REPORT
ON
THE GEOLOGICAL SURVEY
IN THE URUBAMBA RIVER INFERIOR AREA
OF
THE REPUBLIC OF PERU

FINAL REPORT

MARCH 2000

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of the Republic of Peru, the Japanese Government determined to conduct a series of survey related to exploration of ore deposits including analysis of the existing data and satellite image analysis, for the purpose of examining the potentialities of mineral resources in the inferior areas of the Urubamba River of the Republic of Peru, and entrusted the survey to the Japan International Cooperation agency (JICA). In view of the geological and mineralogical nature of the intended survey, the JICA commissioned the Metal Mining Agency of Japan (MMAJ) to implement the survey.

The survey was commenced in FY1998 (Phase I), which was followed by the Phase II (FY1999) or the second year's survey. During Phase II, the MMAJ organized and sent a two-man survey team to the Republic of Peru for the period from February 12 to 18, 2000. The field survey was completed as scheduled, in close collaboration with the Peruvian government agency, the Institute of Geology, Mineralogy and Metallurgy (INGEMMET) under the Ministry of Energy and Mines. This is the final report incorporating the results of surveys in Phases I and II.

We should like to take this opportunity to express our sincere gratitude to the Peruvian government agencies and persons concerned for their valuable cooperation. We are also thankful to the Japanese Ministry of Foreign Affairs, the Ministry of International Trade and Industry, the Embassy of Japan in Lima and persons concerned who have rendered assistance and support for the survey.

March, 2000

Kimio Fujita
President
Japan International Cooperation Agency

Naohiro Tashiro
President
Metal Mining Agency of Japan

THE GEOLOGICAL SURVEY
IN THE URUBAMBA RIVER INFERIOR AREA,
THE REPUBLIC OF PERU

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Summary

This report describes results of the first year's survey in FY1998(Phase I) and the second year's survey in FY1999(Phase II), implemented in the Urubamba river inferior area of the Republic of Peru, under the technical cooperation for the mineral exploration. The survey was conducted with an aim to effectively select promising zones from the extensive survey area in a short period of time, by means of satellite image analysis, existing data analysis and integrated studies of survey findings of an area upstream of the Amazon in eastern Peru, which covers the Ucayali River Basin and its upper streams, the Urubamba and the Tambo, where the metallogenic zoning has not been clarified in detail.

The Urubamba river inferior area covers an area of about 65,500 km^2, spreading over the 27 quadrangles of the 1:100,000-scale topographic map issued by the National Geographical Institute of Peru. Topographically, the area extends from the Sub-Andes in the west to the Selva in the east.

In Phase I, the analysis of the JERS-1 SAR images was conducted of the 15 quadrangles (approx. 37,500km^2 ; 72° 30' to 75° 00' W of longitude and 9° 30' S to 11° 00' S of latitude) west of the Urubamba inferior area, while the analysis of existing Data was conducted of the whole inferior area of the Urubamba. Simultaneously, the technology transfer to the INGEMMET , the Peruvian counterpart for the survey, was implemented concerning the methods of satellite image analysis.

In Phase II, the analysis of the JERS-1 SAR images was conducted of the 12 quadrangles (approx. 28,000km2 ; 70° 30' to 72° 30' W of longitude and 9° 30' to 11° 00' S of latitude) west of the Urubamba inferior area. Besides, an integral analysis was conducted on the basis of the combined results of the satellite image analysis in Phases I and II and the analysis of the existing data, in order to evaluate potentials for occurrence of ore deposits in the entire inferior areas of the Urubamba River.

The integral analysis of the survey findings revealed the following facts:

(1) Satellite image analysis using JERS-1/SAR data

a. From the analysis of drainage patterns in the Ucayali sedimentary basin, data suggesting presence of anticlinal structures or dome structures and possible presence of intrusive rocks were obtained. In the Selva zone in eastern Peru as represented by the Ucayali sedimentary basin, drainage analysis utilizing satellite images is effective for the interpretation of geology and geologic structure.

b. In the thrust zone trending NNW-SSE located in the east of the Sira range, many parallel lineaments to the thrusts, considered to reflect small faults accompanying the thrusts, and many intersecting lineaments to the thrust trending ENE-WSW, possibly reflecting tension fractures or strike-slip faults, have been extracted and those lineaments form high density zones of lineament in this zone. Generally, tension fractures are likely to be accompanied by intrusive rocks and hydrothermal activity having the intrusive rocks as the thermal source. At Agua Caliente in the northeast of the study area, there are thermal springs accompanying faults with the NE-SW trend. Therefore, the high concentration zone of lineaments in the thrust fault zone east of the Sira range is considered to be important for metallic mineral resources exploration.

(2) Analysis of the existing data

a. It was ascertained by recent geological survey conducted by INGEMMET that an intrusive rock accompanied by gold and copper ore showings is present 13 km east of Puerto Inca in the quadrangle 19-n of the 1:100,000-scale topographic map. This indication is similar with the placer gold deposit in the Negro river (located in Quad. 20-n) in structural setting, whereas the indication is considered to be a source (primary deposit) of placer gold. It may be said that to discover both primary and secondary (placer) types of ore deposit might be possible, depending on a systematic prospecting in future.

b. In the Ucayali sedimentary basin, gold and tin concentration have been reported in heavy minerals in stream sediments along the Urubamba river near Atalaya (Quad. 22-o) and Sepa (Quad. 22-p). Especially, near Sepa, panning samples of heavy minerals is reported to assay Au: 1.6 g/t, which suggests high possibility of occurrence of alluvial gold deposits.

In the light of the integral analysis referred to above, it is considered desirable that field survey aimed for discovering new ore deposits, including geochemical survey, ore showings survey and confirmation of lithofacies along the survey route, should be undertaken in the promising ore-bearing areas which follow:

- The surrounding areas of the Negro River where the known alluvial gold deposits are located.

- The area stretching from the Urubamba riverbanks including the Atalaya-Sepa zone, where alluvial gold showings are located, to the eastern part of the Sira Range west of the Ucayali, where intrusive rocks occur and high density zones of lineament have been extracted.

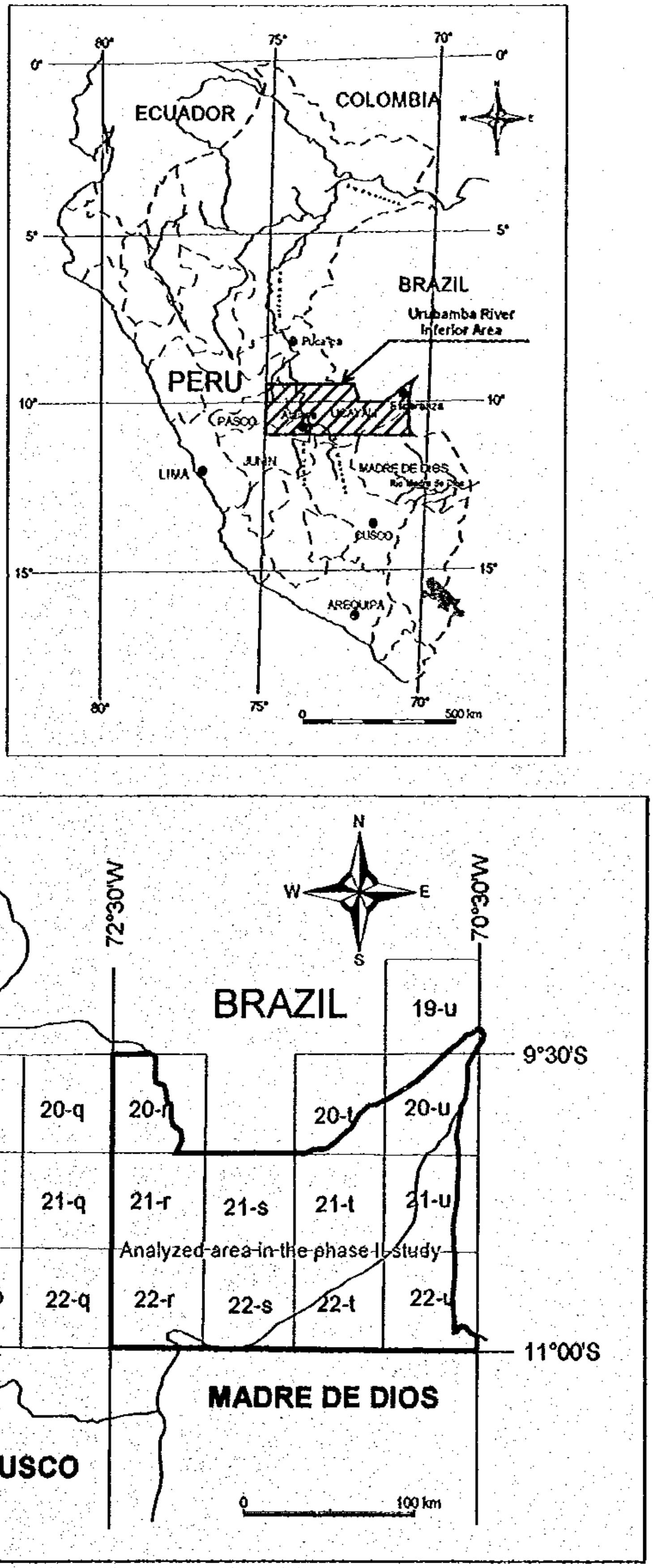


Figure 1   Location of the survey area

PART I

GENERALITIES

Chapter 1 Outline of the Survey

1-1 Antecedents and Purposes of the Survey

Peru ranks among the nations most richly endowed with underground resources. The land covers an area of 1,285,220 km^2 and its zonal distribution of the topography, geologic provinces and metallogenic provinces are nearly parallel from the Pacific coast eastward.

The metallogenic provinces in Peru consist of 1) the iron belt in the southern coastal range, 2) the copper belt in the Pacific coastal piedmont, 3) the polymetallic belt in the highlands (Sierra), 4) the polymetallic belt in the east Andes, and the zone called Selva spreading farther east of 4) in the Amazon upstream basin whose metallogenic zoning has not been fully clarified as yet. Large-scale and low-grade dissemination type gold ore deposits in massive silicified rocks have been discovered and noticed in the polymetallic belt in the northern highlands recently.

In compliance with the request of the government of Peru, the survey was conducted with an aim to effectively select promising zones from the extensive area in a short period of time, by means of satellite image analysis, existing data analysis and integrated studies of survey findings of an area upstream of the Amazon in eastern Peru, which covers the Ucayali River Basin and its upper tributaries, the Urubamba and the Tambo, where the metallogenic zoning has not been clarified in detail.

Simultaneously, it is intended to promote technology transfer to the INGEMMET - Instituto Geológico Minero y Metalúrgico, the Peruvian counterpart, concerning the methods of survey and analysis.

The survey was executed in accordance with the Scope of Work signed by the both governments on November 5, 1998.

1-2 Area and Outline of Phase I Survey

In the first fiscal year's survey, the satellite image analysis was performed on 15 quadrangles (72°30' - 75° W, 9°30' - 11° S, Figure 1) of the Urubamba river inferior area (about 65,500 km^2), designated in the Scope of Work agreed to between the JICA/MMAJ and the Ministry of Energy and Mines/INGEMMET, that consists of 27 quadrangles of 1:100,000-scale topographic maps, whilst the existing data analysis covered the whole area of the Urubamba river inferior area.

The survey was carried out in the following manner.

The satellite image processing and interpretation were conducted mainly in Japan after obtaining the JERS-1 SAR data and the 1:100,000-scale topographic map (partly in satellite map). The existing data analysis was conducted in Lima and Japan after the geological and mining information were obtained in Peru. During the survey, some parts of the JERS-1 SAR data processing and interpretation were conducted at the INGEMMET's head office in Lima, in collaboration with its engineers, in an effort to transfer of image analysis technique.

As the result of the satellite image analysis and the existing data analysis, the geologic interpretation maps and the lineament maps, as well as the list of ore deposits/mineral indications and the regional potential evaluation map, were elaborated.

1-3 Area and Outline of Phase II Survey

In Phase II, analysis of the JERS-1 SAR images was carried out of the 12 quadrangles (70° 30' to 72° 30'W of longitude and 9° 30' to 11° 00' S of latitude) in the 1:100 000 topographic map of the eastern side of the inferior area of the Urubamba River. In addition, an integral analysis incorporating the whole results of Phase I and II surveys was undertaken.

These surveys were conducted in the following manner:

The satellite image analysis was conducted in the same manner as in Phase I.

In the integral analysis, promising ore-bearing zones were extracted on the basis of the results of the analysis of existing data in Phase I and the image analysis in Phase II; and, evaluation of potentials for occurrence of deposits in the whole inferior area of the Urubamba River was implemented, for which the results of the Phase-I image analysis was referred to, as well.

1-4 Organization of the Survey Team

The members from the field survey team are listed in the Tables 1.

Table 1 Mission for the field survey

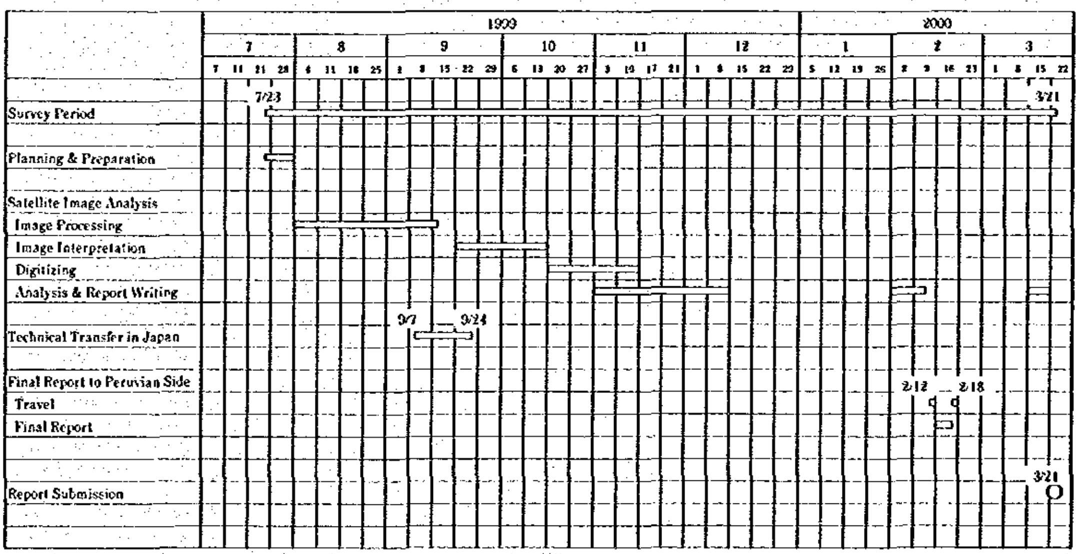
Peruvian side		*Japanese side*	
Ing. Juan Mendoza Marsano	INGEMMET	Mr. Hiroaki Kagawa	MMAJ
Ing. Hugo Rivera Mantilla	INGEMMET	Mr. Kaoru Sakogaichi	MINDECO
Ing. Oscar Palacios Moncayo	INGEMMET		
Ing. Manual Paz Maidana	INGEMMET		
Ing. José León Aparicio	INGEMMET		
Ing. Marco A. Lara Moreno	INGEMMET		

INGEMMET: Instituto Geológico Minero y Metalúrgico
MMMJ: Metal Mining Agency of Japan
MINDECO: Mitsui Mineral Development Engineering Co., Ltd.

1-5 Period and Quantity of the Survey

The survey period is indicated in Table 2.

Table 2 Study period



The quantities of the survey are indicated in Table 3.

Table 3 Quantity of the study

Survey items	*Quantities*
Satellite image analysis	12 quadrangles (the eastern potion of survey area)
Integrated analysis	The entire Urubamba river inferior area

Chapter 2 Geography of the Survey Area

2-1 Location and Transportation

The survey area expands 750 km in E-W direction, from 250 km ENE (75°W) of Lima, a capital of Peru, to the Brazilian border (70°30'W) and 170 km in N-S direction from the down stream of Urubamba river towards north, and it covers about 65,500 km^2 (Figure 1).

The main administrative divisions covered by the area are the Departments of Pasco, Ucayali and Madre de Dios, as well as the Cities of Atalaya and Esperanza, the former falling on the south end while the latter on the east end of the area. Atalaya, population 15,200, is the seat of the Atalaya District government and has the police and military stations, hotels and restaurants, etc.

Atalaya is accessible by air from Lima, via Pucallpa. It takes 1:15 hours from Lima to Pucallpa and one hour from there to Atalaya.

The transportation in the survey area is limited to either chartered small planes or small vessels. Major towns and villages have runways in nearby areas for landing of small planes.

2-2 Topography and Drainage System

The western part of the survey area topographically included in the Sub-Andes mountains adjacent east to the Cordillera Oriental of the Andes, and the eastern part included in the Selva, or the lowlands embracing the Amazon's upstream.

The Sira range, altitude 2,000 m, trending NNW-SSE, lies in the survey area at around long. 74°75' W within the Sub-Andes. A stretch from the Ucayali basin to the Brazilian border is the Selva, where flatlands, alt. 200 to 300 m, spreads out; the Ucayali river flows down along the east side of the Sira range in the NNE direction.

The main upper tributaries of the Ucayali river are the Urubamba and the Tambo river, which merge near Atalaya. The Urubamba river has its origin in the Lake Titicaca in southern Peru. By way of Cuzco and the Camisea gas field, it enters the survey area where it changes course from northwest to west to join the Ucayali. Within the survey area, tributaries such as the Inuya (from the right bank) and the Sepa (from the left bank) flow into the Urubamba river.

The northeast side of the line connecting lat. 11°S - long. 72°30' W and lat. 9°30' S - long. 75°30' W in the survey area pertains to the basin of the Purús and the Yurúa, both of which enter Brazil and run into the Amazon. Within the survey area, the Purús runs down northeastward whereas the Yurúa meanders but generally runs northward.

2-3 Climate and Vegetation

Both the Sub-Andes including the Sira range and the Selva have the rainy season roughly from November to April and the dry season from May to October. The climate in the Selva is generally hot and humid, with certain fluctuations of the atmospheric temperature in a day. The average annual temperature and precipitation in Atalaya (1934 - 1935) are 15.7℃ and 3,029.5 mm, respectively. The average monthly temperatures and precipitation are tabulated below.

Table 4 Monthly average temperature and precipitation in Atalaya (1934-1935)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Temp. (℃)	26.2	26.4	25.9	25.6	26.1	25.6	24.4	24.3	25.0	25.7	26.4	26.0
Precip. (mm)	294.0	291.4	423.4	364.4	121.2	156.2	100.0	137.4	208.9	211.1	421.1	300.0

The zonal distribution of flora in the survey area is as follows:

a) Tropical jungles (Selva)
The flora comprises trees parasitized by orchids, vines, etc., and the lichens. As thick forests block off the sunlight, plants in the Selva tend to have leaves of gigantic sizes.
b) Evergreen trees in highlands
Compared with the Selva, the density of trees is low due to strong wind, forest fires, fall of old trees, etc.
c) Ferns in marshlands
d) Ranges of reeds
Reeds range along rivers and grow up to 10 m tall.
e) Forest zones on river terraces outside of floodplains
f) Forests of trees and shrubs on fords and playas of large rivers such as the Ucayali.

The greater part of the survey area falls within either the a) or the b) categories.

Chapter 3 Existing Geological Information of the Survey Area

3-1 Outline of Existing Geological Information

In the highlands of the Cordillera Oriental, precious metals, copper, etc. were mined since the Pre-Inca times. During the Colonial period, prospecting, though not systematic, was carried out so vigorously in search of precious metals that gold and silver production increased tremendously. The survey area spreads over the transitional region of the Sub-Andes toward the Selva, which has imposed enormous constraints on transportation and has retarded progress of comprehensive geological studies on the area.

Information on the Selva is very limited due to the transportation difficulties. Geological and mineral surveys were initiated in the 1950's by petroleum companies, which included interpretation of aerial photographs and satellite images and surface geological reconnaissance based on the former. Petróleos del Perú ("Petroperú"), Oficina Nacional de Evaluación de Recursos Naturales ("ONERN," presently Instituto Nacional de Recursos Naturales - "INRENA") have been involved in the survey activities. ONERN's natural resources surveys were carried out along the Urubamba, the Tambo and the Alta Yurna upstream, situated in the central part of the survey area.

As regards surveys of placer deposits undertaken by private firms, the Banco Minero del Perú is engaged in the systematic assessment in accordance with the Presidential Decree D.S. No. 010-74-EM/DGM, which is purported to protect small miners and also to ensure effective utilization of natural resources. Occurrence of placer gold deposits in the survey area is not clearly defined.

As for geologic maps of the survey area, INGEMMET has elaborated 1:100,000 and 1: 200,000-scale maps, while a geologic map at 1: 2,000,000-scale was also compiled by the same Institute in 1995.

3-2 Outline of Geology

According to the geologic map of Peru(INGEMMET, 1995, Figure 2), the highlands in the survey area is underlain by Precambrian metamorphic rocks as the basement; sedimentary rocks of the Ordovician Contaya Formation and of the Carboniferous to early Permian Ambo, Tarma and Copacabana Formations; sandstone of Permian to Triassic Ene Formation; limestone of the Triassic Pucara Formation; sandstone of the late Jurassic Sarayaquillo Formation; sandstone of the Oriente Group; marl and limestone of the Chonta Formation, sandstone of the Vivian Formation and shale of

the Cachiyaku-Huchpayacu Formation of the Cretaceous age; and, sandstone-shale-slate of the Paleogene Huayabamba Group. The intrusive rocks are granites presumably of Permian age and monzodiorite correlated with the Paleogene age.
The Selva zone, stretching from the Ucayali-Urubamba basin to the Brazilian border, is underlain by sandstone-conglomerate of the Neogene Ipururo Formation, gravel of the Ucayali Formation and the Madre de Dios Formation of Pleistocene age, and the Alluvium.

3-3 Outline of Known Ore Deposits

According to the metallogenic studies of Peru, the Cordillera Oriental belongs to the East Andes metallogenic province underlain by the Paleozoic to Cenozoic units, where occurrence of gold-silver bearing copper, lead and zinc ore deposits and prospects, as well as mineral indications of rare metals such as tin, tungsten, nickel and cobalt, has been known. In the highlands of the survey area, which is contiguous with the East Andes metallogenic province, however, only some placer gold deposits are known. Small-scale placer gold mining is still ongoing in the Negro river, a tributary of the Pachitea river at the western piedmont of the Sira range in the west of the survey area.

In the Selva region, whose geologic-metallogenic provinces are not yet clearly defined, Tertiary to Quaternary sedimentary rocks are widespread on the west margin of the Brazilian shield. Ore deposits in the Selva are petroleum, gas and placer gold deposits. Petroleum and gas deposits were investigated by Petroperu and oil companies from 1950's to 70's but the activities have since declined. In March, 1983, the Camisea gas field was discovered 50 km south of the survey area by oil companies including Shell. Small mining of placer gold deposits in Tertiary-Quaternary stream sediments are said to be conducted in the Ucayali and Urubamba river in the central part of the survey area.

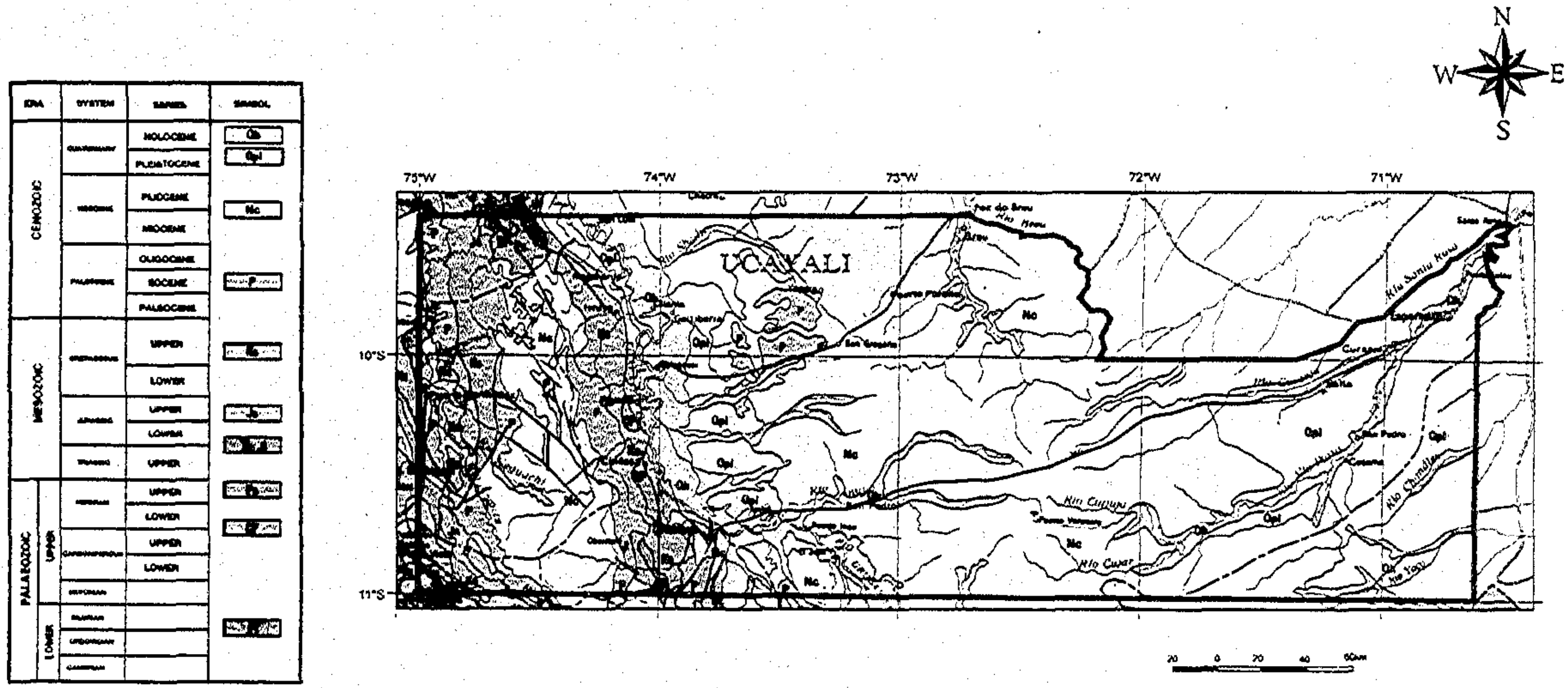


Figure 2 Geology of the survey area

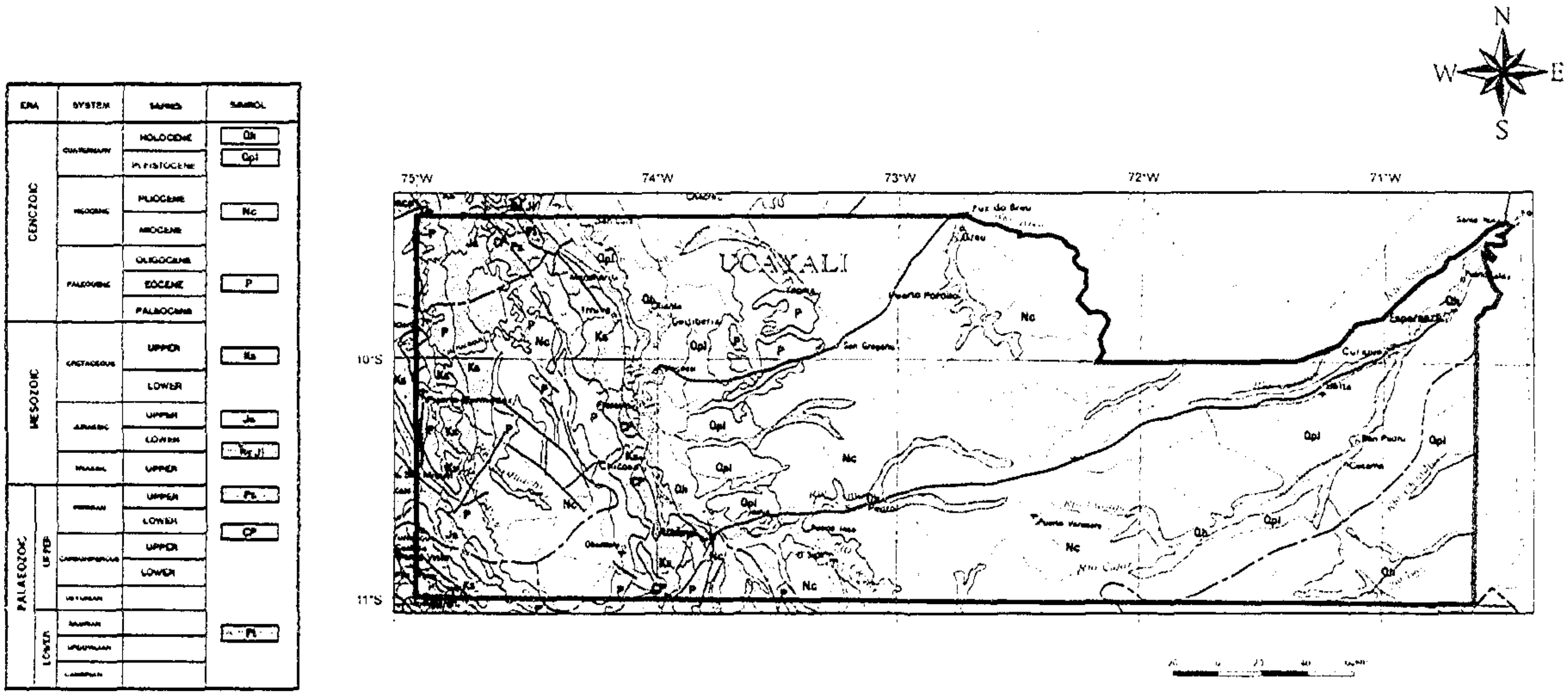


Figure 2 Geology of the survey area

PART II

PARTICULARS

Chapter 1 Satellite Image Analysis

1-1 Purpose of the Image Analysis

The image analysis is intended to produce geologic interpretation maps and lineament maps of JERS-1 SAR images, to examine the regional geologic structure of the survey area, thereby providing basic data for the evaluation of mineral resource potentials in the survey area. The geologic interpretation map elaborated in Phase II covers the 12 quadrangles, 20 to 22-r, 21 to 22-s, 20 to 22-t and 19 to 22-u -- a quadrangle represents a square with a side equivalent to 30' of the latitude and longitude -- of the 1:100,000-scale topographic map of the Instituto Geográfico Nacional (IGN).

1-2 Image processing

1-2-1 Data used

Data used for the analysis are 18 scenes(No.1 to No.18 in Table 5) of JERS-1 SAR data in Phase II, and 24 scenes(No.14 to No.37) of JERS-1 SAR data in Phase I as indicated in Table 5 and Figure 3.

1-2-2 Procedures for image processing

12 quadrangles of image for interpretation have been processed in the following procedure.

1) Loading data: All the JERS-1 SAR data provided by ERSDAC with EXABITE tapes are copied to the hard disk (HD) connected to an engineering work station (EWS).

2) Separation of header information and image data: From transferred data files, the header files including positioning information of images are extracted and saved in text format. Image data files are converted to the standard image database format of PCI/EASI-PACE, an image processing software developed by PCI of Canada.

3) Bit number conversion: 16-bit image data is converted into 8-bit image data.

4) Histogram normalization: Simultaneously with bit conversion, histograms of digital numbers are normalized.

5) Image rotation: Images are rotated clockwise by 90 degrees.

6) Antenna pattern correction: In order to re-correct the characteristics of antenna pattern of JERS-1 SAR data that an average DN gradually decreases from far range to near range, averages in the azimuth direction of each scene are calculated, and each pixel value is divided by the average.

7) Coordinates assignment: UTM coordinates of the corners of each scene are read from header information and assigned.

8) Preparing image database for mosaicking: PCI image database file that has UTM coordinate system for making mosaic image is prepared.

9) Pasting of a center image: A scene near the center of mosaicking area is pasted to the database file for making mosaic images. The pasting position is determined by the information in header file.

10) Mosaicking: Mosaicking is starting from images adjoining the center image. Several dozens of tie-points are collected in an overlapping of images and geometric correction is applied so that the residual error may be reduced to less than 1 pixel. Simultaneously, the brightness is adjusted so that difference in DN value between two images is reduced.

11) Speckle noise reduction: The Enhanced Lee filter (7 x 7) is employed to reduce speckle noises.

12) Extraction of sub-scene images: From the prepared mosaic image, 12 sub-scene images are made so as to correspond to the quadrangles of the 1:100,000-scale topographic map. Geometric correction is again applied so that the sub-scene images may exactly be overlaid on the topographic map, for which confluence and bending points of rivers, etc. are utilized as ground control points for georeferance.

13) Annotation: Each sub-scene image is annotated with the UTM coordinates, scale bars and titles.

14) File format conversion: The format of image files is converted from PCI database format to TIFF format, so as to fit to the output device used.

15) Alteration of image resolution: Resolution of each sub-scene image is adjusted so as to output at 300 dpi and at a 1:100,000-scale. As the result, the spatial resolution of images was altered to about 8.45 m per pixel.

16) Hard copy output: Two sets of the 12 sub-scene images, totaling 24 images, were output at a 1 :100,000-scale by digital photo-printer (Lightjet 5000). One set was used for the analysis in Japan while the other was prepared as the final product.

1-3 Image Interpretation, Preparation of GIS Data Set and Lineament Analysis

The output images at a scale of 1:100,000 of the respective quadrangles prepared in the above mentioned procedures were used for image interpretation, and the obtained results were digitized and output at a 1:100,000-scale. The digitized lineament map was used as the input data for computation of the lineament density, whereby the lineament densities of the entire survey area was mapped.

The work was done in the following procedures:

1) Geologic interpretation: Geologic units were classified using surface texture and topographic features on images as criteria. Correlation between the photo-geologic characteristics of each geologic unit and the existing geologic map was tabulated, using the geologic map of the INGEMMET (1995) as reference.

2) Interpretation of lineament and geologic structure: Elements of geologic structure such as faults, lineaments and folding structures were delineated, for which micro-topography was considered.

3) Digitizing: Scanned data of hand-written geologic interpretation maps and lineament maps was loaded on a computer as raster data, which, in turn, was converted to vector data. Figures such as polygons and lines included in the vector data were manually retouched on monitor screen and attributes such as names of structures were added to respective figures. For the series of processing, the TNT Mips, a GIS software developed by Micro Image Inc., USA was employed.

4) Preparation of GIS data set: Geographic data such as drainage systems, lakes, roads, villages and national borders in Arc/Info "Coverage" format provided by INGEMMET was loaded to TNT Mips database file and overlaid on the interpretation results, then annotated with legends, scale, quadrangle numbers, names, etc. and, in turn, output by a color plotter at 1:100,000-scale. The output maps were two types: a geologic interpretation map and a lineament map. From the respective vector data of geologic boundaries, faults, geologic structures and lineaments included in the database files of TNT Mips, the files in the "Export" format (E00 format) of Arc/Info were prepared as the final products.

5) Lineament density map: Lineament data prepared of each quadrangle were integrated into a MOSS (Map Overlay and Statistical System) format -- one of the GIS standard format by USGS --, and lineament densities (m/km^2) of 2 km x 2 km grids were calculated by obtaining a cumulative extension of all faults and lineaments included in each grids. For the computation, an analysis tool developed by MINDECO was employed. The lineament density distribution in the entire area of analysis was output at a 1:1,000,000-scale and rose diagrams of each quadrangle

were simultaneously produced.

Table 5 Satellite data used

No.	*Date*	*sat.*	*Sensor*	*Path*	*row*	*lati.*	*long.*	*Qual.*	*station*
1	1996/06/11	J1	SAR	430	319	-11.04	-70.21	G	FAIS
2	1996/06/12	J1	SAR	431	316	-9.17	-70.30	G	FAIS
3	1996/06/12	J1	SAR	431	317	-9.52	-70.39	G	FAIS
4	1996/06/12	J1	SAR	431	318	-10.28	-70.46	G	FAIS
5	1996/06/12	J1	SAR	431	319	-11.04	-70.54	G	FAIS
6	1996/06/13	J1	SAR	432	316	-9.17	-71.03	G	FAIS
7	1996/06/13	J1	SAR	432	317	-9.52	-71.12	G	FAIS
8	1996/06/13	J1	SAR	432	318	-10.28	-71.19	G	FAIS
9	1996/06/13	J1	SAR	432	319	-11.04	-71.27	G	FAIS
10	1996/06/14	J1	SAR	433	316	-9.17	-71.35	G	HEOC
11	1996/06/14	J1	SAR	433	317	-9.53	-71.43	G	HEOC
12	1996/06/14	J1	SAR	433	318	-10.29	-71.51	G	HEOC
13	1996/06/14	J1	SAR	433	319	-11.04	-71.59	G	HEOC
14	1996/06/15	J1	SAR	434	316	-9.17	-72.08	G	HEOC
15	1996/06/15	J1	SAR	434	317	-9.52	-72.17	G	HEOC
16	1996/06/15	J1	SAR	434	318	-10.28	-72.25	G	HEOC
17	1996/06/15	J1	SAR	434	319	-11.04	-72.33	G	HEOC
18	1996/06/16	J1	SAR	435	316	-9.17	-72.41	G	HEOC
19	1996/06/16	J1	SAR	435	317	-9.52	-72.50	G	HEOC
20	1996/06/16	J1	SAR	435	318	-10.28	-72.58	G	HEOC
21	1996/06/16	J1	SAR	435	319	-11.04	-73.06	G	HEOC
22	1996/06/17	J1	SAR	436	316	-9.17	-73.14	G	FAIS
23	1996/06/17	J1	SAR	436	317	-9.52	-73.23	G	FAIS
24	1996/06/17	J1	SAR	436	318	-10.28	-73.31	G	FAIS
25	1996/06/17	J1	SAR	436	319	-11.04	-73.39	G	FAIS
26	1993/03/18	J1	SAR	437	316	-9.17	-73.49	G	FAIS
27	1993/03/18	J1	SAR	437	317	-9.53	-73.49	G	FAIS
28	1993/03/18	J1	SAR	437	318	-10.28	-74.05	G	FAIS
29	1993/03/18	J1	SAR	437	319	-11.04	-74.12	G	FAIS
30	1996/06/19	J1	SAR	438	316	-9.15	-74.19	G	HEOC
31	1996/06/19	J1	SAR	438	317	-9.51	-74.27	G	HEOC
32	1996/06/19	J1	SAR	438	318	-10.27	-74.35	G	HEOC
33	1996/06/19	J1	SAR	438	319	-11.04	-74.43	G	HEOC
34	1994/08/30	J1	SAR	439	316	-9.16	-74.54	G	FAIS
35	1994/08/30	J1	SAR	439	317	-9.52	-75.02	G	FAIS
36	1994/08/30	J1	SAR	439	318	-10.28	-75.10	G	FAIS
37	1994/08/30	J1	SAR	439	319	-11.04	-75.18	G	FAIS

J1: JERS-1, SAR: synthetic aperture radar, G: good, HEOC: Hatoyama, FAIS: Fairbanks

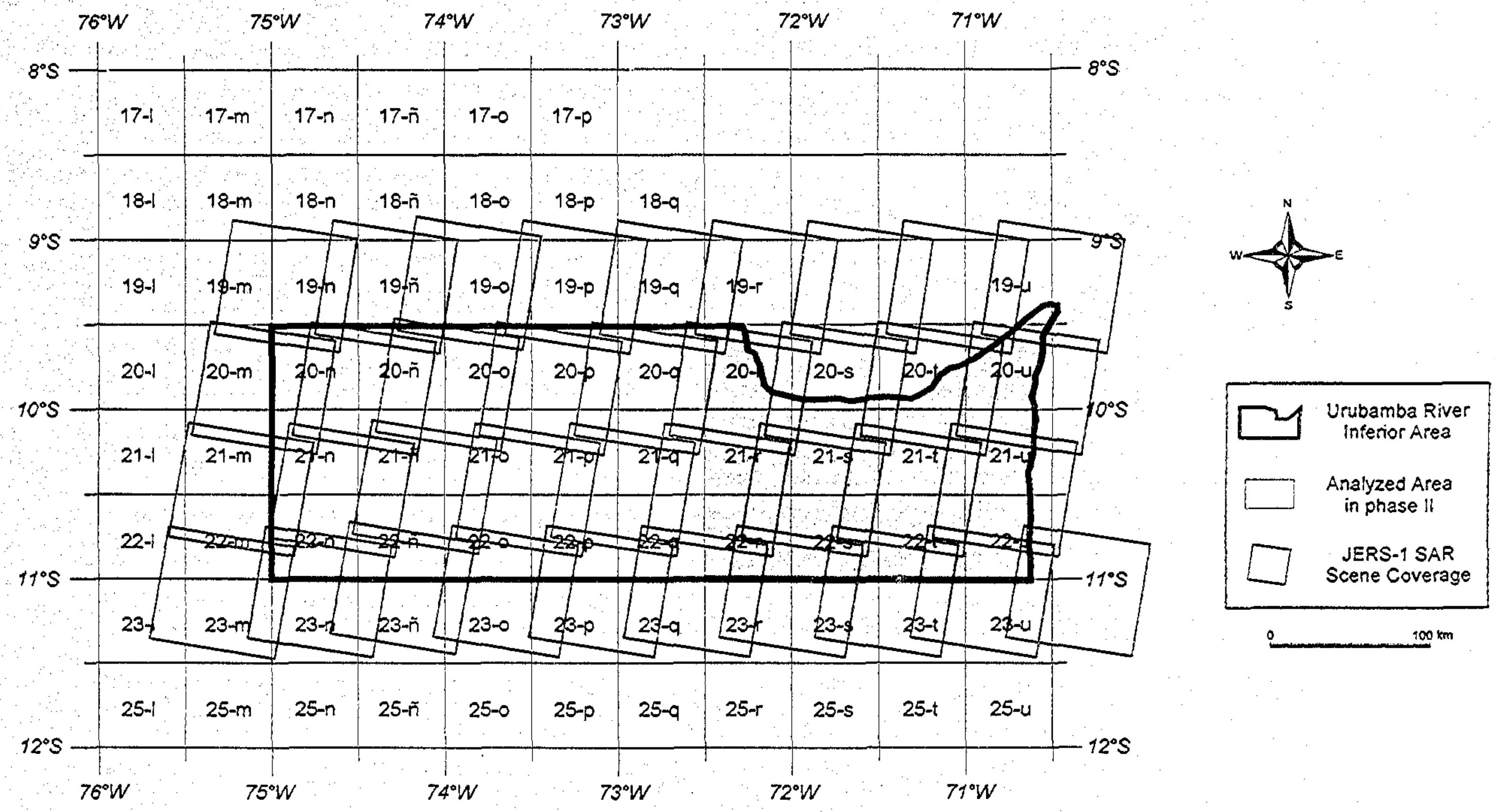


Figure 3 Coverage of Satellite Data Used

1-4 Results of the Image Analysis

1-4-1 Geologic Interpretation

For interpretation of the images, the existing 1:2,000,000-scale geologic map (INGEMMET, 1995) was used as reference. For geologic interpretation, the geologic map was referred to, while new information obtained through the image interpretation was considered as much as possible. For symbols of geologic units, the geologic ages in the map were referred to, and serial numbers were assigned, in ascending order, to the units sub-divided by the interpretation. SAR image of the entire analyzed area is shown in Figure 4, its geologic interpretation in Figure 5 and lineament map with in Figure 6. Table 6 indicates correlation between geologic units of the interpretation map and those of the existing geologic maps.

Characteristic of the respective geologic units are summarized in the following paragraphs:

(1) Unit Q4
The unit develops along main streams. Countless meandering tracks of old channels are seen. The surface texture of the unit looks smooth and flat. Tones ranging from very light to very dark (in the old channels) are mingled. (Alluvium)

(2) Unit Q3
The unit develops along main streams, forming lower terrace surfaces. Though flat, the surface plane appears to be of rough (sandy) texture. The tone is somewhat dark. (Quaternary terrace deposit)

(3) Unit Q2
The unit forms middle terrace surfaces. Sand grain-like or patch-like, light speckles are seen while the tone is somewhat light. The surface texture looks coarse. (Quaternary terrace deposit)

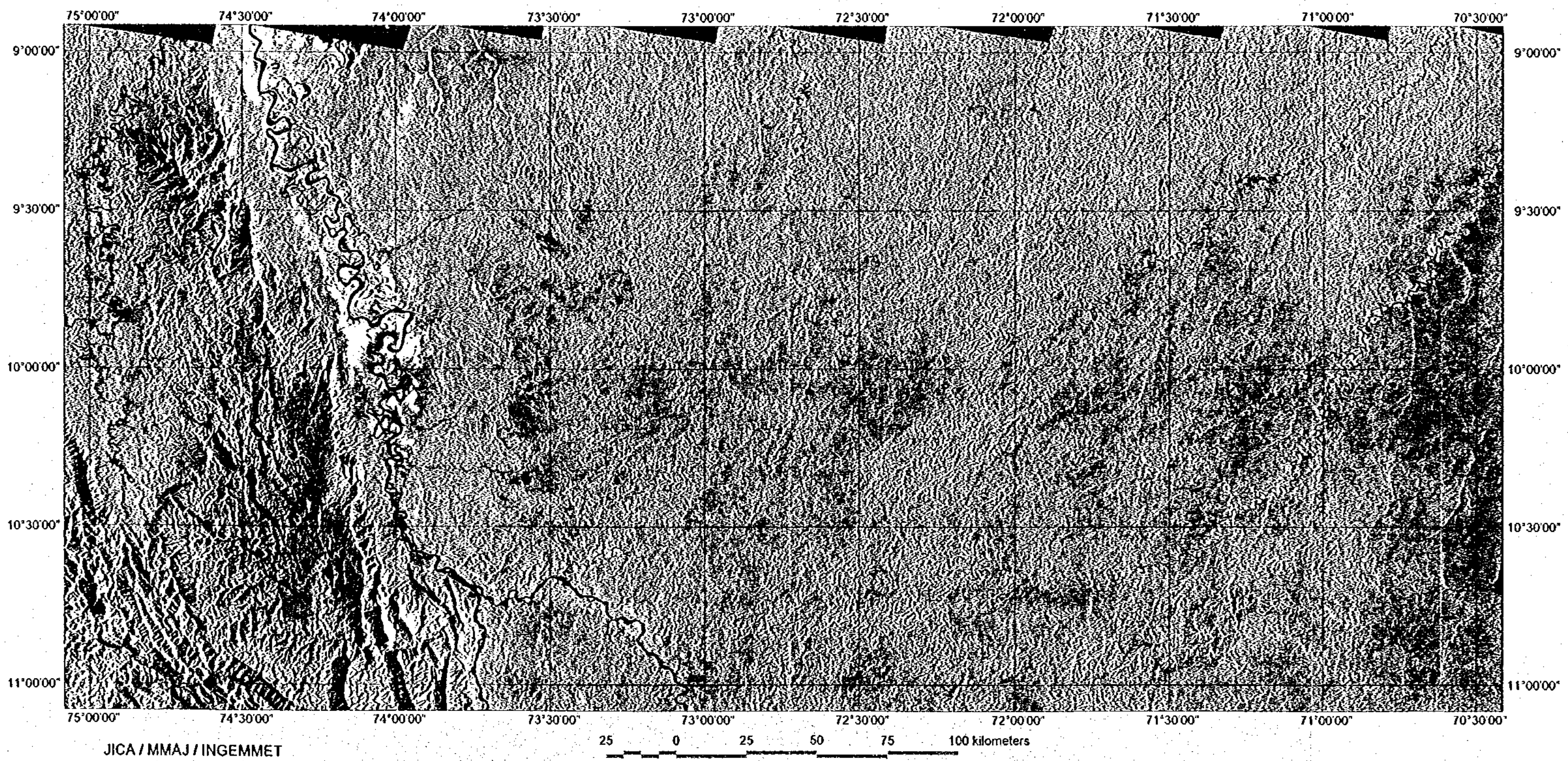
(4) Unit Q1
The unit forms higher terrace surfaces. It has light and somewhat large-sized patchwork pattern, while the surface texture looks somewhat coarse. (Quaternary terrace deposit)

(5) Unit T4
The area of occurrence is very limited. The unit is a thin bed covering the flat parts of the Unit T2. Although it has rather smooth surface texture, patchwork-like or pinnate drainage pattern is slightly seen. (Upper Tertiary)

(6) Unit T3
The Tertiary unit is seen overlying the Unit T2 in the east part of the interpretation

Table 6 List of geologic units

No.	Units	Units in Geologic Maps after INGEMMET 1:2,000,000 (1995)	Units in Geologic Maps after INGEMMET 1:100,000 (1997-1998)	Inferred Lithology and Geologic Age
1	Q4	Qh	Qhal	sand, gravel (Quaternary)
2	Q3		NQ-u	lower terrace deposit (Quaternary)
3	Q2	Qpl		middle terrace deposit (Quaternary)
4	Q1		N-i～NQ-u	higher terrace deposit (Quaternary)
5	T4	Nc		sandstone, conglomerate (Late Tertiary)
6	T3			sandstone, conglomerate (Middle Tertiary)
7	T2			
8	T1	P		sandstone, conglomerate (Early Tertiary)
9	K4	Ks	Ksh, Ksv, Ks-ch	sedimentary rocks (Late Cretaceous)
10	K3		Ki-o	sedimentary rocks (Middle Cretaceous)
11	K2		Pi-c	
12	K1			sedimentary rocks (Late Jurassic to Early Cretaceous)
13	J	Js	Js-s, TrJi-pu, PsR-e	sedimentary rocks (Jurassic)
14	P	Pi-c	Pe-cm	sedimentary rocks (Permian)



JERS-1 SAR MOSAIC IMAGE OF THE URUBAMBA RIVER INFERIOR AREA, PERU

THE GEOLOGICAL SURVEY IN THE URUBAMBA RIVER INFERIOR AREA OF THE REPUBLIC OF PERU

Figure 4 JERS-1 SAR Mosaic Image

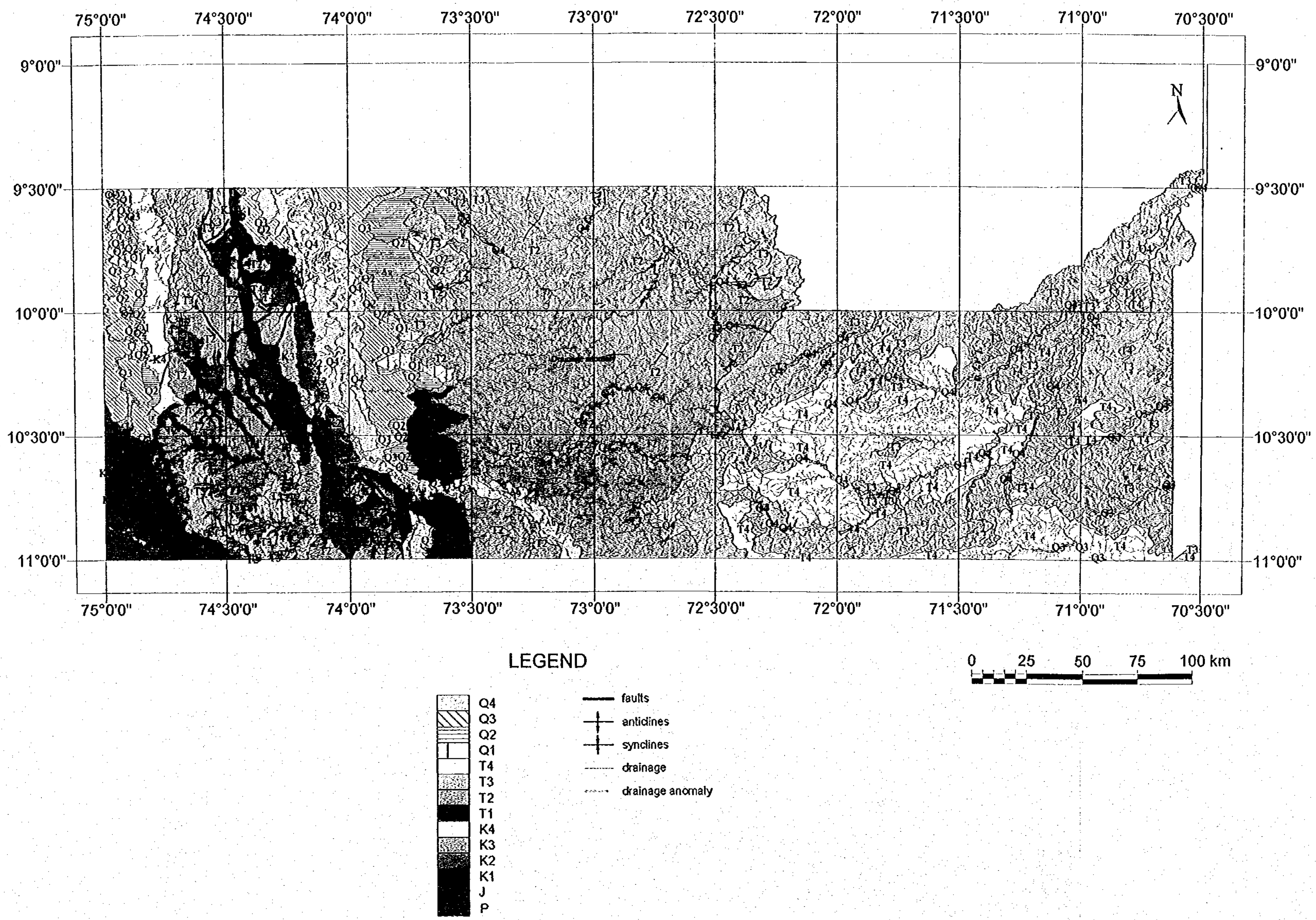


Figure 5 JERS-1 SAR Geologic Interpretation Map

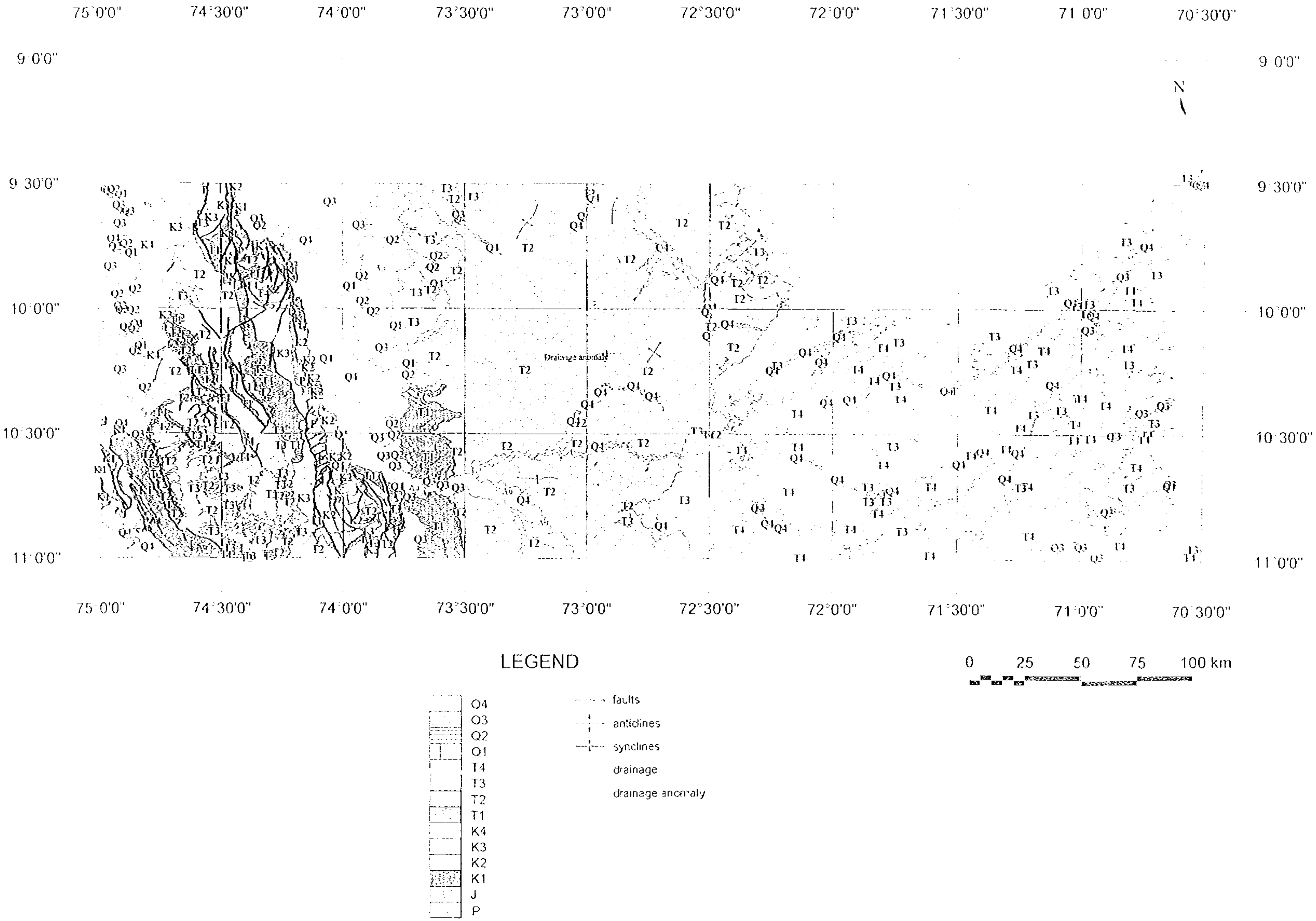


Figure 5 JERS-1 SAR Geologic Interpretation Map

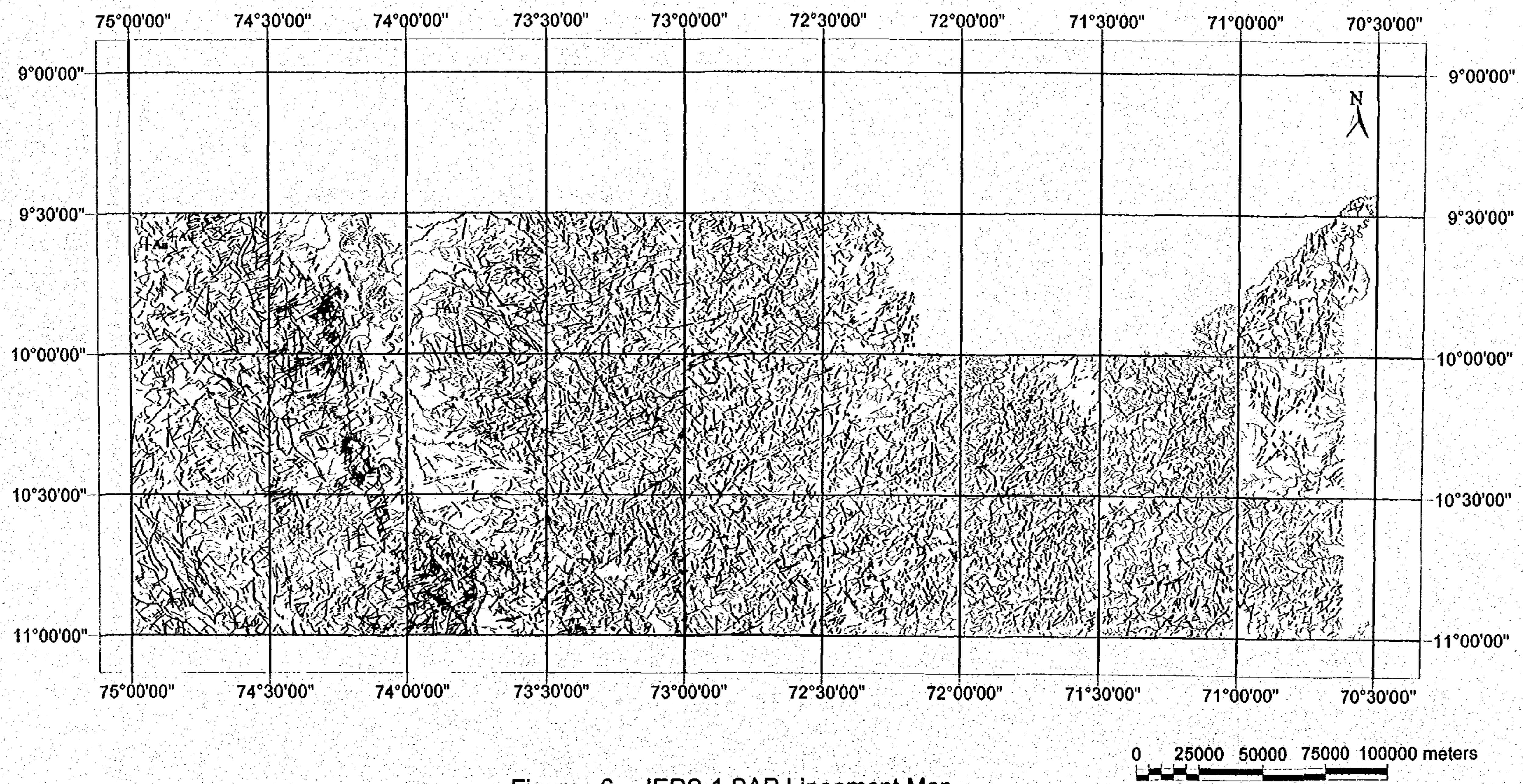


Figure 6 JERS-1 SAR Lineament Map

area. The unit resembles the Unit T2 but has deeper valleys, characterized by the parallel drainage pattern presumed to reflect the strike of the bed. The tone is light on the east side of the slopes and dark on the west side. (Middle Tertiary)

(7) Unit T2
Tertiary unit is predominant especially in the east part of the interpretation area. On flat portions, it has fine, dendritic drainage pattern. The tone is somewhat light. In images, bedding planes are partially traceable but generally unclear, probably because the unit is composed of alternation of thin beds. It is inferred that the unit is chiefly composed of fine-grained, pelitic rocks, intercalating conglomerate beds, sandstone beds, etc. (Lower Tertiary)

(8) Unit T1
The unit, underlain by the Unit T2, is observable at valley portions in areas dominated by the T2. The bed is inferred to be considerably thick. At steep slopes or valleys, fine, parallel drainage patterns develop, and bedding planes in well continuity are occasionally observable but, in general, it appears massive. (Lower Tertiary)

(9) Unit K4
The unit is rarely seen overlying the Unit K2 at flat portions or on gently dipping slopes. The surface texture is smooth but weak undulation develops. As for the tone, light and shade are repeated in a spotted pattern. Bedding is not clear. (Upper Cretaceous)

(10) Unit K3
The unit is often seen forming extensive, moderately dipping slopes while, in some cases, it forms large or small fold structures. As the bedding planes develop and include members which have strong resistance to erosion, steep scarps are frequently formed in the peripheries of the unit. The tone is dark but, at places, there are light patches due to thin covers of the Unit T2, etc. Basically, the drainage shows dendritic patterns but parallel patterns are observed at steep slopes. The unit contacts the Unit J with thrust faults in many portions. (Middle Cretaceous)

(11) Unit K2
The unit is underlain by the Unit K3. These units form fold structures accompanying thrust faults. The K2 has relatively smooth surface texture, though somewhat coarse on gentle slopes. Drainage patterns are not so well developed, and only parallel drainage patterns are observable especially on steep slopes. The tone is somewhat dark but light dots are seen all over. (Middle Cretaceous)

(12) Unit K1
The unit is dominated by joints and the surface texture is coarse. The tone ranges widely from light to dark. Bedding planes are recognizable but not so clearly.

(Lower Cretaceous to Upper Jurassic)

(13) Unit J
The surface texture is rough and banding with light and dark tonal portion is observed. Bedding and joint are generally well developed and dipping northeast. NNW-SSE to NW-SE trending large range is developed in the portion showing clear bedding planes. ENE-WSW to NE-SW trending joints are dominant, that is perpendicular to bedding. NNE-SSW trending large-scale thrust is seems to be developed at the boundary between this unit and Cretaceous. Massive portions without clear bedding plane are partly observed and where dominant range direction does not appear. (Jurassic)

(14) Unit P
Fissures parallel to bedding planes or joint planes are well developed and surface texture is generally coarse. The tone is light, except the dark slope in the west. Bedding planes are occasionally visible but they are generally unclear. The unit is often seen as inliers in K2 or K1, presumably accompanied with thrust faults. The unit is inferred to be mainly composed from hard rocks such as sandstones or limestones. (Paleozoic)

The geological interpretation of images is partially exhibited in Fig. 7-2(quadrangle 20-u) and Fig. 8-2(21-r), respectively, while Fig. 7-3(20-u) and Fig. 8-3 (21-r) display the respective lineament interpretation maps.

The area of Phase II analysis is underlain by the Neogene T2 to T4 units and the Holocene Q3 to Q4 units. The Holocene lies only along main drainage systems and is mostly underlain by the Neogene. The T2 unit is exposed in the west part of the Quadrangles 20-r and 21-r in the northwest. From the fact that the T3 unit contacts the T2 generally forming scarps, it is presumable that upper part of the T3 consists of rocks of high erosion resistance such as sandstone. The T4 lies in topographically elevated portions in the central and south parts of the subject area of analysis, and its boundaries with the T3 also form scarps in many instances. Therefore, the uppermost part of the T4 is also presumed to be composed of facies of high erosion resistance, similarly to the T3.

The interpretation of the respective quadrangles is given in the following paragraphs:

(1) 19-u
A major part of the quadrangle is occupied by the Brazilian territory, while the Peruvian territory only covers a small part in the southeast end. The geology is composed of fluvial deposits of the Alto Purús River (Q4) and the Tertiary rocks (T3). Although bedding is barely discernible in the Tertiary, the formation is inferred to be

nearly horizontal.

(2) 20-r
The eastern half of the quadrangle is the Brazilian territory. The west part of the Peruvian territory is underlain by the Middle Tertiary (T2) whereas the east part is by the Upper Tertiary (T3). The T3, compared with the T2, lies in topographically elevated areas, which tend to have somewhat strong relief. Scarps are often formed on boundaries between the T3 and T2. From these facts, the T3 is presumed to be composed of rocks of high resistance to erosion, compared with the T2.

(3) 20-t
Most part of the quadrangle is the Brazilian territory and the Peruvian territory barely occupies the southeast end, where the Curanja River, a tributary of the Alto Purús, meanders and runs northeast. The both river banks are underlain by the fluvial deposits, about 2 km in width. The northwest and southeast parts, intercalating the Q4, are underlain by the Tertiary (T3), where the bed is presumed to be nearly horizontal in the light of tracing of the bedding.

(4) 20-u
A JERS-1 SAR image and a geological interpretation map of the quadrangle are exhibited in Figs. 7-1 and 7-2, respectively. The east and northeast parts of the quadrangle are included in the Brazilian territory. The Alto Purús meanders, running from northwest to northeast in the central part of the quadrangle. This NE-SW trend is concordant with the direction of the high of basement in depths of the area, possibly reflecting it. The both banks of the Alto Purús are covered with fluvial deposits (Q4) of 3 km in average width, and intercalated by the Tertiary (T3). The T3 has relatively strong relief and has a tendency that ridges and valleys trending NE-SW are dominant. From the barely interpretable tracing of the bedding, the formation is presumed to be nearly horizontal. The relatively low portion in the south of the quadrangle is underlain by the uppermost Tertiary (T4).

(5) 21-r
A JERS-1 SAR image and a geological interpretation map are displayed in Figs. 8-1 and 8-2, respectively. The Envira River flows from WSW to ENE, meandering near the center of the quadrangle. The Curanja River, a tributary of the Alto Purús, also meanders running almost in parallel with the Envira in the southeastern end of the quadrangle. This suggests the possibility that the flow of rivers in the area is controlled by the underground structure in the depths as discussed above.

The northwest to westernmost part of the quadrangle is mostly underlain by the Middle Tertiary rocks (T2). In the central part of the quadrangle, the Middle Tertiary (T3) that overlies the T2 is widespread, stretching NE-SW. On the boundaries between the T2 and T3, the T3 clearly forms scarps, which suggests that the T3 is composed of rocks of high resistance to erosion, compared with the T2. The southeast part of the quadrangle is underlain by the uppermost Tertiary (T4). The T4 also forms clear scarps on its boundaries with the T3.

It is inferred from the drainage pattern that an aticlinal structure stretching nearly in the E-W direction is present in the southeast part of the quadrangle. The axis of the anticlinal structure is higher in elevation than the flanks, showing coarse structure. The northern flank is bounded by drainage systems with the E-W trend whereas the southern flank is by those with the WNW-ESE trend. Apparently, therefore, the anticlinal structure is presumed to plunge westward. The boundary between the T3 and T4 to the north of the anticlinal structure is cut by two faults in the NEN-SWS to N-S direction. These faults appear to show right lateral movement. However, the formation is presumed to dip nearly horizontal. In case a fault movement includes vertical slip, horizontal slip is exaggerated. Presumably, the lateral movement is not as large as the apparent displacement of approx. 1.5km.

(6) 21-s
Crossing a near-center of the quadrangle in the E-W direction, the Curanja River runs meandering generally from west to east. The northern half of the quadrangle is mostly underlain by the Upper Tertiary (T3) whilst the other part of the northern half and the whole southern half are extensively underlain by the uppermost Tertiary (T4). On the boundary between the T3 and T4, the latter often forms scarps. The Curanja changes its flow from the NE to ESE direction near the center of the quadrangle. This may suggest possible presence of an anticlinal structure stretching E-W to the south of the river, but it is not necessarily clear. Some fluvial deposits (Q4) are observed on the both banks of the Curanja River.

(7) 21-t
Both the Alto Purús and its tributary, the Curanja, flow meandering generally toward northeast. The quadrangle is extensively covered by the Upper Tertiary (T3) while the southwest part is underlain by the uppermost Tertiary (T4). As the T4 often forms scarps on its boundaries with the T3, the border lines are relatively clear. Fluvial deposits (Q4) lie rather extensively on the both banks of the two rivers.

(8) 21-u
The Brazilian border runs in the east of the quadrangle. The quadrangle is mostly underlain by the Upper Tertiary (T3) while the other parts including the southwest portion is underlain by the uppermost Tertiary (T4). As compared with the T3, the T4 lies on topographically elevated lands but boundaries between them are not necessarily clear. On the banks of the Alto Purús, which meanders in the northwestern tip of the quadrangle, fluvial deposits spread rather extensively.

(9) 22-r

The quadrangle is situated in the headwaters of the Alto Purús system; its west side belongs to the Urubamba system. Starting from the northwest of the quadrangle, the Ronsoco and Curiuja Rivers of the Alto Purús system, as well as the Inuya River of the Urubamba system, flow in radial directions -- east, southwest and south, respectively. It is clear that the area is the center of topographic elevation. Possible presence of a dome structure centering around the headwaters of these river systems can be pointed out. The east to south parts of the quadrangle is underlain mainly by the Upper Tertiary (T3) which, in turn, is extensively covered by the uppermost Tertiary (T4) from the central to east parts. The T4 often forms scarps on its boundaries with the T3, and the boundary lines are relatively clear.

(10) 22-s

The Curiuja River flowing northeast from the southwest tip of the quadrangle while the Ronsoco flowing southeast from the western tip merge into the Alto Purús in the central part of the quadrangle and meanders northeastward. The southeast side of the Curiuja and Alto Purús Rivers is underlain chiefly by the extensive Upper Tertiary (T3) whereas the northeast side is extensively underlain by the uppermost Tertiary (T4). The banks of major rivers are covered by belts of fluvial deposits.

(11) 22-t

An extensive area of the quadrangle is underlain by the Upper Tertiary (T3) while the uppermost Tertiary (T4) overlies the south and northwest parts. On the boundaries between the T3 and T4, the latter forms scarps; the boundary lines are very clear. Especially, the T4 in the south of the quadrangle has little erosion, forming a broad mesa-type topography. Belts of fluvial deposits cover the both banks of major rivers.

(12) 22-u

The east part of the quadrangle comes under the Brazilian domain. Winding like an S and passing near the center of the quadrangle, the Iaco River runs from west to east flowing into the Brazilian territory. An extensive area of the quadrangle is underlain by the Upper Tertiary (T3) while the uppermost Tertiary (T4) overlies the south and the north parts. The T4 in the south forms an extensive mesa-type topography, similarly to the Quadrangle 22-t. From tracing of the bedding, it can be inferred that an anticlinal structure is present to the north of the portion where the Iaco River bends like an S protruding southward. The bend of the Iaco can be interpreted to reflect the anticlinal structure.

1-4-2 Lineament analysis

The results of lineament interpretation of the respective quadrangles are described in the following paragraphs:

(1) 19-u
In the southeast end of the quadrangle covered by the Brazilian territory, several lineaments with the NNW-SSE and NE-SW trends were extracted.

(2) 20-r
Lineaments with the NE-SW to ENE-WSW trends and with the N-S to NNW-SSE trends tend to be dominant. Those with the NNE-SSW trends are intermittent, especially near the Brazilian border a little to the east of the south part of the quadrangle, where the lineament density is high.

(3) 20-t
Lineaments with the N-S trend are intermittent and those with the NE-SW trend tend to predominate in the Upper Tertiary (T3) lying on the left bank of the Curanja River in the southeast part of the quadrangle, which comes under the Peruvian domain.

(4) 20-u
Fig. 7-3 displays a lineament map of the quadrangle. Lineaments with the NE-SW trend are dominant in the area northwest of the Alto Purús which flows from southwest to northeast meandering near the center of the quadrangle. The direction is interpreted to reflect the geologic structure in the depths. In a zone vertically traversing a near-center of the quadrangle, high concentration of lineaments with the N-S trend is discerned. A circular structure, 1.2km in diameter, was extracted in the north of the quadrangle. To the southeast of the Alto Purús, lineaments with the N-S trend are dominant. High density zones of lineament are formed in the vicinity of intersections of those with the NE-SW trend and those with the N-S trend.

(5) 21-r
On the northeast side of the Envira River which flows from WSW to ENE meandering near the center of the quadrangle, observed are intermittent lineaments with the ENE-WSW trend running almost in parallel with the mentioned river. In general terms, there is a tendency that lineaments with the same trend predominate on the north side of the intermittent lineament zone whereas, on the south side, those with the N-S trend are predominant. The fault that cuts the boundary between the T3 and T4 is included in the lineaments with the N-S trend. High density zones of lineament are formed at intersections of those with the ENE-WSW trend and those with the N-S trend.

(6) 21-s
This quadrangle has higher lineament density, compared to the others. Dominant trends are NNE-SSW, NE-SW to ENE-WSW, NNW-SSE, etc. Especially, the river systems within the uppermost Tertiary (T4) which has high resistance to erosion

have flow directions controlled by these lineaments, often assuming trellis-like drainage patterns.

(7) 21-t
Lineaments with the NE-SW and NNW-SSE trends are dominant in the area intercalated by the Alto Purús and its tributary, the Curanja. High density zones are formed at intersections of these lineaments. Two of circular structures, though incomplete, were extracted from the northwest side of the area where the Alto Purús gently changes its direction from ENE to NE in the southeast part of the quadrangle. To the northeast of the Curanja, rather dominant are lineaments with the NW-SE trend, whereas, to the southeast of the Alto Purús, those with the NNW-SSE and NE-SW trends are conspicuous.

(8) 21-u
Intermittent zones of lineament with the N-S trend are present in the east part of the quadrangle whilst those with the NE-SW trend traverses a little to the northwest of the center of quadrangle, both stretching in the same direction as those of the lineaments. At the northeastern end of the intermittent zones with the NE-SW trend, observed is a portion in which lineaments with the N-S trend concentrate. Intermittent zones of lineaments with the NE-SW trend appear in the southeast end of the Peruvian territory. High density zones of lineament are formed in the vicinity of intersections of these zones.

(9) 22-r
An intermittent zone of lineaments with the NNE-SSW trend is discerned, which passes a little to the east of the center of the quadrangle. The northern half of the quadrangle has an area in which lineaments with the ENE-WSW trend predominate. The lineament density tends to be especially high in the northwest part where presence of a dome structures is inferred. This conforms to the results of analysis of drainage patterns, as well. It is presumed that tension fractures accompanying formation of the dome structure were extracted as lineaments.

(10) 22-s
The quadrangle has relatively high density of lineament. The main trends are the NE-SW, NW-SE and N-S, and lineaments with the same trend to be intermittent. In the eastern half of the quadrangle, the N-S trend is especially conspicuous. An incomplete circular structure was extracted in the east of the confluence of the Curiuja and Ronsoco Rivers.

(11) 22-t
Intermittent zones of lineaments with the ENE-WSW trend traverse the central part of the quadrangle nearly east to west. Intermittent zones with the NE-SW trend are distributed from the south-central end to the northeast end of the quadrangle. The

northwest part of the quadrangle has an area where lineaments with the ENE-WSW trend paralleling with the flow of major rivers are dominant while, in the north part, there is an area where those with the NW-SE trend predominate.

(12) 22-u
To the north of the Iaco River which gently meanders like an S around the center of the quadrangle and traverses it west to east, lineaments with the NE-SW and NW-SE trends tend to be intermittently present. To the south of the same river, intermittent lineaments with the ENE-WSW trend are dominant, as well as those with the NE-SW and N-S trends.

1-5 Considerations

A comparative study on the results of the Phase I and II image analysis and the 1:100 000-scale geological map published by the INGEMMET in 1997-98(List of references and data collected, 1) has revealed the following aspects:

a. The interpretation findings and the existing geologic map are in substantial agreement, in terms of the general division of geologic unit.

b. Due to the lack of ground data for the verification of interpretation findings, the respective geologic time units are hard to identify and, precision-wise, the interpretation results are inferior to the geologic map, in terms of detailed division of the geologic unit.

c. Owing to the distortion particular to a radar image, the fault lines and geologic boundary lines in the interpretation map tend to be distorted, especially in mountainous zones with high specific altitude.

d. In the Tertiary zone in the east where bedding planes are observable all over in spite of its flat topography, a verification survey, if conducted, is expected to be able to clarify the large and small folding structures more in detail.

e. The geologic map and the interpretation map do not agree as to the geologic division of Permian in the quadrangles 20-ñ, 20-n, etc. of the geologic map. In the map, the unit underlain by the horizontal to moderately dipping Cretaceous that constitutes the main body of the Sira range and apparently conforming to the overlying stratum is classified into the Permian. Since it is clear from the SAR images that Cretaceous is composed of a number of members (alternation of beds of high and low resistance to erosion), the unit is dealt with in the interpretation map to be the lowest member of Cretaceous.

f. The unit with rough texture and with well developed lineaments, lying in the vicinity of the Sira anticlinal axis in the quadrangles 20-ñ and 20-n, is classified in the geologic map into Proterozoic, whereas the interpretation map classifies it into Paleozoic in conformity to the division of the 1:2,000,000-scale geologic map, since no reference to Proterozoic have so far been found in the Sub-Andes studies and in view of the mentioned relations with Cretaceous.

g. The eastern part of the study area (Phase II survey area) tends to have low density of lineaments in comparison with the western part (Phase I survey area). From the tendency, it is considered that the eastern area has lesser potentials for metallic mineral resources compared with the western area.

h. In the eastern part of the study area, lineaments with the NNE-SSW trend are predominant. Different tendency is observed when compared with the Selva zone in the eastern part, underlain by the Neogene rocks, where the NE-SW trend is dominant. The difference possibly reflects difference in the orientation of the basement structures in the depths.

The western part of the interpretation area on the left bank of the Ucayali- Tambo rivers, where the Sira range is formed, is mainly composed of Paleozoic to Cretaceous, whilst the Ucayali sedimentary basin area in the eastern part, Tertiary to Quaternary are widespread forming relatively moderate landforms. The two areas are clearly divided by the thrust faults in NNW-SSE direction which serve as the boundary. In Paleozoic to Cretaceous in the Sub-Andean region, large to small-scale fold structures with axes parallel to the strike of the thrust faults are formed.

In Tertiary to Quaternary in the Ucayali sedimentary basin area, presence of a number of anticlinal structures or dome structures are inferred from drainage patterns. These structures are likely to reflect concealed Cretaceous or lower depths structures. The anomalous drainage pattern discerned in the quadrangle 21-p -- a distinctive trellis pattern -- appears interesting as it possibly suggests presence of an intrusive rock. In the Selva zone as represented by the Ucayali sedimentary basin area, drainage analysis is effective for interpretation of geology and geologic structure.

Figure 9 demonstrates a lineament density map. In the thrust zone trending NNW-SSE located in the east of the Sira range, many parallel lineaments to the thrusts, considered to reflect small faults accompanying the thrusts, and many intersecting lineaments to the thrust trending ENE-WSW, possibly reflecting tension fractures or strike-slip faults, have been extracted and those lineaments form high density zones of lineament in this zone. In general, tension fractures are possibly accompanied by intrusive rocks and hydrothermal activity related with the intrusive rocks; therefore, they are considered important for exploration.

The presence of small-scale intrusive rock bodies in Paleozoic in the southeast of the Sira range has been confirmed from the field data by INGEMMET, which suggests that similar rock bodies possibly lie in the zone. Although a zone of intrusive rocks cannot be interpreted from SAR images, the most part of the Phase I study area is covered by Jurassic to Quaternary sedimentary rocks or unconsolidated sediments and therefore fissures are presumed not to be well developed. It is also inferable that, in such an area, intrusive rocks and metamorphic rocks are likely to be present in portions of high lineament density.

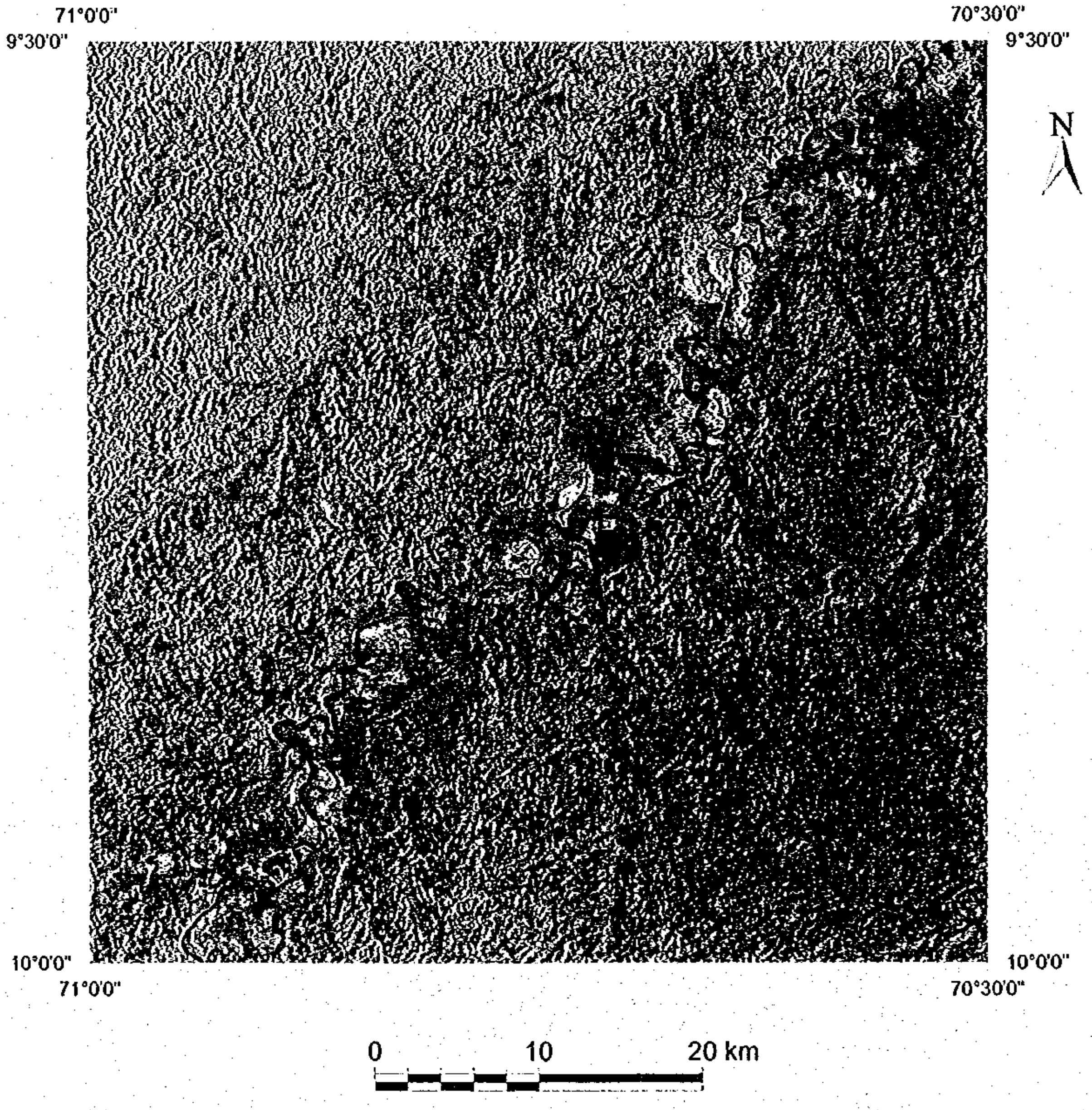


Figure 7-1 Puerto Esperanza (20-u) JERS-1 SAR image

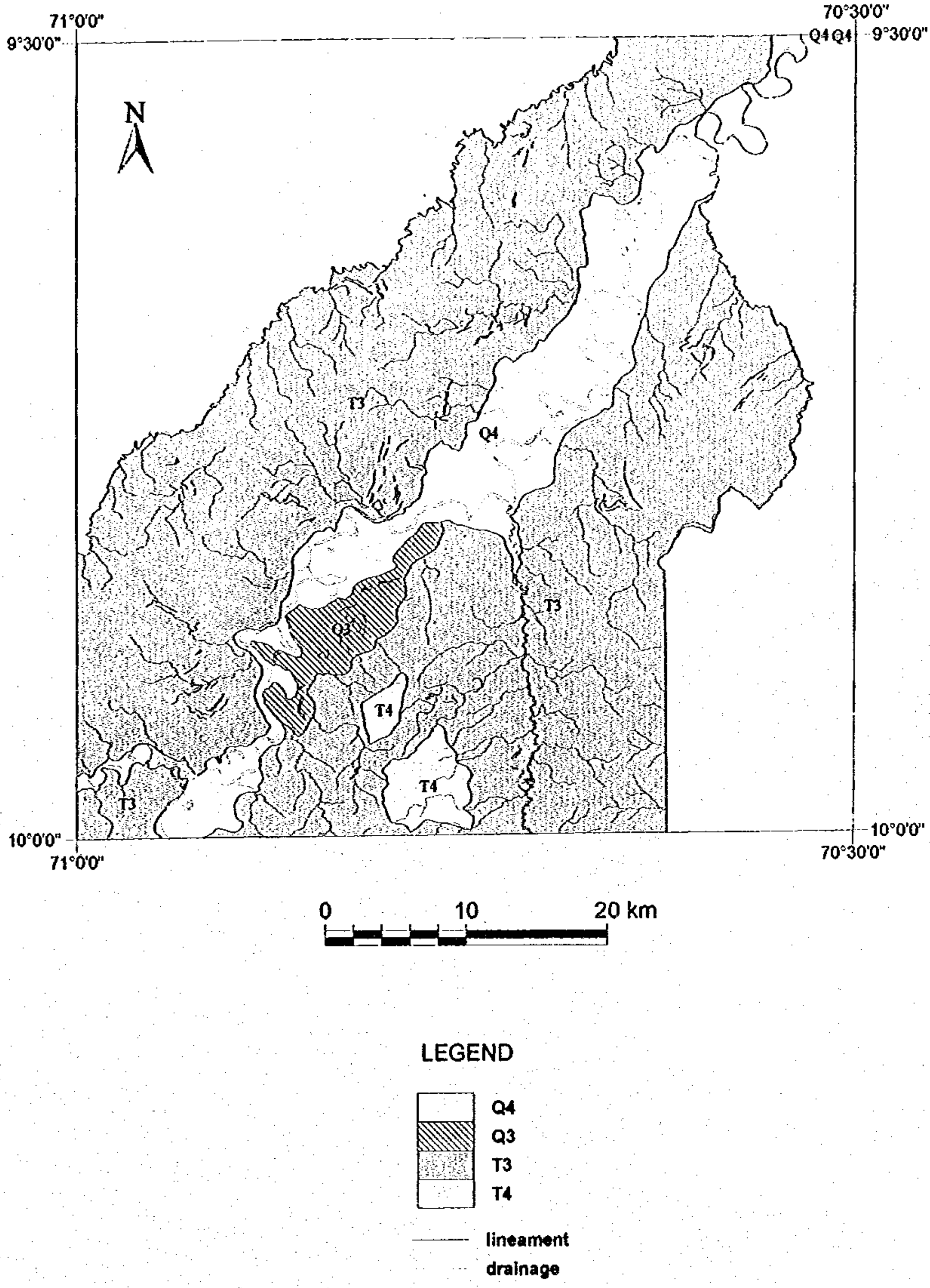


Figure 7-2 Puerto Esperanza (20-u) Geologic Interpretation Map

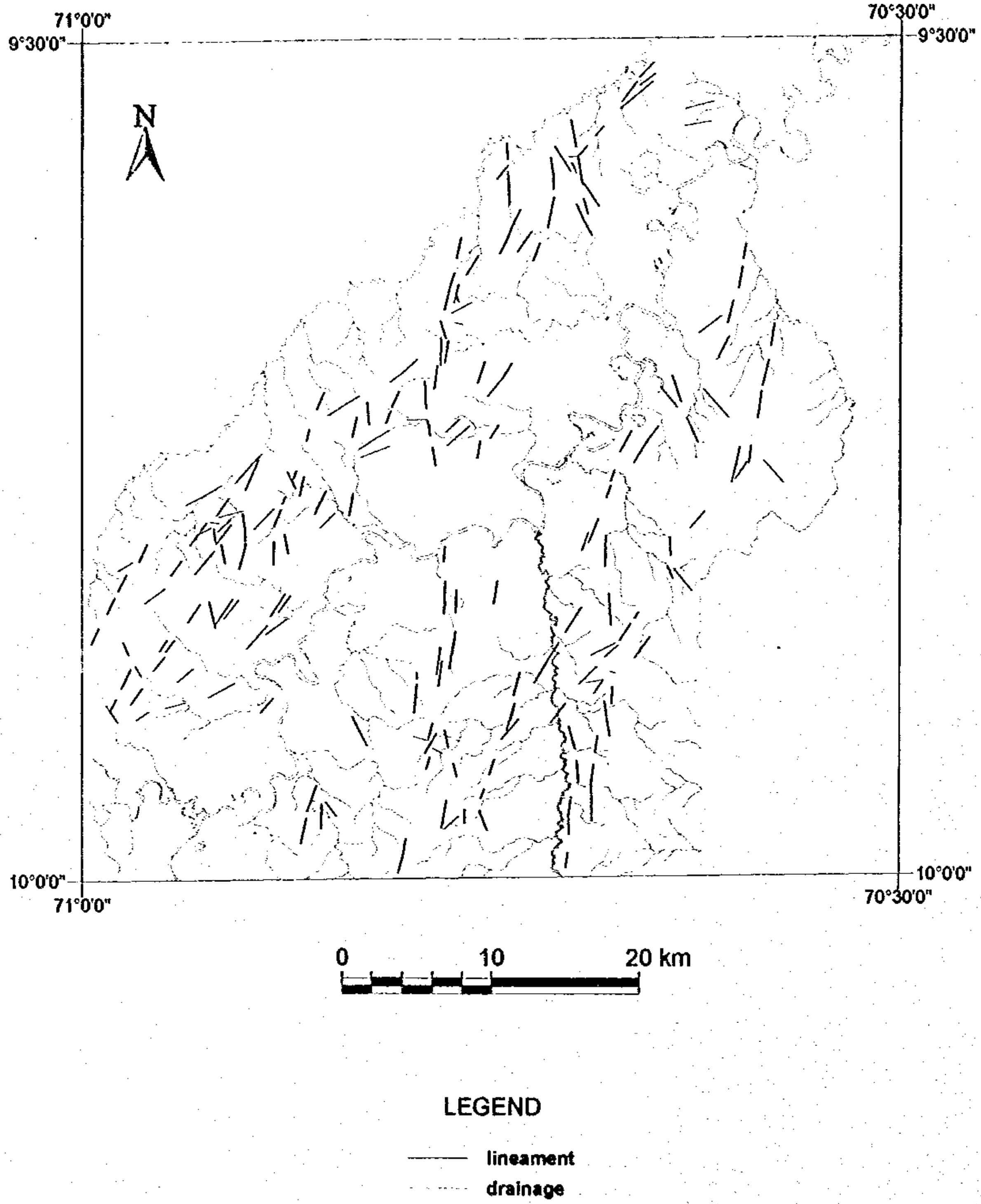


Figure 7-3 Puerto Esperanza (20-u) Lineament Map

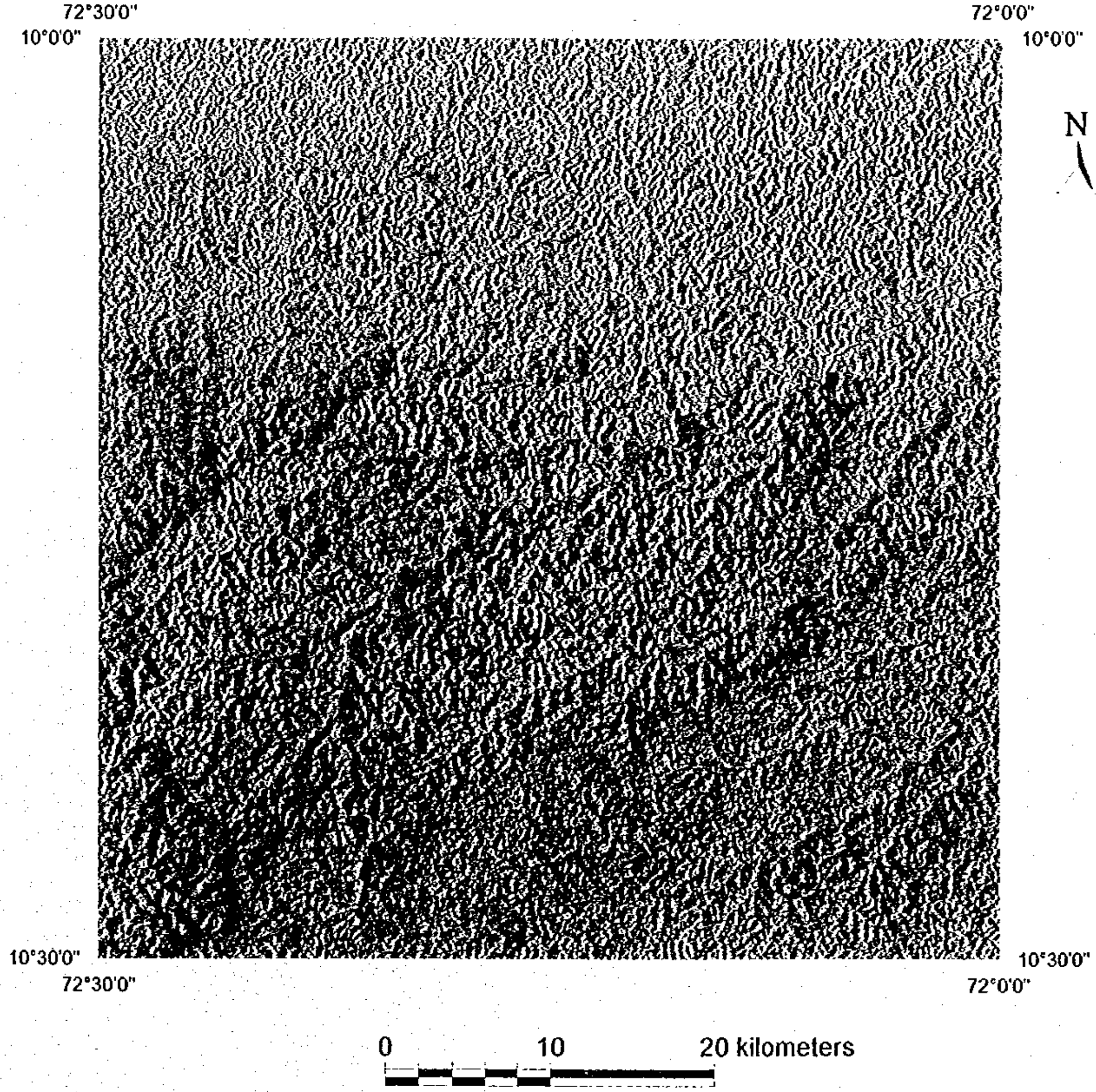


Figure 8-1 La Reparticion (21-r) JERS-1 SAR Image

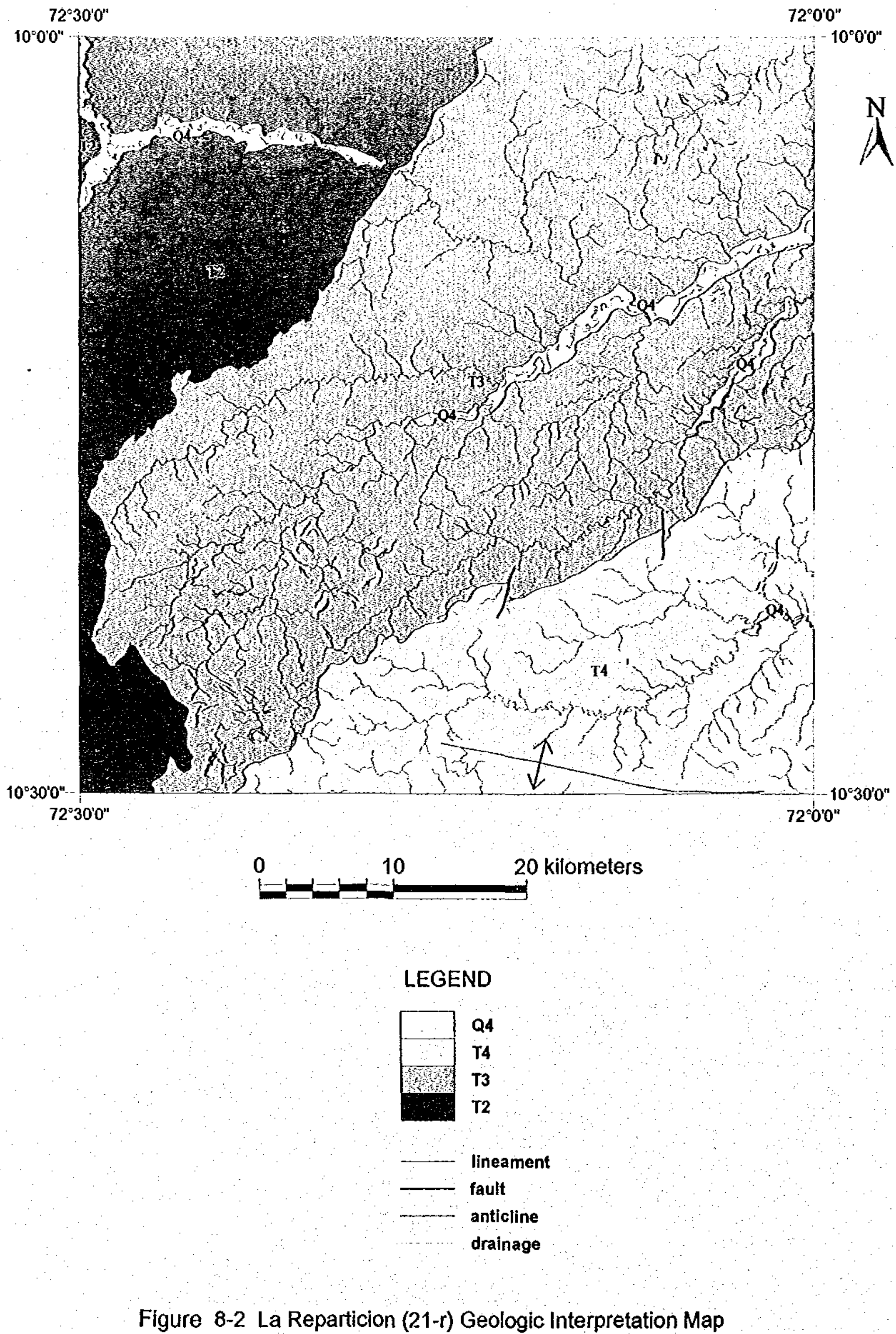


Figure 8-2 La Reparticion (21-r) Geologic Interpretation Map

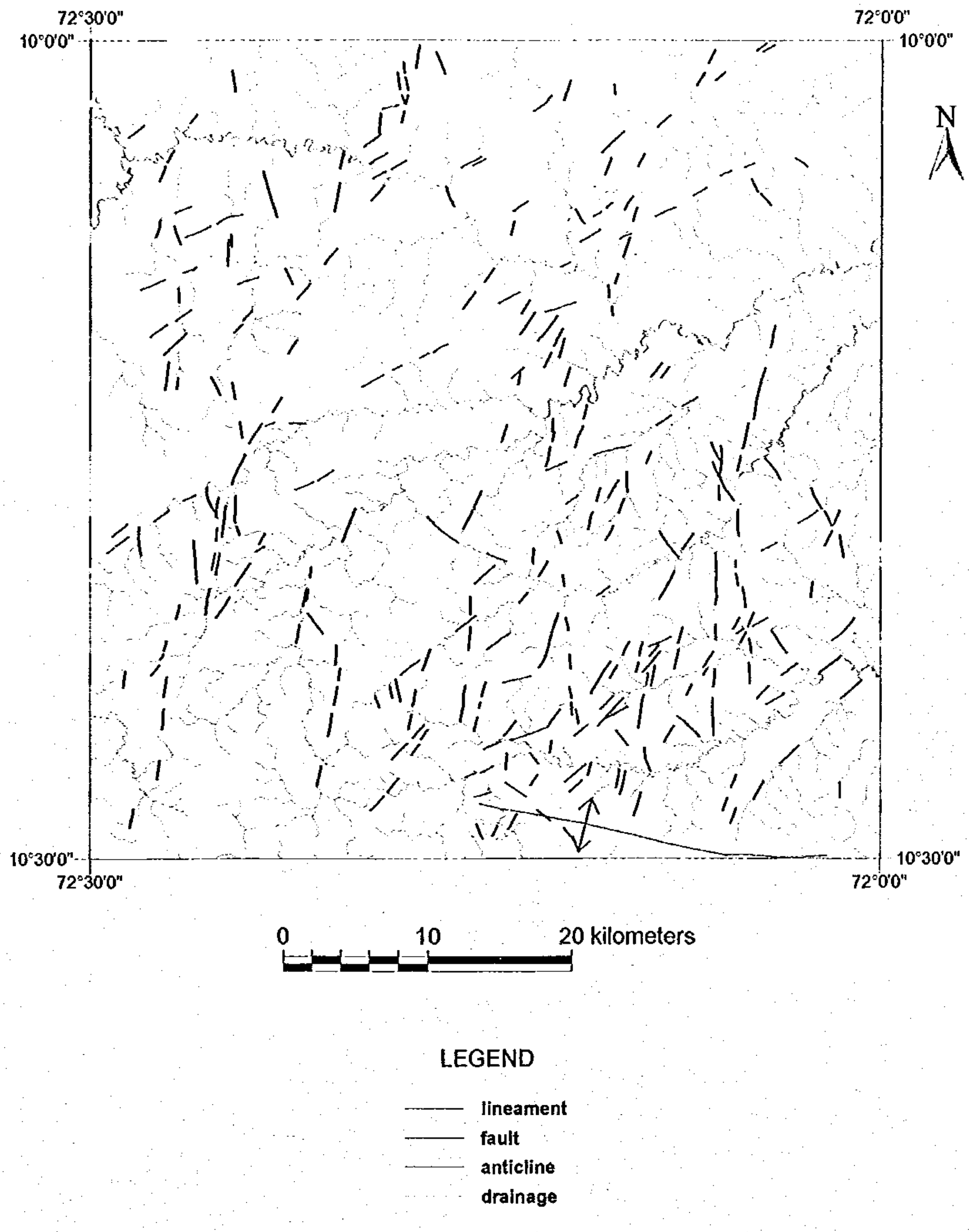


Figure 8-3 La Reparticion (21-r) Geologic Interpretation Map

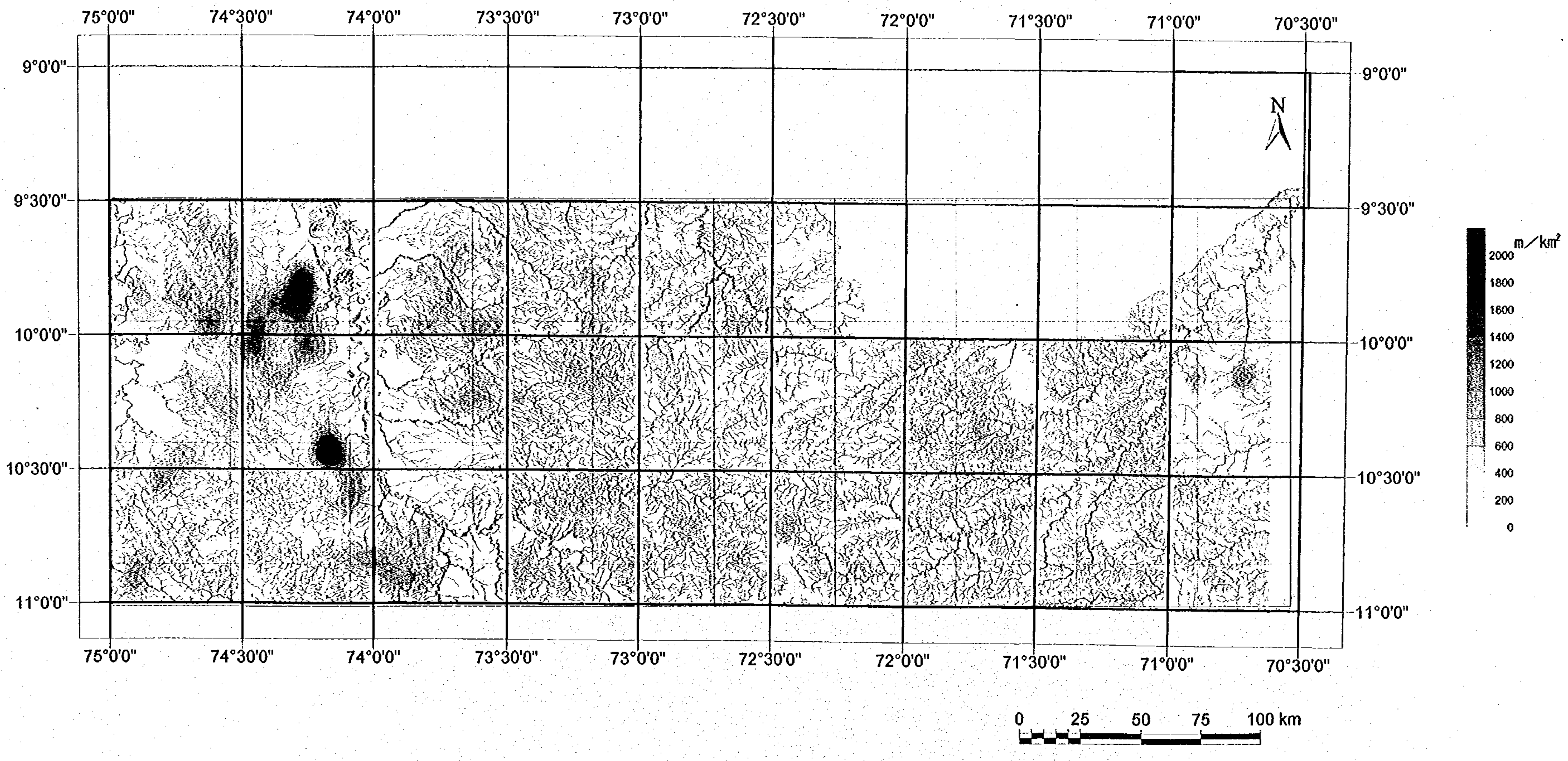


Figure 9 Lineament Density Map

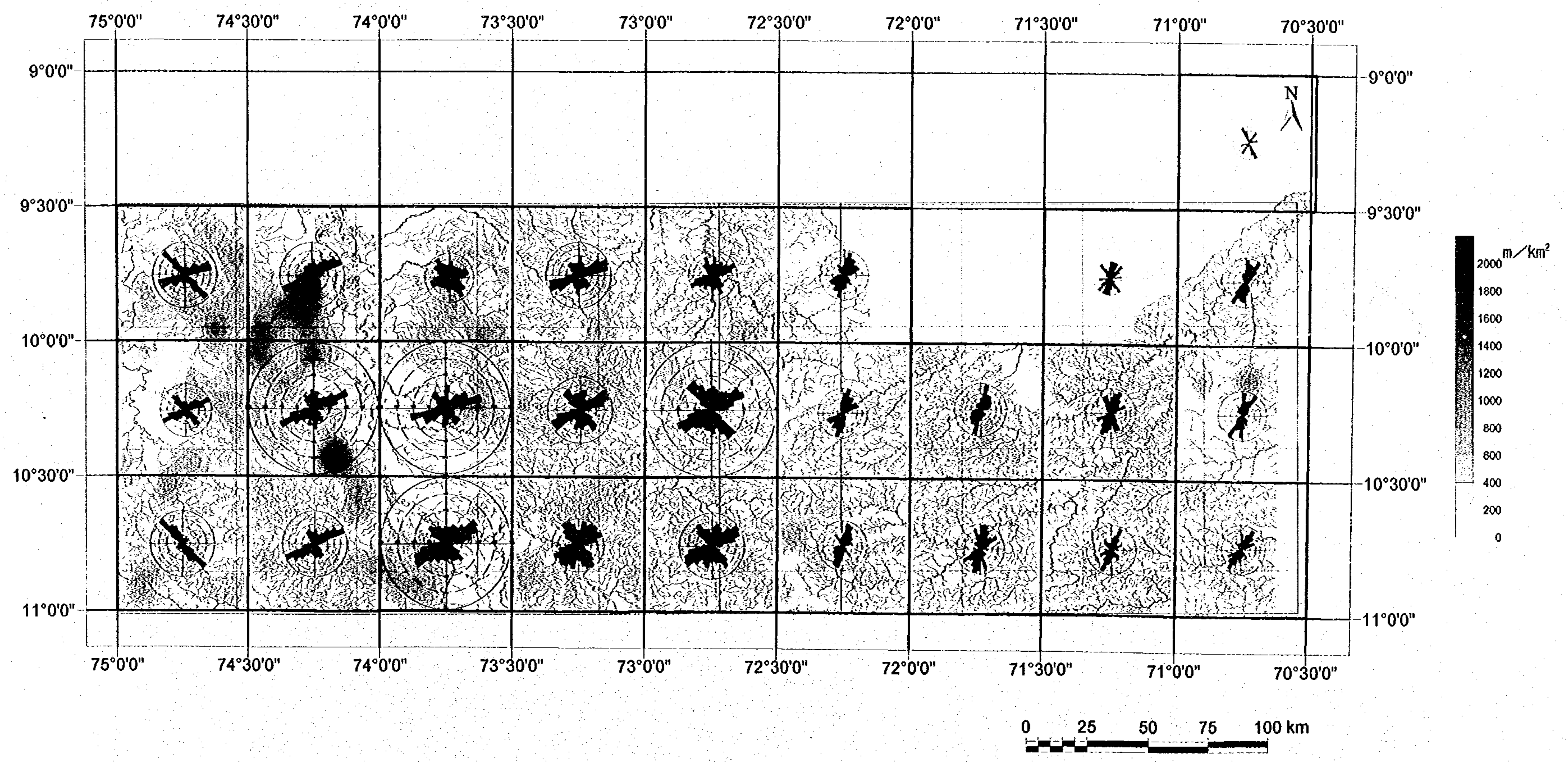


Figure 10 Lineament rose diagram

Chapter 2 Data Analysis

2-1 Purpose of the Data Analysis

The data analysis is intended to outline the ore deposits and showings and to ascertain the mode of occurrence in the survey area by collecting, compiling and analyzing the existing data.

The Phase-I descriptions on the analysis of the existing data that covers the whole inferior areas of the Urubamba River, are reproduced in the paragraphs below, since the data are essential for extraction of promising ore-bearing zones, combined with the satellite image analysis in Phase II :

2-2 Geology

2-2-1 Data collection

The collected data include among others the INGEMMET geological reports, the Petroperu's geologic maps and reports, and the ONERN survey reports. For details of the collected data, refer to the list of reference and data collected, at the end of this volume.

2-2-2 Summary of Geology

(1) Stratigraphy

The survey area is underlain by the Precambrian, the lower and upper Paleozoic formations, the Mesozoic and Cenozoic rocks, and intrusive rocks. The Sira range, which is situated in the west of the survey area and constitutes a part of the Sub-Andes, is composed of Precambrian, Lower and Upper Paleozoic, Mesozoic, and intrusive rocks. The Ucayali-Urubamba rivers, which run northward while meandering along the east margin of the Sira range, form the Ucayali sedimentary basin with N-S trending axis, composed of the Paleozoic and Mesozoic rocks.

In the central to eastern part of the survey area, the Selva spreads extensively from the Ucayali basin to the Brazilian border, forming flatlands chiefly underlain by the Cenozoic rocks. Figure 11 demonstrates a schematic geologic column of the survey area.

The geologic units of the survey area are described, in ascending order, in the following paragraphs:

Figure 11 Compiled Geological Column

Geological Age			Formation Name	Thickness m	Lithology
CENOZOIC	Quaternary	Holocene	Aluvial Deposit, Talus		Sand, Gravel [Unconformity]
CENOZOIC	Quaternary	Pleistocene	East Selve Area: Formation Madre de Dios	20	Brownish Sand, Clay, Gravel
CENOZOIC	Quaternary	Pleistocene	West Selva Area: Formation Ucayali	30	Brownish Sand, Clay, Gravel [Angular Unconformity]
CENOZOIC	Neogene	Pliocene / Miocene	Formation Ipururo (West Sira Area: 500m thick-ness)	1,200	Calcareous Sandstone (Sandstone with lignite layer) [Unconformity]
CENOZOIC	Paleogene	Oligocene	East Sira: Group Huayabamba	1,600	Sandstone, Mudstone, and Limestone
CENOZOIC	Paleogene	Eocene	West Sira: Formation Chambira	(400)	Reddish violet Claystone
CENOZOIC	Paleogene	Eocene	Formation Pozo	(400)	Tuff, Shale
CENOZOIC	Paleogene	Eocene	Formation Yahuarango	(800)	Calcareous Claystone [Unconformity]
MESOZOIC	Cretaceous	Upper	Formation Cachiyacu-Huchpayacu	150	Shale, Sandstone
MESOZOIC	Cretaceous	Upper	Formation Vivan	350	Siliceous Sandstone
MESOZOIC	Cretaceous	Upper	Formation Chonta	650	(Shaly) Limestone with thin Limonite Layer
MESOZOIC	Cretaceous	Upper	Group Oriente	600	Siliceous Sandstone with thin Limonite Layer [Unconformity]
MESOZOIC	Jurassic	Upper	Formation Sarayaquillo	600	Feldspasic Sandstone with Basal Conglomerate [Angular Unconformity]
MESOZOIC	Jurassic / Tiassic	Lower / Upper	Group Pucara	1,500	Limestone～Shaly Limestone
MESOZOIC / PALEOZOIC	Tiassic / Permian	Lower / Upper	Formation Ene	700	(Calcareous) Sandstone [Unconformity]
PALEOZOIC	Permian	Lower	Group Copacabana	500	Dolomitic Limestone
PALEOZOIC	Carboniferous	Upper	Group Tarma	500	Siliceous Sandstone with thin Coal layer
PALEOZOIC	Carboniferous	Lower	Group Ambo	600	Sandstone with Limonite layer [Angular Unconformity]
PALEOZOIC	Ordovician		Formation Contaya	400	Limonitic Shale [Angular Unconformity]
	Proterozoic		Complex Sira Complex del Marannon		Gneiss, Semischist Dioritic Gneiss

1) [Sira complex and Marañon complex] - Precambrian
These complexes occur as the inliers within the Upper Paleozoic Copacabana Group which corresponds to the anticline east of the Sira range (Quadrangles 21-ñ and 22-ñ). These are the oldest strata in the survey area, forming the basement of the Ucayali sedimentary basin. The Sira complex (Quad. 21-ñ) is composed of gneiss and slate whilst the Marañon complex (Quad. 22-ñ) is mainly of dioritic gneiss.

2) [Contaya Formation] - Ordovician
The formation lies in a small area to the south of the Bajo Pichanaqui (Quad. 22-n) at the southwest end of the survey area. It is about 400 m thick, in unconformable covered by the Ambo Group.

3) [Ambo Group] - Early Carboniferous
The Carboniferous to Permian overlies the Ordovician in angular unconformity, constituting the Ambo Group, Tarma Group and Copacabana Group in ascending order. In Quad. 22-n, the formations lie in a small area at Autiki. The Group consists of gray colored, medium to coarse grained sandstone containing mica, accompanied by thin layers of dark gray colored limonite containing fossil flora. The Group is 600 m thick.

4) [Tarma Group] - Late Carboniferous
In Quad. 21-n, 22-n and 22-ñ, the formations lie in Obenteni. The layer consists of greenish white-colored, coarse grained quartzitic sandstone. In the lower horizon, gray colored sandstone including coal layers is observable. The Group is 500 m thick.

5) [Copacabana Group] - Early Permian
The Group is widespread over the entire area of the Sira range (Quad. 20-n, 20-ñ, 21-n, 21-ñ, 22-n, 22-ñ and 22-o). The layer is mainly composed of limestone, partially dolomitic. The upper horizons are dominated by fossil-rich marl. The Group is 500 m thick, in unconformable covered by the Ene Formation.

6) [Ene Formation] - Late Permian to Early Triassic
The Formation lies northwest of Bajo Pichanaqui (Quad. 22-n) in the southwest end of the survey area. The Formation is composed of fine to medium-grained sandstone accompanied by limonite and thin layers of poorly sorted calcareous sandstone. The thickness of the Formation is 700 m.

7) [Pucara Group] - Late Triassic to Early Jurassic
The Group lies in the vicinity of Bajo Pichanaqui (Quad. 22-n) in the southwest end of the survey area. The Group is mainly composed of thick beds of neritic limestone, accompanied by thin layers of marl. The upper horizons abound in fossils. The Group is 1,500 m thick, covered by the Sarayaquillo Formation in angular unconformity.

8) [Sarayaquillo Formation] - Late Jurassic

The Formation lies in a small area to the south of Puerto Bermudez (Quad. 21-n). The Formation is composed of somewhat thick beds of feldspathic sandstone, accompanied by limonitized basal conglomerate. The Formation is 600 m thick, in unconformable covered by the Oriente Formation.

9) [Oriente Group] - Early Cretaceous

Cretaceous in unconformable covers Jurassic, constituting the Oriente Group, Chonta Formation, Vivian Formation and Cachiyacu-Huchpayacu Formation, in ascending order. The Group spreads most broadly over the entire area of the Sira range in the survey area. (Quad. 20-n, 20-ñ, 21-n, 21-ñ, 22-n, 22-ñ, 22-o and 22-p) The Group is composed mainly of white-colored siliceous sandstone accompanied by thin layers of reddish feldspathic sandstone and limonite. The Group is 600 m thick.

10) [Chonta Formation] - Late Cretaceous

The Formation extends in strip north to south along the east and west flanks of the Sira range. (Quad. 20-n, 20-ñ, 21-n, 21-ñ, 22-n, 22-ñ, 22-o and 22-p) The Formation is composed mainly of somewhat thick beds of yellowish gray colored marl and limestone which yields abundant fossils, accompanied by thin layers of limonitized shale. The thickness of the Formation is 650 m.

11) [Vivian Formation] - Late Cretaceous

The Formation extends north to south along the west flank of the Sira range in Quad. 20-n, 21-n and 22-n, whilst, in Quad. 22-ñ, 22-o and 22-p, it extends along the southeastern part of the range. The Formation is composed of somewhat thick beds of fine to medium-grained siliceous sandstone. The Formation is 350 m thick.

12) [Cachiyacu-Huchpayacu Formation] - Late Cretaceous

In the quadrangles 20-n and 21-n, the Formation extends in strip along the west flank of the Sira range. The Formations are mainly gray colored shale and medium-grained sandstone including coal layers. In the upper horizons, "carofitas (small plant fossil)", are observed. The Formation is 150 m thick, in unconformable covered by the Huayabamba Group.

13) [Huayabamba Group] - Eocene to Oligocene

The Group lies in strip north to south along the Pachitea, Pichis and Autiki basins (Dwgs. 20-n, 21-n and 22-n) on the west side of the Sira range, whilst, on the east side of the range, it extends on the west banks of the Ucayali and Urubamba rivers (Dwgs. 10-ñ, 21-ñ, 22-ñ, 22-o and 22-p). On the west side of the Sira range, the Group is classified into the three formations: the Eocene Yahuarango Formation, the late Eocene Pozo Formation and the Oligocene Chambira Formation. The total thickness is 1,600 m.

[Yahuarango Formation]
The lower to middle part of the Formation is composed of reddish violet-colored claystone in thick beds which intercalates thin layers of greenish gray colored sandstone, whereas the upper part is of reddish violet-colored, massive claystone which intercalates thin layers of limestone including limonite and fossils. The Formation is 800 m thick.

[Pozo Formation]
The Formation consists of the lowermost part composed of yellowish gray colored tuff, the middle part of greenish gray colored shale including fossils, and the upper part of reddish gray colored claystone including fossils. The thickness of the Formation is 400 m.

[Chambira Formation]
The lower part is composed of reddish brown-colored, massive calcareous claystone including coarse grained sandstone in lenses, while brick red-colored, massive calcareous claystone including calcareous nodules comprises the upper part. The Formation is 400 m thick.

The lithofacies on the east side of the Sira range is of red-colored, fine-grained sandstone, reddish brown-colored mudstone accompanied by limonite in thin layers, limonitized claystone, dark gray colored limestone, dark gray colored conglomeratic sandstone, clayish sandstone, etc. The total thickness is 1,500 m.

14) [Ipururo Formation] - Pliocene to Miocene
On the west side of the Sira range, the Formation extends in strip north to south along the Pachitea and Pichis Rivers (Quad. 20-n and 21-n) while, on the east side of the range, it spreads broadly over the Selva from the Ucayali-Urubamba basin to the Brazilian border.

The Formation of the west side of the Sira range comprises reddish to grayish white-colored, coarse grained sandstone in thick beds, accompanied by a horizon of clayish mudstone, and is 500 m thick.

The Formation on the east side of the Sira range comprises sandstone accompanied by reddish brown-colored mudstone and lenticular calcareous rocks, yellowish brown-colored, fine-grained sandstone accompanied by reddish brown-colored limonite and fossil plants, dark gray colored calcareous sandstone accompanied by thin layers of reddish brown-colored mudstone including fossil tortoises, conglomerate accompanied by thin layers of tuff, breccia assuming various colors, etc. The thickness of the Formation reaches 1,200 m. The Formation is covered by the Pleistocene Ucayali and Madre de Dios Formations in angular unconformity.

15) [Ucayali Formation] - Pleistocene

The Pleistocene Series in unconformable overlies the Ipururo Formation of Miocene to Pliocene age, spreading over the Selva on the east side of the Sira range from the Ucayali-Urubamba basin to the Brazilian border. The portion west of the long. 73°30' W is called Ucayali Formation whereas the eastern portion is called Madre de Dios Formation. The lithofacies of the Ucayali Formation comprise red-colored clay, coarse grained sand, and pebble including thin layers of gravel. The thickness of the Formation is about 30 m.

16) [Madre de Dios Formation] - Pleistocene

The Formation comprise limonitized sand, yellowish brown-colored clay and yellowish brown-colored, unconsolidated pebble. The Formation is 20 m thick.

17) [Alluvium] - Holocene

The Alluvium spreads over the Sira range and river basins in the Selva, comprising unconsolidated sand, pebble, etc.

(2) Intrusive rocks

Two types of stocks presumably of different intrusion stages lie in the Sira range in the west of the survey area. One of the stocks comprising gneissic granite, diorite, etc., which is inferred to have intruded in the Permian time, is situated in the center of the anticline of the Sira range (Quad. 21-ñ and 22-ñ) and intrudes into Precambrian metamorphic rocks. The other stock, situated in the north of the range (Quad.19-n), comprises monzodiorite inferred to have intruded in the Paleogene time and is altered by contact metasomatism and mineralization. (Although the latter is situated outside the survey area, reference is herein made in view of its necessity for the evaluation of potential ore deposits.)

The characteristics of the intrusive rocks in and around the survey area are summarized as follows:

1) Southeastern part of the Sira range (I)

Locality: southeastern part of Quad. 21-ñ: "Bolognesi"
Rock types: gneissic granite, diorite
Occurrence: gneissic granite (EW: 2 km, NS: 5 km), diorite (EW: 0.5 km, NS:1.5 km)
Altitude: 500 m to 1,200 m
Wall rock: Precambrian slate and gneiss (Sira Complex)
Age: Permian
Mineral indications: none
Source: INGEMMET geological report (4)

2) Southeastern part of the Sira range (II)

Locality: northeastern part of Quad. 22-ñ: "Obenteni"
Rock types: amphibolite, basalt, granite

Occurrence: small scale (undescribed in the 1:100,000-scale geologic map)
Altitude: about 500 m to 800 m
Wall rock: Precambrian dioritic gneiss, etc. (Marañon complex)
Age: Permian
Mineral indications: none
Source: INGEMMET geological report (5)

3) Northern part of the Sira range

Locality: southwestern part of Quad.19-n: "Puerto Inca"; 13 km east of Puerto Inca, Dept. Huanuco, on the right bank of the Rio Pachitea; UTM coordinates (N 8,963,000; E 517,000); the placer gold deposit in the Negro River is located about 23 km southward.
Rock type: Monzodiorite
Occurrence: E-W: 3.5 km; N-S: 1.5 km
Altitude: about 300 m
Wall rocks: sandstone of the lower Cretaceous Oriente Group, limestone-sandstone beds (gently dipping west) of the upper Cretaceous Chonta Formation, limestone of the Chonta Formation in the vicinity of the stock; the sandstone of the Oriente Group is altered to hornfels.
Age: Paleogene
Mineral indications: In some limestone of the Chonta Formation, contact metasomatic alteration with Au-Cu dissemination occurs. Au-Cu anomalies (Au 0.02 to 0.18 g/t) are detected in the stream sediments in the vicinity of the stock.
Source: INGEMMET geological report (9)

(3) Structure

1) Geologic structure near the surface

The survey area is situated north of the structurally transitional zone called the "Abancay" bend in southern Peru, and represents the NNW-SSE direction, the typical Andean trend.

The western part of the survey area is called Sub-Andes where the Cordillera Oriental shifts into the Selva. The Sira range, alt. 2,000 m, is formed within the Sub-Andes.

The Sira range, composed of the Precambrian, Paleozoic, Mesozoic and Paleogene, constitutes an anticline thrusted on the west and east margins of the range while, internally, anticlinal and synclinal structures develop with the Andean trend.

On the east side of the Sira range, the Selva composed of the Neogene to Quaternary spreads extensively up to the Brazilian border, while the Ucayali-Urubamba rivers are situated on the western margin of the Ucayali sedimentary basin. The Ucayali basin has the Precambrian basement which constitutes the Brazilian shield, underlain by the Paleozoic, Mesozoic and Paleogene rocks, extending in the N-S direction and reaching 6,000 m in depth. Oil and natural gas prospecting have long since been conducted in the sedimentary basin.

As regards intrusive rocks, granite stocks are observed in the Sira range in the west of the survey area, which have caused contact metamorphism to the Precambrian and Mesozoic of the Sira range.

2) Deep geologic structure

An overview of the geotectonic framework of the survey area, based on the survey data of the Petroperu, indicates the following structural units from west to east. Figure 12 exhibits the deep geologic structure of the survey area.

a. Vilcabamba-Sira anticline, Sira thrust zone and Ucayali depression

The Vilcabamba-Sira anticline represents a large-scale anticlinal structure extending from Agua Caliente in the northwest of the survey area to the Vilcabamba range in the south of the survey area. The total extension reaches 400 km. The anticlinal axis generally trends N10°W. In the north, it plunges northward and sinks into the Tertiary System while, in the south, it is bounded by the Abancay bend. In the survey area, the anticline forms the Sira range. Its east and west flanks are asymmetric, the former dipping steeply while the latter gently. The anticline is bounded by the thrust zone in the east.

The northern area of the anticlinal structure is called Sira high, where sudden ascension of the basement is inferable from gravity and seismic data. At the northern end of the anticlinal structure, out of the survey area, there is the Agua Caliente gas field. In the Vilcabamba-Sira anticline, many fractures develop in NE-SW direction, which are interpreted to be left-lateral faults. The hot spring at Agua Caliente is presumed to ascend through one of such fractures as the path. Besides the thrust zone bounding the east flank of the anticlinal structure, there is a parallel thrust zone in the interior of the anticlinal structure. In these thrust zones, a block structure consisting of the normal and reverse faults is formed.

Along the Ucayali river east of the Sira thrust zone which bounds the east flank of the anticlinal structure, a sudden subsidence of basement caused by the development of the thrust is observed, which is called the Ucayali depression. From seismic prospecting data and well logs, the amount of vertical displacement is inferred to exceed 2,000 m.

b. Ucayali sedimentary basin

The Ucayali sedimentary basin broadly extends in the NNW-SSE direction over the Selva in eastern Peru within the approximate area of lat. 6°30' - 12°S and long. 72°-

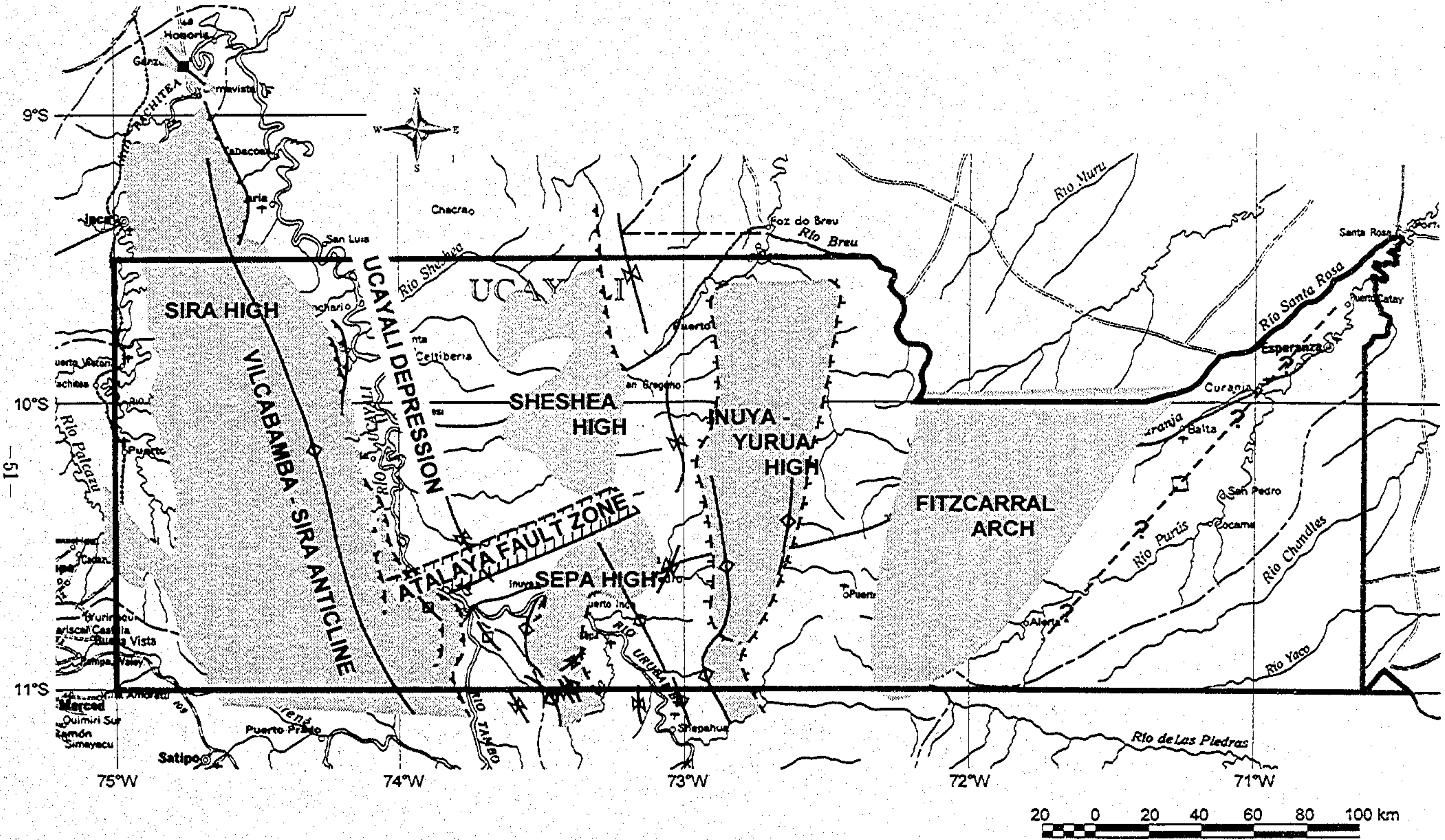


Figure 12 Deep geologic structure map

76°W. It has the Precambrian basement, overlain by the lower Paleozoic to Cretaceous. In the survey area, the Ucayali sedimentary basin is located outside the both flanks of the Vilcabamba-Sira anticline and bounded in the east by the Fitzcarral arch. The depth of the basement reaches 6,000 m in the vicinity of Sepa in the lower reach of the Urubamba river.

c. Atalaya fault zone, Sheshea high and Sepa high

About 10 km north of Atalaya, in the south of the survey area, presence of a fault zone striking N70°E, 15 km wide, has been inferred, which is called the Atalaya fault zone. The fault zone, as a whole, is inferred to have a left-lateral displacement. The occurrence of the Atalaya fault zone is not necessarily clear from the surface geology.

The ascension of the basement with the N-S trend observable at around long. 73°20' W is cut by the Atalaya fault zone. The north side of the fault zone is called the "Sheshea high" while the south side is called the "Sepa high." The latter forms an anticlinorium, where the anticlinal structures such as Sepa, Pucacuro, Leigh and Victor lie intercalating a small synclinal structure. The depth of the basement is inferred to be 5,000 m in the vicinity of the Sepa anticline.

d. Inuya-Yurua high

The high represents an ascending portion of the basement observable at around long. 72°30' - 73°W and is inferred, as a whole, to assume a horst-like structure bounded in the east and west by normal faults. The depth of the basement is about 2,000 m in shallow portions.

e. Fitzcarral arch

From around long. 71° to 72°30'W, there is an ascending portion of the basement with the NE-SW trend, called the Fitzcarral arch. The arch bounds between the Ucayali sedimentary basin and the Madre de Dios sedimentary basin.

f. Madre de Dios sedimentary basin

The sedimentary basin spreads from the southwest part of the Fitzcarral arch to Brazil and Bolivia, its southern limit being at lat. 13°20' S. Similar to the Ucayali sedimentary basin, it has the Precambrian basement, overlain by the Lower Paleozoic to Cretaceous rocks.

g. Others

An anticlinal structure with the NE-SW trend is inferred to extend along the Alto Purús river in the northeast of the survey area, but its details are unknown.

2-3 Ore Deposits

2-3-1 Data collection

The collected data include the INGEMMET geological reports and data base of ore deposits and showings, the data of the Mine Inspection Bureau (la Dirección de Fiscalización Minera) of The Ministry of Energy and Mines and the Mining Registry (Registro Público de Minería), the Banco Minero's financing-related technical reports, Petroperu's geologic maps and reports and ONERN's survey reports. For details of the collected data, refer to the list of reference and data collected, at the end of this volume.

2-3-2 Mineralization

From the geologic-metallogenic point of view, the survey area is situated east of the East Andean metallogenic province, and where few deposits have so far been developed because of the poor accessibility and the lack of information on ore deposits and showings. Mineralization in the survey area is described below, on the basis of the topographic division, into the Sira range division, the Ucayali-Urubamba division and the eastern Selva division.

The Sira range division, alt. 2,000 m, is a part of the Sub-Andes area where the Cordillera Oriental shifts into the Selva, and is underlain by Paleozoic including Precambrian and by Mesozoic. The area has the best accessibility in the survey area from the Andes Mountains side; therefore, small placer gold mining has long since been conducted on the western margin of the Sira range. The INGEMMET's recent geological survey has verified occurrence of intrusive rocks accompanied by Au-Cu mineral indications, and new applications for mining claims are being filed.

The Ucayali-Urubamba division is situated on the west margin of the Ucayali basin stretching in the central part of the survey area, bounded by the thrust fault trending N-S on the east edge of the Sira range. The Ucayali basin, with the 6,000 m-deep Precambrian basement, is composed of the Paleozoic and Mesozoic rocks. The area has high potentials of petroleum and natural gas, where seismic prospecting and long-hole drilling have been conducted long since, in an effort to examine geological structure of the Ucayali basin. As for metallic minerals, however, sufficient prospecting and development have not yet been done, owing to the poor accessibility to the Selva zone. Nonetheless, information on showings of placer gold deposits has been increasing recently, near small towns along the Ucayali-Urubamba rivers which serve as the major transportation routes.

The eastern Selva division covers the Selva up to the Brazilian border, a sparsely populated area of hard access. Descriptions of ore deposits and showings are scarce, as well as information on mineral resources development. From the topographical and geological points of view, occurrence of placer gold deposits is considered to be possible.

2-3-3 Ore deposits and showings

Table 7 lists ore deposits and mineral indications in the survey area extracted from the INGEMMET data base. Location, geology, mineralization and source described in the existing data are summarized below, in respect of the topographic division.

(1) Sira range

1) Piraje Pintuyacu

a. Locality: Quad. 19-n: "Puerto Inca", 13 km east of Puerto Inca, Dept. Huanuco, in the northwest of the Sira range; UTM coordinates (N 8,963,000, E.517,0000; alt. about 300 m. The locality -- out of the survey area -- is about 23 km north of the placer gold deposit in the Negro river referred below.

b. Geology: Sandstone of the Oriente Group of the Lower Cretaceous System and limestone-sandstone of the Chonta Formation of the Upper Cretaceous System are overlying with a gentle dip westward. Monzodiorite intrude in stock (2 km ϕ) into the Cretaceous. Limestone of the Chonta Formation and sandstone of the Oriente Group around the stock are metamorphosed to hornfels.

c. Mineralization: Contact metasomatic portions exist in part of limestone of the Chonta Formation, accompanied by dissemination with Au, Cu, etc. In stream sediments around the stock, Au and Cu anomalies (Au: 0.02 to 0.18 g/t; Cu: 10 to 27.5 ppm) are detected. Assay of rock samples collected in the surroundings of the intrusive rock indicates max. Au: 0.567 g/t and Cu: 900 ppm.

d. Source: INGEMMET geological report (9)

2) Negro River (HUA 0071, 0072, 0073, 0074)

a. Locality: Quad. 20-n: "Rio Palcazu," in the Negro river at Puerto Inca, Dept. Huanuco, in the northwest of the Sira range; UTM coordinates (N 8,937,522, E 506,827); alt. about 300 m.

b. Geology and mineralization: The placer gold deposits occur in the Llullapichis river and the Negro river, tributaries of the Pachitea. Mining dates back to 1935-45, when 2,000 to 2,500 miners were engaged in gold production at a monthly rate of 100 kg. From 1970 to 80, gold prospecting was active. At the two claims, Oro del Río Negro and El Sira, 10 km east of the Pachitea river, 37 pits were dug and resource-geological evaluation had been done. It indicated 300,000 m^3 (Au: 1.55 g/m^3; 465 kg) of confirmed reserves, 460,000 m^3 (Au: 1.48 g/m^3; 680 kg) of probable reserves and 1,500,000 m^3 (Au: 1 g/m^3; 1,500 kg) of possible reserves (Moya, R. Carlos, 1974). At present, some 200 people are engaged in panning to produce gold of 1 g per man-day.

c. Source: Reference (11), INGEMMET geological report (1)

3) Inti Mantaro (JUN 0320, 0319)

a. Locality: Quad. 22-n: "Baja Pichanaqui," Chanchamayo Huachiriki, Dept. Junin, in the southwest of the Sira range; UTM coordinates (N 8,800,600, E 520,038); alt. 900 m to 1,000 m.

b. Geology and mineralization: In the small mining claims of Inti Mantaro and Villa El Sol, minor-scale tunnel prospecting is ongoing to examine occurrence of the Pucara Group and Chonta Formation of Mesozoic. It has been reported, however, that the mineral indications and alteration are weak. No intrusive rocks are observable in the nearby areas.

c. Source: INGEMMET geological report (2)

4) Autiki

a. Locality: Quad. 22-n: "Baja Pichanaqui," Chanchamayo Autiki, Dept. Junin, in the southwest of the Sira range; UTM coordinates (N 8,789,000, E 541,0000); alt. 500 m.

b. Geology and mineralization: A foreign company is conducting geological survey to examine a paleo-placer deposit which occur in the basement of the Oriente Formation of the Lower Cretaceous System.

c. Source: INGEMMET geological report (2)

(2) Ucayali-Urubamba division

1) Cumaria valley

a. Locality: Quad. 20-o: "Cumaria," 105 km north of Atalaya, Dept. Ucayali, in one of the Ucayali tributaries; UTM coordinates (N 8,912,000, E 622,000); alt. 210 m.

b. Geology and mineralization: Fluvial sediments (sand) around the Cumaria valley, a tributary of the Ucayali on the right bank, assay Au: 0.025 g/t. The Ipururo Formation of the Neogene System is exposed in the area. No intrusive rocks nor the Mesozoic-Paleozoic rocks are existent in the vicinity or upper streams; it has been pointed out that the Ipururo Formation possibly contains gold.

c. Source: INGEMMET geological report (3)

2) Vicinity of Atalaya

a. Locality: Quad. 22-o: "Atalaya," Dist. Atalaya, Dept. Ucayali, near the confluence of the Tambo and Urubamba river; an island near Mardonadillo (UTM coordinates: N 8,812,500, E 642,000) and the Tambo river near Atalaya (UTM coordinates: N 8,815,000, E 636,500)

b. Geology and mineralization: In the Ucayali river and its tributaries north of Atalaya, occurrence of placer gold deposits and heavy minerals has been reported, but exact localities of many mineral indications are unknown and many are not covered by mining claims. However, the placer gold deposits at the two localities indicated above are well known.

c. Source: INGEMMET geological report (4)

3) The Urubamba

a. Locality: Quad. 22-p: "Rio Inuya," Dist. Atalaya, Dept. Ucayali. M-8, near the Mapalija Island on the right bank of the Urubamba river (UTM coordinates: N 8,813,000, E 678,000; alt. 285 m; 12 km northwest of Sepa, and M-7, at Esperanza on the right bank of the Urubamba river (UTM coordinates: N 8,799,000, E 694,000); alt. 286 m; 9 km southeast of Sepa.

b. Geology and mineralization: placer gold showings are observable in the gravel beds mixed with clay along the Urubamba river from Sepa to Camisea. Panning samples of stream sediments at the mentioned M-8 and M-7 are reported to assay 1.6 g/t and 0.8 g/t of Au, respectively. It has been pointed out that places where current velocity is abruptly reduced, such as confluence, and curvatures of meanders are important as locations where placer gold deposits tend to be formed. The gold is thought to be originated from gold-bearing quartz lenses and veinlets which fill bedding planes and fissures in Paleozoic sedimentary rocks such as slate and quartzite in Andes mountains, which are accompanied with acidic intrusions. 0.17% of Sn contained in a panning sample has also been reported.

c. Source: Reference (10)

(3) Eastern Selva division

1) East of the Ucayali

a. Locality: Quad. 20-p, 20-q, 20-r, 21-p and 21-q

b. Geology and mineralization: The area is the Selva zone from the right bank of the Ucayali to the Brazilian border, having hard access and sparse population. Descriptions and information on placer gold deposits and mineral resources development are hardly available.

c. Source: Reference (12) and INGEMMET geological reports (6) and (7)

2) Districts of Purús, Department of Ucayali (the east margin of the survey area)

a. Locality: Quad. 21-r, 22-r, 21-s, 22-s, 20-t, 21-t, 22-t, 19-u, 20-u, 21-u and 22-u (the Selva zone up to the Brazilian border)

b. Geology and mineralization: The area being hardly accessible and sparsely populated, few descriptions and information on placer gold deposits and mineral resources development are available.

c. Source: INGEMMET geological reports (7) and (8)

2-4 Considerations

The survey area consists of Precambrian, Lower Paleozoic, Upper Paleozoic, Mesozoic, Cenozoic and intrusive rocks. In recent years, geological survey of the extensive area including this survey area has been undertaken by the INGEMMET and its geological reports were published in 1997 and 98.

The survey area is situated in the remote region beyond the Andes Mountains and the access is impeded by the Selva zone. Such constraints have obstructed progress of systematic surveys. At present, there is no operating mines of metallic minerals in the survey area.

Considerations on the geology and ore deposits in the survey area, based upon the data collected during the Phase I survey, may be summarized as follows.

On the western margin of the Sira range, which has relatively good access from the Andes side, placer gold mining has been carried out long since. In the Negro river, a tributary of the Pachitea river in the north of the Sira range (Quad. 20-n), placer gold mining was conducted since the 1930's to produce gold of 100 kg a month. In the 1970's, prospecting including pitting was done, which indicated 1.2 tons of gold content in the confirmed and probable ore reserves. At present, some 200 people are engaged in panning operation.

As the INGEMMET geological survey in recent years in the area 13 km east of

Puerto Inca (Quad. 19-n), or about 23 km north of the Negro river, verified presence of an intrusive rock accompanied by Au-Cu indication, a number of applications for mining claims have been filed. This indication is similar with the placer gold deposit in the Negro river in structural setting, whereas the indication is considered to be a source (primary deposit) of placer gold. Therefore, it may be said that to discover both primary and secondary (placer) types of ore deposit might be possible, depending on a systematic prospecting in future.

Gold and tin concentration in stream sediments are reported in a eastern tributary of the Ucayali river in Quad. 20-o, near Atalaya (Quad. 22-o) and Sepa (Quad. 22-p) along the Ucayali itself. A report says that, near Sepa, some panning sample assays 1.6 g/t of Au, which suggests a high probability of occurrence of placer gold deposits. At present, mining contractors seem to inactively engage placer gold mining at this prospect. It is possible that minable placer gold deposits can be discovered by future surveys in the unexplored Selva zone east of the Ucayali-Urubamba rivers, as well.

Table 7 List of ore deposits and mineral indications (1)

ID	*NOMBRE*	*DEPARTAMENTO*	*UBICACION*	*LATITUD*	*LONGITUD*	*CUADRANGULO*	*ELEMENT O*	*MINERAL*	*FORMA*	*DEPOSITO*
HUA0071	ORO DEL RIO NEGRO, MINA	HUANUCO	PUERTO INCA, PROVINCIA DE PACHITEA	09-36-42S	074-56-16W	RIO PALCAZU 20-N	AU	ORO	IRREGULAR	ALUVIAL
HUA0072	LORENA, MINA	HUANUCO	PUERTO INCA, PROVINCIA DE PACHITEA	09-36-42S	074-56-06W	RIO PALCAZU 20-N	AU	ORO	IRREGULAR	ALUVIAL
HUA0073	EL SHIRA, MINA	HUANUCO	PUERTO INCA, PROVINCIA DE PACHITEA	09-35-00S	074-50-36W	RIO PALCAZU 20-N	AU	ORO	IRREGULAR	ALUVIAL
HUA0074	MISTERIO, MINA	HUANUCO	PUERTO INCA, PROVINCIA DE PACHITEA	09-34-24S	074-44-24W	RIO PALCAZU 20-N	AU	ORO	IRREGULAR	ALUVIAL
JUN0319	VILLA EL SOL, PETITORIO	JUNIN	BAJO PICHANAQUI, PROVINCIA DE CHANCHAMAY O	10-53-00S	074-51-00W	BAJO PICHANAQUI 22-N	AU	ORO		
JUN0320	INTI MANTARO, CONCESIO N	JUNIN	BAJO PICHANAQUI, PROVINCIA DE CHANCHAMAY O	10-51-00S	074-49-00W	BAJO PICHANAQUI 22-N	AU	ORO		

ID : CODIGO INGEMMET

Table 7 List of ore deposits and mineral indications (2)

ID	COMENTARIO DE EXPLORACION	COMENTARIO DE EXPLOTACION	COMENTARIO DE LA EXPLORACION Y DESARROLLO	COMENTARIO GENERAL	COMENTARIOS MINERALES	REFERENCIAS BIBLIOGRAFICAS	COMENTARIOS RESERVAS	COMENTARIOS DE UBICACION	COMENTARIO GEOLOGICO
HUA0071	EL YACIMIENTO CONSISTE EN DEPOSITOS AURIFEROS EXISTENTES EN TERRAZAS ALUVIALES (CUATERNARIO) . EL ORO SE ENCUENTRA DENTRO DE UNA CAPA DE GREDA QUE CONTIENE TAMBIEN RODADOS (40 CM A 0.5 CM DE DIAMETRO) . LA SECUENCIA DE LAS CAPAS DE ARRIBA HACIA ABAJO ES C	EXISTEN HUELLAS DE ZONAS TRABAJADAS EN UNA EXTENSION DE 20 X 30 M HOY CUBIERTA DE MALEZAS (ZONA A). ADEMAS SE HA ENCONTRADO UNA TRINCHERA DE 20 X 2 0 M (ZONA B). SEGUN MANIFESTACION DE LOS MINEROS DE LA ZONA TAMBIEN HAN SACADO DEL LECHO DEL RIO	DESPUES QUE FUERON CONOCIDOS LOS DEPOSITOS FUERON INTENSAMENTE EXPLOTADOS Y ASEGURAN MINEROS DE LA ZONA QUE HAN SACADO HASTA 7 KG EN UN ANO	EL DENUNCIO "ORO DEL RIO NEGRO" ABARCA UN AREA DE 5,000 X 1,200 M , QUE EN UN INICIO PERTENECIO A LA SELORITA NELLY LOPEZ GALLARDO Y QUE LUEGO TRASPASO EL 5 DE SETIEMBRE DE 1973 A LOS ACTUALES PROPIETARIOS . EN LA FECHA DE LA INSPECCION , EL LABOREO MINER	EL ORO SE HALLA EN FORMA DE CHARPAS, LAMINILLAS Y FINOS GRANOS	MOYA FERRADAS, CARLOS; ANTEPROYECTO DE EXPLOTACION DE GRAVAS AURIFERAS "RIO NEGRO", BMP.1974; COD.B6975 ;GALVAN L, MIGUEL; INFORME TECNICO MINA "ORO DEL RIO NEGRO", BMP.1972; COD.B7642		SE UBICA EN EL PARAJE DE YANAYACU, ENTRE LOS DENUNCIOS "LORENA"Y "EL SHIRA" , EN LA CONFLUENCIA DEL RIO YUYAPICHIS CON EL RIO NEGRO, A LA CUAL SE ACCEDE DE ACUERDO AL SIGUIENTE ITINERARIO. PUCALLPA - PUERTO INCA 120 KM (VIA AEREA) , PUERTO INCA - PARAJE M	EN LA ZONA DE LOS DEPOSITOS AURIFEROS EXISTEN TERRAZAS ALUVIALES (CUATERNARIO) EN LAS MARGENES DEL RIO NEGRO . EL RIO TIENE UN ANCHO PROMEDIO DE 15 M Y U CAUDAL APROXIMADO DE 30 LITROS/SEG Y SU LECHO SO PAQUETES DE ARENISCAS CUARCIFERAS EN LAS OQUEDADE
HUA0072	EL YACIMIENTO CONSISTE EN DEPOSITOS AURIFEROS EXISTENTES EN TERRAZAS ALUVIALES (CUATERNARIO) . EL ORO SE ENCUENTRA DENTRO DE UNA CAPA DE GREDA QUE CONTIENE TAMBIEN RODADOS (40 CM A 0 5 CM DE DIAMETRO) . LA SECUENCIA DE LAS CAPAS DE ARRIBA HACIA ABAJO ES C	EXISTEN HUELLAS DE ZONAS TRABAJADAS EN UNA EXTENSION DE 20 X 30 M HOY CUBIERTA DE MALEZAS (ZONA A). ADEMAS SE HA ENCONTRADO UNA TRINCHERA DE 20 X 2 0 M (ZONA B) SEGUN MANIFESTACION DE LOS MINEROS DE LA ZONA TAMBIEN HAN SACADO DEL LECHO DEL RIO	DESPUES QUE FUERON CONOCIDOS LOS DEPOSITOS FUERON INTENSAMENTE EXPLOTADOS Y ASEGURAN MINEROS DE LA ZONA QUE HAN SACADO HASTA 7 KG EN UN ANO	EL AREA DEL DENUNCIO LORENA ES DE 5,000 M X 1,200 M . EN LA FECHA DE LA INSPECCION , EL LABOREO MINERO ESTABA PARALIZADO DESDE HACE 2 ALOS APROXIMADAMENTE Y SE TRABAJABA EN FORMA EMPIRICA . EL MAYOR PROBLEMA PARA LAS OPERACIONES MINERAS RESIDE EN LA DIFIC	EL ORO SE HALLA EN FORMA DE CHARPAS, LAMINILLAS Y FINOS GRANOS	GALVAN J , MIGUEL; INFORME TECNICO MINA "ORO DEL RIO NEGRO", BMP.1972; COD B7642		SE UBICA EN EL PARAJE DE YANAYACU Y SE ENCUENTRA ADYACENTE AL OESTE DEL DENUNCIO "ORO DEL RIO NEGRO" Y AL CUAL SE ACCEDE DE ACUERDO AL SIGUIENTE ITINERARIO: PUCALLPA - PUERTO INCA 120 KM (VIA AEREA) , PUERTO INCA - PARAJE MAQUISAPAYOC 16 KM (DESLIZADOR) .	EN LA ZONA DE LOS DEPOSITOS AURIFEROS EXISTEN TERRAZAS ALUVIALES (CUATERNARIO) EN LAS MARGENES DEL RIO NEGRO . EL RIO TIENE UN ANCHO PROMEDIO DE 15 M Y U CAUDAL APROXIMADO DE 30 LITROS/SEG Y SU LECHO SO PAQUETES DE ARENISCAS CUARCIFERAS EN LAS OQUEDADE
HUA0073	EL YACIMIENTO CONSISTE EN DEPOSITOS AURIFEROS EXISTENTES EN TERRAZAS ALUVIALES (CUATERNARIO) . EL ORO SE ENCUENTRA DENTRO DE UNA CAPA DE GREDA QUE CONTIENE TAMBIEN RODADOS (40 CM A 0 5 CM DE DIAMETRO) . LA SECUENCIA DE LAS CAPAS DE ARRIBA HACIA ABAJO ES C	EN EL AREA CORRESPONDIENTE AL DENUNCIO "EL SHIRA" SE HAN EJECUTADO 76 POZOS EXPLORATORIOS CON EL FIN DE EVALUAR EL AREA MINERALIZADA Y SE HA DETERMINADO UN AREA MAS FAVORABLE DENOMINADO "ZONA A" Y TIENE 25 HAS. DE EXTENSION	DESPUES QUE FUERON CONOCIDOS LOS DEPOSITOS FUERON INTENSAMENTE EXPLOTADOS Y ASEGURAN MINEROS DE LA ZONA QUE HAN SACADO HASTA 7 KG EN UN ANO	EL AREA DEL DENUNCIO "EL SHIRA" ES DE 3,000 M X 3,000 M , E INICIALMENTE PERTENECIO A LA SELORITA NELLY LOPEZ GALLARDO (1972), QUIEN LUEGO LA TRASPASO A LOS ACTUALES PROPIETARIOS. TIENE UN CLIMA CALUROSO Y EL 80 % DE LA PROPIEDAD SE ENCUENTRA CUBIERTA POR	EL ORO SE HALLA EN FORMA DE CHARPAS, LAMINILLAS Y GRANOS FINOS.	CARLOS MOYA, FERRADAS; ANTEPROYECTO DE EXPLOTACION DE LAS GRAVAS AURIFERAS "ORO NEGRO", BMP.1974; COD.B6975,GALVAN J.,MIGUEL; INFORME TECNICO MINA "ORO DEL RIO NEGRO", BMP.1972; COD B7642	ESTOS DATOS ESTAN REFERIDOS A RESERVAS PROBABLES UNICAMENTE CON UN CONTENIDO FINO DE 680 KG DE AU	SE UBICA EN EL PARAJE DE YANAYACU Y SE ENCUENTRA ADYACENTE AL NE DEL DENUNCIO "ORO DEL RIO NEGRO" Y AL CUAL SE ACCEDE DE ACUERDO AL SIGUIENTE ITINERARIO: PUCALLPA - PUERTO INCA 120 KM (VIA AEREA) , PUERTO INCA - PARAJE MAQUISAPAYOC 16 KM (DESLIZADOR) , MA	EN LA ZONA DE LOS DEPOSITOS AURIFEROS EXISTEN TERRAZAS ALUVIALES (CUATERNARIO) EN LAS MARGENES DEL RIO NEGRO . EL RIO TIENE UN ANCHO PROMEDIO DE 15 M Y UN CAUDAL APROXIMADO DE 30 LITROS/SEG Y SU LECHO PAQUETES DE ARENISCAS CUARCIFERAS. EN LAS OQUEDADES O
HUA0074	EL YACIMIENTO CONSISTE EN DEPOSITOS AURIFEROS EXISTENTES EN TERRAZAS ALUVIALES (CUATERNARIO) . EL ORO SE ENCUENTRA DENTRO DE UNA CAPA DE GREDA QUE CONTIENE TAMBIEN RODADOS (40 CM A 0 5 CM DE DIAMETRO) . LA SECUENCIA DE LAS CAPAS DE ARRIBA HACIA ABAJO ES C	EXISTEN HUELLAS DE ZONAS TRABAJADAS EN UNA EXTENSION DE 20 X 30 M HOY CUBIERTA DE MALEZAS (ZONA A). ADEMAS SE HA ENCONTRADO UNA TRINCHERA DE 20 X 2 0 M (ZONA B) SEGUN MANIFESTACION DE LOS MINEROS DE LA ZONA TAMBIEN HAN SACADO DEL LECHO DEL RIO	DESPUES QUE FUERON CONOCIDOS LOS DEPOSITOS FUERON INTENSAMENTE EXPLOTADOS Y ASEGURAN MINEROS DE LA ZONA QUE HAN SACADO HASTA 7 KG EN UN ANO	EL AREA DEL DENUNCIO "MISTERIO" ES DE 3,000 M X 2,000 M ,TINE UN CLIMA CALUROSO . EN LA FECHA DE LA INSPECCION , EL LABOREO MINERO ESTABA PARALIZADO DESDE HACE 2 ALOS APROXIMADAMENTE Y SE TRABAJABA EN FORMA EMPIRICA . EL MAYOR PROBLEMA PARA LAS OPERACIONE	EL ORO SE HALLA EN FORMA DE CHARPAS, LAMINILLAS Y GRANOS FINOS.	GALVAN J., MIGUEL; INFORME TECNICO MINA "ORO DEL RIO NEGRO", BMP.1972; COD B7642		SE UBICA EN EL PARAJE DE YANAYACU Y SE ENCUENTRA ADYACENTE AL NE DEL DENUNCIO "EL SHIRA" Y AL CUAL SE ACCEDE DE ACUERDO AL SIGUIENTE ITINERARIO. PUCALLPA - PUERTO INCA 120 KM (VIA AEREA) , PUERTO INCA - PARAJE MAQUISAPAYOC 16 KM (DESLIZADOR) , MAQUISAPAYO	EN LA ZONA DE LOS DEPOSITOS AURIFEROS EXISTEN TERRAZAS ALUVIALES (CUATERNARIO) EN LAS MARGENES DEL RIO NEGRO . EL RIO TIENE UN ANCHO PROMEDIO DE 15 M Y U CAUDAL APROXIMADO DE 30 LITROS/SEG Y SU LECHO SO PAQUETES DE ARENISCAS CUARCIFERAS. EN LAS OQUEDADE
JUN0319	EL PROPOSITO DE ESTE PETITORIO ES DESARROLLAR TRABAJOS DE EXPLORACION POR ELEMENTOS METALICOS		EL PETITORIO ABARCA UNA EXTENSION DE 600 HAS.	EN EL CATASTRO MINERO SE REGISTRAN DOS AREAS UBICADAS EN EL CUADRANGULO DE BAJO PICHANAQUI CERCA AL POBLADO DE HUACHIRIKE, UNO DE ESTOS PETITORIOS ES VILLA EL SOL		INGEMMET, GEOLOGIA DE LOS CUADRANGULOS DE BAJO PICHANAQUI Y PUERTO BERMUDEZ, BOLETIN 85 DE LA CARTA GEOLOGICA NACIONAL, 1997		EL PETITORIO VILLA EL SOL SE UBICA EN LA QUEBRADA HUACHIRI, DISTRITO DE BAJO PICHANAQUI, PROVINCIA DE CHANCHAMAYO, DPTO. DE JUNIN	EL AREA COMPRENDE ROCAS DE LAS UNIDADES PUCARA Y CHONTA, NO HABIENDOSE DETECTADO ROCAS INTRUSIVAS NI INDICIO DE MINERALIZACION Y/O ALTERACION
JUN0320	LAS CIAS. HAN HECHO MUESTREO DE SEDIMENTOS DE QUEBRADA		EL AREA HA SIDO SOLICITADA PARA HACER TRABAJOS DE EXPLORACION POR ORO	LA CONCESION COMPRENDE UNA EXTENCION DE 1000 HAS., HA SIDO SOLICITADA PARA REALIZAR TRABAJOS DE EXPLORACION POR ORO.		INGEMMET, GEOLOGIA DE LOS CUADRANGULOS DE BAJO PICHANAQUI Y PUERTO BERMUDEZ, BOLETIN 85, 1997		SE UBICA LA CONCESION EN EL DISTRITO DE BAJO PICHANAQUI, PROVINCIA DE CHANCHAMAYO, DPTO. DE JUNIN	EL AREA COMPRENDE ROCAS DE LAS UNIDADES PUCARA Y CHONTA, NO HABIENDOSE DETECTADO LA PRESENCIA DE ALGUN INTRUSIVO NI INDICIOS DE MINERALIZACION Y/O ALTERACION HIDROTERMAL.

ID : CODIGO INGEMMET

Chapter 3 Integrated Analysis

In the integral analysis, promising ore-bearing zones were extracted on the basis of the combined results of the analysis of the existing data in Phase I and the satellite image analysis in Phase I and II, whereby potentials for occurrence of ore deposits in the entire inferior areas of the Urubamba River were evaluated. The integral analysis of the survey findings revealed the following aspects(Ref. Figure 13) :

(1) The data suggesting presence of anticlinal or dome structures in the Ucayali sedimentary basin have been obtained from the drainage patterns delineated by JERS-1 SAR image interpretation. As it has been confirmed with the Sira anticline, anticlinal structures and dome structures tend to be accompanied by a stockwork intrusive rock nearby those central portion. Generally, presence of an intrusive rock suggests possible presence of the thermal source for formation of ore deposits; the anticlinal or dome structures are of particular importance from the viewpoint of prospecting not only for petroleum or gas but for metallic mineral resources, as well.

(2) In the east part of the quadrangle 21-p, there is an area in which an anomalous drainage pattern - a distinctive trellis pattern - is observed. As the anomaly is possibly reflecting the presence of intrusive rocks, the area is also considered important for exploration of mineral resources.

(3) The lineament interpretation using the JERS-1 SAR data has revealed that the lineament density tends to be low in the eastern part of the study area (Phase II survey area), as compared with the western part (Phase I survey area). From the fact, it is inferred that the eastern part has lesser potentials for metallic mineral resources in comparison with the western part.

(4) In the thrust zone trending NNW-SSE located in the east of the Sira range, many parallel lineaments to the thrusts, considered to reflect small faults accompanying the thrusts, and many intersecting lineaments to the thrust trending ENE-WSW, possibly reflecting tension fractures or strike-slip faults, have been extracted and those lineaments form high density zones of lineament in this zone. Generally, tension fractures are likely to be accompanied by intrusive rocks and hydrothermal activity having the intrusive rocks as the thermal source. At Agua Caliente in the northeast of the study area, there are thermal springs accompanying faults with the NE-SW trend. Therefore, the high concentration zone of lineaments in the thrust fault zone east of the Sira range is considered to be important for metallic mineral resources exploration.

(5) Analysis of the existing geologic data indicates the possibility that primary gold

deposits occur in the vicinity of the alluvial gold deposits in the Negro river in the quadrangle 20-n.

(6) Minable alluvial gold deposits are possibly present in the fluvial sediments along the Urubamba river near Atalaya (Quad.22-o) and Sepa (Quad. 22-p).

In the light of the integral analysis referred to above, it is considered desirable that field survey aimed for discovering new ore deposits, including geochemical survey, ore showings survey and confirmation of lithofacies along the survey route, should be undertaken in the promising ore-bearing areas which follow:

- The surrounding areas of the Negro River where the known alluvial gold deposits are located.

- The area stretching from the Urubamba riverbanks including the Atalaya-Sepa zone, where alluvial gold showings are located, to the eastern part of the Sira Range west of the Ucayali, where intrusive rocks occur and high density zones of lineament have been extracted.

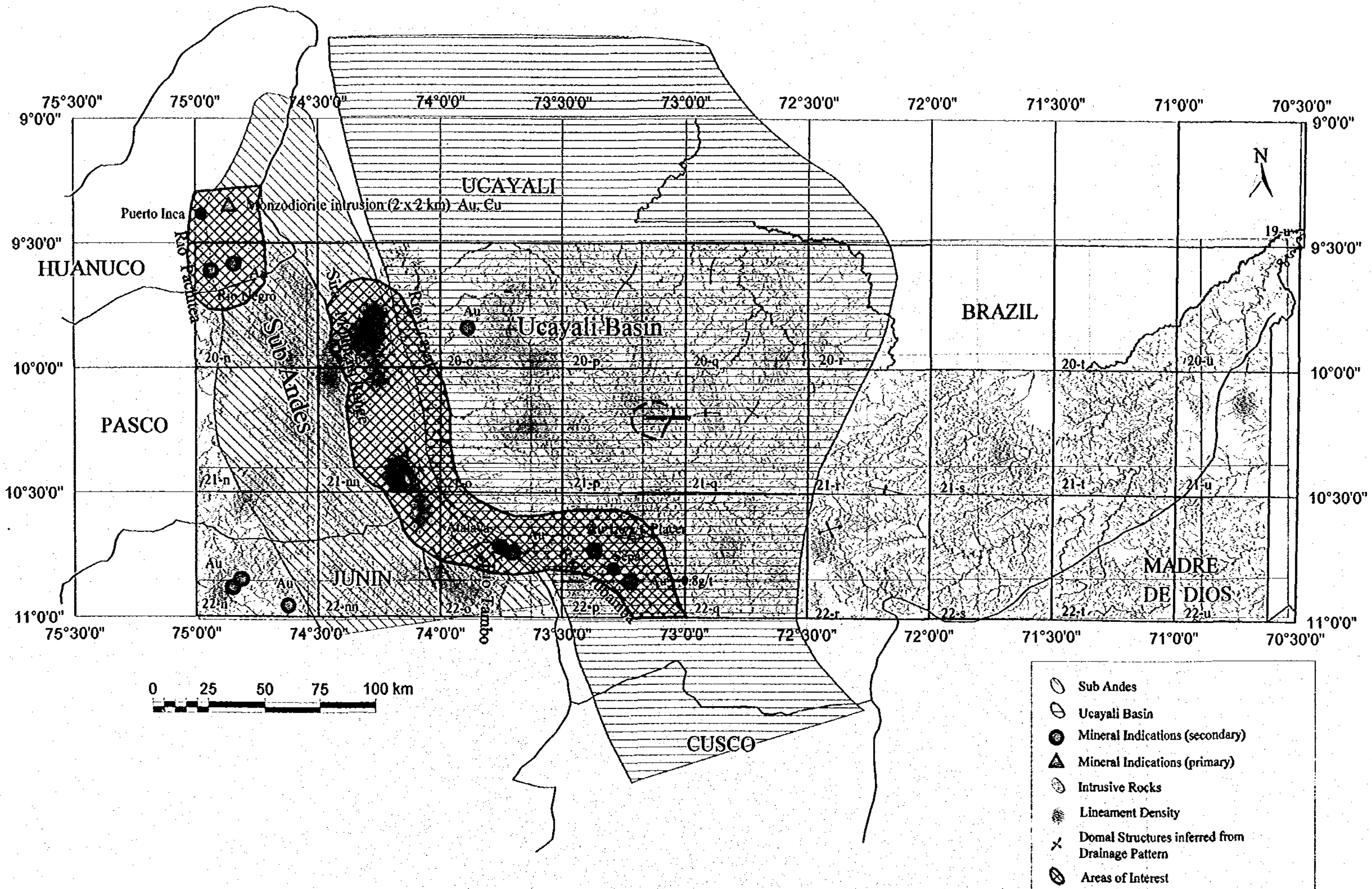


Figure 13 Potential Evaluation Map

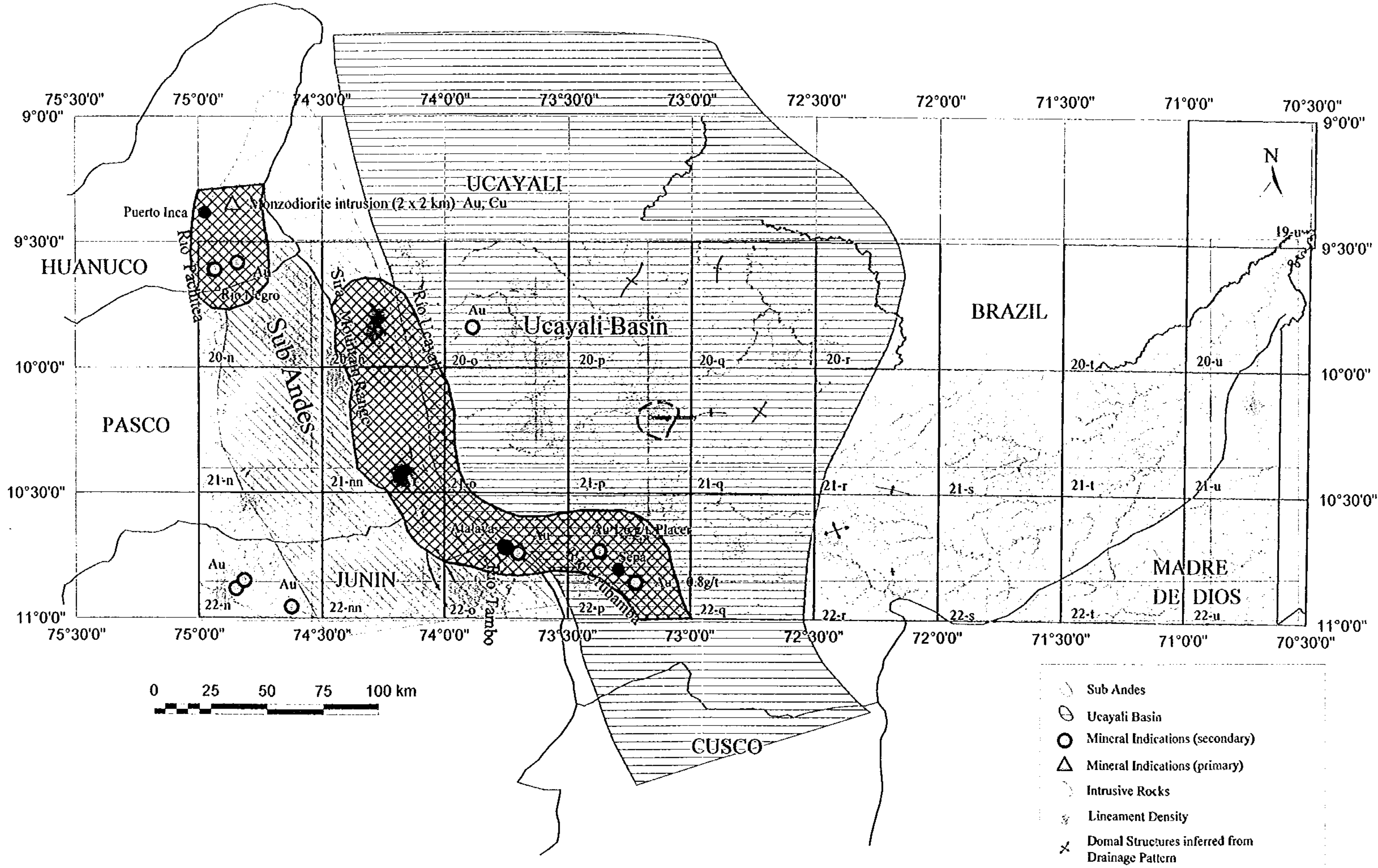


Figure 13 Potential Evaluation Map

PART III

CONCLUSIONS

AND

RECOMMENDATIONS

Chapter 1 Conclusions

The following conclusions are drawn from the Phase I and Phase II study.

(1) Satellite image analysis using JERS-1/SAR data

a. From the analysis of drainage patterns in the Ucayali sedimentary basin, data suggesting presence of anticlinal structures or dome structures and possible presence of intrusive rocks were obtained. In the Selva zone in eastern Peru as represented by the Ucayali sedimentary basin, drainage analysis utilizing satellite images is effective for the interpretation of geology and geologic structure.

b. In the thrust zone trending NNW-SSE located in the east of the Sira range, many parallel lineaments to the thrusts, considered to reflect small faults accompanying the thrusts, and many intersecting lineaments to the thrust trending ENE-WSW, possibly reflecting tension fractures or strike-slip faults, have been extracted and those lineaments form high density zones of lineament in this zone. Generally, tension fractures are likely to be accompanied by intrusive rocks and hydrothermal activity having the intrusive rocks as the thermal source. At Agua Caliente in the northeast of the study area, there are thermal springs accompanying faults with the NE-SW trend. Therefore, the high concentration zone of lineaments in the thrust fault zone east of the Sira range is considered to be important for metallic mineral resources exploration.

(2) Analysis of the existing data

a. It was ascertained by recent geological survey conducted by INGEMMET that an intrusive rock accompanied by gold and copper ore showings is present 13 km east of Puerto Inca in the quadrangle 19-n of the 1:100,000-scale topographic map. This indication is similar with the placer gold deposit in the Negro river (located in Quad. 20-n) in structural setting, whereas the indication is considered to be a source (primary deposit) of placer gold. It may be said that to discover both primary and secondary (placer) types of ore deposit might be possible, depending on a systematic prospecting in future.

b. In the Ucayali sedimentary basin, gold and tin concentration have been reported in heavy minerals in stream sediments along the Urubamba river near Atalaya (Quad. 22-o) and Sepa (Quad. 22-p). Especially, near Sepa, panning samples of heavy minerals is reported to assay Au: 1.6 g/t, which suggests high possibility of occurrence of alluvial gold deposits.

In view of the results of analysis, the following areas are extracted as promising areas:

- The area along the Negro river where occurrence of alluvial gold deposits are known.

- The area stretching from around Atalaya and Sepa, where alluvial gold showings are present, to the eastern part of the Sira range on the west bank of the Ucayali river, where the intrusive rock is present and the high density zones of lineament have been extracted.

Chapter 2 Recommendations

(1) Analysis of geology and geologic structure based on the JERS-1 SAR data is an effective means for geological mapping and for collection of basic exploration data, especially, in areas that have thick cloud coverage as in the study area. The INGEMMET's project of compiling the 1:100 000-scale geological maps which cover the whole territory of Peru was completed in 1999; however, some of the maps contained in the old editions do not satisfy the required level of precision. Renewal of such maps will have to be undertaken in due course. Utilization of the JERS-1 SAR data to this execution would prove to be effective for efficient renewal work and improvement of the precision.

(2) When the JERS-1 SAR data are utilized for analysis of geology and geologic structure, the geometric distortions called foreshortening and layover, which are theoretically included in SAR images, will be a serious hindrance especially to analysis of mountainous zones with strong relief. To solve the problem, it is necessary to convert SAR images into geocoded images -- geometrically corrected and geo-referenced images having coordinate system referred from specific topographic map -- using the DEM (Digital Elevation Model). It will be necessary to transfer to the Peruvian counterpart such kind of advanced technologies for SAR data utilization.

(3) It is desirable to implement field survey such as geochemical survey, survey of ore showings and confirmatory survey of rock facies along the survey route, in an effort to discover new ore deposits in the promising ore-bearing zones extracted in the Phase I and II surveys, which follow:

- The surrounding areas of the Negro River, where the known alluvial gold deposits are situated.

- The area from the Urubamba riverbanks, including the Atalaya-Sepa zones, where the alluvial gold showings are located, to the eastern part of the Sira Range on the west bank of the Ucayali River, where intrusive rocks occur and high density zones of lineament have been extracted.

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(3) Antonio Guzman M., Segundo Nunez J. (1998) : Geología de los cuadrángulos de Masisea 18-ñ, Huariman 18-o, Iparía 19-ñ, Noaya 19-o, Sempaya 20-ñ y Cumaria, Bol., No.114, Serie A, SC18-3 y SC18-7, INGEMMET

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Geological Data of PERUPETRO S.A. (1)

Title	Scale	Year	Reference number	Researcher
Figures & Maps				
Columna Estratigrafica Generalizada del Area del Maranon		1974	GB-9467	Petroleos del Peru
Columna Estratigrafica Generalizada del Area del Rio Ucayali		1974	GB-9468	Petroleos del Peru
Mapa de Rasgos Estructurales del Ucayali Sur	1/500,000	1976	GB-9622	Petroleos del Peru
Seccion Estructural A'-C Lotes - 38 y 39	1/1,000,000	1967	GB-9627	Petroleos del Peru
Mapa Isopaco del Cretacico Total, Hoja-C	1/1,000,000	1976	GB-9724	Petroleos del Peru
Mapa Isopaco del Cretacico Total, Hoja-G	1/1,000,000	1976	GB-9726	Petroleos del Peru
Mapa Isopaco del Cretacico Total, Hoja-G	1/1,000,000	1976	GB-9726	Petroleos del Peru
Mapa Geologico, Hoja-G	1/2,000,000	1977	GB-9731	Petroleos del Peru
Bosquejo de Los Elementos del Marco Tectonico Regional del Centro y Sur del Peru en el Paleozoico Inferior, Hoja-C	1/1,000,000	1977	GB-9733	Petroleos del Peru
Bosquejo de Los Elementos del Marco Tectonico Regional del Centro y Sur del Peru en el Paleozoico Superior, Hoja-C	1/1,000,000	1977	GB-9735	Petroleos del Peru
Bosquejo de Los Elementos del Marco Tectonico Regional del Centro y Sur del Peru en el Paleozoico Superior, Hoja-G	1/1,000,000	1977	GB-9736	Petroleos del Peru
Seccion Estructural Regional a Traves de las Sub-Cuencas del Pachitea, Sierra del Shira y Sub-Cuenca del Ucayali Area Sur	1/500,000	1977	GB-9740	Petroleos del Peru

Geological Data of PERUPETRO S.A. (2)

Title	Scale	Year	Reference number	Researcher
Reports				
Estudio Geologico Regional Sector Sur - Cuenca Ucayali		1995	PP0054	Murphy Peru Oil Co., Sucursal del Peru
Informacion Geologico del Lote 38, p.6-8			PP0057	
Informe Preliminar del Area del Sepa		1970	PP0070	Petroleos del Peru S.A.
Informacion Geologica Basica, Lote 37 Cuenca Ucayali		1991	PP0072	Petroleos del Peru S.A.
Evaluacion Geologica Lotes 39 y 43 (Cuenca Ucayali)		1987	PP0077	Petroleos del Peru S.A.
Evaluation Final del Lote 36 Cuenca Ucayali Peru		1992	PP0084	Occidental Petroleum Corp. of Peru
Evaluacion de Posibilidades Petroliferas del Lote 39, Cuenca Ucayali		1992	PP0106	Petroleos del Peru S.A.
Geological Reconnaissance in the Upper Ucayali Basin		1972	PP0118	
Other				
Seismic Reflexion Data			PP0123	Total Peru - Sucursal del Peru