(7) Unit S_7

This unit is distributed east of S , outside of the survey area. It is characterized by medium resistance to erosion, coarse dendritic drainage, and flat ridge topography. Boundary between Unit S_6 and Unit S_7 is sharply defined by a steep cliff. Bedding strike is clearly recognizable. It is interpreted to consist of sedimentary rocks. According to the previous geological map, it is a Triassic sandstone formation.

(8) Unit S_8

This unit is distributed along Sungai Menyke in the central eastern part of the survey area. Drainage is characterized by low density and meander pattern of streams. Weak resistance to erosion and flat topped ridges characterise the topography. Accordingly, this unit is identified as sedimentary rocks. Previous geological map considered it a Cretaceous sandstone formation.

(9) Unit Q

This unit is distributed principally along big rivers in the area. It consists of terrace and alluvium deposits.

2-1-2 Igneous Rocks

(1) Unit G_1

This unit is distributed in the central and southern parts of in the survey area. It is characterized by weak resistance to erosion, dense dendritic drainage pattern, low relief and round shaped ridges. Trees are high and vegetation is dense. According to the old geological map, it is composed of granitic rock.

(2) Unit G_2

This unit is situated in the central and northern parts of investigated area. This unit has high resistance, steep topography and dense dendritic drainage pattern. Though the old geological map shows Unit G_1 and Unit G_2 as the same granitic rock, in this survey the area divided into two different granits, on the basis of different photogeological feature and pattern.

(3) Unit G_3

This unit is distributed in Bengkayang area as a small scale intrusive body. It is topographically characterized by high resistance to erosion, steep coned ridge, and dense radial drainage pattern. Based on these characteristics, this granitic rock is different from Unit G_1 and Unit G_2, and is probably a younger intrusive.

(4) Unit D_1

This unit is distributed in the central and southern part of the survey area. It is topographically characterized by coarse radial drainage pattern, very high resistance and steep ridges. This unit is quartz diorite or diorite, according to the previous geological map.

(5) Unit D_2

This unit is distributed in the west central part of the interpreted area. It is topographically characterized by coarse radial or dendritic drainage pattern, high resistance to erosion, and steep mountains. According to the old geological map, this unit is regarded as quartz porphyry, the same as Unit D_1. But in this study it is divided from D_1, because it is distributed in a separated area from Unit D_1.

(6) Unit A_1

This unit is distributed in the central part of the survey area. It is characterized by coarse dendritic drainage pattern, high resistance to erosion, round-shaped mountains. It is interpreted as andesite.

(7) Unit A_2

This unit is distributed in the central part of the photo geological interpretation area. It is characterized by parallel or sub parallel drainage pattern, medium resistance to erosion, and gently sloping mountains. This unit has local lineaments, probably due to bedding. It is interpreted as andestic pyroclastic rock, and the old geological map described it as andesite.

2-2 Geological Structure

Large scale fold and fault structures have not been observed on airphotographs, but lineaments, suggesting small scale folding and faulting, are evident in many places. Lineaments interpreted as folding structure dipping generally S and SW are observed in Unit S_2 (Triassic sedimentary rock). In the area of Bengkayang, there are small scale syncline and anticline structures.

In Unit S_4, Unit S_5, Unit S_6, and Uni S_7, lineaments striking N - S, dipping gently E, are also present.

Lineaments supposed to be faults or joints are present in the whole area. The predominant lineaments in the area trend NNW - SSE and are comparatively large scale. The next most common are lineaments striking N - S and NE - SW. Lineaments trending NNW - SSE and supposed to be faults are especially observable in Unit G_2, D_1 and D_2 as faults.

PART VII

CONCLUSIONS

CHAPTER 1 SURVEY RESULT SUMMARY

The geological, geochemical and geophysical surveys conducted in the project area (1,500 km^2) clarified the geology and mineralization of the area. The stratigraphy and periods of igneous activities are clear now and better understanding of their relations with mineralization has been reached and in this chapter, the geology and mineralization that have been clarified through this survey are summarized.

1. The project area can be divided into steps of the following geological episodes as the result of the latest geological survey.

   (1) Thick fylish type sedimentary rocks deposited during the late Triassic to early Jurassic periods

   (2) Extrusion of andesitic and dacitic volcanic rocks and deposition of their pyroclastic rocks of the late Jurassic age

   (3) Intrusion of granodioritic batholith during the early to middle Cretaceous age

   (4) Intrusion of the Tertiary dacitic and tonalitic rocks and deposition of dacitic pyroclastic rocks.

   The upper Triassic to lower Jurassic sedimentary rock stratum (Bengkayang Group) is a fylish type sedimentary rock stratum that started with sedimentation of sandstones accompanied with some acidic tuff and consists of alternated beds of sandstones, siltstones and mudstones. Two species of ammonite belonging to the lower Jurassic system Lias Toarcian stage were discovered in the upper stratum (Sungairbetung Formation) of this Group. These ammonite fossils are related with those of the Tethys fauna and the discovery is very important for correlation with the Himalayan to Tethys system from Europe, southern part of the Indochina Peninsular and Japan (Toyora Group).

Andesitic and dacitic lavas and dacitic pyroclastic rocks (Jirak and Belang Formations) are widely distributed in the area formed during the late Jurassic. A unconformable relation can be assumed between these Formations and the Bengkayang Formation because of existent of conglomerate (basal conglomerate) in some parts. Also, these Formations received contact metamorphism from intrusion of the Cretaceous granodiorite and are distributed as roof pendant on the bathalith.

The volcanic rock Formation (Matan Complex : Bemmelen 1949) that is widely distributed in the south (southwest Kalimantan) of the Schwaner mountain range used to be correlated with the upper Triassic, but it may be correlated with the Jirak and Belango Formations which are determined to be the Jurassic through this survey. Also, the Matan Complex may have a relation of volcanic rocks being erupted and plutonic rock intrusion and these points must be studied further.

The batholithic G. Raya and G. Sebiawak granodiorites that are widely distributed in the middle to south parts of the survey area have intruded into the Jirak and Belango Formations giving thermal alteration (sericitization, silicification, epidotization and andalusitization). The batholith mainly consists of tonalite and granodiorite and quartz diorite stocks, and granite dykes are recognized in the batholith. The K-Ar absolute age measurement indicates that the tonalitic granodioritic batholith is 124 m.y. to 103 m.y. old and the quartz diorite stocks are 98 to 95 m.y., which means these rocks intruded in the early to middle Cretaceous age.

As to the younger igneous activities, the Sirih and Banyi tonalitic rocks have intruded into the G. Bawang mountain area, Bengkayang area and Senakin-Pahuman area as stocks. The tolanite is determined to be 27 to 20 m.y. through the K-Ar absolute age measurement, indicating intrusion timing of the Oligocene to early Miocene of the Tertiary. Prior to the tonalite intrusion, intrusion of the dacite (51 m.y. by the K-Ar method) and associated deposition of pyroclastic rocks (Serantak dacitic pyroclastic rocks) occurred. These can be regarded as younger igneous activities that consistently took place.

The Sijangku quartz diorite, which was regarded to be younger granitic rocks, and the G. Raya granodiorite (different type rock from the G. Raya granodiorite of the project area and called by T. Suhanda) among the G. Ibu granitic rocks that is distributed in the eastern Singkawang area, are both determined to be 30 m.y. through the K-Ar method. This confirms that the both made the intrusion during the younger igneous activities, the same as the Sirih and Banyi tonalite.

All granitic rocks formed by igneous activities during the Cretaceous to the Tertiary Miocene are of calc-alkali rock series and they can be classified as the magnetite series granitic rocks that are generally accompanied by the porhyry copper deposit according to the classification by the opaque mineral examination under microscope.

2. West Kalimantan, including the project area, is situated in the Cretaceous Magmatic Arc that extends from the south China through southern part of the Indochina Peninsular up to West and Central Kalimantan, and in the southern area of the Lupar chert-ophiolite zone (south margine of the Tertiary northwest Borneo syncline) that lies along the boundary between Kalimantan and Malaysian Sarawak. Accordingly, the Cretaceous granitic batholith is affected by the magmatic activities and the intrusion direction is in the WNW-ESE direction. Also, the older structures (anticlinal and synclinal axes) of the Bengkayan and Belango Formations are in the WNW-ESE direction.

The anticlinal axis of dome structure and faults caused by intrusion of the younger igneous rocks (Sirih tonalite) and the andesite intruding into these are in the NNW-SSE direction and faults of the same system are observable in the tonalite area of

Senakin to Pahuman, and these structures are considered to have been formed by the younger igneous activities. Also, the Banyi tonalite has intruded into the contact part between the G. Raya granodiorite and older sedimentary rock stratum (Bengkayang Formation) and a tectonic line is assumed. Another conspicuous fault zone having the ENE-WSW direction is recognized in the contact part between the G. Raya granodiorite and G. Sebiawak granodiorite.

3. The following mineralizations are recognized in the project area:

(1) (Chalcopyrite)-molybdenite quartz veins (Takap, Sirih and Kunylt)

(2) Mineralization zones consisting of tourmaline, chalcopyrite-(molybdenite), pyrite dissemination and gold (Banyi and Panji)

(3) Gold bearing chalcopyrite-pyrrhotite deposits (Serantak)

(4) Gold-silver bearing chalcopyrite-sphalerite-arsenopyrite vein deposit (Selakean)

(5) Placer gold deposits

(6) Manganese ore deposits (Sasan)

In addition, pyrite dissemination areas accompanied with silicification and argilization are recognized in many places.

Among these mineralizations, the Selakean gold-silver bearing chalcopyrite-sphalerite-arsenopyrite vein deposit can be considered to be mineralization caused by intrusion of the G. Raya granodiorite. The other mineralizations are caused by acidic plutonic to hypabyssal igneous activities and volcanic activities, that is, the Serantak dacite and the Sirih and Banyi tonalite of the younger igenous activities (late Cretaceous to the early Tertiary Miocene).

Distribution of placer gold was found in the neighborhood of the abovementioned mineralization area through the placer gold panning prospecting on sediments of main rivers and this has proven that placer gold panning prospecting is useful in exploration of mineralization zones.

4. In the Project area existance of tectonic lines into which the Banyi tonalite has intruded along the G. Raya granodiorite, the NEN-SWS fault zone along the boundary between the G. Raya and G. Sebiawak granodiorite and the fault zone in the neighborhood of Darit, and the G. Raya granodiorite seems to have been lifted up by block movement. Thus, distribution of the Belango Formation roof pendant is fewer in the G. Raya granodiorite area than in the G. Sebiawak granodiorite area. Less mineralization in the G. Raya granodiorite area is probably caused by exposure of the deep part of the rock.

5. Resulting from the geochemical reconnaissance on stream sediments (Samples were collected at a rate of 0.8 sample per square kilometer) and analysis of pathfinder elements of copper, molybdenum, zinc and lead), 8 or more anomalous areas were found. In all these areas, mineralization zone or indication were recognized through geological survey and this confirmed that geochemical reconnaissance on stream sediments is an effective exploration method. Four promising areas of Serantak 15 km^2, Sanyi 35 km^2, Selakean 6 km^2 and Panji 20 km^2 were selected for detailed survey based on the reconnaissance survey results. Geochemical survey conducted on the soil of these areas (samples were collected at a rate of 3 to 5 per square kilometer and one sample per 200 meter along the IP survey line) resulted in good coincidence with the copper and molybdenum anomalies and mineralizations. Therefore, the geochemical survey method on soil is an effective exploration method for determination of the mineralization range in the project area.

6. Anomalous zone related to mineralization was discovered in seven places by the geophysical survey. From the result of quantitative analysis using a computer simulation, the anamalies were interpreted as reflection of dissemination zones existing in the surface parts of granodiorite.

CHAPTER 2 CONCLUSIONS

The metallic mineral exploration survey for gold, copper, molybdenum and others distributed in the northern marginal area of the Cretaceous granitic batholith of West Kalimantan was conducted for 3 years from 1979 to 1981. Conclusions of the survey are outlined in the following.

1. The survey revealed the geology, geological stratigraphy, period of igneous activities and characteristics of granite, especially the stratigraphy of the early Mesozoic sedimentary rocks. Also clarified through the survey is the intrusion period of the Cretaceous granitic batholith and intrusive rocks. The relationship between the volcanic rocks and pyroclastic rocks which were extruded and deposited widely during the middle to late Jurassic and the Cretaceous granite is not clarified yet and study of it is very much desired.

   The survey results should be important basic informations for future exploration of mineral deposits in Kalimantan.

2. A number of gold, copper, molybdenum, lead, and zink mineralized zones have been found in the project area, and it was clarified that these mineralized zones have close relationship with younger igneous activities in the early Tertiary. The relationship has also been proven through the integrated geological survey for metallic mineral resources in Central Kalimantan which was conducted from 1974 to 1978 and age determination measurement conducted on G. Ibu granitic rocks. For metallic mineral resources survey in the west to central Kalimantan area, the relationship between mineralization and younger igneous activities must be clarified based on the survey results of this project.

3. In Kalimantan area, in order to prospect and exploration of mineralizations related with younger intrusions, geochemical survey and placer gold panning prospecting on stream sediments, conducted simultaneously with geological survey, are effective in discovering mineralized zones in a vast area. Also, geochemical on soil and geophysical surveys conducted simultaneously and along with detailed geological survey is a very effective exploration method of distribution range and grade of mineralized zones selected through reconnaissance.

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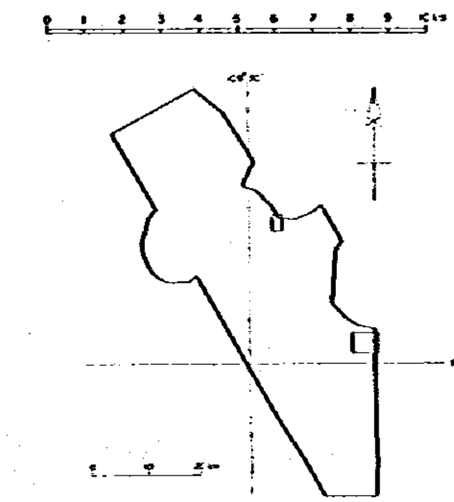
PL 1

METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY
— DIRECTORATE OF MINERAL RESOURCES
DIRECTORATE GENERAL OF MINES
MINISTRY OF MINES AND ENERGY
REPUBLIC OF INDONESIA

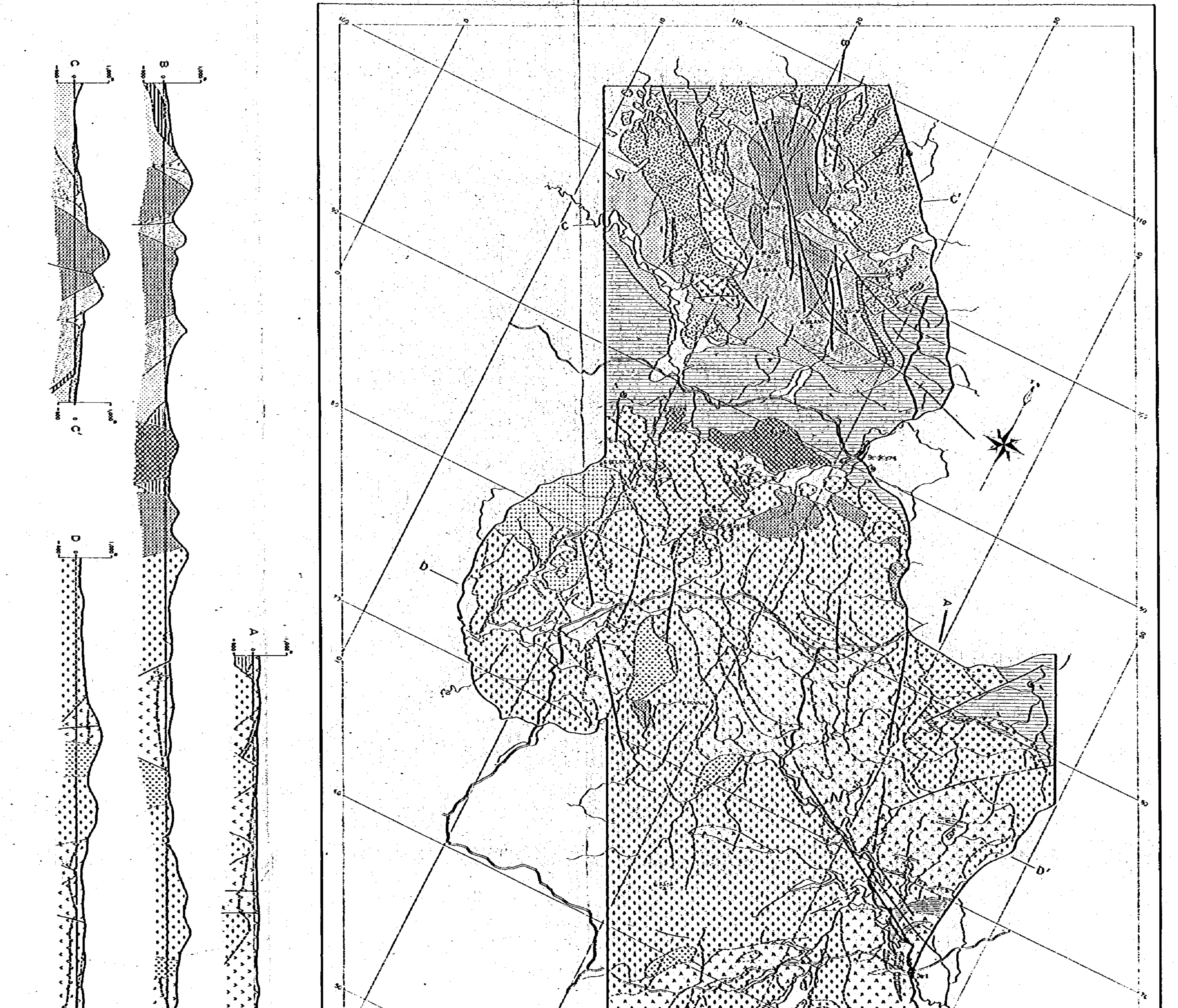
METALLIC MINERAL EXPLORATION SURVEY
IN
WEST KALIMANTAN INDONESIA

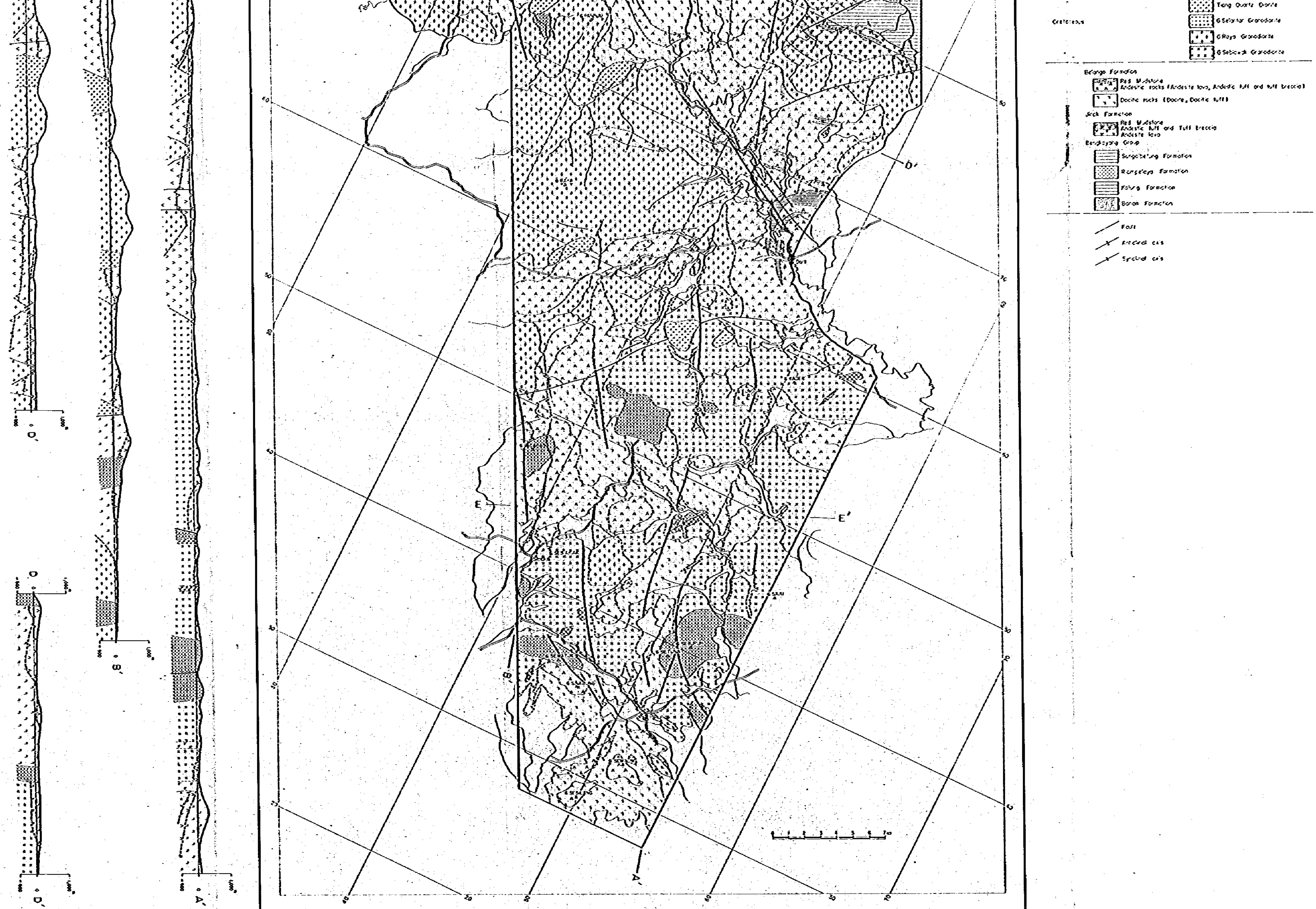
GEOLOGICAL MAP OF THE PROJECT AREA

Scale 1:100,000

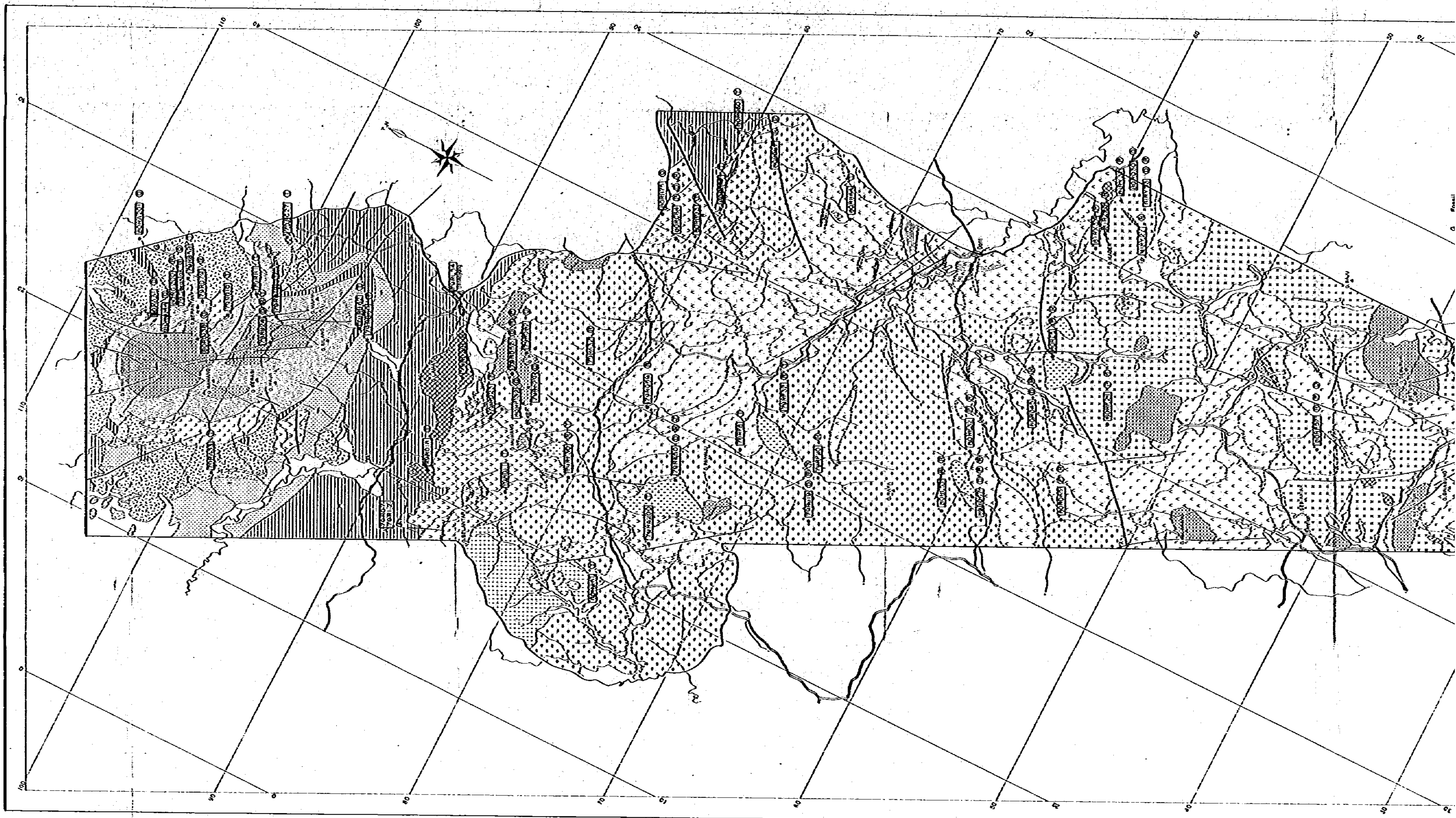


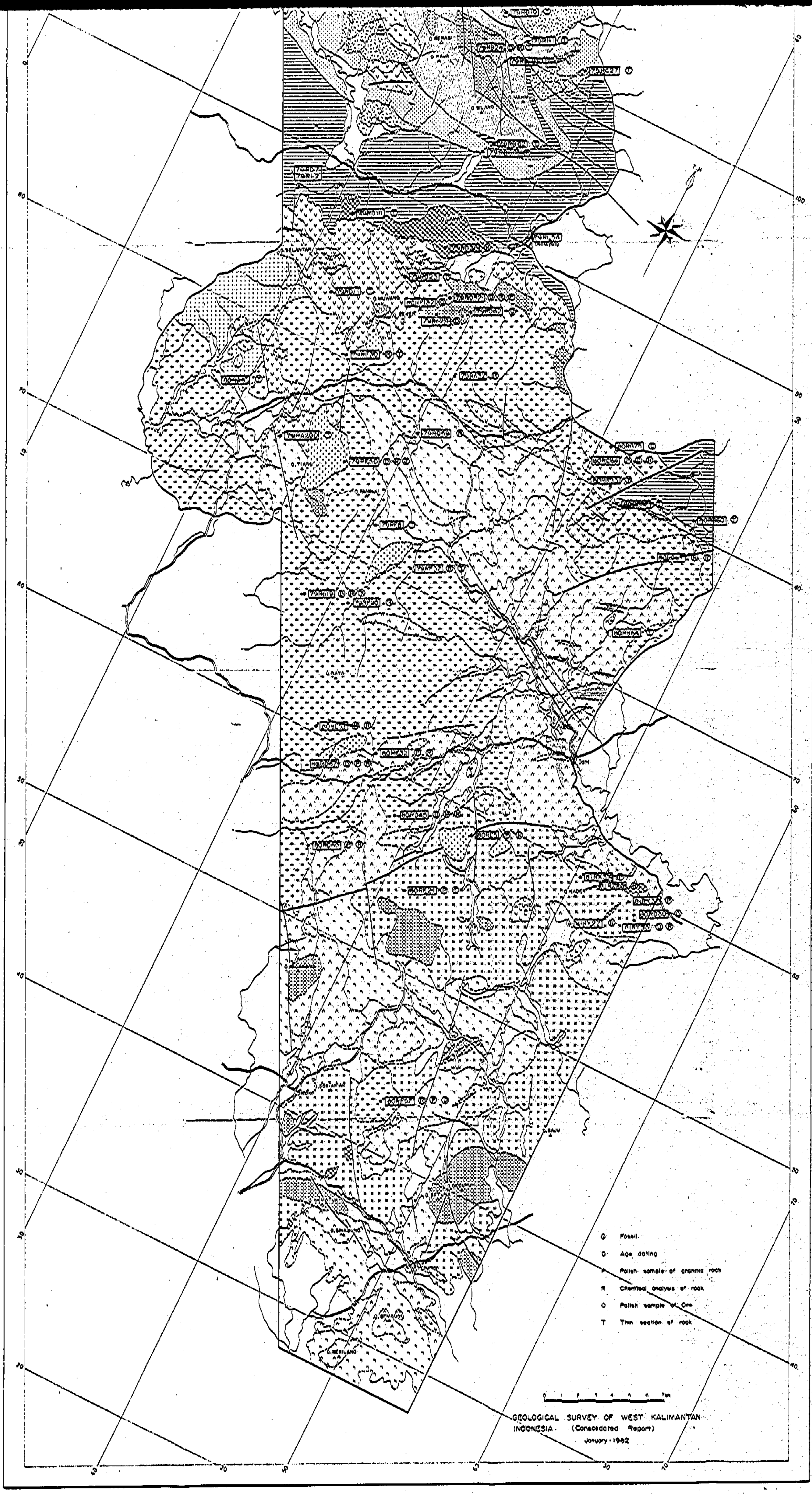
January 1982





D
D'
B'
A'
E
E'
Cretaceous
Red Mudstone
Andesite lava
Formation





PL. 2 LOCATION MAP OF SAMPLES

PL. 3

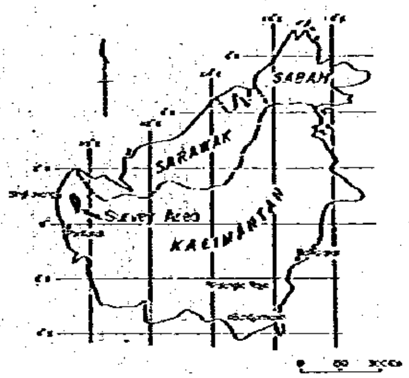
METAL MINING AGENCY OF JAPAN — DIRECTORATE OF MINERAL RESOURCES
JAPAN INTERNATIONAL COOPERATION AGENCY — DIRECTORATE GENERAL OF MINES
MINISTRY OF MINES AND ENERGY

METALLIC MINERAL EXPLORATION SURVEY IN WEST KALIMANTAN INDONESIA

PHOTOGEOLOGICAL MAP OF PROJECT AREA

Scale 1:100,000

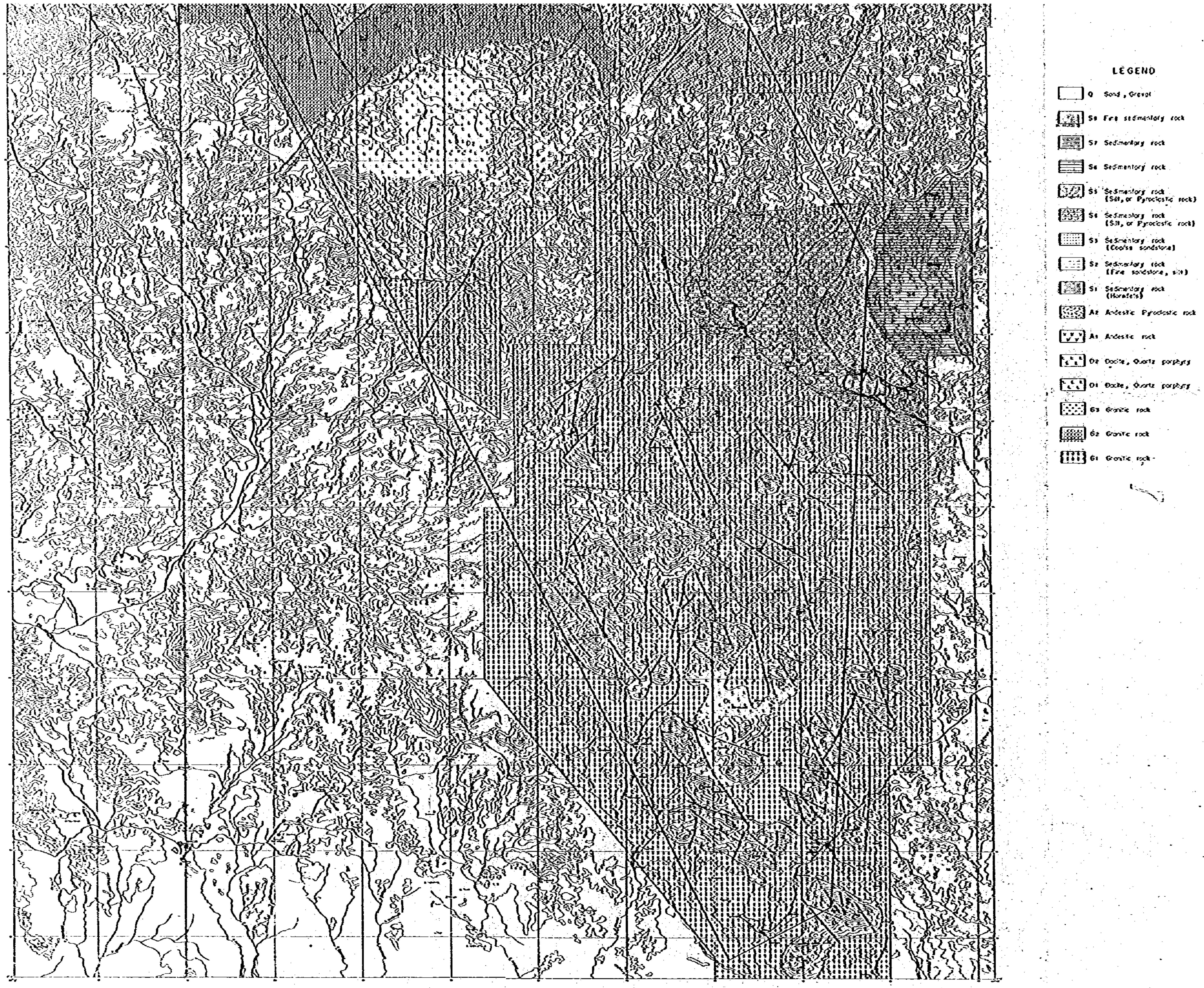
0 1 2 3 4 5 6 7 8 Km



Jonuary - 1982

LEGEND

- O Sand, Gravel
- S8 Fine sedimentary rock
- S7 Sedimentary rock
- S6 Sedimentary rock
- S5 Sedimentary rock (Silt, or Pyroclastic rock)
- S4 Sedimentary rock (Silt, or Pyroclastic rock)
- S3 Sedimentary rock (Coarse sandstone)
- S2 Sedimentary rock (Fine sandstone, silt)
- S1 Sedimentary rock (Horsfels)
- A2 Andesitic Pyroclastic rock
- A1 Andesitic rock
- D2 Dacite, Quartz porphyry
- D1 Dacite, Quartz porphyry
- G3 Granitic rock
- G2 Granitic rock
- G1 Granitic rock



LEGEND
Q Sand, Gravel
S8 Fine sedimentary rock
S7 Sedimentary rock
S6 Sedimentary rock
S5 Sedimentary rock (Silt, or Pyroclastic rock)
S4 Sedimentary rock (Silt, or Pyroclastic rock)
S3 Sedimentary rock (Coarse sandstone)
S2 Sedimentary rock (Fine sandstone, silt)
S1 Sedimentary rock (Hornfels)
A2 Andesitic Pyroclastic rock
A1 Andesitic rock
D2 Dacite, Quartz porphyry
D1 Dacite, Quartz porphyry
G3 Granitic rock
G2 Granitic rock
G1 Granitic rock