and dip, the anticlinal axis was marked on the map. The direction of dip or shoot of fault were presumed and marked on the map.

Interpreted characteristics on the image were compared with a 1:500000 geological map (Ministry of Geology, USSR, 1980), and the lithofacies of each geological unit were presumed.

(5) Extraction of spectral anomaly areas

In the above described alteration extraction image, a zone where ratioing Band 3/Band 1 value is high may suggest to be a distribution of iron oxide minerals or iron hydroxide minerals, and a zone where the second principal component in DPCA is high may suggest to be a distribution of clay minerals or carbonate minerals. In the present survey, the zone where both ratioing Band 3/Band 1 value and the second principal component in DPCA is high, that is, yellow zone shown on the image, is presumed to be the highest possibility of alteration zone. Therefore this zone was extracted as spectral anomaly areas.

In extraction spectral anomaly areas, anomaly which have obviously no relation with ore-forming alteration, such as clay minerals or iron hydroxides of Quaternary, was excluded from object of extraction. Also, if single geological unit shows the same color tone anomaly to some extent all over the unit area, the anomaly didn't suggest ore-forming alteration but was interpreted to be due to lithofacies itself.

1-2 Results of analysis

1-2-1 Lineament analysis

Lineament map interpreted from false color synthetic image (Fig. II-1-2) shows Fig. II-1-3. Extracted lineaments are distributed as following;

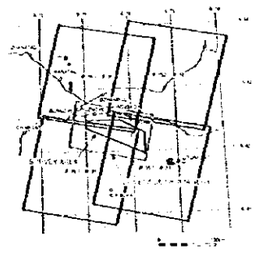
(1) Many north-northeast - south-southwest or northeast - southwest lineaments were extracted in Quaternary of the west part of the area.

(2) Silver ore deposits and mineral occurrences such as Dzholsay deposit in the west part, are located near the fault which strike east - west, and arrange in parallel to the fault. In area of about 15 km in east - west and about 4 km north - south to the north of the fault, a lot of northeast - southwest lineaments were extracted uncertainly but continued well.

(3) In area of about 20 km in length and about 5 km in width, from the west of Kumyshtag deposits group in east part, to Sarymsak deposit in the central part, north-northwest - south-southeast or northwest - southeast lineaments is predominantly distributed.

THE MINERAL EXPLORATION
IN THE TALAS AREA,
THE KYRGYZ REPUBLIC
(PHASE I)

LANDSAT TM DIGITAL MOSAIC IMAGE



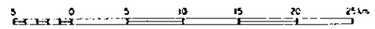
THE JAPAN INTERNATIONAL COOPERATION AGENCY
THE METAL MINING AGENCY OF JAPAN
FEBRUARY, 1995

Data Acquisition Date:

Path 152	Row 30 July	27,	1990
Path 152	Row 31 July	03,	1993
Path 153	Row 30 Sept.	04,	1990
Path 153	Row 31 July	02,	1990

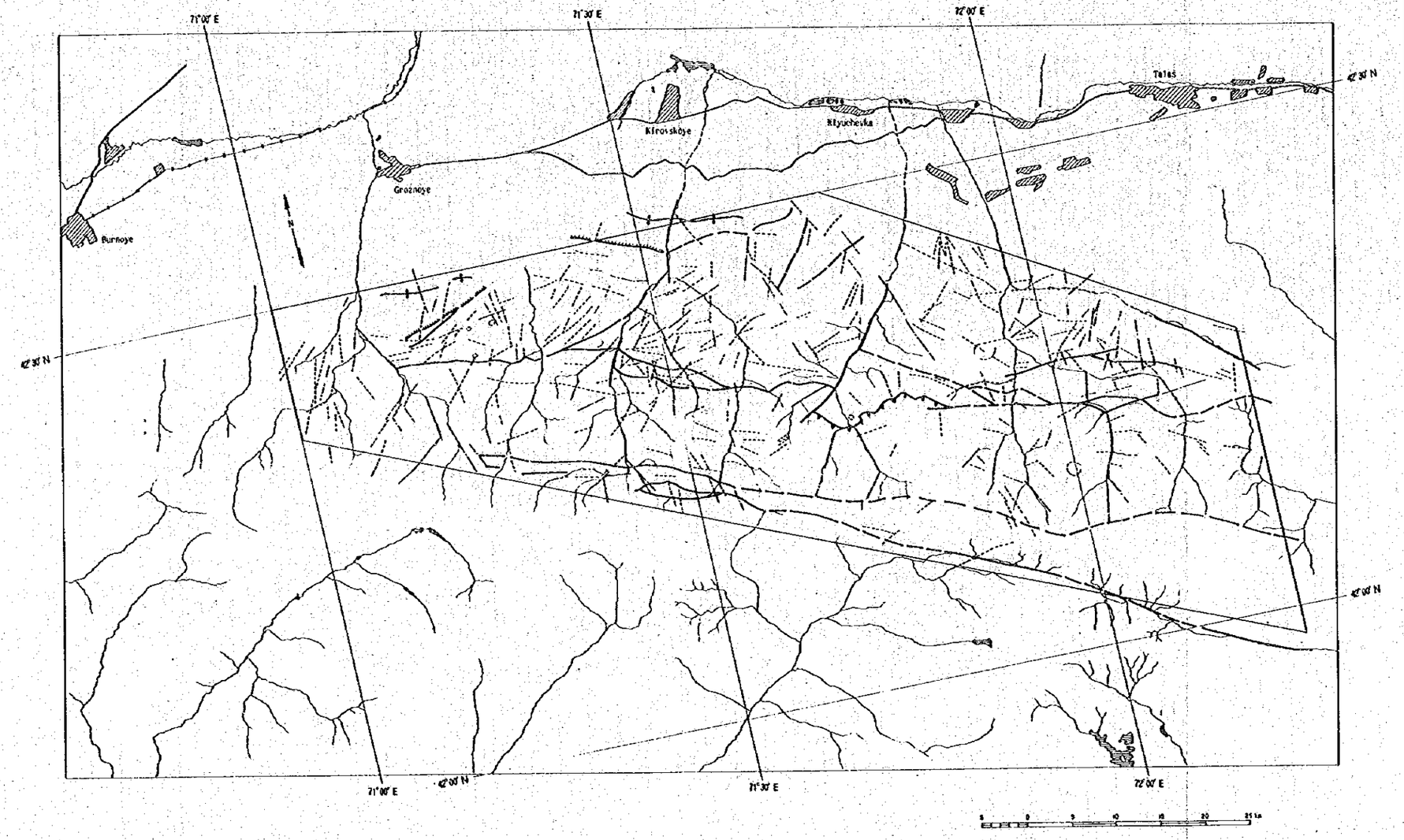
Color Combination:

Band 1 = blue
Band 4 = green
Band 5 = red



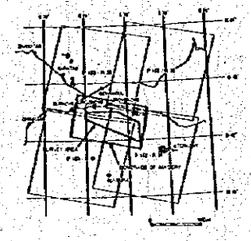
Prepared by Mitsui Mineral Development Engineering CO., LTD. (MINDECO)

Fig. II-1-2 LANDSAT TM False Color Digital Mosaic Image



THE MINERAL EXPLORATION
IN THE TALAS AREA,
THE KYRGYZ REPUBLIC
(PHASE I)

LINEAMENT MAP OF LANDSAT TM IMAGE



JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN
FEBRUARY, 1998

LEGEND

	Fault (barbs on downfall side)
	Inferred Fault (barbs on downfall side)
	Thrust Fault
	Major Lineament
	Minor Lineament
	Circular Structure
	Anticline
	Drainage
	Lake, Pond
	Urban Area
	Major Road
	Main Way

Fig. II-1-3 Lineament Map of LANDSAT TM Image

(4) Three circular structures, ranging from about 400 to 600 m in diameter, were extracted in Gr1 unit in the following geologic interpreted map.

1-2-2 Geologic interpreted units

Thirteen geological units in the survey area are classified, according to false color synthetic image. Geologic interpretation map of units is shown in Fig. II-1-4. Photogeologic characteristics of each geological unit and the comparison with the 1:500000 geological map are shown in Table. II-1-2. Compared with the geological map, the geologic interpretation map shows that the result of interpretation has a good agreement with the geological map, but some small unit of Riphean have quite difference between them. Among intrusive rocks, Kumyshtag granite was interpreted in wider distribution than that in the geological map. The comparison between presumed lithofacies and the geological map based on photogeologic characteristics of each unit on the image is described as follows:

(1) Unit a:

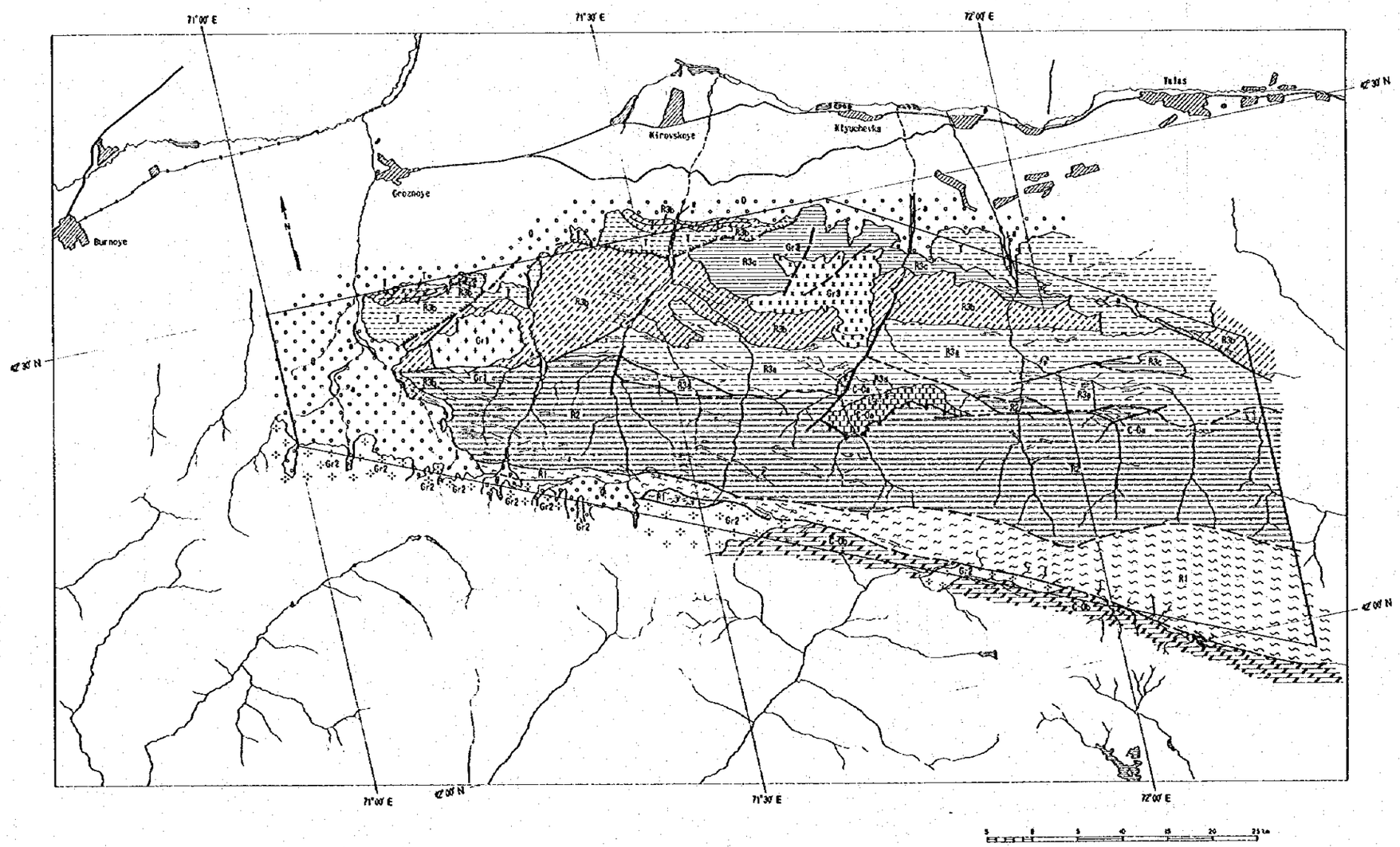
This unit consists of parts which displays green or reddish brown on false color image. The former corresponds to vegetation areas, and the latter to bald lands. This unit is distributed in plane lands of the wide valley and the small basin along the drainage. As the surface is smooth and has very low erosion resistance, this unit is presumed to be Alluvium which is mainly composed of unconsolidated sand, gravel and silt. In the geological map this unit is included in unclassified Quaternary and its lithofacies is gravel or loam.

(2) Unit Q:

This unit displays the same color tone as Unit a and is interpreted that its surface conditions are the same but the brightness is all over high. The reason of this is presumed that this unit is a lithofacies which has low water content compared with Unit a. As the surface is smooth and has very low erosion resistance, this unit is presumed that the main component is unconsolidated sand, gravel and silt. In addition, from the fact that this unit is distributed in the slope of mountainside and forms alluvial fan and is covered with unit a, the age of this unit is presumed to be a little older than Unit a. This unit corresponds to unclassified Quaternary (gravel or loam).

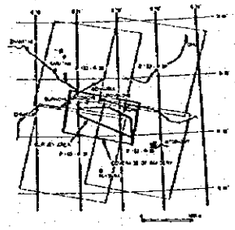
Table II-1-2 Photogeologic Characteristics of Interpretation Units

No.	Units	Color	Tone	Drainage			Geomorphological aspects					Vegetation Density	Landuse	Correlation	Rock Types
				Pattern	Density	Cross Profile	Resistance	Texture	Bedding, Schistosity	Lineament Density	Landform				
1	a	green, red-brown	moderate	contorted	moderate	gentle U-shape	very low	smooth	none	very low	valley, basin	high	frequent	Q	gravel, loam
2	Q	green, red-brown	light	radial	high	gentle V-shape	low	smooth	none	low	alluvial fan	low	sparse	Q	gravel, loam
3	T	reddish brown	moderate	pinnate	high	sharp V-shape	moderate	rough	very poor	moderate	hilly	very low	none	N1-2, P3-N1	clay, sandstone
4	C - Os	purple, red brown	dark, light	parallel	high	shallow V-shape	moderate	rough	very well	low	hilly	low	none	C - O2 ls	limestone
5	C - Ob	green	moderate	dendritic	moderate	gentle V-shape	moderate	smooth	poor	low	hilly	high	none	C - O2 ls	limestone
6	R3c	reddish brown	light	dendritic	high	shallow V-shape	low	rough	very poor	moderate	hilly	sparse	none	R3sr	shale, siltstone, sandstone
7	R3b	reddish brown	moderate	dendritic	high	V-shape	moderate	rough	poor	high	hilly	sparse	none	R3sr	shale, siltstone, sandstone
8	R3a	purplish brown	dark	pinnate	moderate	deep V-shape	high	fine	well	high	mountainous	moderate	none	R3sr, R3ct	shale, siltstone, sandstone
9	R2	grey-blue, brown	dark	dendritic	moderate	deep V-shape	high	smooth	fine	moderate	mountainous	high	none	R3ct, R1-2kb	sandstone, shale, phyllite, limestone
10	R1	greyish blue	moderate	parallel	moderate	shallow V-shape	moderate	fine	well	low	mountain range	high	none	R1-2kb	phyllite, limestone
11	Gr3	green	light	dendritic	moderate	gentle V-shape	moderate	smooth	none	low	hilly	very high	none	γ Sd	granite
12	Gr2	greenish brown	moderate	parallel	high	shallow V-shape	moderate	fine	none	low	hilly	high	none	-	granite ?
13	Gr1	reddish brown	light	dendritic	high	shallow V-shape	moderate	rough	none	moderate	hilly	low	none	γ Ov ?	granite



THE MINERAL EXPLORATION
IN THE TALAS AREA,
THE KYRGYZ REPUBLIC
(PHASE I)

GEOLOGIC INTERPRETATION MAP OF
LANDSAT TM FALSE COLOR IMAGE



JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN
FEBRUARY, 1998

LEGEND

Symbol	Unit	Correlation with Geologic Map	Probable Rock Types
	Q	Q	gravel, loam
	T	N1-2 Pg-N1	clay, sandstone
	C - Cb	C-Cb	limestone
	C - Cb		
	R3c	R3c	shale, siltstone, sandstone
	R3b		
	R3a	R3a, R3d	shale, siltstone, sandstone
	R2	R2d, R1-R2b	sandstone, shale, phyllite, limestone
	R1	R1-R2b	phyllite, limestone
	Gr3	γ Sd	granitic rock
	Gr2		granitic rock ?
	Gr1	γ Gr ?	granitic rock

	Bedding trace or Schistosity (arrows show dip direction)
	Fault (barbs on downfall side)
	Inferred fault (barbs on downfall side)
	Thrust fault
	Anticline
	Drainage
	Lake, Pond
	Urban Area
	Major Road
	Rail Way

Fig. II-1-4 Geologic Interpretation Map of LANDSAT TM False Color Image

(3) Unit T:

This unit shows reddish brown on false color image and is presumed to be bald lands where there is few vegetation. It shows rough surface and forms small hills. Its erosion resistance is middle and bedding plane is slightly recognized. This unit is presumed to be sedimentary rock which consists of sandstone or conglomerate with middle degree hardness. This unit corresponds to clay or sandstone of Paleogene to Neogene.

(4) Unit C-Oa:

This unit apparently consists of two parts. One is upper part which displays dark purple and the other is lower part which is slightly bright reddish brown. Both parts have middle degree of erosion resistance and rough surface and forms hills. Reddish brown part is well bedded and forms alternation of soft rock and hard rock. It is presumed to be alternating beds of carbonate rock and marl or sandstone and shale. In the purple part, bedding is not developed and thick layers of dark colored sandstone may be distributed there. This unit corresponds to the distribution area of limestone of Carboniferous to Ordovician.

(5) Unit C-Ob:

This unit covers the southwest side of structural line which runs from northwest to southeast in south part of the survey area. It shows green on the image and it is seemed that the density of vegetation is high. It has a middle degree of erosion resistance and smooth surface, but partly bedding is developed. It is difficult to presume lithofacies because of coverage of vegetation. But this unit can be sedimentary rock which consists of sandstone or carbonate rock. This unit corresponds to the distribution area of limestone of Carboniferous to Ordovician as Unit C-Oa.

(6) Unit R3c:

This unit covers from the northern part to the eastern part and shows bright reddish brown. It has low erosion resistance and rough surface. Bedding is undeveloped. This unit is presumed to be soft sedimentary rocks such as shale, siltstone and it corresponds to shale, siltstone and sandstone of upper Riphean.

(7) Unit R3b:

This unit is covered with Unit T unconformably and is covered with Unit R3c

conformably. It is zonally distributed from north to east of the area. According to the dip direction of beddig, it is presumed that anticlinal structure is formed in the northern part of the area. On the image it shows reddish brown in middle degree of brightness, and has middle degree of erosion resistance and rough surface. Bedding is undeveloped but developed more than unit R3c. It is presumed to be mainly soft sedimentary rock such as shale or siltstone with intercalation of hard rocks such as sandstone. It corresponds to shale, siltstone and sandstone of upper Riphean as unit R3c.

(8) Unit R3a:

This unit is covered with Unit R3b conformably and is zonally distributed from the central part to the eastern part of the area. It shows dark purplish brown on the image and has high erosion resistance and fine surface. According to the well developing of bedding, it is seemed to be hard sedimentary rock mainly composed of sandstone. It corresponds to shale, siltstone and sandstone of upper Riphean.

(9) Unit R2:

This unit is bordered on other units by faults and covers widely and zonally from the southwestern part to the southeastern part of the area. Its brightness on the image is dark and it shows bluish gray or brown. It is characterized by its high erosion resistance, smooth surface and development of fine bedding or schistosity. It is seemed to consist of alternating beds of hard sedimentary rocks such as dark sandstone or carbonate rock. It corresponds to sandstone or shale of upper Riphean and phyllite or limestone from lower Riphean to middle Riphean.

(10) Unit R1:

This unit covers the northern side of the structural line which runs from northwest to southeast of the area, and is bordered on other units by faults. Especially the boundary between this unit and Unit C-Oa can be a thrust fault according to the dip direction of the fault. On the image it shows bluish gray in general and intercalates many thin reddish brown beds. The erosion resistance of bluish gray part is middle degree and that of reddish brown part is high. It is characterized by fine surface and well development of bedding or schistosity. It is presumed that it mainly consists of dark, middle hard sedimentary rock such as slate and interbeds hard sandstone or carbonate rocks. It corresponds to phyllite or limestone of lower Riphean or middle Riphean.

(11) Unit Gr3:

This unit is massive and covers in the northern central part of the area. It shows bright green on the image. It is presumed to be covered with the vegetation densely. Erosion resistance is middle degree and it forms hills with smooth surface. According to no existence of bedding and massive form, it is seemed to be intrusive rock of granite. It corresponds to Kumyshtag granite.

(12) Unit Gr2:

This unit covers in the southwest end of the area and shows greenish brown on the image. The erosion resistance is middle degree and the surface is fine. The bedding or schistosity is not be recognized. According to the massive form and a little bright color tone, it is seemed to be granite. It corresponds to Manas granite.

(13) Unit Gr1:

This unit covers in the northeast part of the area. It shows bright reddish brown on the image and has middle degree of erosion resistance and rough surface. The bedding or schistosity is not recognized. Based on these features it is seemed to be intrusive rock of granite. It corresponds to Babahan granite.

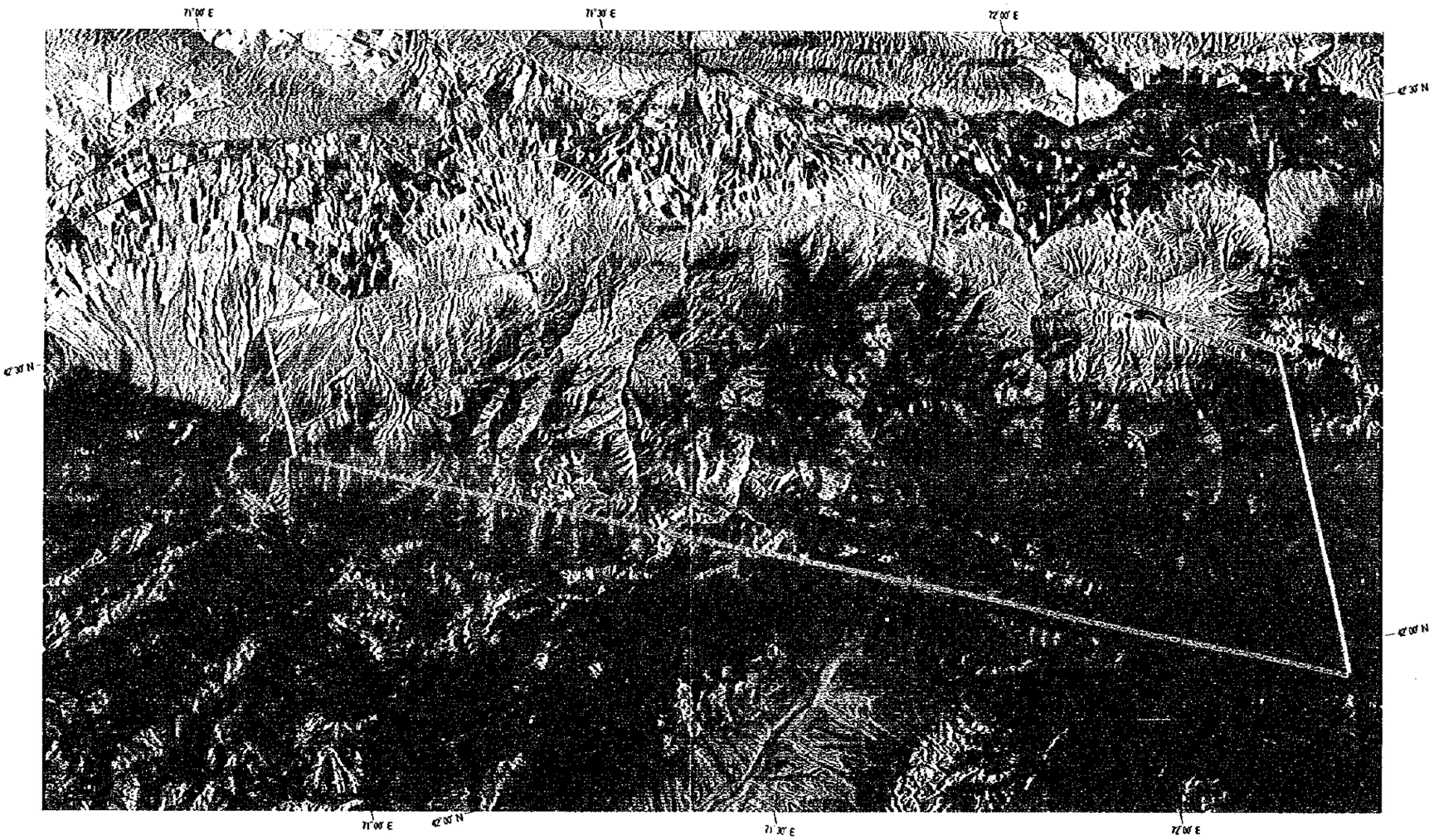
1-2-3 Spectral analysis

The spectral analysis image of LANDSAT for extraction of alteration zone is shown in Fig. II-1-5. The spectral anomalies on the image is shown in Fig. II-1-6. The spectral anomalies are extracted in the following area.

(1) Around the upstream of Babahan river in the western part of the area, lots of small spectral anomaly zones that arrange west-northwest - east-southeast direction. They are parallel to the same direction fault bordered on Unit R1. One of the anomaly zone is located on Tuyuktor mineral occurrence.

(2) Small spectral anomaly zones are studded in Unit R2 covered around the upstream of Kumyshtag river in the central part. The anomaly zones are parallel to northwest - southeast bedding.

(3) Spectral anomaly zones are studded in Unit R1 covered around the upstream of Chymtash river in the southeastern part. The anomaly zones are developed parallel to west-northwest - east-southeast fault bordered on Unit R1.



THE MINERAL EXPLORATION
IN THE TALAS AREA,
THE KYRGYZ REPUBLIC
(PHASE II)

LANDSAT TM 3/1 RATIO AND DPCA
COMPOSITE IMAGE

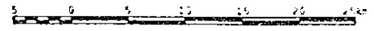
THE JAPAN INTERNATIONAL COOPERATION AGENCY
THE METAL MINING AGENCY OF JAPAN
FEBRUARY, 1995

Data Acquisition Date:

Path 152	Row 30	July 27	1990
Path 152	Row 31	July 03	1993
Path 153	Row 30	Sept.04	1990
Path 153	Row 31	July 02	1990

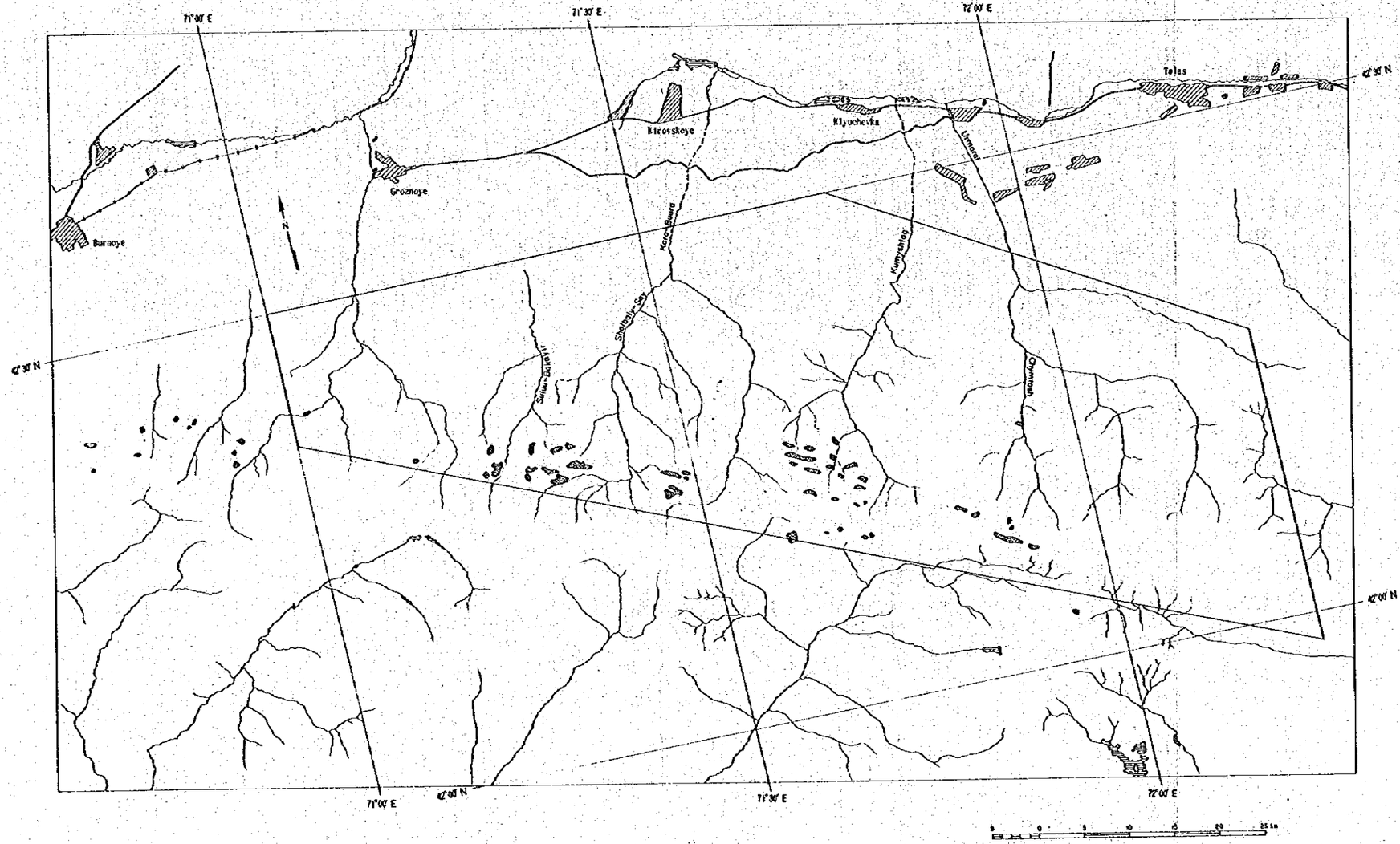
Color Combination:

Red = Band3 / Band1 Ratio
Green = Principal Component 2 of
DPCA (Directed Principal Component Analysis)



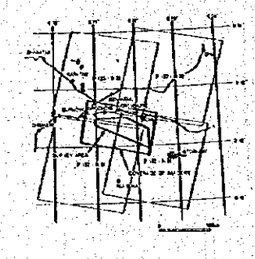
Prepared by Metals Mineral Development
Engineering CO., LTD (MINDECO)

Fig. II-1-5 TM Band3 / Band1 Ratio and DPCA Composite Image



THE MINERAL EXPLORATION
IN THE TALAS AREA,
THE KYRGYZ REPUBLIC
(PHASE I)

DISTRIBUTION OF SPECTRAL ANOMALIES
ON LANDSAT TM IMAGE



JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN
FEBRUARY, 1995

LEGEND

	Spectral Anomalies on Band5/Band7 Ratio and NDVI Image
	Drainage
	Lake, Pond
	Urban Area
	Major Road
	Main Way

Fig. II-1-6 Distribution of Spectral Anomalies on LANDSAT TM IMAGE

1-3 Consideration

1-3-1 Lineament Analysis

Comparing the distribution of the faults and lineaments interpreted from the images with the distribution of the ore deposits and mineral occurrences in the survey area, the followings are described.

(1) The area of silver ore deposits in the western part (especially around Dzholsay deposit)

It is recognized that ore deposits and mineral occurrences are located along the east - west faults and their subordinated northeast - southwest lineaments.
It is possible that silver mineralization is controlled by the fracture zone of the same series.

(2) The area of ore deposits and mineral occurrences of silver, lead, zinc, arsenic and tungsten in the eastern part (especially around Kumyshtag deposits)

Many ore deposits and mineral occurrences are located in the triangle area surrounded by the east - west thrust, the northeast - southwest fault and the northwest - southeast lineament. It is possible that these mineralization is formed with controlled by the fracture zone which is equivalent to the south - north stress formed the east - west thrust.

1-3-2 Classification of Geological Units

Comparing the geologic units map interpreted from the false color synthetic images with the distribution of ore deposits and mineral occurrences, the followings are described.

(1) An area around Unit Gr3 in the central part of the area

As above described, this unit corresponds to Kumyshtag granite. This unit in the interpreted map covers a little wider range than the distribution of Kumyshtag granite the 1:500,000 geological map and shows the same distribution in the 1:200,000 geological map (Ministry of Geology, USSR, 1963a).

Near the boundary of this unit, many ore deposits such as Shyraldzhyn gold deposit and mineral occurrences of copper, lead, tungsten and beryllium are distributed. It is indicated the possibility that these deposits are formed in relation to the contact metamorphism resulted from the intrusion of the granitic rock or to the hydrothermal activities where intrusive rock worked as a heat source.

(2) Southeast of Unit Gr1 in the western part of the area (around Dzholsay deposit)

Silver deposits and mineral occurrences such as Dzholsay deposit are located from the south to the southeast around this unit. As above described, the east - west lineament and the northeast - southwest lineament predominant in this area. It is indicated the possibility that these mineralization is controlled by the east - west or the northeast - southwest fractures, and Babahan granite worked as a heat source.

1-3-3 Spectral Analysis

As the result of spectral analysis, the extracted spectral anomalies hardly cover with ore deposits or mineral occurrences in the survey area. Many of ore deposits and mineral occurrences in the area are vein type deposits whose width is several meters and wall rock almost consists of sedimentary rock. The extent of hydrothermal alteration zone with the mineralization would not be as large as the size recorded by TM data whose spatial resolution is 30 meters wide. Accordingly, it was presumed that the spectral anomalies are not extracted at ore deposits or mineral occurrences.

Lots of the extracted spectral anomaly are distributed in Unit R1 and R2, and are especially located near the west-northwest - east-southeast faults which bordered on Unit R1. The anomalies show a stretched form parallel to the strike of the fault. It is presumed that the fault may be related to the formation of the geologic context which occurred these spectral anomalies.

The following considerations are presumed about each extracted zone of the spectral anomalies with the related mineralization in the area.

(1) The spectral anomalies are studded along the west-northwest - east-southeast fault bordered on Unit R1 unit at the upstream of Babahan. It might be possible that the spectral anomalies indicate the existence of the hydrothermal process along the same series faults.

(2) The spectral anomalies which are extracted in Unit R2 at the upstream of Kumyshtag river in the central part of the area, are studded parallel to the strike of the same unit. It might be possible that the spectral anomalies reflect alteration or skarn resulted from the part of the carbonate rock of Unit R2.

(3) The spectral anomalies which are extracted at the upstream of Chymtash river

in the southeastern part of the area, are stretched to the strike of the west-northwest - east-southeast faults bordered on Unit R1. It might be possible that the spectral anomalies indicate the existence of the hydrothermal process along the same series faults.

CHAPTER 2 COMPILATION OF EXISTING DATA

2-1 Geology

2-1-1 Talas marginal massif

The survey area is included in Talas marginal massif in the geological structures of Kyrgyz. This massif is a small one between the Nikolaevsky tectonic line (Talas-Fergansky fault ~ Nikolaevsky fault) and the Eachkeletau-Susamyrsky fault in the western edge of Tien-Shan mountain range (Fig. I -3). The western part of this massif extends into Kazakhstan to form the Talas-Katarauskaya block. After folded in Caledonian stage, it has behaved as a stable block and was not effected by strong folding in Hercynian stage.

The Talas block is divided into Uzunahmatsky block and Karagainsky block by Uzunahmat-Kumyshtagsky thrust, and moreover Karagainsky block is divided into Karaburinsky block and Kolbinsky block by Beshtashsky fault (Fig. II -2-1, Fig. II-2-2).

The Talas block is characterized by prominent sedimentary rock with carbonate rock and acid igneous rock intruding it, and shows complex structures where many thrust faults and folds are developed.

A lot of igneous activities from PreCambrian age to Silurian period are recognized and many granite batholith intruded. Many ore deposits of gold, silver, copper and lead are recognized to be related with leucocratic granite of Silurian.

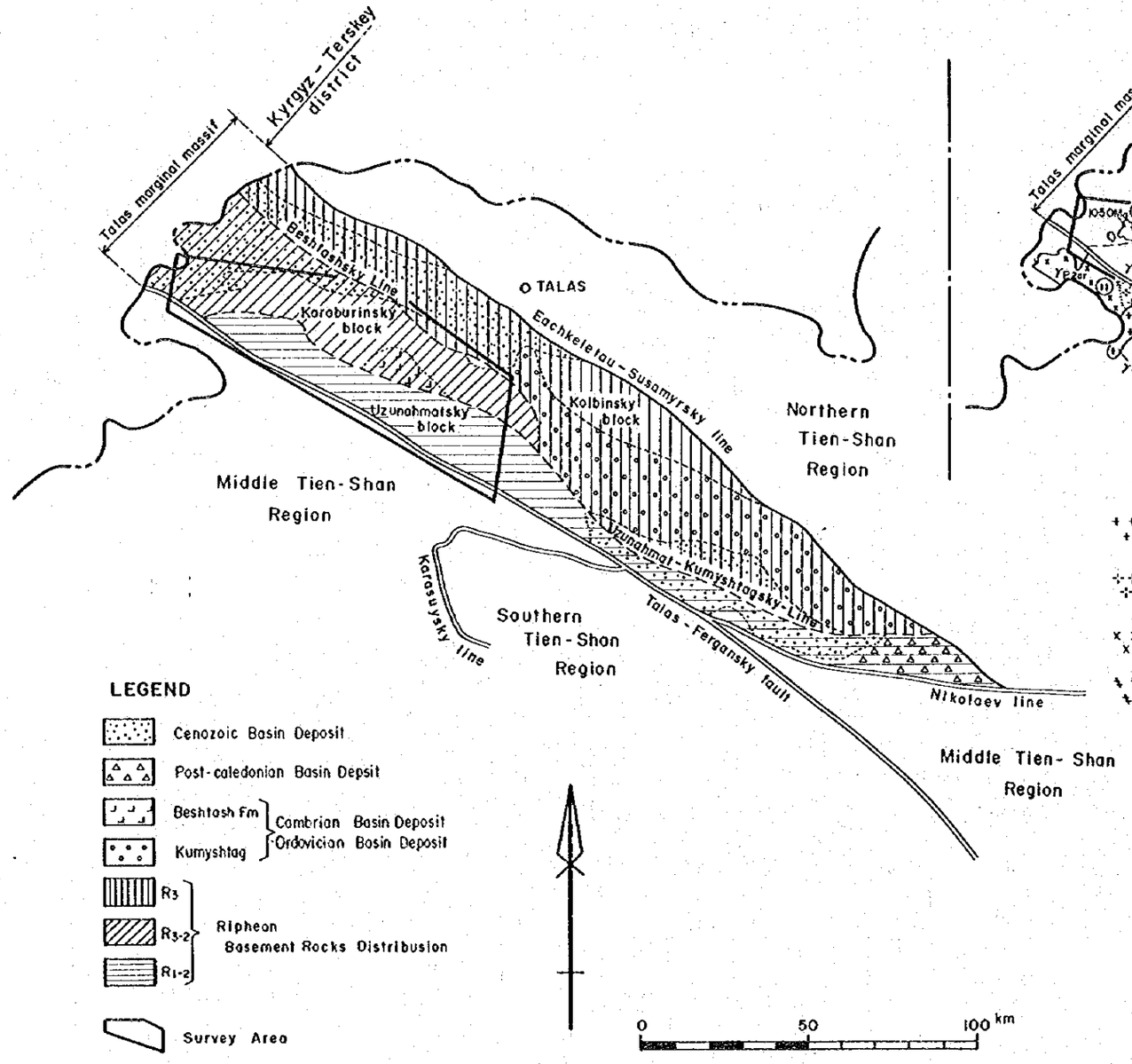
2-1-2 General geology

Basement rock of this survey area is Riphean system of Proterozoic era which was folded in Baikalian stage, is covered with Vendian system, Paleozoic group and Cenozoic group unconformably. The area is bordered on the Middle Tien-Shan massif by the Talas-Fergansky fault in the southern edge of the area, and it is divided into the Uzunahmatsky block and the Karagainsky block by the Uzunahmat-Kumyshtagsky thrust which runs through the central part of the area in west-northwest direction.

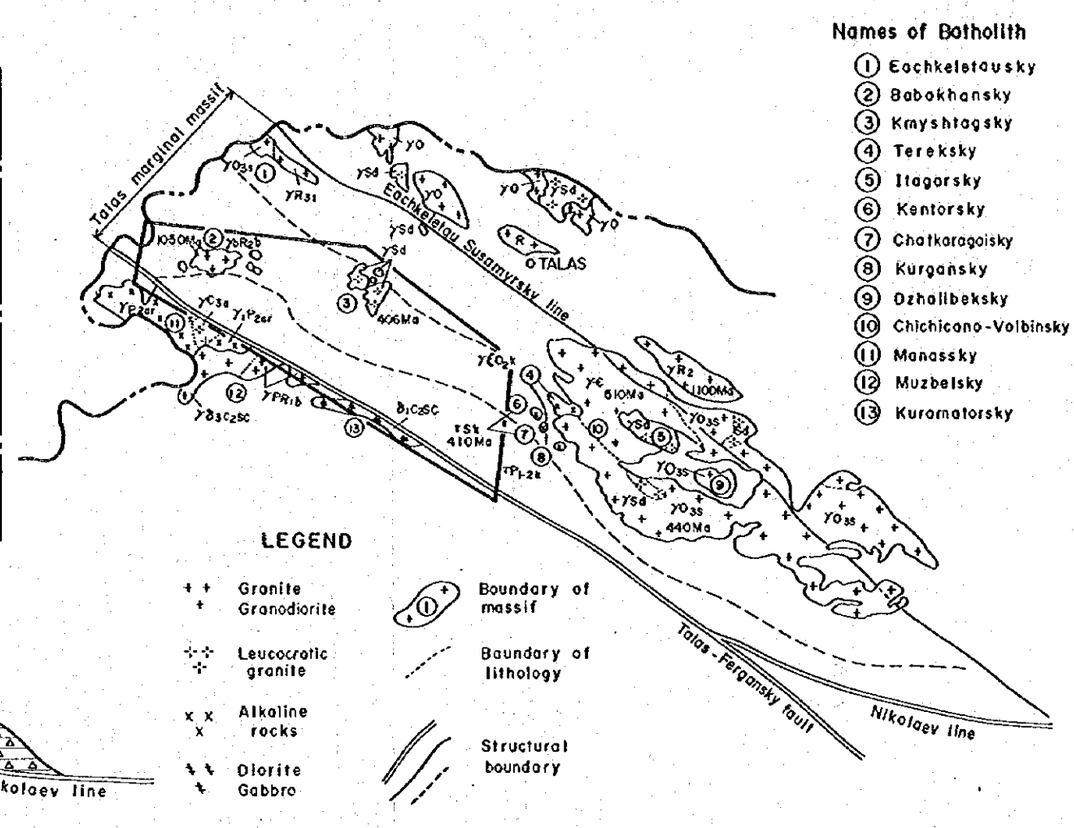
The prominent direction of fold axis and strike is west-northwest, that is, the parallel direction to the main faults mentioned above.

The geological map and profile of the survey area are shown in Fig. II-2-2, the schematic geologic column in Fig. II-2-3, and the stratigraphic columns in Fig. II-2-4.

Geologic Blocks of Talas Area



Batholiths of Talas Area



Names of Botholith

1. Eachkeletausky
2. Babokhansky
3. Kmyshtagsky
4. Tereksky
5. Itagorsky
6. Kentorsky
7. Chatkaragoisky
8. Kurgansky
9. Dzhalibeksky
10. Chichicono-Volbinsky
11. Manassky
12. Muzbelsky
13. Kuromatorsky

AGE		SYMBOL	LITHOLOGY	DISTRIBUTION: Northern Tien-Shan	DISTRIBUTION: Middle Tien-Shan
Permian	U	$\gamma_1 P_2 or$	alkoline granite		(11)
	L	$\chi\tau P_{1-2} k$	alkaline trachite	(8) ?	
Carboni-ferous	U	$\gamma C_3 a$	leucocratic granite		(11)
	M	$\gamma o_3 C_2 sc$	granodiorite		(12)
		$\delta_1 C_2 sc$	granire, diorite, gabboro		(13)
Silurian		γSd	granite, aloskite	(3) (5) (10)	
		$\chi\tau Sk$	alkaline trachite	(6) (7)	
Ordo-vician	U	$\gamma O_3 s$	granite, diorite, adamerite	(1) (9) (10)	
	M	$\gamma\xi O_2 k$	granite, syenite	(4)	
Cambrian	L	$\gamma \epsilon_3 t$	granite, granodiorite	(10)	
Pre-cambrian		$\gamma R_3 t$	granite, granodiorite	(1)	
		$\gamma_a R_2 b$	granite, quartzdiorite	(2)	

Fig. II-2-1 Geologic Blocks and Batholiths of Talas Massif

Age		Symbol	Formation	Intrusive rock
Cenozoic	Quaternary	Q		
	Tertiary – Neogene	N1-2		
	Tertiary – Paleogene	Pkk	Kokturnakskaya Fm.	γSd Kumyshtag batholith (Silurian)
Paleo-zoic	Cambrian-Ordovician	€-O2bc	Beshtashskaya Fm.	
Upper Proterozoic	Vendian	Vkn	Konurtobinskaya Fm.	
		Vkr	Kurganskaya Fm.	
		Vcc	Chichicanskaya Fm.	
	Vendian Riphean	R-Vkz	Kyzylbelskaya Fm.	
	Riphean – Upper	R3ct	Chatkaragaiskaya Fm.	
		R3sr	Sarydzhonskaya Fm.	γσV2b Babakhansky batholith (Riphean)
	Riphean – Middle	R2uz	Uzunahmatskaya Fm.	
	Riphean – Lower	R1-2kb	Karaburinskaya Fm.	

(Modified Geological Map of Kyrghystan)
1:500.000 1980

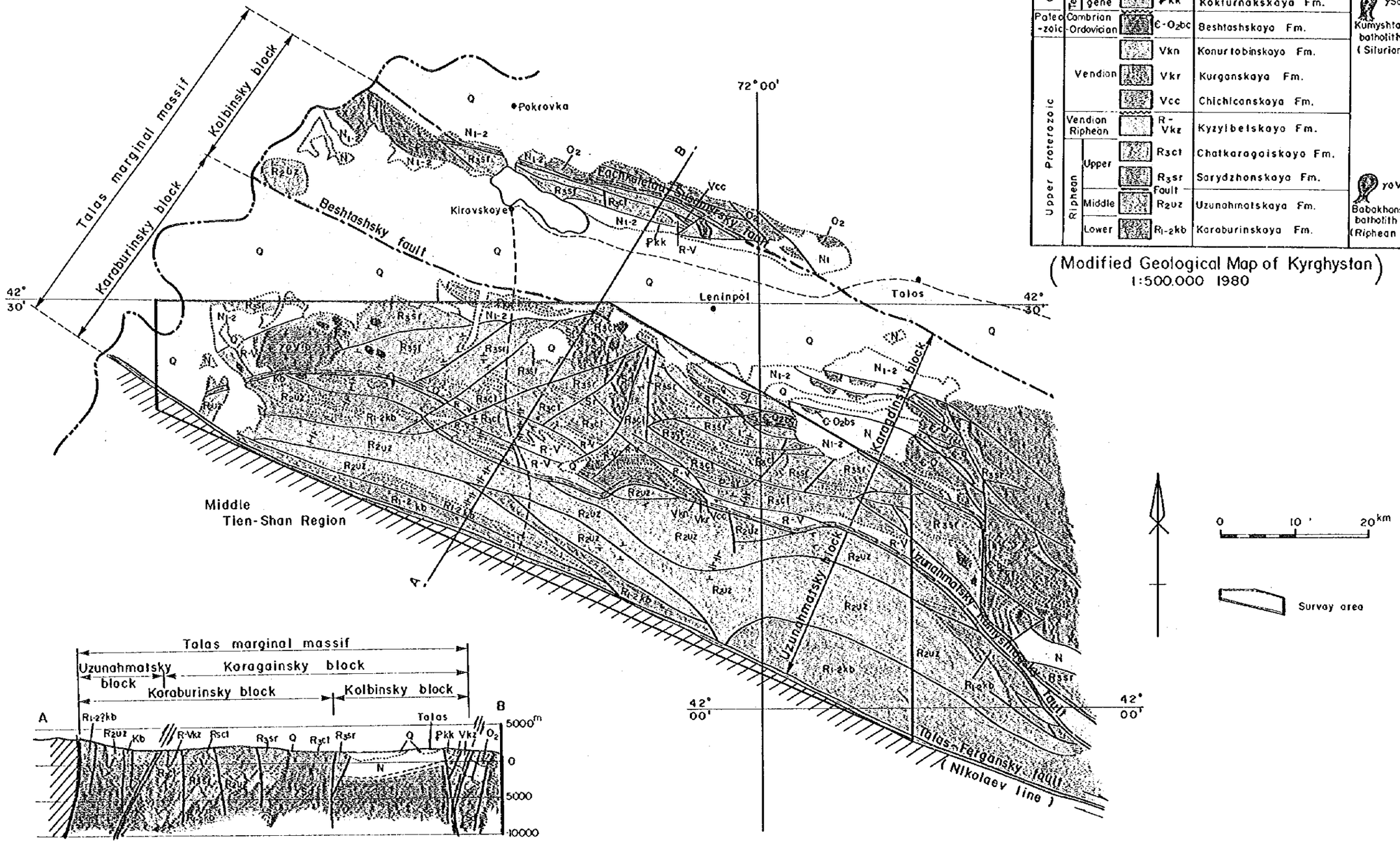


Fig. II-2-2 Geological Map and Profile of the Survey Area

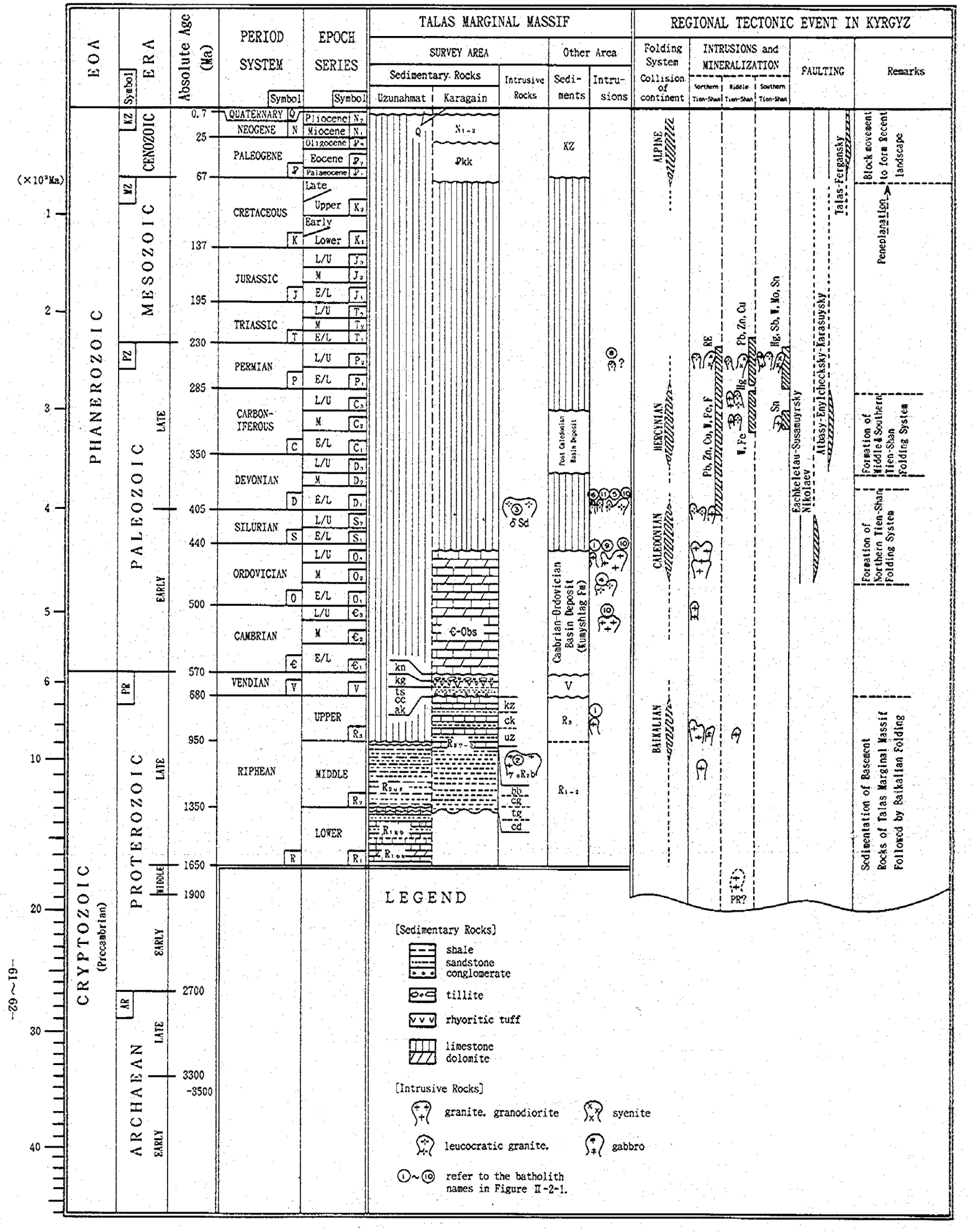


Fig. II-2-3 Schematic Geologic Column of the Survey Area

New Geological Column in Talas Area

AGE			Symbol	Formation Name		Lithology and Stratigraphy ( ): thickness in meter
CENOZOIC	QUATERNARY		N2-Qlsz	Sharphyldakskaya Fm.		conglomerate, clay (>600)
	TERTIARY	Neogene	N2lc	Eachkeletauskaya Fm.	layer 3	clay with thin conglomerate (400)
					layer 2	clay conglomerate (200-350)
					layer 1	conglomerate, clay ≧(550-600)
			N1ul	Ulubashatskaya Fm.		clay, sandstone, (600-700)
		Paleo-gene	Pkk	Kokturnakskaya Fm.		clay, conglomerate (20)
PALEOZOIC	CAMBRIAN-ORDOVICIAN		€-Obs	Beshtashskaya Fm.	Upper	limestone, dolomite (>1250)
					Lower	dolomite, limestone (650-700)
	570Ma					
UPPER PROTEROZOIC	VENDIAN		Vkn	Konurtobinskaya Fm.		tillite, sandstone, conglomerate (55-145)
			Vkg	Kurganskaya Fm.		acidic tuff with layer of rhyolite, clay, sandstone (90-300)
			Vts	Tereksayskaya Fm.		conglomerate, sandstone, siltstone (0-300)
			Vcc	Chichikanskaya Fm.		siltstone, sandstone, flint, with occasional limestone (50-140)
			Vak	Aktugayskaya Fm.		sandstone with basal conglomerate (0-150)
	650Ma					
	RIPHEAN	Upper	R3kz	Kyzylbelskaya Fm.		siltstone and sandstone with occosional basal conglomerate (400)
			R3ck	Chokutashskaya Fm.	layer 2	limestone with layers of siltstone (360)
					layer 1	siltstone and sandstone (300)
			R3uz	Urmaralskaya Fm.	Upper	alt. of limestone and siltstone (650)
					Lower	limestone (600)
			R3bb	Birbulakskaya Fm.	Upper	sandstone, siltstone (390)
					Lower	alt. of cgl, ss, siltst and ls (480)
			R3cg	Chydygoloyskaya Fm.	Upper	alt. of ls and siltst (200)
					Middle	sandstone and siltstone (530)
					Lower	limestone, sandstone, siltst (650)
			R3tg	Tagyrtauskaya Fm.	layer 3	alt. of siltst and ss (500)
					layer 2	sandstone (500)
					layer 1	siltstone (300)
			R3cd	Chondzholskaya Fm.	layer 2	siltstone with thin limestone (250)
					layer 1	sandstone with thin siltstone (450)
	1100Ma					
		Middle	R2uz	Uzunahmatskaya Fm.	Upper layer 3	phyllite (400)
					Upper layer 2	sandstone (350)
					Upper layer 1	phyllite, sandstone, limestone (250)
					Lower layer 3	sandstone (850)
					Lower layer 2	Phyllite, sandstone (250)
					Lower layer 1	phyllite, sandstone, cgl (240)
	1400Ma					
		Lower	R1kb	Karaburinskaya Fm.		alternation of limestone and shale (550)
			R1bk	Bakayrskaya Fm.		crystalline limestone (400)

Flysh Deposits — Tabylgatin Block — Kumyshtag Block — Uznahmat block — Karagain block

Collerated Horizon

Kumyshtag batholith
406±14Ma
(Silurian)
leucocratic granite,
alaskite,
alkaline granite

Babakhansky batholith
1050±50Ma
(R_1～,?)
plagiogranite,
granite porphyry

Geological Column in Talas Area
(after Geological Map of Kyrghystan 1:500,000, 1980)

AGE			Symbol	Formation Name	Lithology and Stratigraphy
CENOZOIC	QUATERNARY	Recent	Qiv		gravel, sand, clay, loam
		Upper	QIII		gravel, sand, clay, loam
		Middle	QII		
		Lower	QI		
	TERTIARY:	Neo-gene	N1-2		conglomerate, sandstone, siltstone, marl, gypsum
		Paleo-gene	Pkk	Kokturnakskaya Fm.	marl, limestone, siltstone, sandstone, conglomerate,
PALEOZOIC	CAMBRIAN-ORDOVICIAN		€-O2bs	Beshtashskaya Fm.	limestone, dolomite
UPPER PROTEROZOIC	VENDIAN		Vkn	Konurtobinskaya Fm.	tillite typed conglomerate
			Vkr	Kurganskaya Fm.	tuff, dacite, with occasional sandstone
			Vcc	Chichicanskaya Fm.	shale, conglomerate, sandstone, occasional conglomerate at base
	RIPHEAN ? VENDIAN		R-Vkz	Kyzylbelskaya Fm.	sandstone, shale with thin limestone
	RIPHEAN	Upper	R3ct	Chatkaragaiskaya Fm.	alt. of sandstone and shale thick limestone at the base
			R3sr	Sarydzhonskaya Fm.	sandstone, siltstone, shale rarely limestone
		Middle	R2uz	Uzunahmatskaya Fm.	phyllite, sandstone, siltstone
		Lower-Middle	R1-2kb	Karaburinskaya Fm.	phyllite, calcareous shale, limestone

Kumyshtag batholith
γ Sd
(Silurian)

γ ₀V?b
Babakhansky Batholith
(Vendian)

Fault

Fig. II-2-4 Stratigraphic Columns of the Survey Area

The summary of stratigraphic relationship and lithofacies are as follows:

(Age)			(Main lithofacies)
Cenozoic	Tertiary - Recent		gravel, sand, silt, clay, gypsum
Paleozoic	Cambrian- Ordovician		limestone, dolomite
Proterozoic	Vendian		conglomerate,sandstone,tuff,tillite
	Ripheian	upper	sandstone, shale, phyllite, limestone
		middle	sandstone, shale, phyllite
		lower	limestone, dolomite

This area is intruded by Babahan intrusive in the western part, and by Kumyshtag intrusive in the eastern part. Babahan intrusive is exposed in the area between Babahan river and Suluu-Bakayir river, whose width is about 6 km in north to south and about 10 km in east to west. It mainly consists of coarse- and fine-grained biotite-plagiogranite. Some part is plagiogranite porphyry. Intrusion of a aplite dike can be seen at the end of the activity. The result of resent absolute age measurement (U/Pb method) shows 1,050±50 Ma, which corresponds to middle to late Riphean (R_2-R_3) (after Geological Institute of the Academy Science, unpublished data).

Kumyshtag intrusive is exposed in the west of the midstream of the Kumyshtag river, where the width is about 10 km in north and south and about 9 km in east and west. It mainly consists of leucoratic granite and alaskite, and some part is diorite. The result of recent absolute age measurement (U/Pb method) shows 406 ±14 Ma, which corresponds to late Silurian (S_3). The results of analyzing nine samples taken from different area all showed Silurian (after Geological Institute of the Academy Science, unpublished data).

2-1-3 Particular stratigraphy

Talas marginal massif is divided into the Uzunahmatsky block and the Karagainsky block by Uzunahmat-Kumyshtagsky thrust, but the stratigraphic relationship between both blocks has not been established. Estimation of sedimentary age is mainly based on comparison of lithofacies and fossil pollen, partly using nannofossils and macrofossils. In late 1980's, new data about accurate absolute age of intrusive rocks are accumulated by the U-Pb method in replace of the old K-Ar method. The stratigraphy and the age determination are improving by these results.

The layer classifications in the 1:500,000 geological map published in 1980, is based on the investigation in 1960~70's. After that, as the result of the investigation and lithofacies comparison of Riphean and Vendian conducted in 1980's, classification at the general level of layers became possible, and the new detailed stratigraphy was established (Fig.II-2-4). But the regional geological map based on the detailed new stratigraphy has not be completed yet. So, the geological map in this report (Fig. II-2-2) follows the 1:500,000 geological map of the old classification published in 1980.

(1) Uzunahmatsky Block

Uzunahmatsky block is a block which ranges between the Uzunahmat-Kumyshtagsky fault and Talas-Fergansky fault in the southern part of the survey area. It consists only of sedimentary rock (carbonate and clastic rock) of lower and middle Riphean. Riphean of this block was divided into the Karaburinsky formation ($R_{1\text{-}2kb}$) mainly consisting of carbonate rock and the Uzunahmat formation (R_{2uz}) consisting of clastic rock in the 1:500,000 geological map . After the 1980's investigation, the Karaburinsky formation is now divided into the Bakayrskaya formation and the Karaburinsky formation.

① Bakayrskaya Formation (R_{1bk})

This formation mainly consists of stratified crystalline limestone and dolomite which are dark or whitish gray. Partly, thin layers of calcareous shale are interbedded. The formation is 400m in thickness.

② Karaburinsky Formation (R_{1kb})

This formation consists of alteration of thin strata (unit thickness: 1~10cm) of limestone and shale whose colors are whitish to dark gray. It is 550m in thickness. It conformably overlies Bakayrskaya formation.

③ Uzunahmatkaya Formation (R_{2uz})

This formation mainly consists of phyllite and sandstone, and is divided into the lower part which is rich in sandstone and the upper part which is rich in phyllite. It conformably covers Karaburinskaya formation at many places. It is inferred that there was no geologic time gap between two formations because some basement conglomerate contains limestone rubble of lower Karaburinskaya formation.

Lower member (1,300m): It consists of gray phyllite which has thin layers of fine-

grained sandstone and ill-sorted sandstone which has thin layers of phyllite. Lenticular conglomerate layers are recognized in some part of the basement.

Upper member (1,000m): It consists of gray phyllite which includes a few thin layers of sandstone and limestone, ill-sorted gray sandstone which includes thin layer of phyllite, and greenish gray phyllite.

(2) Karagainsky Block

This is the block sited in the northern part of the Uzunahmat-Kumyshtagsky thrust. It includes Riphean (carbonate rock and clastic rock), Vendian (tillite, tuff), and Paleozoic (carbonate rock), which are intruded by two granite batholith of Babahan and Kumyshtag. Each rock in Riphean has undergone the strong folding in the Baikalian stage, and sediments after Vendian period clinounconformably cover them.

The Riphean in the Karagainsky block has been considered as upper Ripheian(R_3). But the absolute age (1,050±50 Ma) measured recently at the Babahan intrusive indicates middle Riphean. Accordingly, the sedimentary age and stratigraphic relationship must be reconsidered.

In the 1:500,000 geological map, the Riphean and the Vendian in this block are divided into three formations: the Sardzhonsky formation (R_{3sr}) mainly consisting of clastic rock, the Chatkaragaisky formation (R_{3ct}) where carbonate rock and clastic rock alternate beds, and the Kyzylbelskaya formation ($R\text{-}V_{k_2}$). But, as a result of the investigation in 1980's, they became to be classified into seven formations, which were all renamed except the Kyzylbelskaya formation. As for the Vendian, it was classified into five formations from three formations (Fig. II-2-4).

2-1)Middle-Upper Riphean ($R_{2?-3}$)

(A) Sarydzhonslky Series

This series corresponds to the former Sarydzhonslky formation, and is divided into the following two formations; the Chondzholskaya formation and the Tagyrtauskaya formation. This series mainly consists of sandstone, shale and silt, and rarely limestone.

④ Chondzholskaya formation (R_{3cd})

This formation is classified into the lower member mainly consisting of

sandstone and the upper member mainly consisting of pleochroic siltstone. It is studied in detail at the folding axis of the Chon-Dzhol Valley. This formation is the lowest layer of the Karagainsky block and its basement is not exposed.

Lower member (450m): It consists of ill-sorted sandstone, partly intercalates thin layers of purple siltstone.

Upper member (250m): It consists of pleochronic to green siltstone, and interbeds thin layers of limestone and calcareous sandstone and shale.

⑤ Tagyrtauskaya formation (R_{3tg})

This formation widely ranges in the lower reaches of the Kumyshtag river and the Urmaral river and in the Tagyrtau mountains. The composition of this formation is comparatively simple, which is characterized by alternation of strata of coarse-grained sandstone and siltstone. It is classified into three members, i.e., lower, middle, and upper layer. This formation conformably covers the Chondzholskaya formation.

Lower member (300m): It consists of grayish green siltstone, and interbeds thin layer of fine-grained gray sandstone.

Middle member (500m): It consists of ill-sorted sandstone and grayish green sandstone, and intercalates thin layers of green silt.

Upper member (500m): It consists of alternation of strata of grayish green siltstone and sandstone, and partly intercalates purple siltstone.

(B) Chatkaragainsky Series

This series corresponds to the former Chatkaragainsky formation, and are classified into the following five formations. This series has prominent carbonate rock which intercalates sandstone, shale and siltstone.

⑥ Chydygoloyskaya formation (R_{3tg})

This formation consists of clastic rock and carbonate rock and is classified into three members of the lower, middle and upper. The total thickness of the formation is 1,300m. This formation is conformably covered by the Tagyrtauskaya formation. The composition changes gradually from the sandstone and silt stone of the Tagyrtauskaya formation. The horizon where carbonate rock first appears is the boundary between the Tagyrtauskaya formation and the Chydygoloyskaya formation.

Lower member (650m): It consists of four lithofacies: siltstone intercalated a

layer of sandstone and silty limestone, calcareous siltstone, bedded limestone, and alternation of strata of limestone and calcareous siltstone. The volume of carbonate rock increases with upward.

Middle member (530m): It consists of thin layers of grayish green siltstone and sandstone. The sandstone becomes coarse-grained with upward and the basement of the sandstone includes granule.

Upper member (200m): It consists of sandstone intercalated gray and grayish green calcareous siltstone.

⑦ Birblaskaya formation (R_{3bb})

This formation is named after the Birbulak valley which is located on the left side of the Karagainsky river. It consists of typical flysh sediments. It is divided into two members.

Lower member (480m): It consists of carbonate rock and clastic flysh. Graded bedding consisting of granule conglomerate, sandstone, siltstone and silty limestone accumulates. Each bedding ranges from 0.4 to 5 m in thickness. The thickness of sediment layer increases upwards and gradually changes into the upper member.

Upper member (390m): It consists of alternating beds of clastic flysh, sandstone and shale. Differing from the lower member, each graded bedding lacks a calcareous part and consists of two or three rock facies.

⑧ Urmaraskaya formation (R_{3uz})

This formation mainly consists of dark gray limestone, and also includes calcareous sandstone and siltstone. Cycle of sedimentation of graded bedding comprised calcareous sandstone, limestone and siltstone is observed. It is divided into the upper and the lower member by the feature of intercalated siltstone. Limestone in the basement of this formation conformably covers thin layers of sandstone and shale in the upper Birblaskaya formation.

Lower member (600m): It consists of stratified dark gray limestone, and intercalates siltstone and a few layers of calcareous sandstone.

Upper member (650m): It consists of dark gray limestone, and intercalates purple siltstone and a few layers of sandstone. It is characterized by this intercalating of purple siltstone, and contains the thick silt layer (100m) in the basement.

⑨ Chokutashskaya formation (R_{3ck})

This formation mainly consists of pink limestone and sandstone. This characteristic limestone layer makes it easy to recognize the formation in the field. In this formation, cycle of sedimentation as seen in the lower flysh layer (the Birblaskaya formation or the Urmaraskaya formation) is not recognized. It is divided into two members.

Lower member (300m): It mainly consists of sandstone and siltstone. It is monotonous in comparison with other formations. Grayish green siltstone, and gray and grayish green fine-grained polymictic sandstone (layer thickness: 20~80m) forms alternating beds.

Upper member (360m): Carbonate rock is prominent. It consists of gray, dark gray, black, pink and purple bedding limestone. Pink and purple limestone increases upwards. Gray, purple and green siltstone layers are intercalated in some place.

⑩ Kyzylbelskaya formation (R_{3ck})

This formation consists of dark red, purple, and green siltstone which form alternating beds ranging from 5 to 20 m in intervals. Green and purple siltstone layers intercalate thin layers of fine-grained sandstone (0.2~0.5m). The basement contains sandstone layer and conglomerate layer in some parts.

There are various opinions about interpretation of age and stratigraphy about the Kzylbelskaya formation; it is inferred to be the upper Riphean in some time or the lower Vendian in other time. Though polymictic conglomerate exits in some parts of basement, it is difficult to suppose that there was long time interval or erosion before the sedimentation of the Kzylbelskaya formation, because this formation has a close relationship with the Karagainsky Series beneath it.

This formation is clinounconformably covered with upper formation of the Vendian system with conspicuous erosion.

2-2) Vendian system

Sokolov (1979, 1984) described the Vendian system as "the global group accumulated between the Riphean and the early Cambrian, which has different sedimentary environment and biofacies from the Riphean and the Cambrian." The Vendian system unconformably covers lower formations, and contains the characteristic glacial sediments which can be compared with all the world. At

some horizons, plant microfossils showing the characteristic stromatolite structure are recognized. According to the geological time table of the defunct USSR published in 1978, the Vendian system is situated at the top of Proterozoic and its lower limit is determined to be 650 Ma. This lower limit corresponds to the beginning of the Lapland Glaciation.

In this survey area, this system overlies only in the Karagainsky block with the upper Paleozoic (the Beshtashskaya formation), near the upstream of the Kumyshtag river and the middle of the Urmaral river. It unconformably covers the lower Riphean.

In the 1:500,000 geological map, the Vendian system was divided into three formations of the Cichkanskaya formation, the Kuruganskaya formation and the Konurtbinskaya formation in ascending order. After the later investigation, each formation is divided into two formations. The Vend system is classified into the following six formations.

⑪ Aktugayskaya formation(V_{ak})

The Aktugayskaya formation mainly consists of bedded arkose sandstone and often contains lamina. In basement, it intercalates lenticular greywacke or conglomerate.

The formation ranges from 0 to 150 m in thickness. It unconformably covers the lower Riphean.

⑫ Cichkanskaya formation (V_{ck})

The Cichkanskaya formation mainly consists of siltstone characterized by carbonate rock and silicate rock. Siltstone shows green and fine lamina structures. It intercalates clayey shale, dark gray cherty shale, gray sandstone, stromatolite limestone and dolomite.

The formation ranges from 50 to 140 m in thickness. It conformably covers the Aktugayskaya formation.

⑬ Terekusayskaya formation (V_{ts})

This formation mainly consists of conglomerate and sandstone. In the conglomerate, granule of well-sorted and rounded quartz and granitic rock accumulates over the talus sediment of its basement. At the top of the conglomerate, it gradually changes into sandstone layer containing green and dark red siltstone. The formation remarkably ranges from 0 m to 300 m in thickness.

It unconformably covers the Riphean system, and distributes at various places fragmentary. It conformably cover the Cichkanskaya formation.

⑭ Kuruganskaya formation (V_{kg})

This formation mainly consists of rhyolitic tuff, and intercalates clay and tuffaceous sandstone. It rarely intercalates a layer of extrusive rock such as trachyte or alkali basalt. Tuff is pleochroic and shows lamina structure. Bedded silicified part is recognized in tuff. Conglomerate layers are recognized at some parts of the basement.

The formation usually ranges from 90 to 300 m in thickness, and has a maximum thickness of 700 m. It unconformably covers the Terekusayskaya formation or the Cichkanskaya formation.

⑮ Konurtbinskaya formation (V_{kn})

This formation consists of tillite, conglomerate and sandstone which are glacial sediments. Glacial striations are recognized in tillite.

The formation has a maximum thickness of 145 m. It unconformably covers the Kuruganskaya formation.

2-3) Lower Paleozoic

⑯ Beshtashskaya formation (C-O_{bs})

In the survey area, this formation is distributed with the Vendian system and forms the top of basin formation of the later Baikalian stage.

Marine limestone and dolomite are prominent in this formation. It is divided into the upper and the lower member.

Lower member (700m): It consists of gray and dark gray stratified dolomite and dolomitic limestone.

Upper member (over 1250m): It consists of gray and dark gray stratified dolomite and limestone.

Trilobites of index fossil for the Cambrian period are recognized in limestone near the basement. It unconformably covers the Vendian system.

2-4) Cenozoic

Terrestrial sediment after Paleogene accumulates at the foot of mountains or the plain along valleys.