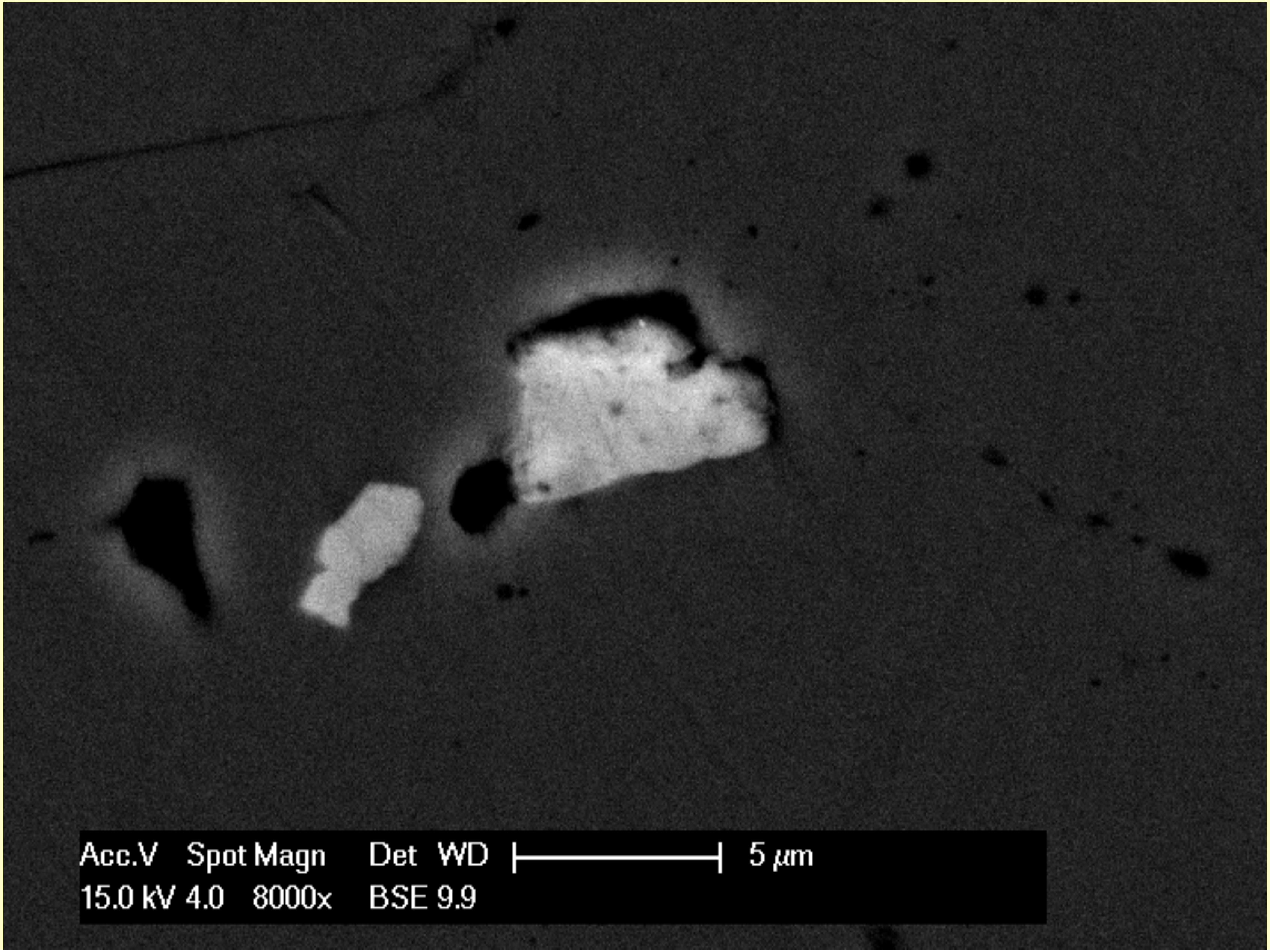
# Samples examined

- Polished grain mounts were made of a silica sand sample from the property that had been subjected to a mineral dressing procedure in which the sample had been put through an electrostatic procedure
- Mineral phases were searched for and analysed on the Scanning electron Microscope at the University of Melbourne
- Three samples were examined
  - Head sample (90B-2)
  - Non conductive fraction (90B-2-200500NC)
  - Conductive fraction (90B-2-75200C)

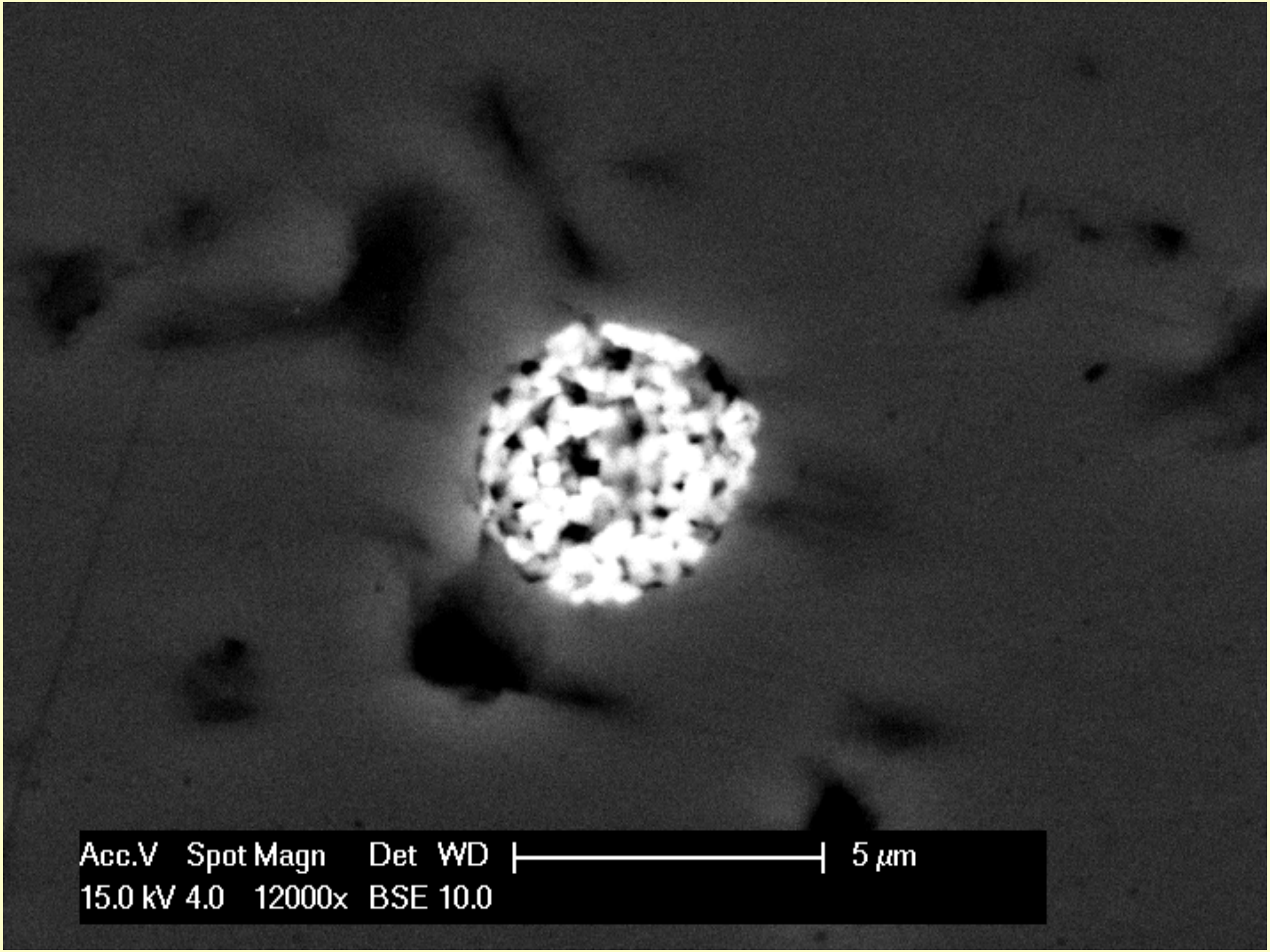
# Head Sample (90B-2)

- Chemical analyses indicates it contains
  - 1050 ppm$TiO_2$
  - 210 ppm $Fe_2O_3$
  - Raw and unscreened
  - This sample contained a large number of mineral impurites including apatite, ilmenite enclosing rutile), chalcopyrite, iron enveloped by tin, zircon, lead carbonate, iron oxide, and rutile.

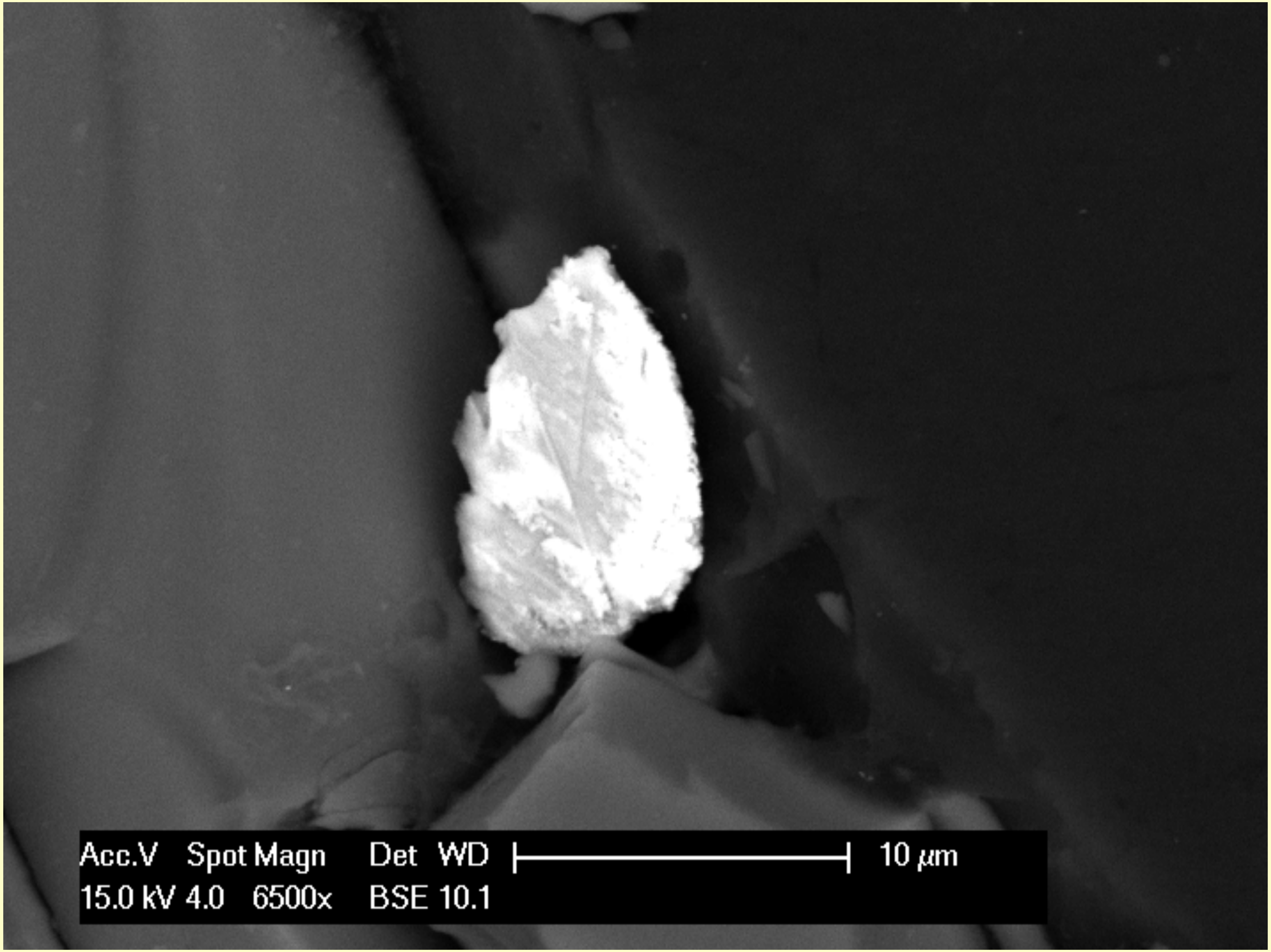
# Two grains of apatite hosted by quartz in Head sample



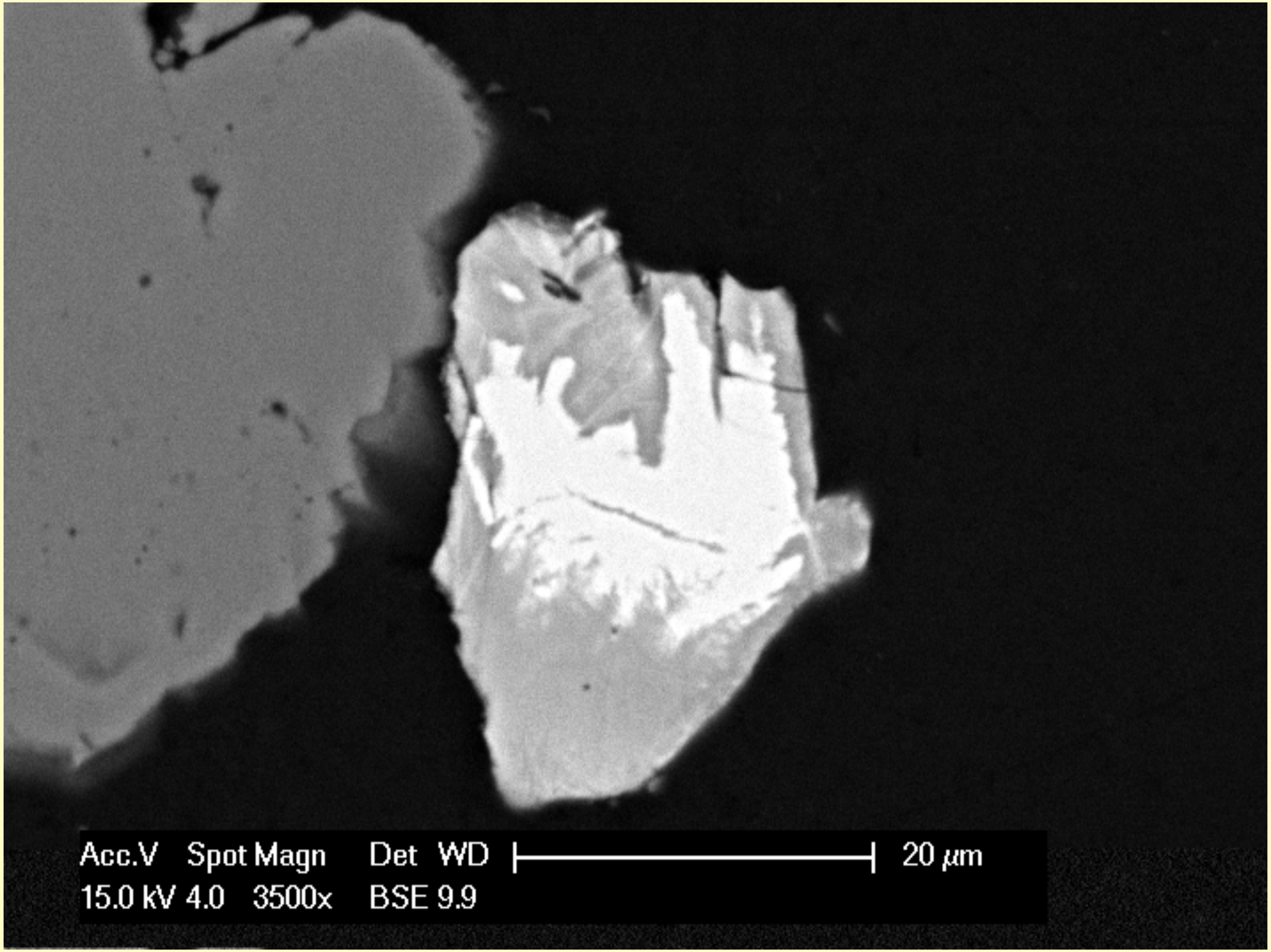
# Cluster of Pyrite Crystals in quartz grain in Head Sample



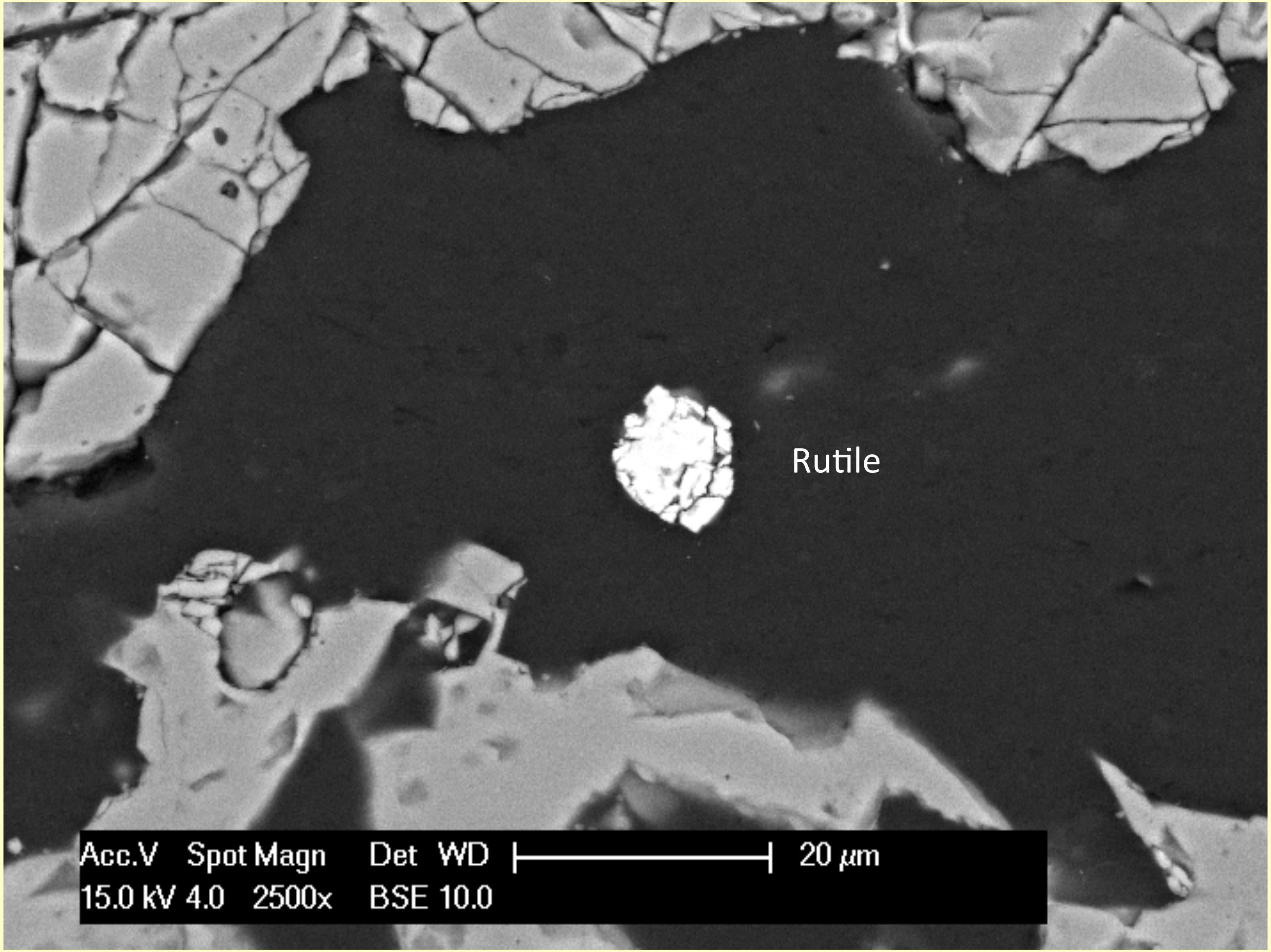
# Native iron with a tin overgrowth in matrix of Head Sample



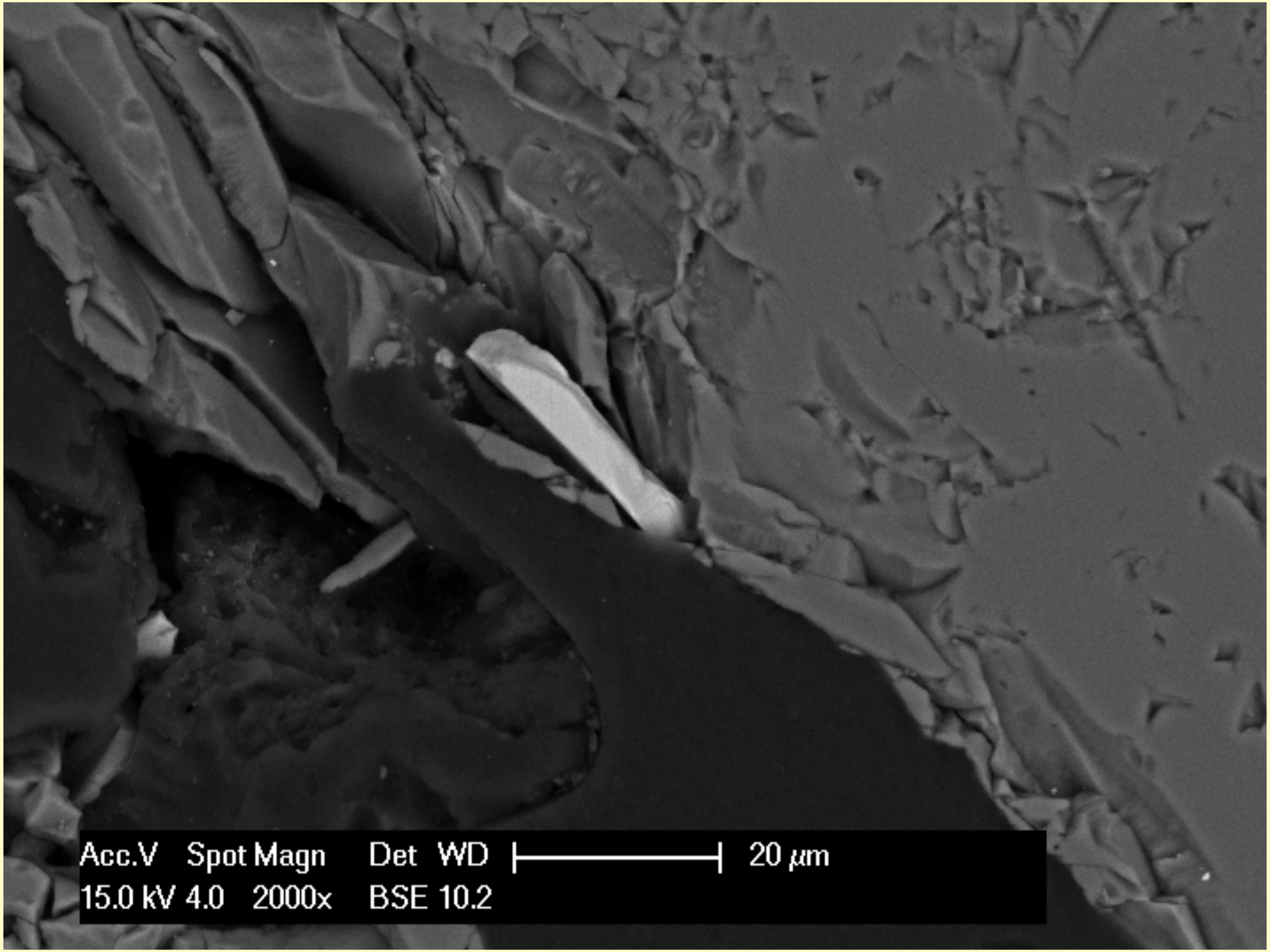
Ilmenite overgrown by rutile in Head Sample



# Fractured rutile in matrix of  Head Sample



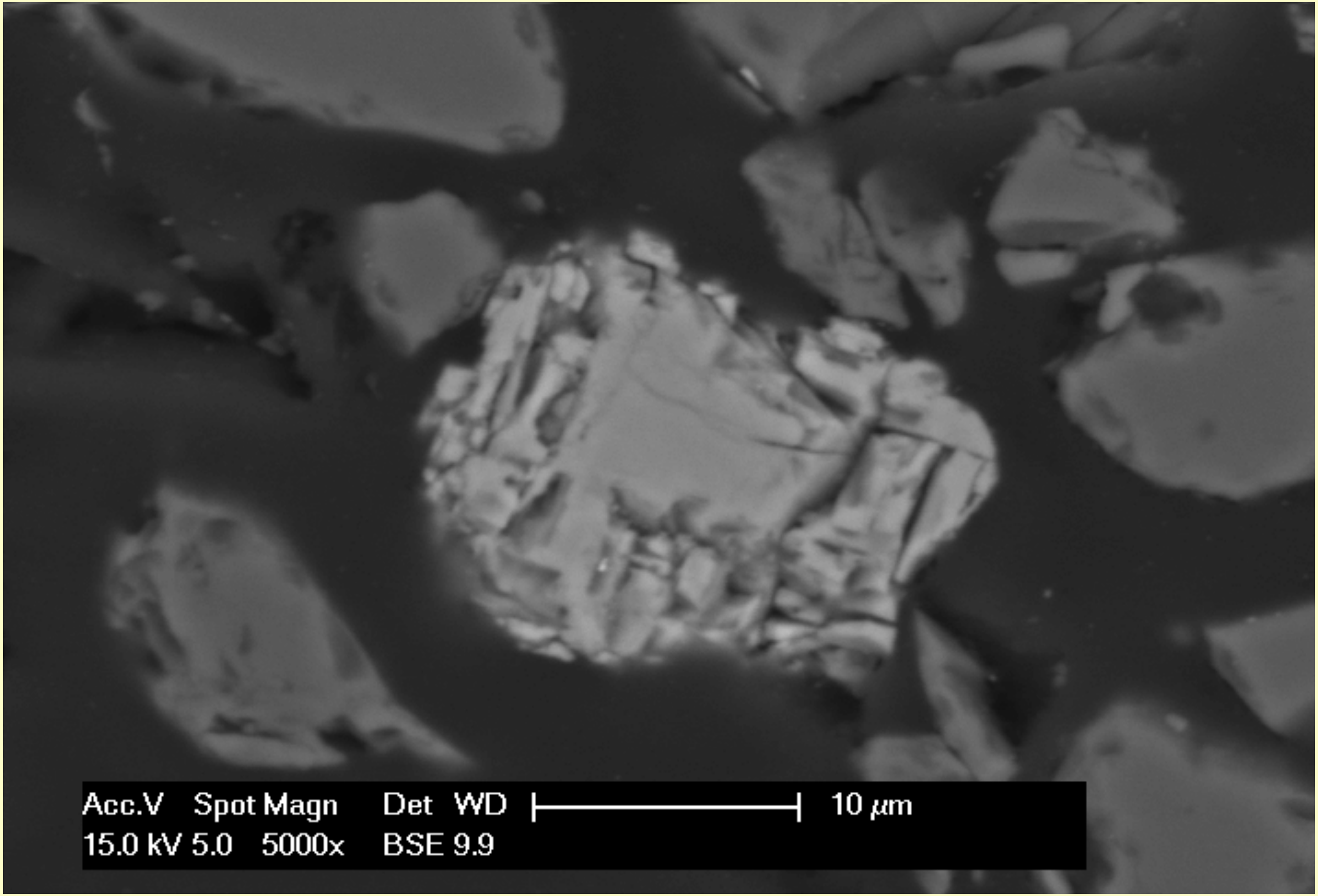
## Iron oxide along quartz grain boundary in Head Sample



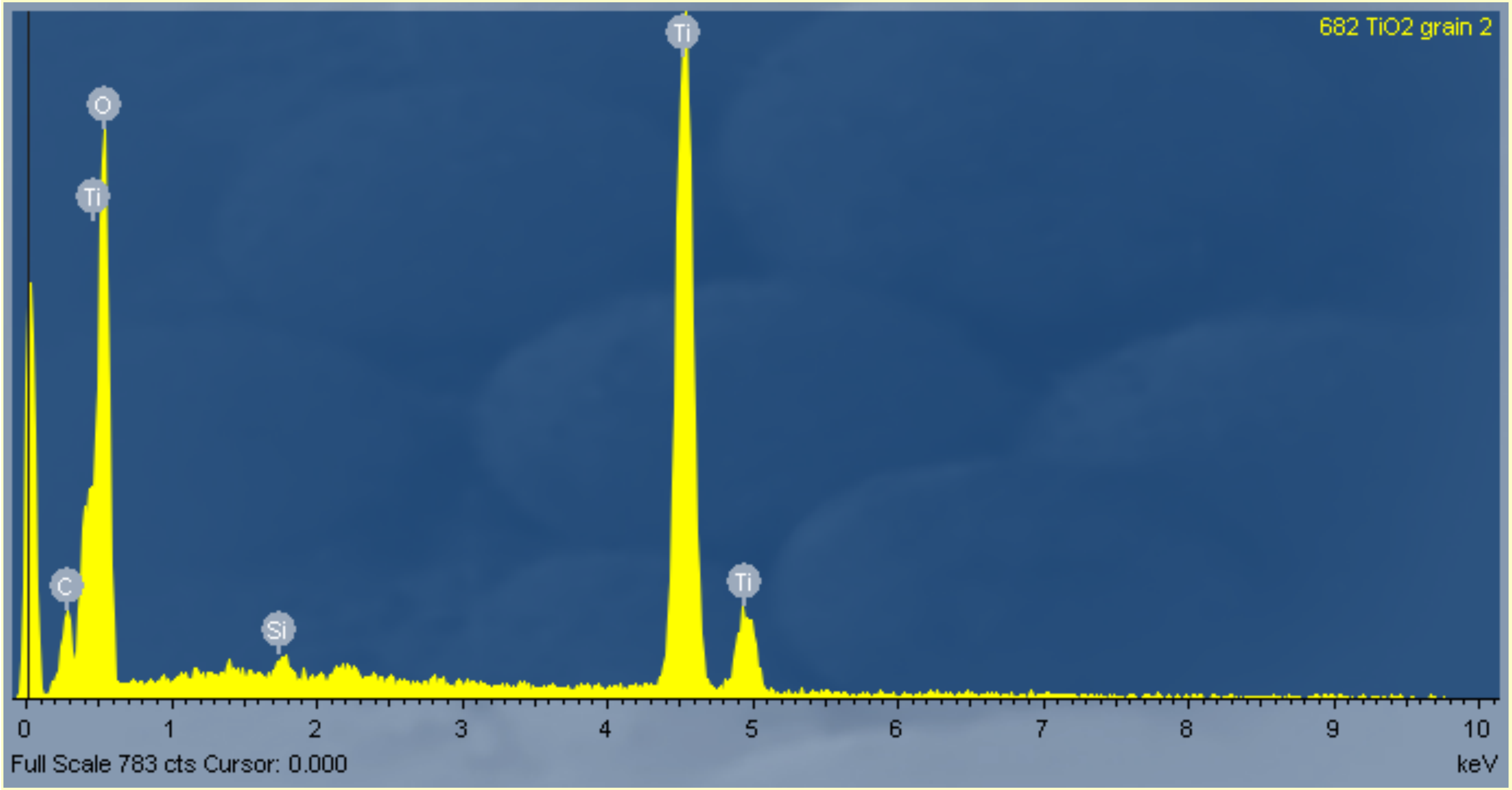
# Conductive fraction of sample (90B-275200C)*

- Chemical analyses indicates it contains
  - 580 ppm$TiO_2$
  - 230 ppm $Fe_2O_3$
  - Conductive product after processing electrostaticaly the +75-200μm size fraction of the head sample

# Rutile in matrix of sample



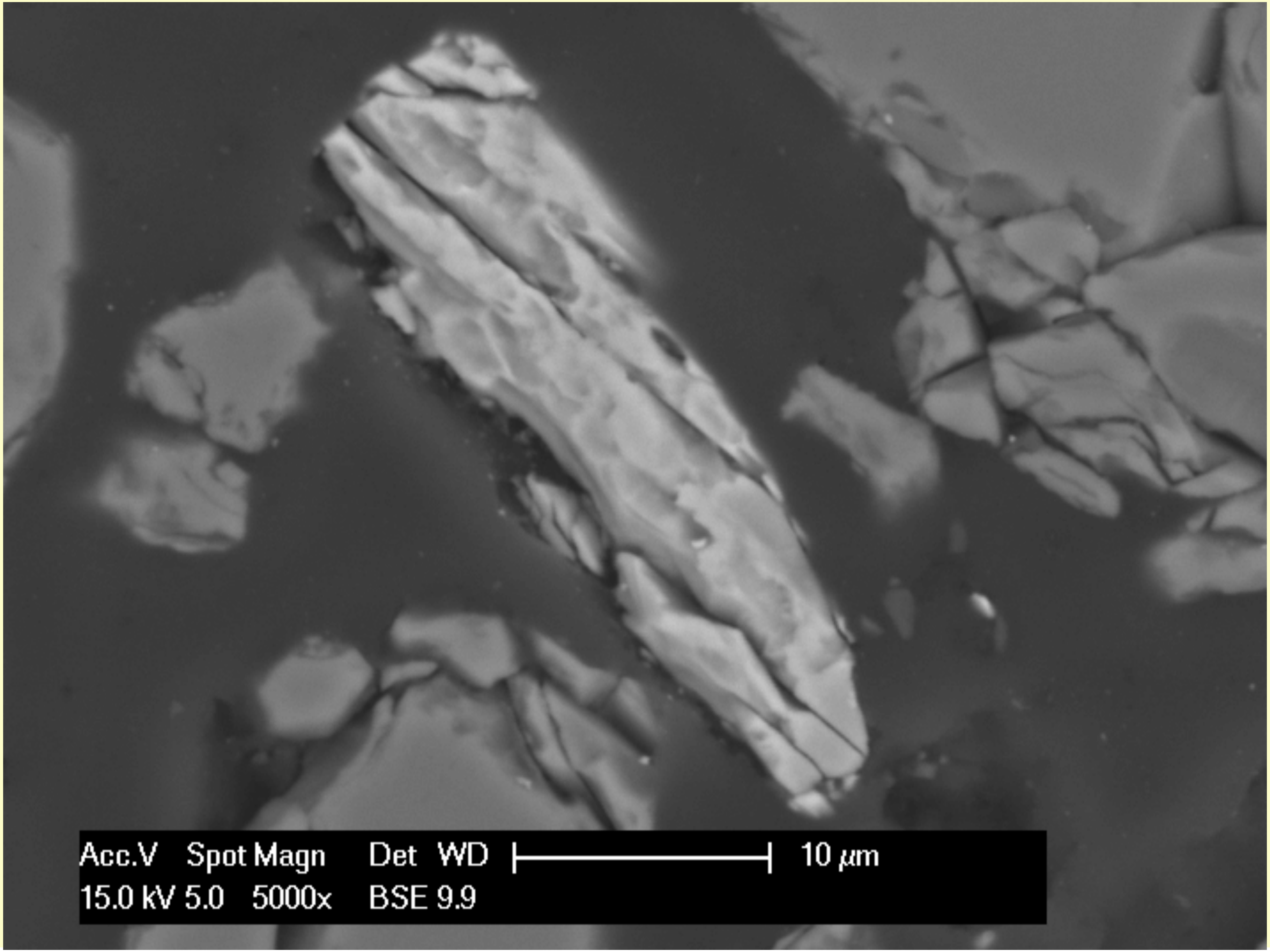
# Rutile Spectrum



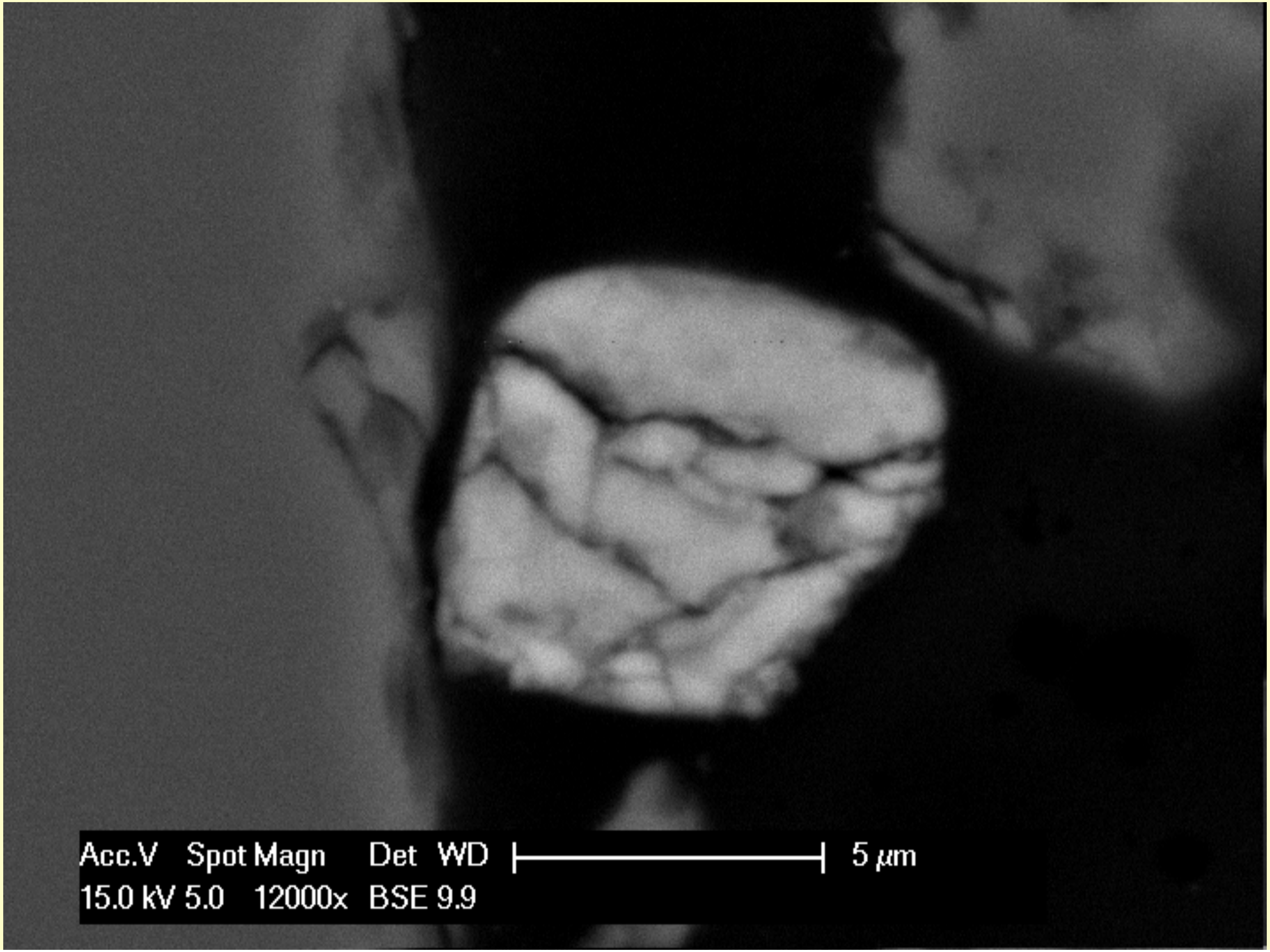
# Rutile Grains

- Numerous rutile grains were observed
- Grains sizes ranged from up to 30 microns to below 5 microns
- The grains often have a scalloped appearance because they are have irregular shapes
- All are hosted within the matrix of the sample

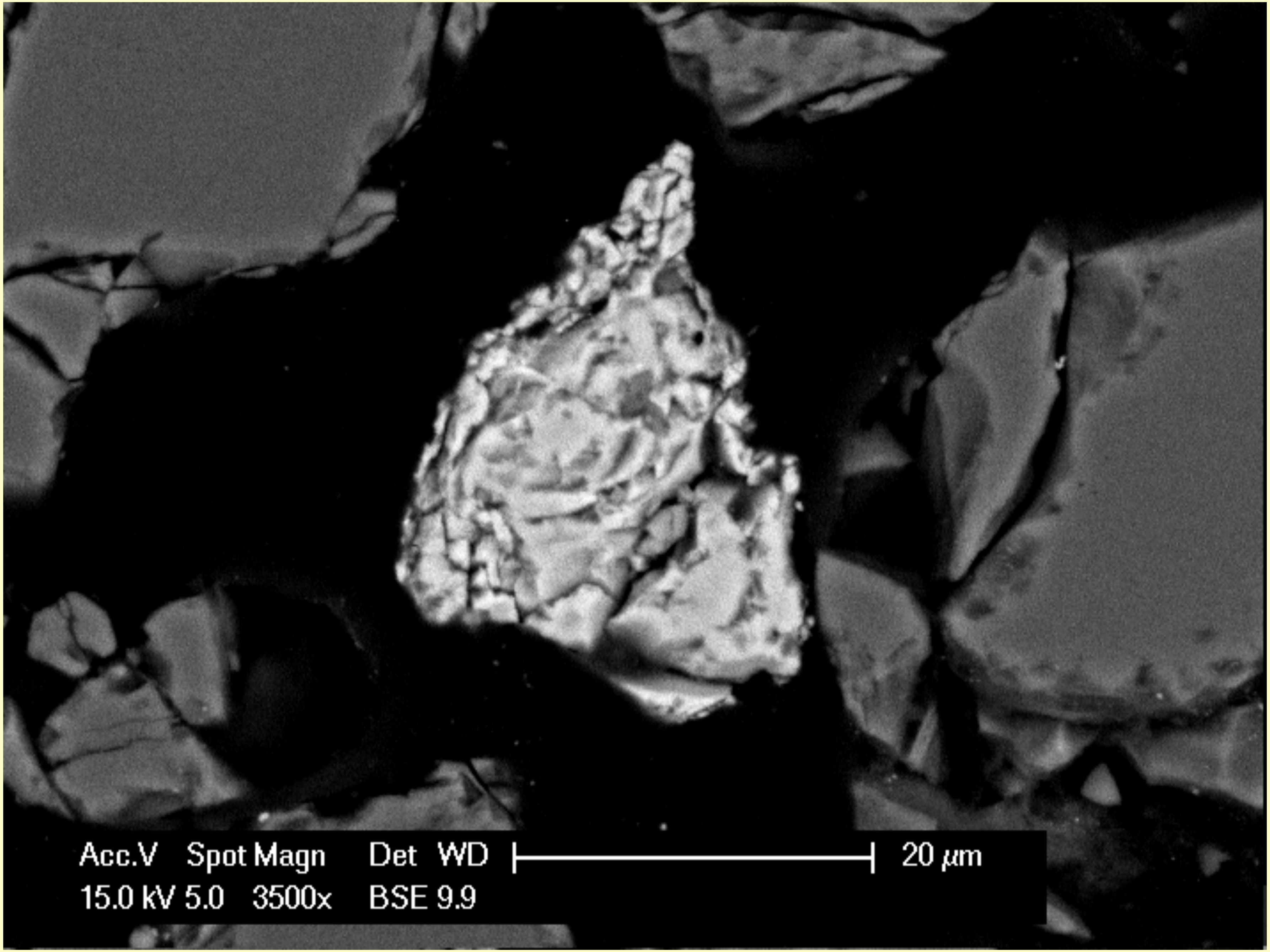
# Rutile in matrix position



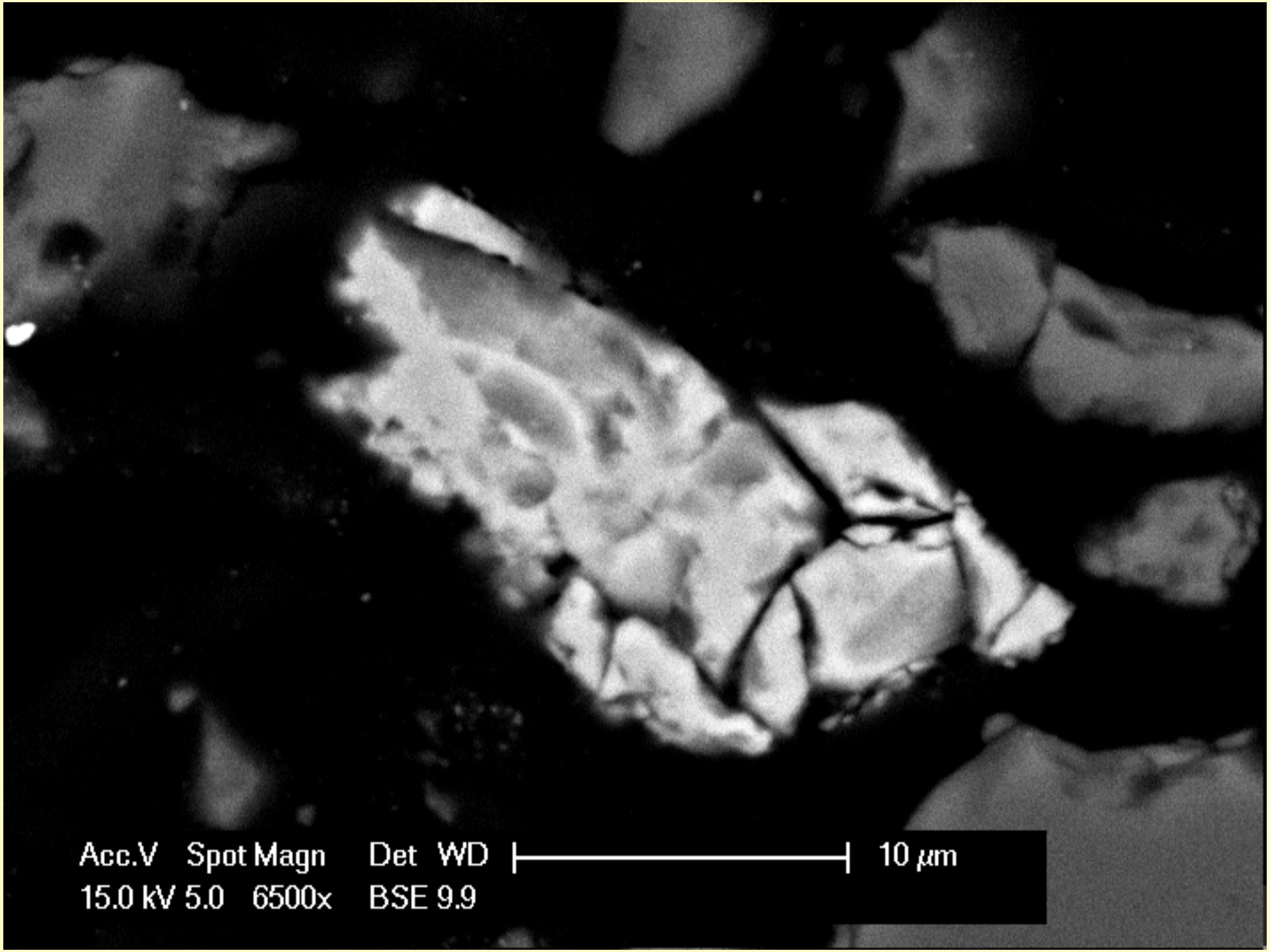
# Rutile in matrix position



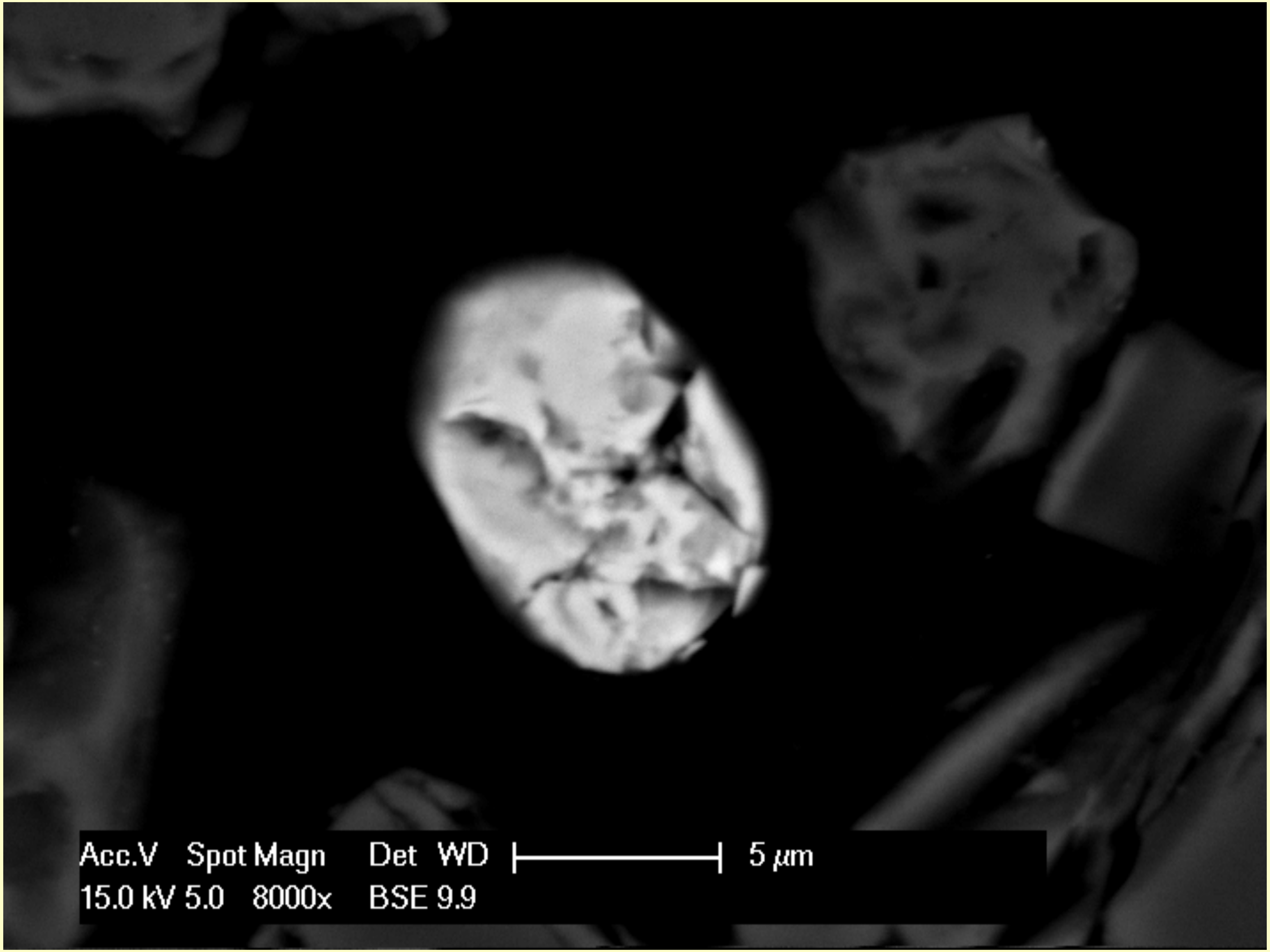
# Rutile



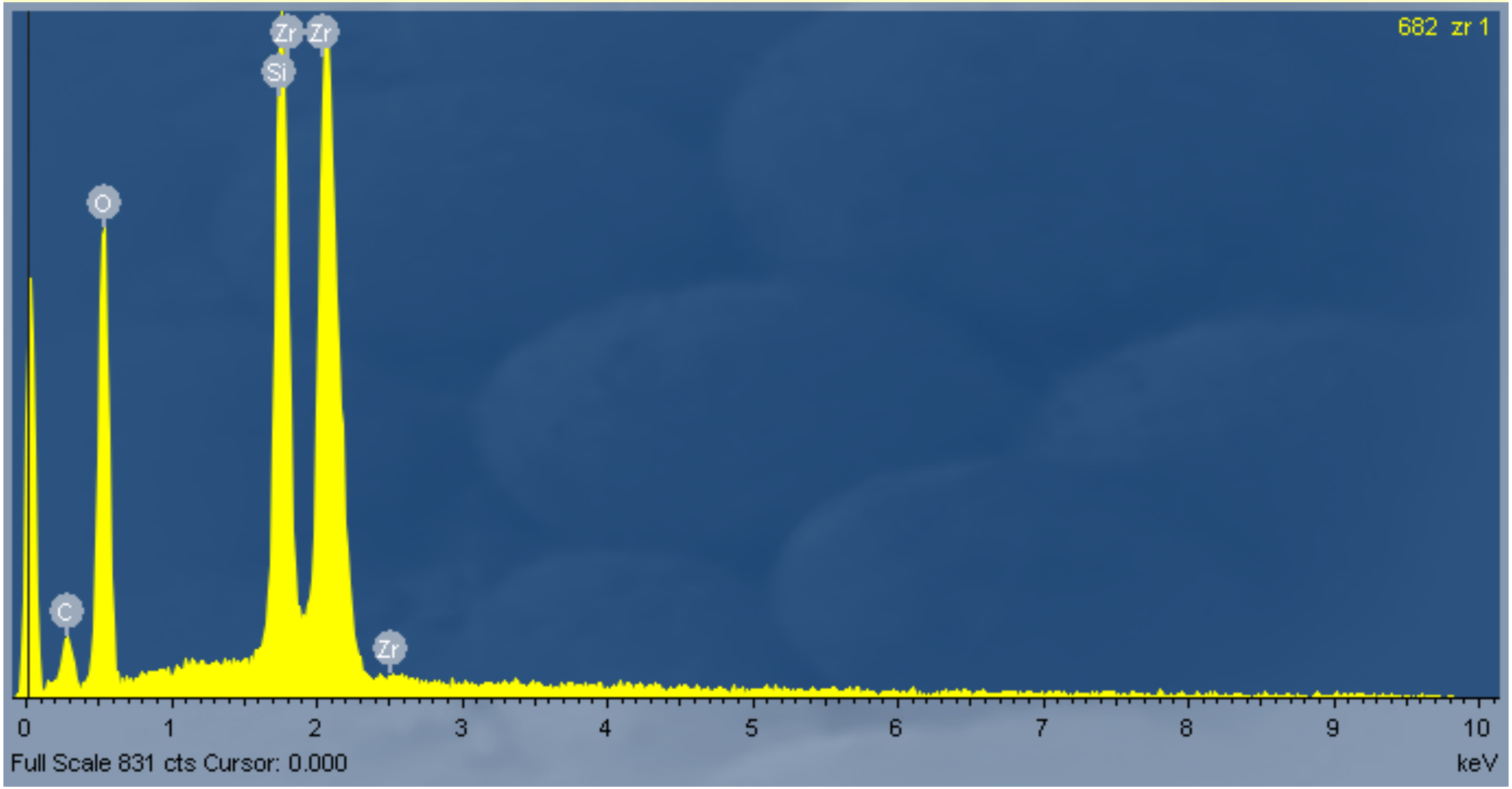
# Rutile



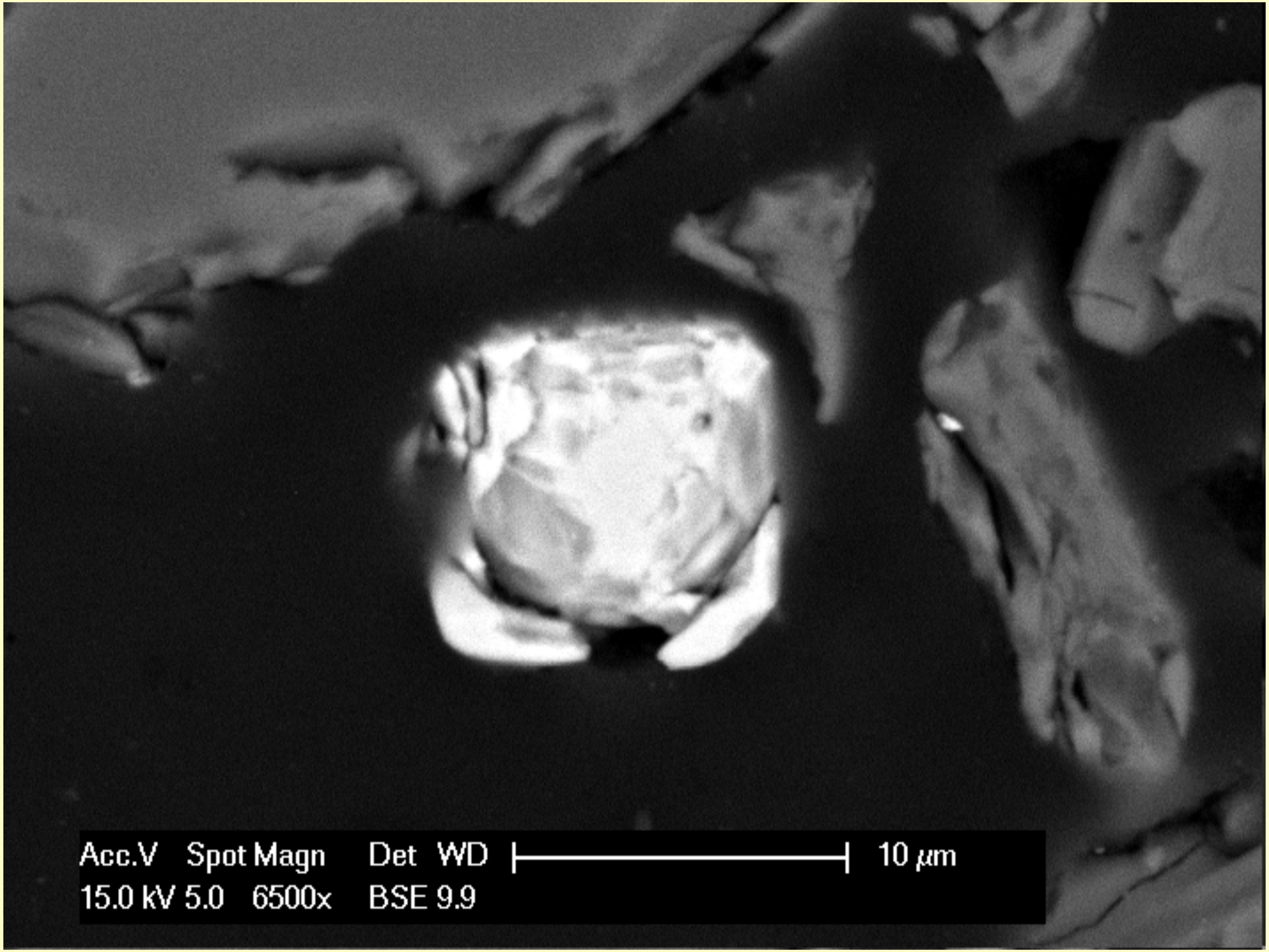
# Zircon



# Zircon Spectrum



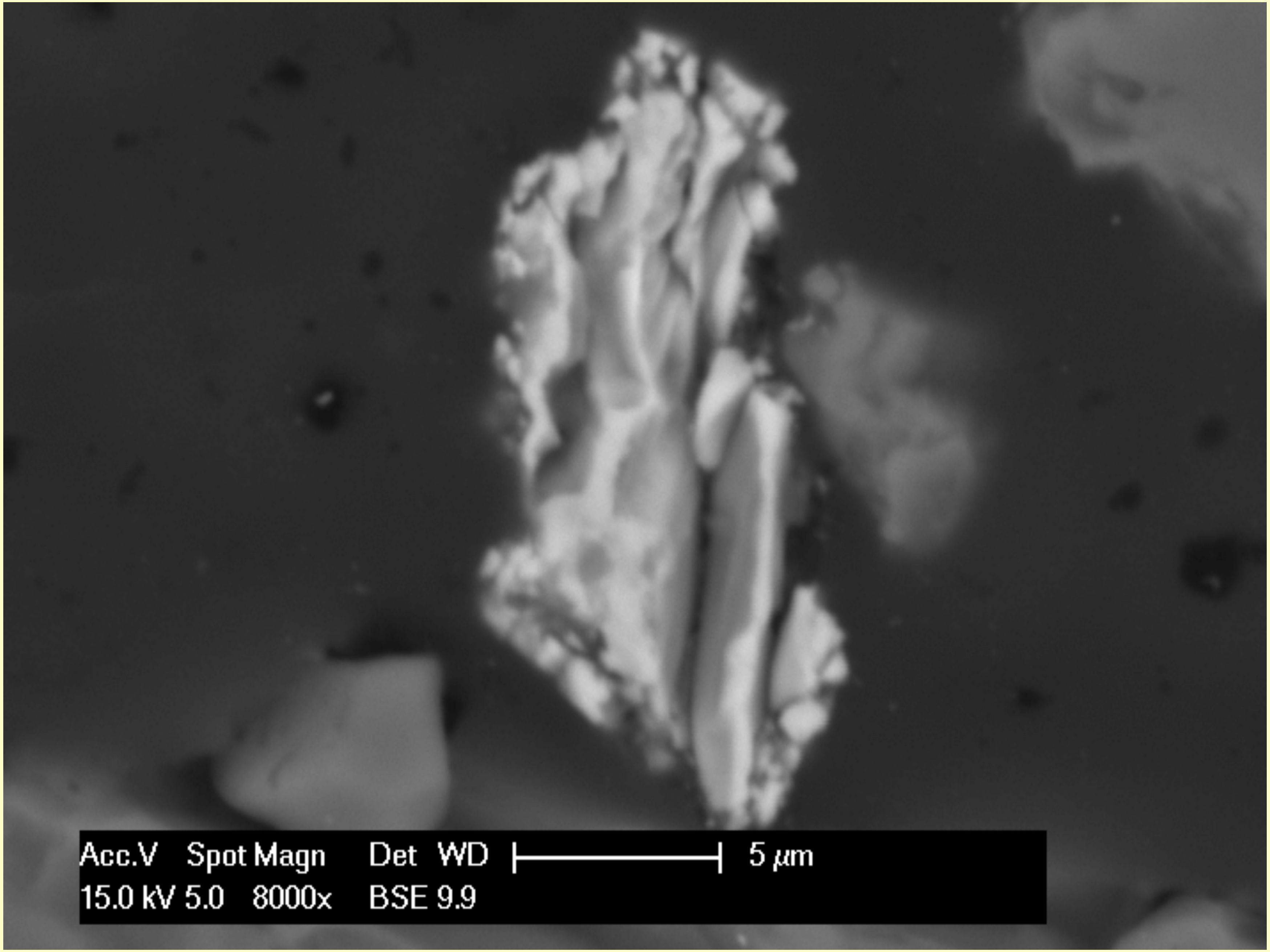
# Zircon



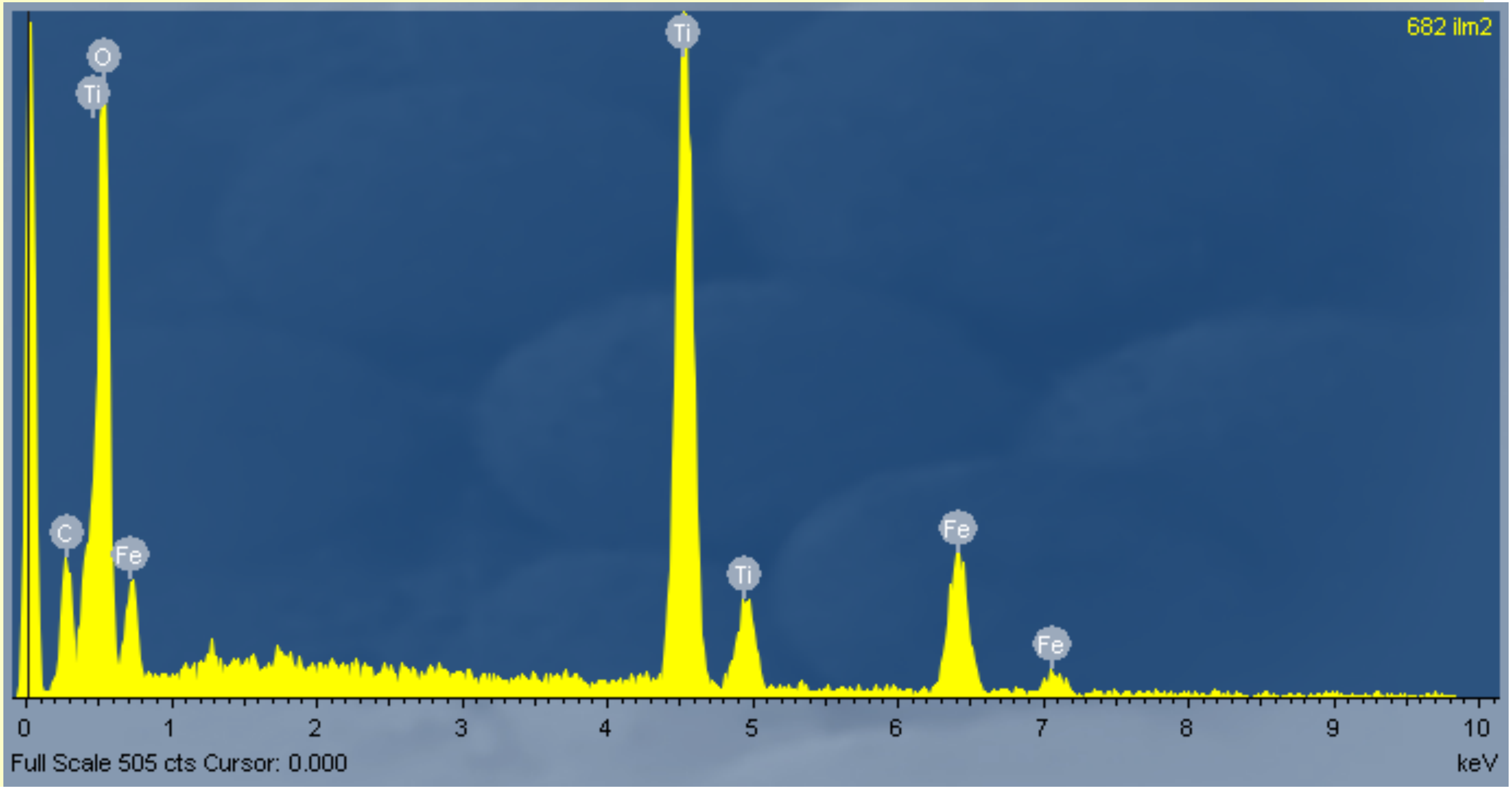
# Zircon Grains

- A number of these were observed
- All were less than 10 microns

# Ilmenite in matrix of sample



# Ilmenite

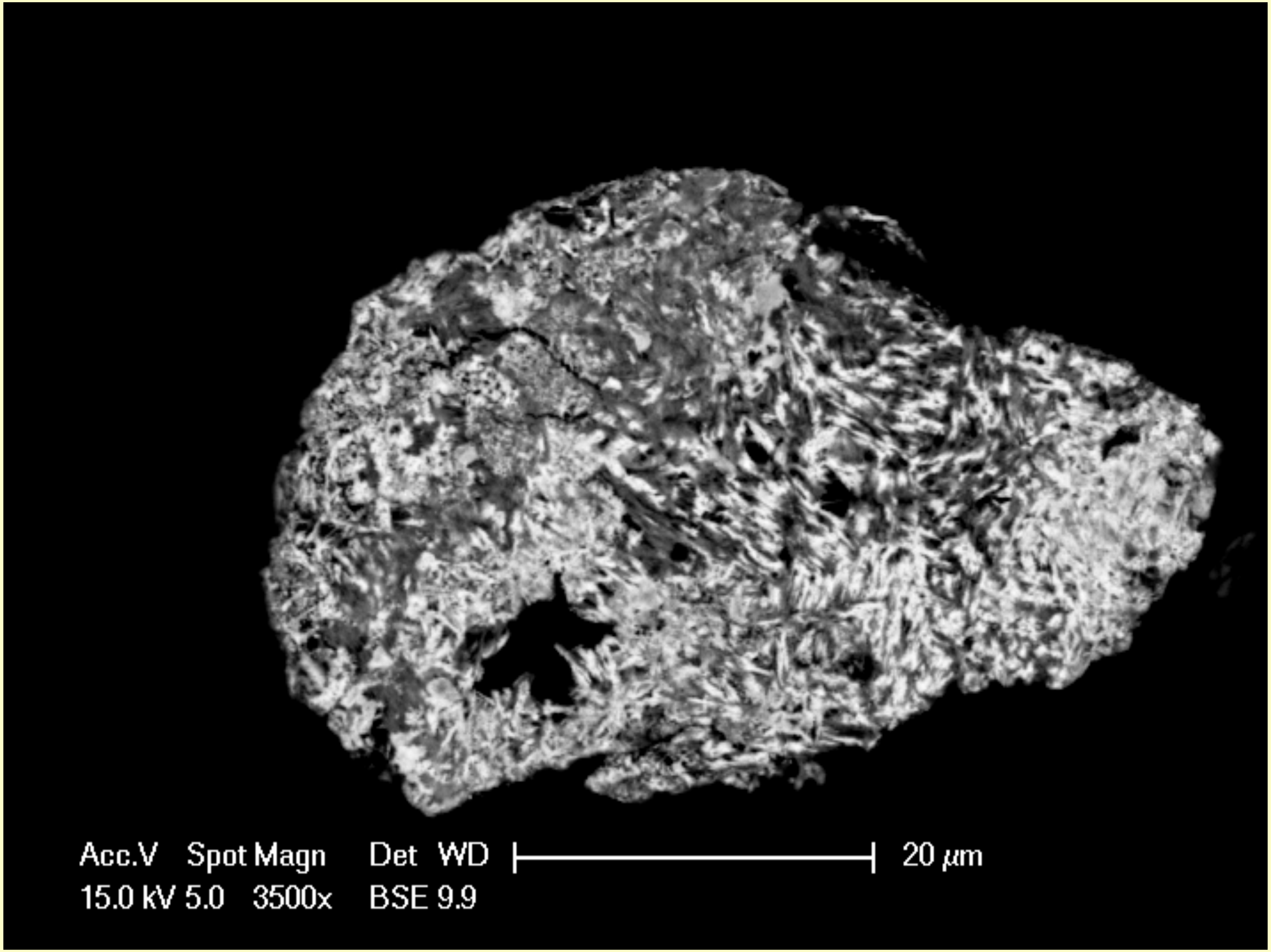


682 ilm2
O
Ti
C
Fe
Ti
Ti
Fe
Fe
0
1
2
3
4
5
6
7
8
9
10
Full Scale 505 cts Cursor: 0.000
keV

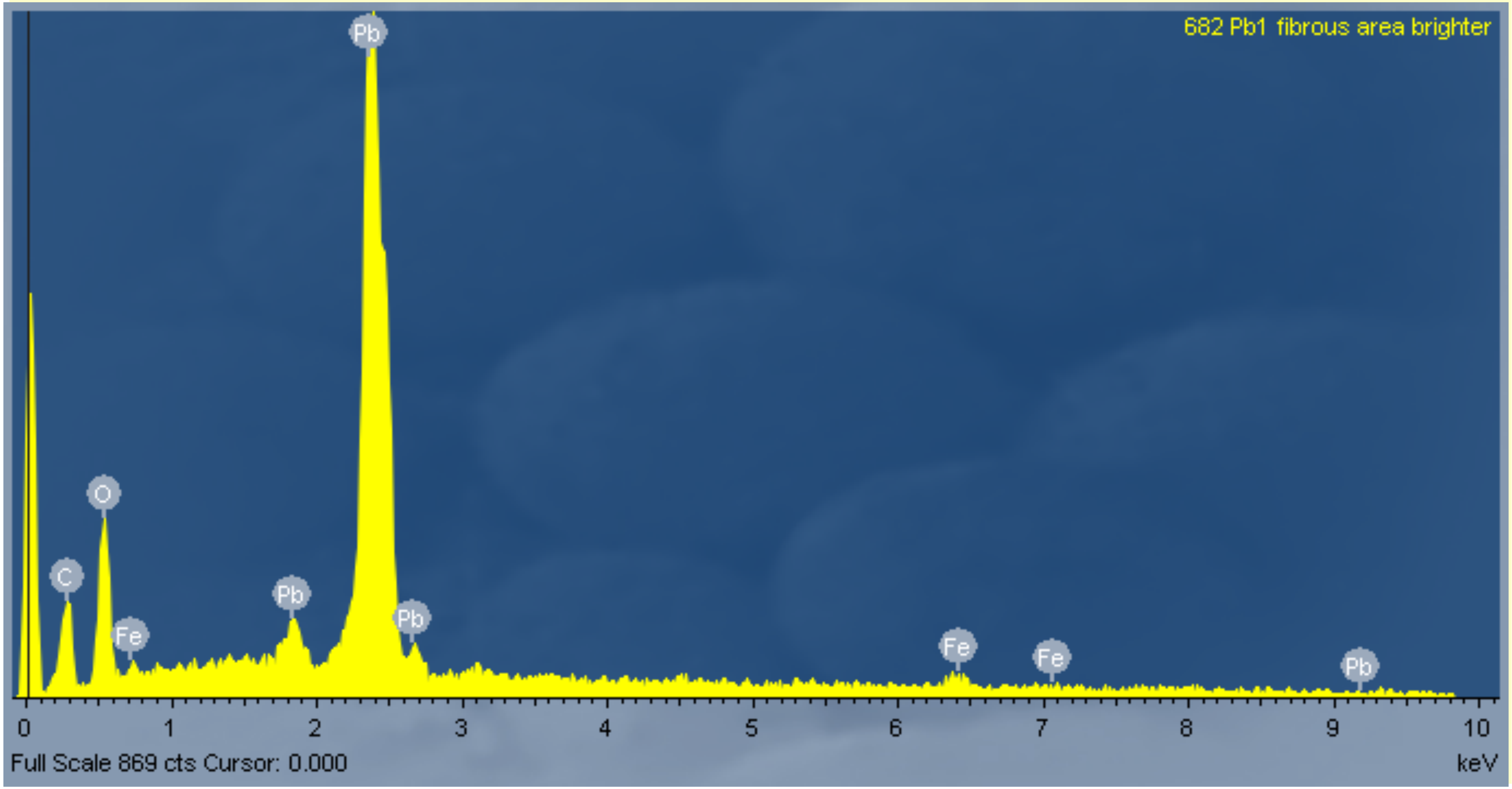
# Ilmenite Grains

- A number of ilmenite grains were observed
- The maximum size is 15 microns
- They have a very irregular appearance because they are grain mounts and much their surfaces are poorly polished

# Lead grain in matrix of sample



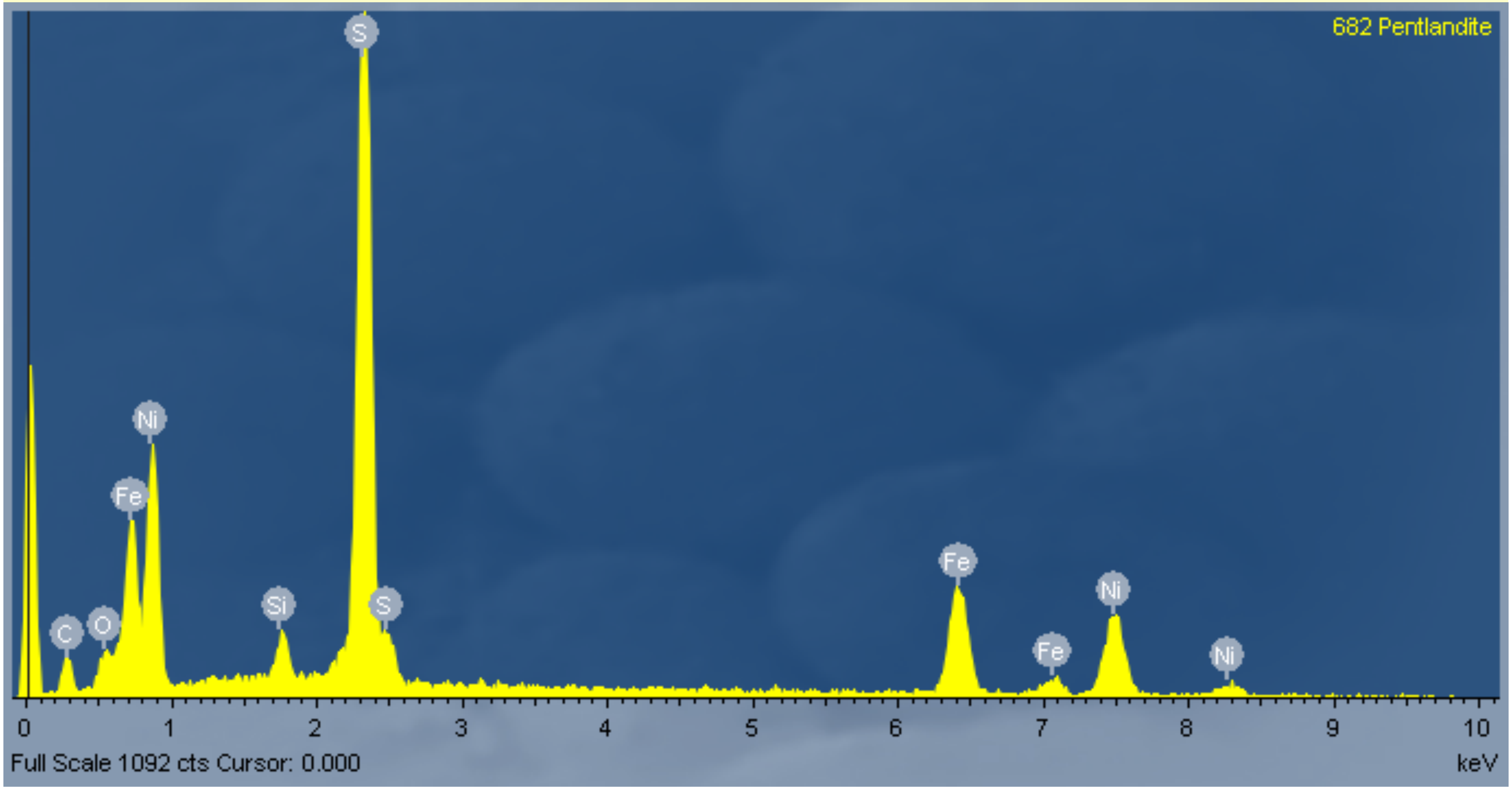
# Lead Spectrum



# Lead grains

- A number of lead grains were observed
- Their presence was unexpected
- They have variable oxygen contents

# Pentlandite-a single grain in a fracture in a quartz grain



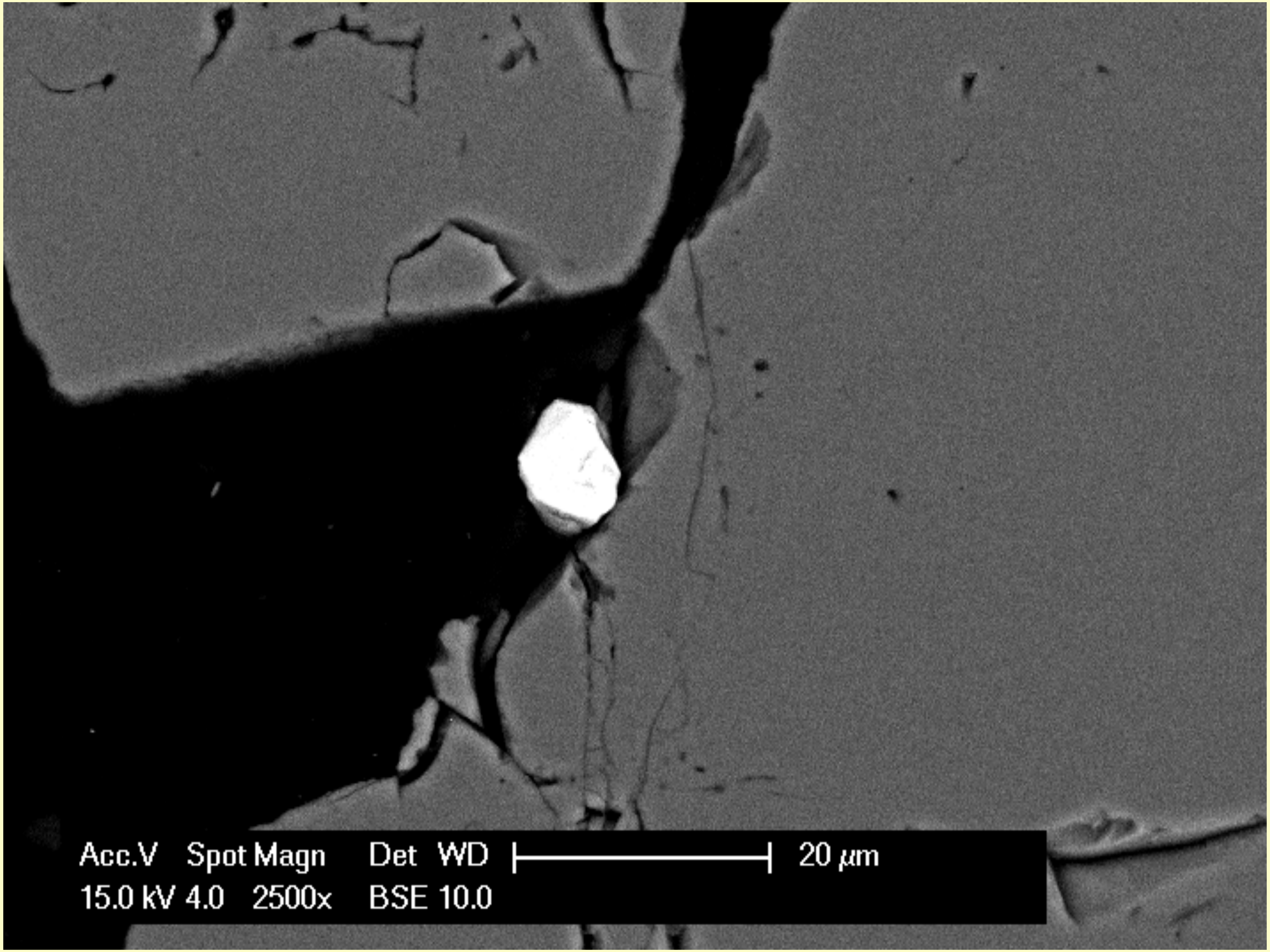
# Summary

- A significant number of rutile grains are present
- Although some ilmenite is also present, there is less ilmenite than rutile

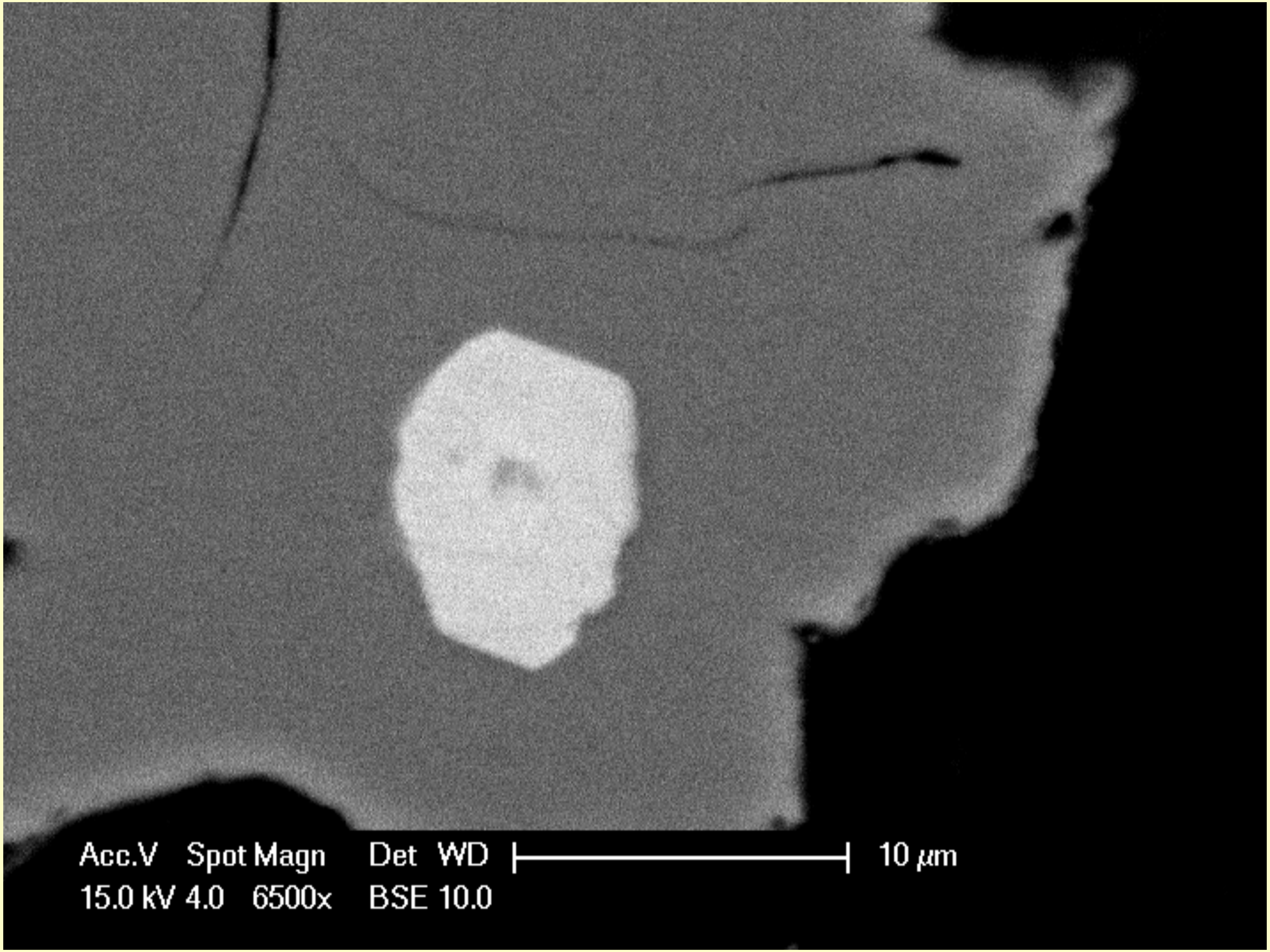
# Non-Conductive Fraction (90B-200500NC)

- Chemical analyses indicates it contains
  - 100 ppm$TiO_2$
  - 40 ppm $Fe_2O_3$
  - non-conductive product after processing electrostaticaly the +200-500$\mu$m size fraction of the head sample
  - There are very few impurities in this fraction

# Iron oxide in matrix position of non-conductive fraction



# Apatite in silica grain in non-conductive fraction



# Summary

- No B- or Li-bearing phases were found in the sample
- The apatite grains observed are all hosted by quartz
  - Hence, the P contents of the sample can not be improved through mineral processing
- Although no Ti-bearing phases were found in the one thin section examined of the non-conductive fraction it must contain these phases:
  - The non-conductive fraction contains 100 ppm $TiO_2$
  - Ti-bearing phases are present in both the Head sample and the Conductive fraction of the sample
  - Only a few grains need be present to account for the 100 ppm $TiO_2$ determined in the sample
  - On the other hand, a thin represents a tiny fraction of a sample
  - Any Ti-phases in the parent sample would probably be its matrix and hence could be removed by mineral processing