DIGITAL FRACTURE ANALYSIS

EL 6/68

NORTHEAST TASMANIA

GEOPHOTO RESOURCES CONSULTANTS
BRISBANE, QUEENSLAND.

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DENVER, COLORADO, U.S.A.

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INTRODUCTION

An attempt has been made to utilise digital fracture analysis in problems relating to exploration of lode, stockwork and placer deposits associated with the Blue Tier Batholith. This method has been used as a regional exploration tool in determining sites of buried reefs and anticlines covered by younger, less disturbed strata in petroleum exploration.

Some facets of the geology of Northeastern Tasmania are such that the techniques may be applied to finding metalliferous target zones. However, in this field and in this district, the study should be considered experimental at this stage.

THEORY AND TECHNIQUES OF DIGITAL FRACTURE ANALYSIS

The concept of the use of geo-fractures to interpret structural anomalies goes back many years. Studies of joint orientation, derived from stress fields produced in structurally deformed rocks are well known. In solution of field problems, detailed joint orientation studies are often too time consuming to use as a broad metalliferous exploration tool over permits of limited tenure.

At the beginning of the twentieth century it became recognised that the surface of the earth also exhibits large scale lineaments in addition to the familiar joint patterns exhibited by rocks at field outcrop scale. One of the early pioneers in this study was William Herbert Hobbs who studied the drainage lineaments of the northeastern U.S. and related these to the regional structure.

A characteristic of the geo-fracture type of lineament is that it can be best viewed from a distance. Their surface expression is too subtle for field mapping on the ground.

The advent of aerial photography made it apparent that when the earth's crust is viewed from a distance many linear patterns can be seen. One of the early workers in interpreting linear patterns as seen on the air photography was D.C. Barton in his study on the linear features of the Gulf Coast area of the United States. Today such studies are being made on satellite photography wherein extremely interesting and sometimes unsuspected regional lineaments and structural features are obvious.

A systematic study on the potential uses of lineaments, as seen on air photographs, to the problem of subsurface structural mapping commenced primarily in Western Canada in the early 1950s. The initial aims of these studies was an attempt to perfect techniques which would indicate the presence of buried subsurface reefs in the Alberta Plains. The technique was only marginally successful due mainly to the inability of adequately processing the data. The major breakthrough in this type of analysis occurred about 5 years ago when digital computer processing techniques were first applied.

In Tasmania the aim has been a test of the value of the method from three aspects :

1) for distinguishing structurally anomalous areas in a complex composite granite batholith by reason of increased density which might result from forceful intrusion;

2) for distinguishing buried cupolas under metasediments of the contact aureole;

3) for distinguishing shallow granite under Cainozoic cover as a lead to placer channels;

4) for interpreting any structural pattern that may be relevant to localisation of gold bearing veins in the Mathinna-Avenue River area.

BASIC PRINCIPLES BEHIND UTILISATION OF FRACTURE ANALYSIS AS AN EXPLORATION TOOL

Forces that stress any solid body will produce a predictable set of related fractures if the forces are of sufficient intensity. The earth revolving about its axis, and in addition moving about the sun, is subjected to forces obeying the standard laws of physics. If the earth were a perfectly uniform sphere or consisted of uniform concentric shells, each shell homogenous in composition, then the stress and strain patterns appearing on the surface would be regular. However, if a lateral discontinuity is present within a shell then such a discontinuity would result in stress differences that would be reflected by a disturbance of the surface strain pattern. By mapping such a disturbance, it would be possible to predict the existence and position of the subsurface discontinuity.

The foregoing is the basic philosophy behind digital fracture analysis. Unfortunately, the near surface crust is extremely complex in its lateral discontinuities because of structural and stratigraphic changes.

As a result, the lineament patterns and their interpretation is not as simple as the ideal case. Nevertheless, it is possible to interpret the patterns provided certain very necessary preliminary steps are taken. These are described more fully in the next section on techniques.

DIGITAL GEOFRACTURE TECHNIQUE

As stated in the previous section, surface crustal lineaments of the type used in geofracture analysis can best be seen on air photographs. The quality of the data is directly related to the quality of the photographs. However, an even more important criteria is that the photographs within the area studied be of uniform tone. This is rarely achieved unless custom flying and processing photography specifically for this purpose is done. It is still possible to use photographs of uneven tone provided this fact is recognized and allowance is made in the processing of the data. This point will be discussed more fully later.

Prior to actual lineament mapping the annotator scans the entire area stereoscopically. This allows the annotator to become familiar with the terrain and cultural features and serves as an orientation for the actual mapping of the lineaments.

The initial mapping of the lineaments is done directly on the air photographs. The photographs are then assembled into a mosaic on which the lineament mapping is completed. If this were not done there would be a tendency to map a greater concentration of lineaments in the centre of each photograph than on the edges. This tendency also applies to the mosaic as a whole and usually there is a fall off in lineament density towards the edges. To counteract this it is essential that an area larger than the actual boundaries of the project be annotated.

In the early studies connected with fracture analysis the lineament plot thus obtained was analysed directly. We now know that this is not satisfactory as there are a variety of reasons which will affect lineament density that are not related to subsurface structural control. Some of these are :

1. Variations in quality and tone of the photographs over the area.

2. Uneven distribution of cultivation. For example ploughed fields versus bush.

3. Any marked changes in topography within the area.

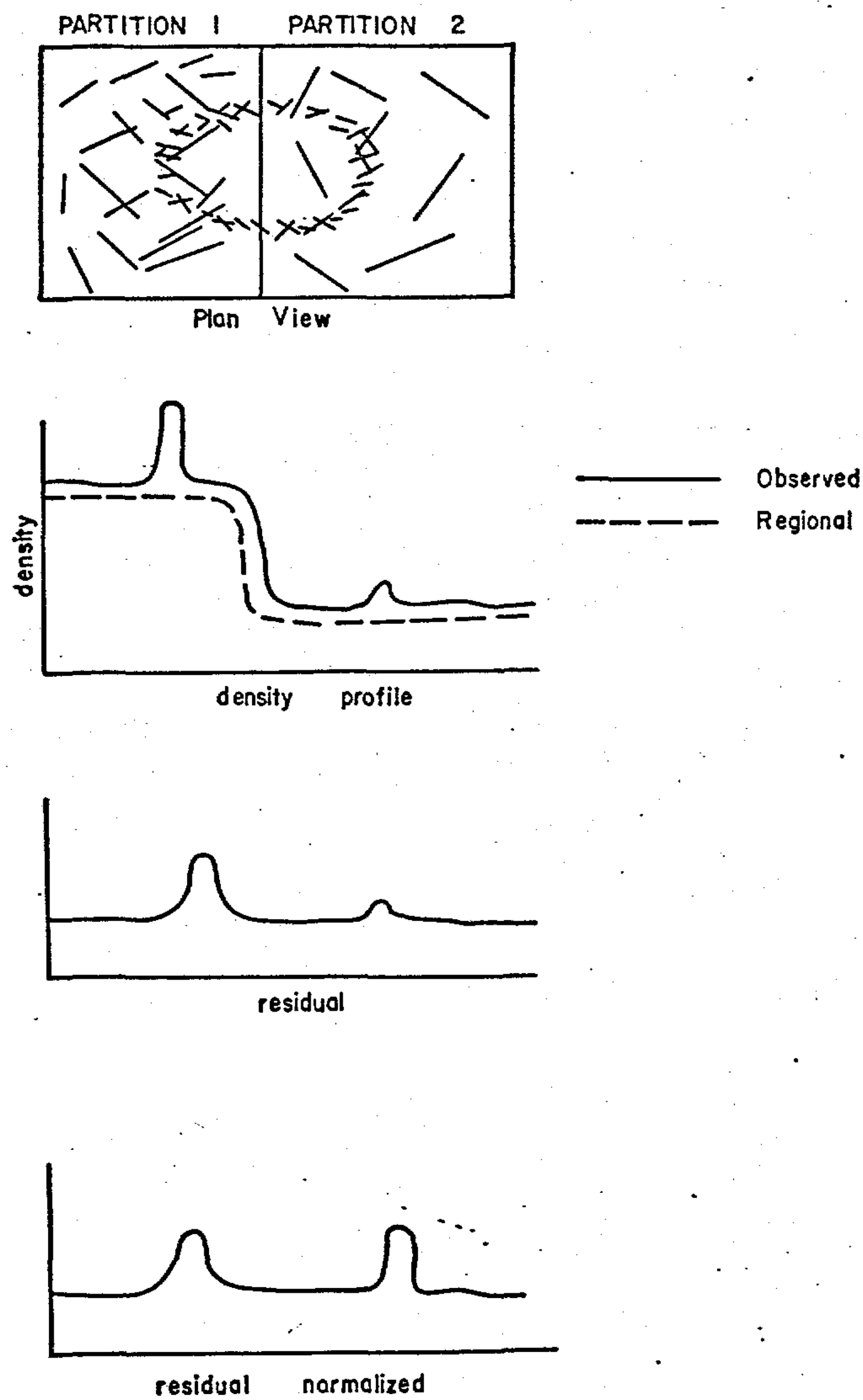
PARTITION 1
PARTITION 2
Plan View
Observed
Regional
density
density profile
residual
residual normalized

Plate 11

4. The style of a particular annotator.

While every effort is made to keep the mapping of the lineaments as objective as possible, certain individuals have the ability to perceive these lineaments to a greater degree than others. This in itself will not affect the analysis provided that a single individual annotates the lineaments for the entire area.

All the above factors will have a direct influence on the density of lineaments mapped. It is readily apparent that these factors in themselves bear no relationship to the structural problem that is being investigated. Therefore, it is necessary to eliminate these affects. Since the advent of computers to this type of analysis, it is now possible to employ a technique known as residualizing to the data prior to the actual processing of the lineaments themselves. Figure 1 is a simplified diagram illustrating the concept involved. At the top of Figure 1 an area can be seen that has two contrasting surface textures. A fracture anomaly is postulated to lie astride this texture boundary. It is apparent that if the difference in surface texture were ignored then the greater dominance of lineaments in partition one versus partition two will tend to obscure the existence of the true anomaly. This fact is indicated in the first graph where the overall greater density in partition one dominates the anomaly over the less dense patterns of partition two.

Using residual processing of the individual partitions the general background density of each partition is brought to the same level thus resulting in a true picture of the anomaly without the surface texture affect.

After the data has been partitioned and normalized, a raw density plot of all the fractures is made. Initially this was accomplished manually by simply gridding off the area involved and counting the number of lineaments within each square. The number was then placed in the square and upon completion the squares were manually contoured. A more sophisticated technique of overlapping pentagons and running averages is now used. These pentagons are termed cells and the size of the cell will determine the degree of complexity of the contouring.

The raw data plot by itself is of limited use and is now only used as an intermediate step in the interpretation. A trend surface analysis is carried out on the raw data density plot. A simple example would be a first order trend surface analysis.

A first order trend surface is defined as that plane which best fits all the points within the area. Once this plane is established it is subtracted from the existing raw data density contour map and a first order residual contour map is produced.

Similar techniques are used in processing gravity data where the main purpose is to remove regional effects. The same principle applies to digital fracture analysis where the purpose of the residual maps is to remove the regional (normal) stress pattern leaving a residual map which should show the lineament distribution caused by local subsurface structural features. Unfortunately this cannot be done precisely as the trend surface analysis is still a somewhat empirical technique. However, sufficient work has been done on data from many districts over the last 5 years to indicate that a fourth order trend surface residual map is the best one in determining local subsurface structural conditions.

In addition to the trend surface analyses of the total density data, it is possible to analyse other parameters. The three main ones are :

1. Directional plots.

   In these cases a certain azimuth angle is selected and only those lineaments falling within a predetermined angular arc range are analysed.

2. Lineament lengths plots.

In this situation only lineaments over or under a certain length are considered while the others are screened out. It is possible to combine both a directional plot and a length plot.

3. Intersection Plots.

In this instance only the number of lineaments intersections are analysed.

These specialized plots are generally not used in the initial exploration analysis. Their value lies when a specific problem within a known framework has to be solved.

PRACTICAL INTERPRETATION

The basic concept in interpreting the residual data is that of the fracture halo indicating a subsurface lateral density contrast. This concept is illustrated in a simplified form on the block diagram of Plate 2.

The particular block diagram illustrates a reef build up; however, the same conditions would apply to a buried anticlinal feature or intrusive block under younger cover. The aspect of forceful intrusion of buried magma into existing crystalline or sedimentary cover is under study.

The actual mechanism responsible for the propagation of these lineaments from a deep seated structure through younger strata to the surface has not been fully established. A number of theories have been put forth. The most likely explanation utilizes the micro-seismic activity of the earth's crust which is continually in motion as a mechanism whereby the strain focus existing at the point of maximum density gradient is transmitted to the surface by these micro tremors.

The halo concept relating to buried structures envisages the maximum strain to be present along the flanks of a structure with a relative minima along the crest. That such a distribution actually exists is borne out by numerous studies of joint distribution on folds as well as studies based on deformation boxes in the laboratory.

PRELIMINARY INTERPRETATION AND RESULTS

The quality of the photography used in this interpretation is very marginal. Due to the pressure of time it was decided to use the data obtained from these exceedingly uneven prints. Arrangements have been concluded with the Tasmania Lands Department to refly the entire area of EL6/68 in order to have better primary material to work with.

The maps presented with this report should be considered preliminary and will be redone upon receipt of the custom flown photography.

The basic structural interpretation arising out of the lineament study is one of wrench fault tectonics. The theoretical strain ellipsoid orientation used in this interpretation is shown on the Dorset River lineament. Applying this interpretation to the other postulated faults in the area, a series of possible tension areas is indicated. These tension areas may have some significance in relation to ore emplacement.

Those anomalies arising entirely out of the geo-fracture study are shaded in red . Complete interpretation of the significance of the geo-fracture anomalies will have to await considerable ground follow up work.

The anomaly areas shaded in green and labeled geologic and/or geomorphic anomalies are based primarily on anomalous stream configurations and tonal patterns. Because of the poor tonal quality of the photographs the reliability of tonal patterns is questionable. As is the case with the geofracture anomalies these geologic and geomorphic anomalies will have to be closely scrutinized on the ground.

The other major interpretative item on the preliminary map are the faults . The reliability of these is considered good with the only questionable part being the existence and direction of the postulated transcurrent movement. As is the case with all faults mapped by this technique , they may not represent a single fault plane, but are more likely to be the reflection of a faultzone. Such a zone would probably be discontinuous and therefore may not exist along the entire length of the lineament as mapped.

At the present time , the preliminary results of the geo-fracture analysis are being correlated with the gamma ray spectrometer survey and field interpretations.

Respectfully submitted,

GEOPHOTO RESOURCES CONSULTANTS

Forwarded by but not written by

J.H. Rattigan.

J.H. RATTIGAN
Minerals Exploration Manager.

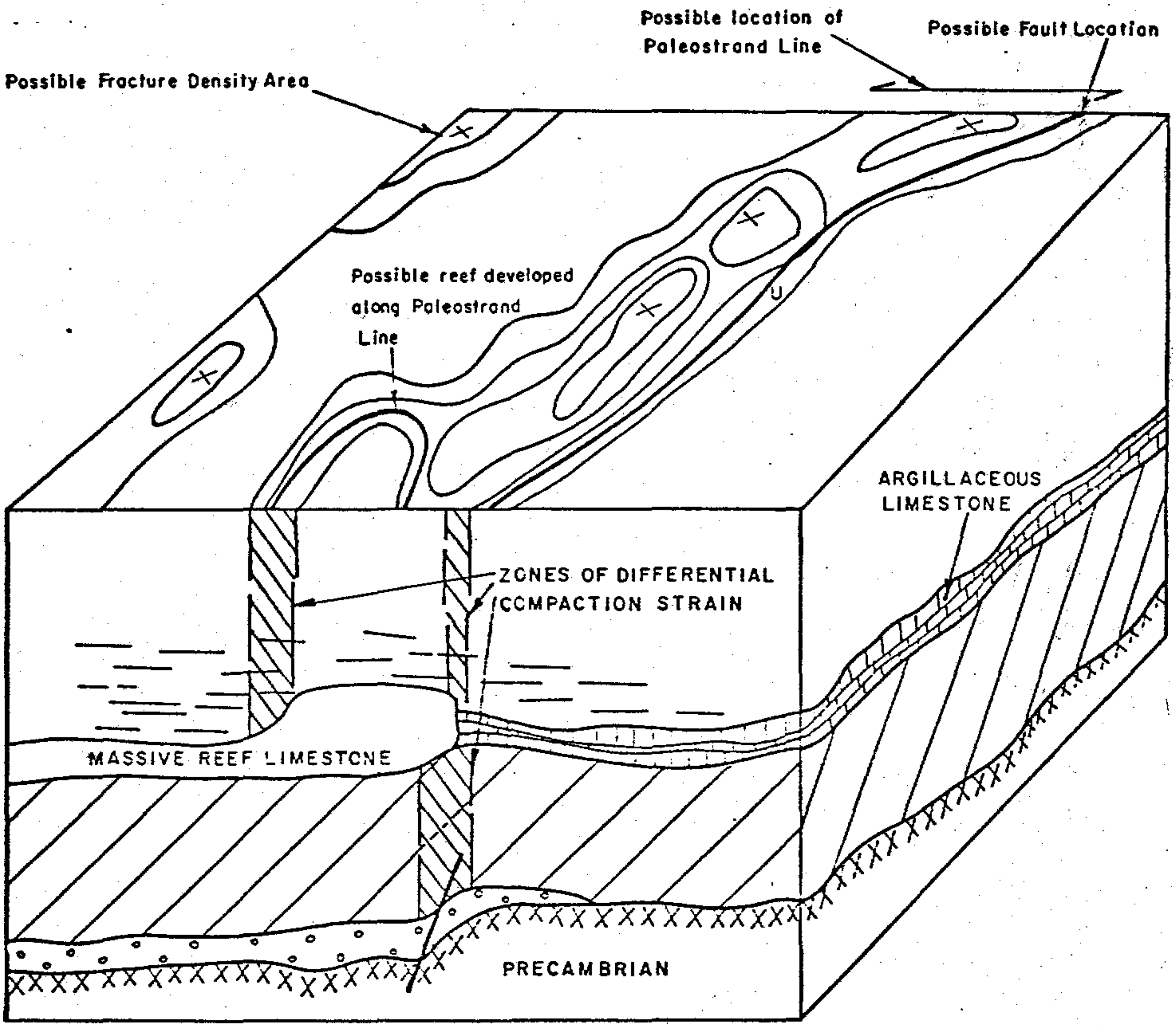
Possible location of
Paleostrand Line
Possible Fault Location
Possible Fracture Density Area
Possible reef developed
along Paleostrand
Line
ARGILLACEOUS
LIMESTONE
ZONES OF DIFFERENTIAL
COMPACTION STRAIN
MASSIVE REEF LIMESTONE
PRECAMBRIAN

Plate 2


1803
NE Corner
Project Area
GEOLOGIC AND/OR GEOMORPHIC ANOMALY
GEOFRACTURE ANOMALY
TENSION
GEOLOGIC AND/OR GEOMORPHIC ANOMALY
TENSION
GEOFRACTURE ANOMALY
GEOLOGIC AND/OR GEOMORPHIC ANOMALY
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GEOLOGIC AND/OR GEOMORPHIC ANOMALY
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GEOFRACTURE ANOMALY
GEOFRACTURE ANOMALY
TENSION
GEOFRACTURE ANOMALY?
TENSION
DORSET RIVER LINEAMENT
GEOLOGIC AND/OR GEOMORPHIC ANOMALY
GEOLOGIC AND/OR GEOMORPHIC ANOMALY
GEOFRACTURE ANOMALY
GEOFRACTURE ANOMALY?
TENSION?
GEOFRACTURE ANOMALY?
GEOFRACTURE ANOMALY?
GEOFRACTURE ANOMALY?
69-585
SW CORNER
PROJECT AREA
INTERPRETIVE SOLUTION MAP BASED ON LEFT-LATERAL MOVEMENT ON DORSET RIVER LINEAMENT DEFINING STRESS-STRAIN RELATIONS ILLUSTRATED BY STRAIN ELLIPSOID DIAGRAM.
054018
1803
PRELIMINARY COPY

1798

69-585

~~QUAD~~ 1-2000'

PROJECT NO 4692

7 -30-69

1 50000

NUMBER OF FRACTURES = 5234

0 TO 180 DEGREES

5 cm

054019

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1798

SEND TO : GEOPHOTO
2149 S. H
DENVER, C

1799

69-585

~~QUAD~~ 4-20,000'

PROJECT NO 4692

7 -30-69

1 50000

NUMBER OF FRACTURES = 902

0 TO 180 DEGREES

054020

5 cm

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1799

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QUAD 2

PROJECT NO 4692

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NUMBER OF FRACTURES = 11703

0 TO 180 DEGREES

TOTAL FRACTURES

054021

5 cm

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1797

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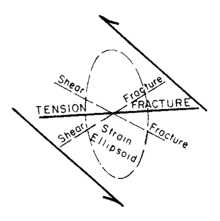
DENVER.



69-585

QUAD 1-2000'

PROJECT NO 4692

7-30-69

1 50000

NUMBER OF FRACTURES = 8239

55 TO 65 DEGREES 85 TO 95 ; 115 TO 125 ; DEGREES

Shear Tension Shear

054022

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1800

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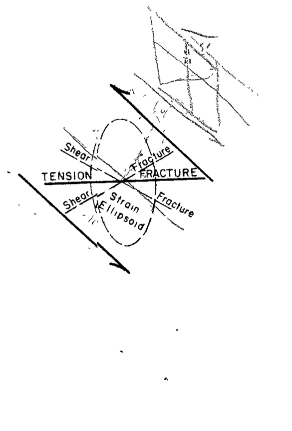
DENVER, COLORADO

1801



69-585

QUAD 2

PROJECT NO 4692

7 -30-69

1 50000

NUMBER OF FRACTURES = 2139

55 TO 65 ; 85 TO 95 ; 115 TO 125 ; DEGREES

Shear Tension Shear

054023

5 cm

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1801

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1802

69-5815

QUAD 4-20,000'

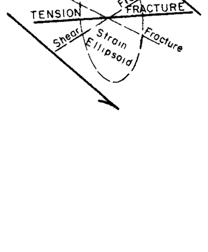
PROJECT NO 4692

7 -30-69

054024

1 50000

NUMBER OF FRACTURES = 3029



95 TO 890 DEGREES0 95 ; 115 TO 125 ; DEGREES

Shear Tension Shear

5 cm

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1802

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