GL02052

GEOLOGIC REPORT

KELSH PLOTTER PHOTOMAPPING

LEACH HOT SPRINGS PROJECT

HUMBOLDT AND PERSHING COUNTIES, NEVADA

AMINOIL, USA INC.

SANTA ROSA, CALIFORNIA

By

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OCTOBER, 1978

Prepared for:
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INTRODUCTION

This Kelsh plotter photointerpretation study was initiated to test the theory that latest fault movement, along old geologic features, will reflect in surface rocks as low, topographic scarps. Since a majority of the interpretation took place in unconsolidated valley fill deposits, it was deemed necessary to do the photo work on a stereoscopic instrument that is capable of reading small changes in topographic expression. The Kelsh plotter can read topographic changes as subtle as 2-4' and is capable of greatly enlarging the original photographic scale and plotting all the photogeologic information on direct overlays to U.S.G.S. topographic maps.

The Kelsh photointerpretation was done in two stages. The groundwork for this more detailed photoanalysis was a Landsat, space photo, evaluation which determined the regional, geologic setting of the Leach Hot Springs Project. Once this initial work was completed, the Kelsh interpretation of stage one, a study at the final scale of 1" = 2000', was undertaken. This work was done from 1:80,000 scale photography from U-2 aircraft flown by NASA. The interpretation was finalized on August 14, 1978 and a five-day field check was completed on August 18, 1978. The second stage was then initiated and was interpreted on lower altitude photography and plotted at a scale of 1" = 1000'. This photointerpretation was finished on September 16, 1978 and field checked September 17-22, 1978.

The quality of photographs, used in all phases of the project study, is considered excellent and weather conditions during both field checking trips were ideal.

SUMMARY

This geologic report will demonstrate that the combination of photo work and field checking accurately delineated numerous surface faults in both areas of bedrock and valley fill material. Since a major fault can be traced through the Leach Hot Springs vents, it is concluded that other surface faults, of similar magnitude, could be aquifers for other Hot Springs or be indicating areas of subsurface magmatic activity which has not yet reached the present ground surface. Areas of fault movement could be checked in detail with gravity interpretation to determine basement configuration.

The Landsat photointerpretation revealed many regional, linear features that may be indicating areas of possible, near surface magmatic activity that could be explored at a later date. The two-stage Kelsh plotter maps are pin-pointing many small areas of suspected thermal activity which can be investigated by gravity methods and core hole drilling immediately.

LOCATION

The general location of the Leach Hot Springs Project is 26 miles south of Winnemucca, Nevada. This locates the actual area of the

Leach Hot Springs vents. The interpretation expands, from this central point, 22 miles north-south and 13 miles east-west. The Landsat photointerpretation covers a much larger area than either Kelsh plotter maps. There are a total of 144 townships or 5184 square miles within the boundary of this map. The townships by number are T26N - T37N and R33E - R44E and approximate degree ticks are 40° 00' to 41° 00' of longitude and 117° 00' to 118° 15' of latitude. The Sonoma mountain range bounds the project to the east and the East range forms the west limit. The project area may be traversed north-south by the Grass Valley road which originates at Winnemucca.

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The Kelsh plotter projects a stereoscopic model on a complete flat working surface, enlarged five times the original scale and free of all airborne inaccuracies. Each photo, of the stereo pair, is placed in its exact position in the sky as the picture was snapped. If the wing tip was down 2° from the horizontal, this is restored by a system of tip-tilt adjustments. Once all distortion is removed, and the image is enlarged five times, very accurate measurements may be made with a dot that "floats" in the stereo model. All interpretation is then placed directly on overlays to existing United States Geological Survey topographic maps. All readings made with the floating dot are accurate to 8-10' on photos at a scale of 1:60,000. Horizontal placements, on the base map, are recorded with a pantograph

arm which is adjustable to all topographic map scales.

PHOTOGEOLOGIC INTERPRETATION MAPS

LANDSAT (MAP A)

This interpretation was worked from Landsat 1 and 2 mission photographs on the 29.2" on a side size format, band 6 and 250,000 scale image. All prints were cloud free, of excellent quality, and were flown at a time frame where no snow was covering the surface. Each individual photograph was interpreted by placing red marks for linears and faults, green for bedding contacts and blue for geomorphic and tonal anomalies. The base map was constructed from township lines that appeared on the McDermitt, VYA, Winnemucca and Lovelock 1:250,000 scale U.S.G.S. topographic maps. All interpretive symbols were then transferred to these maps, then to an overlay at the same scale. A total of four photos were used in the interpretation and they are considered to be of superior quality with sharp, gray tone differences that are needed for accurate photoanalysis. There are 9 separate interpretive symbols used on this map and they are described as follows:

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movement. They may be zones of faulting.

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Fault: A dashed line on the map which traces a plane of faulting. The scale of the photography is too small to allow the interpreter to determine the direction of throw movement. Some of these breaks are thrusts and tend to have an arcuate pattern. The normal faults surface as straight lines.

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the unconsolidated, valley fill material.

Playa: These are extremely flat lying old lake beds that photograph a brilliant white. There is no stream development within these areas and some contain small areas of open water.

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Quaternary Valley Fill (Qvf): This is an area of relatively flat lying sediments where stream development is sparce or downcutting is in its beginning stages.

Bedrock (B): These are broad areas of mid-tone grays on the photographs where stream development is intense.

The results of this interpretation are twofold:

1) It placed the Leach Hot Springs Project area into a broad, regional geologic setting where comparisons could be made with known areas of geothermal acitivity and areas of suspected geothermal acitivity.

2) There were numerous areas delineated where additional detail work could be conducted. Cross-faulting or cross-linears are two examples of areas to pursue further and tonal anomalies point

out areas that could be investigated by detail photo work with back-up field checking.

KELSH PLOTTER - REGIONAL (MAP B)

This mapping was accomplished by use of NASA, U-2 aircraft, photography flown at a 40,000' elevation with a resulting 1:80,000 scale print. The Kelsh plotter enlarged this photo scale to a 1:16,000 plotting scale. Each stereo image covered 50 square miles; thus regional mapping could be accomplished on one single model. Faults could be traced sometimes for 3-5 miles with ease. This type of photointerpretation could not be done on low altitude prints where each stereo model covers only 1-1.5 square miles.

The Kelsh work was done at a final scale of 1" = 2000' and completed on August 18th. The field checking on this map confirmed the faulting found on the Kelsh plotting phase. Many areas of suspected faults were confirmed by walking them out in the field and taking color photos of fault scarps, outcrops and springs. Where good outcrops were encountered, a reading of strike and dip magnitude was recorded. This information was used to locate areas of domal uplift and to determine outcrop attitudes on fault planes. Over the majority of this project, the dips read on outcrops are considered to be of excellent quality. Where vp or very poor symbols are used, the quality is only fair due to poor lateral exposures of outcrop.

The final base map scale for this interpretation is 1" = 2000' and

matches the published 1:24,000 scale topographic maps. A pantograph arm reduced the stereo model scale to this 1" = 2000' scale and plotted all interpretive symbols directly on an overlay to these topo maps. Not all of the symbols used in the detailed 1" = 1000' interpretation were placed on this map due to the scale. For the most comprehensive interpretation the detail Kelsh map, with field check results, should be consulted.

KELSH PLOTTER - DETAIL (MAP C)

To construct this map low altitude photos were utilized. They allow the photointerpreter a closer look at the surface outcrops and subtle changes in topography. The projected photo scale of 1" = 1000' was used in this mapping and the pantograph reduction was not used. This allowed the plotting of a great number of dips, faults, and other features that would not be possible at a condensed photo scale.

The photointerpretation on this map took place in August and September with field checking occurring from September 17 - 22, 1978. The field work added a great deal of detailed information to the final map. There were numerous faults that were extended through field observations by subtle vegetative and topographic changes. Stratigraphic boundaries were closely delineated by color changes and topographic expression of different rock types. The final map scale is 1" = 1000'. The base map was a blowup of the 1" = 2000' U.S.G.S. topographic maps that cover the project. This was placed on the Kelsh plotting surface and the photo scale adjusted to fit the final

map scale. On completion of the field checking, all the information obtained was viewed a second time on the stereo image and accurately plotted on the original base. The color photographs were positioned exactly where they were taken on the ground and the arc of coverage was established.

The following is an explanation of interpretive symbols used on the map:

A. Dips and strikes:

1. N60°E indicates the Brunton compass reading taken on out-cropping exposures.
2. ? indicates good bedding was available for reading a strike and dip however, the lateral extent of the bed was not sufficient to obtain an accurate reading of dip magnitude.
3. vp indicates very poor bedding. Here the surface expression of outcrop may be partially obscured by valley fill material or colluvium. In determining structure, these dips are of low priority.
4. ds these dips were read on a dip slope and assume that the dip slope surface is held up by covered bedding planes.

B. Faults:

1. Dashed lines indicate the trace of a normal fault as it breaks to the surface. If the break has a U on one side this indicates the upthrown block. A reading in feet appears on some faults and it shows the number of feet of topographic throw as

read directly on the stereo image or in the field.

2. Thrust faults are depicted as dashed lines with saw-teeth on the upper plate.

C. Other symbols:

1. Lineations. They depict one of three things:

   a. faults

   b. strike of steeping dipping beds

   c. covered intrusive igneous dikes.

2. Bedding contacts. These are solid lines where a sharp change occurs and dashed where covered by unconsolidated sediments.

3. KB indicates a key bed which can be traced for a short distance and then disappears. They were utilized in reading dips and strikes and also in determining faults. Many times the key bed truncates at a fault plane.

GEOGRAPHY

The project lies in a typical Basin and Range type geographic setting. Flat valley floors are abruptly punctuated with sharp, blocky mountain ranges. The valleys are extremely flat near the center where flood plains develop during times of heavy runoff. From these flat areas, the elevation gradually rises, along colluvial dip slopes and fans to the intersection with the deeply eroded mountain front. There is a gentle loss of elevation from the Mud Springs area, where 4880'

readings are the norm, to the north where the general elevation at the north edge of the map is 4500'. The highest topographic elevation on the map is 6940' in the extreme northwest corner of section 9 of T32N - R39E in the Sonoma Range. The Leach Hot Springs vents issue at an elevation of 4660'.

Drainage is generally northward in Grass Valley to the Humboldt River system flowing to the north of the project. Rainfall is sparse and a cloudburst would be necessary for any water to flow in Grass Valley. The valley fill material is coarse and allows little runoff. Mudslides, or colluvial fans, occur near the mountain fronts where streams drop their sediments on reaching the gentle slope change of the valley floor. There were numerous spring-fed streams observed during field checking which flow a good volume of water at the mountain front but never reach the Grass Valley drainage system.

The accessibility within the broad valley floors is excellent. There was a dense system of old seismic roads available for travel. A good number of ranch roads occur in the valleys and in canyons cut in the bounding mountain ranges.

There is sparse vegetative cover on the map. Small clumps of cottonwoods are found in areas where springs feed the creeks and sagebrush growth occurs sporadically along stream channels. A thin cover of grass is sufficient to support a cattle grazing business.

Only two ranches are located within the bounds of this project. They are named Leach Hot Springs Ranch and Mud Springs Ranch and both are located adjacent to flowing springs. The nearest town is Winnemucca which is 26 miles north of Leach Hot Springs.

One open pit mine was located in the field. It is still producing malachite ore through a leaching of old tailings. There are numerous claim stakes throughout the more rugged, mountainous terrain, but little development has taken place. To the present, nothing has been done to harness the potential of the Leach Hot Springs. The water is used for irrigation and livestock.

GEOMORPHOLOGY

An analysis of stream patterns on Landsat photos indicates broad, northerly deflected drainage emptying into the north flowing Grass Valley system. Some of these deflected streams follow in linears, and thus may be along zones of weakness such as fault or fracture planes. In the Kelsh mapping, gentle deflections of drainage were important clues as to the presence of faulting. Slight topographic scarps found in valley fill material were often times the trace of faults as they break the surface and offset recent deposits.

This portion of Nevada shows a prominent north-south alignment. All of the major drainage parallels this trend.

There are numerous subtle topographic scarps located in the valley

fill material. They generally are indicative of faulting with the latest movement recorded in these recent sediments. Some of these scarps are as small as 2-4' vertically and by tracing them in detail on the stereo image it was found that faulting is just as intense where bedrock is covered as where it is well exposed.

The Landsat interpretation works well to locate tonal anomalies. Usually they photograph as a mid-tone gray and are circular in shape. They are often topographic highs with radial drainage patterns. The color change from surrounding outcrops indicates a change in rock type or may be showing a zone of alteration.

By using the geomorphic expression of outcrops, it was relatively easy to determine the age of geologic formations. There are conglomerate beds in the section that hold up prominent ridges while weathered andesite beds occupy low topographic positions.

The low valleys are receiving sediments to the present geologic time. Sculpture of the mountain ranges is recorded in remnants of old erosion surfaces at varying altitudes. One of these is at a present day altitude of 8000' in the Sonoma Range, just off this project, where a subdued topography is present with gentle slopes. Below this, at an altitude of 6000 - 7000', is another stage shown in the Sonoma Range and is represented as gravel terraces. A third erosional remnant is found at a 5000' level. It is a pediment and gravel bench underlain by down-faulted rhyolite.

STRATIGRAPHY

There are rocks ranging in age from Quaternary alluvium, colluvium and fans to undifferentiated Cambrian within the map's boundary. The Landsat mapping determined that bedrock-valley fill deposits cover equal amounts of total map area. The contact between bedrock-valley fill is sharp and, when viewed from the extreme height that space photos are flown, the mountain ranges seem to be "choking" in their own debris.

The lithologic character of outcropping formations within this mapping project vary greatly but may be summarized as late Jurassic plutonic rocks intruding a great thickness of sedimentary and volcanic rocks of Triassic and Paleozoic age that are strongly metamorphosed and deformed through intense faulting. Cambrian rocks are represented by quartzites and are ridge formers as is the Valmy formation of Ordovician age. The Carboniferous and Permian is well represented with widespread sequences of deposits. In the Sonoma Range, on the east side of the regional Kelsh map, great masses of metavolcanic and sedimentary rocks are present. Here the Havallah (Permian?) and Pumpernickel (Pennsylvanian?) formations outcrop above and below the Tobin thrust. There are extensive outcrops of Koipato formation which is dominantly volcanic in origin. Along the west flanking fault of the Sonoma Range, this formation is the first to surface. On the weathered outcrop its dominant color is red. There are several white

to light gray andesitic volcanic beds present. This same reddish material outcrops about 100 yards northeast of the Leach Hot Springs fault and would suggest that major, recent movement has taken place on the feature. The Triassic rocks of this area are mostly marine in origin and consist of equal amounts of clastics and carbonates. The Triassic seas invaded from the east and the oldest formation laid down consists of the Prida which at its base is a conglomerate, followed by 50-100' of clastic sediments with interbedded brown dolomite. In the middle is a 100 - 200 zone of dark, bituminous and calcareous shale with thin-bedded limestone. The Cane Spring and Augusta Mountain formations outcrop only locally on this project. The Augusta Mountain is a thick carbonate unit of Middle Triassic age. It is overlain by the Upper Triassic Cane Spring formation which is a carbonate unit. There are Jurassic granitic intrusives present in the Sonoma Range centered in section 6 T32N - R39E. This mass is composed of granite, quartz monzonite, and granodiorite. The dominant Tertiary rocks of the mapping project are composed of rhyolitic lavas and associated tuffs. There is a layer of basalt which caps Table Mountain to the south which delineates the north end of extensive lava flows spreading from the south. This basalt is likely much younger than the rhyolites found elsewhere on the interpretation. Near Leach Hot Springs there are some slightly consolidated sediments, some with distinctive reddish coloration, cropping out. Along the Leach Hot Springs fault there are extensive, hard, siliceous sinter deposits. These deposits may be responsible for the topographic

scarp which forms along the fault zone.

The recent sediments, of Quaternary age, are divided into two groups. Stream-deposited alluvium covers about 20% of the total valley fill material. Topographically, these sediments lie on very flat flood plains near the central Grass Valley drainage system. The area from the mountain fronts to the boundary with the alluvium is occupied by colluvial dip slope deposits. They are gently sloping, display some stream downcutting, and are of unconsolidated wash derived from the high mountain ranges. It is in this large area of outcrop that many faults could be traced. The latest fault movement is recorded as slight topographic scarps within this loose material.

REGIONAL GEOLOGY

The entire project lies within the Basin and Range geologic province. It is characterized by very arid climate with little rainfall and no streams that reach the sea. There is a distinctive north-south alignment to the mountain ranges and the intervening valleys. The high mountain ranges are horst blocks that have been uplifted and are contributing sediments to the low, valley areas. These valleys are filled with wash material of undetermined thickness. The ranges are not simply horst blocks of unaltered rocks, but rather broad masses of highly complex sediments that have been subjected to intense normal and thrust faulting along with magmatic intrusion.

This faulting continues to the present as evidenced by the measurable displacement found on faults cutting the colluvial deposits. In 1903 a fault movement was recorded on the west flank of the Tobin Range in section 34 T30N - R39E. Here slippage of 75-100' occurred and is readily identified on the aerial photographs.

STRUCTURE

Folding and faulting, on this mapping, took place during several geologic periods, beginning in the Paleozoic and extending to the present. Granitic intrusions followed the initial structural warping and may be the cause of a broad dome formed on the south portion of the detailed Kelsh map. These intrusions may be satellitic to the larger, Sierra Nevada batholith. The Tobin thrust can be observed in several areas on the regional Kelsh map. This fault is the major structure of the last orogeny to occur in this portion of Nevada. The major period of normal faulting was during the Tertiary and Quaternary. It is this deformation that was largely responsible for blocking out the present day mountain ranges.

This interpretation has swarms of lineations coming to the surface. They probably represent fault zones, however, they generally follow drainage systems that are low topographically with no outcrops present on which to measure stratigraphic throw.

There are two areas of probable structural doming present on the regional Kelsh plotter interpretation. One occurs in sections 32

and 33 T32N - R39E and sections 3 and 4 T31N- R39E. The dip magnitudes reversing this structure are in the 20° range and are taken on beds of short lateral extent. The second dome seems to be centered in sections 26, 27, 34 and 35 of T31N - R39E. Both domes are accompanied by intense normal faulting.

Along the west flank of the Sonoma Range, there is a north-south trending fault. On the east side of this fault, dip is approximately 5° to the east. The same dip relationship occurs to the southeast of the Leach Hot Springs fault.

FAULTING

A detailed analysis of fault trends on all three maps, A, B, and C, indicates a dominant northeast-southwest trend with an intervening set at N45°W. To the northeast set belongs the main fault which cuts the Leach Hot Springs vents. One exception to the dominant faulting is the normal faults which bound the Sonoma and Tobin ranges. They trend north-south and display recent movement in young sediments of Quaternary age.

Portions of the Tobin thrust appear on the regional Kelsh plotter map. Movement on this fault is probably to the north. Where the fault plane breaks the surface in sections 8, 9, 16 and 21 of T31N - R39E the Permo-Pennsylvanian Pumpernickel formation is thrust over the Triassic (?) Koipato formation. Through the west half of

T31N - R38E the Cambrian, probably a part of the Tobin, is thrust over on the Permo-Pennsylvanian Havallah formation.

The throw on normal faults, found in this mapping project, was measured by use of the floating dot in the stereo image and also checked in the field. The magnitude of throw varies from 10-80'. This does not constitute the total amount of vertical movement. The footage readings are only the elevation differences on either side of a topographic scarp and represent only the latest slippage.

The last movement on the Tobin thrust probably took place in the Jurassic period. Truncation of the Leach Hot Springs fault, B on the Kelsh regional map, against the north-south trending west boundary fault on the Sonoma Range shows that this break is younger in age than faults with a north to south alignment.

There is a definite correlation of the occurrence of hot and warm springs to fault zones. In all cases these springs surface along the fault planes determined by Kelsh and field work. The Leach Hot Springs have been issuing along a topographic scarp, which marks the trace of the fault plane, in several different places. Old, eroded vents were located approximately 200 yards northeast of the present vents. A hard, siliceous sinter deposit was found along the entire northeast extension of this fault.

Five criteria were used in determining the presence of faulting:

1) Straight drainage patterns

2) Springs

3) Streaks of green vegetation

4) Topographic scarps

5) Deflections in streams

CONCLUSIONS

The project area was investigated through the use of aerial photographs worked on a highly accurate stereoscopic instrument which removes all inaccuracies, induced in flying and plotted in exact planimetric position on a base map directly, by use of a pantograph arm. This photo work is backed up with a field check of both the regional map and the detail interpretation. A complete investigation was made in the field of additional hot springs that may be coming to the surface, and comparisons are made as to fault trends through areas of known hot springs and areas of suspected geothermal activity. A series of 55 color photos were taken during the two field checking stages. They show the quality of outcrops used for dip and strike readings and the subtle nature of fault scarps that were checked on the surface.

The next exploratory step on this project should be detailed gravity and seismic surveys to determine subsurface faulting, and additional core hole drilling with temperature measurements to locate geothermal "highs".

The geothermal prospects, within the boundaries of this mapping project, are considered excellent.

October 18, 1978

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matches the published 1:24,000 scale topographic maps. A pantograph arm reduced the stereo model scale to this 1" = 2000' scale and plotted all interpretive symbols directly on an overlay to these topo maps. Not all of the symbols used in the detailed 1" = 1000' interpretation were placed on this map due to the scale. For the most comprehensive interpretation the detail Kelsh map, with field check results, should be consulted.

KELSH PLOTTER - DETAIL (MAP C)

To construct this map low altitude photos were utilized. They allow the photointerpreter a closer look at the surface outcrops and subtle changes in topography. The projected photo scale of 1" = 1000' was used in this mapping and the pantograph reduction was not used. This allowed the plotting of a great number of dips, faults, and other features that would not be possible at a condensed photo scale.

The photointerpretation on this map took place in August and September with field checking occurring from September 17 - 22, 1978. The field work added a great deal of detailed information to the final map. There were numerous faults that were extended through field observations by subtle vegetative and topographic changes. Stratigraphic boundaries were closely delineated by color changes and topographic expression of different rock types. The final map scale is 1" = 1000'. The base map was a blowup of the 1" = 2000' U.S.G.S. topographic maps that cover the project. This was placed on the Kelsh plotting surface and the photo scale adjusted to fit the final

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By using the geomorphic expression of outcrops, it was relatively easy to determine the age of geologic formations. There are conglomerate beds in the section that hold up prominent ridges while weathered andesite beds occupy low topographic positions.

The low valleys are receiving sediments to the present geologic time. Sculpture of the mountain ranges is recorded in remnants of old erosion surfaces at varying altitudes. One of these is at a present day altitude of 8000' in the Sonoma Range, just off this project, where a subdued topography is present with gentle slopes. Below this, at an altitude of 6000 - 7000', is another stage shown in the Sonoma Range and is represented as gravel terraces. A third erosional remnant is found at a 5000' level. It is a pediment and gravel bench underlain by down-faulted rhyolite.

STRATIGRAPHY

There are rocks ranging in age from Quaternary alluvium, colluvium and fans to undifferentiated Cambrian within the map's boundary. The Landsat mapping determined that bedrock-valley fill deposits cover equal amounts of total map area. The contact between bedrock-valley fill is sharp and, when viewed from the extreme height that space photos are flown, the mountain ranges seem to be "choking" in their own debris.

The lithologic character of outcropping formations within this mapping project vary greatly but may be summarized as late Jurassic plutonic rocks intruding a great thickness of sedimentary and volcanic rocks of Triassic and Paleozoic age that are strongly metamorphosed and deformed through intense faulting. Cambrian rocks are represented by quartzites and are ridge formers as is the Valmy formation of Ordovician age. The Carboniferous and Permian is well represented with widespread sequences of deposits. In the Sonoma Range, on the east side of the regional Kelsh map, great masses of metavolcanic and sedimentary rocks are present. Here the Havallah (Permian?) and Pumpernickel (Pennsylvanian?) formations outcrop above and below the Tobin thrust. There are extensive outcrops of Koipato formation which is dominantly volcanic in origin. Along the west flanking fault of the Sonoma Range, this formation is the first to surface. On the weathered outcrop its dominant color is red. There are several white

to light gray andesitic volcanic beds present. This same reddish material outcrops about 100 yards northeast of the Leach Hot Springs fault and would suggest that major, recent movement has taken place on the feature. The Triassic rocks of this area are mostly marine in origin and consist of equal amounts of clastics and carbonates. The Triassic seas invaded from the east and the oldest formation laid down consists of the Prida which at its base is a conglomerate, followed by 50-100' of clastic sediments with interbedded brown dolomite. In the middle is a 100 - 200 zone of dark, bituminous and calcareous shale with thin-bedded limestone. The Cane Spring and Augusta Mountain formations outcrop only locally on this project. The Augusta Mountain is a thick carbonate unit of Middle Triassic age. It is overlain by the Upper Triassic Cane Spring formation which is a carbonate unit. There are Jurassic granitic intrusives present in the Sonoma Range centered in section 6 T32N - R39E. This mass is composed of granite, quartz monzonite, and granodiorite. The dominant Tertiary rocks of the mapping project are composed of rhyolitic lavas and associated tuffs. There is a layer of basalt which caps Table Mountain to the south which delineates the north end of extensive lava flows spreading from the south. This basalt is likely much younger than the rhyolites found elsewhere on the interpretation. Near Leach Hot Springs there are some slightly consolidated sediments, some with distinctive reddish coloration, cropping out. Along the Leach Hot Springs fault there are extensive, hard, siliceous sinter deposits. These deposits may be responsible for the topographic

scarp which forms along the fault zone.

The recent sediments, of Quaternary age, are divided into two groups. Stream-deposited alluvium covers about 20% of the total valley fill material. Topographically, these sediments lie on very flat flood plains near the central Grass Valley drainage system. The area from the mountain fronts to the boundary with the alluvium is occupied by colluvial dip slope deposits. They are gently sloping, display some stream downcutting, and are of unconsolidated wash derived from the high mountain ranges. It is in this large area of outcrop that many faults could be traced. The latest fault movement is recorded as slight topographic scarps within this loose material.

REGIONAL GEOLOGY

The entire project lies within the Basin and Range geologic province. It is characterized by very arid climate with little rainfall and no streams that reach the sea. There is a distinctive north-south alignment to the mountain ranges and the intervening valleys. The high mountain ranges are horst blocks that have been uplifted and are contributing sediments to the low, valley areas. These valleys are filled with wash material of undetermined thickness. The ranges are not simply horst blocks of unaltered rocks, but rather broad masses of highly complex sediments that have been subjected to intense normal and thrust faulting along with magmatic intrusion.

This faulting continues to the present as evidenced by the measurable displacement found on faults cutting the colluvial deposits. In 1903 a fault movement was recorded on the west flank of the Tobin Range in section 34 T30N - R39E. Here slippage of 75-100' occurred and is readily identified on the aerial photographs.

STRUCTURE

Folding and faulting, on this mapping, took place during several geologic periods, beginning in the Paleozoic and extending to the present. Granitic intrusions followed the initial structural warping and may be the cause of a broad dome formed on the south portion of the detailed Kelsh map. These intrusions may be satellitic to the larger, Sierra Nevada batholith. The Tobin thrust can be observed in several areas on the regional Kelsh map. This fault is the major structure of the last orogeny to occur in this portion of Nevada. The major period of normal faulting was during the Tertiary and Quaternary. It is this deformation that was largely responsible for blocking out the present day mountain ranges.

This interpretation has swarms of lineations coming to the surface. They probably represent fault zones, however, they generally follow drainage systems that are low topographically with no outcrops present on which to measure stratigraphic throw.

There are two areas of probable structural doming present on the regional Kelsh plotter interpretation. One occurs in sections 32

and 33 T32N - R39E and sections 3 and 4 T31N- R39E. The dip magnitudes reversing this structure are in the 20° range and are taken on beds of short lateral extent. The second dome seems to be centered in sections 26, 27, 34 and 35 of T31N - R39E. Both domes are accompanied by intense normal faulting.

Along the west flank of the Sonoma Range, there is a north-south trending fault. On the east side of this fault, dip is approximately 5° to the east. The same dip relationship occurs to the southeast of the Leach Hot Springs fault.

FAULTING

A detailed analysis of fault trends on all three maps, A, B, and C, indicates a dominant northeast-southwest trend with an intervening set at N45°W. To the northeast set belongs the main fault which cuts the Leach Hot Springs vents. One exception to the dominant faulting is the normal faults which bound the Sonoma and Tobin ranges. They trend north-south and display recent movement in young sediments of Quaternary age.

Portions of the Tobin thrust appear on the regional Kelsh plotter map. Movement on this fault is probably to the north. Where the fault plane breaks the surface in sections 8, 9, 16 and 21 of T31N - R39E the Permo-Pennsylvanian Pumpernickel formation is thrust over the Triassic (?) Koipato formation. Through the west half of

T31N - R38E the Cambrian, probably a part of the Tobin, is thrust over on the Permo-Pennsylvanian Havallah formation.

The throw on normal faults, found in this mapping project, was measured by use of the floating dot in the stereo image and also checked in the field. The magnitude of throw varies from 10-80'. This does not constitute the total amount of vertical movement. The footage readings are only the elevation differences on either side of a topographic scarp and represent only the latest slippage.

The last movement on the Tobin thrust probably took place in the Jurassic period. Truncation of the Leach Hot Springs fault, B on the Kelsh regional map, against the north-south trending west boundary fault on the Sonoma Range shows that this break is younger in age than faults with a north to south alignment.

There is a definite correlation of the occurrence of hot and warm springs to fault zones. In all cases these springs surface along the fault planes determined by Kelsh and field work. The Leach Hot Springs have been issuing along a topographic scarp, which marks the trace of the fault plane, in several different places. Old, eroded vents were located approximately 200 yards northeast of the present vents. A hard, siliceous sinter deposit was found along the entire northeast extension of this fault.

Five criteria were used in determining the presence of faulting:

1) Straight drainage patterns

2) Springs

3) Streaks of green vegetation

4) Topographic scarps

5) Deflections in streams

CONCLUSIONS

The project area was investigated through the use of aerial photographs worked on a highly accurate stereoscopic instrument which removes all inaccuracies, induced in flying and plotted in exact planimetric position on a base map directly, by use of a pantograph arm. This photo work is backed up with a field check of both the regional map and the detail interpretation. A complete investigation was made in the field of additional hot springs that may be coming to the surface, and comparisons are made as to fault trends through areas of known hot springs and areas of suspected geothermal activity. A series of 55 color photos were taken during the two field checking stages. They show the quality of outcrops used for dip and strike readings and the subtle nature of fault scarps that were checked on the surface.

The next exploratory step on this project should be detailed gravity and seismic surveys to determine subsurface faulting, and additional core hole drilling with temperature measurements to locate geothermal "highs".

The geothermal prospects, within the boundaries of this mapping project, are considered excellent.

October 18, 1978

Donald W. Anderson

GEOLOGIC REPORT

KELSH PLOTTER PHOTOMAPPING

LEACH HOT SPRINGS PROJECT

HUMBOLDT AND PERSHING COUNTIES, NEVADA

By: Donald W. Anderson

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INTRODUCTION

This Kelsh plotter photointerpretation study was initiated to test the theory that latest fault movement, along old geologic features, will reflect in surface rocks as low, topographic scarps. Since a majority of the interpretation took place in unconsolidated valley fill deposits, it was deemed necessary to do the photo work on a stereoscopic instrument that is capable of reading small changes in topographic expression. The Kelsh plotter can read topographic changes as subtle as 2-4' and is capable of greatly enlarging the original photographic scale and plotting all the photogeologic information on direct overlays to U.S.G.S. topographic maps.

The Kelsh photointerpretation was done in two stages. The groundwork for this more detailed photoanalysis was a Landsat, space photo, evaluation which determined the regional, geologic setting of the Leach Hot Springs Project. Once this initial work was completed, the Kelsh interpretation of stage one, a study at the final scale of 1" = 2000', was undertaken. This work was done from 1:80,000 scale photography from U-2 aircraft flown by NASA. The interpretation was finalized on August 14, 1978 and a five-day field check was completed on August 18, 1978. The second stage was then initiated and was interpreted on lower altitude photography and plotted at a scale of 1" = 1000'. This photointerpretation was finished on September 16, 1978 and field checked September 17-22, 1978.

The quality of photographs, used in all phases of the project study, is considered excellent and weather conditions during both field checking trips were ideal.

SUMMARY

This geologic report will demonstrate that the combination of photo work and field checking accurately delineated numerous surface faults in both areas of bedrock and valley fill material. Since a major fault can be traced through the Leach Hot Springs vents, it is concluded that other surface faults, of similar magnitude, could be aquifers for other Hot Springs or be indicating areas of subsurface magmatic activity which has not yet reached the present ground surface. Areas of fault movement could be checked in detail with gravity interpretation to determine basement configuration.

The Landsat photointerpretation revealed many regional, linear features that may be indicating areas of possible, near surface magmatic activity that could be explored at a later date. The two-stage Kelsh plotter maps are pin-pointing many small areas of suspected thermal activity which can be investigated by gravity methods and core hole drilling immediately.

LOCATION

The general location of the Leach Hot Springs Project is 26 miles south of Winnemucca, Nevada. This locates the actual area of the

Leach Hot Springs vents. The interpretation expands, from this central point, 22 miles north-south and 13 miles east-west. The Landsat photointerpretation covers a much larger area than either Kelsh plotter maps. There are a total of 144 townships or 5184 square miles within the boundary of this map. The townships by number are T26N - T37N and R33E - R44E and approximate degree ticks are 40° 00' to 41° 00' of longitude and 117° 00' to 118° 15' of latitude. The Sonoma mountain range bounds the project to the east and the East range forms the west limit. The project area may be traversed north-south by the Grass Valley road which originates at Winnemucca.

PHOTOGEOLOGIC METHODS

The Kelsh plotter projects a stereoscopic model on a complete flat working surface, enlarged five times the original scale and free of all airborne inaccuracies. Each photo, of the stereo pair, is placed in its exact position in the sky as the picture was snapped. If the wing tip was down 2° from the horizontal, this is restored by a system of tip-tilt adjustments. Once all distortion is removed, and the image is enlarged five times, very accurate measurements may be made with a dot that "floats" in the stereo model. All interpretation is then placed directly on overlays to existing United States Geological Survey topographic maps. All readings made with the floating dot are accurate to 8-10' on photos at a scale of 1:60,000. Horizontal placements, on the base map, are recorded with a pantograph

arm which is adjustable to all topographic map scales.

PHOTOGEOLOGIC INTERPRETATION MAPS

LANDSAT (MAP A)

This interpretation was worked from Landsat 1 and 2 mission photographs on the 29.2" on a side size format, band 6 and 250,000 scale image. All prints were cloud free, of excellent quality, and were flown at a time frame where no snow was covering the surface. Each individual photograph was interpreted by placing red marks for linears and faults, green for bedding contacts and blue for geomorphic and tonal anomalies. The base map was constructed from township lines that appeared on the McDermitt, VYA, Winnemucca and Lovelock 1:250,000 scale U.S.G.S. topographic maps. All interpretive symbols were then transferred to these maps, then to an overlay at the same scale. A total of four photos were used in the interpretation and they are considered to be of superior quality with sharp, gray tone differences that are needed for accurate photoanalysis. There are 9 separate interpretive symbols used on this map and they are described as follows:

Regional Linear: A straight line of over 50 miles in length that follows through valleys, mountain ranges and into the adjoining valley areas. They appear to not be influenced by topography and seem to be showing broad areas of crustal, plate tectonic

movement. They may be zones of faulting.

Linear: These are straight lines of less than 30 miles in length. In many cases, they follow in stream channels or along steep-sided canyons. They are influenced by topography and seem to bend with changes in strike of outcropping beds or along stream deflection. They show local structure and probably are faults.

Fault: A dashed line on the map which traces a plane of faulting. The scale of the photography is too small to allow the interpreter to determine the direction of throw movement. Some of these breaks are thrusts and tend to have an arcuate pattern. The normal faults surface as straight lines.

Stream Deflection: This geomorphic symbol shows drainage patterns that are adjusting to fit the present day landscape. They are flowing along areas of least resistance which may be along fault or fracture zones. Since bedrock is hard for a stream to traverse, many times the stream is deflected around these areas. They commonly also are diverted around positive, structural highs and thus may be revealing anticlines.

Bedrock Contact: This line is solid and depicts the contact between hard, consolidated, outcrops and areas of loose, unconsolidated sediments. There is a distinct color change from mid-tone grays of the consolidated outcrops to light gray over

the unconsolidated, valley fill material.

Playa: These are extremely flat lying old lake beds that photograph a brilliant white. There is no stream development within these areas and some contain small areas of open water.

Tonal Anomaly: Appear as hachured, circular area on the final map. The domal shape indicates possible areas of uplift. The color is generally mid to dark gray and may be indicating a zone of alteration.

Quaternary Valley Fill (Qvf): This is an area of relatively flat lying sediments where stream development is sparce or downcutting is in its beginning stages.

Bedrock (B): These are broad areas of mid-tone grays on the photographs where stream development is intense.

The results of this interpretation are twofold:

1) It placed the Leach Hot Springs Project area into a broad, regional geologic setting where comparisons could be made with known areas of geothermal acitivity and areas of suspected geothermal acitivity.

2) There were numerous areas delineated where additional detail work could be conducted. Cross-faulting or cross-linears are two examples of areas to pursue further and tonal anomalies point

out areas that could be investigated by detail photo work with back-up field checking.

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The Landsat interpretation works well to locate tonal anomalies. Usually they photograph as a mid-tone gray and are circular in shape. They are often topographic highs with radial drainage patterns. The color change from surrounding outcrops indicates a change in rock type or may be showing a zone of alteration.

By using the geomorphic expression of outcrops, it was relatively easy to determine the age of geologic formations. There are conglomerate beds in the section that hold up prominent ridges while weathered andesite beds occupy low topographic positions.

The low valleys are receiving sediments to the present geologic time. Sculpture of the mountain ranges is recorded in remnants of old erosion surfaces at varying altitudes. One of these is at a present day altitude of 8000' in the Sonoma Range, just off this project, where a subdued topography is present with gentle slopes. Below this, at an altitude of 6000 - 7000', is another stage shown in the Sonoma Range and is represented as gravel terraces. A third erosional remnant is found at a 5000' level. It is a pediment and gravel bench underlain by down-faulted rhyolite.

STRATIGRAPHY

There are rocks ranging in age from Quaternary alluvium, colluvium and fans to undifferentiated Cambrian within the map's boundary. The Landsat mapping determined that bedrock-valley fill deposits cover equal amounts of total map area. The contact between bedrock-valley fill is sharp and, when viewed from the extreme height that space photos are flown, the mountain ranges seem to be "choking" in their own debris.

The lithologic character of outcropping formations within this mapping project vary greatly but may be summarized as late Jurassic plutonic rocks intruding a great thickness of sedimentary and volcanic rocks of Triassic and Paleozoic age that are strongly metamorphosed and deformed through intense faulting. Cambrian rocks are represented by quartzites and are ridge formers as is the Valmy formation of Ordovician age. The Carboniferous and Permian is well represented with widespread sequences of deposits. In the Sonoma Range, on the east side of the regional Kelsh map, great masses of metavolcanic and sedimentary rocks are present. Here the Havallah (Permian?) and Pumpernickel (Pennsylvanian?) formations outcrop above and below the Tobin thrust. There are extensive outcrops of Koipato formation which is dominantly volcanic in origin. Along the west flanking fault of the Sonoma Range, this formation is the first to surface. On the weathered outcrop its dominant color is red. There are several white

to light gray andesitic volcanic beds present. This same reddish material outcrops about 100 yards northeast of the Leach Hot Springs fault and would suggest that major, recent movement has taken place on the feature. The Triassic rocks of this area are mostly marine in origin and consist of equal amounts of clastics and carbonates. The Triassic seas invaded from the east and the oldest formation laid down consists of the Prida which at its base is a conglomerate, followed by 50-100' of clastic sediments with interbedded brown dolomite. In the middle is a 100 - 200 zone of dark, bituminous and calcareous shale with thin-bedded limestone. The Cane Spring and Augusta Mountain formations outcrop only locally on this project. The Augusta Mountain is a thick carbonate unit of Middle Triassic age. It is overlain by the Upper Triassic Cane Spring formation which is a carbonate unit. There are Jurassic granitic intrusives present in the Sonoma Range centered in section 6 T32N - R39E. This mass is composed of granite, quartz monzonite, and granodiorite. The dominant Tertiary rocks of the mapping project are composed of rhyolitic lavas and associated tuffs. There is a layer of basalt which caps Table Mountain to the south which delineates the north end of extensive lava flows spreading from the south. This basalt is likely much younger than the rhyolites found elsewhere on the interpretation. Near Leach Hot Springs there are some slightly consolidated sediments, some with distinctive reddish coloration, cropping out. Along the Leach Hot Springs fault there are extensive, hard, siliceous sinter deposits. These deposits may be responsible for the topographic

scarp which forms along the fault zone.

The recent sediments, of Quaternary age, are divided into two groups. Stream-deposited alluvium covers about 20% of the total valley fill material. Topographically, these sediments lie on very flat flood plains near the central Grass Valley drainage system. The area from the mountain fronts to the boundary with the alluvium is occupied by colluvial dip slope deposits. They are gently sloping, display some stream downcutting, and are of unconsolidated wash derived from the high mountain ranges. It is in this large area of outcrop that many faults could be traced. The latest fault movement is recorded as slight topographic scarps within this loose material.

REGIONAL GEOLOGY

The entire project lies within the Basin and Range geologic province. It is characterized by very arid climate with little rainfall and no streams that reach the sea. There is a distinctive north-south alignment to the mountain ranges and the intervening valleys. The high mountain ranges are horst blocks that have been uplifted and are contributing sediments to the low, valley areas. These valleys are filled with wash material of undetermined thickness. The ranges are not simply horst blocks of unaltered rocks, but rather broad masses of highly complex sediments that have been subjected to intense normal and thrust faulting along with magmatic intrusion.

This faulting continues to the present as evidenced by the measurable displacement found on faults cutting the colluvial deposits. In 1903 a fault movement was recorded on the west flank of the Tobin Range in section 34 T30N - R39E. Here slippage of 75-100' occurred and is readily identified on the aerial photographs.

STRUCTURE

Folding and faulting, on this mapping, took place during several geologic periods, beginning in the Paleozoic and extending to the present. Granitic intrusions followed the initial structural warping and may be the cause of a broad dome formed on the south portion of the detailed Kelsh map. These intrusions may be satellitic to the larger, Sierra Nevada batholith. The Tobin thrust can be observed in several areas on the regional Kelsh map. This fault is the major structure of the last orogeny to occur in this portion of Nevada. The major period of normal faulting was during the Tertiary and Quaternary. It is this deformation that was largely responsible for blocking out the present day mountain ranges.

This interpretation has swarms of lineations coming to the surface. They probably represent fault zones, however, they generally follow drainage systems that are low topographically with no outcrops present on which to measure stratigraphic throw.

There are two areas of probable structural doming present on the regional Kelsh plotter interpretation. One occurs in sections 32

and 33 T32N - R39E and sections 3 and 4 T31N- R39E. The dip magnitudes reversing this structure are in the 20° range and are taken on beds of short lateral extent. The second dome seems to be centered in sections 26, 27, 34 and 35 of T31N - R39E. Both domes are accompanied by intense normal faulting.

Along the west flank of the Sonoma Range, there is a north-south trending fault. On the east side of this fault, dip is approximately 5° to the east. The same dip relationship occurs to the southeast of the Leach Hot Springs fault.

FAULTING

A detailed analysis of fault trends on all three maps, A, B, and C, indicates a dominant northeast-southwest trend with an intervening set at N45°W. To the northeast set belongs the main fault which cuts the Leach Hot Springs vents. One exception to the dominant faulting is the normal faults which bound the Sonoma and Tobin ranges. They trend north-south and display recent movement in young sediments of Quaternary age.

Portions of the Tobin thrust appear on the regional Kelsh plotter map. Movement on this fault is probably to the north. Where the fault plane breaks the surface in sections 8, 9, 16 and 21 of T31N - R39E the Permo-Pennsylvanian Pumpernickel formation is thrust over the Triassic (?) Koipato formation. Through the west half of

T31N - R38E the Cambrian, probably a part of the Tobin, is thrust over on the Permo-Pennsylvanian Havallah formation.

The throw on normal faults, found in this mapping project, was measured by use of the floating dot in the stereo image and also checked in the field. The magnitude of throw varies from 10-80'. This does not constitute the total amount of vertical movement. The footage readings are only the elevation differences on either side of a topographic scarp and represent only the latest slippage.

The last movement on the Tobin thrust probably took place in the Jurassic period. Truncation of the Leach Hot Springs fault, B on the Kelsh regional map, against the north-south trending west boundary fault on the Sonoma Range shows that this break is younger in age than faults with a north to south alignment.

There is a definite correlation of the occurrence of hot and warm springs to fault zones. In all cases these springs surface along the fault planes determined by Kelsh and field work. The Leach Hot Springs have been issuing along a topographic scarp, which marks the trace of the fault plane, in several different places. Old, eroded vents were located approximately 200 yards northeast of the present vents. A hard, siliceous sinter deposit was found along the entire northeast extension of this fault.

Five criteria were used in determining the presence of faulting:

1) Straight drainage patterns

2) Springs

3) Streaks of green vegetation

4) Topographic scarps

5) Deflections in streams

CONCLUSIONS

The project area was investigated through the use of aerial photographs worked on a highly accurate stereoscopic instrument which removes all inaccuracies, induced in flying and plotted in exact planimetric position on a base map directly, by use of a pantograph arm. This photo work is backed up with a field check of both the regional map and the detail interpretation. A complete investigation was made in the field of additional hot springs that may be coming to the surface, and comparisons are made as to fault trends through areas of known hot springs and areas of suspected geothermal activity. A series of 55 color photos were taken during the two field checking stages. They show the quality of outcrops used for dip and strike readings and the subtle nature of fault scarps that were checked on the surface.

The next exploratory step on this project should be detailed gravity and seismic surveys to determine subsurface faulting, and additional core hole drilling with temperature measurements to locate geothermal "highs".

The geothermal prospects, within the boundaries of this mapping project, are considered excellent.

October 18, 1978

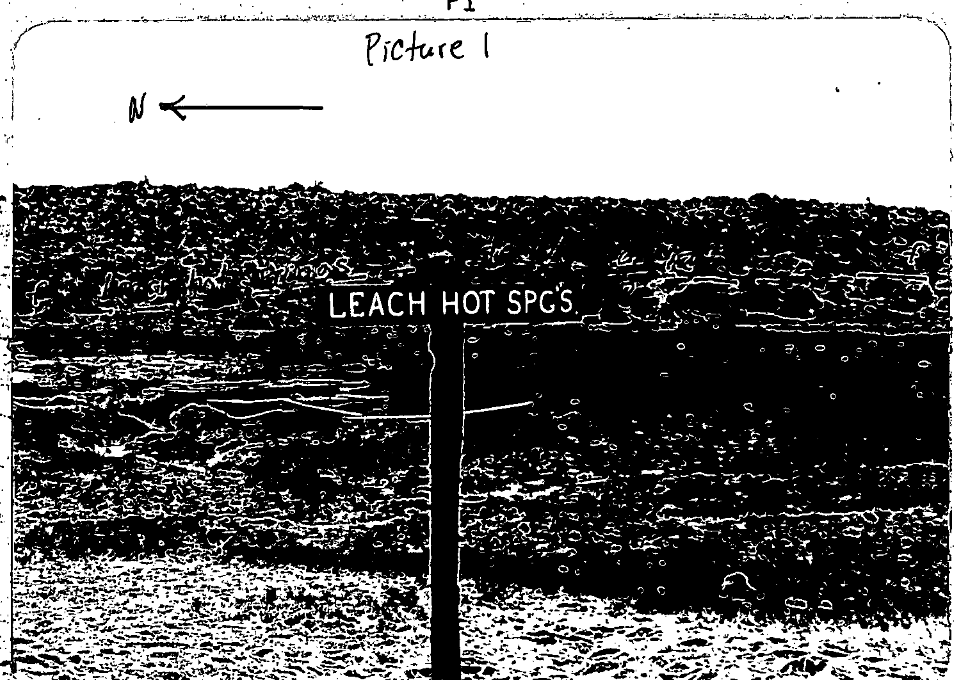
Donald W. Anderson

COLOR PHOTOGRAPHS

KELSH PLOTTER REGIONAL - MAP B

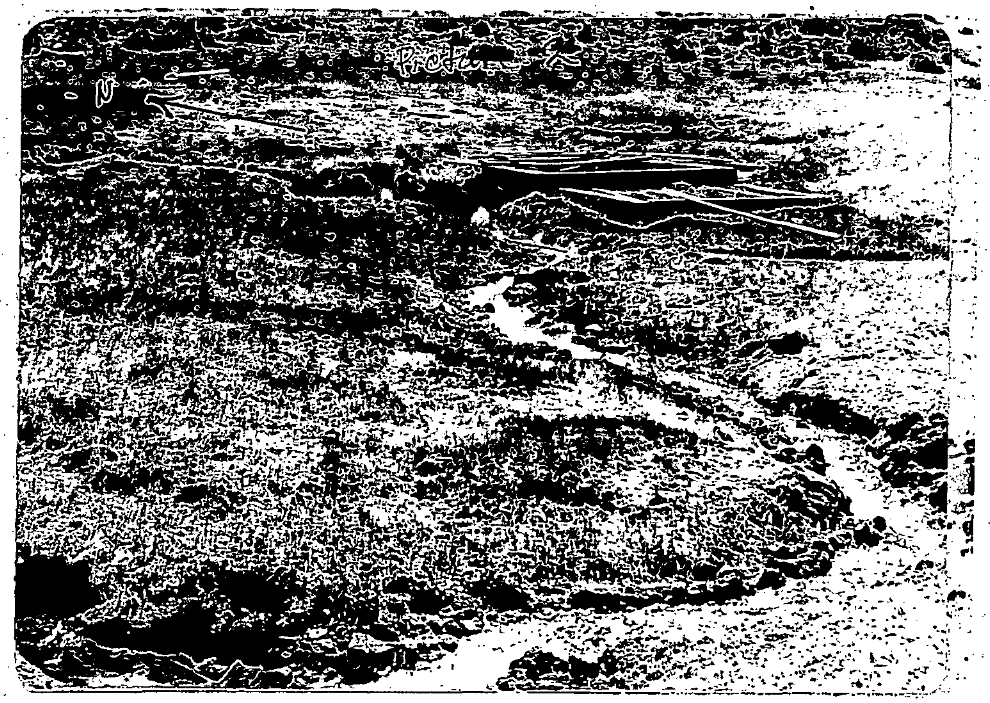
The following 20 color photographs were taken during the field checking of the first Kelsh plotter interpretation at the scale of 1" = 2000'. This work was done August 14 - 18, 1978. To locate each picture's position, refer to the Kelsh plotter regional map. The X indicates the position, on the ground, where the photograph was taken. The two arrowed lines show the approximate arc of coverage. Each photograph is oriented to true north compass readings.

P1



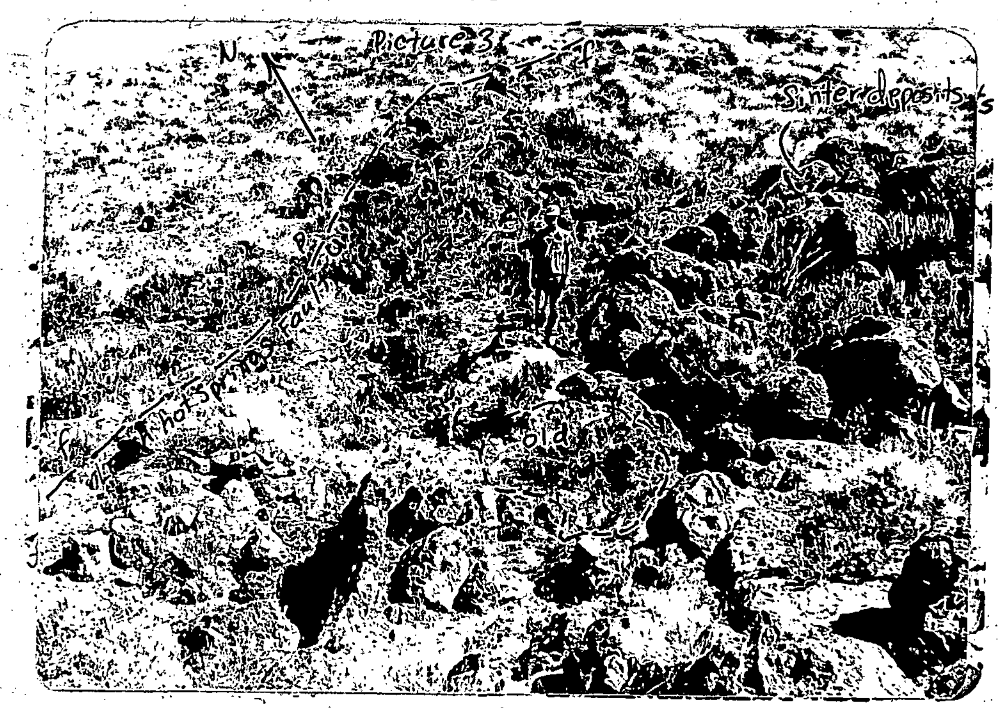
Oriented N80°W Looks SE

P2



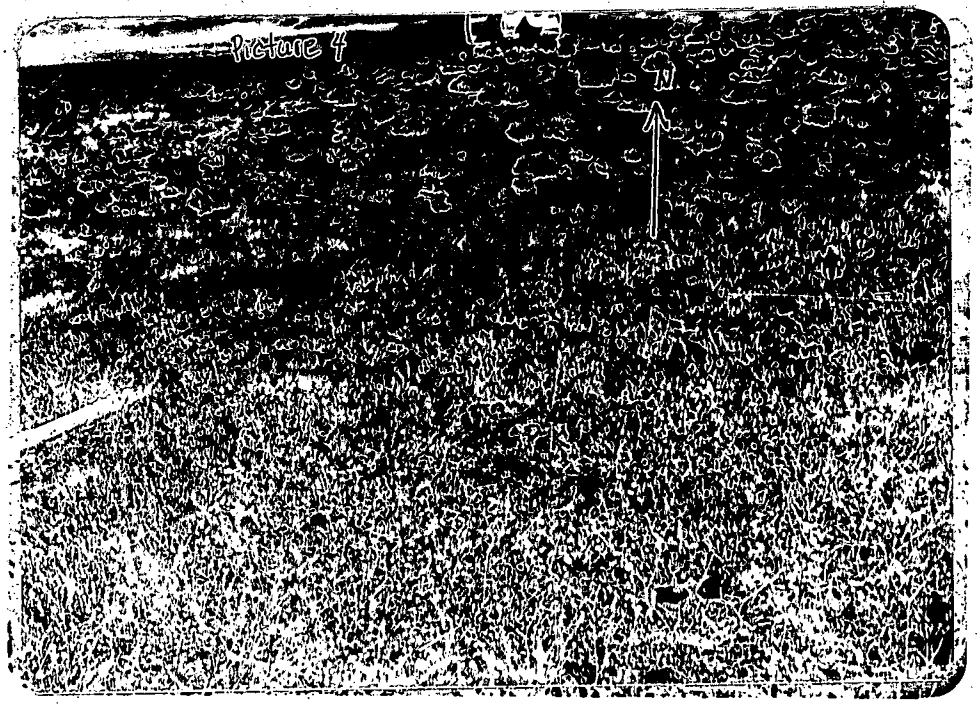
Oriented N85°W Looks SE

P3



Oriented N23°E Looks NE

P4

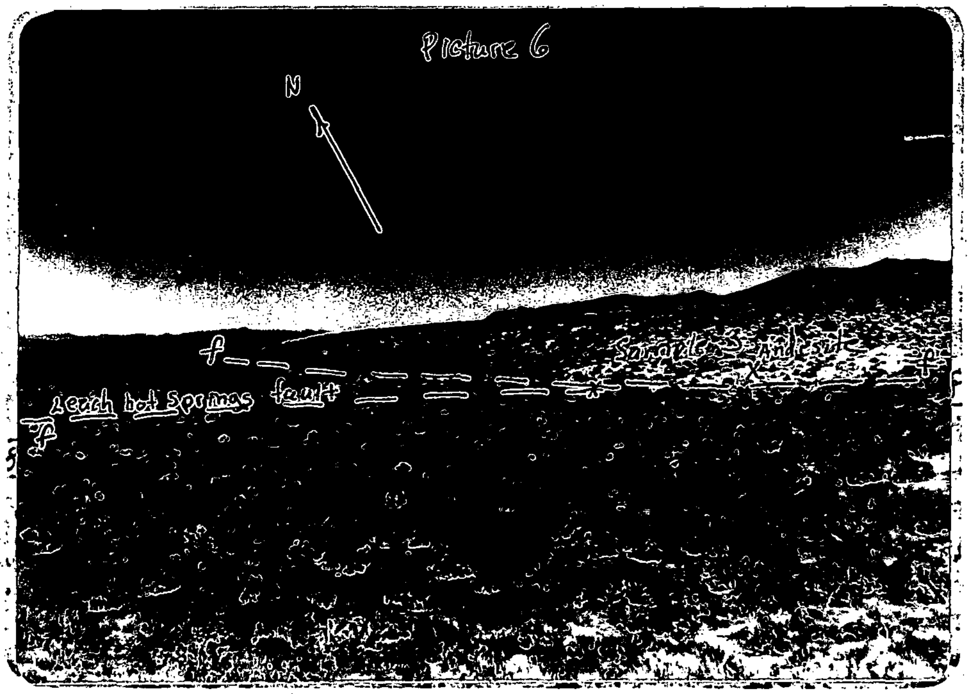


Oriented N10°E Looks NE

P5

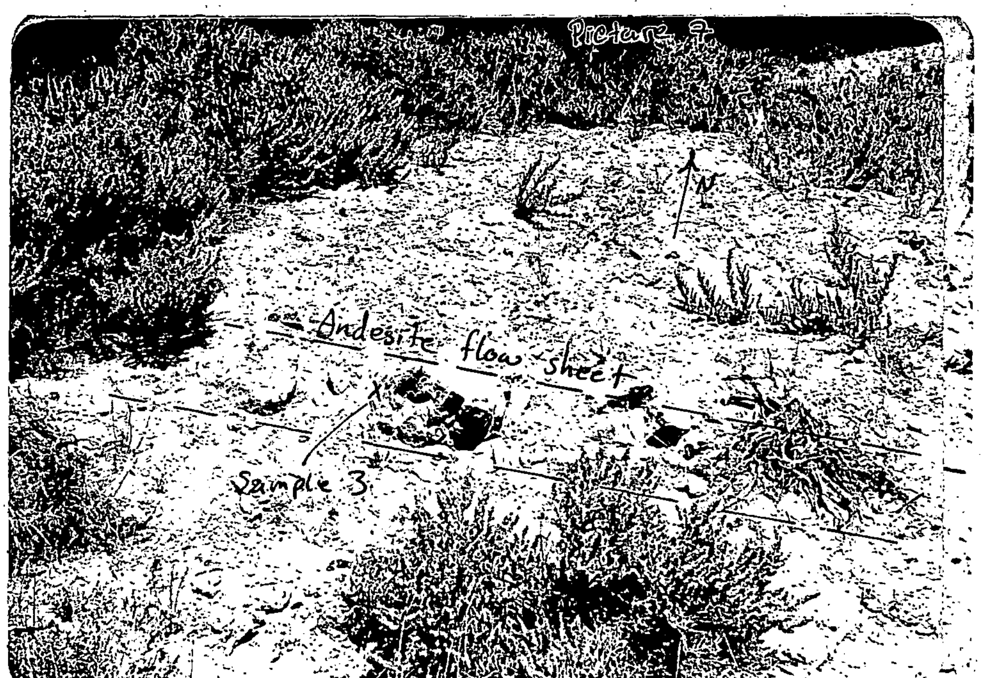
Oriented N20°E Looks NE

P6



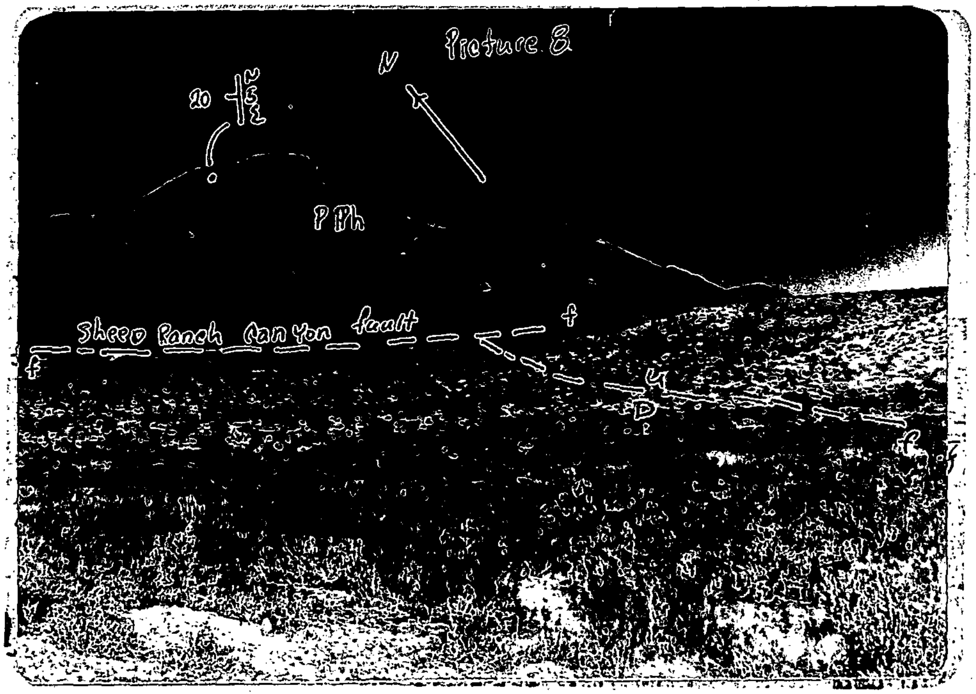
Oriented N40°W Looks NW

P7



Oriented N12°W Looks NW

P8

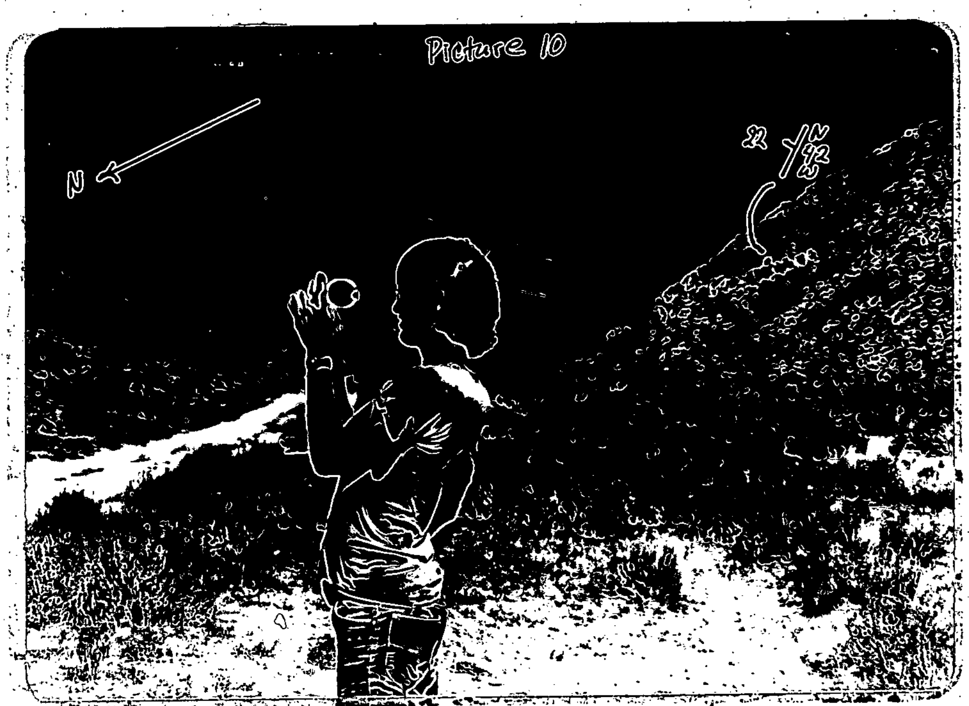


Oriented N50^{o}E Looks NE

P9

Oriented N3^{o}E Looks NE

P10

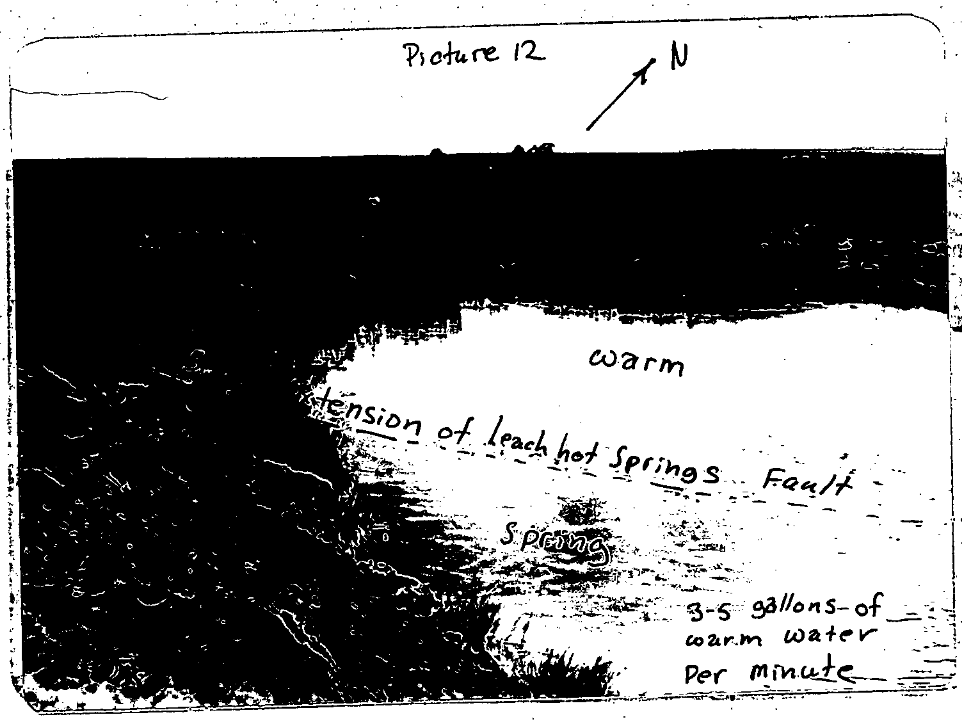


Oriented N77°W Looks SE

P11

Oriented N50°W Looks SE

P12

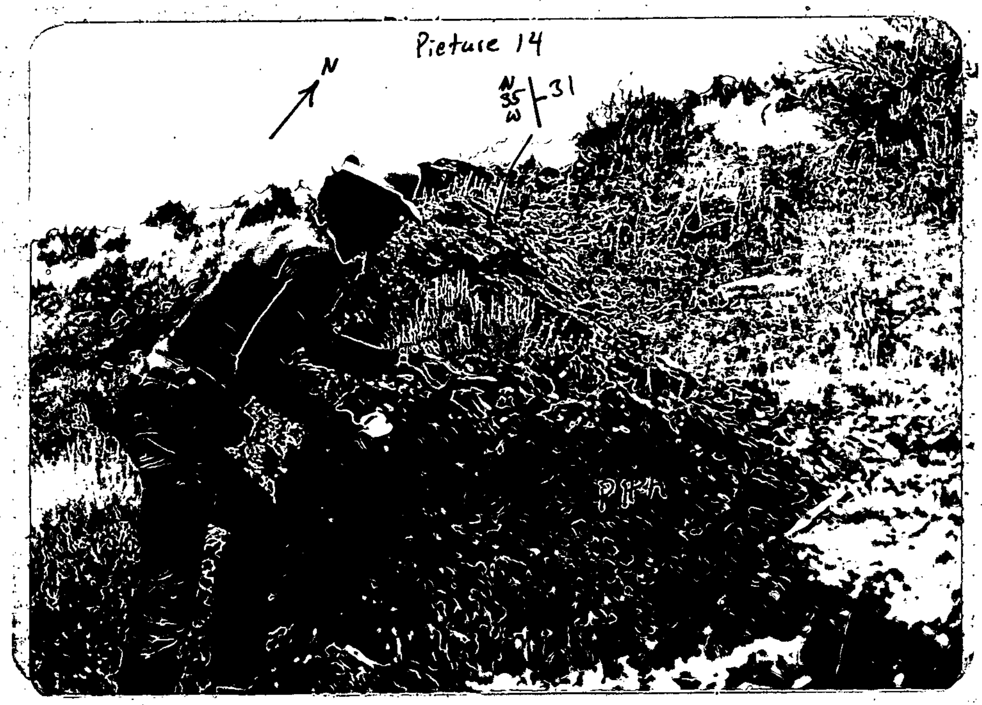


Oriented N49°W Looks NW

P13

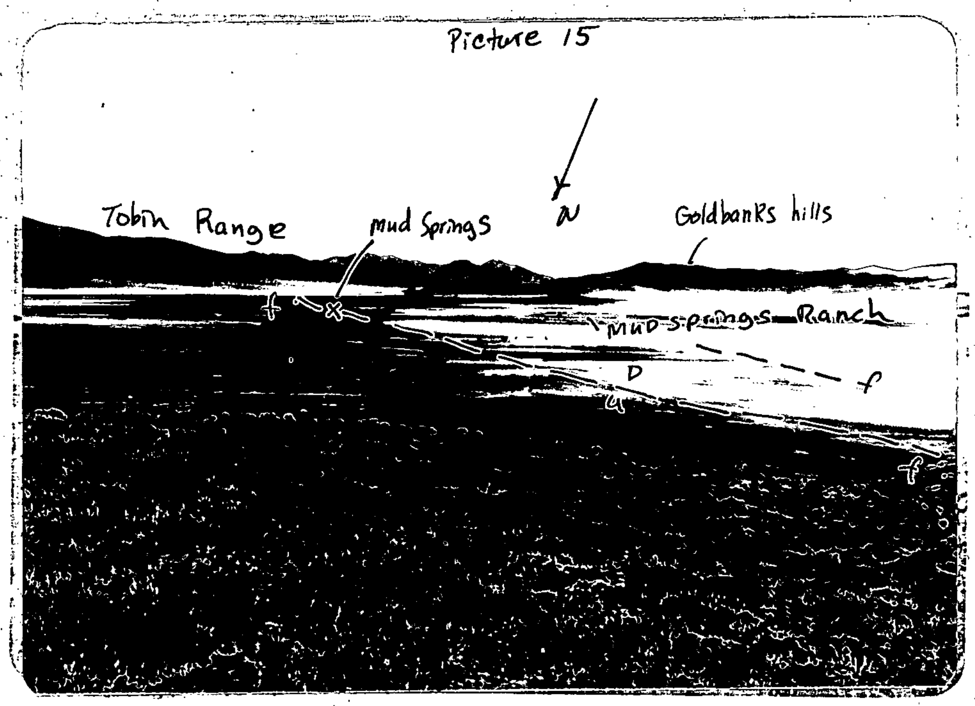
Oriented N25°E Looks NE

P14



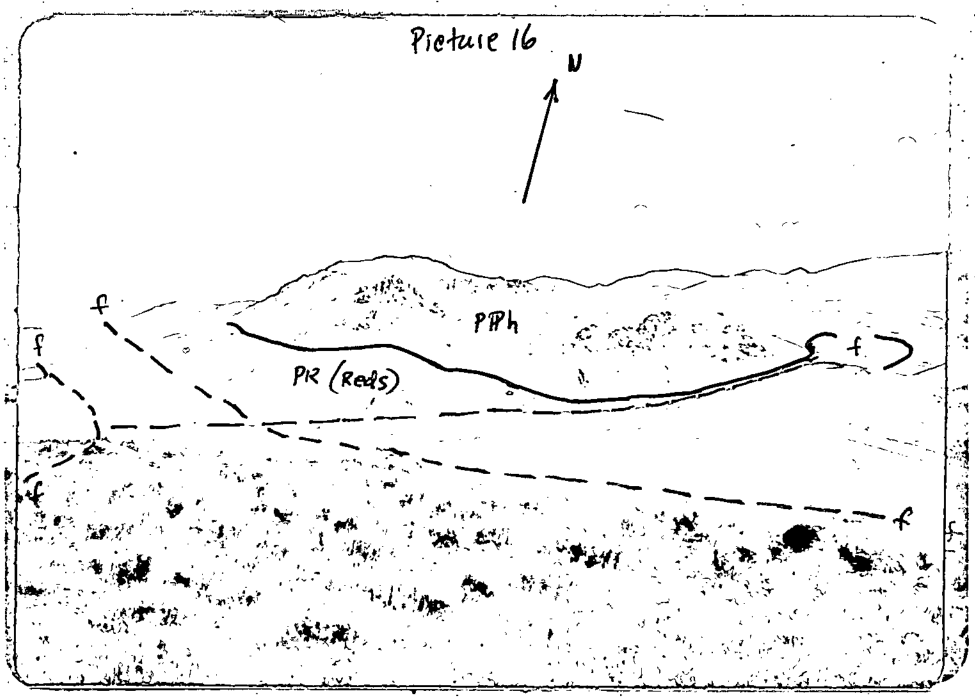
Oriented N40°W Looks NW

P15



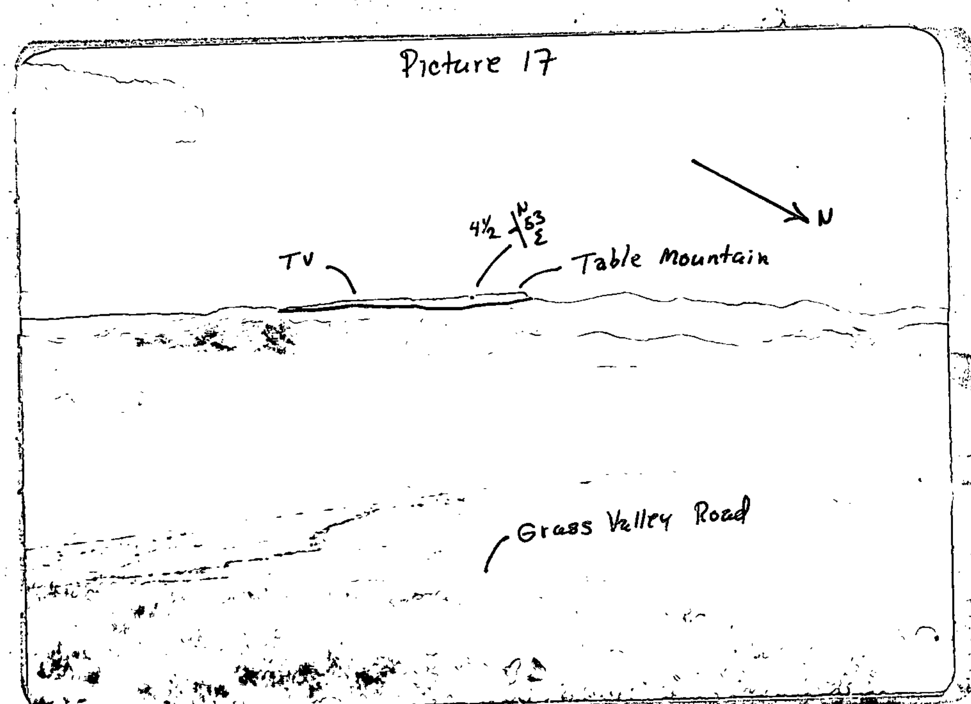
Oriented N14°W Looks SE

P16



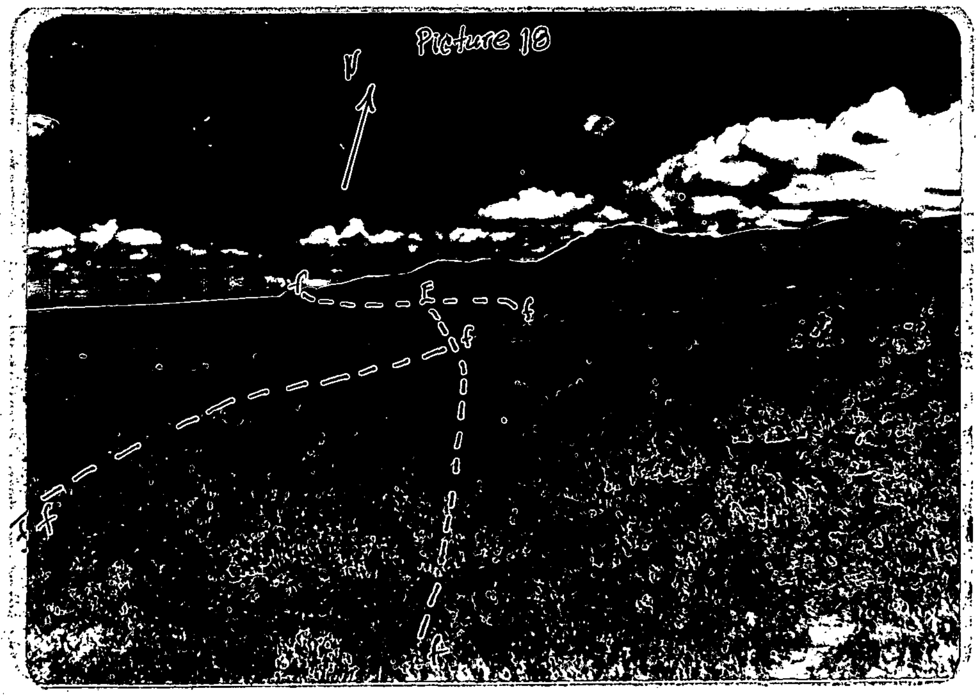
Oriented N5°W Looks NW

P17



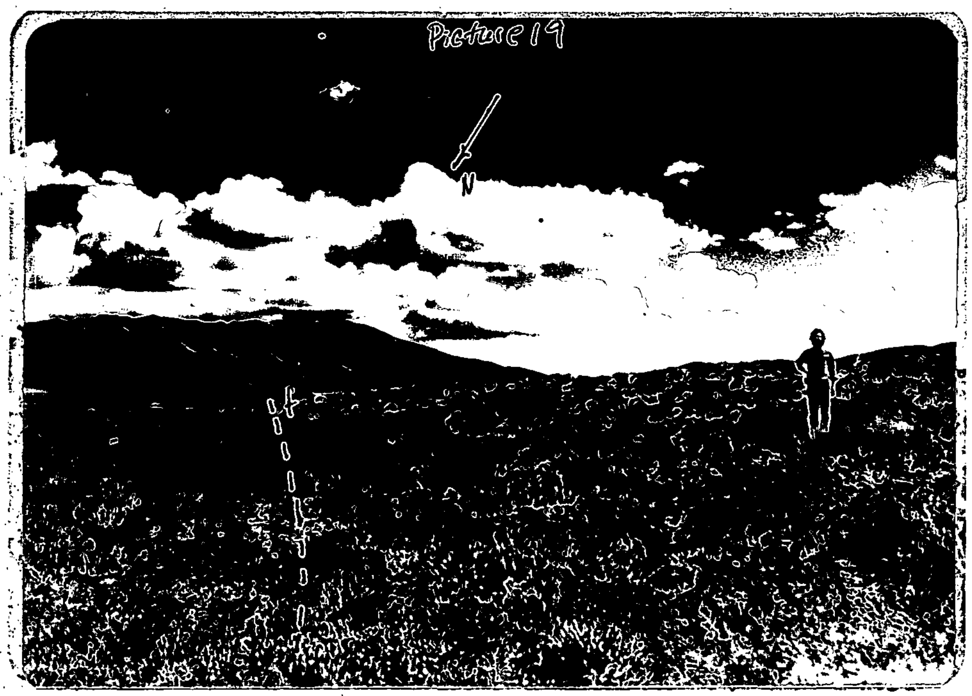
Oriented N65°E Looks SW

P18

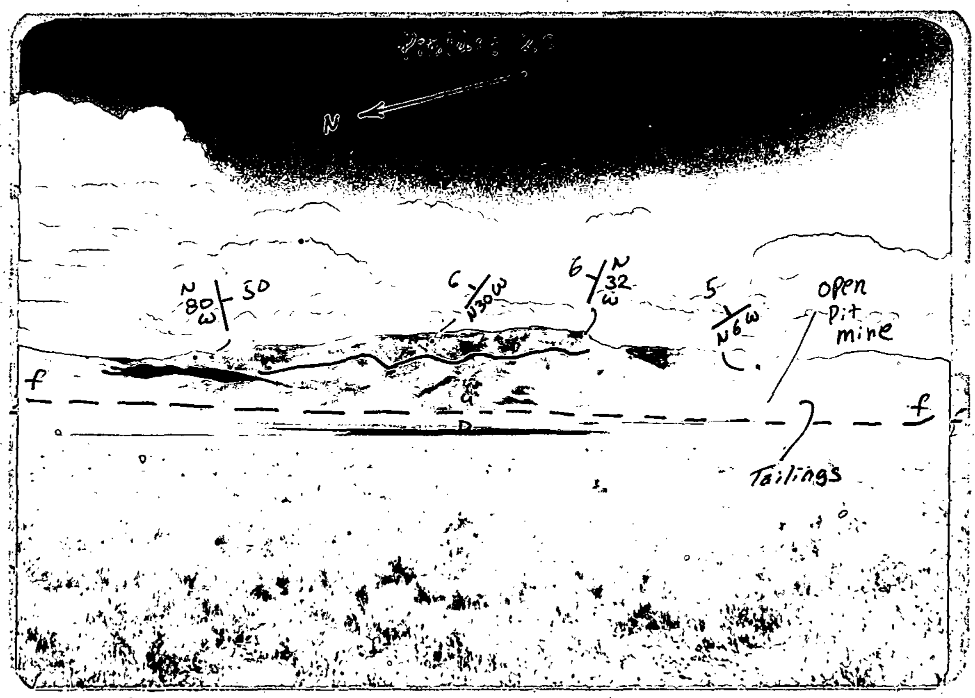


Oriented N5°W Looks NW

P19



Oriented N30°W Looks SE



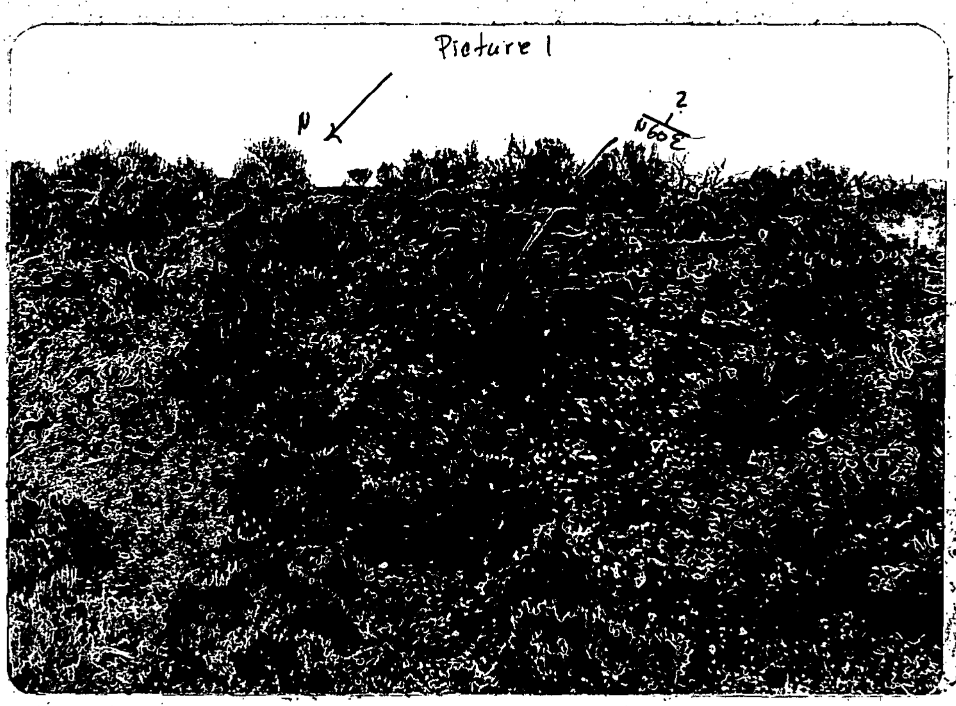
Oriented N87°W Looks SE

COLOR PHOTOGRAPHS

KELSH PLOTTER DETAIL - MAP C

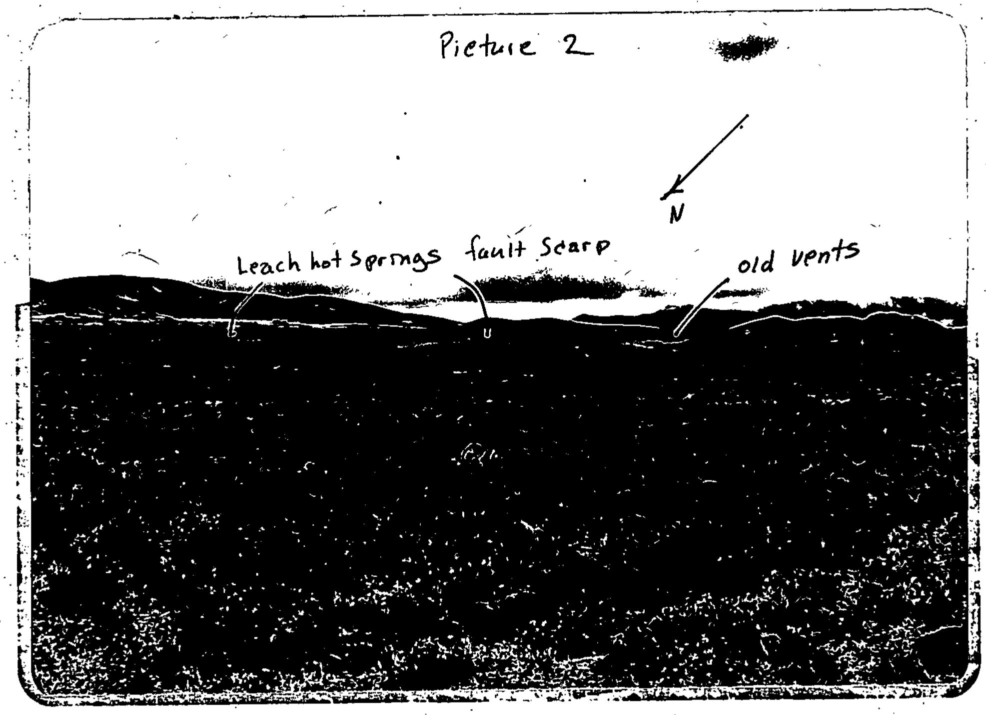
These 35 color photographs were taken during the intense field check on the Kelsh plotter detail map, at the scale of 1" = 1000', on September 17 - 22, 1978.

P1



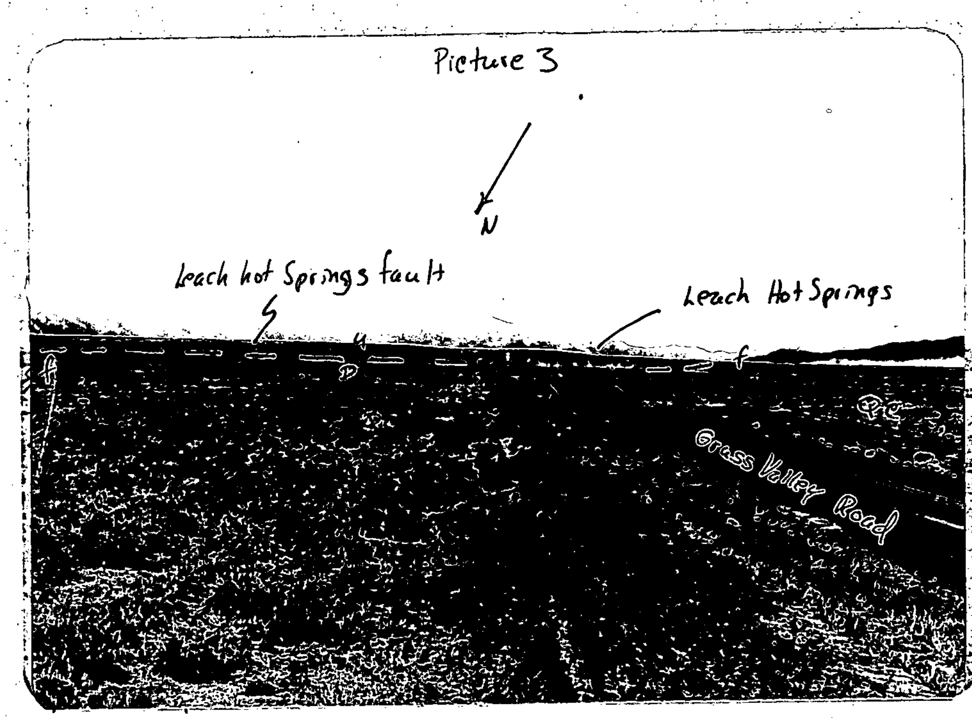
Oriented N44°W Looks SE

P2



Oriented N55°W Looks SE

P3

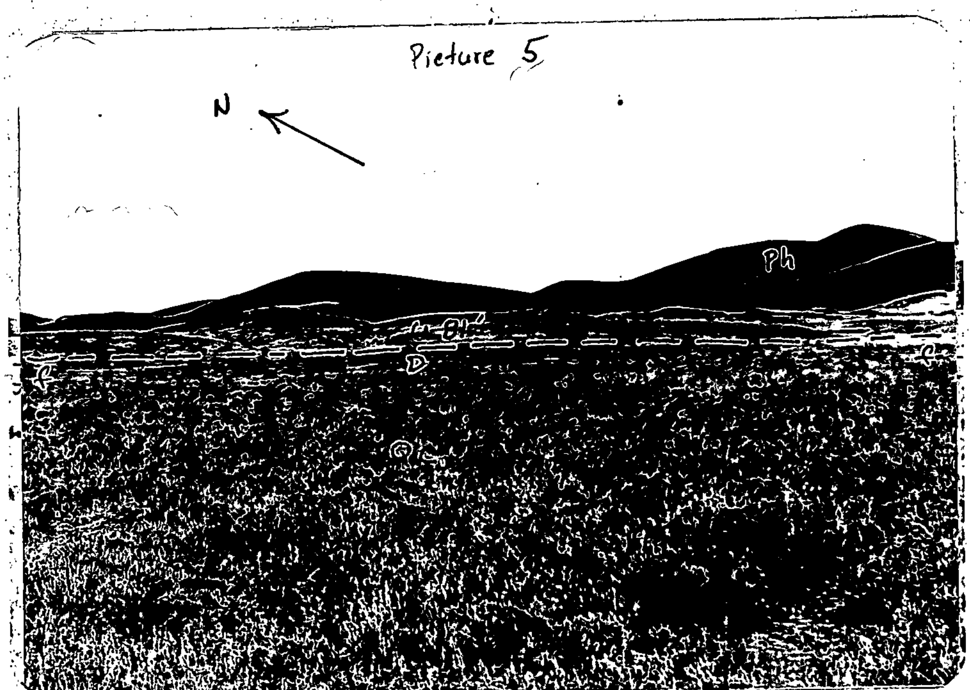


Oriented 17°W Looks SE

P4

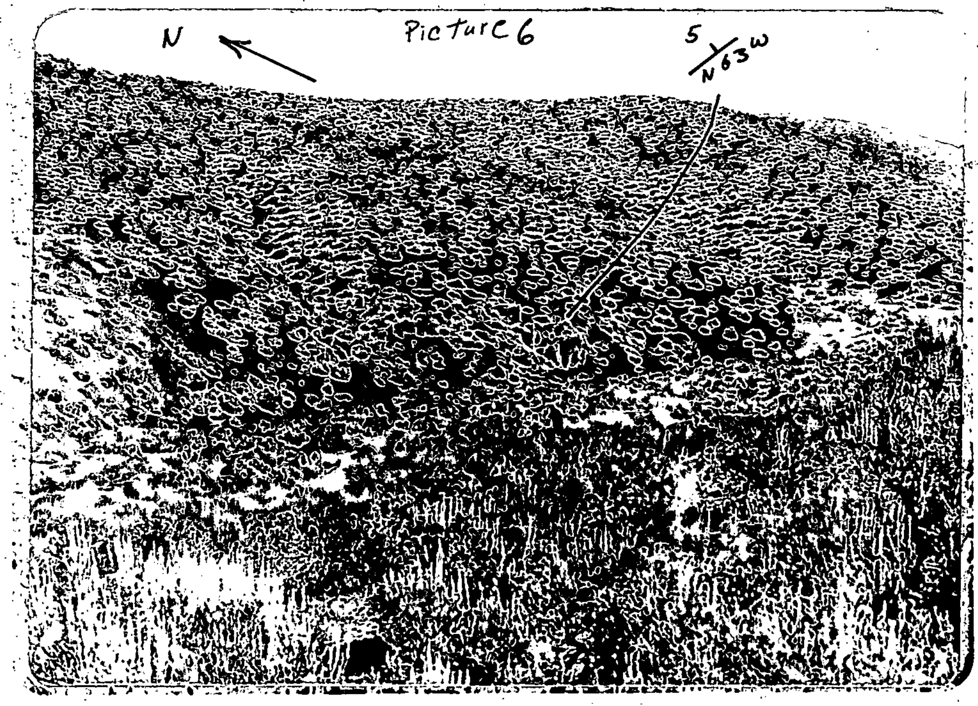
Oriented N62°E Looks NE

P5



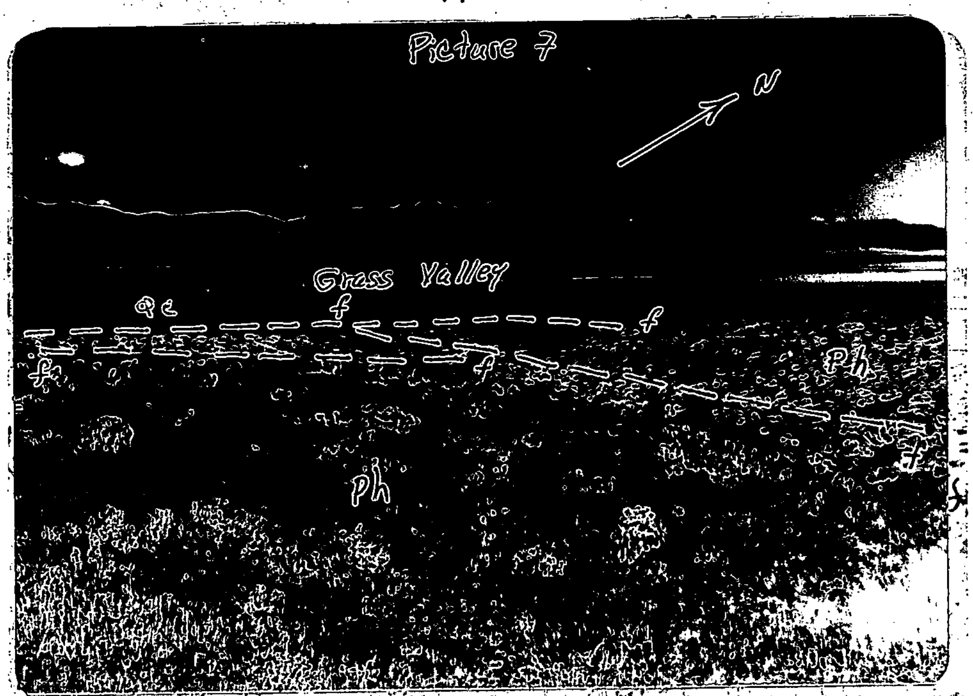
Oriented N80°E Looks NE

P6



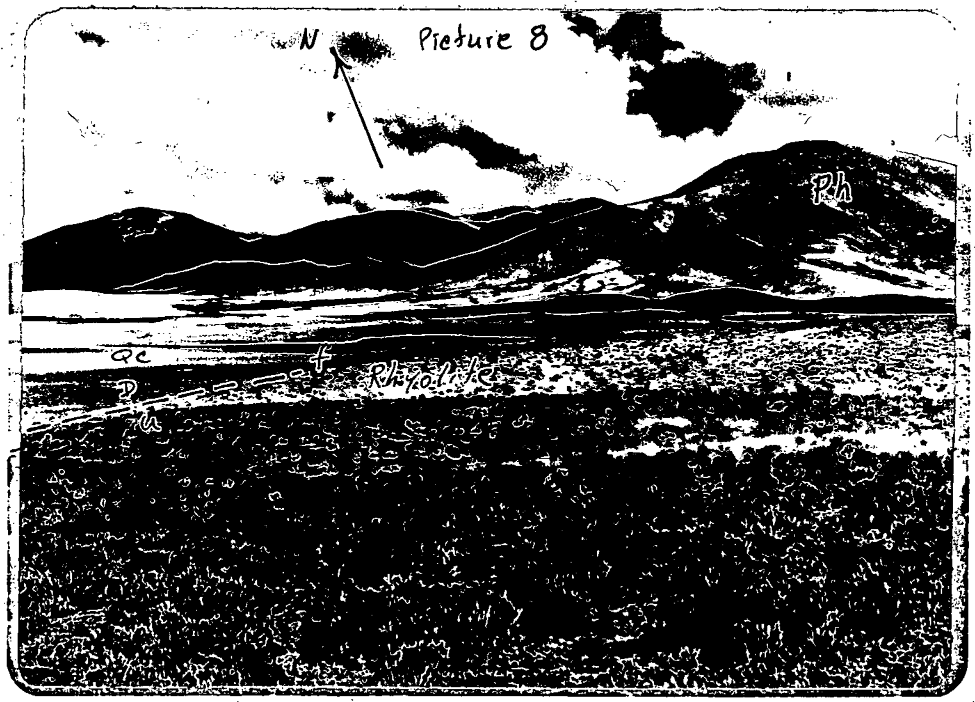
Oriented N48°E Looks NE

P7



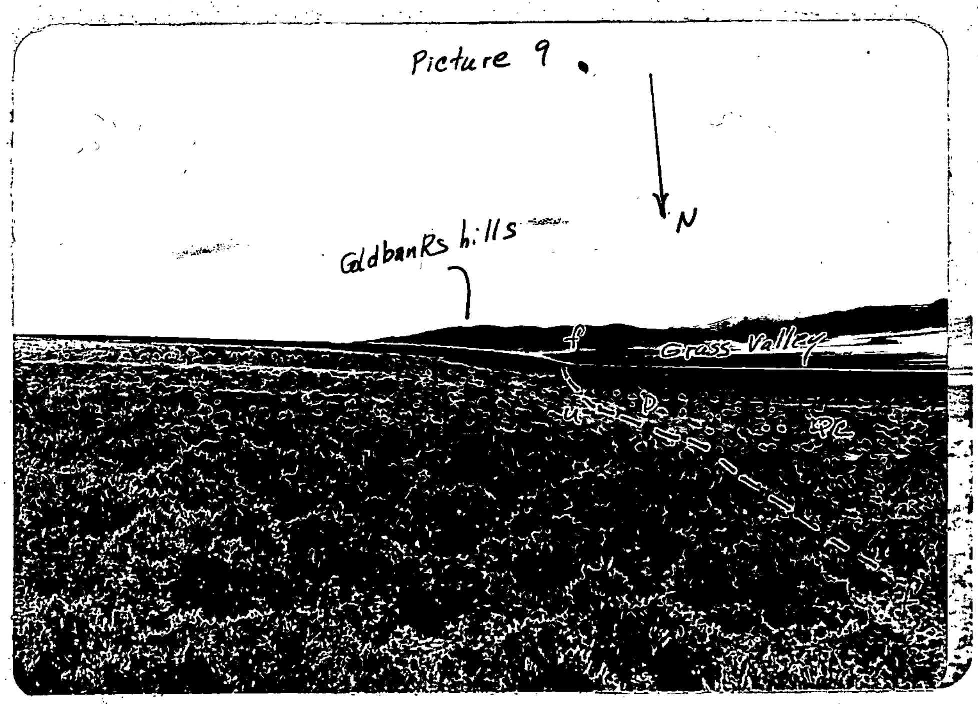
Oriented N53°W Looks NW

P8



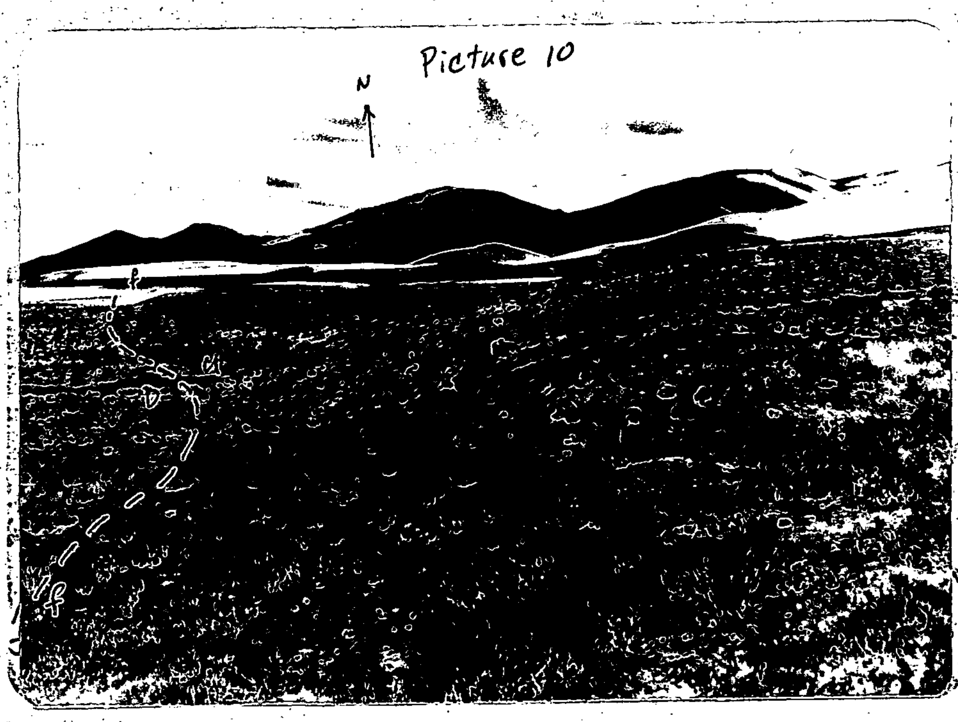
Oriented N20°E Looks NE

P9



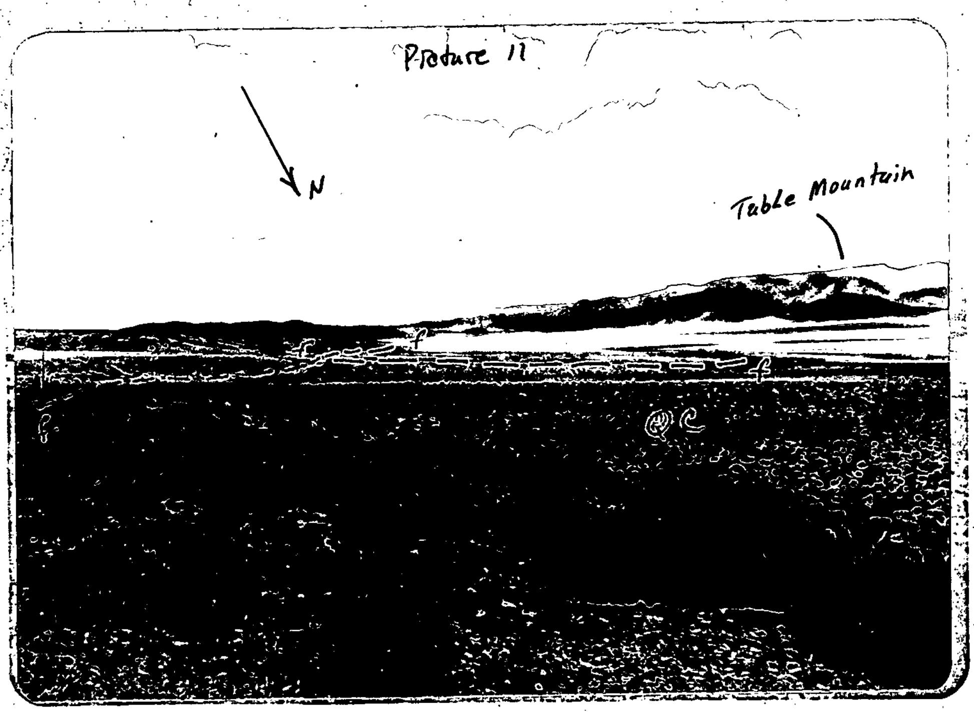
Oriented N11°E Looks SW

P10



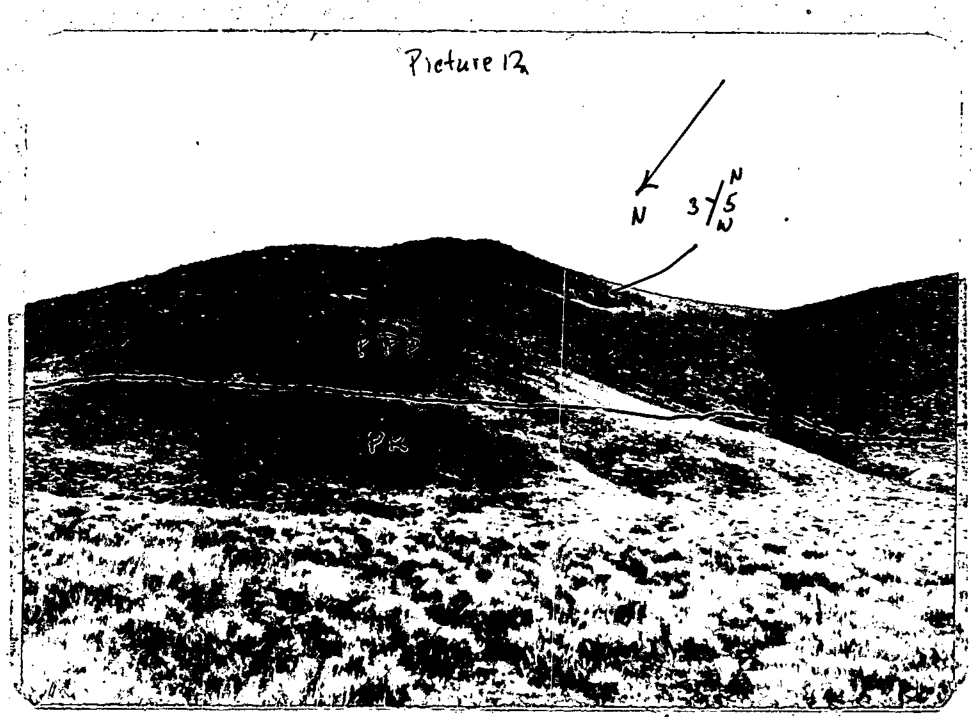
Oriented N6°E Looks NE

P11



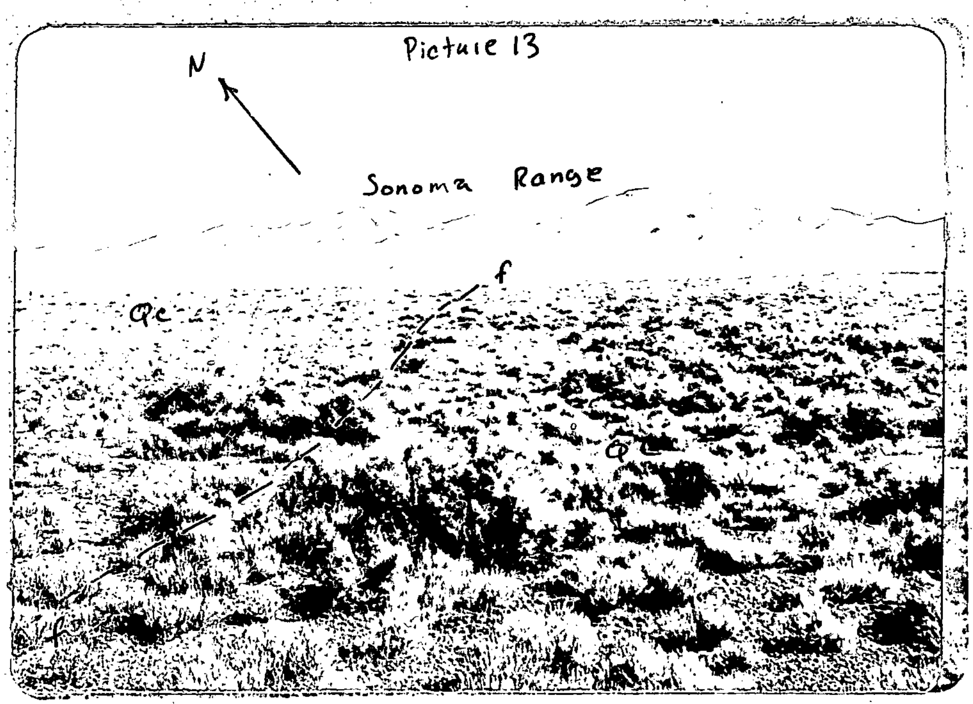
Oriented N16°E Looks SW

P12



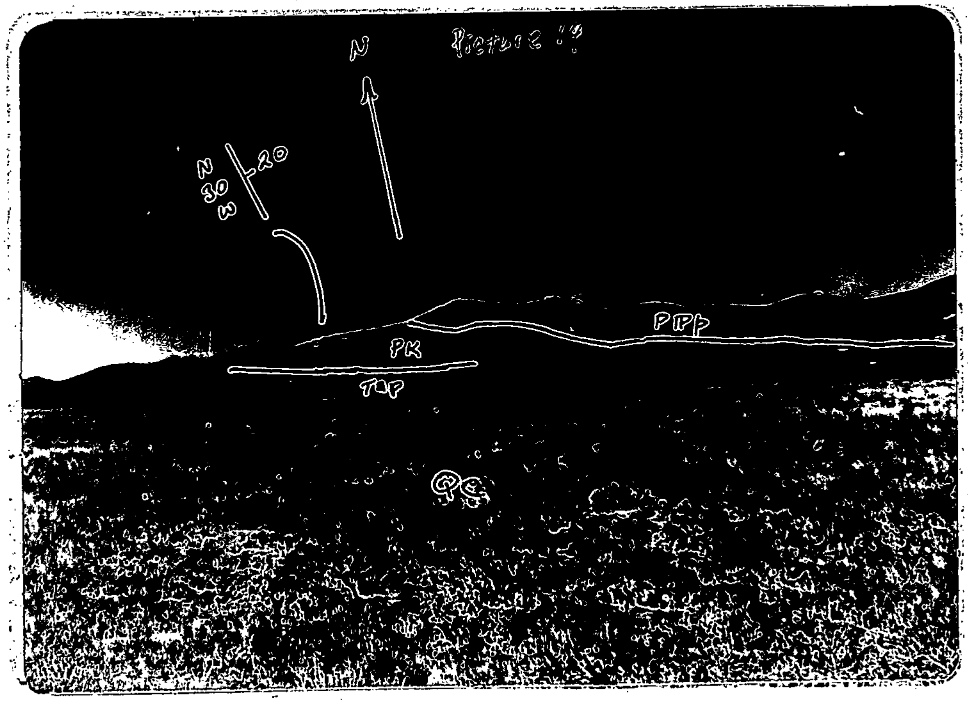
Oriented N55°W Looks SE

P13



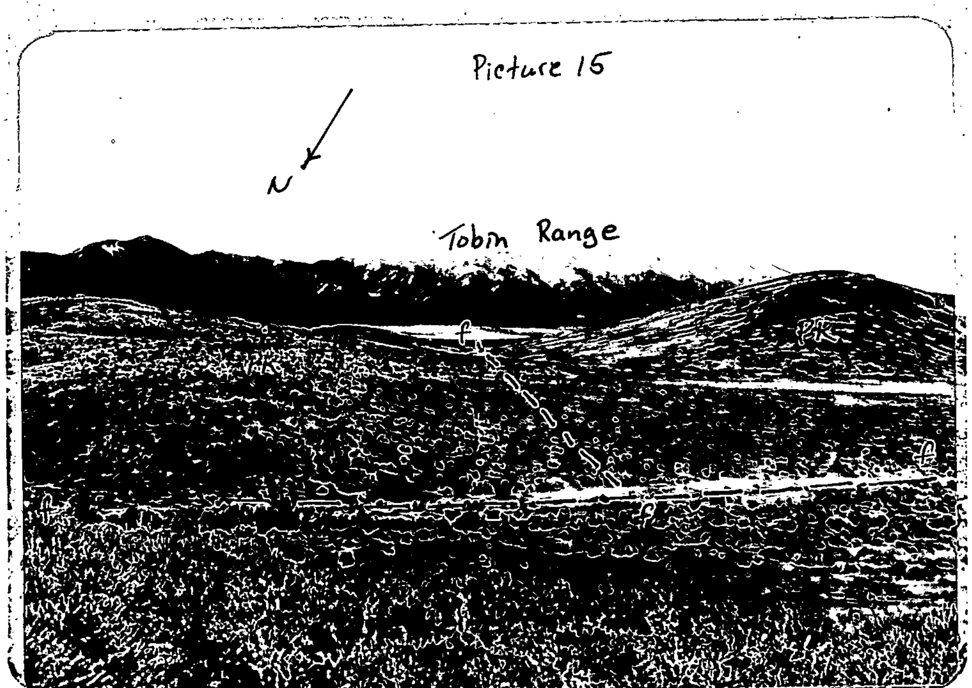
Oriented N19°E Looks NE

P14



Oriented N9°E Looks NE

P15

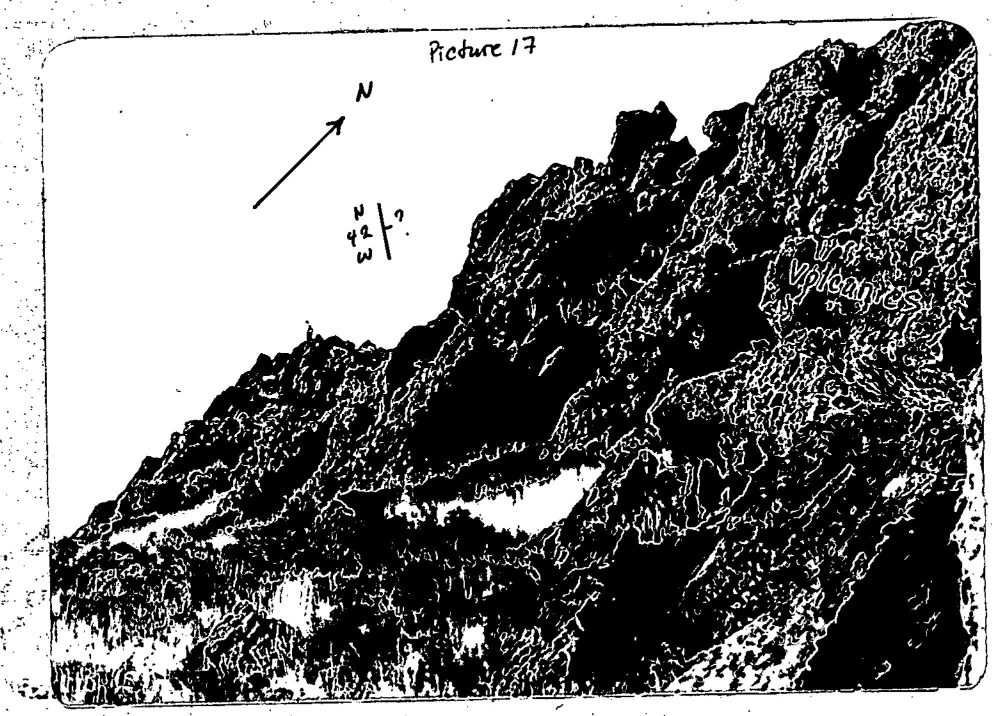


Oriented N31°W Looks SE

P16

Oriented N80°W Looks SE

P17

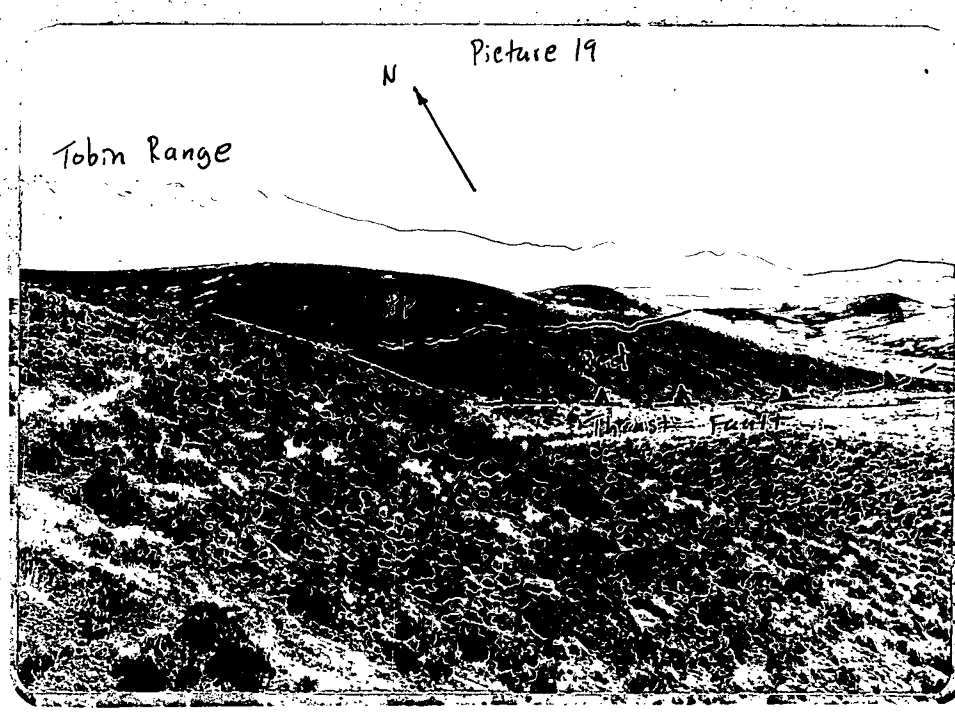


Oriented N42°W Looks NW

P18

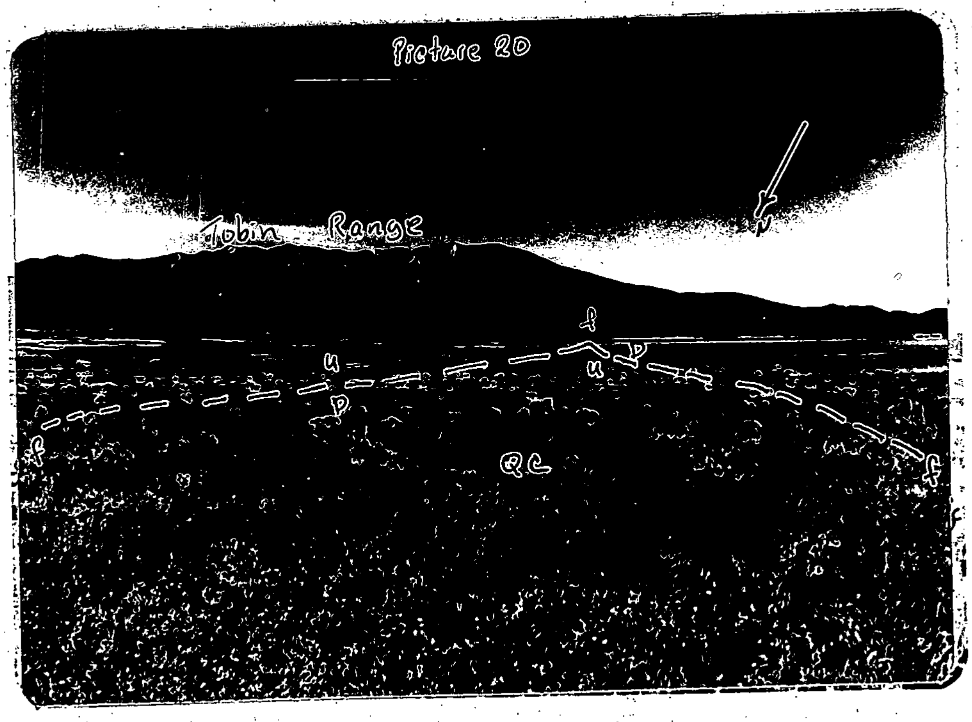
Oriented N30^{o}E Looks NE

P19



Oriented N16^{o}W Looks SE

P20

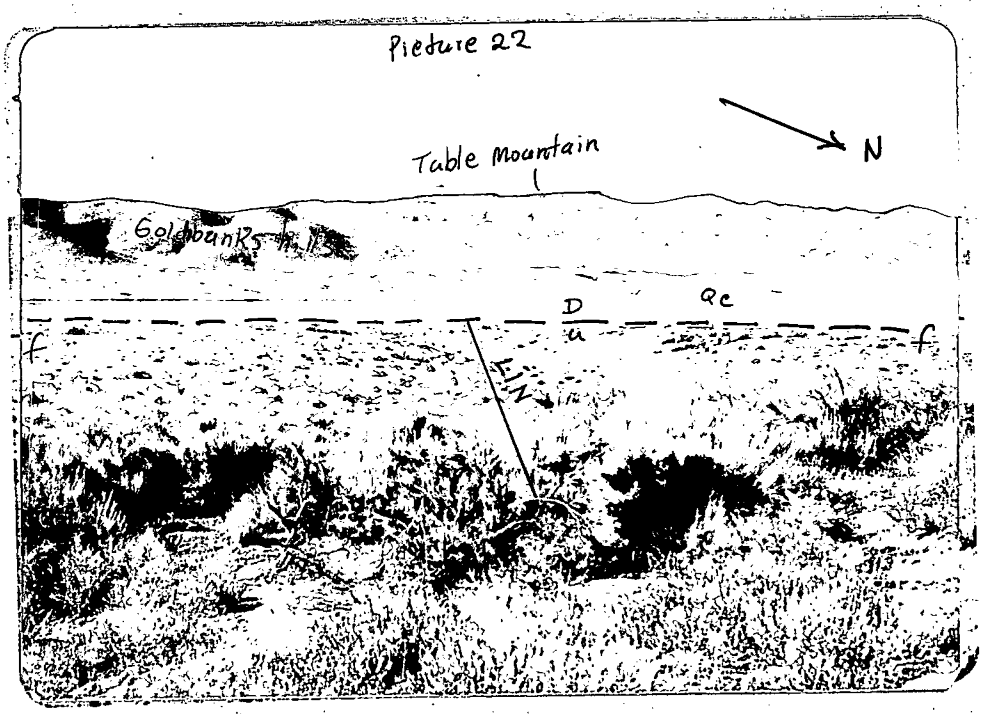


Oriented N19°W Looks SE

P21

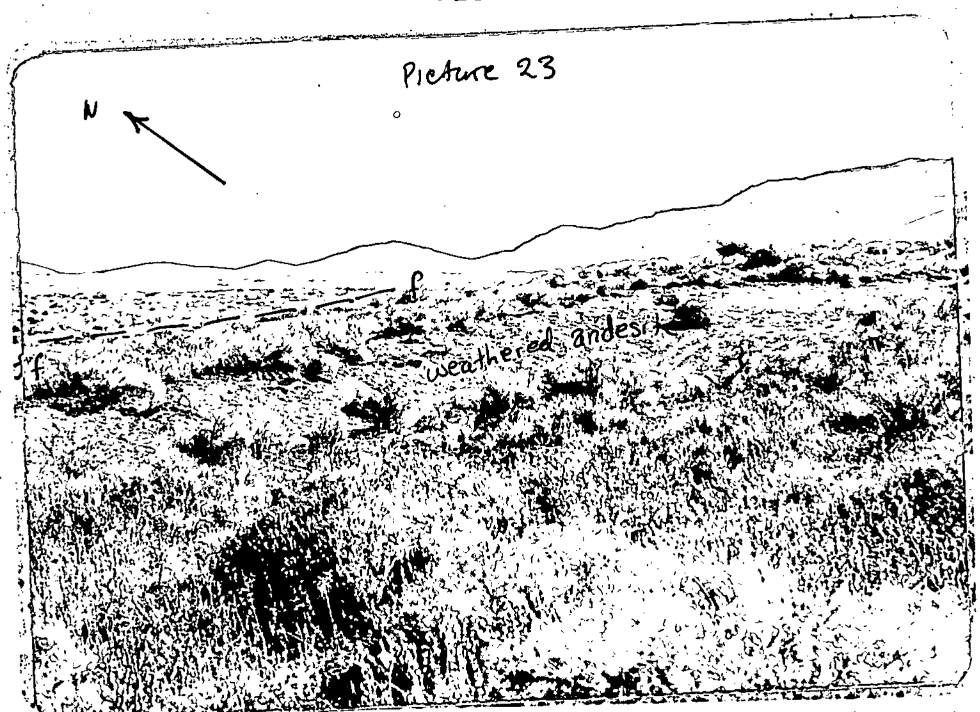
Oriented N65°W Looks SE

P22



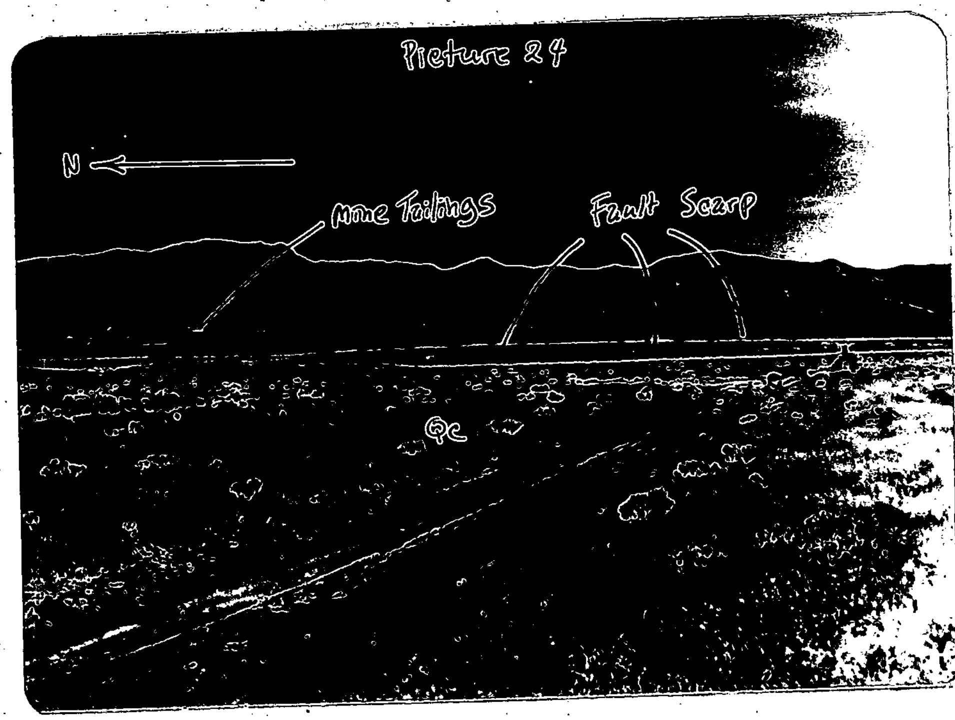
Oriented N71°E Looks SW

P23



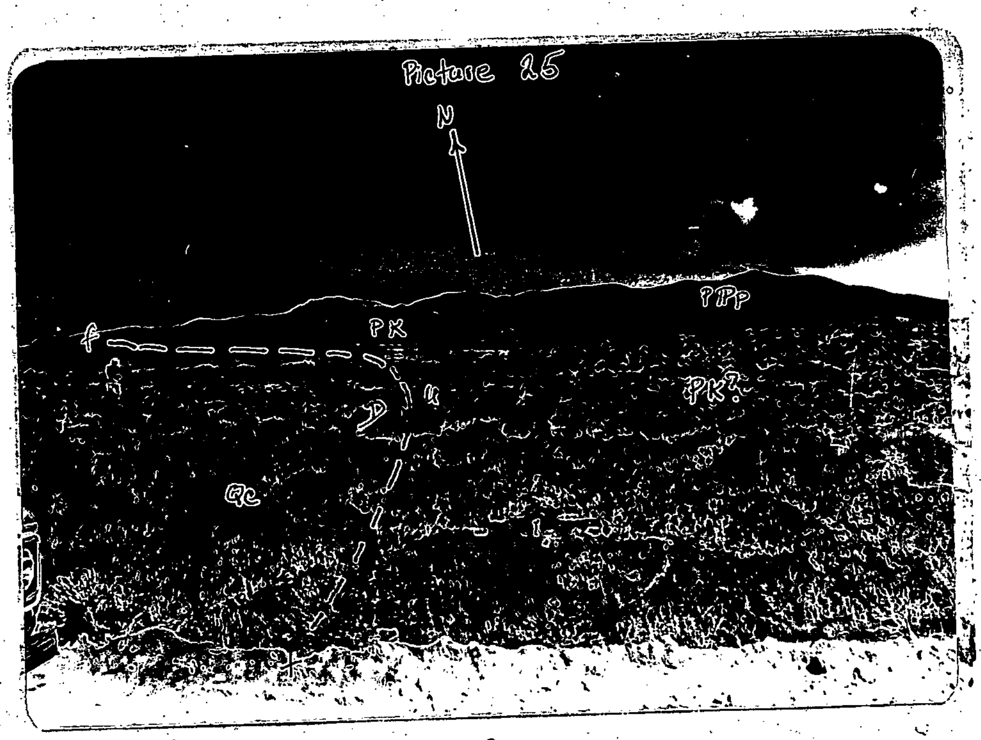
Oriented N55°E Looks NE

P24



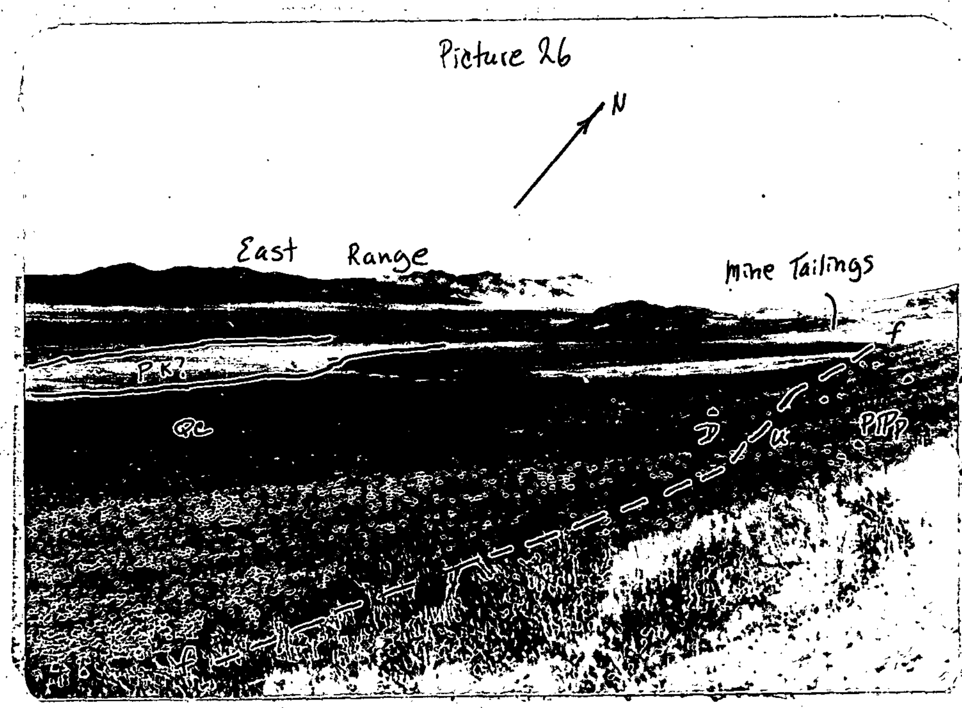
Oriented N86°E Looks NE

P25



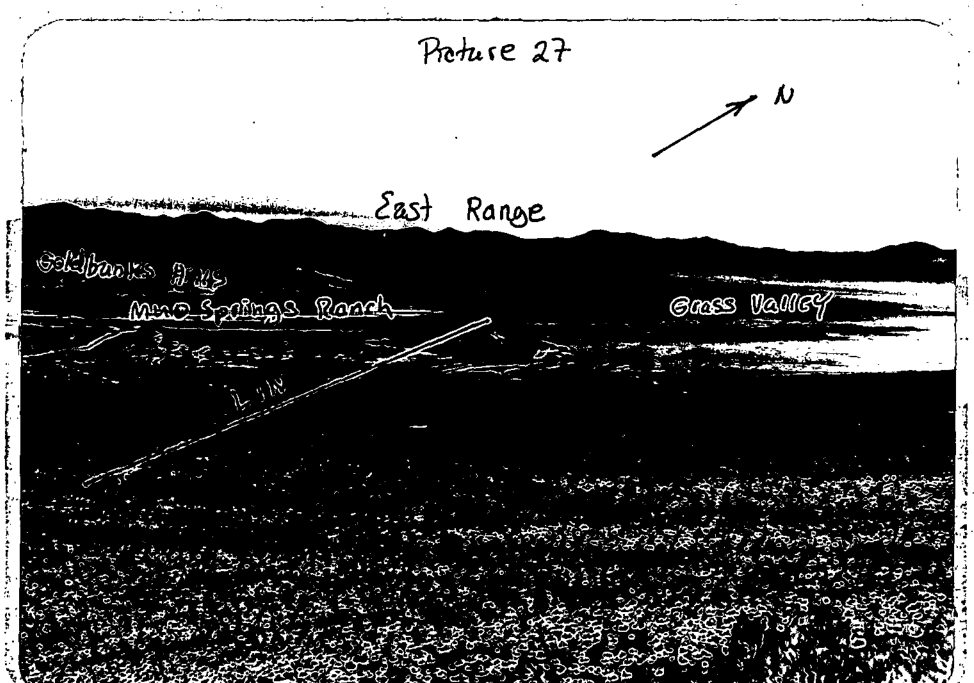
Oriented N4°E Looks NE

P26



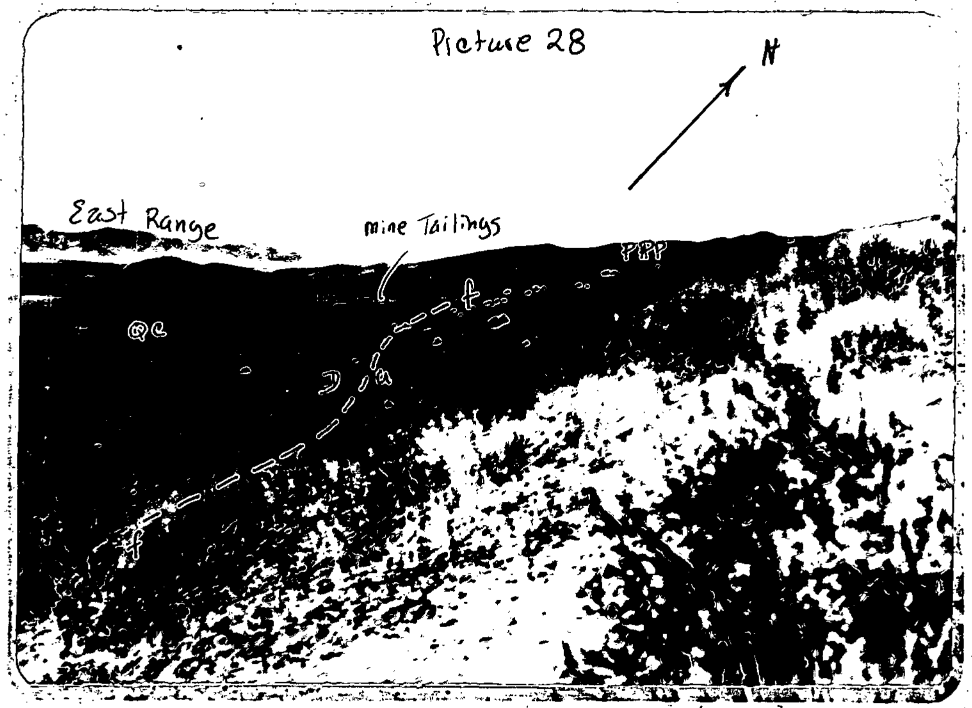
Oriented N45°W Looks NW

P27



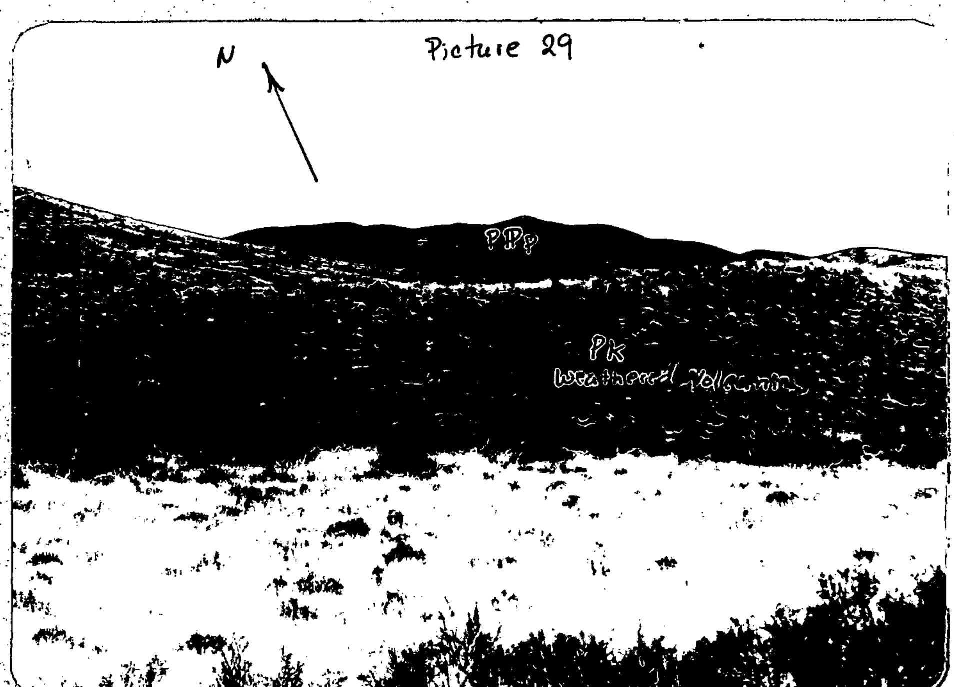
Oriented N72°W Looks NW

P28



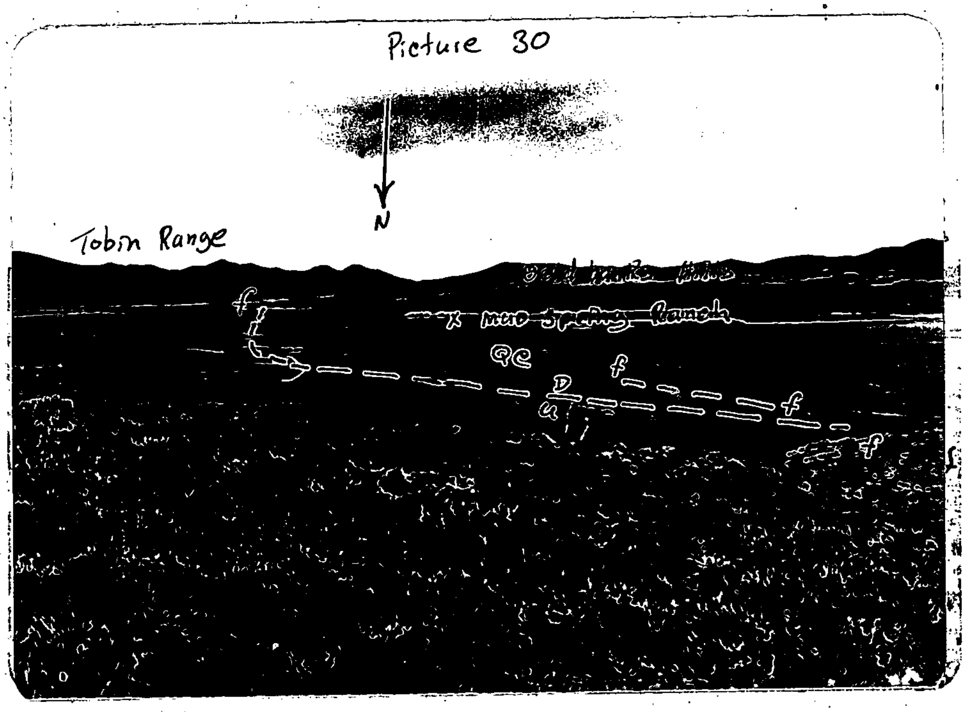
Oriented N30°W Looks NW

P29



Oriented N16°E Looks NE

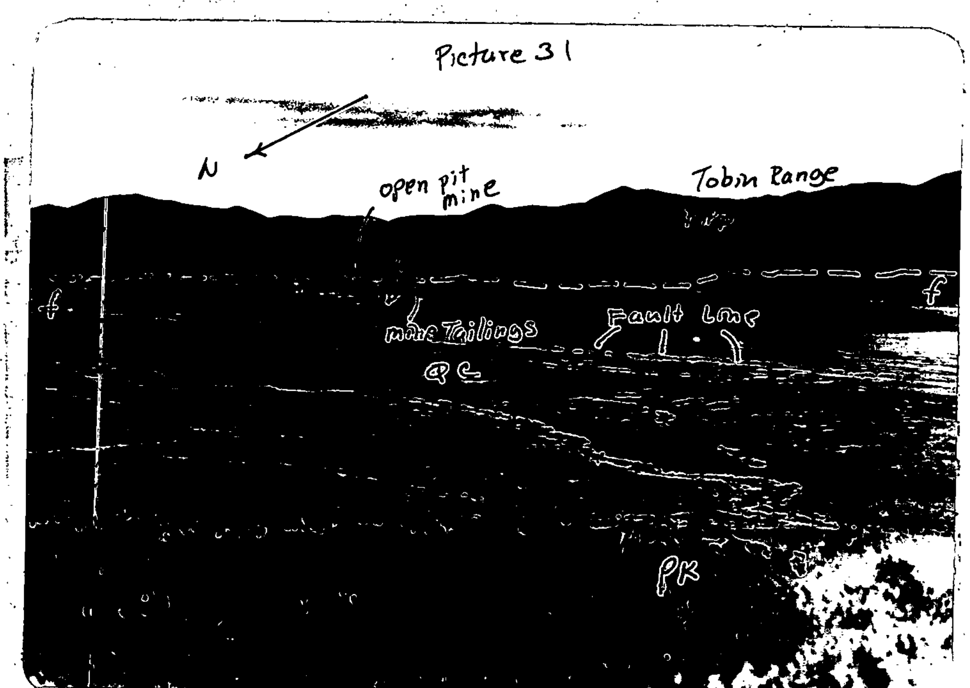
P30



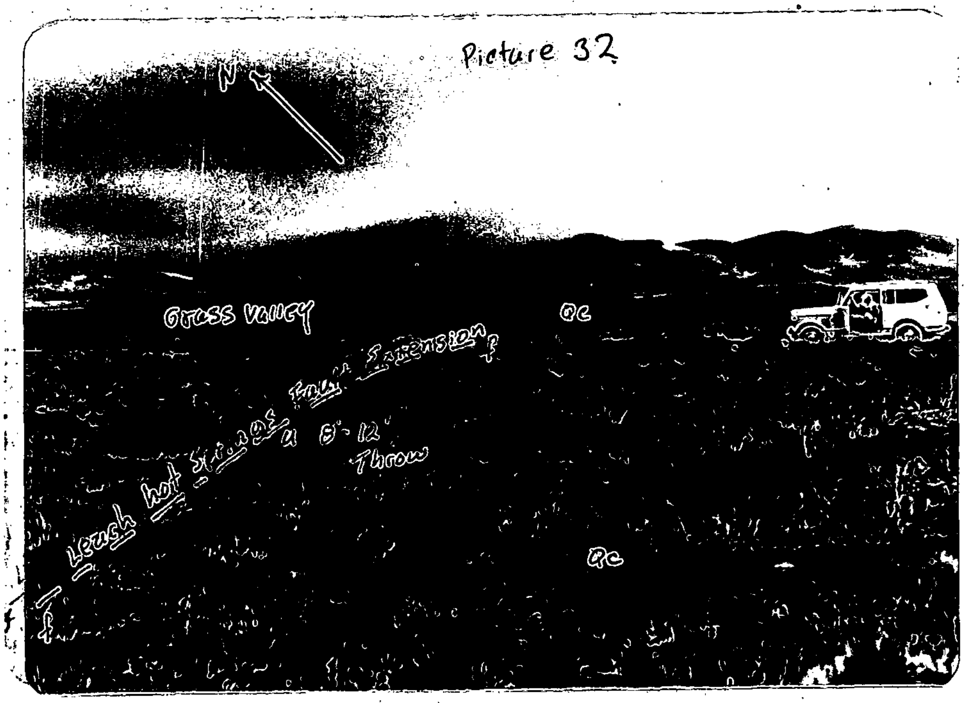
Oriented N2°W Looks SE

P31

Picture 31

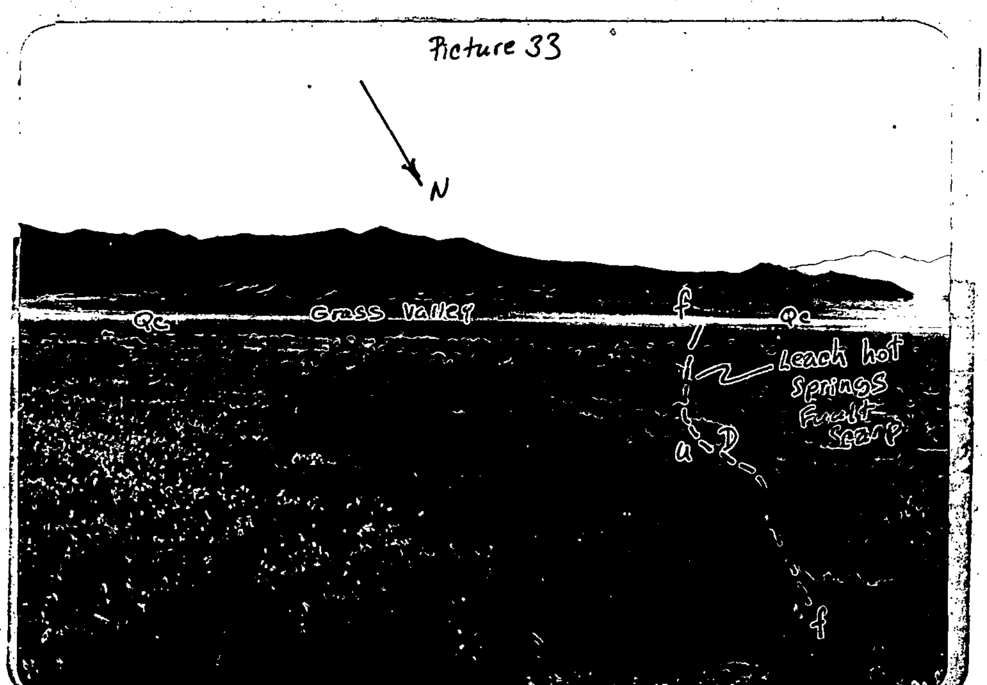


P32



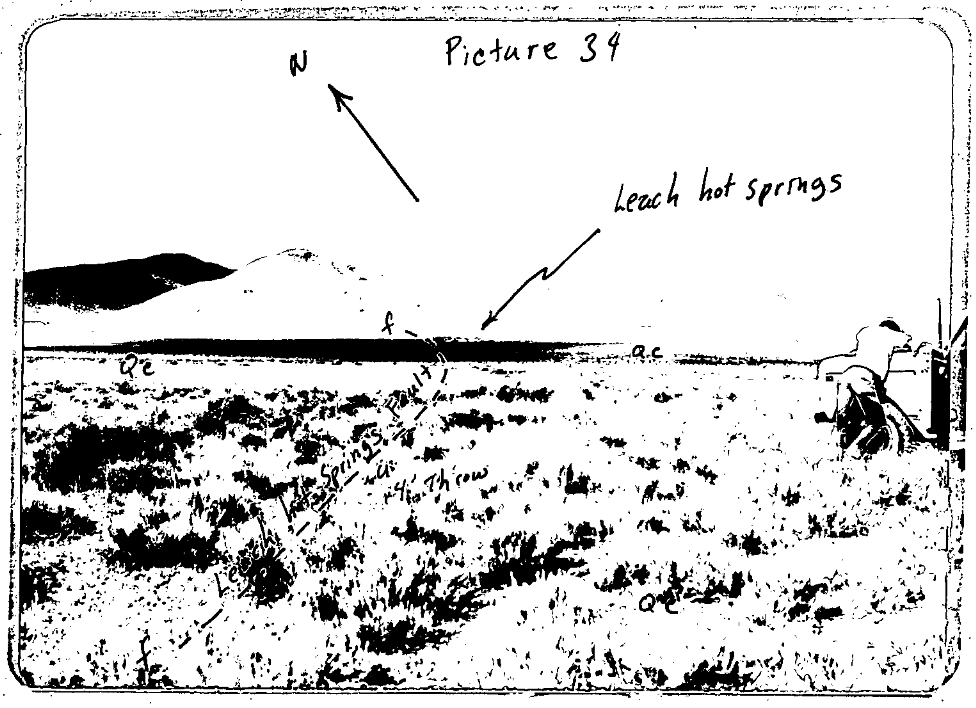
Oriented N50°E Looks NE

P33



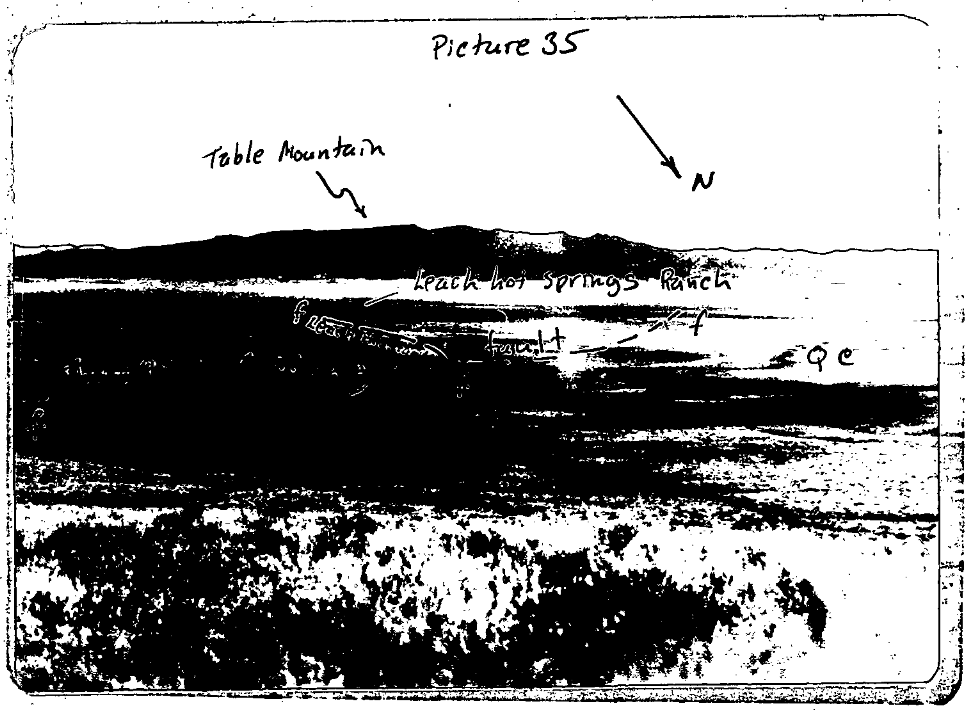
Oriented N40°E Looks SW

P34



Oriented N37°E Looks NE

P35



Oriented N40°E Looks SW

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PHOTOGRAPHS

Landsat Map A

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E-5834-16432-6

Kelsh Plotter Regional Map B

Project G5-VEEV 2-39 through 2-50

Kelsh Plotter Detail Map C

Project AMS 109, 6347-6349

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Infrared NASA JSC 268

Low altitude verticals, NASA JSC April, 1974
numbers 05-007 through 05-0276