Appendix H

Contents

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Data Verification Summary

Data Verification Title: **CNS Geologic Zone Reports, Petrographic Descriptions and C.E. Weaver Report and Historic NRC Correspondence**
ID Number: **HRQ-FCL-003**
Date of Qualification Review Team Meeting: **September 19, 2011**

Quality Review Team:

Name	Sign (Initials)	Organization	Qualifications
Jerry Standridge	JAS	Duke Energy	QA/QC Verification
John McConaghy	JMMc	Duke Energy	Engineering
Fred Redwanz	[illegible]	ENERCON Services Inc.	Engineering
Juan Vizcaya	JV	ENERCON Services Inc.	Engineering
Malcolm Schaeffer	MFS	HDR | DTA	Former Duke Power Project Geologist
Michael Gray	MGG	FCL	Project Principal Geologist
Robert Turner	RJT	FCL	Project Geologist

Data / Evidence Considered During the Reviews:

The contents of the files outlined in Attachments 2 and 3 were reviewed for applicability and completeness.

Critical Attributes Considered During the Reviews:

Files comprise reviewed and approved geologic zone reports, independent laboratory data reports and historic NRC correspondence. Attributes considered include procedures used, documentation of those procedures, Duke Power supervision and oversight of independent lab work, and review and acceptance of the products.

Basis for Qualification / Non-Qualification:

The data is qualified to use in WLS evaluations to document final foundation geology beneath former CNS Units 1, 2 and 3 and NRC interactions and review of geologic data collection. The geologic zone reports documented in these files were acquired, prepared, and verified using the applicable specifications and Duke QA procedures governing at the time of gathering and preparation. The lab reports, including the petrographic descriptions and the C.E. Weaver report were prepared by independent laboratories under close supervision by Duke Power personnel and the data from these lab reports was subsequently incorporated into reports prepared, reviewed and accepted under Duke Power QA procedures.

The Historic NRC correspondence was continuously maintained within Duke records.

Is the data considered Nuclear Safety Related QA Qualified? _____Yes_____ (Yes / No)

Recommendations for Additional Qualification Activities:

None

Dissenting conclusions or comments: If the team reaches concensus, enter "None" here. Otherwise, document the dissenting view as follows:

Reviewer Name and Organization: ____________________

Dissenting Statement: __________None__________

Signature and Date: ____________________

I hereby certify this Data Verification Package is complete:

Quality Review Team Lead: Michael G. Gray **(Sign)** **Date:** 9/22/2011

Michael Gray, FCL Project Manager

I approve this Data Verification Package for the usage identified above:

Approved By: [signature] **(Sign)** **Date:** 10 06 11

(Duke Project Manager or designee)

Data Verification Planning Form

Data Verification Title: **CNS Geologic Zone Reports, Petrographic Descriptions and C.E. Weaver Report and Historic NRC Correspondence** **ID Number:** **HRQ-003**

Scope of Historical Data Requiring Review:
Cherokee Nuclear Station (CNS) Geologic Reports on Zones 1-5 and 7-10, CNS petrographic descriptions for Zone 5 Samples CS4-1 to C-18-1, petrographic descriptions for Zone 10 Samples C-31 to C44, petrographic descriptions for Zone 14 Samples C-45 to C-49, Fine-Grained Material Report prepared by C.E. Weaver. Historic correspondence, including memoranda, between Duke Power representatives and the NRC. Attachment 1 contains a detailed table of all documents to be qualified. Attachment 2 contains PDF copies of these documents. Attachment 3 contains copies of the CNS-era NRC correspondence. Attachment 4 contains copies of formal records of transmittal.

Purpose / Applicability of Data: This data will be used to support development of an expanded geochronologic bedrock deformation history for the William States Lee III (WLS) site. The historical correspondence is used to document the fact that NRC and Duke Power had periodic technical interactions during geological mapping activities, and that the NRC conducted independent reviews of those geologic mapping activities.

Methods of Verification (X):
Peer Review X Data Corroboration ______ Confirmatory Testing ______

Rationale: The Zone Reports and Petrographic descriptions completed for the CNS were produced using approved standards and procedures by Duke Power Company, now. Duke-Energy. The C.E. Weaver report is based on the joint examination of samples by CNS Project Geologist, Malcolm F. Schaeffer and the Director of the Georgia Institute of Technology School of Geophysical Sciences, Charles E. Weaver. ~~Attachment 5 contains procedures used to produce the geologic zone reports.~~ The historic correspondence was maintained within Duke records.

MMK 9/22/11

Note: Attachment 5 was deleted since the procedures are already contained in HRQ-FWLA-001 MMK 9/22/11

MMK 9/22/11

Need for Data Qualification Affirmed By: Michael Gray **Date:** 9/21/2011
FCL Project Manager (or designee)

Required Organizations for Verification:
FCL with support from Duke-Energy and ENERCON Services, Inc.

Duke Approval of Scope and Methods Used: ______ **Date:** 09 22 11
Duke Project Manager (or designee)

Attachments:

Attachment 1 Listing of Records to be Qualified
Attachment 2 CNS Zone Reports, Petrographic Descriptions and C.E. Weaver Report
Attachment 3 Records of Historic Correspondence
Attachment 4 Record Transmittals

Attachment 1

Listing of Documents to be Qualified

File Name	Date of Transmittal	Date of Document	Number of Pages	Comments
Geologic Zone Reports on Zones 1-5, 7-10 Mar 8, 78.pdf	7/15/2011	3/8/1978	36	This file contains geologic reports for Zones 1-5 and 7-10. The report is signed by its author and two reviewers. Zones 1-5 were discovered in the final foundation excavation for the CNS Unit 1 turbine building. Zones 7-9 were discovered in the final foundation excavation for the CNS Nuclear Service Water dam. Zone 10 was discovered in the final foundation excavation for the CNS Unit 2 turbine building.in CNS Unit 2 Turbine buildings.
Petrographic Descr for Zone 10 C31-C44 2-25-78.pdf	7/15/2011	2/25/1978	19	Descriptions for C-31-1, C-33-1, C-33-2, C-35, C-36, C-37, C-38, C-40, C-41, C-42, C-43, C-44
Petrographic Descr for Zone 14 C-45 to C-49 8-6-79.pdf	7/15/2011	8/6/1979	14	Descriptions for C-45, C-46, C-47, C-48 and C-49 (2 copies of each description)
Petrographic Descr for Zone 5 CS4-1 to C-18-1 8-16-77.pdf	7/15/2011	8/16/1977	6	Descriptions for CS-4-1, C-16-1, C-17-1, C-17-2, C-17-3, C-18-1,
Photomicrographs Zones 10 and 14.pdf	7/15/2011	Various	7	Photomicrographs for C-36, C-38, C-41, C-43, C-44, C-45, C-46-A, C-46-B, C-47
SKMBT_C25006100513201 Zone 6 Stereograph.pdf	7/22/2011	---	4	Stereonet figures from Zone 6 Geologic Report
Weaver Report Fine-Grained Material 9-20-1977	7/15/2011	9/20/1977	25	This report is signed by its author. It describes results of Scanning Electron Microscope (SEM) investigation of fine grained white minerals found in CNS shear zones. The report is referenced in geologic Zone Report 2.

File Name	Date of Transmittal	Date of Document	Number of Pages	Comments
FC-1 to FC-14 Petrographic Descriptions.pdf	7/28/2011	Various	18	Descriptions for FC-1, FC-2, FC-3, FC-5, FC-6, FC-7, FC-7-1A, FC-7-1B, FC-8, FC-9, FC-10, FC-11, FC-12, FC-13 and FC-14
FC-101 to FC-113 Petrographic Descriptions.pdf	7/28/2011	Various	18	Descriptions for FC-101, FC-102, FC-103, FC-104, FC-105, FC-106, FC-107, FC-108, FC-110, FC-111, FC-112 and FC-113
FCS-1 to FCS-37 Petrographic Descriptions.pdf	7/28/2011	Various	53	Descriptions for FCS-1, FCS-2, FCS-3, FCS-4, FCS-5, FCS-6, FCS-7, FCS-8, FCS-9, FCS-10, FCS-11, FCS-12, FCS-13, FCS-14, FCS-15, FCS-16, FCS-17, FCS-18, FCS-19, FCS-20, FCS-21, FCS-21-2, FCS-22, FCS-23, FCS-24, FCS-25, FCS-26, FCS-27, FCS-28, FCS-29, FCS-30, FCS-31, FCS-32, FCS-33, FCS-34, FCS-35, FCS-36 and FCS-37
FCS-101 to FCS-103 Petrographic Descriptions.pdf	7/28/2011	Various	3	Descriptions for FCS-101, FCS-102 and FCS-103
Extract from 0017 (MF Reel 3184 CK-1108) 32 NRC Interfaces Bookmarked.pdf	7/15/2011	Various	77	32 Excerpts from 0017 (MF Reel 3184 CK-1108)
Extract from 0327 (MF Reel 0018 CK-1412) 7 NRC Letters Bookmarked.pdf	7/15/2011	Various	59	7 Excerpts from 0327 (MF Reel 0018 CK-1412
Extract from MFS CK-1108 Memos (18 NRC Interactions Bookmarked).pdf	7/15/2011	Various	33	18 Excerpts from MFS CK-1108 Memoranda

Attachment 2

CNS Zone Reports, Petrographic Descriptions and C.E. Weaver Report

CHEROKEE NUCLEAR STATION

GEOLOGIC REPORTS ON ZONES 1 through 5, 7 through 10

March 8, 1978

Prepared by Malcolm F. Schaeffer Date 3/8/78

Reviewed by Donald R Pruett Date 4/28/78

Reviewed by [illegible] Date 4/28/78

ZONE 1

Zone 1 was discovered in the excavation for the Unit 1 Turbine Building during top of rock mapping. The exposure was mapped at 1"=20' and 1"=5', thin sections studied, and the zone related to the geologic history established in the Cherokee PSAR.

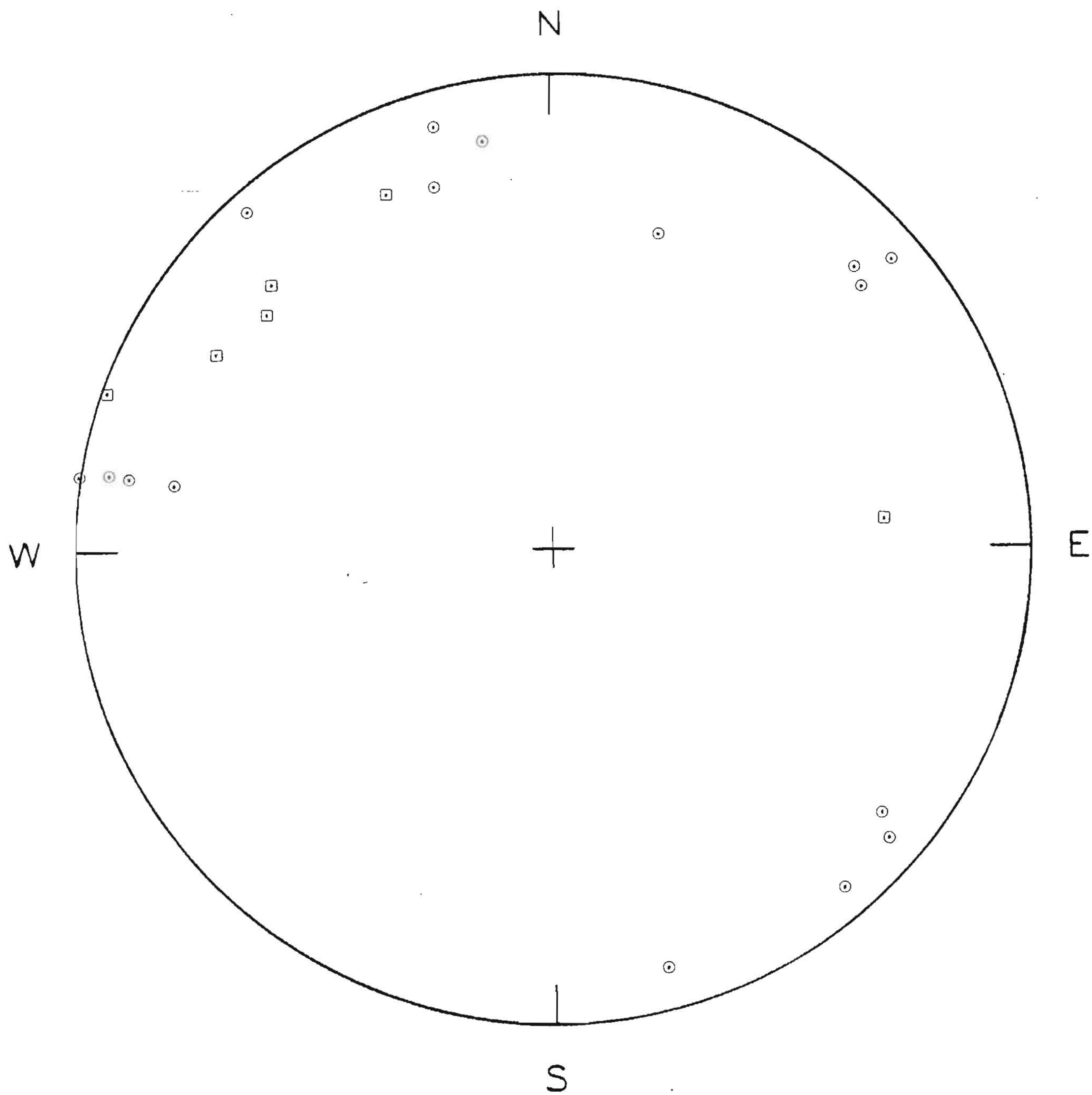
The shear zone extends from plant coordinates 94+98X, 96+29Y to 95+59X, 96+70Y for a length of 82.5 feet along an average strike of N45°E (Ref. Drawing CK-0016-07). The dip of the shear plane varies from 69° to 74°SE. The shear plane terminates to the northeast where it curves into a mafic gneiss contact. To the southwest the shear splays out in undeformed felsic gneiss before reaching a similar contact. Minor splays strike N20°E and N5°W and terminate in undeformed felsic gneiss. The disturbed zone near the shear plane varies in thickness from 1 to 4 inches. Macroscopically the falt zone has a brittle appearance but thin-section evidence indicates a ductile or semiductile origin. A 3 inch thick pegmatite (quartz and potassium feldspar) has an apparent offset (when viewed in a horizontal plane) of 5 inches right-lateral at coordinates 95+50X, 96+64Y; other quartz veins and pegmatites cut across orparallel the shear zone.

Two angle core borings (CA-1 and CA-2) were drilled to obtain undisturbed samples of the fault. The boring locations are shown on drawing CK-0016-07. Mineral paragenesis as related to fracturing and shearing was studied in two thin sections of rock from the borings.

The country rock is a medium-grained granoblastic felsic gneiss composed primarily of quartz and plagioclase with varying amounts of microcline, muscovite, and biotite. Minor amounts of chlorite, calcite, and epidote are present. Shear zones in the thin sections vary from 1mm to 8mm in width and have a schistose or lepidoblastic texture marked by parallel to subparallel subhedral to euhedral mica grains with fine-grained and/or polygonized quartz. The larger shear zones contain augen of polygonized quartz and are characterized by higher concentrations of oriented micas and chlorites parallel to the shear zones. Large quartz veins throughout the thin sections have sutured contacts. The undeformed, randomly oriented, subhedral to euhedral micas and polygonized quartz in the shear zone indicate that shearing was followed by crystallization at pressure-temperature conditions at least as high as greenschist rank. Therefore, shearing predates greenschist metamorphism.

Zone 1 is similar to the shear and breccia zones described in Section 3.6.2.1, Appendix 2C, Cherokee PSAR and as such is at least 170 and probably more than 250 million years old. It correlates with Event III, Table 2C-1A, "Site Geologic Events as Related to Regional Geology", Cherokee PSAR.

Supporting documents (maps, thin-section reports, boring logs, and point-plots of joints and shear planes) are located in the file labeled "Geologic Reports - Zones 1 to 3" and File No. CK 20-02.



POINT PLOT
(23 OBSERVATIONS)
⊙ JOINT, ⊡ SHEAR PLANE

EQUAL AREA PROJECTION OF POLES TO PLANES

ZONE 1

ZONE 2

Zone 2 was discovered in the excavation for the Unit 1 Turbine Building during top of rock mapping. The exposure was mapped at 1"=20' and 1"=5', thin sections studied, and the zone related to the fault features and geologic history studied and established in the Cherokee PSAR.

The shear zone extends from coordinates 97+17X, 97+20Y to 97+30X, 98+10Y for a mapped length of 90 feet along an average strike of north-south (Ref. Drawing CK-0016-07). The dip of the individual shear planes range from 71° east to 76° west with the average near vertical. The zone appears to terminate against a mafic gneiss-felsic gneiss contact to the north. To the south the zone was not exposed and could not be traced further. Additional information on the extent of the fault in the powerhouse area and its relationship to other faults or shear zones will be developed during final foundation mapping.

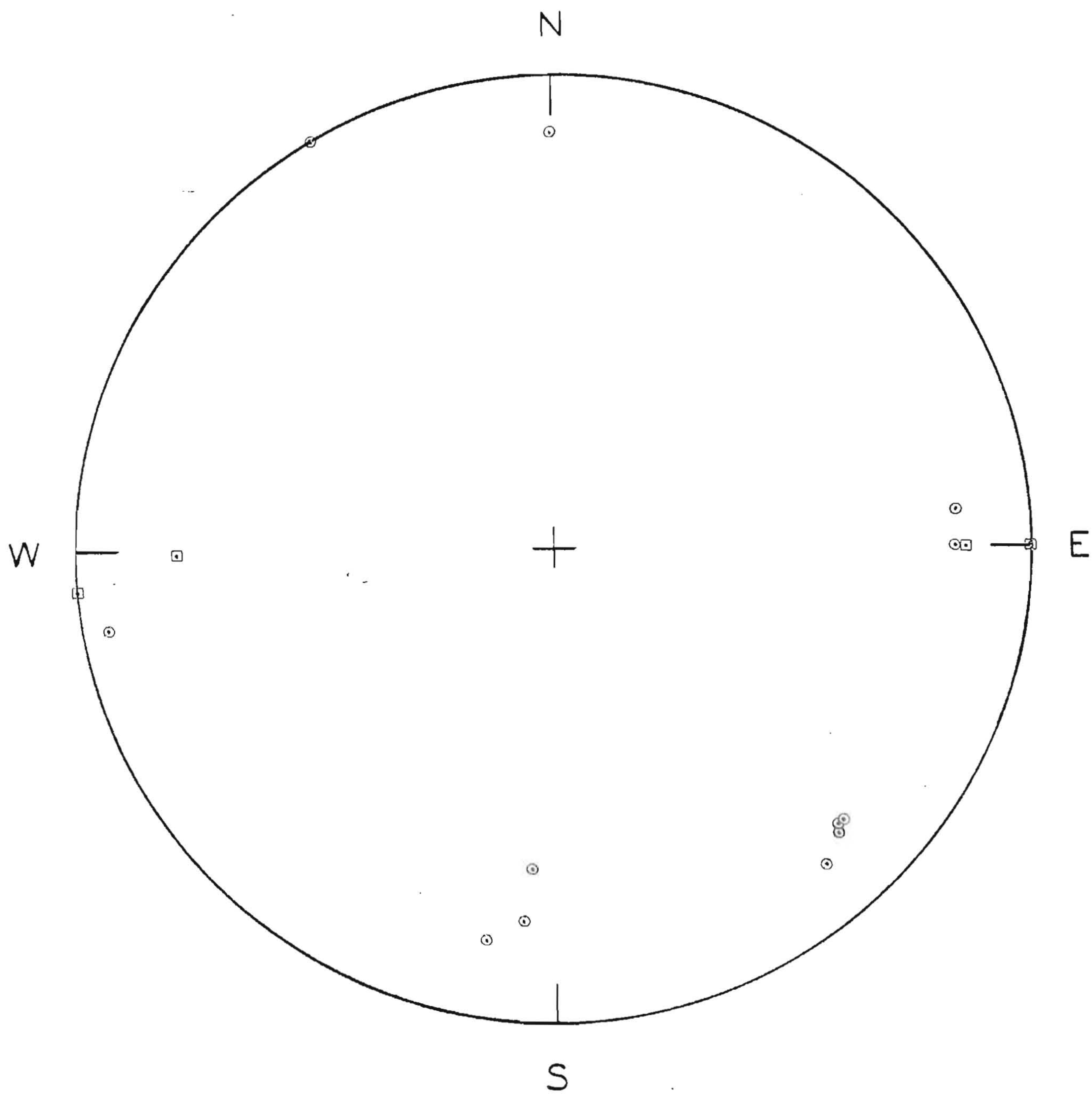
The fault consists of shear-breccia zones 6 inches to 5 feet wide, composed of numerous, closely-spaced, near vertical breaks trending in a northerly direction. Near the northern termination of the zone there are four en-echelon shear planes. Within the shear zone, individual shear planes alternate with thin mica-rich schistose material not observed outside the shear-breccia zones. These schistose materials contain thin lens-shaped slices of non-schistose rock. The micas within and near the shear-breccia zones are essentially parallel. Thin films of reddish-brown opaque material (iron oxide) commonly occur as coatings on shear planes. Individual shear planes disappear into undeformed rock along portions of the shear zone. Quartz veins and pegmatites (quartz-feldspar, quartz-biotite, and quartz-chlorite) terminate against shear planes, however, correlation cannot be made across the shear plane with other quartz veins or pegmatites. Therefore no maximum or minimum offset could be determined. At some locations quartz veins cut across and/or parallel shear planes. An angle core boring (CA-8) was drilled to obtain undisturbed samples. The boring location is shown on drawing CK-0016-07. Mineral paragenesis as related to fracturing and shearing was studied in five thin sections of rock from the boring.

The country rock is a fine to coarse grained granoblastic felsic gneiss with contact suturing and polygonization of finer-grained material surrounding larger quartz and plagioclase grains which are the dominant mineral constituents.

Up to 10% microcline and muscovite with minor amounts of chlorite, biotite, apatite, calcite, and epidote are present. Within the schistose zone the rock is lepidoblastic and composed essentially of parallel muscovite. Mylonitic shear zones 1 to 3 mm wide cut the schistose zones and are defined by individual shears filled with iron oxide film. Individual shears splay off main shears and terminate in undeformed rock. The shears surround augen-like pods of polygonized quartz, feldspar, muscovite schist, and a low birefringent mineral (potassium feldspar). Small offsets occur along some iron oxide, mica, and biotite filled shear zones. Most mica is aligned parallel to shearing, but some randomly oriented mica flakes are present. Some large feldspar crystals outside the shears are slightly brecciated along fractures that parallel the main shear direction. Fine-grained masses of randomly oriented chlorite formed in and near shears and associated schistose zones and cut earlier schistose and mylonitic textures. Veinlets parallel and cutting the mylonite zones are healed by combinations of chlorite, calcite, muscovite, and a low birefringent material (potassium feldspar). These veinlets are dilation fractures and postdate shearing.

Zone 2 is similar to the shear and breccia zones described in Section 3.6.2.1, Appendix 2C, Cherokee PSAR and as such is at least 170 and probably more than 250 million years old. The fractures which cut the shear-breccia zones at varying angles are similar to those described in Section 3.6.2.2, Appendix 2C, Cherokee PSAR. In the PSAR investigations, quartz and smaller amounts of pink potassium feldspar with minor amounts of other minerals fill the dilation fractures. The low birefringent mineral observed in the present thin sections is potassium feldspar (Reference: Report by C. E. Weaver dated 9-20-77, "Identification of Fine-Grained Mineral"). Potassium feldspar in the fractures discussed in the Cherokee PSAR has been determined to be 219 million years old (See Table 2C-3A, Cherokee PSAR). The zone correlates with Events III and IV, Table 2C-1A, "Site Geologic Events as Related to Regional Geology", Cherokee PSAR.

Supporting documents (maps, thin section reports, boring log, and point-plots of joints and shear planes) are located in the file labeled "Geologic Reports - Zones 1 to 3" and File No: CK 20-02.



POINT PLOT
(16 OBSERVATIONS)
⊙ JOINT . ⊡ SHEAR PLANE

EQUAL AREA PROJECTION OF POLES TO PLANES
ZONE 2

ZONE 3

Zone 3 was discovered in the excavation for the Unit 1 Turbine Building during top of rock mapping. The exposure was mapped at 1"=20' and 1"=5', thin sections studied, and the zone related to the fault features and geologic history studied and established in the Cherokee PSAR.

The shear zone extends from plant coordinates 96+96X, 94+55Y to 97+84X, 95+32Y for a mapped length of 115 feet along an average N45°E strike (Ref. Drawing CK-0016-07). The dip of the shear zone varies from 80°SE to 67°NW with an average vertical dip. To the southwest two shear planes have a N35°E orientation. The shear zone continues to the northeast into the Unit 2 Powerhouse and will be mapped during top of rock mapping in that unit. The continuation and relationships to the southwest will be determined during final foundation mapping.

The fault consists of one major shear-breccia zone, 6 inches to 2 feet wide, along with several minor en-echelon shear planes to the southwest and northeast. Near coordinates 97+42X, 95+00Y a mafic gneiss is offset 7 1/2 feet left-lateral (apparent offset viewed in a horizontal plane) by the major shear-breccia zone. Small folds with axial planes parallel to the shear zone are present in mica-rich schistose rocks in and near the zone and are related to shearing. The axes of the folds plunge to the southwest indicating some vertical displacement as well as the strike-slip type movement. The magnitude of the vertical displacement cannot be determined, however oblique-slip movement has occurred on this fault.

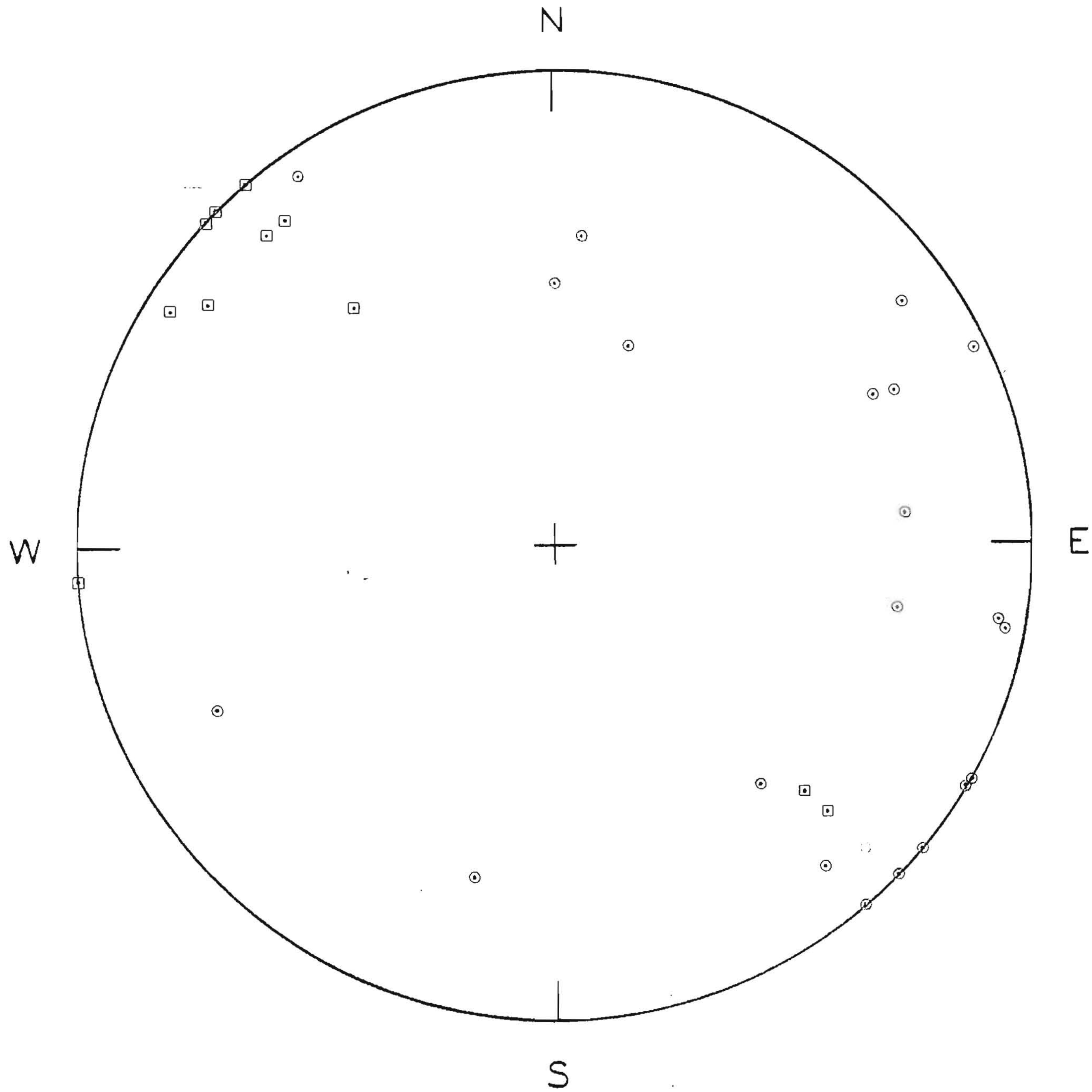
Two angle core borings (CA-3 and CA-4) were drilled to obtain undisturbed samples. The boring locations are shown on drawing CK-0016-07. Mineral paragenesis as related to fracturing and shearing was studied in twelve thin sections of rock from the borings.

The country rock is a fine-to medium-grained granoblastic felsic gneiss with fine-grained polygonized material between larger quartz and feldspar grains. The textures in the shear zones are lepidoblastic, mylonitic, and ultramylonitic. The rock is composed of varying amounts of quartz, muscovite, plagioclase, biotite, and microcline, with minor amounts of chlorite, calcite, epidote, zircon, apatite, and iron oxide. The original rock appears to have been medium-grained, but recrystallization after strain and brecciation produced much finer-grained material principally by polygonization of quartz and, to a lesser extent, feldspar. The polygonized quartz occurs in augen like forms and fine-grained quartz and feldspar developed along sutured boundaries. Shearing is indicated by the augen-like form of quartz pods and micacaeous bands. Micas are locally tightly folded but unbroken and generally are aligned parallel to the iron filled shear fractures in the schistose zones. Small offsets occur along some iron oxide and mica filled shear zones.

The original rock was strained by slight shear to produce a schistose to slightly augen texture. Strained crystals were polygonized, feldspars were sericitized, and muscovite developed along foliation planes probably during greenschist metamorphism. Faulting that cuts across foliation occurred prior to the end of greenschist metamorphism as shown by the concentration of iron oxide released from biotite and by minor development of micas within the fault zone. Small dilation fractures filled with potassium feldspar (low birefringent mineral) cut into and run parallel to the iron-filled fault zone. Therefore, the end of greenschist metamorphism and the development of the potassium feldspar filled dilation fractures postdate shearing.

Zone 3 is similar to the shear and breccia zones described in Section 3.6.2.1, Appendix 2C, Cherokee PSAR and as such is at least 170 and probably more than 250 million years old. The dilation fractures which cut the shear-breccia zones at varying angles are similar to those described in Section 3.6.2.2, Appendix 2C, Cherokee PSAR. In the PSAR investigations, quartz and smaller amounts of pink potassium feldspar with minor amounts of other minerals fill the dilation fractures. The potassium feldspar in the fractures discussed in the Cherokee PSAR has been determined to be 219 million years old (See Table 2C-3A, Cherokee PSAR). The Zone correlates with Events III and IV, Table 2C-1A, "Site Geologic Events as Related to Regional Geology" Cherokee PSAR.

Supporting documents (maps, thin section reports, boring logs, and point-plots of joints and shear planes) are located in the file labeled "Geologic Reports - Zone 1 to 3" and File No: CK 20-02.



POINT PLOT
(33 OBSERVATIONS)
⊙ JOINT. ⊡ SHEAR PLANE

EQUAL AREA PROJECTION OF POLES TO PLANES
ZONE 3

ZONE 4

Zone 4 was discovered in the excavation for the Unit 1 Turbine Building during top or rock mapping. The exposure was mapped at 1"=20' and 1"=5', thin sections studied, and the zone related to the fault features and geologic history studied and established in the Cherokee PSAR.

The shear zone extends from coordinate 94+95X, 93+29Y to 95+33Y in the vicinity of 95+56X for a mapped length of approximately 220 feet along an average north-south strike (Ref. Drawing CK-0016-08). The strike of individual shears varies from N16°W to N20°E with dip varying from 59°W to 52°E with the average near vertical. To the south the zone continues beyond the Turbine Building excavation. Its extent in the Unit 1 Powerhouse area will be established during top of rock mapping to the north. The extent of the fault in the Powerhouse area and its relationship to other faults or shear zones will be established further during final foundation mapping.

The zone consists of up to five subparallel major shear-breccia zones 3 inches to 2 feet wide with smaller minor shears related. In some locations shear planes parallel quartzite lenses. The shear planes tend to parallel mafic gneiss-felsic gneiss contacts, but in two locations offset the mafic gneiss. One, located near coordinate 95+37X, 94+26Y has a left-lateral offset of at least 28 feet. The other, located near coordinate 95+66X, 95+10Y has a left-lateral offset of 10 to 15 feet (Ref. Drawing CK-0016-08). These are apparent offsets, as the amount of vertical displacement, if any, could not be determined. No offsets of quartz veins or pegmatites were noted; however, in places they are stretched and drawn out along shear planes where they cross indicating they formed very close in time with the shearing. Elsewhere quartz veins and/or pegmatites parallel shear planes. A breccia up to 6 inches wide occurs between stations 95+37X, 94+20Y and 95+40X, 94+32Y. The breccia fragments consist of quartzite, mica schist, and aggregates of quartz and feldspar with minor amounts of mica and range up to 6 cm in size. The matrix includes fine-grained material with small rectangular crystals of potassium feldspar. It could not be determined by thin section study if the potassium feldspar crystals are breccia fragments or later formed crystals. This rock and its origin is discussed in detail in the paragraphs on thin section analysis.

Eleven undisturbed samples (C-9, C-10, C-10A, C-10B, C-10C, C-11, C-11A, C-12, C-12A, C-14, and C-15) were obtained along the zone. Five of these samples (C-10B, C-11, C-11A, C-12A, and C-15) were not suitable for thin section preparation. The sample locations are shown on drawing CK-0016-08. Mineral paragenesis as related to fracturing and shearing was studied in twelve thin sections of rock from the samples.

The country rock is a fine to medium-grained granoblastic to lepidoblastic felsic gneiss composed primarily of quartz, feldspar, biotite, and muscovite with minor amounts of chlorite, microcline, iron oxide, opaques, and epidote. Up to 10% epidote is present in some thin sections. Anastomosing shears are iron-filled and contain muscovite and minor amounts of biotite aligned parallel to and oblique to the shears. Shearing is also indicated by rounded fragments of quartz and bent and broken plagioclase that has recovered from strain by polygonization and is healed by the development of muscovite. Fine-grained epidote, pale red-brown biotite, randomly oriented muscovite, and chlorite formed after shearing. Irregular veinlets filled with a low birefringent mineral parallel and cut individual shear planes. Epidote filled fractures are also cut by the low birefringent veinlets. Iron in the shear fractures is later than these veinlets and may be iron released from biotite during greenschist alteration. Breccia fragments are composed of altered feldspar and quartz and are healed with randomly oriented epidote and muscovite.

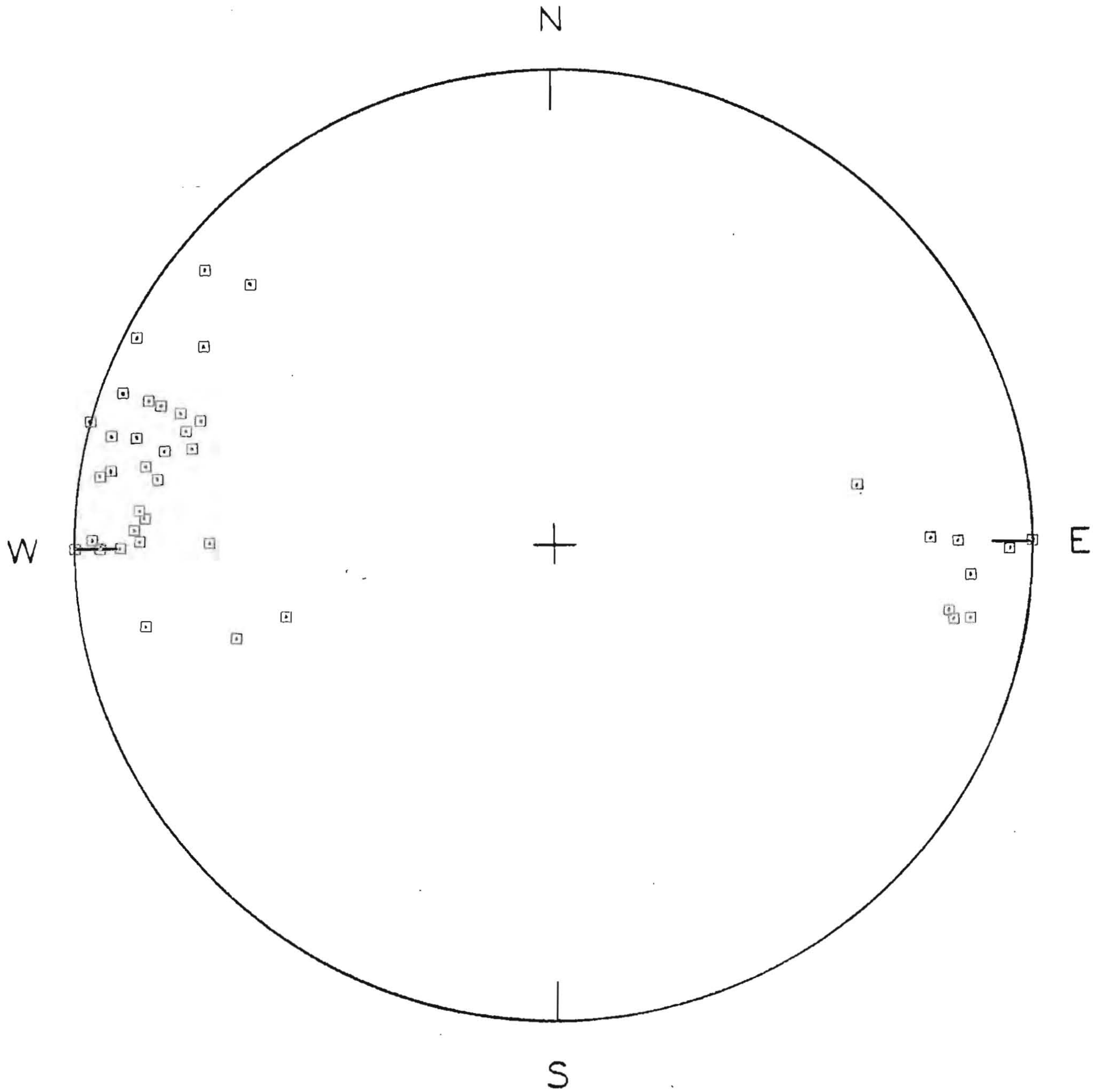
Sample C-12 was taken along the breccia zone described above (thin-section C-12-2, see Drawing CK-0016-08 for location). The texture is brecciated with breccia fragments up to 2 cm long. It also displays a lepidoblastic texture with some feldspar and polygonized quartz augen. Breccia fragments are angular to somewhat rounded and comprise 80% or more of the rock. They range in composition from quartzite to muscovite schist with the average fragment being a mixture of polygonized quartz, sericitized feldspar, and muscovite. The matrix is a fine-grained, iron-oxide stained material containing randomly oriented to radiating groups of long, thin muscovite crystals and small, subhedral to euhedral epidote crystals. The sequence of events that formed this rock appear to be as follows:

1. The rock was stressed under relatively high confining pressures causing a shearing or stretching out of most feldspar and quartz grains.
2. Following shearing, the rock recrystallized to produce polygonized quartz pods and bands from stretched, once larger, quartz grains and muscovite schist bands, and in part, from stretched out feldspar grains. Some augen composed of larger quartz and feldspar grains formed. Minor amounts of small crystals of olive to red-brown biotite formed during this episode of recrystallization.
3. Following shearing and recrystallization, the rock was brecciated indicating lower confining pressure than that which accompanied shearing. This suggests either a considerably later time (following unloading) for brecciation, or else a different type of stress (partially dilational?) than that which produced earlier shearing.
4. Following brecciation, the rock was again (or was continuing to be) recrystallized. This latest crystallization must have been under green-schist metamorphic conditions because the breccia matrix contains sub-hedral to euhedral randomly oriented muscovite and epidote crystals. Biotite is not recognized in the matrix. It is possible that some of the "muscovite" is really a low-iron phlogopite. The iron released in the alteration of biotite to phlogopite could account for the extensive iron-oxide staining now present in the matrix and coating breccia fragments.

There are no veinlets of low-birefringent minerals in either the breccia fragments or the matrix. The rock has not been subject to deformation since greenschist metamorphism.

Zone 4 is similar to the shear and breccia zones described in Section 3.6.2.1, Appendix 2C, Cherokee PSAR and as such is at least 170 and probably more than 250 million years old. The fractures which cut the shear zones at varying angles are similar to those described in section 3.6.2.2, Appendix 2C, Cherokee PSAR. In the PSAR investigations, quartz and smaller amounts of pink potassium feldspar with minor amounts of other minerals fill the dilation fractures. The low birefringent mineral observed in the present thin-sections is potassium feldspar (Reference: Report by C. E. Weaver dated 9-20-77, "Identification of Fine-Grained Mineral"). Potassium feldspar in the fractures discussed in the Cherokee PSAR has been determined to be 219 million years old (See Table 2C-3A, Cherokee PSAR). The zone correlates with Events III and IV, Table 2C-1A, "Site Geologic Events as Related to Regional Geology", Cherokee PSAR.

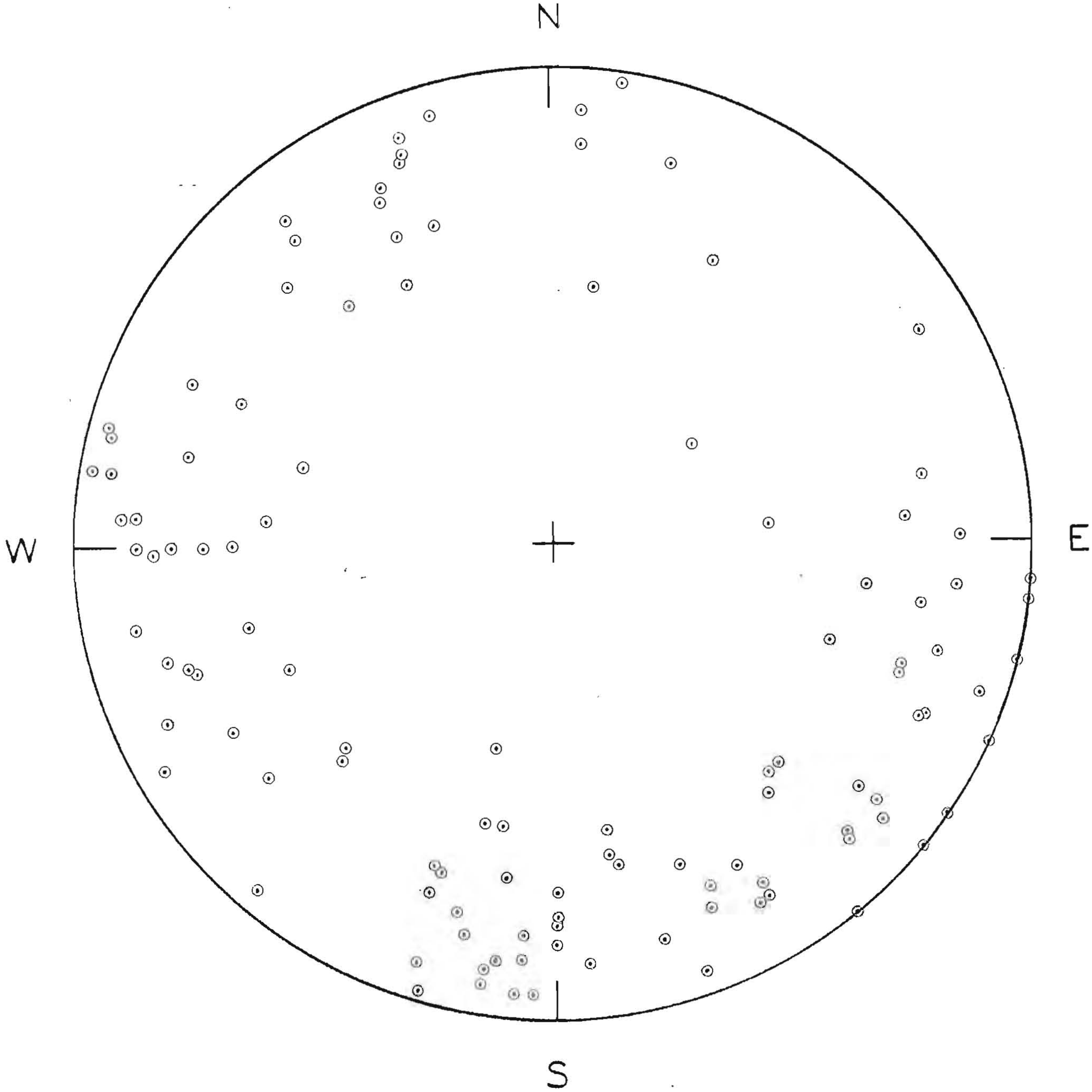
Supporting documents (maps, thin-section reports, and point-plots of joints and shear planes) are located in the file labeled "Geologic Report - Zone 4" and File No: CK 20-02.



POINT PLOT
(40 OBSERVATIONS)
▫ SHEAR PLANE

EQUAL AREA PROJECTION OF POLES TO PLANES

ZONE 4



POINT PLOT
(114 OBSERVATIONS)
⊙ JOINT

EQUAL AREA PROJECTION OF POLES TO PLANES

ZONE 4

ZONE 5

Zone 5 was discovered in the excavation for Unit 1 Turbine Building during top of rock mapping. The exposure was mapped at 1"=20' and 1"=5', thin sections studied, and the zone related to the geologic history established in the Cherokee PSAR.

The shear zone extends from plant coordinates 93+70X, 96+30Y to 93+73X, 98+32Y for a mapped length of 202 feet along an average strike of N11°W (Ref. Drawing CK-0016-09). The dip of the major shear planes vary from 56° east to 50° west. The average dip is nearly vertical. Several minor slpays have an average strike of N40°E with dips varying from 56°-80°SE. The zone continues to the north and south into areas that were not mapped during the top of rock phase. Its extent and relationship to other zones will be further studied during final foundation mapping.

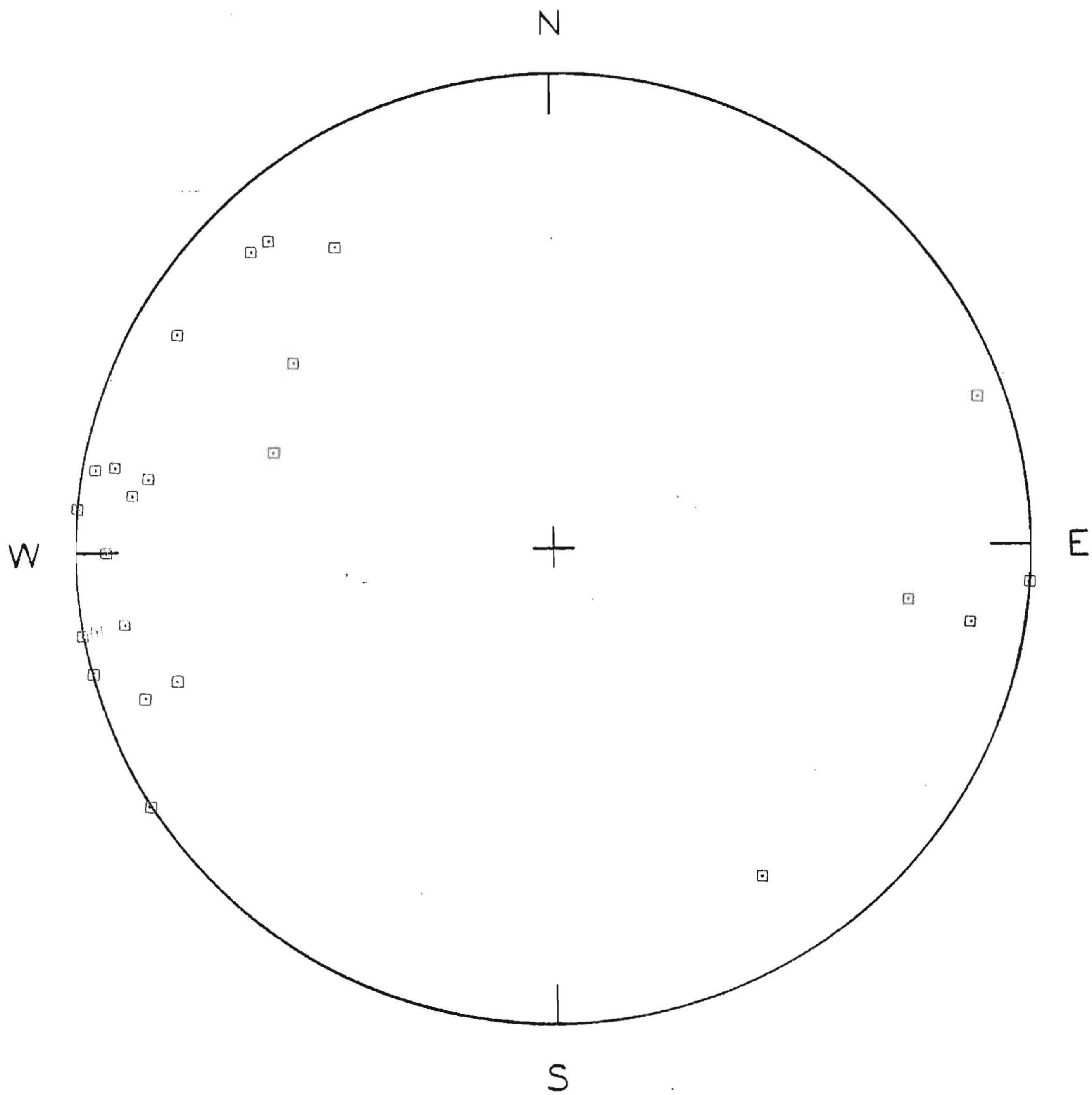
The zone consists of up to five subparallel major shear-breccia zones. Individual shear-breccia zones are 2 inches to 2 feet wide. Areas of felsic schist, 6 inches to 2 feet wide, possibly related to shearing parallel the shear-breccia zones. Small pods or lens-shaped stringers of mafic gneiss are also present along the zone. No offsets were noted along the exposed portion of Zone 5, although small folds in the shear zone indicate a left-lateral (strike-slip) component of movement.

Five undisturbed samples (C-15, C-16, C-17, C-18, and CS-4) were obtained along the zone. The sample locations are shown on drawing CK-0016-09. Mineral paragenesis as related to fracturing and shearing was studied in six thin sections of rock from the samples.

The country rock is a fine- to medium-grained granoblastic felsic gneiss composed primarily of quartz and plagioclase with varying amounts of microcline, muscovite, and biotite. Some fine-grained lepidoblastic felsic schist composed essentially of quartz and mica is present. A foliated mica-rich phase and an unfoliated polygonized quartz phase alternate. Augen-like feldspar crystals occur within the foliated portions, and quartz-filled fractures tend to cut schistosity. Irregular fractures filled with very fine-grained quartz and feldspar with randomly oriented mica or with very fine-grained mica and/or iron oxide curve, branch, and disappear. Some mica is aligned parallel to fractures and oblique to foliation. The randomly oriented mica in the fractures and cutting across foliation developed after shearing. Broken feldspar, quartz, and muscovite (some bent) are rehealed with like minerals suggesting brecciation occurred during metamorphism. Polygonization and randomly oriented mica flakes in the matrix indicate that there has been no post-greenschist deformation.

Zone 5 is similar to the shear and breccia zones described in Section 3.6.2.1, Appendix 2C, Cherokee PSAR and as such it is at least 170 and probably more than 250 million years old. It correlates with Event III, Table 2C-1A, "Site Geologic Events as Related to Regional Geology", Cherokee PSAR.

Supporting documents (maps, thin section reports, and point-plots of joints and shear planes) are located in the file labeled "Geologic Report - Zone 5" and Files No. CK 20-01 and CK 20-02.

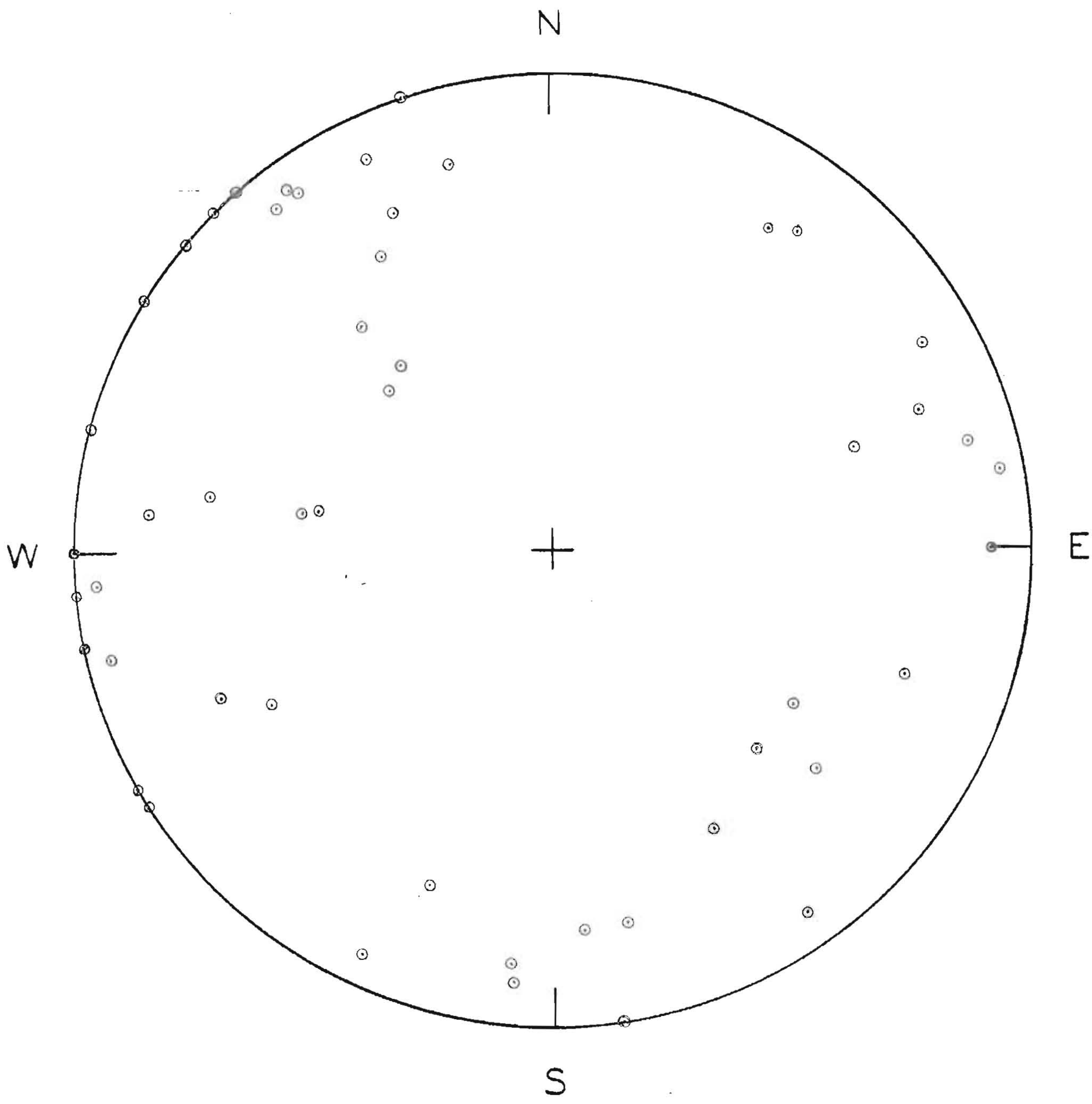


POINT PLOT
(24 OBSERVATIONS)

▫ SHEAR PLANE

EQUAL AREA PROJECTION OF POLES TO PLANES

ZONE 5



POINT PLOT
(50 OBSERVATIONS)
⊙ JOINT

EQUAL AREA PROJECTION OF POLES TO PLANES
ZONE 5

ZONE 7

Zone 7 was discovered in the Nuclear Service Water Dam excavation during final foundation mapping. The exposure was mapped at 1"=10', thin sections studied, and the zone related to the fault features and geologic history studied and established in the Cherokee PSAR.

The shear zone extends from coordinates 17+74, 352R to 16+11, 51L for a mapped length of 408 feet. Strike of the major shear varies from N6°E to N30°E with dip varying from 55° to 78°SE. To the southeast the zone extends beyond the limits of the NSW Dam foundation. Continued mapping of the downstream portion of the dam will establish the extent of the fault in the foundation and its relationship to other faults or shear zones present.

The fault consists of shear-breccia zones 1 inch to 1.5 feet wide, composed of numerous, closely-spaced, southeast dipping breaks trending northeast (Ref. Drawings: CK-0018-07 and CK-0018-08). Associated with the major shear are numerous subparallel splays. Shearing often occurs along contacts between rock types, but in some areas occurs with similar rock on either side of the shear (See Drawing Nos: CK-0019-07 and CK-0019-08). Displacement of lithologic units was not recognized; however, minor offsets of quartz veins and pegmatites are present (EX: near 16+59, 90R, Drawing CK-0018-07).

Four undisturbed samples (DS-8, DS-9, DC-10, and DC-11) were obtained along the major shear zone and four samples (DC-1, DC-2, DC-3, and DC-4) were obtained along splays of the major shear. Three of these samples (DC-1, DC-3, and DC-10) were not suitable for thin section preparation. The sample locations are shown on drawings CK-0018-07 and CK-0018-08. Mineral paragenesis as related to fracturing and shearing was studied in seven thin sections of rock from the samples.

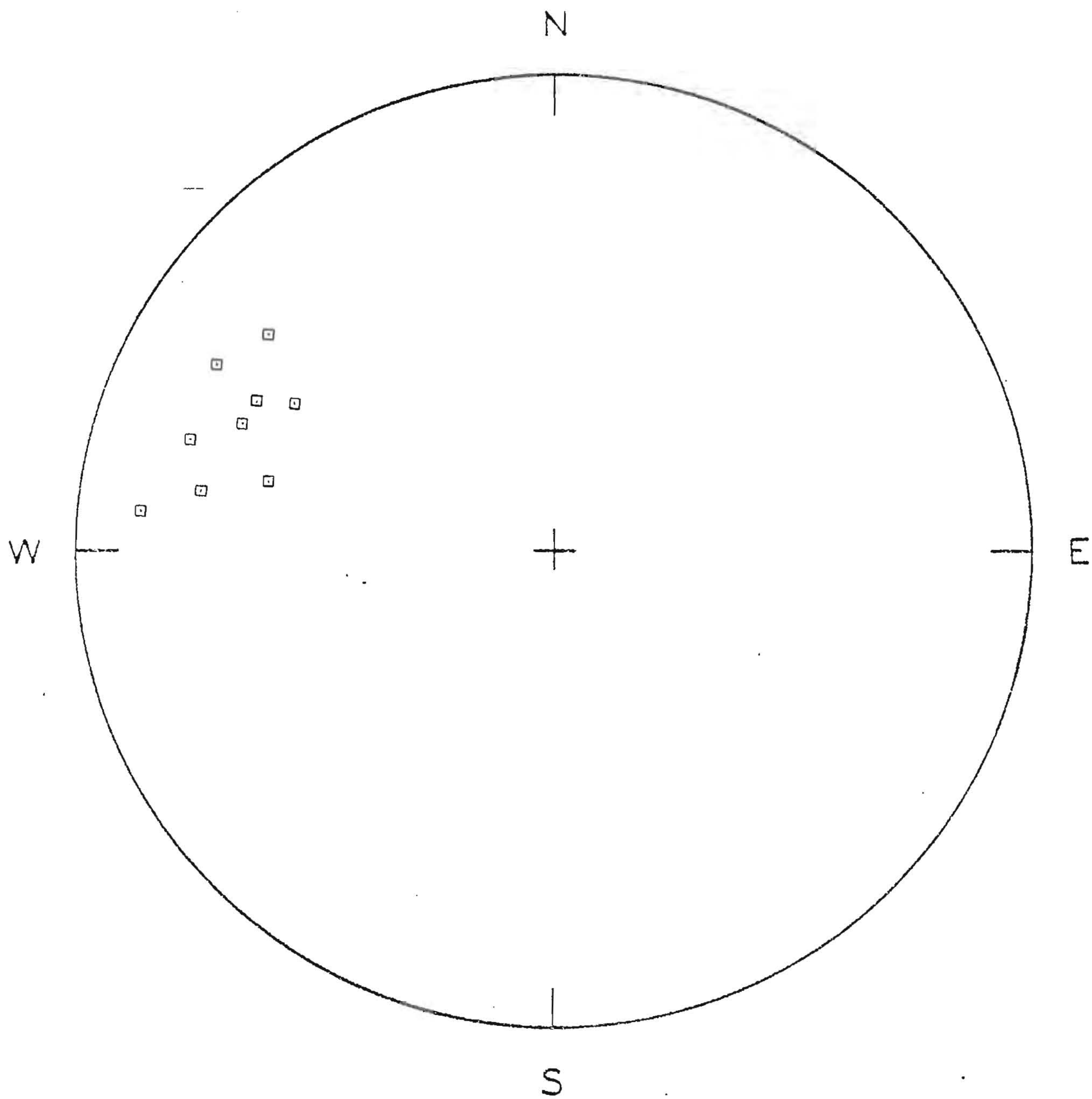
The rock along Zone 7 has been mylonitized, sheared, and brecciated. Iron oxide films have developed in shear planes surrounding quartz and quartz-chlorite augen in mylonitized zones. The iron was released from biotite alteration (from olive-green to red-brown biotite) and migrated to the old shear planes surrounding augen. The shear-breccia zones contain subrounded to subangular fragments of quartz-chlorite, plagioclase-quartz, plagioclase, polygonized quartz, and in some sections fragments of a plagioclase-quartz-biotite gneiss. The brecciation produced a large amount of fine-grained matrix material. Following or during brecciation, the rock was recrystallized under greenschist metamorphic conditions causing extensive replacement of feldspar by muscovite and almost complete replacement of the matrix by chlorite and epidote with sericite present along thin dilation fractures. Polygonization of quartz occurred as a recovery process. The breccia matrix in sections DC-4-1A and DC-4-1C was healed by minor muscovite and epidote development in fractures parallel with and branching into the matrix under greenschist conditions. The matrix was then replaced by prehnite so that essentially all the breccia zone, with the exception of large fragments, consists of interlocking and unbroken prehnite crystals. In some sections calcite and laumontite patches formed in and replaced fine-grained fault material and also filled dilation fractures cutting the shear-breccia zones. Some large laumontite crystals appear to be kinked but are cut by calcite veinlets associated with smaller undeformed laumontite crystals. The large, deformed laumontite crystals appear to have been present prior to final dilation fracturing and hydrothermal activity.

In summary, mylonitization, shearing, and brecciation have been healed by the following sequence of events:

1. Development of iron oxide in shear planes surrounding augen in mylonitized zones under greenschist metamorphic conditions.
2. Recrystallization under greenschist metamorphic conditions involving replacement of feldspars by muscovite, polygonization of quartz, development of fine-grained chlorite, and replacement of the breccia matrix by fine-grained chlorite, epidote, and sericite.
3. Selective replacement of breccia matrix by undeformed, interlocking crystals of prehnite under hydrothermal conditions, and
4. Development of large laumontite crystals followed by veinlets of calcite and smaller crystals of laumontite in dilation fractures that cut the breccia matrix.

Zone 7 is similar to the shear-breccia zones described in Section 3.6.2.1, Appendix 2C, Cherokee PSAR. Events 1 and 2 described above correlate with Event III, Table 2C-1A, "Site Geologic Events as Related to Regional Geology," Cherokee PSAR. Events 2 and 4 correspond with Events VA and VB respectively, Table III-2, "Site Geologic History as Related to Regional Geology," Final Geologic Report on Brecciated Zones, Catawba Nuclear Station. Laumontite in fractures at Catawba Nuclear Station has a potassium-argon date of 86± 30 million years (Section 5.10.2, Final Geologic Report on Brecciated Zones.) Features of Zone 7 correspond with previously studied features at Cherokee and Catawba Nuclear Stations. Shearing and brecciation are therefore at least 56 and probably more than 150 million years old.

Supporting documents (maps, thin-section reports, and point-plots of shear planes) are located in the file labeled "Geologic Reports - Zones 7 to 9" and Files No: CD10-07 and CD10-08.



POINT PLOT
(9 OBSERVATIONS)
▫ SHEAR PLANE

EQUAL AREA PROJECTION OF POLES TO PLANES
ZONE 7

ZONE 8

Zone 8 was discovered in the Nuclear Service Water Dam excavation during final foundation mapping. The exposure was mapped at 1"=10', thin sections studied, and the zone related to the fault features and geologic history studied and established in the Cherokee PSAR.

The shear zone extends from coordinates 17+82, 166R to 16+43, 20L for a mapped length of 230 feet. Strike of the major shear varies from N-S to N22°E with dip varying from 46° to 78°SE. Continued mapping of the upstream and downstream portions of the dam will help establish the extent of the zone in the foundation and its relationship to other faults or shear zones present.

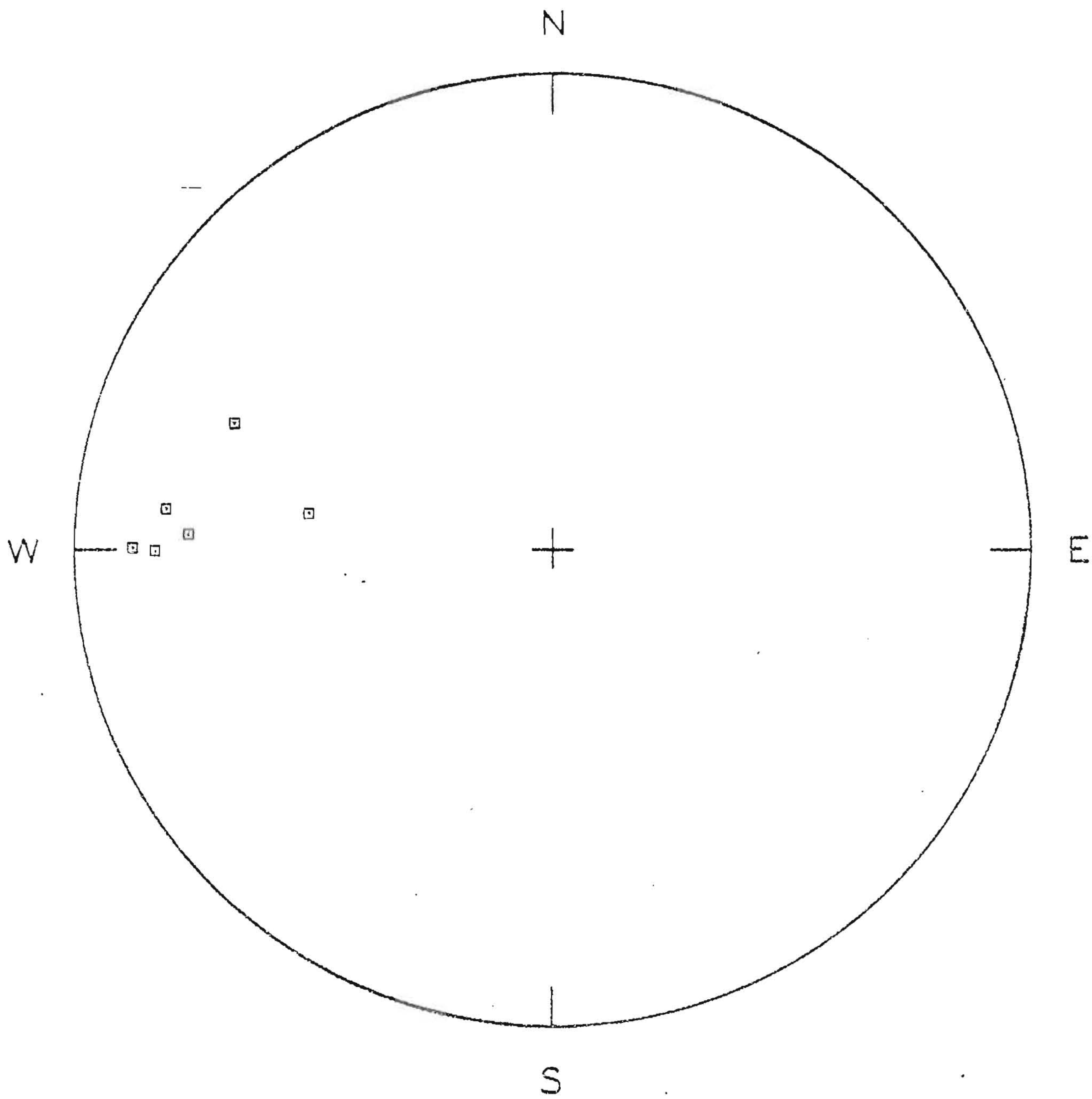
The fault consists of shear-breccia zones 1 inch to 1 foot wide composed of numerous, closely spaced, southeast dipping breaks trending northeast. Associated with the major shear are numerous subparallel splays (See Drawing Nos: CK-0018-07 and CK-0018-08). Shearing often occurs along contacts between rock types, but in some areas occurs with similar rock on either side of the shear. A possible displacement (approximately 5 feet, right-lateral) of a mafic gneiss unit occurs near coordinates 16+90, 43R along the main shear. Splays in the vicinity and the irregular shape of the mafic gneiss unit make a assessment of total offset impossible. A 25-foot, right-lateral offset of two parallel quartz veins is centered on coordinates 17+17, 84R along the main shear. Smaller, minor offsets of quartz veins and pegmatites are present along splays.

Two undisturbed samples (DC-8 and DC-12) were obtained along the major shear zone and three samples (DC-5, DC-6, and DC-7) were obtained along splays of the major shear. One of those samples(DC-8) was not suitable for thin section preparation. The sample locations are shown on drawings CK-0018-07 and CK-0018-08. Mineral paragenesis as related to fracturing and shearing was studied in eight thin sections of rock from the samples.

Rock along the zone has been sheared and mylonitized under high confining pressure. Greenschist metamorphism followed causing extensive development of muscovite-sericite and minor epidote. Quartz recovered from strain through polygonization. Later dilation fractures that primarily opened up old shear planes and a few that are oblique to shear planes are filled with fine-grained potassium feldspar and minor quartz and/or iron oxide. Some dilation fractures remained open with later iron oxide being deposited (possibly as late as the saprolization episode). One section (DC-6C-1B) contains a 2-5 cm wide brecciated zone in which the majority of matrix material is goethite and the fragments consist mainly of pulled apart and slightly rotated augen of feldspar, plagoclase, and/or polygonized quartz. Potassium feldspar fills some dilated shear planes and also occurs as scattered patches throughout the thin-section. The sequence of events illustrated in this thin-section is as follows: (1) The rock was sheared and mylonitized producing an augen texture, (2) greeschist metamorphism, (3) the rock was fractured (brecciated) principally from dilation producing minor displacement and rotation of augen, (4) greenschist metamorphism continued with crystallization of red-brown biotite along shear fracture walls and (5) crystallization of potassium feldspar in dilated shear planes. Some dilational fractures were not completely filled during metamorphism and contain later-formed iron oxide.

Zone 8 is similar to the shear and breccia zones described in Section 3.6.2.1, Appendix 2C, Cherokee PSAR and as such is at least 170 and probably more than 250 million years old. The fractures which parallel and cut the shear-breccia zones at varying angles are similar to those described in Section 2.6.2.2, Appendix 2C, Cherokee PSAR. Potassium feldspar in the fractures discussed in the Cherokee PSAR has been determined to be 219 million years old (See Table 2C-3A, Cherokee PSAR). The zone correlates with Events III and IV, Table 2C-1A, "Site Geologic Events as Related to Regional Geology", Cherokee PSAR.

Supporting documents (maps, thin section reports, and point-plots of joints and shear planes) are located in the file labeled "Geologic Reports Zone 7 to 9" and Files No: CD10-07 and CD10-08.



POINT PLOT
(6 OBSERVATIONS)
▫ SHEAR PLANE

EQUAL AREA PROJECTION OF POLES TO PLANES
ZONE 8

ZONE 9

Zone 9 was discovered in the Nuclear Service Water Dam foundation during final foundation mapping. The exposure was mapped at 1"=10', thin sections studied, and the zone related to the fault features and geologic history studied and established in the Cherokee PSAR.

The shear zone extends from coordinates 15+23, 55L to 16+53, 375R for a mapped length of approximately 460 feet. Strike of the major shear varies from N9°E to N53°E with dip varying from 32° to 53°SE. To the southeast the zone extends beyond the limits of the NSW Dam foundation. Continued mapping of the downstream portion of the dam will help establish the extent of the fault in the foundation and its relationship to other faults or shear zones present.

Zone 9 consists of a major shear-breccia zone 1 inch to 6 inches wide with one major shear plane trending in a northeasterly direction. Associated with the major shear plane are a few minor subparallel splays (See Drawing Nos: CK-0018-04, CK-0018-07, and CK-0018-08). Shearing often occurs along contacts between rock types, but in some areas occurs with similar rock on either side of the shear. Displacement of lithologic units was not recognized along the portion of the zone mapped.

Six undisturbed samples (DS-17, DS-18, DS-19, DS-20, DS-37, and DS-38) were obtained along or near the major shear zone. Two core borings (DCH-1 and DCH-2) were drilled to intersect the shear zone at depth to obtain relatively unweathered samples to aid in the identification of the fine-grained matrix material in the breccias discussed in the following paragraph. The sample and boring locations are shown on drawings CK-0018-07 and CK-0018-08. Mineral paragenesis as related to fracturing and shearing was studied in twenty-nine thin sections (in many cases there are two thin sections per sample cut perpendicular) of rock from the samples and core borings.

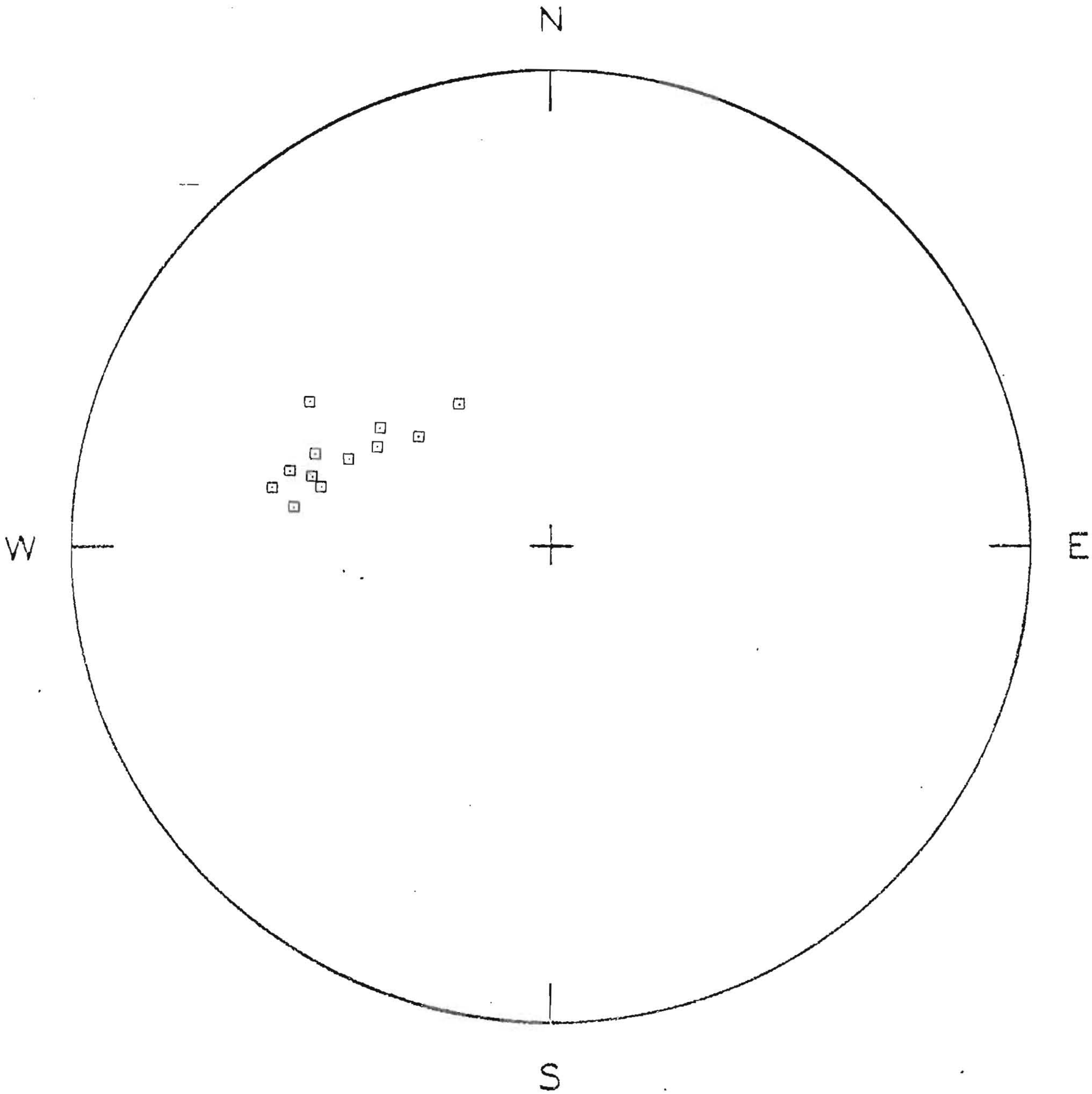
The rock along Zone 9 has been mylonitized, sheared, and brecciated. The texture is gneissic as defined by subparallel and anastomosing seams of iron oxide, epidote, and biotite cutting through an otherwise rather equidimensionally textured rock. Shear zones are somewhat mylonitic and are marked by development of iron oxide staining and by crystallization of greenschist minerals (epidote and micas) along these early strain and fracture planes. Shearing was followed by brecciation in which breccia fragments are subrounded to rounded and rotated. The breccia fragments are somewhat gneissic and are composed essentially of quartz and plagioclase. The plagioclase has been extensively replaced by epidote, muscovite, chlorite, and pale biotite. Matrix material is very fine-grained and identification of minerals in the samples collected at the level of the exposed foundation was difficult due to weathering. Examination of relatively unweathered samples of the breccia from the two core borings (DCH-1 and DCH-2) confirmed that undeformed fine-grained epidote and mica have extensively replaced the fine-grained matrix material. Calcite and epidote filled veins cut across the epidote replaced breccia matrix. Although calcite crystals in these veins are strongly twinned and thus may have been strained somewhat, they are not brecciated. Finally dilation fractures filled with calcite, quartz, and barite(?) veins cut all earlier fractures with no detectable offsets. Further dilation fracturing with minor offsets healed by undeformed calcite and laumontite crystals is the last event to affect these rocks.

In summary the following sequence of events have affected these rocks: (1) development of gneissic texture (foliation), (2) shearing and mylonitization under greenschist metamorphic conditions as indicated by the development of epidote, biotite, muscovite, chlorite, and iron oxide along the shear planes, (3) brecciation subparallel to foliation, with breccia fragments composed essentially of quartz and plagioclase , the plagioclase is extensively replaced by epidote, muscovite, chlorite, and pale biotite, (4) continued brecciation under greenschist metamorphic conditions with rotated and rounded to subrounded breccia fragments in a very fine-grained matrix , the matrix has been extensively replaced by fine-grained epidote and minor muscovite (locally brecciation was intense enough to destroy the majority of evidence for the earlier shear and mylonite development), (5) formation of veins filled with calcite and minor epidote that cut the epidote replaced breccia matrix, (6) dilation fractures with no detectable offsets filled with calcite, quartz, and barite (?), and (7) further dilation fracturing with minor offsets healed by undeformed calcite and laumontite crystals cut all the above features and is the last event to affect to these rocks.

Zone 9 is similar to the shear-breccia zones described in Section 3.6.2.1, Appendix 2C, Cherokee PSAR. Events 1 to 5 described above correlate with Events III and IV, Table 2C-1A, "Site Geologic Events as Related to Regional Geology," Cherokee PSAR. Event 6 may correspond to an early phase of Event V of Table III-2, "Site Geologic History as Related to Regional Geology," Final Geologic Report on Brecciated Zones, Catawba Nuclear Station. Event 7 corresponds with Event VB, Table III-2, Final Geologic Report on Brecciated Zones.

Laumontite in fractures at Catawba Nuclear Station has a potassium-argon age of 86±30 million years (Section 5.10.2, Final Geologic Report on Brecciated Zones). Features of Zone 9 correspond with previously studied features at Cherokee and Catawba Nuclear Station. Shearing and brecciation are therefore at least 56 and probably more than 150 million years old.

Supporting documents (maps, thin section reports, point-plot of shear planes, and boring logs) are located in the file labeled "Geologic Reports - Zones 7 to 9" and Files No: CK 10-04, CK 10-07, and CK 10-08.



POINT PLOT
(12 OBSERVATIONS)
▫ SHEAR PLANE

EQUAL AREA PROJECTION OF POLES TO PLANES
ZONE 9

ZONE 10

Zone 10 was discovered in the excavation for the Unit 2 Turbine Building during top of rock mapping. The exposure was mapped at 1"=20' and 1"=5', thin sections studied, and the zone related to the fault features and geologic history studied and established in the Cherokee PSAR.

The shear zone is within the triangular area defined by the following coordinates: (1) 102+50X, 97+15Y, (2) 101+60X, 97+98Y, and (3) 102+50X, 99+ 16Y (Ref. Drawing No: CK-0016-12). The major shears have been mapped for 100 and 105 feet. Numerous smaller parallel shears and splays have also been mapped. Strike of the shears varies from N14°E to N 58°E with the average strike of the major shears being approximately N25°E. Dip varies from 60°NW to 47°SE with the average near vertical or dipping steeply northwest. Top of rock mapping in Unit 3 and final foundation mapping in Unit 2 will help establish the extent of the zone and its relationship to other faults or shear zones present.

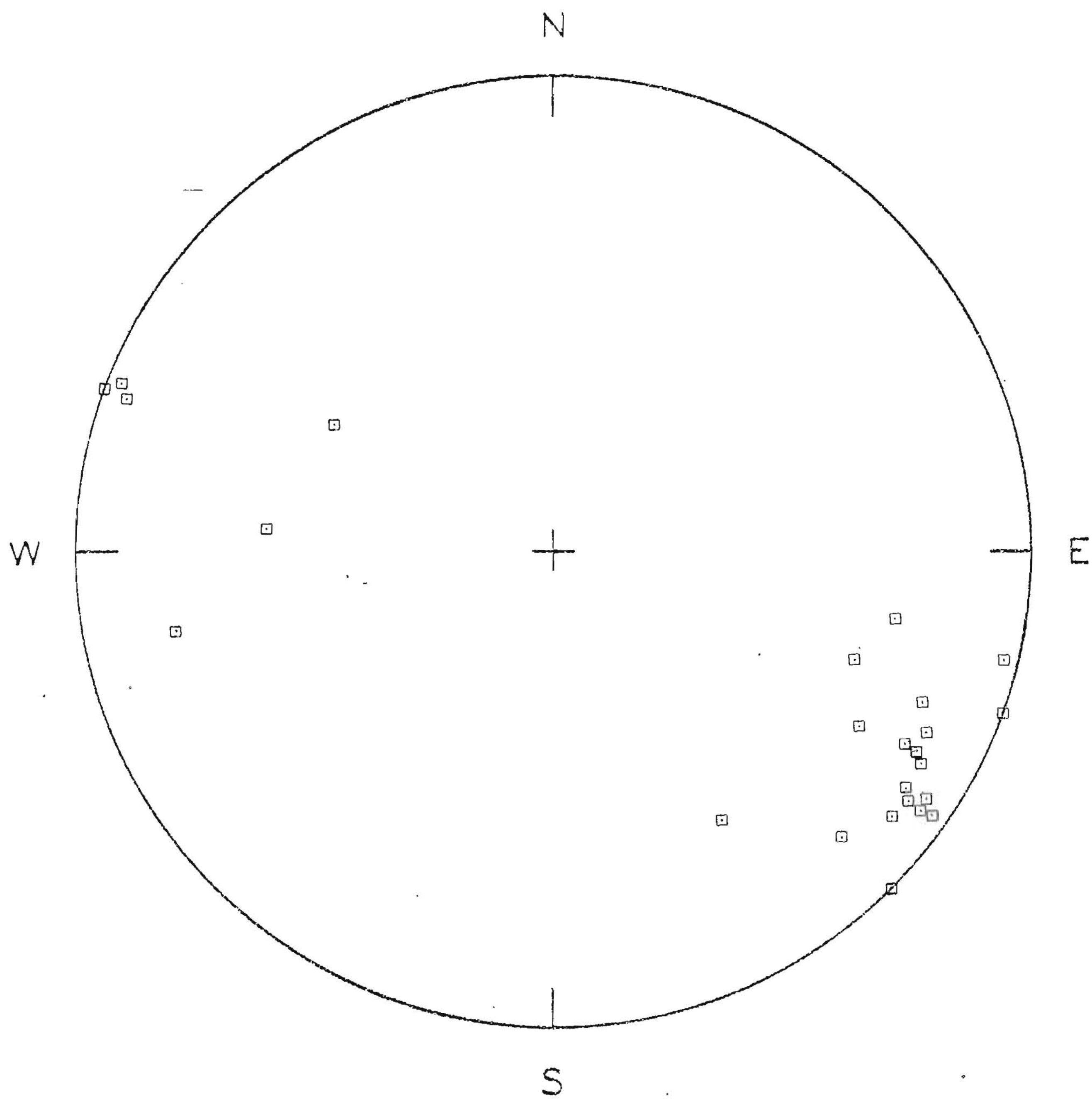
Zone 10 consists of shear-breccia zones 1 inch to 1 foot wide comprised of single planes of shearing to numerous, closely-spaced, parallel fractures. The major shear planes occur along mafic gneiss-felsic gneiss contacts, but in some locations shear planes cut the mafic gneiss bodies without a detectable offset. It appears that in these cases movement is taken up by the mafic unit in the form of numerous, closely-spaced, parallel fractures with less concentrated shearing than in the felsic gneiss. Five offsets of quartz veins were observed and measured. The apparent (viewed in a horizontal plane) right-lateral displacements range from 1 to 12 inches ((1) 2" RL at 102+26.5X, 98+80Y, (2) 1" RL at 102+45.5X, 98+97Y, (3) 2" RL at 102+50.5X, 98+98.5Y, (4) 4" RL at 102+35X, 98+15.5Y, and (5) 12" RL at 102+40X, 97+45Y). A quartz-feldspar pegmatite may be offset 2 inches right-lateral at 102+13X, 98+02.5Y. In other places along the zone quartz-feldspar veins cut across or are dragged out along the shear plane with apparently undeformed quartz-feldspar parallel to the shear plane. Shear planes are healed with greenschist minerals, quartz, feldspar, micas, and minor chlorite and epidote.

Four undisturbed samples (C-31, C- 32, C- 33, and C-34) were obtained along the zone. The sample locations are shown on drawing CK-0016-12. Mineral paragenesis as related to fracturing and shearing was studied in eight thin sections of rock from the samples.

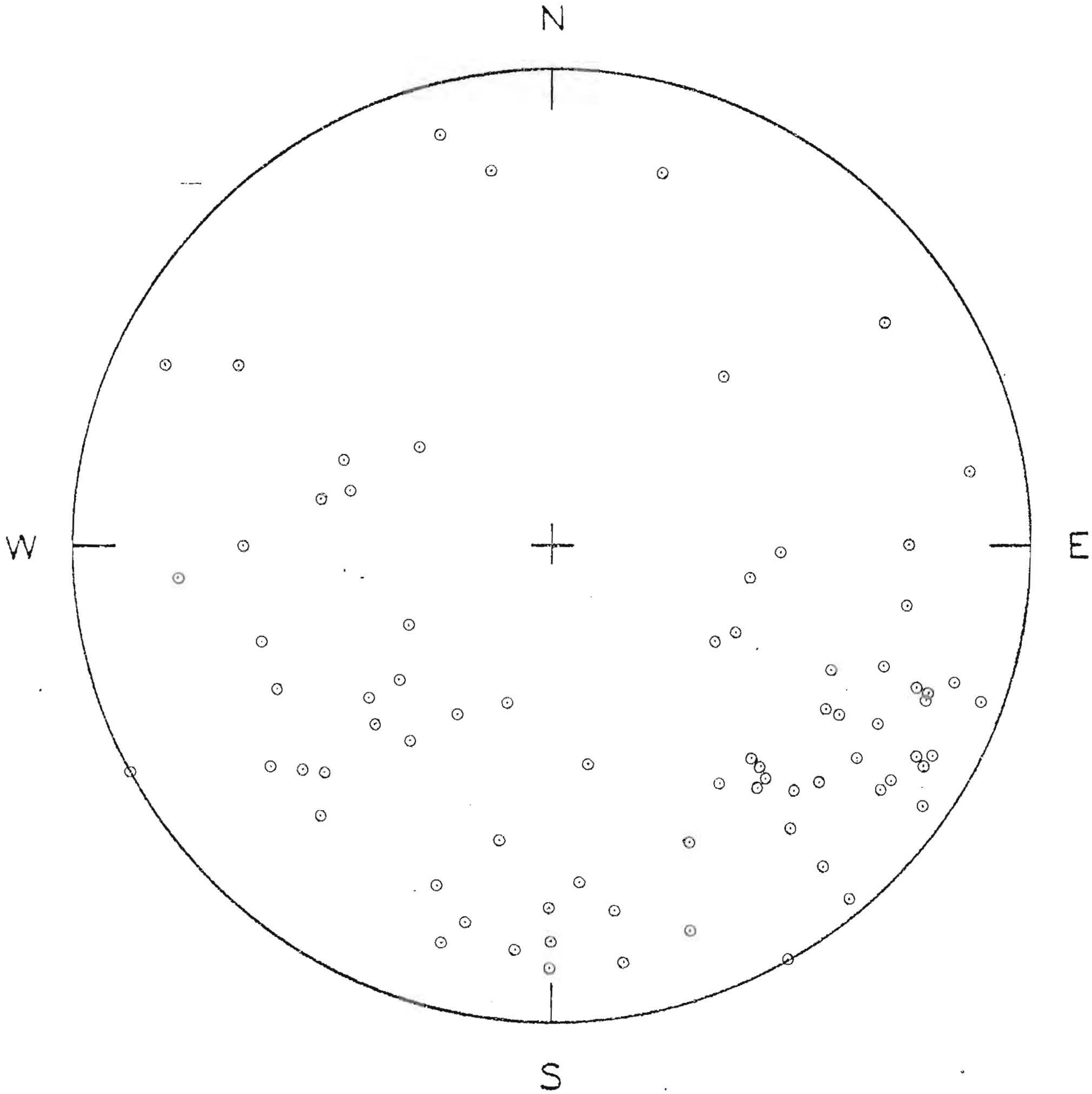
The country rock is a fine- to medium-grained hypidiomorphic granular "felsic gneiss" upon which weak gneissic texture (foliation) as defined by muscovite bands and essentially parallel oriented single grains of biotite and muscovite has been superimposed. The rock is composed primarily of quartz and plagioclase, subordinate amounts of potassium feldspar, muscovite, and biotite with minor amounts of iron oxide, epidote, apatite, and opaques. Quartz has been strained and has recovered through polygonization of grain boundaries. Feldspars are usually sericitized. Thin, somewhat mylonitic, shear zones are oriented at a slight angle to foliation. The shears are branching, curving, and discontinuous surfaces filled with well-developed muscovite and iron oxide. Secondary mica, mostly muscovite, is strongly oriented parallel to shears with occassional muscovite grains oblique to shears. Minor brecciation is indicated by randomly oriented and slightly rounded breccia fragments within the major shear zone. Unbroken, fine-grained subhedral to euhedral epidote crystals are developed in a few shear planes. A few thin potassium feldspar veinlets are present in the shear zones. Some are oriented parallel to and within the shear zone, probably due to dilation along the shear planes. Fine-grained, undeformed potassium feldspar also occurs in dilation fractures that cut the shear planes at varying angles. The following sequence of events has affected these rocks: (1) Development of foliation in a relatively massive rock, (2) shearing at a low angle to foliation, (3) recrystallization under greenschist metamorphic conditions (greenschist minerals are most abundant in and along shear zones indicating that shearing must have occurred in the greenschist event and stopped before the end of the event), (4) dilation fracturing parallel and oblique to shear planes, and crystallization of undeformed potassium feldspar in the dilation fractures.

Zone 10 is similar to the shear and breccia zones described in Section 3.6.2.1, Appendix 2C, Cherokee PSAR and as such is at least 170 and probably more than 250 million years old. The fractures which parallel and cut the shear-breccia zones at varying angles are similar to those described in Section 3.6.2.2, Appendix 2C, Cherokee PSAR. Potassium feldspar in the fractures discussed in the Cherokee PSAR has been determined to be 219 million years old (See Table 2C-3A, Cherokee PSAR). The deformational history of the zone correlates with Events III and IV, Table 2C-1A, "Site Geologic Events as Related to Regional Geology", Cherokee PSAR.

Supporting documents (maps, thin section reports, and point-plots of joints and shear planes) are located in the file labeled "Geologic Report - Zone 10" and File No: CK 20-03.



POINT PLOT
(25 OBSERVATIONS)
▫ SHEAR PLANE
EQUAL AREA PROJECTION OF POLES TO PLANES
ZONE 10



POINT PLOT
(76 OBSERVATIONS)
⊙ JOINT

EQUAL AREA PROJECTION OF POLES TO PLANES
ZONE 10

PETROGRAPHIC DESCRIPTION
ROCK SAMPLE

Sample Submitted By: Duke Power Company
Specimen Number: C-31-1
Location:

Megascopic: Brownish-gray, medium-sized grain, foliated crystalline rock that is cut by a 2cm wide shear-breccia zone. The zone is inclined to the foliation at a low angle and is stained more brown than the remainder of the rock. It also contains weathered vugs suggesting the removal, by weathering, of a mineral that was well developed in the zone.

Microscopic: Two thin sections (A&B), furnished.

Major Components:	Percent:	Comments:
Potash feldspar	15	Altering to sericite.
Plagioclase feldspar	15	Much altered, some is brecciated.
Quartz	25	Large grains in rock, polygonized grains with iron oxide in shear zones.
Muscovite	30	Much developed in shears.
Biotite	10	Red-brown variety; most is in unsheared rock.
Epidote	5	Fine grained, sub- to euhedral grains in bands in the shear zones.

Minor Components: Opaque minerals, iron oxides, apatite.

Texture: Gneissic; cut by a shear-breccia zone. All the rock minerals contain evidence of strain followed by greenschist rank mineral development, especially in the most deformed parts of the rock. Fine-grained, subhedral to euhedral epidote and randomly-oriented, unbroken mice crystals are developed in faults. A few, thin K-spar veinlets are present in the fault zone. They are not faulted. Randomly oriented and slightly rounded breccia fragments are located within the main fault zone.

Origin: This (apparent) plutonic rock was sheared and, probably later, slightly brecciated. Greenschist metamorphism then caused micas and epidote to grow in faulted material. Quartz was polygonized. Finally some dilation occurred and these fractures were filled with potash feldspar.

Rock Classification: Sheared and brecciated felsic gneiss.

Petrography By: Henry S. Brown Date: 2-25-78
M.F.H.

PETROGRAPHIC DESCRIPTION
ROCK SAMPLE

Sample Submitted By: Duke Power Company
Specimen Number: C-33-1, C-33-2
Location:

Megascopic: Very much like C-31-1 except the shear (-breccia?) zone consists of two parallel parts; one ~3mm and the other ~10cm wide.

Microscopic: Two thin sections, furnished.

Major Components:	Percent:	Comments:
Plagioclase feldspar	25	Altering to quartz and muscovite and quartz (?) grains.
Microcline	15	Altering to quartz and muscovite and quartz (?) grains.
Quartz	30	Most is strained (large grains) or polygonized (small grains).
Biotite	10	Dark brown (large grains) or red-brown (small grains).
Muscovite	20	Secondary, well oriented.

Minor Components: Apatite, iron oxides, epidote.

Texture: Hypidiomorphic granular on which has been superimposed much alteration consisting of fine-grained muscovite and quartz replacing feldspar. Muscovite and iron oxide filing are also well developed along thin, discontinuous shears. Secondary mica, mostly muscovite, is strongly oriented parallel to shears and imparts a slight gneissic texture to the rock. Shears have been healed by greenschist alteration. Some K-spar veins are in shear zones and appear to occur in dilated shear planes.

Origin: This plutonic rock was sheared and then rehealed by greenschist metamorphism. Most abundant greenschist minerals are located in and along shear zones indicating that shear zones were responsible for locating greenschist mineral develpoment. Thus shearing had to preceed or occur early in the greenschist and stop before the end of the greenschist event. Some potash feldspar grains were found in and parallel with old shear zones. These are probably occupying dilation fractures and are the last feature formed in the sample.

Rock Classification: Sheared felsic gneiss.

Petrography By: Henry S. Brown Date: 2-25-78

MFH.

Zone 10 cont
thin-section reports
C-35 to C-44

Zone 10 file

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-35
Location: Cherokee Nuclear Station Site, S. C.

Megascopic:

Microscopic: One thin section, furnished

Major Components	Percent	Comments
Microcline	40	As irregular grains with variable degrees of strain and in veinlets, occasionally with epidote
Plagioclase	20	Some large, irregular grains and as small grains; most contain muscovite flakes
Quartz	20	Most is strained and polygonized
Biotite	10	Olive and brown varieties
Muscovite	10	Mostly in sub-parallel bands cutting across older textures

Minor Components: Epidote, opaque minerals, chlorite (in plagioclase)

Texture: Essentially granular arrangement of feldspars and quartz. These major mineral grain boundaries are polygonized. Superimposed is a schistose texture created by sup-parallel alignment of mica grains and bands of grains. Small irregular veinlets of potash feldspar, sometimes with epidote, follow apparent dilation fractures parallel to and at low angles to mica bands.

Origin: This apparent igneous rock was strained and deformed probably by a combination of shearing and brecciation. Past deformation crystallization, probably in the greenschist range of metamorphism, caused growth of micas on shear and fracture planes and polygonization rehealing of feldspars and quartz brecciated areas. Following development of micas, dilation fracturing opened schistose planes in old shear zones. These were later filled in with potash feldspar and minor epidote. There has been no fracturing following development of potash feldspar veinlets.

Classification: Felsic gneiss (sheared granite?)

Petrography By: Danny N. Brown Date: 2-6-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-36
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is brownish-gray, medium fine grain sized, and possesses a schistose texture. Occasional fractures (very thin) are filled with dark brown limonitic stain.

Microscopic: One thin section, furnished

Major Components	Percent	Comments
Microcline	20	Small (or polygonized) grains with much fine-grained, randomly oriented micas; also occurs as veinlets with micas
Plagioclase	25	Rather long, well-twinned crystals; small inclusions of muscovite are common; grain boundaries usually polygonized
Quartz	35	Strained and polygonized
Muscovite	15	In shears (parallel orientation), fractures, and in feldspars

Minor Components (5%): Biotite, epidote, opaque minerals, limonite

Texture: The rock is hypidiomorphic granular onto which has been superimposed a schistose texture. A thin, iron-oxide filled breccia zone crosses the section. Minor masses and veinlets of potash feldspar are developed in and slightly cross cut schistose and breccia layers. Quartz is commonly polygonized. Feldspars (except for potash feldspar in veinlets) usually contain small muscovite inclusions and have strained and polygonized grain boundaries.

Origin: This (apparently) plutonic rock was sheared under rather high confining pressure. The shearing served to localize and encourage development of muscovite-rich zones that formed during greenschist metamorphism. Metamorphism also recrystallized quartz and feldspar creating some polygonization. Minor brecciation followed shearing. Considerable iron oxide has filled in the breccia matrix. The last tectonic event to affect this rock was minor dilation fracturing. This, in turn, was followed by introduction of potash feldspar veinlets, probably while the rock was still under greenschist metamorphic conditions. Potash feldspar veinlets that fill dilation fractures are simple and rather regular in form. These are the features of the last-formed, potash feldspar veinlets. On the other hand, this rock also contains irregular masses and veinlets of potash feldspar that appear to have developed during or shortly after the shearing and greenschist events. While it appears that potash feldspar has been introduced over a long period of time, it is probable that the earlier feldspar veinlets were formed by mobilization and recrystallization of original microcline crystals in the plutonic rock. This is suggested by the somewhat augen-like shape and essentially parallel to schistosity orientation of the "irregular masses" of potash feldspar.

Classification: Sheared and brecciated adamellite (quartz monzonite)

Petrography by: Henry S Brown Date: 8-6-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-37
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample consists of a medium grain sized, gray colored, granular rock that contains a three inch thick zone of pink to brown-colored, sheared material. Large (up to one inch in diameter) pink feldspar and gray quartz masses occur in the sheared material.

Microscopic: One thin section, furnished

Major Components	Percent	Comments
Microcline	50	Large, strained grains and smaller grains in bands parallel to micaceous bands
Quartz	15	Rather large grains (veinlet blobs) and smaller grains in potash feldspar
Muscovite	30	Enriched in irregular bands
Biotite	5	Minor, with muscovite

Minor Components: Epidote, opaque minerals, iron oxide

Texture: Schistose, with augen of microcline surrounded by muscovite, zones pass through essentially granular textured rock. Some augen are large and may have "grown in place" since they are larger than average mineral grains in unsheared rock.

Origin: This plutonic rock was weakly sheared during or before greenschist metamorphism. The metamorphism healed shearing effects by developing micas and epidote in the rather widely spaced and irregular shear planes. Large, irregular masses of microcline and quartz may also have grown post shearing.

Classification: Felsic gneiss (sheared granite)

Petrography by: Henry S Brown Date: 8-6-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-38
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a medium grain sized, gray, essentially massive rock that contains a 3½ inch wide shear zone. The zone contains rounded to augen-shaped masses of unsheared rock up to ½ x 1 inch.

Microscopic: One thin section, furnished

Major Components	Percent	Comments
Microcline	45	Large to small grains and in very irregular veinlets
Quartz	20	Small, polygonized grains
Muscovite	25	Generally stubby crystals following old shear planes
Biotite	5	Minor; associated with muscovite and "dusty" iron oxide
Plagioclase	5	Small, twinned grains

Minor Components: Epidote, apatite, iron oxide

Texture: Schistose with feldspars and quartz occupying augen defined by undulating bands of micas. Thin microbreccia (and in part dilation) fractures are subparallel to schistosity and are partially filled by potash feldspar. Thin, irregular potash feldspar veinlets are also observed to cross the microbreccia zones.

Origin: This plutonic rock was sheared and later healed during greenschist metamorphism. Essentially dilation fracturing then occurred but it contained enough lateral movement to cause some brecciation. Still later potash feldspar was introduced into these microbreccias, essentially rehealing them. Some areas of the dilation-breccia fractures still contain unfilled void spaces. No fracturing has affected these rocks since potash feldspar mineralization.

Classification: Felsic gneiss (sheared granite)

Petrography by: Henry S Brown Date: 8-6-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-39
Location: Cherokee Nuclear Station Site, S. C.

Megascopic:

Microscopic: One thin section, furnished

Major Components	Percent	Comments
Potash feldspar	65	Apparently secondary, filling shear and breccia zones
Muscovite	30	Sub-parallel arrangement, related to shearing
Biotite	5	

Minor Components: Chlorite, opaque minerals, epidote, limonite (stain), quartz(?)

Texture: Schistose on which has been superimposed a breccia zone consisting of rounded feldspar grains and a very fine-grained granular matrix.

Origin: This apparent igneous rock was sheared and shearing was followed by greenschist rank metamorphism that developed micas in the shear plane. Some potash feldspar mineralization appears to have occurred at this time. The rock was then brecciated with the breccia zone exhibiting strong comminution. Irregular veinlets of iron oxide are within the breccia zone. The next event was dilation fracturing essentially in the breccia zone. These dilation fractures were later filled with potash feldspar and appear to be the last event that affected the rock.

Classification: Felsic gneiss (sheared granite?)

Petrography By: [signature] Date: 7-6-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-40
Location: Cherokee Nuclear Station Site, S. C.

Megascopic:

Microscopic: One thin section, furnished

Major Components	Percent	Comments
Microcline	35	Polygonized larger grains and in secondary veinlets and masses of smaller grains
Plagioclase	10	Commonly altering to micas
Quartz	20	Strained and polygonized
Biotite	5	Small thin flakes with muscovite
Muscovite	30	Irregular bands and in shear planes and breccia matrix

Minor Components: Epidote, opaque minerals, limonite (stain), chlorite, apatite

Texture: Was originally granular on which has been superimposed shearing and brecciation. Micas are extensively developed in shear planes and in breccia matrix and in plagioclase feldspar. Feldspars and quartz are commonly strained and polygonized. Thin fractures carrying potash feldspar are parallel and sub-parallel to bands of micas.

Origin: Similar to C-35

Classification: Felsic gneiss (sheared granite?)

Petrography By: Denny S. Brown Date: 7-6-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-41
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a medium gray, medium grain sized, essentially massive rock containing a rounded, dark gray, fine-grained inclusion. The sample does not appear to be faulted.

Microscopic: One thin section, furnished

Major Components	Percent	Comments
Microcline	20	Strained, with micas and sutured contacts (mostly in coarse-grained rocks)
Plagioclase	45	Strained, with micas and sutured contacts
Quartz	20	Most is polygonized
Biotite	10	Olive green in rock (15% in fine-grained mafic, 5% in coarse-grained rock) and red-brown with iron oxide in schistose bands (old shears?)
Muscovite	5	Random, in feldspars and along grain boundaries

Minor Components: Epidote, opaque minerals (mostly in mafic inclusions), chlorite, apatite

Texture: Hypidiomorphic granular textures are seen in both the medium-grained plutonic host and in the fine-grained mafic inclusion. The contact between the two rock types is gradational from medium- to fine-grained. The mafic rock contains more biotite, epidote, and opaque minerals. The percentage of plagioclase may also be higher. A schistose zone crosses the two rock types and may represent an old, healed shear.

Origin: The light-colored, medium-grained plutonic rock with rounded inclusions (partially digested?) of mafic rock was apparently sheared with only a minor amount of displacement. Later greenschist metamorphism healed by recrystallization this shear zone creating a minor schistose band.

Classification: Felsic gneiss/mafic inclusion (granodiorite)

Petrography by: Henry S Brown   Date: 8-6-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-42
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a medium gray, medium grain sized, essentially massive, crystalline rock crossed by a 2½ inch wide quartz-potash feldspar pegmatite vein. There is a concentration of micas along the pegmatite-host rock contact.

Microscopic: One thin section, furnished

Major Components	Percent	Comments
Pegmatite		
Microcline	60*	Perthitic, clear of micas
Quartz	40*	Some strain, but only micor contact suturing with microcline
Rock		
Microcline	30	Not perthitic, micas well-developed, some contact polygonization
Plagioclase	25	Contains micas and has polygonized contacts
Quartz	30	
Biotite	10	More abundant and coarser grained near pegmatite contact

Minor Components in rock (5%): Epidote, apatite, opaque mineral, muscovite

Texture: Hypidiomorphic granular rock cut by a pegmatite dike

Origin: The plutonic rock was cut by a granitic pegmatite. There is no evidence of of faulting in the thin section.

Specimen Number: C-42

Classification: Felsic gneiss/pegmatite (adamellite)

Petrography by: Henry S Brown Date: 8-6-79

* Hand specimen exhibits a quartz-microcline ratio of 80-20.

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-43
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a medium grain sized, essentially massive, crystalline rock that is medium gray in color except alongside several small, irregular pegmatite veins, where the color is light brown. The hand specimen appears to contain an approximately one inch offset of one of the pegmatite veins. The thin section was cut to examine this offset to determine whether or not is represents a post-pegmatite fault.

Microscopic: One thin section, furnished

Major Components	Percent	Comments
Pegmatite		
Microcline	50	Clear grains that are perthitic in part; some grain boundaries are quite irregular and contain rounded quartz grains
Quartz	50	Most is strained
Rock		
Microcline (plagioclase?)	50	Most is small-grained, polygonized, and rather intimately mixed with micas
Quartz	30	Small grains mostly polygonal
Biotite	15	Red-brown with iron oxide; developed along old strain (shear?) zone
Muscovite	5	

Minor Components in rock: Epidote, iron oxide, pyrite (developed adjacent a pegmatite contact)

Texture: Pegmatites are equigranular with some minor strain but no apparent faulting indicated. The rock contained within the thin section is bounded on both sides by pegmatitic material. The rock is fine-grained and schistose.

Origin: Pegmatites have invaded this plutonic rock and the position of their emplacement appears to have been controlled by an old strain, or possibly a healed shear plane. There is no textural evidence on the microscopic scale to indicate that the pegmatite was emplaced and later faulted.

Classification: Felsic gneiss with pegmatites

Petrography by: Henry S Brown Date: 8-6-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-44
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is medium gray, essentially massive, and consists of randomly oriented, small black, and larger light-colored crystal aggregates in a gray, fine-grained groundmass.

Microscopic: Three thin sections, furnished

Major Components	Percent	Comments
Microcline	20?	Generally small cyrstals with polygonized boundaries and containing micas
Plagioclase	30?	Generally small crystals with polygonized boundaries and containing micas
Quartz	30?	Common in both the larger grain and as polygonal grains in the groundmass
Biotite	10	Mostly in the groundmass
Muscovite	10	Large crystals developed randomly throughout

Minor Components: Apatite, epidote, opaque minerals

Texture: The rock is granular with individual grains isolated in a sea of fine-grained quartz, feldspars, and micas. Muscovite crystals are poikilitic and are developed in both fine-grained as well as remnant larger crystal materials.

Origin: This plutonic rock appears to have been strongly deformed or strained but not faulted. Later recrystallization during greenschist metamorphism developed micas and polygonized quartz and feldspars especially in the most strained areas.

Classification: Felsic gneiss (adamellite?)

Petrography by: Henry S Brown Date: 8-6-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-45
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a gray, medium grain sized, essentially massive, crystalline rock that is crossed by a brown-colored schistose zone. A thin (1-2 mm) wide, regular vein of epidote is within and near one side of and oriented parallel to the schistose zone.

Microscopic: One thin section, furnished

Major Components	Percent	Comments
Microcline (plagioclase?)	45	As rounded, polygonized grains and as veinlets parallel and subparallel to mica-epidote zones; some grains are strained (brecciated)
Quartz	35	Most is polygonized
Biotite	5	In shear and polygonized zones
Muscovite	10	In shear and polygonized zones
Epidote	5	Best developed in shear and breccia zones

Minor Components: Chlorite, apatite, opaque minerals

Texture: The texture is granular onto which has been superimposed shearing and strain that has been converted to schistose zones by greenschist rank recrystallization. Thin, breccia and microbreccia zones are superimposed on granular and schistose texture. Thin, dilation fractures now filled with potash feldspar are in the breccia zones.

Origin: This plutonic rock was sheared and strained. Greenschist rank metamorphism converted deformed portions of the rock to schistose zones. Following shearing, and still within the greenschist event, the rock was affected by minor brecciation. Epidote and potash feldspar developed extensively in the breccia zones. Dilation fracturing opened up some old fault planes and potash feldspar was introduced into these. No faulting has affected this rock subsequent to potash feldspar vein formation.

Classification: Sheared and brecciated felsic gneiss

Petrography by: Henry S Brown Date: 8-6-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-46
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a gray, medium grain sized, essentially massive, crystalline rock that contains a 1.5 inch wide schistose zone. Portions of non-schistose rock occur within the zone. The zone is blue-gray to brownish and is generally fine-grained.

Microscopic: Two thin sections, furnished

Major Components	Percent	Comments
Microcline	15	Smaller grains in the rock and as augen-like patches and veinlets within schistose bands
Plagioclase	45	Large, well-twinned grains; much alteration to micas; polygonized boundaries
Quartz	30	Most is polygonized
Biotite	5	Red-brown variety with iron oxide
Muscovite	5	In feldspars (minor percentage) and in the schistose zone (15%)

Minor Components: Epidote, apatite, iron oxide, pyrite (in schistose zone)

Texture: Hypidiomorphic granular with a muscovite-potash feldspar-quartz schistose band passing through. Considerable development of micas is observed in the feldspars not in the schistose zone.

Origin: This plutonic rock was sheared and later greenschist rank metamorphism recrystallized and healed the shear zone. This sample has not been affected by faulting since greenschist metamorphism.

Classification: Felsic gneiss (granodiorite)

Petrography by: Henry S Brown Date: 8-6-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-47
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a gray, medium fine-grained, essentially massive, crystalline rock that contains a 1.5 inch wide granitic schistose band bordered by a one-half inch wide granitic pegmatite vein. The schistose band is fine-grained and blue-gray to brownish (weathered) in color.

Microscopic: One thin section, furnished

Major Components	Percent	Comments
Microcline	10	Small, rounded grains
Plagioclase	30	Small grains
Quartz	30	Most is polygonized
Biotite	25	Stubby, brown crystals, rather uniformly distributed

Minor Components (5%): Muscovite, pyrite, epidote, apatite

Texture: Schistose with a few augen of quartz and feldspar. An irregular, pyrite-filled veinlet may mark the position of an early fracture.

Origin: This rock, probably plutonic, was sheared and the shear zone was later healed by development of micas, and by polygonization of feldspars and quartz during greenschist rank metamorphism. A pyrite-filled, irregular veinlet was probably formed during the greenschist event. No fracturing has occurred since greenschist metamorphism.

Classification: Felsic gneiss

Petrography by: Henry S Brown Date: 8-6-75

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-48
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a gray colored, medium grain sized, essentially massive, crystalline rock that contains a 4+ inch wide schistose, brown-colored zone that contains grains of feldspar and clots of quartz. Numerous (shrinkage?) cracks cut across the zone and may be related to weathering. A rounded, mafic inclusion is alongside the schistose zone in the plutonic rock.

Microscopic: Three thin sections, furnished

Major Components	Percent	Comments
Microcline	15	A few large crystals with some strain and polygonized borders; minor veinlets of microcline present
Plagioclase	40	A few large crystals with some strain and polygonized borders
Quartz	35	Polygonized
Biotite	5	Red-brown with iron oxide; mostly in zones; some is quite fine-grained
Muscovite	5	In fine-grained and polygonized areas and in schistose bands

Minor Components: Epidote, opaque minerals

Texture: Schistose and brecciated. Brecciation is superimposed on portions of both the rock's original granular texture and the schistose zone. Brecciation is seen as thin seams (microbreccias) and more general, especially within the schistose zone. Individual quartz and feldspar grains are extensively brecciated and/or polygonized. Potash feldspar veinlets, sometimes following old microbreccia lines, cut across earlier schistosity. In places potash feldspar and iron oxide are enriched in the breccia matrix. Muscovite grains are also developed in the breccia matrix and it is common in iron oxide poor regions for relatively large muscovite flakes to occupy the entire matrix area between breccia fragments. Numerous, large dilation fractures cut across the shear-breccia zone. These fractures are essentially empty except for minor iron oxide staining. They tend to pinch or splay out in the less-deformed portions of the rock. In a few cases they turn essentially parallel with the shear-breccia zone and are seen to lead into feldspar-mica veinlets and this suggests they predate the end of the greenschist event.

Origin: This plutonic rock was sheared and brecciated. Greenschist metamorphism followed shearing and continued during brecciation. This metamorphic event produced subparallel micas in schistose zones and randomly oriented micas in the breccia matrix. Iron oxide, probably released from recrystallized biotite, migrated into portions of the breccia matrix. Potash feldspar fills thin fractures crossing schistosity and forms pods and irregular masses within the breccia matrix. Dilation fracturing may have occurred before the end of greenschist metamorphism but the fractures remain essentially unfilled. The sections studies present no evidence of any faulting occurring after the greenschist metamorphic event.

Classification: Sheared and brecciated felsic gneiss

Petrography by: Henry Brown Date: 8-1-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-49
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a gray-colored, medium grain sized, essentially massive crystalline rock that has a one-half inch wide brown to black colored schistose zone passing through. The sample is deeply weathered and the black material is quite soft.

Microscopic: Four thin sections, furnished

Major Components	Percent	Comments
Microcline	20	Rather small grains, much polygonized along boundaries; in thin veinlets following fractures parallel to the pegmatite contact and to schistosity
Plagioclase	40	Some grains small, some large; larger contain inclusions of micas; polygonized boundaries
Quartz	30	Polygonized
Biotite	5	In irregularly oriented bands usually following old strain zones

Minor Components (5%): Muscovite (large flakes near pegmatite are bent and broken by faulting), epidote, opaque minerals

Pegmatite:	Microcline	50	Minor strain, some polygonization
	Quartz	50	Minor strain, some polygonization

Texture: Sheared and brecciated rock cut by a granitic pegmatite that possesses a granular texture and no evidence of faulting. Some micas in the pegmatite host rock are truncated and/or bent along shear planes. However, these planes are open and filled with potash feldspar in places (C-49A-1, C-49[2]).

Specimen Number: C-49

Origin: This plutonic rock was sheared and brecciated. Greenschist rank metamorphism has recrystallized all fractures created by these two types of faulting. The pegmatite vein was emplaced into the fault zone, before the end of greenschist mineralization and possibly before the end of all faulting. The pegmatite possesses no fault structures. However, large muscovite flakes adjacent the pegmatite that are probably genetically related to the pegmatite have been faulted. This late faulting was simple, minor movement apparently along an old shear plane. This last faulting may have been related to dilation because displacement is extremely small and these fractures are opened and filled in places with undeformed potash feldspar crystals. No faulting has affected this rock since the formation of potash feldspar veinlets.

Classification: Sheared and brecciated felsic gneiss (granodiorite)

Petrography by: Danny N Brown Date: 8-1-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-45
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a gray, medium grain sized, essentially massive, crystalline rock that is crossed by a brown-colored schistose zone. A thin (1-2 mm) wide, regular vein of epidote is within and near one side of and oriented parallel to the schistose zone.

Microscopic: One thin section, furnished

Major Components	Percent	Comments
Microcline (plagioclase?)	45	As rounded, polygonized grains and as veinlets parallel and subparallel to mica-epidote zones; some grains are strained (brecciated)
Quartz	35	Most is polygonized
Biotite	5	In shear and polygonized zones
Muscovite	10	In shear and polygonized zones
Epidote	5	Best developed in shear and breccia zones

Minor Components: Chlorite, apatite, opaque minerals

Texture: The texture is granular onto which has been superimposed shearing and strain that has been converted to schistose zones by greenschist rank recrystallization. Thin, breccia and microbreccia zones are superimposed on granular and schistose texture. Thin, dilation fractures now filled with potash feldspar are in the breccia zones.

Origin: This plutonic rock was sheared and strained. Greenschist rank metamorphism converted deformed portions of the rock to schistose zones. Following shearing, and still within the greenschist event, the rock was affected by minor brecciation. Epidote and potash feldspar developed extensively in the breccia zones. Dilation fracturing opened up some old fault planes and potash feldspar was introduced into these. No faulting has affected this rock subsequent to potash feldspar vein formation.

Classification: Sheared and brecciated felsic gneiss

Petrography by: Henry S Brown Date: 8-6-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-46
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a gray, medium grain sized, essentially massive, crystalline rock that contains a 1.5 inch wide schistose zone. Portions of non-schistose rock occur within the zone. The zone is blue-gray to brownish and is generally fine-grained.

Microscopic: Two thin sections, furnished

Major Components	Percent	Comments
Microcline	15	Smaller grains in the rock and as augen-like patches and veinlets within schistose bands
Plagioclase	45	Large, well-twinned grains; much alteration to micas; polygonized boundaries
Quartz	30	Most is polygonized
Biotite	5	Red-brown variety with iron oxide
Muscovite	5	In feldspars (minor percentage) and in the schistose zone (15%)

Minor Components: Epidote, apatite, iron oxide, pyrite (in schistose zone)

Texture: Hypidiomorphic granular with a muscovite-potash feldspar-quartz schistose band passing through. Considerable development of micas is observed in the feldspars not in the schistose zone.

Origin: This plutonic rock was sheared and later greenschist rank metamorphism recrystallized and healed the shear zone. This sample has not been affected by faulting since greenschist metamorphism.

Classification: Felsic gneiss (granodiorite)

Petrography by: Henry S Brown Date: 8-6-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-47
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a gray, medium fine-grained, essentially massive, crystalline rock that contains a 1.5 inch wide granitic schistose band bordered by a one-half inch wide granitic pegmatite vein. The schistose band is fine-grained and blue-gray to brownish (weathered) in color.

Microscopic: One thin section, furnished

Major Components	Percent	Comments
Microcline	10	Small, rounded grains
Plagioclase	30	Small grains
Quartz	30	Most is polygonized
Biotite	25	Stubby, brown crystals, rather uniformly distributed

Minor Components (5%): Muscovite, pyrite, epidote, apatite

Texture: Schistose with a few augen of quartz and feldspar. An irregular, pyrite-filled veinlet may mark the position of an early fracture.

Origin: This rock, probably plutonic, was sheared and the shear zone was later healed by development of micas, and by polygonization of feldspars and quartz during greenschist rank metamorphism. A pyrite-filled, irregular veinlet was probably formed during the greenschist event. No fracturing has occurred since greenschist metamorphism.

Classification: Felsic gneiss

Petrography by: Henry S Brown Date: 8-6-75

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-48
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a gray colored, medium grain sized, essentially massive, crystalline rock that contains a 4+ inch wide schistose, brown-colored zone that contains grains of feldspar and clots of quartz. Numerous (shrinkage?) cracks cut across the zone and may be related to weathering. A rounded, mafic inclusion is alongside the schistose zone in the plutonic rock.

Microscopic: Three thin sections, furnished

Major Components	Percent	Comments
Microcline	15	A few large crystals with some strain and polygonized borders; minor veinlets of microcline present
Plagioclase	40	A few large crystals with some strain and polygonized borders
Quartz	35	Polygonized
Biotite	5	Red-brown with iron oxide; mostly in zones; some is quite fine-grained
Muscovite	5	In fine-grained and polygonized areas and in schistose bands

Minor Components: Epidote, opaque minerals

Texture: Schistose and brecciated. Brecciation is superimposed on portions of both the rock's original granular texture and the schistose zone. Brecciation is seen as thin seams (microbreccias) and more general, especially within the schistose zone. Individual quartz and feldspar grains are extensively brecciated and/or polygonized. Potash feldspar veinlets, sometimes following old microbreccia lines, cut across earlier schistosity. In places potash feldspar and iron oxide are enriched in the breccia matrix. Muscovite grains are also developed in the breccia matrix and it is common in iron oxide poor regions for relatively large muscovite flakes to occupy the entire matrix area between breccia fragments. Numerous, large dilation fractures cut across the shear-breccia zone. These fractures are essentially empty except for minor iron oxide staining. They tend to pinch or splay out in the less-deformed portions of the rock. In a few cases they turn essentially parallel with the shear-breccia zone and are seen to lead into feldspar-mica veinlets and this suggests they predate the end of the greenschist event.

Origin: This plutonic rock was sheared and brecciated. Greenschist metamorphism followed shearing and continued during brecciation. This metamorphic event produced subparallel micas in schistose zones and randomly oriented micas in the breccia matrix. Iron oxide, probably released from recrystallized biotite, migrated into portions of the breccia matrix. Potash feldspar fills thin fractures crossing schistosity and forms pods and irregular masses within the breccia matrix. Dilation fracturing may have occurred before the end of greenschist metamorphism but the fractures remain essentially unfilled. The sections studies present no evidence of any faulting occurring after the greenschist metamorphic event.

Classification: Sheared and brecciated felsic gneiss

Petrography by: [signature] Date: 8-1-79

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Specimen Number: C-49
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is a gray-colored, medium grain sized, essentially massive crystalline rock that has a one-half inch wide brown to black colored schistose zone passing through. The sample is deeply weathered and the black material is quite soft.

Microscopic: Four thin sections, furnished

Major Components	Percent	Comments
Microcline	20	Rather small grains, much polygonized along boundaries; in thin veinlets following fractures parallel to the pegmatite contact and to schistosity
Plagioclase	40	Some grains small, some large; larger contain inclusions of micas; polygonized boundaries
Quartz	30	Polygonized
Biotite	5	In irregularly oriented bands usually following old strain zones

Minor Components (5%): Muscovite (large flakes near pegmatite are bent and broken by faulting), epidote, opaque minerals

Pegmatite:	Microcline	50	Minor strain, some polygonization
	Quartz	50	Minor strain, some polygonization

Texture: Sheared and brecciated rock cut by a granitic pegmatite that possesses a granular texture and no evidence of faulting. Some micas in the pegmatite host rock are truncated and/or bent along shear planes. However, these planes are open and filled with potash feldspar in places (C-49A-1, C-49[2]).

Origin: This plutonic rock was sheared and brecciated. Greenschist rank metamorphism has recrystallized all fractures created by these two types of faulting. The pegmatite vein was emplaced into the fault zone, before the end of greenschist mineralization and possibly before the end of all faulting. The pegmatite possesses no fault structures. However, large muscovite flakes adjacent the pegmatite that are probably genetically related to the pegmatite have been faulted. This late faulting was simple, minor movement apparently along an old shear plane. This last faulting may have been related to dilation because displacement is extremely small and these fractures are opened and filled in places with undeformed potash feldspar crystals. No faulting has affected this rock since the formation of potash feldspar veinlets.

Classification: Sheared and brecciated felsic gneiss (granodiorite)

Petrography by: Denny N Brown Date: 8-1-79

PETROGRAPHIC DESCRIPTION

JOB NAME Cherokee Nuclear Station JOB NUMBER CH 2920

SAMPLE NUMBER CS - 4 - 1

LOCATION West Side Unit I - - Top of Rock (Zone 5)

MEGASCOPIC:

MICROSCOPIC: One thin section

Major Components	Percent	Comments
Quartz	50	Polygonized
Biotite	30	Mostly brown, some green-brown.
Muscovite	13	
Feldspar	5	Untwinned, commonly with mica inclusions

Minor Components

(2%) Opaques, Apatite

Texture

Micaceous part: fine grained lepidoblastic.

Quartzose part: fine to medium grained granoblastic.

DISCUSSION: Rock consists of two intercalated portions, a foliated mica-rich phase (2/3) and an unfoliated phase of polygonized quartz (1/3). Feldspar occurs in the foliated portion as elongated crystals or groups of crystals (augen?). Quartz occurs in the foliated portion as polygonized pods and stringers. Quartz tends to be cross cutting in relation to schistosity but crystallization has healed any cross cutting fractures that may have controlled quartz emplacement. One quartz stringer could be isoclinally folded. A few micas are oriented oblique to foliation. Quartz is mostly unstrained. No indication of deformation since development of foliation.

CLASSIFICATION:

Schistose Mica Gneiss (Felsic Gneiss)

By [signature]

Date 8-16-77

PETROGRAPHIC DESCRIPTION

JOB NAME Cherokee Nuclear Station JOB NUMBER CH 2920

SAMPLE NUMBER C - 16 - 1

LOCATION West Side Unit I - - Top of Rock (Zone 5)

MEGASCOPIC:

MICROSCOPIC: One thin section

Major Components	Percent	Comments
Feldspar	48	Mostly plagioclase. Sericitized.
Quartz	35	Undulatory extinction in larger grains. Smaller grains are mostly polygonized.
White Mica	15	Muscovite and sericite.

Minor Components

(2%) Opaques, A deep red-brown, high birefringent mineral (biotite?), Iron oxide.

Texture

Fine grained granoblastic. Strained and slightly brecciated.

DISCUSSION: Highly weathered. Some feldspar, quartz and muscovite crystals are broken (micas also bent) and rehealed with like minerals, suggesting that brecciation occurred during metamorphism. The breccia matrix is mostly polygonized. A few irregular fractures occur. They are filled with very fine grained quartz and feldspar and randomly oriented micas and the fractures are iron stained. No indication of post-greenschist deformation.

CLASSIFICATION:

Felsic Gneiss

By [signature]

Date 8-16-77

PETROGRAPHIC DESCRIPTION

JOB NAME Cherokee Nuclear Station JOB NUMBER CH 2920

SAMPLE NUMBER C - 17 - 1

LOCATION West Side Unit 1 - - Top of Rock (Zone 5)

MEGASCOPIC:

MICROSCOPIC: One thin section

Major Components	Percent	Comments
Quartz	45	Polygonized
Muscoyite	30	Most crystals small and undeformed.
Biotite	15	Olive Brown. Larger crystals tend to be bent with some being replaced by red-brown, shred-like variety plus iron oxide near fractures.
Microcline	5(?)	
Plagioclase	5(?)	

Minor Components

(< 1%) Opaques, Iron oxide.

Texture

Fine grained lepidoblastic

DISCUSSION: Feldspars occur in augen surrounded by micas. Quartz occurs in polygonized pods (some augen-like) and veinlets. A few very thin fractures occur. In most cases, the filling material has been removed during slide preparation. The one intact fracture is filled with very fine micas and iron stained. No indication of deformation after metamorphism.

CLASSIFICATION:

Quartz-Mica Schist
(Felsic Schist)

By [signature]

Date 8-16-77

PETROGRAPHIC DESCRIPTION

JOB NAME Cherokee Nuclear Station JOB NUMBER CH 2920

SAMPLE NUMBER C - 17 - 2

LOCATION West Side Unit I -- Top of Rock (Zone 5)

MEGASCOPIC:

MICROSCOPIC: One thin section

Major Components	Percent	Comments
Quartz	65	Polygonized. Undulatory extinction.
Muscovite	20	Some crystals in quartz are very small and almost equidimensional.
Biotite	8	Mostly borwn. Some green-brown. Some chloritized.
Feldspar	5	Fine grained. Untwinned

Minor Components

(2%) Opaques, Iron oxide, Chlorite, Apatite.

Texture

Micaceous portion (1/2): Fine grained lepidoblastic. Quartzose portion (1/2): Fine to medium grained granoblastic.

DISCUSSION: Rock consists of two intercalated portions, a foliated micaceous phase (1/2) and and an unfoliated phase of polygonized quartz (1/2). A few pods of polygonized quartz and feldspar have an augen-like appearance. Several filled fractures cross the thin section. These fractures are irregular and tend to curve, branch and disappear. They are filled mostly by iron oxide, but locally contain very fine grained micas and quartzo-feldspathic material. At some places, micas are alligned parallel to the fractures and oblique to the main foliation. No indication of post-greenschist deformation.

CLASSIFICATION:

Schistose Mica Gneiss (Felsic Gneiss)

By [signature]

Date 8-16-77

PETROGRAPHIC DESCRIPTION

JOB NAME Cherokee Nuclear Station JOB NUMBER CH 2920

SAMPLE NUMBER C - 17 - 3

LOCATION West Side Unit I -- Top of Rock (Zone 5)

MEGASCOPIC:

MICROSCOPIC: One thin section (thick).

Major Components	Percent	Comments
Quartz	80	Polygonized
Muscovite	10	Much is very fine-grained in polygonized quartz.
Biotite	5	Brown and red-brown with iron oxide
Feldspar	5	Mostly microcline

Minor Components

(<1%) Opaques, Iron oxide, Apatite.

Texture

Fine grained granoblastic

DISCUSSION: Mostly polygonized quartz with intercalated micaceous bands. Some of these bands grade into iron oxide filled fractures that eventually disappear into polygonized quartz.

CLASSIFICATION:

Quartz-Mica Gneiss
(Micaceous Quartzite)

By [signature]

Date 8-16-77

PETROGRAPHIC DESCRIPTION

JOB NAME Cherokee Nuclear Station JOB NUMBER CH 2920

SAMPLE NUMBER C - 18 - 1

LOCATION West Side Unit I -- Top of Rock (Zone 5)

MEGASCOPIC:

MICROSCOPIC: One thin section. (Partly masked by excess mounting medium)

Major Components	Percent	Comments
Microcline	55	Some highly sericitized.
Plagioclase	10	Most highly sericitized.
Quartz	14	Polygonized
White Mica	14	Muscovite and sericite.
Biotite	5	Brown, unually with iron oxide.

Minor Components

(2%) Opaques, Iron oxide.

Texture

Hypidiomorphic granular. Sheared and brecciated(?)

DISCUSSION: Highly weathered. Bands of shearing and possible microbrecciation cut across what appears to be originally an igneous rock, perhaps a granite. Microbreccias are now polygonized and contain mica crystals oriented generally subparallel to major bands. Bands of micas cut across some microbreccias. Some biotite tends to be randomly oriented, especially in the short, minor polygonized microbreccias oblique to the major bands.

CLASSIFICATION:

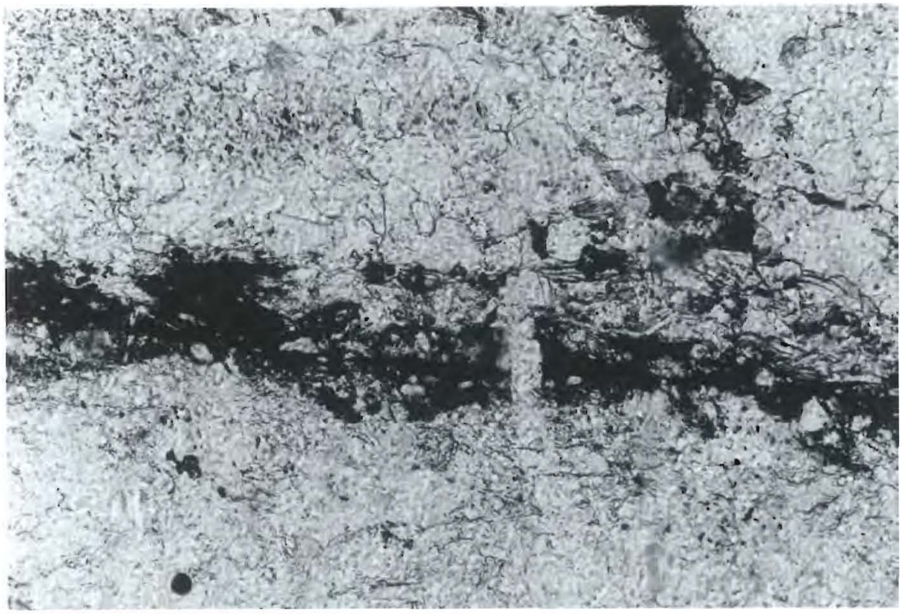
Sheared Felsic Gneiss

By [signature]

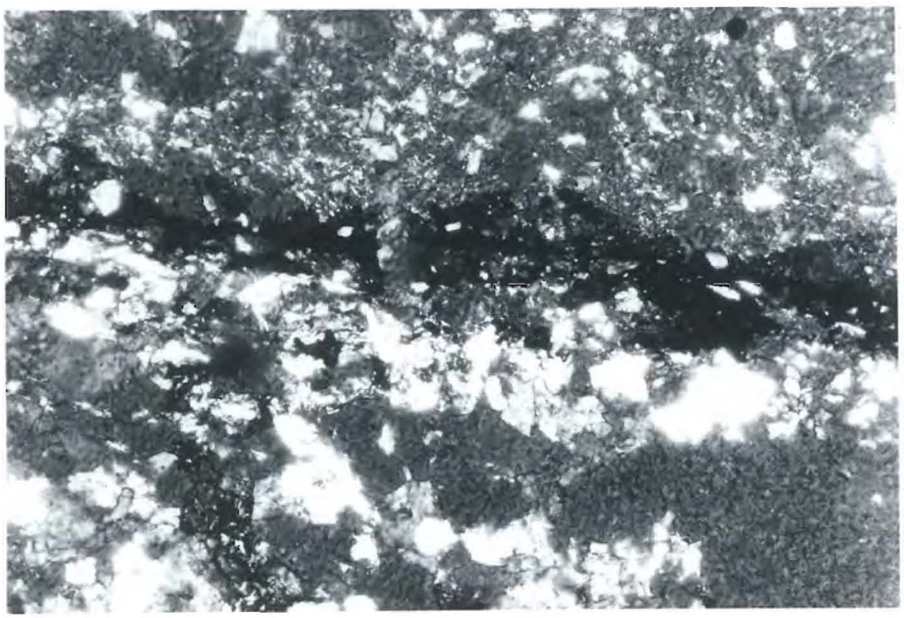
Date 8-16-77

PHOTOMICROGRAPHS
DUKE POWER COMPANY
CHEROKEE NUCLEAR STATION SITE

Thin Section Number	Negative Number	Magnification	P or X	Subject
C-36	0	100	P	K-spar veinlet crossing iron-filled shear breccia zone
C-36	1	100	X	K-spar veinlet crossing iron-filled shear breccia zone
C-38	2	40	X	Thin, irregular K-spar veinlet crossing schistosity
C-38	3	40	X	Partially filled dilation fracture (filling is K-spar/minor mica - void is in center of view)
C-44	4	25	X	Remnant crystals of quartz and feldspar in a "sea" of polygonized material. (Note larger muscovite flakes in "sea")
C-45	5	100	P	Shear breccia zone with epidote strongly developed in breccia matrix. Clear area is filled with K-spar.
C-45	6	100	X	Shear breccia zone with epidote strongly developed in breccia matrix. Clear area is filled with K-spar.
C-47	7	40	P	Pyrite along possible shear zone now healed mostly by biotite and pyrite
C-46-A	8	25	X	Muscovite-K-spar-quartz schistose zone in granular rock
C-46-B	9	40	X	(Better photograph of above)
C-43	10	25	P	Pegmatite-schistose zone contact (neither rock is faulted post greenschist metamorphism)
C-41	11	25	X	Micas and polygonized quartz and feldspar along old (possible) shear

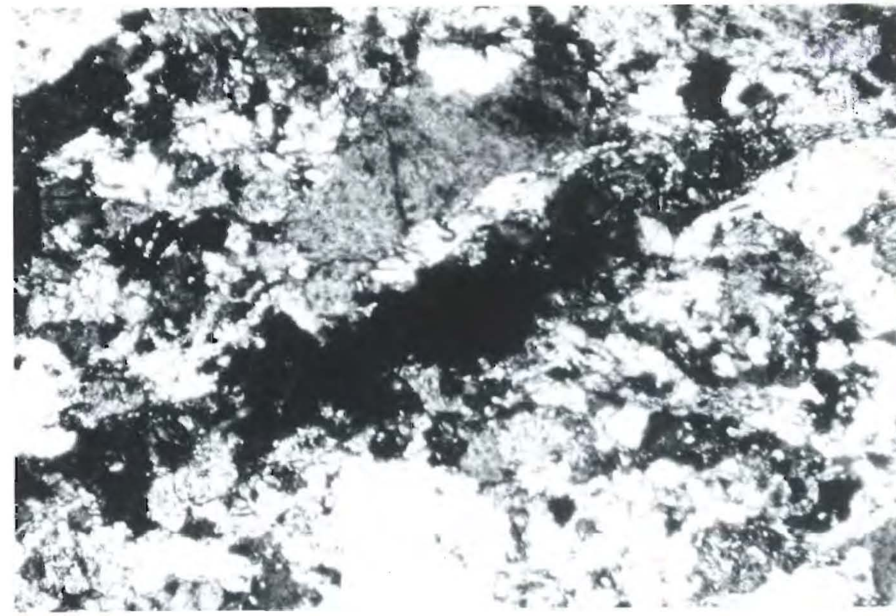


Neg. 0
T.S. C-36
MAG. 100
P

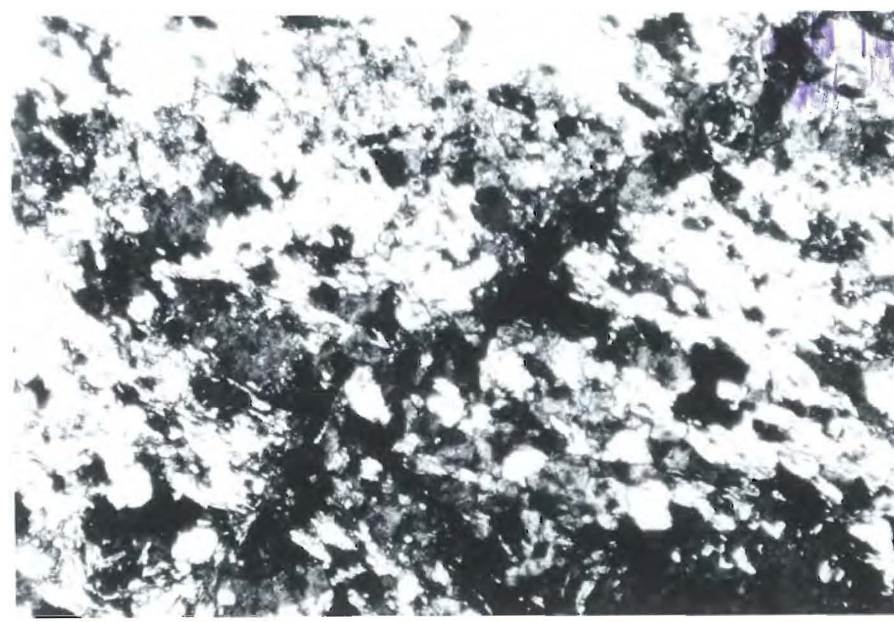


Neg. 1
T.S. C36
Mag. 100
X

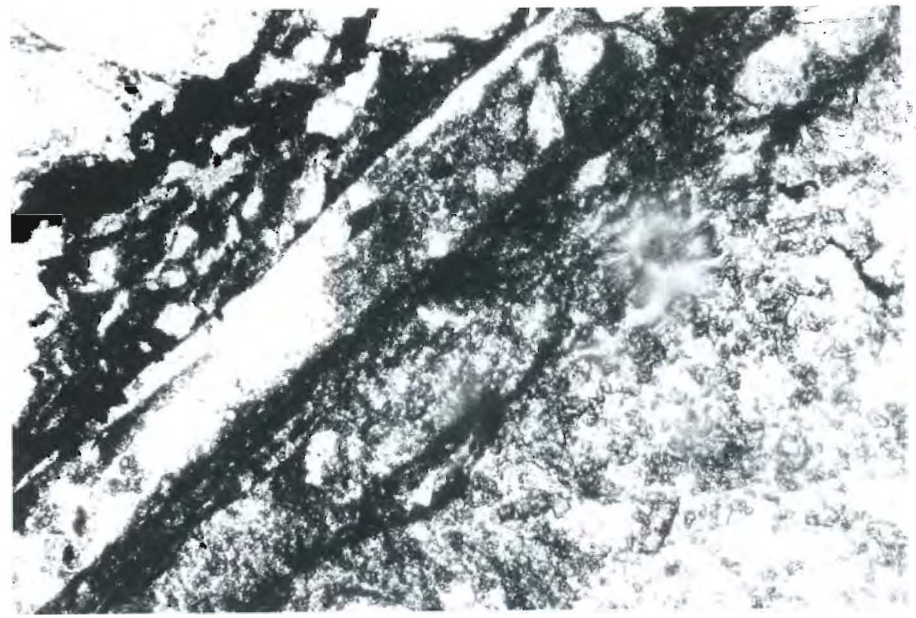
Neg. 3
T.S. G38
Mag. 40
X



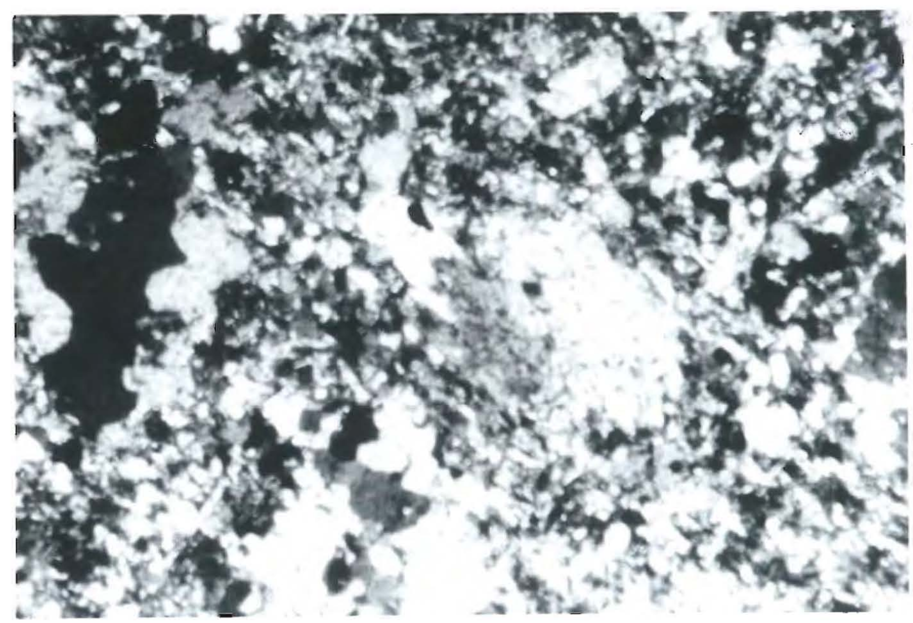
Neg. 2
T.S. G38
MAg. 40
X



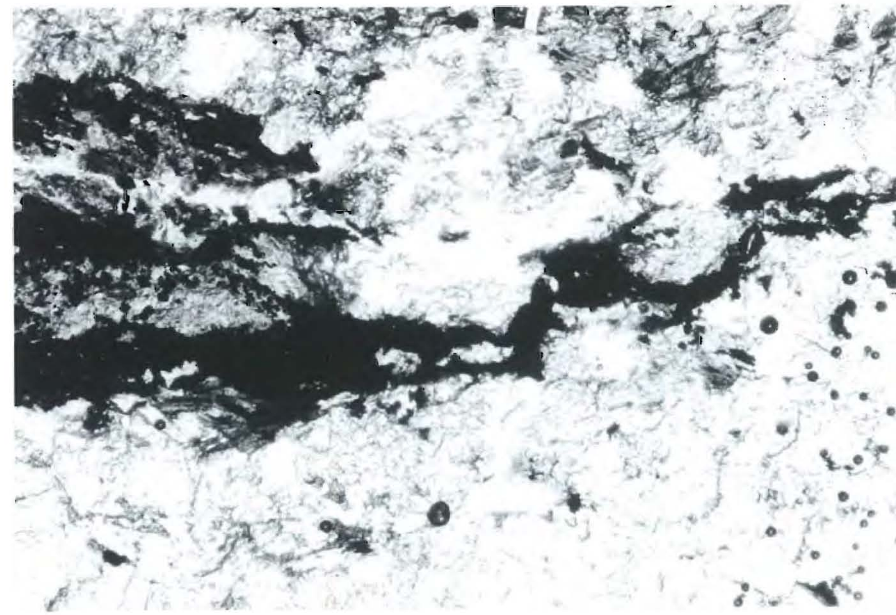
Neg. 5
T.S. C-45
Mag. 100
P



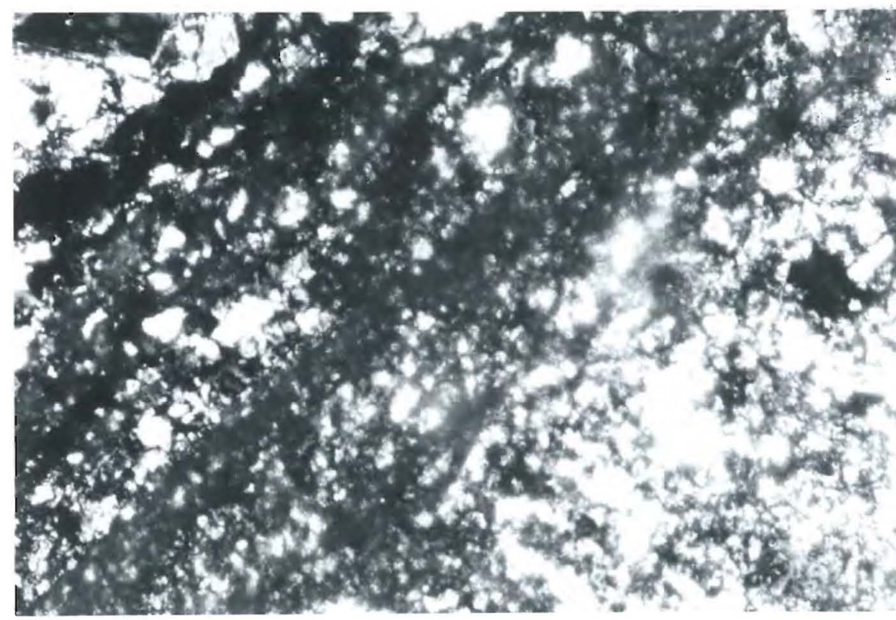
Neg. 4
T.S. C-44
Mag. 25
X



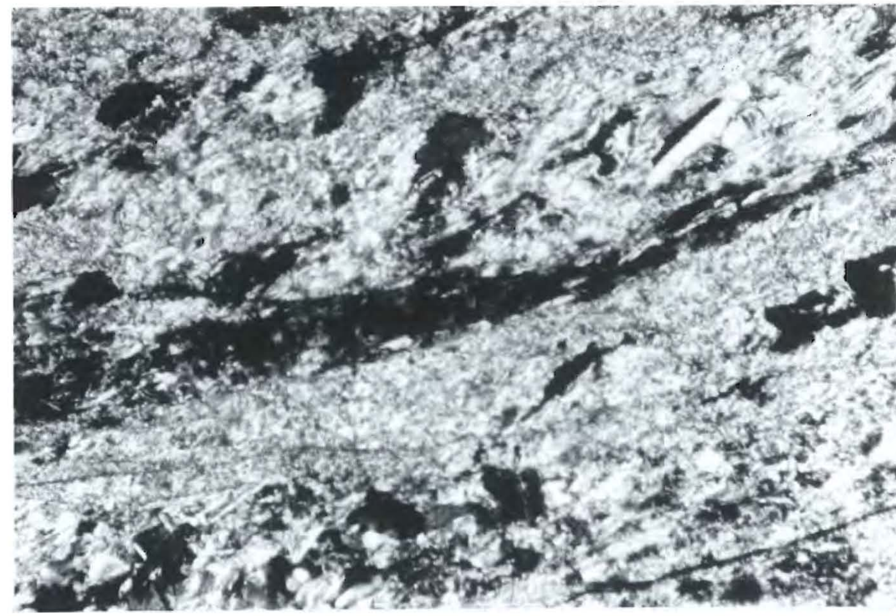
Neg. 7
T.S. C-47
Mag. 40
P



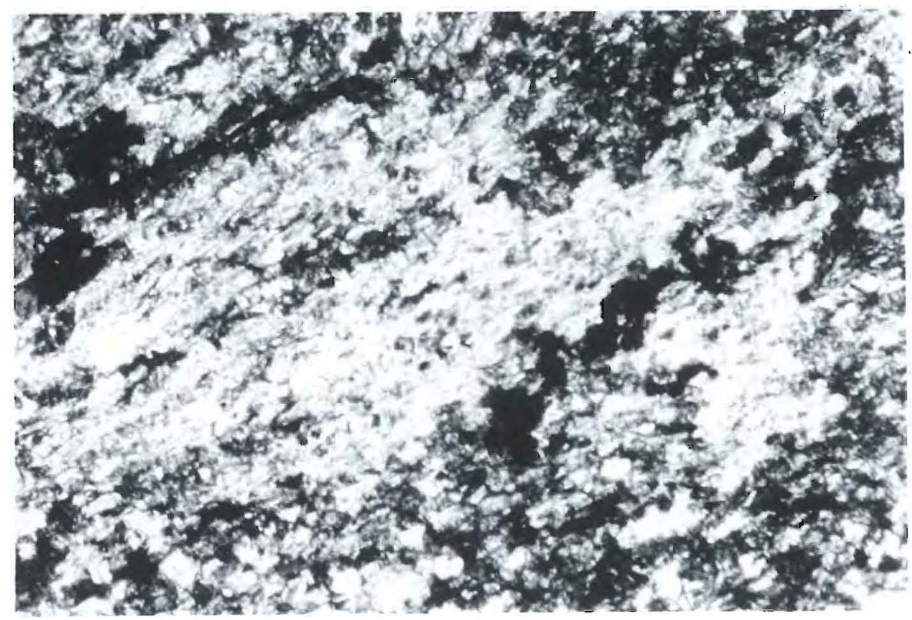
Neg. 6
T.S. C-45
Mag. 100
X



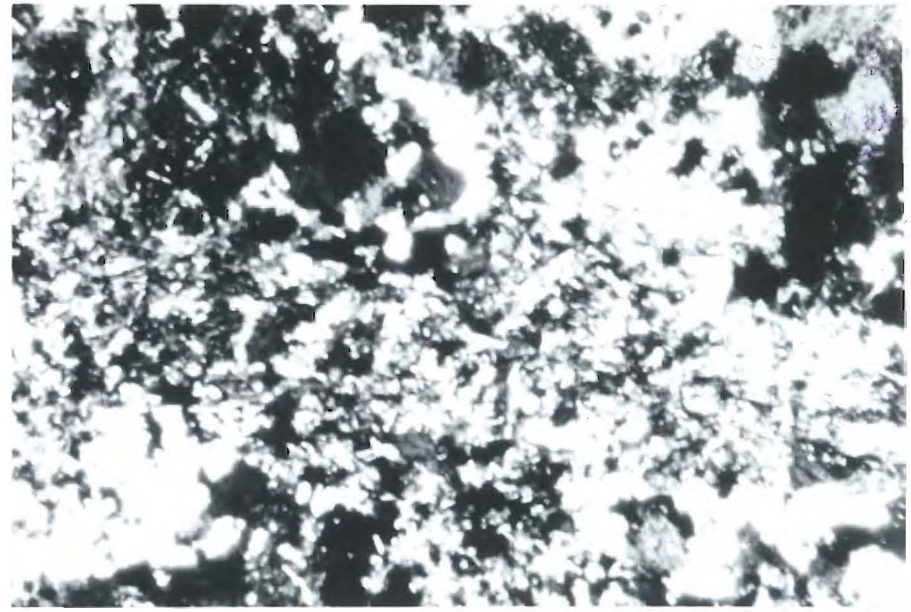
Neg. 9
T.S. C-46-B
Mag. 40
X



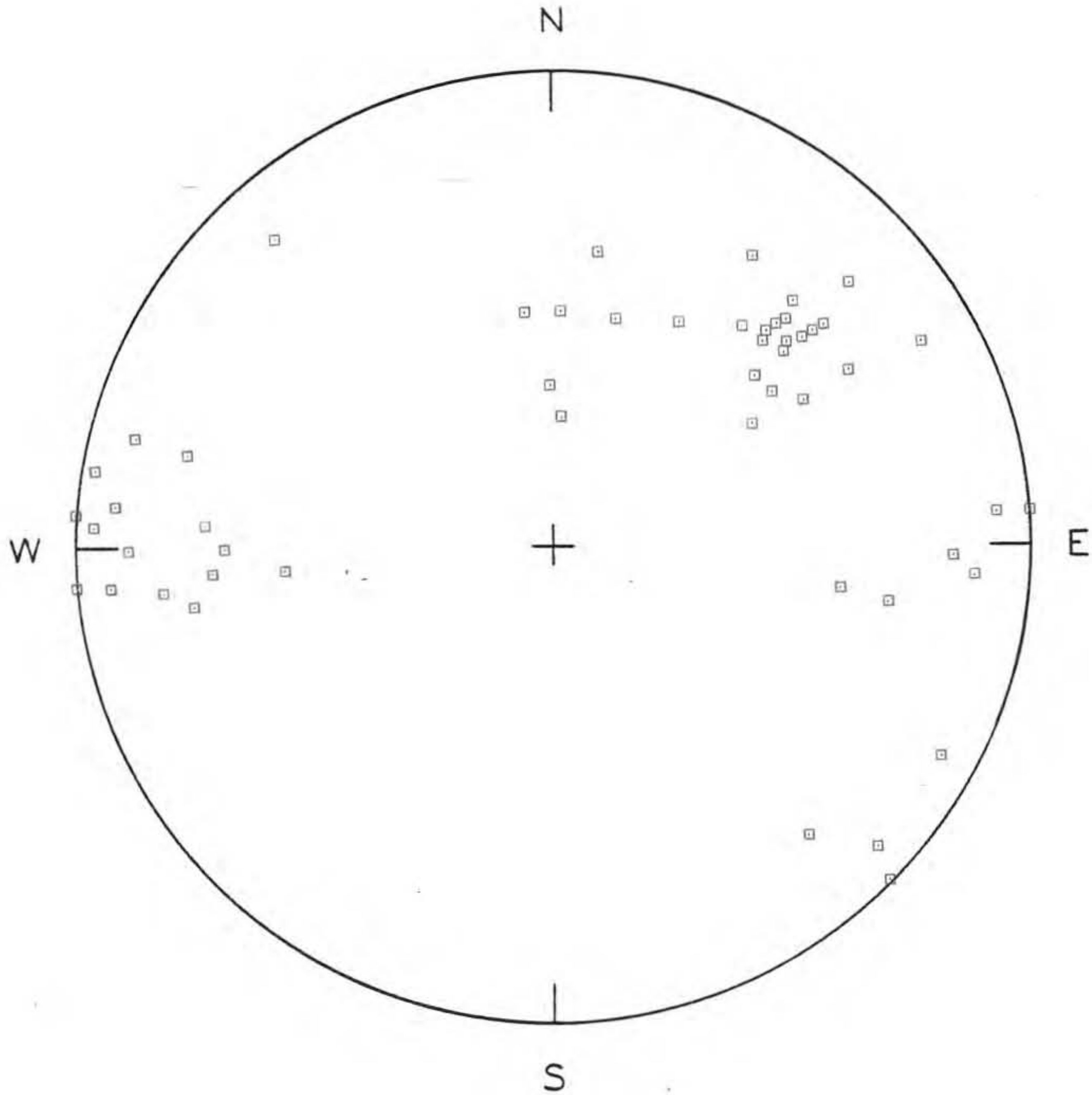
Neg. 8
T.S. C-46-A
Mag. 25
X



Neg. 11
T.S. C-41
Mag. 25
X



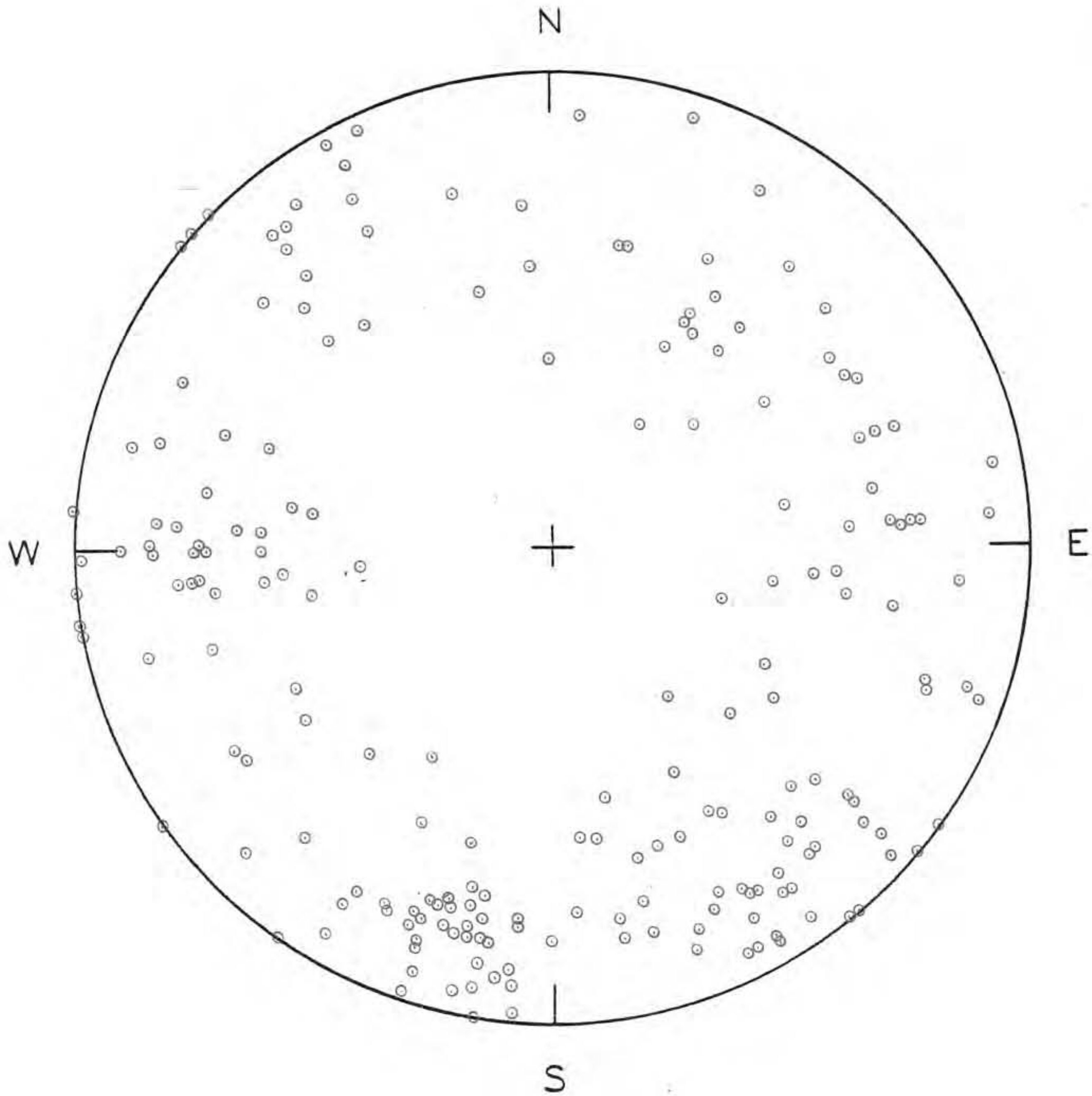
Neg. 10
T.S. C-43
Mag. 25
P



POINT PLOT
(52 OBSERVATIONS)
▫ SHEAR PLANE

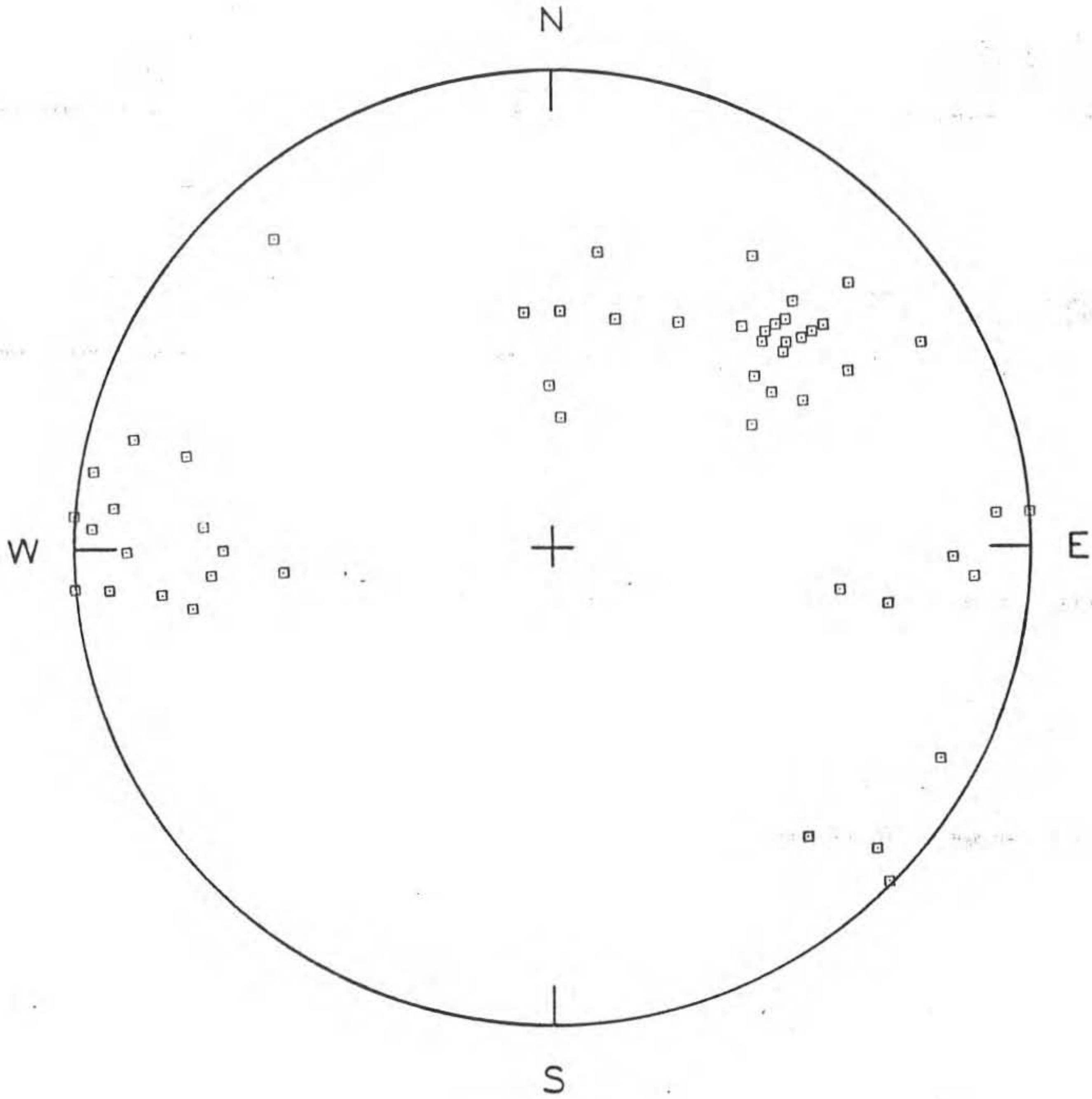
EQUAL AREA PROJECTION OF POLES TO PLANES

ZONE 6



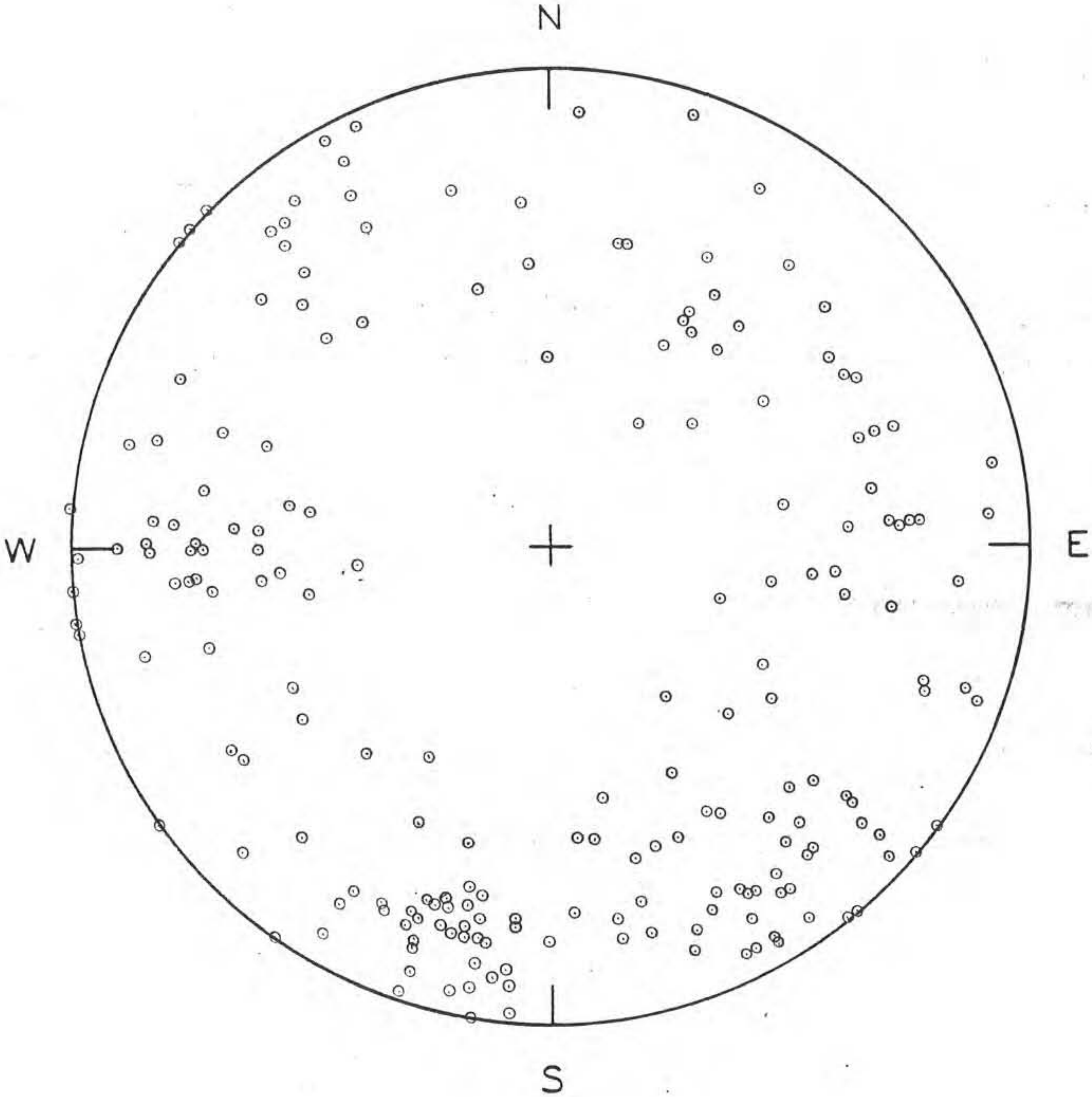
POINT PLOT
(199 OBSERVATIONS)
⊙ JOINT

EQUAL AREA PROJECTION OF POLES TO PLANES
ZONE 6



POINT PLOT
(52 OBSERVATIONS)
▫ SHEAR ZONE

EQUAL AREA PROJECTION OF POLES TO PLANES
ZONE 6



POINT PLOT
(199 OBSERVATIONS)
⊙ JOINT

EQUAL AREA PROJECTION OF POLES TO PLANES
ZONE 6

WBS DWP MF

September 20, 1977

Ira W. Pearce
Principal Engineer
Duke Power Company
P. O. Box 2178
Charlotte, North Carolina 28242

Dear Mr. Pearce:

Enclosed is a report on the Cherokee samples we examined during Malcolm Schaeffer's visit. Please let me know if you need additional information.

Sincerely,

Charles E. Weaver, Director
School of Geophysical Sciences
Georgia Institute of Technology
Atlanta, Georgia 30332

dc

Identification of Fine-Grained Mineral

Charles E. Weaver
Georgia Institute of Technology

The object of the investigation was to identify the fine-grained white minerals which occurs in shear zone rocks from the Cherokee site. Optical studies suggest the mineral is K-feldspar.

Thin sections and polished chips of the samples were examined with the scanning electron microscope (SEM); chemical analyses made using an energy dispersive x-ray analyser (EDXA).

EDXA analyses indicate the major constituents of the rocks are K-feldspar, muscovite-sericite, and quartz. K-feldspar typically has an SiO_2/Al_2O ratio of 3.3 and a Al_2O_3/K_2O ratio of 1.8. Muscovite has an SiO_2/Al_2O_3 ratio of 1.3 and Al_2O_3/K_2O ratio of 3.5.

Figure 1 is an SEM picture of a coarse grained K-feldspar (4) that had previously been identified with the optical microscope. Note the well developed cleavage. Figures 2 and 3 are EDXA patterns of the K-feldspar in Figure 1. The Si/Al ratio is high and the Al/K ratio low, as would be expected for K-feldspar.

Figure 4 is a picture of sample 9 and shows an abundance of K-feldspar with well developed cleavage. The loose "flake" in the center of the sample is K-feldspar that was apparently created when the sample was cut.

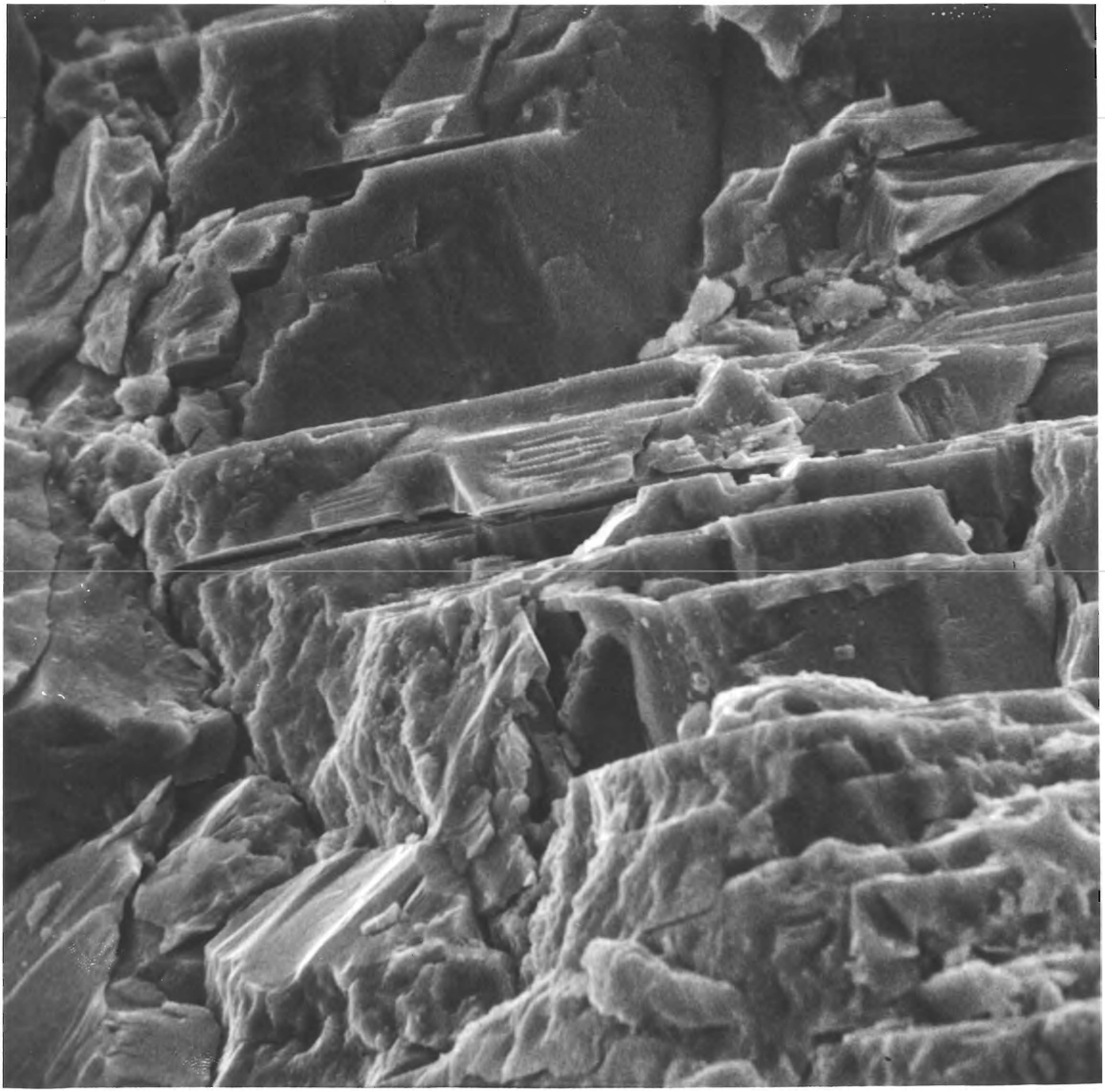
Figures 5 and 6 are SEM pictures of sample 8 showing packets of mica. The EDXA patterns (Fig. 7 and 8) show a relatively low Si/Al ratio and a relatively high Al/K ratio, as would be expected for muscovite. In addition a small amount of Fe is present and is presumably in the octahedral layer of the mica. No Fe was observed in the K-feldspar.

Figures 9 and 10 are EDXA Fe maps of sample 8 that was made in order to locate areas low in Fe (K-feldspar). The concentration of Fe increases as the density of the white dots increase. Due to the low content of Fe, the pattern is not well developed but in Figure 9 the centered portion is low in Fe. Figure 11 is a picture of the low Fe area and shows a small lense of fine grained material in a mica matrix. Figure 12 is a higher magnification view of the lense. Figures 13, 14, 15 are EDXA patterns of various portion of the lense. Figures 13 and 14 have Si/Sl, Al/K, and Fe values intermediate between those of the pure K-feldspar and the mica. This suggest the fine grained material in the lense is a mixture of the two minerals. Figure 15 is of a mica flake near the edge of the lense.

Figure 16 is an Fe map of sample 4. A weak band of low Fe material occurs near the center of the picture. Figure 17 is a higher magnification Fe map showing the Low-Fe band. Figure 18 is a SEM picture showing that the low-Fe material occurs as a smooth, narrow layer (40 to 80 um thick). Figure 19 is a higher magnification view of this material, showing the smooth surface. An EDXA pattern (Fig. 20) indicates the material is pure K-feldspar.

Figure 21 is a picture of the rougher surface outside the smooth layer. An EDXA pattern (Fig. 22) indicates the material is a mixture of K-feldspar and muscovite.

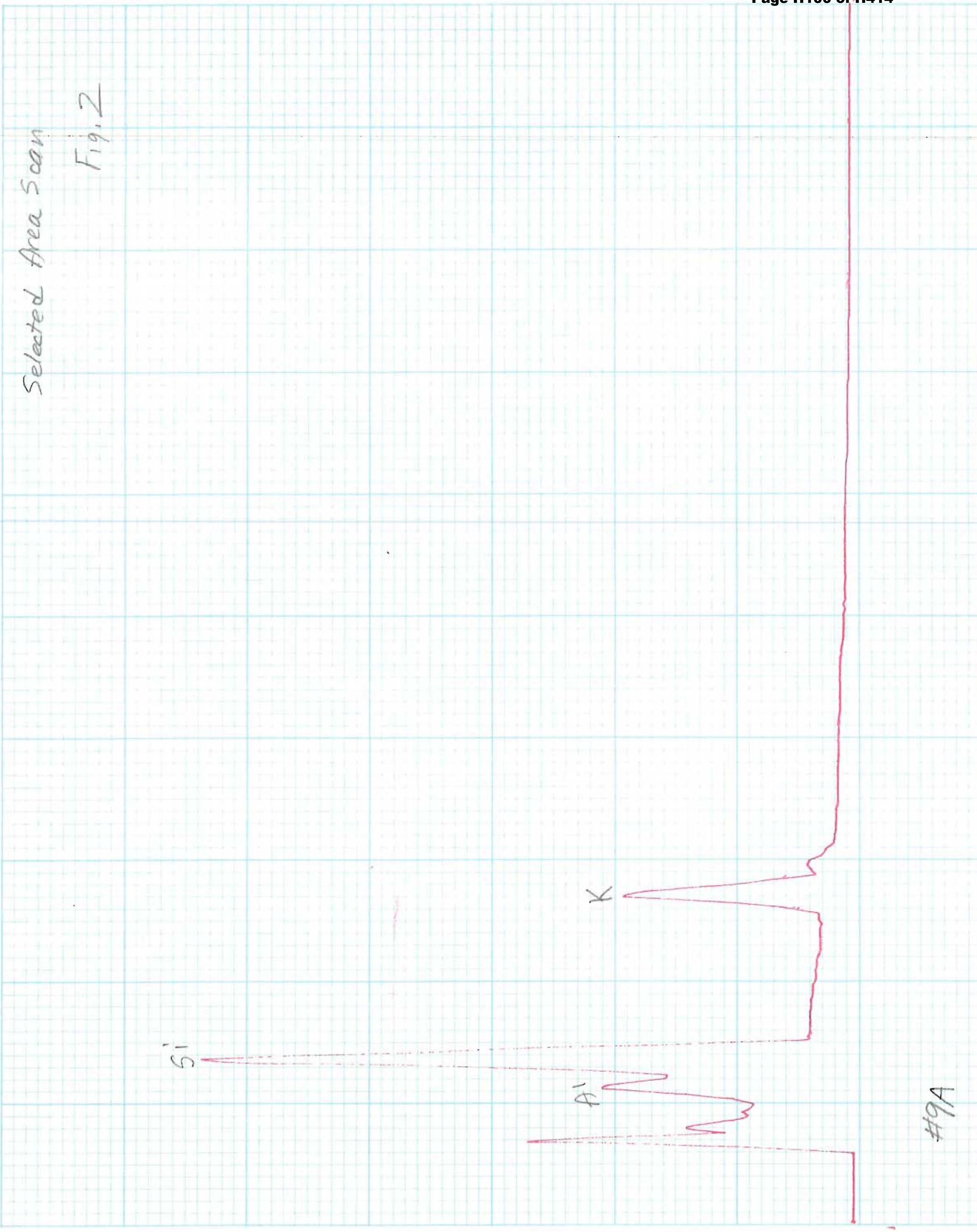
These analyses indicate that the fine-grained white material is K-feldspar. It occurs alone, in small lenses and in lenses that are mixtures of K-feldspar and muscovite. It is also present in the goundmass.



9A 1320X

10μ

F-1


Selected Area Scan
Fig. 2
K
Si
Al
#9A

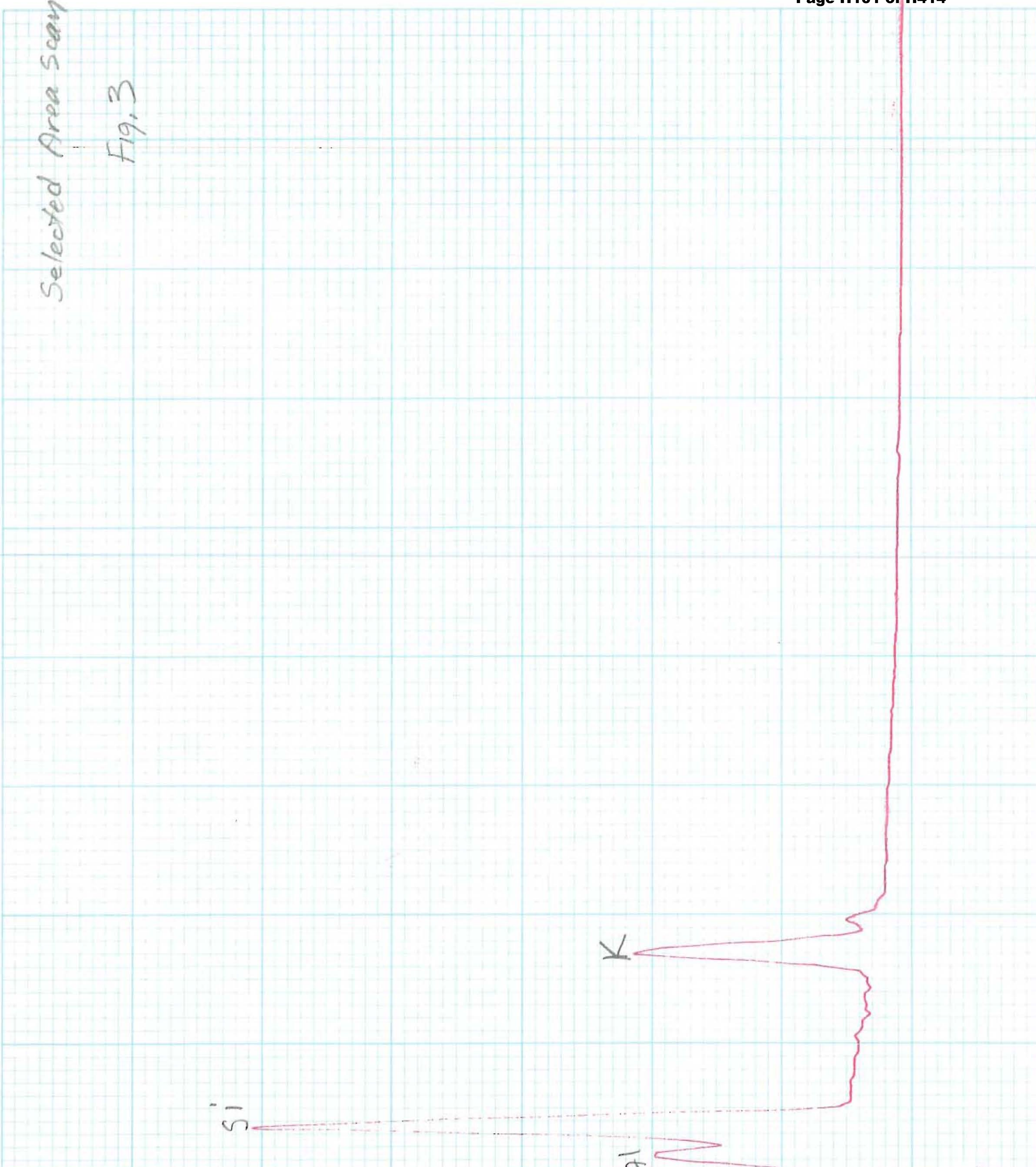

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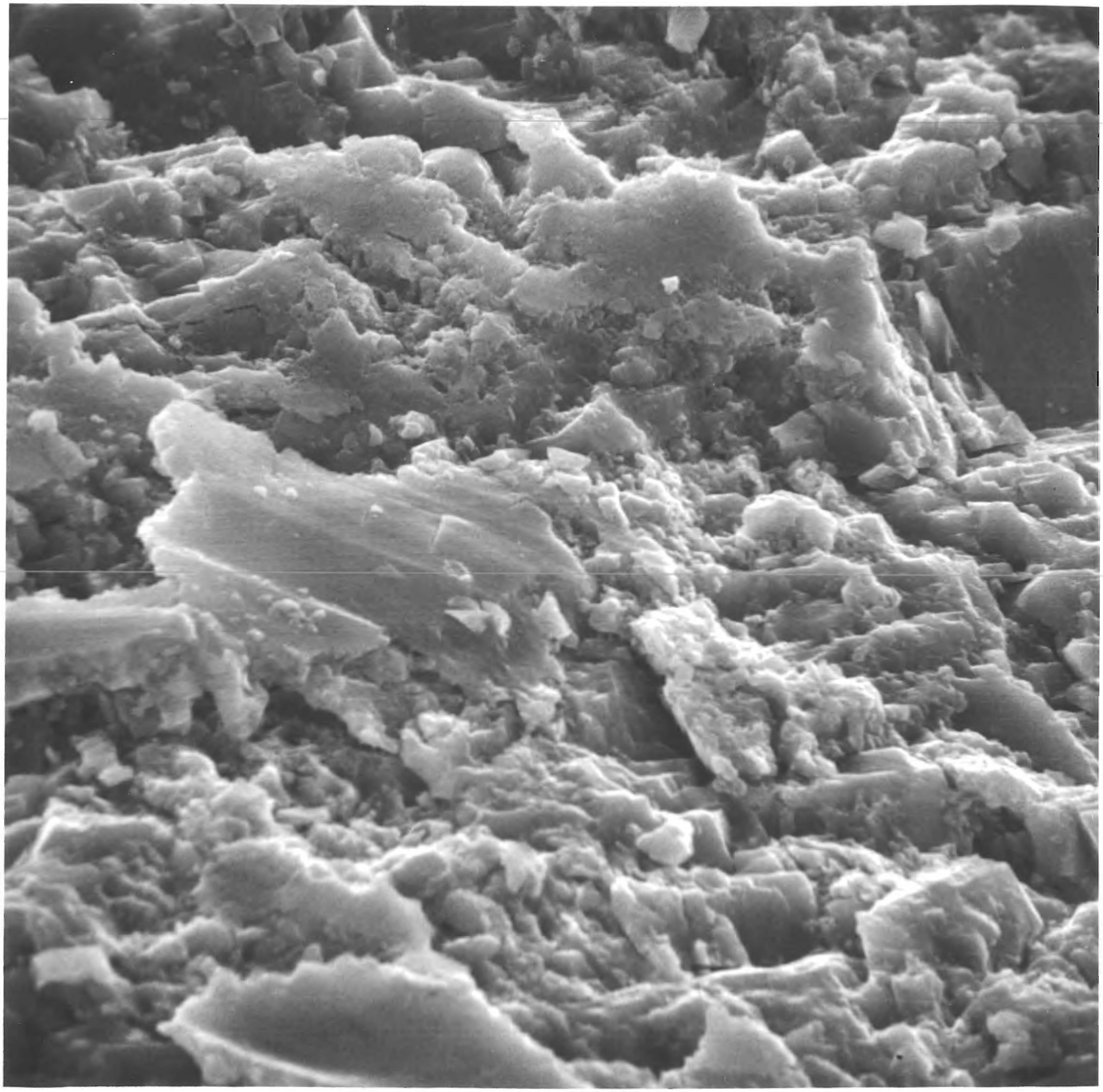
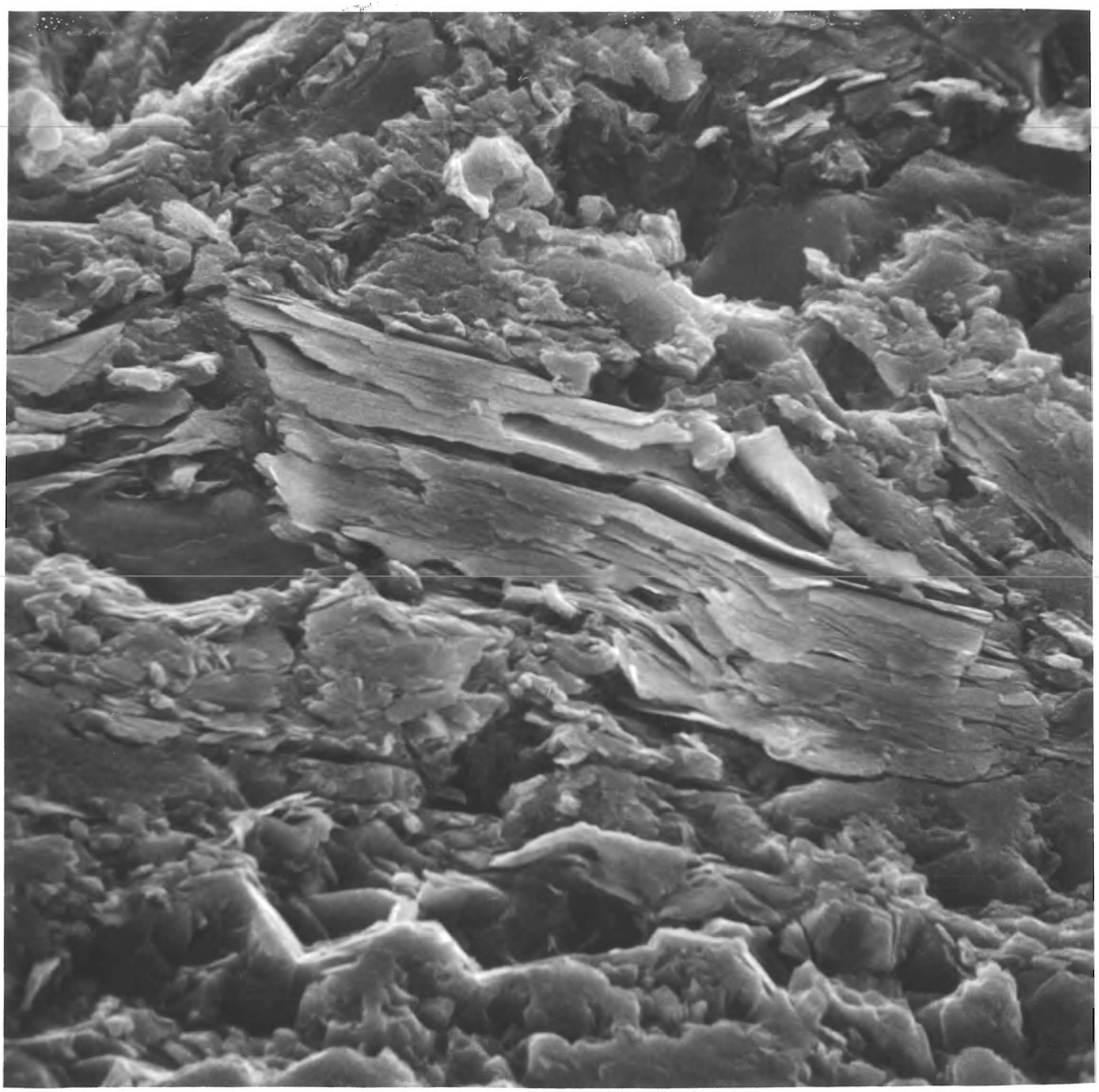
Fig. 3
Si
Al
K
#9B



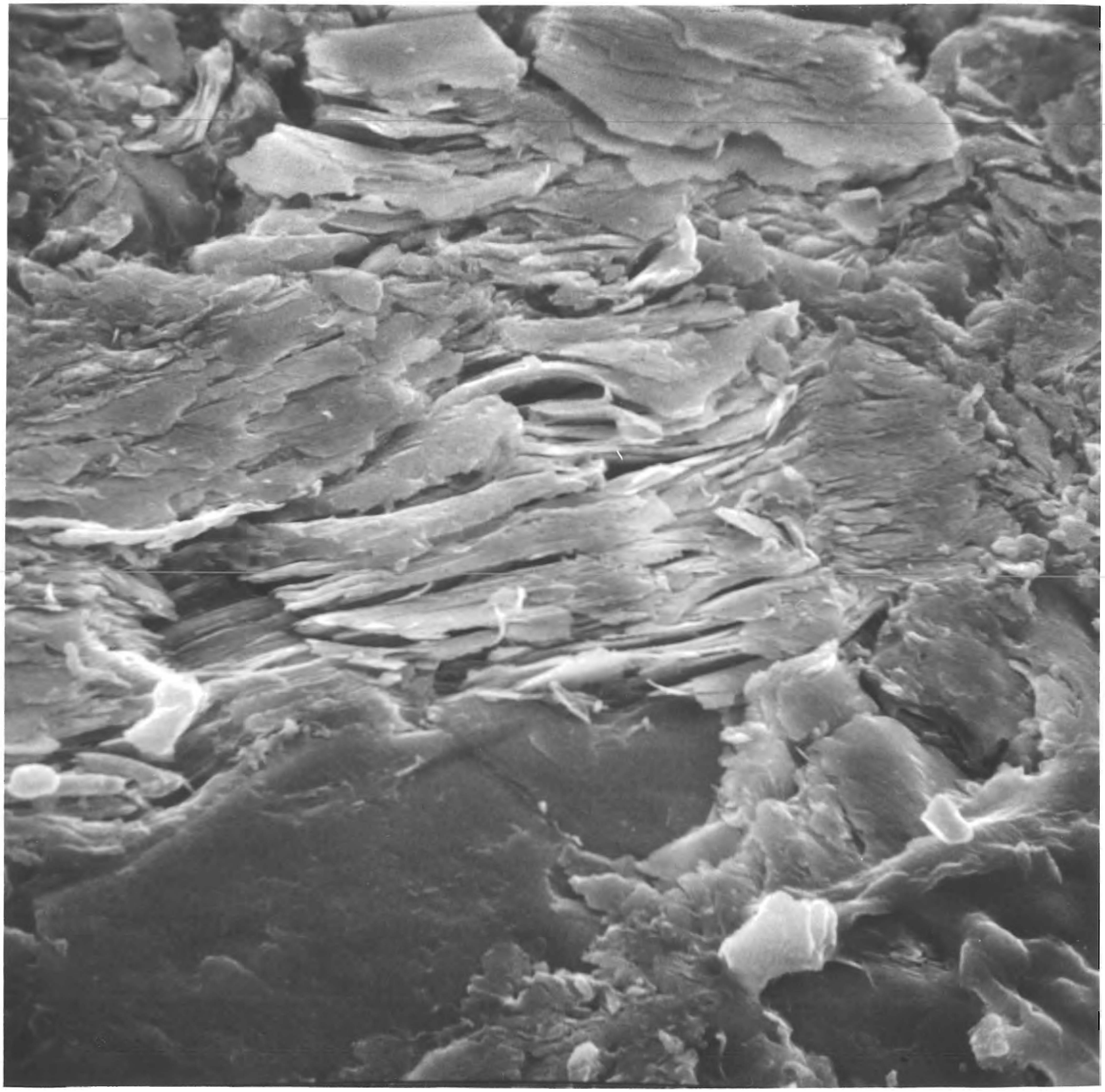
9B 2650X

1μ F-4



8A 2420X

1μ F-5



8B 2420X

1μ F-6

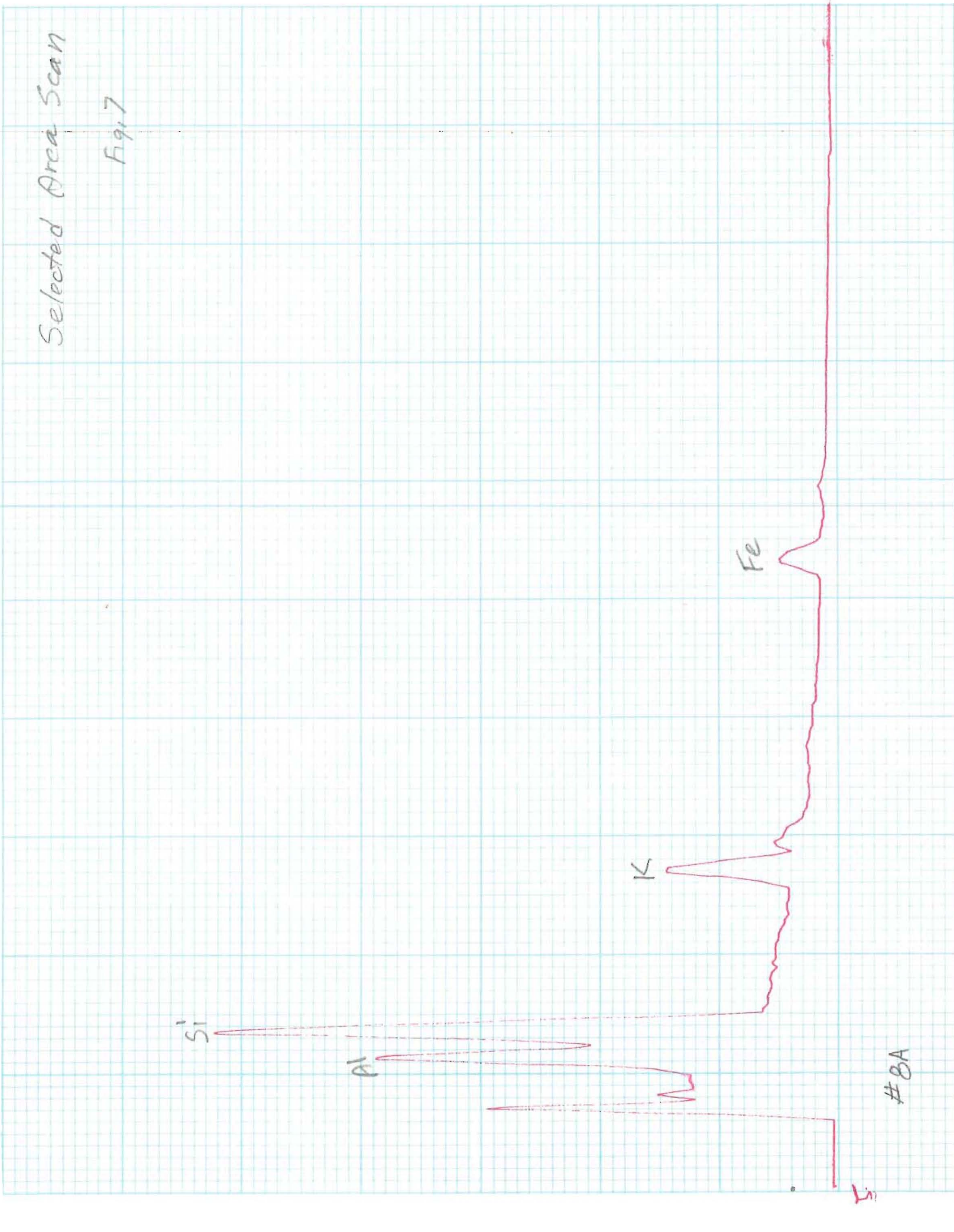

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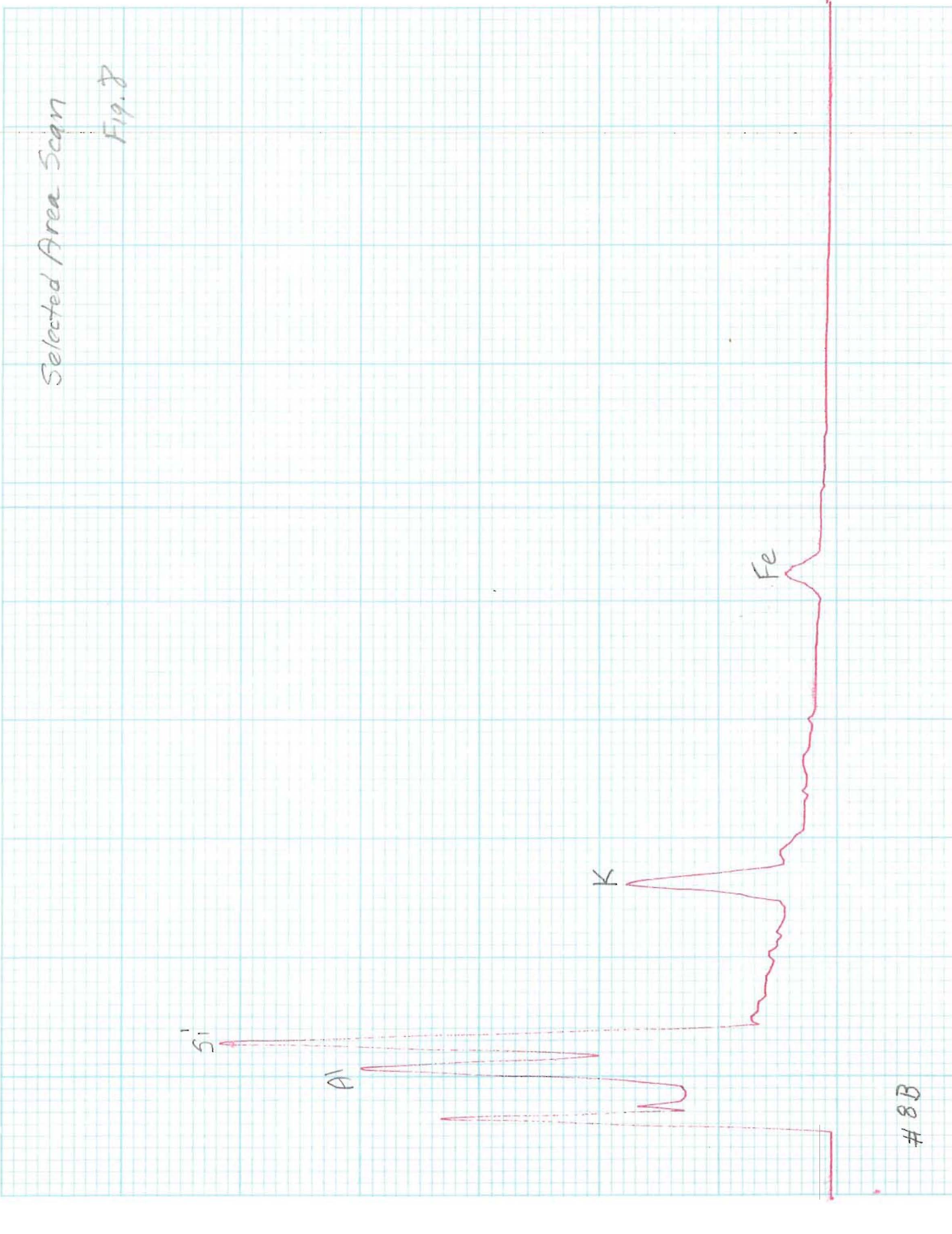
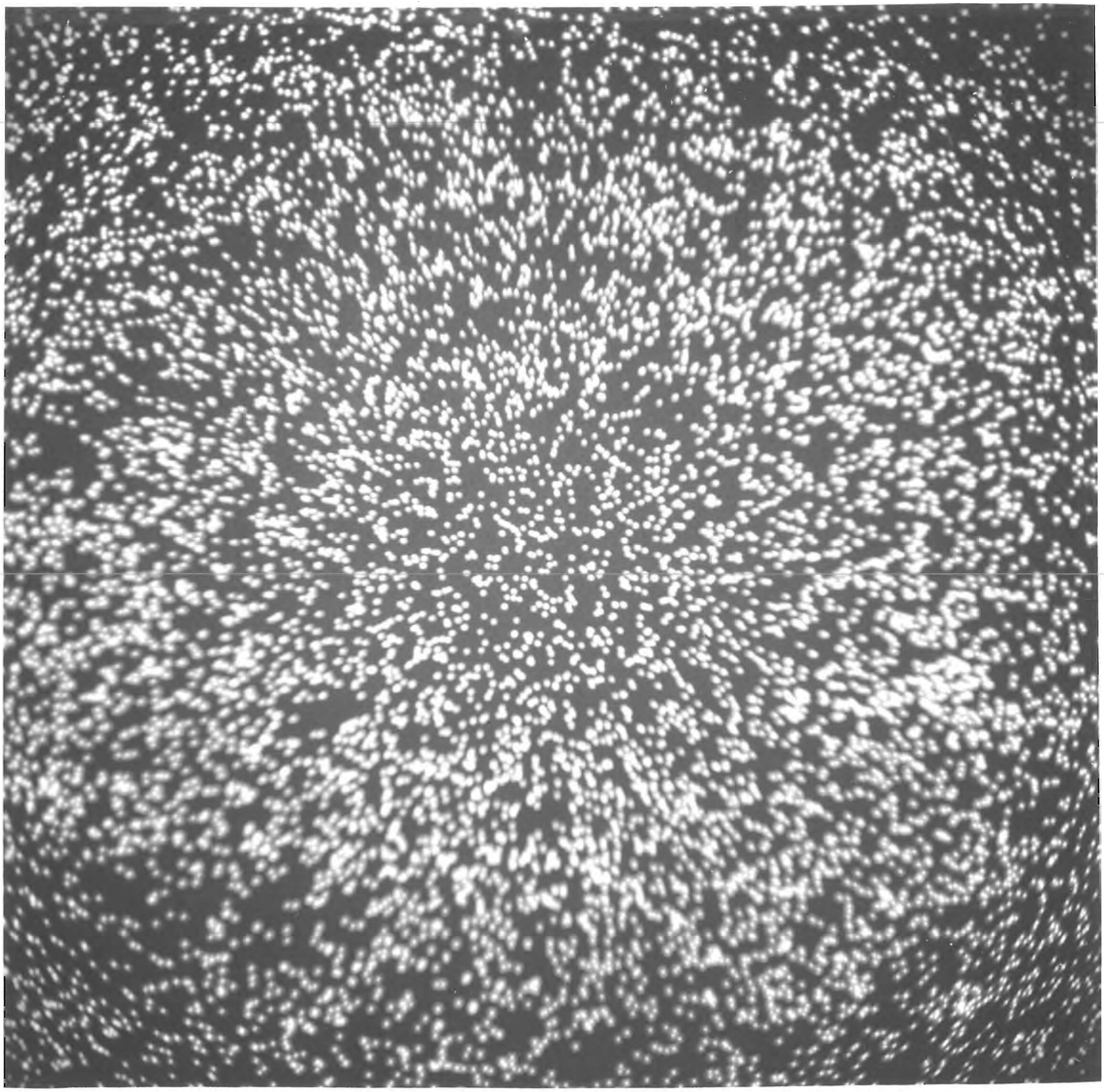
Fig. 7
Fe
K
Si
Al
#8A
Li

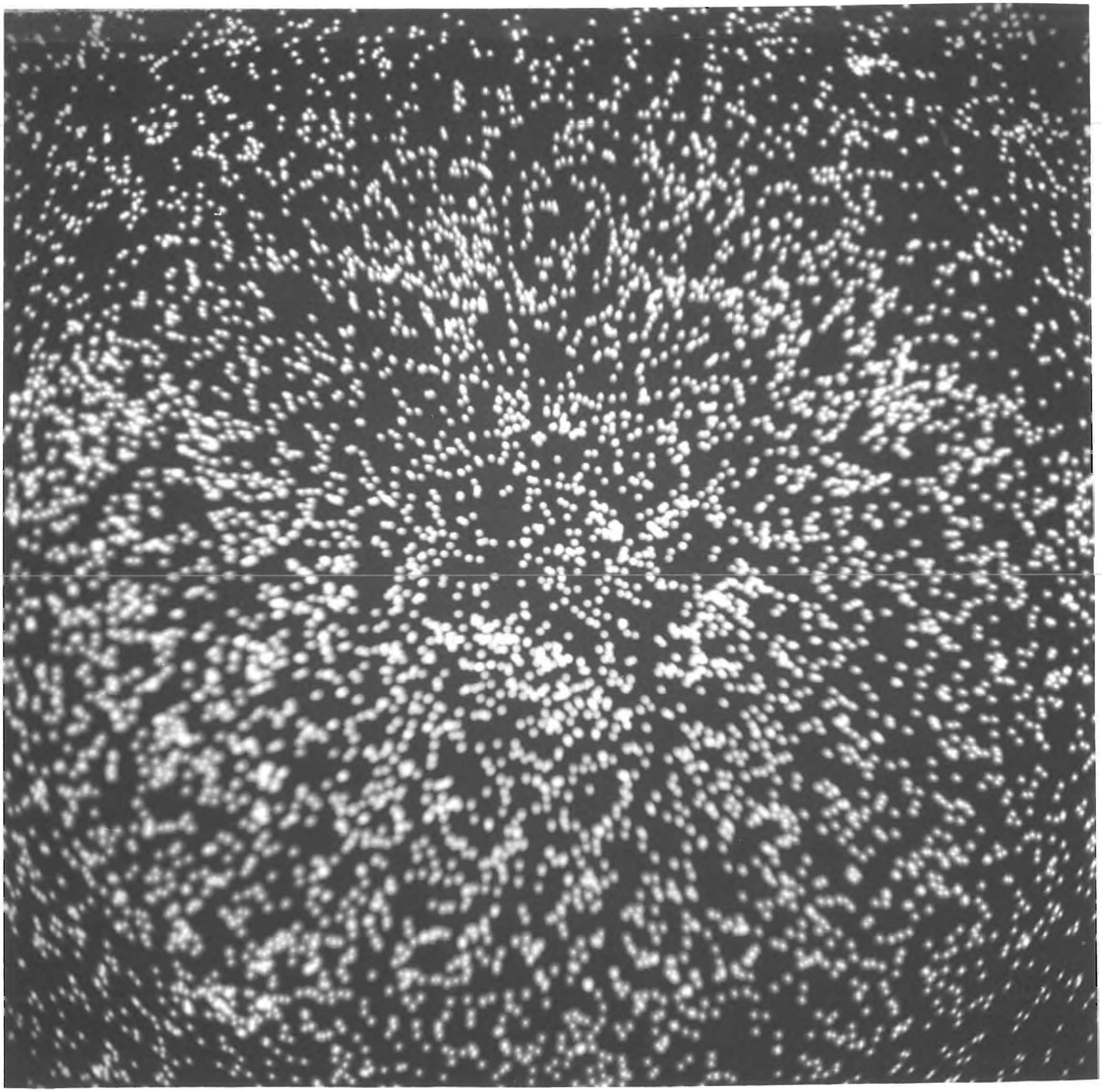

Selected Area Scan
Fig. 8
Fe
K
Si
Al
#8B



8C Fe 48X

100μ

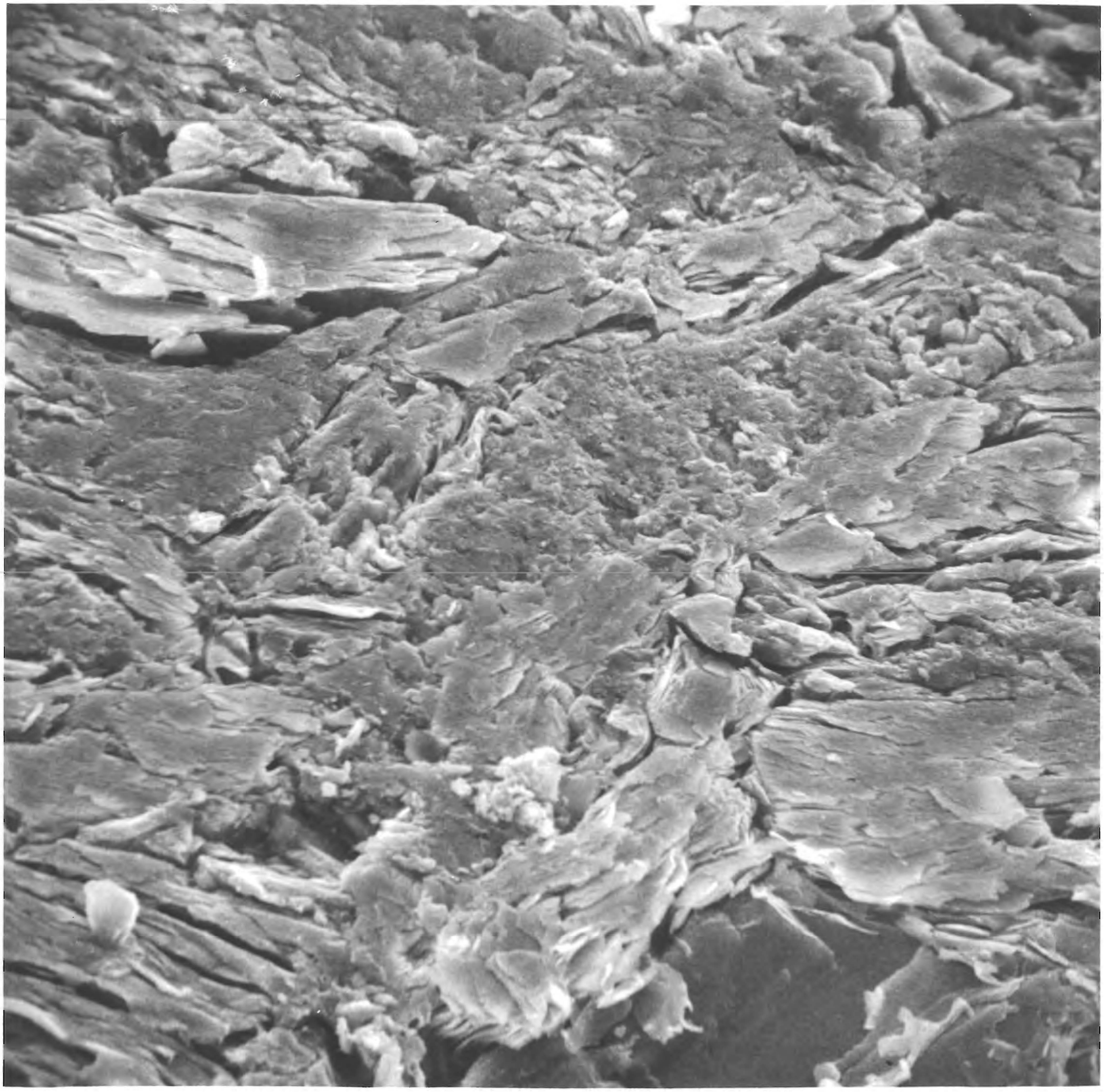
F-9



8D Fe 240X

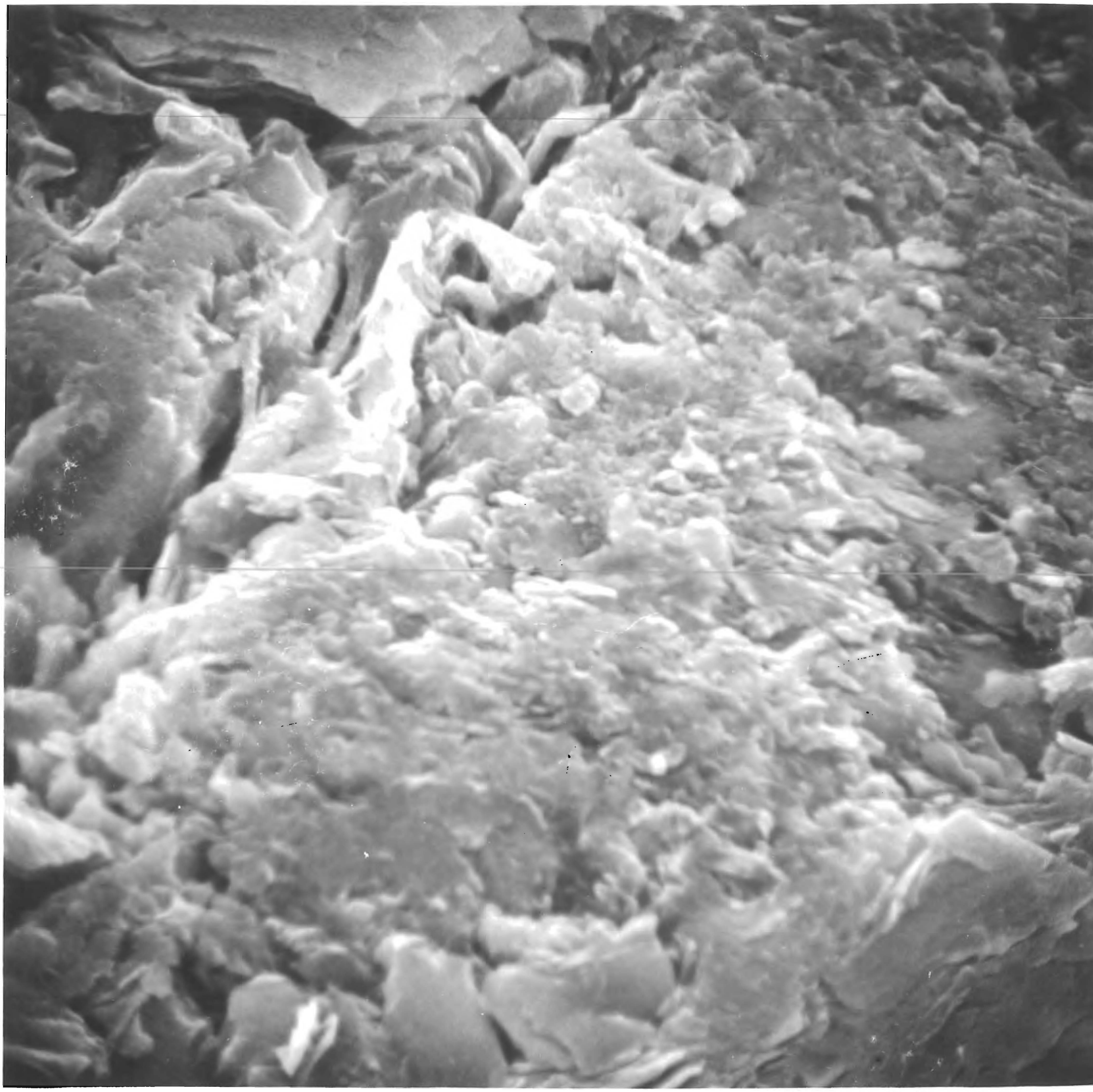
10μ

F-10



8H 1200X

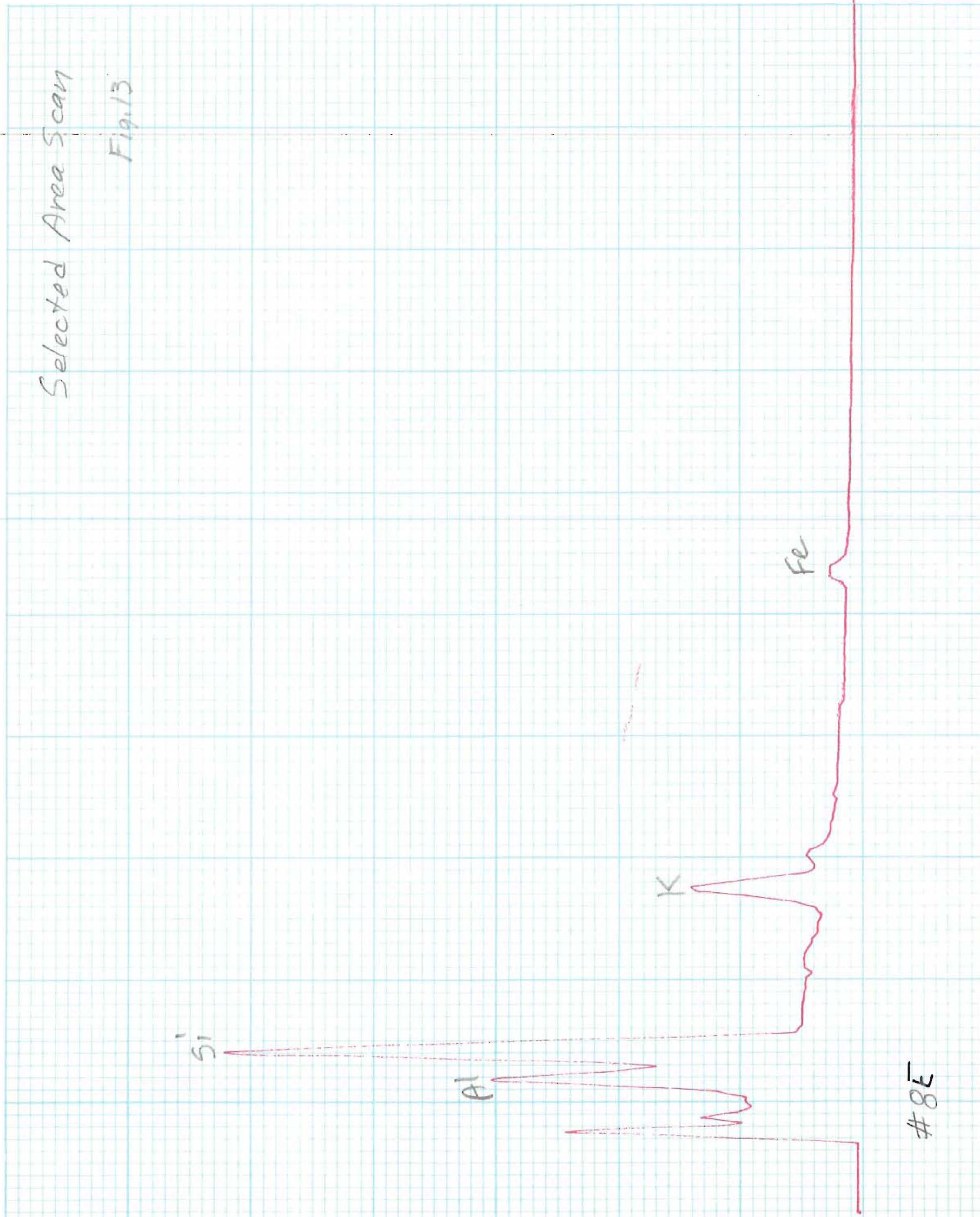
10μ F-11

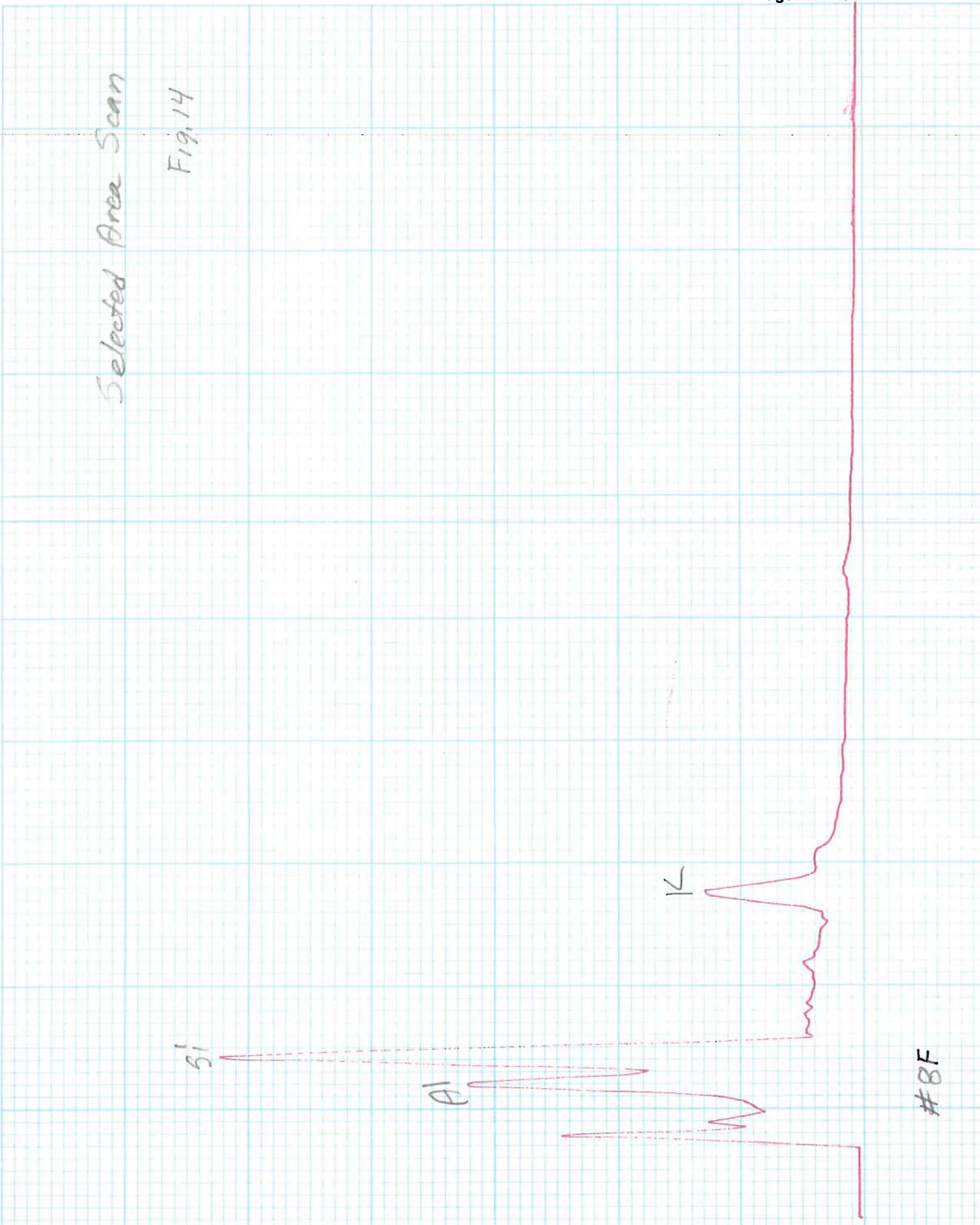


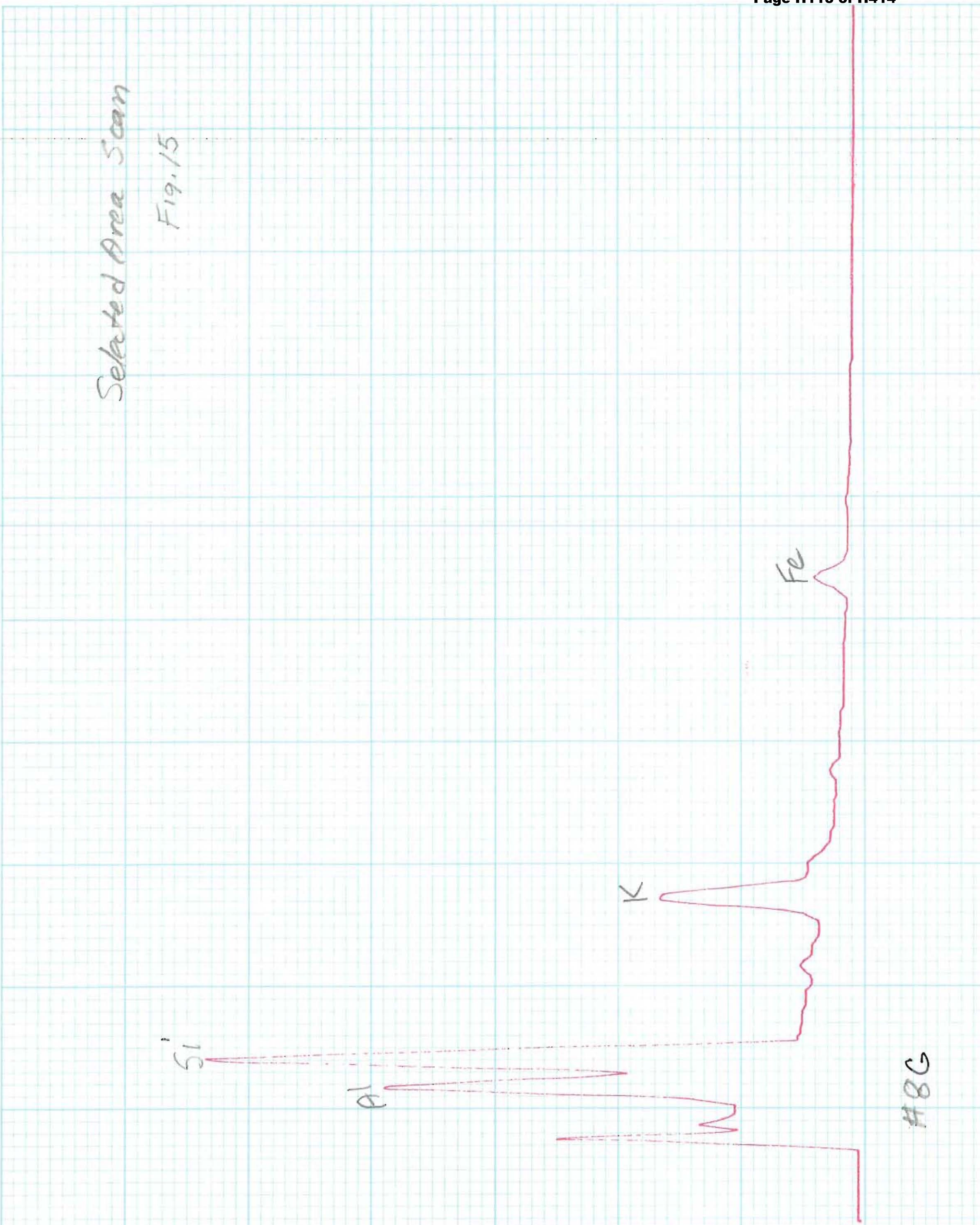
8FG 4850X

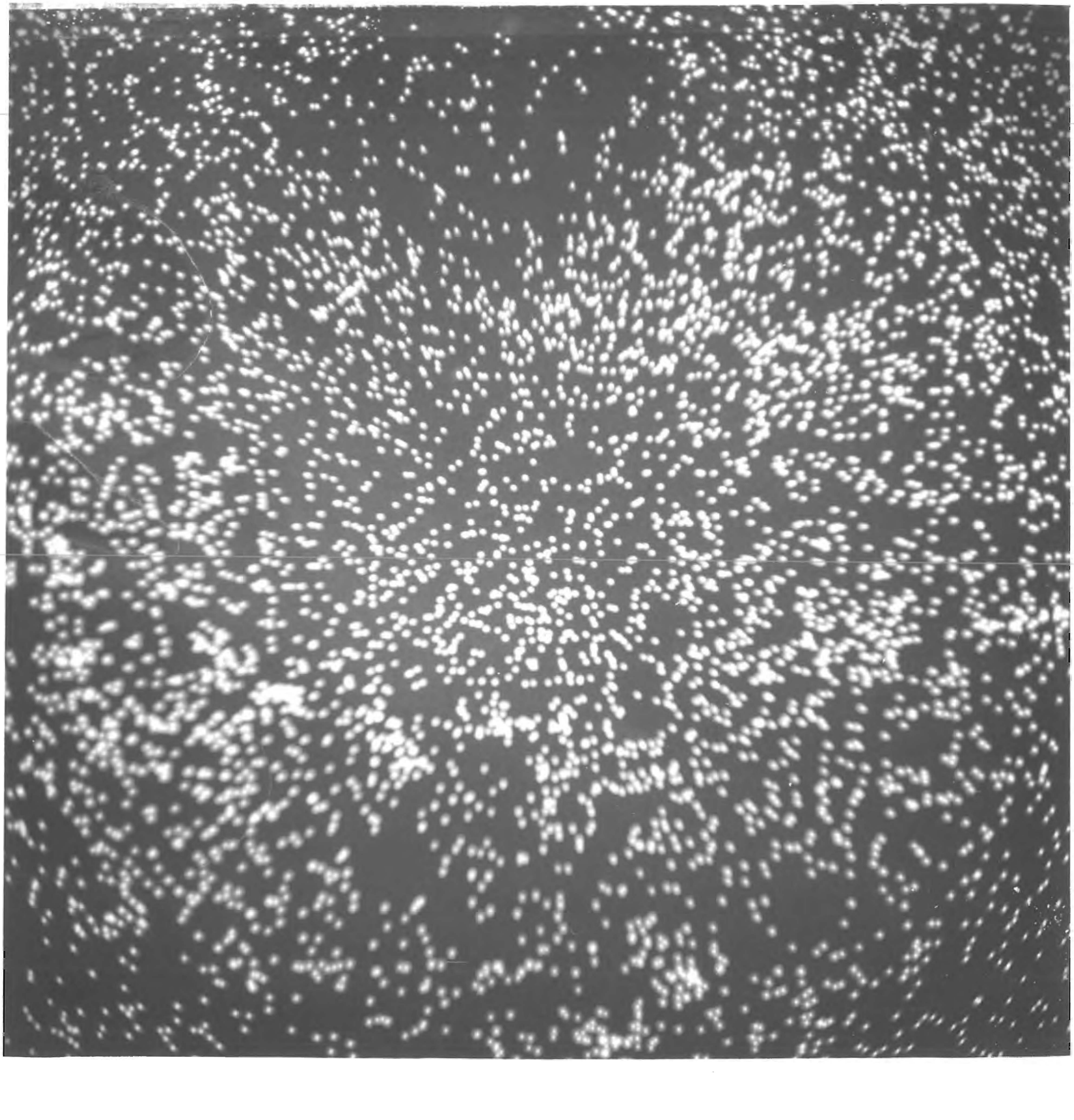
1μ

F-12


Selected Area Scan
Fig. 13
Fe
K
Si
Al
#8E

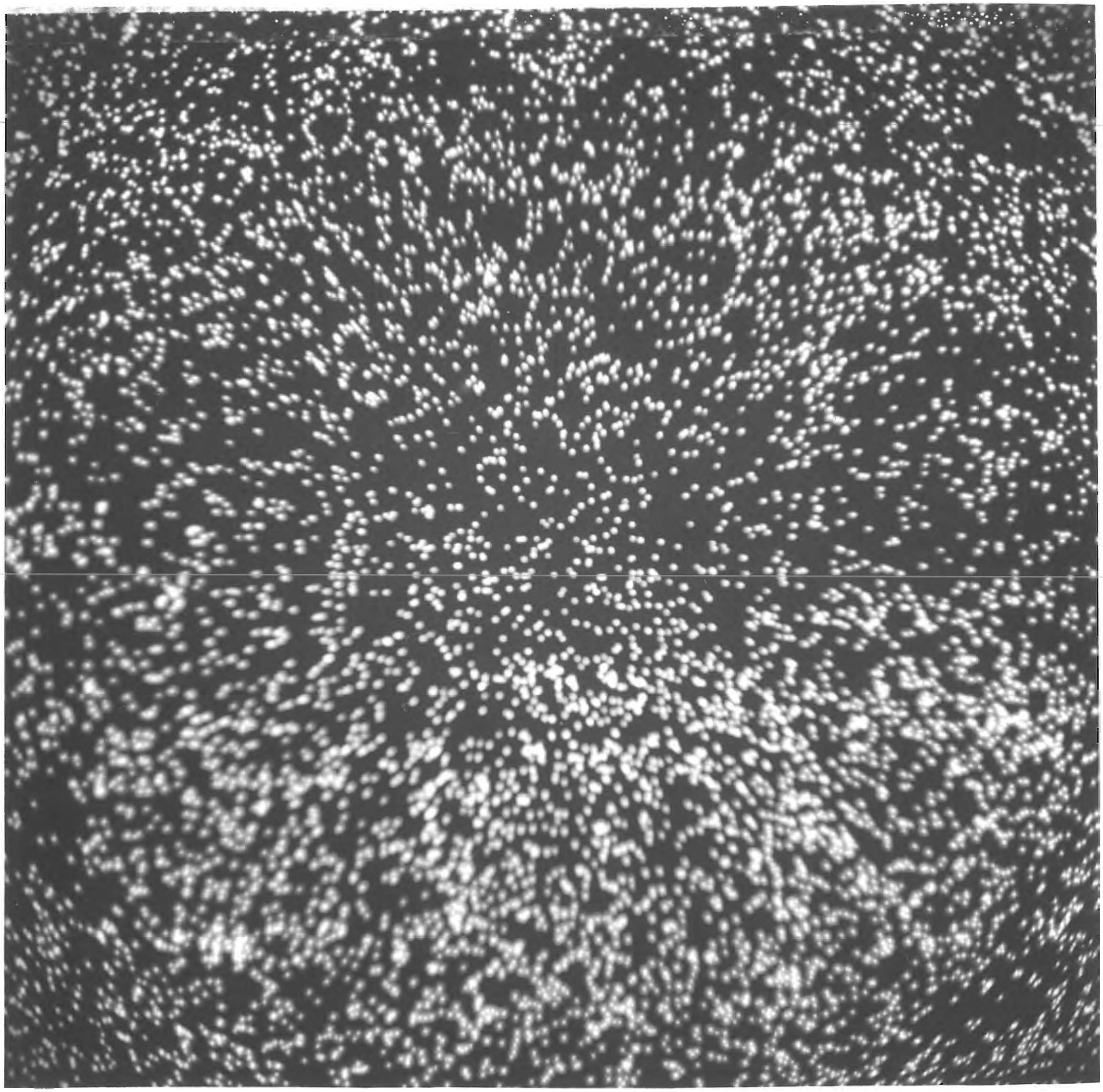

Selected Area Scan
Fig. 14
Si
Al
K
#8F


Selected Area Scan
Fig. 15
Fe
K
Si
Al
#8C



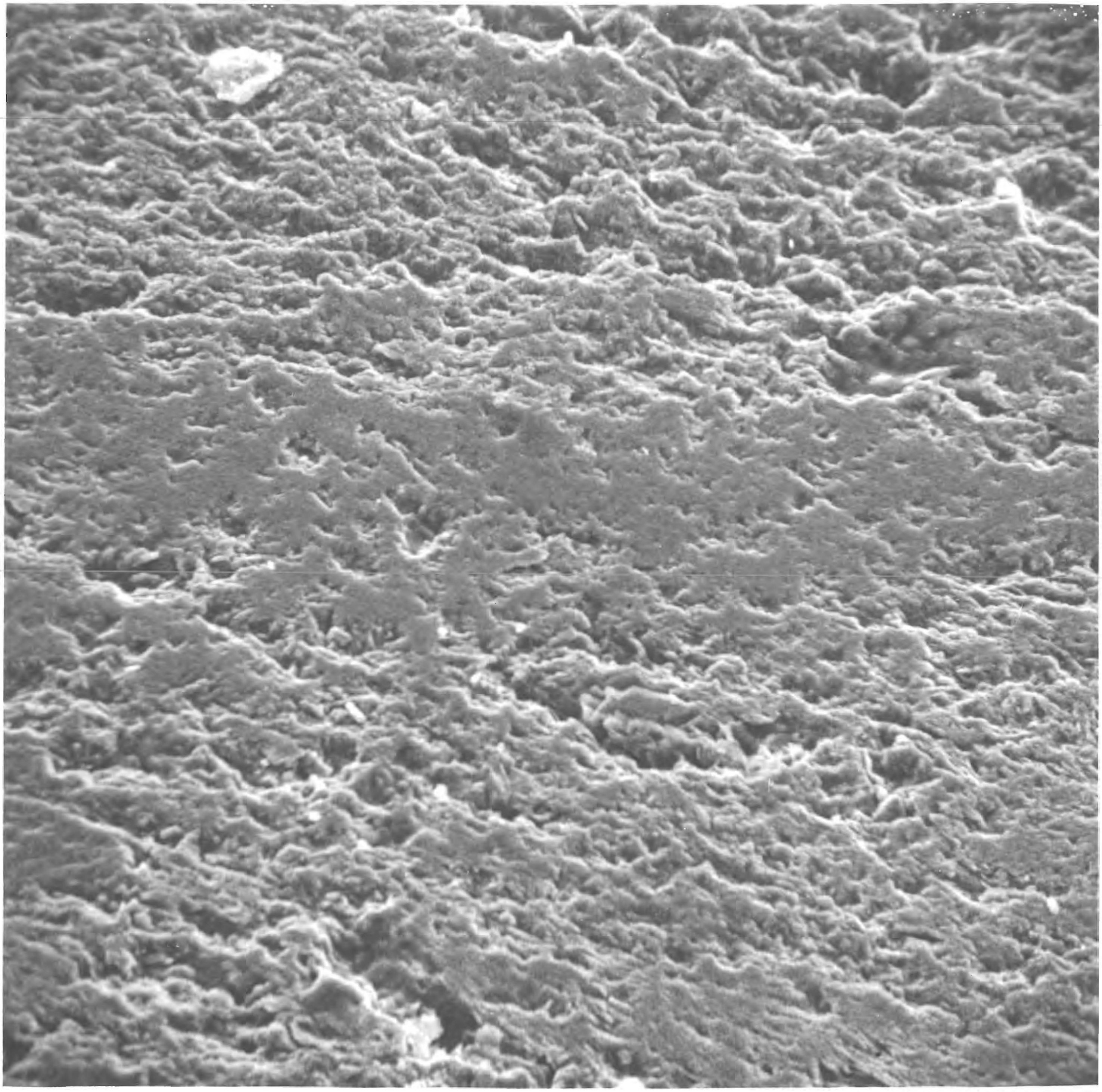
4A Fe 120X

100μ F-16



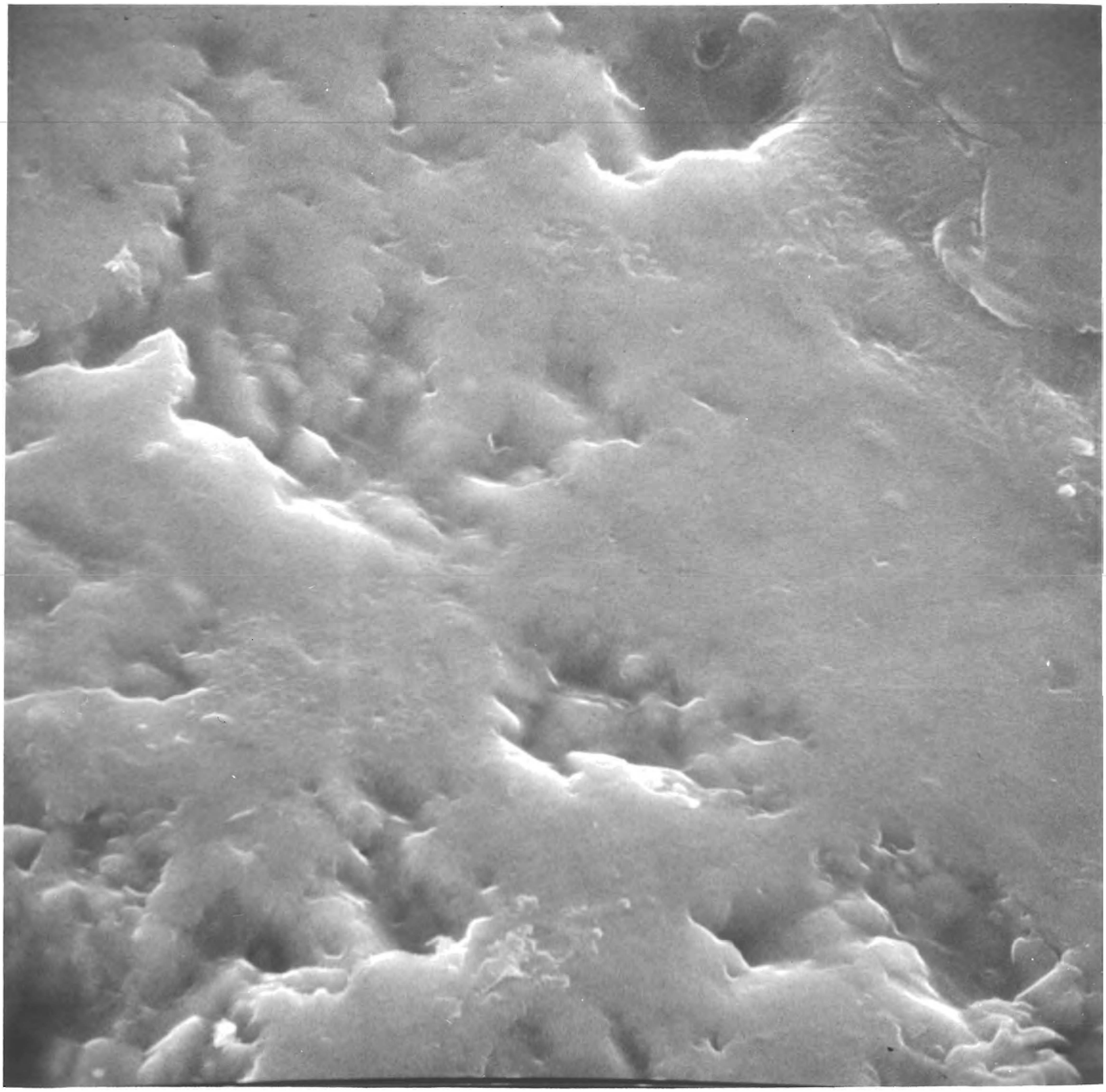
4B Fe 485X

10μ F-17



4B 485X

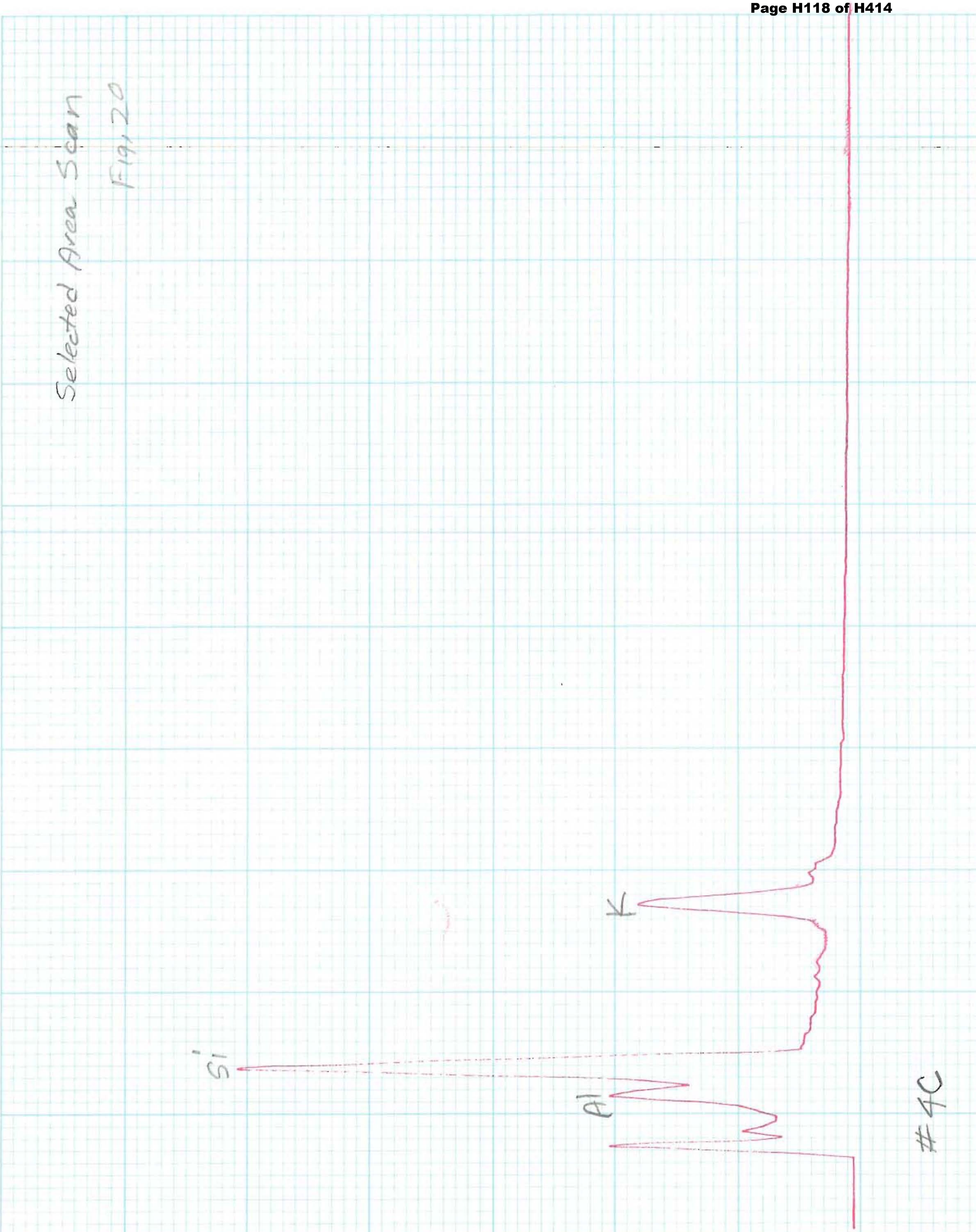
10μ F-18

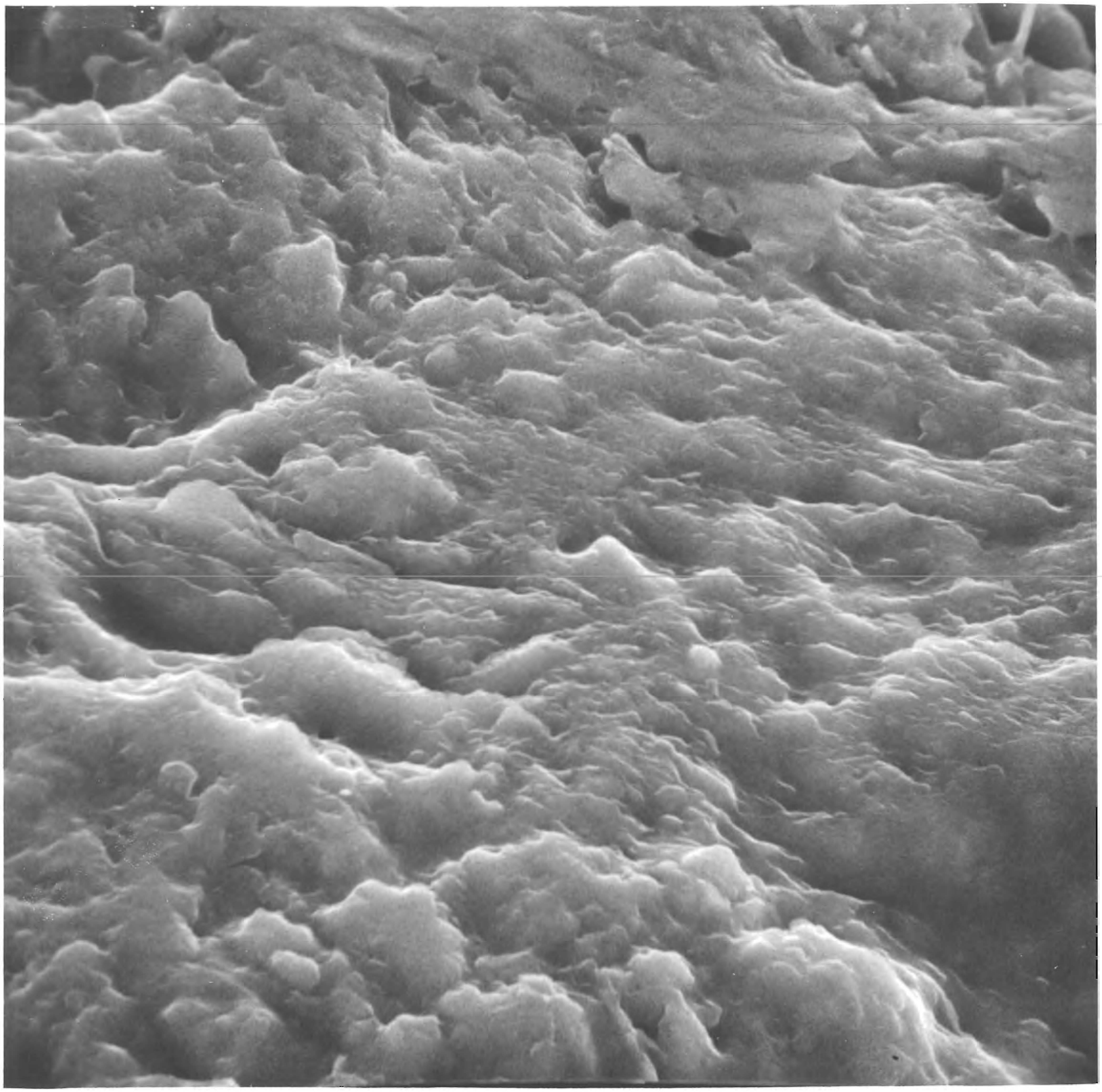


4C 4850X

1μ

F-19

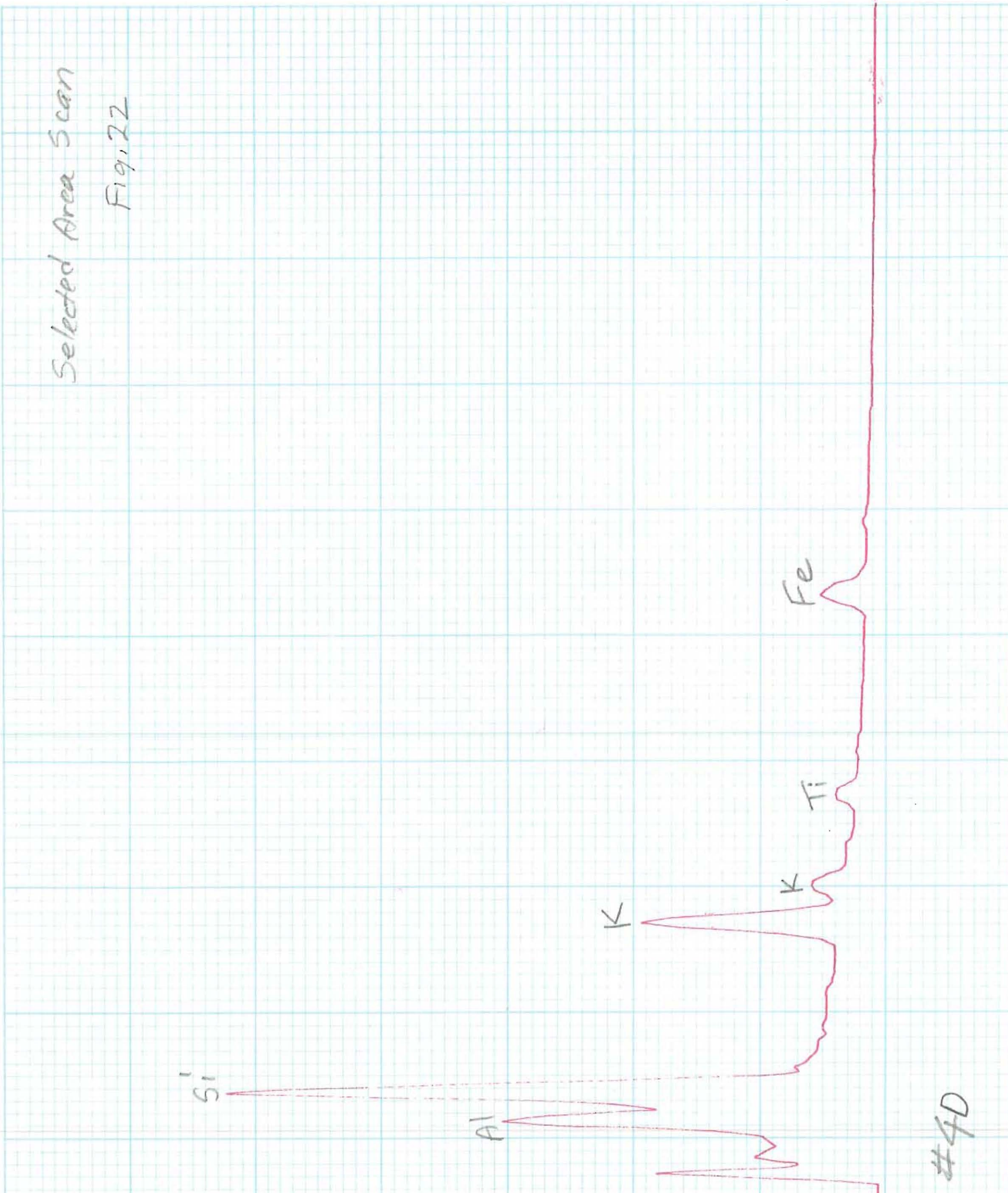

Selected Area Scan
Fig. 20
K
Si
Al
#4C



4D 4850X

1μ

F-21


Selected Area Scan
Fig. 22
Si
Al
K
K
Ti
Fe
#4D

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Speciman Number: FC - 1
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: A gray-colored, fine-grained, schistose rock containing an apparent shear zone. The zone is marked by thin, anastomosing films of dark material alternating with thicker layers of pale green and orange materials. All features in the shear zone are quite irregular and appear to have been cut by irregular veinlets of quartz.

Microscopic: Three thin sections (1,2 & 3), furnished.

Major Components:	Percent	Comments
Plagioclase	25	Large crystals, much sericitized
Quartz	35	As polygonized grains and as veinlets
Biotite	5	Olive-colored crystals altering to chlorite
Chlorite	10	Pseudomorphic after biotite and garnet (common occurrence) and associated with iron oxide
Calcite	10	As bands and scattered grains

Minor Components (10%): sphene, epidote, apatite, muscovite, garnet, opaque minerals, potash feldspar (in veinlets)

Texture: Schistose as produced by subparallel crystals of chlorite and micas and by bands enriched in either quartz or calcite. Quartz-calcite-chlorite and potash feldspar-calcite-chlorite assemblages form veins in probable dilation fractures that both parallel and cut across planes of schistosity. There is no evidence of post-vein faulting in the rock.

Origin: The rock appears to have been somewhat sheared before or during greenschist metamorphism but shearing ceased prior to the end of the metamorphic event. Dilational fracturing opened up some planes of schistosity and cut across others at low angles. Into these fractures was deposited typical greenschist rank minerals and is the last event to affect this rock.

Classification: Felsic (Intermediate?) gneiss

Petrography by : Danny B. Brown Date: 3-26-78

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Speciman Number: FC - 2
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: A pale, tannish-gray mylonitic rock that is medium fine-grained. Leached out veinlets and rusty discolorations along shear planes are attributable to weathering.

Microscopic: Two thin sections (1A & 1B), furnished.

Major Components	Percent	Comments
Quartz	55	Most is polygonized and in bands
Muscovite	30	Strongly developed in bands imparting good schistosity; iron-stained along some planes
Biotite	5	Mostly small, olive-colored grains
Plagioclase	5	Small grains, sericitized

Minor Components (5%): microcline (in augen showing slight snowball texture), potash feldspar (in thin veinlets parallel to schistosity), iron oxides, epidote, apatite

Texture: Schistose to mylonitic with old shear planes marked by iron oxide films. Some muscovite bands are folded in the vicinity of shear planes but muscovite crystals are also seen to have grown across shear planes in places.

Origin: The rock was sheared before and/or during greenschist metamorphism. Some early formed greenschist muscovite bands appear to have been deformed along shear planes but movement along the planes must have ceased prior to the end of metamorphism since some muscovite crystals have grown across shear planes. There may have been some dilation fracturing late in the metamorphic episode because thin,potash feldspar veinlets have formed in shear planes. No faulting has affected this rock since the end of greenschist metamorphism.

Classification: Felsic gneiss (schist?)

Petrography by: Henry S. Brown Date: 3-26-78

PETROGRAPHY DESCRIPTION

Sample Submitted By: Duke Power Co.
Specimen Number: FC - 3
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is gray, medium-fine grained and has a schistose to contorted texture.

Microscopic: Two thin sections (1A, 1B), furnished

Major Components:	Percent:	Comments:
plagioclase	15	well-twinned, inclusion of mica
K-feldspar	35	as small veinlet fillings and as single grains with many inclusions of mica
quartz	10	small grains (polygenized)
biotite	15	olive-brown color, some crystals strained and faulted
muscovite	20	secondary; developed in feldspar, along grain boundaries and in shear zones

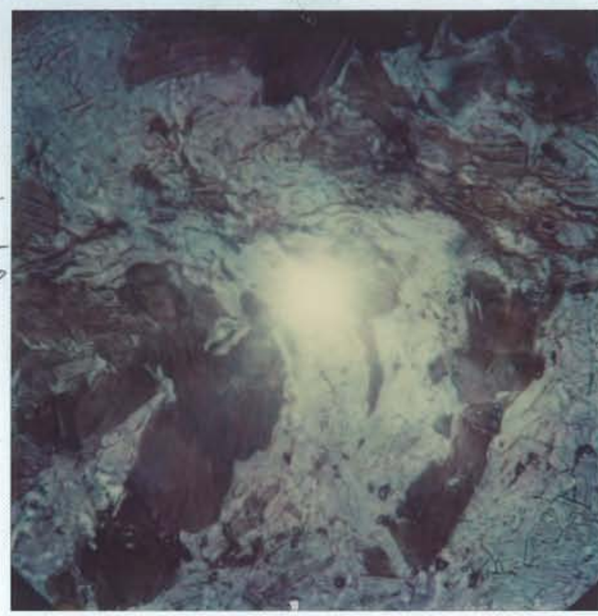
Minor Components: (5%) apatite, iron oxides, opaque minerals

Texture: The rock is rather equigranular except where it was sheared. Shear zones are now quite schistose due to tectonic orientation of biotite and development of secondary muscovite along shear planes. Some shear planes contain iron oxide staining and intermittant veinlets of potash feldspar.

Origin: This apparently plutonic rock was sheared before or during greenschist metamorphism. Muscovite mica and potash feldspar veinlets developed in shear zones and quartz grains were polygenized during past shearing greenschist metamorphism. The rock has not been deformed since it was metamorphosed.

Classification: felsic gneiss

Petrography By: Henry S. Brown / MFH Date: 4-27-78



FC-3 Deformed biotite with muscovite developed in fracture zone
x100 Plane Pol. light

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Speciman Number: FC - 5
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The rock is gray to brownish-gray, medium grain sized and is in contact with a quartz vein. The contact zone is approximately 2 cm wide and appears to have been sheared.

Microscopic: Two thin sections (1A & 1B), furnished.

Major Components	Percent	Comments
Quartz	35	Most is polygonized, with large grains in quartz augen
Muscovite	50	Parallel oriented, imparts schistosity
Biotite	5	Both olive and red-brown colors

Minor Components (10%): sphene, apatite, epidote, goethite, opaque minerals

Texture: Schistose to mylonitic with some large augen made up of polygonized quartz. Old shear zones are marked by iron oxide films and parallel oriented muscovite crystals.

Origin: The rock has been sheared and this was followed, at least in part, by greenschist metamorphism as shown by the termination of shear planes (marked by iron oxide films) within areas of polygonized quartz. No faulting has affected the rock since the end of greenschist metamorphism.

Classification: Felsic gneiss (schist?)

Petrography by: Danny W. Brown Date: 3-26-78

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Speciman Number: FC - 6
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: (No chip furnished)

Microscopic: Two thin sections (1A & 1B), furnished.

Major Components	Percent	Comments
Microcline	35	Somewhat strained, some is brecciated
Plagioclase	10	Sericitized
Quartz	35	As strained and polygonized grains and as veinlets
Biotite	5	Olive colored grains
Muscovite	10	Developed in strained and fractured zones

Minor Components (5%): apatite, sphene, opaque minerals, iron oxide, potash feldspar (in veinlets)

Texture: Hypidiomorphic granular onto which has been superimposed minor amounts of brecciation. Brecciated areas have been healed by greenschist metamorphic recrystallization as shown by the development of polygonized quartz, muscovite mica and potash feldspar veinlets in these areas. Brecciation consists of a network of interconnected and branching fractures that show minor to no offsets where they cross grains. Iron oxide is commonly in these fractures.

Origin: The rock underwent minor brecciation before or (more likely) during greenschist metamorphism. Greenschist metamorphic effects are mostly confined to brecciated areas. No faulting has affected this rock since metamorphism.

Classification: Felsic gneiss

Petrography by: Dhmy A. Brown Date: 3-26-78

PETROGRAPHY DESCRIPTION

Sample Submitted By: Duke Power Co.
Specimen Number: FC - 7
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is light, yellow-gray, medium-grain sized and appears to be mylonitic.

Microscopic: Two thin sections (1A, 1B), furnished

Major Components:	Percent:	Comments:
plagioclase	15	much alter to micas
microcline	35	mostly as augen, with mica inclusions, minor veinlets
quartz	30	polygenized and as large, strained augen
biotite	10	small, olive-brown crystals
muscovite	10	small, secondary crystals

Minor Components: opaque minerals, iron oxide, gratite, epidote

Texture: augen gneiss

Origin: This apparently originally plutonic rock was sheared and then completely recrystalized to an augen gneiss during greenschist metamorphism. There is no evidence of part greenschist faulting.

Classification: felsic gneiss

Petrography By: Henry S. Brown /MFH Date: 4-27-78

PETROGRAPHIC DESCRIPTION

NAME Cherokee Nuclear Station

SAMPLE NUMBER FC-7-1A

LOCATION Final Foundation

MEGASCOPIC: Light-gray fine-grained rock composed of mica, quartz and feldspar. Rock has been sheared in some areas inparting a schistose fabric

MICROSCOPIC: very fine (< 0.1mm) to fine (0.4mm) grained

Major Components	Percent	Comments
quartz	20	undulatory extinction polygonized
plagioclase	30	some fractured crystals
biotite	10	
muscovite	30	
microcline	20	in small clusters and as porphyroblasts

Minor Components

iron oxide, magnetite

Texture

lepidoblastic to granoblastic

DISCUSSION:

Schistose rock metamorphosed to amphibolite facies then retrogressively metamorphosed to greenschist facies evidenced by partial replacement of microcline by muscovite. Slightly sheared evidenced by fracturing of plagioclase but shearing terminated prior to the end of greenschist metamorphism shown by muscovite partly replacing broken plagioclase.

CLASSIFICATION: felsic gneiss (meta-quartz diorite?)

By Donald R. Pruett   Date 4/18/78

PETROGRAPHIC DESCRIPTION

NAME Cherokee Nuclear Station

SAMPLE NUMBER FC-7-1B

LOCATION Final Foundation - Unit 1

MEGASCOPIC: light-gray fine-grained rock composed of mica, quartz and feldspar. Rock has been sheared in some areas imparting a schistose fabric

MICROSCOPIC: fine-grained (0.1 - 0.5mm)

Major Components	Percent	Comments
muscovite	15	
quartz	40	in augen-like cluster, undulatory extinction
plagioclase	35	sericitized
biotite	5	
microcline	5	

Minor Components

iron oxide

Texture

lepidoblastic to porphyroblastic

DISCUSSION:

This rock has been metamorphosed to amphibolite grade. A later greenschist event is evidenced by crystallization of muscovite perpendicular to foliation.

CLASSIFICATION: felsic gneiss (meta-quartz diorite?)

By Donald P. Pruett Date 4/18/78

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Speciman Number: FC - 8
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: A brown to gray colored, medium grain sized, schistose rock.

Microscopic: Two thin Sections (1A &1B) furnished.

Major Components	Percent	Comments
Microcline	15	Rather clear crystals; fractured
Plagioclase	10	Sericitized and some grains contain inclusions of microcline
Quartz	25	Polygonized
Biotite	5	Small olive to red-brown crystals
Muscovite	45	Extensively developed in old shear zones. Deformed near some shear planes.

Minor Components: apatite. opaque minerals, iron oxide, potash feldspar (in tiny veinlets)

Texture: Hypidiomorphic granular onto which has been superimposed a schistose texture composed of fine-grained, polygonized quartz, and parallel oriented micas. The schistose texture is not uniformly developed throughout the rock. In some schistose areas the texture approached an augen texture. A series of thin, sub-parallel fractures containing iron oxide has been superimposed onto the schistose texture. Some muscovite is folded near these youngest fractures. These fractures, however, are older than the potash feldspar veinlets for they serve as the site for their deposition. Potash feldspar veinlets are the youngest features in the rock.

Origin: The rock, probably originally a plutonic rock, was slightly sheared and recovered during greenschist metamorphism by developing a schistose texture. Prior to the end of greenschist metamorphism, however, minor fracturing deformed the earlier greenschist minerals. This last fracturing was followed by the deposition of potash feldspar veinlets which was the last event to affect these rocks.

Classification: Felsic gneiss

Petrography by: Danny S. Brown Date: 3-26-78

FC -8-1A x100, crossed nicols
K-spar veinlets healing fractures in
deformed muscovite schist

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Company
Speciman Number: FC - 9
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The speciman is a gray-colored, medium fine-grained rock containing an iron oxide stained breccia zone approximately 5 mm wide

Microscopic: Two thin sections (1A & 1B), furnished.

Major Components	Percent	Comments
Microcline	20	Numerous inclusions of muscovite
Plagioclase	30	Numerous inclusions of muscovite
Quartz	25	Some grains show strain; contacts are often sutured or polygonized
Muscovite	10	Secondary mineral in feldspars and as occasional large grains
Biotite	10	Tiny, brown-colored, equidimensional grains developed in the breccia matrix

Minor Components (5%): Chlorite, iron oxide, opaque minerals

Texture: The sample is hypidiomorphic granular with enough development of micaceous minerals with preferred orientation to give the rock a slightly gneissic character. A zone of brecciation crosses the rock and mineral grains alongside the zone show variable degrees of strain. Secondary mineral development and polygonization of some quartz grain boundaries indicate a metamorphic event. The event followed brecciation as shown by development of biotite in the breccia matrix.

Origin: This plutonic rock was strained and brecciated. This was followed by greenschist rank metamorphism developing micas in the rock and in the breccia matrix. Most of the biotite was developed in the breccia zone suggesting that perhaps iron was added to the zone during the event. There is no evidence of faulting post greenschist.

Classification: Brecciated felsic gneiss

Petrography By: Jimmy M. Brown Date: 5-21-78

PETROGRAPHIC DESCRIPTION

NAME Cherokee Nuclear Station

SAMPLE NUMBER FC-10

LOCATION

MEGASCOPIC: Light blue gray fine grained rock composed of mica and feldspar; granoblastic texture.

MICROSCOPIC: very fine grained (≤0.1-0.1mm)

Major Components	Percent	Comments
plagioclase	20	
muscovite and biotite	20	fine grained in cluster and bands
quartz	60	

Minor Components

iron oxide and opaques

Texture

granoblastic to slight lepidoblastic in mica rich areas

DISCUSSION:

The rock was metamorphised to greenschist facies. Consists of alternating very fine quartz-mica layers with fine quartz rich layers. Biotite is partly altered to chlorite releasing iron.

CLASSIFICATION: felsic gneiss (mica quartzite)

By Donald R. Pruett Date 5/22/78

PETROGRAPHIC DESCRIPTION

NAME Cherokee Nuclear Station

SAMPLE NUMBER FC-11

LOCATION

MEGASCOPIC: Fine grained gray black rock with granoblastic texture composed of biotite and feldspar, Slightly weathered (iron stained)

MICROSCOPIC:

Major Components	Percent	Comments
plagioclase	30	
biotite	40	polkiloblastic in bands and clusters
quartz	30	

Minor Components

iron oxide, opaques and muscovite

Texture

granoblastic to slightly lepidoblastic

DISCUSSION:

Igneous rock metamorphosed to greenschist facies.

CLASSIFICATION: mafic gneiss (biotite-plagioclase rock)

By Donald R. Pruett Date 5/22/78

PETROGRAPHY DESCRIPTION

Sample Submitted By: Duke Power Co.
Specimen Number: FC - 12
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is pale, yellow-gray, medium-grain sized, and possesses a mylonitic texture.

Microscopic: Two thin sections (1A, 1B), furnished

Major Components:	Percent:	Comments:
plagioclase	5	small grains, with inclusions
microcline	3.0	as augen and smaller grains with many mica inclusions
quartz	40	evidence of early ribboning but now most is polygenized
biotite	5	small, red-brown crystals with iron oxide
muscovite	20	secondary, developed in grains, along grain boundaries and along shear planes.

Minor Components: apatite, epidote, opaque minerals, iron oxide

Texture: schistose with some augens of feldspar and quartz

Origin: Similar to FC-7, no evidence of post-metamorphism faulting.

Classification: felsic gneiss

Petrography By: Henry S. Brown / MEH Date: 4-27-78

PETROGRAPHIC DESCRIPTION

Sample Submitted By: Duke Power Co.
Specimen Number: FC - 13
Location: Cherokee Nuclear Station Site, S. C.

Megascopic: The sample is gray, fine-grained and is in contact with (vein?) quartz. The contact zone is yellow-stained and porous suggesting something has weathered out.

Microscipic: Two thin section (1A, 1B), Furnished

Major Components:	Percent:	Comments:
microcline	10	very small grains
quartz	60	much polygenized and also as veinlets
chlorite	10	as masses and veinlets, especially in breccia matrix
muscovite	10	very small grains associated mostly with polygenized quartz

Minor Components: (10%): apatite, epidote, opaque minerals, goethite, biotite, plagioclase

Texture: The rock is somewhat gneissic and is in contact with vein quartz that shows some micaceous inclusions and is polygenized. The contact zone is marked by minor brecciations with the breccia matrix being replaced by epidote and chlorite.

Origin: The rock was slightly sheared to produce a gneissic texture. Following development of gneissic texture the rock was brecciated. There is no good evidence that will allow a determination of whether the quartz vein was pre, syn or post brecciation. It is not brecciated but the rock alongside is. Following brecciation, extensive development of chlorite and minor fractures extending outward from the breccia zone. No faulting has occurred since greenschist metamorphism.

Classification: felsic gneiss (with quartz vein)

Petrography By: Henry S. Brown /MFH Date: 4-27-78

PETROGRAPHIC DESCRIPTION

NAME Cherokee Nuclear Station

SAMPLE NUMBER FC -14

LOCATION Final Foundation - Unit 1

MEGASCOPIC: A gray schistose to layered fine-grained rock composed of chlorite and biotite, cut by both narrow irregular calcite veins and larger (2 cm) wide necked calcite veins.

MICROSCOPIC: very fine to fine grained (0.1-0.6mm)

Major Components	Percent	Comments
plagioclase	45	xenoblastic
hornblende	15	untwined, poikiloblastic
biotite	15	
calcite	25	replaces hornblende and fills fractures

Minor Components

iron oxide, chlorite, and opaques (pyrite)

Texture

granoblastic to dicussate

DISCUSSION:

This rock has been metamorphosed to amphibolite facies evidenced by hornblende and later retrograded to greenschist shown by replacement of hornblende by chlorite and also calcite fills fractures and replaces hornblende.

CLASSIFICATION: mafic gneiss (biotite schist)

By Donald R. Prowell Date 11/30/78

PETROGRAPHIC DESCRIPTION

JOB NAME Cherokee Nuclear Station JOB NUMBER CH 2920

SAMPLE NUMBER FC-14

LOCATION Final Foundation - Unit 1

MEGASCOPIC:
Very Slightly Weathered, Brown, Green and White Hornblende - Chlorite - Biotite Gneiss (Mafic Gneiss) With Irregular Stringers and Pods of Calcite

MICROSCOPIC: One thin section

Major Components	Percent	Comments
Quartz	45	
Hornblende	20	Partly altered to chlorite
Calcite	20	
Biotite	15	

Minor Components

Opaques, Muscovite

Texture

Fine to medium grained; Granoblastic to Lepidoblastic; Locally Poikiloblastic

DISCUSSION:
Thin section is segregated into quartz-rich, calcite-rich and hornblende-biotite-rich areas. Greenschist metamorphic conditions indicated by partial (slight) chloritization of hornblende and by replacement and "invasion" of hornblende by quartz, biotite and calcite. Some quartz is polygonized, and some is shattered and recovered by polygonization or healed with micas(?).

CLASSIFICATION:
Mafic Gneiss
(Hornblende - Calcite - Biotite Gneiss)

By [signature]

Date 1-6-79