Chapter 1 Introduction

1-1 Objective of the project

The purpose of the project is to discover new zone of mineralization by defining the mineral potential and geology of the Terektinsky Uplift area (Figure1-1).and at the same time to accomplish technology transfer to the Kazakhstan counterperts.

1-2 Scope of work

Figure 1-2 shows the flow chart of the survey for three years. Table 1-1 and Table 1-2 are the quantities of work involved.

1-3 Survey Area

Terektinsky Uplift area is located in the central part of the Republic of Kazakhstan. The area covers an area of 6,900km^2 between latitude 48° 10'00"N ～ 48° 10'00"N and 67°45'00"E～69°00'00"E (Figure 1-1).

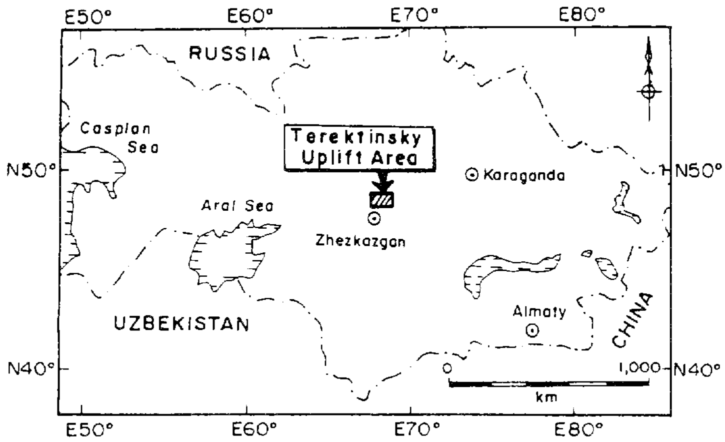
Terektinsky Uplift area is located in the south-west of Central Kazakhstan, approximately 50 km northeast of Zhezkazgan. The southern boundary of the area can be accessed by car from Zhezkazgan along a paved road, and major unsealed roads provide access to the western and eastern sides of the area. Numerous small tracks give four wheel drive vehicle access to the northern boundary and centre of the area.

The topography of the area belongs to the "stage of old age" or "peneplain" topographic classification, and is predominantly characterized by low rolling hills cut by small seasonal drainages. In the western part of the area, where uplifted Carboniferous sediments have been deeply eroded, relief is greatest and elevations range from 372.3 m. to 645.3 m above sea level. In the eastern part of the area, which is underlain by Devonian volcanoplutonic rocks, relief is more moderate and elevations range from 413.6 m to 535.9 m above sea level.

The climate of the survey area is semiarid with sufficient precipitation to support sparse treeless grasslands. The temperature ranges between+33 °C in summer to –33°C in winter. Annual precipitation is 250mm per annum with the wettest months being June. The major vegetation is feathergrass, sagebrush and other grasses. Trees are notable by their total absence.

1-4 Field survey team

Table 1-3 indicates the personnel who comprised the field surveys team.



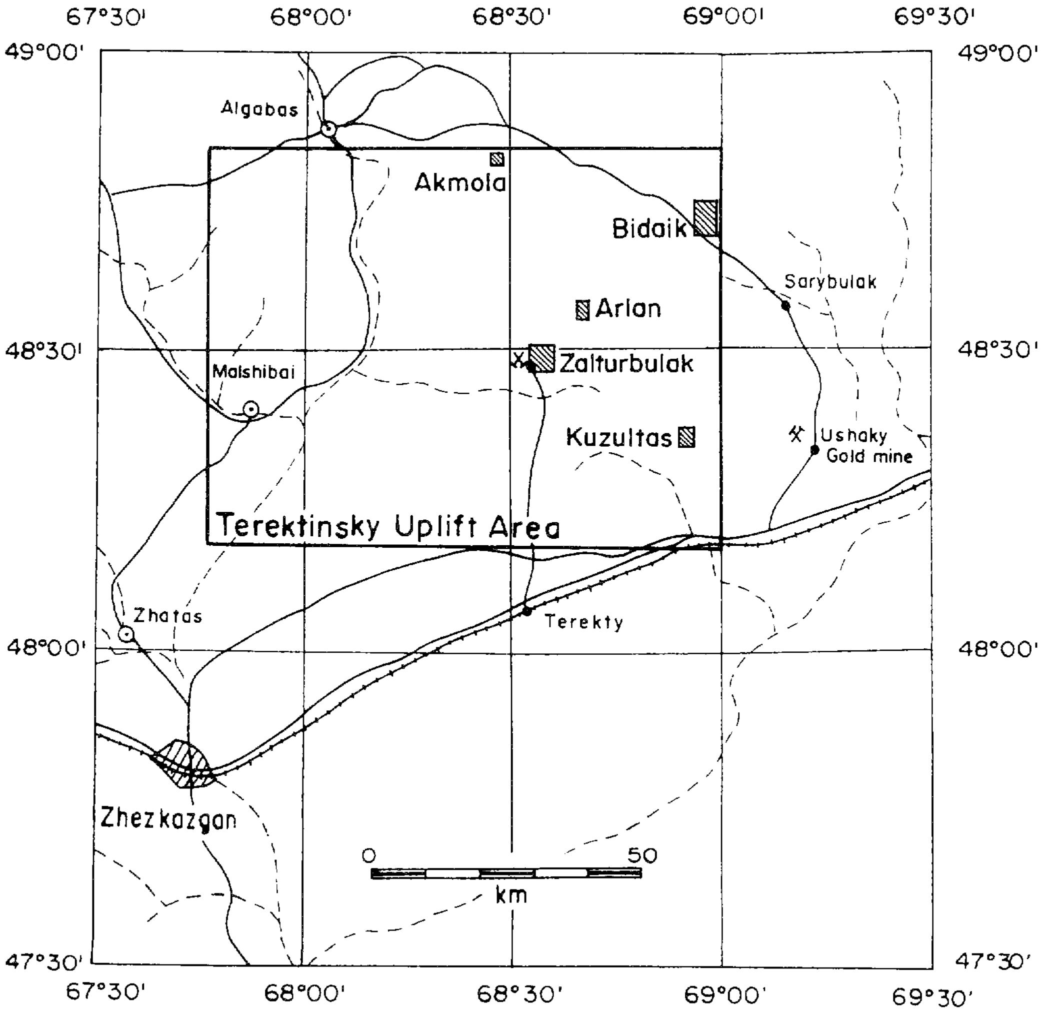


Figure 1-1 Location Map of the Project Area

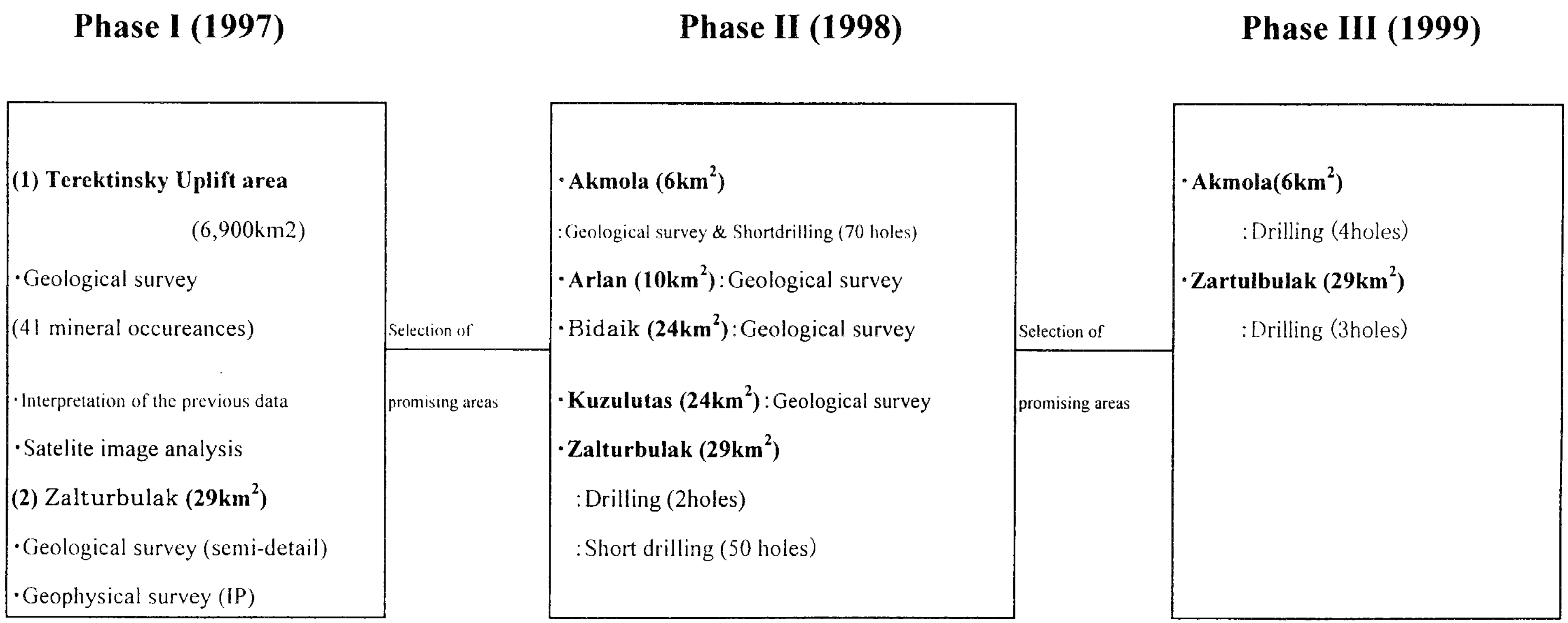


Figure 1-2 Flow Chart of the Terektinsky Uplift area project

Table 1-1 Survey Works

Phase	Survey method	Prospect area	Quantity of field works	
			Area	
PhaseI	Satelite image analysis	All area	6,800km^2	
	Geological survey	41prospects	6,800km^2	
	Geological survey(semi-detail)	Zalturbulak	29km^2	
			Measuring line	Sampling points
	Geophysical suevey(IP)	Zalturbulak	55.7km	497

Phase	Survey method	Prospect area	Quantity of field works	
			Area	
Phase II	Geological survey(semi-detail)	·Akmola ·Bidaik ·Arlan ·Kuzulutas	6 km^2 10 km^2 24 km^2 24 km^2	
			Holes	Total depth (m)
	Short drilling (geochemical exploration)	·Akmola ·Zalturbulak ·Arlan	70 50 2	1370 1400 30
			Holes	Total depth (m)
	Drilling survey	·Central Zalturbulak zone · West of Aktau	1 1	350 350

Phase	Survey method	Prospect area	Holes×Depth	Total depth (m)
Phase III	Drilling survey	· West of Aktau	2×250	500
		·Wetern Zalturbulak	1×300	300
		·Akmola	3×250, 1×288	1038

Table 1-2 List of laboratory tests and measurement

(1) Phase I

Survey method	Item	Number
Geological survey	・Chemical analysis (Au, Ag, Cu, Pb, Zn, Mo)	305
	・Polished thin section	66
	・Thin section	78
	・Fluid inclusion (homogenization temp.)	46
	・X-ray diffraction	77
	・Age dating	4
Geological survey (semi-detail)	・Chemical analysis (Au, Ag, Cu, Pb, Zn, Mo)	161
	・Polished thin section	35
	・Thin section	31
	・X-ray diffraction	51
	・Fluid inclusion (homogenization temp.)	26
	・Age dating	3
Geophysical survey	・Resisitivity	25
	Chargeability	25

(2) Phase II

Survey method	Item	Number
Geological survey	・Chemical analysis of Ore(Au, Ag, Cu, Pb, Zn, Mo)	300
	・Polished thin section	40
	・Thin section	35
	・Fluid inclusion (homogenization temp.)	6
	・X-ray diffraction	25
	・Age dating	3
Short drilling	・Chemical analysis of Ore(Au, Ag, Cu, Pb, Zn Mo)	450
	・Polished thin section	40
	・Thin section	10
	・X-ray diffraction	10
Drilling	・Chemical analysis of Ore(Au, Ag, Cu, Pb, Zn, Mo)	400
	・Polished thin section	40
	・Fluid inclusion (homogenization temp.)	6
	・Thin section	10
	・X-ray diffraction	20

(3) Phase III

Survey method	Item	Number
Drilling	・Chemical analysis of Ore(Au, Ag, Cu, Pb, Zn, Mo)	850
	・Chemical analysis of Ore(S)	74
	・Polished thin section	50
	・Thin section	50
	・Fluid inclusion (homogenization temp. & salinity measurment)	10
	・X-ray diffraction	40
	・whole rock analysis	9
	・Age dating	5

Table 1-3 Survey team

Phase	Japan	Republic of Kazakhstan
Phase I	Mr.Mitsuru Suzuki (Leader) Mr.Takaaki Nagao (Geologist) Mr.Goto Motomu (Geologist) Mr.Steven Luke Wolliamson (Geologist) Mr.Hiroyuki Ii (Chief Geophysist) Mr.Jyunnichi Sasaki (Geophysist) Mr.Zdenek Duchoslav (Geophysist)	Dr. Yriy Vasilenko (Chief Geophysist) Dr. Malik Rakhymbayev (Chief Geologists) Mr.Sergey Yaskevich (Geophysist) Mr.Askar Kazybekov (Geologist) Mr.Alexey Novikov (Geologist) Mr.Marat Usipbayev (Geologist) Mr.Oleg Solovyev (Geophysist) Mr.Dmitriy Danilin (Geophysist)
Phase II	Mr.Mitsuru Suzuki (Leader) Mr.Takaaki Nagao (Geologist) Mr.Norio Ikeda (Geologist) Mr.Kazuhiro Yamamoto (Geologist)	Dr. Yriy Vasilenko (Chief Geophysist) Dr. Malik Rakhymbayev (Chief Geologists) Mr.Sergey Yaskevich (Geophysist) Mr.Askar Kazybekov (Geologist) Mr.Alexey Novikov (Geologist) Mr.Marat Usipbayev (Geologist) Mr.Dmitriy Danilin (Geophysist)
Phase III	Mr.Mitsuru Suzuki (Leader) Mr.Takaaki Nagao (Geologist)	Dr. Yriy Vasilenko (Chief Geophysist) Dr. Malik Rakhymbayev (Chief Geologists) Mr.Askar Kazybekov (Geologist) Mr.Marat Usipbayev (Geologist)

Chapte 2 Geology and mineralization in the Central Kazakhstan

2-1 Regional geological setting

In present day Central Kazakhstan, the Precambrian massifs, Paleozoic fold belts and related granitic plutons form an arch, convex to the northwest, with rock ages decreasing to the southeast (Figure2-1).

In the Paleozoic rocks, five fold systems have been identified which are interpreted to be the result of the progressive subduction of Cambrian oceanic crust beneath Precambrian massifs, commencing in the Late Ordovician and continuing, with various relocations of the subduction zone, up to the Late Carboniferous (Glukhan and Serykh, 1996). Initially, the subduction occurred along the rim area of Turkestan sea in eastern Kazakhstan. Later, other subduction zone appeared in the southern part of Central Kazakhstan. As the result of this, Central Kazakhstan have been taken lateral compression from south.

The Hercynian orogenies, (which involved continental collision that joined Europe and Asia), extended from the Middle Carboniferous into the Early Permian, and are interpreted to have resulted in a NNE-SSW directed compression of the region. The fold belts are believed to have formed linear zones, but later underwent bending and lateral displacement along major strike-slip shear zones. The Terektinsky uplift area lies at a major bend in the Caledonian fold belt .

The Terektinsky Uplift area is located within the Sarysu-Teniz Block Fault sytem which lies between the Late Paleozoic Teniz and Zhezkazgan basins. The Sarysu-Teniz zone consists of alternating, relatively long but narrow, horst-anticlines and graben-synclines trending northwest, cut by closely spaced sub-parallel reverse faults trending approximately east-west (Khain,1985). The cores of the horst-anticlines contain Precambrian and Early Paleozoic basement while the graben-synclines consist generally of tightly folded Upper Devonian carbonates. Lower-Middle Devonian volcanic molasse separate the basement from the Upper Devonian rocks.

2-2 Metallogeny of the Central Kazakhstan

A general outline of the mineral resources of Central Kazakhstan, including a description of metallogenic zones, metallogenic epochs, and deposit types, is presented in Malchenko and Ermolov (1996). The Terektinsky Uplift area lies in the Koktas-Sonaly metallogenic zone which contains Late Caledonian epoch tungsten, tin, molybdenum, copper, and gold mineralization hosted by Devonian volcanoplutonic rocks. The known tungsten, tin and molybdenum mineral occurrences are small and of sub-economic grade (by previous Soviet standards), and are therefore not considered an attractive exploration target. The Koktas-Sonaly metallogenic zone is believed to have a greater potential for economic copper-molybdenum and gold mineralization as, over the last decade, porphyry copper-molybdenum-gold, and quartz vein gold deposits have been found elsewhere in Central Kazakhstan's Devonian volcanoplutonic rocks

The main styles of mineralization noted in Central Kazakhstan's Devonian volcanoplutonic rocks are:

1. Samarsky type, copper (Cu)-gold porphyry style mineralization related to the contact between volcanogenic sedimentary rocks and Middle Devonian porphyritic granitic intrusions
2. Ushoky type, vein style, quartz-sulphide-gold (Au) mineralization hosted by Lower Devonian volcanic rocks, with a possible association to Upper Devonian granitic intrusives
3. Granite related, quartz-cassiterite, cassiterite-tourmaline, and cassiterite-sulphide, tin (Sn) mineralization, and
4. Granite related, tungsten (W) and molybdenum (Mo) occurrences

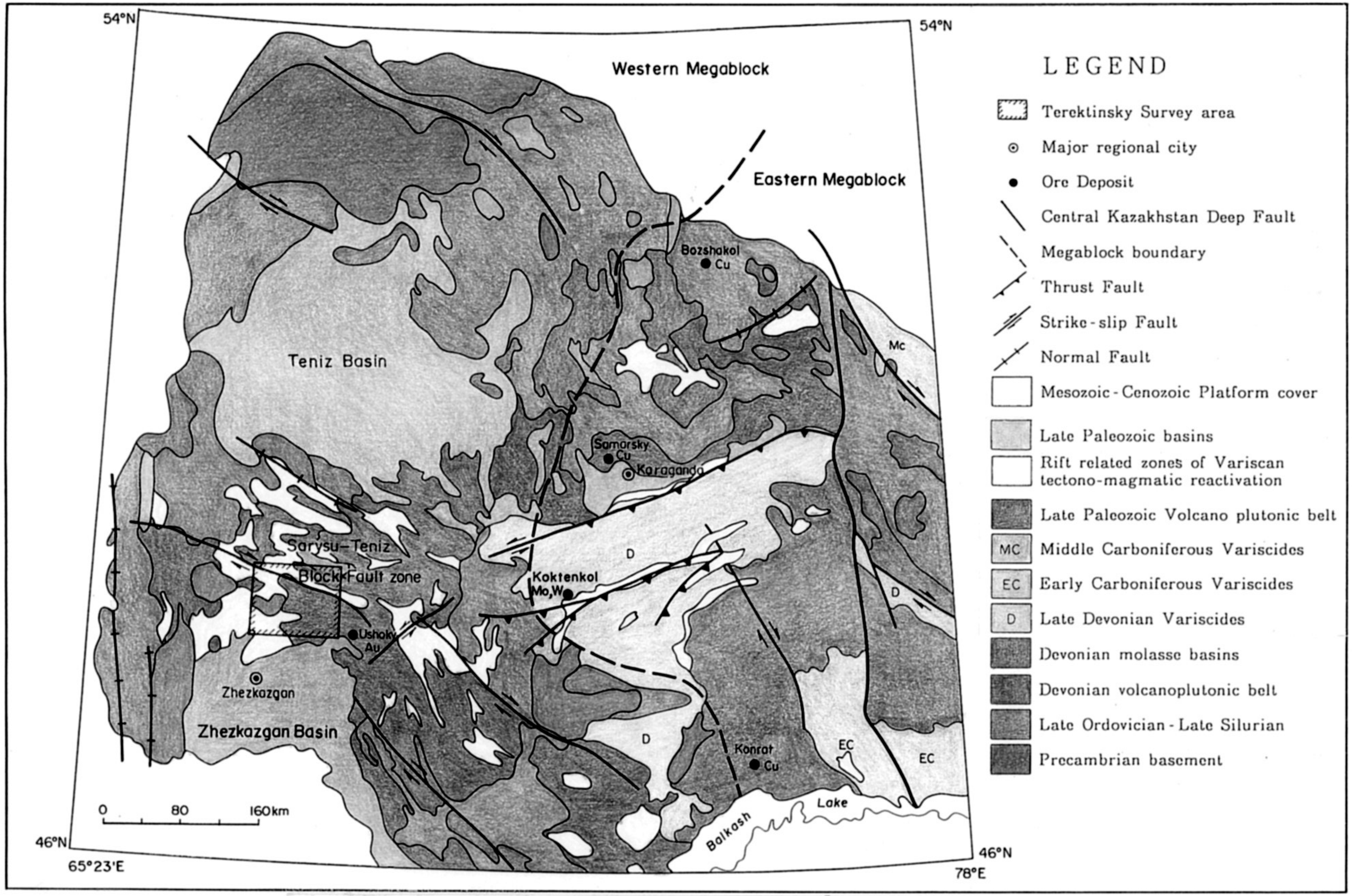


Figure 2-1 Geological Map of Central Kazakhstan

(modified after Orlov, Kondrashenkov, Shchebunyaev, in Glukhan and Serykh,1996)

Chapter 3 Geology of the Terektinsky Uplift area

3-1 Image Interpretation of LANDSAT/TM Data

Prior to the field investigation in Phase I survey, to grasp the regional geology and geological structure, false color and ratioing images were composed using LANDSAT/TM data.

(1) Satellite image data used and Image data processing

1) Image data

The following LANDSAT/TM data were selected as the best quality image covering the investigation area:

- Path : 156, Row : 026
- Image acquisition : 07/12/86
- Scene ID : LT5156026008619310

2) Composite images

Production of color composite images by using false color and ratioing images was carried out in order to extract geologic information from them. TM bands 1(assigned Blue), 4(assigned Green) and 5(assigned Red) were selected as the best band combination for the false color image by taking into account the reflectance behavior of surface materials such as soils and rocks and high spectral contrasts between neighboring pixels. Ratioing image process was performed by using the ratios 3/1(assigned Blue) and 5/4(assigned Green) to discriminate iron oxides, and the ratio 5/7(assigned Red) to discriminate clay minerals.

3) Image data processing

Image data processing applied to these composite images are as follows:

- Format transformation
- Quality checking of original data
- Geometric correction referring to "Navigation Chart"
- Trimming investigation area
- TM band selection(B:G:R=1:4:5)
- Rating(B:G:R=3/1:5/4:5/7)
- Contrast stretch
- Edge enhancement
- Annotation

・Positive film generation

(2) TM image interpretation

The false color and rating images are shown in Figures 3-1 and 3-2 respectively. Geologic unit discrimination, geologic structural extraction, lineament extraction and alteration zone extraction were carried out on the generated images. Geological interpretation chart, Geological unit interpretation map and Geological structural interpretation map are shown in Table 3-1, Figure 3-3 and Figure 3-4 respectively. These results were evaluated by groundtruth.

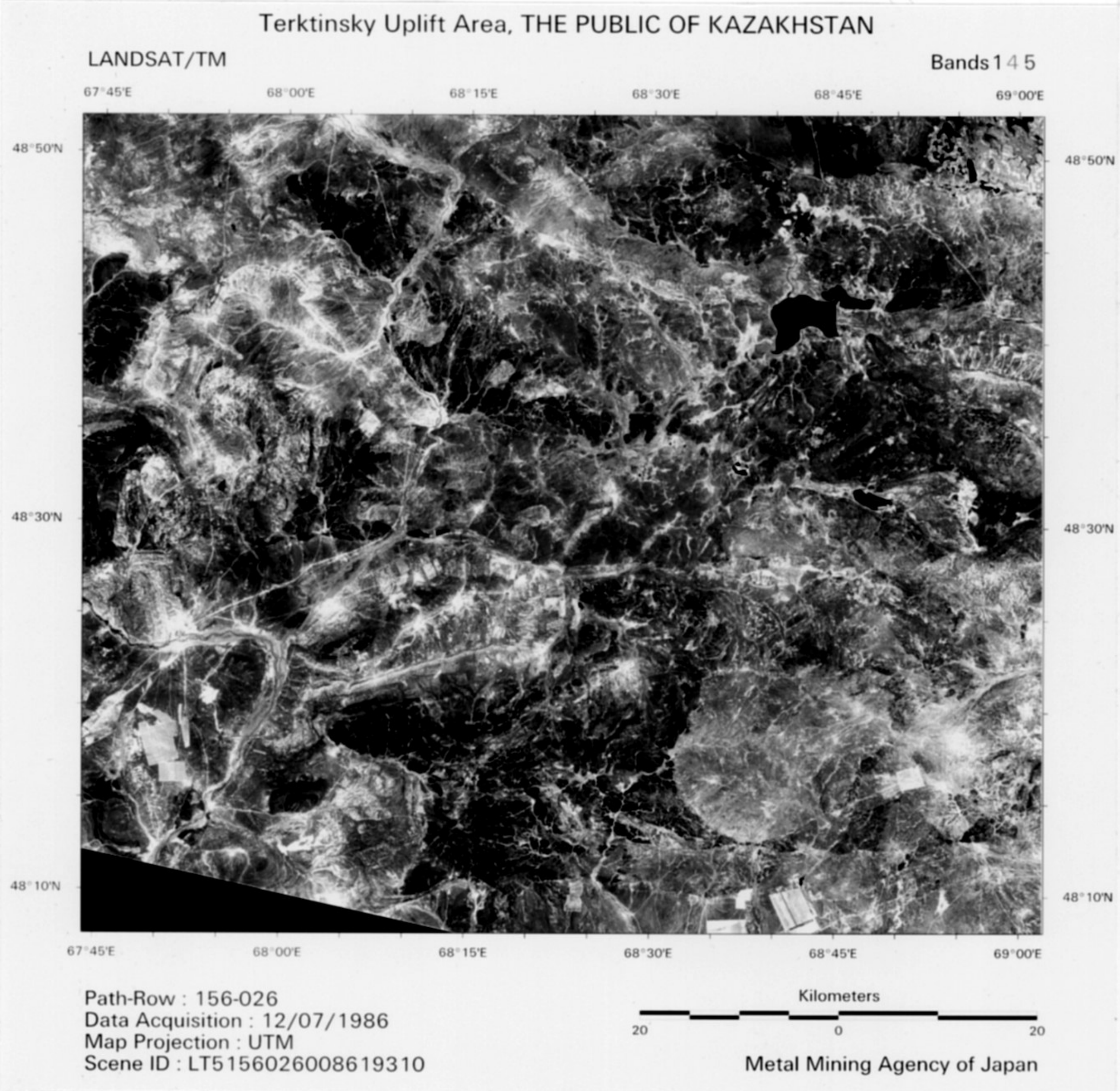


Figure 3-1 LANDSAT/TM False Color Image

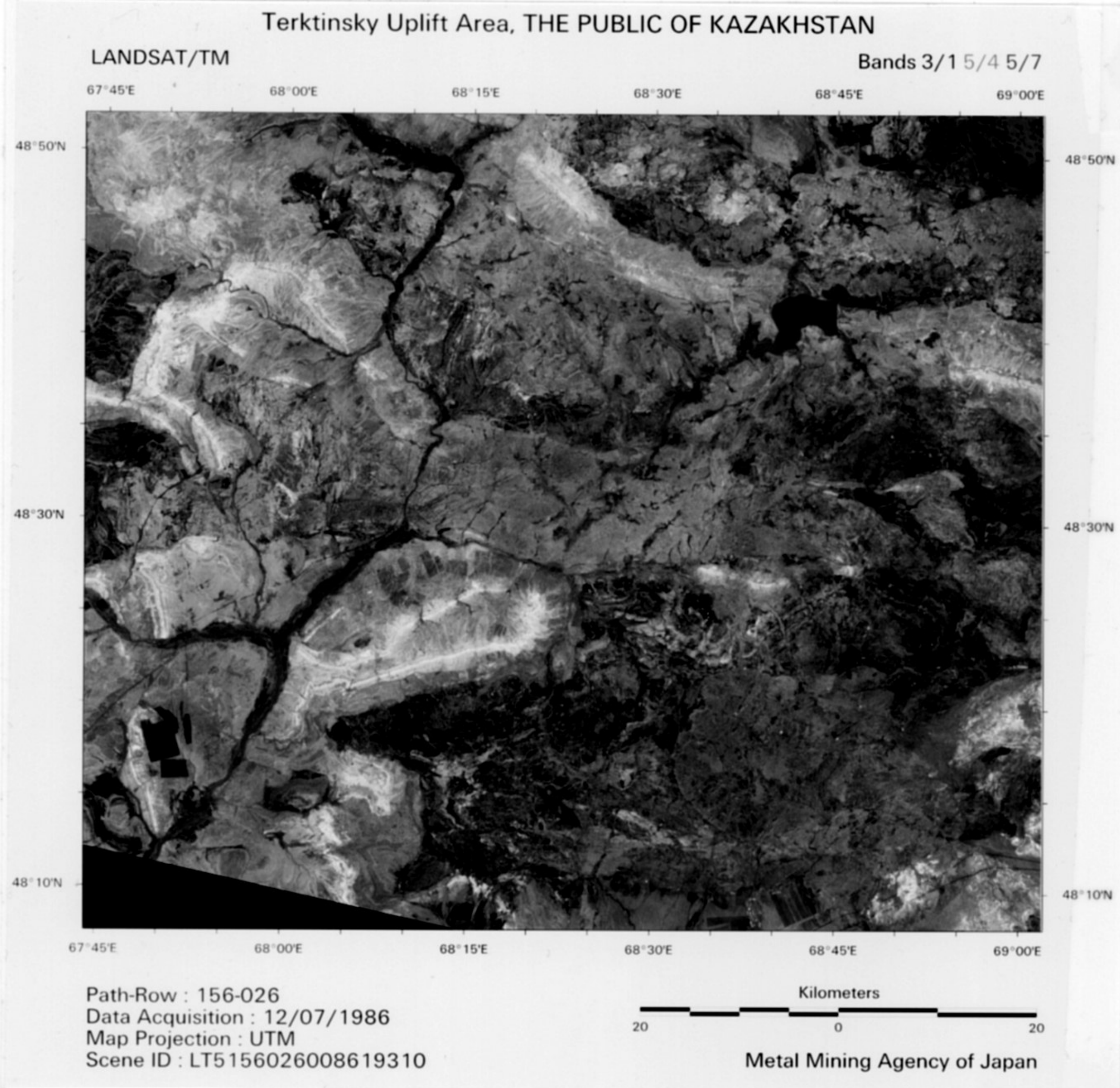


Figure 3-2 LANDSAT/TM Ratioing Image

Table 3-1 Geological Interpretation Chart

Geologic Unit	Tone *1	Pattern	Density	Resistance	Texture	Landuse	Vegetation	Remarks	Comparison *2
Q	green, white	none	very high	very low	none	little	sparse	stream sediments, evaporites	Q(Quaternary)
P	reddish brown	dendritic	low	low	smooth	very poor	none	well bedded	P(Permian)
C	Orange	parallel	very high	high	very rough	very little	very poor	well bedded	C(Carboniferous)
D3	purple	subdendritic, parallel	high	intermediate	rough	very little	very poor	bedded	D3(Upper Devonian)
D2	dark brown	subdendritic	moderate	intermediate	smooth	none	very poor	well bedded	D2(Upper Devonian)
D1b	brown	subdendritic	high	intermediate	rough	very little	very poor	bedded, dykes	D1(Lower Devonian)
D1a	dark brown (bluish)	dendritic	high	intermediate	rough	none	very poor	poor bedded, dykes	D1(Lower Devonian)
S	reddish brown	subdendritic	high	low	smooth	very little	very poor		S(Silurian)
O	purple	subdendritic	high	low	smooth	very little	very poor	mottle	O(Ordovician)
I3	light grey	subparallel	high	intermediate	rough	very little	very poor	intrusive-like, dykes	D2-3(Upper Devonian)
I2	yellowish brown	subparallel	very high	intermediate	rough	very little	very poor	intrusive-like, dykes	D2-3(Upper Devonian)
I1	greenish brown	radial, parallel	very high	intermediate	smooth	little	very poor	intrusive-like, dykes	D2-3(Upper Devonian)

*1) Tone on LANDSAT/TM false color image

*2) Compared with "Regional Geological Map of the Tretinsky Uprift Area"

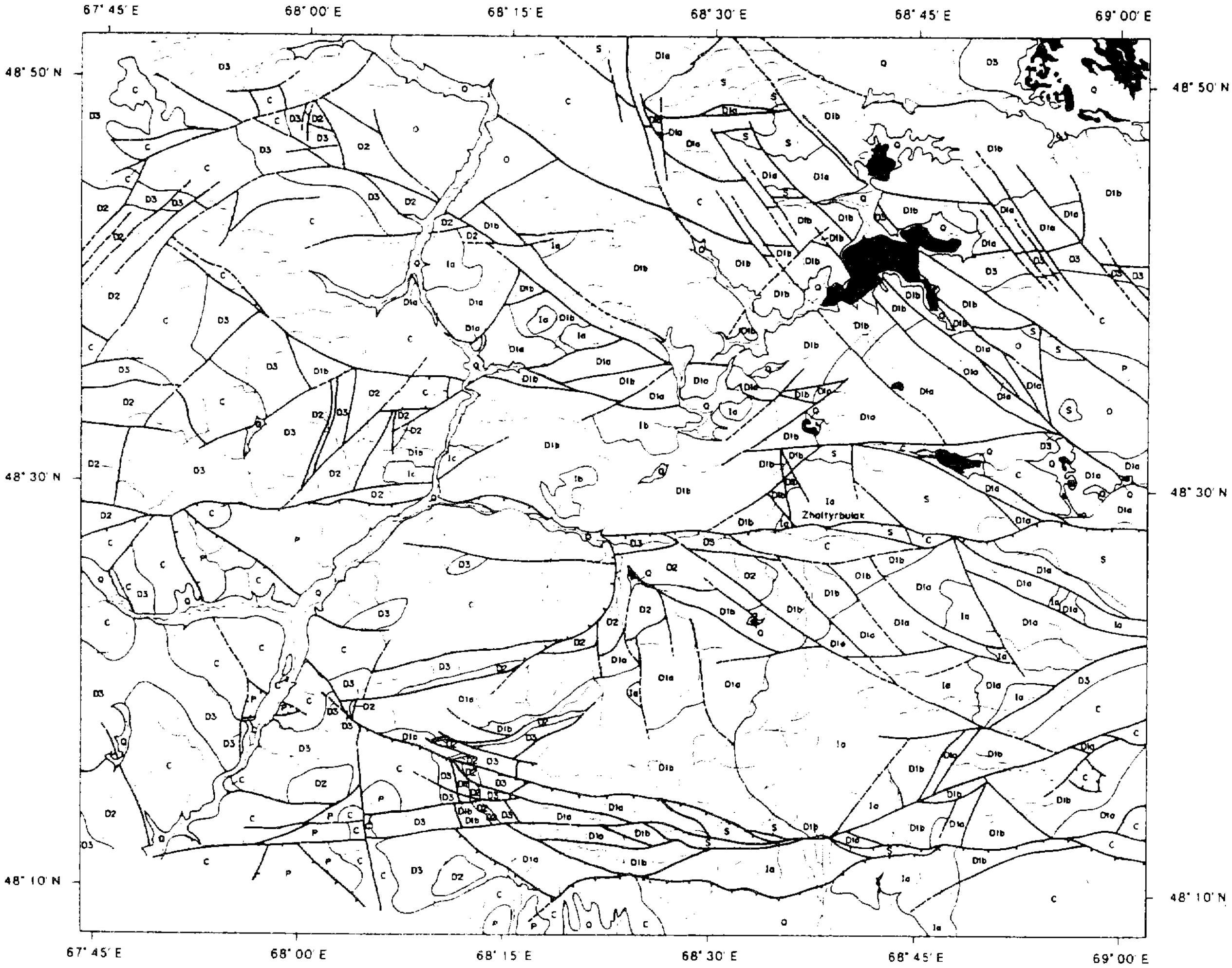


Image Data used : LANDSAT/TM
Path-Row : 156-026
Data Acquisition : 12/07/1986
Map Projection : UTM
Scene ID : LT5156026008619310

Kilometers
20 0 20

Metal Mining Agency of Japan

LEGEND

Geologic unit boundary

D1a Geologic unit name

Fault(certain/inferred, thorn showing younger block)

Drainage

Lake/pond

Figure 3-3 Results of Geologic Unit Interpretation

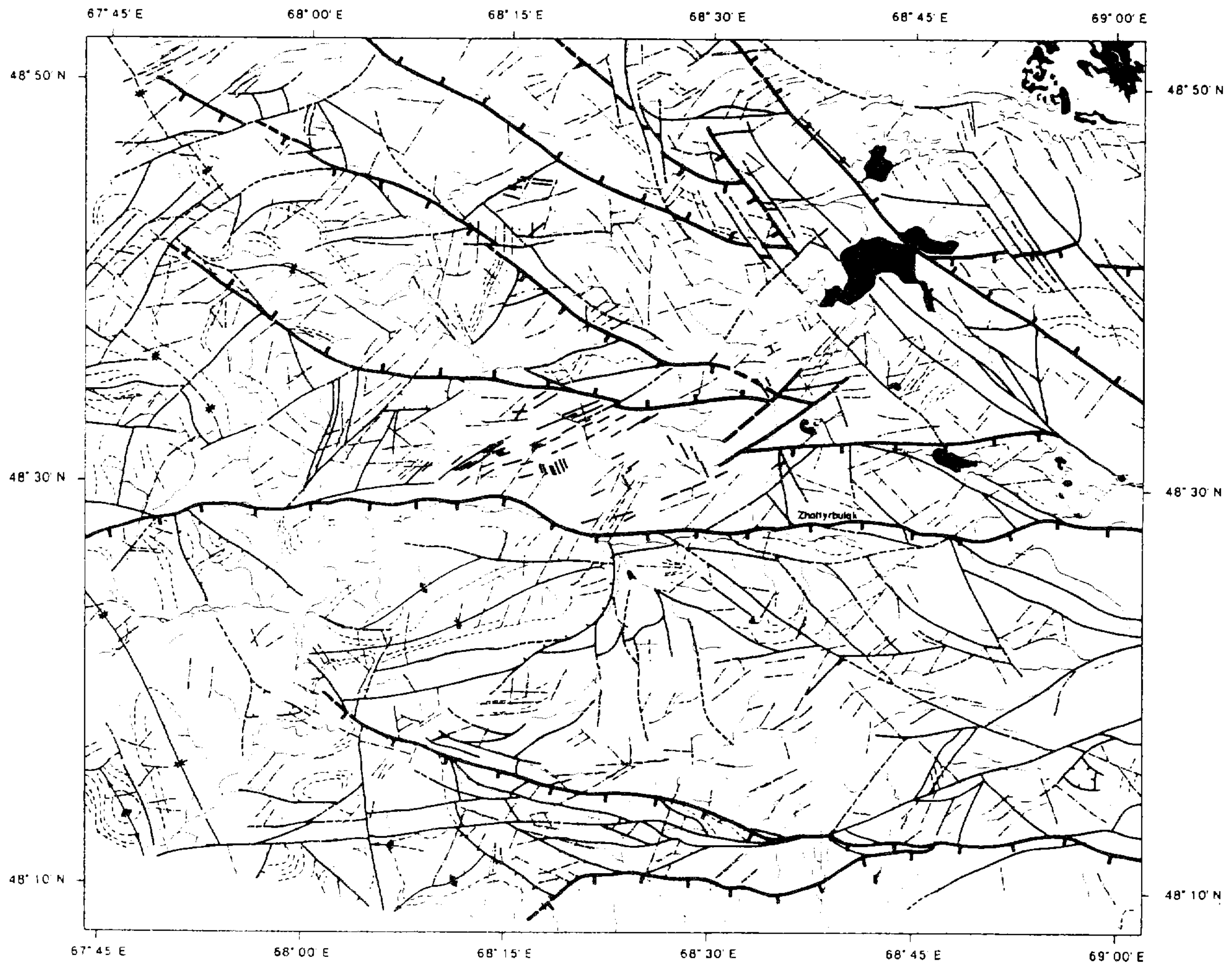


Image Data used : LANDSAT/TM
Path—Row : 156—026
Data Acquisition : 12/07/1986
Map Projection : UTM
Scene ID : LT5156026008619310

Kilometers
20 0 20

Metal Mining Agency of Japan

LEGEND

- Major fault(certain/inferred, thorn showing younger block)
- Minor fault(certain/inferred, thorn showing younger block)
- Anticlinal axis (with plunging direction)
- Synclinal axis (with plunging direction)
- Lineament
- Dyke
- Bedding trace
- Drainage
- Lake/pond

Figure 3-4 Results of Geologic Structural Interpretation

3-2 Geology of the Terektinsky Uplift Area

3-2-1 Geologic Setting

The Terektinsky Uplift area is located within the Late Paleozoic Sarysu-Teniz Block Fault system which consists of alternating, long but narrow, horst-anticlines and graben-synclines trending northwest, cut by closely spaced sub-parallel reverse faults trending approximately east-west (Khain, 1985). In the Terektinsky survey area, the cores of the horst-anticlines contain Precambrian and Early Paleozoic basement, while the graben-synclines consist generally of folded Upper Devonian and Lower Carboniferous carbonates and shallow marine sediments. Igneous rocks, which intruded Early Paleozoic basement during the Ordovician and Lower to Middle Devonian, are exposed in the horst-anticlines. The igneous rocks primarily belong to the Devonian volcano-plutonic belt which formed during the Caledonian orogenic phase in Central Kazakhstan.

3-2-2 Stratigraphy

The stratigraphy of the survey area consists of Proterozoic basement, Ordovician volcanics and sediments, Lower to Middle Devonian volcanics, pyroclastics and interbedded sediments, Upper Devonian and Lower Carboniferous carbonates and sediments, and unconsolidated Quaternary alluvial and lacustrine sediments. A schematic columnar section of the stratigraphy in the survey area is presented in Figure 3-5 and Figure 3-6 and Figure 3-7 present a geological map and geological cross sections of the survey area respectively. The detailed description of each formation was shown in Phase II report.

(1) Proterozoic Era

The oldest rocks in the survey area belong to a block of uplifted Precambrian basement. They outcrop in the western half of the survey area, and according to previous regional geological mapping, consist of Lower Proterozoic porphyrite and chlorite-sericite-albite schist, and Lower-Middle Riphean quartz-sericite and quartz-chlorite schist.

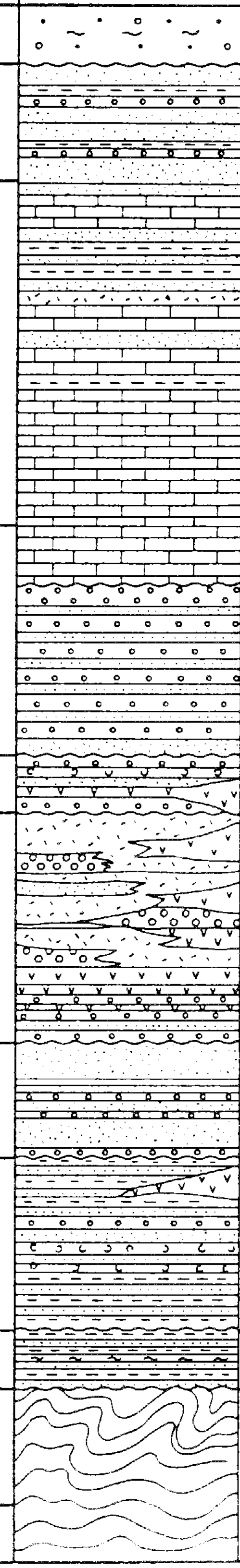
(2) Paleozoic Era

1) Ordovician System - Middle and Upper Ordovician Series (O_2 and O_3)

These series occur in the northwest and center of the survey area in horst blocks, and are believed to be oldest Paleozoic rocks in the survey area. The Middle Ordovician series (O_2) consists of sandstones and siltstones with lenses of limestone and andesite-

Geologic Age			Symbol	Russian Formation Symbol	Thickness (m)	Lithology	Tectonic Event
Cenozoic	Quarternary		QI-QIII	Q	1-10	Undifferentiated clay, sand, gravel and loam	Stable platform
Paleozoic	Carbon-ferous	Upper-Middle	C	C2-3dz	365-630	Postorogenic marine terrigenous and carbonate sequence: limestone, sandstone, siltstone and conglomerate	Basin and trough formation by tectono-magmatic reactivation
				C2ts			
		Lower		C1Bl	150-250		
				C1dl			
				C1jag			
				C1is			
				C1rg	100-250		
				C1ks			
	Devonian	Upper	D3	D3slsm	200-500		
				D3ut	200-1200		
				D3zd	800-1000		
				D3dz	1000		
		Middle	D2	D2tl	2400	Synorogenic intermontane basin sequence: conglomerate, sandstone, rhyolite, rhyodacite, andesite-basalt tuff and lava	Subduction
		Lower	D1a	D1uz	900		
			D1b	D1z:	600		
				D1tz	1125		
			D1c	D1ut	930-1550		
	Ordovician	Upper	O3	O3	1800	Geosynclinal marine sedimentary sequence: sandstone, siltstone, conglomerate tuff and andesite-basalt lava	Rifting
				O3krb			
		Middle	O2	O2al	1500		
				O2sv	600		
				O2kt	600		
		Lower		O1-2ks	500		
Proterozoic	Riphean	Middle-Lower	PR	R1-2		Quartz-sericite and quartz-chlorite schist and porphyrite	Metamorphism
	Lower Proterozoic			PR1			

Columnar Section



Igneous Activity / Mineralization

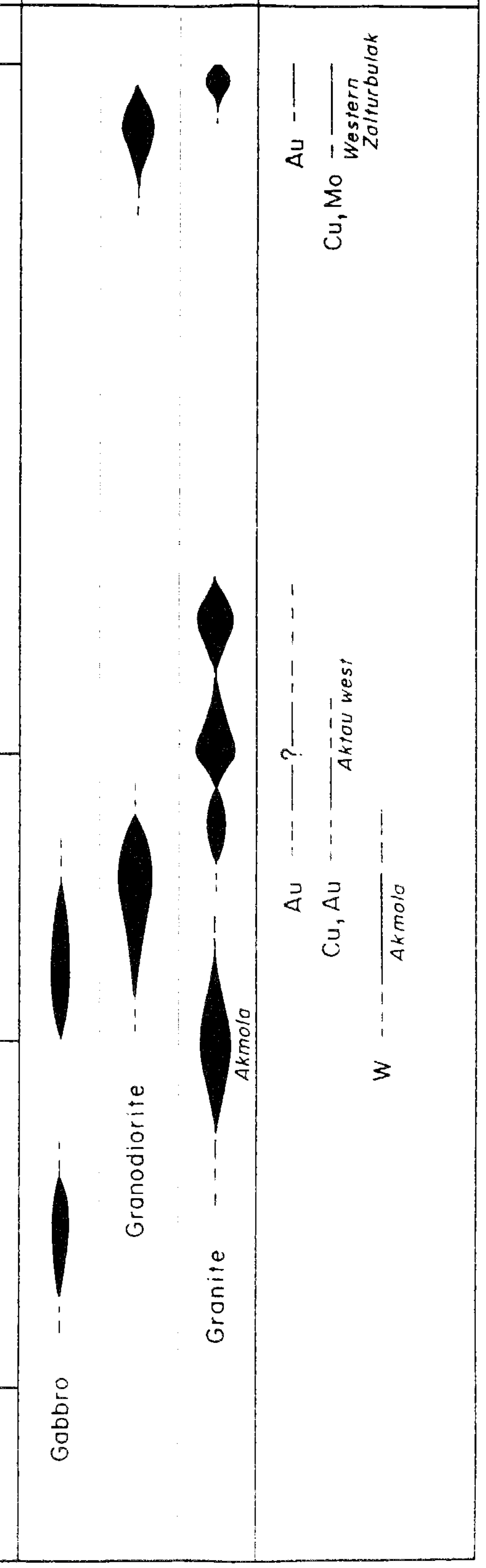


Figure 3 5 Columnar Section of Terektinsky Uplift Area

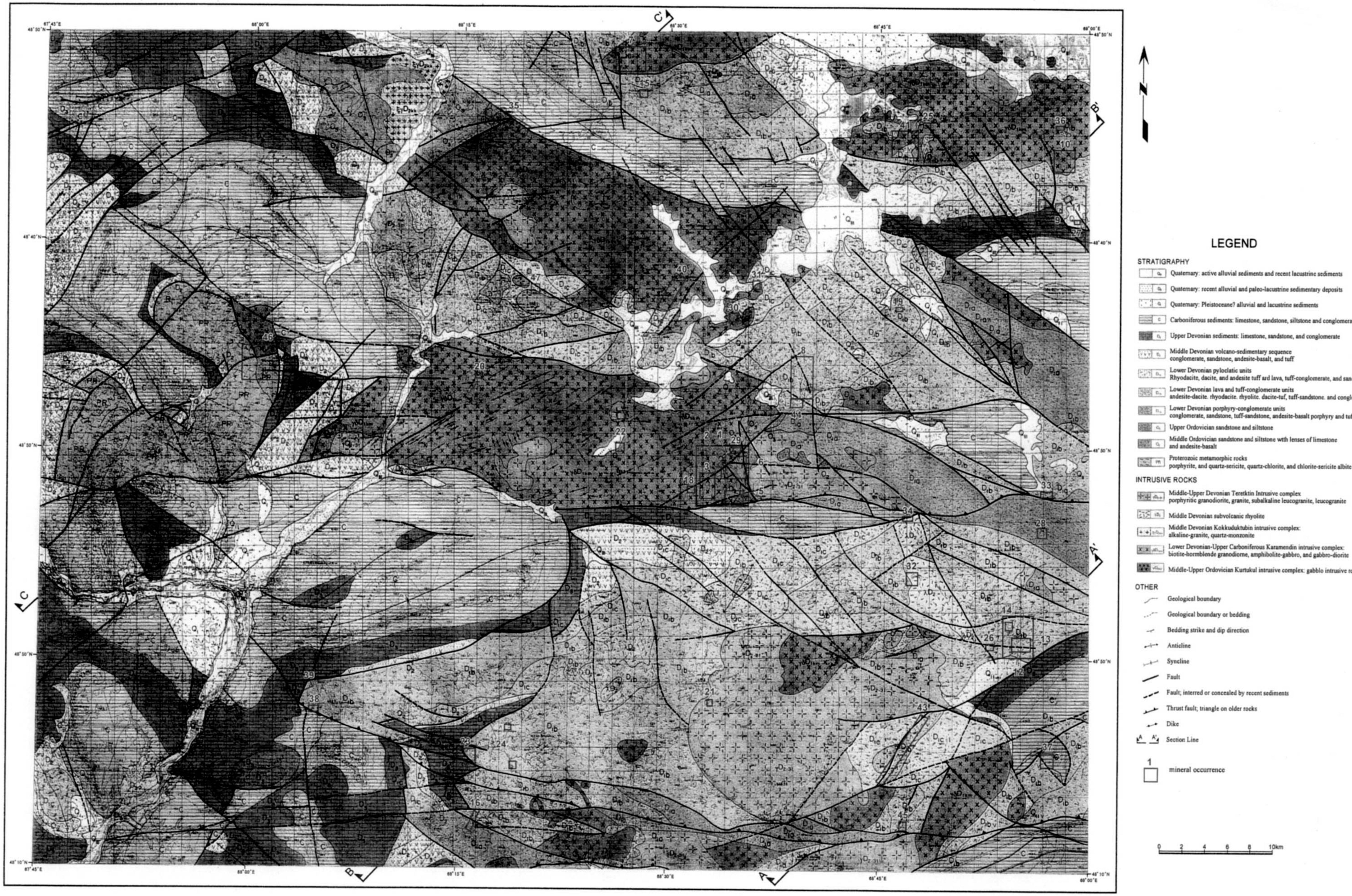


Figure 3-6 Geology and Mineral Occurrence Location Map, Terektinsky Uplift Area

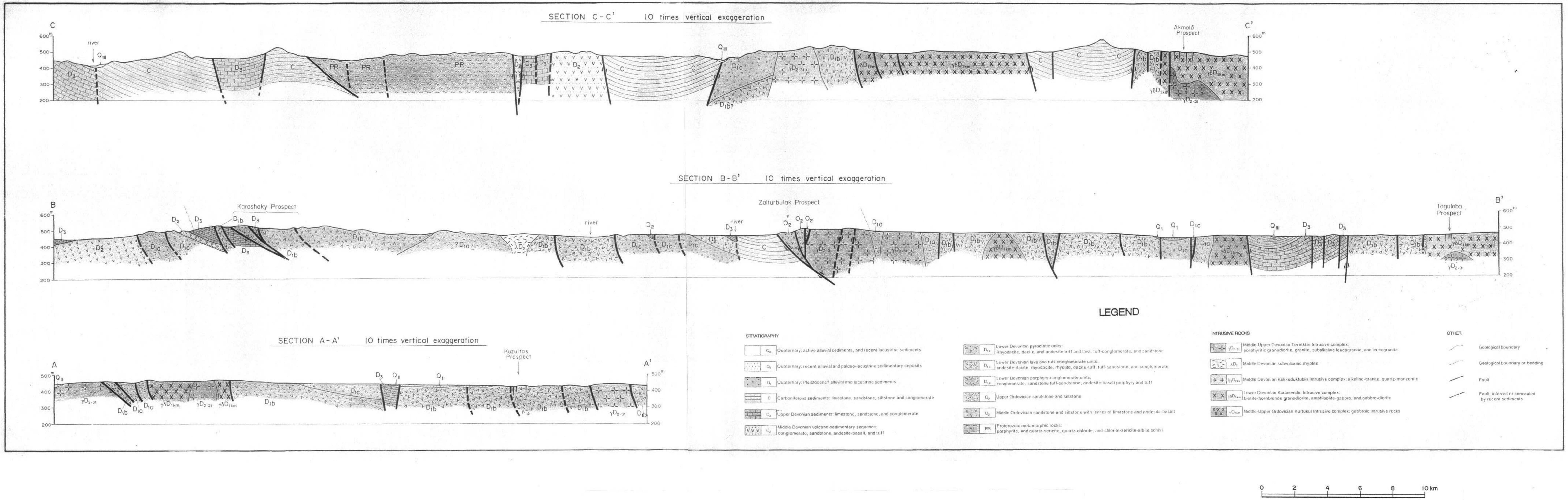


Figure 3-7 Geological Cross Sections of the Terektinsky Uplift Area

basalt lava. The Upper Ordovician series (O_3) consists primarily of sandstone and siltstone. Prior to uplift they were intruded by Lower and Middle Devonian granitoids, and overlain by Upper Devonian and Carboniferous rocks, which have since eroded.

According to previous detailed mapping, the Ordovician rocks are a geosynclinal sequence of sediments, pyroclastics and lavas. Descriptions of the formations suggests they represent a marine transgressive sequence from deep water to subaerial depositional environments.

The total thickness of the Formations is between 3,000 and 5,000 meters.

2) Devonian System - Lower and Middle Devonian Series (D_{1a}, D_{1b}, D_{1c}, and D_2)

Unconformably overlying the Ordovician geosynclinal sequence are Lower and Middle Devonian synorogenic extrusive volcanic rocks and postorogenic continental molasse sediments, including red sandstone, conglomerate, tuff-sandstone, tuff-conglomerate, and tuff and lava of rhyolitic, rhyodacitic, dacitic, andesitic and basaltic compositions.

The Lower Devonian series occur through-out the center and east of the survey area in both anticlinal and synclinal structures., These units have been intruded by Lower and Middle-Upper Devonian granitoids.

The Middle Devonian series (D_2), which is also exposed in both anticlinal and synclinal structures, is mainly confined to the west of the survey area. It consists of conglomerate, sandstone, andesite-basalt lava, and tuff.

Total thickness of the Lower Devonian units is between 3,500 and 4,100 meters.

3) Devonian System - Upper Devonian Series (D_3)

The Upper Devonian series unconformably overlies the Middle Devonian series rocks. It consists of several conglomerate and sandstone Formations (postorogenic continental molasse) unconformably overlain by limestones. The limestones indicate a change to deposition in shallow marine sedimentary basins, which were probably formed by the reactivation of Caledonian structures.

The Upper Devonian series rocks occur primarily in synclinal structures around the margins of the survey area.

Total thickness of the Upper Devonian units is between 2,200 and 3,700 meters.

4) Carboniferous System (C)

Carboniferous System rocks conformably overlie Upper Devonian limestones, and primarily occur in synclinal structures around the margins of the survey area. These units broadly consist of Lower Carboniferous sandstone, siltstone, limestone, dolomite and marl, characteristic of deposition in shallow marine sedimentary basins, and Upper Carboniferous sandstone, siltstone, shale and conglomerate, characteristic of a lacustrine depositional environment.

The total thickness of the Carboniferous units is between 600 and 1150 meters.

5) Quaternary System (Q_I, Q_{II}, and Q_{III})

The Quarternary System is composed of recent alluvium and lacustrine sediments in major drainages and several lakes (Q_{III}), unconsolidated recent alluvium and lacustrine sediments in paleo-drainages and paleo-lakes (Q_{II}), and some older, possibly Pleistocene, sand and gravel beds (Q_I).

Quaternary sediments consist of unconsolidated clay, sand, loam, and shingle, and have a total thickness of between 1 and 10 meters.

3-2-3 Intrusive rocks

Intrusive lithologies comprise approximately 25% of the survey area. They occur in the center and east of the area as massifs and plutons in anticlinal structures and up faulted blocks. Three intrusive phases, with rock types varying from gabbro to aklaine-granite, have been defined based on stratigraphic relationships and previous K-Ar dating.

The oldest intrusive phase is believed to be a gabbroic pluton of the Middle Ordovician Kurtukul (or Qurtukul) Intrusive Complex. All other phases belong to either the Lower Devonian to Carboniferous Karamendin Intrusive Complex or Middle-Upper Devonian Terektin Intrusive Complex.

The Karamendin Complex is important in connection with the mineralization. The current shape of Karamendin Complex bodies in the area relates to late Paleozoic tectonomagmatic reactivation and uplift, which imposed northwest and east-west trending fault boundaries on many of the rock units in the area. The main rock facies of the Karamendin Complex consists of granodiorite to granite. According to the Isotope age, the activity of the Karamendin Complex varies from middle Caledonian to Variscan in age (Figure 3-9).

Chapter 4 Minerlization in the Terektinsky Uplift area

In the Terektinsky Uplift area there are numerous occurrences of precious, base and other metals. A 1:200,00 scale geochemical anomaly map, showing the location of all known mineral occurrences, was used as the basis for planning field investigations. During the phase I survey period, 41 mineral occurrences (excluding the Zalturbulak area) were investigated.

4-1 Survey method

Topographic maps at 1:100,000 scale and Landsat images were used for field survey. Tape and compass survey and detailed mapping (including sketching outcrops) was carried out in the mineralized zone. At the same time, rock samples for laboratory tests were collected. The samples for chemical analysis were collected mainly in mineralized zones. Outcrops vein systems were mainly channeled sampled and quartz float zones were grab sampled with several kilogram of material collected at each sampling location.

4-2 Results

Using the data obtain from these investigations, the mineral occurrences have been divided into the following categories:

1: Porphyry type mineralization(Samarsky porphyry type): Intrusive hosted disseminated sulfide mineralization.

2:. Vein style gold (Au) mineralization (Ushoky type):Vein style, quartz-sulfide-gold(Au) mineralization hosted by Lower Devonian volcanic rocks

3: Others

3-1:Vein style, quartz-sulfide-gold (Au) mineralization hosted by Lower Devonian granitic rocks

3-2:Volcanic hosted disseminated and fracture controlled sulfide mineralization (no significant quartz veining)

3-3:Intrusive contact related quartz-sulfide veins.

3-4:Miscellaneous occurrences including alluvial gold and uranium occurrences, and unclassifiable occurrences due to insufficient data.

All mineral occurrences investigated for three years are summarized in Table 4-1

Table 4-1: Summary of mineral occurrence and their characteristics in the Terektinsky Uplift Area (Regional survey area)

No.	Mineral Occurrence Name	Latitude	Longitude	Host rock	Mineralization zone	Fault System Orientation	Mineralogy			Inclusion Homogen. Temp. (°C)	Metal Grade (ppm)							Ore Minerals (Polished Section)	Minerali zation Type	Size of Alteration zone + Mineralization zone	Previous Prospectings
		N	E				Alteration Intensity	Visual	X-ray Diffraction		No.	Au	Ag	Cu	Pb	Zn	other				
15	Akmola Southeast (Zabutaia)	48°47'07"	68°27'56"	altered Devonian sediment and f. gd. Granite	Intense alt zone	?	S	Qz-Ser-Clay	Qz-Ser-Kao		3	<0.01	<0.2	5.5	12	3.4	Ba:429		2b?	50 m × 50 m (Alteration zone)	
16	Baidos	48°12'38"	68°16'08"	granite porphyry	silicified zone	NS	S	Qz-Ser-Clay-Hem	Qz-Prp-Dia-Py±		4	<0.01	<0.2	39.8	11	2	Ba:697	Cp, Py, Po	2b	700 m × 50 m (Silicified zone)	
17	Demdi	48°41'52"	68°56'41"	Devonain sediment, volcanics	qz floats zone	?	?	?			4	<0.01	0.4	54	59	33.3	Ba:1150	Cp, Py, Po	7		Drilling Hole : 1 site
18	G1	48°28'	68°31'	granodiorite (Karamendin)	qz vein zone	N5W	W	Qz	Qz-Pl-Or-Hor-Chl		2	<0.01	<0.2	9.3	3	2.2			2b	20 m × 4 m (Quartz vein)	
19	G2	48°37'	68°46'	Lower Devonian	qz vein-qz network		W	Qz-Hem	Qz-Pl		2	0.08	0.3	89.5	11	3.7	Ba:1330	Cp, Py, Ht, Lm	2a	Many quartz boulder zone in 2km × 2km area	Trench : 1 line
20	G3	48°34'	68°16'	granodiorite (Karamendin)	5 qz veins	N10E	W	Qz-Clay	Qz-Or-Pl-Chl±Ser	158-338	2	<0.01	<0.2	20.5	5	<0.5			2b	10 m × 3 m (Average of Quartz vein)	Trench : 3 lines
21	G4	48°18'	68°33'	Bt granite (Terektin)	qz network-qz floats zone	N20E	W	Qz	Qz-Pl-Or-Bi	259-419	5	<0.01	<0.2	17.2	6	2.7			2b	117 m × 3 m (Quartz boulder zone)	
22	Greisen	48°32'	68°27'	granodiorite (Karamendin)	qz floats zone	N45W	W	Qz		229-366	2	<0.01	<0.2	17.7	<2	<0.5			2b	50m×20m, 10m×15m (Quartz boulder zone)	Trench : 1 line
23	Karashaky -A	48°15'43"	68°15'19"	Devonain volcanics	intense alt zone	N75E	S	Qz-Clay	Qz-Ser-Kao-Or		9	<0.01	<0.2	12.4	13	9.9	Ba:5360		2a?	1000 m × 300 m (Alteration zone)	Trench : 4 lines (Total 1,600m)
24	Karashaky B, C, D	48°16'	68°17'	Devonain volcanics	qz vein	E-W&NE	S	Qz-Clay	Qz-Ser-Kao		5	<0.01	<0.2	26.2	15	19.2	Ba:364		2a	4km × 4km	Lots of Trenches (Total 1,600m)
25	Koktal	48°45'44"	68°48'15"	contacted of granitoid and diabase	qz veinlets	N30W	VW	Qz-Zeolite?	Qz-Pl-Or-Bi-Ser		3	<0.01	<0.2	76	5	35.3			4	400m × 50m	Trench : 10 lines (Total 132m), Previous Drilling Hole : 2 sites
26	Kuzultas West	48°20'43"	68°53'11"	Devonain acidic volcanics	qz vein and breccia zone	N50W	W	Qz-Py		324-343	1	0.29	2.1	16.3	18	3.7			2a	20 m × 2 m (Quartz boulder zone)	
27	Luguvoe	48°41'07"	68°59'12"	Devonain volcanics	qz vein?														7		Previous Drilling Hole:3 sites
28	N1	48°26'11"	68°56'30"	Lower Devonain volcanics	qz floats zone	N30E	W	Qz-Hem			5	<0.01	<0.2	18.5	23	5.1		Ht	7	120 m × 80 m (Quartz boulder zone)	
29	N2	48°30'03"	68°34'27"	Lower-Middle Devonain volcanics	qz floats zone	N80E	W	Qz			1	<0.01	<0.2	21.3	6	2.2			7	80 m × 60 m	
30	N3 (Koktem?)	48°36'28"	68°34'29"	Quartz porphyry, granite, porphyry	intense silicified zone	N40W	S	Qz				<0.01	<0.2	50.2	17	11.4		Ht, Go	2b?	300 m × 70 m (Silicified boulder zone)	
31	N4 (Shilde-1?)	48°37'58"	68°36'19"	Devonain volcanics	qz floats zone	N35E	W	Qz		246-379		<0.01	0.2	19.7	2	2.5			2a?	150 m × 1 m	
32	Reper	48°24'00"	68°47'30"	Lower-Middle Devonain rhyolitic volcanics	fissure filling zone, fissure develop randomly	NS (General trend)	M	Qz-Ser-Hem	Qz-Ser-Pl	234-305	7	0.07	5.6	58.5	643	177	As:928, Sb:103	El, Go, Lm	3	200 m × 50 m (Quartz vein and boulder zone)	
33	S1	48°28'18"	68°56'01"	Lower Devonain volcanics	Mineralization zone developing in the contact zone of Devonian and Carboniferous	N40W	M	Qz			1	<0.01	0.3	31.5	4	4			2a	80 m × 2 m	
34	S2	48°26'49"	68°46'56"	Lower Devonain f. gd acidic volcanics	qz network and brecciated zone. Mineralization zone developing in the contact zone of Devonian and Carboniferous	N75E	W	Qz			1	<0.01	<0.2	11.3	3	5.9			2a	150 m × 1 m	
35	S3	48°45'30"	68°18'30"	granodiorite, diorite (Karamendin) and sediment	qz veinlets	N35W	W	Qz			6	<0.01	<0.2	37	9	35.5		Cp, El			
36	S4	48°45'24"	68°57'55"	granodiorite	qz zone	N90E	M	Qz		134-328	4	<0.01	<0.2	14	4	5.4			2b	60 m × 2 m	Trench : 2 lines
37	Sartas	48°15'	68°57'	granite porphyry	qz network zone	N0E	W?	Qz-Hem	Qz-Ser-Anh-Pl	222-295		0.56	0.2	37.2	11	11.1	Ba:665	Iron oxides	2a?	50 m × 50 m	
38	Shenber-A	48°17'44"	68°04'44"	intense silicified rock	qz floats zone	N70W	S	Qz			4	0.01	<0.2	16.9	28	9.9	Ba:5360		7	<200 m × 100 m	
39	Shenber-B	48°18'38"	68°04'14"	Lower Devonain volcanics and upper Devonain sediment	qz floats zone	N80W	M?	Qz-Hem	Qz-Pl±Kao		4	<0.01	<0.2	14.6	8	57	Ba:4590		7	500 m × ?	
40	Shilde-2	48°36'	68°29'	sandstone (hornfels)	qz vein	NE	M	Qz			6	<0.01	<0.2	17.9	26	7.6	As:102.Ba:1940		4	100 m × 40 m	
41	Shubarkol	48°44'35"	68°46'35"	granodiorite (Karamendin) and Devonian volcanics	qz vein zone	N75E	W	Qz-Ser	Qz-Ser-Pl	126-169	8	0.04	0.4	36.7	333	21.5	As:29	Cp, Go, Jar, Lm	2a	1500 m × 2 m	Trench : 9 lines
42	Shubarkol NW	48°45'17"	68°46'10"	ditto	qz floats zone	ENE	W	Qz-Epi	Qz-Dol-Hor-Py	159-263	3	<0.01	<0.2	19.6	31	13.1		Cp, Go, Jar, Lm	2b	100 m × 50 m	
43	Sn1	48°17'	68°48'	Lower Devonian acidic volcanics	qz network zone	NE?	W	Qz-Clay-Py	Qz-Ser-Kao	220-306		<0.01	1	43.5	48	47.6		Go, Ht	7	8 km × 2 km	
44	Tamuz	48°32'	68°38'	Lower Devonian volcanics and sediment	qz floats zone	?	S	Qz-Hem	Qz-Pl±Kao ±Hem± Ser ±Bi±Or	156-165	6	0.62	2.2	91.6	1150	11.8	As:104, Sb:129	El, Cp, Mt, Py, Go, Lm	2a?	100 m × 100 m	
45	Uchastok "B"	48°12'	68°47'	granodiorite (Karamendin)	qz floats zone	N35E	W	Qz-Epi	Qz-Pl-Ser± Py±Cc	125-385	4	<0.01	<0.2	16.5	3	1.4			4?	100 m × 60 m	
46	Western Karamendin	48°34'	68°00'	quartz porphyry in Ordovician sediment	qz network and floats zone	N60E	W	Qz	Qz-Ser-Pl-Kao	175-404	7	0.02	17.7	51.3	901	170		El, Po	2a?	4km × 4km (Quartz boulder zone)	Lots of Trenches
47	Zhamantas II	48°38'	68°20'	granodiorite (Karamendin)	qz floats zone	?	?	Qz				0.01	<0.02	16.4	3	1.5			2b?	30 m × 30 m	Pit : 1 hole

Mineralization Type : 1 Porphyry type : Intrusive hosted quartz vein and disseminated sulphide mineralization (Samarsky porphyry type); 2 Gold bearing quartz vein type : Sulphide-gold mineralization hosted by Lower Devonian volcanics with possible association to Upper Devonian granitic intursives (Usnoky type)
3 : Others. 3-1 Vein style quartz sulphide-Au mineralization hosted by Lower Devonian granitic rocks; 3-2 : Volcanic hosted disseminated and fracture controlled sulphide mineralization; 3-3 : Intrusive contact related quartz-sulphide veins; 3-4 : Miscellaneous occurrences

Table4-2 Summary of mineral occurrence and their characteristics in the Terektinsky Uplift Area (Detail-subdetail survey area)

No.	Mineral Occurrence Name	Host rock	Mineralization zone	Fault System Orientation	Alteration		Inclusion Homogen. Temp. (°C)	Metal Grade (This survey)	Ore Minerals (Polished Section)	Mineralization zone	Size of Alteration zone + Mineralization zone	Resources	Previous Prospectings
					Discription	X-ray Diffraction							
1	Central Zalturbulak (Aktau west)	diorite porphyry in Devonian andesite	Cu bearing qz network	NE-SW	Qz-Ser→prop	Qz-Ser-(Chl)→Py-Chl-Epi-Ca	>300 (from ore min. assemblage)	Cu : 1308,934ppm (MJTA-4, W=3m), Au : 477ppm (MJTA-4, W=3m)	Cp, Py, Mt, Po, Cb	Porphyry Cu-Au	0.3km×0.5km	-	Drilling Hole:2 sites, Trench:more than 10 lines
2	Central Zalturbulak (Aktau west)	granite in granodiorite	Cu, Mo bearing qz network	NE-SW	Qz-Ser→prop	Qz-Ser→Py-Chl-Epi-Ca	-	Cu : 645,605ppm (MJTA-3, W=1m), Mo : 400ppm (MJTA-3, W=3m)	Cp, Py, Mo, Mt, Po	Porphyry Cu-Mo	0.15km×0.5km	-	-
3	Central Zalturbulak (Western Zalturbulak)	ditto.	ditto.	NNW-SSE	Qz-Ser→prop	Qz-Ser→Py-Chl-Epi-Ca	205-324	Cu : 645,605ppm (MJTA-3, W=1m), Mo : 695ppm (MJTA-5, W=1m)	Cp, Py, Mo, Mt, Po	Porphyry Cu-Mo	0.7km×2km	-	Drilling Hole:4 sites, Trench:more than 15 lines
4	Zalturbulak prospect (Central Zalturbulak zone)	granodiorite	Au bearing qz veins (12 veins)	NNW-SSE	Ser→prop	Ser-Chl-Py	164-424	Au : 20.8ppm (W-4 vein ; grab), Au : 0.95ppm (C-1 vein ; W=30m), Au : 18.9ppm (P-5 vein ; W=1.5m), Au : 2.5ppm (P-4 vein ; W=1.5m), Au : 3.0ppm (P-2 vein ; W=1.6m)	El, Py, Cp, Mo, Thd, Gn, Mt	Au vein	300m×200m	7398kg (C1+C2): Prev. data	Costean:2 lines, Drilling Hole:more than 40sites, Trench:more than 15lines
5	NE Zalturbulak	hornblende diorite	vein type gold	E-W	prop	Epi-Chl-Ca	-	-	El, Py	Au vein	150m×80m	777kg (P2): USSR data	Drilling Hole:8 sites, Trench:8lines
6	Aktau	diorite in andesite	vein type gold	ENE-WSW	prop	Qz-Ser-Kao-Py→Chl-Epi	±170	Au : 17.1ppm (W=1m): USSR data	El, Py	Au vein	400m×400m	616kg (P2): USSR data	Drilling Hole:5sites, Trench:more than 30lines
7	Akmola	quartz porphyry, granitoids	Mo bearing qz network	NW-SE	Qz-Ser→prop	Qz-Ser→Py-Chl-Epi-Ca	150-360	Mo : 445ppm (MJTA-9, W=38m)	Mo, Py, Cp	Porphyry Mo	Mo mineralization zone ; L:±400m?, D:±100m?, W:20m	2Mt? (Mo:0.04%)	Drilling Hole:4sites, Trench:35lines
8	Arlan	diorite	vein type gold	NNE-SSW	Qz→clay→prop, tourmalline in silicified zone	Qz-Ser-Tour-Kao-Py-Chl-Epi	±180	Au : 4.16ppm (boulder)	Cp, Py, Po, El	Au vein	2000m×300m	-	Drilling Hole:4sites, Trench:more than 4lines
9	Bidaik	Lower Devonian dacite～andesitic volcanics	Au bearing qz vein	NS	Qz→Chl	Qz-Ca-Ser	129-288	Au : 29.08ppm (boulder)	El, Cp, Py, Oxides	Au vein	275m×20m	129kg (P2): USSR data	Drilling Hole:7sites 1031m, Trench:4lines 450m
10	Taguloba	granite porphyry	qz vein	NNE-SSW	Qz→Chl	Qz-Ser/Smec-Tour?	115-189	Au : 1.7ppm (boulder)	Iron Oxides	Au vein	800m×400m (Quartz veinlets)	-	Drilling Hole:1site 145.6m, Trench:9lines:3380m
11	BidaikNE (No.2 zone)	Devonian dacite～andesitic volcanics	Au bearing qz vein	NNE-SSW	silicified zone along qz vein	Qz-Ser-Ser/Smec-Lm	137-334	Au : 286～364ppm (boulder), Au : 0.93ppm (W=2m)	El, Cp, Py	Au vein	200m×2m (Qz vein)	-	Trench:1lines 10m
12	Kuzulutas zone SW	Lower Devonian acidic volcanics and cgl.	Qz-Hm-Ba veins	NW-SW	silicified zone along qz vein	Qz-Ser/Smec-Ca	183-243	Au : 0.9ppm (W=3m)	Cp, Py	Au vein	700m×100m	5330kg (P2,Depth 0-15m): USSR data	Drilling Hole:more than 3 sites, Trench:70lines 1250m (including zone SE)
13	Kuzulutas zone SE	ditto.	ditto.	E-W, WNW-ESE, NW-SE	silicified zone along qz vein	Hm-Ba, Qz-Ser/Smec-Ca	133.2-267.5 (especially 133.2-190)	Au : 0.36ppm (boulder)	Cp, Iron Oxides	Au vein	1400×600m	-	Trench:10lines 3380m
14	Kuzulutas zone NW	ditto.	qz veins and silicified rocks	E-W, N-S, NE-SW	silicified zone along qz vein		-	Au : 0.46ppm (boulder)	-	-	400×300m		-

and Table 4-2. The locations of these mineral occurrences are shown in Figure 3-6. Of the mineralization type above mentioned, many promising occurrences belong to type 1 and type 2. The mineral occurrences listed in Table 4-2 were considered to be specially promising and were investigated continuously after Phase I survey. The results of the survey in those occurrences are described in Chapter 5. While, the mineral occurrences listed in Table 4-1 were estimated not to be prospective. JICA/MMAJ presents the descriptions of theses occurrences in detail.

4-3 Geological structure and mineralization

In this section, the relationship between geological structure and mineralization zone is described.

The trend of mineralization in this area have a dominant NNE-SSE～NS direction (upper left in Figure 3-8). In Zalturbulak area, the majority of mineralized veins run in the N-S or NNW-SSE direction. The diorite porphyry intrusions, which are implied to have brought about the mineralization of the Central Zalturbulak Zone, indicate similar trends. Based on this fact, it was considered that the regional compression stress might well have formed numerous open fissures of the N-S and NNW-SSE directions, which played a role of channels for ascending magmas and hydrothermal solutions (JICA/MMAJ, 1999).

In Kuzulutas, two dominant directions of fractures are recognized, namely NNW-SSE and WNW-ESE directions (lower right in Figure3-9). T he NNW-SSE fractures lining up echelon and forming right-stepping fracture system (JICA/MMAJ, 1998:P103) are left –lateral strike-slip faults. Therefore, two trending fractures are considered to be conjugate faults forming in the NW-SE compression field.

Most mineralization zone of the Terektinsky uplift area is estimated to form to be affected by either open fissures or left-lateral strike-slip faults. Either way, the compression field from southeastern direction basically controlled the mineralization zone.

On the other hand, there are many indications of ENE-WSW compression in northern to northwestern part of Terektinsky uplift area such as the direction of intrusive bodies of Akmola area, dyke swarm in western part of Zalturbulak and general trend of Shubarkol prospect. In general, the relative older rocks are distributed in the northwestern part of the Terektinsky uplift area, and before getting ENE-WSW compression these older rocks were considered to be suffered from ENE-WSW compression.

According to Sengor et al.(1993), Central Kazakhstan was placed in a new stress field after appearance of subduction zone in the southern part of Central Kazakhstan after early Carboniferous. The change of the regional stress field in Terektinsky uplift area mentioned above may correspond to the new appearance of the subduction zone. However this is only speculation because of poor evidences.

There are some mineral occurrences (Shenber, Karashaky and so on) which show E-W trend in southern part of Terektinsky uplift area. These occurrences have formed along reverse fault distributed nearby. No promising occurrences have been discovered in this area.

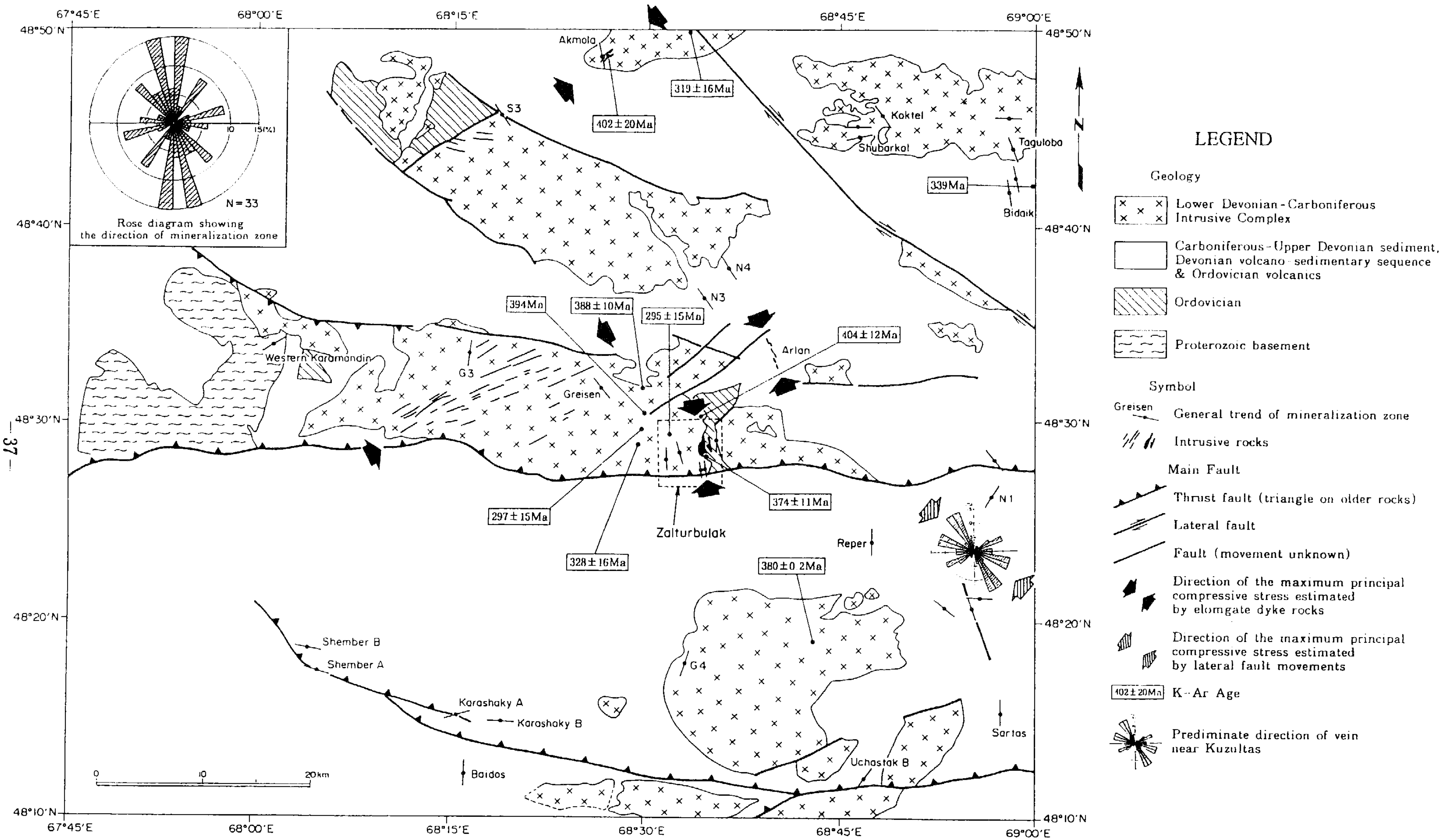
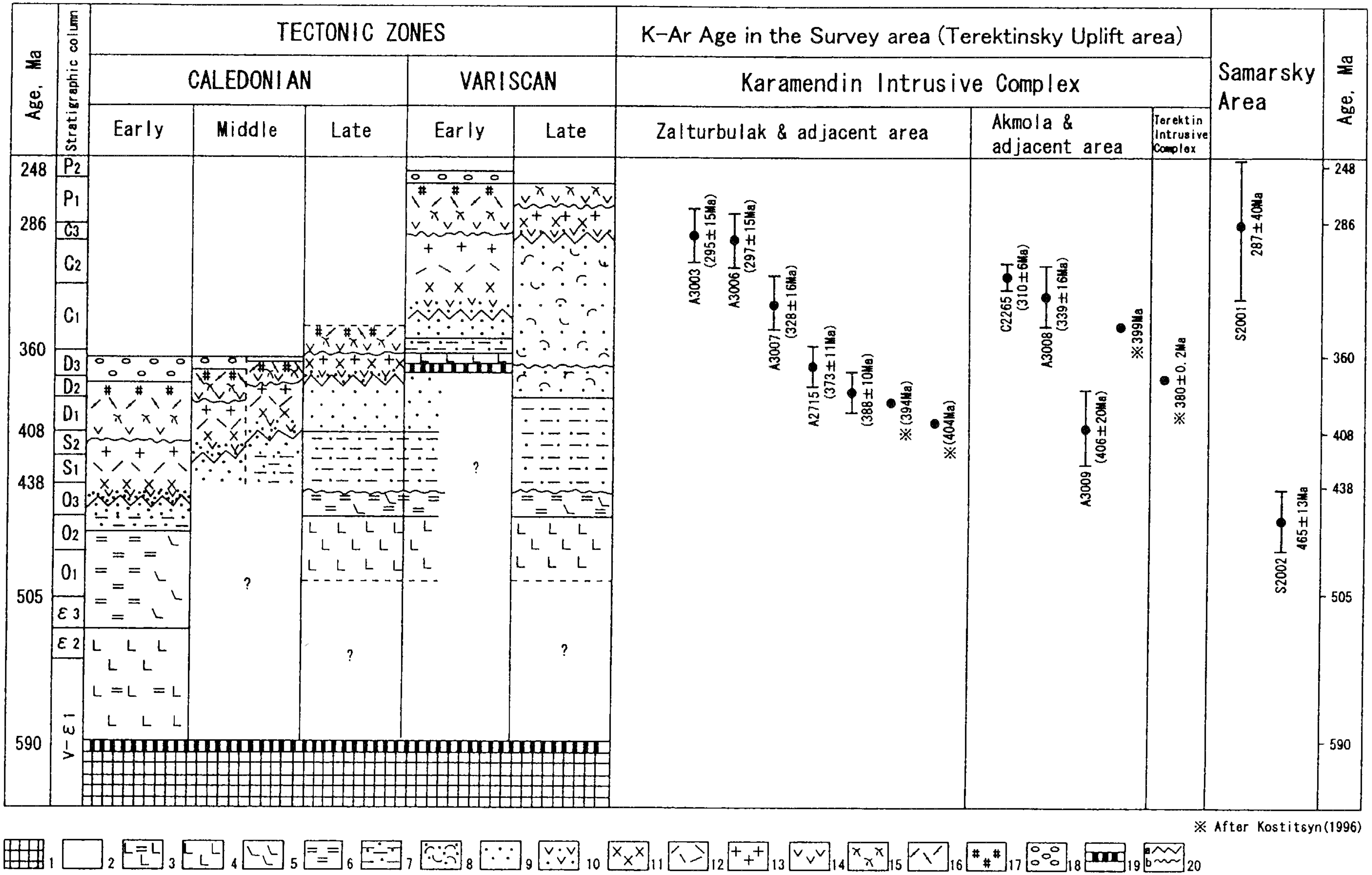


Figure 3-8 Geotectonic map and results of age dating in Terektinsky Uplift Area



1- Precambrian basement; 2- platform sedimentary cover; 3~18- Paleozoic rock associations: 3- cherty-basalt, 4- trachybasalt, 5- andesitic basalt, 6- jasper, 7- flysch, 8- tuffaceous-terrigenous, 9- terrigenous variegated (in early Caledonides with olistostromes), 10- island arc andesite-rhyodacite, 11- tonalite-granodiorite, 12- rhyolite (subaerial), 13- leucogranite, 14- trachyandesite-trachyrhyodacite (subaerial), 15- granosyenite, 16- subalkaline rhyolite, 17- alaskite, 18- continental red molasse, 19- continental breakup events; 20- main folding events and corresponding unconformities: a- main, b- secondary.

Figure 3-9 Age of the Igneous Rock

4-4 Whole rock chemical analysis

Chemical analysis for principal rock forming elements('whole rock analysis') is made for a total of 9 intrusive rock samples, two collected in West Aktau, three in West Zalturbulak and three in Akmola. The analytical results are compared for various compositional indices with the chemical compositions of intrusions responsible for other mineral occurrences in Kazkhstan such as Qonyrat porphyry molybdenum copper (Late Carboniferous: Kudryavtsev, 1996), Bozhakol porphyry molybdenum copper deposit (Cambrian: Kudryavtsev, 1996) and Koktenkol porphyry molybdenum tungsten (Late Carboniferous: Mazurov1996) deposits. The locations of these ore deposits are shown in Figure2-1. The complete set of analytical data is shown in Appendix 8 of the Phase III report of this project (JICA/MMAJ, 2000).

(1) AFM diagram (Figure 3-10; Irvine and Baragar, 1971)

All the 9 samples of intrusions in the project area are plotted in the domain of calc-alkine suite on AFM diagram. The compositions of those associated with the porphyry style ore deposits also indicate the same compositional range in general with one exception for Qonyrat.

(2) Granitoid Series: Magnetite Series vs. Ilmenite Series(Fig. 3-11)

($Fe^{3+}/Fe^{2+}+Fe^{3+}$)-SiO_2 diagram is used for magnetite-ilmenite series classification. All the Aktau and West Zalturbulak samples are plotted along the boundary line between the magnetite and ilmenite granitoid series, while two of the three Akmola samples fall well inside the magnetite series domain and one, in that of the ilmenite series close to the boundary line. According to the microscopic observation, however, magnetite occurrences are much less common in Akmola than in Aktau or West Zalturbulak, which is contradictory to the above classification based on the chemical compositions. The number of samples is too scarce to make any satisfactory explanation for the contradiction at this stage.

With respect to the intrusions associated with the three major ore deposits, those of Qonyrat and Bozhakol are generally of magnetite series with a few samples plotted close to the boundary line, while those of Koktenkol, being low in $Fe^{3+}/Fe^{3+}+Fe^{2+}$, fall within the ilmenite series domain. This difference suggests that the intrusions related to the former two deposits have been formed in different magmatic processes from those for the intrusions related to the latter deposit.

(3) Granitoids Series: I type vs. S type

Granitoids are also differentiated into S type and I type(Chappell and White (1974)) for their genetical implication; the former type involves partial melting of pelitic sedimentary rocks in its genesis while the latter type is generated by partial melting of igneous rocks. Molar ratios between CaO, Al_2O_3+Na_2O+K_2O and FeO+MgO and variation of Al_2O_3/(CaO+Na_2O+ K_2O) against SiO_2 are used for discriminating S type and I type granitoids.

The intrusions of the project area are invariably plotted in the I type side both on ACF diagram(Fig. 3-12) and variation diagram of Al_2O_3/(CaO+Na_2O+ K_2O) against SiO_2(Fig. 3-13). The Bozshakol granitoids fall in the I type domain close to the boundary line with the S type domain on ACF diagram, while those of Qonyrat are generally of S type with a few plotted in the I type domain very close to the boundary line. The granitoids of Koktenkol are mostly of I type with a couple of exceptions which are plotted close to the boundary line in the S type domain. As for variation diagram of Al_2O_3/(CaO+Na_2O+ K_2O) against SiO_2, the Qonyrat and Bozshakol granitods are plotted both in the S type and I type domains, while those of Koktenkol fall mostly in the I type domain with one exception.

(4) K_2O / Na_2O (Figure 3-14)

Variation diagram of K_2O / Na_2O against SiO_2 is prepared.

The intrusions of West Aktau are higher in Na_2O and lower in K_2O than those of Western Zalturbulak and Akmola. The Bozshakol intrusions are generally higher in Na_2O and lower in K_2O than those of Qonyrat and Koktenkol.

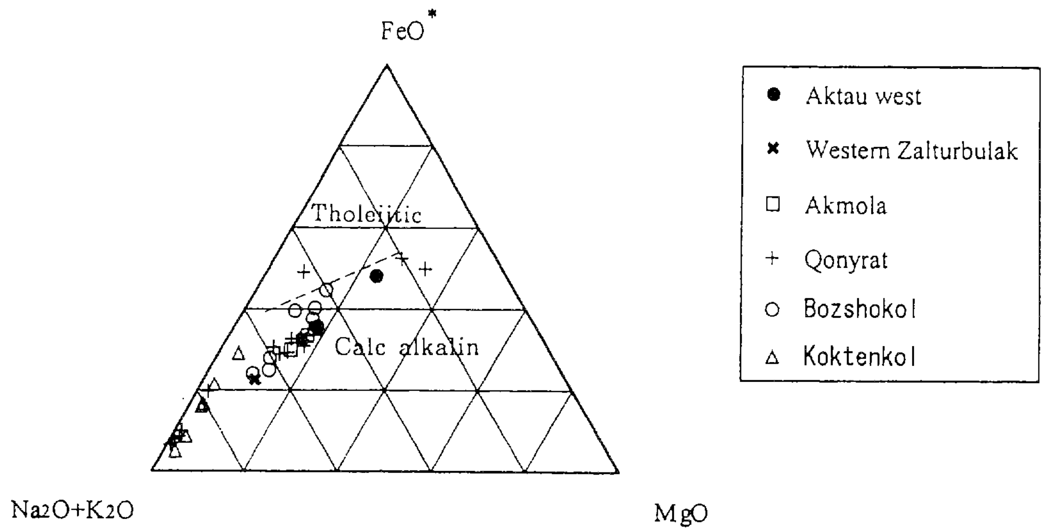


Figure 3-10 Molar proportion of Na_2O+K_2O, FeO^*(total iron) and MgO

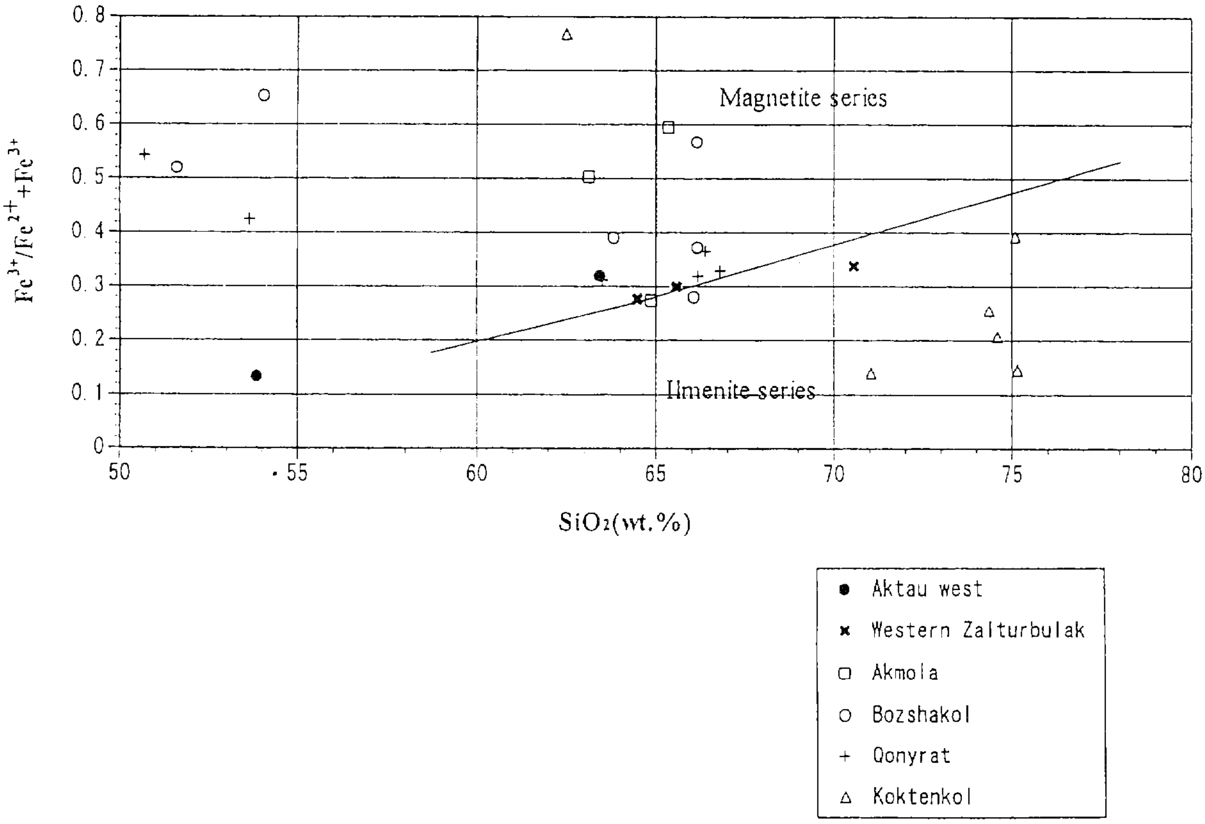


Figure 3-11 $SiO_2/Fe^{3+}/Fe^{2+}+Fe^{3+}$ variation diagram

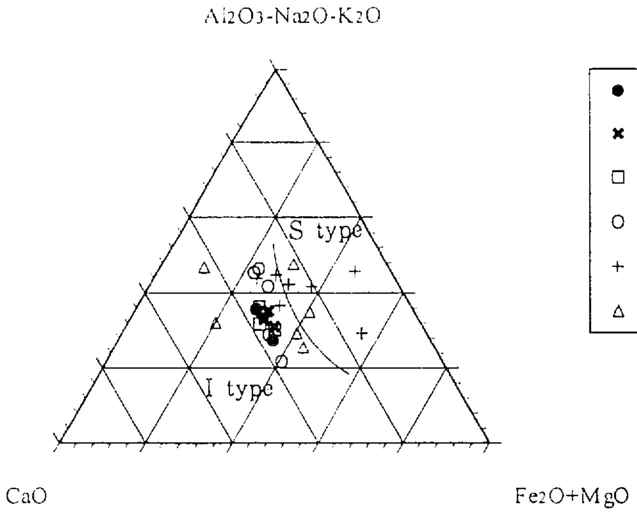


Figure 3-12 Molar proportion of CaO, Al_2O_3-Na_2O-K_2O and Fe_2O+MgO

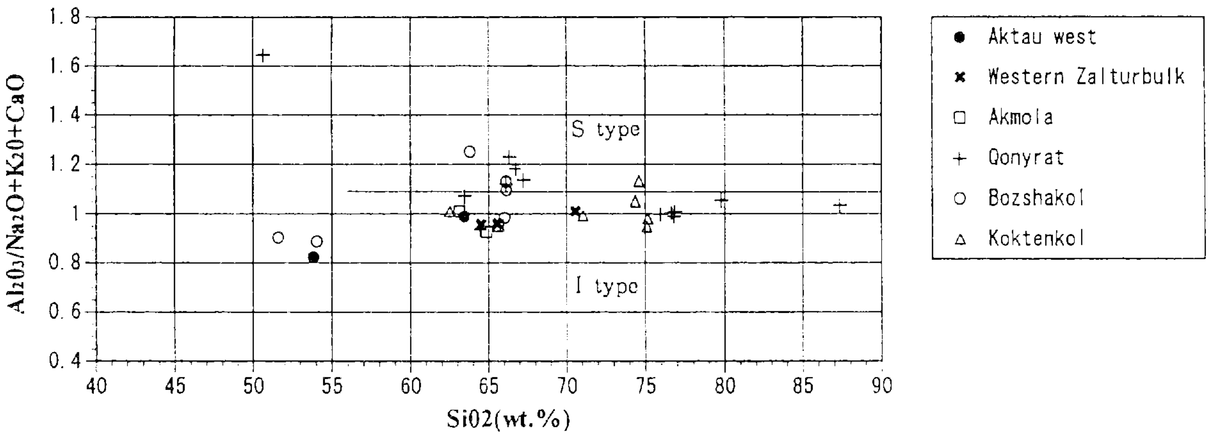


Figure 3-13 Al_2O_3/Na_2O+K_2O +CaO/ SiO_2 variation diagram

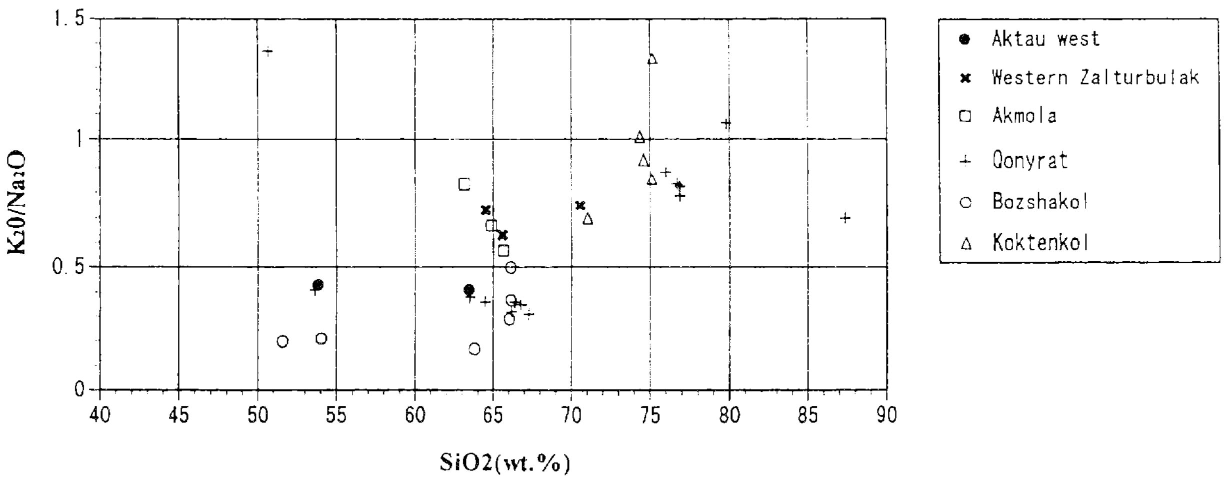


Figure 3-14 K_2O /Na_2O/ SiO_2 variation diagram