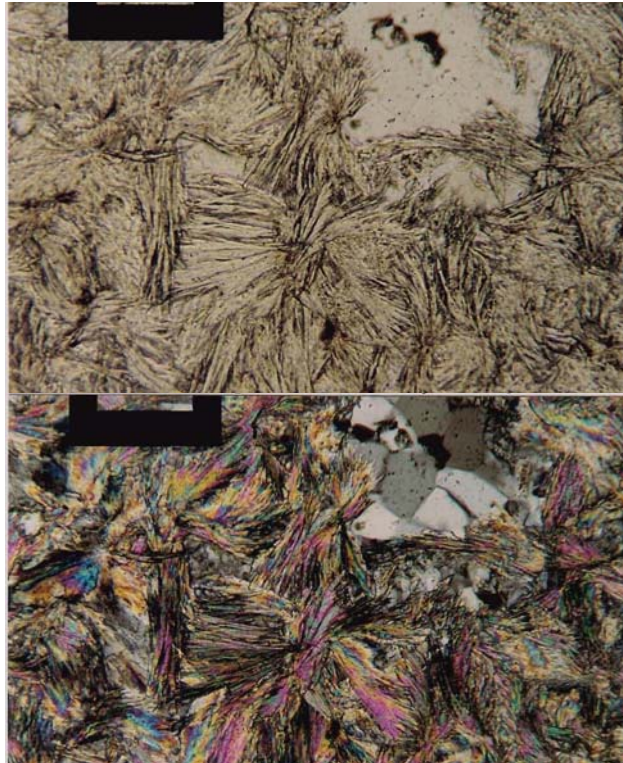


**NRRI/RI-2009/03**

**PHOTOMICROGRAPHS OF THE  
MINERALS OF THE CENTRAL AND  
WESTERN MESABI RANGE**

by

Harlan B. Niles



**September 2009  
Report of Investigations  
NRRI/RI-2009/03**

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Duluth MN 55811-1442**

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*Date of release: September 2010*

*Cover Photo Caption*

Minnesotaite and Quartz, Thin Section No. 46, Mt. Iron Drainage Shaft, UC

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The following pages consist of photomicrographs that show colors, forms, occurrences, and associations of minerals of the central and western Mesabi Range. These minerals are minnesotaite, talc, stilpnomelane, greenalite, chlorites, quartz, carbonates (mostly siderite and ankerite), magnetite, hematite, and goethite.

Most of the thin sections are from U.S. Steel diamond drill holes stored at the Coleraine Minerals Research Laboratory of the Natural Resources Research Institute. Each has a cover glass so no SEM analyses of minerals could be made. Several polished sections were examined in reflected light and photographed to show colors and associations of magnetite, hematite, and goethite. Section numbers, and where available, drill hole numbers, footages, and geologic units are given.

The photos were produced using a 35 mm camera on a Ziess Ultraphot microscope. Both 400 and 800 speed Kodak film were used. Variations in microscope optics in other microscopes and cameras may produce variations in mineral colors, pleochroism, and birefringence. However, any differences should be slight.

Several magnifications were used to photograph the minerals. These are 42, 136, 170, and 274 times. The length of the bright window inside the black rectangle on each photo represents 530, 165, 132, and 82 microns, respectively, for these magnifications.

References used to identify the optical characteristics of minerals were "Mineralogy and Geology of the Mesabi Range" by John W. Gruner and "Rock-Forming Minerals" by W.A. Deer, R.A. Howie, and J. Zussman.

This project was requested and financed by the Natural Resources Research Institute of the University of Minnesota, Duluth.

Minnesotaite and Quartz  
Thin section No.46, Mt. Iron Drainage Shaft, UC

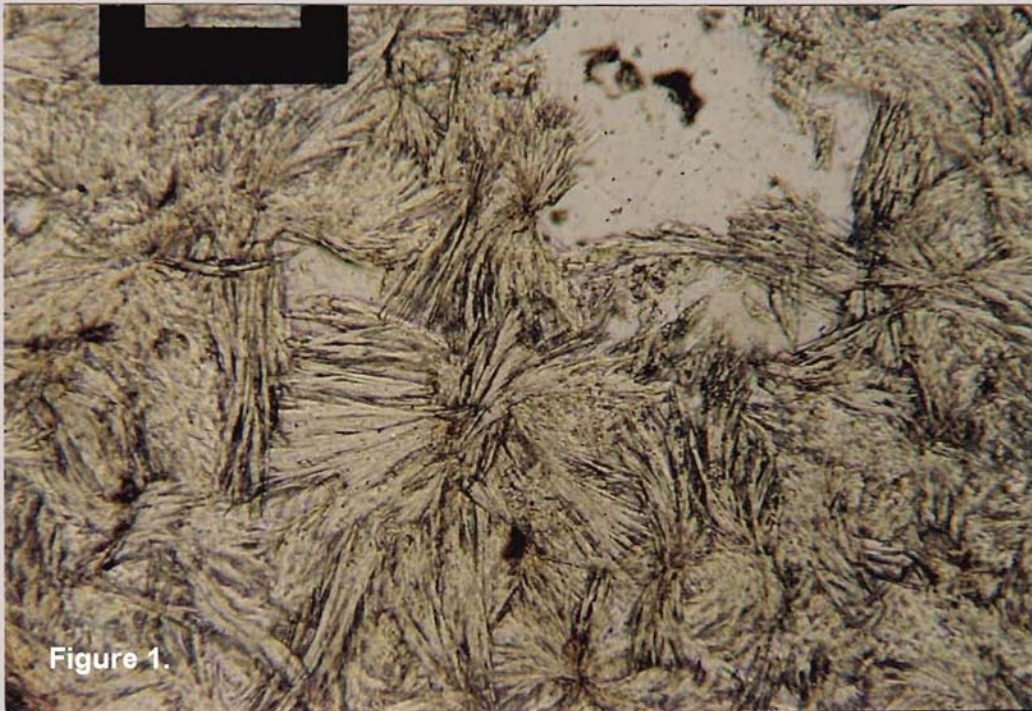


Figure 1.

Plane light, Mag. 170X  
Radiating acicular Minnesotaite crystals and Quartz

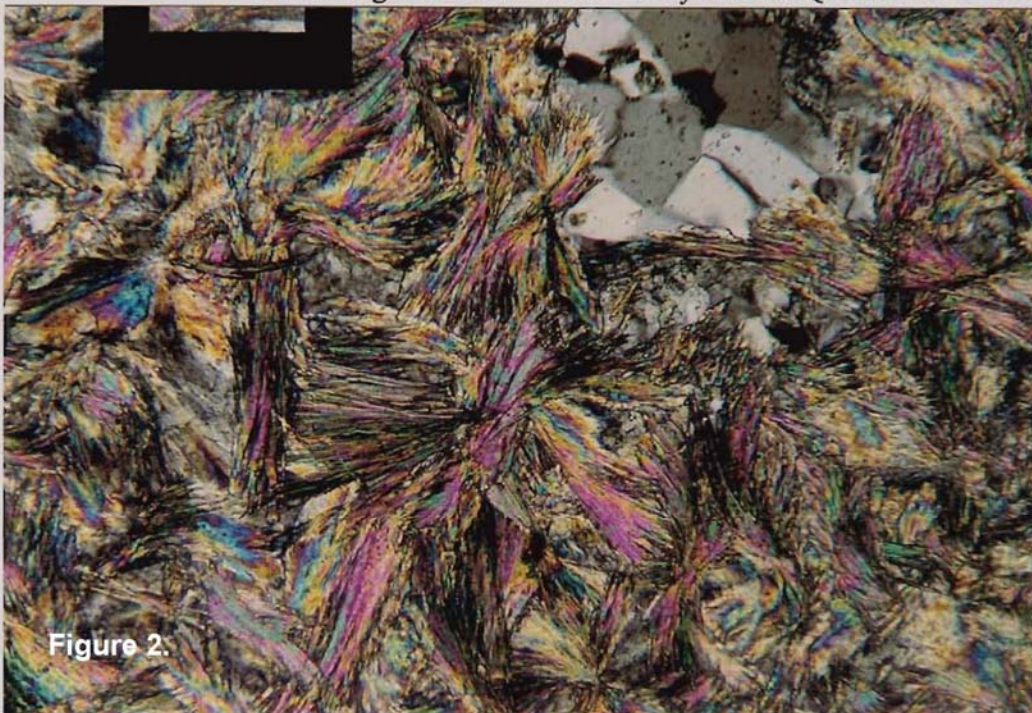
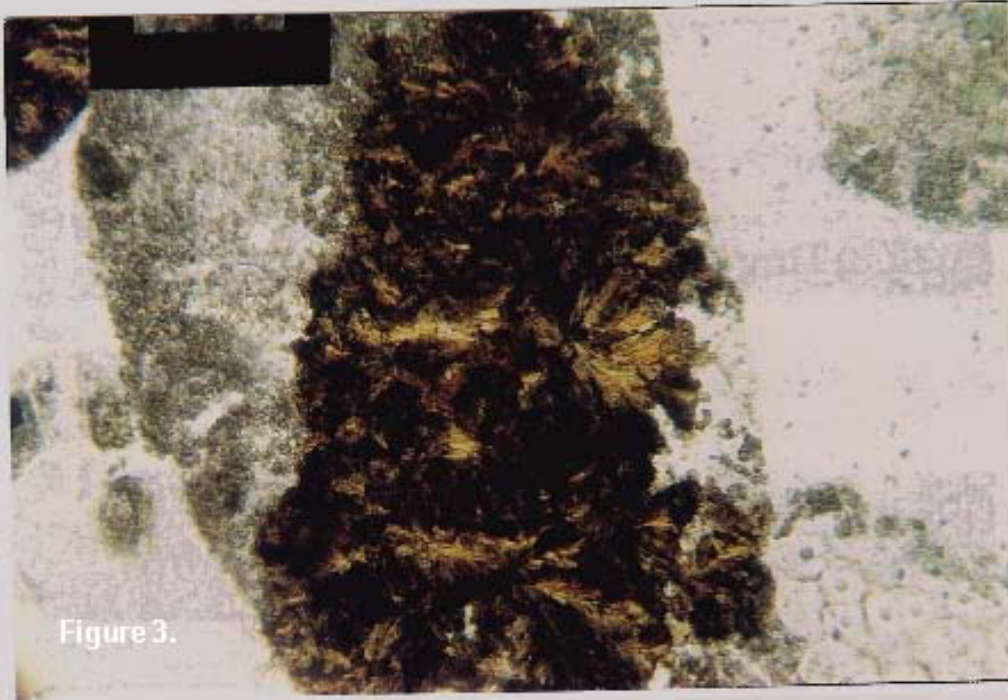


Figure 2.

Polarized light, Mag. 170X  
Shows birefringence Quartz and Minnesotaite

Stilpnomelane(ferric), Quartz, Greonolite  
Thin section No. 712, drill hole 8414, 129 to 134 ft., Hibbing District



Plane light, Mag. 170X

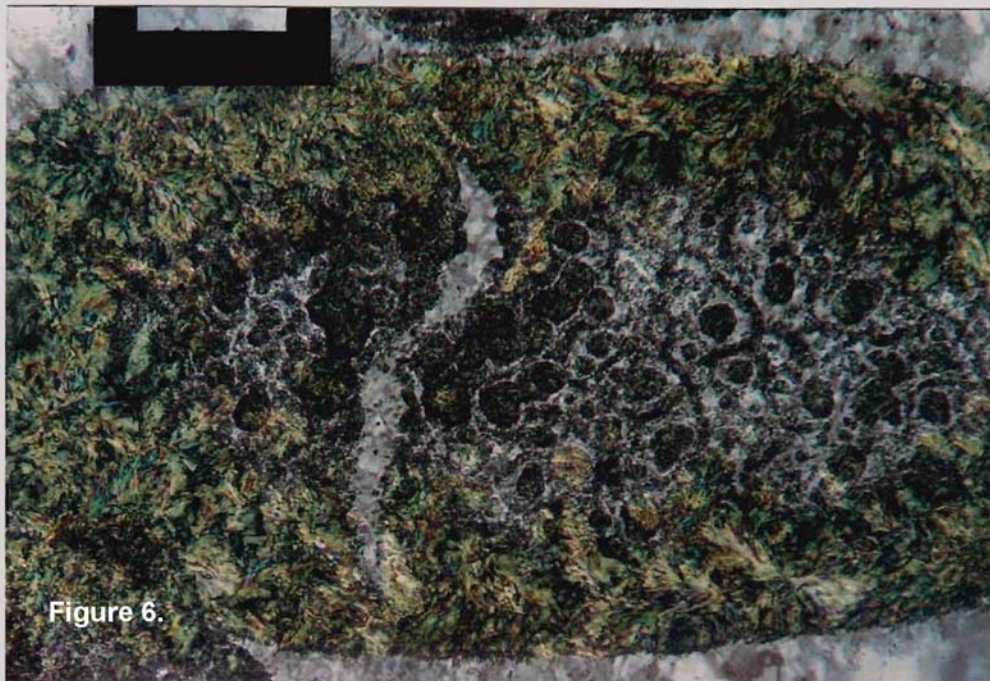


Plane light, Mag. 170X  
Shows stilpnomelane pleochroism

Stilpnomelane(ferrous), Quartz, Greenalite  
Thin section No.712, drill hole 8414, 129 to 134 ft., Hibbing District

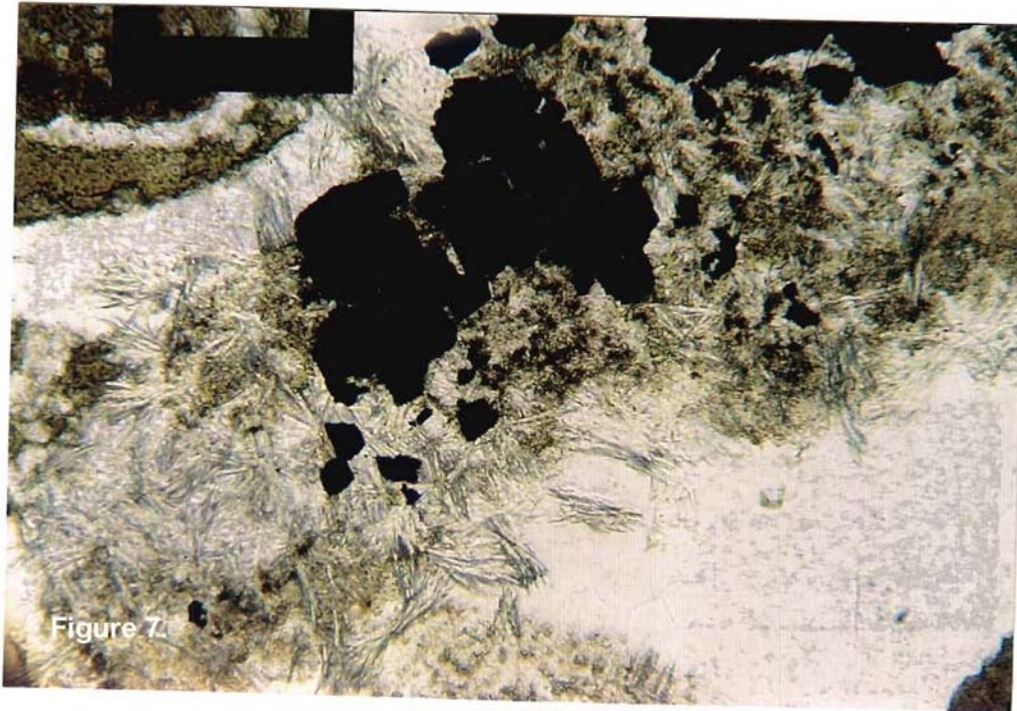


Plane light, Mag. 170X  
Outer granule is stilpnomelane, inner is greenalite grains and chert

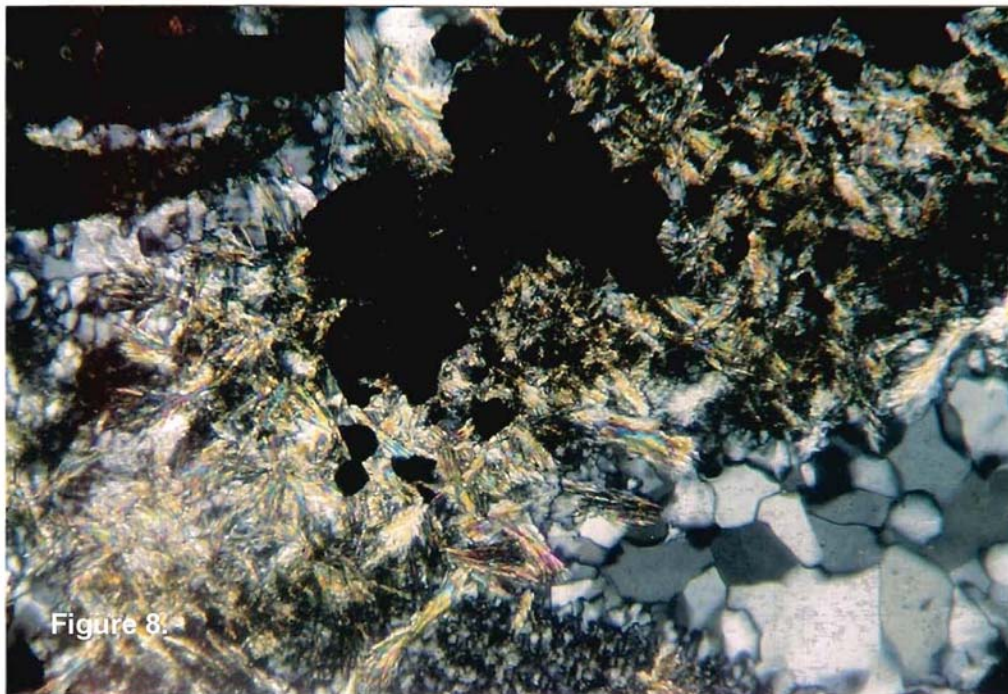


Polarized light, Mag. 170X  
Shows stilpnomelane birefringence

Minnesotaite, Magnetite, Quartz, Greenalite  
Thin section No. 1621, DH17710, 71 ft., LC5B



Plane light, Mag.170X  
Granule of acicular Minnesotaite, euhedral Magnetite, Greenalite patches, in Quartz



Polarized light, Mag.170X  
Shows Minnesotaite and Quartz birefringence, Greenalite appears isotropic

Minnesotaite, Magnetite, Quartz  
Thin section No.1627, DH17710, 87 ft., LC5A

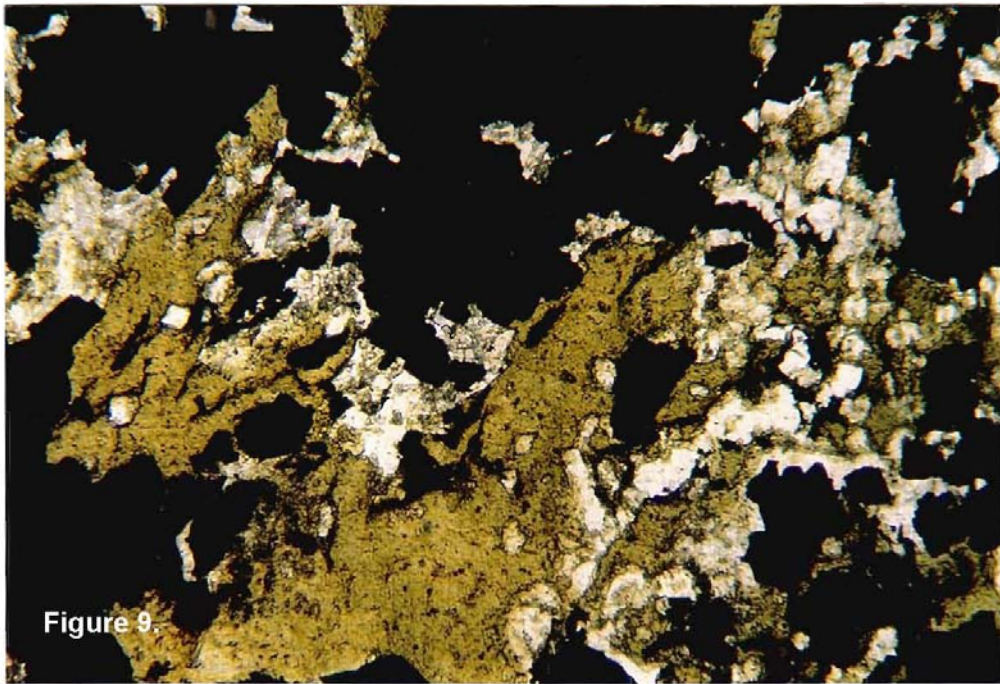


Figure 9.

Plane light, Mag.170X  
Irregular patches of Minnesotaite, Magnetite aggregates, Quartz

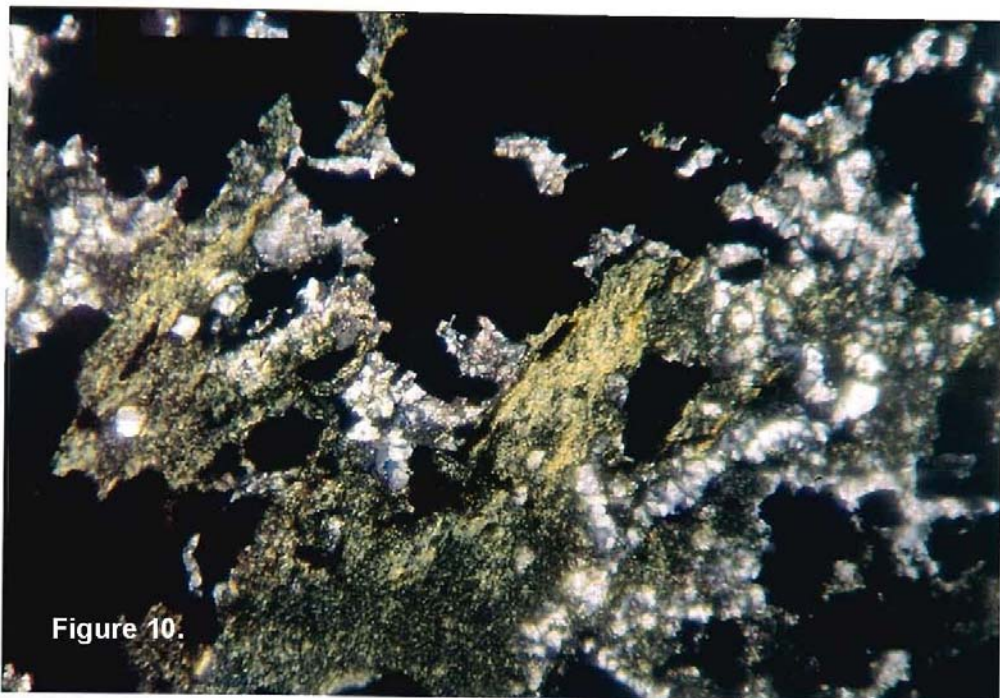
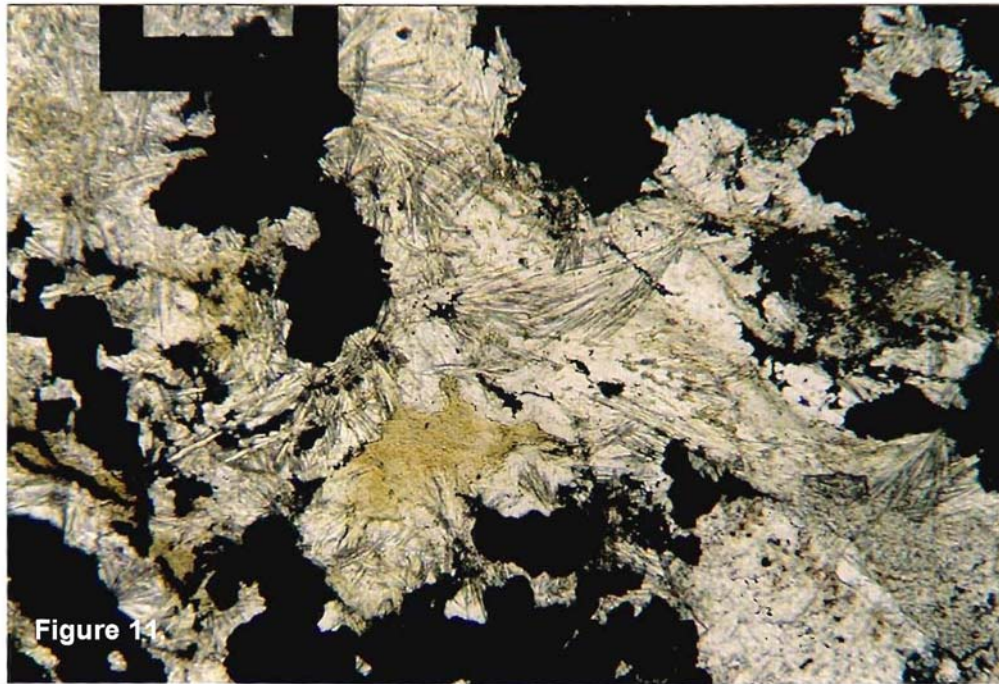


Figure 10.

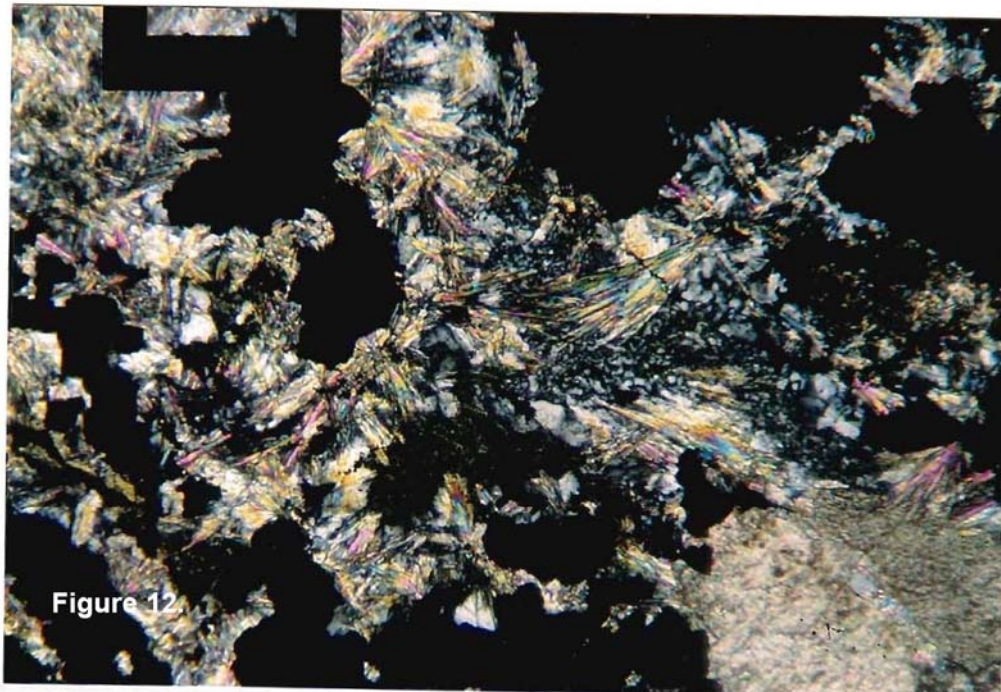
Polarized light, Mag.170X  
Shows partially oriented fine Minnesotaite in patches, Quartz, opaque Magnetite



Minnesotaite, Magnetite, Quartz, Greenalite, Carbonate  
Thin section No.1630, DH17710, 93 ft., LC5A



Plane light, Mag.170X  
Acicular Minnesotaite, Magnetite aggregates, Quartz, tan Greenalite patches,  
coarse Carbonate

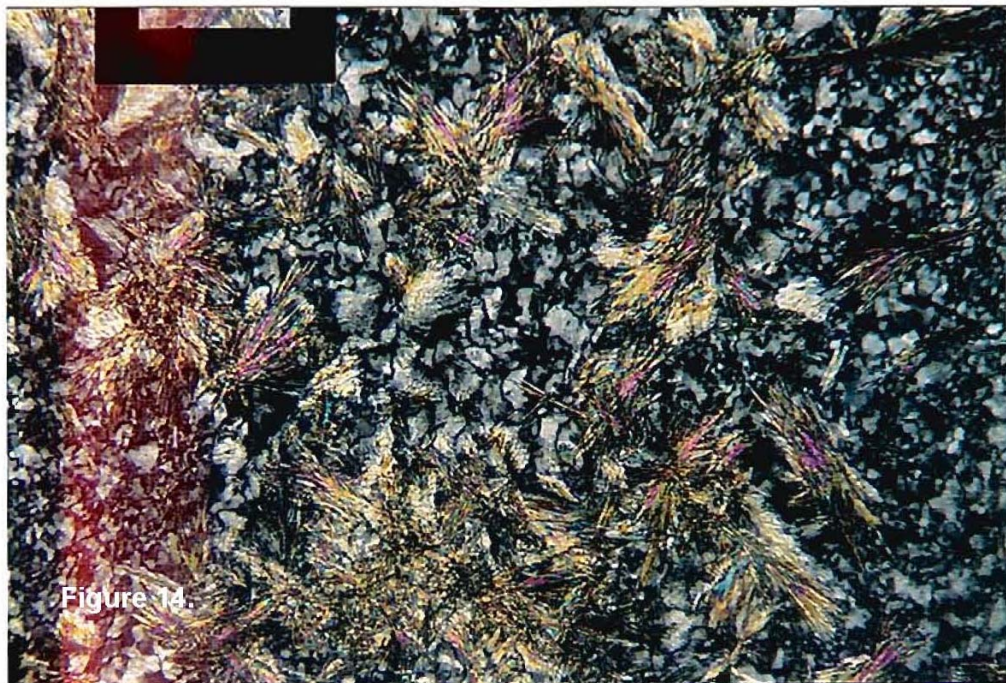


Polarized light, Mag.170X  
Shows birefringence of Minnesotaite and Quartz, opaque Magnetite and Greenalite

Minnesotaite, Quartz  
Thin section No.1684, DHI7714, 68 ft., LC5A



Plane light, Mag. 170X  
Acicular Minnesotaite, Quartz



Polarized light, Mag. 170X  
Shows birefringence of Minnesotaite and Quartz

Minnesotaite, Quartz, Magnetite, Carbonate, Greenalite  
Thin section No.1630, DH17710, 93 ft., LC5A

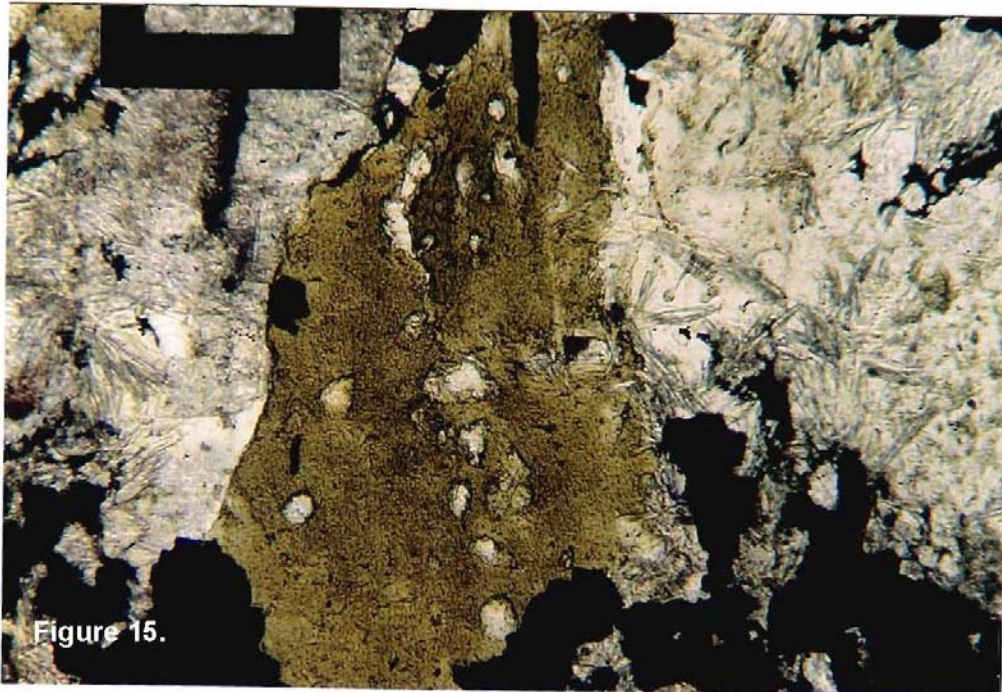


Figure 15.

Plane light, Mag.170X  
Acicular and large patch of oriented fine Minnesotaite, Quartz, Magnetite, Greenalite,  
Carbonate

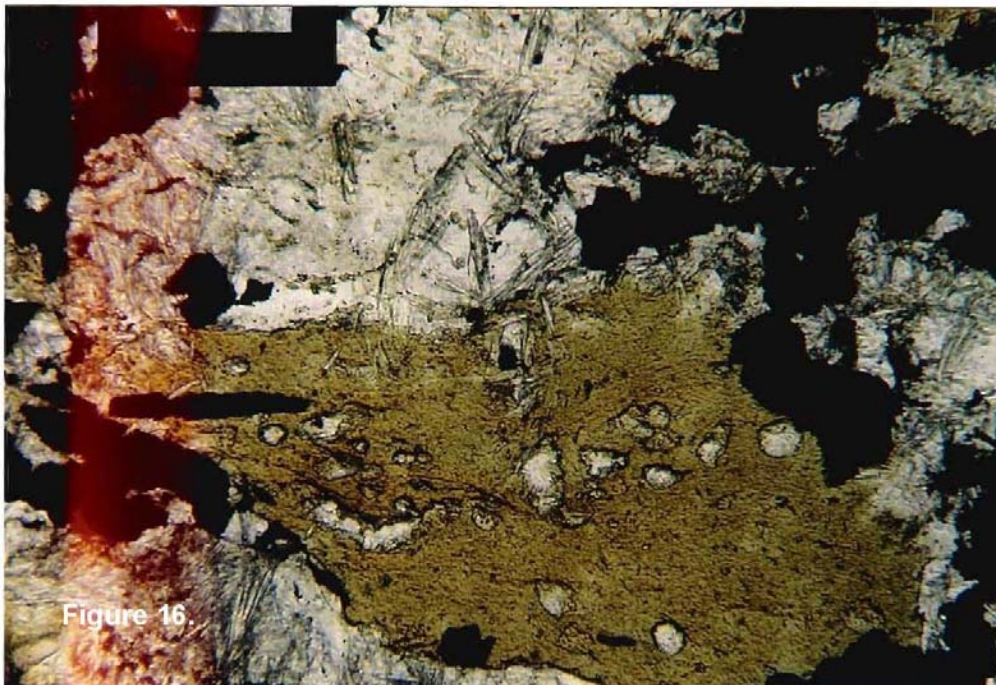
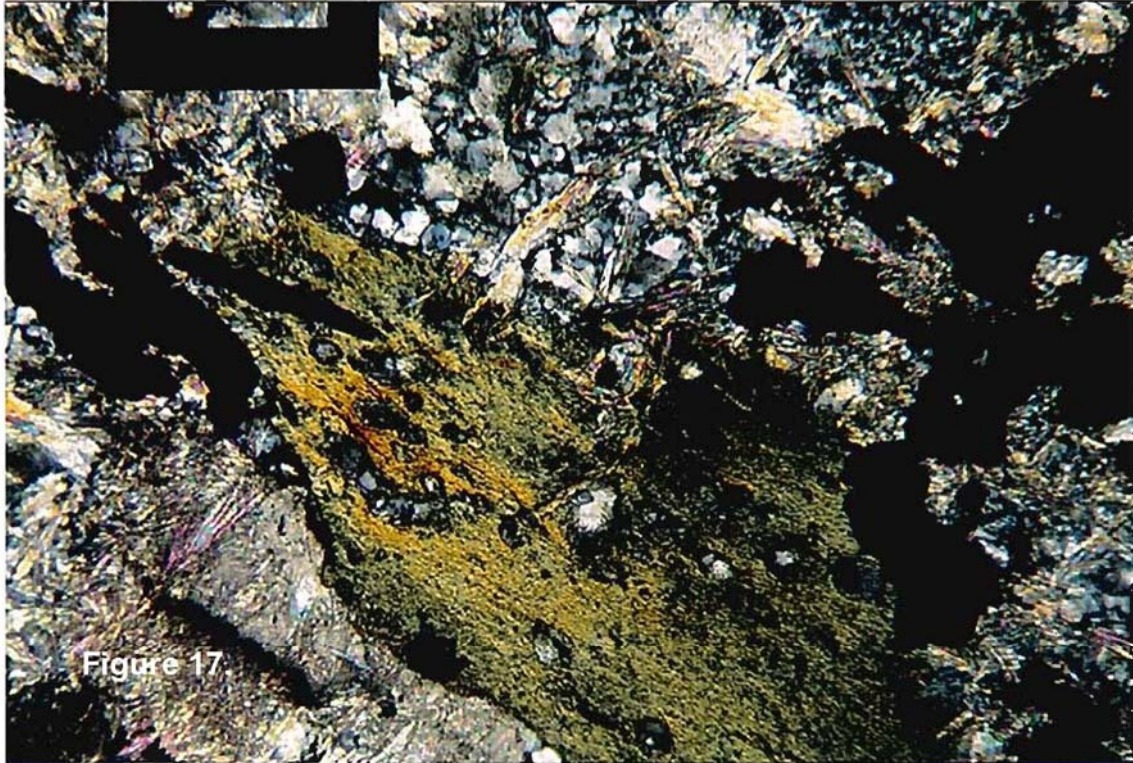


Figure 16.

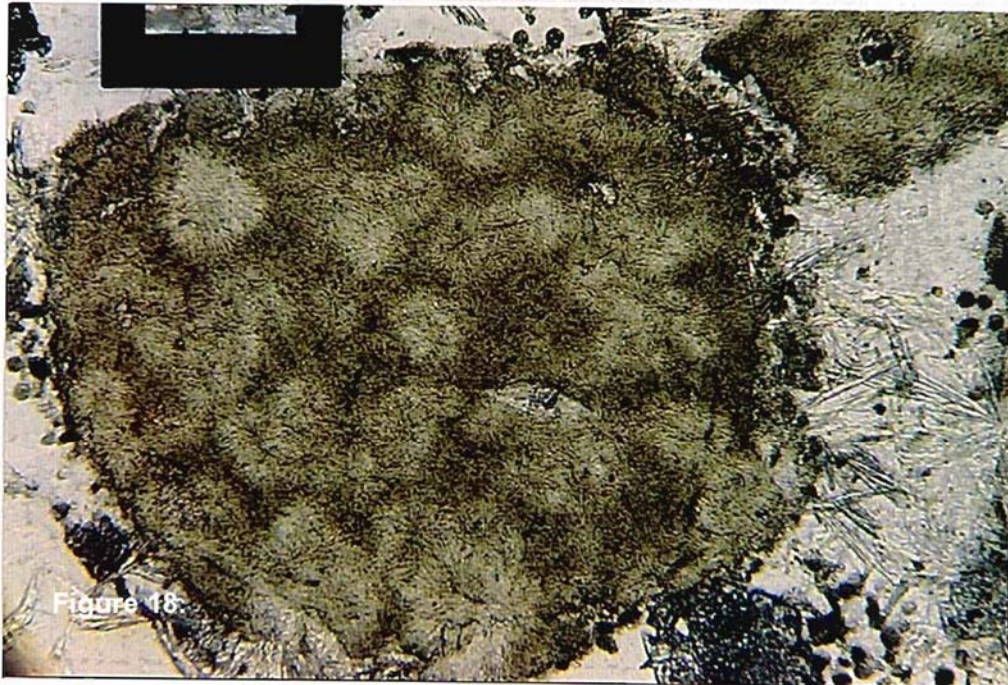
Plane light, Mag.170X  
Shows slight pleochroism of acicular Minnesotaite and of patch

Minnesotaite, Quartz, Magnetite, Carbonate, Greenalite  
Thin section No.1630, DH17710, 93 ft., LC5A

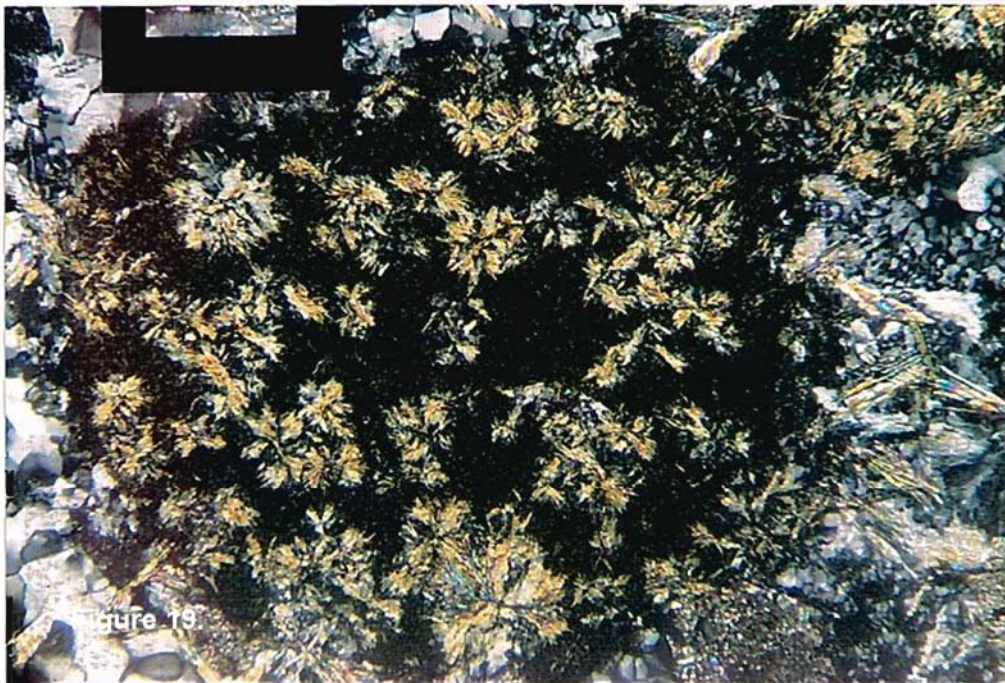


Polarized light, Mag.170X  
Shows birefringence of Minnesotaite, Quartz, and Carbonate (at lower left)  
and apparently isotropic Greenalite (upper right part of patch)

Minnesotaite, Greenalite, Quartz, Carbonate  
Thin section No.1619, DH17710, 65 ft., LC5B



Plane light, Mag.170X  
Minnesotaite-Greenalite(darker green) Granule, Acicular Minnesotaite in Quartz,  
Carbonate at lower right, roughly circular radiating Minnesotaite in Granule



Polarized light, Mag.170X  
Shows birefringence of Minnesotaite and Quartz, Greenalite appears isotropic in Granule

Minnesotaite, Quartz, Magnetite  
Thin section No.1070, DH20016, 442-453 ft., LC3

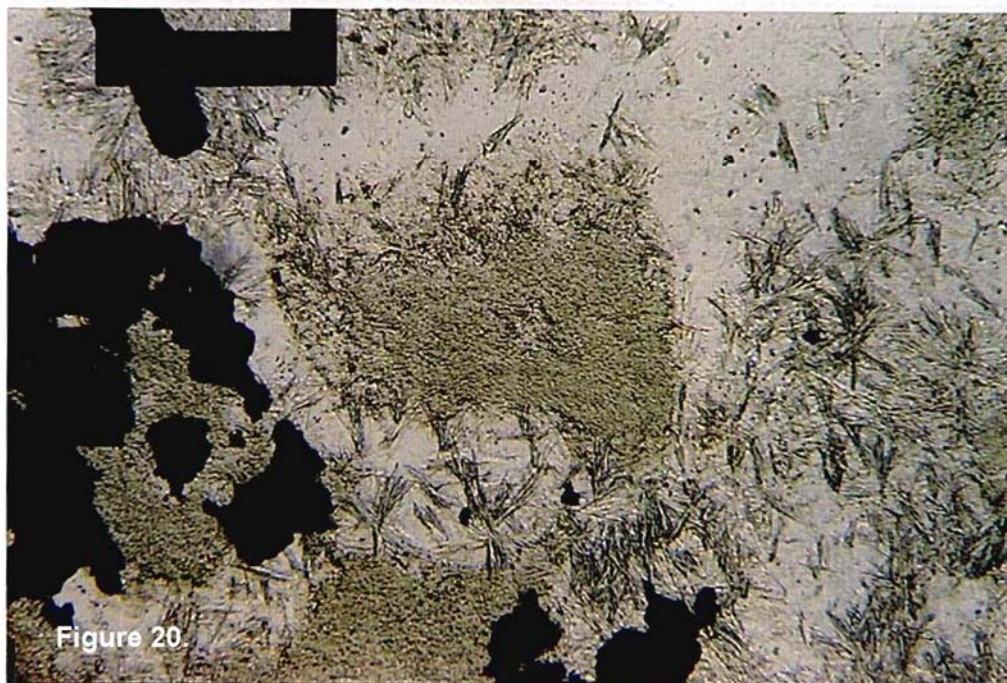


Figure 20  
Plane light, Mag.170X  
Acicular Minnesotaite in Quartz and patches of fine, partially oriented Minnesotaite, anhedral Magnetite

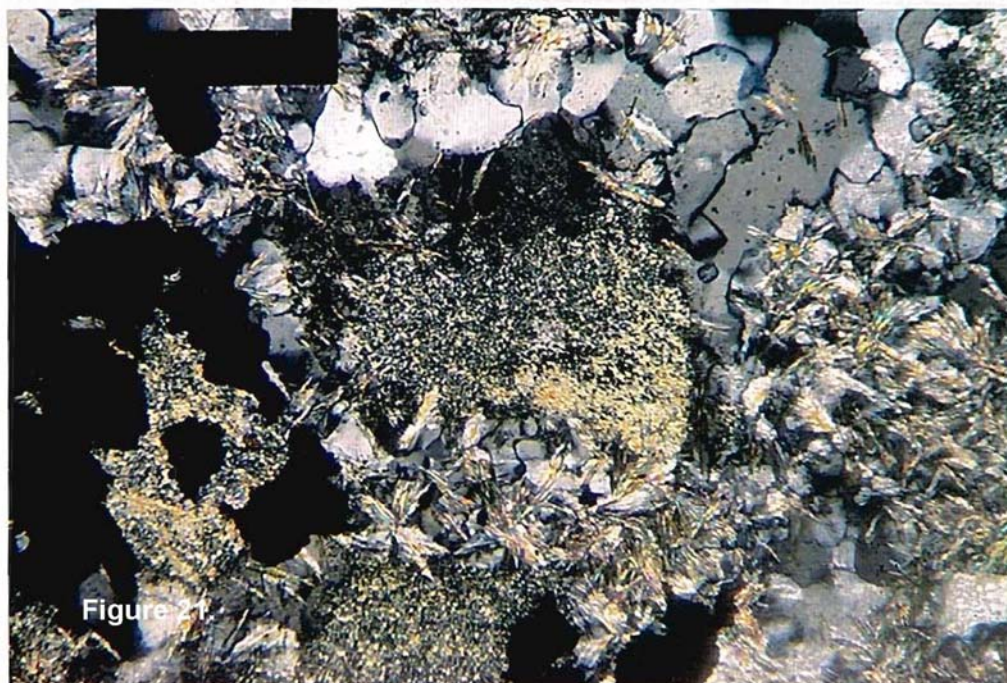


Figure 21  
Polarized light, Mag.170X  
Shows birefringence of Minnesotaite and Quartz

Minnesotaite, Quartz, Magnetite, Carbonate  
Thin section No.1069, DH20016, 442-453 ft., LC3

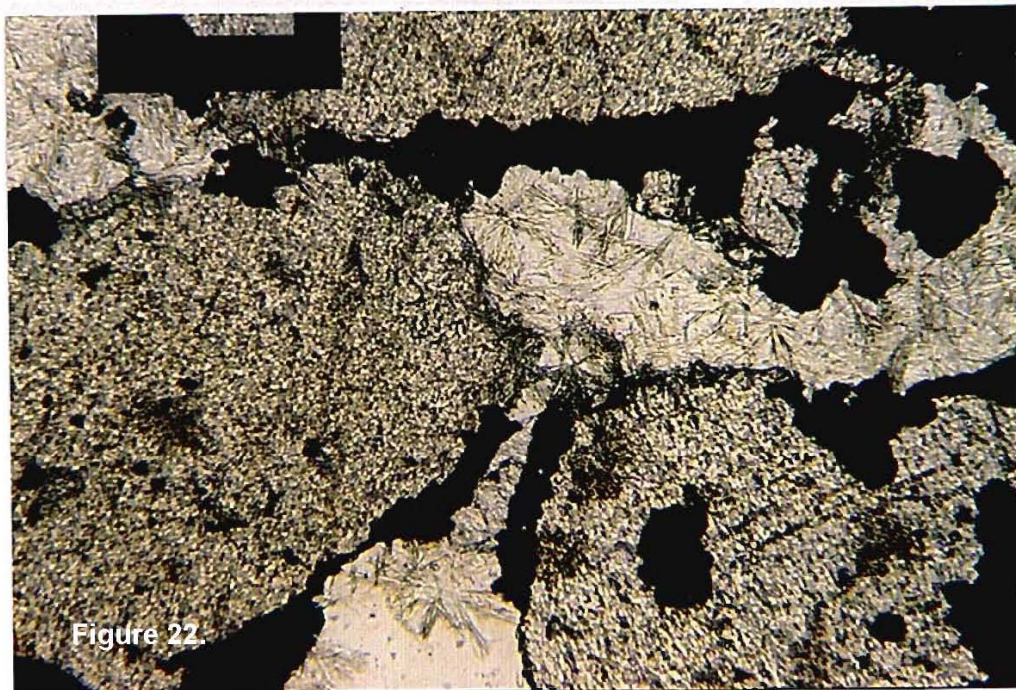


Figure 22

Plane light, Mag.170X  
Coarse Carbonate with Magnetite rims, acicular Minnesotaite in Quartz

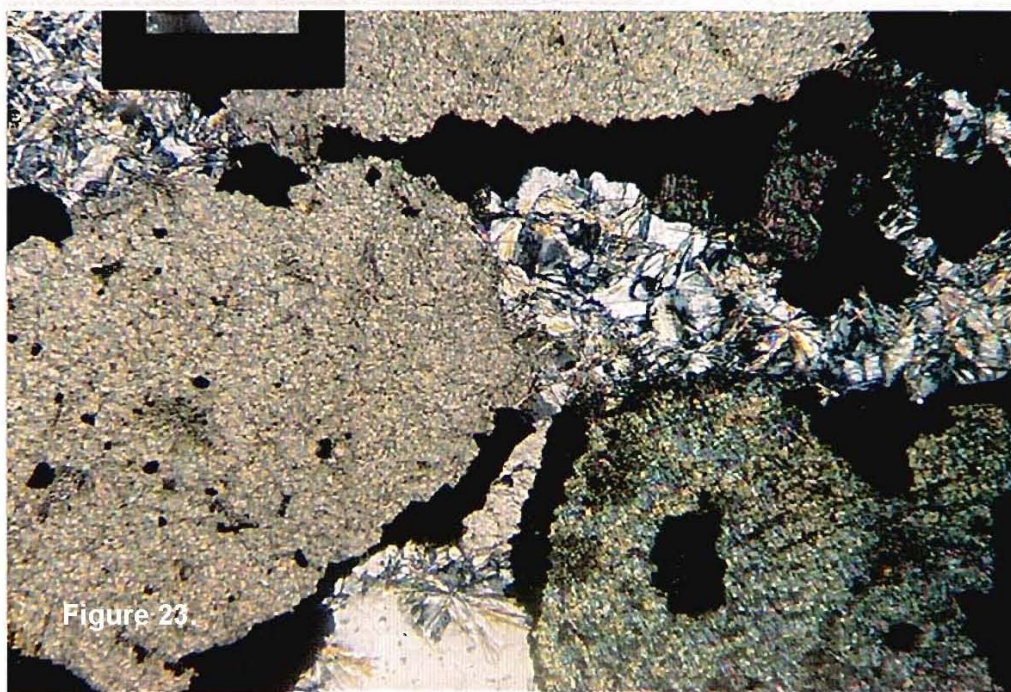


Figure 23

Polarized light, Mag.170X  
Shows birefringence of Carbonate, Minnesotaite and Quartz

Minnesotaite, Quartz, Greenalite, Magnetite  
Thin section No. 1586, DH17695, 39 ft., LC4

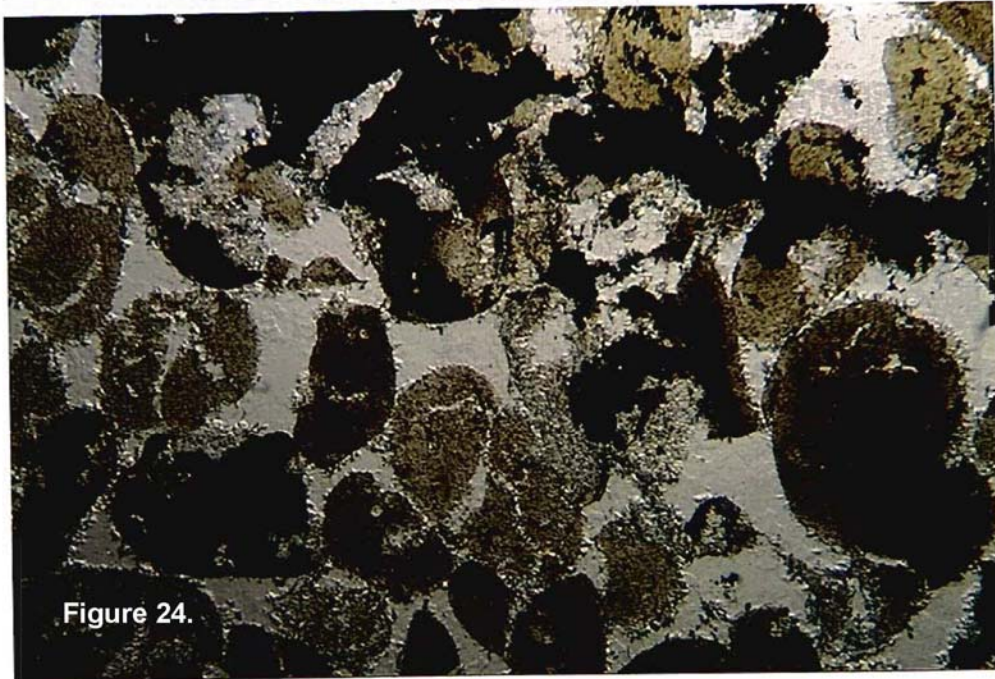


Figure 24.

Plane light, Mag. 42X  
Granules of Minnesotaite, Greenalite, Magnetite, and Quartz

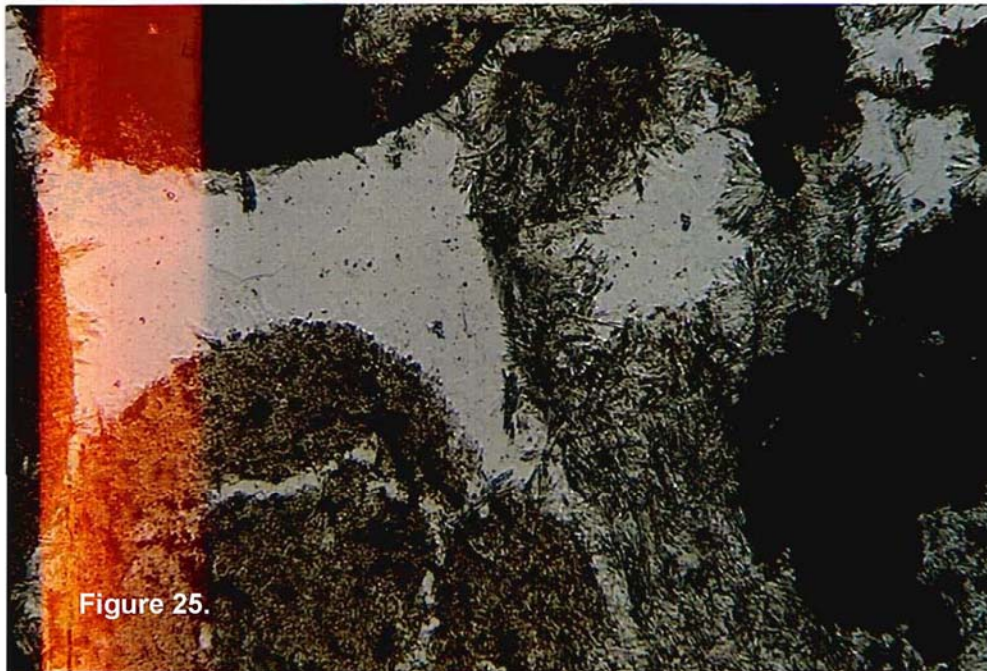


Figure 25.

Plane light, Mag. 170X  
Granule with acicular Minnesotaite, Quartz and Magnetite and a Greenalite granule  
at the lower left



Minnesotaite, Quartz, Greenalite, Magnetite  
Thin section No. 1586, DH17695, 39 ft., LC4

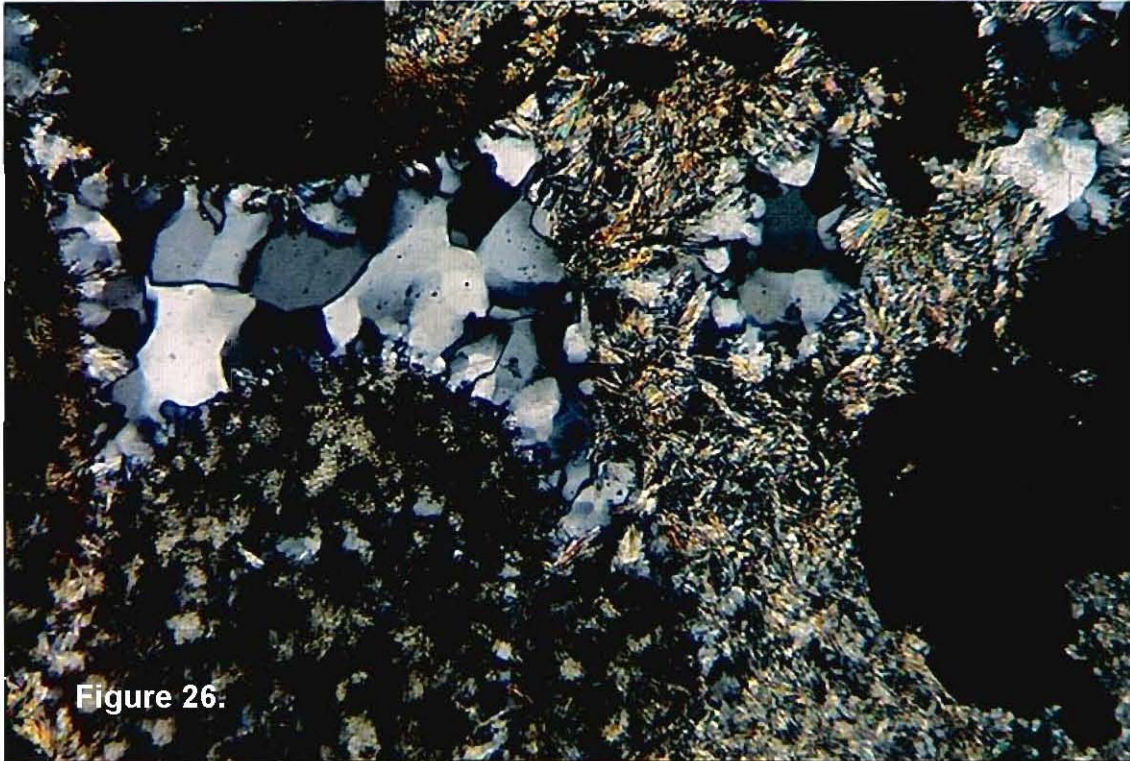


Figure 26.

Polarized light, Mag. 170X

Shows birefringence of Minnesotaite and Quartz, Greenalite appears isotropic, some  
Quartz and Minnesotaite in Greenalite granules

Minnesotaite, Quartz, Greenalite, Magnetite  
Thin section No. 1639, DH17710, 118 ft., LC4

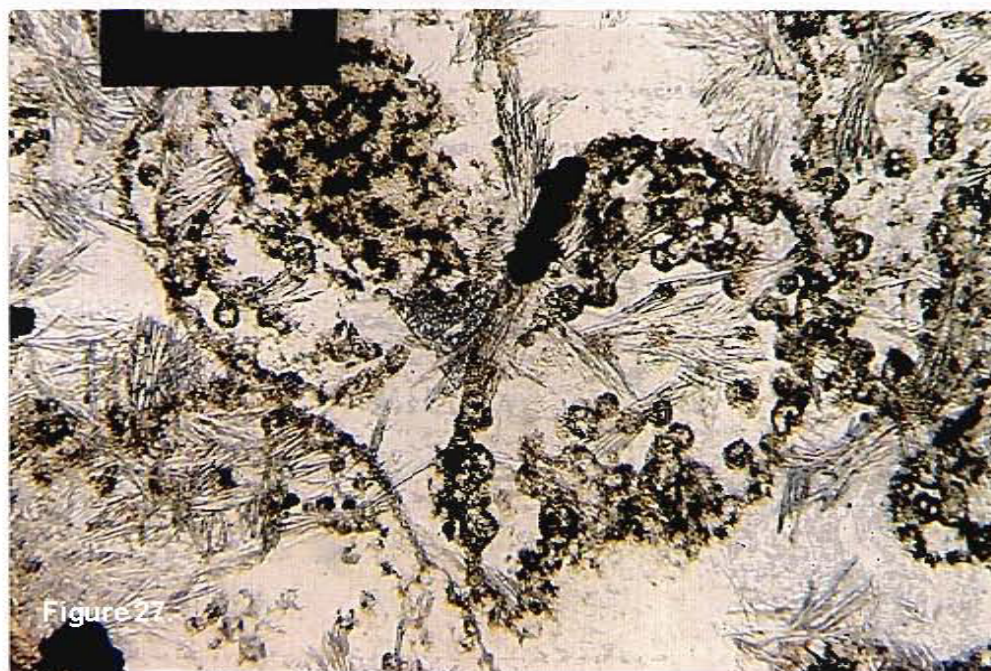


Figure 27

Plane light, Mag. 170X

Acicular Minnesotaite-Quartz-Greenalite(fabric and grains)granules, scattered Magnetite,  
black rims on Greenalite grains are apparently Magnetite

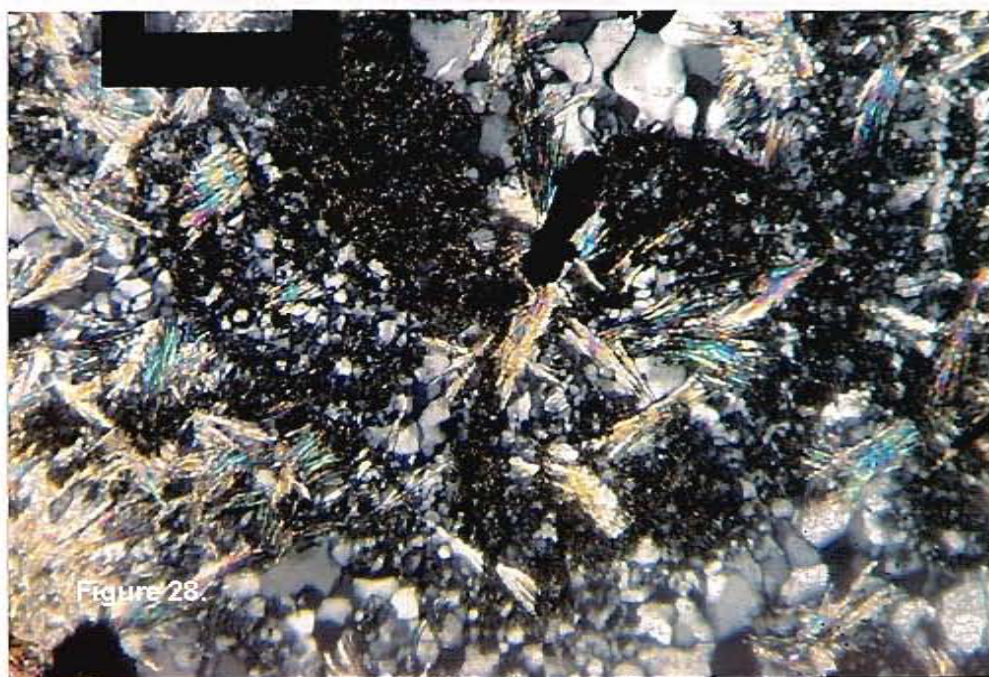


Figure 28

Polarized light, Mag. 170X

Shows birefringence of Minnesotaite and Quartz, nearly opaque Greenalite in  
fabric and grains

Minnesotaite, Quartz, Greenalite  
Thin section No. 1639, DH17710, 118 ft., LC4



Figure 29

Plane light, Mag. 170X  
Acicular Minnesotaite-Quartz-Greenalite(fabric and grains)granules

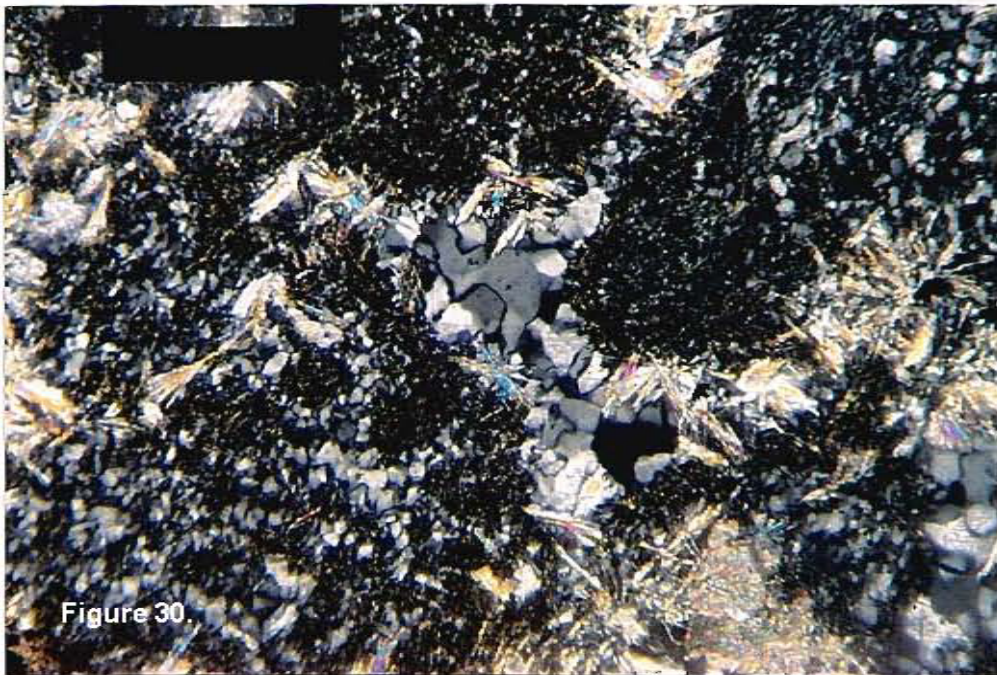
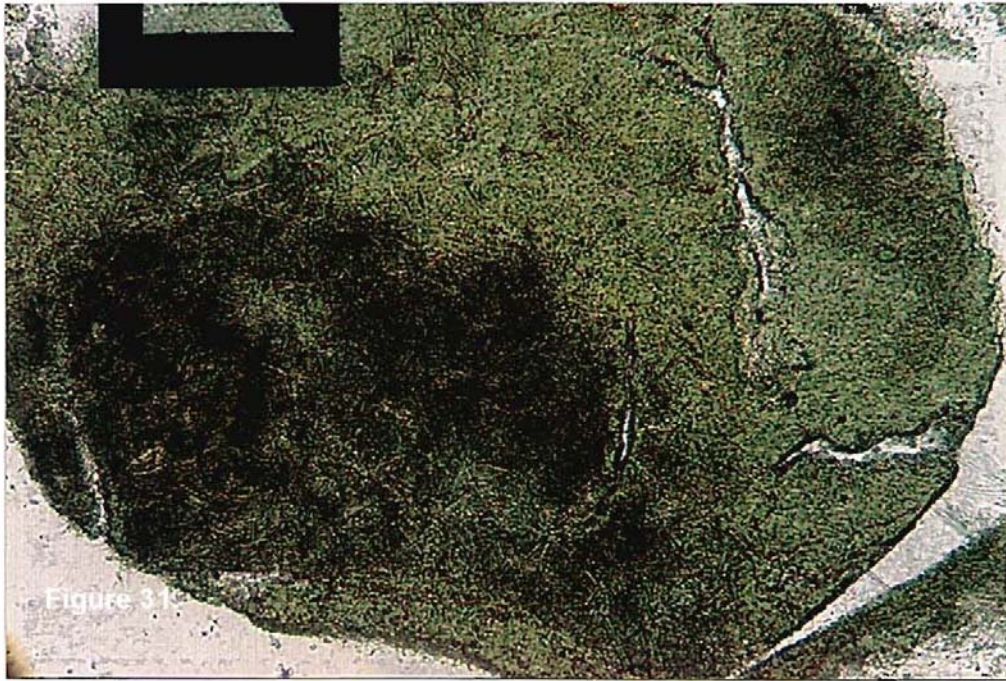


Figure 30

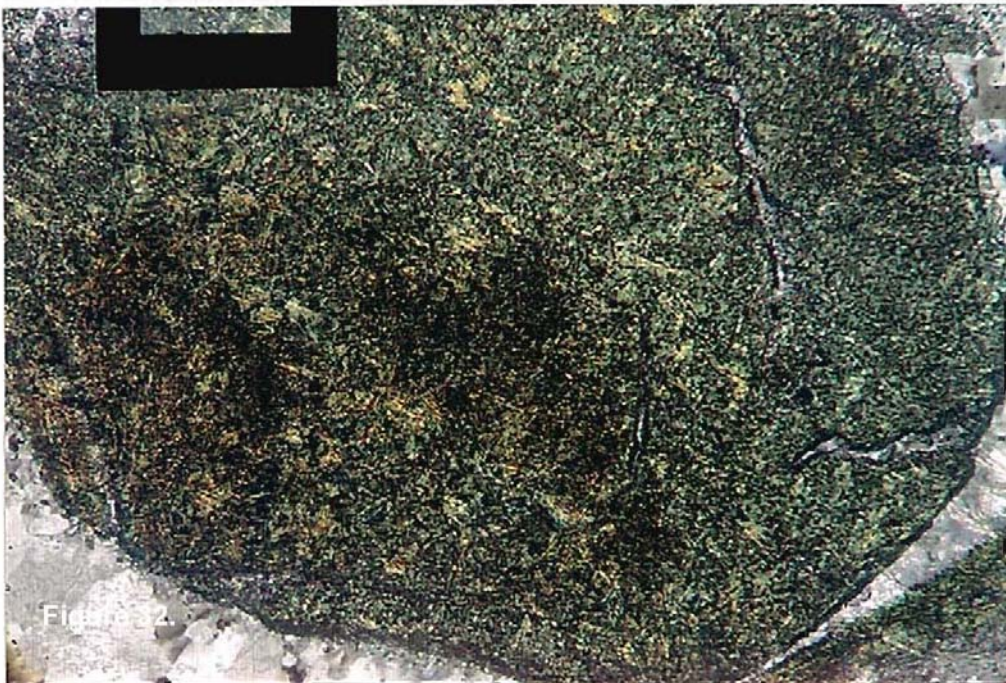
Polarized light, Mag. 170X  
Shows birefringence of Minnesotaite and Quartz, nearly opaque Greenalite in fabric and grains

Stilpnomelane, Quartz, Greenalite  
Thin section No.712, DH8414, 129-134 ft., Hibbing District



Plane light, Mag.274X

Granule of fine grained Stilpnomelane particles that are not aligned so that little pleochroism is evident. Some of the darkest areas are probably Greenalite



Polarized light, Mag.274X

Shows birefringence of Stilpnomelane particles and Quartz, nearly opaque Greenalite

Stilpnomelane, Quartz, Minnesotaite, Carbonate, Magnetite, Greenalite  
Thin section No.1621, DH17710, 71 ft., LC5B

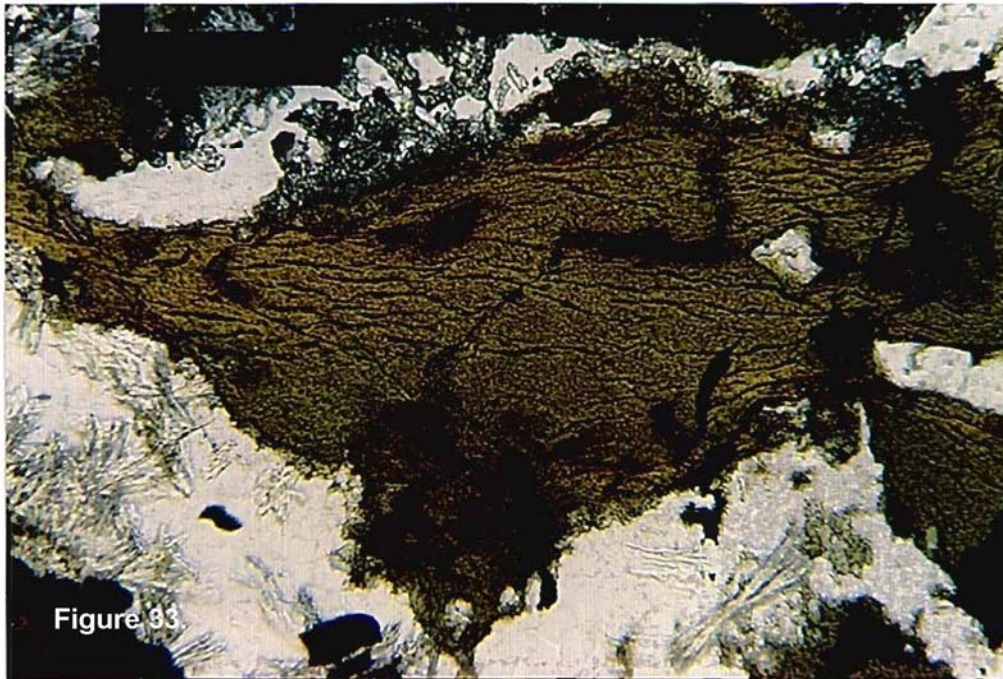


Figure 33

Plane light, Mag.170X

Large grain of Stilpnomelane, acicular Minnesotaite, Carbonate (top) and small Greenalite grains (pale green, at lower right) in Quartz

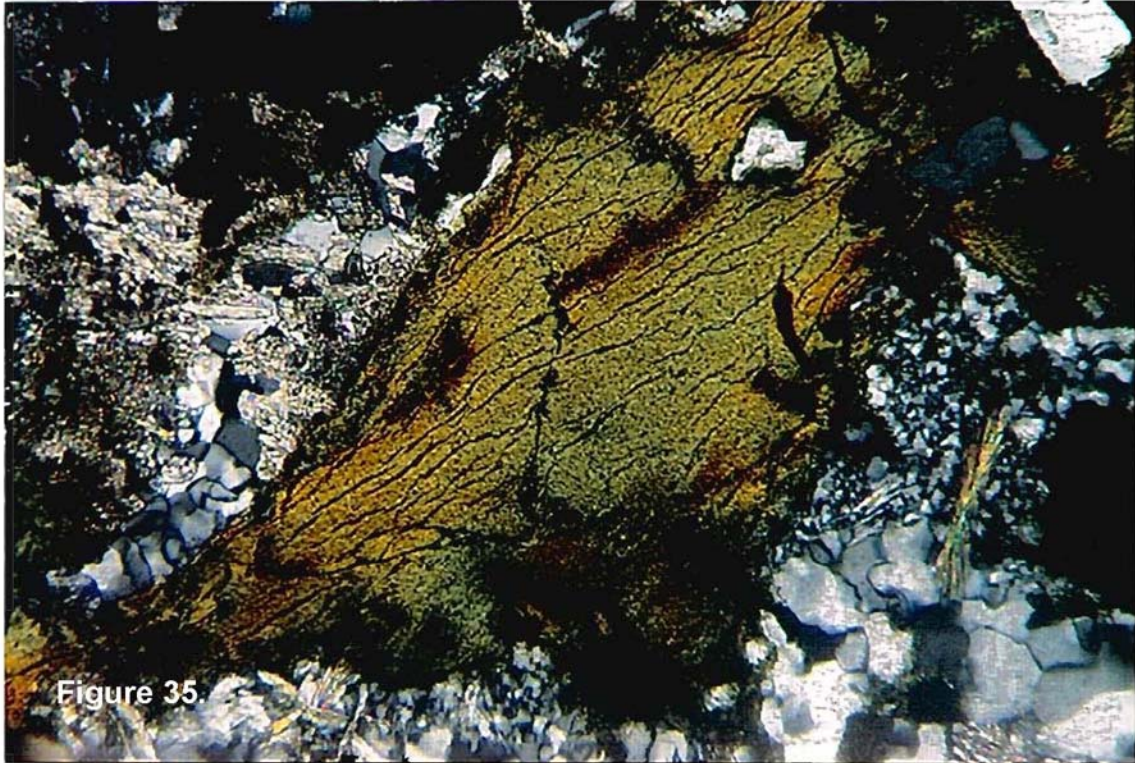


Figure 34

Plane light, Mag.170X

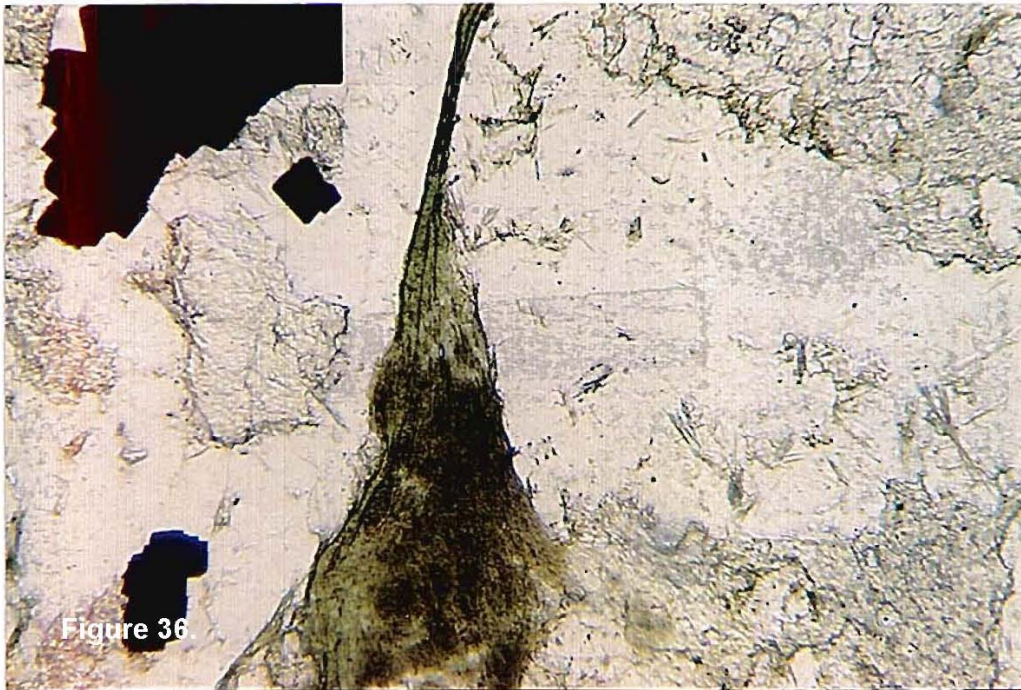
Shows Stilpnomelane pleochroism and demonstrates extreme relief of Carbonate

Stilpnomelane, Quartz, Minnesotaite, Carbonate, Magnetite, Greenalite  
Thin section No.1621, DH17710, 71 ft., LC5B

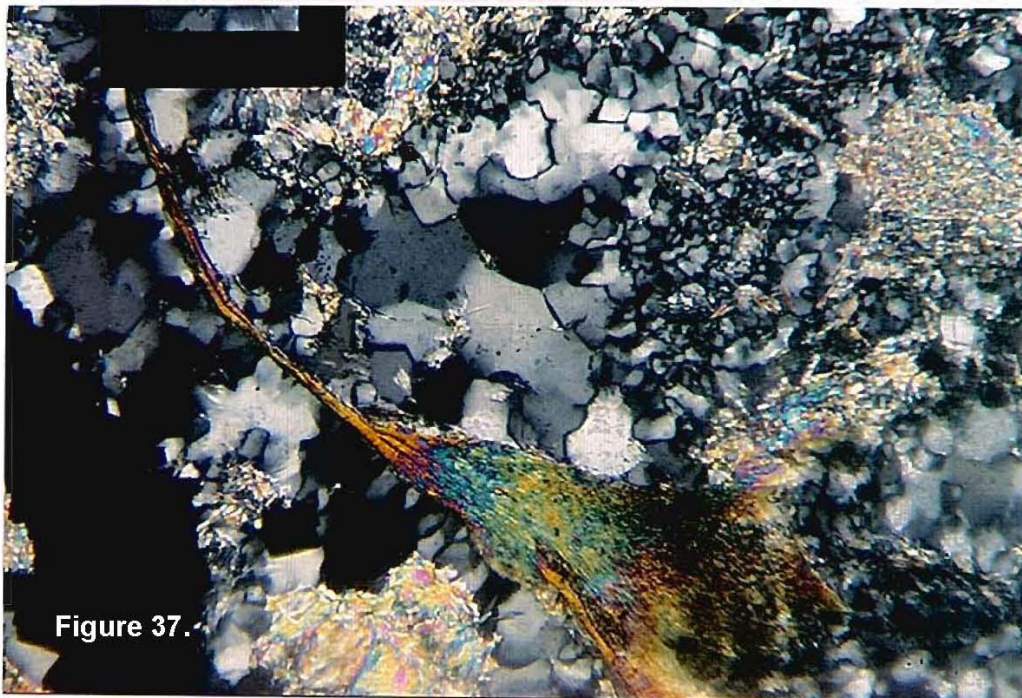


Polarized light, Mag. 170X  
Shows birefringence of Stilpnomelane, Minnesotaite, Carbonate, and Quartz,  
Greenalite grains appear opaque

Stilpnomelane, Quartz, Carbonate, Magnetite  
Thin section No. 1646, DH17710, 152 ft., LC4

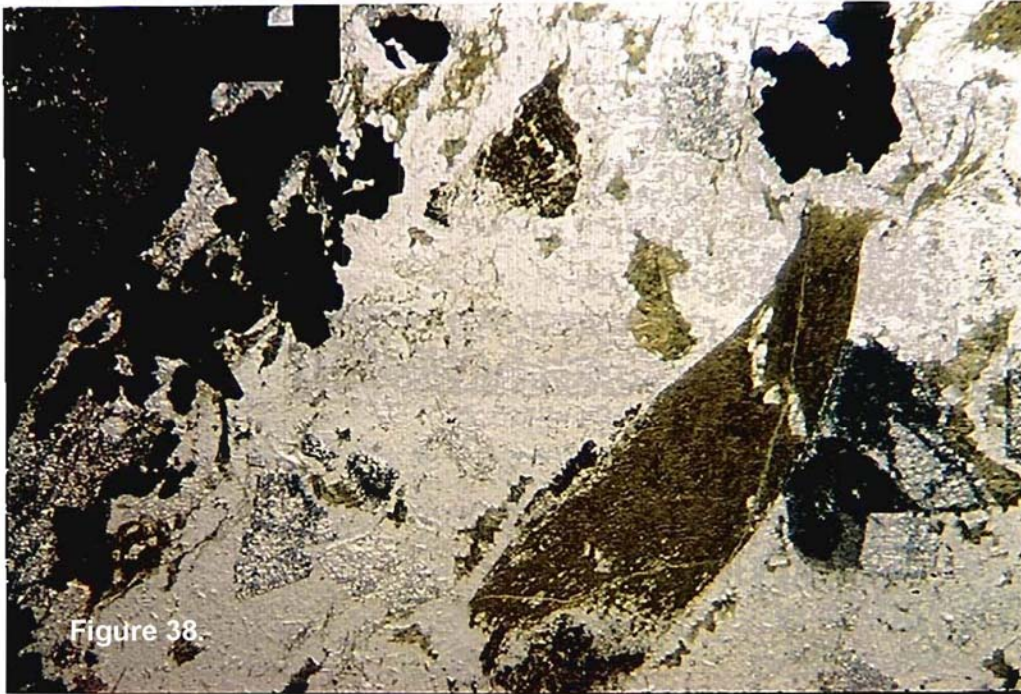


Plane light, Mag. 170X  
Large grain of Stilpnomelane, Carbonate, Magnetite in Quartz

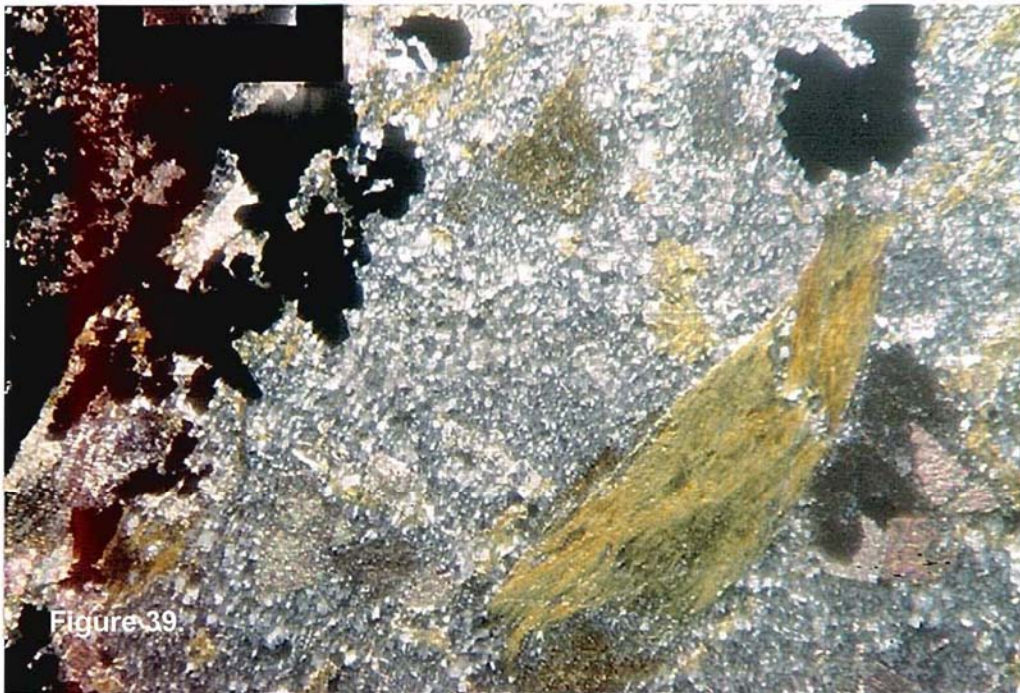


Polarized light, Mag. 170X  
Shows birefringence of Stilpnomelane, Carbonate, and Quartz

Stilpnomelane, Quartz, Carbonate, Magnetite  
Thin section No. 1648, DH17710, 159 ft., LC4



Plane light, Mag.42X  
Stilpnomelane granule and radiating crystals, Carbonate, Magnetite in Quartz



Polarized light, Mag.42X  
Shows birefringence of Stilpnomelane, Carbonate, and Quartz



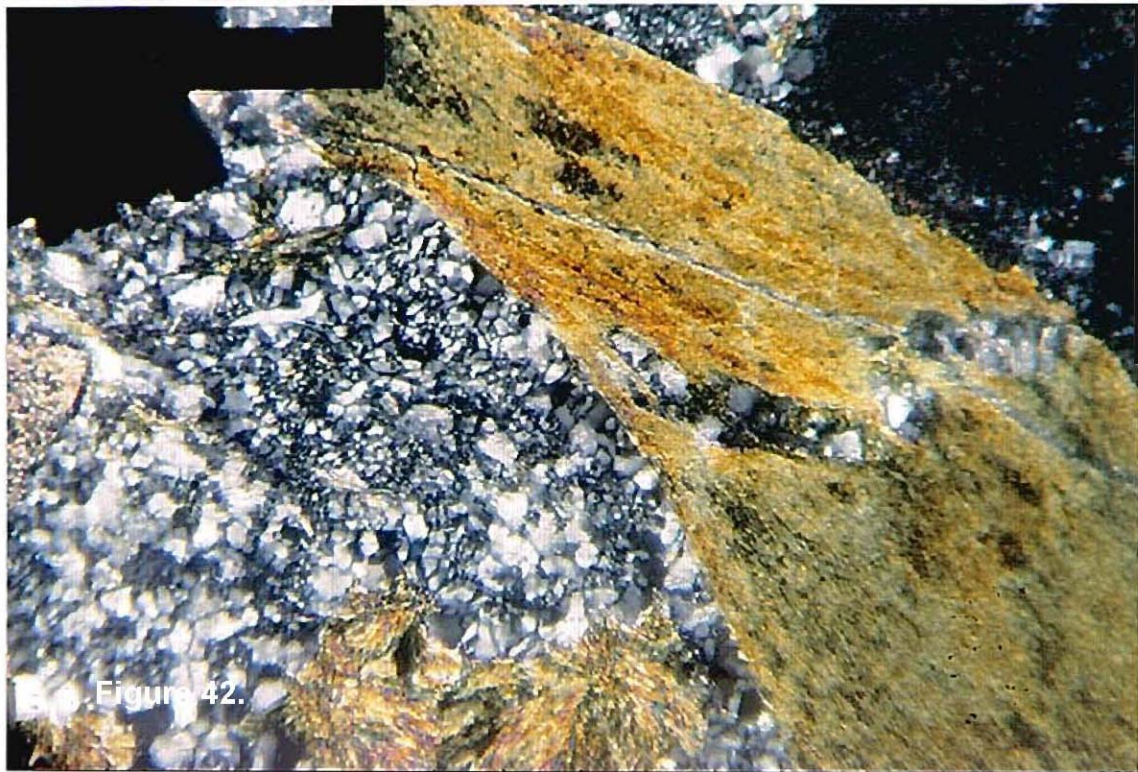
Stilpnomelane, Quartz, Carbonate, Magnetite  
Thin section No. 1648, DH17710, 159 ft., LC4



Plane light, Mag. 170X  
Stilpnomelane granule and radiating crystals, Carbonate, Magnetite in Quartz



Plane light, Mag. 170X  
Shows Stilpnomelane pleocroism

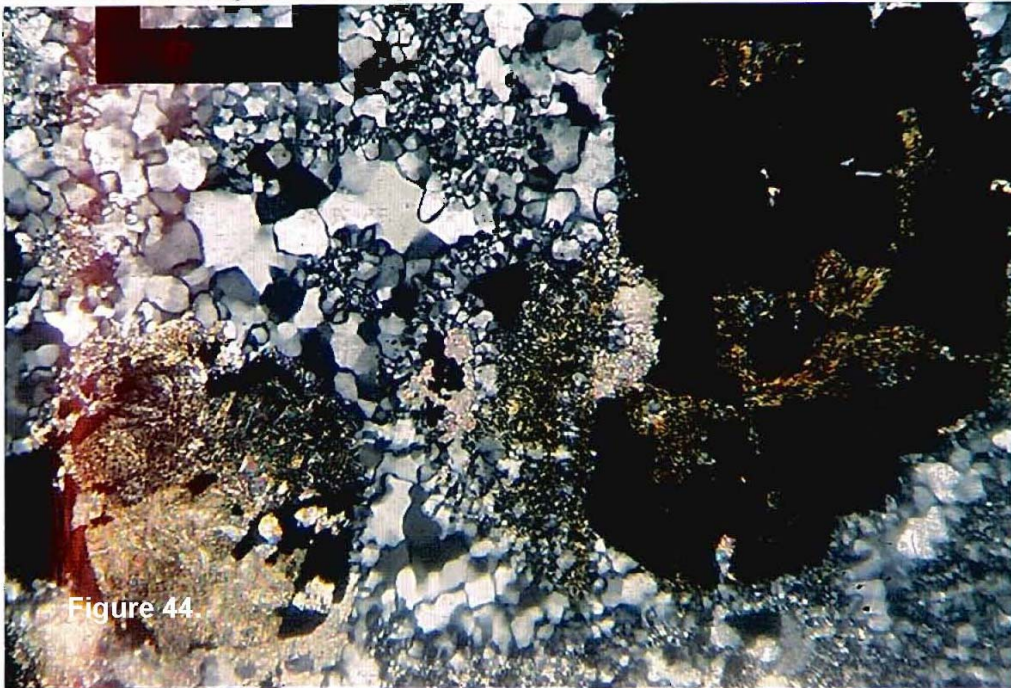


Polarized light, Mag. 170X  
Shows birefringence of Stilpnomelane, Quartz, and Carbonate

Stilpnomelane, Quartz, Carbonate, Magnetite  
Thin section No. 1655, DH17710, 186 ft., LC3

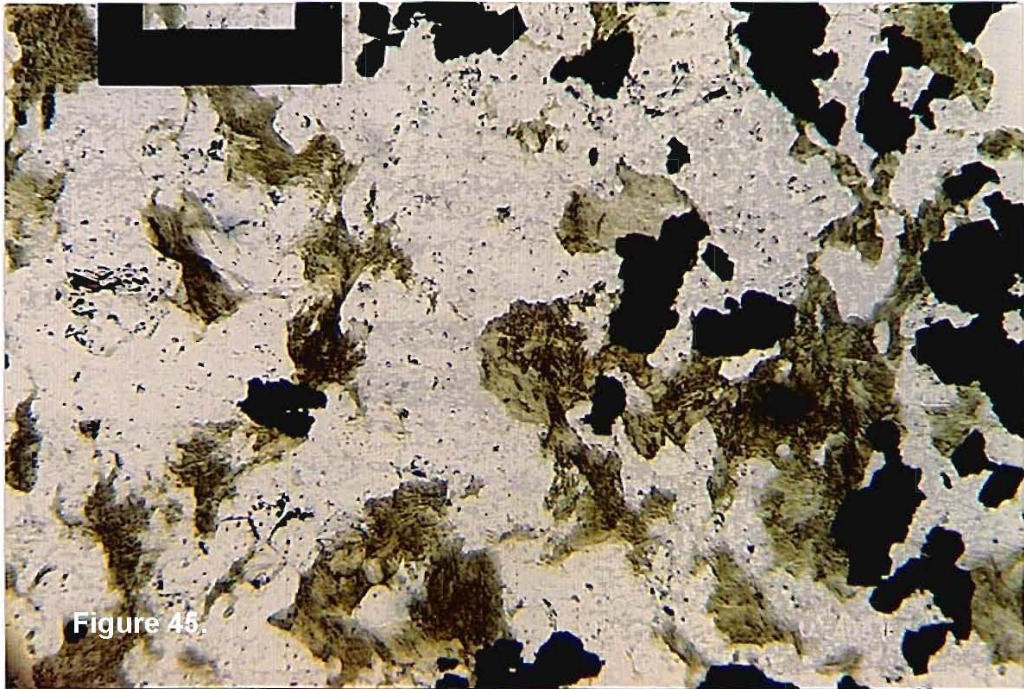


Plane light, Mag. 170X  
Large granule of euhedral Magnetite and Stilpnomelane, Stilpnomelane fabric,  
smaller granule of Magnetite, Carbonate, and acicular Stilpnomelane

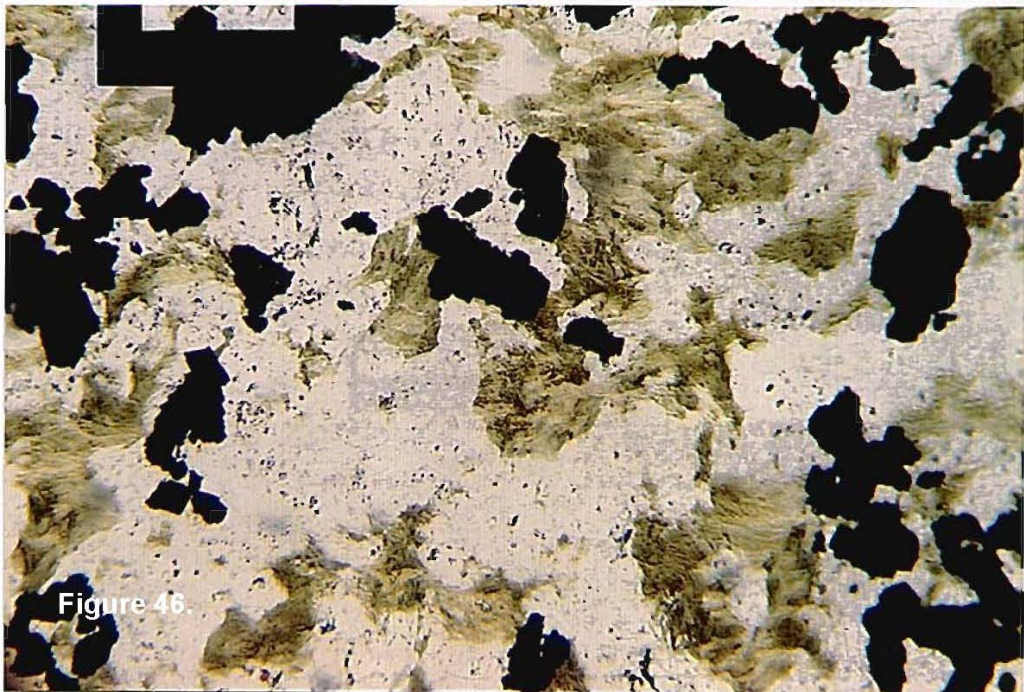


Polarized light, Mag. 170X  
Shows Stilpnomelane, Quartz, and Carbonate pleochroism

Stilpnomelane, Quartz, Magnetite  
Thin section No.153, DH17001, 199 ft., LC3

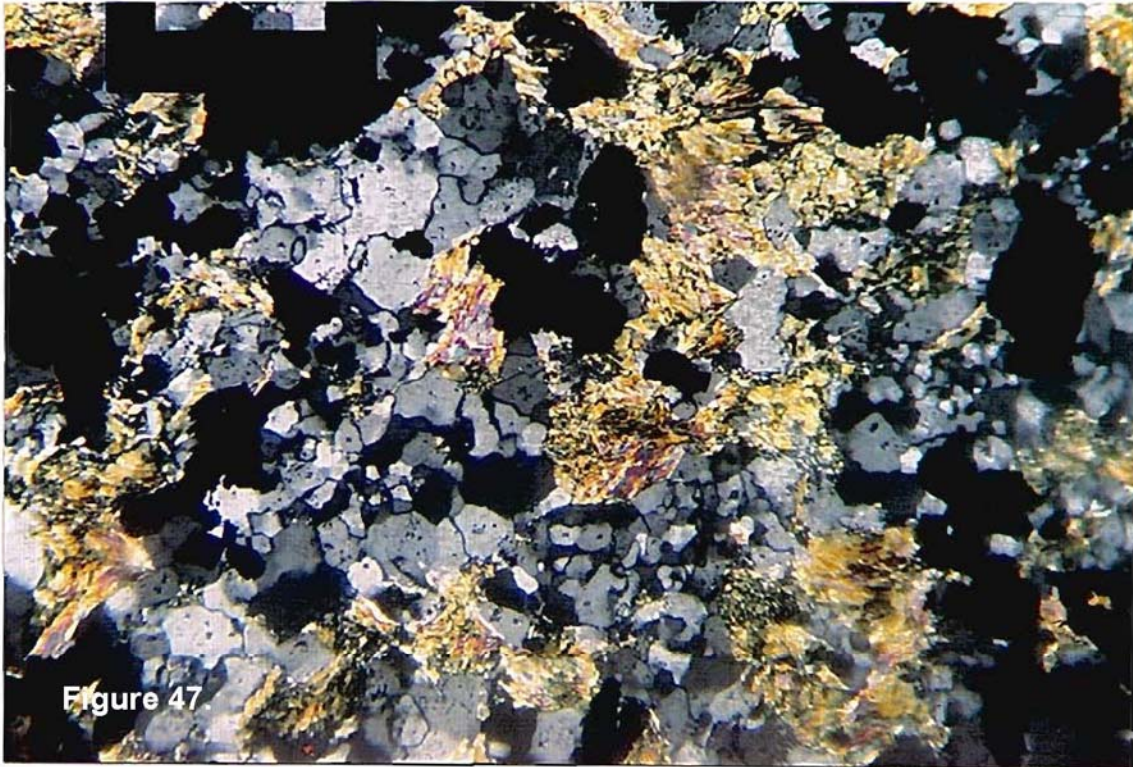


Plane light, Mag.170X  
Stilpnomelane crystals and Magnetite in Quartz



Plane light, Mag.170X  
Shows Stilpnomelane pleochroism

Stilpnomelane, Quartz, Magnetite  
Thin section No.153, DH17001, 199 ft., LC3



Polarized light, Mag.170X  
Shows birefringence of Stilpnomelane and Quartz

Stilpnomelane, Quartz, Magnetite  
Thin section No.153, DH17001, 199 ft., LC3

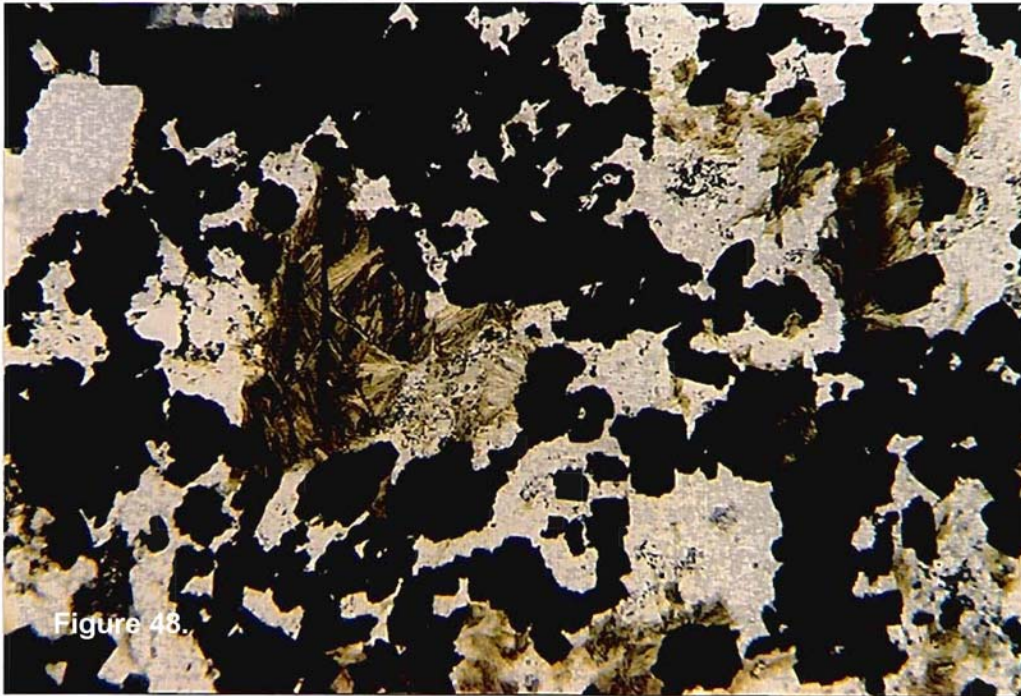


Figure 48.

Plane light, Mag. 170X  
Stilpnomelane crystals and Magnetite in Quartz

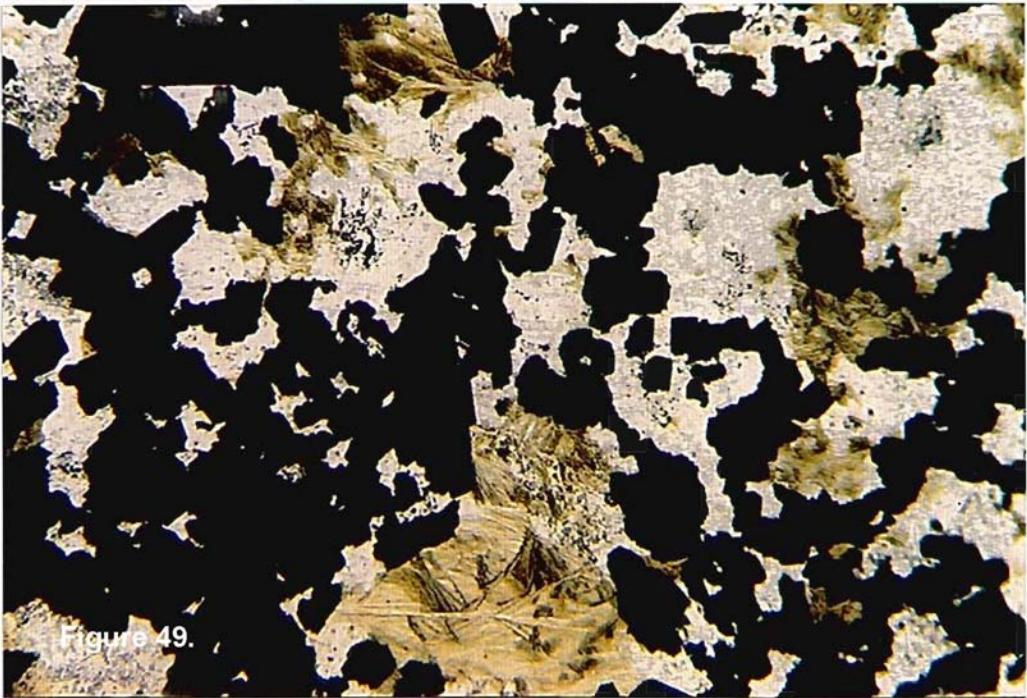


Figure 49.

Plane light, Mag. 170X  
Shows Stilpnomelane pleochroism

Stilpnomelane, Quartz, Carbonate  
Thin section No. 1062, DH20016, 422-433 ft., LC3

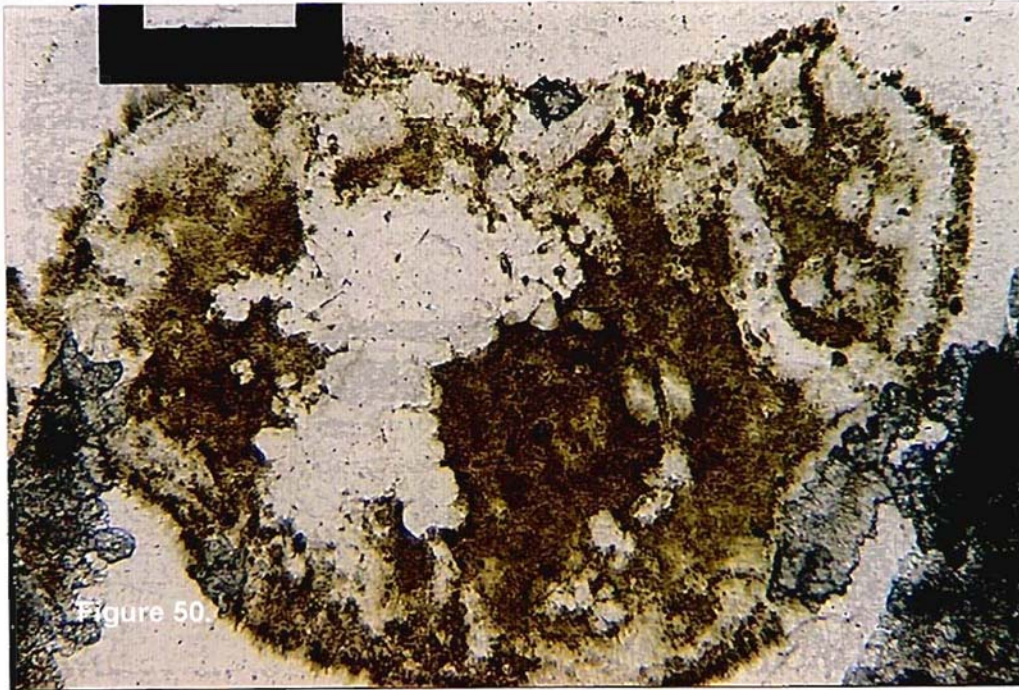


Figure 50.

Plane light, Mag. 170X  
Stilpnomelane-Quartz granule and Carbonate

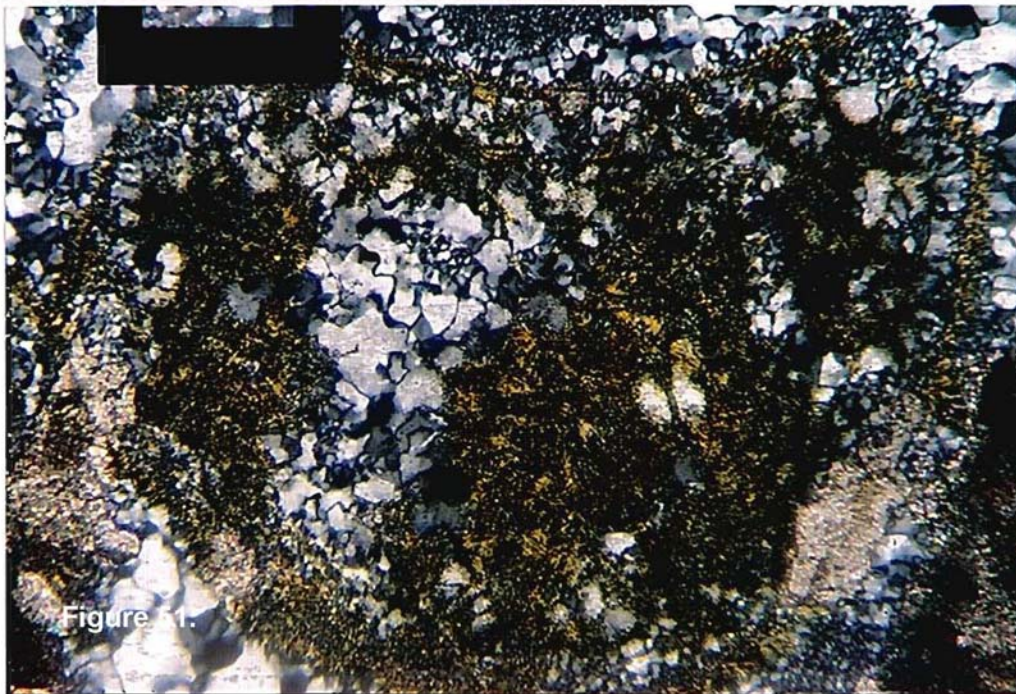
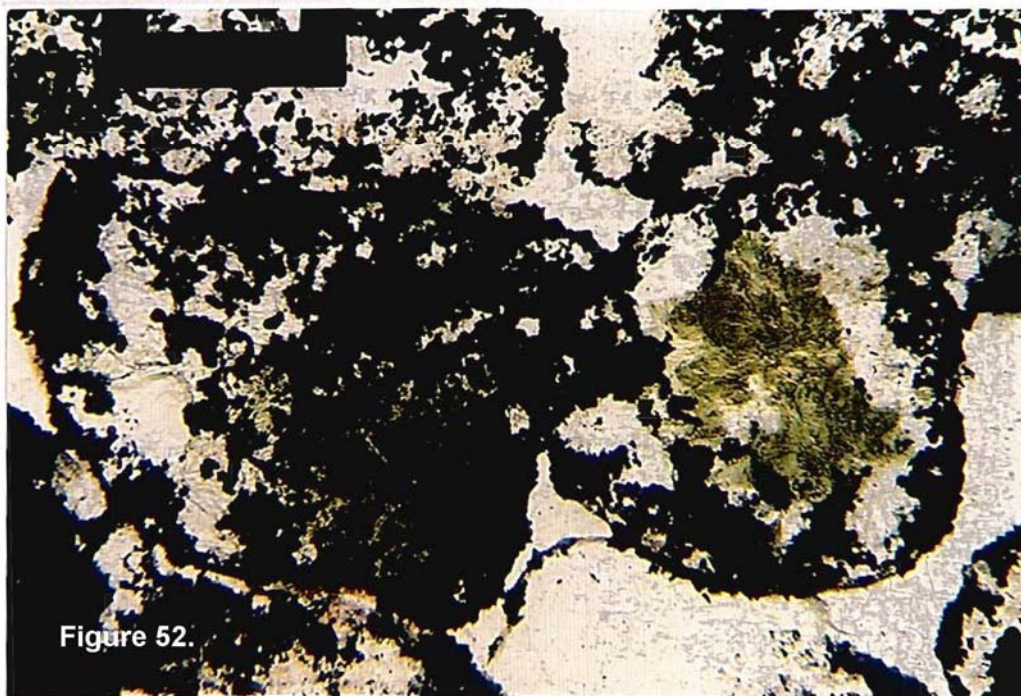


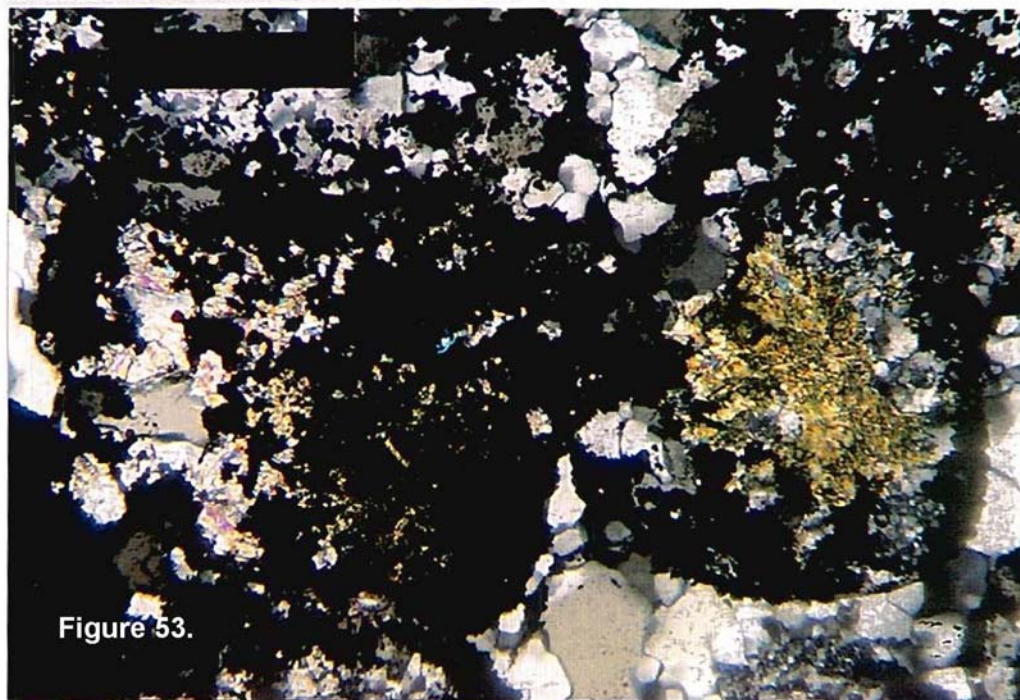
Figure 51.

Polarized light, Mag. 170X  
Shows birefringence of Stilpnomelane, Quartz, and Carbonate

Stilpnomelane, Quartz, Magnetite, Talc(?)  
Thin section No.1596, DH17695, 101 ft., LC2



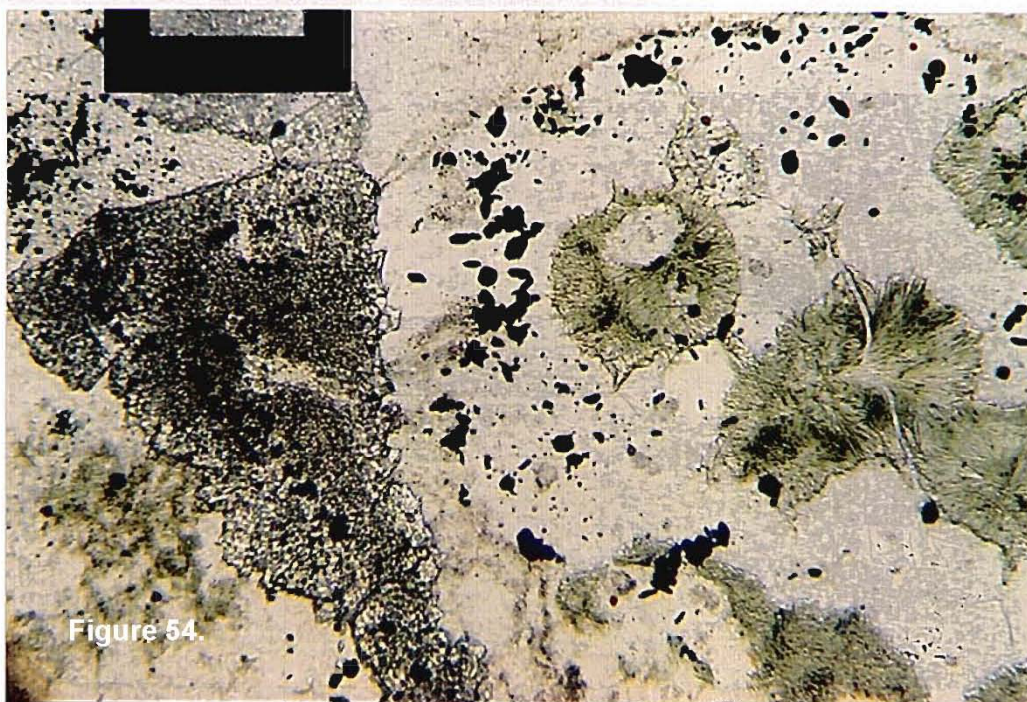
Plane light, Mag. 170X  
Stilpnomelane-Quartz-Magnetite granules in Quartz



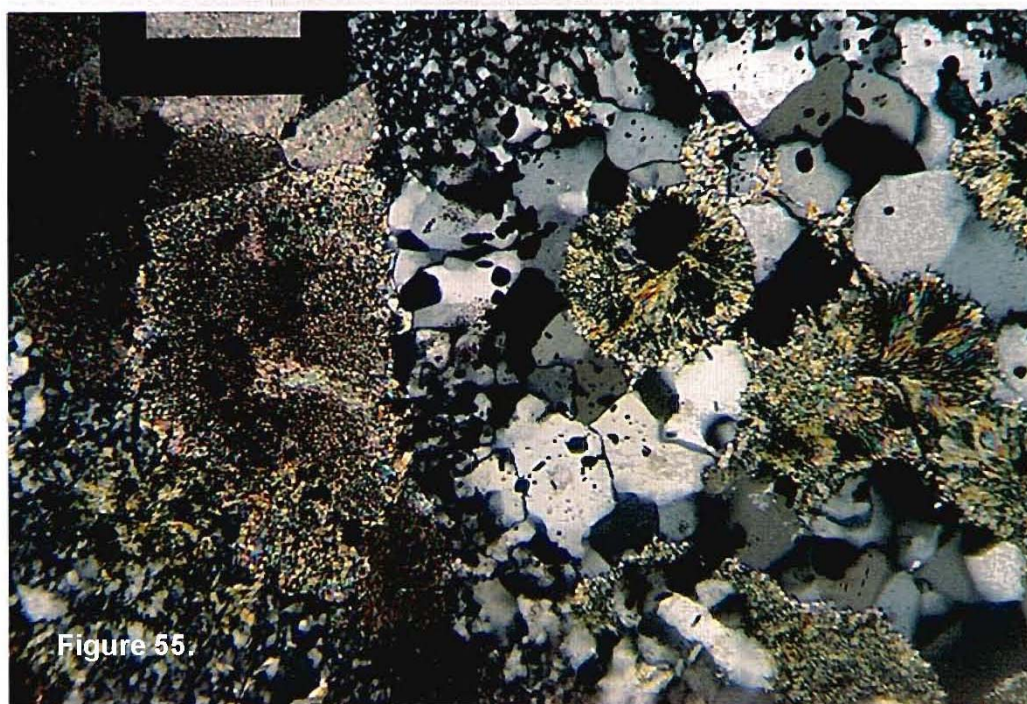
Polarized light, Mag. 170X  
Shows birefringence of Stilpnomelane, Quartz, and Talc(in granule at the left)



Stilpnomelane, Quartz, Hematite, Talc(?), Carbonate  
Thin section No.1596, DH17695, 101 ft., LC2



Plane light, Mag.170X  
Radiating Stilpnomelane crystals, Carbonate, Talc(?), and Hematite in Quartz



Polarized light, Mag.170X  
Shows birefringence of Stilpnomelane, Quartz, Talc(?), and Carbonate

Stilpnomelane, Quartz, Fe Oxide  
Thin section No.1598, DH17695, 115 ft., LC2

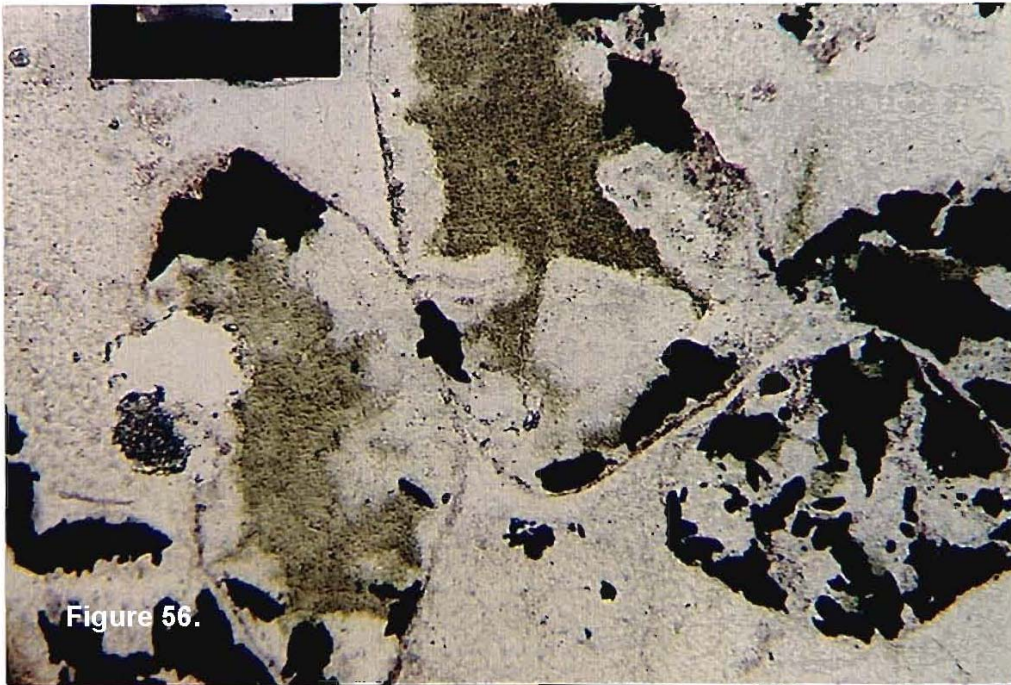


Figure 56.

Plane light, Mag.170X  
Fine grained Stilpnomelane as fabric, Quartz, and opaque Oxides

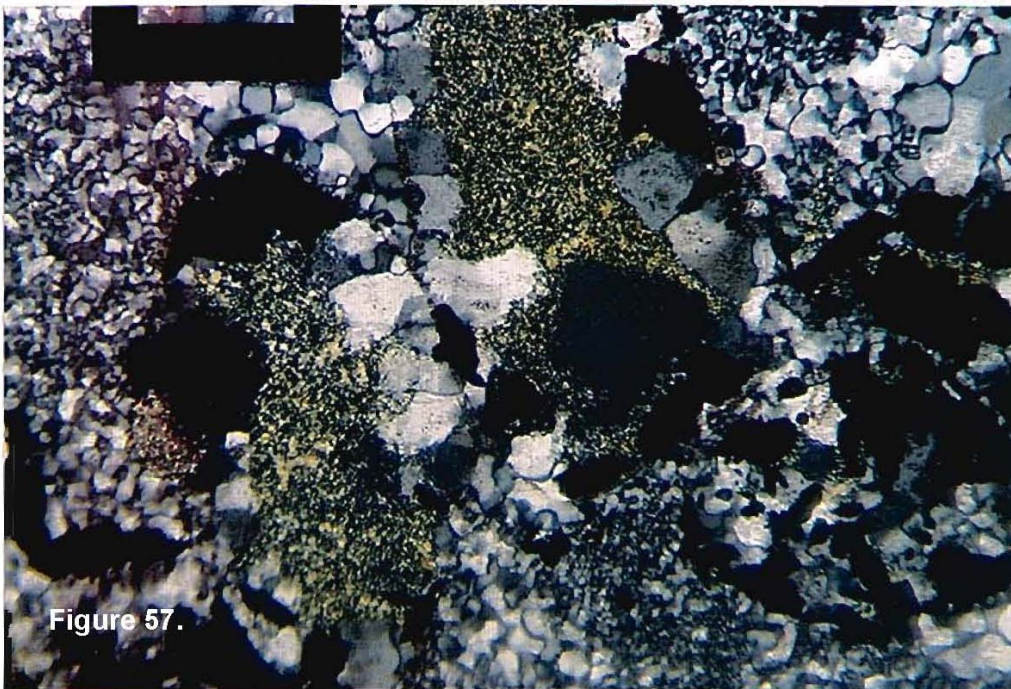


Figure 57.

Polarized light, Mag.170X  
Shows birefringence of Stilpnomelane and Quartz

Stilpnomelane, Quartz, Carbonate, Fe Oxide  
Thin section No. 1599, DH17695, 124 ft., LC2

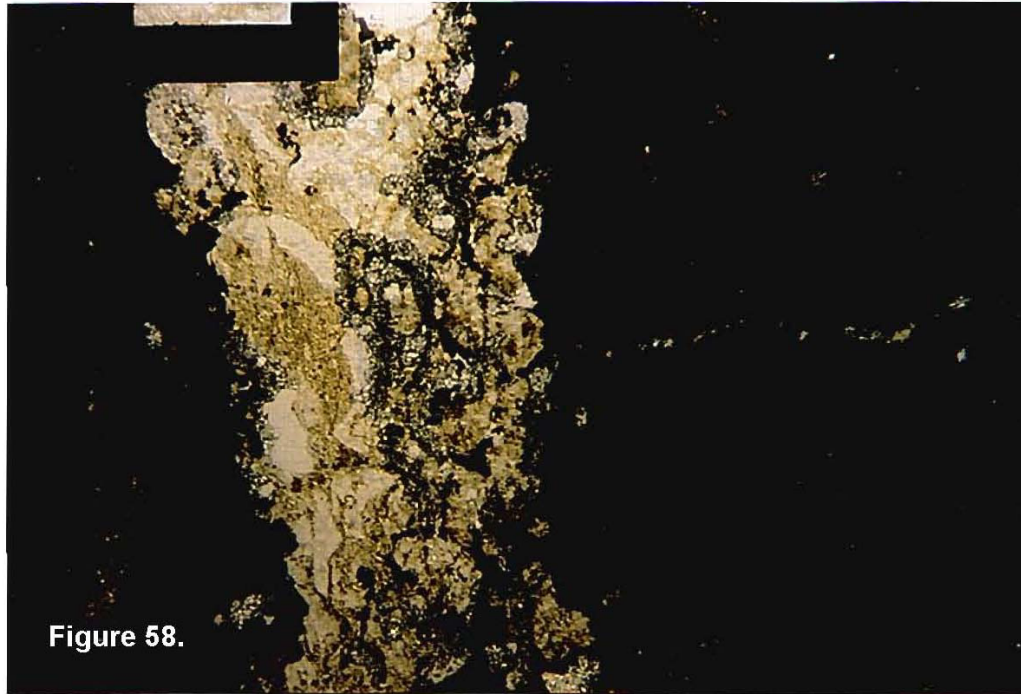


Figure 58.

Plane light, Mag. 42X  
Stilpnomelane, Carbonate, Quartz, Fe Oxide bed between thick Oxide beds

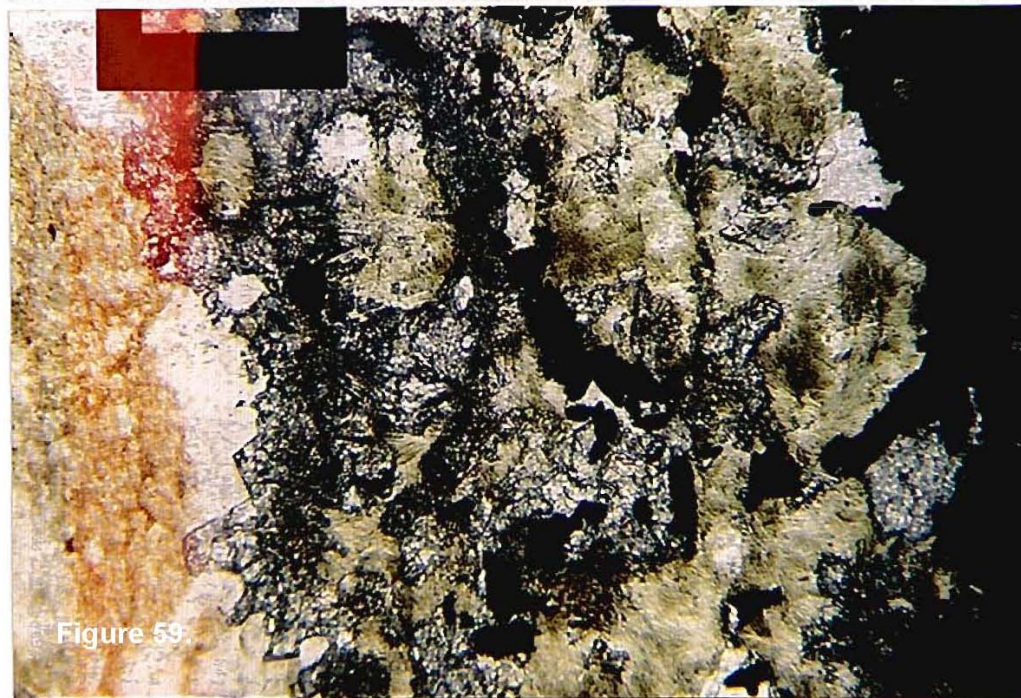


Figure 59

Plane light, Mag. 170X  
Stilpnomelane as radiating acicular crystals and fine grained fabric, Carbonate,  
Quartz, and Fe Oxide

Stilpnomelane, Quartz, Carbonate, Fe Oxide  
Thin section No.1599, DH17695, 124 ft., LC2

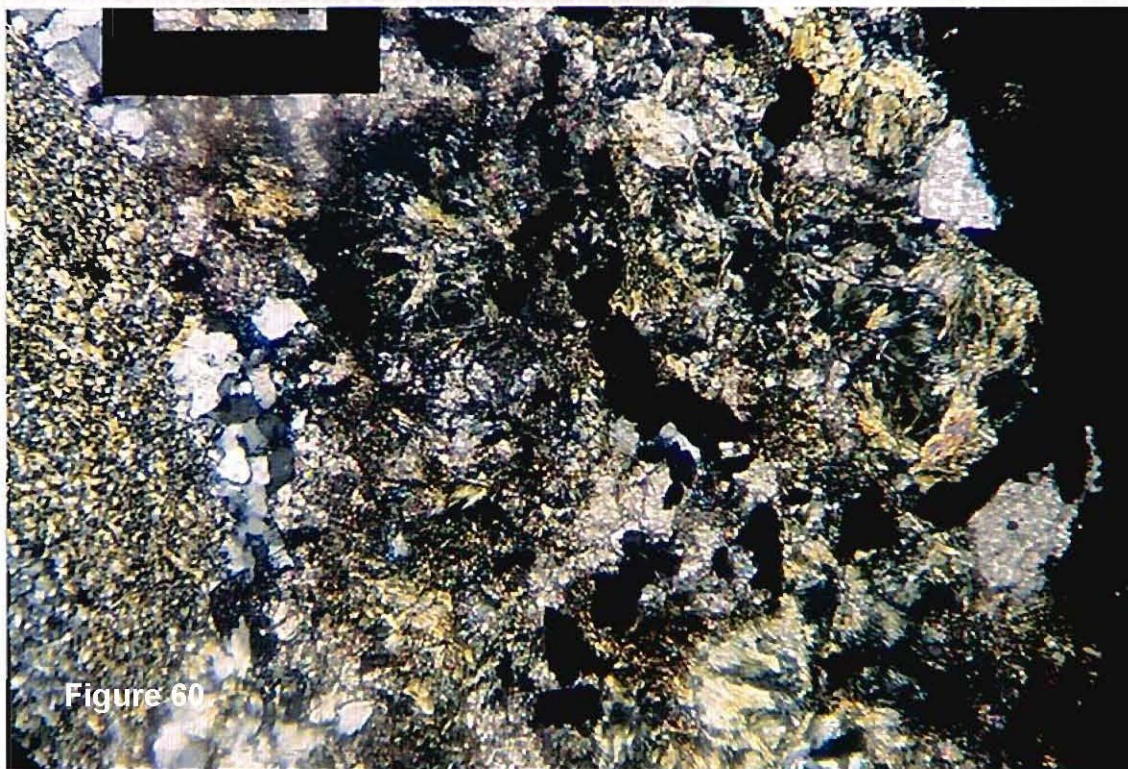
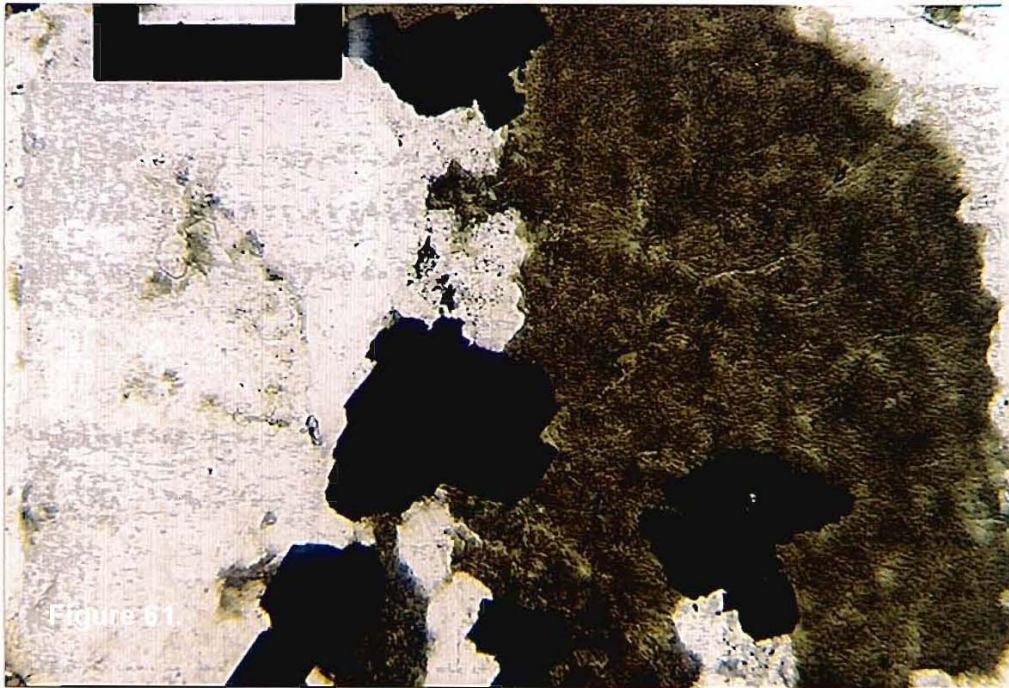


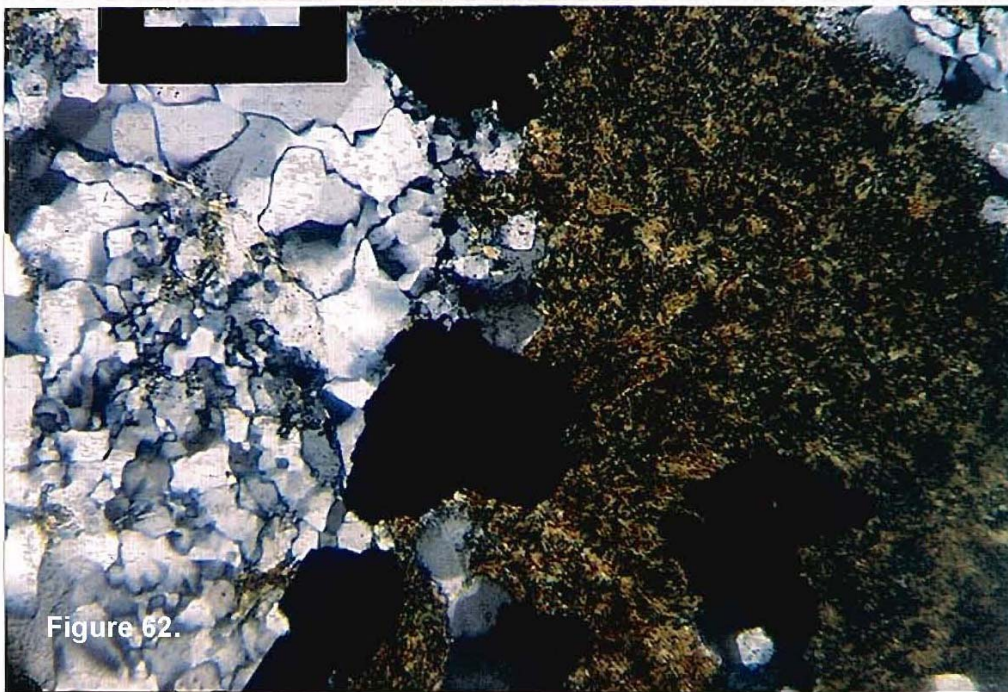
Figure 60

Polarized light, Mag.170X  
Shows birefringence of Stilpnomelane, Carbonate, and Quartz

Stilpnomelane, Quartz, Magnetite  
Thin section No.1599, DH17695, 124 ft., LC2



Plane light, Mag.170X  
Fine grained Stilpnomelane as fabric in Quartz, scattered Magnetite



Polarized light, Mag.170X  
Shows birefringence of Stilpnomelane and Quartz

Stilpnomelane, Quartz  
Thin section No.1599, DH17695, 124 ft., LC2

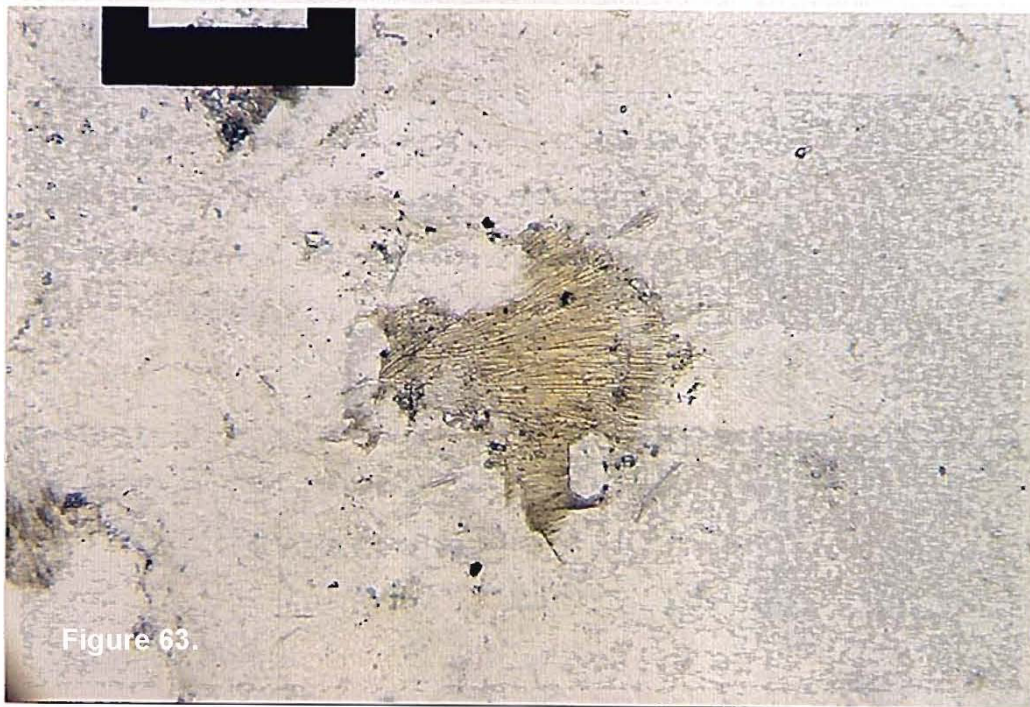


Figure 63.

Plane light, Mag.170X  
Elongated Stilpnomelane crystals in a fan shaped aggregate in Quartz

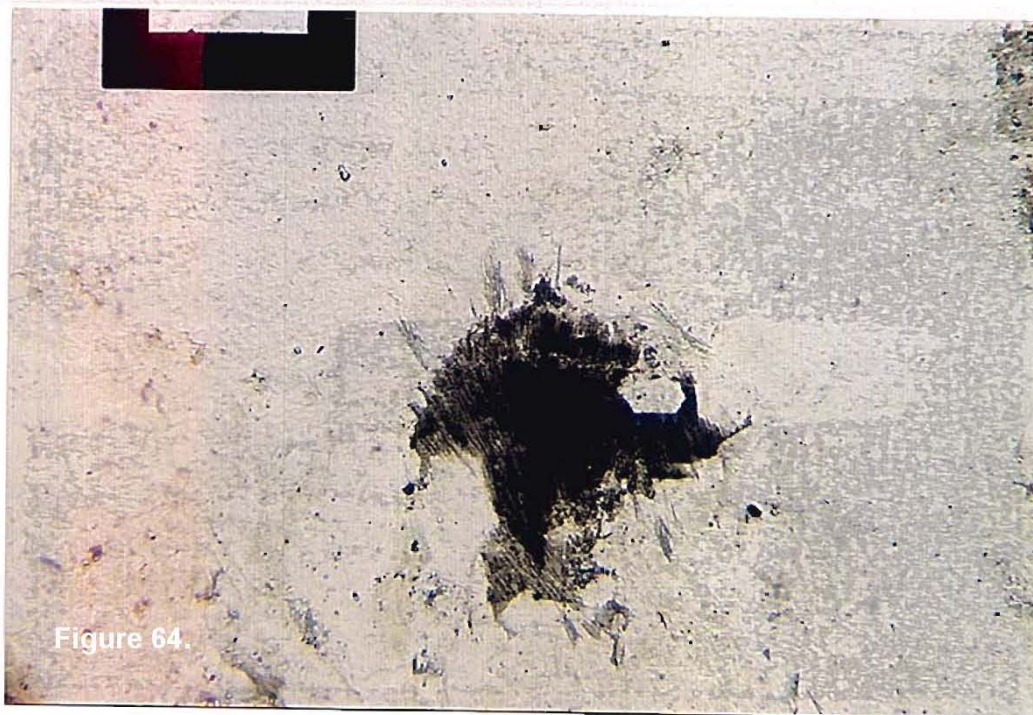


Figure 64.

Plane light, Mag.170X  
Shows pleochroism of Stilpnomelane

Stilpnomelane, Quartz  
Thin section No. 1599, DH17695, 124 ft., LC2

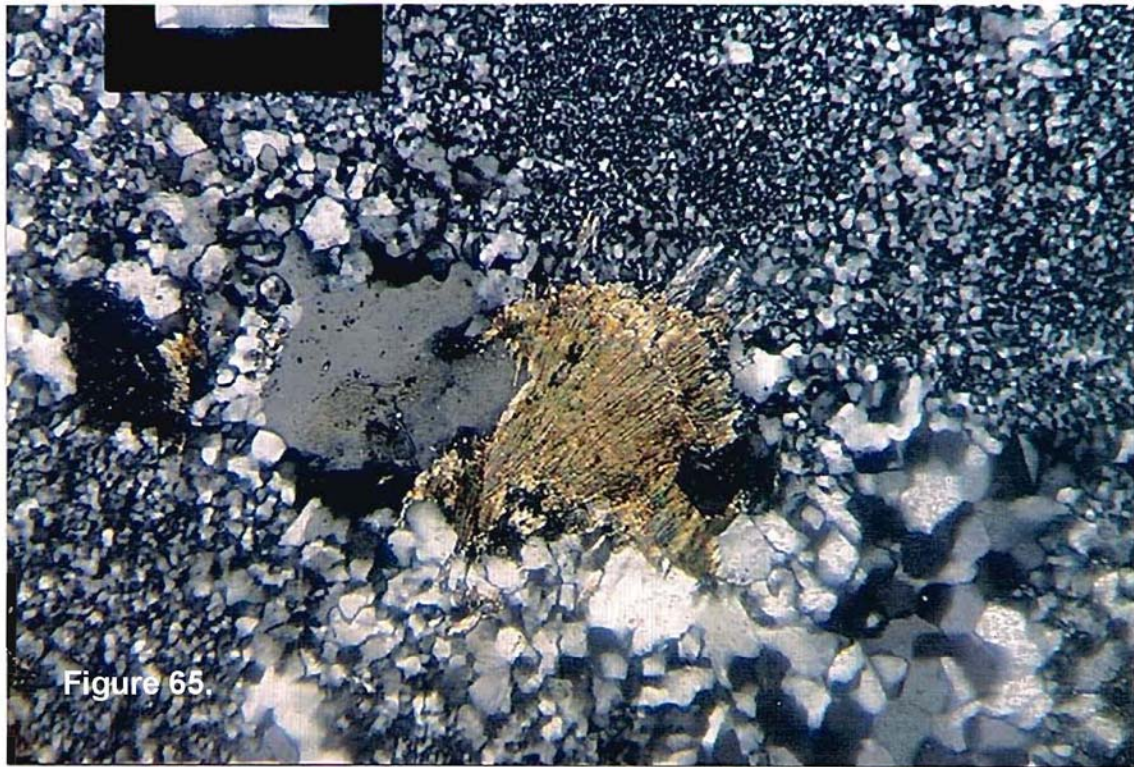


Figure 65.

Polarized light, Mag. 170X  
Shows birefringence of Stilpnomelane and Quartz

Stilpnomelane, Quartz, Fe Oxide  
Thin section No.1663, DH17710, 207 ft., LC2



Figure 66.

Plane light, Mag. 170X  
Stilpnomelane, Quartz, Oxide granules in Quartz

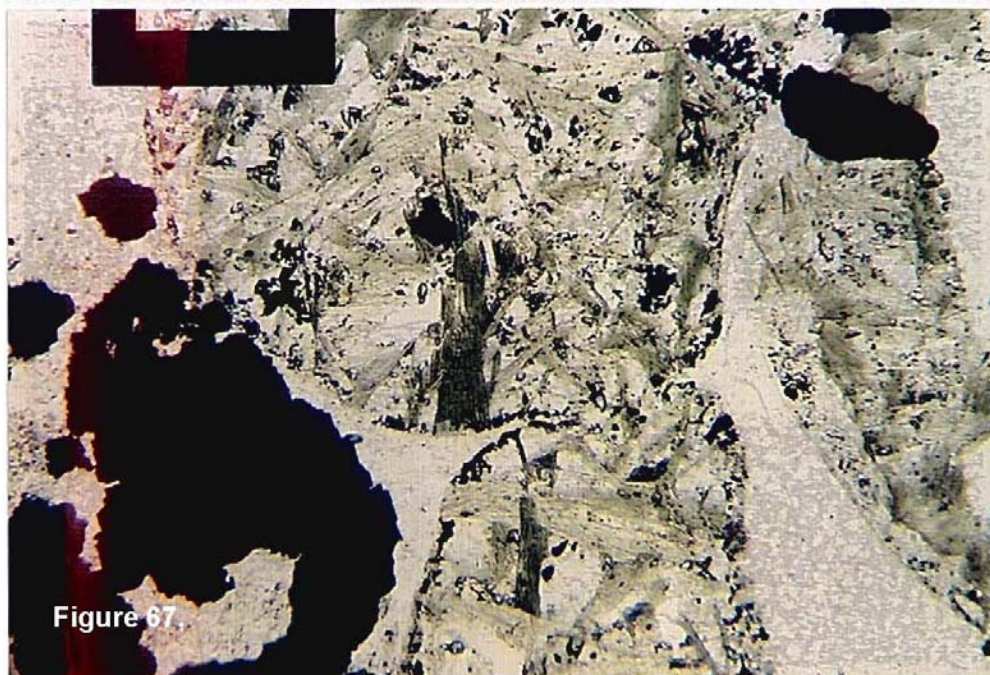
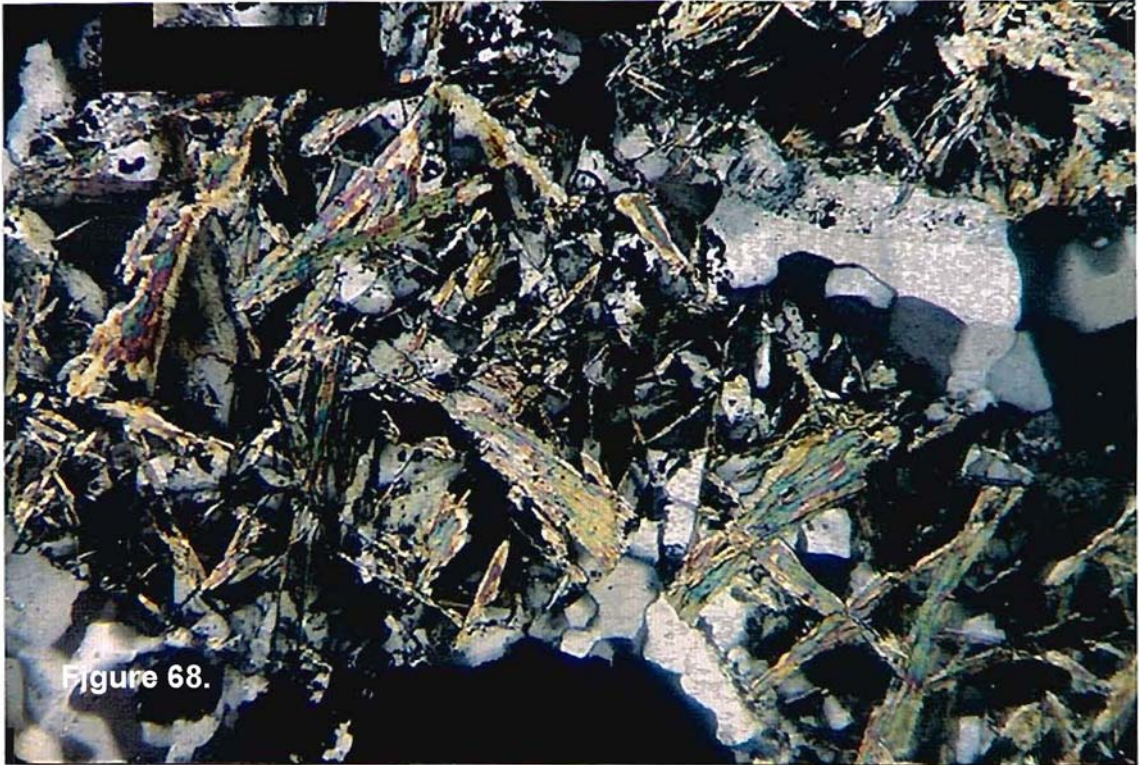


Figure 67.

Plane light, Mag. 170X  
Shows pleochroism of Stilpnomelane



Stilpnomelane, Quartz, Fe Oxide  
Thin section No.1663, DH17710, 207 ft., LC2



Polarized light, Mag.170X  
Shows birefringence of Stilpnomelane and Quartz

Stilpnomelane, Quartz, Carbonate, Magnetite  
Thin section No.175, DH15187, 685-690 ft., LC2

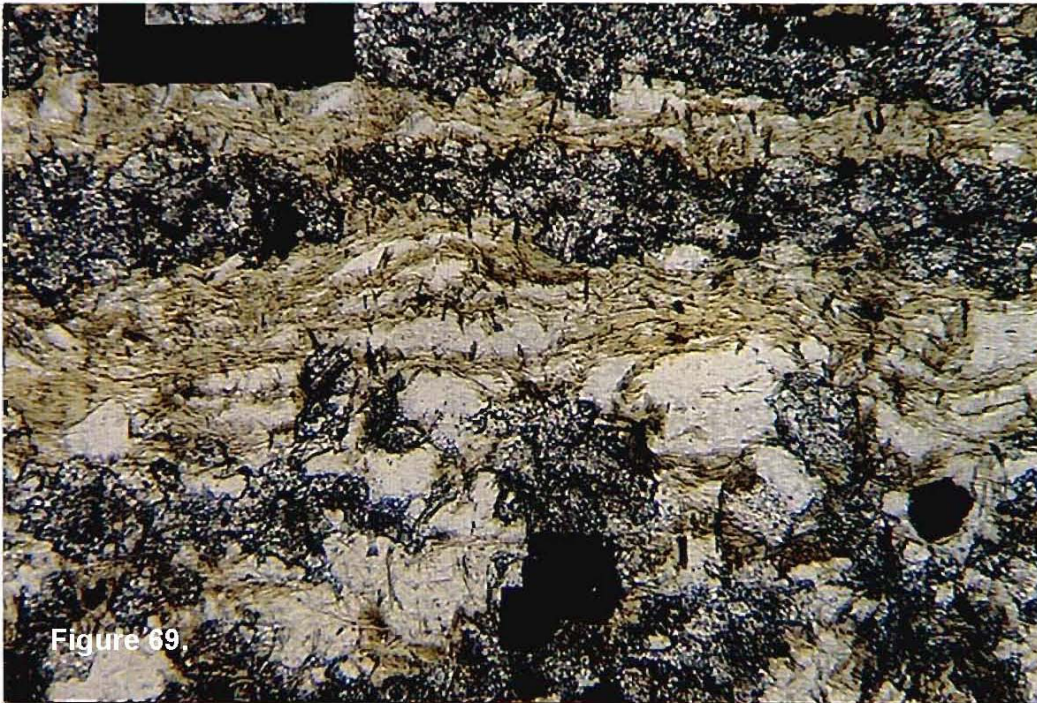


Figure 69

Plane light, Mag.170X  
Thin beds of Stilpnomelane-Quartz and thin Carbonate beds, scattered Magnetite



Figure 70

Plane light, Mag.170X  
Shows pleocroism of Stilpnomelane and change in Carbonate relief

Stilpnomelane, Quartz, Carbonate, Magnetite  
Thin section No.175, DH15187, 685-690 ft., I.C2

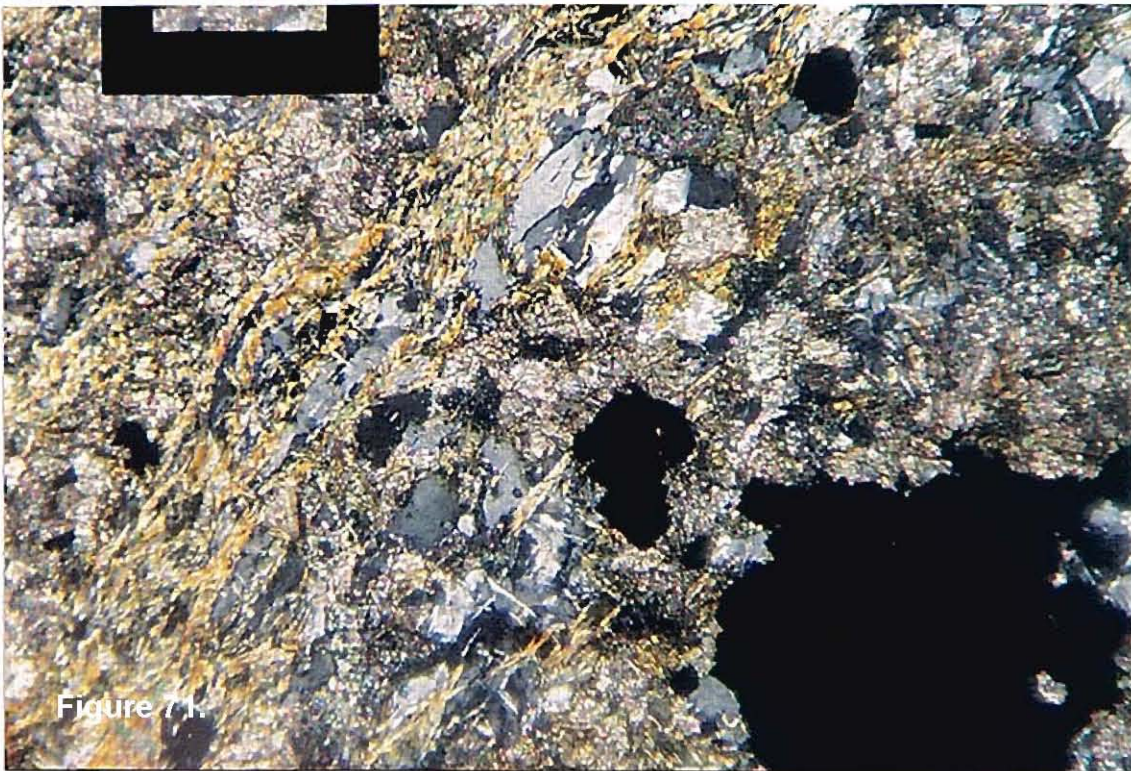


Figure 7.1.

Polarized light, Mag.170X  
Shows birefringence of Stilpnomelane, Quartz, and Carbonate

Stilpnomelane, Quartz, Carbonate, Magnetite  
Thin section No.246, DH15187, 270-275 ft., UC

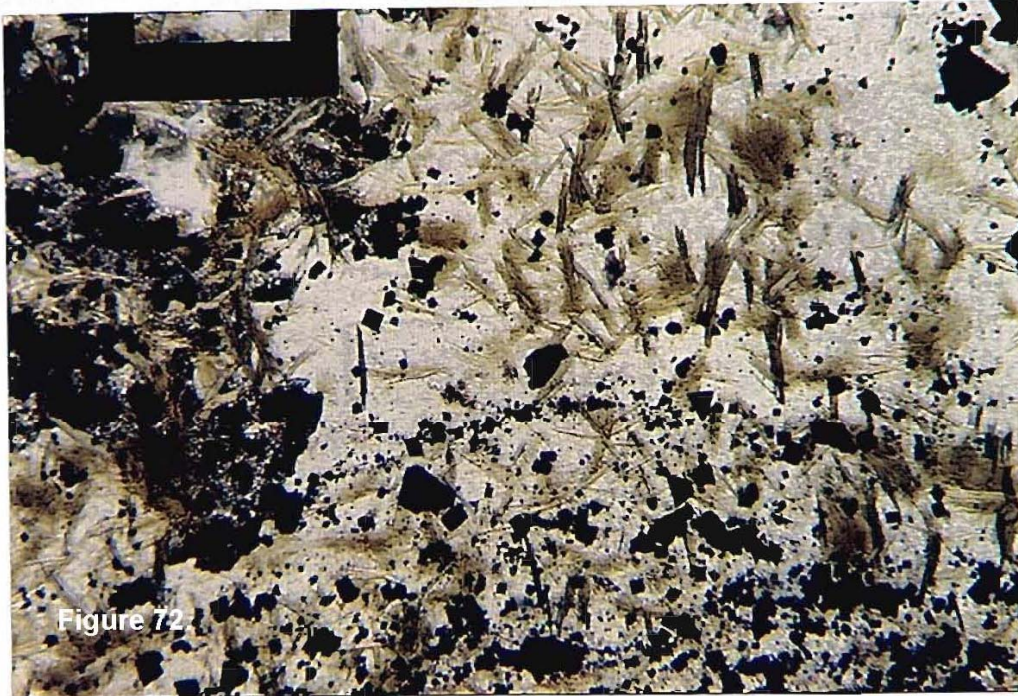


Figure 72

Plane light, Mag.170X  
Scattered Stilpnomelane, Magnetite, and Carbonate in Chert

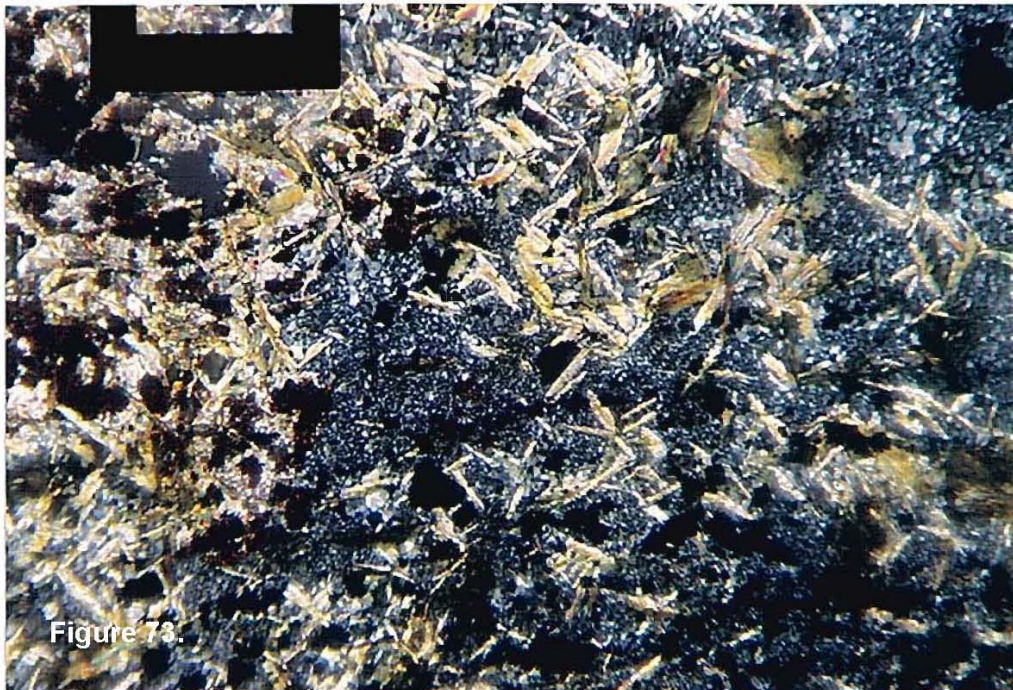


Figure 73

Polarized light, Mag. 170X  
Shows birefringence of Stilpnomelane, Chert, and Carbonate

Greenalite, Stilpnomelane, Quartz  
Thin section No. 712, DH8414(Hibbing District), 129-134 ft.



Figure 74

Plane light, Mag. 274X  
Granules of Greenalite, Stilpnomelane, and Quartz

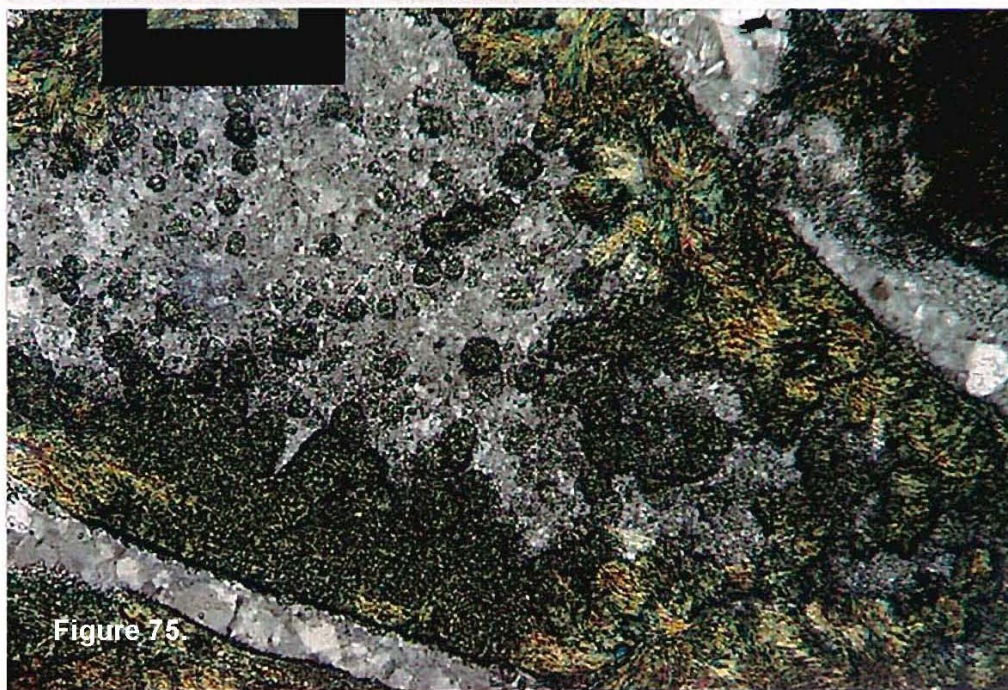
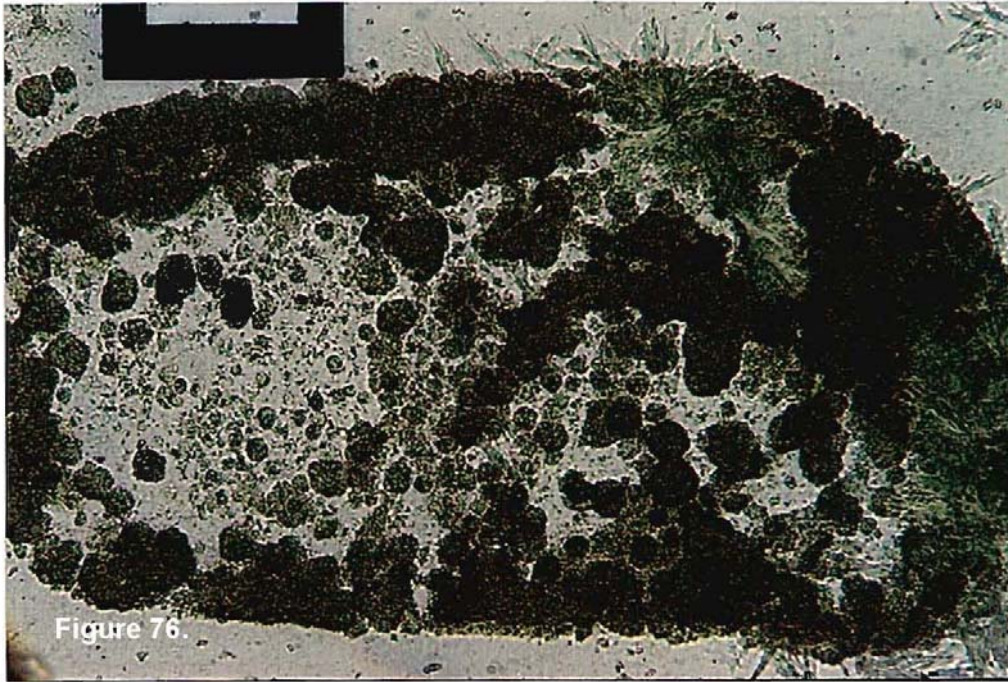


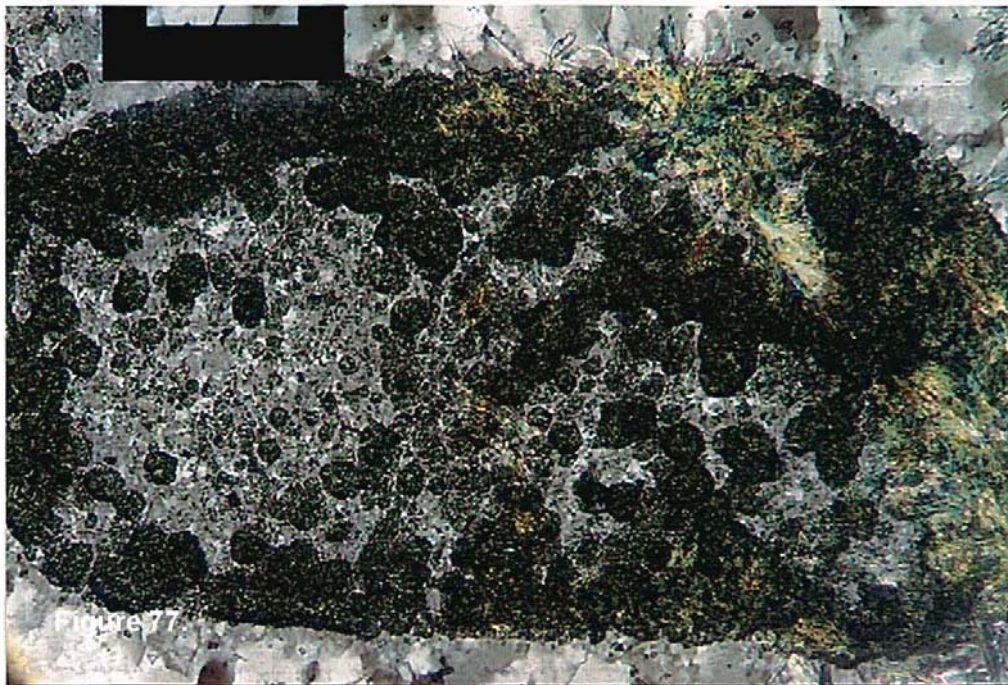
Figure 75

Polarized light, Mag. 274X  
Shows birefringence of Stilpnomelane and Quartz, very fine grains of Greenalite appear almost opaque

Greenalite, Stilpnomelane, Quartz  
Thin section No.712, DH8414(Hibbing District), 129-134 ft.



Plane light, Mag.274X  
Granule of Greenalite, Stilpnomelane, and Quartz



Polarized light, Mag. 274X  
Shows birefringence of Stilpnomelane and Quartz, very fine grains of Greenalite  
appear almost opaque

Greenalite, Stilpnomelane, Quartz  
Thin section No.712, DH8414(Hibbing District), 129-134 ft.

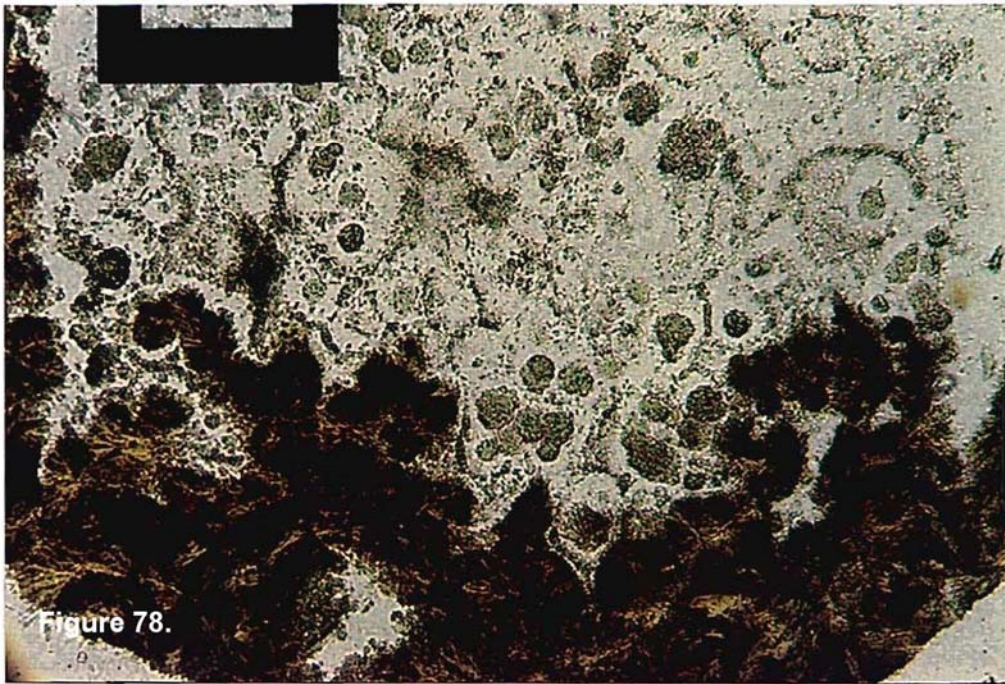


Figure 78.

Plane light, Mag.274X

Part of a granule of Greenalite grains, Stilpnomelane (high in ferric iron), and Quartz

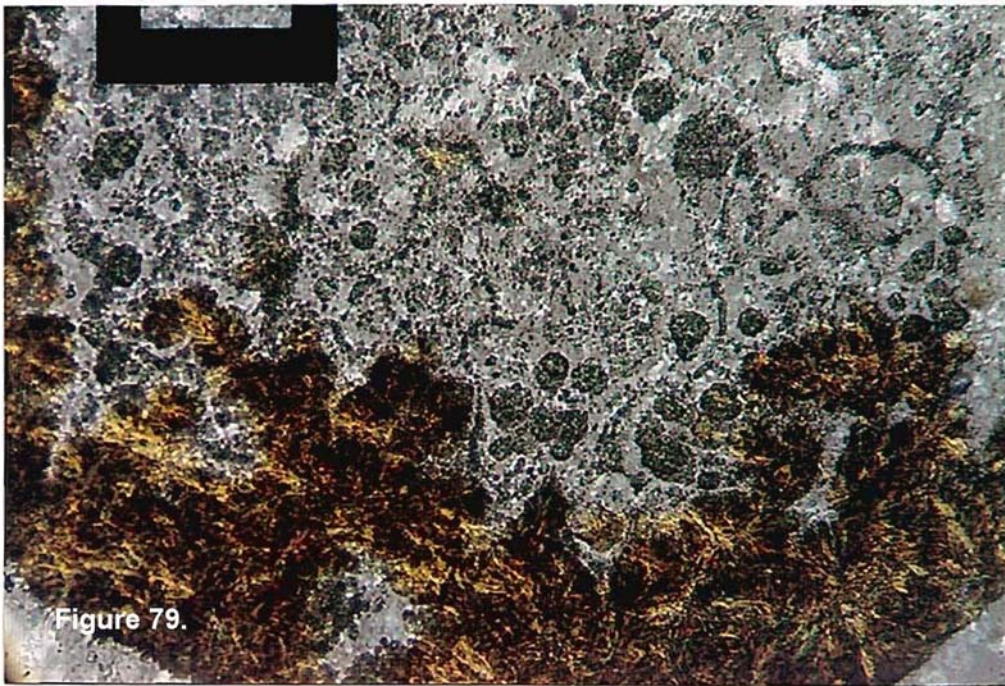
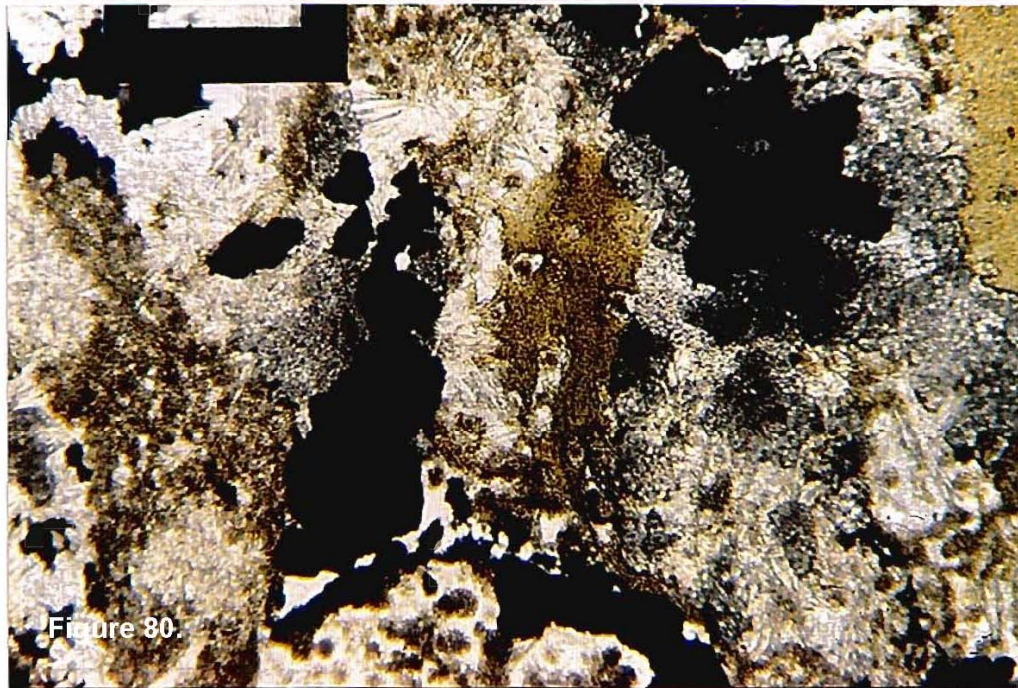


Figure 79.

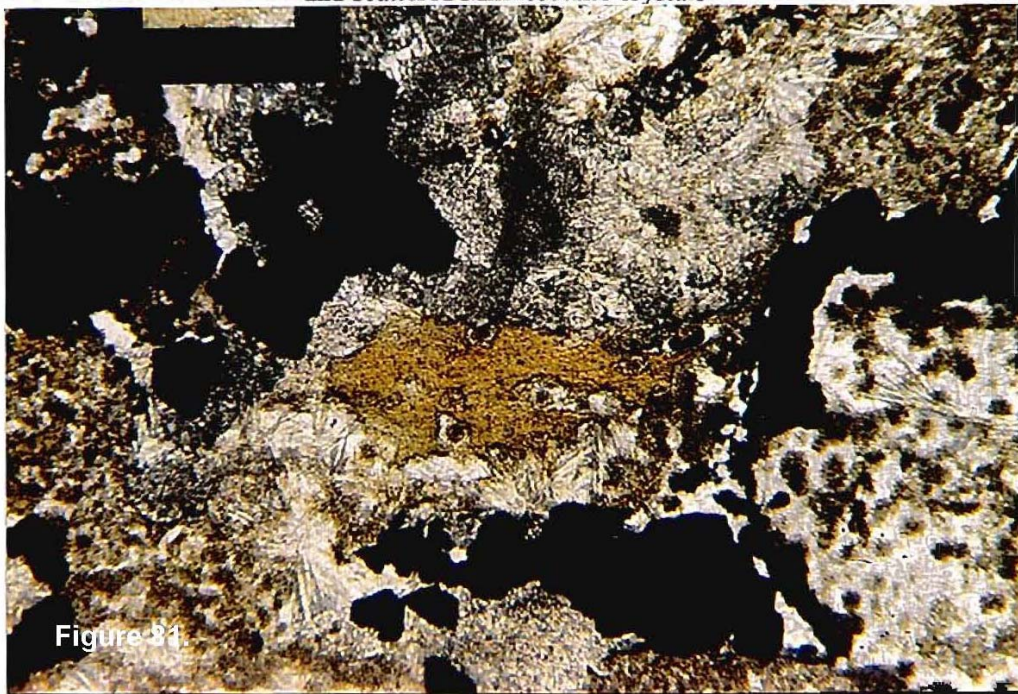
Polarized light, Mag. 274X

Shows birefringence of Stilpnomelane (yellow to brown) and Quartz, grains of Greenalite are composed of very fine crystals

Greenalite, Stilpnomelane, Minnesotaite, Magnetite, Carbonate, Quartz  
Thin section No.1639, DH17710, 118 ft., LC4



Plane light, Mag.170X  
Greenalite grains, Stilpnomelane (center), Carbonate, euhedral Magnetite,  
and scattered Minnesotaite crystals



Plane light, Mag. 170X  
Shows pleochroism of Stilpnomelane and Carbonate relief



Greenalite, Stilpnomelane, Minnesotaite, Magnetite, Carbonate, Quartz  
Thin section No.1639, DH17710, 118 ft., LC4

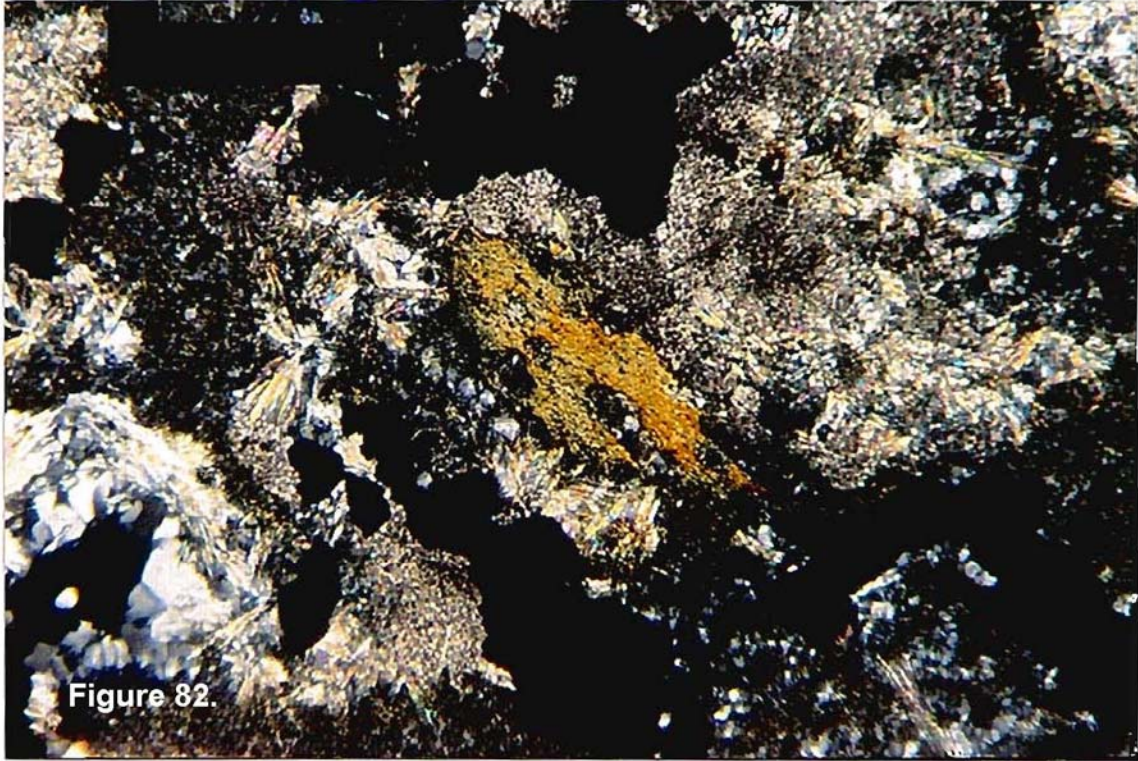
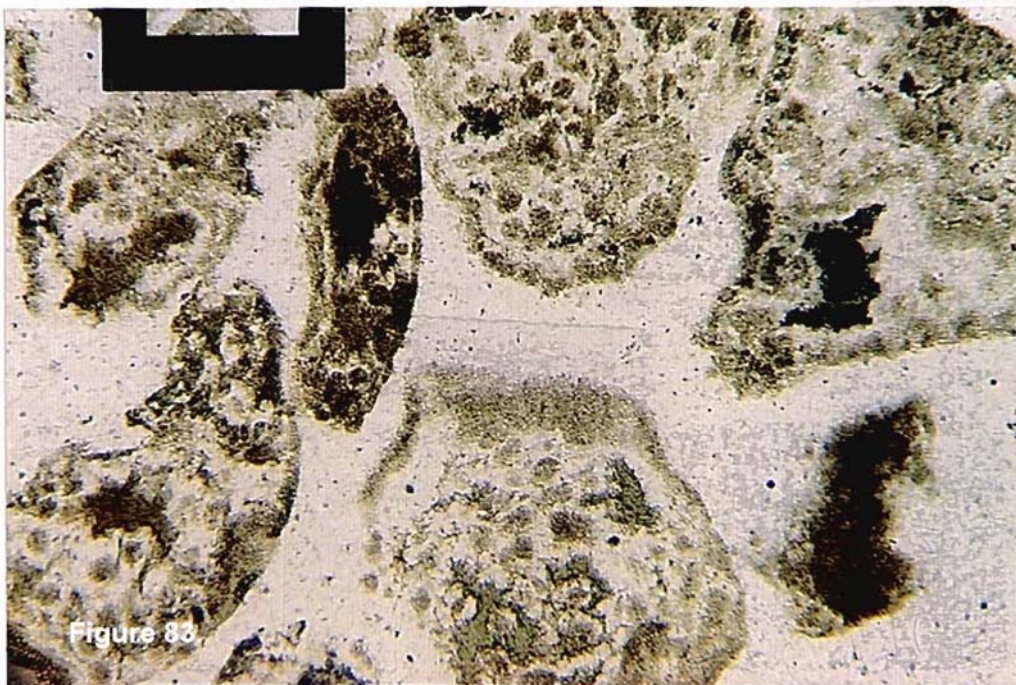


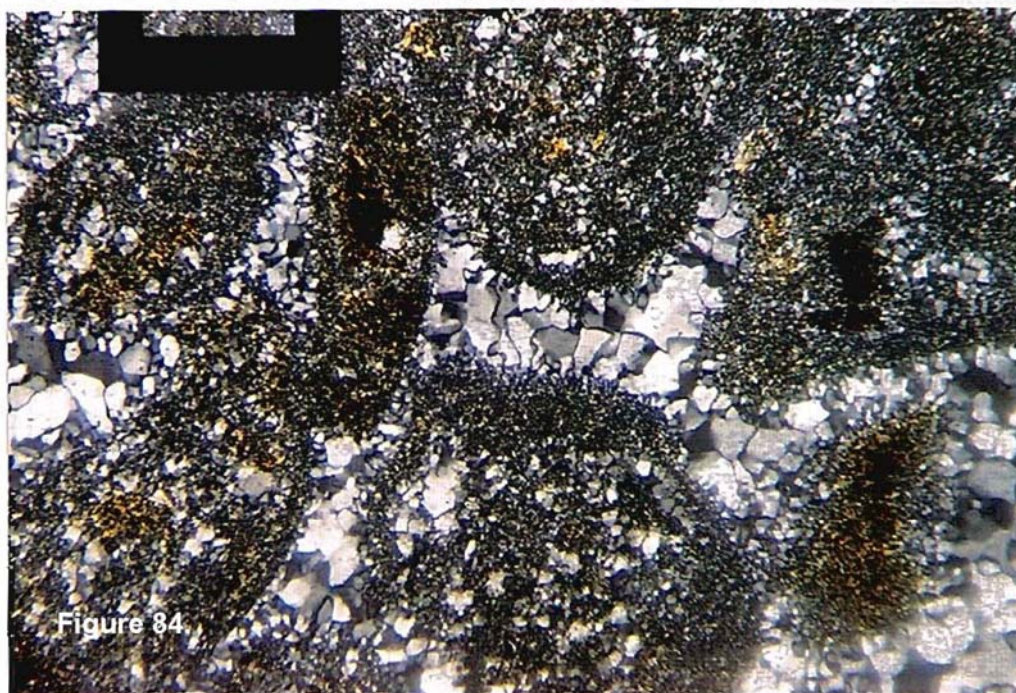
Figure 82.

Polarized light, Mag. 170X  
Shows birefringence of Stilpnomelane, Carbonate, Minnesotaite, and Quartz,  
nearly opaque Greenalite

Greenalite, Stilpnomelane, Quartz  
Thin section No.351, DH17001, 172 ft., LC3

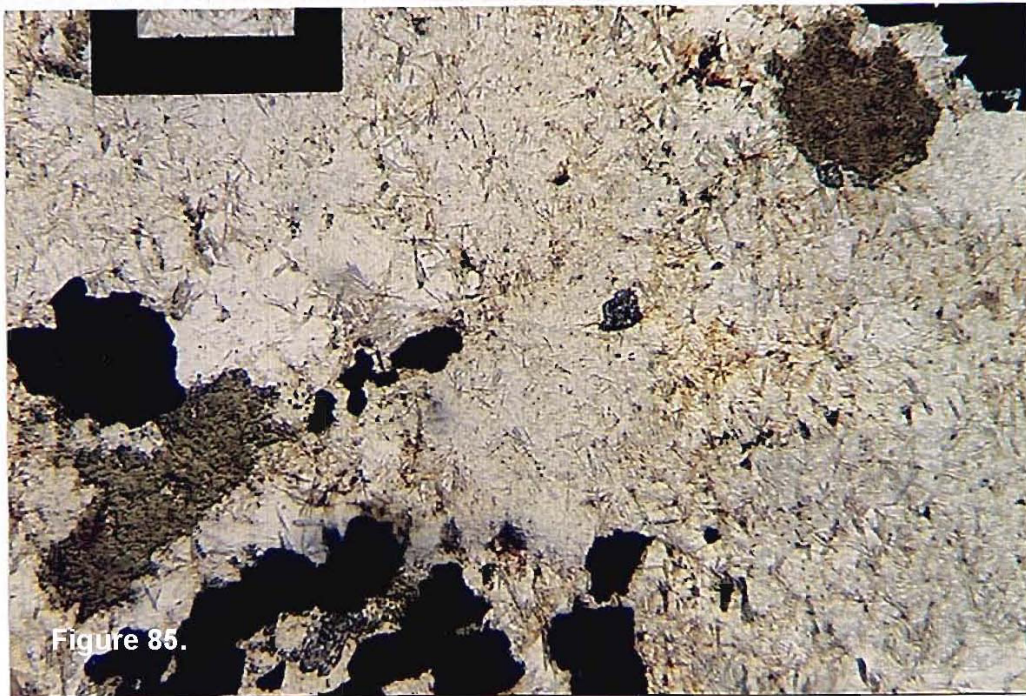


Plane light, Mag. 170X  
Chert granules with Greenalite and Stilpnomelane in coarser Quartz



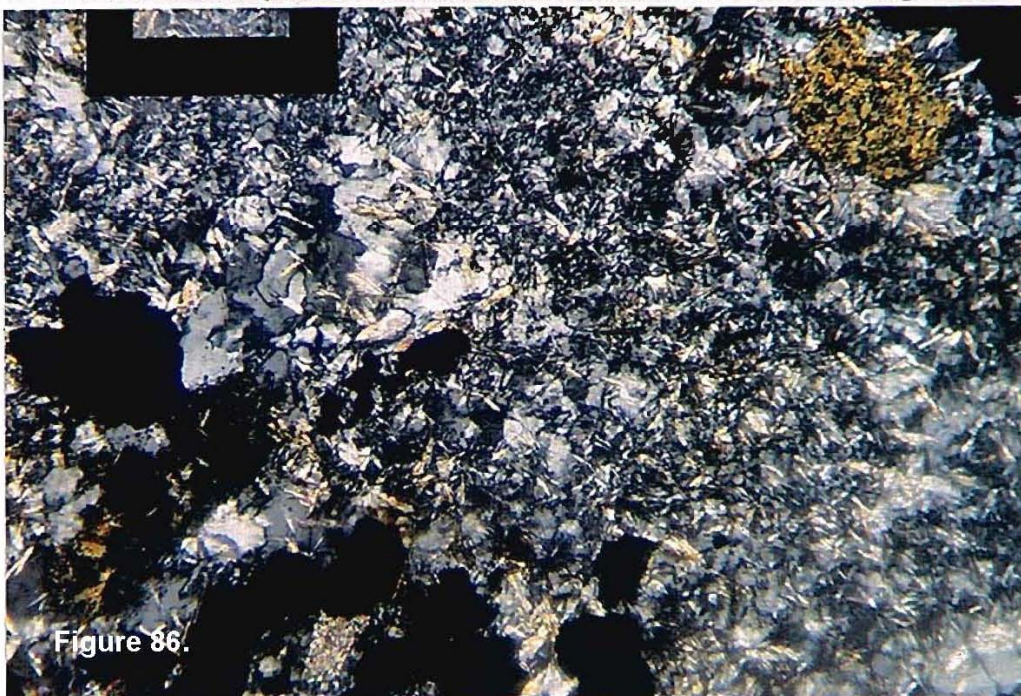
Polarized light, Mag. 170X  
Shows birefringence of Stilpnomelane and Quartz, Greenalite grains consist  
of very fine crystals and appear nearly opaque

Greenalite, Stilpnomelane, Quartz, Magnetite, Minnesotaite  
Thin section No.176, DH15187, 690-695 ft., LC2



Plane light, Mag. 170X

Stilpnomelane granule(upper right), Greenalite-Stilpnomelane fabric(lower left)  
in a matrix of Quartz and fine acicular Minnesotaite with scattered Magnetite



Polarized light, Mag. 170X

Shows birefringence of Stilpnomelane, Quartz, and Minnesotaite, Greenalite  
appears opaque

Chlorite, Quartz, Magnetite  
Thin section No.264, DH8810, 92-97 ft.

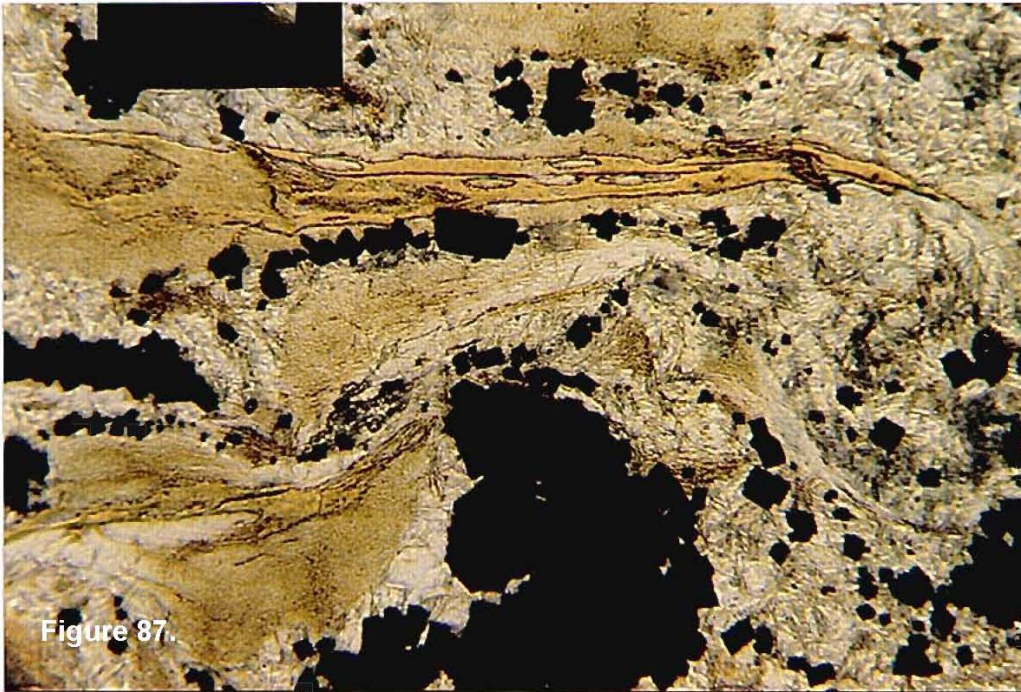


Figure 87.

Plane light, Mag.170

Elongated crystalline Chlorite and Chlorite fabric and euhedral Magnetite in Quartz matrix

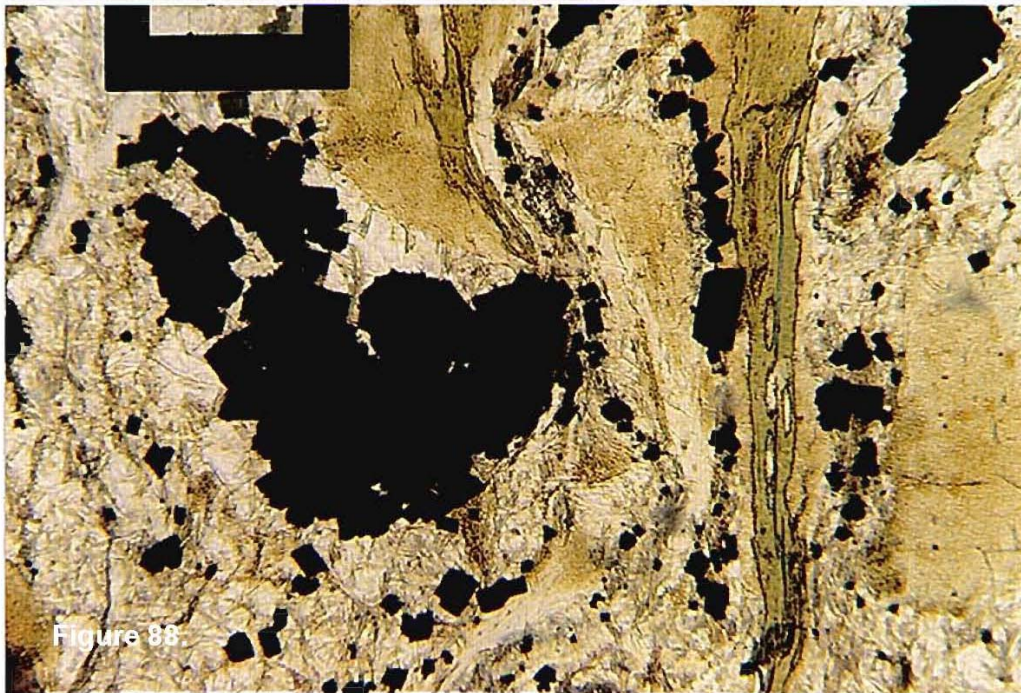
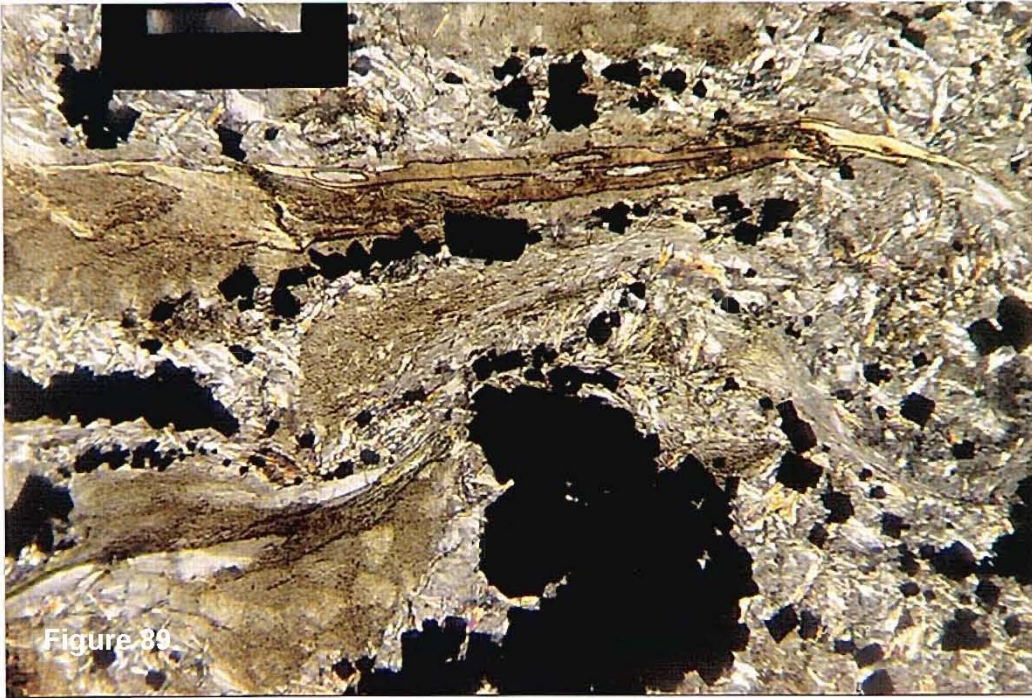


Figure 88

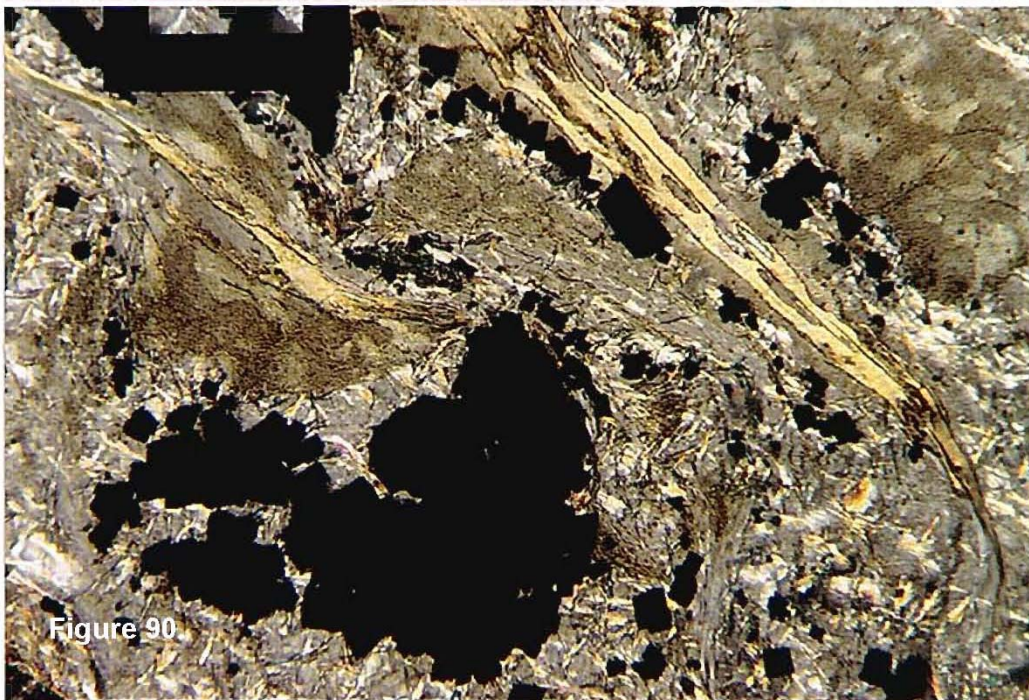
Plane light, Mag. 170X

Shows pleochroism of crystalline Chlorite

Chlorite, Quartz, Magnetite  
Thin section No.264, DH8810, 92-97 ft.



Polarized light, Mag. 170  
Shows extinction of elongated crystalline Chlorite



Polarized light, Mag. 170X  
Shows low birefringence of crystalline and fabric Chlorite

Chlorite, Quartz, Fe Oxides  
Thin section No.973, No Location Available



Figure 98:

Plane light, Mag. 170  
Shows elongated crystalline Chlorite

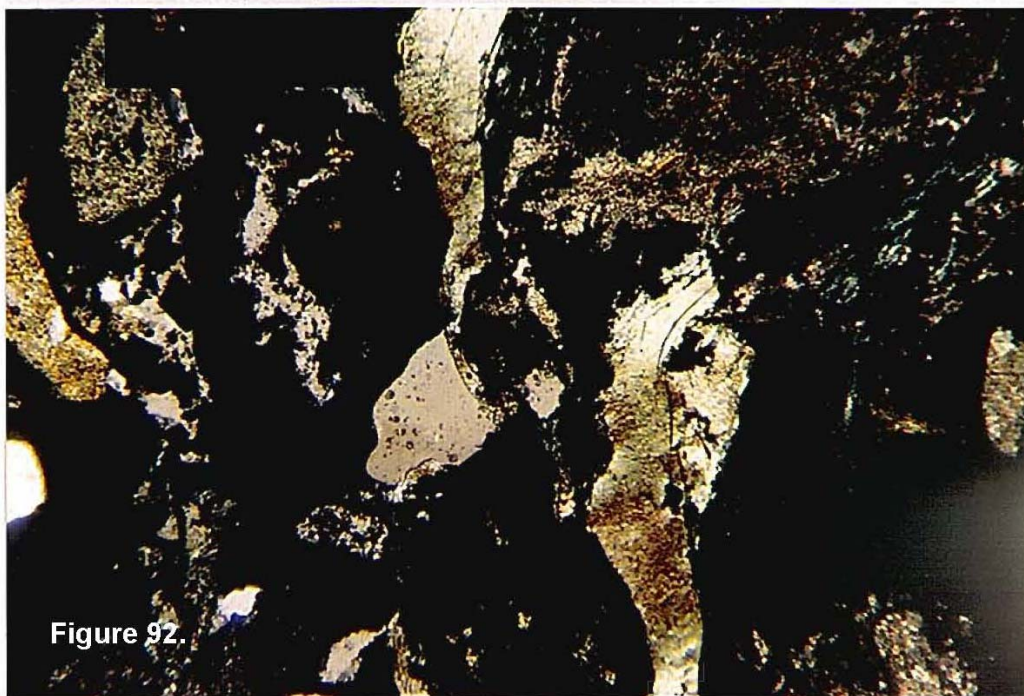


Figure 92:

Polarized light, Mag. 170X  
Shows low birefringence of crystalline Chlorite and Quartz

Chlorite, Clastic Quartz, Carbonate  
Thin section No. 192, DH15187, 770-775 ft., LC1



Figure 93.

Plane light, Mag. 170

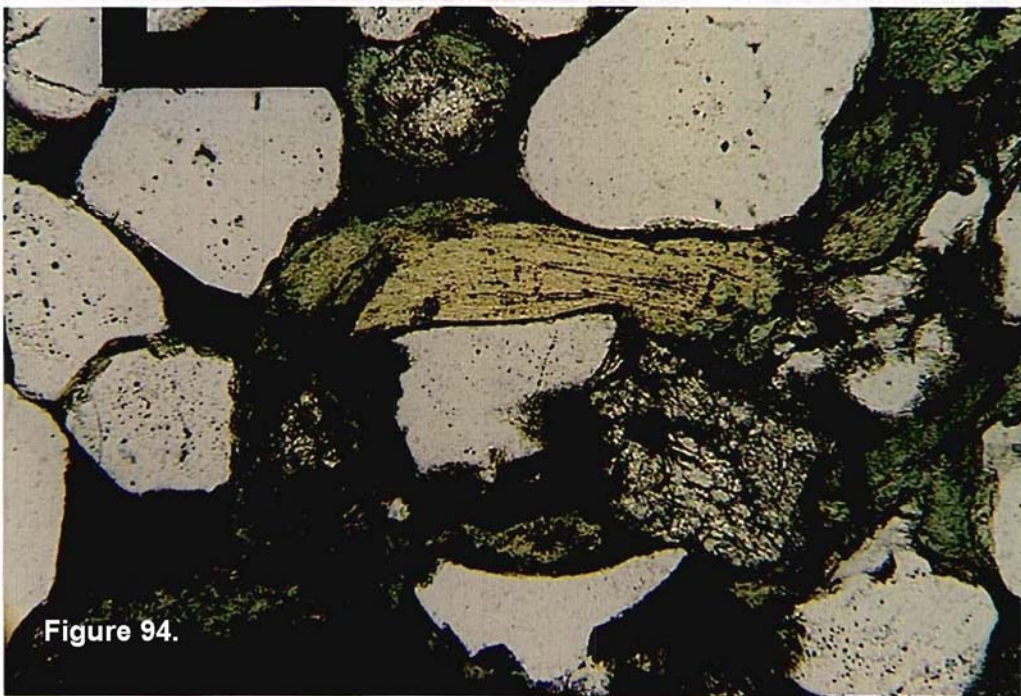


Figure 94.

Plane light, Mag. 170X  
Shows pleochroism of Chlorite and Carbonate relief

Chlorite, Clastic Quartz  
Thin section No.192, DH15187, 770-775 ft., LC1



Figure 95.

Plane light, Mag. 170  
Shows pleocroism of Chlorite at different orientations

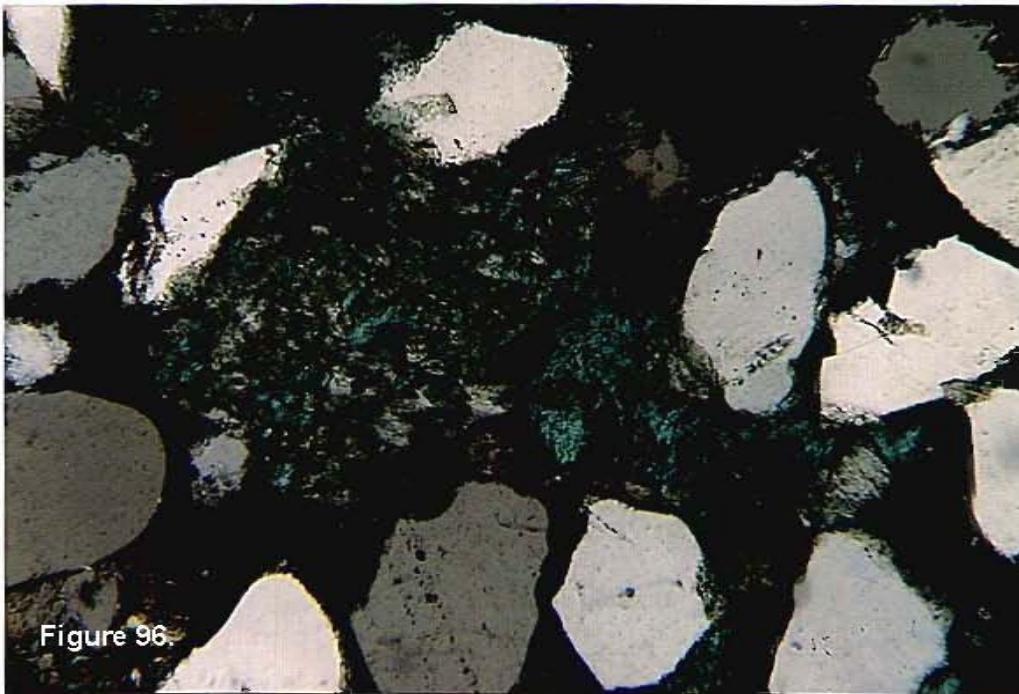
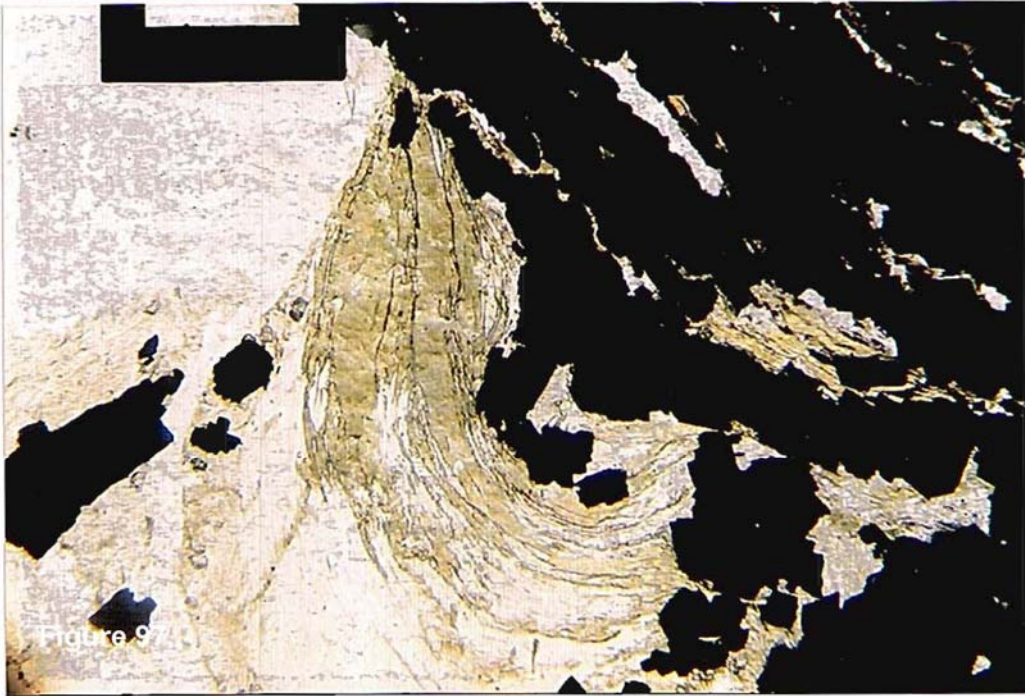


Figure 96.

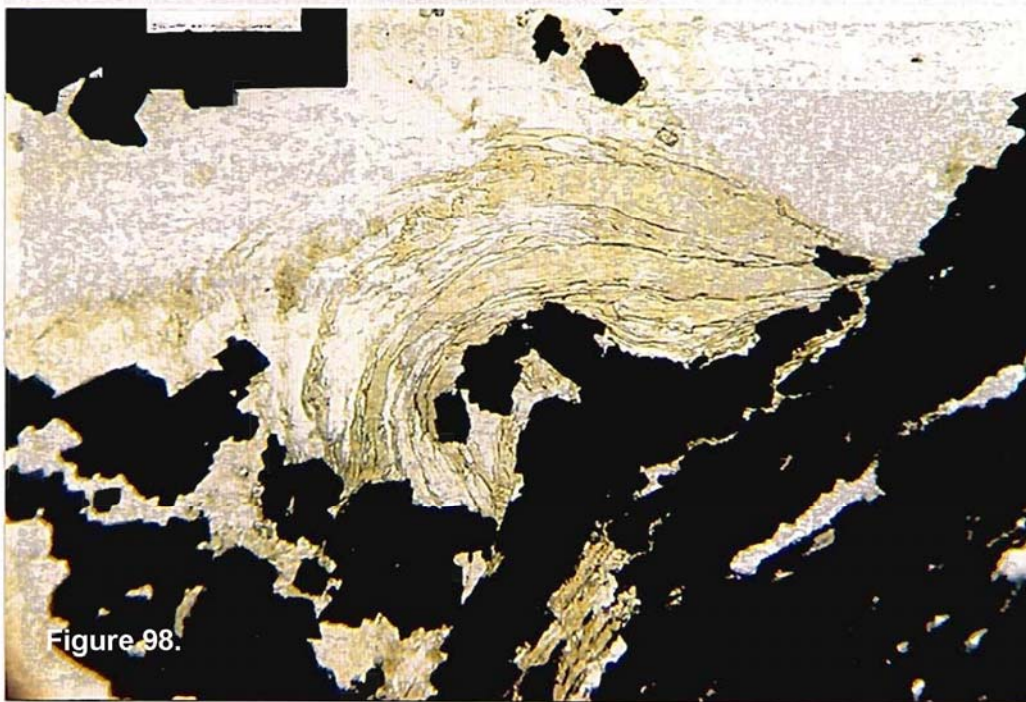
Polarized light, Mag. 170X  
Shows birefringence of Chlorite and Quartz and anomalous interference colors in Chlorite



Chlorite, Quartz, Magnetite  
Thin section No.1064, DH20016, 422-433 ft., LC3

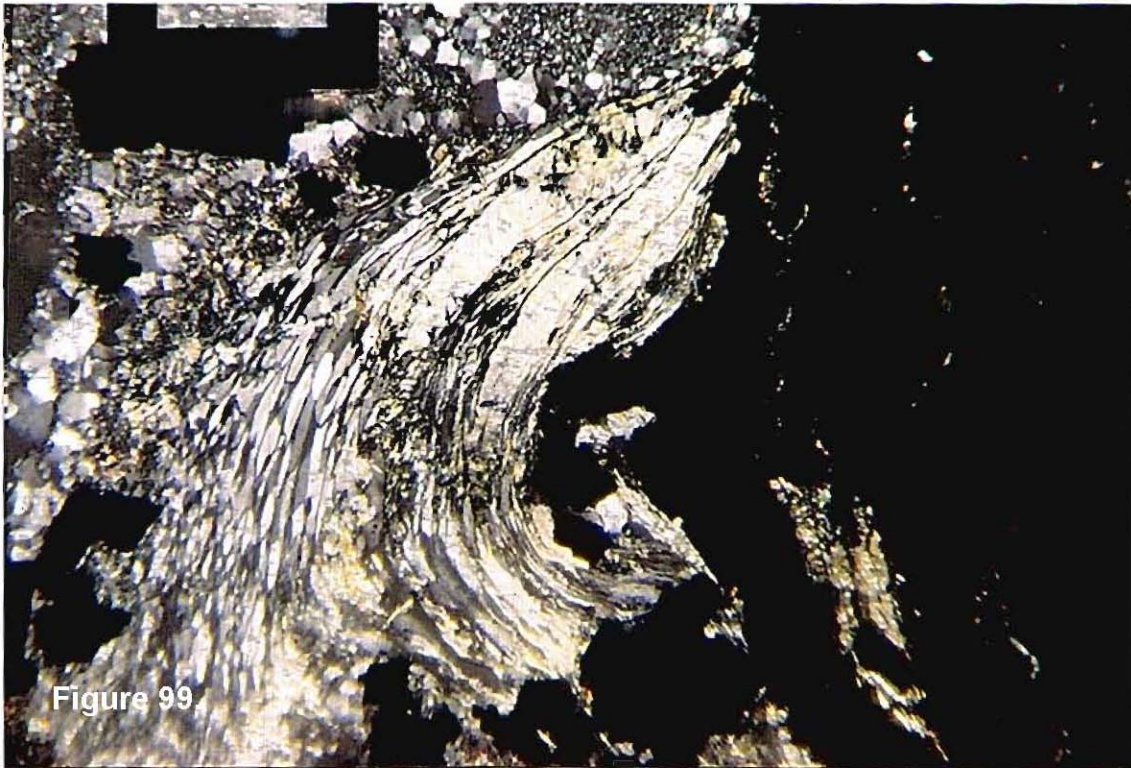


Plane light, Mag. 170  
Shows pleochroism of Chlorite at different orientations



Plane light, Mag. 170X  
Also shows pleochroism of Chlorite

Chlorite, Quartz, Magnetite  
Thin section No.1064, DH20016, 422-433 ft., LC3



Polarized light, Mag.170  
Shows the very low birefringence of Chlorite

Chlorite, Stilpnomelane, Quartz, Magnetite  
Thin section No.178, DH15187, 700-705 ft., LC2

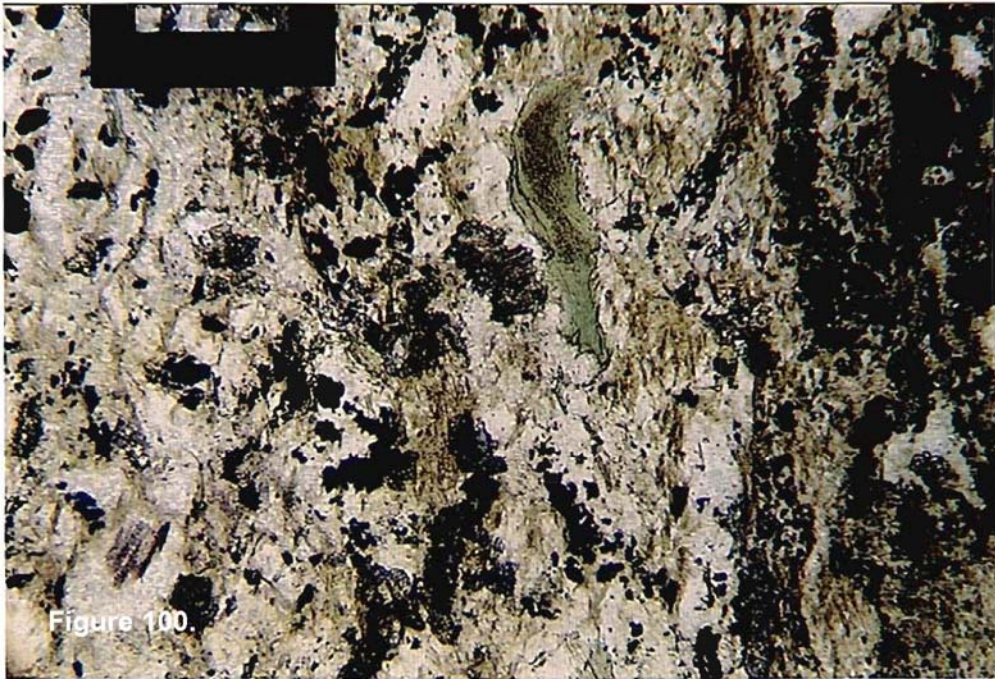


Figure 100.

Plane light, Mag. 170

Shows green Chlorite, brown, acicular, Stilpnomelane that is generally parallel to the Magnetite banding and the elongated Chlorite

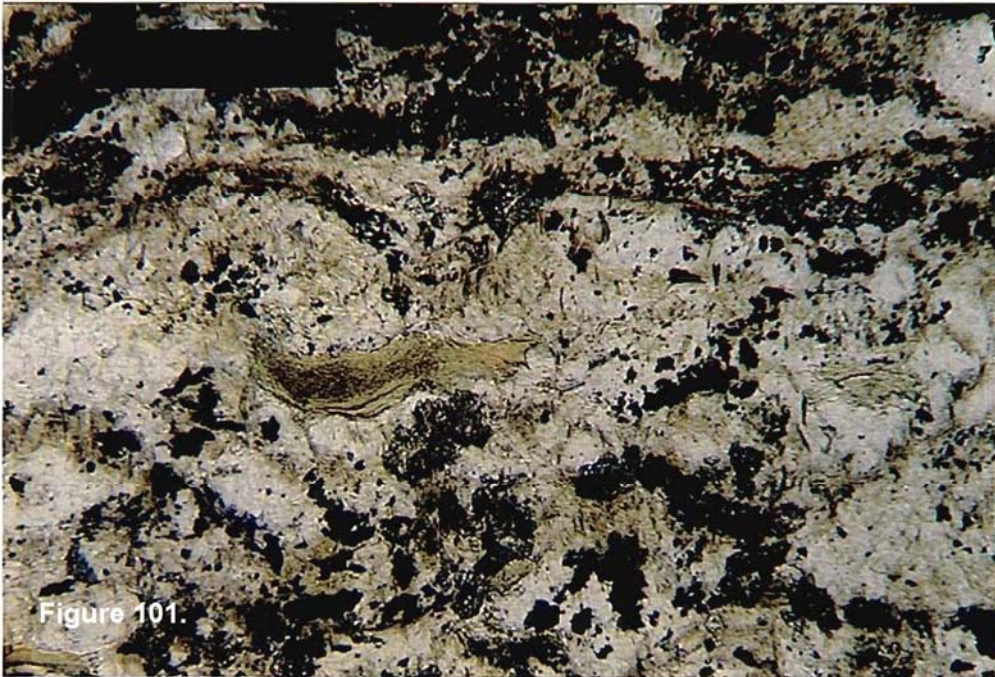


Figure 101.

Plane light, Mag. 170X

Shows pleochroism of Chlorite and Stilpnomelane

Chlorite, Stilpnomelane, Quartz, Magnetite  
Thin section No.178, DH15187, 700-705 ft., LC2

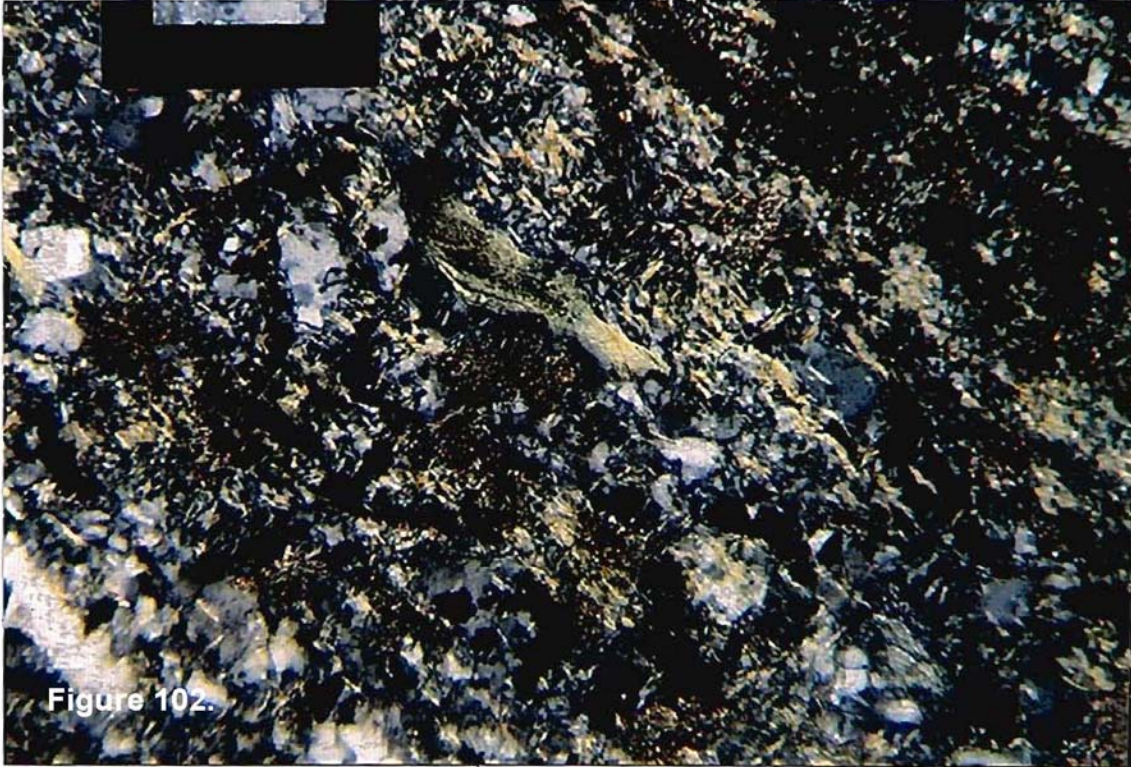


Figure 102.

Polarized light, Mag.170  
Shows birefringence of Chlorite, Stilpnomelane, and Quartz

Chlorite, Stilpnomelane, Clastic Quartz  
Thin section No.195, DH15187, 785-790 ft., LC1

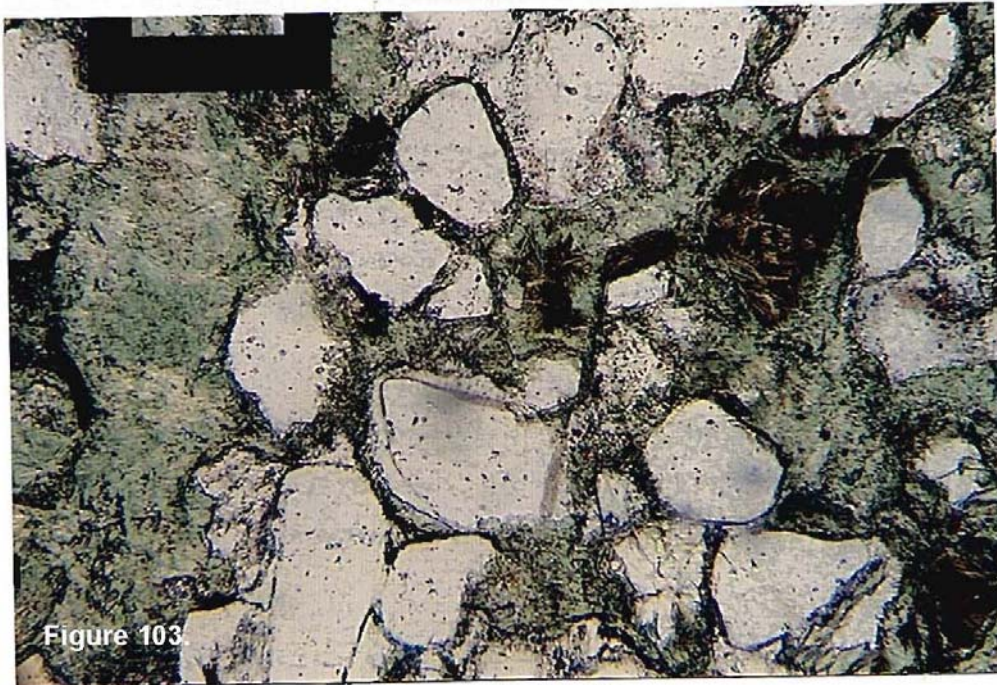


Figure 103

Plane light, Mag. 170

Shows clastic Quartz grains and brown Stilpnomelane in a matrix of green Chlorite

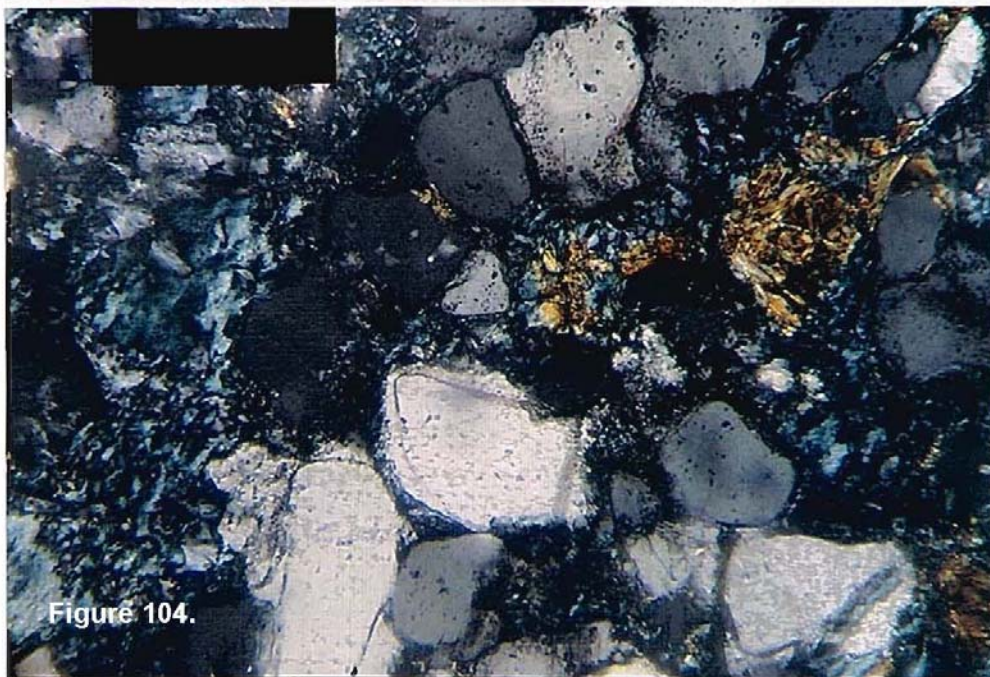


Figure 104.

Polarized light, Mag. 170X

Shows birefringence of Chlorite, Quartz, and Stilpnomelane

Chlorite, Stilpnomelane, Clastic Quartz, Carbonate  
Thin section No.196, DH15187, 790-798 ft., LC1

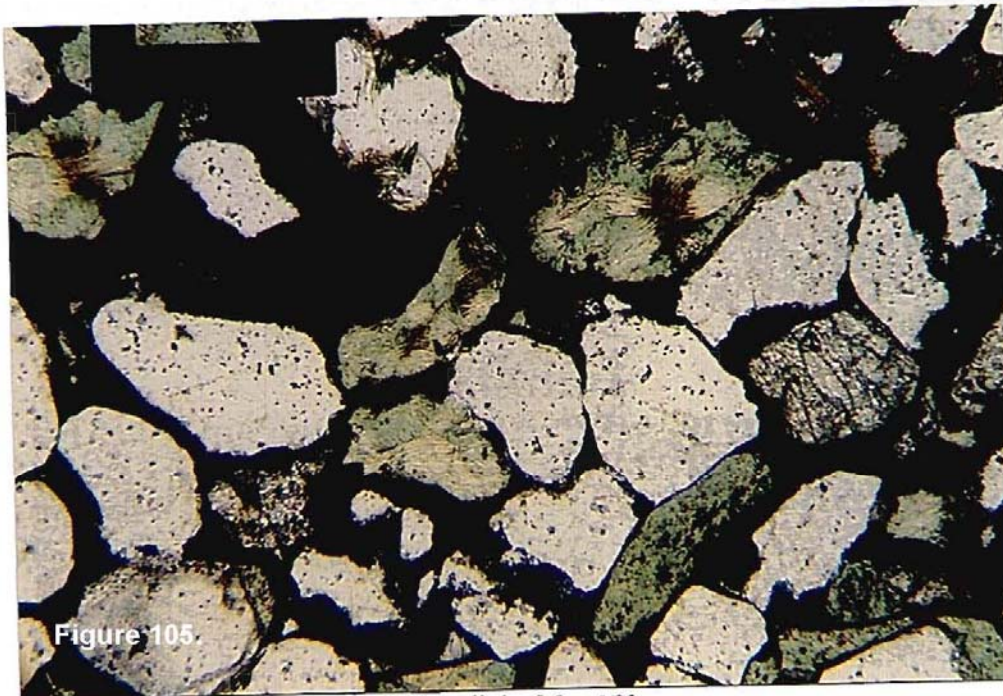


Figure 105.

Plane light, Mag.170

Shows clastic Quartz grains, bundles of acicular brown Stilpnomelane, green Chlorite and a Carbonate grain all in a black matrix

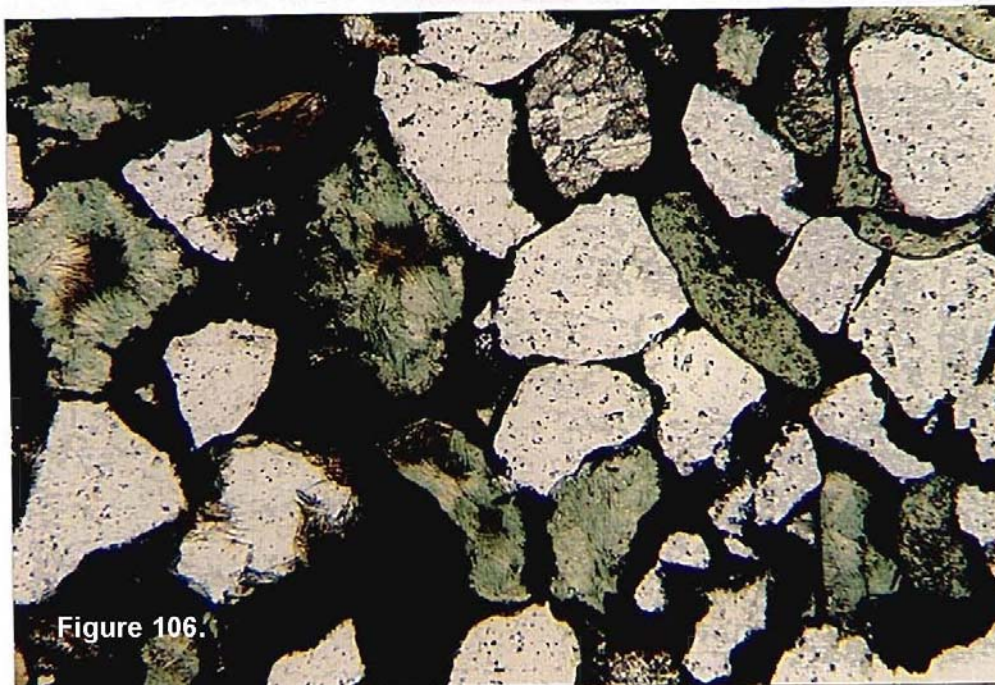


Figure 106.

Plane light, Mag. 170X

Shows pleochroism of Chlorite and Stilpnomelane and Carbonate relief change

Chlorite, Stilpnomelane, Clastic Quartz, Carbonate  
Thin section No. 196, DH15187, 790-798 ft., LC1

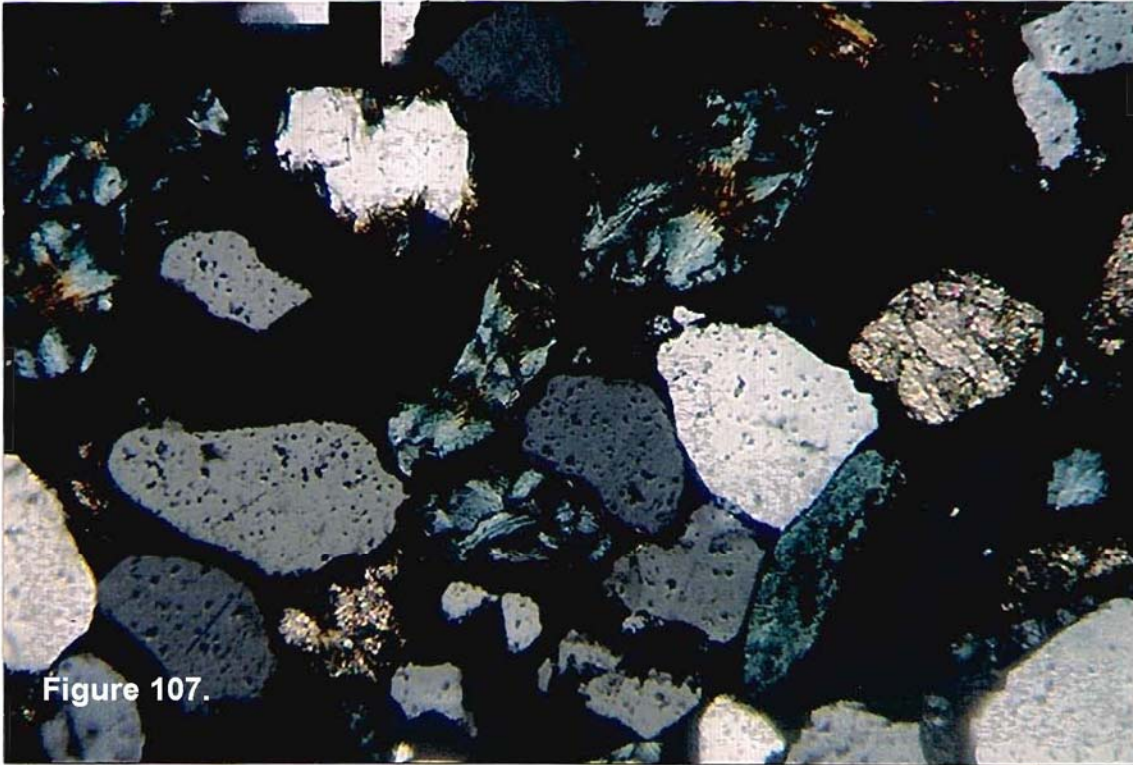


Figure 107.

Polarized light, Mag. 170  
Shows birefringence of Chlorite, Quartz, Stilpnomelane, and Carbonate

Chlorite, Carbonate, Minnesotaite, Magnetite  
Thin section No.5-1, Minntac West Pit, UC-LS Transition Zone

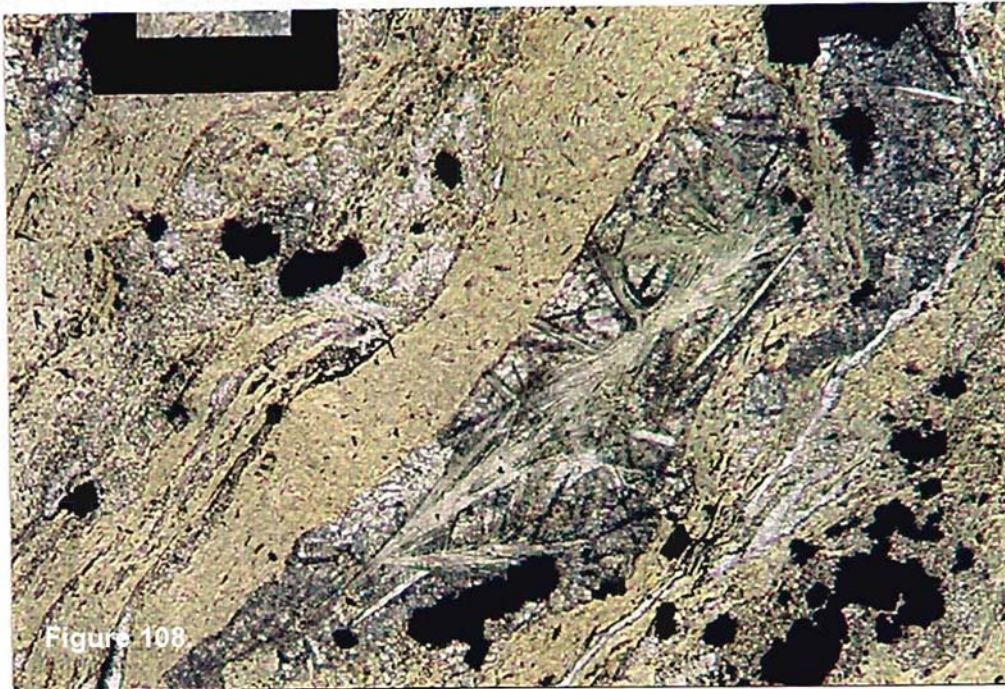


Figure 108

Plane light, Mag.274

Shows Chlorite stringers, acicular Minnesotaite, Carbonate, and slight oxidation staining around some Magnetite

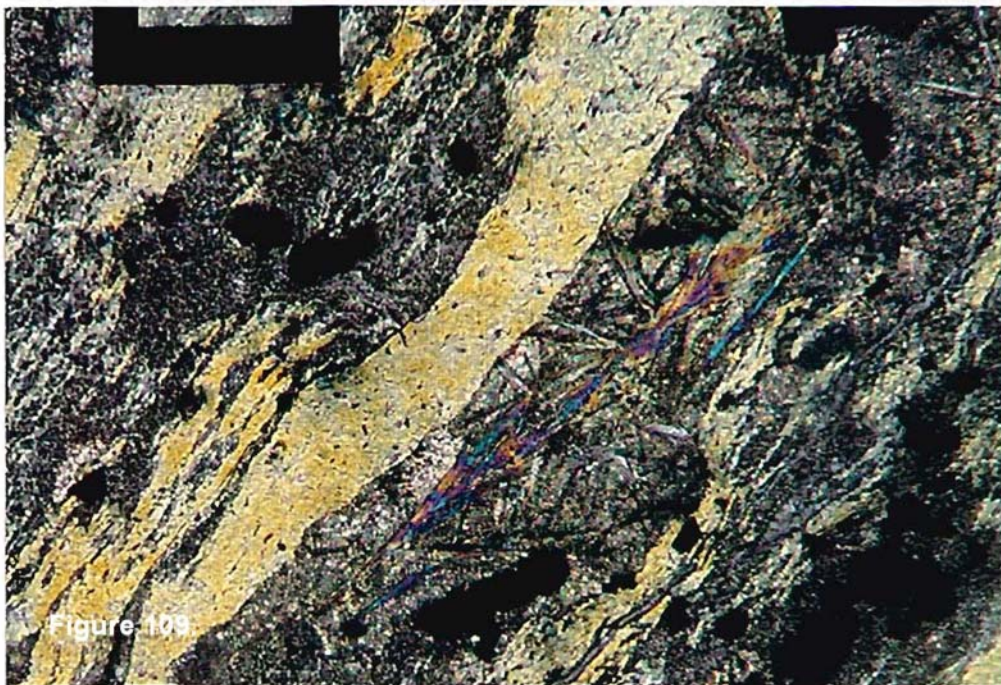


Figure 109

Polarized light, Mag. 274X

Shows birefringence of Chlorite and Minnesotaite



Quartz, Goethite, Magnetite  
Thin section No.1598, DH17695, 115 ft., LC2



Figure 110  
Plane light, Mag.170X  
Acicular Goethite and Magnetite in Quartz. Goethite is apparently an alteration product of Minnesotaite

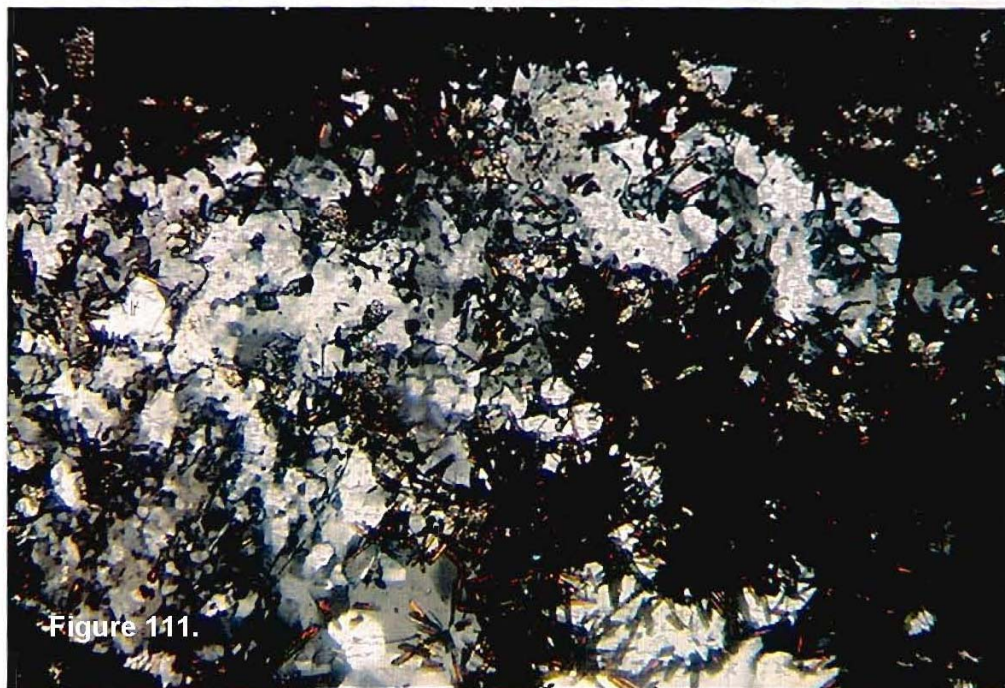


Figure 111.  
Polarized light, Mag.170X  
Shows birefringence of Quartz

Quartz, Carbonate, Magnetite  
Thin section No. 1663, DH17710, 207 ft., LC2

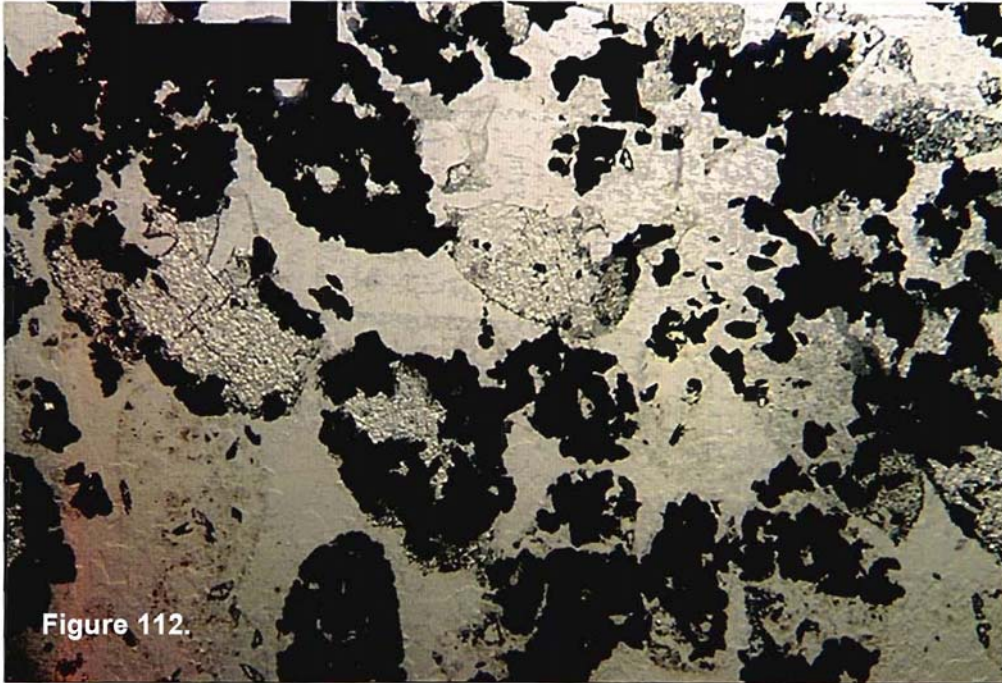


Figure 112.

Plane light, Mag. 170X  
Granules of Magnetite and Carbonate in a Quartz matrix

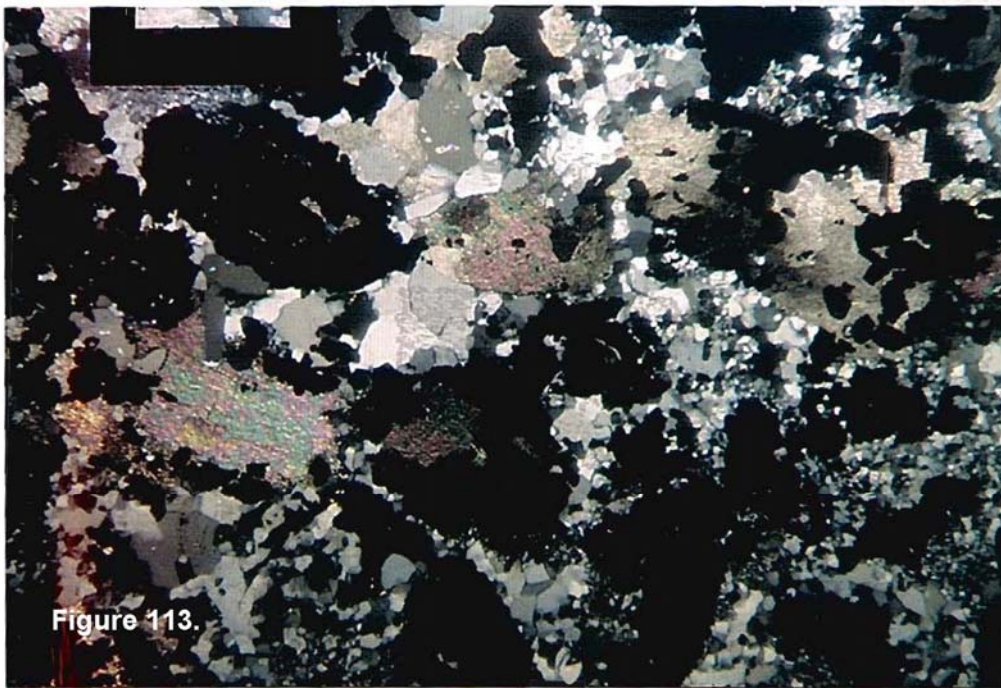


Figure 113.

Polarized light, Mag. 170X  
Shows birefringence of Quartz and Carbonate

Quartz, Carbonate, Hematite  
Thin section No.180, DH15187, 710-715 ft., LC2

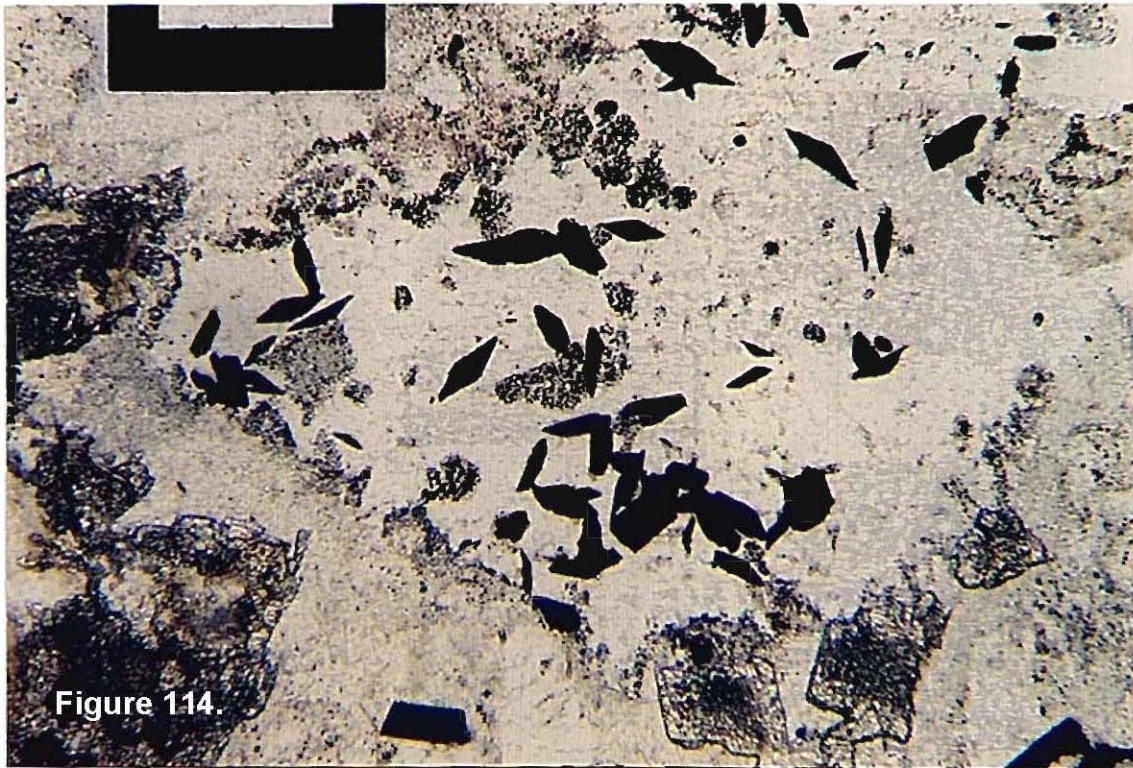


Figure 114.

Plane light, Mag.170X  
Scattered "primary" Hematite crystals, many showing scalenohedral outlines,  
and Carbonate in a Quartz matrix

Quartz, Magnetite, Apatite(?)  
Thin section No.156A, DH15187, 590-595 ft., LC3

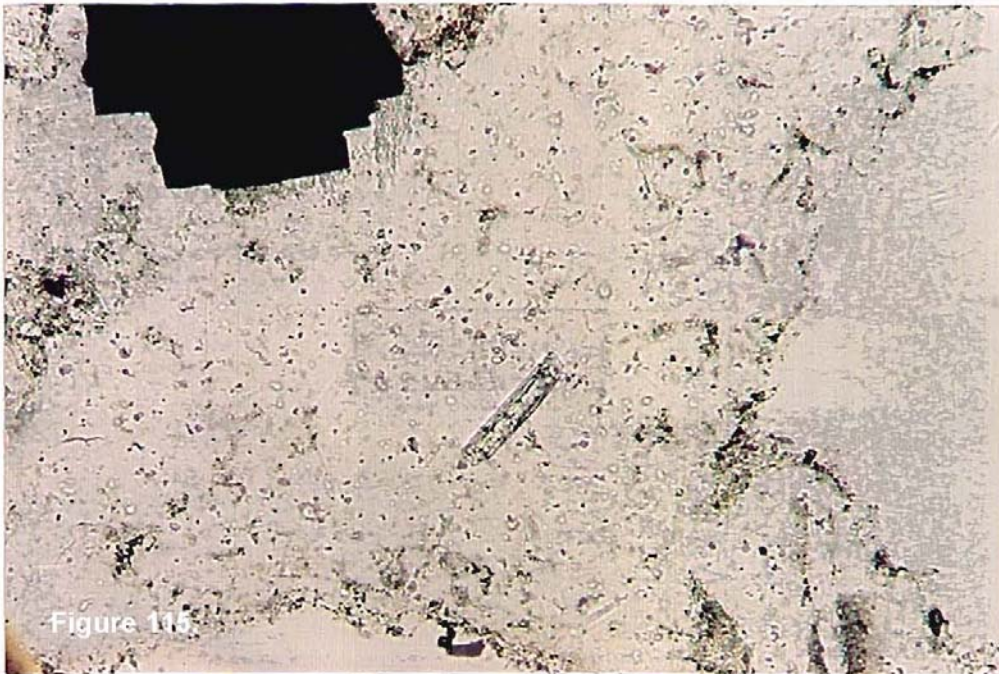


Figure 115

Plane light, Mag.274X  
Quartz, euhedral Magnetite, high relief crystal is apparently an Apatite mineral

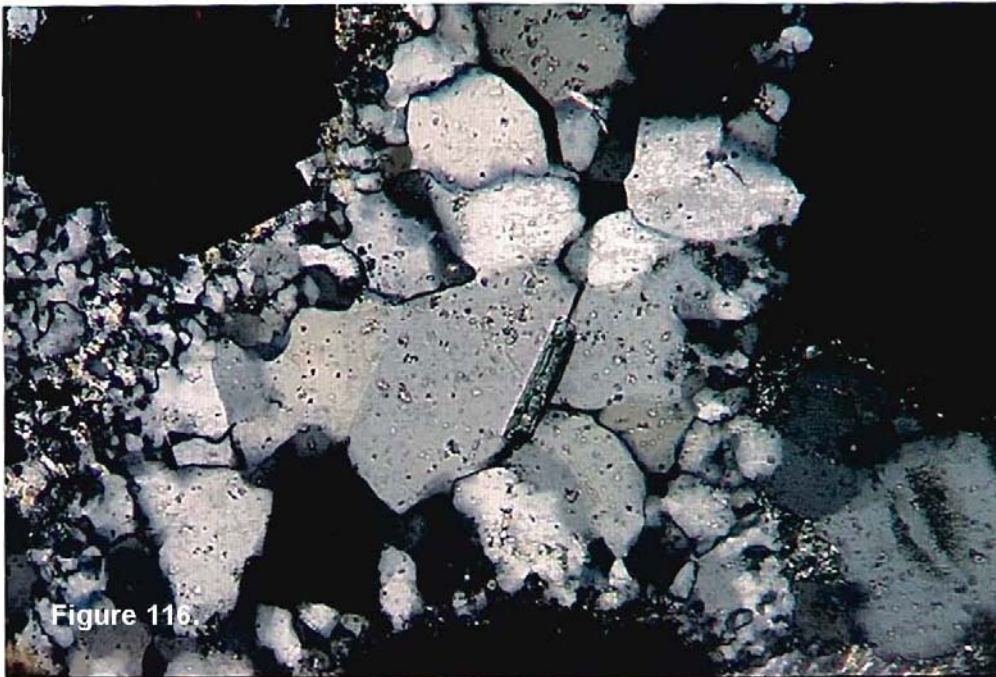


Figure 116

Polarized light, Mag.274X  
Shows birefringence of Quartz and Apatite

Quartz, Goethite, Hematite, Magnetite  
West Mesabi polished section No.C-5, DH471, 325 ft., LC

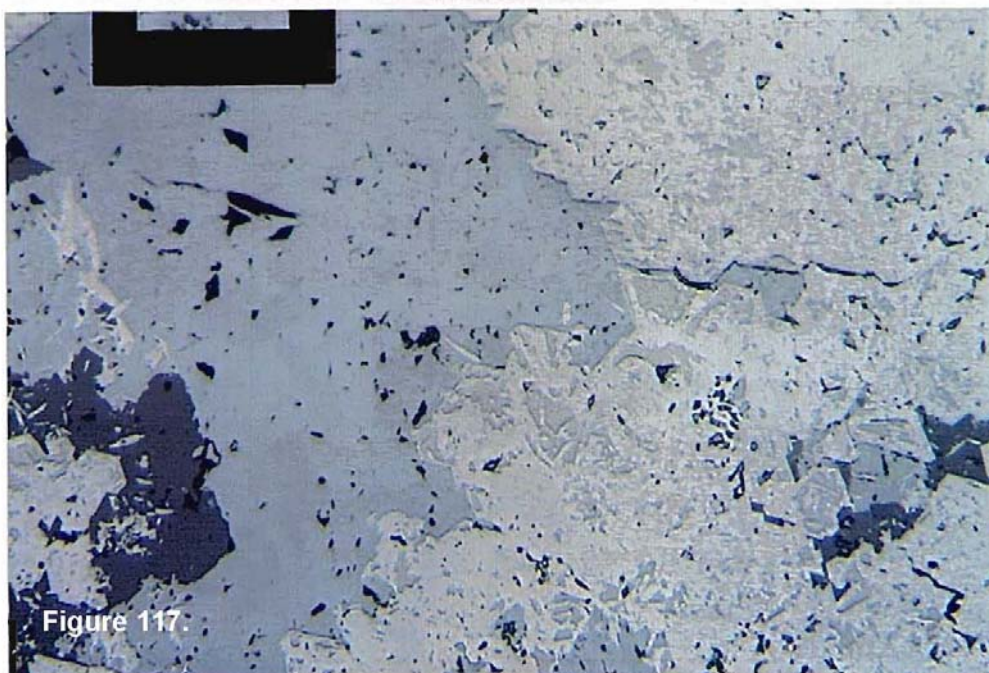


Figure 117:

Reflected light, Mag.274X  
Goethite(medium gray) enclosing Hematite(white) with Magnetite(tan) remnants.  
Dark gray is Quartz

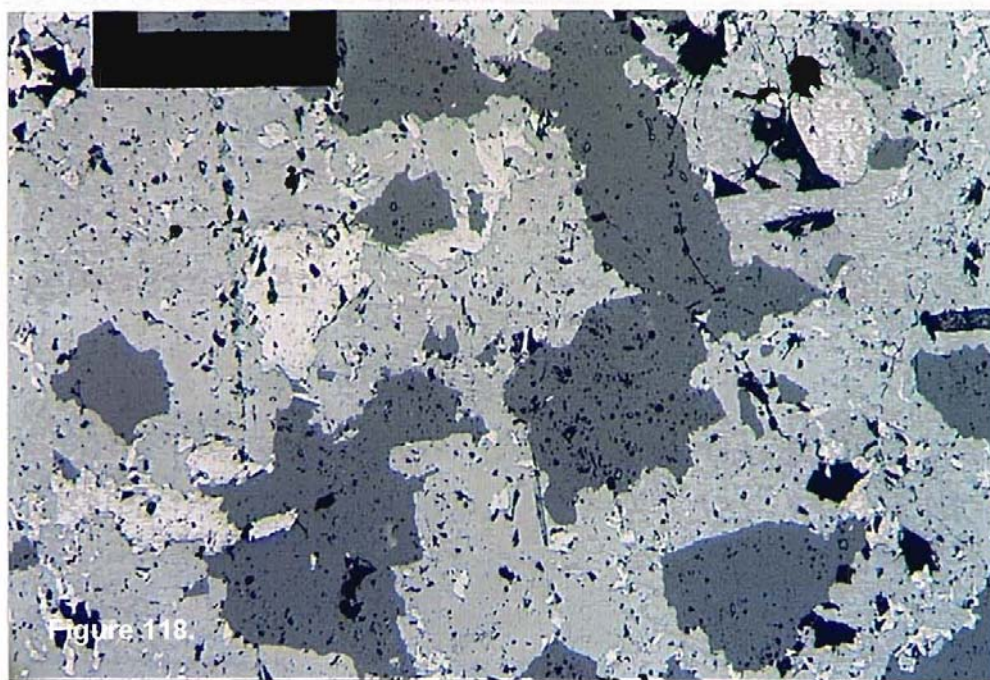
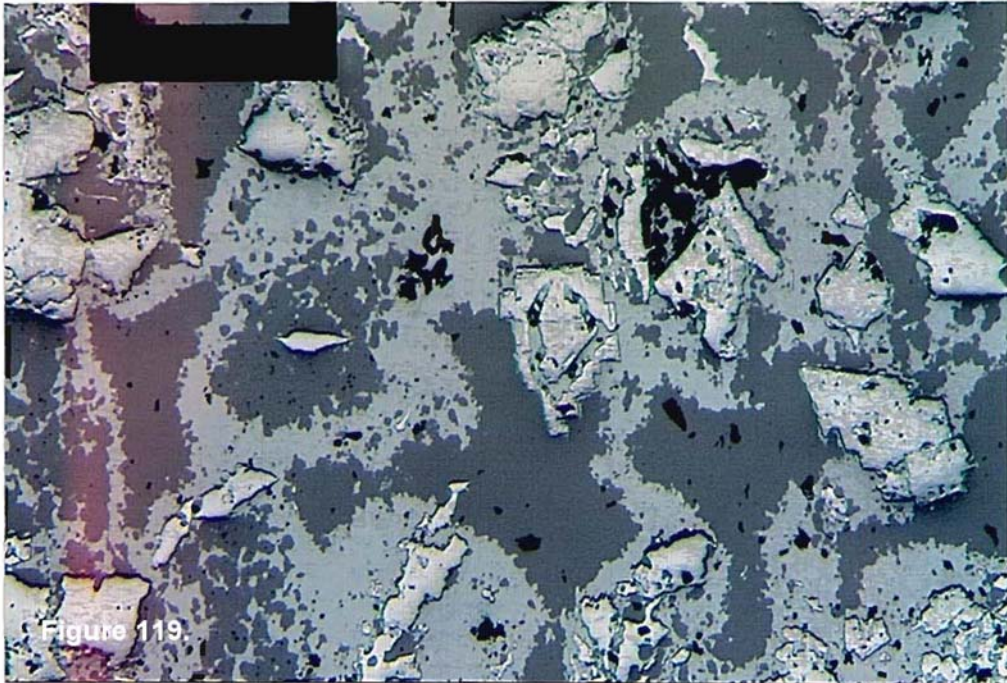


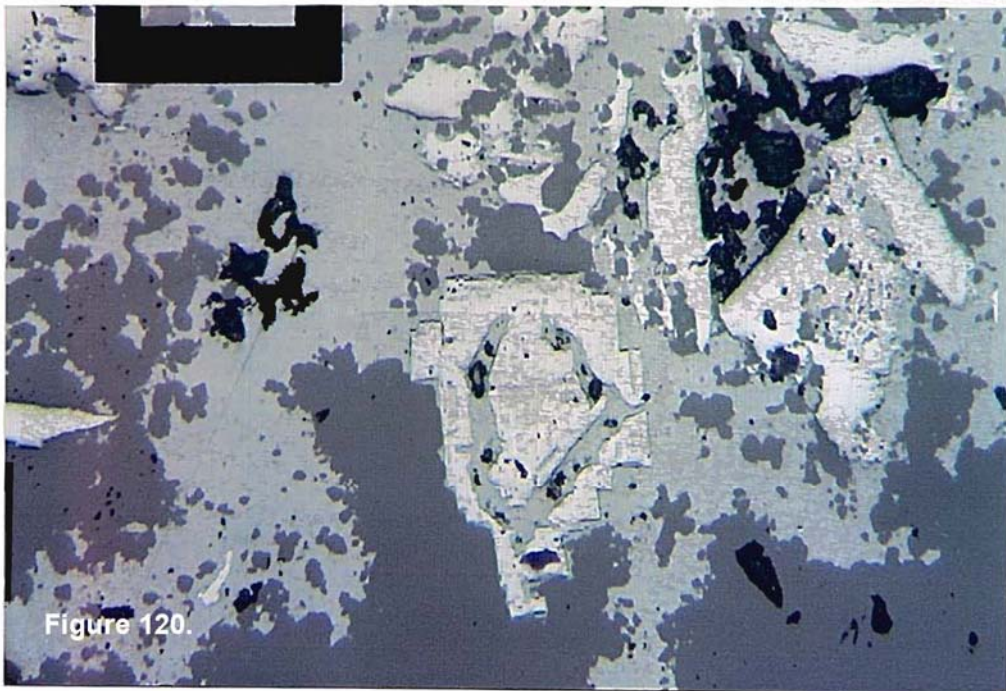
Figure 118:

Reflected light, Mag.136X  
Polished section No.C-44, Walker Pit, LC  
White Hematite in Goethite and Quartz. Black are polish pits

Quartz, Goethite, Hematite, Magnetite  
West Mesabi polished section No.C-49, DH8330, 521 ft., LC

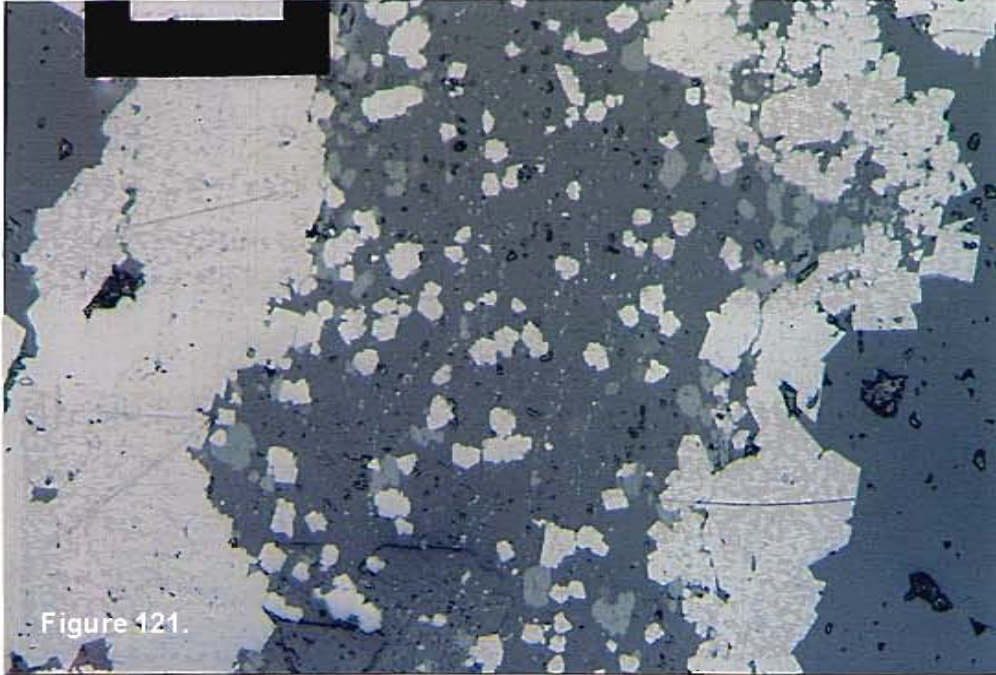


Reflected light, Mag.136X  
Goethite(medium gray) enclosing Hematite(white) with Magnetite(tan) remnants.  
Dark gray is Quartz

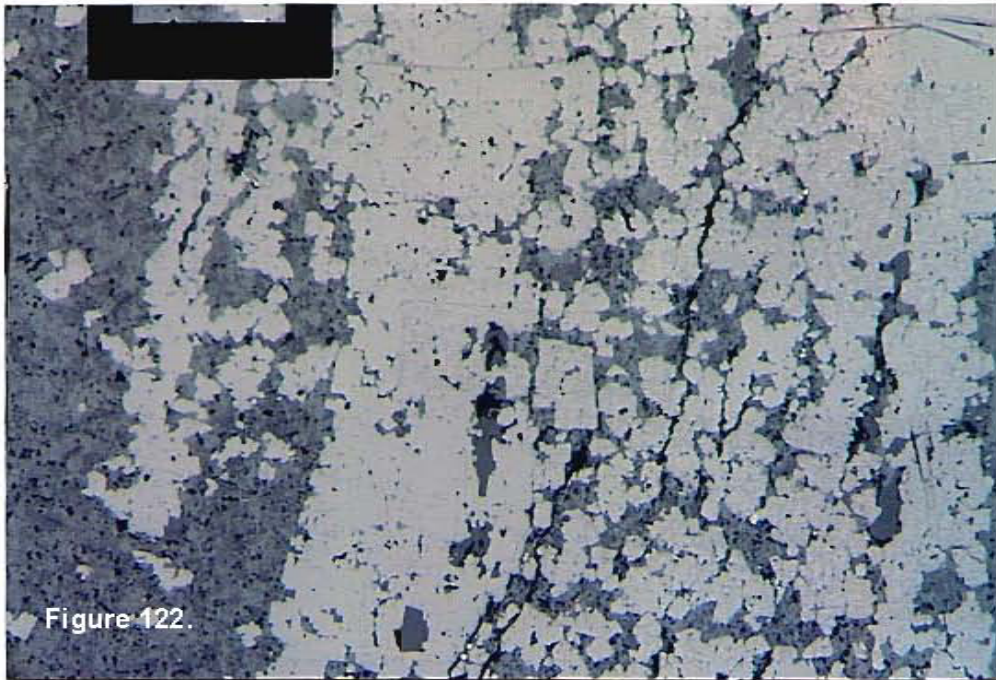


Reflected light, Mag.274X  
Higher magnification to better show remnant Magnetite

Magnetite, Quartz, Carbonate  
West Mesabi polished sections showing Magnetite textures and the range of  
grain sizes



Reflected light, Mag. 136X  
Polished section No.C-8, DH8483, 728 ft., LC



Reflected light, Mag. 136X  
Polished section No.C-9, DH8483, 814 ft., LC