

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

(PHASE I)

MARCH 1999

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 potentials of mineral resources in the Urubamba river inferior area of the Republic, 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 started in FY1998 (Phase I), and the MMAJ organized and sent a two-man survey team to the Republic of Peru for the period from January 24 to February 13, 1999.

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.

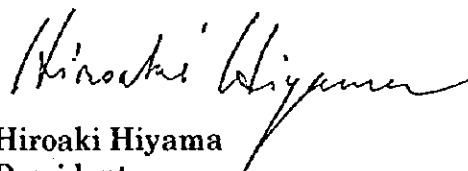
This report summarizes the results of the first year's survey and is designed to form an integral part of the final survey report to be elaborated.

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, 1999



Kimio Fujita
President
Japan International Cooperation Agency



Hiroaki Hiyama
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, 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. Simultaneously, the technology transfer to the INGEMMET - Instituto Geológico Minero y Metalúrgico, the Peruvian counterpart for the survey, was carried out concerning the methods of survey and analysis. Collection and analysis of existing data and the satellite image analysis for the purpose of the technology transfer was executed from January 24 to February 23, 1999.

The Urubamba river inferior area covers an area of about 65,500 km², spreading over the 28 quadrangles of the 1:100,000-scale topographic map issued by the National Geographical Institute of Peru. In Phase I, the analysis of the JERS-1 SAR images was conducted of the 15 quadrangles in the western part of the mentioned area, situated at 75° to 70°30' W of longitude and 11° to 9°30' S of latitude, whilst the existing data analysis was conducted of the entire Urubamba river inferior area.

The results of the Phase I survey are summarized as follows:

- (1) As the analysis of the drainage patterns using JERS-1 SAR data of the Ucayali sedimentary basin, presence of anticlines or dome structures and possible presence of intrusive rocks were obtained. Of the eastern "Selva" (forest) zone of Peru, as represented by this interpretation area, the drainage analysis utilizing satellite images proved to be effective for interpretation of geology and geologic structure.
- (2) The image analysis using the JERS-1 SAR data revealed the existence of high density zones of lineament in the NNW-SSE trending thrust zone in the east of Sira range, where many NNW-SSE lineaments supposed to be suggesting the presence of small-scale faults accompanying to the above mentioned thrust, and ENE-WSW lineaments possibly indicating tension fractures or strike-slip faults, were delineated. Tension fracture generally has a possibility to accompanied with intrusive rocks and/or hydrothermal activities related to intrusions. A hot spring related to NE-SW trending fault are known in Agua Caliente in the Northwest of the survey area. A high density zones of lineament in the east of Sira range, therefore, are considered to be important areas for mineral exploration.
- (3) It was learned from the existing data analysis that the geological survey recently undertaken by INGEMMET ascertained presence of intrusive rocks

accompanied by gold and copper mineral indications 13 km east of Puerto Inca, which is included in the quadrangle 19-n of the 1:100,000-scale topographic map. Since the mineral indications and placer gold deposits in the Negro River in the quadrangle 20-n occur in the similar ambience in terms of geologic structure, the showings are likely to be a source (primary deposit) of placer gold deposits. Accordingly, it is possible that both primary and secondary (placer) gold deposits will be discovered by future systematic exploration.

- (4) It has been reported that, in the Selva, gold and tin are contained in heavy minerals in the stream sediments along the Urubamba river near the tributary on the east bank of the Ucayali (20-o), Atalaya (Quad. 22-o) and Sepa (Quad. 22-p). A report says that, near Sepa, some panning sample of heavy minerals assays Au 1.6 g/t, which indicates a high possibility of occurrence of placer gold deposits. At present, small mining contractors seem to inactively engage in placer gold mining there. It is possible for minable placer gold deposits to be discovered by future surveys to the east of the Ucayali-Urubamba rivers, as well.

Based on the survey findings summarized above, the following recommendations may be made for the future survey:

- (1) Satellite image analysis: Execute, in collaboration with the Peruvian engineers, the JERS-1 SAR data processing to prepare mosaic images covering the 13 quadrangles in the eastern part of the Urubamba river inferior area, in an effort to ensure the transfer of the SAR image processing technology in Peru. Successively, execute image interpretation including geologic mappings and lineament delineations, digitizing of interpretation results, preparation and analysis, such as lineament density mapping, of GIS data set.
- (2) Analysis of existing data: Collect and compile additional data prepared in Peru after the Phase I survey (mainly information related with mining claims).
- (3) Field survey: Consider the possibility to execute the field surveys aimed to ascertain mineralization, with the base camp at Atalaya, situated in the east foot of the Sira range where the Tertiary intrusive rocks are present and relatively close to the placer gold mineral indications in the Urubamba-Ucayali rivers. The survey will include the following items:
 - Geochemical sampling of stream sediments, heavy minerals and rocks.
 - Investigation of mineral indications.
 - Verification of lithofacies along survey routes.

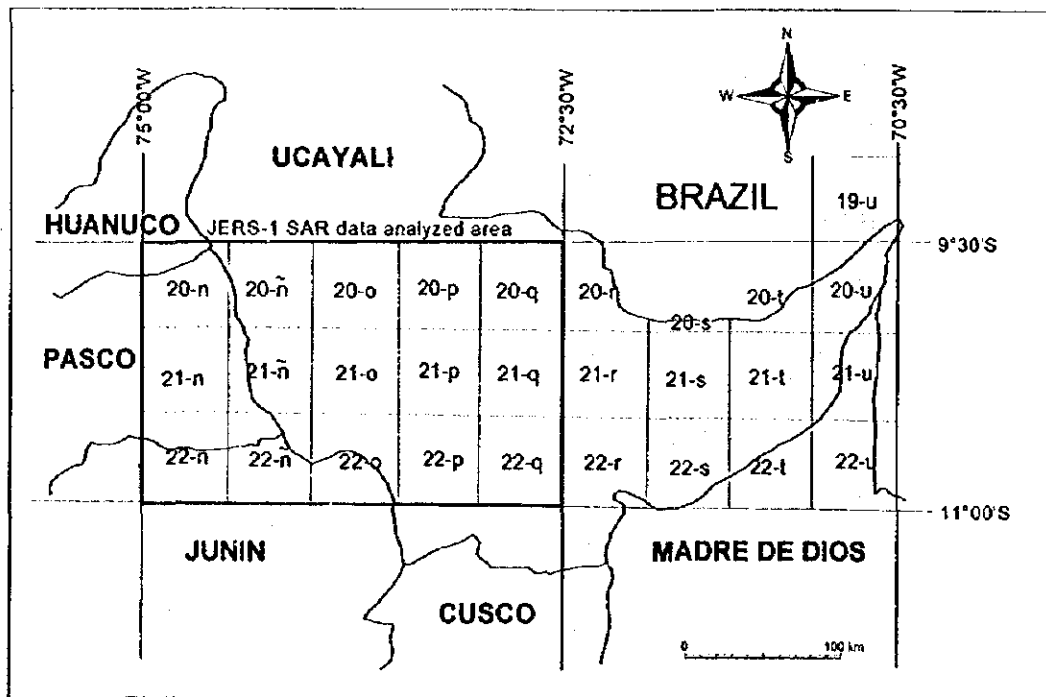
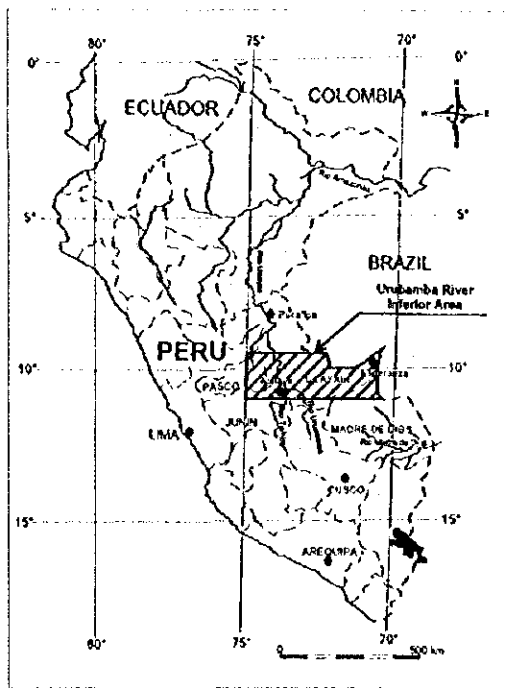


Figure 1 Location of the survey area

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 km² 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 Scope and Outline of the 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 km²), designated in the Scope of Work agreed to between the JICA/MMAJ and the Ministry of Energy and Mines/INGEMMET, that consists of 28 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 technic.

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 Organization of the Survey Team

The members from the both countries of the prior consultation team and the field survey team are listed in the Tables 1 and 2, respectively.

Table 1 Mission for previous agreement and negotiation

<i>Peruvian side</i>		<i>Japanese side</i>	
Ing. Juan Mendoza Marsano	INGEMMET	Mr. Humihiko Kimura	MMAJ
Ing. Hugo Rivera Mantilla	INGEMMET	Mr. Hidefumi Nakashima	MITI
Ing. José León Aparicio	INGEMMET	Mr. Takashi Kamiki	MMAJ
Ing. Oscar Palacios Moncayo	INGEMMET	Mr. Hiroaki Kagawa	MMAJ
Ing. Yorry Elena Carrasco Pinares	INGEMMET	Mr. Tomoo Hayakawa	JICA
Ing. Julio C. Zedano Cornejo	INGEMMET	Mr. Hitoshi Shimoda	MMAJ
Ing. Marco A. Lara Moreno	INGEMMET		

INGEMMET: Instituto Geológico Minero y Metalúrgico

MMMJ: Metal Mining Agency of Japan

MITI: Ministry of International Trade and Industry

JICA: Japan International Cooperation Agency

Table 2 Mission for the field survey

Peruvian side		Japanese side	
Ing. Manuel Paz Maidana	INGEMMET	Mr. Kaoru Sakogaichi	MINDECO
Ing. Marco A. Lara Moreno	INGEMMET	Mr. Kazuhiro Adachi	MINDECO
Ing. Washington Larico Cayo	INGEMMET		

INGEMMET: Instituto Geológico Minero y Metalúrgico
 MINDECO: Mitsui Mineral Development Engineering Co., Ltd.

1-4 Period and Quantity of the Survey

The survey period is indicated in Table 3.

Table 3 Study period

	1988					1989																		
	Nov.				Dec.					Jan.				Feb.				Mar.			Apr.			
	4	11	18	25	2	9	16	23	30	6	13	20	27	3	10	17	24	3	10	17	24	31	7	14
Survey Period																								
Planning & Preparation																								
Satellite Image Analysis																								
Image Processing																								
Image Interpretation																								
Digitizing																								
Analysis & Report Writing																								
Existing Data Analysis																								
Travel																								
Existing Data Analysis																								
Satellite Image Analysis																								
Report Submission																								

The quantities of the survey are indicated in Table 4.

Table 4 Quantity of the study

<i>Survey items</i>	<i>Quantities</i>
Satellite image analysis	15 quadrangles (the western portion of survey area)
Existing data 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 km² (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°C and 3,029.5 mm, respectively. The average monthly temperatures and precipitations are tabulated below.

Table 5 Monthly average temperature and precipitation in Atalaya (1934-1935)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Temp. (°C)	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 Oldovician 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, sanstone-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.



ERA	SYSTEM	SUBES	SUBES	SUBES	
CENOZOIC	QUATERNARY	HOLOCENE	Qh	Qh	
		PLEISTOCENE	Qp	Qp	
	TERTIARY	PALEOCENE	Ne	Ne	
		MIOCENE			
		OLIGOCENE			
	PALEOZOIC	PALEOZOIC	PERMIAN	P	P
			TRIASSIC		
		MESOZOIC	CRETACEOUS	Ca	Ca
			JOHANNESBURG		
			JOHANNESBURG		
PALAEZOIC	MESOZOIC	UPPER			
		LOWER			
	PALEOZOIC	UPPER			
		LOWER			
	PALAEZOIC	PALEOZOIC	UPPER		
			LOWER		
		PALAEZOIC	UPPER		
			LOWER		
			UPPER		
			LOWER		

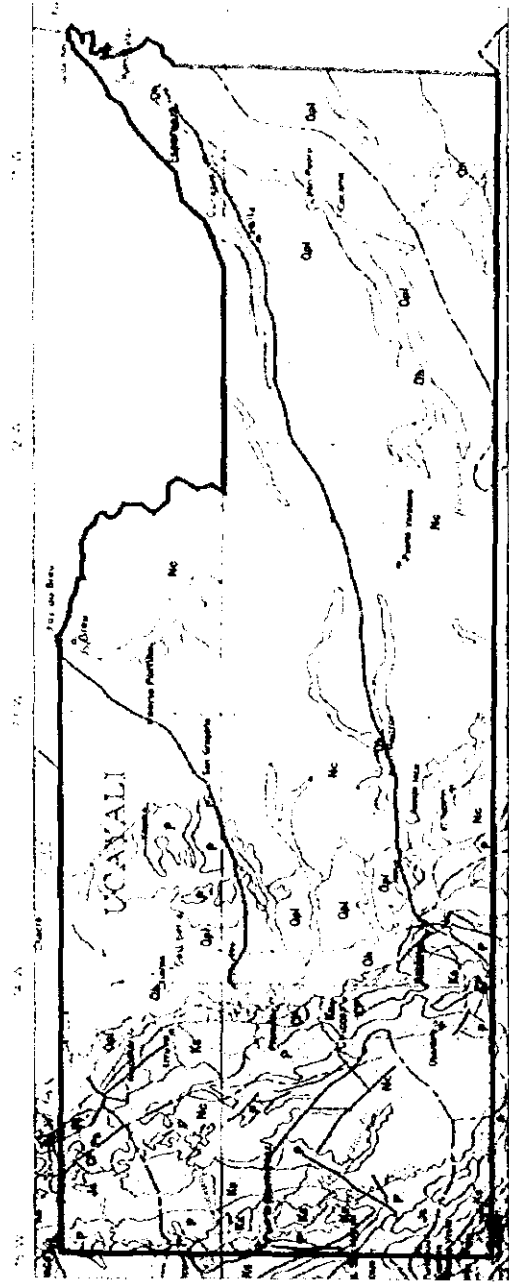


Figure 2 Geology of the survey area

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 I covers the 15 quadrangles, 20 to 22 - n, ñ, o, p and q -- 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 24 scenes of JERS-1 SAR data as indicated in Figure 3 and Table 6.

1-2-2 Procedures for image processing

15 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 four 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: Scene P436/R318 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, 15 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 confluences and bending points of rivers, etc. are utilized as ground control points for georefferancing.
- 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 15 sub-scene images, totaling 30 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 used in Peru.

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 the MOSS (Map Overlay and Statistical System) format -- one of the GIS standard format by USGS -- 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-format file, 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.

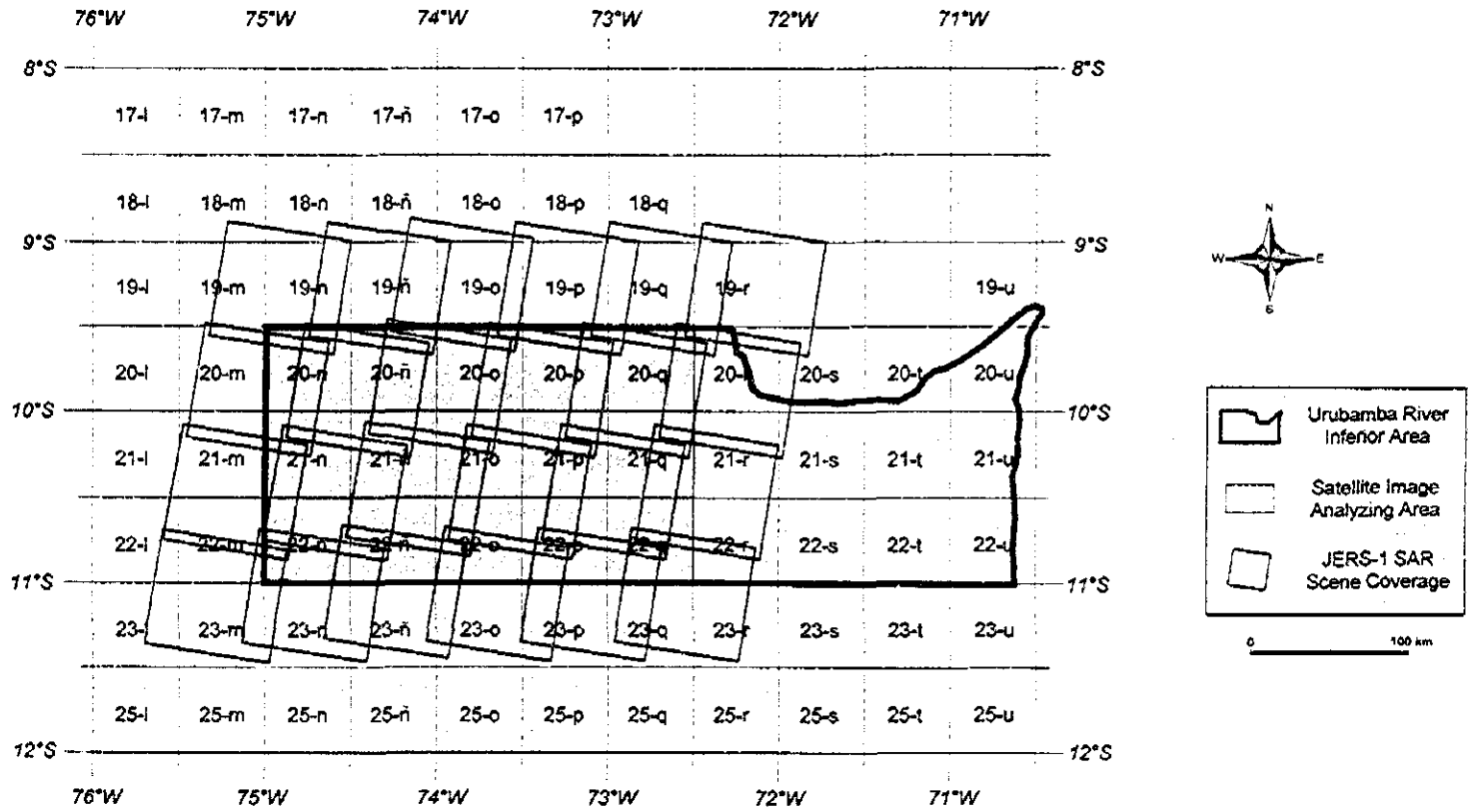


Figure 3 Coverage of satellite data used

Table 6 Satellite data used

	<i>date</i>	<i>sat.</i>	<i>sensor</i>	<i>path</i>	<i>row</i>	<i>lati.</i>	<i>long.</i>	<i>qual.</i>	<i>station</i>
1	1996/06/15	J1	SAR	434	316	-09.17	-72.08	G	HEOC
2	1996/06/15	J1	SAR	434	317	-09.52	-72.17	G	HEOC
3	1996/06/15	J1	SAR	434	318	-10.28	-72.25	G	HEOC
4	1996/06/15	J1	SAR	434	319	-11.04	-72.33	G	HEOC
5	1996/06/16	J1	SAR	435	316	-09.17	-72.41	G	HEOC
6	1996/06/16	J1	SAR	435	317	-09.52	-72.50	G	HEOC
7	1996/06/16	J1	SAR	435	318	-10.28	-72.58	G	HEOC
8	1996/06/16	J1	SAR	435	319	-11.04	-73.06	G	HEOC
9	1996/06/17	J1	SAR	436	316	-09.17	-73.14	G	FAIS
10	1996/06/17	J1	SAR	436	317	-09.52	-73.23	G	FAIS
11	1996/06/17	J1	SAR	436	318	-10.28	-73.31	G	FAIS
12	1996/06/17	J1	SAR	436	319	-11.04	-73.39	G	FAIS
13	1993/03/18	J1	SAR	437	316	-09.17	-73.49	G	FAIS
14	1993/03/18	J1	SAR	437	317	-09.53	-73.49	G	FAIS
15	1993/03/18	J1	SAR	437	318	-10.28	-74.05	G	FAIS
16	1993/03/18	J1	SAR	437	319	-11.04	-74.12	G	FAIS
17	1996/06/19	J1	SAR	438	316	-09.15	-74.19	G	HEOC
18	1996/06/19	J1	SAR	438	317	-09.51	-74.27	G	HEOC
19	1996/06/19	J1	SAR	438	318	-10.27	-74.35	G	HEOC
20	1996/06/19	J1	SAR	438	319	-11.04	-74.43	G	HEOC
21	1994/08/30	J1	SAR	439	316	-09.16	-74.54	G	FAIS
22	1994/08/30	J1	SAR	439	317	-09.52	-75.02	G	FAIS
23	1994/08/30	J1	SAR	439	318	-10.28	-75.10	G	FAIS
24	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

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 rose-diagrams of each quadrangle in Figure 6. Table 7 indicates correlation between geologic units of the interpretation map and those of the existing geologic maps.

Characteristic of the respective geologic unit 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)

Table 7 List of geologic units

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

(6) Unit T3

The Tertiary unit is seen overlying the Unit T2 in the east part of the interpretation area. The unit resembles the Unit T2 but has deeper valleys, characterized by the parallel drainage pattern presumed to reflect the strike of

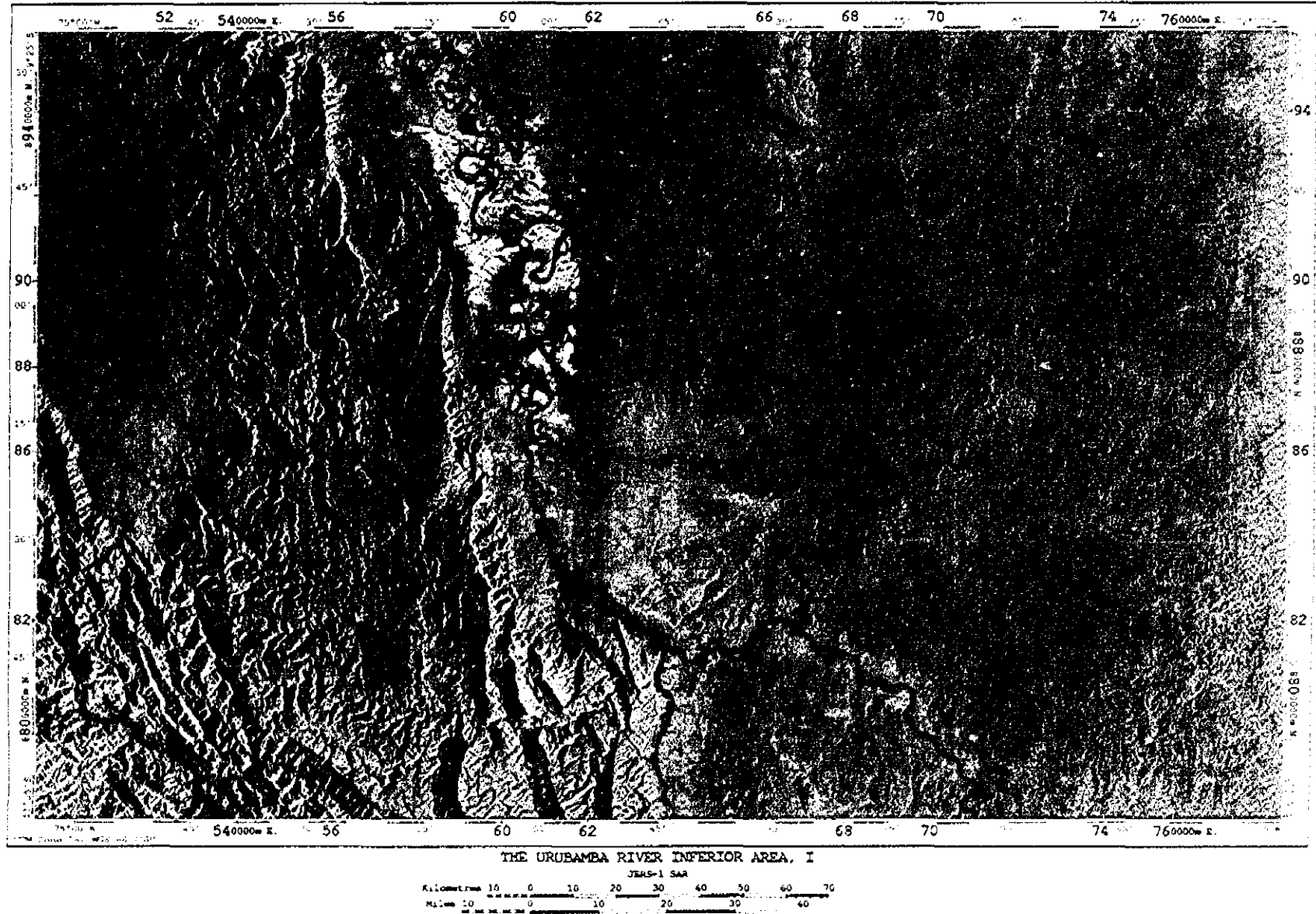


Figure 4 JERS-1 SAR mosaic image

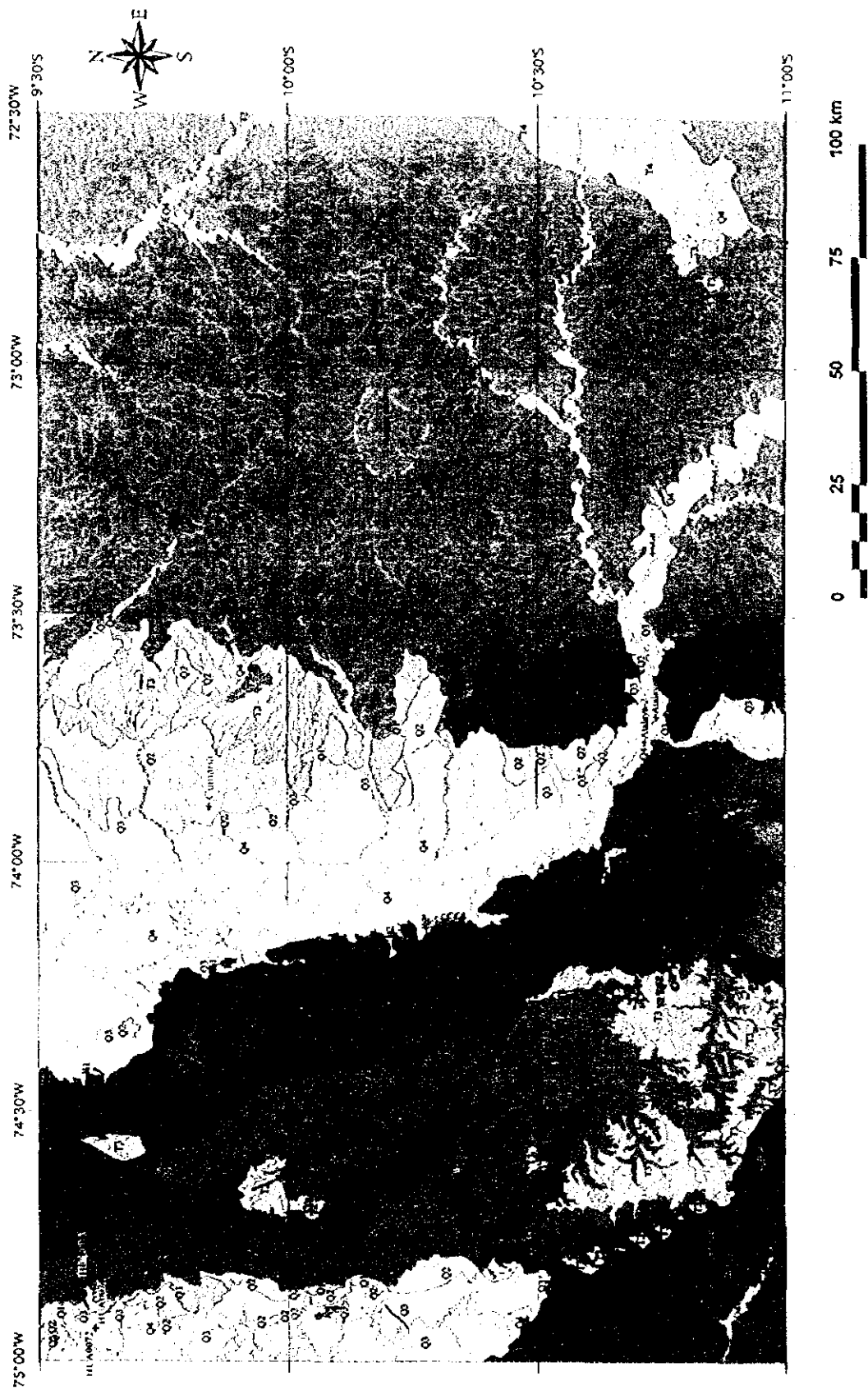


Figure 5-1 JERS-1 SAR geologic interpretation map

Quaternary		Q4
		Q3
		Q2
		Q1
Tertiary		T4
		T3
		T2
		T1
		K4
Cretaceous		K3
		K2
		K1
		J
Jurassic		J
Paleozoic		P

- faults
- † --- anticlines
- * --- synclines
- drainage
- drainage anomaly
- mineral indications

Figure 5-2 Legend of geologic interpretation map

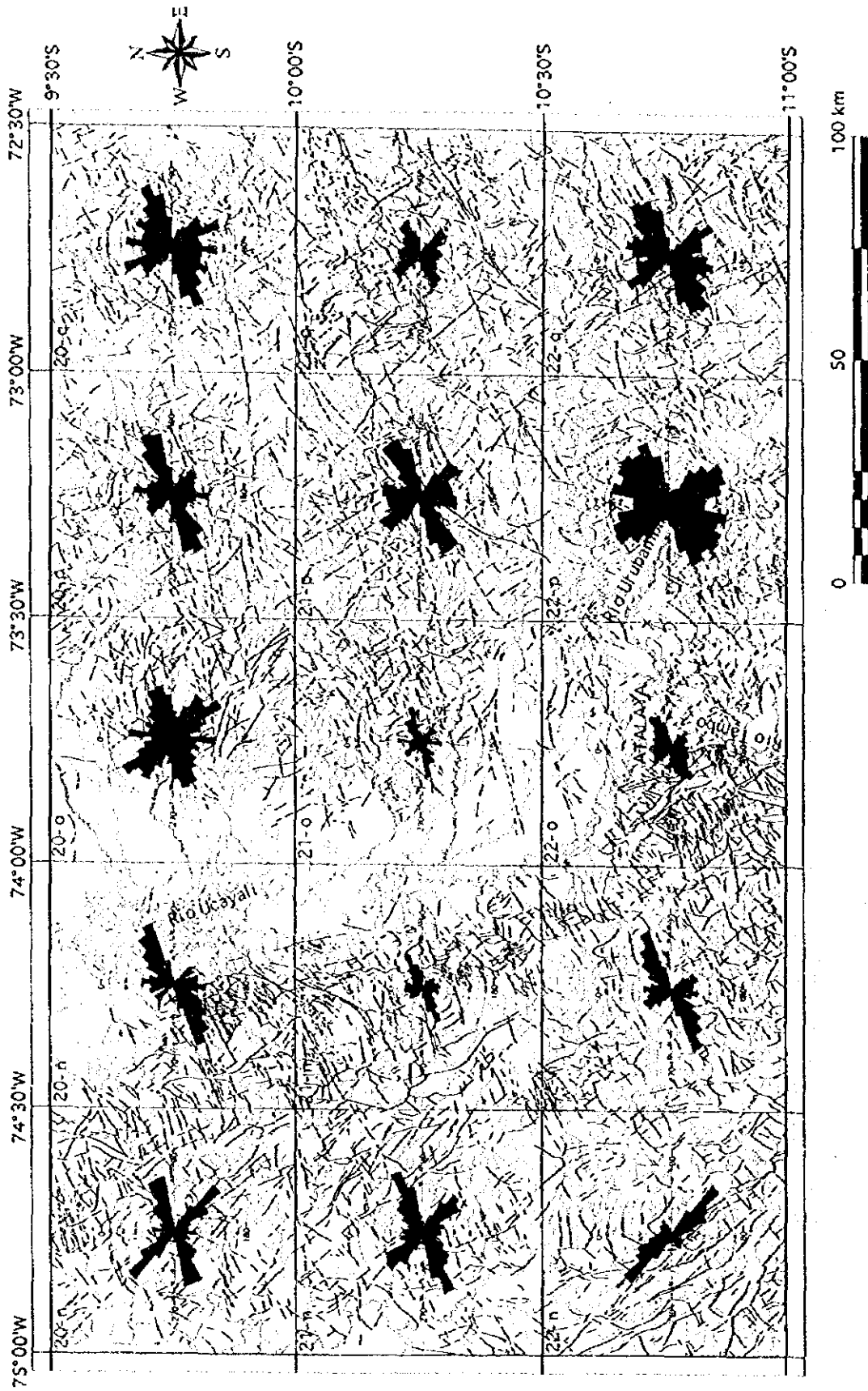


Figure 6 JERS-1 SAR lineament map

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)

Some examples of geologic interpretation maps are exhibited in Figures 7-2 (quadrangle 20-n), 8-2 (21-ñ), 9-2 (22-o) and 10-2 (22-p), and those of lineament maps are in Figures 7-3 (20-n), 8-3 (21-ñ), 9-3 (22-o) and 10-3 (22-p).

The interpretation of the respective quadrangles is summarized below.

(1) 20-n

The extreme west of the quadrangle corresponds to upper stream of the Pachitea river, where an extensive basin composed of Alluvium and terrace deposit is formed. In the central part of the quadrangle, Cretaceous extends south to north, gently dipping westward, while the east part is underlain by Tertiary. In the extreme east of the quadrangle, Cretaceous bedding plane is clear, stretching south to north and dipping west, whilst Tertiary appears to the east. From this, it can be inferred that these are bounded by thrust faults.

(2) 20-ñ

On the east side of the quadrangle, an extensive basin is seen in the Urubamba river inferior area. Around Alluvium, embracing countless tracks of meandering old channels, terrace deposits spread on the surface. The Sira range composed from Paleozoic to Tertiary units lies in the west. A fault supposed to be a thrust is running in N-S direction and changes its direction to NW-SE in the south. Anticlines formed in the east of the fault have N-S to NNW-SSE trending axes parallel to the strike of thrust fault.

(3) 20-o

Quaternary overlies most of the area. On the extreme west of the quadrangle, an extensive alluvial basin develops along the Ucayali river, in the east of which, low and middle terrace spread out. On the extreme east of the quadrangle, Tertiary Units T2 and T3 are seen. Faults and folding structures

are unclear.

(4) 20-p

Most of the area is covered by Tertiary Unit T2. Undulation is generally weak and valleys are relatively shallow. In the east, NNW-SSE to N-S trend bedding planes with eastward dips are continually observed. The radial drainage pattern observed in the northern-central portion of the quadrangle suggests the existence of NNW-SSE trending syncline or dome structure. While the basic drainage pattern is dendritic, parallel patterns and fine pinnate patterns also develop, which are presumably controlled by bedding.

(5) 20-q

Like the 20-p, Tertiary Unit T2 prevails all over. Undulation is moderate, and valleys are relatively shallow. Along the Alto Yurua river which runs from south to north in the central part of the quadrangle, fluvial sediments of Q3 are seen. The radial drainage pattern in the Northeast of the quadrangle presumably indicates the existence of anticline elongated in N-S direction. The drainage patterns are basically dendritic but parallel patterns and fine pinnate patterns also develop, which are presumably controlled by bedding.

(6) 21-n

The western area of the quadrangle covers upper stream basin of the Pachitea river and an extensive flat plane is formed. Narrow Cretaceous unit crops out in the Center with N-S trend but, in the east of there, it is completely covered by Tertiary. Cretaceous is gently dipping westward, whereas Tertiary is almost flat.

(7) 21-n̄

The east side of the quadrangle corresponds to the upper stream of the Ucayali river, where an extensive alluvial basin is formed. To the west of Quaternary, Cretaceous, partially including Jurassic, is widespread. Cretaceous forms anticlinorium with the axes in N-S trend in its east periphery where it accompanied by thrust fault, whereas, in the west side of the thrust, it forms a gentle monoclinial structure. The west side in the quadrangle is completely covered with Tertiary. Tertiary has nearly horizontal structure and is cut by large faults with N-S or NW-SE trend.

(8) 21-o

On the extreme west of the quadrangle, the alluvial basin (Q4) on the right bank of the Ucayali river continues south to north. On the east side of the basin, an extensive terrace surfaces consisting of Q3 (lower terrace surface), Q2 (middle terrace surface) and Q1 (higher terrace surface) spread out. Dendritic drainage pattern develops in Q1, while the other terrace surfaces are flat and have low drainage density. The extreme right portion of the quadrangle is underlain by T2. The drainage patterns are mainly dendritic or fine pinnate patterns, but valleys are not deep. There are many linear features presumably indicating bedding planes, and other lineaments intersecting the bedding

planes also dominant. It is hard to distinguish those lineations and to interpret the details of geologic structure.

(9) 21-p

The entire area is underlain by T2. Undulation is generally small and deep valleys are not observed. The drainage density is very high and the main streams make dendritic patterns whilst the tributaries make fine pinnate patterns. Bedding planes are observable everywhere, which however cannot continuously be traced, because of disturbance by fine drainages. A zone having characteristic trellis drainage pattern is located in the central east of the quadrangle, which possibly suggests the existence of intrusive unit.

(10) 21-q

The T2 covers most of the area. On the whole, undulation is scarce and deep valleys are not developed. The drainage is very dense. The main streams have dendritic patterns while the tributaries have fine pinnate patterns. Bedding planes are observable everywhere, which however cannot continuously be traced, because of disturbance by fine drainage. A dome structure is inferred from the radial drainage pattern in the central east of the quadrangle.

(11) 22-n

On the east side of the quadrangle, a nearly horizontal Tertiary forms "Mesa" and broadly overlies Cretaceous. As seen in the central portion of the quadrangle, Tertiary is cut by faults in NNW-SSE to NW-SE direction and is not present on the west side of the faults. Cretaceous and Jurassic form synclinal structure and cover the southwest of the quadrangle.

(12) 22-ñ

On the east side of the quadrangle, Cretaceous and Jurassic are widespread and accompanied by thrust faults in nearly N-S direction. Cretaceous forms anticlinal structure with the axis parallel to the thrust faults and is gently dipping westward in the west side of the fault. In the east half of the quadrangle, Tertiary is widespread, overlying Cretaceous. Tertiary forms a nearly flat structure, whose continuous bedding planes are clearly observed.

(13) 22-o

Near the central portion of the quadrangle, the Urubamba river from the east and the Tambo river from the south merge into the Ucayali river, which flows down northwestward. Along these rivers, an extensive basin, covered by Q4, is formed. Outside of the basin, lower terrace (Q3), middle terrace (Q2) and higher terrace (Q1) are observed. Of these, the higher terrace is markedly superior to the others in respect of the height. While there remain surfaces where drainage systems are undeveloped, erosion has proceeded in valleys. On the east side of the Tambo river, T2 is widespread. Large, meandering rivers are seen but, on the whole, fairly fine drainage systems are assembled. Countless linear patterns are observed but they are traversed by other linear patterns, or directions of their dips are unclear due to weak undulation; the structure is hard to clarify.

The Sira range mainly composed of K1, K2 and K3 rises on the west side of the Tambo and Ucayali river. A number of faults trending NNW accompanied by oblique faults are seen. Valleys along the faults are deep and steep. At least two thrusts with NNW-SSE to N-S trend are developed near the boundary between Sira range and Ucayali basin and three anticlines divided by these thrusts are formed.

(14) 22-p

Fluvial sediments of Q2 are widespread along the Urubamba river, the Inaga river, the northern tributary of that, and the Sepa river, the southern tributary of the same, which flow in the central portion of the quadrangle. The surrounding areas of these rivers are fully covered by the Tertiary unit T2, where the undulation is weak and valleys are shallow, in general. Near the extreme east of the quadrangle, linear patterns seemed to be bedding planes are hardly observed, which, occasionally bending, stretches almost in parallel with each other in the N-S direction and generally dipping southeast. In a little north of the center of the quadrangle (centering around the area between the Urubamba and Inuya river), a semi-circular bedding planes are seen if not clearly. Since a radial drainage pattern is also observed there, a dome structure possibly formed.

(15) 22-q

Almost all the area is covered with Tertiary (T2 and T3). Similar to the 21-q, the area has little undulation in general and no deep valleys are observed, but valleys in T3 are little deeper than that in T2. The drainage systems are very dense, composed of the main streams with dendritic patterns and the tributaries with fine pinnate patterns. Bedding planes(?) dipping gently southeast are hardly observable in the northwest to southwest portion of the quadrangle, where T3 mainly underlies the surface. The drainage pattern in the same portion is clearly controlled in NE-SW direction and shows rectangular pattern. This direction certainly represents strike of bedding.

1-4-2 Lineament analysis

The results of lineament analysis of the respective quadrangles are summarized below:

(1) 20-n

In the areas covered by the Quaternary and the Unit K2, lineament density is very low. On the whole, lineaments with NW-SE, NNW-SSE and ENE-WSW trends are predominant.

(2) 20-ñ

The lineaments in the areas covered by the Quaternary include innumerable parallel lines presumed to reflect the strikes of the underlying beds. These lineaments are unclear and the direction of dips are uncertain. Lineament density is high in the west area, especially where the Cretaceous is present.

Lineaments with N-S and ENE-ESW trends are predominant.

(3) 20-o

In the western area covered by the Alluvium, there is no lineament worthy of mention, except the numerous meandering tracks of old river channels. In the area covered by T2 and T3, lineaments with NW trend are dominant and are good in continuity, which are followed by those with ENE and EW trends.

(4) 20-p

The lineament density is high. Lineaments with NNW and ENE trends predominate. Many bedding planes are observable, but the structure is hard to ascertain since they are intersected with numerous lineaments.

(5) 20-q

Similar to the 20-p, the quadrangle has high lineament density, and lineaments with NNW and ENE trends are predominant. In the area covered by Q3, innumerable lineaments with the ENE trend are seen.

(6) 21-n

Lineaments with NW-SE and ENE-WSW trends are dominant and good in continuity. In the areas covered by the Tertiary Unit T2, lineament density is low.

(7) 21-n̄

In the area covered by the Quaternary, lineament density is very low. Lineaments with NNW-SSE and ENE-WSW are dominant. Especially near the thrust faults in the east, lineament density tends to increase.

(8) 21-o

Few lineaments are observable in the areas covered by Quaternary, while lineament density is high in the east area covered by T2. Lineaments with ENE and NNW trends are especially dominant.

(9) 21-p

On the whole, lineament density is high. Especially, lineaments with ENE and NW trends are dominant and good in continuity.

(10) 21-q

Similar to the 21-p, lineament density is high, on the whole. Especially, lineaments with ENE and NW trends are dominant and good in continuity.

(11) 22-n

Lineaments with NNW-SSE and NW-SE trends which are parallel to the thrust fault are dominant. In the area covered by Tertiary on the east side of the quadrangle and by Jurassic in the southwest end, lineaments with NE-SW trend are also dominant.

(12) 22-n

On the whole, lineaments with ENE-WSW and NWN-SES trends are dominant. In the area covered by Tertiary in the central portion of the quadrangle, lineaments are not so well developed.

(13) 22-o

In the area covered by K2 and K1 on the west side of the quadrangle, lineament density is high, as compared with the east area covered by Quaternary and Tertiary. Above all, deep valleys presumably formed by faults develop and lineaments with NNW and NS trends are dominant along the valleys. Lineaments with NE trend also develop and few of them are good in continuity and large in size. In the Unit T2 on the east side of the quadrangle, lineaments with NNW to NW and ENE trends are good in continuity. Many lineaments presumed to reflect bedding are observed but these are too poor in continuity and untraceable to clarify the structure.

(14) 22-p

On the whole, lineament density is high. Especially, lineaments with ENE and NW trends are dominant and good in continuity.

(15) 22-q

Similar to the 22-p, lineament density is high, in general. Especially, lineaments with NE, NW and NS trends are dominant and good in continuity. As compared to the Unit T2, lineaments in T3 are clearer.

1-5 Considerations

A comparison between the image interpretation and the 1:100,000-scale geologic map published by the INGEMMET in 1997-98 (List of Reference and Data Collected -1) is summarized as follows:

- 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 peculiar 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.

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 11 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.

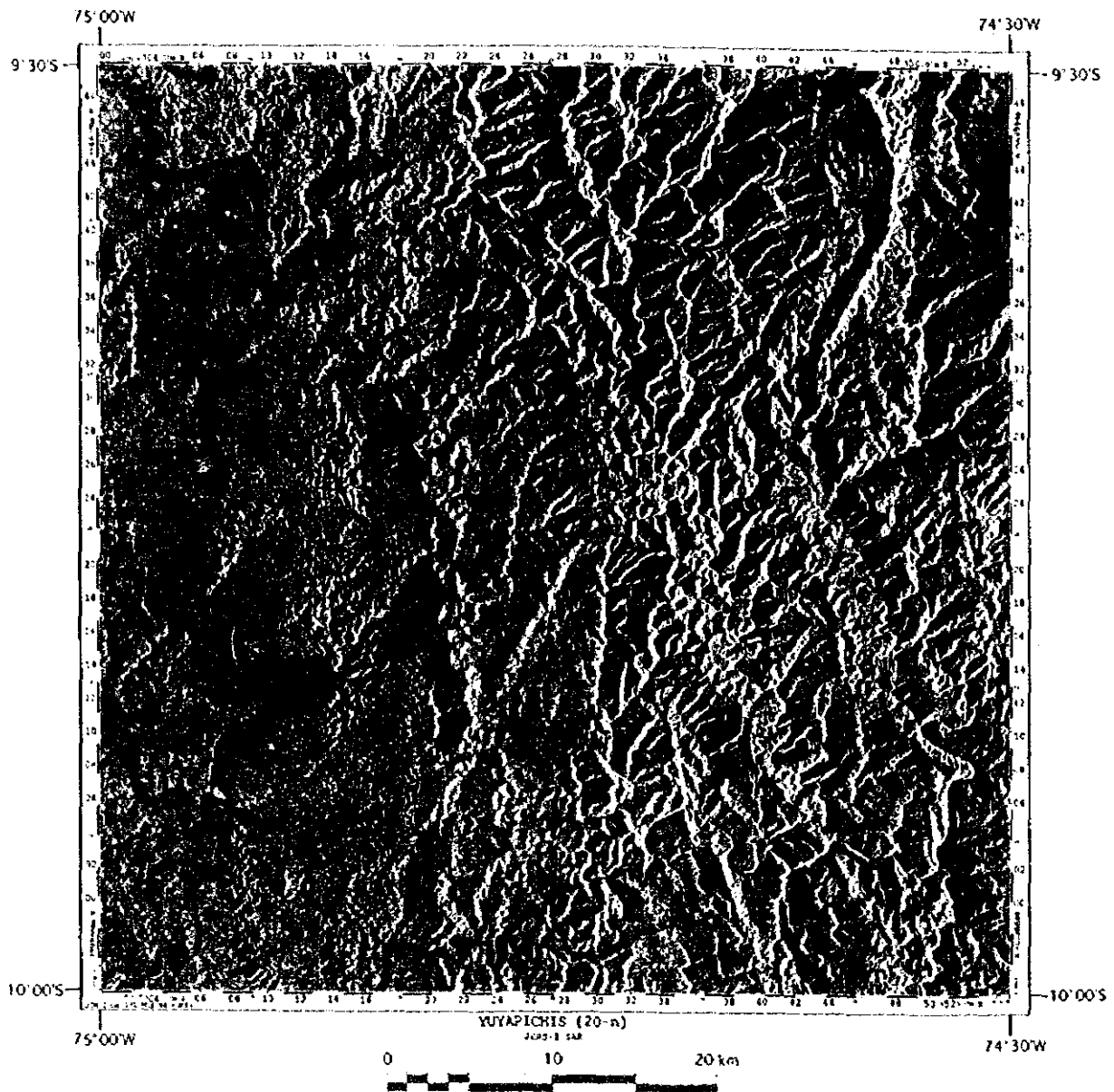


Figure 7-1 Yuyapichis (20-n) JERS-1 SAR image



Figure 1. Micrograph of the surface of the material.

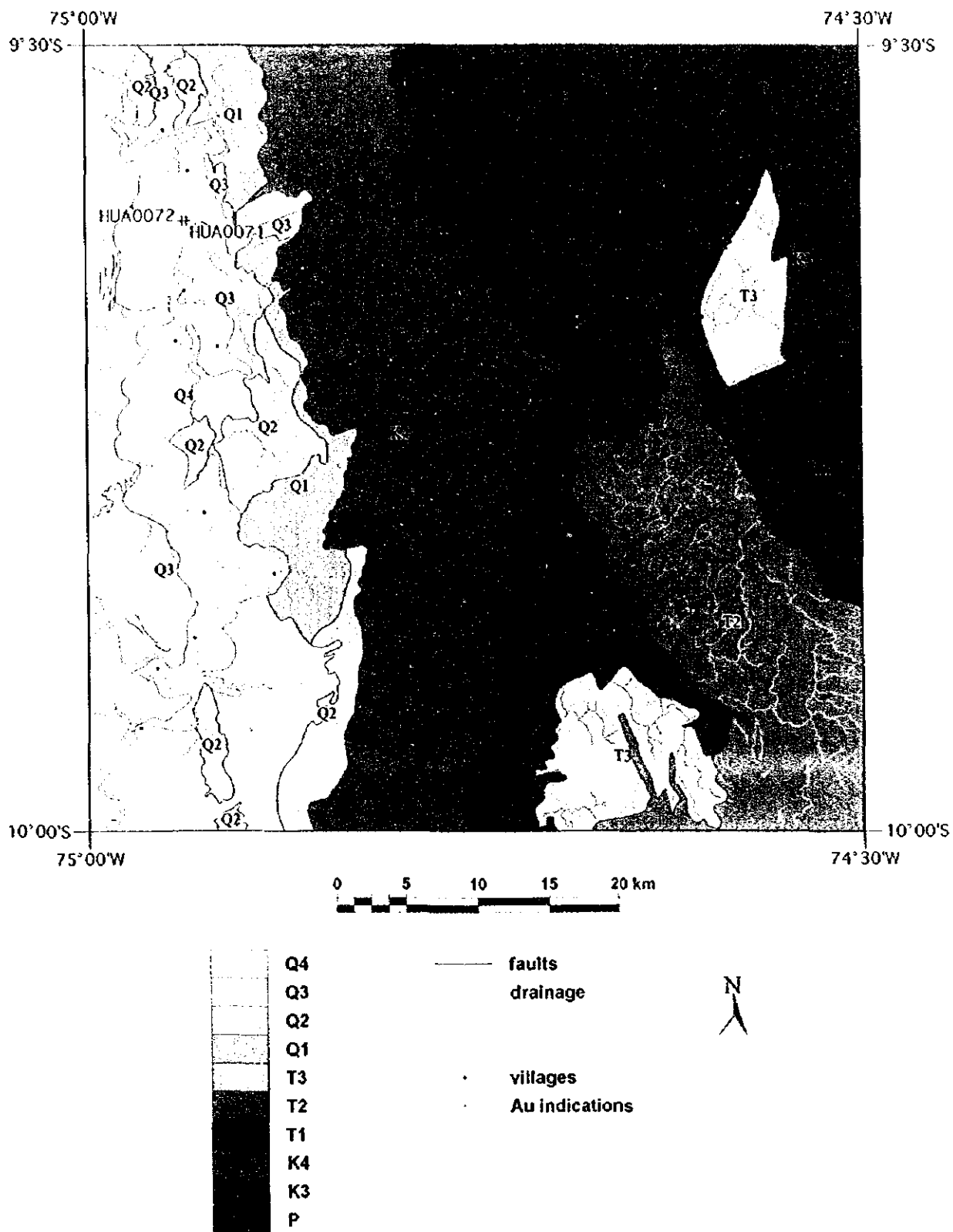
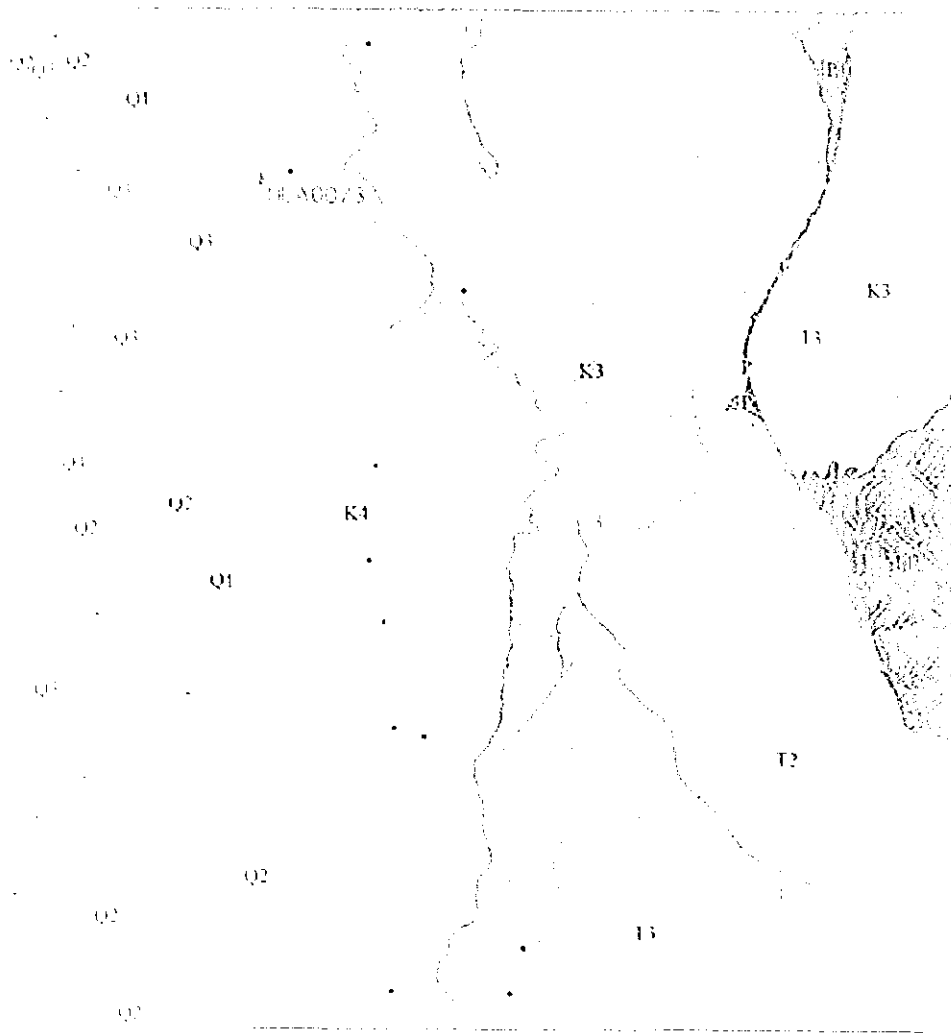


Figure 7-2 Yuyapichis (20-n) geologic interpretation map



- Q4
- Q3
- Q2
- Q1
- T3
- T2
- T1
- K4
- K3
- P
- faults
- drainage
- villages
- Au indications

Figure 7-2 Yuyapichis (20-n) geologic interpretation map

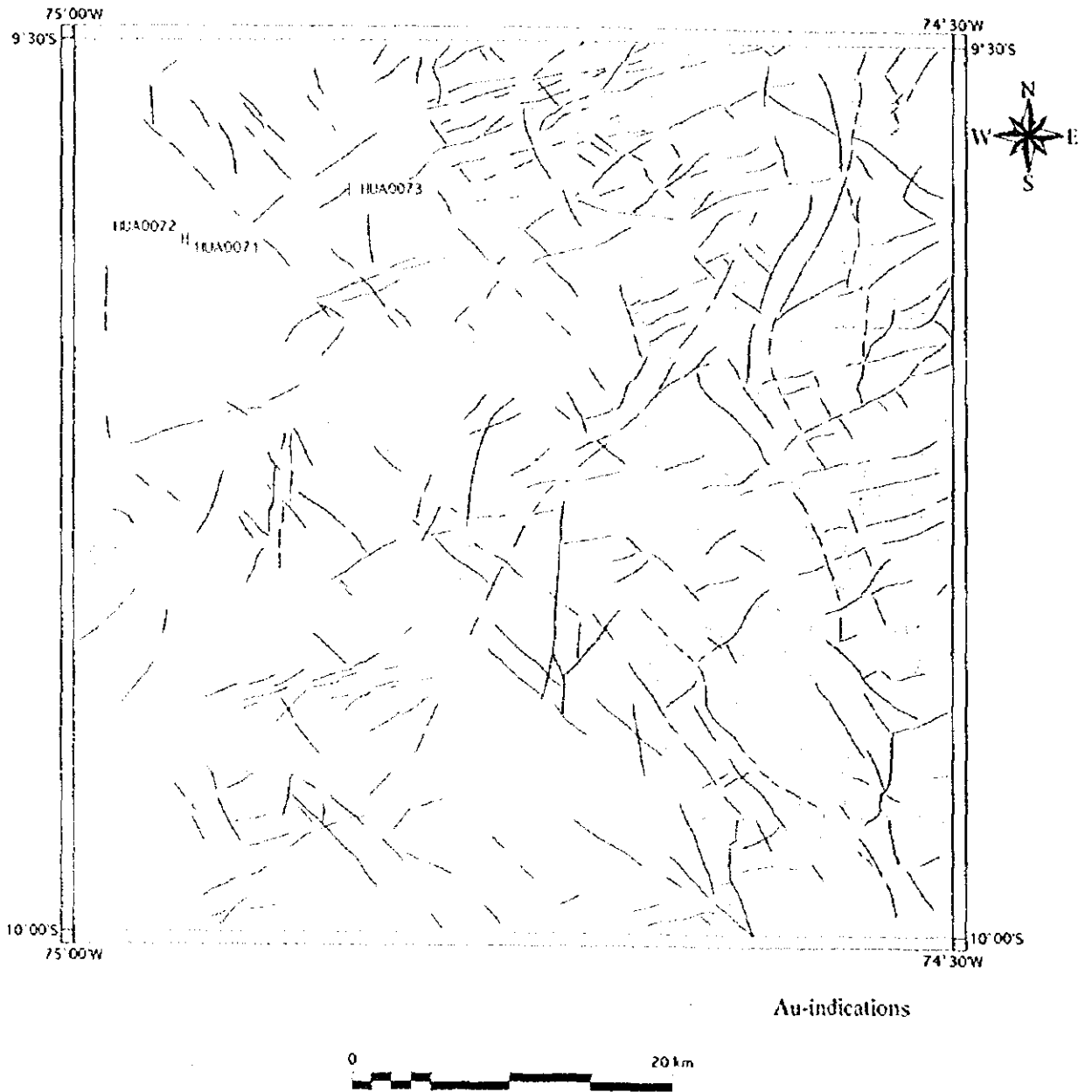


Figure 7-3 Yuyapichis (20-n) lineament map

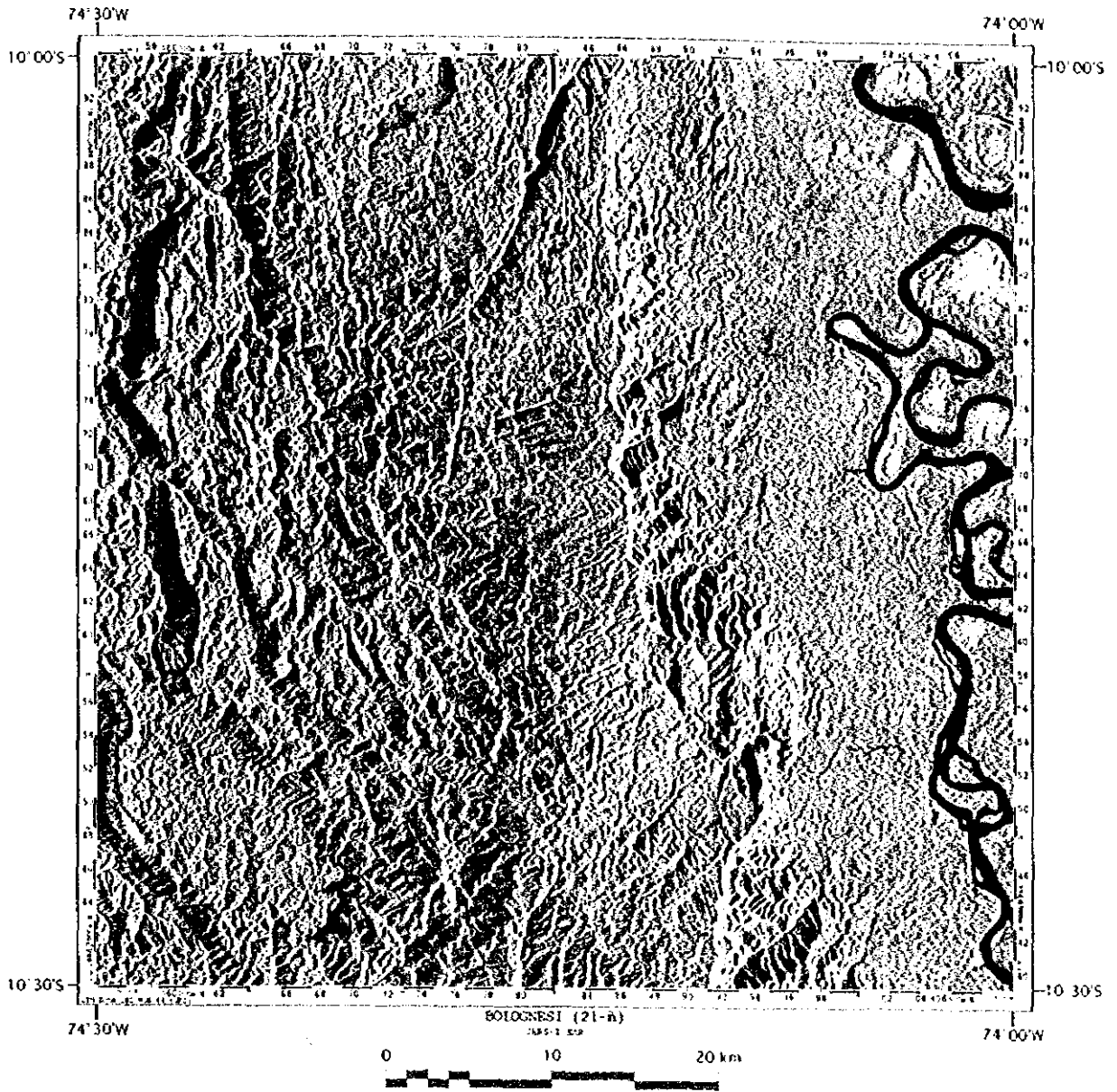


Figure 8-1 Bolognesi (21-n) JERS-1 SAR image

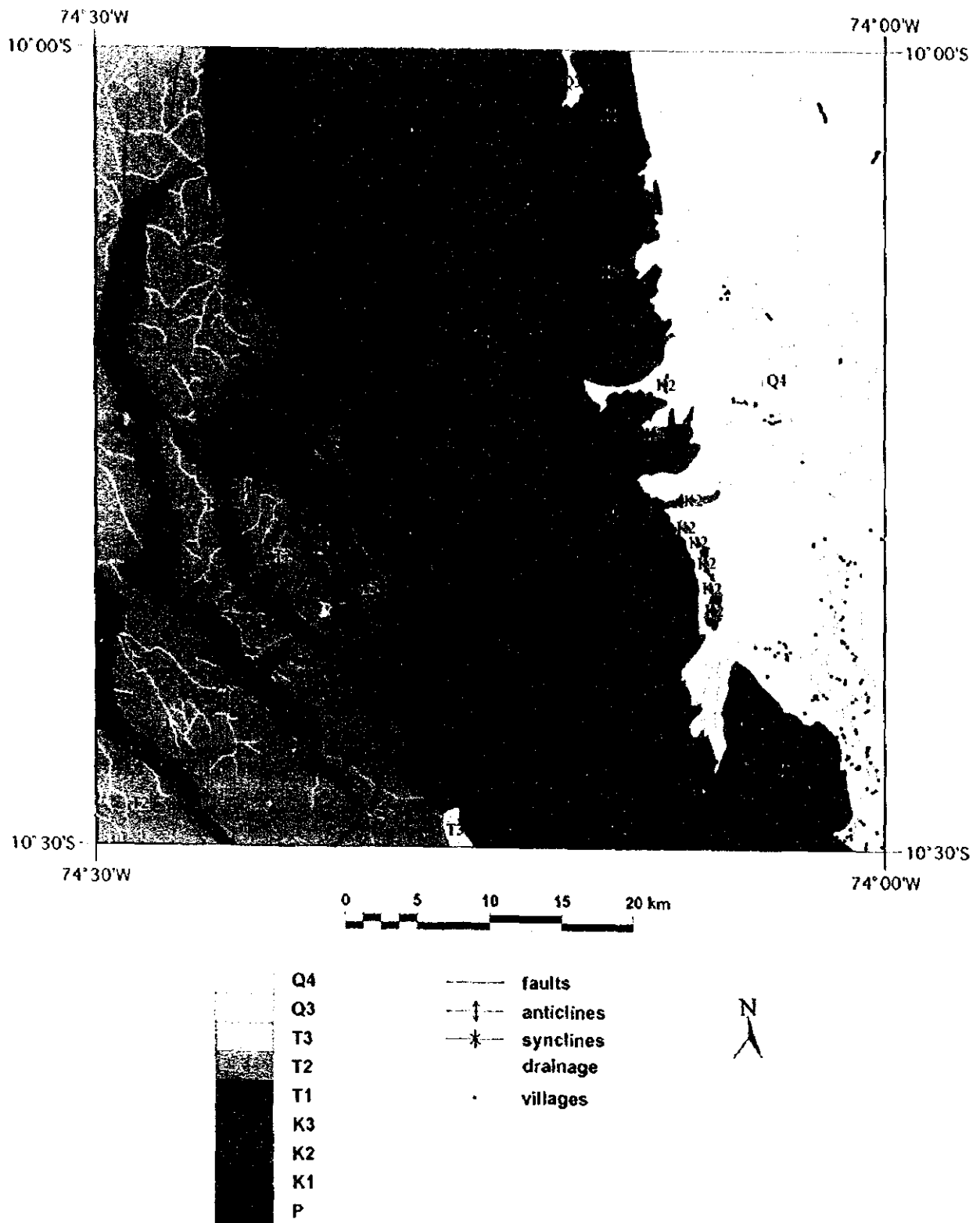


Figure 8-2 Bolognesi (21-n) geologic interpretation map



Figure 1. Geological map of the study area showing structural features and drainage patterns.

- faults
- - - anticlines
- ~ ~ ~ synclines
- drainage
- ranges

Figure 1. Geological map of the study area showing structural features and drainage patterns.



Figure 8-3 Bolognesi (21-n) lineament map

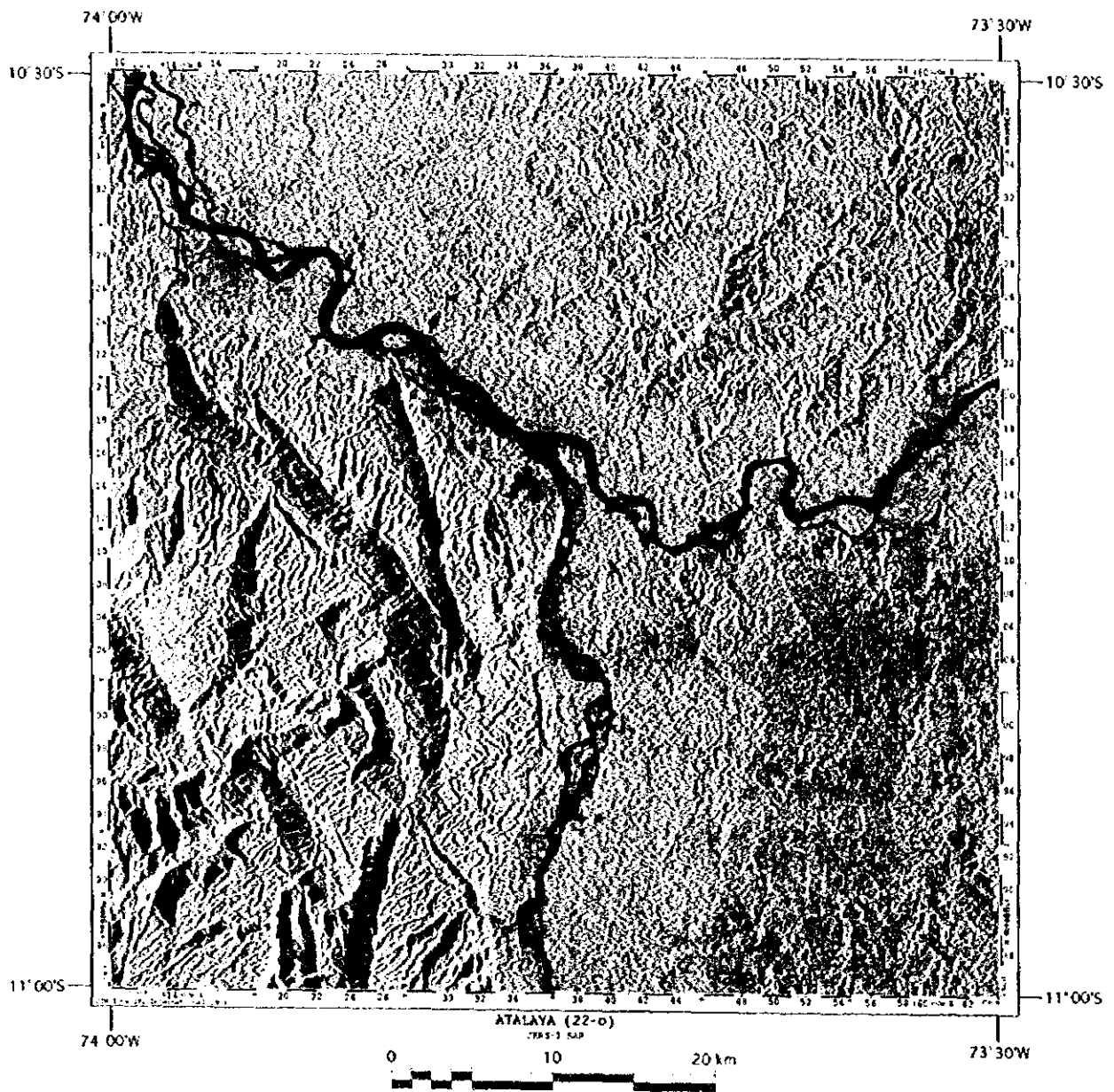
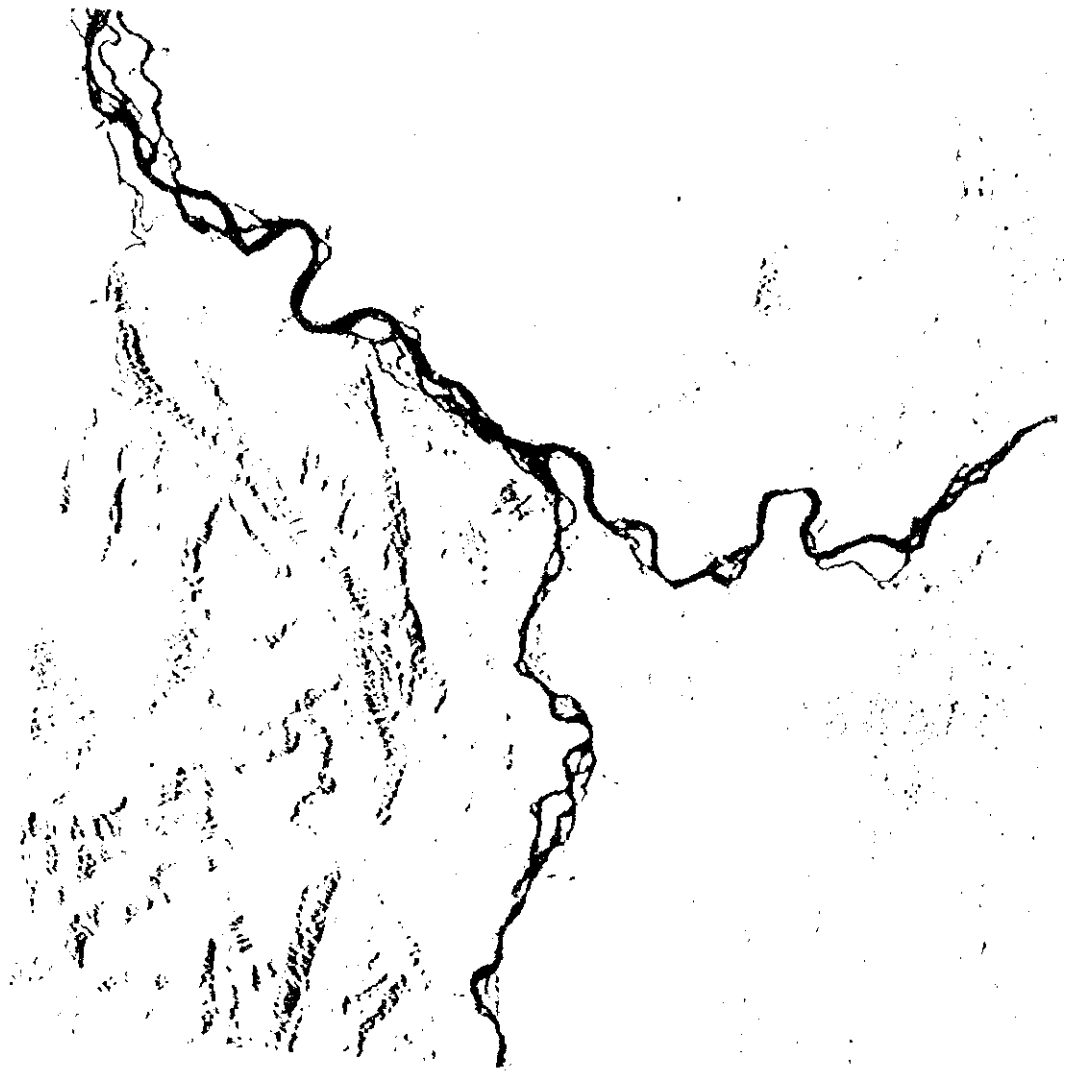


Figure 9-1 Atalaya (22-o) JERS-1 SAR image



Malaysia - JERK Y SAR image

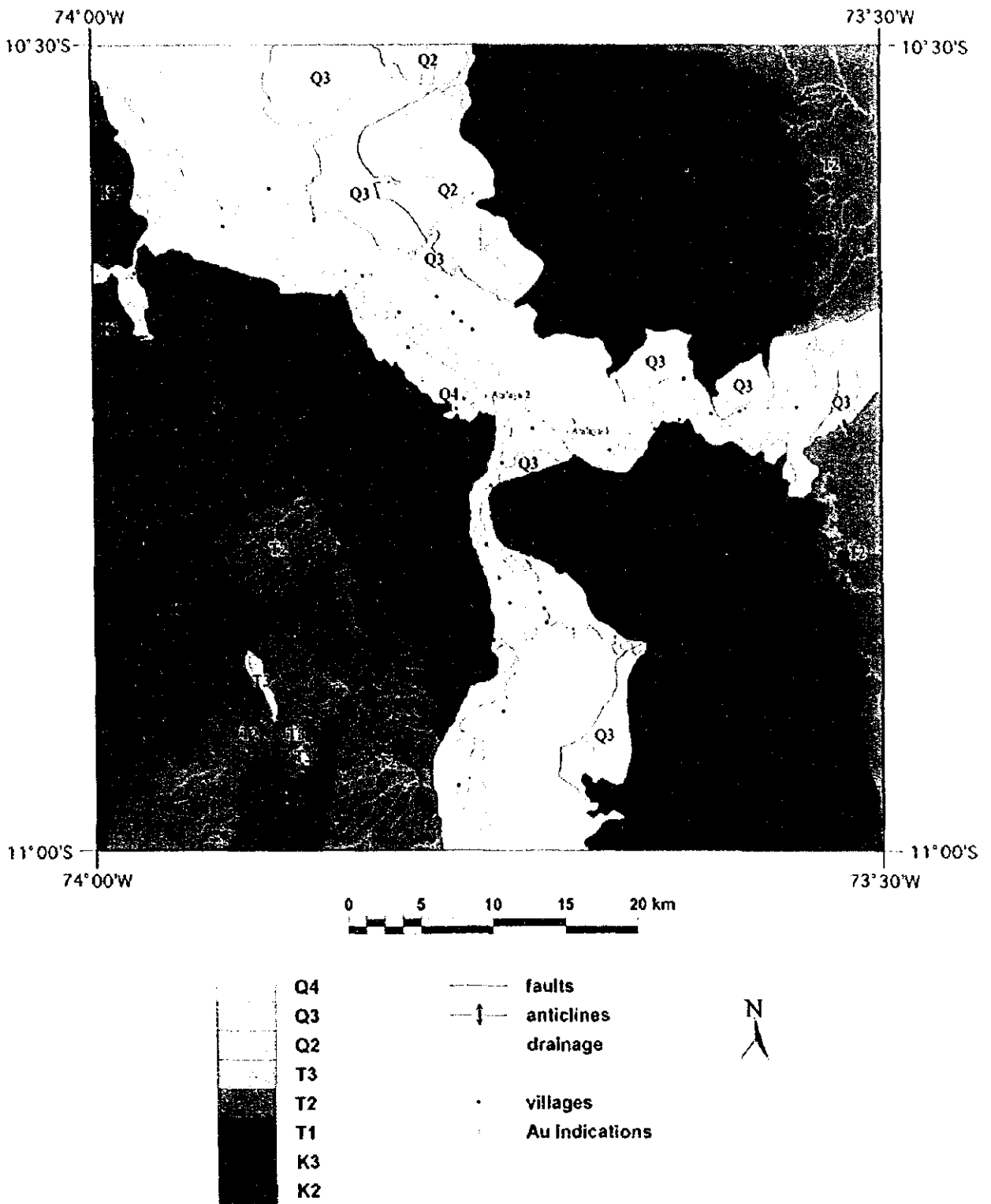
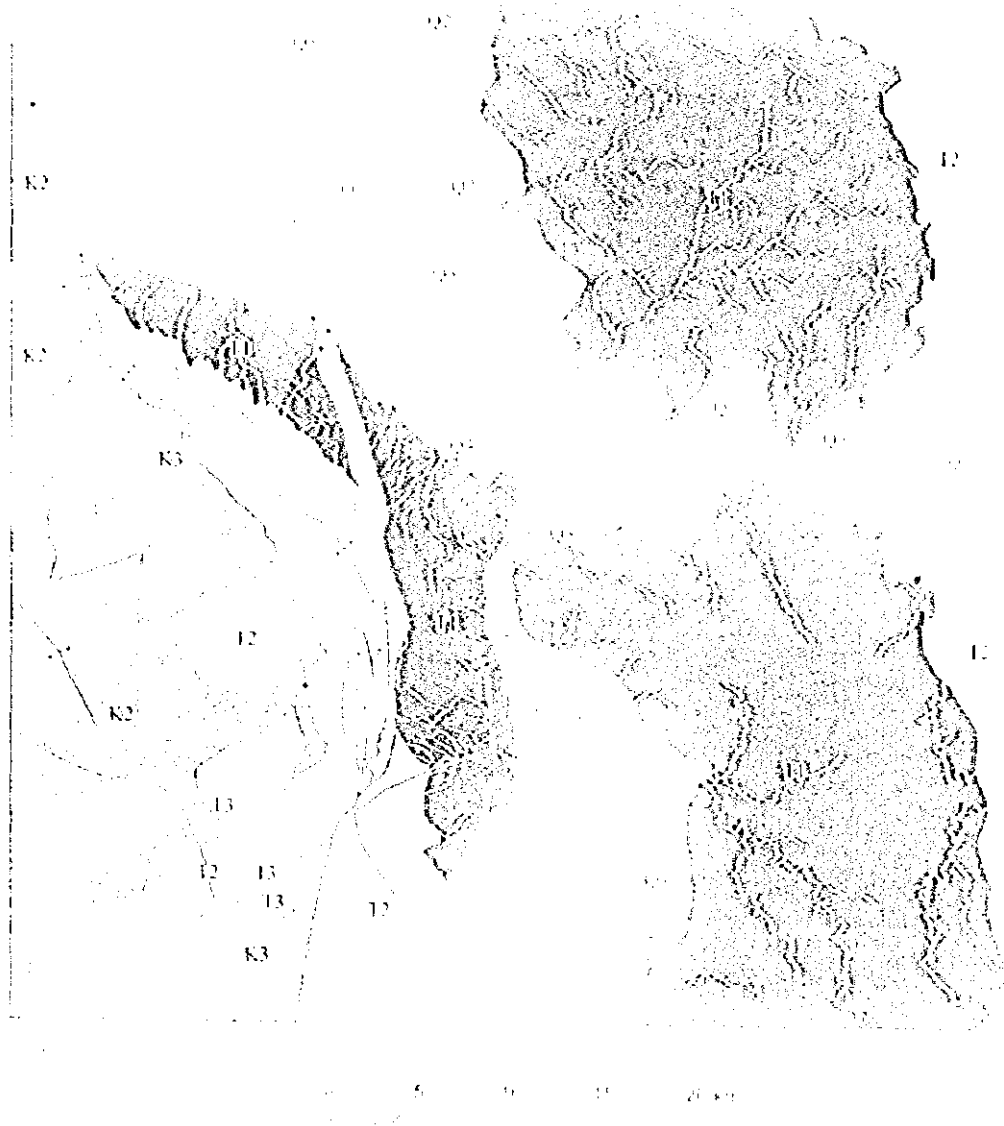


Figure 9-2 Atalaya (22-o) geologic interpretation map



- | | |
|----|-----------------|
| Q4 | faults |
| Q3 | anticlines |
| Q2 | drainage |
| I3 | |
| I2 | villages |
| T1 | anticlinal axes |
| K3 | |
| K2 | |

Fig. 1. Geological map of the Tula region (topographic contours are not shown).

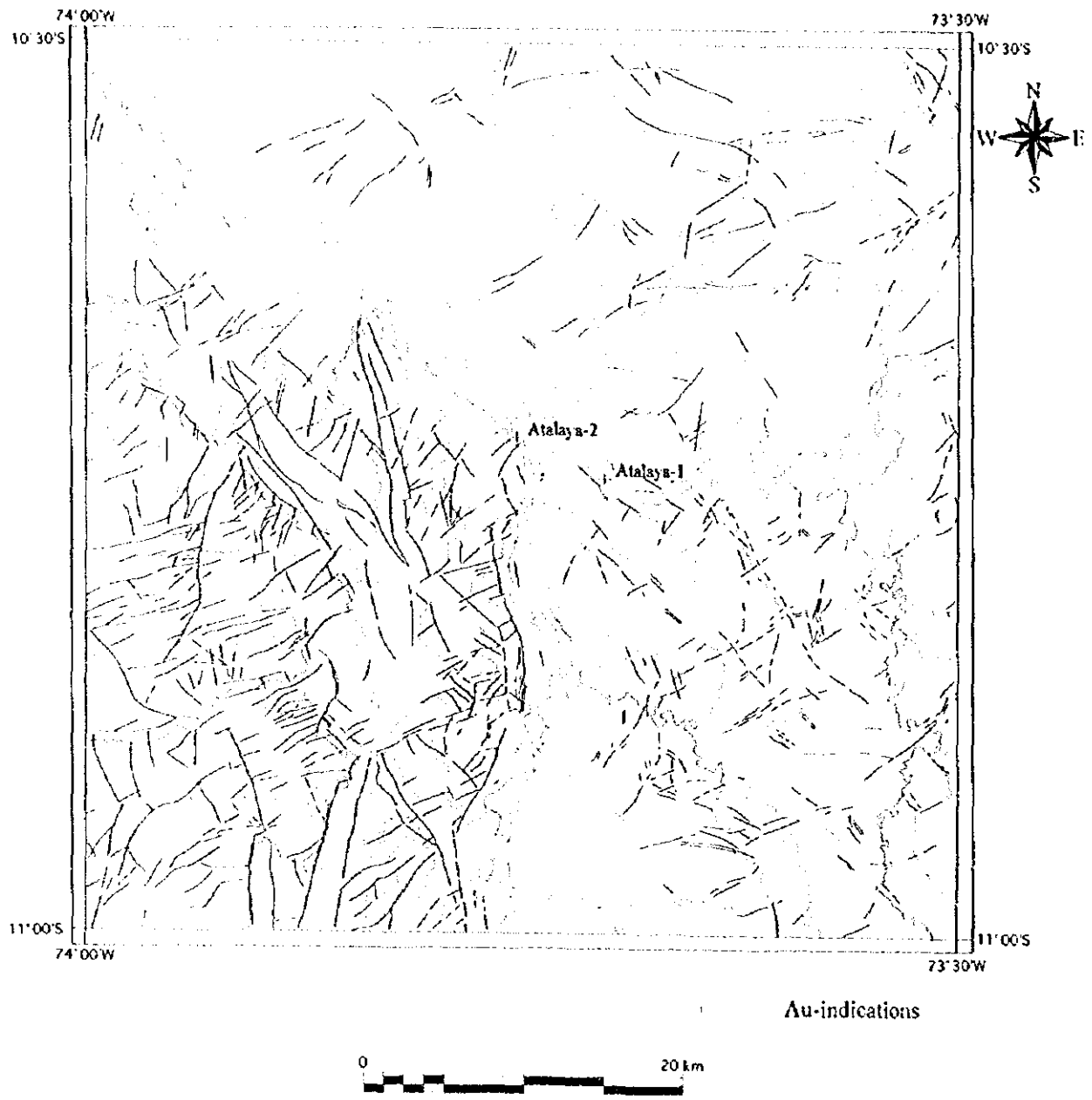


Figure 9-3 Atalaya (22-o) lineament map

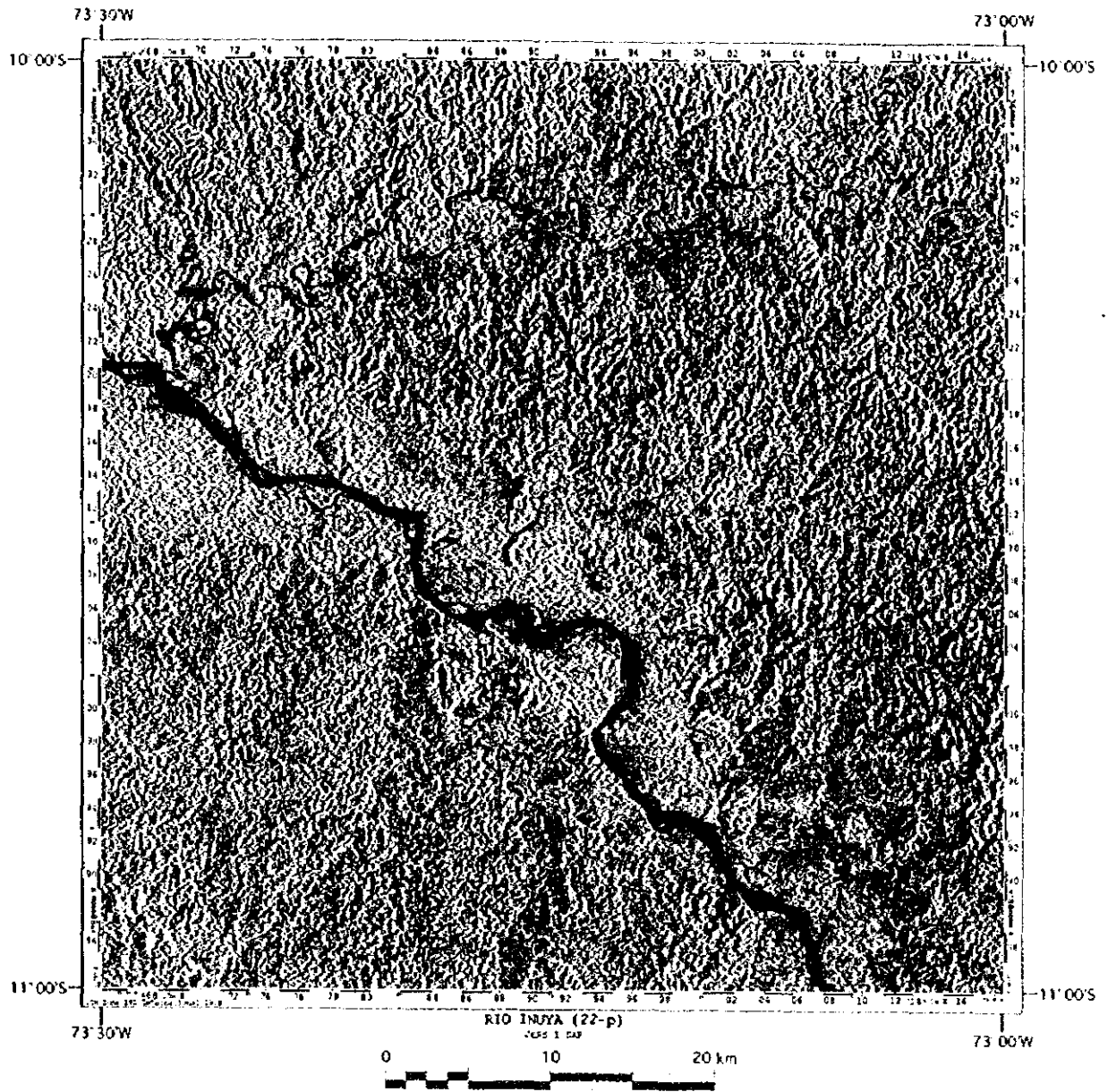


Figure 10-1 Río Inuya (22-p) JERS-1 SAR image

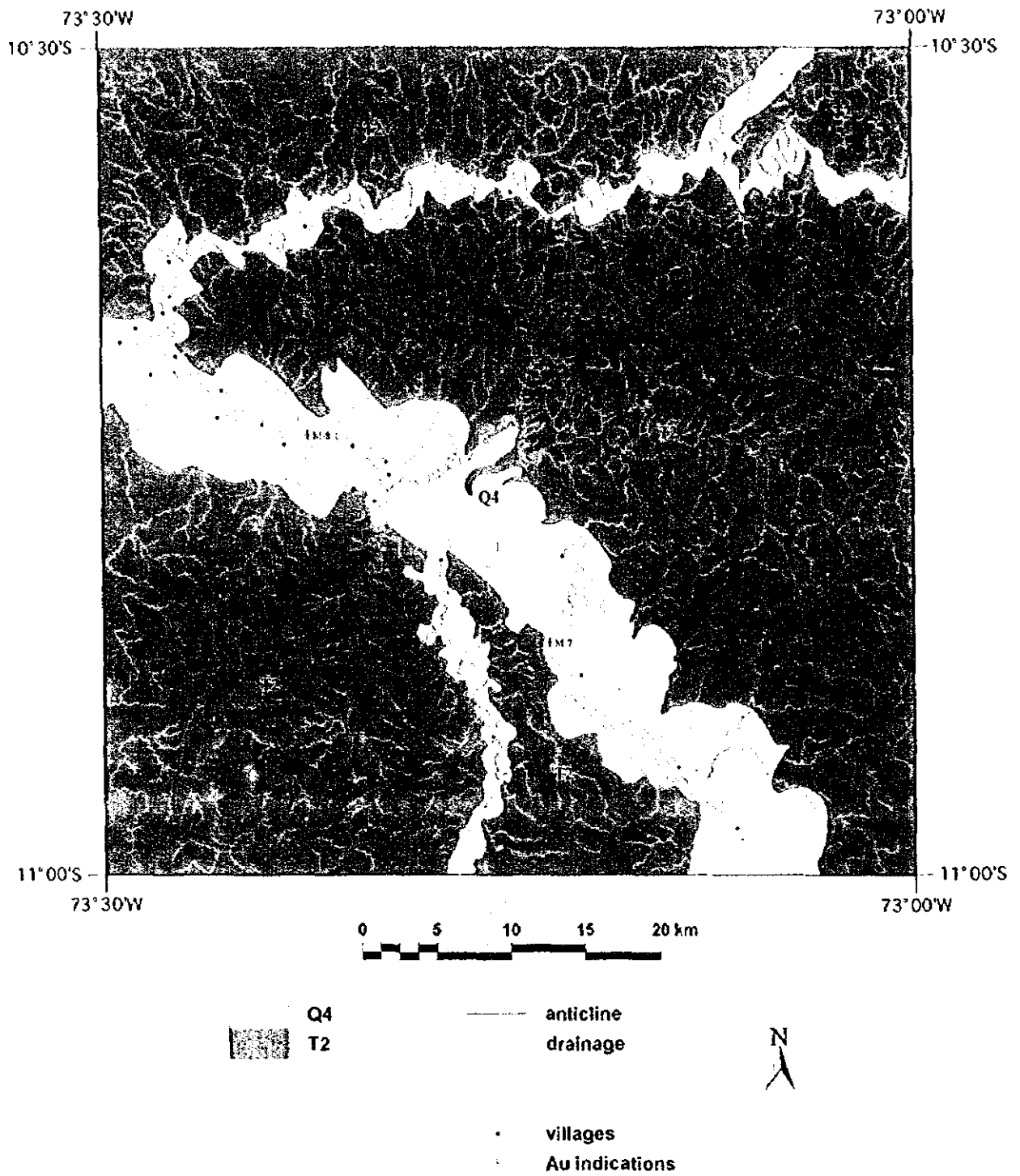


Figure 10-2 Río Inuya (22-p) geologic interpretation map

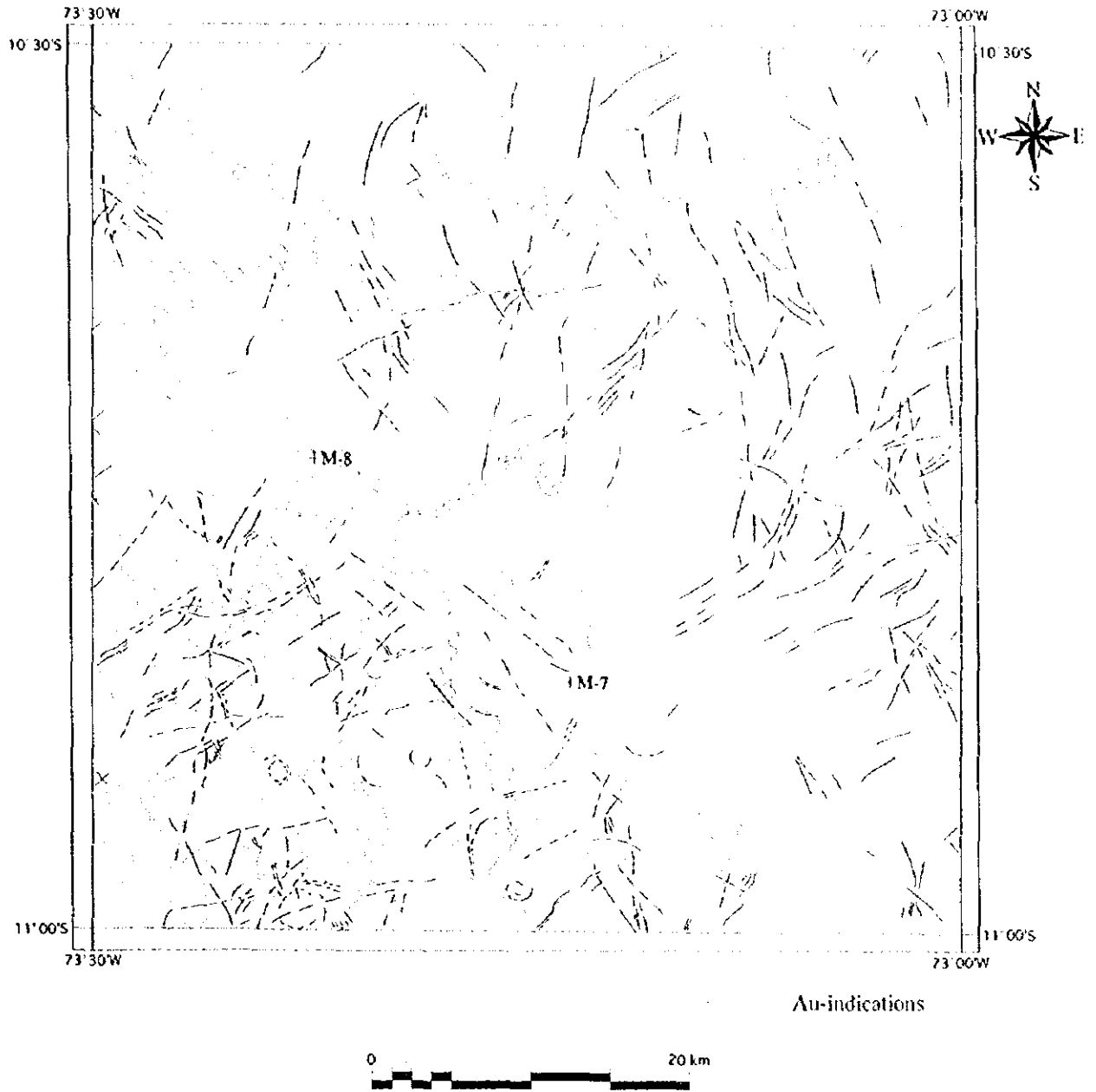


Figure 10-3 Río Inuya (22-p) lineament map

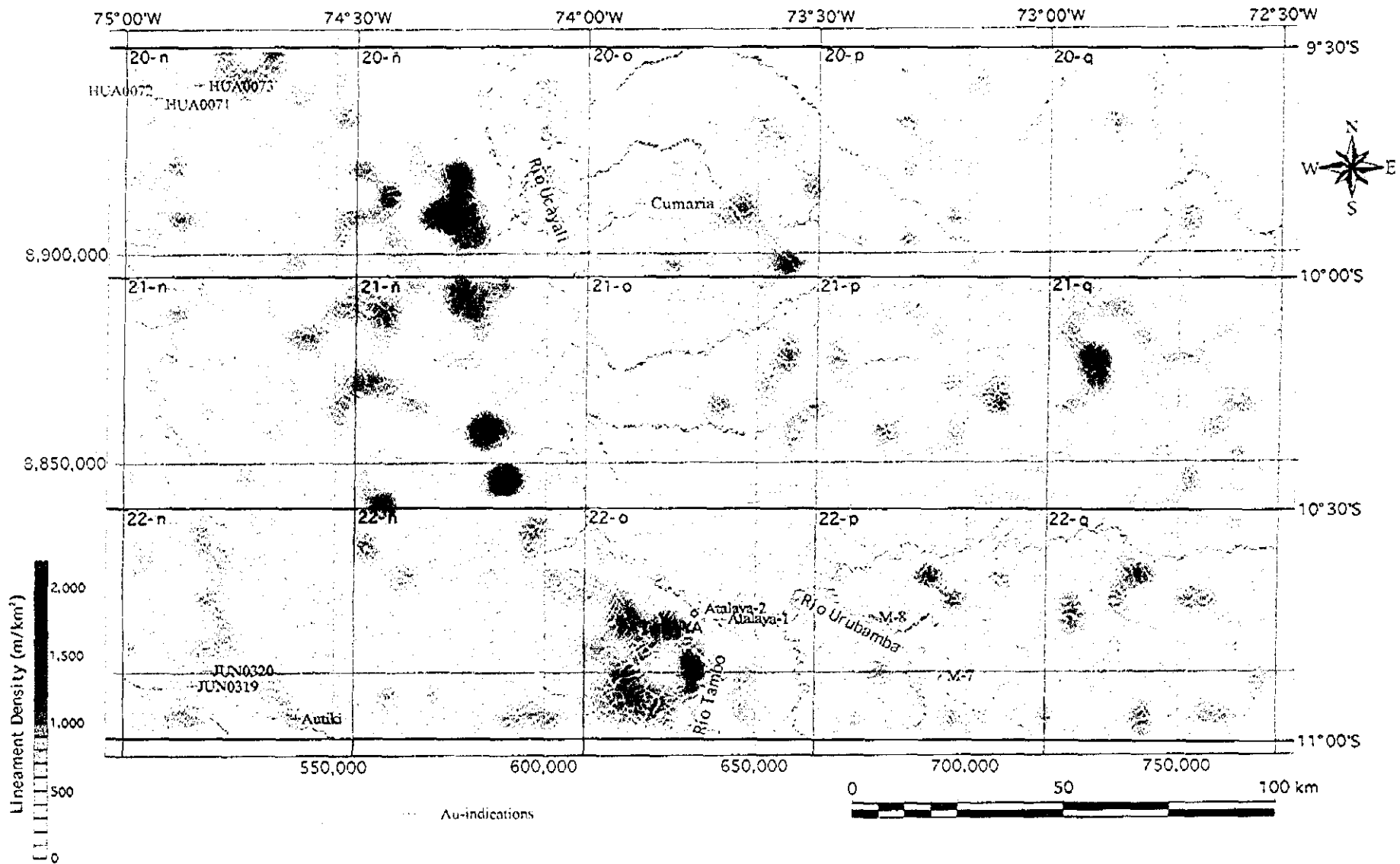


Figure 11 Lineament density map

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.

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 12 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:

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.

Figure 12 Schematic geologic column

Geological Age		Formation Name	Thick-ness m	Lithology	
C E N O Z O O L I C M E S O Z O O L I C P A L E O Z O I C P R O T E R O Z O I C	Quaternary	Holocene	Aluvial Deposit, Talus	Sand, Gravel [Unconformity]	
		Pleistocene	East Selva Area: Madre de Dios Formation	20	Brownish Sand, Clay, Gravel
	West Selva Area: Ucayali Formation		30	Brownish Sand, Clay, Gravel [Angular Unconformity]	
	Neogene	Pliocene	Ipururo Formation (West Sira Area: 500m thick -ness)	1,200	Calcareous Sandstone (Sandstone with lignite layer) [Unconformity]
		Miocene			
	Paleogene	Oligocene	East Sira: Huayabamba Group West Sira: Chambira Formation Poza Formation Yahuarango Formation	1,600 (400) (400) (800)	Sandstone, Mudstone, and Limestone Reddish violet Claystone Tuff, Shale Calcareous Claystone [Unconformity]
		Eocene			
	Cretaceous	Upper	Cachiyacu-Huchpayacu Formation	150	Shale, Sandstone
			Vivian Formation	350	Siliceous Sandstone
			Chonta Formation	650	(Shaly) Limestone with thin Limonite Layer
Oriente Group			600	Siliceous Sandstone with thin Limonite Layer [Unconformity]	
Jurassic	Upper	Sarayaquillo Formation	600	Feldspasic Sandstone with Basal Conglomerate [Angular Unconformity]	
	Lower	Pucara Group	1,500	Limestone Shaly Limestone	
Triassic	Upper	Ene Formation	700	(Calcareous) Sandstone [Unconformity]	
	Lower				
Permian	Upper	Copacabana Group	500	Dolomitic Limestone	
Carboniferous	Upper	Tarma Group	500	Siliceous Sandstone with thin Coal layer	
	Lower	Anbo Group	600	Sandstone with Limonite layer [Angular Unconformity]	
Ordovician		Contaya Formation	400	Limonitic Shale [Angular Unconformity]	
Proterozoic		Sira Complex Marafon Complex		Gneiss, Semischist 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 the 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 Solva, 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 Paleozoic including the Precambrian and the Mesozoic, constitutes an anticline thrust 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 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 13 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° - 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

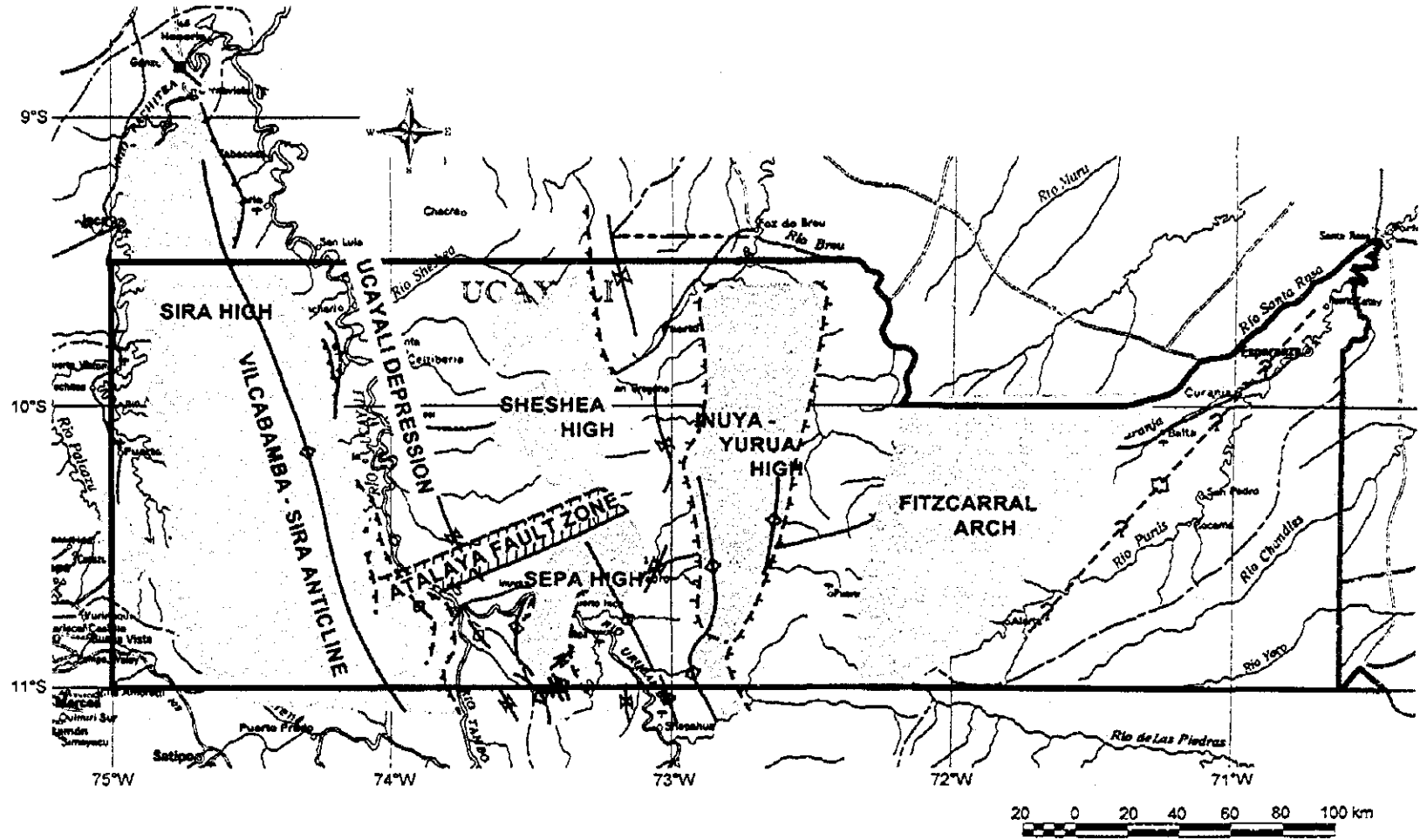


Figure 13 Deep geologic structure map

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 8 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 km²) 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 Shira, 10 km east of the Pachitea river, 37 pits were dug and resource-geological evaluation had been done. It indicated 300,000 m³ (Au: 1.55 g/m³; 465 kg) of confirmed reserves, 460,000 m³ (Au: 1.48 g/m³; 680 kg) of probable reserves and 1,500,000 m³ (Au: 1 g/m³; 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 an 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 confluences, 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 Purus, 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 8 List of ore deposits and mineral indications (1)

ID	NOMBRE	DEPARTAMENTO	UBICACION	LATITUD	LONGITUD	CUADRANGULO	ELEMENTO	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 CHANCHAMAYO	10-53-00S	074-51-00W	BAJO PICHANAQUI 22-N	AU	ORO		
JUN0320	INTI MANTARO, CONCESION	JUNIN	BAJO PICHANAQUI, PROVINCIA DE CHANCHAMAYO	10-51-00S	074-49-00W	BAJO PICHANAQUI 22-N	AU	ORO		

ID : CODIGO INGEMMET

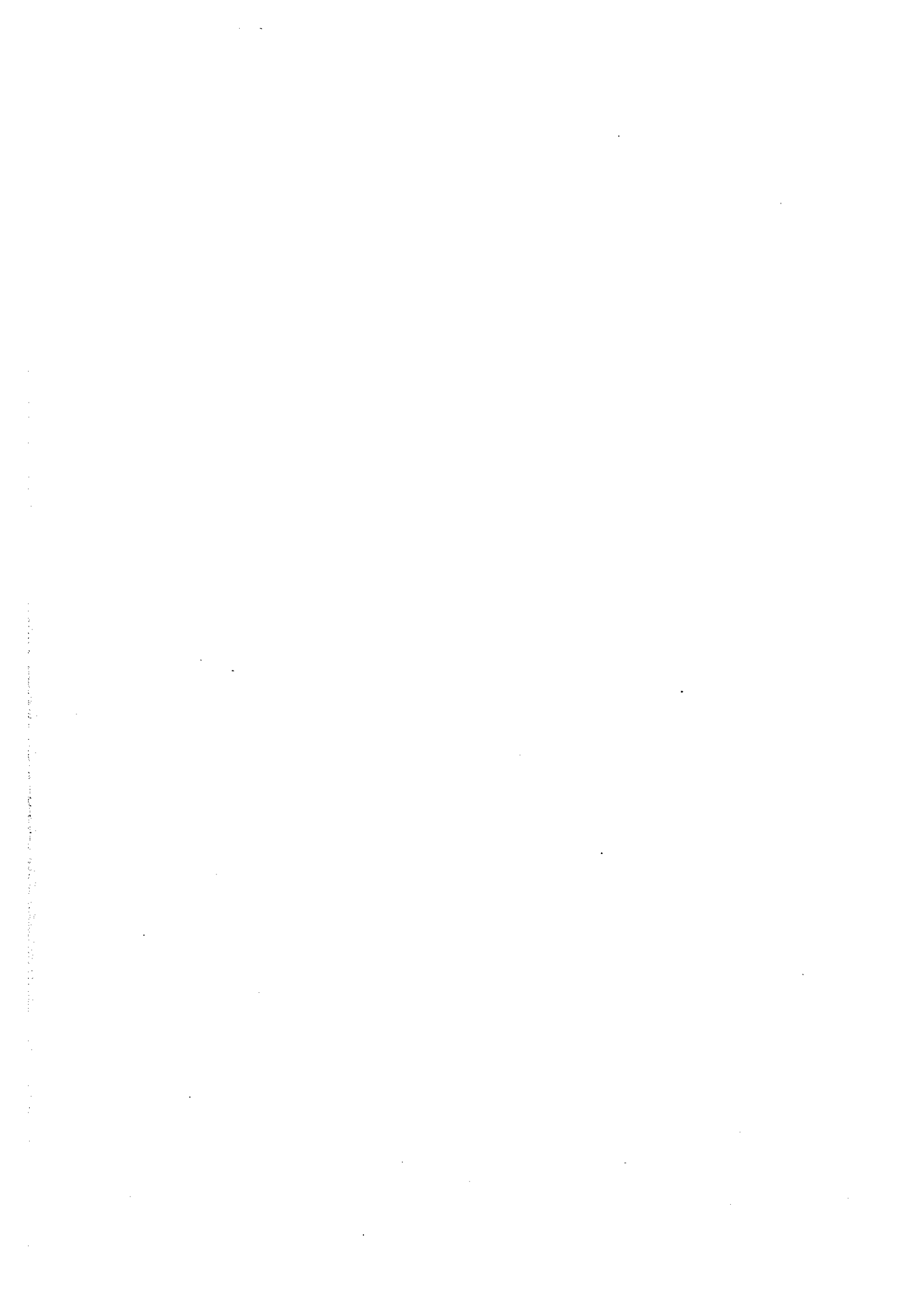


Table 8 List of ore deposits and mineral indications (2)

ID	COMENTARIO DE EXPLORACION	COMENTARIO DE EXPLORACION	COMENTARIO DE LA EXPLORACION Y DESARROLLO	COMENTARIO GENERAL	COMENTARIOS MINERALES	REFERENCIAS BIBLIOGRAFICAS	COMENTARIOS RESERVAS	COMENTARIOS DE UBICACION	COMENTARIO GEOLOGICO
HJA0071	EL YACIMIENTO CONSISTE EN DEPOSITOS AURIFEROS EXISTENTES EN TERRAZAS ALUVIALES (CUATERNARIO) EL ORO SE ENCUENTRA DENTRO DE UNA CAPA DE GREDAS QUE CONTIENE TAMBIEN RODADOS (40 CM A 85 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 20 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 EXPLORADOS Y ASEGURAN MINEROS DE LA ZONA QUE HAN SACADO HASTA 7 KG EN UN AÑO	EL DENUNCIO "ORO DEL RIO NEGRO" ABARCA UN AREA DE 8.000 X 1.200 M. QUE EN UN INICIO PERTENECIO A LA SEÑORITA NELLY LOPEZ GALLARDO Y QUE LUEGO TRASPASO EL 8 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 CRAYAS AURIFERAS "RIO NEGRO", BMP 1974, COD 80979, GALVAN J. MIGUEL, INFORME TECNICO MINA "ORO DEL RIO NEGRO", BMP 1972, COD 87642		SE UBICA EN EL PARAJE DE YANAYACU, ENTRE LOS DENUNCIOS "LORENA" Y "EL SHIRA", EN LA CONFLUENCIA DEL RIO YANAYACU CON EL RIO NEGRO A LA CUAL SE ACCDE DE ACUERDO AL SIQUENTE 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 UN CAUDAL APROXIMADO DE 30 LITROS/SEG Y SU LECHO SO PAQUETES DE ARENISCAS CUARCIFERAS EN LAS QUEDEADE
HJA0072	EL YACIMIENTO CONSISTE EN DEPOSITOS AURIFEROS EXISTENTES EN TERRAZAS ALUVIALES (CUATERNARIO) EL ORO SE ENCUENTRA DENTRO DE UNA CAPA DE GREDAS QUE CONTIENE TAMBIEN RODADOS (40 CM A 85 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 20 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 EXPLORADOS Y ASEGURAN MINEROS DE LA ZONA QUE HAN SACADO HASTA 7 KG EN UN AÑO	EL AREA DEL DENUNCIO "LORENA" ES DE 8.000 M X 1.200 M. EN LA FECHA DE LA INSPECCION, EL LABOREO MINERO ESTABA PARALIZADO DESDE HACE 2 AÑOS APROXIMADAMENTE Y SE TRABAJABA EN FORMA EMPÍRICA. 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 87642		SE UBICA EN EL PARAJE DE YANAYACU Y SE ENCUENTRA ADYACENTE AL NE DEL DENUNCIO "ORO DEL RIO NEGRO" Y AL CUAL SE ACCDE DE ACUERDO AL SIQUENTE ITINERARIO PUCALLPA - PUERTO INCA 120 KM (VIA AEREA), PUERTO INCA - PARAJE MAQUISAPAYOC 18 KM (DESPLAZADOR)	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 SO PAQUETES DE ARENISCAS CUARCIFERAS EN LAS QUEDEADE
HJA0073	EL YACIMIENTO CONSISTE EN DEPOSITOS AURIFEROS EXISTENTES EN TERRAZAS ALUVIALES (CUATERNARIO) EL ORO SE ENCUENTRA DENTRO DE UNA CAPA DE GREDAS QUE CONTIENE TAMBIEN RODADOS (40 CM A 85 CM DE DIAMETRO). LA SECUENCIA DE LAS CAPAS DE ARRIBA HACIA ABAJO ES C	EN EL AREA CORRESPONDIENTE AL DENUNCIO "EL SHIRA" SE HAN EVALUADO 78 POZOS EXPLORATORIOS CON EL FIN DE EVALUAR EL AREA MINERALIZADA Y SE HA DETERMINADO UN AREA MAS FAVORABLE DE NOMINADO "ZONA A" Y TIENE 25 HAS. DE EXTENSION	DESPUES QUE FUERON CONOCIDOS LOS DEPOSITOS FUERON INTENSAMENTE EXPLORADOS Y ASEGURAN MINEROS DE LA ZONA QUE HAN SACADO HASTA 7 KG EN UN AÑO	EL AREA DEL DENUNCIO "EL SHIRA" ES DE 3.000 M X 3.000 M, E INICIALMENTE PERTENECIO A LA SEÑORITA 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 GRAYAS AURIFERAS "ORO NEGRO", BMP 1974, COD 80979, GALVAN J. MIGUEL, INFORME TECNICO MINA "ORO DEL RIO NEGRO", BMP 1972, COD 87642	ESTOS DATOS ESTAN REFERIDOS A RESERVAS PROBABLES UNICAMENTE CON UN CONTENIDO FIJO DE 883 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 ACCDE DE ACUERDO AL SIQUENTE ITINERARIO PUCALLPA - PUERTO INCA 120 KM (VIA AEREA), PUERTO INCA - PARAJE MAQUISAPAYOC 18 KM (DESPLAZADOR), 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 SO PAQUETES DE ARENISCAS CUARCIFERAS EN LAS QUEDEADES O
HJA0074	EL YACIMIENTO CONSISTE EN DEPOSITOS AURIFEROS EXISTENTES EN TERRAZAS ALUVIALES (CUATERNARIO) EL ORO SE ENCUENTRA DENTRO DE UNA CAPA DE GREDAS QUE CONTIENE TAMBIEN RODADOS (40 CM A 85 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 20 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 EXPLORADOS Y ASEGURAN MINEROS DE LA ZONA QUE HAN SACADO HASTA 7 KG EN UN AÑO	EL AREA DEL DENUNCIO "MISTERIO" ES DE 3.000 M X 2.000 M, TIENE UN CLIMA CALUROSO. EN LA FECHA DE LA INSPECCION, EL LABOREO MINERO ESTABA PARALIZADO DESDE HACE 2 AÑOS APROXIMADAMENTE Y SE TRABAJABA EN FORMA EMPÍRICA. EL MAYOR PROBLEMA PARA LAS OPERACIONES	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 87642		SE UBICA EN EL PARAJE DE YANAYACU Y SE ENCUENTRA ADYACENTE AL NE DEL DENUNCIO "EL SHIRA" Y AL CUAL SE ACCDE DE ACUERDO AL SIQUENTE ITINERARIO PUCALLPA - PUERTO INCA 120 KM (VIA AEREA), PUERTO INCA - PARAJE MAQUISAPAYOC 18 KM (DESPLAZADOR), 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 UN CAUDAL APROXIMADO DE 30 LITROS/SEG Y SU LECHO SO PAQUETES DE ARENISCAS CUARCIFERAS EN LAS QUEDEADE
JUN0319	EL PROPOSITO DE ESTE PETITORIO ES DE SARROLLAR TRABAJOS DE EXPLORACION POR ELEMENTOS METALICOS		EL PETITORIO ABARCA UNA EXTENSION DE 800 HAS	EN EL CATASTRO MINERO SE REGISTRAN DOS AREAS UBICADAS EN EL CUADRANGULO DE BAJO PICHANAQUI CERCA AL POBLADO DE HUACHIRKE. 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 HUACHIRKE, DISTRITO DE BAJO PICHANAQUI, PROVINCIA DE CHANCHAMAYO, OPTO 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 EXTENSION 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, OPTO 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 HIDROTHERMAL

ID: CODIGO INGENMET

Chapter 3 Integrated Analysis

Following findings have been obtained by the integration of the survey results in Phase I (Ref. Figure 14).

- (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) 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.
- (4) 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.
- (5) Minalable alluvial gold deposits are possibly present in the fluvial sediments along the Urubamba river near Atalaya (Quad.22-o) and Sepa (Quad. 22-p).

As to the above items (1) and (2), it is hard to evaluate the possibilities since no ground verification has been made. Therefore, the following are considered to be promising areas for future exploration:

- The area along the Negro river where occurrence of alluvial gold deposits is 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 lincament have been extracted.

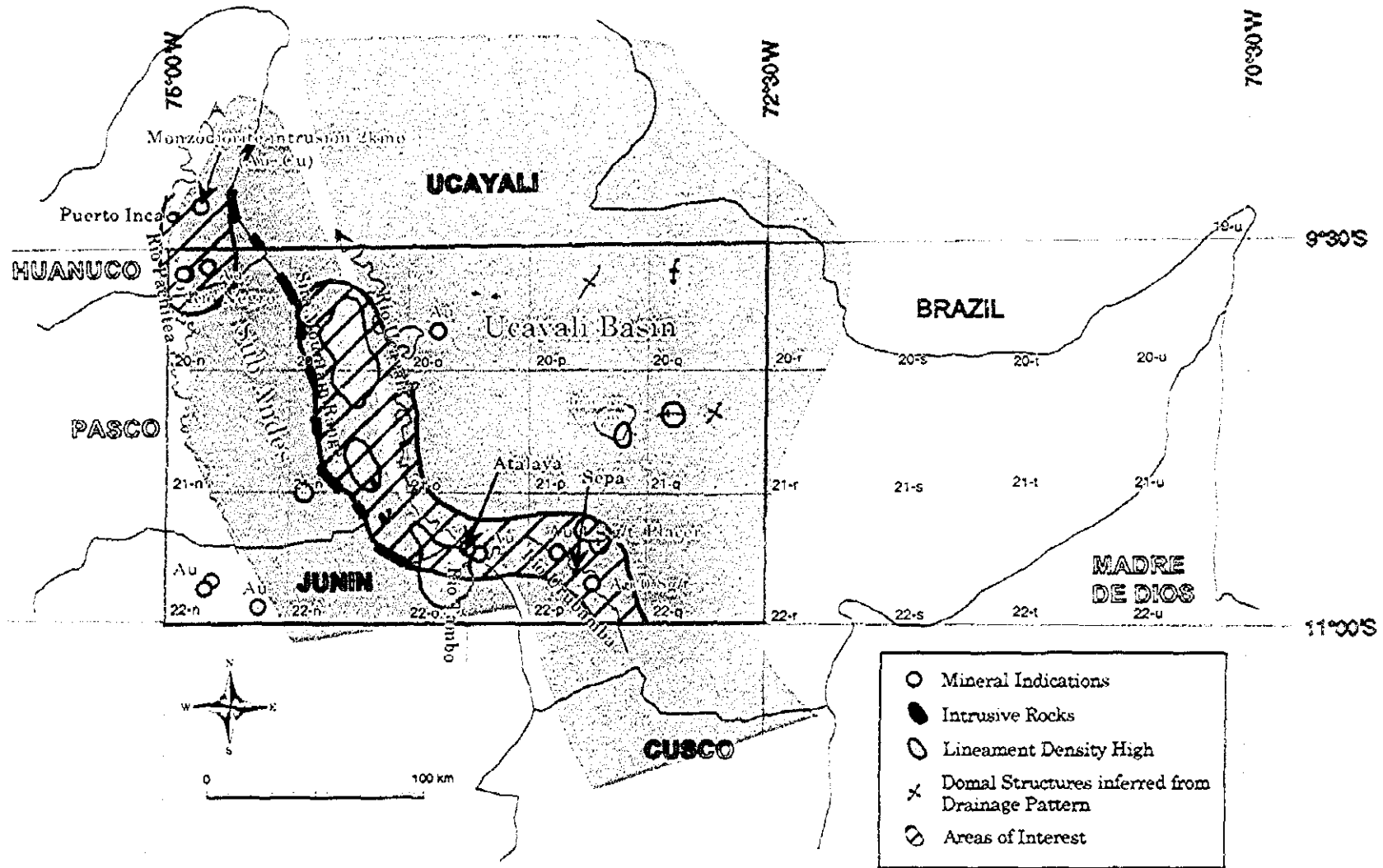


Figure 14 Potential evaluation map

PART III

**CONCLUSIONS
AND
RECOMMENDATIONS**

Chapter 1 Conclusions

The following conclusions are drawn from the Phase I 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 for the Phase II

Based on the survey findings summarized above, the following recommendations may be made for the second phase:

- (1) **Satellite image analysis:** Execute in collaboration with the Peruvian engineers the JERS-1 SAR data processing to prepare mosaic images which are to cover the 13 quadrangles in the east part of the Urubamba river inferior area, in an effort to ensure the transfer of the SAR image processing technology. Successively, image interpretation including mapping of the geologic interpretation and lineaments, digitizing of interpretation results, preparation of the GIS data set and analysis of such data as lineament density.
- (2) **Existing data analysis:** Collect and compile additional data prepared in Peru after the Phase I survey (mainly mining claims-related information).
- (3) **Field survey:** Consider the possibility to execute field survey aimed to ascertain mineralization, with the base camp at Atalaya, situated in the east piedmont of the Sira range where the Tertiary intrusive rocks are present and relatively close to the placer gold mineral indications in the Urubamba-Ucayali rivers. The survey will include the following items:
 - Geochemical sampling of stream sediments, heavy minerals and rocks.
 - Investigation of mineral indications.
 - Verification of lithofacies along survey routes.

List of Reference and Data Collected

1. Geological reports by INGEMMET

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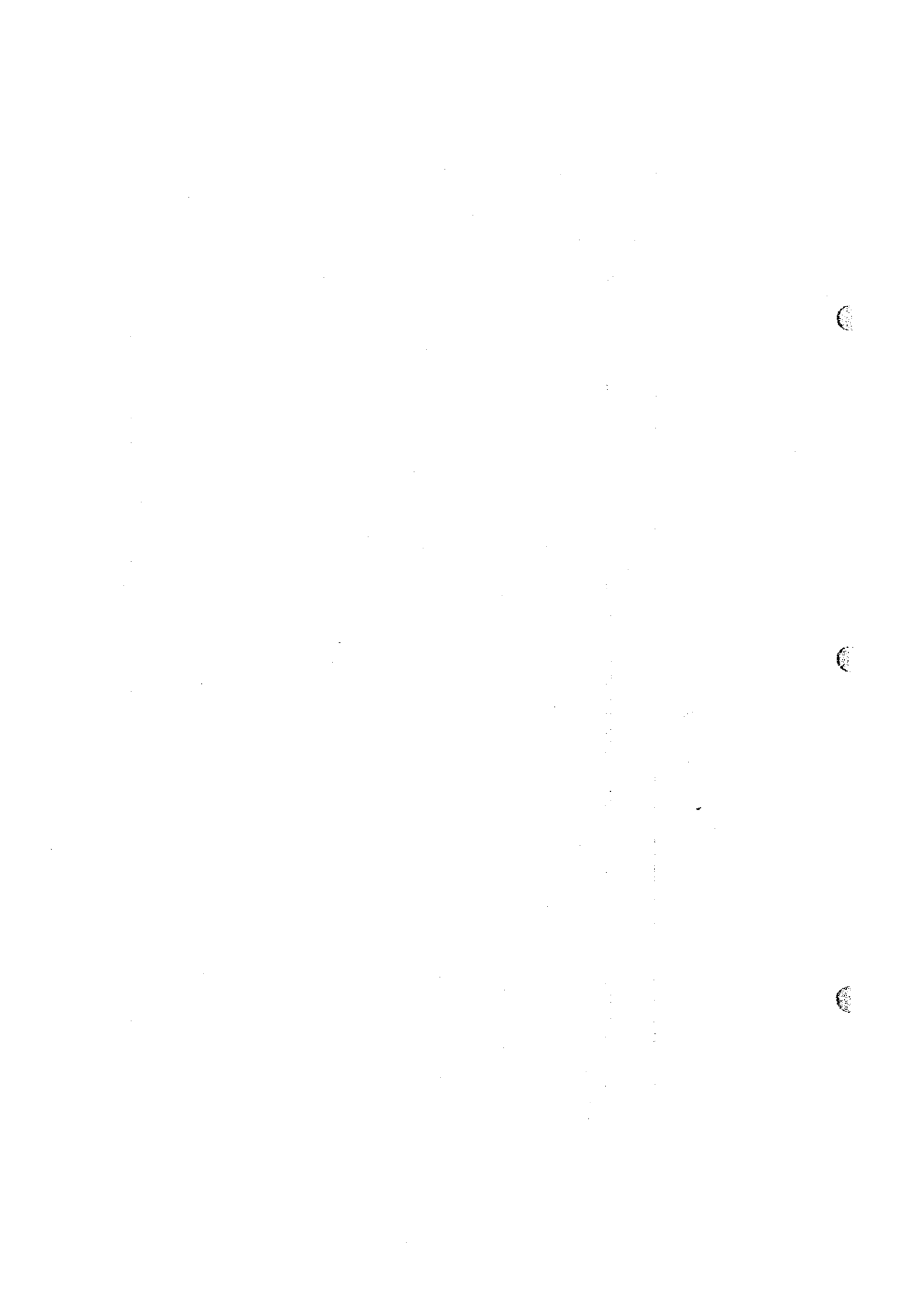
Geological Data of PERUPETRO S.A. (1)

Title	Scale	Year	Reference number	Researcher
Figures & Maps				
Columna Estratigrafica Generalizada del Area del Marañon		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



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