PART II PARTICULARS

Chapter 1 Satellite Image Analysis

1-1 Purpose of Image Analysis

Through the interpretation of the JERS-1 SAR and LANDSAT TM images, the geologic interpretation maps and lineament maps were prepared with the aim of grasping the regional geologic structure, thereby providing basic data necessary for the evaluation of potentialities for occurrence of mineral resources in the survey area. The prepared interpretation maps correspond to the 13 Quadrangles numbered 29-l, 30-m, 30-n, 31-m, 31-n, 31-r, 32-n, 32-ñ, 32-o, 32-p, 32-q and 32-r of the 1:100 000-scale topographic maps elaborated by the Instituto Geográfico Nacional (IGN). Each side of a quadrangle is equivalent to 30 minutes of the latitude and longitude.

1-2 Image Processing

1-2-1 Data Used

Data used for the analysis are 21 scenes of the JERS-1 SAR data and 7 scenes of the LANDSAT TM data as indicated in Fig. 3 and Table 4.

1-2-2 Procedures for Processing of JERS-1 SAR Images

Respective images of the 13 quadrangles were processed for the interpretation, in the following procedures:

1. Data loading: All the JERS-1 SAR data included in the EXABITE tapes provided by ERSDAC were loaded down on the hard disk (HD) connected to an engineering work station (EWS).
2. File conversion: The transferred image data files were converted to the standard image database format of PCI/EASI-PACE, an image processing software developed by PCI of Canada.
3. Bit number conversion: The 16-bit image data were converted into the 8-bit image data.
4. Histogram normalization: Simultaneously with the bit number conversion, histograms of digital numbers were normalized.
5. Image rotation: Images were rotated clockwise by 90 degrees.
6. Correction of antenna pattern: In order to re-correct the characteristics of antenna pattern of JERS-1 SAR data, an average DN gradually decreases from the far range to the near range, an average of the azimuth direction of each scene was calculated so that each pixel value might be divided by the average.
7. Assignment of coordinates: The UTM coordinates of the four corners of each scene were read from the header information and assigned.
8. Preparation of image database for mosaicking: The PCI image database file was prepared, which has the UTM coordinate system for making mosaic images.
9. Pasting of center image: The scene nearest to the center of the survey area was pasted to the database file for making mosaic images. The pasting position was determined by the positional information in the header file.
10. Image mosaicking: Image mosaicking was done in order starting from the images adjoining the central image. Several dozens of tie-points were fixed at an overlap of images and geometric correction was applied so that the residual error might be reduced to 1 pixel or less. Simultaneously, the brightness was adjusted so that difference in the DN value between two images might be reduced.

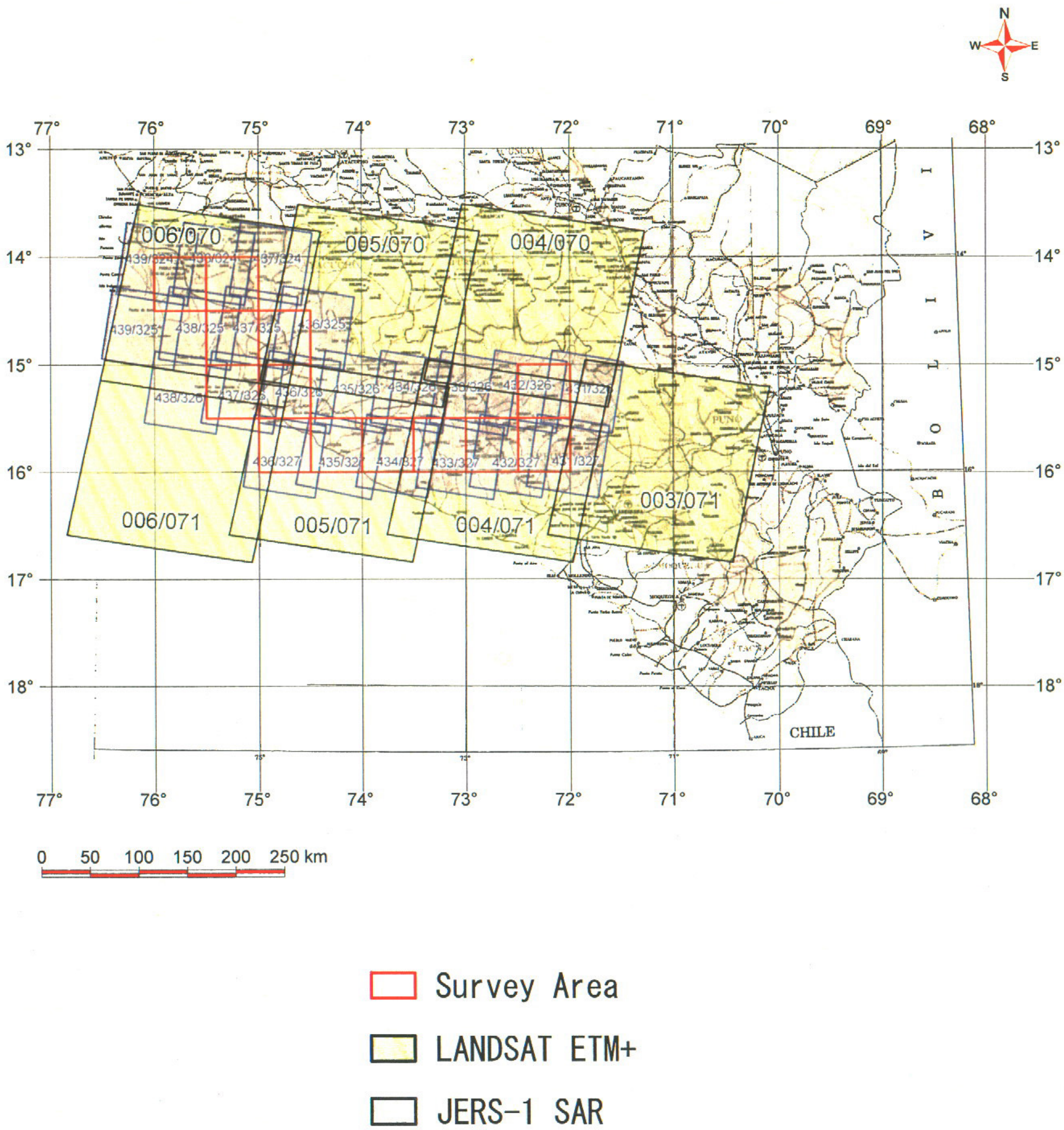

Fig.3 Coverage of satellite data used

Table 4 Satellite data used

JERS-1 SAR DATA

	Path	Row	Date	Level
1	431	326	1996/02/01	2.1
2	431	327	1996/02/01	2.1
3	432	326	1996/02/02	2.1
4	432	327	1996/02/02	2.1
5	433	326	1997/01/20	2.1
6	433	327	1997/01/20	2.1
7	434	326	1996/02/04	2.1
8	434	327	1996/02/04	2.1
9	435	326	1996/02/05	2.1
10	435	327	1996/12/09	2.1
11	436	325	1994/03/04	2.1
12	436	326	1994/03/04	2.1
13	436	327	1996/06/17	2.1
14	437	324	1996/02/07	2.1
15	437	325	1996/02/07	2.1
16	437	326	1996/02/07	2.1
17	438	324	1996/02/08	2.1
18	438	325	1996/02/08	2.1
19	438	326	1996/02/08	2.1
20	439	324	1996/02/09	2.1
21	439	325	1996/02/09	2.1

LANDSAT DATA

	Path	Row	Date	Sensor
1	003	071	2000/06/24	ETM+
2	004	070	2000/08/02	ETM+
3	004	071	2000/11/06	ETM+
4	005	070	2000/06/22	ETM+
5	005	071	2000/05/21	ETM+
6	006	070	2000/04/26	ETM+
7	006	071	2000/04/26	ETM+

11. Speckle noise reduction: An Enhanced Lee Filter (5 x 5) was employed to reduce speckle noises.
12. File conversion: After converting the PCIDSK file to an image file of the TIFF format, the image data was imported to the data format(.rvc) of the TNTmips, an integrated GIS software of the Microimages, Inc. of USA.
13. Projection on the maps: With the projection function of the TNTmips, the imported image data were projected on the maps, for which confluences, towns and other landmarks were utilized as the ground control points for georeferencing. The scanned images of the 1:100 000-scale topographic maps published by the IGN were utilized as the reference. The method of projection on a map was based on the UTM (zone=18) while the 1956 Venezuela was used for the earth ellipsoid model.
14. Extraction of sub-scene images of respective quadrangles: Based on the map projection data, 13 sub-scene images corresponding to the respective quadrangles in the survey area were prepared.
15. Annotation: The respective sub-scene images were annotated with the UTM coordinates, scale bars, titles of quadrangles, etc.
16. Conversion of file format: The format of image files was converted from the .rvc to the TIFF format so as to fit to the output device used.
17. Resampling of image resolution: Resolution of each sub-scene image was adjusted to output at 300 dpi and at a 1:200 000-scale. Consequently, the spatial resolution of images was resampled to about 16.9 m per pixel.
18. Hard copy output: Two sets of the 13 sub-scene images, totaling 26 images, were output at a 1:200 000-scale by a digital photo-printer (Lightjet 5000). The prepared JERS-1 SAR mosaic images are exhibited in Fig.4, while a part of the same sub-scene images are exhibited in Figs. 9-1 (Quad. 32-q) and 10-1 (Quad. 31-r).

1-2-3 Procedures for Processing of LANDSAT TM color composite images

The respective images of the 13 quadrangles were processed for the interpretation, in the following procedures:
1. Data loading and file conversion: The LANDSAT TM data recorded in a CD purchased from the RESTEC were loaded down on the hard disk(HD) connected to an engineering work station(EWS). The image data files were then converted to the format of PCIDSK and 6 PCIDSK for each scene to be used were prepared. The transferred data are those of Bands 1, 2, 3, 4, 5 and 7, while the thermal ultra-red band (Band 6) is excepted.
2. Assignment of coordinates: The UTM coordinates of the four corners of each scene were red from the header information and assigned.
3. Preparation of image database for mosaicking: The PCIDSK that has the UTM coordinate system for making mosaic image was prepared.
4. Pasting of center image: The scene nearest to the center of the survey area was pasted to the database file for making mosaic images. The pasting position was determined by the positional information in the header file.
5.Image mosaicking: Image mosaicking was done in order starting from the images adjoining the central image. Several dozens of tie-points were fixed at an overlap of images and geometric correction was applied so that the residual error might be reduced to 1 pixel or less. Simultaneously, the brightness was adjusted at each band so that difference in DN value between two images might be reduced.
6.Enhancement of contrast: Histogram equalized stretching was applied to each of the mosaicked images of bands 1, 4 and 5 to enhance the contrast.
7.Enhancement of edges: The edges of images were enhanced by the Laplacian filter

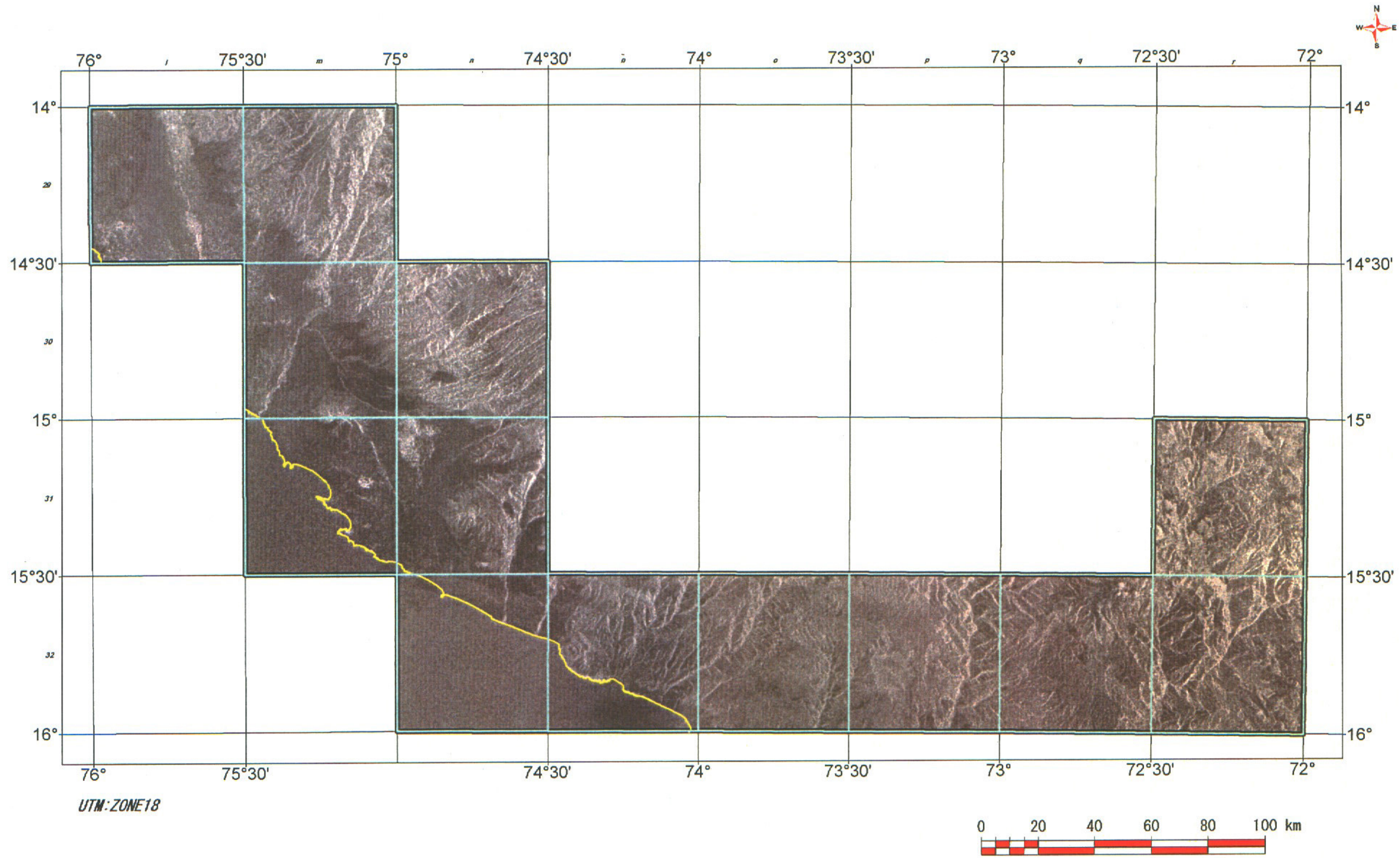

Fig.4 JERS-1 SAR mosaic image

processing.
8. Conversion of file format: The PCIDSK file format was converted to the TIFF format which, in turn, was converted to the .rvc format.
9. Projection on the maps: With the projection function of the TNTmips, the imported image data were projected on the maps, for which confluence, towns and other landmarks were utilized as the ground control points for georeferencing. The scanned images of the 1:100 000-scale topographic maps published by the IGN were utilized as the reference. The projection on a map was based on the UTM (zone=18) while the 1956 Venezuela was used for the earth ellipsoid model.
10. Extraction of sub-scene images of respective quadrangles: Based on the data projected on the maps, 18 sub-scene images corresponding to the respective quadrangles in the survey area were prepared, when the Bands 1, 4 and 5 were assigned blue, green and red colors, respectively.
11. Annotation: The respective sub-scene images were annotated with the UTM coordinates, scale bars, titles of quadrangles, etc.
12. Conversion of file format: The format of image files was converted from the .rvc to the TIFF format so as to fit to the output device used.
13. Resampling of image resolution: Resolution of each sub-scene image was adjusted to output at 300 dpi and at a 1:200,000-scale. Consequently, the spatial resolution of images was resampled to about 16.9 m per pixel.
14. Hard copy output: Two sets of the 13 sub-scene images, totalling 26 images, were output at a 1:200 000-scale by a digital photo-printer (Lightjet 5000). The prepared LANDSAT TM mosaic images are exhibited in Fig. 5, while a part of the same sub-scene images are exhibited in Figs. 9-2(Quad. 32-q) and 10-2(Quad. 31-r).

1-2-4 Procedures for Preparation of LANDSAT TM ratioing images

Ratioing images of the 13 quadrangles were prepared in the following procedures:

1. Preparation of masks: The masks corresponding to vegetation, water body + shadow + blank, and to cloud + snow + alluvium were prepared. The thresholds of the respective masks are as follows:
- Vegetation: NDVI > 0.1

NDVI(Normalized Differential Vegetation Index)

NDVI = (Band 4 – Band 3) / (Band 4 + Band 3)

- Water body, shadow and blank: Band 5 < 42
- Cloud, snow and alluvium: Band 1 < 120

2. Ratioing: With the pixels not covered by the mentioned masks, Band (2-1)/(2+1) for the purpose of extracting iron oxide zones (hereafter called 'R21'), and Band (5-7)/(5+7) for the purpose of extracting argillization zones (hereafter called 'R57') were calculated, which were exported to 32-bit real data.
3. Extraction of anomalies: From the ratioing results of the mentioned two types of anomalies, statistical values were calculated, as follows:

Rationing type	Mean	Standard deviation	2σ
R21	−0.563	0.308	0.054
R57	−0.200	0.646	1.092

2σ = Mean + 2 × Standard Deviation

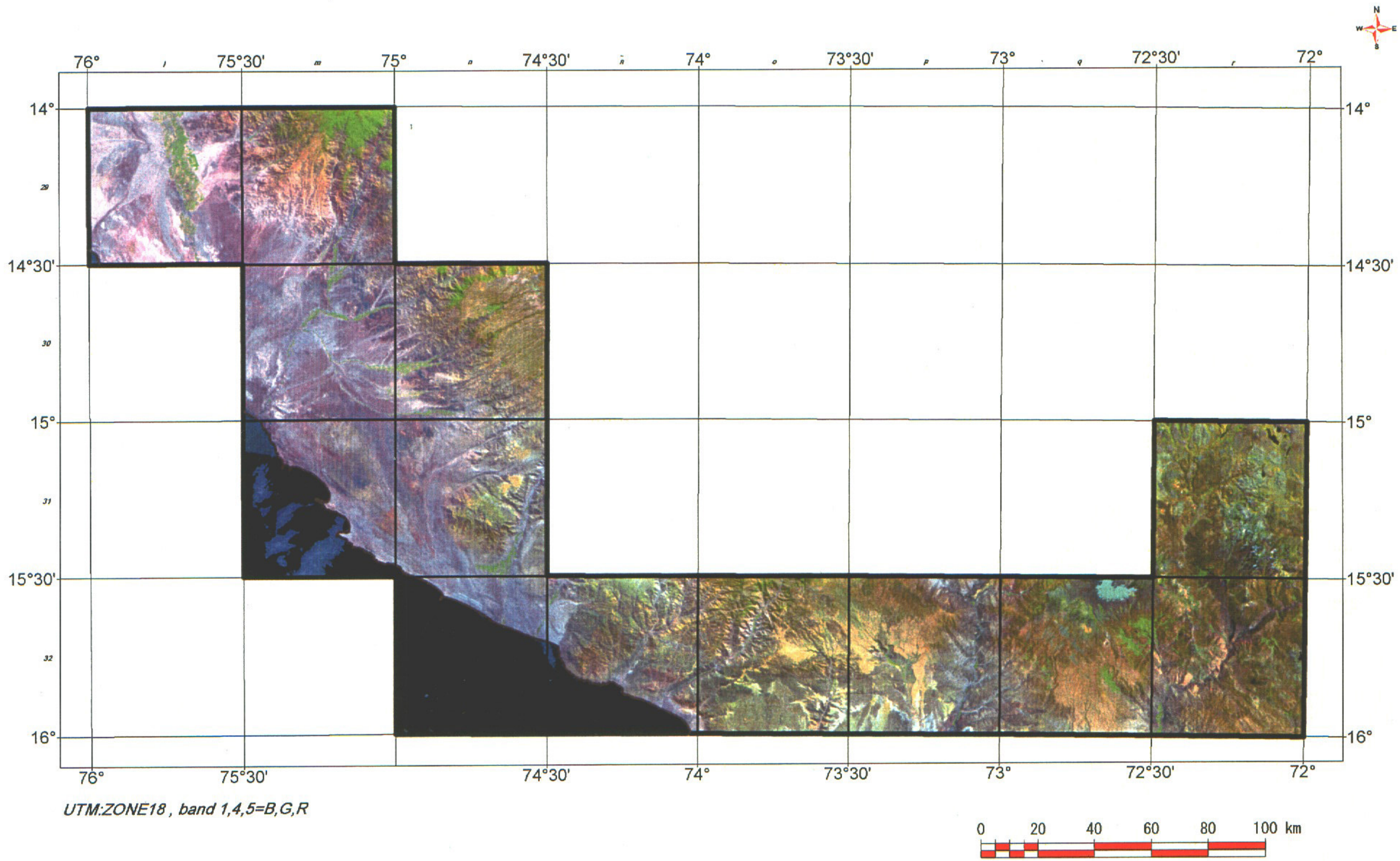

Fig.5 LANDSAT TM mosaic image

For the R21 and R57, 2 σ was used as the thresholds to extract anomaly areas.
4. Image composition: The extracted anomaly areas were shown in a composite image, laid over the LANDSAT TM band-5 image, in red color for R21-anomaly areas and in green color for R57-anomaly areas.
5. Extraction of sub-scene images of respective quadrangles: Based on the data projected on the maps, 13 sub-scene images corresponding to the respective quadrangles in the survey area were prepared.
6. Annotation: The respective sub-scene images were annotated with the UTM coordinates, scale bars, titles of quadrangles, etc.
7. Conversion of file format: The format of image files was converted from the .rvc to the TIFF format, so as to fit to the output device used.
8. Resampling of image resolution: Resolution of each sub-scene image was adjusted to output at 300 dpi and at a 1:200 000-scale. Consequently, the spatial resolution of images was resampled to about 16.9 m per pixel.
9. Hard copy output: Two sets of the 13 sub-scene images, totalling 26 images, were output at a 1:200 000-scale by a digital photo-printer (Lightjet 5000).

1-2-5 Results of Ratioing (Fig.6-1 and Fig.6-2)

Results of anomaly extraction in each quadrangle from the west of the objective area toward east are described as follows;

1) Quadrangle 29-l
A very weak R21 anomaly is detected in the unit P-sn (Paleozoc intrusives) distributed in the west of the Quad. A long elongated narrow anomaly is recognized in the area of Quaternary, which probably indicate the trace of paleo-river.
A R57 anomaly is recognized only in the alluvial plain around the present river.

2) Quadrangle 29-m
Several small anomalies of R21 are recognized in the unit P-sn in south of the Quad., which probably indicate the trace of the paleo-river.
R57 anomalies are widely distributed in the area of the unit JK-yu (Jurassic to Cretaceos sediments) and also the present river.

3) Quadrangle 30-m
Small anomalies of R21 are recognized around the area of the unit Pe-pa (Paleogene sediments) distributed in the southwest of the Quad. R57 anomalies are also recognized in a small area of the unit Pe-pa and conspicuous anomalies are recognized along the present river.

4) Quadrangle 30-n
R21 anomalies are recognized in the unit JK-yu, the unit Ks-ti (upper Cretaceous intrusives) and the unit Nm-na (Neogene volcanics) distributed in the north of the Quad. A small anomaly of R21 is also recognized in the unit Ks-ti distributed in the south of the Quad.
R57 anomalies are recognized in the units of JK-yu and Ks-ti distributed in the north and center of the Quad. A conspicuous anomaly of R57 is also recognized in the downstream of the present river.

5) Quadrangle 31-m
R21 anomaly is recognized only in the unit P-sn located in the north of the Quad. which is

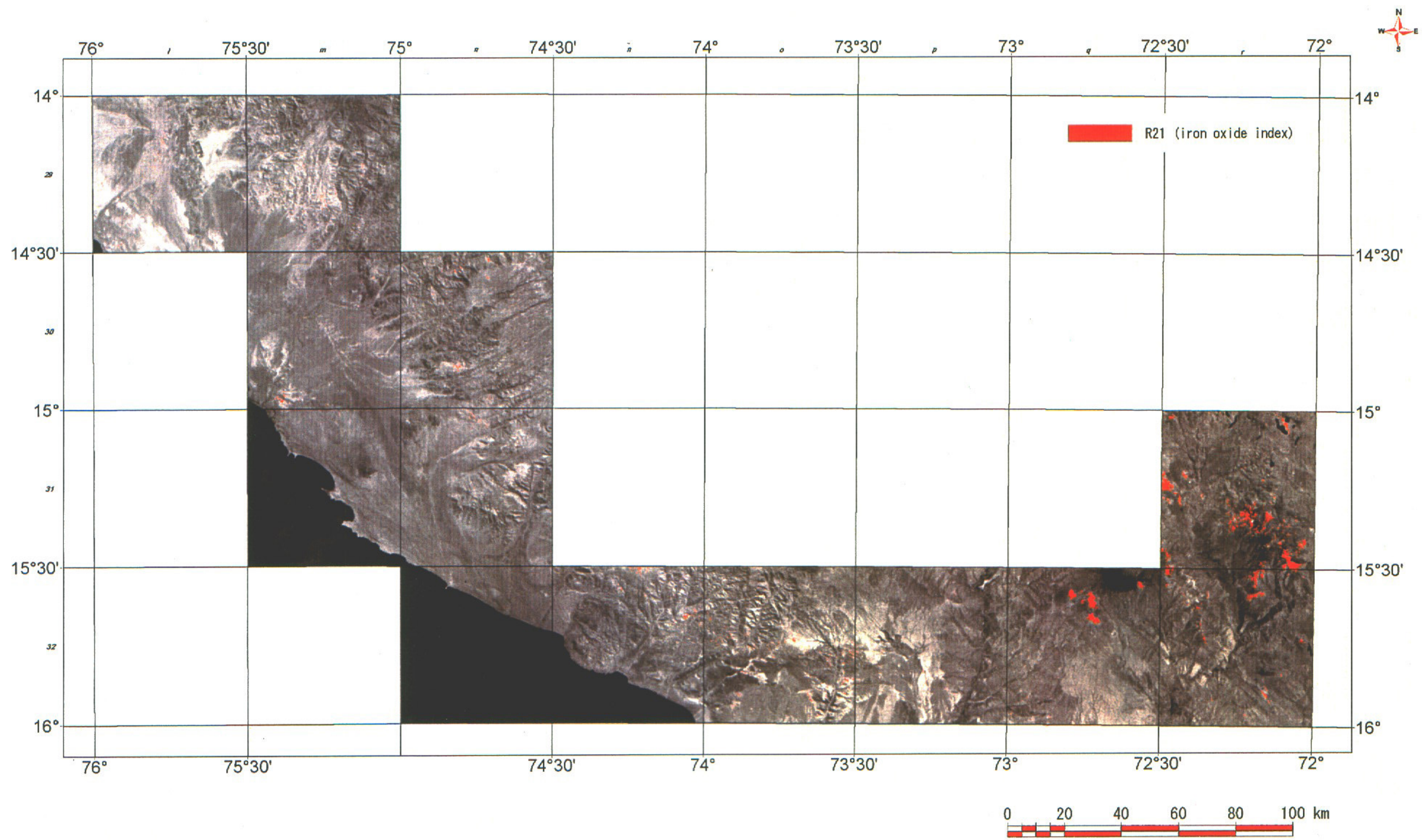

Fig.6-1 LANDSAT TM ratio anomaly map 1 (Index of iron oxide minerals)

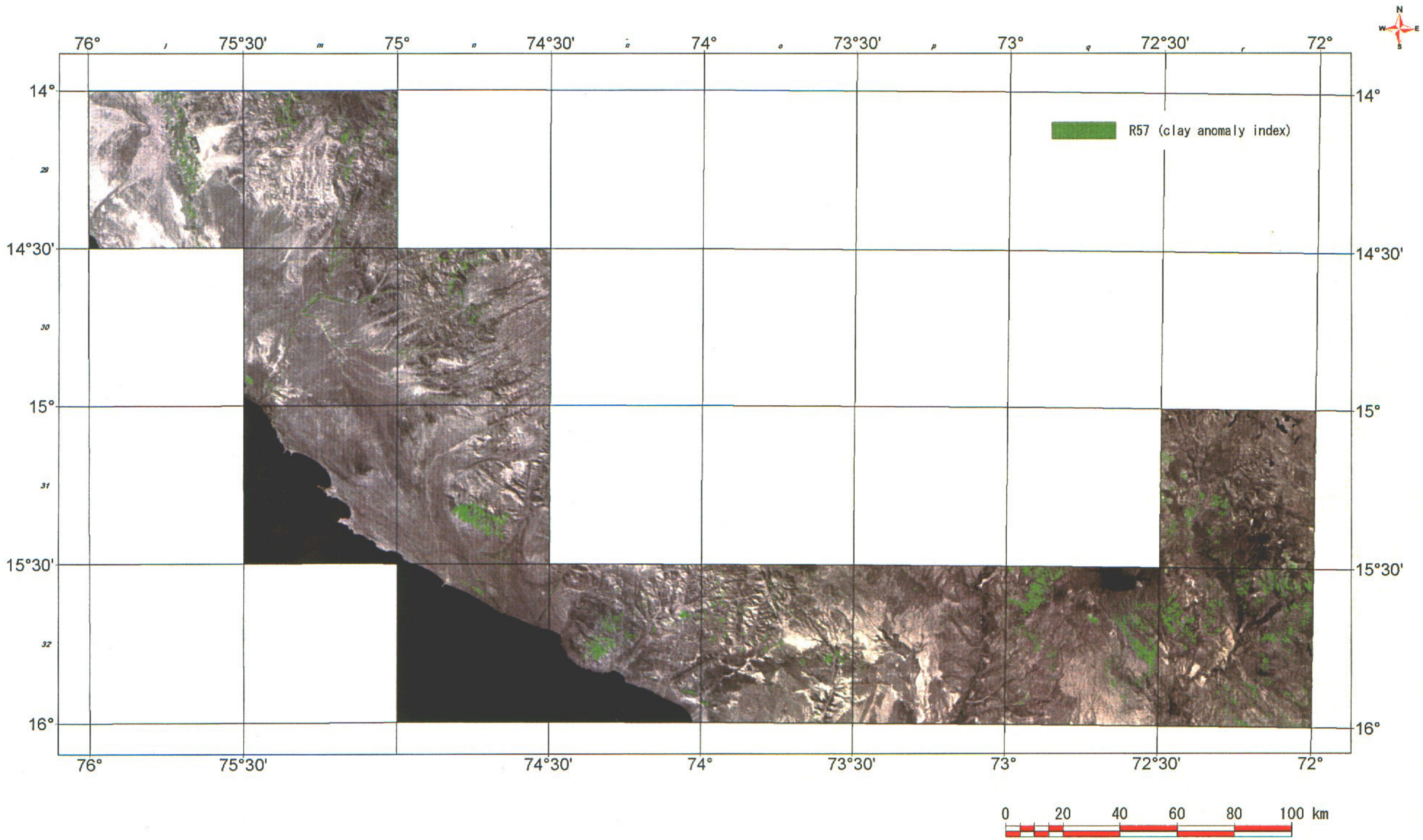

Fig.6-2 LANDSAT TM ratio anomaly map 2 (Index of clay minerals)

extending northward to the Quad. 30-m. None of R57 anomaly was detected.

6) Quadrangle 31-n
Weak anomalies of R21 are detected in the unit Ki-pt (lower Cretaceous intrusives), distributed in the central part of the Quad. and in the unit Nm-na distributed in the northeast of the Quad. Long narrow anomalies are recognized in the area of Quaternary, which probably indicate the trace of paleo-river.
R57 anomaly is recognized extensively in the center and the south of the Quad. in the units of JK-yu, Ki-ca (lower Cretaceous volcanics) and Ki-bu, Ki-pt, Ki-li (lower Cretaceous intrusives).

7) Quadrangle 32-n
None of R21 anomaly is recognized. R57 anomalies are detected in the unit Q-tm (coastal terrace) and along the present river.

8) Quadrangle 32-ñ
R21 anomalies are scattered in the unit Ks-ti located in the north center to southeast of the Quad. and in Js-gu located on the south of the above unit.
A R57anomaly is located extensively in the center to the west of the Quad. in those units of Ki-pt, Ki-li (lower Cretaceous intrusives) and Ji-ch (lower Jurassic sediments). Overlapping of two types anomalies (R21 and R57) is recognized at the contact of the unit Js-gu and Ks-ti located in the southwest corner of the Quad.

9) Quadrangle 32-o
R21 anomalies are detected in the unit Nm-hu (Neogene volcanics) located in the east of the central part of the Quad. Other anomalies are small and scattered. Small anomalies of R57 are recognized in the units of Ks-ti, Ks-in and Ki-bu distributed in the west center to east center of the Quad. In the north of quadrangle an anomaly is recognized in line conformable to the topography of valley. This anomaly probably corresponds to the fluvial deposits as the base rock is the unit Ks-ti.

10) Quadrangle 32-p
Very small anomalies of R21 are scattered in the unit Nm-hu located in the south of central part of the Quad. R57 anomalies are recognized around the unit Ki-bu located in the west center of the Quad. and in a sizeable area in the unit NQ-ba (Quaternary volcanics), the unit Ks-ti located in the north of the Quad. Another weak anomalies are observed along the present river.

11) Quadrangle 32-q;
Conspicuous anomalies of R21 are detected in the unit PN-ta (Paleogene to Neogene volcanics), NQ-ba and northeast corner of Q-and (Holocene volcanics) distributed in the north center of the Quad.
A conspicuous anomaly of R57 is widely recognized in two areas of northwest to south and east center of Quad. Geologically, western part of the area is overlain by the units Pe-B, Ks-ti, Ks-in and Ki-bu. And eastern part of the area is overlain by the units Pe-B and NQ-ba. In a small area of the unit PN-ta, R57 anomalies overlapping with R21 anomalies are recognized.

12) Quadrangle 32-r
Two series of R21 anomaly are detected. A series of small anomalies are intermittently located from the northwest to the southeast of the Quad. And the other series of anomalies are intermittently located from the north center to the east of the Quad. In the north of both anomalies, the country rock is the unit PN-ta, while in the south of the area, small anomalies are

hosted in the units Ki-ar (lower Cretaceous sediments), Ks-se (upper Cretaceous sediments) and Ks-ti.

R57 anomalies are detected in the widely distributing the units JK-yu and Ki-mu (lower Cretaceous sediments). Another anomalies are deteced in the units Ki-ar, Ks-ti and Q-and.

13) Quadrangle 31-r

R21 anomalies are recognized in a sizeable area in the unit PN-ta which is intermittently distributed in the west to the center to the east of the Quad., unit PN-ta distributed in the southwest corner of the area and unit NQ-ba distributed in the southeast of the area. Small anomalies are also recognized in the units PN-ta and NQ-ba in the north of the Quad.

Megascopically, R57 anomalies surround R21 anomalies, which trend to be extensive in the units JK-yu and PN-ta distributed in the southwest of the Quad.

1-3 Geologic Interpretation of Images

1-3-1 Interpretation Procedure

The output images of the 1:200 000-scale SAR images and TM color composite images prepared were used for the interpretation work. The results of interpretation were digitized and converted to the GIS data convertible with the ArchInfo, a GIS software produced by the ESRI of the USA.

1. Geologic units: Based on differences in surface textures and topographic characteristics, the survey area was divided into a number of the geologic units. Correlation of photogeologic characteristics of the respective geologic units and the existing geologic maps was tabulated. For the division of the geologic units, reference was made to the existing 1:100 000-scale geologic maps of the respective quadrangles.

2. Interpretation of lineament and geologic structure: The geologic structural factors such as fault, lineament and folding structure were delineated, for which micro-topographic features were considered.

3. Digitizing: Scanned data of hand-written geologic interpretation maps and the lineament maps were loaded on a computer as raster data which, in turn, were converted to vector data. Figures such as polygons and lines included in the vector data were manually retouched on the monitor screen and the attributes such as names of the geologic units and structures were added to the respective figures. The TNTmips was employed for the series of processing.

4. Preparation of GIS data set: Geographic data such as drainage patterns, lakes, roads, villages and national borders in the Arc/Info "Coverage" format provided by the INGEMMET were converted to a vector object of the .rvc file, overlaid on the interpretation results, annotated with legends, scale, quadrangle numbers, names, etc., and then output by a color plotter at a 1:200 000-scale. Two types of output maps, the geologic interpretation map and the lineament map, were prepared. From the respective vector data of the geologic boundaries, faults, geologic structures and lineaments included in the .rvc file, the files in the Arc/Info Coverage format were prepared as the final products.

1-3-2 Division of Geologic Units

Table 5, in which correlation with those in the above mentioned data (INGEMMET, 1999) is demonstrated under the title of "Geological Correlation." In Table5, the correlation with the INGEMMET, 1999 is limited to main formations only.

For the interpretation, the survey area is divided into the following 35 geologic units.

Table 5 List of geologic units

GEOLOGIC UNIT	COLOR on False color image BGR=145	TEXTURE	DRAINAGE		ROCK RESISTANCE	BEDDING	LINEAMENT DENSITY	LITHOLOGY	GEOLOGICAL CORRELATION	
			PATTERN	DENSITY					1	2
Q-tm	bluish gray	very fine	–	–	very low	–	–	sand, gravel	Marine terrace deposit	Marine terrace deposit
Q-g	gray,pale gray,brown	fine-medium	–	–	low	–	–	clay,sand,gravel	Glacial deposit	Glacial deposit
Q-el	palegrey, white, purpurish gray	medium-coarse	–	–	low	–	–	clay,sand,gravel	Eluvial deposit	Eluvial deposit
Q-e	pale gray	fine	–	–	very low	–	–	sand	Eolian deposit	Eolian deposit
Q-al	pale brown	medium	sub-dendritic	low	low	–	–	sand, gravel	Aluvial	Aluvial
Q-and	dark grey,redish brown,bluish gray	medium-coarse	sub-dendritic	low-medium	medium-high	–	–	lava, pyroclastics	Andahua Gp.	Andahua Gp.
NQ-ba	greenish gray, dark brown	medium	dendritic	medium	medium-high	–	low	lava	Barroso Gp.	Barroso Gp.
Np-ch	pale brown, purplish gray	medium-coarse	dendritic	high	low	–	very low	siltstone, sandstone, conglomerate	Millo Fm. Changuillo Fm.	Changuillo Fm.
Nm-hu	pale brown, pale greenish gray	fine	parallel	high	low	–	very low	tuff, tuff-breccia	Huaylillas Fm.	Huaylillas Fm.
Nm-al	pale gray	fine	dendritic	medium	low-medium	–	very low	tuff	Alpabamba Fm.	Alpabamba Fm.
Nm-na	pale brown, pale gray	coarse	parallel	high	low	–	very low	tuuf,ignimbrite	Nasca Gp.	Nasca Gp.
Nm-pi	pale bluish gray, pale gray	medium	dendritic	medium	medium	very poor bedded	very low	sandstone	Pisco Fm.	Pisco Fm.
Nm-ca	grayish brown	coarse	dendritic	medium-high	low-medium	very poor bedded	very low	pyroclastics	Camaná Gp.	Camaná Gp.
PN-ta	bluish gray, brown, pale brown	medium	dendritic	medium	medium	–	very low-medium	lava, pyroclastics	Orcopampa Fm. Tacaza Gp.	Tacaza Gp.
Pe-pa	pale gray, gray	medium-coarse	dendritic	low	low	poor bedded	–	shale, sandstone, conglomerate	Paracas Gp.	Paracas Gp.
Pe-ca	gray, pale brown	medium	dendritic	high	low-medium	very poor bedded	–	conglomerate	Caraveli Fm.	Caraveli Fm.
KP-sj	pale brownish gray, brown, light gray,pale greenish gray	fine-medium	dendritic	medium-low	medium	very poor bedded	–	sandstone, conglomerate	Sotillo Fm. Huanca Fm. San Jose Fm.	San Jose Fm.
Ks-se	brown	medium	dendritic	medium	medium	very poor bedded	–	sandstone, siltstone	Saraj Fm.	Saraj Fm.
Ki-ar	dark brown, bluish gray	medium	dendritic	medium	medium	very poor bedded	medium	sandstone, limestone	Arcurquina Fm.	Arcurquina Fm.
Ki-pa	light redish gray	coarse	dendritic	high	low-medium	bedded	low	limestone	Portochuelo Fm.	Pariatambo Fm.
Ki-ca	brown, light redish gray, dark gray	coarse	dendritic	high	medium	poor bedded	high	pyroclastics	Copora Fm	Casma Fm
Ki-mu	brown	medium	dendritic	medium-high	medium	very poor bedded	medium	sandstone, limestone	Murco Fm.	Murco Fm.
JK-yu	pale gray, light redish brown	fine	dendritic	high	medium-high	poor bedded	low	sandstone	Yura Gp.	Yura Gp.
Js-gu	greenish gray, dark brown	medium	dendritic	high	medium-high	poor bedded	high	sandstone, mudstone	Guaneros Fm.	Guaneros Fm.
Jm-so	light redish gray, pale brown	medium	dendritic	low-medium	medium	poor bedded	–	sandstone, limestone	Socosani Fm.	Socosani Fm.
Ji-ch	greenish gray, brown	medium	dendritic	medium	low-medium	–	medium	sandstone, andesite	Chocolate Fm.	Chocolate Fm.
Per-mi	light greenish gray	medium	dendritic	medium-high	medium	–	low	sandstone	Mitu Gp.	Mitu Gp.
Cs-ta	light yellowish brown	medium-coarse	dendritic	medium	low-medium	–	low	sandstone, mudstone, siltstone	Tarma Gp.	Tarma Gp.
Ci-am	gray	medium-coarse	–	–	low	–	–	sandstone, shale	Ambo Gp.	Ambo Gp.
Cmb-ma	light redish grey	coarse	–	–	low	poor bedded	low	limestone	Marcona Fm.	Marcona Fm.
PeB	light bluish gray, pale gray, brown	coarse	dendritic	medium	medium	very poor-bedded	low-medium	metasediments, metamorphic rock	San Juan Fm. Basal Complex	Basal Complex
P-an/ri	gray, bluish gray, brown, pale brownn	medium	dendritic	medium	medium	–	low	andestic intrusives	Andesitic Intrusives	Andesitic Intrusives(P-an/ri)
Ks-ti	pale brown, brown, greenish gray, light purplish gray, gray	medium-coarse	dendritic	medium-high	medium	–	low - medium	granite	Tiabaya superunit Lucumayo granite Huamay granite	Tiabaya superunit
Ks-in	gray, brown, pale gray	medium-coarse	dendritic	low-medium	medium	–	medium	tonalite, granodiorite	Incahuasi superunit	Incahuasi superunit
Ks-pa	pale brown, light purplish gray	medium	dendritic	medium-high	medium	–	low	granodiorite, diorite	Panpahuashi superunit	Pampahuasi superunit
Ki-li	light greenish gray, pale brown	medium	dendritic	medium-high	medium	–	low	monzonitic intrusives	Linga superunit Cobrepampa monzonite	Linga superunit
Ki-pt	pale brown, brown	medium	dendritic	low-medium	medium	–	low	diorite, gabro	Patap superunit Acari diorite	Patap superunit
Ki-tun	bluish gray, purplish gray	coarse	–	–	medium-high	–	medium	andestic intrusives	Tunga Andesite	Bella Union Complex
Ki-bu	bluish gray, light greenish gray, pale brown	coarse	dendritic	medium-high	medium	–	medium	andestic intrusives	Bella Union Complex	Bella Union Complex
P-sn	llight gray, bluish gray, light purplish gray	coarse-medium	dendritic	medium-high	medium(-high)	–	low	granite porphyry	San Nicolas Batholith	San Nicolas Batholith

1:「501 Cuadrangulos Geologicos Digitales de la Varta Nacional 1960-1999」
2:This study

- The geologic unit Q represents the Quaternary System.
- The unit NQ-ba represents the Neogene to the Quaternary (Pleistocene).
- The units Np-ch, Nm-hu, Nm-al, Nm-na, Nm-pi and Nm-ca represent the Neogene.
- The unit PN-ta represents the Palaeogene to the Neogene.
- The Units Pe-pa and Pe-ca represent the Palaeogene.
- The unit KP-sj represents the Cretaceous to the Palaeogene.
- The units Ks-se,Ki-ar, Ki-pa, Ki-ca and Ki-mu represent the Cretaceous.
- The unit JK-yu represents the Jurassic to the Cretaceous.
- The units Js-gu,Jm-so and Ji-ch represent the Jurassic.
- The unit Per-mi represents the Permian.
- The units Cs-ta and Ci-am represent the Carboniferous.
- The unit Cmb-ma represents the Cambrian.
- The unit PeB represents the Precambrian.
- The units P-an/ri, Ks-ti, Ks-in, Ks-pa, Ki-li, Ki-pt, Ki-tun, Ki-bu and P-sn represent the intrusive rocks.

Features of the respective geologic units appearing on the images are described in the following paragraphs.

(1) Unit Q
Unit Q of Quaternary is subdivided into following six units.

a) Unit Q-al

This unit is composed of alluvial and fluvial deposits, widespread along the rivers in the whole survey area.

b) Unit Q-e

This unit is correlated to aeolian deposits forming sand dune. The unit is situated in the Quads. 29-l, 30-m, 30-n, 31-m, 31-n and 32-o.

c) Unit Q-el

This unit is correlated to autochthonous deposits such as talus in mountain area and residual deposits, situated in the coastal plain in the northwest of the survey area (Quads. 29-l and 29-m).

d) Unit Q-g

This unit is correlated to glacial deposits and moraine, distributed in mountain area in the east of the survey area. The unit is located in the Quads. 32-q, 32-r and 31-r.

e) Unit Q-tm

This unit is correlated to coastal terrace deposits, located in coastal area, the west of the survey area. It is observed that a pair of terrace surface and terrace cliff is repeatedly appears up to 10km far from the coastline in the Quads. 31-n and 32-n.

f) Unit Q-and

This unit is correlated to the Holocene pyroclastics and lava located in Altiplano, in the east of the survey area. The unit is situated in the Quads. 31-r, 32-r and 32-q. Volcanic cone of 2 km in diameter and flow structure of lava are distinguished.

(2) Unit NQ-ba
The unit is in the Quads. 32-p, 32-q, 32-r, and 31-r. The unit on the whole is dark brown to greenish gray-colored, medium in the drainage density and medium-textured. Erosion resistance is medium to high. A volcanic cone of 1 km in diameter is observed in Quad. 31-r. The unit corresponds to the Barroso Group composed of Pliocene to Pleistocene pyroclastics.

(3) Unit Np-ch
The unit lies in the Quads. 30-m, 30-n, 32-o and 32-p. It is pale brown to purplish gray-colored,

rough to medium-textured, high in the drainage density, and relatively low in the erosion resistance. It corresponds to the Changuillo Formation and Millo Formation composed of Pliocene to Pleistocene continental to marine sediments.

(4) Unit Nm-hu
The unit is in the Quads. 32-ñ, 32-o, 32-p and 32-q distributed along the western slope of the Cordillera Occidental, is pale brown and pale greenish gray-colored and fine-textured. The drainage density is high with parallel characteristic drainage pattern, while the erosion resistance is at a low level. The unit corresponds to the Huaylillas formation, composed of Miocene pyroclastics.

(5) Unit Nm-al
The unit is in the Quads. 32-q and 32-r, pale gray colored, fine-textured and medium in the drainage density. The erosion resistance is low to medium. The unit corresponds to the Alpabamba Formation composed of Miocene pyroclastics.

(6) Unit Nm-na
The unit is in the Quads. 29-m, 30-m, 30-n and 32-ñ distributed along the western slope of the Cordillera Occidental. It is pale brown and pale greenish gray colored, rough-textured, having high drainage density with parallel characteristic drainage pattern and low erosion resistance. The unit corresponds to late Miocene pyroclastic rocks, such as the Nazca Formation.

(7) Unit Nm-pi
The unit is in the Quad. 29-l, 30-m, 31-m and 32-n distributed in the coastal area in the western part of the survey area. It is light gray and pale bluish gray, medium-textured, having medium drainage density and medium erosion resistance. The unit corresponds to the Pisco Formation composed of Miocene sediments.

(8) Unit Nm-ca
Presence of the unit is confined only to the Quads. 32-p. It is grayish brown and rough-textured, having medium to high drainage density and low to medium erosion resistance. The unit corresponds to Miocene sedimentary rocks, such as the Camaná Group.

(9) Unit PN-ta
The unit is in the Quads. 32-q, 31-r and 32-r distributed in the eastern part of the survey area. It is pale brown to brown and blueish gray, and medium-textured, having medium drainage density and also medium erosion resistance. It corresponds to the Tacaza Group, composed of Paleocene to Miocene volcanics.

(10) Unit Pe-pa
The unit is in the Quads. 29-u, 29-v, 29-x, 30-x and 30-y distributed in the eastern part of the survey area. It is gray to light gray to pale gray and medium to rough-textured, having low drainage density and medium erosion resistance. It corresponds to Eocene sedimentary rocks such as the Paracas Formation.

(11) Unit Pe-ca
The unit is in the Quads. 32-p and 32-q distributed in the southeast part of the survey area. It is gray and light brown and medium-textured. The drainage density is at a high level; many fine drainage patterns are observable. The erosion resistance is medium to low. The unit corresponds to Eocene molasse, such as Caraveli Formation.

(12) Unit KP-sj

The unit, as confirmed in the Quads. 32-p, 32-q and 32-r, is pale grayish brown to brown, pale greenish gray to light gray and fine-textured, having low to medium drainage density. The erosion resistance is medium. The unit corresponds to latest Cretaceous to Paleocene sedimentary rocks such as the San José formation, the Sotillo Formation and the Huanca Formation.

(13) Unit Ks-se

The unit has been confirmed in a small scale in the Quad. 32-r in the east of the survey area. It is brown and medium-textured, having medium drainage density. The erosion resistance is medium. The unit corresponds to Cretaceous sedimentary rocks, such as the Seraj Formation.

(14) Unit Ki-ar

The unit is in the Quads. 31-r and 32-r, is dark brown and blueish gray, and medium-textured, having medium drainage density. The erosion resistance is mudium. The unit corresponds to Cretaceous sedimentary rocks such as the Arcurquina Formation.

(15) Unit Ki-pa

The unit, lying in a small scale in the west of the survey area in the Quads. 29-m, 30-m and 30-n, is light reddish gray and rough-textured. The drainage density is at high levels while the erosion resistance is at low to medium level. The unit corresponds to Cretaceous sedimentary rocks such as the Pariatambo Formation.

(16) Unit Ki-ca

The unit is in the Quads. 29-l, 29-m, 30-m, 30-n, 31-m and 31-n in the west the survey area. It is light reddish gray to dark gray-colored and rough-textured, having high drainage density and low to medium erosion resistance. The unit corresponds to lower Cretaceous pyroclastic rocks such as the Casma Group.

(17) Unit Ki-mu

The unit is in the Quads. 31-r and 32-r in the east of the survey area. It is brown-colored and medium to rough-textured, having medium drainage density and medium erosion resistance. It corresponds to the Murco Formation, composed of upper Jurassic to lower Cretaceous sedimentary rocks.

(18) Unit JK-yu

The unit is distributed in almost every Quad., particularly widespread in the Quads. 29-l, 30-n in the northwest of the survey area and 32-r in the east of the area. It is light reddish brown to pale gray-colored and fine-textured, having high drainage density and medium to high erosion resistance. The bedding trace is observed in Quad. 32-r. It corresponds to the Yura Group, composed of upper Jurassic to lower Cretaceous sedimentary rocks.

(19) Unit Js-gu

The unit is in the Quads. 29-l, 29-m, 30-m, 30-n, 32-ñ and 32-o. It is reddish brown to pale gray-colored and medium-textured, having high drainage density and medium to high erosion resistance. The bedding trace is slightly observed in Quad. 32-ñ. The unit corresponds to upper Jurassic sedimentary rocks such as the Guaneros Formation.

(20) Unit Jm-so

The unit is in the Quads. 32-q and 32-r in a small scale. It is light reddish ray to pale brown-colored and medium-textured, having low to medium drainage density and medium erosion resistance. It corresponds to the Socosani Formation, composed of middle Jurassic sedimentary rocks.

(21) Unit Ji-ch
The unit is in the Quads. 29-l and 32-ñ. It is greenish gray and brown-colored and medium-textured, having medium drainage density and low to medium erosion resistance. It corresponds to the Chocolate Formation, composed of lower Jurassic sedimentary rocks.

(22) Unit Per-mi
The unit is in the Quads. 32-o in a small scale. It is light greenish gray-colored and medium-textured, having medium to high drainage density and medium erosion resistance. It corresponds to the Mitu Group, composed of Permian continental sediments.

(23) Unit Cs-ta
The unit is in Quad. 32-o in a small scale. It is light yellowish brown-colored and medium coarse-textured, having medium drainage density and low to medium erosion resistance. It corresponds to the Tarma Group, composed of upper Carboniferous sedimentary rocks.
(24) Unit Ci-am

The unit is in the Quad. 32-ñ in a small scale. It is gray-colored and medium to rough-textured, having low erosion resistance. It corresponds to the Ambo Group, composed of lower Carboniferous sedimentary rocks.
(25) Unit Cmb-ma

The unit is in the Quads. 31-m and 31-n in the west of the survey area. It is light blueish gray to light reddish gray-colored and rough-textured, having medium to high erosion resistance. It corresponds to the Marcona Formation, composed of Cambrian metamorphic rocks.

(26) Unit PeB
The unit is in the coastal area of the Quads.31-m, 31-n, 32-n and the Quads. 32-p, 32-q, 32-r in the east of the survey area. It is pale blueish gray to pale gray to brown-colored and coarse-textured, having medium drainage density and medium erosion resistance. The unit corresponds to Precambrian metamorphic rocks, such as the San Juan formation and the Coastal Basal Complex.

Intrusive rocks

(27) Unit P-an/ri
The unit is in the Quads. 31-r and 32-r in a small scale in the east of the area. It is gray to blueish gray and pale brown to brown-colored and medium-textured, having medium drainage density and medium erosion resistance. The unit corresponds to Neogene andestic intrusive rocks.

(28) Unit Ks-ti
The unit is in the coastal area of the Quads. 31-n, 32-ñ, 31-r and 32-r. It is greenish gray to pale brown to brown-colored and medium to coarse-textured, having medium to high drainage density and medium to high erosion resistance. The unit corresponds to the Tiabaya Super unit consisting of upper Cretaceous intrusive complex forming the Coastal Batholith.

(29) Unit Ks-in
The unit is in the Quads. 29-m, 32-o, 32-p and 32-q. It is light gray to gray and brown-colored and medium to coarse-textured, having low to medium drainage density and medium erosion resistance. The unit corresponds to the Incahuasi Super unit consisting of upper Cretaceous intrusive complex forming the Coastal Batholith.

(30) Unit Ks-pa
The unit is in the Quad. 29-m in the northwest of the area and in the Quads. 32-p, 32-q in the east of the area. It is light purplish gray and pale brown-colored and medium-textured, having medium to high drainage density and medium erosion resistance. The unit corresponds to the Pampahuasi Super unit consisting of upper Cretaceous intrusive complex forming the Coastal Batholith.

(31) Unit Ki-li
The unit is in the Quads. 31-n and 32-ñ in the south of the survey area. It is light greenish gray and pale brown-colored and medium-textured, having medium to high drainage density and medium erosion resistance. The unit corresponds to the Linga Super unit consisting of lower Cretaceous intrusive complex forming the Coastal Batholith.

(32) Unit Ki-pt
The unit is in the Quads. 31-n, 32-ñ and 32-n in the south of the survey area. It is brown to pale brown-colored and medium-textured, having medium to low drainage density and medium erosion resistance. The unit corresponds to the Patap Super unit consisting of upper Cretaceous intrusive complex forming the Coastal Batholith.

(33) Unit Ki-tun
The unit is in the Quads. 30-m, 31-m and 31-n in the west of the survey area. It is blueish gray and purplish gray-colored and rough-textured and medium erosion resistance. The unit corresponds to late Cretaceous Tunga andesitic intrusives.

(34) Unit Ki-bu
The unit is intermittently distributed in the coastal area of the survey area. It is blueish gray, light greenish gray and pale brown-colored and rough-textured, having medium to high drainage density and medium erosion resistance. The unit corresponds to the Bella Union Complex, composed of late Cretaceous intrusive rocks.

(35) Unit P-sn
The unit is in the Quads. 29-l, 30-m, 31-m in the northwest of the survey area. It is light gray in usual and partly light purplish gray to blueish gray-colored. Texture is rough and occasionally medium, having medium to high drainage density and medium erosion resistance. The unit corresponds to the San Nicolas Batholith, composed of lower Paleozoic intrusive rocks.

Results of the interpretation of the respective quadrangles are described in the following paragraphs (Figs.7 and 8).

(1) Quad. 29-l
Quaternary sediments including autochthonous deposits (Q-el), aeolian deposits (Q-e) and alluvium (Q-al) are extensively distributed in a lowland area of the central part of the quadrangle which are elongated principally NW-SE direction and subordinately NE-SW direction. Lower Paleozoic intrusives (P-sn) including Precambrian metamorphics (Pe-B) are

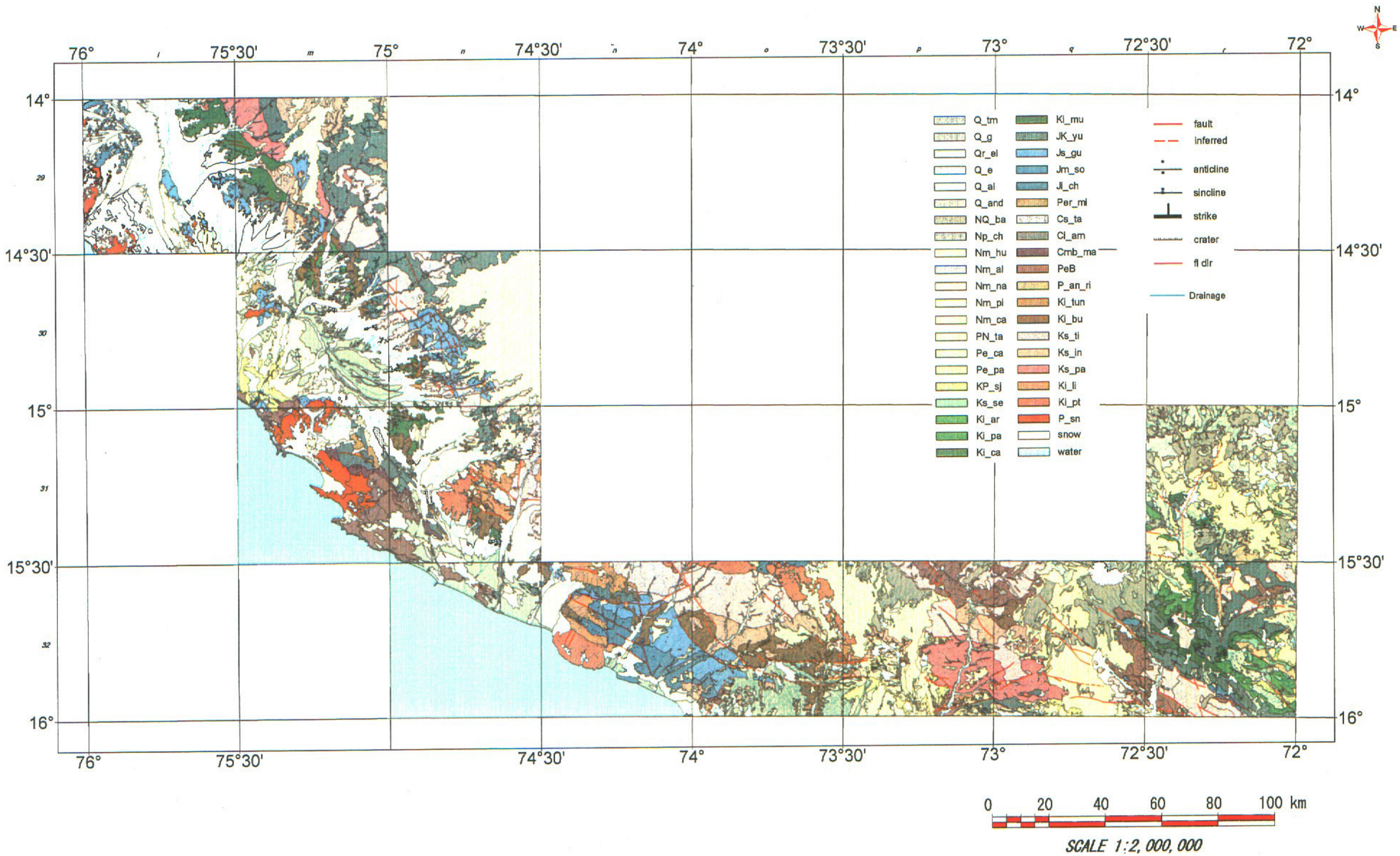

Fig.7 Geologic interpretation map

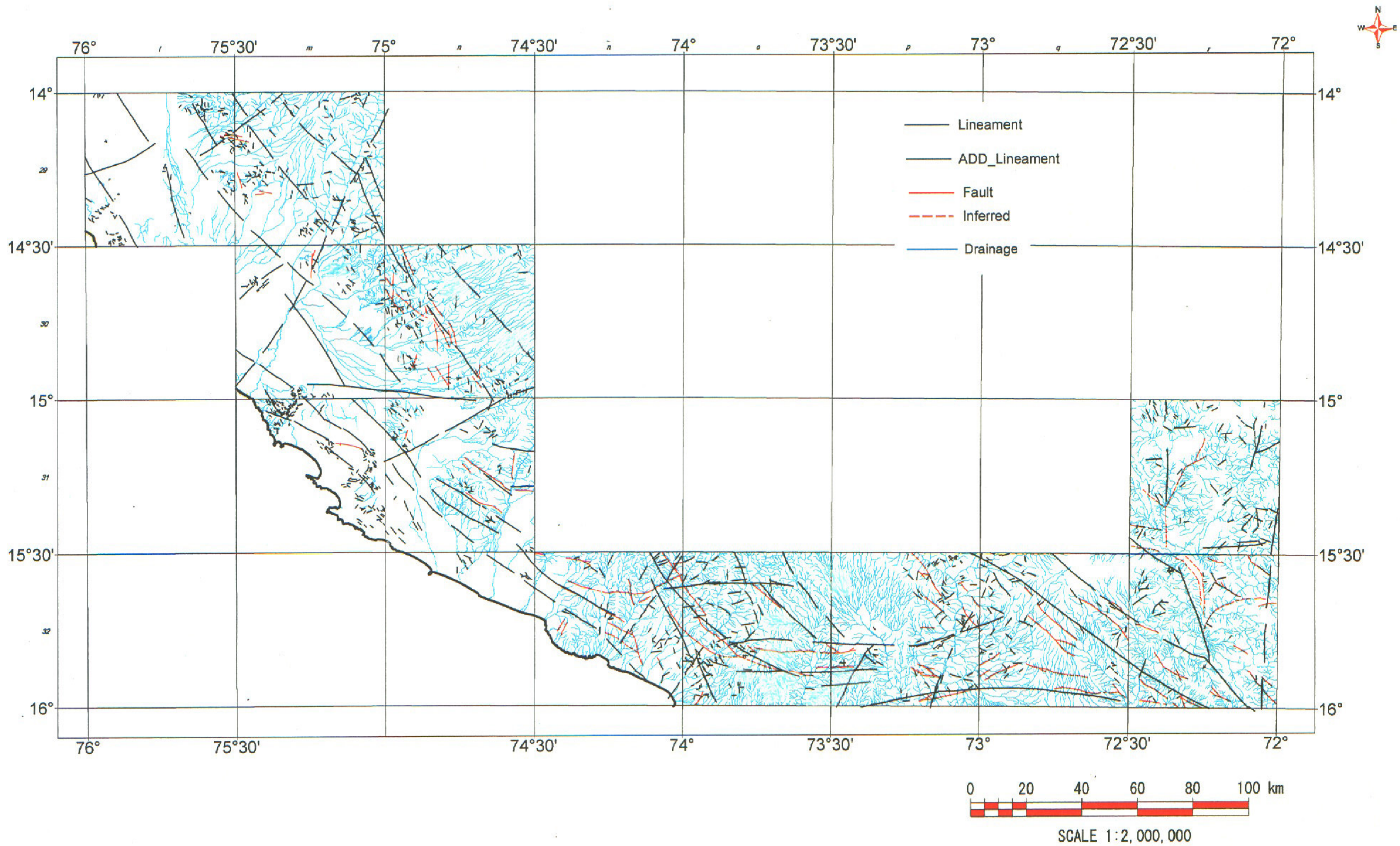

Fig.8 Lineament map

located in the west of the area. On the east of that lower Jurasic sediments (Ji-ch) and upper Jurassic sediments (Js-gn) are located in the east and central part of the area. Miocene sedimentary rocks (Nm-pi) are also located in the central part of the area. In the east of the area, upper Jurassic sediments and lower Cretaceous pyroclastics (Ki-ca) which is intruded by lower Cretaceous intrusives (Ki-pt), upper Cretaceous intrusives (Ks-in, Ks-ti, Ks-pa) are distributed in the northeast corner.
Conspicuous anomalies of R57 in Quaternary alluvium and R21 anomalies in aeolian sediments are recognized.

(2) Quad. 29-m
A lowland area in the southwest corner of the Quad. is occupied by alluvium and the foot of the western slope of the Andes is covered with talus of Quaternary. The upper Jurassic sedimentary rocks (Js-gn), Jurassic to Cretaceous sedimentary rocks (JK-yu), lower Cretaceous sedimentary rocks (Ki-ca) are distributed toward northeast which are intruded by the small bodies of lower Cretaceous intrusives (Ki-pt) and the large bodies of intrusives (Ks-in, Ks-pa, Ks-ti). They are covered by Miocene pyroclastics (Nm-na) trending NE-SW to N-S. As the upper Jurassic sedimentary rocks (Js-gu) and Jurassic to Cretaceous sedimentary rocks (JK-yu) are exposed again from the center to the northeast of the area, existence of either fault and/or folding structure in the area of intrusive rock is predicted. R57 anomalies are observed only in the Jurassic to Cretaceous sedimentary rocks (JK-yu).

(3) Quad. 30-m
Major part of this Quad. is occupied by the lowland of the Pre-Andean Plain. In the coastal area a small block of the Basal Complex (PeB) and Jurassic sedimentary rocks (Js-gn) are distributed, and they are overlain by Paleogene sedimentary rocks (Pe-pa). In the west of the Quad., the area is underlain by the lower Paleozoic intrusive (P-sn), upper Jurassic sedimentary rocks (Js-gu) and the small bodies of Cretaceous intrusives (Ki-tun) which has intruded into the above rocks. In the western slope of the Andes in the northeast of the Quad., Jurassic to Cretaceous sedimentary rocks (Js-gu, JK-yu, Ki-pa) and pyroclastics (Ki-ca) and Cretaceous intrusives (Ki-bu, Ks-ti) which intrude into the former are distributed. All the above rocks are covered with Quaternary sediments (NQ-ch) including alluvium in lowland, talus in the foot of the western slope and aeolian sediments forming dune located from coastline to central part of the area.
A R21 anomaly is observed in a small area in the southwest of the quadrangle.

(4) Quad. 30-n
The units of Ki-pa, Ki-ca, JK-yu and Js-gu with the trend of NW-SE are orderly distributed from the center of western part to the northeast. The unit JK-yu appears again at the east end of this block. They are intruded by Cretaceous intrusives (Ki-bu, Ki-li, Ks-ti). Neogene volcanics (Nm-na) is extensively distributed in the east of the Quad. In the southwest of the Quad., the area is extensively covered by alluvium. Aeolian sediments appear at the south end of the Quad. which extend to the Quad. 31-n.
The fault of NW-SE and N-S directions are recognized in the west of the Quad. and the existence of folding structure is presumed from the distribution of geologic units.

(5) Quad. 31-m
This Quad. covers the main part of the Coastal Cordillera located along the coastline. Precambrian metamorphics (PeB) are located in the northeast and southeast of the area and Cambrian sedimentary rocks (Cmb-ma) lie to the northeast. They are penetrated by lower Paleozoic intrusives (P-sn), and then covered with Jurassic to Cretaceous sedimentary rocks

(JK-yu). All of the above rocks is again intruded by Cretaceous intrusives (Ki-tun), and then covered with Neogene sediments (Nm-pi), and furthermore covered with Quaternary coastal terrace (Q-tm), aeolian sediments and alluvium.

(6) Quad. 31-n
Precambrian metamorphics (PeB) extended from the Quad. 31-m elongating NW-SE and Combrian sedimentary rocks (Cmb-ma) are distributed in the southwest of the area. Lower Cretaceous sedimentary rocks (Li-ca) and Cretaceous intrusives (Ki-bu, Ki-pt, Ki-li) which penetrated into the former, are located in the northwest and southeast of the area. In the northeast of the area Jurassic to Cretaceous sedimentary rocks (JK-yu), Cretaceous intrusives (Ki-bu, Ki-li, Ks-ti) which penetrate the former and Neogene volcanics (Nm-na) which cover the above rocks, are distributed. In the lowland in the center of the area, aeolian sediments extended from the Quad. 30-n is extensively distributed and further extending to southeast. A part of the Basal Complex is covered with Quaternary coastal terrace in the southwest of the area.

(7) Quad. 32-n
The area is widely covered with Quaternary coastal terrace, aeolian sediments and alluvium which are extended from the Quad. 31-n. Small bodies of Precambrian metamorphics, Jurassic to Cretaceous sedimentary rocks, lower Cretaceous sedimentary rocks (Ki-ca), Cretaceous intrusives (Ki-bu) and Neogene sedimentary rocks (Nm-pi) are exposed in places.

(8) Quad. 32-ñ
Lower Carboniferous sedimentary rocks (Ci-am) is exposed in a very small area of the southeast corner of the Quad. Jurassic sedimentary rocks (Ji-ch, Js-gn), Jurassic to Cretaceous sedimentary rocks (JK-yu), elongating to NW-SE, are distributed in the central part of the area. Various Cretaceous intrusives (Ki-bu, Ki-pt, Ki-li, Ks-in, Ks-ti) which penetrae into the above rocks are extensively distributed. All the above units are covered with Neogene sediments (Nm-pi) in lowland in the southwest of the area and locally Neogene volcanics (Nm-na, Nm-hu) in the foot of the western slope of the Andes in the northeast of the Quad. They are furthermore overlain by aeolian sediments in the northwest and southeast corner of the area, coastal terrace in the central area and alluvium along the river.
The lineaments of NW-SE, E-W, N-S, NW-SE with good continuity are clearly observed in this quadrangle.

(9) Quad. 32-o
Lower Carboniferous sedimentary rocks extended from the Quad. 32-ñ is exposed in a small area of southwest corner of the Quad. On the east of them, upper Carboniferous sedimentary rocks (Cs-ta) are located in a small area. On the north of them, lower Jurassic sedimentary rocks (Ji-ch) and upper Cretaceous sedimentary rocks (Js-gn) are distributed. The upper Jurassic sedimentary rocks are exposed again at the north end of the Quad. Cretaceous intrusives (Ki-bu, Ki-pt, Ki-li, Ks-in, Ks-ti) are extensively distributed between above two areas. In the above mentioned sedimentary rocks located in the southwest corner of the Quad., small bodies of Cretaceous intrusives (Ki-bu, Ks-in) are located. They are widely overlain by Neogene pyroclastics (Nm-hu) and sediments (Np-ch) in the west of the Quad.
The lineament of NW-SE and E-W are clearly obserbed and the lineaments of NE-SW are also recognized in the southwest corner of the Quad.

(10) Quad. 32-p
Precambrian metamorphics (PeB) is exposed in the north and south along the river in the east of

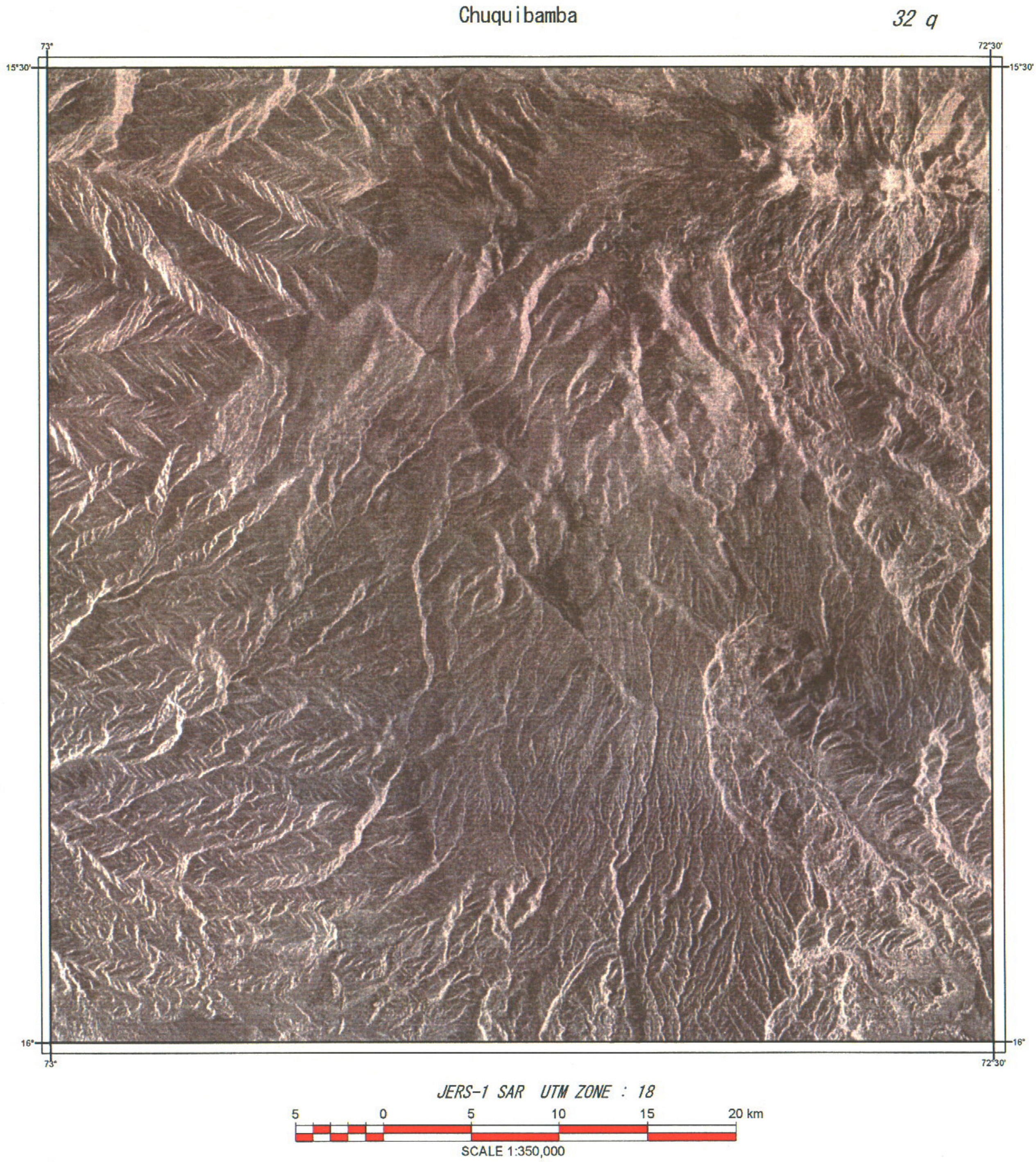

Fig.9-1 Chuquibamba quadrangle (32-q) JERS-1 SAR image

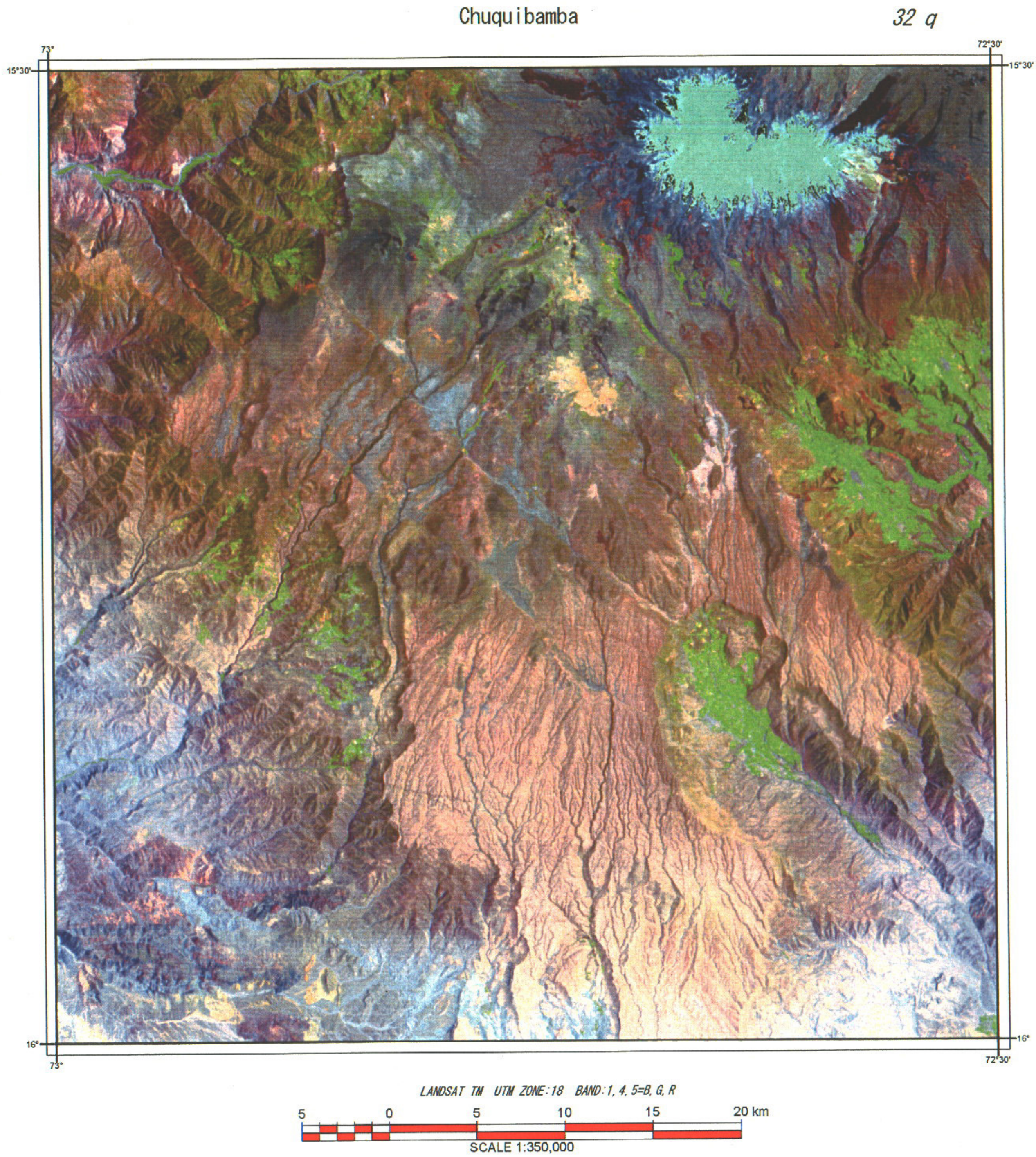

Fig.9-2 Chuquibamba quadrangle (32-q) LANDSAT TM image

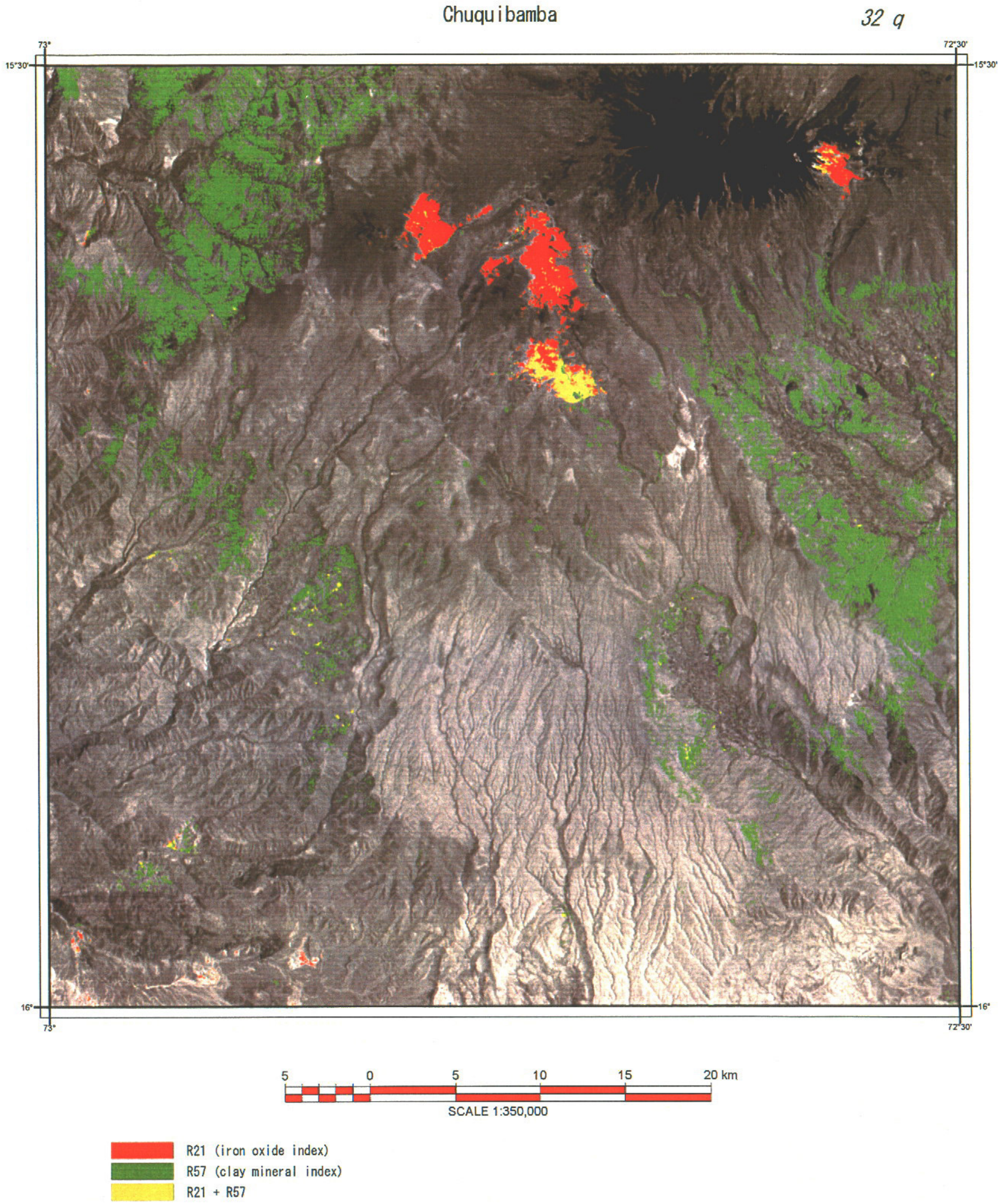

Fig.9-3 Chuquibamba quadrangle (32-q) LANDSAT TM ratio anomaly map

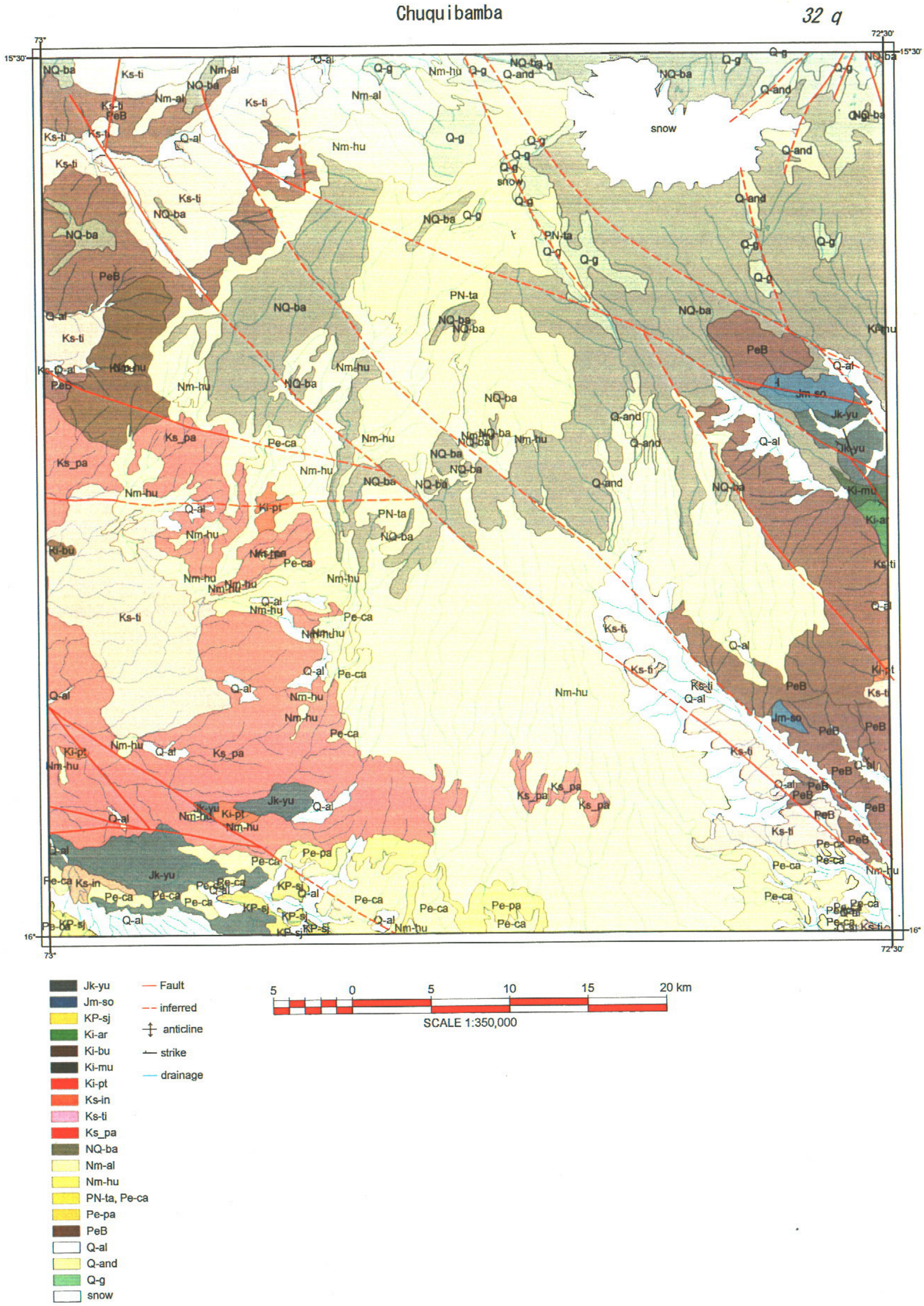

Fig.9-4 Chuquibamba quadrangle (32-q) Geologic interpretation map

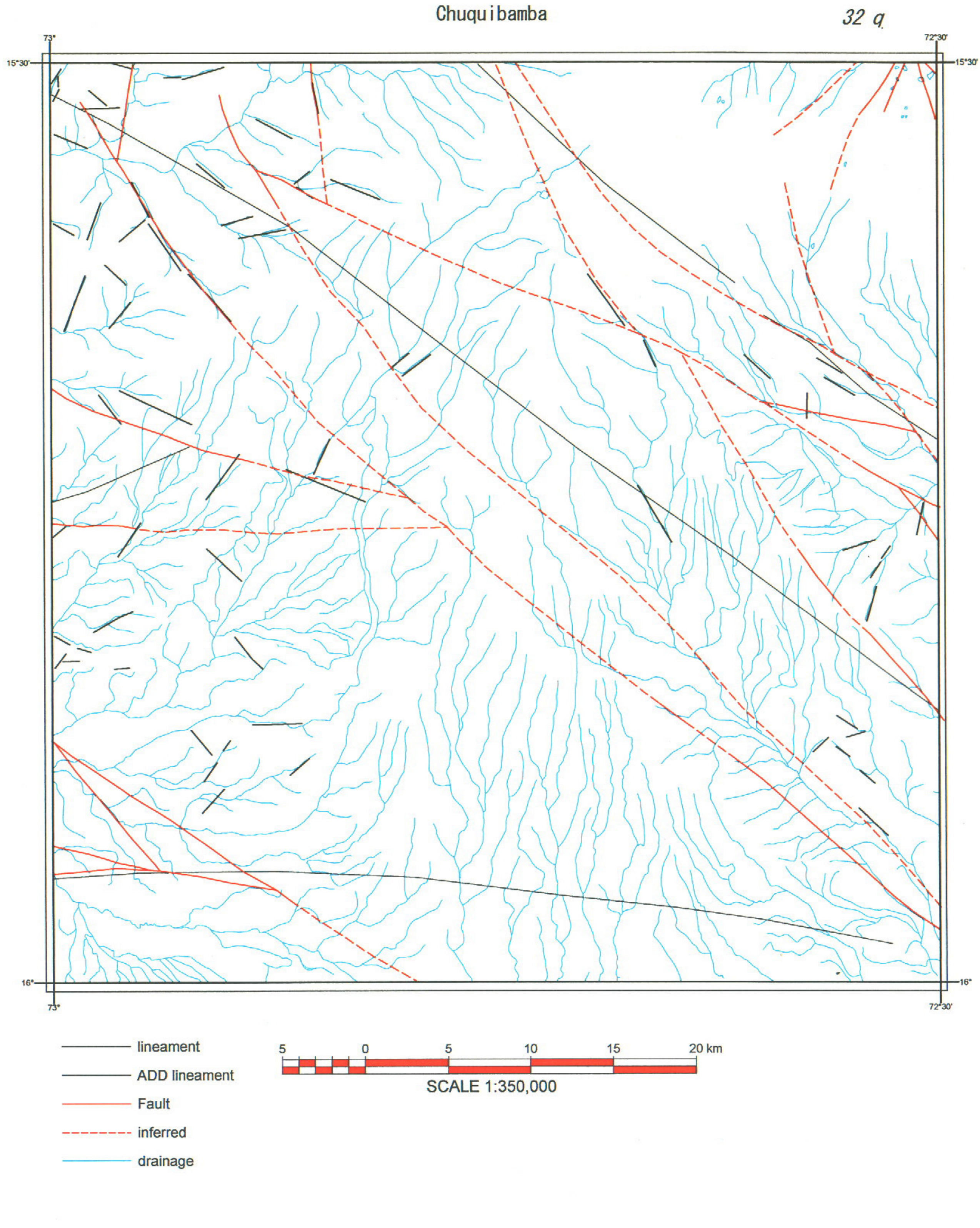

Fig.9-5 Chuquibamba quadrangle (32-q) Lineament map

the Quad. In the south of the area, Jurassic to Cretaceous sedimentary rocks (Jk-yu), Cretaceous to Paleogene sediments (KP-sj), which are penetrated by Cretaceous intrusives (Ki-bu, Ki-pt, Ki-li, Ks-in, Ks-ti) are distributed. They are overlain by Paleogene sediments (Pe-ca, Pe-pa), Neogene volcanics (Nm-ca, Nmhu), Neogene sediments (Np-ch) and Quaternary volcanics (NQ-ba). The major part in the west of the area is overlain by the above mentioned Tertiary and Quaternary systems.
The lineaments of E-W direction extended from the Quad. 32-o is clearly observed in the west of the area. And the lineaments of NW-SE, ENE-WSW(E-W) are also observed in the east of the area.

(11) Quad. 32-q (Fig. 9)
Precambrian metamorphics are located in the northwest and the center in the west of the Quad. Jurassic to Cretaceous sedimentary rocks (JK-yu), extended from the Quad. 32-p, is located in the southeast corner. On the north of the Precambrian area, middle Jurassic sediments (Jm-so), Jurassic to Cretaceous sediments (JK-yu), lower Cretaceous sediments (Ki-mu, Ki-ar) are located in a small area. They are intruded by Cretaceous intrusives (Ki-pt, Ks-in, Ks-ti), and then overlain by Cretaceous to Paleogene sediments (Pe-ca, Pe-pa), Paleogene to Neogene volcanics (PN-ta) and Neogene pyroclastics (Nm-al, Nm-hu). They are further overlain by Quaternary volcanics (NQ-ba). Tertiary system is located in the central part of the Quad. from north to south, and Quaternary system is distributed in the north of the area. Small bodies of glacial sediments (Q-g) and Holocene volcanics (Q-and) are scattered in the north of the area.
The lineaments of NE-SW are observed in the southwest of the Quad. The lineaments of E-W and NW-SE are clearly observed in the south of the area and center to northeast of the area respectively.

(12) Quad. 32-r
Precambrian metamorphics extended from the Quad. 32-q are located in a small area in the southwest of the Quad. Another Precambrian rocks are covered with Jurassic to Cretaceous sediments (JK-yu), lower Cretaceous sediments (Ki-mu, Ki-ar), upper Cretaceous sediments (Ks-se), Cretaceous to Paleogene sediments (KP-sj) with the trend of NW-SE. They are penetrated by Cretaceous intrusives (Ks-ti) and Tertiary intrusives (P-an/ri), and then covered with Paleogene to Neogene volcanics (PN-ta), Neogene pyroclastics (Nm-hu) and Quaternary volcanics (NQ-ba) in a small area. Glacial sediments (Q-g) and Holocene volcanics (Q-and) are extensively located in place.
Around the area of Precambrian metamorphics and Cretaceous intrusives in the southwest of the Quad., conspicuous lineaments of NW-SE, E-W are observed. Indistinct lineaments of N-S, NW-SE, E-W are observed in the north of the area.

(13) Quad. 31-r (Fig. 10)
Jurassic to Cretaceous sediments (JK-yu) and lower Cretaceous sediments (Ki-mu, Ki-ar) of the trend of NW-SE are scattered in the southwest of the Quad. They are covered with Paleogene to Neogene volcanics (PN-ta) in the central part and southwest corner of the area, and then penetrated by Tertiary intrusives. Furthermore they are sporadically covered with Neogene pyroclastics (Nm-hu) and Quaternary volcanics (NQ-ba) mainly in the northeast of the area. Glacial sediments (Q-g) and Holocene volcanics (Q-and) are extensively distributed in place.
Indistinct lineaments of E-W, NW-SE, N-S, NE-SW are recognized in the southwest of the area.

1-4 Analysis of GIS Data

1-4-1 Methods of Analysis