# SHEARON HARRIS NUCLEAR POWER PLANT
# FAULT INVESTIGATION

PROGRESS REPORT
BY
EBASCO SERVICES INCORPORATED

VOLUME 1 of 2

TABLE OF CONTENTS

VOLUME I

APPENDICES



VOLUME 2

PHOTOS

PLATES



NOTE: Large plates 1, 2, 3 and 5 are in pocket of back cover Volume II.

## I. INTRODUCTION

Carolina Power and Light Company is proposing the construction of a nuclear electricity generating plant near New Hill, Wake County, North Carolina. Broken ground noted by the Contractor and CP&L was identified as a fault by Dr. J. L. Stuckey on 3 July, 1974, in the foundation of the plant Waste Processing Building. See Photos A and B.

This fault had not been discovered in earlier explorations because of short distance lateral changes in the nature of the Triassic sedimentary rocks of this basin and because displacement along the fault is small.

An investigation into the nature of the fault, its history of movement and its relation to the regional geological setting is underway. The purpose of the investigation is to determine whether seismic activity or renewed movement on the fault could be expected to occur in the geologically near future or in relation to physiographic changes associated with the construction of the proposed plant.

This report is to outline the progress of the fault investigation through the month of September, 1974.

## II. SUMMARY AND PRELIMINARY CONCLUSIONS

The Shearon Harris Nuclear Power Plant Site is located a short distance southwest of New Hill, North Carolina, which in turn is about twenty miles southwest of Raleigh, North Carolina, off U S Highway 1. Highest elevation in the immediate plant site area is 270. General plant foundation grade is at elevation 225. The topography is gently rolling and few natural elevations in the plant site area are lower than elevation 230.

On discovery of the fault in the excavation for the plant waste processing building, a comprehensive investigation program was initiated which now has the following goals:

1. Determination of age of last movement on the fault.
2. Determination of vertical component of movement on the fault at several locations if feasible. Determination of horizontal component of movement on fault in one location if feasible.
3. Determination of the length of the fault if this can be done by remote sensing methods.
4. Determination of the alignment and attitude of the fault to and beyond the auxiliary reservoir.
5. Completion of other surveys as may be required to satisfy AEC requirements for the Construction Permit.
6. Preparation of geological maps of the plant excavation and of all other features pertinent to other goals stated above.

The methodology established to accomplish these program goals includes the use of Ebasco staff resources, those cooperatively available in CP&L's organization and specialized outside Consultants as need. This methodology includes the following:

1. Literature search, compilation, and analysis of data and bibliographic resources in North Carolina and elsewhere on subjects related to the Triassic Basin sediments, igneous intrusives and faulting will be completed.
2. From published and unpublished sources, a composite geological map of the site area is being prepared. Data from remote sensing methods as field checked will be incorporated.

3. The relationship of the fault to other geological features in the regional setting is being determined.

4. Understanding of the site geologic history is being developed.

5. All available field methods, which in our judgement are applicable are being used to trace the fault.

6. All methods available and known to us and our Consultants to determine the age of movement on the fault are being considered and applied as deemed productive.

7. Published or available gravity and air-borne magnetic data will be analyzed and interpreted.

8. Remote sensing imagery including ERTS, SLAR, Skylab, conventional air photos and others will be analyzed as available. Ground - truth investigations will be conducted on selected features to verify observations.

If movement on the fault is of great antiquity, it can be reliably demonstrated that movement cannot be expected under the minor changes in geological conditions to be imposed by construction of the nuclear plant and related structures.

There appear to be three avenues of approach to determine the age of last movement on the fault:

1. Find that the fault is older than diabase dikes crossed by the fault in the area. These dikes are geologically ancient intrusives which can be age-dated by radio-isotope methods. Dikes of this type and association are commonly found to be older than 150 million years.

2. Find secondary minerals that have "grown" in the material sheared and broken during fault movement and determine minimum ages of these secondary minerals by radioisotope methods.

3. Determine the ages of the undisturbed residual soil profile and underlying saprolite and the age of undisturbed saprolite in the diabase dikes at intersection with the fault, directly or indirectly.

The fault has been traced to and past three diabase dikes in the plant site area. There has been movement along the fault since the intrusion of one of these dikes. Exploration is incomplete and halted at the second dike because other work is expected to be more fruitful. Exploration at the third dike yields evidence that the diabase was intruded after movement on the fault. Generally, the intrusion of diabase dikes and movement on the fault are probably contemporaneous.

Secondary minerals formed in the fault gouge have been found. These minerals include representatives of the zeolite family which are usually datable by radio isotope methods.

The undisturbed soil and saprolite profile overlying the fault may be dated by comparison to other such profiles of known age as perhaps Pliocene, or in excess of one million years. The age of undisturbed saprolite at diabase dike-fault intersections may prove to be much older.

## III. REGIONAL GEOLOGIC SETTING

### A. GEOLOGY

The regional geological study presented in Chapter 2 of the Preliminary Safety Analysis Report is being reviewed and updated. A map showing the geology of the immediate site region is being developed from published and unpublished data sources. The present status of preparation of this map is as shown on Plate 1. This updating of the regional geological picture

will include the correlation of site structural geologic history as it relates to regional faulting including the Jonesboro Fault. This discussion will document the geologic factors which indicate the age of the Jonesboro Fault.

Through a transpositional error, the state geologic map, published in 1958, shows the Jonesboro Fault offsetting Cretaceous (?) materials a few miles southwest of the Project Site. On October 7, 1974, Dr. Jasper L. Stuckey re-examined this outcrop of the intersection of the Jonesboro Fault and overlying Cretaceous (?) materials. Dr. Stuckey's examination now confirms that the Cretaceous (?) material is not offset.

B. SEISMICITY

The site is within the Piedmont Lowland section of the Piedmont Province of the Appalachian Highlands. The southeastern section of the United States has a moderate amount of low level earthquake activity, with the exception of the Charleston, South Carolina earthquake. In this region earthquake frequency per unit time per unit area is about one tenth that of the west coast. Earthquakes occur throughout the region, but are interpreted to occur in small seismic zones both parallel to and transverse to the regional Appalachian structure. These small seismic zones are:

1. Southern Appalachian Seismic Zone. This zone extends from Western Virginia to Central Alabama in the Valley and Ridge and Blue Ridge Province.
2. Northern Virginia - Maryland Seismic Zone. A diffuse northward extension of the Fall Zone.

3. Central Virginia Seismic Zone. This is a relatively narrow isolated zone of activity, offset from the above two zones and located in the Piedmont Province. It is oblique to the northeast southwest structural trend.

4. South Carolina - Georgia Seismic Zone. Transverse to the regional structure, this broad zone spans both the Piedmont and Coastal Plain Provinces. Many thrust faults and normal faults have been mapped in each of these Provinces. These faults do not have a record of movement during historical times. Knowledge of focal depth and focal mechanism is needed in order to obtain a detailed correlation of seismicity and geology.

Macro Seismic Effects

It has been observed by many seismologists that felt areas associated with events in eastern United States are in general about ten times larger than those of earthquakes of similar maximum intensity that occur on the west coast. The general configuration of the felt areas associated with regional shocks are elliptical with major axis aligned with the structural strike. An apparent exception occurs in Central Virginia and Coastal South Carolina and these effects can only be understood with a greater data base than is available.

## IV. SITE GEOLOGIC SETTING

### A. GEOLOGY

The Site Geology Report contained in Chapter 2 of the Preliminary Safety Analysis Report is being reviewed and updated for presentation in the final report on the fault investigation. The final report will include more exhaustive discussion of data bearing on the genesis of

the fault and diabase dikes in the site area and will include a more exhaustive discussion of the residual soil and saprolite profile including any available additional information relative to an estimate of the age of these profiles. The final report will address permeability of the fault plane and associated rocks related to the anticipated effects of the cooling reservoir.

B. SEISMICITY

The State of North Carolina is situated between seismic zones 1, 3 and 4 and exhibits very little seismicity except for the western part of the state which is traversed by the Southern Appalachian Seismic Zone. Within one hundred miles of the site only three shocks with the intensity of 5 or greater have been reported in historic times. Two of these shocks with intensity five were near the Virginia-North Carolina border about 80 miles north of the site. The third with an intensity of six occurred in South Carolina about one hundred miles southwest of the site. No earthquake epicenters are reported closer than 80 miles from the site. United States earthquake history lists fourteen earthquakes as having epicenters in North Carolina. Of these, only two were widely felt.

The Piedmont Province, in which the site is located, is active only in Central Virginia, South Carolina and Northwestern Georgia. Appreciable earthquake activity in the Coastal Plain Province appears only in South Carolina.

V. INVESTIGATION PROCEDURES

A. LOCATING THE FAULT

Subsequent to observation of the fault in the excavation for the Waste

Processing Building, a variety of methods to trace the fault away from the exposure were considered. Our knowledge of the lack of a density difference across the fault and our knowledge that the sedimentary deposits grade laterally within short distances led to the determination that the refraction seismograph could not be successfully used to trace the fault. Several unrecorded traverses across the fault with the proton magnetometer showed that the fault could not be detected using this instrument. It was, therefore, determined that trenching was the best available, most positive method to use in following the fault. The length of the fault as traced to late September, 1974, is shown on Plate 1. The length of the fault as traced through 11 October, 1974, is shown on Plate 2. See also Photo A. The trenches are designated FT (fault trench), serially numbered as excavated (1) in the year 1974 (74).

By projecting the strike of the fault as seen in the excavation exposures, trenches were started both to the east and west of the exposures in the plant excavation. These trenches were excavated using D-9 bulldozers with rippers. Because several trenches failed to expose the fault it was discovered that the fault was sinuous in plan resulting in lack of accuracy in location of the trenches on the basis of projection of fault exposures. By split-spacing trenches back toward known fault exposures the fault was then followed. It was found that the fault, when exposed in sedimentary beds, always exhibited a southerly dip between 60 and 70 degrees, always exhibited drag folding on the hanging wall, never exhibited any disturbance of bedding planes on the northern or foot wall, tended to become oversteepened in coarser grained sandstones and due to refraction was vertical adjacent to the one diabase dike which the fault is known to offset. See Photo B.

It soon became evident that the fault would be very difficult to detect in the soil profile or the immediately underlying saprolite. The fault has not moved during the development of the soil profile or saprolite, since neither shows any evidence of shear in the secondary depositional materials in outcrop, hand specimen or microscopically. Deep trenches were therefore required to definitely locate the fault. Adherence to OSHA regulations greatly increased the quantities of materials involved in the excavation of each trench and rendered observation of the fault more difficult. It was found that because of the general southeasterly dip of the beds the fault was commonly more difficult to observe in the northwestern walls of the trenches than in the southeastern walls.

East of the plant excavation two trenches intersected the fault. The first of these is approximately 200 feet from the exposure in the east wall of the excavation and is designated FT-9-74. The second of these two trenches is approximately 350 feet from the exposure in the wall of the excavation and is designated FT-10-74. See Plate 2. The fault was next located east of the plant excavation adjacent to diabase dike number 2 (East Dike 2) in a long trench excavated using scrapers. The diabase-fault contact at that point is approximately 750 feet from the exposure in the east wall of the plant excavation. The dip of the fault at this location is greatly oversteepened and is essentially vertical.

To the west of the western exposure in the plant excavation the fault was uncovered adjacent to the existing railroad by cleaning side cuts at the railroad and by the excavation of two backhoe trenches through the developed soil horizon and the less leached saprolite horizon below. These two narrow backhoe trenches were designated FT-1-74 and FT-2-74. These trenches are

located respectively approximately 200 feet and 300 feet west of the exposure in the west wall of the plant excavation. Moving westward the fault was encountered next in trench FT-8-74 which is located some 400 feet west of the exposure in the plant excavation. The fault was again encountered in trench FT-3-74 at a distance of approximately 450 feet from the exposure in the west wall of the excavation. Trenches FT-4-74, FT-5-74 and FT-6-74 were not successful in locating the fault, as the fault had swung approximately 9 degrees in a southerly direction from its former essentially east-west bearing. In those trenches where the fault was identified the identification was positive. In the trenches in which the fault was not identified no other feature which could have been construed to be the fault was found. Between trench FT-3-74 and the thicker western diabase dike, designated West Dike 3, the presence of fill, thick overburden and extremely wet ground in a natural drainage channel prevented trenching for the fault. At the expected intersection of the fault with West Dike 3 a very long trench designated FT-7-74 was laid out and excavated using scrapers to a depth of approximately 20 feet below original ground surface. This trench extended along the diabase dike in length sufficient to have exposed any fault projected along the original bearing of the fault as discovered in the excavation. Over a total trench length for trench FT-7-74 of approximately 900 feet the only feature uncovered which could be construed to be a fault was the typical exposure with the beds to the north approaching the fault plane undisturbed, the fault plane dipping approximately 70 degrees down to the south and with pronounced drag folding in the downthrown southern block. This trench was widened laterally to the west over a distance in excess of 100 feet to follow the fault and to define the intersection of the fault additionally with the small dike designated

West Dike 3S. The area of exposure of the fault at the intersection with West Dike 3 is approximately 1350 feet from the exposure of the fault in the west wall of the plant excavation. The exposure of the intersection of the fault with West Dike 3S is approximately 1,450 feet from the exposure of the fault in the west wall of the excavation.

Subsequently westerly trenching using a backhoe and a D-8 bulldozer has disclosed that the fault extends at least an additional distance of about 1,600 feet beyond West Dike 3S. This trenching will continue in a westerly direction in an attempt to trace the fault into and beyond the auxiliary reservoir.

To repeat, the criteria for identification of the fault is threefold. Bedding on the northerly side of the fault is always undisturbed up to the fault plane. Bedding in the south or hanging wall of the fault always exhibits drag folding up toward the fault plane. The fault always dips at a relatively high angle toward the south between 60 and 70 degrees with the exception of the intersect with East Dike 2 at which location the fault dips about 85 degrees. The identifications made have invariably been positive. No other faulting has been seen.

At two locations, the best exposure of which is in the eastern wall of the plant excavation, the fault splits for a horizontal distance of perhaps 100 feet into two distinct planes of offset. Where these splits occur the fault returns to a single plane exposure within a short horizontal distance.

B. LOCATING DIABASE DIKES

This is to summarize the work done by members of Carolina Power & Light Company's Siting Unit using the proton magnetometer in conjunction with Ebasco's investigation of the recently discovered fault at the Harris Plant Site.

Shortly after the discovery of a fault in the main excavation at the Shearon Harris Nuclear Generating Plant Site, a magnetic survey was conducted of the area by members of Carolina Power & Light Company's Siting Unit. This work was done using a Geometrics Proton Magnetometer. The purpose of this survey was to locate and trace out any diabase dikes in the plant areas for use in the dating of the fault, where possible. Four dikes were located and mapped within the plant boundaries. All of these dikes trend north to northwest in the vicinity of the plant.

This survey was carried out in the following manner: Several East-West traverses were run parallel to the known fault plane. The diabase dikes encountered along these traverses created magnetic anomalies that appeared as "magnetic highs" when the traverses were plotted in profile. The intensity of the associated fields ranged from 200 to 500 gammas greater than that of the surrounding country rock. Other dikes were located at and traced from previous exploration trenches and water wells.

Each dike encountered was traced with the magnetometer as far as possible across the cleared plant area. Each dike was staked and flagged every 50 to 100 feet along its trace. The stakes represented the highest reading obtained along a short traverse of the dike. The location of each stake was surveyed and tied into the existing plant coordinate system. These coordinates were then plotted on a plan view base map. The locations for dikes thus obtained are shown on Plates 1 and 2.

Interference was encountered (such as electric motors, heavy equipment, overhead wires and metal buildings) which produced some erratic readings. However, enough good readings were obtained to establish definite trends

for the dikes studied. Most erratic readings along the dike profiles can be attributed to variations within the dike itself. Differential weathering and changes in depth or width are a few of these normally encountered variations.

C. VERTICAL COMPONENT OF FAULT OFFSET

Attempts are being made to determine the vertical component of offset on the fault at several locations. At the location of the exposure in the west wall of the excavation for the Waste Handling Building the strata on the north or upthrown side of the fault contained a thick lens of medium to course-grained, white to grey, arkosic sandstone. A boring, FB-1-74, was completed in the floor of the excavation on the south or down-thrown side of the fault to core through this same sandstone lens and thus determine the vertical component of offset on the fault at that point. This effort is illustrated on Plate 3. The calculated vertical component of offset in this location is therefore established as being 83 feet. A petrographic analysis of samples taken from the outcrop exposure on the north or upthrown side of the fault and from the sandstone in the boring was made by Dr. Robert Butler of UNC. His report on the petrography of these samples is included with this report as Appendix A. The results of his examination indicate that the petrography of the two sandstone samples is sufficiently similar to have come from different thin sections cut on the same hand specimen. However, this is not conclusive since many arkosic lenses near the site are petrographically similar.

Four borings are in progress to the east of East Dike 2 near the fault. Two of these borings are located on the upthrown side of the fault and two are located on the downthrown side. An attempt will be made to correlate among these borings to determine the vertical component of offset at that

point. These attempts may or may not be successful. Correlations in these strata, which change radically over short lateral distahces, are often extremely difficult. Five cored borings are being completed to the west of West Dike 3S at the fault in an attempt to define vertical component of offset at that point. The vertical component of movement must be small, of the order of several feet to tens of feet, because of the lack of offset of diabase dike East Dike 2 as shown on Plate 4 and Photos C through F.

D. HORIZONTAL COMPONENT OF FAULT OFFSET

Because of the gentle southeasterly dip of the beds, their rapid lateral changes in appearance and their general lack of distinctive characteristics from bed to bed, direct stratigraphic measures of the horizontal component of offset in the sedimentary rocks will be very difficult to achieve. Extremely long stripped exposures in sound rock would probably be required to provide a satisfactory measure of overlap demonstrating horizontal offset. The extremely sinuous nature of the fault tends to preclude horizontal displacement of any great magnitude. The left lateral offset by the fault of East Dike 2, which dips at a high angle to the east, has been of the maximum order of 5 to 7 feet. This apparent offset may be partly spurious since the dike borders are vertically sinuous and the minimum horizontal displacement measured is 0.5 foot. See Plate 4 and Photos C through F. These apparent differences in offset could represent movement along the fault as the set of intrusions making up the body named East Dike 2 were emplaced.

E. GRAVITY STUDIES

The most recent available gravity maps of the site region are being analyzed. At this point in time, results of analysis of gravity maps and point readings have not yielded any information on the fault or inimical to the site location.

F. AEROMAGNETIC STUDIES

Northwest trending lineaments seen adjacent to the site on the "Aeromagnetic Map of Parts of the Greensboro and Raleigh $1^{o}$ by $2^{o}$ Quandrangles, North Carolina", published by USGS, NCDNER and WCBC in 1973, represent a diabase dike swarm in this otherwise magnetically quiet area.

G. REMOTE SENSING ANALYSES

This is to present a summary of activities relating to remote sensing analysis conducted for the Shearon Harris Site up to and including 8 October, 1974.

Preliminary review of the PSAR, Appendix 2A, has been conducted to serve as a background to remote sensing analysis.

Imagery

1. Multi-seasonal remote sensing (enlarged earth resources technology satellites - ERTS) images have been obtained from the US Geological Survey EROS Processing Center in Sioux Falls, South Dakota, and General Electric Laboratory in Washington, D. C. Additional multi-seasonal ERTS and Sky Lab imagery covering the site has been placed on order with the U S Government and is expected to arrive during the week of 7 to 12 October.

2. Side Looking Airborne Radar (SLAR). SLAR imagery has been flown in accordance with specifications verbally issued by Ebasco. Two directional flight lines perpendicular to each other east-west and north-south were completed in stereoscopic coverage. Two directional stereo coverage will serve to optimize the SLAR data source reducing the possibility of errors in interpretation resulting from electronic distortion in the imagery.

SLAR imagery of the east-west flight line was received on 4 October. The north-south flight material arrived 8 October. A mosaic consisting of consolidated east-west flight line imagery is expected to be completed and delivered on or about 11 October. The scale of the mosaic will be 1:250,000, permitting direct scale correlation with existing published maps.

The original contract called for one set of imagery at the scale of 1 to 100,000 and a second set at one to 50,000. Because of the grainy appearance of the 1 to 100,000 imagery the 1 to 50,000 set will be substituted with imagery at 1 to 250,000 which is to arrive shortly after mosaic completion.

3. Aerial Photography. Conventional black and white aerial photography flown in May, 1972, (prior to construction activities) is presently available. This photography at a scale of 1 inch = 1000 ft. will provide detailed data for correlation with the small scale high altitude imagery. However, photography at an intermediate scale will be useful to bridge the gap between the small scale and large scale imagery. Consequently an attempt is currently being made to obtain smaller scale black and white aerial photography.

Preliminary Remote Sensing Analysis

Because of the scale involved, preliminary analysis of 1 : 1 million ERTS imagery does not reveal the fault recently discovered at Shearon Harris Site. This is important because the extent of the fault is usually localized if it cannot be discerned on the ERTS imagery. (i.e. a larger more regional lineament would be observed). The Triassic dike discovered near by, however, can be observed on the ERTS imagery albeit with great difficulty. The SLAR imagery has only been recently received and only the most rudimentary attempt has been made at analysis. SLAR imagery must not only be scrutinized for its own worth but it must also be carefully related with Sky Lab and low level black and white photographic imagery for maximum reliability of analysis. Both detailed studies of SLAR imagery and correlation with other remote sensing modes has not yet been done. However, an attempt has been made at preliminary examination and interpretation of SLAR imagery.

1. It appears that SLAR brings out the strongest evidence of the fault of all the remote sensing modes currently available. However, this evidence is not easy to detect and will not be readily acceptable without a painstaking examination of all phases.
2. The fault trace at this stage of analysis does not appear as a continuous clear lineation on the ground surface but rather seems discontinuous and straight.
3. The linearity or straightness of the fault trace is generally indicative of a high angle fault plane. However, the discontinuity of the fault trace is probably a result of strong topographic features on higher ground which are lacking in the sediment filled stream valleys it passes through.

## H. RADIO ISOTOPE DATING

Potassium-argon dates on two samples taken in sound diabase from cored borings have been received. One of these samples, taken from West Dike 3 is identified as sample DB-1-74 and was taken from a depth of 55.0 feet. The other taken from East Dike 2 is identified as sample DB-2-74 and was taken from a depth of 53.0 feet. The confirmed dates for these samples are: (DB-1) 197 million years, (DB-2) 191 million years. The report on these determinations is attached as Appendix B. Blind samples from both of these borings have been submitted for dating. In addition we have submitted a sample from West Dike 3S taken from cored boring DB-3-74 from a depth of 54 feet. In addition to these dating tests and others which may be completed, whole - rock rubidium-strontium age samples of hornsfels associated with East Dike 2 and West Dike 3 have been taken. These samples can be dated if necessary. Isochrons of East Dike 2 K-AR samples are being prepared independently. Additional diabase dikes to the west which are crossed by the fault may be dated.

## I. PALEOMAGNETIC STUDIES

Oriented samples from diabase dikes will be obtained and tested for paleomagnetic orientation. The purpose of these tests is to confirm that the ages of the dikes are not the same.

## J. PROCEDURES NOT USED

1. Refraction seismic methods are not considered reliable in tracing the fault and are not used.

2. Several unrecorded traverses across the fault with the proton magnetometer showed that the fault could not be detected using this instrument.
3. The reflection seismographic method does not reliably trace faulting near the ground surface and was therefore not used.
4. Overcoring methods to measure in-place stresses and stress orientations were expected to yield results of a low order of reproducibility accompanied by mechanical difficulties in the near surface rock at the site and were therefore not used.
5. Microseismic instrumentation to measure microseisms was considered but not used because of the aseismic nature of the site area.

## VI. AGE OF MOVEMENT ON THE FAULT

Latest movement on the fault is very ancient. Independent lines of evidence indicate very strongly that there has been little or no movement on this fault in the past 150 million years or more.

### A. EVIDENCE FROM SOIL AND SAPROLITE EXPOSURES

The fault has not moved during the time of formation of existing soil and saprolite exposures seen in a number of trenches and cuts developed during the investigation program. Clay mineralogy studies have revealed this to be an in-place weathering profile.

The soil is described as White Store, brownish-yellow, fine sandy clay to clay. A complete description is enclosed as Appendix C. This soil horizon has not been disturbed above the fault. Below this soil horizon weathering decreases with depth. For a depth below the soil horizon of from 6 to 15 feet the exposed material is classified as saprolite. Along the fault plane

and in adjacent joints and fractures in-fillings of clay skin, primarily montmorillonites and clay sized micas, are undisturbed at the fault exposures. The time of formation of the soil and saprolite horizons is not directly known. However, exposures of similar soil horizons in Georgia are overlain by early Pleistocene sediments and may be Pliocene in age and be older than 1 million years.

The undisturbed saprolite developed on East Dike 2 is 35 feet thick. Correlative dating of weathering rates in these type rocks at another location in the United States will be used and will indirectly reveal an age of many millions of years for this undisturbed exposure. Undisturbed secondary clay in-filling is seen crossing the fault in weathered diabase at East Dike 2 in Photos G through I. Undisturbed spheroidal weathering in the diabase is seen in several photos including Photo J.

B. EVIDENCE FROM SECONDARY MINERALIZATION

A number of secondary minerals are found in fault gouge at or adjacent to the crossing by the fault at diabase dikes. These minerals include the zeolite minerals stilbite, phillipsite, heulandite and laumontite and are found in fault gouge near both West Dike 3S and East Dike 2. Some examples of the locations from which samples were taken at West Dike 3S are shown on Photo P. The zeolites are probably deuteric minerals which have been formed and are stable only at high temperatures. The contemporaneity of the intrusion of the diabase dikes and the faulting is strongly suggested by the presence of the zeolite minerals which were probably formed at East Dike 2 during the period when the latent heat of the diabase remained high subsequent to movement on the fault.

The minimum age of the zeolite minerals is being determined on the basis of their potassium content. Other secondary minerals identified until

now include calcite, serpentine, pyrite, probable barite and coal. The zeolites and other secondary minerals are all found below the present water table. The coal is found in the fault plane adjacent to the diabase dike-fault intersection at East Dike 2 in association with a carbonaceous shale. The pyrite is found in the fault plane in association with the coal. Serpentine is found as a secondary mineral in the fault gouge at East Dike 2. While the minerals thus far identified other than the zeolites can probably not be accurately dated as to time of formation, certainly they are very ancient and have been formed in the fault plane subsequent to latest movement.

## C. EVIDENCE FROM GEOMETRY

### 1. EAST DIKE 2

It is clear in the hard rock exposure developed by excavation on East Dike 2 that faulting took place subsequent to crystallization of the dike. At the dike-fault intersection, however, there are marked differences in the apparent offset among the three dike bodies making up what is called East Dike 2. This exposure is not illustrated in this report but is presently being mapped and photographed. The exposure supports important interpretations.

1. Sedimentary beds are not grossly offset across the three individual dike bodies. Therefore, the dike does not follow a fault of any magnitude and the three bodies were intruded and crystallized separately.
2. The vertical component of movement must have been small, of the order of feet or tens of feet.
3. The horizontal component of movement must have been small-less than several feet - possibly less than one foot.

4. The differences in apparent offset of the individual dike bodies may reflect their sequential intrusion during the period of movement on the fault.

For views of exposures of the East Dike 2 - fault intersection at higher elevations see particularly Photos C through F and Plate 4.

2. <u>WEST DIKE 3S</u>

West Dike 3S intersects West Dike 3 at a point several hundred feet northerly from the intersection of the fault with the two dikes. Sedimentary beds crossing West Dike 3S are not offset. At elevation 249, the outcrop of the intersection of West Dike 3S and the fault was such that West Dike 3S, if any apparent offset could be seen at all, was out of line only a few inches. This is seen on Plate 5 and in Photo K. Subsequent excavation to elevation 239 revealed relative change in location of all key elements of this exposure as shown on Plate 6 and in Photos L through P. Analysis of these changes indicates that they could not have been produced by fault offset if the dike was planar at the fault as it is elsewhere. That is, had fault movement occurred after intrusion of the dike, the dikes configuration as now seen would not be expected.

D. EVIDENCE FROM MORPHOLOGY OF DIKE INTERSECTS

West Dike 3S intersects and crosses West Dike 3 several hundred feet north of their exposures at the intersections with the fault. Morphology of this exposure in weathered diabase strongly suggests that West Dike 3S is younger than West Dike 3. See Plate 5.

E. EVIDENCE FROM PETROLOGY

The dikes encountered thus far in the investigation have exhibited a uniformly coarsening ground mass toward the center of the dike with small phenocrysts and finer ground mass at the chill margins. The dikes are rather uniformly sub-ophitic in texture in the central part of their exposures. The exception to this observation is West Dike 3S in which part of the cored diabase material exhibits very large phenocrysts embedded in extremely fine ground mass. This suggests vertical segregation in West Dike 3S and strongly indicates that West Dike 3S was intruded at least in part as a crystalline mush which was being tapped off the common parent magma at a later, cooler stage in the history of the magma. Geochemical work is presently underway to verify this relationship. The relationship thus established hopefully will verify that West Dike 3S is younger than East Dike 2 and therefore younger than West Dike 3, since the ages determined by potassium-argon methods on East Dike 2 and West Dike 3 are the same within the resolving power of the potassium-argon method. Present petrographic inferences are that West Dike 3 is in fact the oldest of the three.

F. EVIDENCE FROM OUTCROP

The outcrop of the intersection of West Dike 3S and the fault at elevation 239 offers strong evidence that West Dike 3S was intruded subsequent to movement on the fault. This exposure is seen in attached Photos L through P and on Plate 6. As can be seen in the photos and drawings diabase of West Dike 3S overlaps the sheared clay of the fault zone. The two apophyses of diabase seen at the end of the northern limb of this exposure appear to offer com-

pelling evidence that the diabase was intruded subsequent to faulting. A smaller, football shaped apophysis of diabase is seen immediately west of the stub end of the southern limb of the West Dike 3S at this elevation. Zeolite samples were obtained from this apophysis and adjacent fault gouge.

Where the apophyses enclose country rock against the main body of the dike the intensity of alteration in the country rock is greater than other immediate adjacent areas. This is consistent with the evidence that alteration at this point was proceeding from two sides; from the diabase dike itself and from the apophyses. Clay mineralogy and geochemistry studies of these potential zones of alteration are being carried out.

In connection with the interpretation that West Dike 3S was intruded into this broken rock zone after movement, see Photo Q, which shows such an intrusion form not associated with faulting at East Dike 2.

The opposite page represents solutions to fault movement focusing on the West Dike 3S - fault intersection. West Dike 3S has been drawn at true dip (about 80°) to illustrate what happens during various fault movements. It superficially appears that either Panel 3 or 4 could represent the movement of the fault on the basis of the change in dip of the diabase as shown in Panel 3, or on the basis of the alignment of the two ends as shown in Panel 4. However, these solutions are ruled out by the fact that the dip of the diabase remains the same both north and south of the fault intersection. Therefore, given the linearity of the dike, no model reproducing the field conditions is amenable to interpretation as fault offset after intrusion of the diabase.

## VII. INITIATION OF SEISMS ASSOCIATED WITH RESERVOIR IMPOUNDMENTS

Since the fault is expected to be found to cross the Auxiliary Reservoir of the project, consideration must be given to the possibility that increased pore pressures and/or loading created by the imposition of the reservoir could lead to the initiation of seisms associated with the fault. A thorough review of the literature in this area of interest is in progress.

Our on-going investigations and researches are expected to demonstrate that reservoir filling will not be accompanied by macro seismic activity at Shearon Harris.

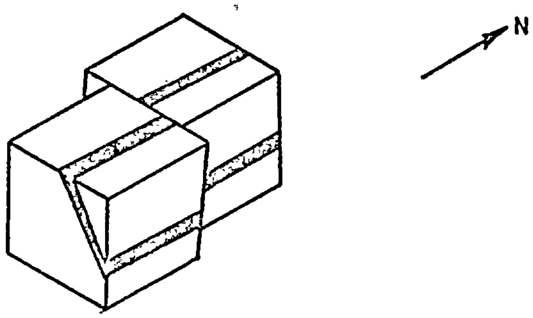
## VIII. RELATIVE PERMEABILITY OF THE FAULT, COUNTRY ROCK, AND DIABASE DIKES

As noted previously the developed soil horizon which is between two and six feet in thickness is not disturbed by movement on the fault. This soil is essentially a clay which in the

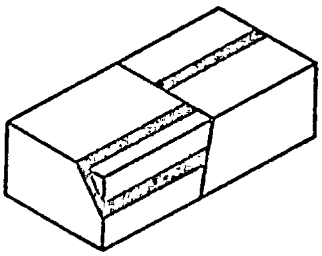
# IDEALIZED FAULTED STRUCTURE DIAGRAMS AT WEST DIKE 3S - FAULT INTERSECTION

PANEL 1.

## STRIKE-SLIP MOVEMENT



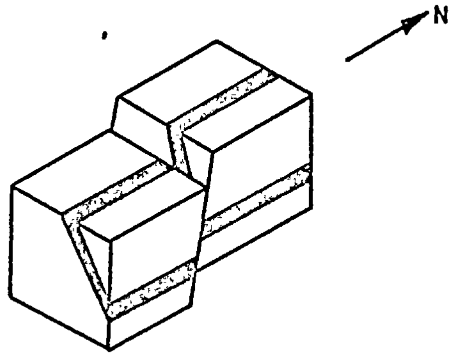

A. DURING FAULTING



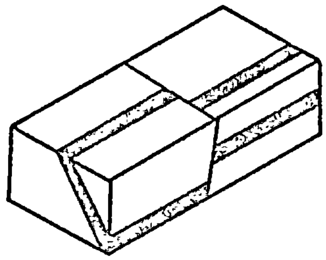
B. AFTER EXCAVATION

PANEL 2

## DIP-SLIP MOVEMENT



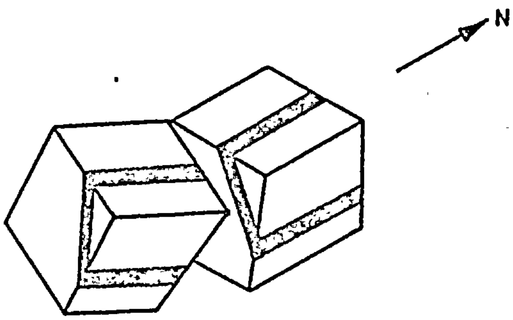

A. DURING FAULTING



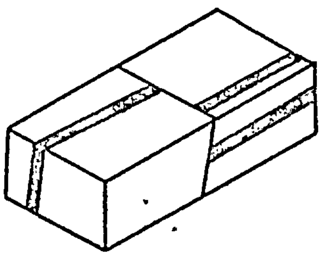
B. AFTER EXCAVATION

PANEL 3

## ROTATIONAL MOVEMENT



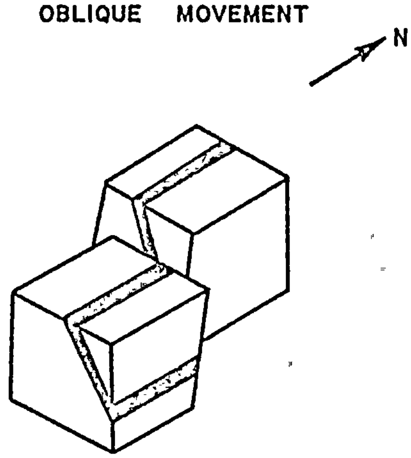

A. DURING FAULTING



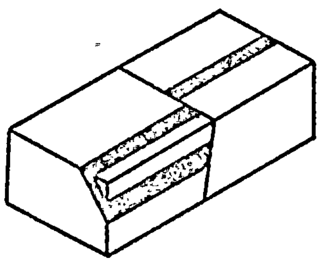
B. AFTER EXCAVATION

PANEL 4

## OBLIQUE MOVEMENT




A. DURING FAULTING



B. AFTER EXCAVATION

Auxiliary Reservoir will not be disturbed and will act as a clay blanket. The saprolite horizon extending from 6 to 15 feet below this soil horizon everywhere exhibits complete infillings of joints and fractures, as well as the fault plane, by clay skins which are themselves essentially impervious. Pump-in tests of country rocks completed in association with exploration for the auxiliary dam and spillway structures indicate that the permeability of this material is low. The broken rock near the fault plane is expected to be somewhat more permeable than the surrounding country rock at elevations below the depth of the saprolite zone and higher than depths of perhaps four to five hundred feet. This permeability will be tested by pump-in tests which will be completed in borings designed to cross the fault in the reservoir area. It is to be noted that the fault crosses four diabase dikes intersecting the area between the auxiliary reservoir and the plant site area. These diabase dikes will serve as barriers to movement of groundwater at greater depths along the fault. Groundwater is concentrated near the diabase dikes in the intermediate depth range down to 400 to 500 feet as verified by the fact that practically all of the water wells that have been drilled successfully in this region have been drilled in or immediately adjacent to diabase dikes. Below depths of 400 to 500 feet the diabase dikes act as aquacludes and trap and confine water on their upstream sides.

## IX. THE FAULT AS AN ORIENTED PLANE OF WEAKNESS

For purposes of this investigation, it is assumed that planes of stress in the rock will be found to be within 30 degree arcs of north-south and east-west. It is expected that the exact alignment and magnitude of these stresses will vary considerably with differences in elevation and differences in lithology. Therefore, the east-west alignment is assumed to be a principle or secondary plane of tensional stress. The fault strikes essentially east-west and is therefore assumed to be a zone of tension as it was at the time of movement. Since the age of the fault is probably greater than 150 million years before the present it does not seem conceivable that movement will be re-initiated under any conditions relating to the construction of the project. It appears that this area has been loaded by great thickness of sediment which were subsequently eroded away, the coming and going of the sea and has been subjected to the incidence of other tectonic stresses during the time subsequent to the intrusion of the diabase dikes. If the fault has not moved during the imposition of these geological stresses, it seems inconceivable that it will move in the near future. Loadings represented by the plant structures and reservoirs are inconsequential compared to past geological loads on these materials.

## X. PRELIMINARY RESPONSE TO AEC LETTER OF 7 OCTOBER, 1974

The material presented in this Progress Report was prepared prior to receipt of the referenced AEC letter. The final report will address these questions in much more detail. For preliminary responses see the following list of references. For the text of the AEC letter see Appendix D.

2.5.1 See Heading II. See Heading V, subheadings C and D, Heading VI, subheadings B, C, D, E and F. See Heading IX. See Captions and Photos C, D, E, K, L. M, N, O, P and Q. See Plates 1, 2, 3, 4, 5 and 6.

2.5.2 See Heading II. See Heading V, subheading H and I.. See Heading VI, subheading B.

2.5.3 See Heading II. See Heading VI, subheading A. See Captions and Photos B, G, H, I and J.

2.5.4 See Heading III, subheading A. See Plate 1.

2.5.5 See Heading IV, subheading A. See Heading VII. See Heading VIII.

2.5.6 See Heading III, subheading B. See Heading IV, subheading B.

2.5.7 See Caption and Photo E.

2.5.8 Shall be done. Photos and Plates with this report are examples.

2.5.9 See Heading VII. See Heading VIII. See Heading IX.

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# APPENDIX A

REPORT ON THIN SECTIONS OF
WHITE SANDSTONE FROM THE
SHEARON HARRIS SITE

BY DR. J. R. BUTLER

September 8, 1974

# REPORT ON THIN SECTIONS OF WHITE SANDSTONE FROM THE SHEARON HARRIS SITE

GENERAL: One sandstone is from core south of the fault, the other sandstone is from an outcrop in the pit north of the fault. Each sample was taken about ten feet from the base of a thick white sandstone unit. Both samples are coarse arkosic sandstone with an overall grayish pink color; the clasts range from white to medium gray.

SANDSTONE IN CORE SOUTH OF FAULT:
Texture: The rock has a clastic sedimentary texture. Most grains are 0.2 to 1 mm in diameter, but some are as much as 3 mm across. Most grains are angular to subrounded. A small amount of very fine-grained cement is present between the grains.

Identification of the clasts:

| | |
|---|---|
| Quartz | 45% (Visual estimate) |
| Plagioclase, partly altered | 15 |
| Microcline | 5 |
| Muscovite | 2 |
| Epidote | 1 |
| Opaque minerals | 2 |
| Biotite | trace |
| Rock fragments | 30 (Mainly fine-grained muscovite and muscovite-chlorite schist and quatrzite) |

SANDSTONE IN PIT NORTH OF FAULT:
Texture: The texture is clastic sedimentary. Most grains are 0.4 to 1 mm in diameter and some range up to 3 mm across. Grains are angular to subangular, with some subrounded. Cement is present in very small amounts.

Identification of the clasts:

| | |
|---|---|
| Quartz | 50% (Visual estimate) |
| Plagioclase, partly altered | 15 |
| Microcline | 10 |
| Muscovite | 2 |
| Epidote | 1 |
| Biotite, partly altered | 1 |
| Opaque minerals | 1 |
| Sphene | trace |
| Rock fragments | 20 (Mainly fine-grained chlorite-muscovite schist, quartzite, and micropegmatite) |

CONCLUSIONS: The two rocks are very similar to each other in all respects. There are minor differences in texture and identification of clasts, but the differences are no greater than might be expected in two thin sections cut from the same hand specimen. The similarities suggest, but do not prove, that the two samples are from the same sandstone bed.

James Robert Butler
James Robert Butler

# APPENDIX B

## K/Ar AGE DETERMINATIONS

BY DR. D. F. SCHUTZ

TELEDYNE ISOTOPES
WESTWOOD LABORATORIES
50 VAN BUREN AVENUE
WESTWOOD, NEW JERSEY 07675
(201) 664-7070 TELEX 134474

30 September 1974

Ebasco Services, Inc.
P. O. Box 186
Liberty, North Carolina 27298

Attention: Mr. Norman R. Tilford

Dear Mr. Tilford: Re: W. O. No. 3-0846-212

We have completed the analysis of your samples submitted for K/Ar age determination. The results are as follows:

| Isotopes Sample # | Your Sample # | Isotopic Age (m.y.) | scc $Ar^{40}$ Rad/gm. x $10^{-5}$ | % $Ar^{40}$ Rad | % K |
|---|---|---|---|---|---|
| KA74-170 | DB-1 | 197 ± 10 | .21 | 83.5 | .24 |
| | | | .19 | 64.5 | .24 |
| | | | | | .24 |
| KA74-171 | DB-2 | 191 ± 10 | .18 | 48.5 | .23 |
| | | | .19 | 40.0 | .23 |

The constants used for the age calculations are: $\lambda_\beta = 4.72x10^{-10}$ $yr^{-1}$ $\lambda_e = 0.585x10^{-10}$ $yr^{-1}$ and $K^{40} = 1.19x10^{-4}$ atom percent of natural potassium.

The error indicated for the reported ages consists of a summation of all analytical errors.

As we have discussed over the telephone, we found DB-2 to be an unusually difficult rock to analyze. This was in part due to the low potassium content and what appears to be a fairly large amount of entrapped or adsorbed atmospheric argon. The latter problem may be associated with rock alteration and secondary mineralization as the results improved considerably when I crushed the rock by hand and picked out the freshest pieces for analysis.

As part of our attempt to obtain consistent argon values, we ran the B3203 MIT biotite standard reference material four times and obtained a standard deviation of ±0.6%, thus giving assurance that our overall mass spectrometry system is in good order. Since the standard is used to calculate the spike volume, an overall system calibration is obtained which includes all errors associated with gas handling, clean-up and mass spectrometric measurement efficiency.

TELEDYNE
ISOTOPES

30 September 1974
Ebasco Services, Inc.
Attention: Mr. Norman R. Tilford
Page two

In addition to the standardization runs, we also ran a system blank for air argon to determine whether an air leak was the cause of our problem. The blank value for Ar-40 represents less than 3% of the radiogenic argon observed for DB-2, so is a small part of the correction for air argon.

If you have any questions regarding the reported analyses, please do not hesitate to contact me. I will be away until October 10, 1974. We are planning to have the most recent three rocks you sent done by Friday, October 4, 1974. I will have our Mr. Perrin call you with the results if there are no difficulties. Otherwise the analysis may go into the following week and I will call you when I return after reviewing the data.

Yours very truly,

Donald F. Schutz/rep

Donald F. Schutz
Vice President
Manager Westwood Laboratories

DFS:mm

cc: K. J. Hession,
Ebasco Services Inc.
21 West Street
New York N Y 10006

# APPENDIX C

## SOILS AND CLAY MINERALOGY

BY DR. S. B. WEED

August 19, 1974

Carolina Power and Light Company Site 2, Profile 1 West, crest of main excavation, Down thrown side of the fault.

Described by: EEG *[signature]* Soil Series White Store

| Horizon and Depth | Description (All Munsell Colors Moist) |
|---|---|
| Ap or Spoil 0-6" | Brownish yellow (10YR6/6) fine sandy clay loam to clay loam; rather compact - probably compacted and disturbed by heavy machinery; abrupt boundary. |
| B21t 6-14" | Brownish yellow (10YR 6/6) smooth fine sandy clay to clay; common fine faint very pale brown (10YR7/4) mottles; coarse subangular blocky structure; apparent clay skins or essentially all ped faces; clear boundary. |
| B22t 14-28" | Light yellowish brown (10YR6/4) silty clay; common medium pale brown (10YR6/3) and common coarse brown (10YR-7.5YR4/3) mottles or bodies; strong medium subangular blocky structure; clay skins or most ped faces; clear boundary. |
| B3? 28-36" | Light gray (10YR7/2) fine loam; many coarse dark yellowish brown (10YR4/4) bodies; common fine and medium subangular blocky structure; clear boundary. |
| C1 36-49" | Light gray (10YR7/2) very fine sandy clay; many fine and medium strong brown (7.5YR5/6) yellowish brown (10YR5/8), brown (7.5YR5/4) and reddish brown (5YR4/3) mottles; some vague nearly vertical orientation of the gray areas; weak to moderate angular blocky structure-has an almost fissile character; gradual boundary. |

| Horizon and Depth | Description (All Munsell Colors Moist) |
|---|---|
| C2 49-63" | Light gray to light greenish gray (10Y7/1) slick, greasy, almost waxy feeling, very fine clay loam forming a vague reticulate pattern 4-6" across; this pattern surrounds common medium and coarse brown (7.5YR4/4) and dark reddish brown (2.5YR3/4) bodies; the light greenish gray material tends to be somewhat firm; the greenish gray appears to merge with the light gray of the overlying horizon; some tendency to medium and coarse angular structure; plant roots are present along some structure faces; gradual boundary. |
| 63"-10' | Reddish brown (5YR-2.5YR4/3) firm (not hard) silty clay stone with a greasy waxy feeling; breaks out in subrounded chunks up to 6-8" diameter; light gray (5Y7/1) present on some of these subrounded chunks - this coating material is traceable up to the light greenish gray to light gray bodies of the overlying horizon; plant roots are present in these coatings in the upper part of the unit; few fine greenish gray bodies and flecks in the interior of the brown subrounded chunks. |

This 63"-10' unit appears to make an abrupt contact with a somewhat harder reddish brown (5YR-2.5YR4/3) fine sandstone that forms a prominent ledge along the edge of the excavation.

There is no evidence of a discontinuity at or near the surface in this section. The soil appears to be developed directly in the somewhat shattered Triassic sediments of the down thrown side of the fault.

# APPENDIX D

LETTER FROM ATOMIC ENERGY COMMISSION

DATED OCTOBER 7, 1974

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D. C. 20545

October 7, 1974

Docket Nos. 50-400
50-401
50-402
and 50-403

Carolina Power and Light Company
ATTN: Mr. J. A. Jones
Executive Vice President
Engineering, Construction
and Operation
336 Fayetteville Street
Raleigh, North Carolina 27602

Gentlemen:

Regulatory staff geologists have made three visits (on July 25, August 30 and September 26, 1974) to the Shearon Harris Nuclear Power Plant site to observe the fault which crosses the plant excavation and to review with your representatives the progress of the geologic investigations which are under way.

As a result of these visits and the discussions with your representatives concerning the scope of the investigative program, we have developed Regulatory positions. These positions describe geologic investigations and documentation of results necessary to enable us to complete our review of the suitability of the Shearon Harris plant site for construction of the proposed reactors.

It is our understanding that you plan to submit an interim report of these investigations later this month and a final report in January 1975. Please confirm this schedule within 7 days after receipt of this letter or provide us with an alternate schedule which you will be able to meet.

Please contact us if you desire additional discussion or clarification of the investigations and documentation of results required.

(ORIGINAL SIGNED)

Walter R. Butler, Chief
Light Water Reactors Projects Branch 1-2
Directorate of Licensing

Enclosure: As stated

cc: See Page 2

cc: George F. Trowbridge, Esq.
Shaw, Pittman, Pitts &
Trowbridge
910 17th Street, N. W.
Washington, D. C. 20006

W. Bryan Howell, Esq.
Carolina Power and Light Company
336 Fayetteville Street
Raleigh, North Carolina 27602

Thomas S. Erwin, Esq.
115 W. Morgan Street
Raleigh, North Carolina 27602

ENCLOSURE

POSITIONS - FAULT INVESTIGATIONS
CAROLINA POWER & LIGHT CO's SHEARON HARRIS SITE
DOCKET NOS: 50-400/401/402/403

323.11 (RSP)

2.5.1 Certain of the site excavations on fault/diabase dike intersects exhibit apparent offset of the dikes. This relationship should be explained in terms of sense of movement of the fault and the apparent genesis of both the fault and the dikes. These discussions should include descriptions and illustrations of the dike-fault system and historical stress regimes existing at the time of their formation. Remaining intersects should be investigated in an effort to locate a dike which has not been offset by the fault.

One exposed intersect has been observed to exhibit considerable irregularity within a short depth interval. The possibility of unique dike irregularities carrying across the fault should be investigated by the excavation of trenches normal to the dike.

2.5.2 Radiometric dating of samples from dikes and other useable fault related material should be conducted whenever pertinent to the investigations.

2.5.3 The forthcoming geologic report should include a discussion of the residual soil cover and an estimate of its relative age.

2.5.4 The final geologic report should provide a structural history of the site faulting as related to regional faulting and, specifically, but not limited to the Jonesboro Fault. This discussion should document, in detail, those geologic factors which indicate the age of the Jonesboro Fault.

2.5.5 The final geologic report should describe in detail the permeability of the fault plane and associated rocks relating to the anticipated effects of the cooling reservoir being located over that geologic environment.

2.5.6 The final geologic report should discuss, to whatever detail possible, the historical seismicity of the area.

2.5.7 The near surface material has shown a tendency to slump on the "up-dip" sides of excavations. This slumping appears to take place along bedding planes. Demonstrate that the stability analysis for the Category I dams includes failure surfaces compatible with the bedding conditions under these structures.

2.5.8 Detailed mapping and pertinent photographs of all fault/diabase dike intersections and exposures should be included in the final geologic report.

2.5.9 Discuss the potential effect of the reservoir loading on the fault and provide assurance that the hydraulic loading will not present a safety hazard to the nuclear station.

# SHEARON HARRIS NUCLEAR POWER PLANT
# FAULT INVESTIGATION

## PROGRESS REPORT
BY
EBASCO SERVICES INCORPORATED

VOLUME 2 of 2

TABLE OF CONTENTS

VOLUME 2

PHOTOS



PLATES



NOTE: Large plates 1, 2, 3 and 5 are in pocket of back cover Volume II.

View eastward across the plant excavation area. The line segment shows exposures of the trace of the fault plane at the plant and eastward. To the west of the plant excavation may be seen trenches FT-1-74 and FT-2-74 on opposite sides of the railroad track. Trenches FT-9-74 and FT-10-74 are seen to the east of the plant excavation west of trench FT-11-74.

View westward in the plant excavation at the location of the waste processing building. The fault is seen as line segment (A). Line segments (B) represent bedding and drag-folding on the south hanging wall of the fault. Note that bedding approaching the fault from the north is completely undisturbed up to the fault plane. Line segment (D) typifies horizontal bedding approaching the fault plane from the north at the higher bench level. Area (E) under the line segment between (C) and (E) represent clay skins deposited in bedding planes and fractures. Note that the bedding planes are drag-folded up to the north. The area above the line segment between designation (C) and (E) represents undisturbed yellow weathering profile seen throughout the area above the fault.

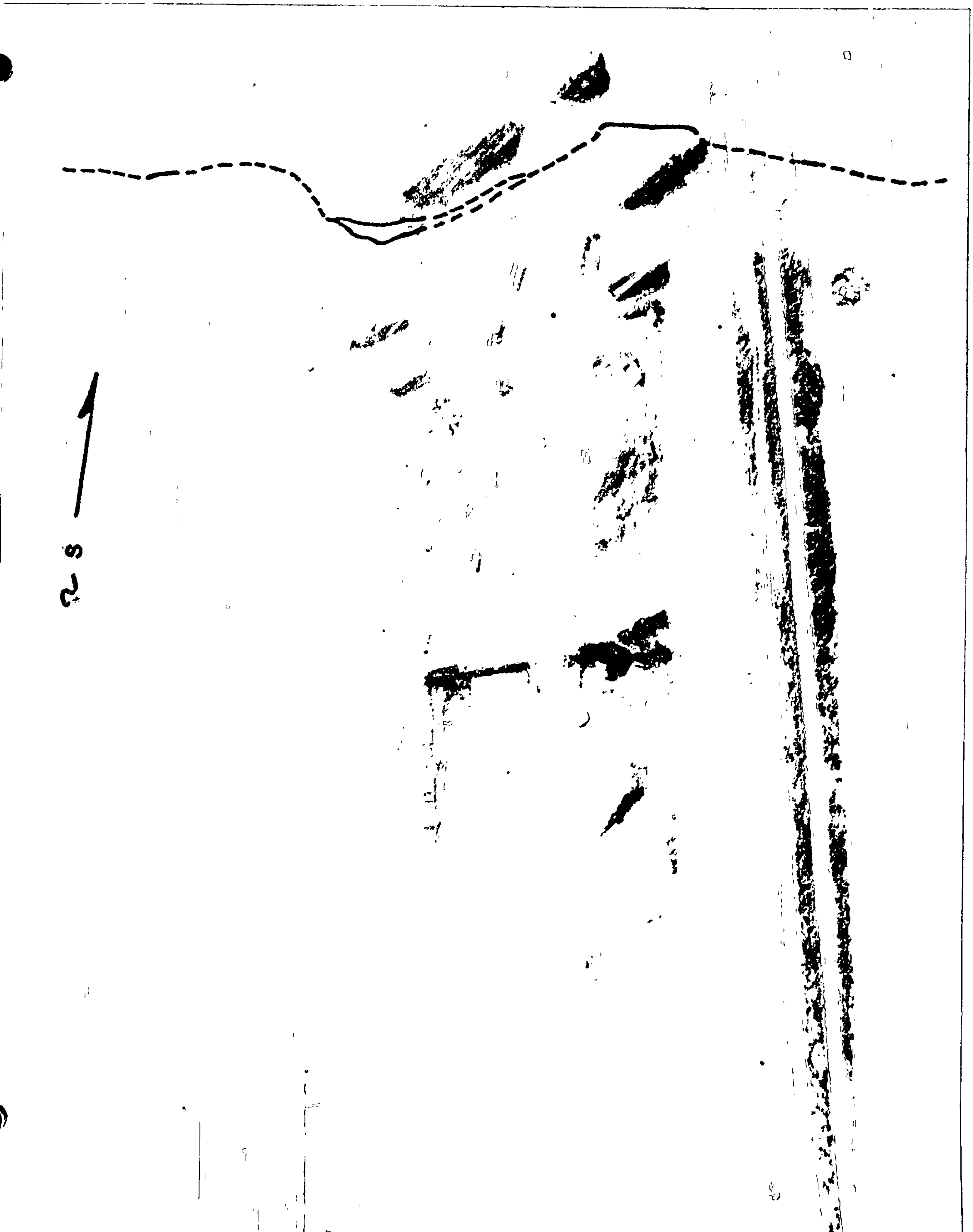


PHOTO A


PHOTO B
C54-238

C54-379
Photo C Caption

View north along East Dike 2 at intersection with the fault at elevation 2.2 feet below beginning elevation 247. Line segments (A) represent limits of segments of diabase. Line segments (B) represent shearing along the trace of the fault. The maximum left lateral sense of movement seen in this photo is 3.5 feet. The minimum sense of left lateral movement is approximately 0.5 foot.

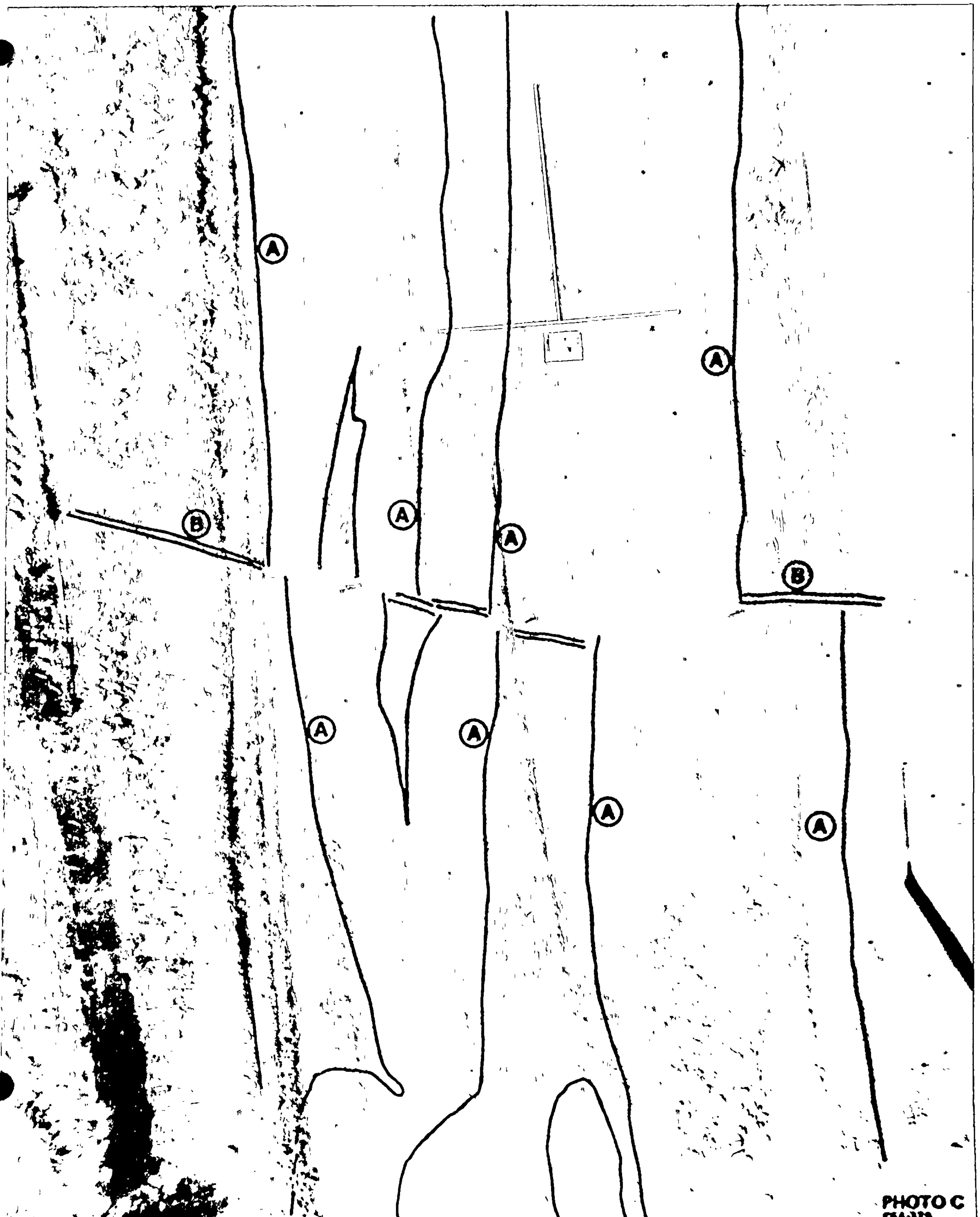



PHOTO C

C54-382
Photo D Caption

View northward along East Dike 2 at the intersection with the fault at 4.9 feet below initial elevation 247. Line segments (A) represent the limits of diabase segments. Line segments (B) represent shearing along the trace of the fault. The maximum sense of left lateral displacement shown is 5.5 feet, diminishing at other points to about 2 feet. The fault at this location is essentially vertical. The dike dips eastward at the very high angle, probably about 85 degrees. Both the horizontal and vertical components of offset must be very small for the preservation of individual dike segment widths and alignments to have remained so similar on opposite sides of the fault.

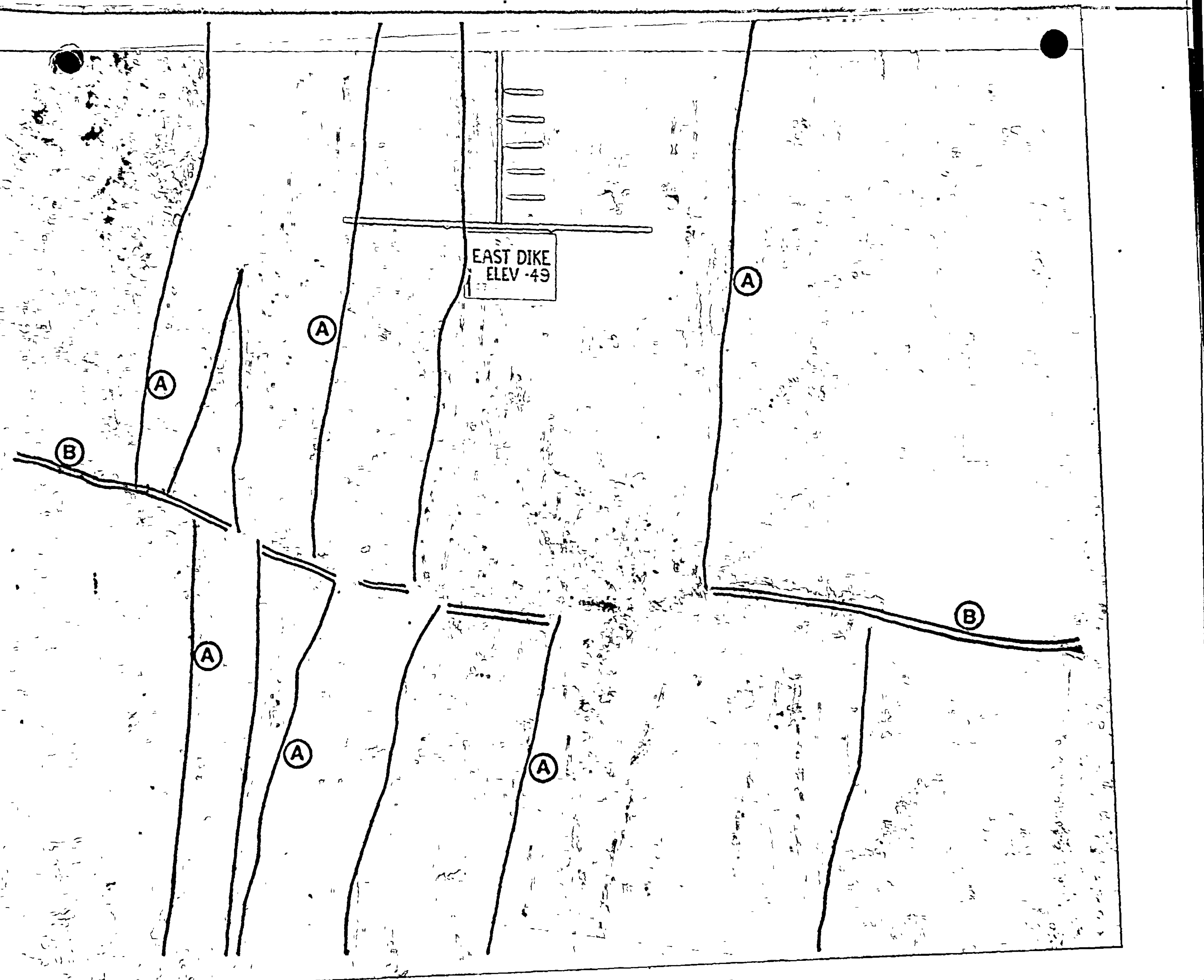



PHOTO D
C54-382

View northward along East Dike 2 at the intersection with the fault. The total exposure of dike is some 800 feet in length. Line segments (B) represent bedding plane slope failures on dip slopes which are common at higher elevations on clays which are found in association with the diabase dikes. These clays are concentrated near the dikes and are not found below the saprolite zone in areas several hundred feet removed from dike exposures. The two drill rigs at points (A) are coring to explore the vertical component of offset along the fault. Line segments (C) show the limits of the diabase dike. Line segments (D) represent the fault. Point location (E) represents apparent offset of the dikes not seen at lower elevations. Note the lack of offset of the dike to the right in this exposure. Point (F) similarly represents apparent but not real offset of one of the smaller dike segments. A cleaned and close-up view of this particular location is seen in Photo Q.

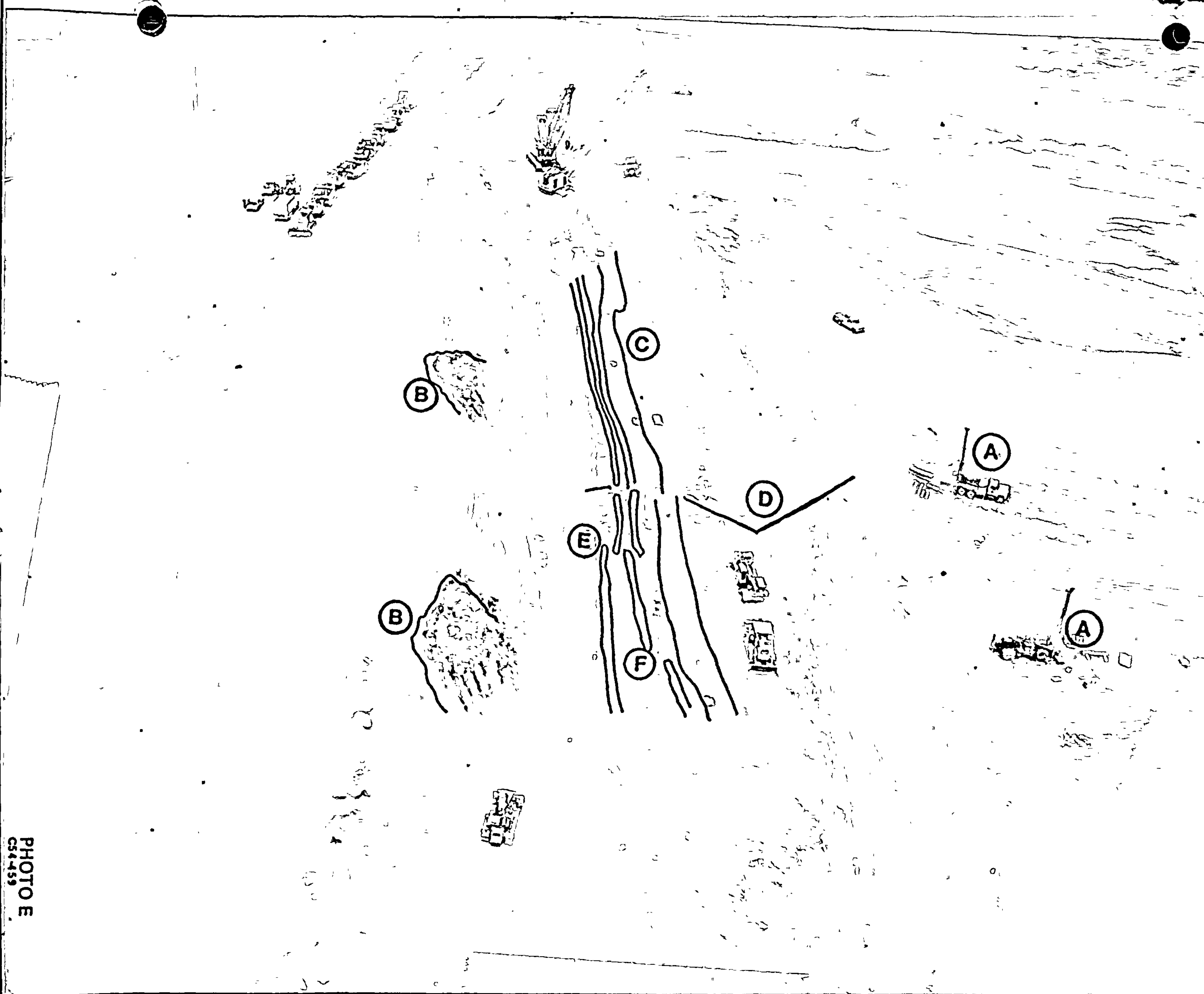
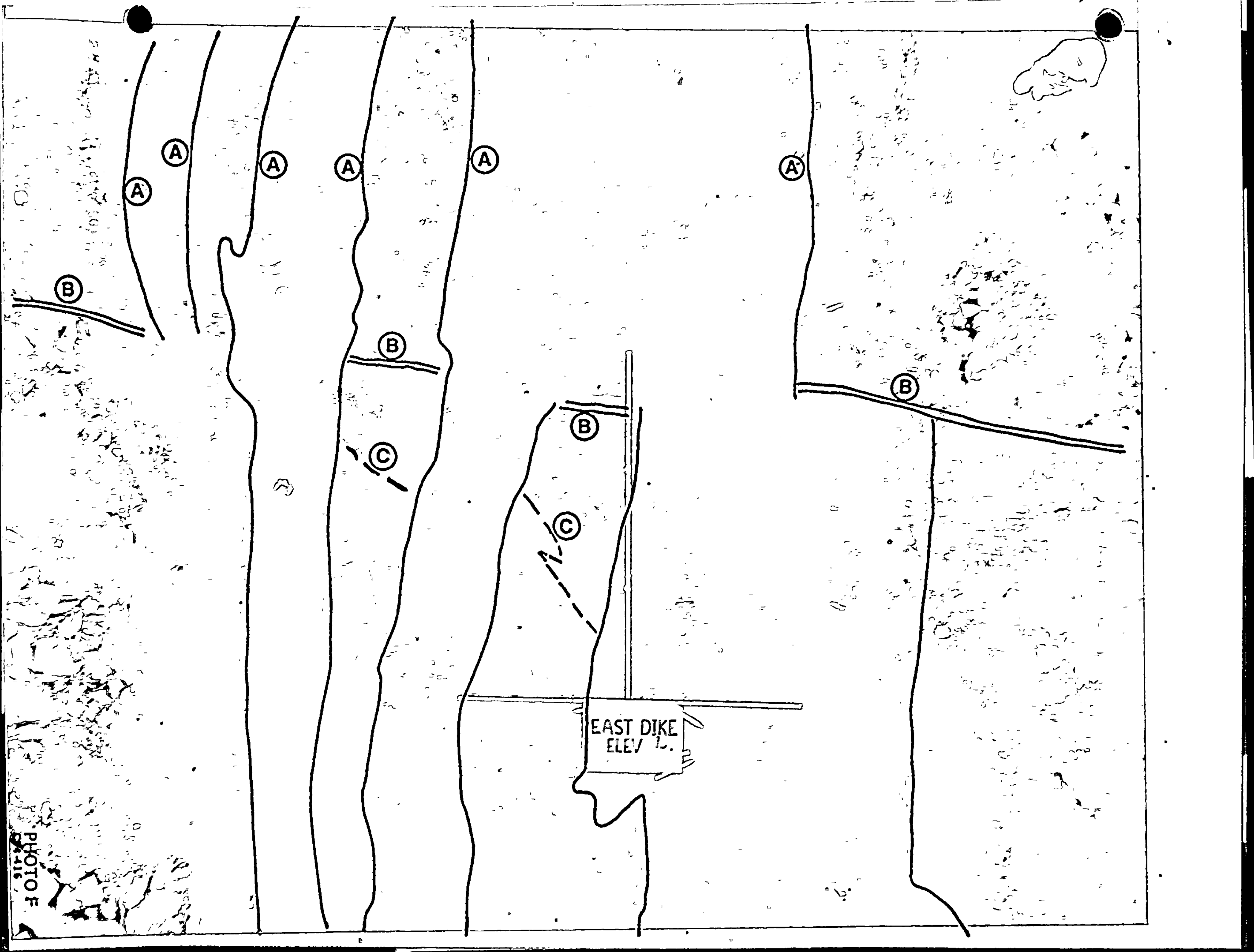



PHOTO E
C54-459

C54-416
Photo F Caption

View north at the intersection of the fault and East Dike 2 at a depth of 13.1 feet below original elevation 247. Line segment (A) represents the limits of diabase. Line segments (B) represent shearing along the trace of the fault. Line segments (C) show the apparent stratigraphic continuity of sedimentary wedges between the diabase segments. Note the fine degree of preservation of cooling fractures and subsequent spherodial weathering in the diabase. Lack of disturbance of these structures in the weathered diabase indicate the lack of movement along the fault since the initiation of the weathering process. The continuity of sedimentary beds trapped as plates within the diabase, not seen clearly in this photo but demonstrated conclusively in hard rock exposures at greater depth, prove that the diabase segments were not intruded at the same time. Exposures at lower elevations indicate that East Dike 2 is in fact offset by the fault. The maximum sense of left lateral displacement at this elevation is approximately five feet.


A
A
A
A
A
A
B
B
B
B
C
C
EAST DIKE
ELEV

C54-494
Photo G Caption

View north along East Dike 2 during excavation. Photo taken 7.1 feet below beginning elevation 247. This photo, one of a set of three, the others being H and I. In this photo line segments (B) show shearing along the fault plane at the dike. Line segment (A) shows a clay-skin in-filling, primarily montmorillonite, which crosses the fault plane. The two succeeding photos are successively closer photos of the clay-skin crossing the fault plane taken after hand cleaning.

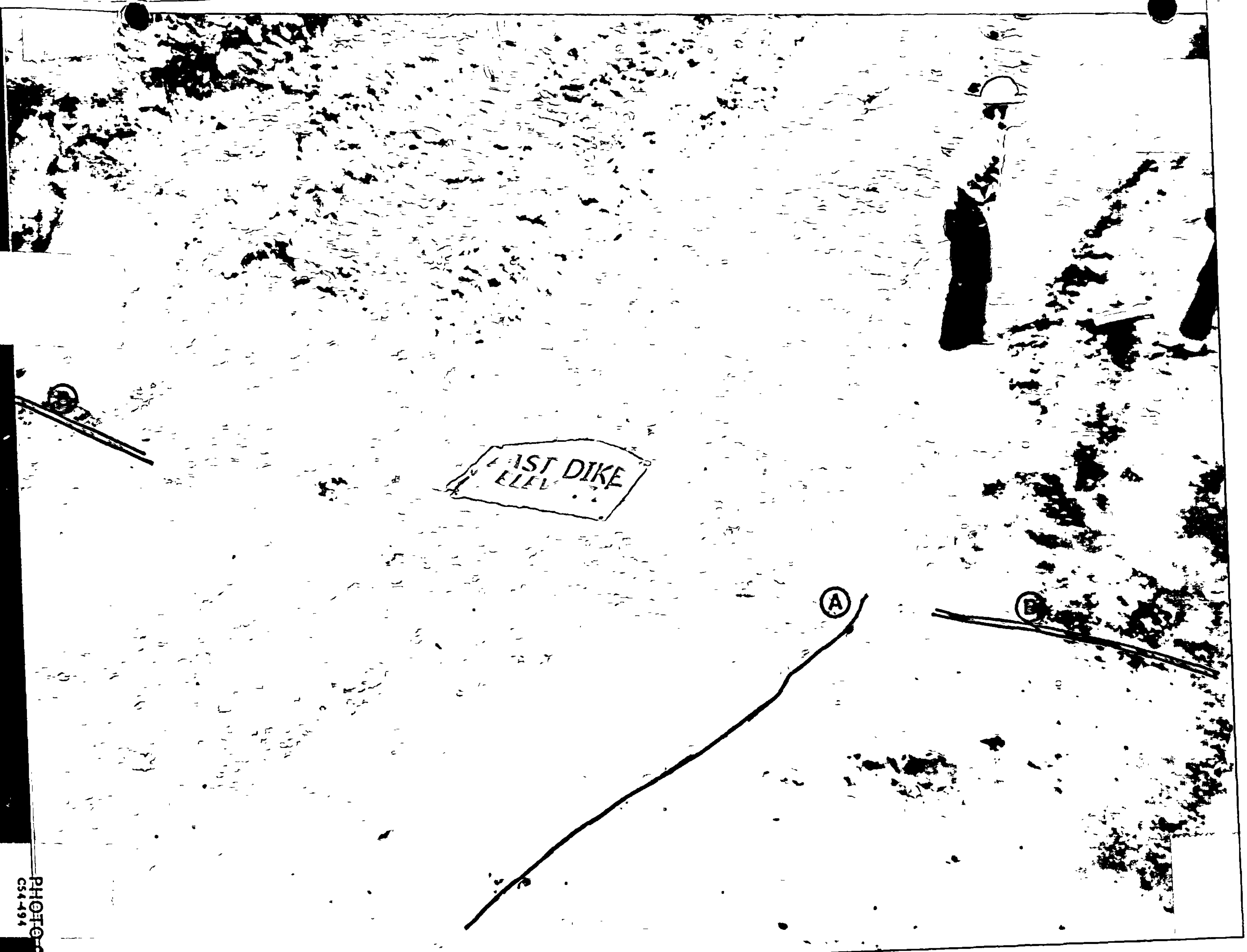



PHOTO C54-494

View west along the fault at intersection with East Dike 2 taken 7.1 feet below beginning excavation level 247. In this view the clay-skin is seen crossing the fault plane undisturbed. Line segments (B) represent the fault plane. Line segment (A) represents the clay-skin. See also the following photograph.


PHOTO H
CJ-495

C54-496
Photo I Caption

View south at the intersection of the fault and East Dike 2 taken 7.1 feet below beginning elevation 247. Close up view of clay-skin, line segment (A), crossing the fault plane undisturbed. The fault is shown by line segments (B).

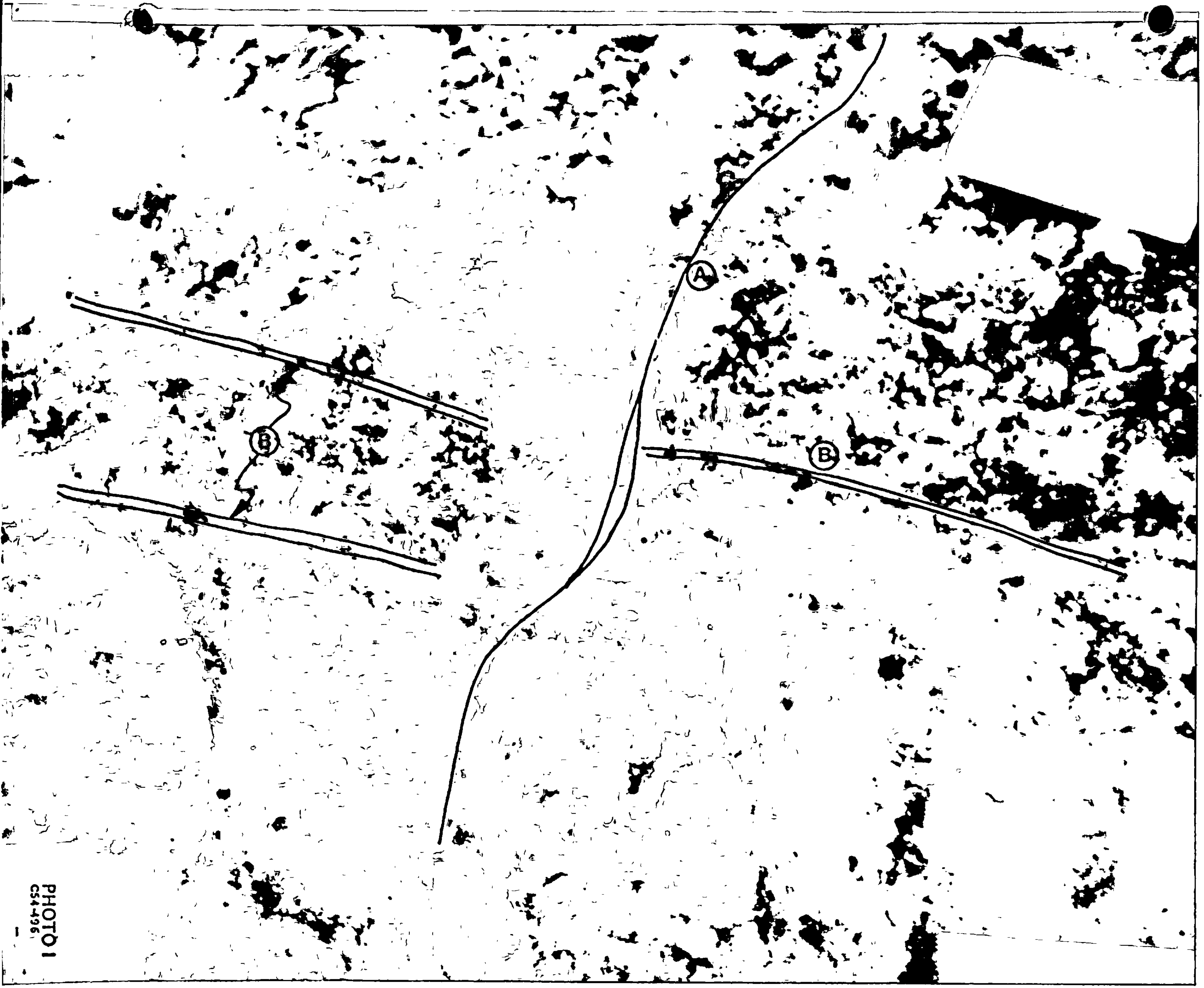
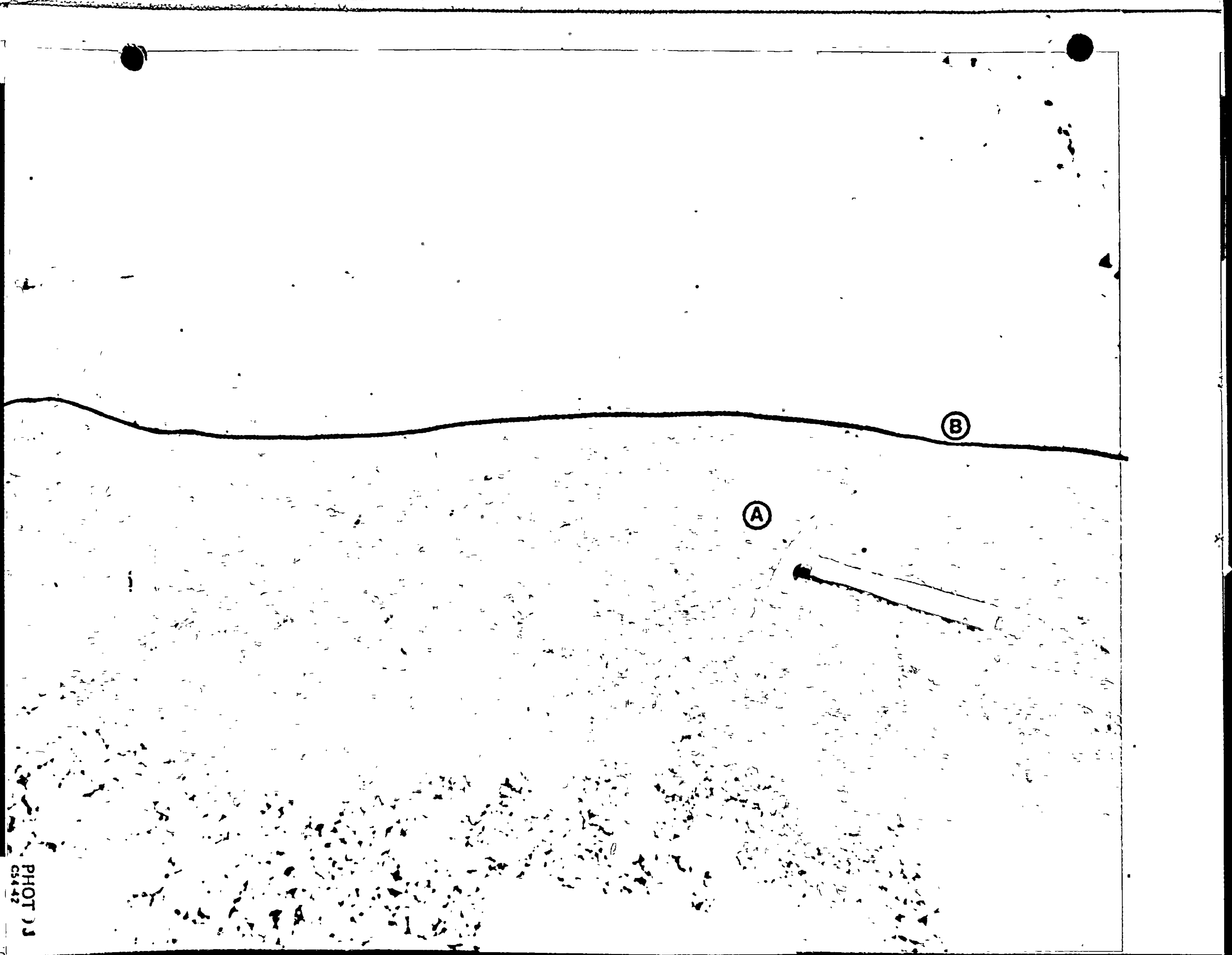


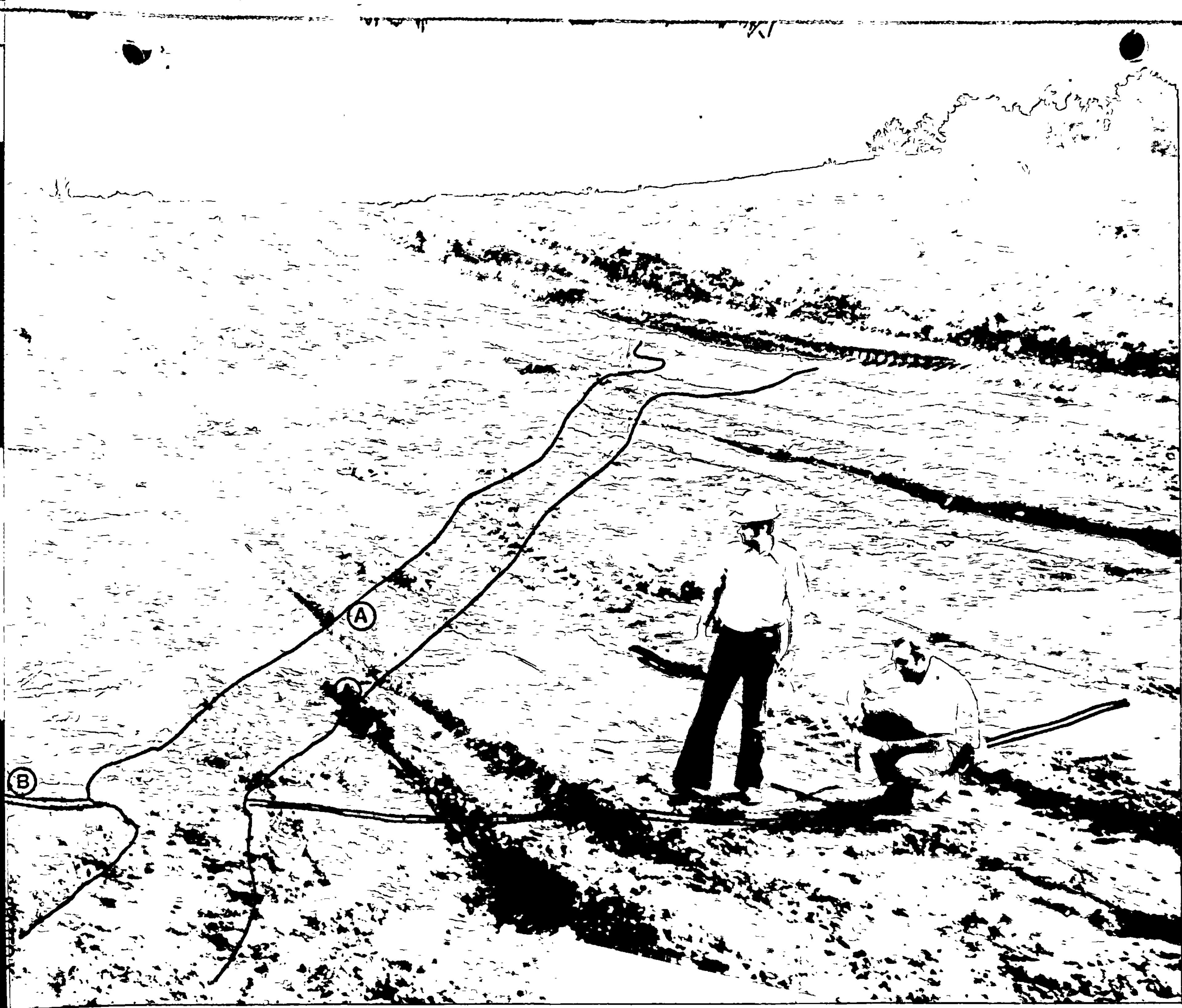

PHOTO I
C54-496

View northward at the intersection of the fault and East Dike 2 taken 13.1 feet below initial elevation 247. Line segment (B) is along the fault. The spheroidally weathered diabase remnant above the head of the hammer illustrates the lack of distortion of weathering structures in the diabase through a weathering profile from original surface to a depth of 35 feet at this location.


A
B

C54-493
Photo K Caption

View south along diabase West Dike 3S taken at elevation 249 at the intersection with the fault. The fault is identified by line segments (B). Line segments (A) represent the boundaries of West Dike 3S. At this elevation there is the suggestion of an apophysis of the diabase into the faulted material in the south limb. Left lateral offset, if any, could be interpreted to be a few inches. The straight alignment of West Dike 3S suggests that the dike is either vertical or exhibits essentially constant dip. There is no evidence of shearing in the diabase in this exposure.


A
B

C54-487
Photo L Caption

View southward along West Dike 3S, at elevation 239. Compare this photo to Photo K. Line segments (A) represent the limits of the diabase dike. Line segments (B) represent the trace of the fault. Line segment (C) represents the limits of the zone of alteration between the two northern segments of West Dike 3S. Compare with Photo Q.

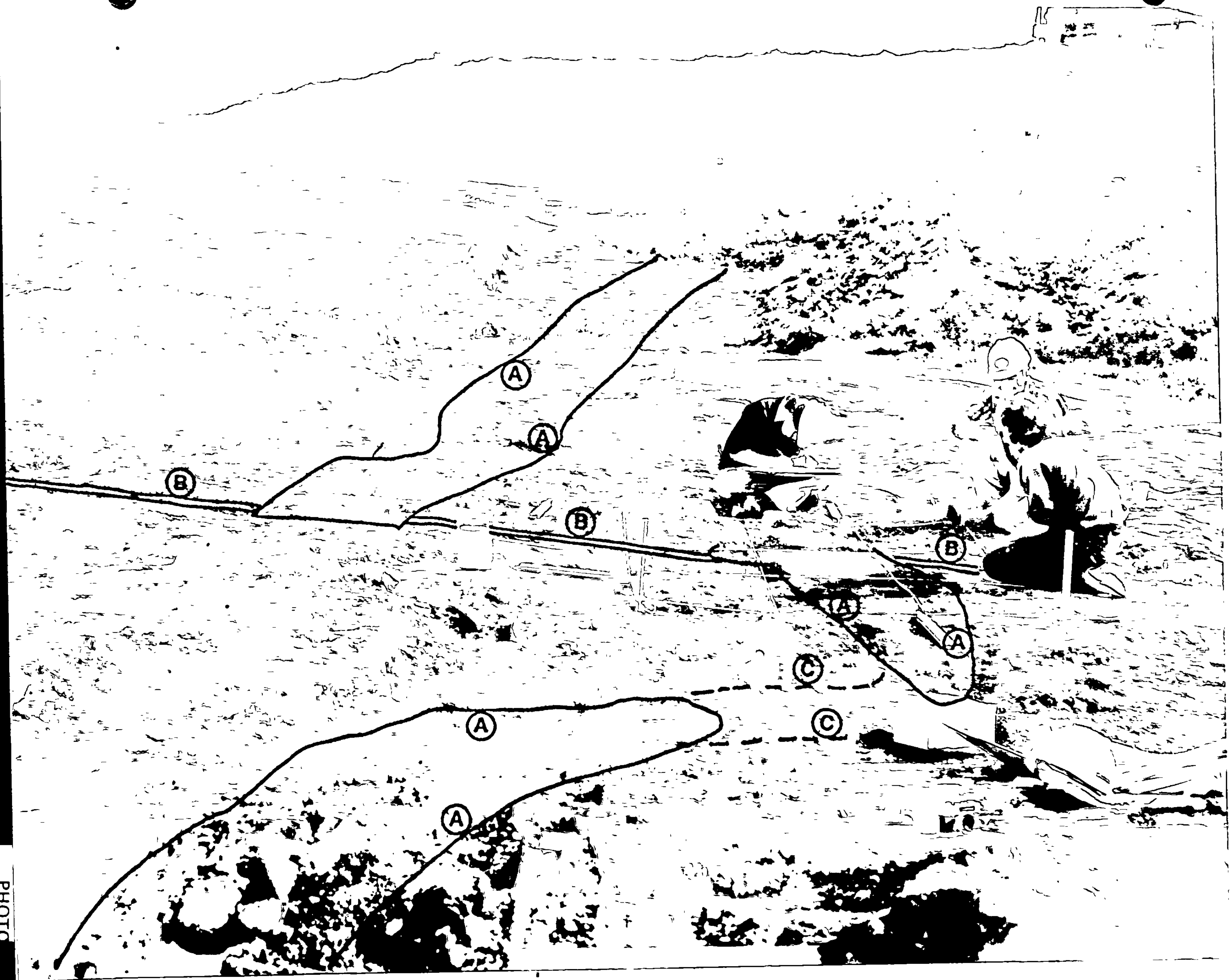



PHOTO C54-487

C54-500
Photo M Caption

View north along West Dike 3S, at reference elevation 239 north or the intersection with the fault. Line segments (A) show the limits of diabase. Line segments (B) indicate the limits of diabase where covered by muck. Line segments (C) represent the limits of the zone of alteration between the two exposed segments of diabase. Line segments (D) enclose zones of highly altered material trending toward diabase composition in this weathered exposure. The straightness of West Dike 3S in this exposure indicates either that the dike is vertical or that it exhibits uniform dip at locations other than the fault zone. Work this photo with vertical Photos N, O and P.

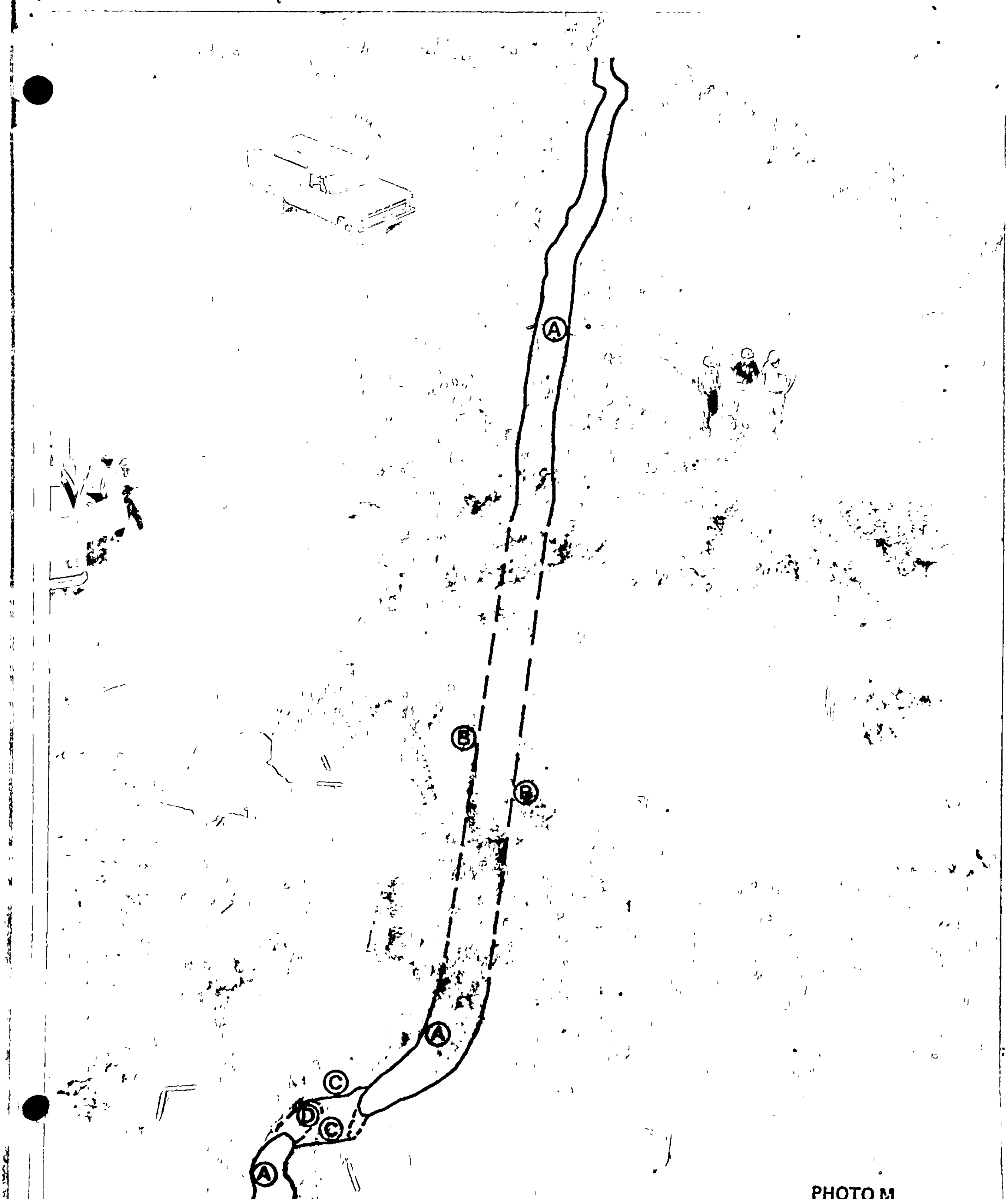



PHOTO M

C54-499A
Photo N Caption

View south along West Dike 3S, at the intersection of the dike with the fault at elevation 239. Line segments (A) represent limits of diabase. Line segments (B) enclose the zone of sheared material, mainly fish-scale clays, in the fault plane. Line segment (C) outlines the zones of darkened, highly altered country rock. Line segments (D) represent a bedding plane in sandstone which crosses West Dike 3S without displacement. Note the apophyses of diabase into the sheared clays of the fault zone in the northerly dike exposure. Note the high degree of alteration on the left or east side of this exposure extending into the sheared clays of the fault. Note the distortion of the diabase of the north limb where it has intruded the broken ground of the fault plane. Compare the lack of distortion on the southern limb of the diabase with the documented observation that all distortion in sedimentary beds observed in numerous other fault outcrops occurs on the south limb as drag folding. See closer views of this exposure on Photos O and P.


A
A
SANDSTONE
SANDSTONE
D
D
D
B
B
B
B
B
B
A
C
C
A
TON
99 A

This represents some enlargement of Photo N. The view is south along West Dike 3S, at the intersection of West Dike 3S with the fault. Line segment (A) represents limits of diabase. Line segments (B) enclose sheared fish-scale clays in the fault. Dashed line segments (C) represent zones of intensive alteration of country rock by the diabase. Line segment (D) represents a bedding plane which crosses West Dike 3S without offset. Note that the dike intrudes the fault plane and that the two limbs of the diabase overlap one another. The fault plane exhibits high angle dip to the south at this point. The apophysis of diabase at the south end of the right or west dike segment are intruded into the sheared clays of the fault. A small football shaped apophysis of diabase is seen in the sheared clay just to the west of the east limb of the dike. See following Photo P for a further enlargement of this intersection and the locations from which zeolite samples were taken.


PHOTO O
CS4-499B

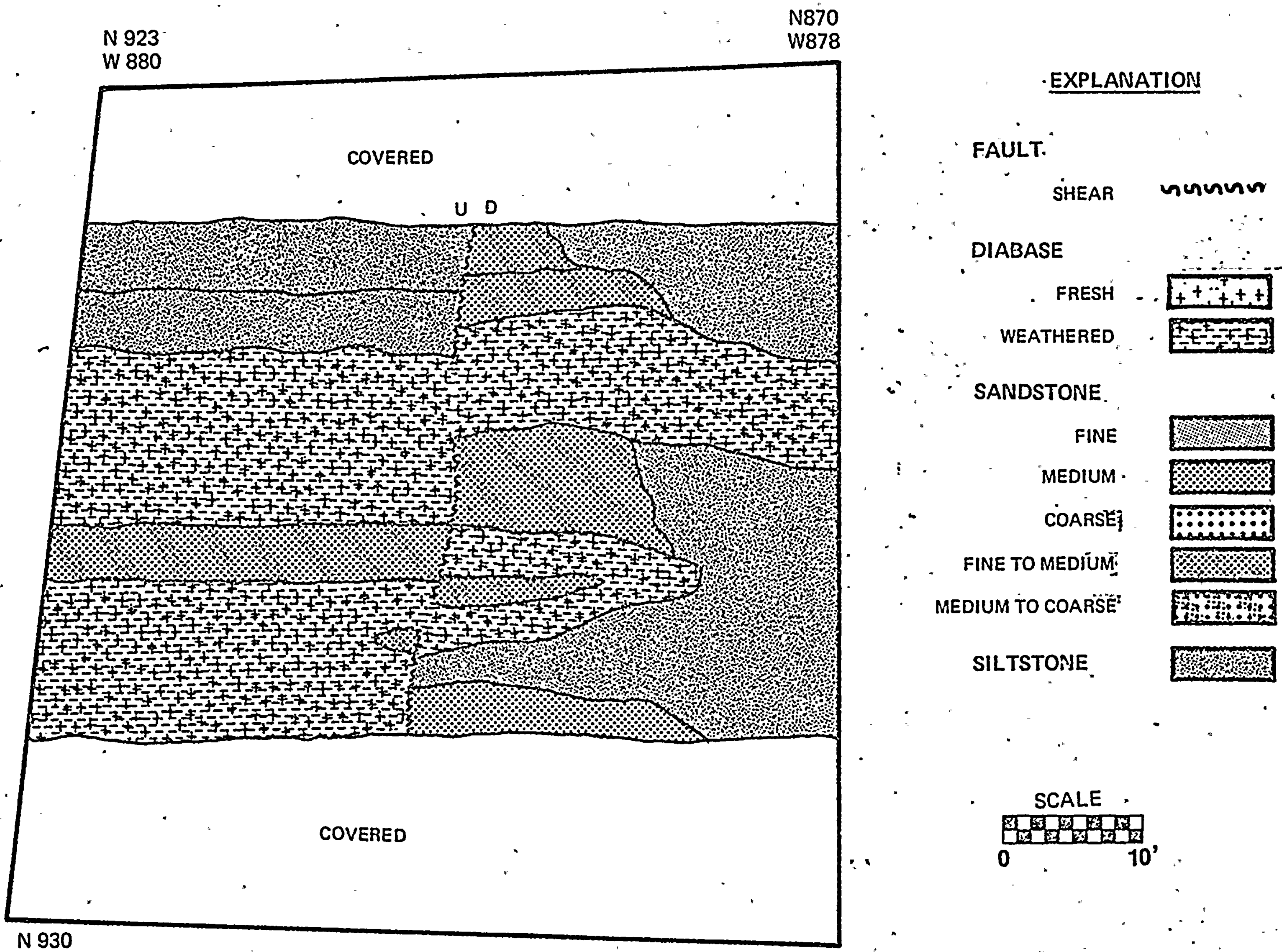
C54-499C
Photo P Caption

View from overhead and northward to the left of the photo as bound. This is an enlargement of a part of Photo N. North is to the left of the photo as bound. Line segments (A) show the limits of diabase. Line segments (B) enclose sheared clay in the fault plane. Dashed line segments (C) show zones of highly altered country rock adjacent to the diabase. Line segment (D) is a bedding plane. Locations designated by (X), 3 in number, are the locations from which samples of zeolite secondary minerals were taken. One of these samples was taken from a small football shaped appothesis of diabase to the west of the east limb of the dike. The other two samples were taken from sheared clay in the fault plane.

D
A
A
B
X
X
X
C
B
B
B
C
A
A
C
PHOTO P
C34-499C

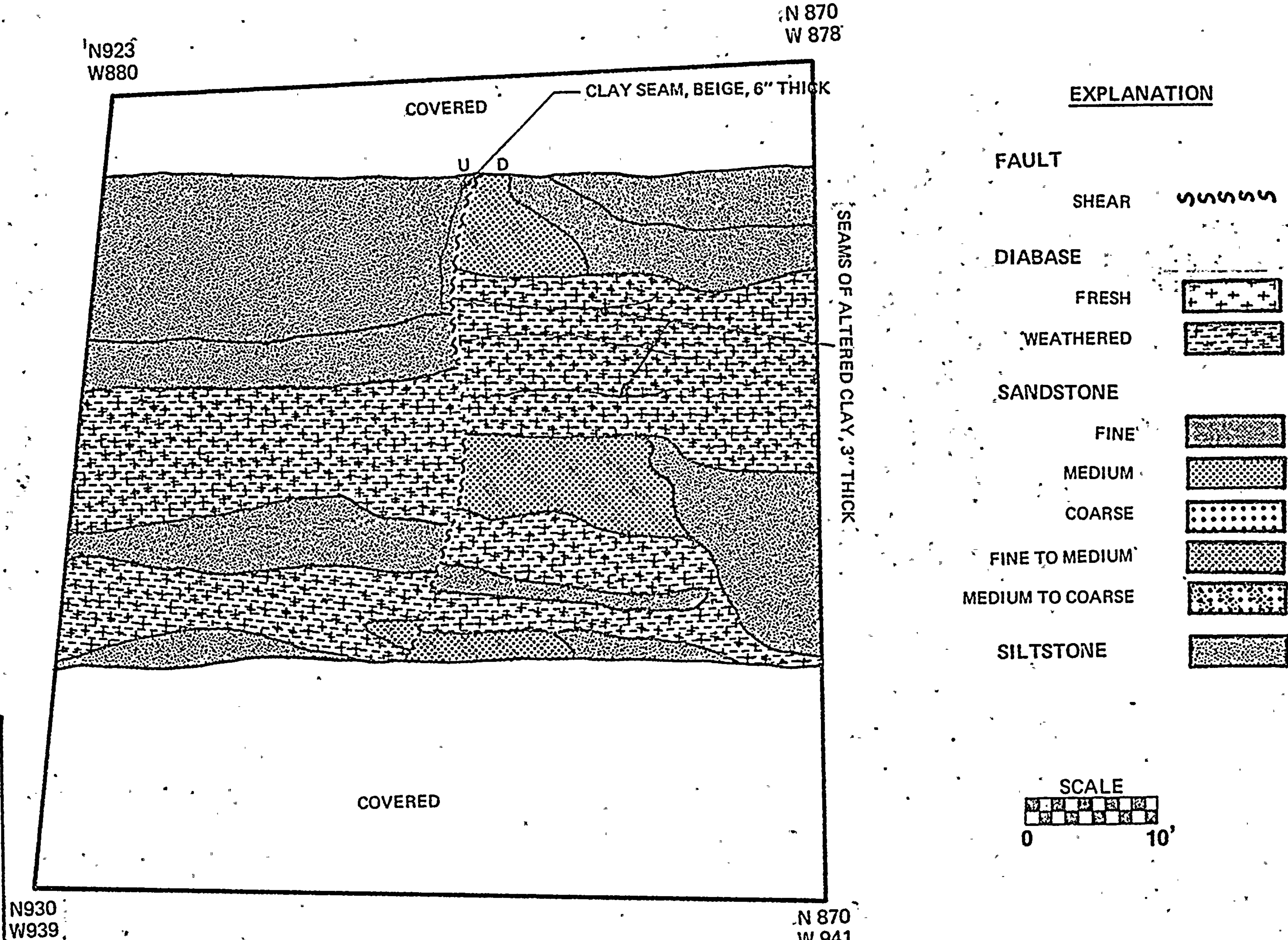
View north at 13.1 feet below beginning elevation 247. This photo is taken of East Dike 2 at a point approximately 90 feet south of the fault crossing. This photo illustrates the precise structural control of the implacement of the diabase dikes. Dike segments (A), if seen alone and in poorer exposure at higher or lower elevations might be construed to be offset by fault displacement. However, there is no evidence of displacement of the surrounding sedimentary beds and no displacement of diabase dike segment (B). The apophysis at the southern tip of northern part of dike segment (A) conclusively demonstrates that the dike was intruded in this configuration and not offset. Dashed line segment (C) represents a zone of intense alteration and halted or frozen progress of diabase emplacement between the two limbs of diabase segment (A). This situation is analagous to the outcrop exposures at West Dike 3S west of the plant excavation.


PHOTO Q
C54436



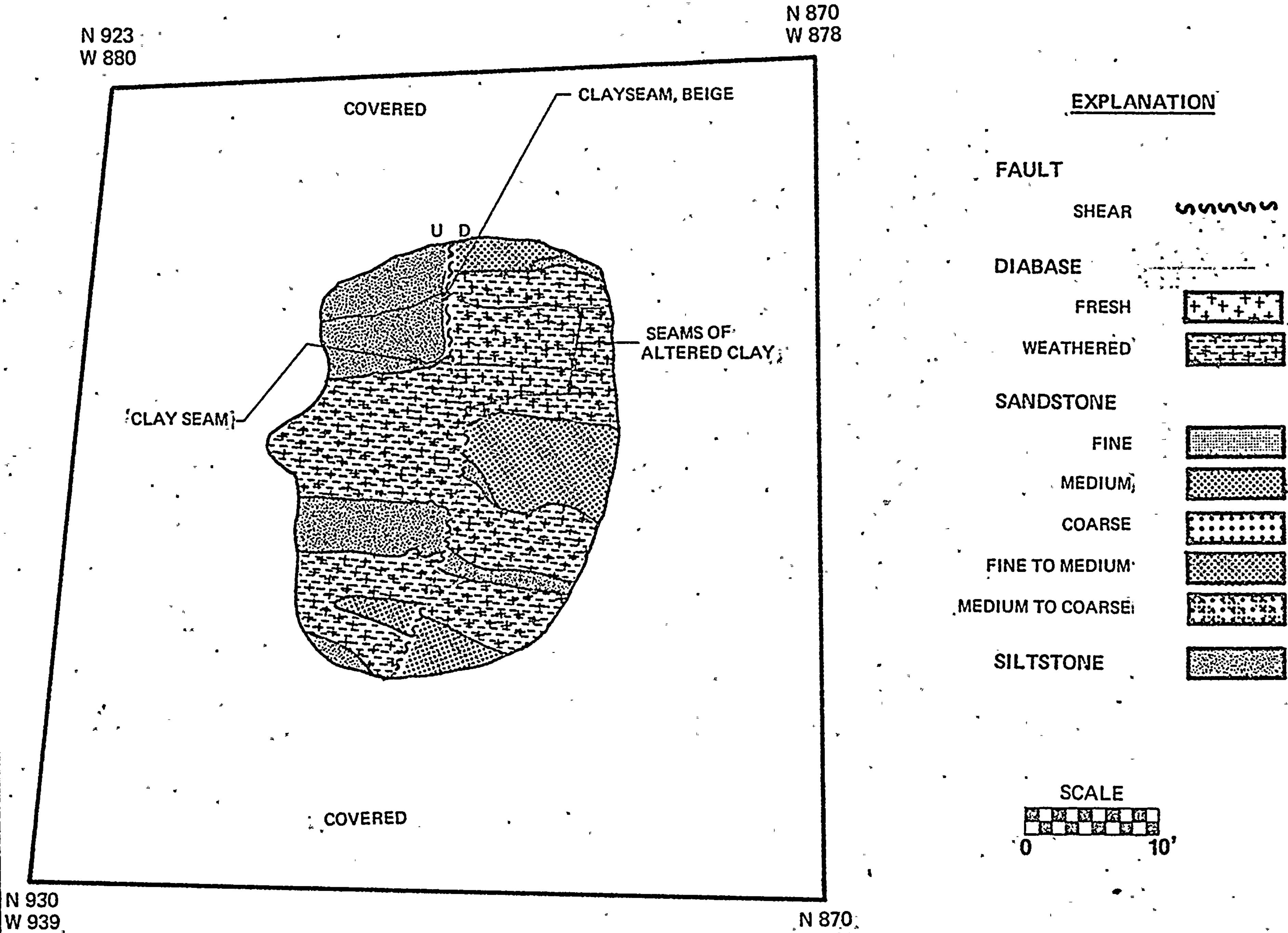

PLAN VIEW AT ELEV. 244.8

FAULT INTERSECTION
WITH EAST DIKE 2
Sheet 1 of 3.
PLATE 4



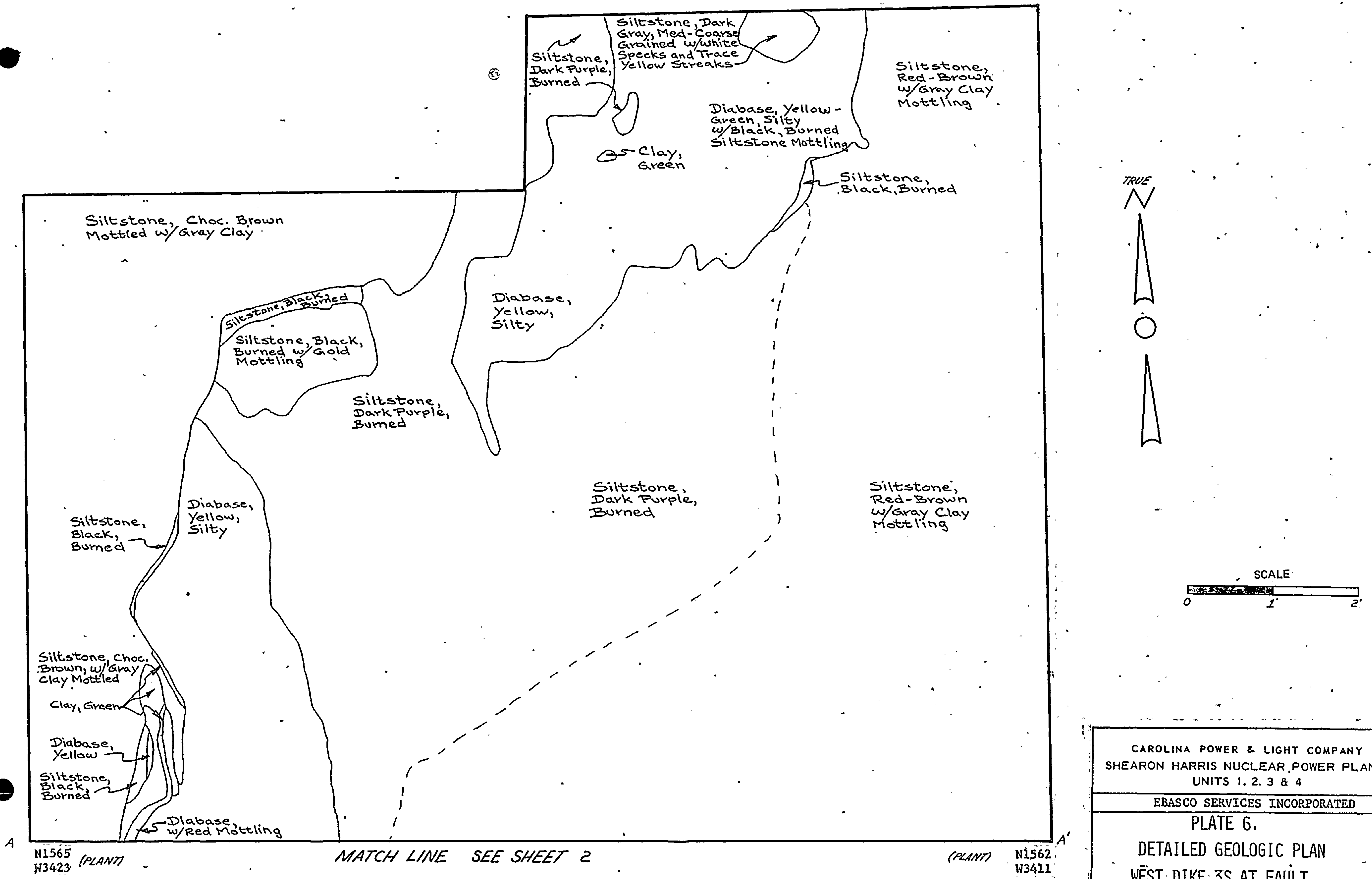

PLAN VIEW AT ELEV. 243.1

FAULT INTERSECTION
WITH EAST DIKE 2
Sheet 2 of 3
PLATE 4




PLAN VIEW AT ELEV. 239.9

FAULT INTERSECTION
WITH EAST DIKE 2
Sheet 3 of 3
PLATE 4




CAROLINA POWER & LIGHT COMPANY
SHEARON HARRIS NUCLEAR POWER PLANT
UNITS 1, 2, 3 & 4

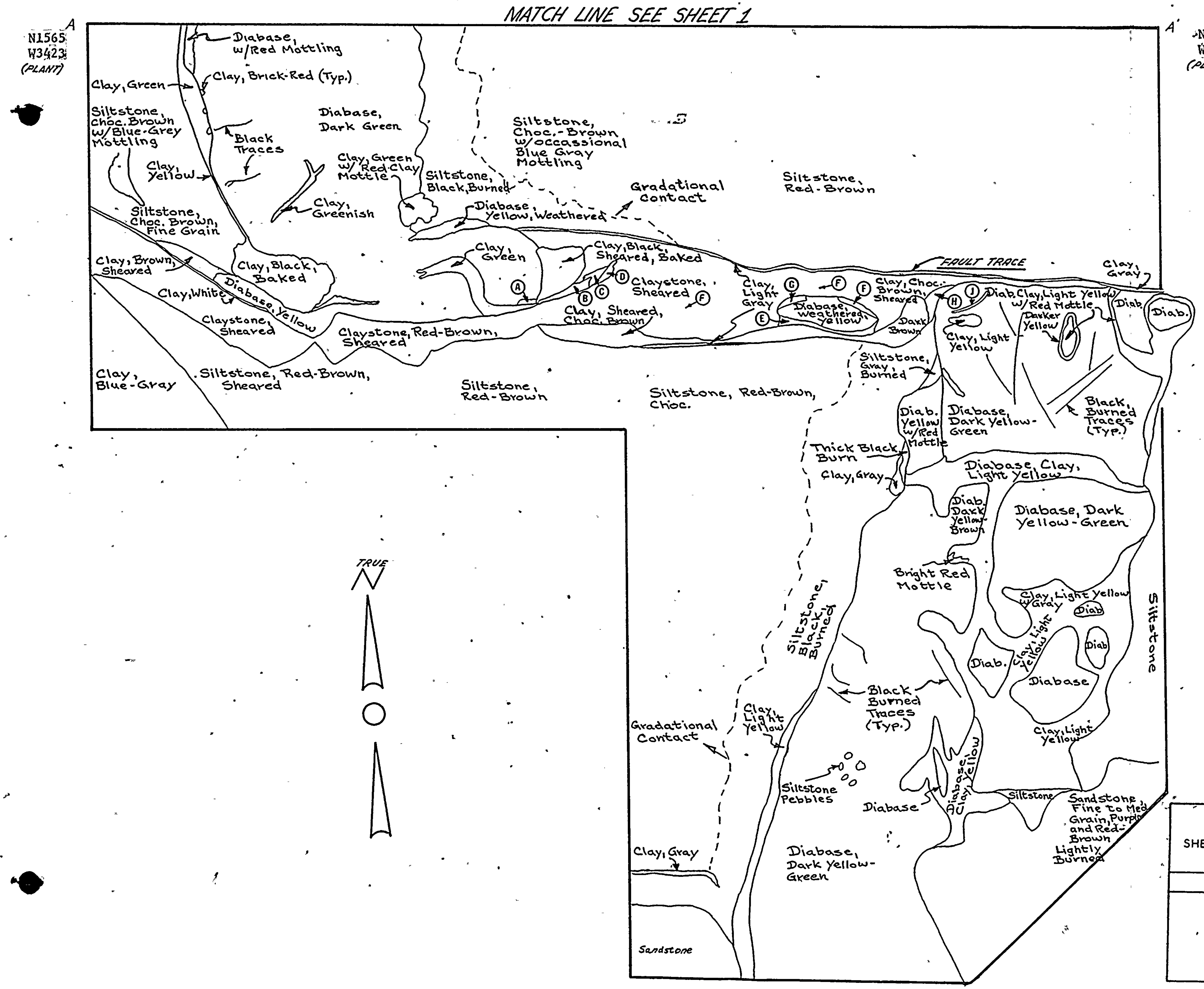
EBASCO SERVICES INCORPORATED

PLATE 6.

DETAILED GEOLOGIC PLAN

WEST DIKE 3S AT FAULT

Sheet 1 of 2




EXPLANATION

Ⓐ Feldspathic Material, Yellow-Pink, Sandy

Ⓑ Diabase, Yellow

Ⓒ Clay, White, Sandy With Red Mottling

Ⓓ Siltstone, Black, Burned

Ⓔ Clay, Yellow-Brown With Red Mottling

Ⓕ Zeolite, Rose

Ⓖ Clay, Gray

Ⓗ Clay, Yellow-Gray

Ⓙ Burned Trace With Rose Zeolite Crystals

NOTE:
All Diabase Highly Weathered

SCALE
0 1' 2'

CAROLINA POWER & LIGHT COMPANY
SHEARON HARRIS NUCLEAR POWER PLANT
UNITS 1, 2, 3 & 4

EBASCO SERVICES INCORPORATED

PLATE 6.
DETAILED GEOLOGIC PLAN
WEST DIKE, 3S AT FAULT

Sheet 2 of 2