

9) The Ojo de Agua area

[Geological unit]

Rocks and sediments distributed in this area were classified into 25 geological units in total (Fig. II-2-27 and Table II-2-10). Seven of them were comparable to the sedimentary rocks of the Jurassic to the Tertiary, and nine units to the volcanic rocks of the Carboniferous to the Quaternary. Four units correspond to the unconsolidated or semi-consolidated sediments of the Quaternary. One geological unit can be compared mainly to the Paleozoic schist and three units to the intrusive rocks generated from the Paleozoic to the Tertiary. Another geological unit was judged to be an alteration zone.

[Alteration zone]

In this area, 22 alteration zones were extracted (Fig. II-2-27 and Table II-2-23): 11 in the Tertiary volcanic rocks (geological unit: Tiv) and one in the Cretaceous granite (geological unit: Ak) distributed in the west, one in the Cretaceous volcanic rocks (geological unit: Kiv) distributed in the southwest end, one in the Carboniferous volcanic rocks (geological unit: Cv) distributed in the north, one in the granitic rocks (geological unit: Ak) in the Paleozoic strata, two in the Tertiary volcanic rocks (geological unit: Kiv) and one in the Carboniferous volcanic rocks (geological unit: Cv) distributed in the central area, and three in the Paleozoic metamorphic rocks (geological unit: Ps) and one in the Tertiary volcanic rocks (geological unit: Tiv) distributed in the south. In the western side bounded by continuous lineaments trending toward the NW-SE and N-S 13 alteration zones are distributed more densely, while those in the eastern side are more sporadically and independently distributed except for three zones located together in the Paleozoic stratum. Those with the most characteristic distribution are 10 alteration zones in the Tertiary volcanic rocks (geological unit: Tiv) in the western side of the lineaments, which are relatively densely distributed.

Morphology of alteration zones is in general ellipsoid or irregularly amoebic. The largest one is an alteration zone distributed in the Tertiary volcanic rocks in the west extending about 2.8 km toward the longer-axis direction.

[Lineament]

A Slight difference is generally recognized in the distribution and direction of lineaments interpreted and extracted in this area, between the east to central and the west. The following characteristics were recognized (Fig. II-2-27):

(1) East to central zone

This zone is mainly composed of the Paleozoic schist, the Carboniferous to Quaternary volcanic rocks, the Jurassic to Tertiary sedimentary rocks and the Quaternary unconsolidated

sediments. In this zone, development of lineaments is low on the whole. Areas where relatively many lineaments are interpreted are located in the south and central. Dominant direction of lineaments is NW-SE and NNE-SSW in the south and WNW-ESE in the central. The lineament with the longest extension is one trending toward the WNW-ESE with extension of about 25 km. In other areas, lineaments are aligned in different directions and scattered in various places. Their extension is about 20 km in the north, while most of the lineaments extend over 5 km.

(2) West zone

Geology of this zone is mainly composed of the Jurassic to Tertiary volcanic and sedimentary rocks and the Cretaceous granitic rocks. Four systems of Lineaments develop trending toward N-S, NW-SE, WNW-ESE and E-W. Lineaments densely occur in the Tertiary volcanics and sedimentary rocks from the central and south, as well as in the Jurassic sedimentary rocks and the Cretaceous granitic rocks at the southwest corner. In the former area lineaments of two systems, that is N-S and NW-SE orientations, are particularly dominant, while in the latter area those in the NW-SE and WNW-ESE directions are dominant. The former lineaments trend toward the N-S in the south and change their direction to the NW-SE in the north, although being partly cut by lineaments of the WNW-ESE or E-W direction. Their intermittent extension reaches about 100 km. Among the latter lineaments, those in the NW-SE direction have good continuity with extension of 20 km. Extension of other lineaments is generally 5 to 7 km.

[Folding and circular structures]

(1) Folding structure

Main rocks comprising this area are volcanic, granitic and sedimentary rocks. Sedimentary rocks occur in various places, and beddings can be clearly recognized while folding structures are not observed (Fig. II-2-27). In the Tertiary sedimentary rocks developing in the west, a part of the eastern wing inclining to the east or northeast is interpreted, which indicates folding structures. The details of this part is not clear because it is cut by a lineament and it contacts with volcanic rocks.

(2) Circular structure

No circular structures were extracted in this area.

10) The Esquel area

[Geological unit]

Rocks and sediments distributed in this area were classified into 21 geological units in total (Fig. II-2-30 and Table II-2-11). Six of them were comparable to the Jurassic to Tertiary

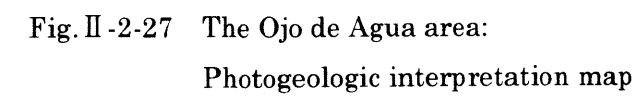
Table II -2-10 Characteristics of photogeologic units of the Ojo de Agua area

Unit	Photo-Characteristics		Morphologic Expression					Superficial Cover		Probable Lithology (Correlation with available Geologic Map)
	Tone	Texture	Drainage		Rock Resistance	Section	Bedding	Vegetation	Cultivation	
			Pattern	Density						
Qa	gray, purplish red, green	very fine	meandering	very low	very low		none	partly dense	partly intense	Unconsolidated sediments composed of gravel, sand, silt and clay (Holocene : Recent alluvial deposits)
Qis3	brown	fine	sub-parallel	low	low		none	partly	partly	Glacial deposits (Pleistocene : Gracial deposits)
Qis2	light gray	medium	sub-parallel	low	low		none	none	none	Glacial deposits (Pleistocene : Gracial deposits)
Qis1	purplish	fine	sub-parallel	low	low		very gentle	rare	none	Unconsolidated sediments composed of gravel, sand, silt and clay (Pleistocene : Fluvial, talus deposits)
Qivb	reddish brown	rough	radial	medium	low		none	none	none	Basic volcanic rocks (Pleistocene : Basalt, pyroclastic rocks)
Tsv	brown	rough	sub-parallel	low	medium		none	none	none	Volcanic rocks (Pliocene: Basalt and pyroclastic rocks)
Tms	grayish purple	coarse-fine	sub-dendritic	low	low		rare	none	partly	Sedimentary rocks (Miocene : Continental sedimentary rocks , Collon Cura, Pedregoso Formations etc.)
Tmv2	brown	coarse	sub-dendritic	medium	medium-high		massive	partly	none	Mainly pyroclastic rocks (Miocene : Pyroclastic rocks, basalt, andesite)
Tmv1	gray	coarse	sub-dendritic	low	low		massive	none	none	Mainly pyroclastic rocks (Miocene : Tuff, ignimbrite, basalt)
Tmv	brown	coarse	sub-dendritic	medium	medium-high		massive	partly	rare	Mainly pyroclastic rocks (Miocene : Basaltic rocks, El Mirador Formation)
Tiv	dark brown	coarse	sub-dendritic	medium	medium-high		massive	dense	partly	Andesitic volcanic rocks(Eocene-Oligocene : Andesite, basalt and pyroclastic rocks)
Tis2	brown, dark purple	coarse	sub-dendritic	high	medium		partly	medium	rare	Sedimentary rocks (Oligocene : Marine and continental sedimentary rocks ,Nirihuau Formation etc.)
Tis1	brown, dark purple	coarse	sub-dendritic	medium	low		partly	none	none	Sedimentary rocks (Eocene-Oligocene : Continental sedimentary rocks, Sarmiento Formation etc.)
Kss	gray	fine-medium	pinnate	medium	low-medium		bedded	none	none	Fine to medium grained sedimentary rocks (Upper Cretaceous : Sandstone, mudstone, conglomerate)
Kis2	brown	fine-medium	sub-parallel	medium-high	medium-high		well bedded	none	none	Fine to medium grained sedimentary rocks (Lower Cretaceous : Sandstone, mudstone, gypsum, limestone etc.)
Kiv	brown	medium	sub-parallel	medium-high	medium-high		well bedded	none	none	Volcanic rocks (Upper Cretaceous: Intermediate volcanic rocks (Devisadero Formation etc.)
Jss	brown	fine-medium	sub-parallel	medium-high	medium-high		well bedded	none	none	Medium grained sedimentary rocks (Upper Jurassic : Conglomerate, sandstone, shale, limestone, gypsum etc.)
Jmv	brown	medium	sub-parallel	medium-high	medium-high		massive	partly dense	none	Volcanic rocks (Middle-Upper Jurassic: Intermediate volcanic rocks, Lago La Plata, Lonco Trapia Formation

Table II -2-10 Characteristics of photogeologic units of the Ojo de Agua area

Unit	Photo-Characteristics		Morphologic Expression					Superficial Cover		Probable Lithology
	Tone	Texture	Drainage		Section	Bedding	Vegetation	Cultivation		
			Pattern	Density					Rock Resistance	
Jis	brown	medium	sub-parallel	low-medium	medium	partly	partly	none	Sedimentary rocks (Lower Jurassic: Marine and continental sedimentary rocks, Pitriguitron Formation)	
Cv	brown	coarse	sub-dendritic	high	high	massive	none	none	Mainly pyroclastic rocks (Carboniferous-Devonian: Andestic tuff, sandstone, shale)	
Ps	dark gray	rough	sub-dendritic	high	high	schistose	none	none	Schistose rocks (Paleozoic :Phyllite, schist, gneiss and migmatite)	
α K	brown	coarse	sub-dendritic, rectangular	medium	high	massive	partly	none	Igneous rocks (Cretaceous- Tertiary : Plutonic rocks and hypabyssal rocks)	
α TR	brown	coarse	sub-dendritic	low	medium	massive	none	none	Igneous rocks (Triassic: Granitic rocks)	
α P	gray	coarse	sub-dendritic, rectangular	medium	medium-high	massive	partly	none	Igneous rocks (Paleozoic : Plutonic rocks and hypabyssal rocks)	
A	light gray	fine	none	low	low	none	none	none	Alteration Zone (Hydrothermal alteration zone)	

WR 231/89



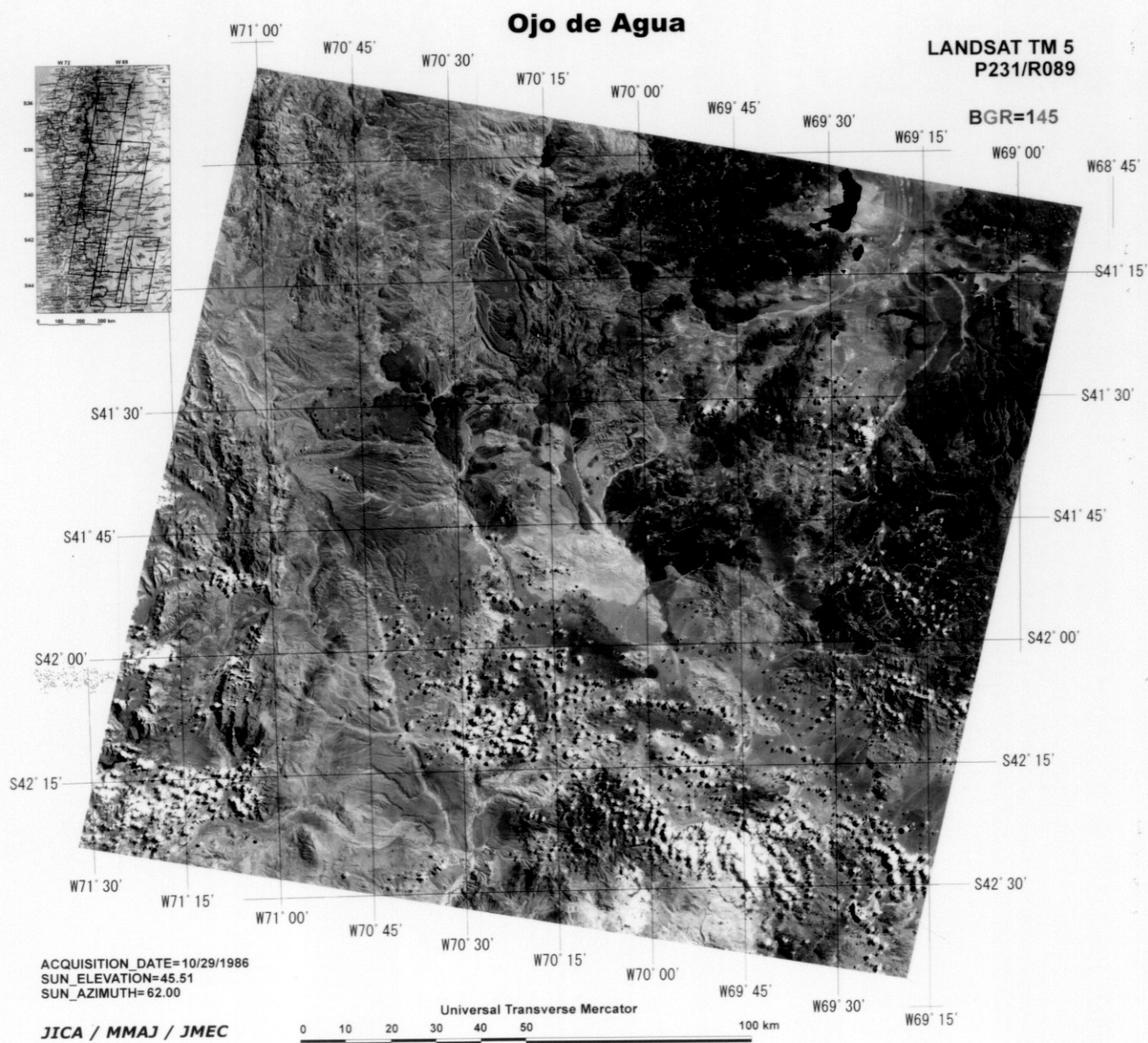


Fig. II -2-28 The Ojo de Agua area: Landsat TM false color image

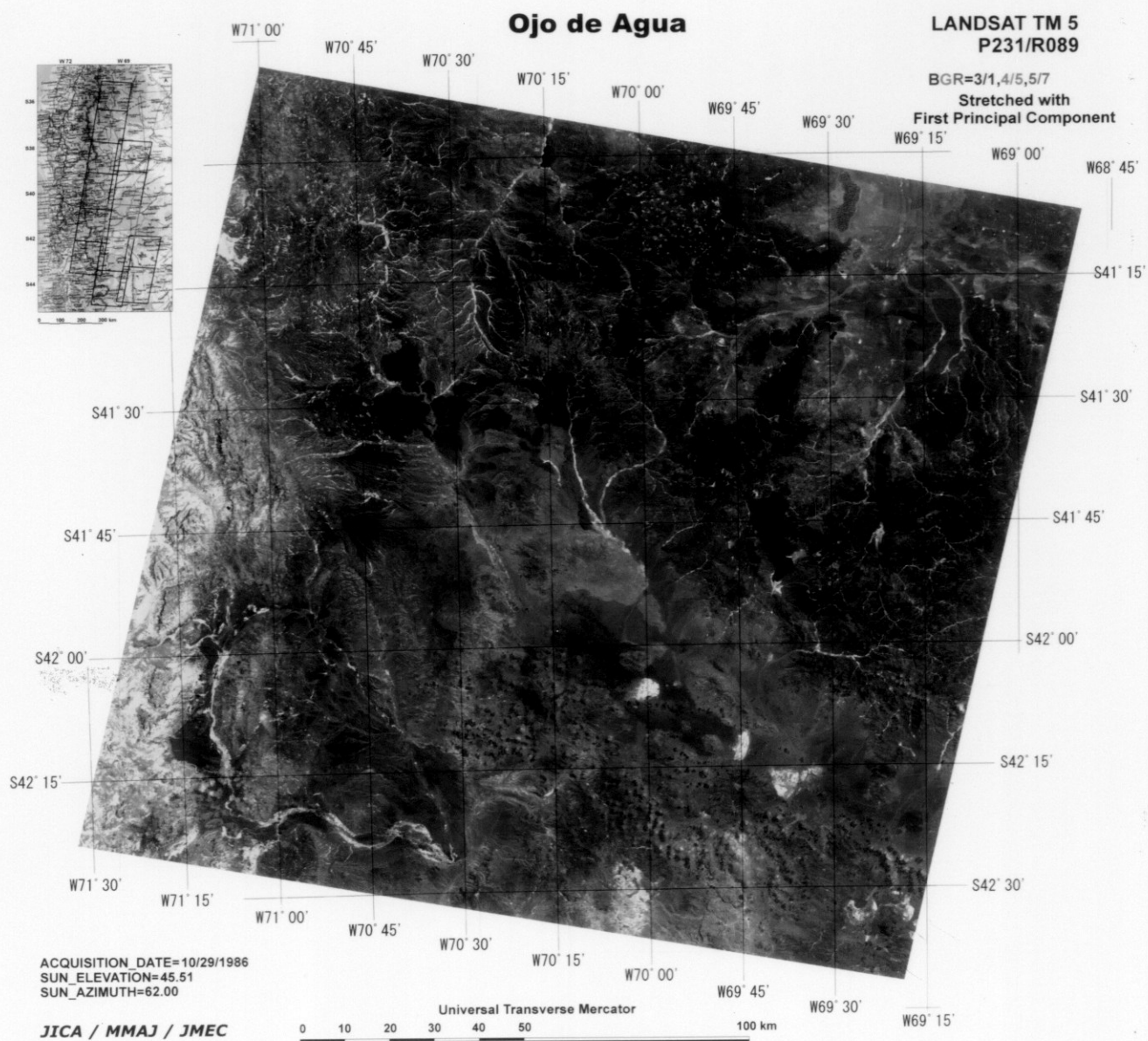


Fig. II -2-29 The Ojo de Agua area: Landsat TM ratio image

sedimentary rocks, and another six to the Jurassic to Quaternary volcanic rocks. Four geological units can be compared to the unconsolidated or semi-consolidated sediments of the Quaternary. In addition, one geological unit is comparable mainly to the Paleozoic schist while three units are compared to the intrusive rocks generated in the Cretaceous. One unit was judged to be an alteration zone.

[Alteration zone]

In this area, 20 alteration zones (EQ001 to EQ020) were extracted (Fig. II-2-30, and Table II-2-24). All of them overlap those extracted from images of the Lago Menendez, San Carlos de Bariloche and Ojo de Agua areas. Morphology of alteration zones is irregularly massive. Large alteration zones are EQ001, EQ002 and EQ003, having the following characteristics, respectively.

- Alteration Zone EQ001: This zone is located about 15 km west of Esquel town and found in the Lower Cretaceous volcanic rocks (geological unit: Kiv). The size is 3.3 km by 2.5 km. It is bordered by a lineament in the N-S direction on the west side.
- Alteration Zone EQ002: This zone is located about 8 km southeast of Esquel town, and found in the Lower Tertiary volcanic rocks (geological unit: Tiv). The size is 2.5 km by 1.5 km.
- Alteration Zone EQ003: This zone is located about 35 km south of Esquel town, and found in the Lower Tertiary volcanic rocks (geological unit: Tiv). The size is 4.0 km by 4.0 km.

These alteration zones are all distributed in the northwest portion of this area, and can be roughly divided into the following four regions:

- Northwest end region: 3 alteration zones (EQ017, EQ018 and EQ019) are closely observed in the Jurassic sedimentary rocks (geological unit: Jis). Each size is around 1 km by 1 km.
- Northwest region: 13 alteration zones (EQ004 to EQ016) are observed in the Cretaceous to Tertiary volcanic rocks (geological units: Tiv and Kiv), the Jurassic sedimentary rocks (geological unit: Jis) and the Cretaceous granitic rocks (geological unit: α K). They are closely located and show concentrated distribution. Both sides of an area of concentration are enclosed by several continuous lineaments trending toward the N-S or NNW-SSE. The largest one is EQ014 (2.4 km x 2.4 km).
- Western central region: Two alteration zones (EQ002 and EQ003) are found in the Tertiary volcanic rocks (geological unit: Tiv). Distance between them is about 25 km. Their characteristics are described above.
- Western central end region: Two alteration zones (EQ001 and EQ020) are found in the Cretaceous volcanic rocks (geological unit: Kiv). Distance between them is about 20 km. EQ020 is 3.2 km by 1.2 km in size. Size and characteristics of EQ001 are described above.

[Lineament]

Concerning distribution and direction of lineaments interpreted and extracted from this area, their characteristics are summarized for the following four zones, that is western zone, central zone, northeast zone and southeast zone. (Fig. II-2-30):

(1) Western zone

This zone is mainly composed of the Cretaceous to Tertiary volcanic rocks and the Cretaceous igneous rocks. In the north, N-S trending lineaments are dominant and have good continuity, while lineaments in different directions develop in the south. Each forms an area of dense lineaments. The longest lineament is located near the central, trending toward the N-S and having extension of 37 km.

(2) Central zone

N-S trending lineaments are dominant, forming a boundary between the Precambrian to Paleozoic metamorphic rocks and the Jurassic sedimentary rocks. These lineaments develop on both wings of an anticlinal structure and have the characteristics of normal faults.

(3) Northeast zone

This zone mainly comprises the Jurassic to Tertiary volcanic and sedimentary rocks. Lineaments in different directions are observed. A lineament with the best continuity changes direction from N-S to NW-SE and extends over 36 km, showing the characteristics of normal fault.

(4) Southeast zone

This zone is mainly composed of the Cretaceous to Tertiary volcanic and sedimentary rocks. Lineaments in different directions are observed. A lineament with the best continuity runs towards the NNE-SSW orientation and has extends as long as 20 km.

[Folding and circular structures]

(1) Folding structure

In this area only two anticlinal structures are found (Fig. II-2-30). One consists of the Lower Jurassic sedimentary rocks distributed in the center of this area, and covers the Precambrian to Paleozoic metamorphic and sedimentary rocks. Its anticlinal structure is assumed from morphology of the mountain like a horse's back. The anticlinal axis trends toward the N-S and extends over about 25 km. The other is an anticlinal structure observed in the Tertiary sedimentary rocks distributed in the west of this area, and has an anticlinal axis of the NE-SW direction.

(2) Circular structures

In this area, two circular structures were extracted (Fig. II-2-30). One is based on the Tertiary igneous rocks (geological unit: α Tm) located near the central zone and is about 5km in diameter involving a landslide scarp and semi-circular drainage inside the structure. The

Table II -2-11 Characteristics of photogeologic units of the Esquel Area

Unit	Photo-Characteristics	Morphologic Expression					Superficial Cover		Probable Lithology (Correlation with available Geologic Map)
		Drainage		Rock Resistance	Section		Bedding		
		Pattern	Density						
	Tone	Texture							
Qa	gray, purplish red, green	very fine	meandering	very low	very low		partly dense	partly intense	Unconsolidated sediments composed of gravel, sand, silt and clay (Holocene : Recent alluvial deposits)
Qis2	purplish gray	fine-medium	sub-parallel	very low	low		rare	rare	Glacial deposits (Pleistocene : Gracial deposits)
Qis1	purplish gray	fine	dendritic	low	low-medium		rare	none	Unconsolidated sediments composed of gravel, sand, silt and clay (Pleistocene : Fluvial, talus deposits)
Qivb	reddish brown	fine-medium	radial, sub-parallel	low-medium	low-medium		none	none	Basic volcanic rocks (Pleistocene : Basalt, pyroclastic rocks)
Tsv2	brown	coarse	sub-dendritic	medium	medium		none	none	Basic volcanic rocks (Pliocene : Basaltic rocks)
Tms	grayish purple	coarse-fine	sub-dendritic	low	low		none	partly	Sedimentary rocks (Miocene : Continental sedimentary rocks, Collon Cura, Pedregoso Formations etc.)
Tmv	brown	coarse	sub-dendritic	medium	medium-high		partly	rare	Mainly pyroclastic rocks (Miocene : Basaltic rocks, El Mirador Formation)
Tiv	dark brown	coarse	sub-dendritic	medium	medium-high		partly dense	partly	Volcanic rocks (Eocene : Andesite, basalt and pyroclastic rocks)
Tis2	brown, dark purple	coarse	sub-dendritic	high	medium		medium	rare	Sedimentary rocks (Oligocene : Marine and continental sedimentary rocks, Nirihua Formation etc.)
Tis1	brown, dark purple	coarse	sub-dendritic	medium	low		none	none	Sedimentary rocks (Eocene-Oligocene : Continental sedimentary rocks, Sarmiento Formation etc.)
Kss	light brown, dark gray	medium	sub-dendritic pinnate	medium	low-medium		rare	none	Fine to medium grained sedimentary rocks (Upper Cretaceous : Sandstone, mudstone, conglomerate)
Ksv	brown, dark brown	medium	sub-dendritic	medium-high	medium-high		rare	none	Volcanic rocks (Upper Cretaceous : Basic volcanic rocks, Tres Picos Prieto Formation etc.)
Kiv	brown	coarse	sub-dendritic	medium	high		partly dense	none	Volcanic rocks (Upper Cretaceous : Intermediate volcanic rocks (Devisadero Formation etc.)
Jmv	brown	medium	sub-parallel	medium-high	medium-high		partly dense	none	Volcanic rocks (Middle-Upper Jurassic : Intermediate volcanic rocks, Lago La Plata, Lonco Trapia Formations etc.)
Jis	brown	medium	sub-parallel	low-medium	medium		partly	none	Sedimentary rocks (Lower Jurassic : Marine and continental sedimentary rocks, Piltriquitron Formation etc.)
Ps	dark gray	coarse	sub-dendritic pinnate	high	high		rare	none	Metamorphic and sedimentary rocks (Precambrian-Paleozoic : Metamorphic rocks, marine and continental sedimentary rocks)

Table II –2-11 Characteristics of photogeologic units of the Esquel Area

Unit	Photo-Characteristics		Morphologic Expression					Superficial Cover		Probable Lithology (Correlation with available Geologic Map)
	Tone	Texture	Drainage		Section	Bedding	Vegetation	Cultivation		
			Pattern	Density					Rock Resistance	
α Tm	brown	coarse	sub-dendritic	medium	high	massive	rare	none	igneous rocks (Middle Tertiary? : Granitic rocks)	
α K	brown	coarse	sub-dendritic	medium	high	massive	partly dense	none	igneous rocks (Upper Cretaceous : Granitic rocks)	
α J	brown	coarse	sub-dendritic	high	high	massive	none	none	igneous rocks (Upper Jurassic-Lower Cretaceous : Granitic rocks)	
α TR	brown	coarse	sub-dendritic	low	medium	massive	none	none	igneous rocks (Triassic : Granitic rocks)	
α P	brown	coarse	sub-dendritic	high	high	massive	none	none	igneous rocks (Silurian : Granitic rocks)	
A	pinkish purple	fine	sub-dendritic	low	medium-high	massive	none	none	Alteration Zone (Hydrothermal alteration zone)	

WRS231/90

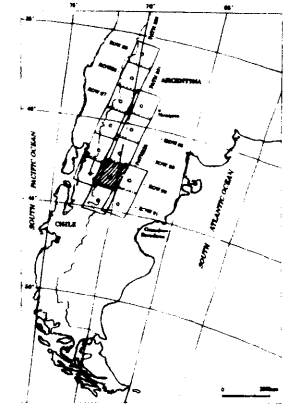


Fig. II -2-30 The Esquel area:
Photogeologic interpretation map

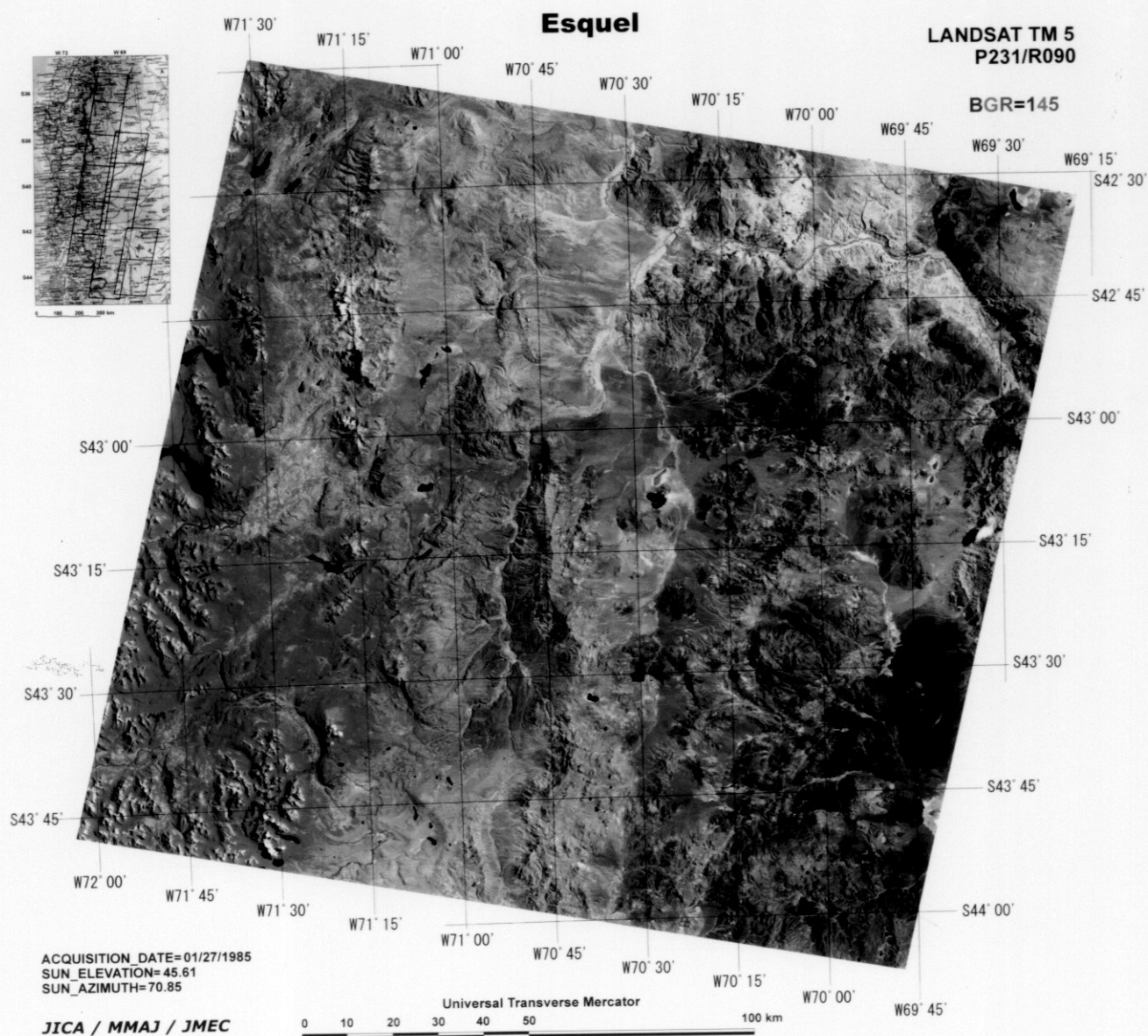


Fig. II -2-31 The Esquel area: Landsat TM false color image



Fig. II -2-32 The Esquel area: Landsat TM ratio image