2) Estimate the density or susceptibility structure from existing geologic, density or susceptibility data, or make a first guess from the observed profile. If the structure is known from drilling data or surface geology, fix the appropriate variables.

3) alculate the response which would be produced by the candidate earth model and compare the profile to the observed data profile.

4) Interactively improve the model to speed inversion or allow geometric and physical model parameters to be variable and perform an automatic inversion to match the field data.

5) Compare the resulting earth model with known geology and check the agreement between the two.

6) If there is disagreement between the two, begin again.

(4) Bouguer Gravity Computation

Regional gravity data was used to estimate deep (3-10*km*) structure in the survey area. From this analysis, several blocks were inferred at depth. These blocks were used to estimate densities and vertices of a regional model and regional gravity profiles were computed. Bouguer gravity was derived from the observed data using these blocks to model regional structure.

In the analysis of magnetic data, regional magnetic trends were removed from the observed data with a filter wavelength of 10,000*m* and only residual anomaly maps were used.

2-4 Results of Data Analysis

2-4-1 Rock Properties

The resistivity, frequency effect (FE), density, and magnetic susceptibility (c) ranges typical of rocks in the survey area, including intrusives, are given in Tables II-2-2 and II-2-3. These parameter ranges have been derived from laboratory measurements made upon drill core and rock samples collected upon the surface in the survey area.

(1) Induced Polarization

Altered sedimentary rocks in the survey area can be clearly divided into two groups by IP measurements. The first, which includes carbonate formation rocks, quartzite, tuff-sandstone, and beresite, is typified by only 5% FE. The second group has a high FE (up to 20%) and includes siltstone, schist and flint, all of which have high carbon content.

Granitoids, lamprophyre, hornfels and skarn in the survey area have a relatively low FE of 5-7%.

(2) Magnetic Susceptibility

The magnetic susceptibility (c) of a material is a measure of the degree to which it can be magnetized. In the Standard International (SI) system the dimensionless magnetic susceptibility, denoted by c, is the ratio of the magnetization, M or I, to the magnetizing force, H.

Most of the rocks in this area are nonmagnetic or only weakly magnetic. Granitoids have low magnetic susceptibilities. While, hornfels and skarn samples have average c of 314 and 730($\times 10^{-5} SI$), respectively. The distribution of hornfels can be determined from isomagnetic maps. Most of the ore deposits here are weakly magnetic with c values of about $100 \times 10^{-5} SI$.

(3) Density

The density of rocks in and around ore deposits are highly variable and therefore many gravity anomalies are observed. The Kokpatas formation, which is composed of sedimentary rocks which originated from metamorphic rocks, has a wide density range (2.61-2.84g/cm^3, av. 2.70g/cm^3). Quartzite and flint densities are the lowest and range from 2.58 to 2.68g/cm^3 with an average value of 2.65g/cm^3. The sparsely distributed dolomite has a relatively high density (2.68-2.84g/cm^3, av. 2.77g/cm^3).

The densities of intrusive rocks in the area are, in order of increasing density; granite-2.61, granodiorite-2.66, diorite-2.80 and lamprophyre-2.81g/cm^3.

The densities of rocks which have been altered are increased by contact metamorphism or hydrothermal metasomatic processes. Examples of this are hornfels, which has a density of 2.75g/cm^3, while the fresh terrigenous sedimentary rock from which it is derived has a density of 2.70g/cm^3 and altered skarn, which has a density of 3.06g/cm^3, while fresh carbonaceous rocks have a density of only 2.76g/cm^3.

Other general features related to the density of rocks in the study area are as follows. The density contrast between crystalline basement rocks and Mesozoic-Cenozoic sedimentary overburden is 0.47g/cm^3.

Hornfels which is bounded on one side by a granitoid intrusion will have a density 0.05 g/cm^3 higher than similar rock not in contact with the intrusion. When hornfels units are flanked on both sides by intrusions, their densities will be 0.09g/cm^3 higher than fresh hornfels.

Near the contact zone of the granitoid and country rocks, the country rock density is increased by $0.04 g/cm^3$.

(4) Seismic Body (p) Wave Velocity

Within the study area, the rocks can be divided into five groups by seismic body wave, or p-wave, velocities. These groups and their characteristic average velocities, in increasing order, are as follows;

weathered, folded and jointed and unsolidified rocks - 4.25 Km/s

Koksai formation rocks - 4.68 Km/s

Kokpatas formation rocks - 5.35 Km/s

Cholcharatau, Karashakh and Khodjaakhniet formation rocks - 5.50 Km/s

Hornfels and skarn - 6.5 Km/s

(5) Relationships between Physical Properties of Rocks

Based upon magnetic susceptibilities and densities, rocks of the Sautbay, Turbay and Sarytau areas, including intrusives, can be divided into two groups.

1) Group 1

These are nonmagnetic or weakly magnetic rocks ($c=0\text{-}60\times10^{-5} SI$) with densities which range from 2.63 to $2.84 g/cm^3$. Most of the rocks in the Sarytau area are altered by the hydrothermal metasomatic process due to intrusion of granitoids. This causes the magnetic minerals in them to change into low density material, resulting in rocks of lower density and susceptibility.

2) Group 2

The rocks of this group have magnetic susceptibilities and densities which are linearly related and their susceptibilities are generally high, ranging from 60 to 320 ($\times10^{-5} SI$). This linear relationship is typical of contact metamorphic rocks. The rocks of this group are less affected by hydrothermal metasomatic processes than those of Group 1. The tungsten deposits in the Sautbay and Sarytau areas show this linear relationship clearly but the gold deposit in the Turbay area shows a weaker linear relationship between density and magnetic susceptibility.

The following can be concluded from existing literature and from seismic and density studies of drill core from the Sautbay and Turbay areas. p-wave velocities and densities of the Karashakh, Koksai and Khodjaakhmet formations are similar, but the Koksai formation has somewhat lower values. p-wave velocities and densities of terriginous formations and other sedimentary units increase toward granitoid rocks. Sedimentary rocks can be separated by differences in magnetic susceptibilities and densities.

2-4-2 Geophysical Surveys

(1) Self Potential Survey

Equipotential lines run parallel to general geological trends which are NW-SE except near Sarytau in the eastern part of the survey area (Figure II-2-3). Equipotential lines in the Sarytau area trend NE-SW. In this area there are outcrops of intrusive rocks and there are several faults striking NE-SW and NW-SE. The geological environment of the Sarytau area is quite different from the rest of the study area.

(2) Gamma Ray Survey

The Turbay and Sarytau ore deposits are located in zones of major airborne gamma ray anomalies. There is also a ground gamma ray anomaly in the vicinity of the Turbay ore deposit. The Sautbay ore deposit and Bulutkan ore showing, while located near airborne anomalies, are not located within areas of peak anomalies.

There is a large gamma ray anomaly west of the Sautbay deposit and east of the Bulutkan ore showing there is a gamma ray anomaly which runs from NW to SE. In that the geologic structure map of the area shows many faults in these anomalous zones, it can be assumed that these gamma ray anomalies are caused by emission of radioactive gas from open fractures along the faults. There is also an anomalous zone, elongate in the NW-SE directions, in the northeastern part of the survey area.

(3) Magnetic Survey

The northeastern and southeastern parts of the survey area have been covered by ground magnetic surveys and the remainder of the area has been covered by airborne magnetic surveys. The ground magnetic data density is sparse and the data is monotonic with no local anomalous zones.

On the residual magnetic field plan map (Plate II-2-1) isomagnetic contour lines run generally NW-SE which coincides well with the general geologic trend. The contours deviate from this trend, however, 7*km* north of the Bulutkan ore showing, 4*km* northwest of the Turbay ore deposit, southeast of the Turbay deposit and to the west of and 4*km* southeast of the Sarytau deposit. In these areas the contours trend NE-SW corresponding to the strike of faults in these areas.

(4) Two Dimensional Analysis of Gravity and Magnetics Data

The existing reports present quantitative analyses along sections through major ore deposits. In this report the results of model studies of the same sections and one new section will be presented. The locations of these sections are shown on Plate II-2-2.

1) Section A-B

Section A-B (Plate II-2-3, Figure II-2-4) is a NNE-SSW line which intersects the Sautbay ore deposit. In the local gravity profile there are two regions of anomalously low gravity which are interpreted as resulting from the presence of low density intrusives. These intrusive rocks are called North Sautbay intrusive rocks and Turbay intrusive rocks. Their density is 0.05 to $0.08 g/cm^3$ less than the host rock which has a density of $2.67 g/cm^3$. Turbay intrusive rocks are not seen on the surface and North Sautbay intrusive rocks outcrop only in limited areas near the Sautbay ore deposit. The model study implies that these intrusions have widths of 4 to $7 km$ and depths of burial of 100 to $600 m$.

On the Geophysical-Geological Model in the figure, the areas with dashed lines are zones of magnetic mineralization which can be inferred from the aeromag map. The broad central magnetic zone coincides with the Sautbay ore deposit.

Magnetic and gravity data inversion results produced by MAGIX XL are presented in Figure II-2-4. The initial gravity model was taken from the geological model of Plate II-2-3. There is a striking similarity between the geologic model of Plate II-2-4 and the gravity model in Figure II-2-4 which resulted from inversion of the gravity data.

The magnetics inversion implied magnetic susceptibilities of 500 and $1000(\times 10^{-5} SI)$ in magnetic bodies near the Sautbay ore deposit and in the Turbay intrusive rock.

2) Section C-D

This section strikes NNE-SSW passing near the Bulutkan ore showing (Plate II-2-4, Figure II-2-5). In the local gravity profile there is a broad anomalous low at the northeastern end and a lesser low anomaly at the center of the section. The location of low density intrusive bodies correspond with the locations of these anomalies. These intrusives are called the Turbay and the Sautbay intrusive bodies. They have densities 0.07 and $0.04 g/cm^3$ less than the host rocks. The Turbay intrusion has a width of about $5 km$ and outcrops of it are wide spread. The Sautbay intrusive body is partially exposed near the Bulutkan ore showing and its width is inferred to be a maximum of $7 km$.

The areas with dashed lines on the Geophysical-Geological Model in this figure, are zones of magnetic mineralization, as inferred from the aeromag map. One of these coincides with the Bulutkan ore showing, which also coincides with IP and gravity anomalies.

MAGIX XL inversion results are presented in Figure II-2-5. The initial gravity model was taken from the geological model of Plate II-2-4. There is good agreement between the geologic model and the gravity inversion results.

The magnetics inversion implied the presence of four magnetic bodies with susceptibilities of about 500 and 1000 ($\times10^{-5}SI$). These bodies are located near zones of high susceptibility marked on Plate II-2-4.

3) Section E-F

Section E-F strikes E-W passing through the Sautbay ore deposit, the Turbay ore deposit and the Sarytau ore deposit. The local gravity profile is anomalously low at both ends. At the west end of the profile there is a broad low with shorter wavelength anomalies within it. The low at the east end of the profile has a long wavelength.

The anomalies near the west end of the profile occur in the vicinity of the low density North Sautbay, Sautbay and East Sautbay intrusive bodies, which are 0.05 g/cm^3 less dense than the host rocks at depth. Near surface extensions of these intrusives are 0.1 g/cm^3 less dense than their host rocks.

The anomalies near the east end of the profile coincide with the Turbay and Sarytau intrusives. At depth these intrusive bodies merge into a single intrusion. These intrusives are 0.06 g/cm^3 less dense than the surrounding host rocks.

MAGIX XL inversion results are presented in Figure II-2-6. The initial gravity model was taken from the geological model of Plate II-2-5. There is good agreement between the geologic model and the gravity inversion results.

4) Section G-H

Section G-H runs from WSW to ENE through the Bulutkan ore showing and the Turbay ore deposit (Figure II-2-7). No sections through these areas have been analyzed in past publications. The regional gravity profile shows a monotonic increase toward the east. In the Bouguer anomaly section, there is a broad low at the west end of the profile, a low near the center and a low at the east end of the profile. This data has been inverted by the program MAGIX XL using existing geological sections of the area to derive a candidate model. The inversion indicated the presence of low density bodies which coincide with the locations of the Turbay intrusive body/Sarytau stock and Taraubay intrusive body. These bodies have densities 0.05 to 0.08 g/cm^3 lower than the host rock. The Sautbay intrusion outcrops near the Bulutkan ore showing (Figure II-2-7). The Turbay intrusive body/Sarytau stock and Taraubay intrusive body are believed from the inversion results to be near surface.

The magnetic data inversion implies the presence of four magnetic bodies with susceptibilities of $500\times10^{-5}SI$. The body near the west end of the profile coincides with the Bulutkan ore showing.

(5) Distribution of Intrusive and Host Rocks

The survey area can be divided into four zones, numbered from southwest to northeast, from geophysical and geological survey results (Figure II-2-8).

1) Zone I

Zone I is in the southwest corner of the survey area and is covered by the Kokpatas Intrusive body, which consists of granite porphyry and quartz porphyry. The contact of the intrusive body and host rocks is at the northeast side of the zone. Magnetic field contour lines in this area trend NW-SE. Gold mineralization is predominate in the area.

2) Zone II

The Sautbay tungsten ore deposit is in Zone II, which is immediately north of Zone I on the central western border of the survey area. There are concealed North Sautbay Intrusive bodies in this area, which cause anomalously low gravity. Wide magnetic anomalies, extending from NW to SE, are also associated with these intrusive bodies.

3) Zone III

Zone III occupies a broad band running from northwest to southeast through the center of the survey area. There are several intrusive bodies in this zone, including the Turbay, Sarytau, Katirtas and other intrusions. There are low gravity and negative magnetic anomalies clearly associated with these intrusive bodies.

Past drilling programs have revealed tungsten-gold and gold-silver mineralization in this area. Gravity, magnetic, and SP contour lines extend NW-SE in the general direction of geologic structure in this zone.

4) Zone IV

Zone IV is at the northeast corner of the survey area. While outcrops of the Taraubay Intrusive body have not been detected in this area, its presence is clearly implied in the gravity map by a low amplitude broad anomaly. Isomagnetic contour lines in this area trend NE-SE. High magnetic anomalies in this area are assumed to be caused by diorite, the Taraubay Intrusive body, with a magnetic susceptibility of $400 \times 10^{-5} SI$.

(6) Host and Intrusive Rock Summary

1) Contacts of Intrusions with Host Rocks

The following statements have been made in existing literature, regarding the contact of granitic host rocks with the Karashakh, Kokpatas, Khodjaakhmet and Koksai formation metamorphic rocks.

In areas where intrusive rocks either outcrop or are near the surface of the ground, intrusive granitic bodies with low densities and low susceptibilities create low gravity and low magnetic anomalies centered near the top of the intrusions. There are also large positive SP anomalies associated with these bodies. The density of host rocks increases toward intrusive rocks. Magnetic survey results show positive anomalies on the host rock side of Intrusions. Hornfels, skarn, and beresite, formed in host rocks by intrusion, have high magnetic susceptibility and cause relatively large anomalies near the intrusive bodies.

In areas where intrusive bodies are covered by thick sediments, it is generally difficult to map their distribution by surface geophysical methods. However, in areas where pyrrhotite is formed at contacts of host rocks with intrusive bodies, magnetic surveys can be used to map the intrusives which create moderate magnetic anomalies.

2) General Features of Ore Bodies

Intrusion of host rocks by granitic bodies results in increases in porosity and in turn fluid permeability, resulting in low gravity anomalies. Sulfide minerals can be formed in these high permeability zones. The known ore deposits in the survey area tend to be associated with pyrrhotite occurrence. Pyrrhotite has a high magnetic susceptibility and rocks with high pyrrhotite content create magnetic anomalies on the surface of the ground. Inversion results show magnetic susceptibilities of anomalous bodies to be around $10^{-3} SI$. Magnetic and gravity anomalies caused by intrusive bodies are most clearly seen in local anomaly maps of relatively short wave length (1,500m).

Major ore deposits in the survey area, the Sautbay, Turbay and Sarytau ore deposits, and other showings occur at or near high magnetic anomalies (Figure II-5-1).

3) Future Exploration

According to existing geophysical information areas recommended for future exploration are shown in Figure II-2-9 with a summary of existing geological and geophysical information. These recommended areas include the Sautbay, Turbay and Sarytau ore deposits and the Bulutkan ore showing. The areas which have been recommended for further exploration have been chosen due to the similarity of their physical environments with those of known deposits.

The following areas near Sautbay ore deposit, which has been an area of extensive geophysical studies, are recommended for further exploration to evaluate development potential.

a) Sautbay South Zone, Sautbay West (Saghinkan) Zone, Sautbay East Zone

The Sautbay South Zone is south of the ongoing exploration project area and covers an area as large as the Turbay ore field. Magnetic data from this zone is moderately anomalous.

b) East Sautbay Area

The East Sautbay Area is between the Bulutkan ore showing and the Turbay ore deposit. The East Sautbay Intrusive bodies are not exposed in this area. This area is geochemically anomalous and drilling surveys encountered rock with a high gold content.

c) Bulutkan Area

The Bulutkan area is about 5.5*km* ESE of the Sautbay ore deposit. Drill cuttings from near surface has high gold content. We suggest geophysical surveys to detail the horizontal and vertical extent of this mineralization.

4) Recommended Geophysical Survey Methods

Past gravity and magnetic surveys have been successfully used to map intrusive bodies and to determine physical features of host rocks.

We suggest future electromagnetic or electrical(resistivity and IP) surveys with short station spacing to compliment gravity and magnetic surveys. Electrical and electromagnetic information will help clarify the nature of ore deposits.

Summary:

The roles of previously used and proposed geophysical methods in mineral exploration in the survey area are summarized as follows:

1) Most known ore deposits in the area are near granitic rocks and are associated with magnetic anomalies.
2) Granitic rocks are less dense than host rocks and produce clear low gravity anomalies.
3) Magnetic surveys can effectively map the location of contacts of intrusive rocks with host rocks. In that magnetite deposits tend to develop during the course of contact metasomatism, high magnetic anomalies are seen around intrusive bodies and are important indicators of ore deposition.
4) Gravity and magnetic surveys have been used successfully and extensively in this area. In addition to these methods, extensive use of electrical and electromagnetic survey methods will help to clarify details of ore fields.

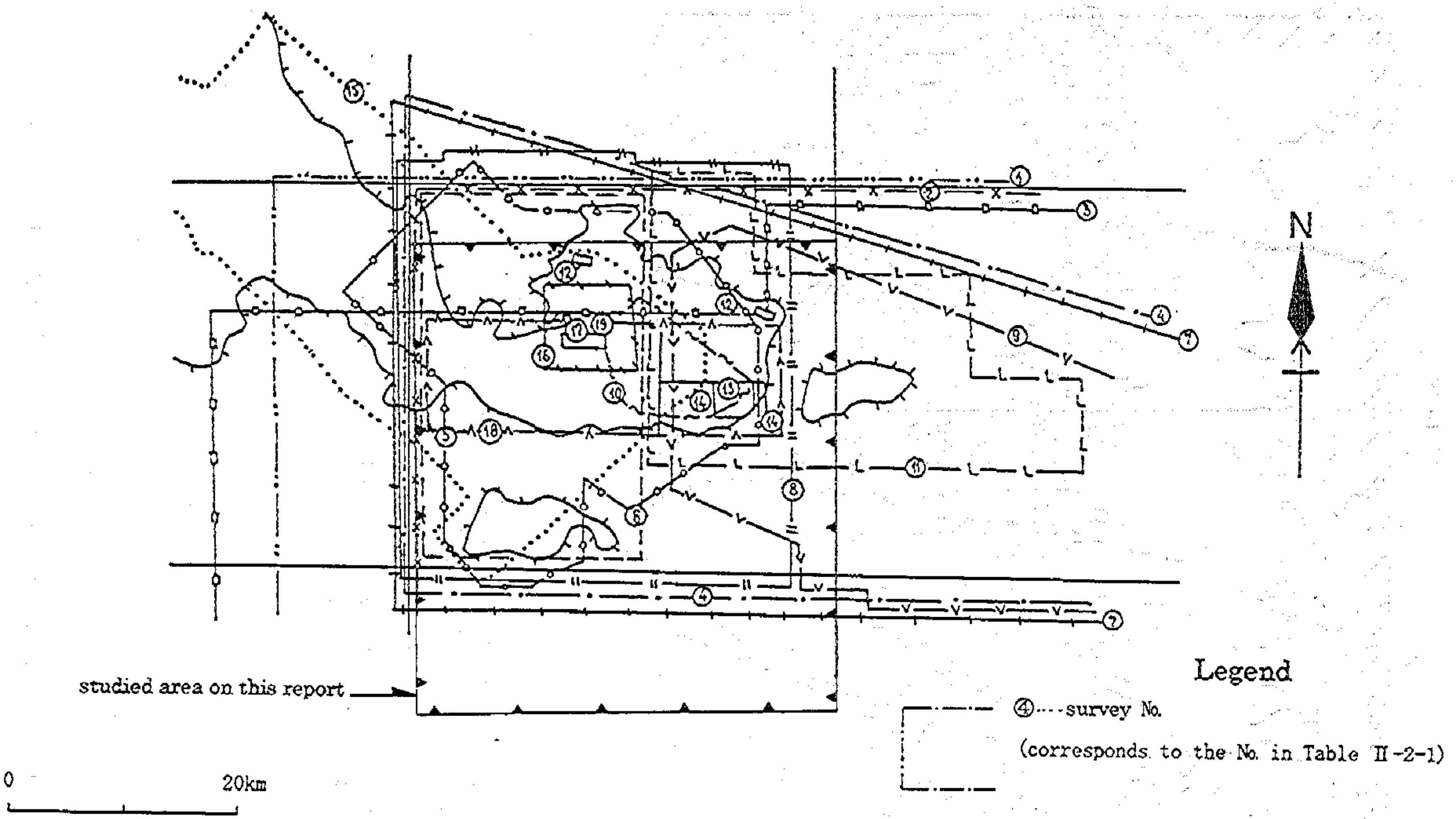
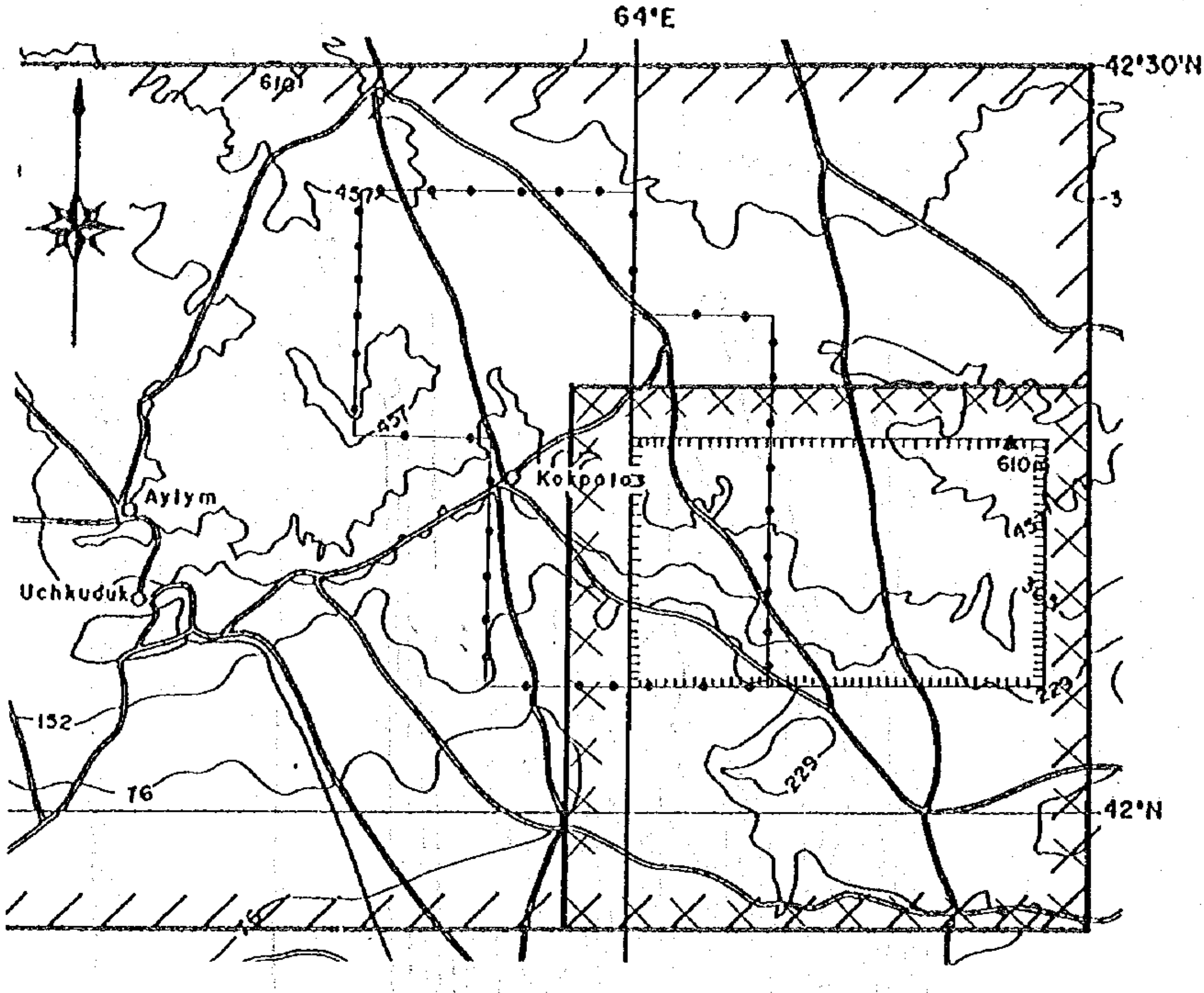


Fig. II-2-1 Geophysical Survey Coverage of the Eastern Bukantau Area



source of data analyzed in this report
(compiled by A.P.Cheshuin:1994)

source of results quoted in this report
(compiled by A.A.Horsov:1991)

0 30km

Fig. II-2-2 Geophysical Data Compilation Area for this Report

after A.P.Cheshuin(1994)

0 5 km

Legend

—100— solid line : positive anomaly

---100--- dashed line : negative anomaly

unit : mV

\\\\\\\\\\ axis of strong SP anomaly, identifying with the silicification zone

●, ■ ore deposits and ore showing

A B geophysical-geological section

Fig. II-2-3 Self Potential Map

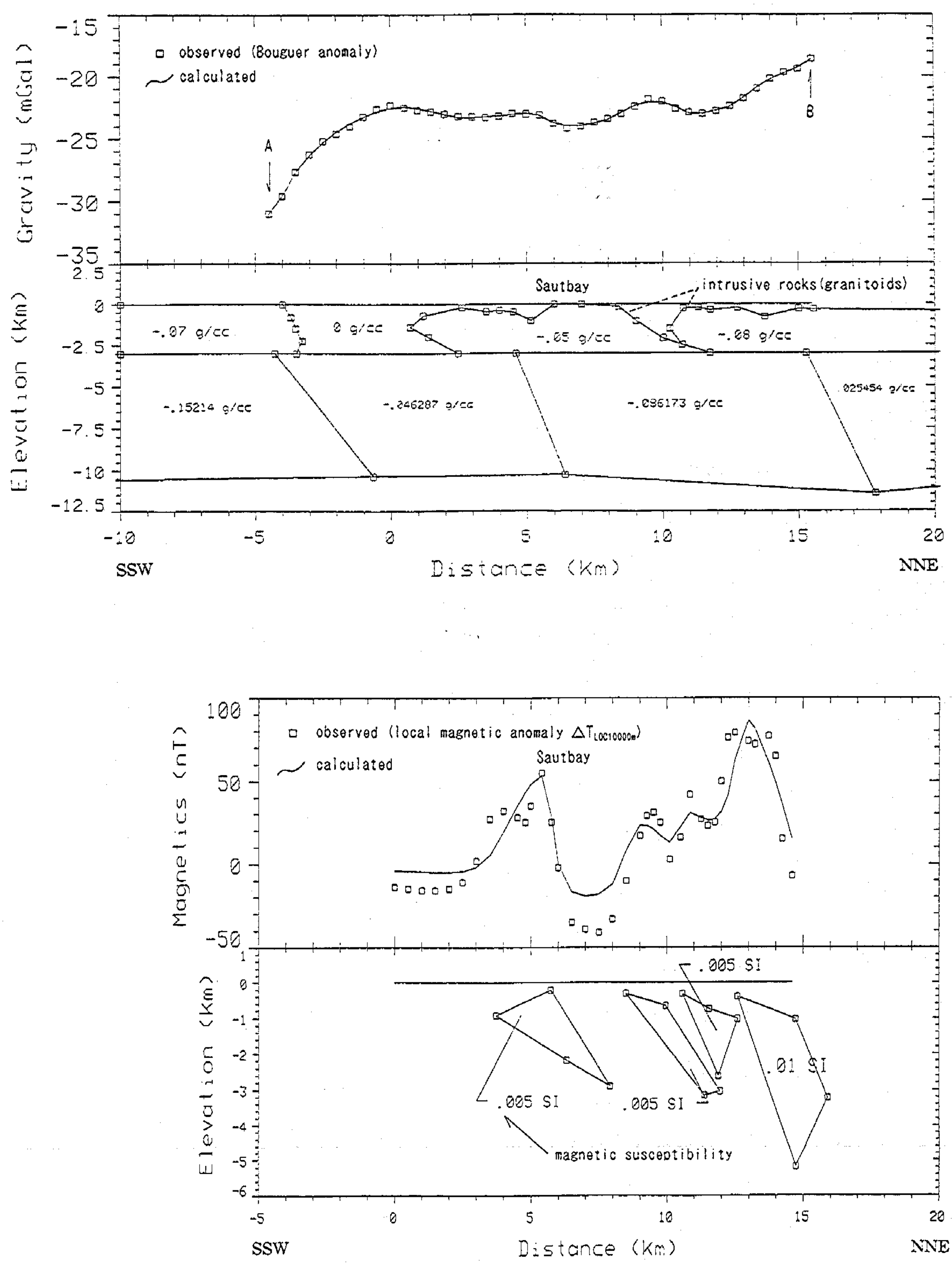


Fig. II-2-4 Modeling Results for Section A-B

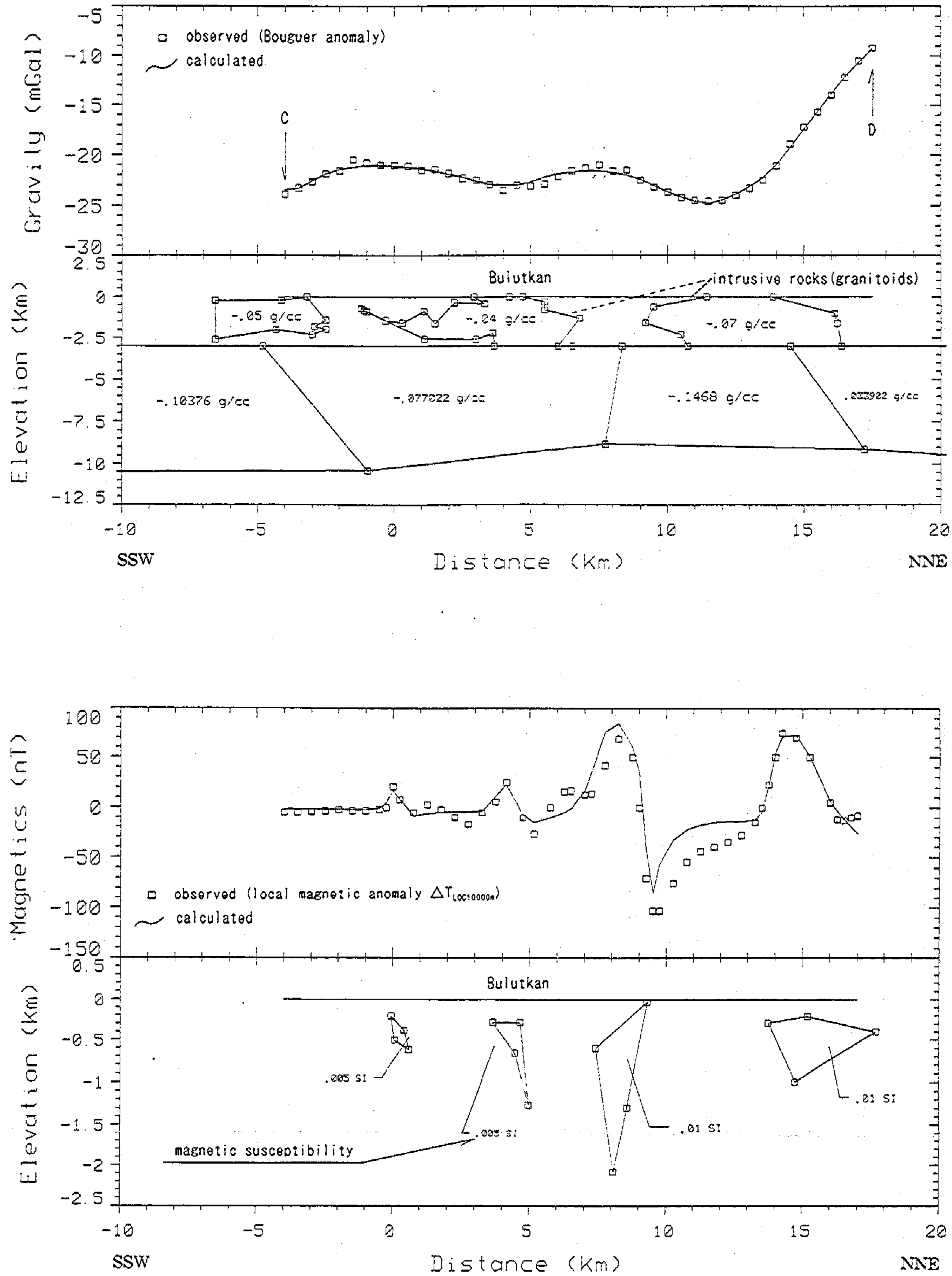


Fig. II-2-5 Modeling Results for Section C-D

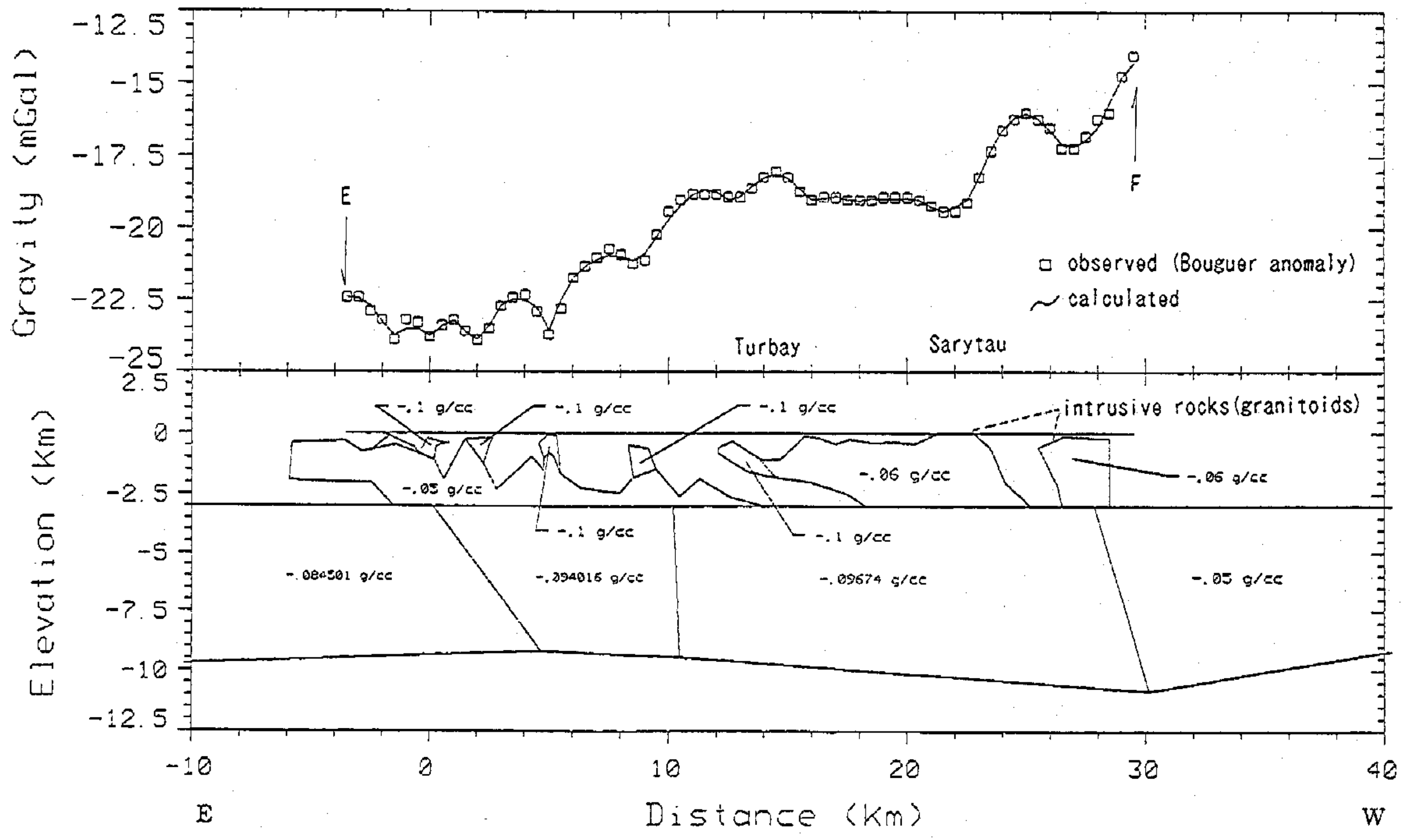


Fig. II-2-6 Modeling Results for Section E-F

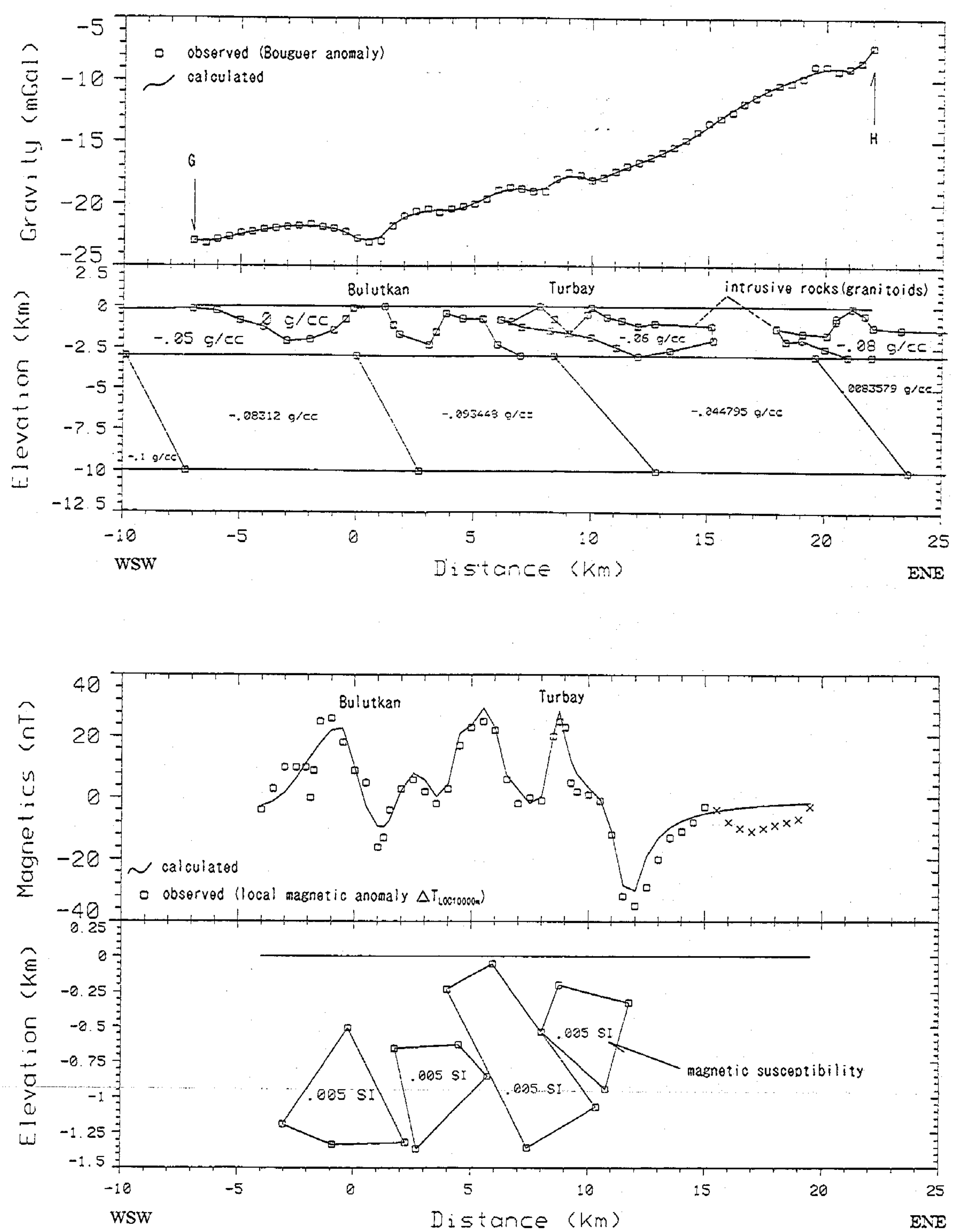
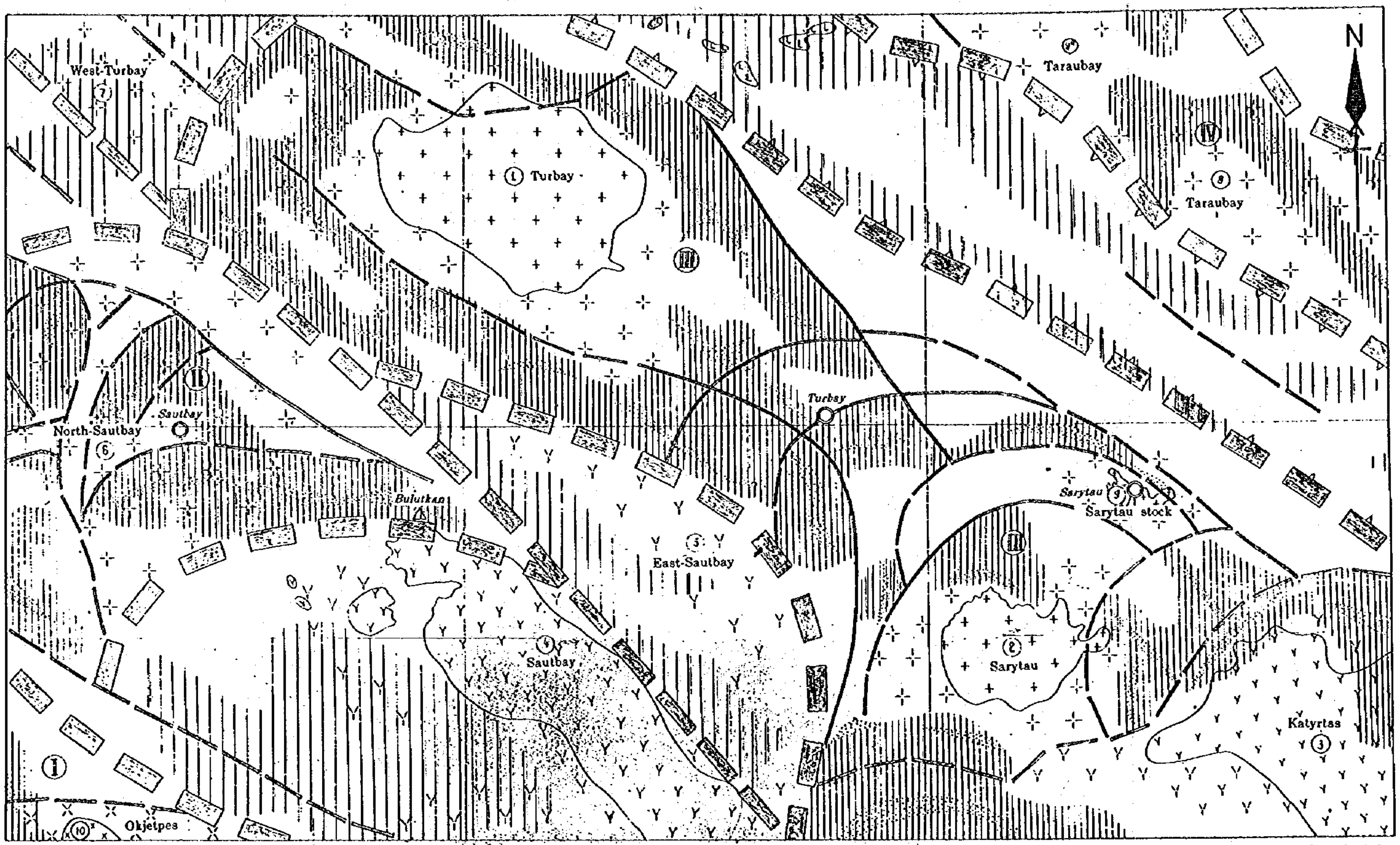


Fig. II-2-7 Modeling Results for Section G-H



Legend

granitoid intrusion

* **

quartzitic diorite, granodiorite, granite, adamellite
syenite-diorite, granosyenite

granite-porphyrie, quartzite, porphyrie

diorite, gabbro-diorite

* according to outcrop and geological data
** inferred from lower density and magnetization, i.e. gravity and magnetic minimum

sedimental-metamorphic complex*, distinguished on positive anomaly of Δ Tloc
a: intensive (50-150 nT)
- longitudinal wave velocity up to 6 km/sec and more
- low SP value and high IP value
(*hydro-thermal metasomatism including hornfels, skarn, sulfide mineralization)
b: same rocks as "a", but lesser intensive
c: undivided

boundary of high gradient gravity field, dividing geological blocks with intrusive rocks

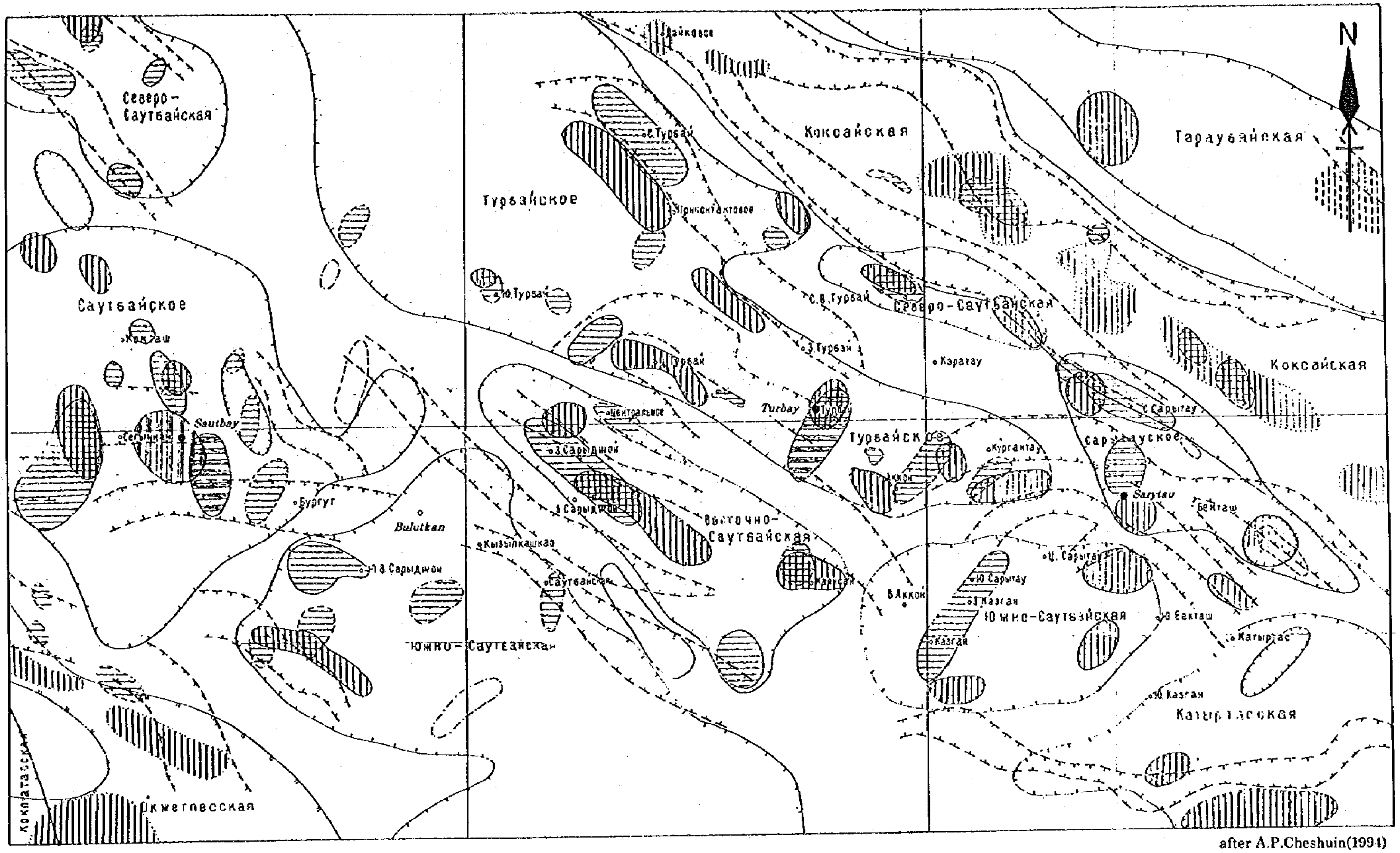
geophysical linear elements, dividing geological blocks
1: strong (Δ T, Δ G and Δ SP)
2: moderate (Δ T, Δ G and Δ SP)
3: weak (Δ T, Δ G, Δ SP)

axis of most intensive positive anomaly of magnetic field (Δ Tloc)

original number of intrusive rock and its name

a: large structural blocks with its number, characterized with above mentioned geophysical anomalies
b: ore deposit with tungsten and gold

Fig. II-2-8 Geophysical - Geological Zone Map



after A.P.Cheshuin(1994)

0 5 km

Legend

- ore deposit
- ore showing
- low magnetic zone and low gravity zone ($\Delta T_{LOC(1500)}$, $\Delta G_{LOC(1500)}$: type "a")
- radio-active anomaly
- a: granitoid and magnetic type "a" zone
  b: granitoid, magnetic type "a" zone and radio-active anomaly
- forecasted area for further survey
- high gravity zone correlated with high velocity zone (supposed hornfelization)
- high permeability zone
- local gravity minimum($\Delta G_{LOC(1500)}$)
- radio-active anomaly (in Koksai area)
- geophysically, anomalous zone
  a: known ore deposit
  b,c: perspective area with ore indication
  (b: Sautbay,Sarytau,Turbay type)
  (c: Okjetpes,Kokpatas,Muruntau type)

Fig. II-2-9 Map of Geophysical "Mineral Potential" Indicators

Table II-2-1 Geophysical Survey History in the Eastern Bukantau Area

Survey No.	Surveyed Year	Survey Method	Survey Scale
1	1960-1964 1964	airborne magnetic survey	1:50,000 1:25,000
2	1964-1965	airborne magnetic survey	1:25,000
3	1965	seismic prospecting	1:100,000
4	1967-1968	seismic prospecting	1:100,000
5	1969-1970	airborne gamma ray survey	1:25,000
6	1970-1974 1974	magnetic survey, SP survey geochemical survey	1:50,000 1:2,500
7	1971-1972	seismic survey	1:50,000
8	1971-1974	gravity survey	1:50,000
9	1972	airborne gamma ray survey, magnetic survey	1:25,000
10	1972-1973 1974	gamma ray survey, geochemical survey gamma ray survey, geochemical survey	1:50,000 1:25,000、 1:10,000
11	1974-1976 1977	electric survey(IP,SP), gamma ray survey, geochemical survey ditto(precise survey)	1:50,000 1:50,000
12	1977-1982 1983	electric survey(IP,SP) ditto(precise survey)	1:50,000 1:25,000、 1:10,000
13	1981-1983 1983	magnetic survey, electric survey(SP) ditto	1:25,000 1:10,000
14	1982-1983 1984	electric survey(EM) ditto	1:50,000 1:25,000
15	1983-1984	airborne geophysical survey(magnetic, electro-magnetic,gamma ray)	1:50,000
16	1988-1989	electric survey(EM)	1:25,000
17	1988-1989	magnetic survey	1:5,000
18	1984-1989 1989	gravity survey, magnetic survey ditto	1:25,000 1:10,000
19	1988-1989	geoelectoro-chemical survey	

Table II-2-2 Electric Properties of Rocks in the Bukantau Mountains

Formation and Rocks	Number of Samples	IP(%) min.- max. (average)	Resistivity min.- max. (average)
Quaternary sediments: pebble, sandy loam, sand, rock debris	107	0.25-1.2 (0.8)	50 - 200 (100)
Cretaceous and Paleogenie sediments: clay, sandstone, marl	34	0.5-1.3 (0.9)	10-50 (30)
Kokpatas formation: siliceous rock, sand stone, siltstone, phyllite, schist, dolomite	117	2.0-10.5 (5.5)	5-75 (20)
Karashakh formation: andesitic tuff, tuff breccia, sandstone, siltstone, schist(slate, shale)	132	3.0-12.5 (7.5)	50-350 (150)
Rock mass "a" : sandstone and siltstone	41	3.5-12.5 (7.5)	5-100 (90)
Intrusive rock: granite, granodiorite	36	1.8-3.5 (2.5)	300-1800 (1000)
lamprophyre, dioritic porphyrite (dike)	19	2.1-3.2 (2.8)	650-1500(850)
Serpentine	15	2.5-4.5 (3.5)	30-160 (100)
zone of graphitization and pyritization in the sediments of Kokpatas and Koksai formations	58	10-30 (12.0)	1-25 (5)

Table II-2-3 Density and Magnetic Susceptibility of Rocks in the Bukantau Mountains

d: (g/cm^3) χ :(x 10^{-5}SI) ( ):average

Formation and Rocks	Structure and Materials	Physical Parameters		Admitted to Interpretation		Characteristic of Gravity and Magnetic Fields
		Density (d)	Magnetic Susceptibility (χ)	Density (d)	Magnetic Susceptibility (χ)	
Quaternary sand, sandy loam, clay, conglomerate, sandstone	terrigenic-sedimental(Meso-Cenozoic)	1.8-2.45 (2.20)	0-20 (10)	2.25	0	lower gravity and neutral magnetic field
Koksai formation sandstone, siltstone, silt	terrigenic-sedimental	2.58-2.67 (2.63)	0-40 (20)	2.63	0	zoned gravity-magnetic minimum values and neutral magnetic field
Kokpatas formation siltstone,silt,sandstone	terrigenic-sedimental silty-sandy	2.62-2.82	0-40 (20)	2.67	0	neutral gravity and magnetic fields
Karashakh formation green stone rock mass, schist, formed sand-tone, siltstone, sandstone, limestone	terrigenic-volcanic	2.67-2.85 (2.76)	0-300 (150)	2.76	300	local gravity and magnetic minimum values
Kumbulok formation greenstone rock mass	metabasific	2.62-2.91 (2.80)	10-5000 (2500)	2.82	2000	regional gravity maximum value and magnetic minimum value
granite		2.54-2.67 (2.60)		2.58	50	isometric and zoned intrusive gravity minimum and weak lower magnetic field
gabbro		2.78-2.86 (2.82)	20-100 (60)	2.82	0	local gravity maximum and neutral magnetic field
hornfels, skarn, beresite	contact - metasomatic	2.77-3.27 (3.00)		2.90	1500	intensive local maximum and changing magnetic field

Chapter 3 . Ore Reserve Estimation of Sautbay and Burgut Deposits

3-1 Objective

The purpose of the ore reserve estimation is to evaluate Sautbay and Burgut deposits based on the existing data collected in Uzbekistan, and to provide useful information for further investigation planning.

3-2 Estimation Methodology

(1) Software

MicroLYNX Plus, released by Lynx Geosystem Inc. of Canada, was used in the reserve estimation of Sautbay and Burgut deposits.

MicroLYNX is a project-oriented system designed to aid geologists and engineers in exploration, mine evaluation and mine planning, and is widely used around the world. The main functions or features are as follows:

① A project-oriented program to manage more than one project in a computer system.

② Entry of drill hole data including assay and geological information, editing where necessary.

③ Graphics display and plotting of drill hole data in section and plan to assist in the interpretation of the spatial nature of the mineralization.

④ Statistical and geostatistical analyses of grade variables to determine the distribution and variability of grade within the deposit.

⑤ Definition of geology, in section or plan, for control of ore reserve modelling.

⑥ Generation of ore reserve models, and interpolation of grades of target components

⑦ Calculation of geological reserves based on the interpolated grades.

⑧ Visual display and plotting of the model in section ore plan to assist in the mining design.

⑨ Designing of open pit or underground tunnel, calculation of mineable reserves.

⑩ Updating the reserve models to reflect the more abundant data available during mining.

(2) Estimation area

Sarydjoy geology team working in the eastern Bukantau region submitted a geological report in Dec. 1993 about Sautbay deposit including Burgut deposit which is about 800m southeast of Sautbay deposit. The report contains not only geological description but also ore reserve estimation of Sautbay and Burgut deposits. Because Burgut deposit is situated very close to Sautbay deposit, both of the deposits were included in our calculation(Fig. II-3-1). The coordinate system adopted by Sarydjoy report is in accordance with true north. The geologic section maps attached in the report, however, are along N60° E, which is not fit for microLYNX. Therefore, a new coordinate system was created by rotating the old system 60° clockwisely and moving the origin to a proper point. This new system was used in our calculation. Fig. II-3-2 shows the ore reserve calculation area of 1,750m by 1,600m, from -5 to 1,745m along X axis and from -5 to 1,595m along Y axis respectively in the new coordinate system.

(3) Assay

613 holes have been drilled around Sautbay and Burgut deposits, but more than half of them are coreless. 159 among the 613 holes were used in our reserve estimation (Fig. II-3-2). Samples for analysis have been collected from the cores every 1 ~ 2m. Samples collected from the walls of the tunnel at the level of 193m in Sautbay deposit were classified into 36 groups depending on tunnel directions, and included in our calculation as horizontal drillholes.

WO_3 and Au are the two primary components of the deposits, and were selected as the estimation targets. There are very few or no data available for other components. The sample numbers for WO_3 and Au are 10,728 and 13,494 respectively.

(4) Definition of ore zones

As described previously, Sarydjoy report provides very detailed descriptions on Sautbay and Burgut deposits. 23 sheets of geologic sections were attached in the report. According to these materials, 21 ore bodies have been identified in the deposits. Because the two deposits are situated very closely, and some of the ore bodies stretches over both of the deposits, they can be considerercd practically as one deposit(PL.II-1-3~PL.II-1-4).

As to the definition of ore zones, 22 of the 23 geologic sections mentioned above were adopted with few correction on them. The section along line 78 was excluded from our calculation due to its long distance from line 70 and few data available around the section. As shown in PL.II-1-3, the intervals between sections are about 40m at Sautbay deposit, and 40 - 170m for other portion. The ranges of a section in positive and negative directions, within which geologic interpretation will be considered to be the same as that of the section, were considered to be equal to halves of the distances between the section and adjacent sections in both directions respectively. Unique geologic codes were assigned to all of the ore bodies for identification.

(5) Variogram

All of the samples should have the same size (length in this case) in geostatistical analysis. Therefore the assay data were composited before the calculation of variograms. Compositing is a procedure in which sample assay data are combined by computing a weighted average over longer intervals to provide a smaller number of data with greater length for use in reserve esitmation. Compositing is usually a length-weighted average. The length of composites used in our calculation is 5m, and the compositing process is as follows: ① assigning geologic codes to assay data based on the geologic cross sections and their ranges, ② computing composites by length-weighted average method according to the geologic codes.

21 ore bodies are separated spatially. Origionally, they are differernt from each other, having different variograms. All of the ore bodies except No.1 have no enough data to produce meaningful variograms. Therefore, only variograms for No.1 ore body were computed in order to examine the charateristics of grade distributions in 3-dimensional space.

No.1 ore body is in the shaple of a plate on the whole, striking N10° W and dipping 60° E. The ore body forms a large block from the surface to 150m deep in Sautbay deposit, and branches into four stratiformed ore bodies below the depth. An new axis system for No.1 ore body was defined for later explaination as shown in Fig. II-3-3.

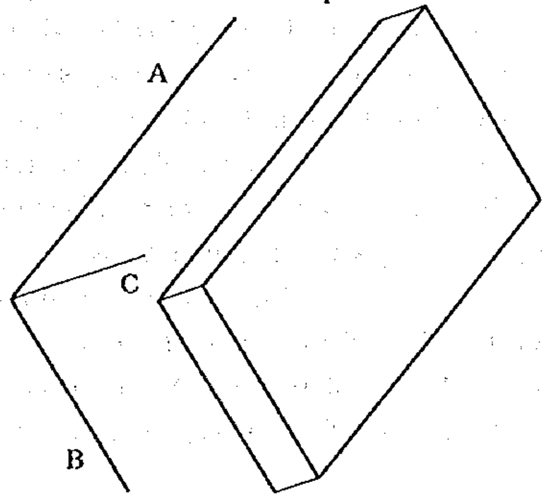


Fig. II-3-3 Definition of 3 axes for No.1 ore body

A axis: along the strike of No.1 ore body, N10° W

B axis: dipping of No.1 ore body, -60° to the horizontal plane

C axis: vertical to the plate of No.1 ore body, +30° to the horizontal plane

Distributions of variables in geological units(for example, Au grade in a deposit) in nature show various characteristics. Some of them are isotropic, others are anisotropic. Anisotropy is expressed geostatistically by the existing of different variograms in different directions. Even the same data set will produce different variograms according to the computing conditions(distance between pairs of samples, angles within which pairs of samples will be found, etc.). Therefore, while doing variogram analysis, it is very important to change conditions to compute various variograms, and then select most typical ones from them.

Fig. II-3-4 ~ II-3-7 show the representative variograms of WO_3 and Au along the different directions for No.1 ore body. They are selected from many variograms examined using various conditions. Table II-3-1 shows the parameters obtained from the variograms, which can represent the variograms. No clear variograms were obtained for WO_3 in B axis direction and Au in C axis direction.

Table II-3-1 Parameters of the variograms for No.1 ore body

Component	Direction	Nugget	Sill	Range
WO_3	A axis	0.019	0.267	85
	C axis	0.060	0.304	15
Au	A axis	0.004	0.138	120
	B axis	0.019	0.502	120

As shown in the table, the ranges of WO_3 along A and C axis directions are apparently different. The former is 85m, and the later is 15m. In another word, along A axis the corelation between WO_3 grades of two samples will disappear if the distance between the two samples are beyond 85m. Similarly, the critical distance is 15m along C axis. Taking into consideration the shape of the ore body, it is reasonable to presume that No.1 ore body has a range along B axis very similar to that of A axis.

As to Au, a range of about 120m was observed along both A and B axes, which means that distribution of Au grade shows the same characteristics along both directions.

On the whole, the distributions of WO_3 and Au in 3-dimensional space might be considered to be a flat ellipsoid with the two long axes parallel to the plate of No.1 ore body.

(6) 3-D block model

In order to estimate the grades of WO_3 and Au in the deposits, a 3-dimensional block model was created. The model covers an area shown in Table II-3-2 by the new coordinate system.

10m was adopted as the block size in the X, Y, Z directions. Most of the ore bodies, however, are very thin, and a block of 10x10x10(m) is too large to present the ore bodies. Therefore, The primary block was subdivided into smaller ones. The size of a subblock is 5x1x1(m) along X, Y, Z directions respectively as shown in Table II-3-2.

Table II-3-2 Attributes of the 3-D block model

Direction	Minimum	Maximun	Range (m)	Block size (m)	Block number	Subblock size(m)
X axis	-5	1745	1750	10	175	5
Y axis	-5	1595	1600	10	160	1
Z axis	-400	250	650	10	65	1

(7) Kriging interpolation

Kriging interpolation is a geostatistical estimation procedeure which uses limited data to estimate grades of components within a block or whole deposit by minimizing the estimation error(Kriging error) based on the geostatistical characteristic of the components in the deposit. In another word, the grade estimated by Kringing interpolation method is most close to the "true value" in the deposit.

Average grades of each block in the block model were interpolated by the Kriging method. The Kriging interpolation is a process that relies on the development of geostatistical analysis, variogram.

The parameters obtained from the variogram analysis as described previously were used in the interpolation of grades for blocks of No.1 ore body. Spherical model was used as the variogram model. As to other ore bodies, no meaningful variograms were obtained, and the origins of these ore bodies can be considered to be similar to that of No.1 ore body, therefore, the variogram parameters of No.1 ore body were applied to the interpolations of other ore bodies.

In the interpolating procedure of the average grades of blocks, it is necessary to limit the data by search distance. Only the data which are within the search distances will be used in interpolation process. Search distances are usually determined based on the Range value obtained from variogram analysis. 100m and 20m were adopted as the search distances of WO_3 along A axis and C axis respectively. As described previously, it is reasonable to presume that No. 1 ore body has a range along B axis very similar to that of A axis, we used the same search distance of 100m for B axis. As to Au, a search distance of 130m was adopted for A and B axes according to the range values, and 20m, which is the same as WO_3; for C axis because no meaningful variogram was obtained for C axis.

In addition, the interpolation was controlled by geology, that is, only the data which belong to the same ore body were used in the interpolation of the block.

(8) Summarization of reserves

The reserves and average grades by the following cutoffs, 0.05, 0.08, 0.1, 0.2, 0.3, 0.4, 0.5% WO_3, were calculated based on the gades of blocks interpolated by the Kriging method.

3-3 Estimation Result

Table II-3-3 shows the estimation result of Sautbay and Burgut deposits by the method described above.

The total reserve of Sautbay and Burgut deposits is 25,885 thou.tons by the cutoff of 0.05%(WO_3). The average grade of WO_3 is 0.27%, and that of Au is 0.24g/t. The metal contents of the two components are about 70 thou.tons(WO_3) and 6 tons respectively.

Table II-3-3 Ore reserve estimation result of Sautbay and Burgut deposits

Cutoff (WO_3%)	Reserves (t)	WO_3 (%)	Au (g/t)	WO_3 (t)	Au (kg)
0.05	25,885,000	0.27	0.24	70,631.7	6,335.1
0.08	23,237,000	0.29	0.26	67,387.3	6,041.6
0.10	21,246,000	0.31	0.28	65,862.6	5,948.9
0.20	11,331,000	0.46	0.36	52,122.6	4,079.2
0.30	6,869,000	0.60	0.45	41,214.0	3,091.1
0.40	5,034,000	0.70	0.50	35,238.0	2,517.0
0.50	3,381,000	0.82	0.55	27,724.2	1,859.6

Table II-3-4 shows the comparison of our result with that of Sarydjoy report. Both of the methods provided almost the same reserve of about 2,600 thou.tons(cutoff 0.05%WO_3) for the open pit in Sautbay deposit. Although the average grades of WO_3 and Au are a little lower than those of Sarydjoy report, the two results can be considered to be practically the same.

Table II-3-4 Comparison of ore reserve estimation results by MMAJ(1995) and Sarydjoy Team(1993)(on the Whole Area Basis)

Area	Reported by	Reserves (t)	WO_3 (%)	Au (g/t)	WO_3 (t)	Au (kg)
Open pit of Sautbay deposit	Sarydjoy(1993)	2,606,250	0.38	0.16	9,960.5	411.4
	MMAJ(1995)	2,621,000	0.35	0.13	9,173.5	340.7
Sautbay,Burgut deposits	Sarydjoy(1993)	39,539,352	0.43	0.34	168,701.5	13,530.7
	MMAJ(1995)	25,885,000	0.27	0.24	70,631.7	6,335.1

On the basis of the whole area of Sautbay and Burgut deposits, however, significant differences were observed not only in ore reserves but also in average grades between the two results. Sarydjoy Team reported a reserve of 39,539 thou.tons, but we estimated the reserve as 25,885 thou.tons, 65% of that of Sarydjoy. The average grades of WO_3 and Au are also lower than those of Sarydjoy, 63% and 71% of those of Sarydjoy respectively.

The following difference between the calculation methods might be considered as the primary reason why the reserves are so different. As described previously, geologic sections attached in Sarydjoy report were used in the definition of ore zones in our calculation. Blocks, whose average grades need to be interpolated, were limited by the search distances. If no data were found within the search distance, average grade of the block will not be interpolated. In another word, some of the blocks were excluded from the ore reserve because their average grades were not interpolated, even though the blocks are shown as ore body in geologic sections. On the other hand, there is no such limitation in Sarydjoy calculation method. The difference between the methods will produce little differnce in ore reserve in densely drilled area, and large difference in sparsely drilled area. In Sautbay and Burgut deposits, there are only a few holes in deep, therefore, Sarydjoy method produced a larger reserve on the whole.

Two main reasons for the difference in average grades may be as follows.

① Sarydjoy method used the length-weighted average of the samples as the average grade of a section without taking into consideration the area of the ore body in the section. Therefore, in sparsely drilled area, a hole with accidentally high grade will increase the average grade of the section.

② Sarydjoy method divided one ore body into several blocks, which is a different concept from the block we used in Kriging interpolation, and calculated the reserve of each block first. They selected a section with the highest grade from all sections intersecting the block of P_1 category, and used the grade of that section as the average grade of the block without taking into consideration the volume between sections. This, of course, increased the average grades of the block.

Table II-3-5 shows the comparison of ore reserve estimation results by MMAJ and Sarydjoy on individual ore body basis.

The brief summary of the ore reserve esitmation result of Sautbay and Burgut deposits is that we have practically the same result as that of the Sarydjoy Team for the densely drilled area (open pit of Sautbay deposit), but they over-evaluated the sparsely drilled area, especially P_1 category.

Table II-3-5 Comparison of ore reserve estimation results by MMAJ(1995) and Sarydjoy Team(1993)

(on individual ore body basis)

Ore body	MMAJ (1995)						Sarydjoy report (1993)					
	Reserves		WO_3	Au	WO_3	Au	Reserves		WO_3	Au	WO_3	Au
	(t)	(%)	(%)	(g/t)	(t)	(kg)	(t)	(%)	(%)	(g/t)	(t)	(kg)
1	11,242,000	43.4	0.27	0.19	30,353.4	2,136.0	15,190,300	38.4	0.40	0.19	60,761.2	2,886.2
2	299,000	1.2	0.17	0.11	508.3	32.9	379,680	1.0	0.30	0.08	1,139.0	30.4
3	844,000	3.3	0.15	0.09	1,266.0	76.0	1,542,800	3.9	0.27	0.04	4,165.6	61.7
4	623,000	2.4	0.12	0.02	747.6	12.5	836,499	2.1	0.40	0.08	3,346.0	66.9
5	521,000	2.0	0.12	0.01	625.2	5.2	478,689	1.2	0.30	0.11	1,436.1	52.7
6	324,000	1.3	0.24	0.01	777.6	3.2	267,300	0.7	0.87	0.02	2,325.5	5.3
7	900,000	3.5	0.15	0.07	1,350.0	63.0	803,475	2.0	0.25	0.01	2,008.7	8.0
8	909,000	3.5	0.18	0.25	1,636.2	227.3	1,684,510	4.3	0.39	0.16	6,569.6	269.5
9	386,000	1.5	0.12	0.11	463.2	42.5	355,680	0.9	0.40	0.45	1,422.7	160.1
10	3,127,000	12.1	0.52	0.54	16,260.4	1,688.6	7,512,810	19.0	0.54	0.56	40,569.2	4,207.2
11	535,000	2.1	0.11	0.08	588.5	42.8	200,520	0.5	0.20	0.00	401.0	0.0
12	2,668,000	10.3	0.36	0.47	9,604.8	1,254.0	4,922,300	12.4	0.60	0.85	29,533.8	4,184.0
13	941,000	3.6	0.16	0.20	1,505.6	188.2	2,116,870	5.4	0.25	0.24	5,292.2	508.0
14	634,000	2.4	0.24	0.31	1,521.6	196.5	1,216,790	3.1	0.23	0.27	2,798.6	328.5
15	594,000	2.3	0.28	0.30	1,663.2	178.2	1,367,690	3.5	0.37	0.52	5,060.5	711.2
16	724,000	2.8	0.11	0.20	796.4	144.8	266,824	0.7	0.23	0.08	613.7	21.3
17	66,000	0.3	0.15	0.10	99.0	6.6	143,970	0.4	0.32	0.20	460.7	28.8
18	98,000	0.4	0.09	0.17	88.2	16.7	-	-	-	-	-	-
19	107,000	0.4	0.13	0.16	139.1	17.1	-	-	-	-	-	-
20	303,000	1.2	0.18	0.01	545.4	3.0	93,480	0.2	0.24	0.01	224.4	0.9
21	40,000	0.2	0.23	0.00	92.0	0.0	159,165	0.4	0.36	0.00	573.0	0.0
Total	25,885,000	100.0	0.27	0.24	70,631.7	6,335.1	39,539,352	100.0	0.43	0.34	168,701.5	13,530.7

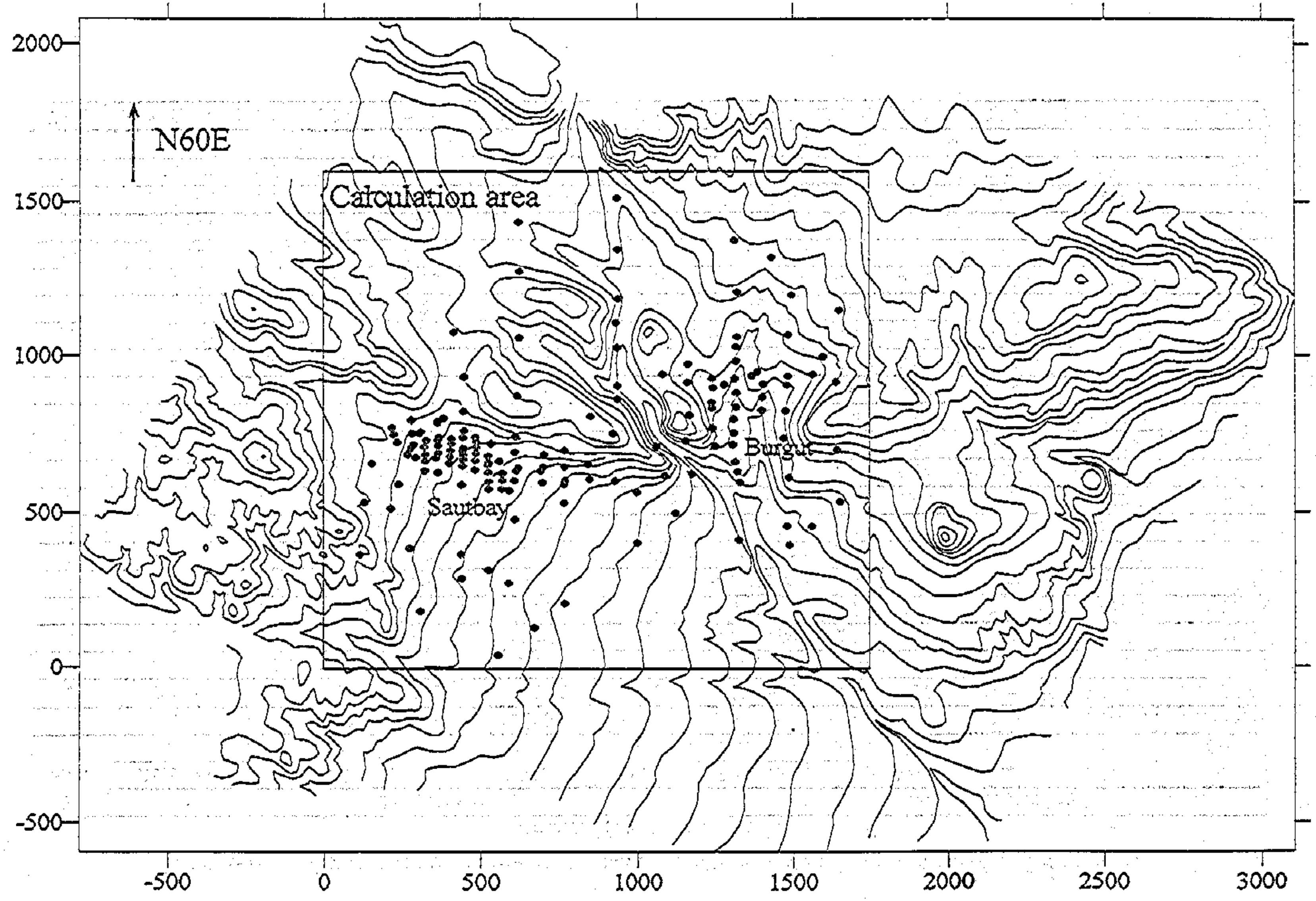


Fig. II-3-1 Location Map of the Ore Reserve Estimation Area

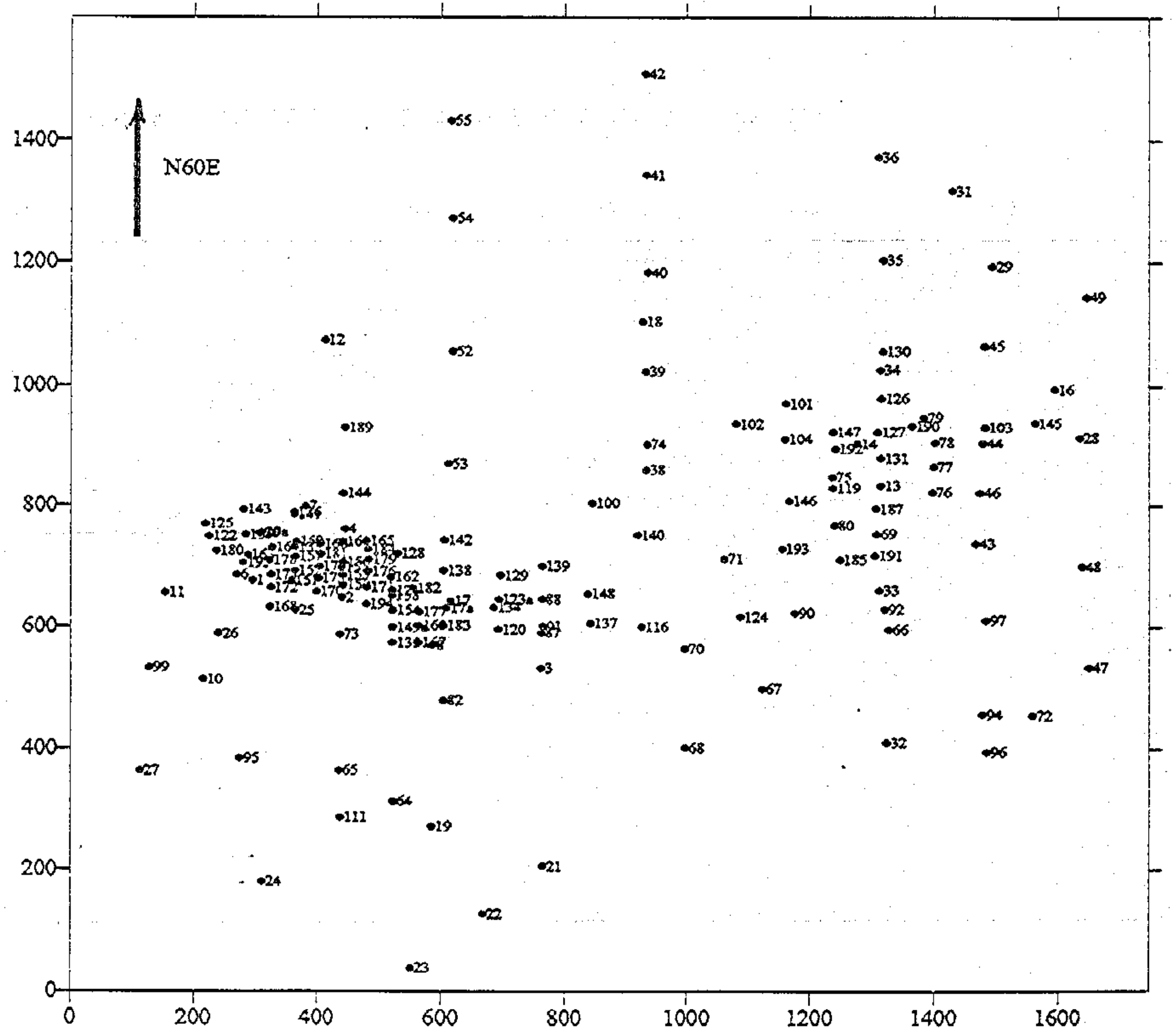


Fig. II-3-2 Location Map of the Drillholes used in the Ore Reserve Estimation

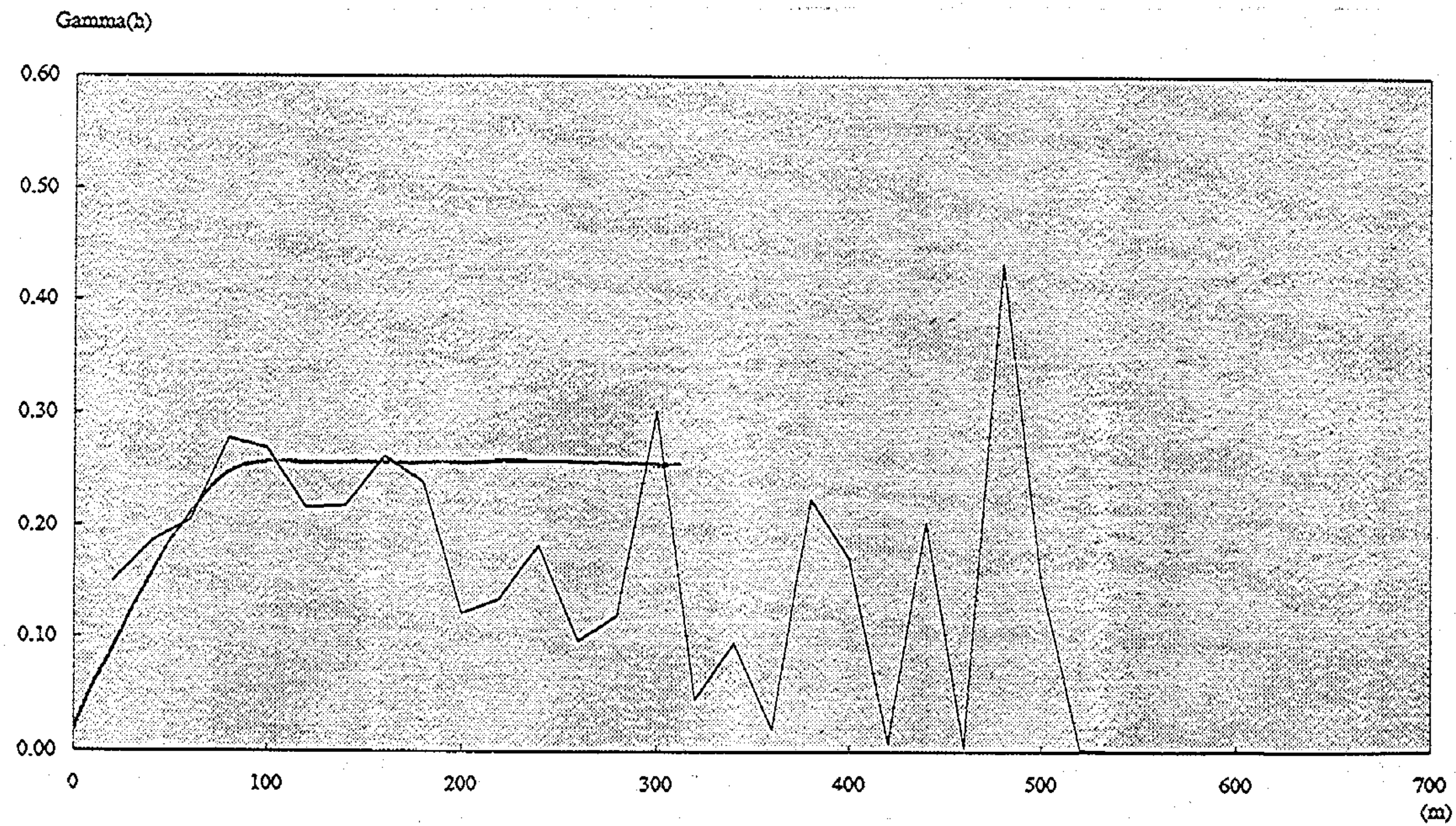


Fig. II-3-4 Variogram of WO_3 along A Axis for No.1 Ore Body

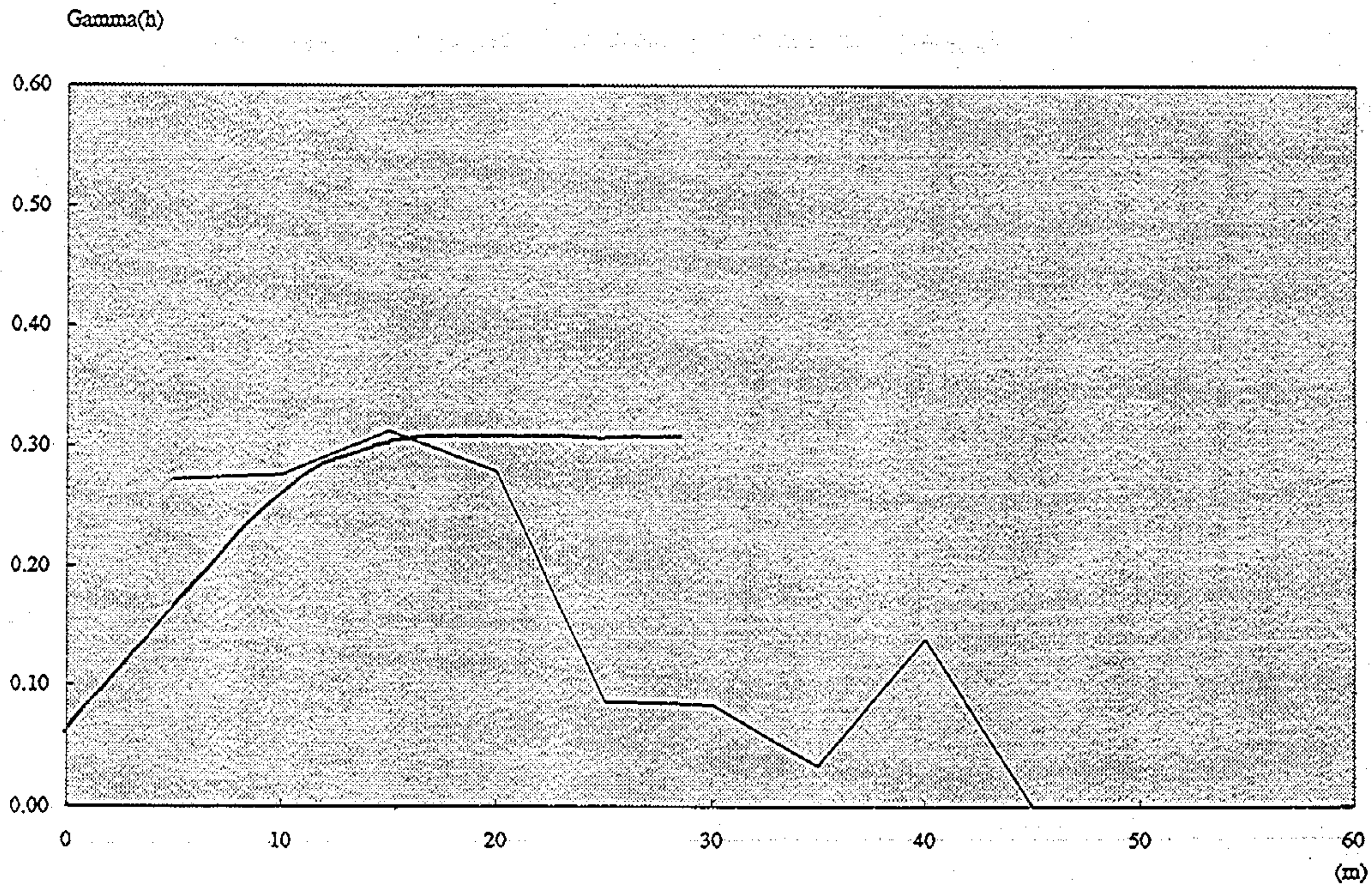


Fig. II-3-5 Variogram of WO_3 along C Axis for No.1 Ore Body

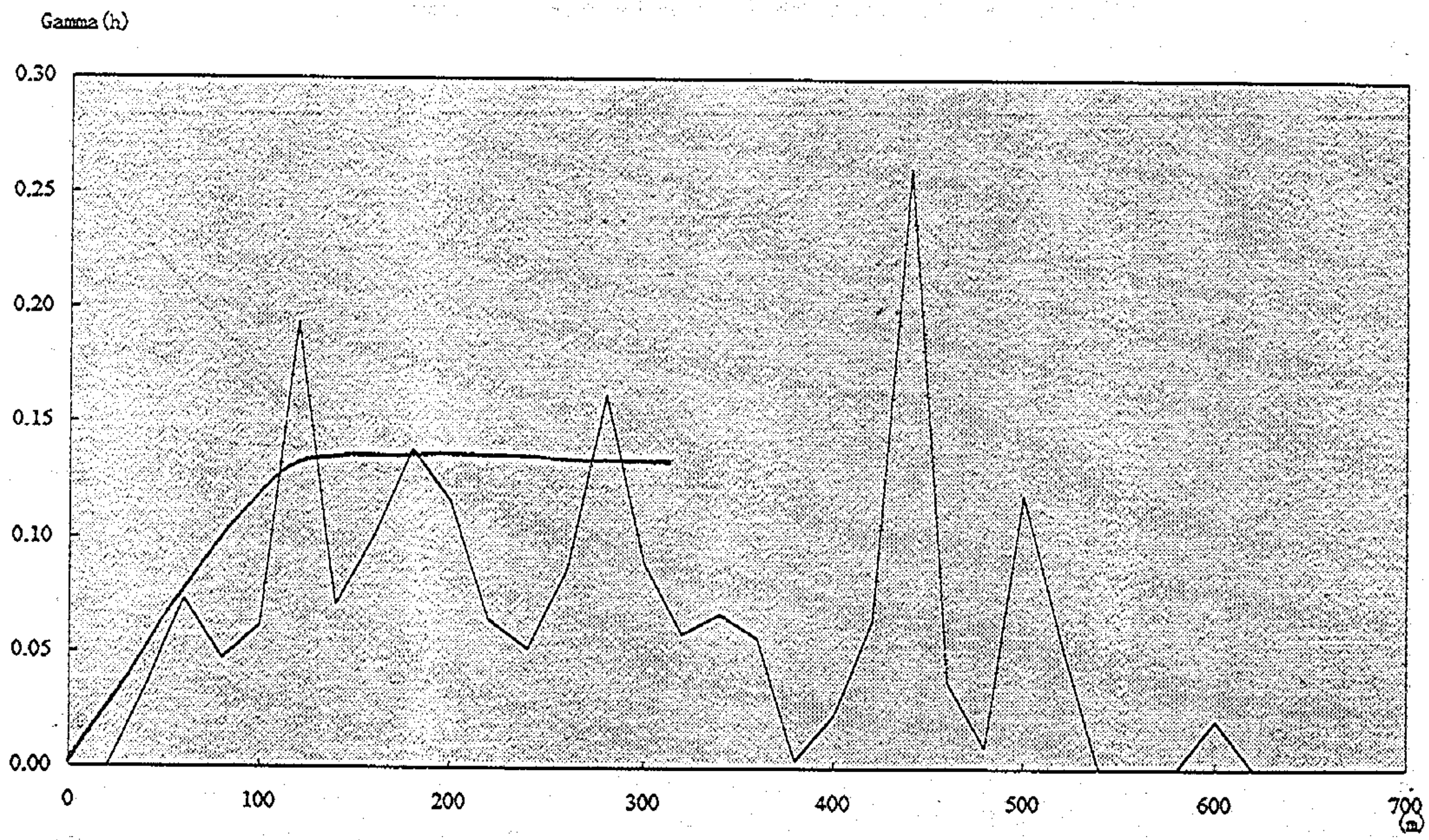


Fig. II-3-6 Variogram of Au along A Axis for No.1 Ore Body

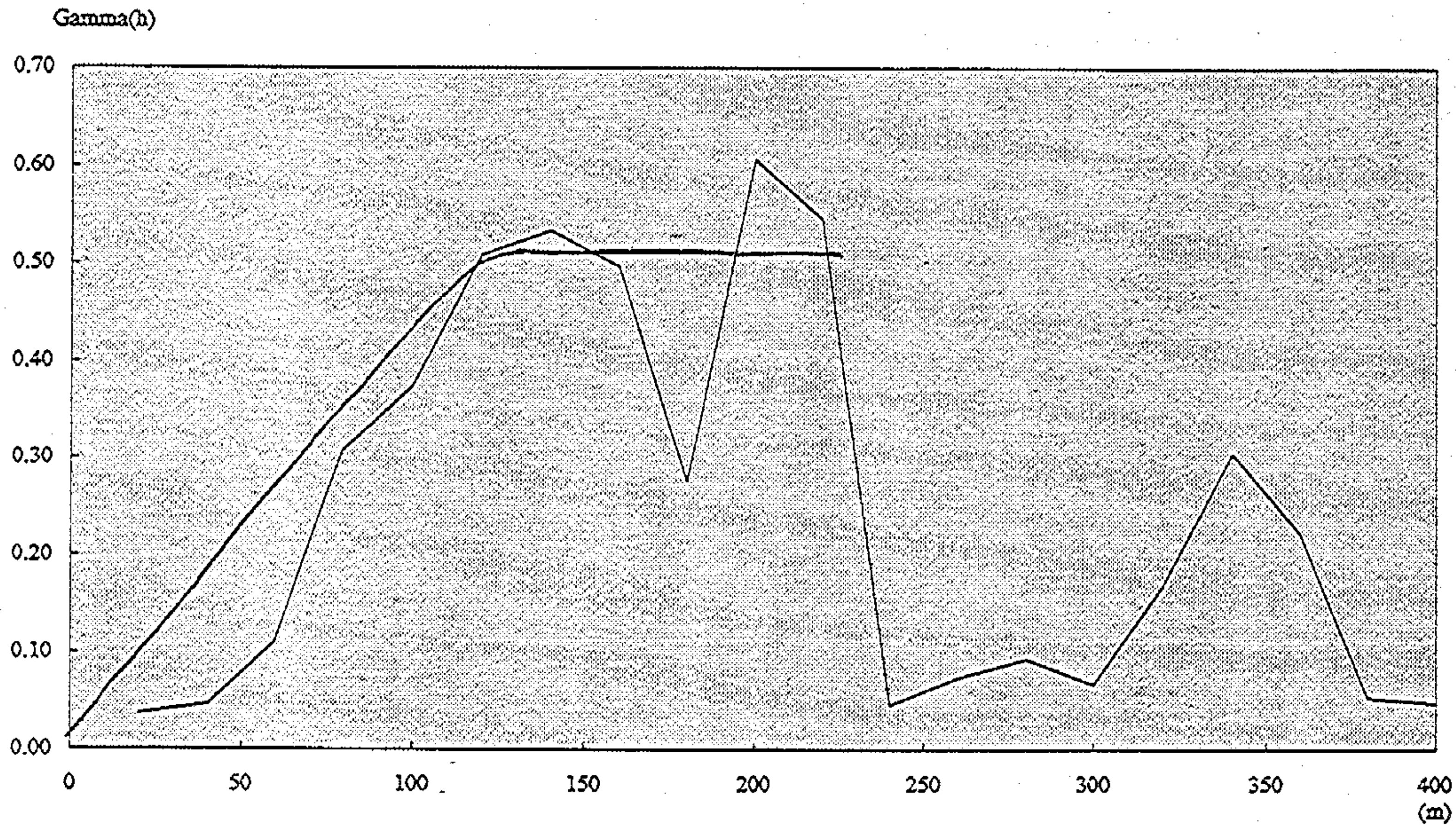


Fig. II-3-7 Variogram of Au along B Axis for No.1 Ore Body

Chapter 4 Satellite Imagery Analysis

4-1 Objective

The satellite imagery analysis is used for reconnaissance of natural resources to select promising areas since it enable us to acquire

① regional data spontaneously,
② without logistic and political restriction,
③ on the same region repeatedly.

In the Survey, therefore, the Landsat image data analyses were conducted to reveal exploration subjects in the Survey Area. The analyses consist of photogeological interpretation of the image to understand the geological structure of the survey area, and spectral analysis to locate possible alteration zones.

4-2 Outline of the Imagery Analysis

4-2-1 Area Analyzed

The Survey Area is located in the center of the Republic of Uzbekistan, covering approximately 5,200km^2, and is bounded by the coordinate below:

Northwest corner	42° 30' N	63° 19' E
Northeast corner	42° 30' N	64° 24' E
Southwest corner	41° 55' N	63° 19' E
Southeast corner	41° 55' N	64° 24' E

4-2-2 Data Used

The following Landsat TM scenes were used

Landsat No.	Orbit		Data Acquisition Date	Cloud Cover	Sun Elevation
	Path	Row			
Landsat 4	158	030	1988/10/11	0%	35°
Landsat 4	158	031	1988/10/11	0%	37°
Landsat 5	157	031	1987/9/24	0%	42°

4-2-3 Analysis Methods

A false color composite image, which should be the most adequate for geological interpretation, was produced from computer compatible tapes(CCT) of Landsat TM data. The rationing method was decided to be the most effective for extracting possible alteration zones after several spectral analysis methods including rationing, decorrelation stretching, and log residuals methods were examined. A workstation (Sun Super Sparc 10) and image analysis software of Central Computer Service Co., Lt. and Nikko Exploration & Development Co., Ltd. were employed for the processing and analysis.

(1) Photogeological interpretation

①Mosaicking

To prepare false color composite image, each band of three scenes was digitally mosaicked to produce one new scene which covers the Survey Area.

Affin transformation was applied to the geometric correction for mosaicking since one of the original image data was acquired on a different day from the other two image data. Then, weighted histogram transformation and edge enhancement and other methods were employed to adjust and enhance the gray levels.

The each band image that has been produced through the above mentioned processing methods is very much effective in lithological classification since it shows subtle color differences of different rock types by minimizing gray level differences of vegetation, clouds, lakes and others that are not related geological interpretation.

②Production of false color composite image

After several trial productions of color composite images, the most adequate result was obtained from the combination of the first band (blue), the fourth band (green) and the fifth band (red).

③Photogeological interpretation

From the false color composite image, geological units and geological structures were interpreted. The criteria for geological classification are photographic features (color, texture: spectral information), topographic features(drainage pattern, drainage density, resistivity, profile, development of bedding, etc. : pattern information) and surface cover (vegetation, cultivation, etc.). The geological structures: foldings and lineaments are interpreted through various topographic features(fault-scarp, fault valley, linear drainage, change of bedding, drainage anomaly, etc.)

Geologists who had studied photogeology at ITC(International Institute for

Aerospace Survey and Earth Science) were assigned for the geological interpretation of the Survey Area.

(2) Extraction of possible alteration zones

Possible alteration zones were extracted on the rationing image, which was produced by dividing the digital number of the third band by that of the first band, the fifth by the fourth and the fifth by the seventh, and assigning them blue, green and red, respectively. Before the division, the minimum value of each bands 1,3,4,5 and 7, were deducted from the digital numbers of each band since they were estimated to be equivalent to the path radiance that were 30,11,2,1 and 0, respectively.

(3) Ground Truth

Ground truth examining the results of photogeological interpretation and spectral analysis was conducted in the Ground Truth Area that is the southeastern part of the Survey Area. Some area outside the Ground Truth Area was also cursorily examined. Ground truth points were selected firstly to examine the possible alteration zones that had been extracted through spectral analysis and secondly intrusive rocks and lineaments (faults) which presumed to be related to mineralization in the area, and thirdly lithology, especially distribution of the carbonate rocks.

Geological information obtained through Landsat data image analyses, ground truth and compilation of existing data were integrated to reveal the relation between mineralization and geology and geological structure.

4-3 Results of Analyses

4-3-1 Photogeological interpretation

(1) Criteria for interpretation

The false color composite image was generally viewed and it was revealed that the vegetation in the Survey Area was distributed only in towns and other inhabited areas and the cultivation was hardly noticed. Therefore, ' Surface cover ' was excluded from interpretation criteria.

(2) Geologic units

Eighteen geologic units were identified within the Survey Area by the above mentioned interpretation. Among the eighteen units, six units are correlated to older metamorphic

～ sedimentary rocks distributed in the mountainous area, nine units to younger unconsolidated～loosely consolidated rocks and three units to Carboniferous～Permian intrusive rocks. Characteristics of the units are listed on TABLE II-4-1. Distribution of the units are explained as follows.

①Unit R

This unit occurs in three areas near Uchkuduk, which is located in the west part of the Survey Area. It elongates in NE-SW, NE-SW, E-W,and N-S directions from the west to the east, intermittently surrounding the Altyntau Intrusives. It extends 8～14 km in strike direction over 2～3km width.

This unit on the image shows the most dark color in the Survey Area and the subtle topographic features is not distinct enough to be identified.

②Unit R-C

This unit occurs widely in the northwest and the central～southeast of the Survey Area. It extends about 20km over 10km width in E-W direction in the northwest area, and about 40km over 10km in NW-SE direction in the other area. It shows plateau like topography in the central ～southeast part.

③Unit R-Cs

This unit occurs widely in the north central part of the Survey Area, occupying the ridge area of the Bukantau mountains. It extends mainly in NW-SE direction and partly in NE-SW direction, and grades into the unit R-C. The topographic features are similar to the unit R-C. This unit is considered to be of the same lithology as the unit R-C. However, it shows brown～ocher in color, and is interpreted to be covered with sands from the Northeast more extensively than the unit R-C.

Therefore this unit is separated from the unit R-C.

④Unit Oa

This unit occurs in the northern margin of the Survey Area, continuing to the outside area to north. It extends 40 km over 3 km width.

⑤Unit OCa

This unit occurs on the plateau of the east part and the mountains in the southeast part (Okjetpes mountains), of the Survey Area. It extends 20km in WNW-ESE direction over 10km width, and 8km over 8km in the east and the southeast parts, respectively, although the former continues to the outside of the Survey Area. It is indicated that this unit is related geologically and structurally with the unit R-C that is often adjacent to it.

⑥Unit Ca

This unit is scattered in the northeast and southeast parts of the Survey Area. It extends 5~10km over 1~5km of average width. Although it generally occurs in irregular shape, this unit in the Southeast extends in WNW-ESE direction that is concordant with surrounding units.

⑦Units K and P

These units are scattered widely on foothills and plains of the Survey Area, surrounding the above mentioned units that are correlated to the older rocks. The unit K occurs mainly on foothills in the Northeast and the West, and the unit P on plains in the North and the South. The unit P is interpreted to be lying sub-horizontally.

⑧Units Na and Nb

These units occur widely on hills and plains in the west part, and extends westwards to the outside of the Survey Area. The unit Nb extends in E-W direction and shows 2~6 km width. It is possible to interpret the unit Nb overlies on the unit Na.

⑨Units Q and Qe

The unit Q occurs mainly on southwestern foothills of major mountains and plains at the south of the Survey Area. It shows irregular shape of distribution. It is unconsolidated sediments of recent alluvium and talus and characterized parallel drainage pattern. The unit Q near outcrops of the older rocks shows the same color as the outcrops and is distinguished from the unit P.

The unit Qe occurs narrowly and is scattered in depressions in the central part and on plains in the south of the Survey Area. The unit Qe is estimated to be evaporates of salt lakes.

⑩Units eb, el, en

These units occur widely in the northeast and at the south margin of the Survey Area. It forms a file of sand dunes. The unit eb includes barchan, and the unit el longitudinal dunes. Both units consist of thick sand layers.

The unit el extends uniformly in NNE-SSW direction. The unit en occurs near the unit el and is interpreted to be sand layers thinner than it.

⑪Units γ b, γ c, M

These units occur near Uchkuduk in the western part of the Survey Area.The unit γ b shows massive, and irregular shape and 12 km in diameter. The unit γ c extends 15km in E-W direction over 2～3 km width.

These units are correlated to granitic rocks of Carboniferous ～Permian age. The unit M is of artificial structures such as open pits and waste dump of uranium mines and it is difficult to interpret the original lithology. Existing data show Cretaceous～Proterozoic sedimentary rocks and the granitic rocks occur at the area of this unit.

4-3-2 Lineaments

(1) Extraction of lineaments

Lineaments, which are extracted by photogeological interpretation of the image, often reflect fractures on or near surface of the earth. In general they are extracted on the basis of following diagnostic criteria:

(a) Existing of fault scarps
(b) Existing of wide linear valley (faults valley)
(c) Distinct linear Drainage
(e) Existing of kerncols or kernbuts
(f) Linear continuity of gradient changing points on mountain slopes
(g) Shifts of ridges or drainage
(h) Drainage anomaly
(i) Linear alignment of lakes, hot springs, volcanoes, springs or landslides
(j) Shifts of fans
(h) Existing of linear vertical or horizontal shifts on river terraces.

The criteria (c) and (e) develop well and (f) and (h) also occur in some part of the Survey Area. Several linear boundaries of two geologic units that are different in color from the other are also observed. It may be necessary to use larger scale of images or stereoscopic pairs of the HRV image of the SPOT to observe the criteria (i),(j) and (k).

(2) Distribution of lineaments

Many lineaments are extracted in the Survey Area on the basis of above mentioned criteria as shown on PL. II-4-2. The lineaments on PL. II-4-2 are drawn by solid lines where the criteria are clear and continuos, and by dashed lines where they are less clear, discontinuous or buried under unconsolidated or partially consolidated sediments.

The lineaments show general characteristics on distribution and directions as follows:

① Lineaments are distributed unevenly in the Survey Area and observed abundantly on the mountains where older rocks occur, and rarely extracted on the foothills and surrounding plains. Lineaments that show more than 10 km length are classified into relatively longer ones in the Survey Area. The longest one is 20km length. It is not evident whether the lineaments shown in PL.II-4-2 correspond to significant faults that control the geology in the Survey Area. Shorter lineaments are 1～5 km in length.

② The lineaments in E-W and NE-SW～ENE-WSW directions are dominant in the North to Northeast part, and ones in the E-W direction have longer length. The lineaments in N-S ～ NNW-SSE and NE-SW ～ NNE-SSW directions are dominant in the central to west part. In the east part lineaments in NE-SW and WNW-ESE ～ E-W directions are characteristic.

③ Directions of longer lineaments generally coincide with the longitudinal direction of the geologic units on which they occur.

④ Some lineaments bound geologic units:

- Boundary of unit R and unit γc (in the West)
- Boundary of unit R and unit R-C (in the center)
- Boundary of unit R-C and unit OCa (in the East)

⑥ Abundant lineaments, showing several directions occur in the unit γb that corresponds to the Altyntau Intrusives are interpreted, based on the topographic features, to be joints in the intrusive body.

4-3-3 Foldings

(1) Criteria of foldings

Bedding of sedimentary rocks may be generally observed on images at a scale of 200,000 or larger. Foldings are easily interpreted where the beddings on both limbs are observed.

Ridges and drainage are often characteristically bent where folding axes are plunging.

Consequently, the patterns are also criteria of foldings.

Where folding mountains are aligned in parallel, the drainage shows parallel or dendritic pattern.

(2) Distribution of foldings

Two foldings have been interpreted. They are anticlines on the unit OCa in the Southeast. The anticlinal axes show E-W and WNW-ESE directions, both plunging in both ends. These are aligned in parallel, separated by a lineament of E-W direction. The criteria of the foldings are bedding and shapes of the ridges on the unit OCa.

The geologic units that form the mountains mostly show beddings and are interpreted to be sedimentary or metamorphic rocks. However, they often dip steeply and the dipping directions cannot be determined even though the strikes are obvious. Therefore, foldings are hardly determined in spite of the wide distribution of sedimentary rocks. It is estimated that the rocks have been metamorphosed and show overturned foldings.

Beddings are observed in the units K and P surrounding the mountains, and the dippings are similar to the slope gradients and become almost flat on plains. Consequently, they do not show significant foldings.

4-4 Extraction of Alteration Zones

The Survey Area on the ratio image was classified into 20 units (Table II-4-2). The units correspond well to the geologic units.

By comparison of the ratio image with known ore deposits and showings, it is presumed that the known deposits and showings display high value in the ratio 5/4 and consequently greenish color on the image. The color is similar to the one that is often observed at alteration zones in other areas. Therefore the areas that show similar color are regarded as the alteration zones. The seventeen zones are identified in the Survey Area as shown on the PL.II-4-3, and listed on Table II-4-3. Besides the zones, there are some areas on the Cretaceous sediments that show similar color on the image, but they are excluded from the alteration zones since all but Quaternary manganese and Cretaceous uranium mineralization occur only in pre-Cretaceous rocks. The ratios 5/4 are high and the ratios 5/7 are low at alterations near the Sautbay and Kokpatas deposits, and it is presumed that the areas are significant in iron oxides and scarce in clay minerals. The zones are to be examined for the ground truth as many as possible.

Characteristics of other units on the ratio image are briefly described below.

①R,RY-L,Gy-L,GpR and RY-D: correspond to Proterozoic～Carboniferous(R,R-

C,R-Cs), and show generally a variety of colors ranging red~yellow~green, which are caused by a variety of sedimentary rocks and sands cover.

②Gb-H and RP: correspond Cretaceous~Paleogene sediments(K, P) and show bluish green in color and partly similar to possible alteration zones.

③GR-L,GR-H,Rp and P: correspond to Neogene to Quaternary sediments(Na, Nb, Q, Qe) and show red dominantly and green and blue partly.

④Gy,RGy-L,RGy-S:correspond to sand dunes (eb,el,en) and show red or yellowish green. These units partly display the similar color to the possible alteration zones on the ratio image, but are clearly different from them on false color composite image. Consequently, these units are distinguished from possible alteration zones.

⑤Y: corresponds to granitic rocks (γ b) and shows yellow and one clearly distinguished from the possible alteration zones.

⑥RG: corresponds to granitic rocks(γ c) and shows red to bluish green.

⑦Yd: is located on uranium mines area, corresponds to Proterozoic to Cretaceous (M, γ c,R~K) and shows red to dark yellow.

⑧rs,ly:correspond to lakes, salt lakes, clouds and their shadows, and show red and pale yellow.

4-5 Ground Truth

The ground truth was conducted during the period between December 19 and 30. During this period the survey work was restricted because the survey area was covered with snow piles. Therefore, known ore deposits and showings, and alteration zones are selected as primary check points. Meanwhile lithologies of the units which have been classified by photogeologic interpretation, and geological structures such as faults and foldings are also examined. Some survey has been conducted at the outcrops of Quaternary and Cretaceous sediments, and at some ore showings outside the ground truth area. The outline of the survey results are shown below. It should be mentioned that vegetation on the survey area is very scarce showing that some species of shrubs grow. Consequently, it does not appear that the vegetation affects the spectral analysis in the area.

①Sautbay ore deposits and surrounding area

Small amount of skarns and iron oxides were observed at the contact zone between a granitic body and black shale near the Sautbay tungsten deposits.

However, clay alteration and substantial iron oxides are not developed.

On the other hand, several alteration zones(a10,a11,a12) near Sautbay are extracted on the spectral image and they are located on the foothills on small mountains or plain areas. Shale and chert which are thermally metamorphosed crop out in the area. Quartz veinlets are widespread in shale, but clay minerals occur scarcely. Schist and hornfels which consist of sericite and chlorite are observed in trenches which are located about 1 km northwest(a10) and 1km east (a 11) of Sautbay ore deposits. These trenches were dug for gold prospecting, and low grade gold mineralization and silver mineralization, while shale outcrops on hill summits near those trenches are black in color and not hydrothermally altered.

In summary, it is interpreted that the iron oxides, which may have produced by oxidation of pyrite and other sulfide minerals which are related to gold and silver mineralization are extracted by spectral analysis at the alteration zones at a10, a11 and a12. In addition, Development of clay minerals may be limited over the zones.

There is no showings of mineralization neither alteration on the Saghinkan deposits since they occur deep under alluvium.

②Sarytau ore deposits

Not an alteration zone is extracted near the Sarytau ore deposits on the ratio image.

The surface of the area on the Sarytau ore deposits is covered with thin loess. Black shale, which have been metamorphosed to hornfels, crops out in a drainage at the east of the area. An andesitic dike, which shows E-W strike and almost vertical dipping, has intruded into it. However, Both rocks have not been hydrothermally altered.

Exiting data show that the Sarytau fault separate the Sarytau stocks into east and west bodies occurs on the ore body area, but the area is so flat that any topographic features which indicate the existence of the fault were not noticed. However, it may be a indication that weathered rocks with well developed schistosity occur at the middle of the two stock bodies in a trench.

③Turbay ore deposits

No alteration zones have been extracted near the Turbay ore deposits.

The area is more undulatory than the former two area, and exposures of rocks are wider. Black to dark gray colored shale and chert are dominant, and sandy rocks are intercalated in the area. Granodiorite, lamprophire and aplite dikes have intruded. Sedimentary rocks are weakly contact-metamorphosed.

Iron oxides occur weakly on the surface of the sedimentary and intrusive rocks. Substantial clay alteration could not be noticed at the outcrops.

Chloritization of shale and of biotite in granitic rocks and small amount of pyrite and copper oxide (malachite) are the main manifestation at the Southern mineralized zone.

A quartz stockwork zone of 5 m wide occurs in siliceous shale at the Northern mineralized zone. Silicification is noticed in the surrounding rock, but Neither significant amount of sulfide nor clay alteration occurs near the zone. Therefore, it is considered that weathering does not produce much iron oxides.

④Okjetpes ore deposits and possible alteration zones(a13 to a17)

No alteration has been extracted at the Okjetpes ore deposits.

Limestone, which partly recrystallized, is the main host rock of the ore deposits. This area also shows relatively undulatory topography and quite good exposures. Soil cover over the area is not thick even where rocks do not crop out. A waste dump by the No. 6 shaft, which is located near the west end of the ore deposits is composed of fragments of shale,hornfels,chert,andesitic and granitic rocks, which have been chloritized, argillized and contains iron oxides (limonite, jarosite). However, outcrops at a distance of about 100m have not been altered.

The alteration zones in the south of Okjetpes ore deposits are located along small hills which run in parallel each others. On the summits of these hills, black to dark gray colored shales in which quartz veinlets occur crop out, while no significant clay alteration zones have not been noticed. On the other hand, quartz vein boulder with iron oxides, and green schists that consist of chlorite and sericite have been noticed in the trench that were dug at the foothills to plain. Boulders at the plain contain small amount of iron oxides, but those amounts may be too weak to be extracted by spectral analysis of the image. The area should be examined more thoroughly while there is no snow pile on the plain area.

⑤Barhanny ore showings

No alteration zone has been extracted in this area.

Exploration work has been conducted extensively, compared to the South of Okjetpes. The area where trenches and shaft exist is covered with loess and rocks crop out very poorly. However, finely stratified limestone, syenite and quartz diorite occur in the trenches. Weakly altered rocks that consist of quartz, chlorite and small amount of iron (rarely, copper) oxides are noticed at waste dumps near a shaft.

⑥Bulutkan ore showings

This area is located southeast of the Sautbay, and it has not been identified as a alteration zone, but weak color anomaly zone has been noticed.

The surface may be covered with loess and difficult to be extracted by spectral analysis. Therefore, the color anomaly may be caused by syenite intrusives that crop out in the area according to existing data. It should be clarified while there are no snow piles on the surface.

The area was currently under drilling. At a trench near the site, schist and chert that have been silicified to quartz-chlorite-(sericite)-hematite, have been noticed. It is assumed that the silicification zone extends to southeast wards, but it was not confirmed by the survey because most of the area was covered with snow during the survey period. Quartz syenite is not hydrothermally altered at the outcrop 200m southwest of the drill collar.

Followings are the results of the survey for geology and geologic structure.

⑦Turbay Intrusives

Turbay Intrusives are located north of the Sautbay ore deposits with wide exposures according to existing data. However, the area has been classified as the unit OCa. The ground truth has revealed that exposures of granitic rocks are limited along narrow drainage and that wide range of the flat area was covered by Quaternary unconsolidated deposits consisting of soils with pebbles of black shale and chert. Therefore, the area does not show granitic features in topography, and the exposures of the granitic rocks are not enough to be identified based on the spectral features.

⑧Sedimentary rocks (units R, R-C,R-Cs,Oca and Ca)

The ground truth has revealed that almost all the units consist of shales, cherty rocks with intercalation of carbonate rocks, parts of which have been metamorphosed, and that they are not distinguished at the survey points. However, The unit OCa at the Okjetpes area consists mainly of limestone and is different from OCa's at other area.

⑨Lineaments

The NE-SW lineaments at the Sarytau, Turbay, Sautbay deposits and Bulutkan ore showing have not been confirmed that they correspond faults because the exposures around the area are limited because of the snow piles at the time of survey. However, existence of the faults has been inferred by development of shear zones, by linear drainage and by existence of fault scarps.

Among the lineaments, on the other hands, the Turbay fault and Eastern Okjetpes fault are well corresponds to a lineament which have been extracted by photogeologic interpretation.

⑩Folding

It has been confirmed that sedimentary rocks at the Okjetpes area show clear bedding by ground truth and that an anticline is shown on geologic maps of the area. The two facts show that the area was correctly interpreted by photogeology.

⑪Quaternary to Cretaceous sediments

It is found that the most of the part is covered with loess, and that Cretaceous deposits consist mainly of finely stratified claystone at the West of Sautbay area and it may be the some cause that the Cretaceous sediments sometimes show similar color to argillic alteration zones.

⑫Other ore showings (Cholcharatau, Boztau, Djylandy)

Cholcharatau area is located north of the Altyntau Intrusives and gold and tungsten showings are distributed along the anticlinal axis. Topographically, anticlinal crest zone is at low elevation and flank zones form ridges. The possible alteration zones are located at relatively flat area near the anticlinal axis. On foothills near the axis silicified black shale and recrystallized dolomite crop out. Dolomite is weakly skarnized dolomite with pyroxene and iron oxides. Clay minerals are not abundant and iron oxidation is generally weak, therefore the alteration zone may be attributed to lower plain that could not be observed because of snow piles.

No exposures have been noticed on the surface at Boztau during the short ground truth survey, although green schist and andesitic tuff breccia have been found in trenches.

Weak skarns that consist mainly of pyroxene are noticed in dolomite at the Djylandy area, but neither significant amount of clay minerals nor iron oxides are noticed in the area.

It is concluded that it is difficult to extract alteration zones from both areas.

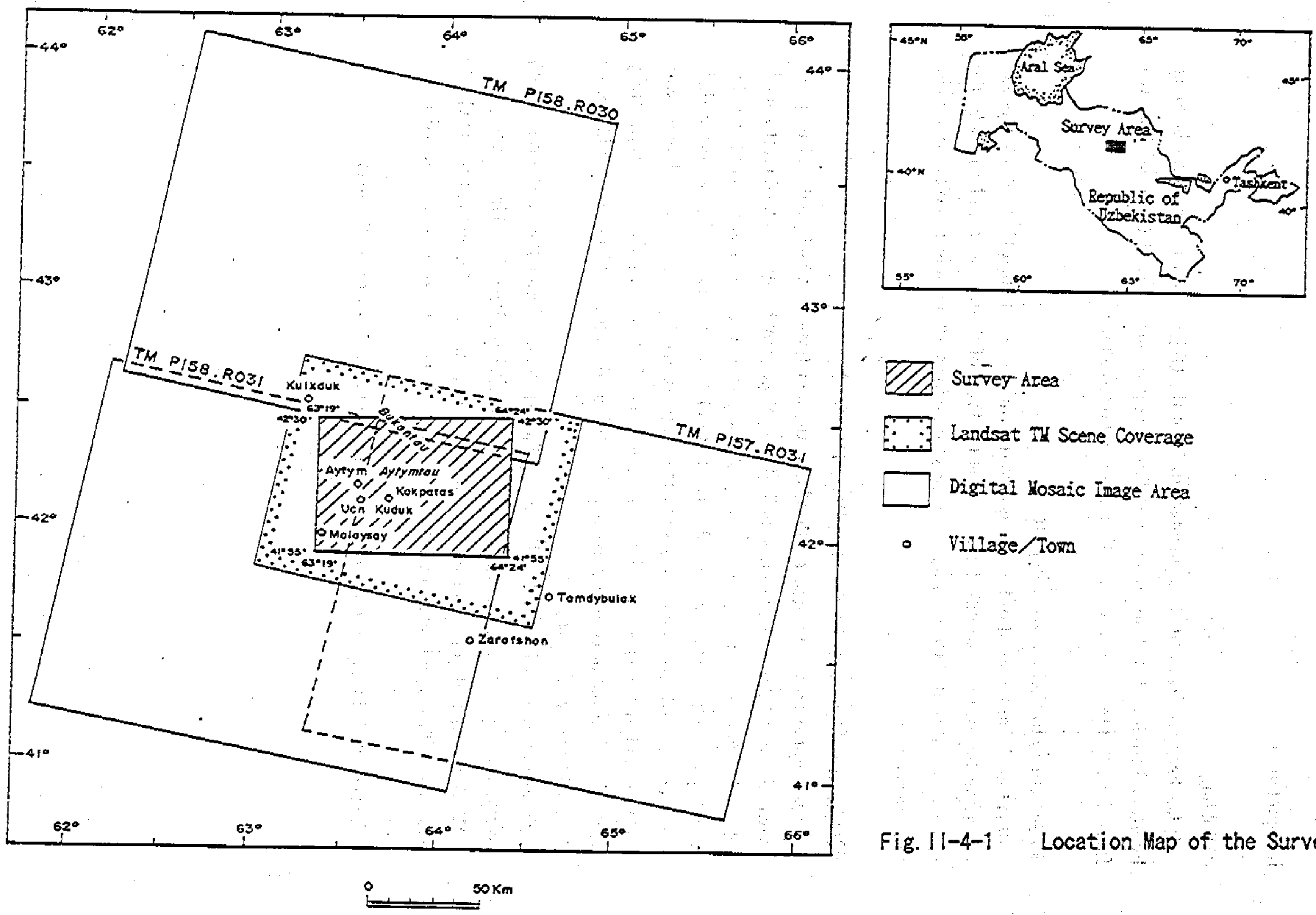
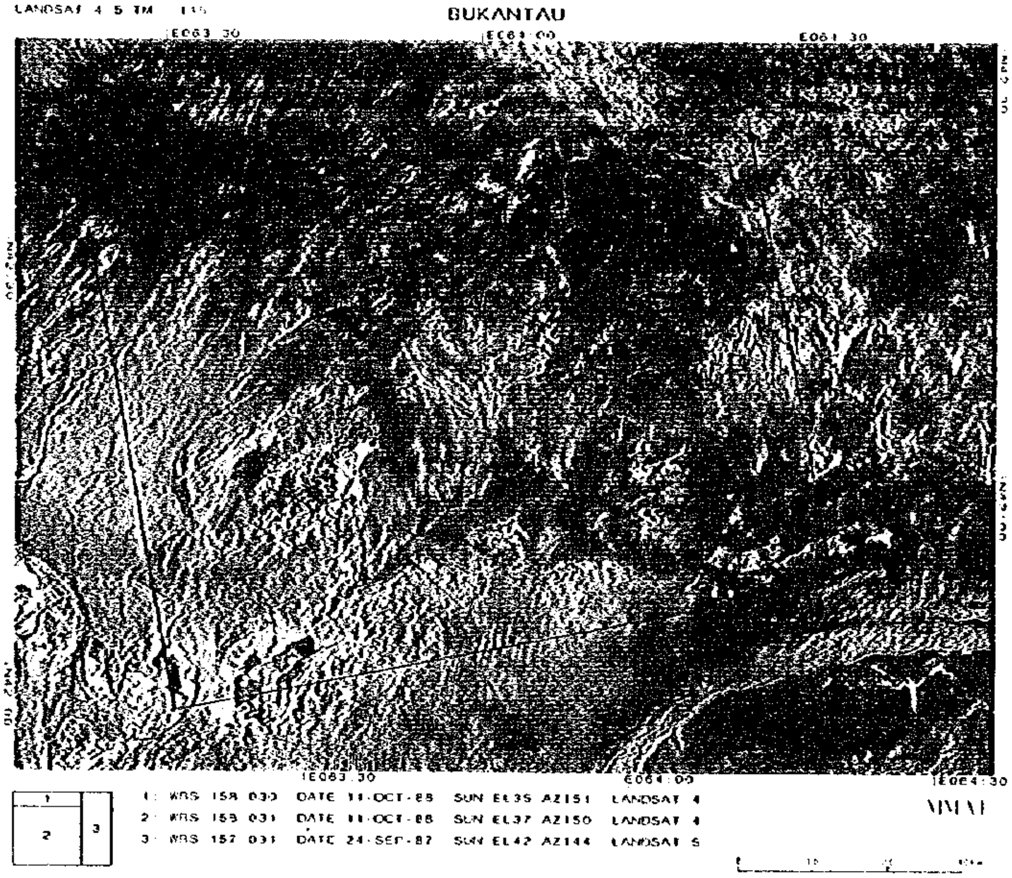


Fig. II-4-1 Location Map of the Survey Area

LANDSAT TM False Color Composite Image



Ratio Image (Band, 3/1. 5/4. 5/7)

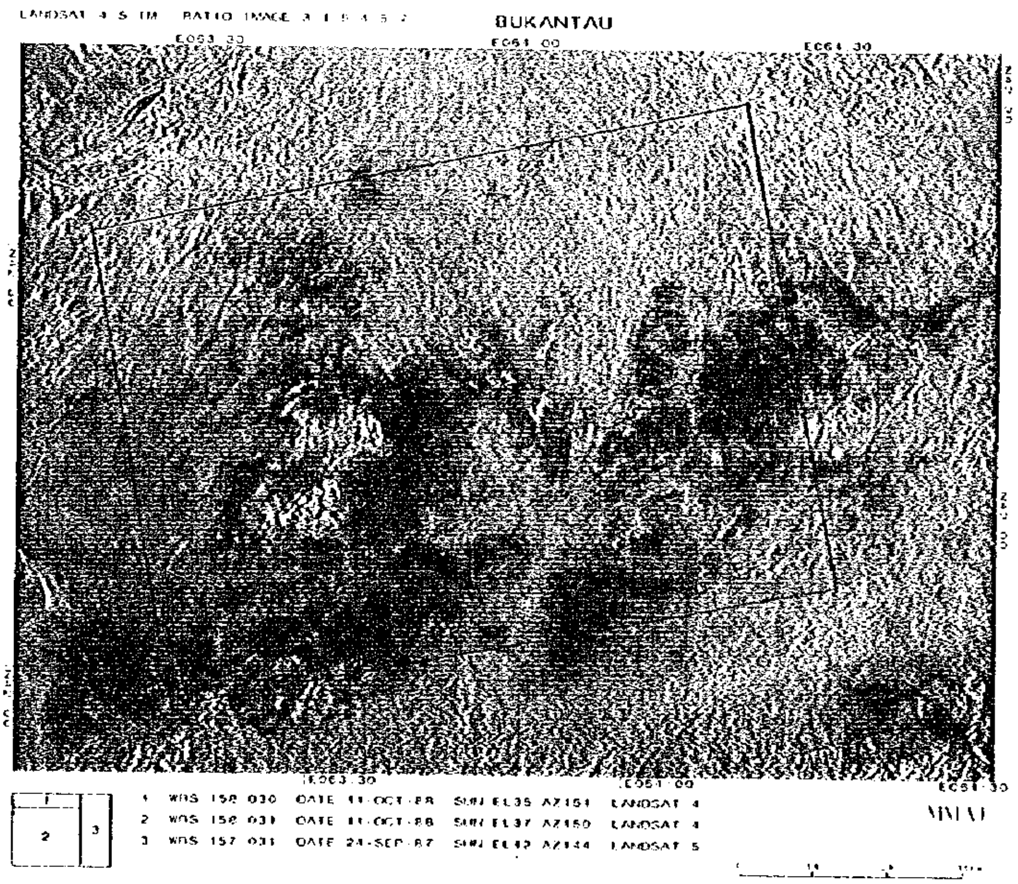


Fig. II-4-2 LANDSAT Image

Table II-4-1 Lithologic Units Classified by Photogeological Interpretation

Unit	Photographic feature		Topographic Features				Lithology Interpreted from Photogeoloy
	Color	Texture	Drainage		Resistivity	Development	
			Pattern	Density		of Bedding	
eb	Yellow, Ocher	coarse	-	-	low	-	aeolian deposits (includes barchans)
el	Whitish, Pale yellow	medium	-	-	low	-	aeolian deposits (includes linear dunes)
en	Whitish, Pale yellow, Reddish brown	fine	-	-	very low	-	aeolian deposits(thinner than 'eb' and 'el')
Qe	Whitish	fine	-	-	low	none	salt lake (evaporates)
Q	Gray, Reddish brown, Dark blue	fine	parallel	moderate	very low	-	alluvium, talus deposits
Nb	Dark blue	medium	sub-parallel	moderate	low	partially well	fine grained sediments (unconsolidated)
Na	Grayish blue	fine	parallel	moderate	low	partially well	medium grained sediments (unconsolidated)
P	Pale pinky-ocher	medium~coarse	parallel	low	low	partially well	fine~medium grained sediments
K	Pale reddish-purplish	medium	parallel	low	low	partially well	fine~medium grained sediments(loosely consolidated)
Ca	Dark grayish blue	fine	pinnate, parallel	high	high	very well	dark colored, fine grained sedimentary rocks
OCa	Pale pinky gray	medium	dendric, parallel	moderate	high	partially well	light colored sedimentary rocks
Oa	Dark green, Dark blue	fine	dendric	high	high	well	dark colored, fine~medium grained sedimentary rocks
R-Cs	Brown	medium	dendric, trellis	high	moderate	well	similar to 'R-C', thicker aeolian sand cover
R-C	Grayish blue, White	medium	dendric, trellis	high	moderate	well	alternation of light and dark colored rocks
R	Dark blue, Black	fine	sub-parallel	moderate	high	well	very dark, fine grained sedimentary~metamorphosed rocks
γb	Grayish purple	medium	pinnate	very high	high	poor (massive)	granitic intrusive
γc	Pale pink	medium	parallel	moderate	moderate	poor (massive)	granitic intrusive
M	Pale yellow, White	fine		-	-	-	mine site(open pit and waste dumps)

TABLE II-4-2 Units Classified by Rationing Analysis

Unit	Color	Texture	Correlation *
R	Reddish	Dotted	R
R Y - L	Red+Yellow	Linear	R – C
G y - L	Yellowish green	Linear	R – C s
G p R	Pale green+Red	Linear	O a
G b - D	Bluish green	Dotted	O C a
R Y - D	Red+Yellow	Dotted	C a
G b - H	Blueish green	Hazy	K
R P	Red+Purple	Hazy	
G R - L	Green+Red	Rather Linear	N a
G R - H	Green>Red	Hazy	N b
R p	Pale red	Smooth	Q
P	Purplish	Smooth	Q e
G y - S	Yellowish green	Sandy	e b
R G y - L	Red+Yellowish green	Sandy, Linear	e l
R G y - S	Red+Yellowish green	Sandy	e n
Y	Yellowish	Dotted	γ b
R G b	Red+Blueish green	Dotted	γ c
Y d	Dark yellow	Dotted	M
rs, ly	Red,light yellow	Smooth	Lake,Salt lake
			Cloud and its shadow
m a	Pale green	Smooth	Alteration zone

* Correlated with Photogeological Interpretation Unit

TABLE II-4-3 List of Alteration Zones

Alteration Area	Location	Color on Ratio Image	Correlation	
			Geology	Ore Deposit
a 1 a 2	N -NNE of Aytym	yellowish green	R-C	Aytym
a 3	NNE of Aytym	yellowish	R	
a 4	Center of the Survey Area	blueish green	R-Cs	Cholcharatau
a 5 a 6	N of Kokpatos	yellowish	R-C	Kokpatas
a 7 a 8	E of Kokpatos	yellowish green	R-C	Kokpatas
a 9	SE of Kokpatos	yellow green	R-C	
a10 a11 a12	SE of Kokpatos	yellowish green	R-C	Sautbay
a13 a14 a15 a16 a17	NW of Beshbulak	yellowish green	R-C (K)	

Capter 5 Synthetic Analysis

(1) Geological structure and characteristics of mineralization

The Bukantau Massif is located in the north-western end of the middle zone of Tien-Shan Range (Hercynian orogeny) and is composed of predominantly sedimentary rocks together with carbonate rocks which are intruded by acidic igneous rocks. They are folded, faulted and thrust faulted to form a complicated geological structure. The principal trend of geological structure is NW-SE which is coincide with the direction of the Bukantau Massif.

The Bukantau Massif is divided into two zones(Northern Bukantau zone and Southern Bukantau zone) by North Bukantau Deep Fractures zone which crosses near the town of Kulkuduk situated in the north-western direction of the Survey Area. Most of the Survey Area is located in the eastern part of Southern Bukantau zone, and narrow area of the north-east part of the Survey Area is located in Northern Bukantau zone.

Geological structure of the Survey Area is characterized by an over thrust by which the group of Paleozoic is overlain by the group of Proterozoic, Kokpatas antiform and overfolding of Proterozoic group. The axis of Kokpatas antiform is extending in NNW-SSE direction from Kokpatas to Okjetpes. A series of lower Devonian to Carboniferous are exposed in the axis as a window.

Smaller scale of structures are the overthrust folding in Turbay, Sautbay, Sarytau and Okjetpes, and a syncline in North Turbay(Fig.II-5-1).

The predominant directions of faults in the Survey Area are NW-SE, NE-SW and NNW-SSE, represented by the Turbay fractures zone (NW-SE), the Kokpatas fractures zone (NNW-SSE), the East Okjetpes faults (NE-SW). Among them, the Turbay fractures zone and the East Okjetpes faults are corresponding to the lineaments extract by the satellite imagery analysis.

Dominant intrusive rocks are the Altyntau Intrusives (granite), the Kokpatas Intrusives (granite-adamellite), the Turbay Intrusives (granite), the Sarytau Intrusives (granodiorite), the Sautbay Intrusives (monzonite to granosyenite). All intrusive rocks have intruded during the late Carboniferous to Permian period and are thought to be cupolas of the deep seated Southern Bukantau Batholith.

Small scale intrusive bodies such as Sautbay stock, Turbay stock, Sarytau stock are controlled by NW-SE fractures, NE-SW fractures, NNW-SSE fractures, especially at the intersections of these fractures.

There are 2 types of tungaten ore deposits; stratiformed ore body of skarns and skarnoids along carbonate-bearing rocks and stockwork ore body in granitoid intrusive, host rocks and skarn (Sarytau ore deposit). The former ore body is developed at a contact of granitoid intrusive and carbonate rocks. The main ore-bearing horizon is Karashakh-Kokpatas Formation of the Upper Proterozoic age. Notable mineralization is not found in Koksai and Khodjaakhmet Formations. High grade ores are generally formed at a distance of 50-150m, rarely up to 200m from the contact of granitoid.

Stockwork type of mineralization is mainly developed in the granitoid intrusives and represents a group of vein-veinlets zone controlled by fractures.

Major gold and silver mineralization is concentruted in Turbay ore deposit(Au) and East Turbay ore showing(Au), and etc., in the Turbay Ore Field. Mineralization is controlled by the structural factors such as the Central Turbay zone of permeability (so called Turbay Ore zone) whith extends to NW-SE direction. The Central Turbay zone of permeability is characteristic of wide development of fractured structures and controls the location of fault clay, breccia, dykes, metasomatic alteration of host rocks and quartz veins. In the Hercynian orogenic movement of late Paleozoic, the tension fractures of NW-SE direction were formed, which were intruded by granite and dykes and provided a passage of hydrothermal solution.

The other gold, silver ore deposits and ore showings in the Survey Area are also controlled by NW-SE, NE-SW and NNW-SSE fractured structures.

(2) Preparation of integrated interpretation map

An integrated interpretation map was prepared by compiling the results of imagery analysis, ground truth results and existing data compilation as follows(PL.II-5-1).

①Ground truth has revealed that the geologic units had been correctly classified and reflect lithology. Therefore photogeological interpretation map is used as a base map for further analysis, with minor changes. The change is made for symbols of geological unit: the unit Ca is changed into R-Ca, the unit OCa into R-OCa since those units may be correlated to Proterozoic. However, the unit OCa at Okjetpes is correlated to Devonian to Carboniferous, therefore the symbols is changed to DCa.

Intrusive bodies have been shown on the map to the extent where they have been confirmed their emplacement by drilling under the Quaternary to Cretaceous cover.

②The major structures such as the North Bukantau Deep Fractures Zone, Turbay Fractures, Okjetpes Fault, Sautbay Fault and NE-SW trending faults at Bulutkan, Turbay and Sarytau ore deposits, are shown with stress.

③Ore showings, which are shown in the report of A.A Horsov(1994) are plotted on the maps. In addition, the mineralized outcrops from the unpublished map of V.F. Rubanov

(1993) have been plotted.

④The metallogenic zones that have been defined by V.H. Ushakov (unpublished report) are plotted. Those are, Northern Bukantau, Eastern Bukantau, Central Bukantau and Western Bukantau. The Northern Bukantau metallogenic zone is defined as the zone in the north of North Bukantau Deep Fracture Zone. No ore showings are shown in the Northern Bukantau because of no data. Other three Zones are located in the south of the Fractures Zone. Central Bukantau is defined as a narrow zone that includes Kokpatas ore field and Okjetpes ore field that are underlain widely by Carboniferous rocks. The eastern and western zones of the Central Bukantau metallogenic zone are defined as Eastern Bukantau and Western Bukantau metallogenic zones, respectively.

The integrated interpretation map that has been prepared through above mentioned procedure shows that the Sautbay, Turbay and Sarytau ore deposits and other many showings in the Survey Area are located in the Eastern Bukantau metallogenic zone. Only Okjetpes ore deposits and Barhanny ore showings are located in the Central Bukantau metallogenic zone. The distribution of ore deposits and showings appears to be controlled by acidic intrusive rocks: the Sautbay deposits and Bulutkan ore showings are controlled by the Sautday Stock and Sautbay Intrusives, the Sarytau and Turbay ore deposits by Turbay Intrusives and Sarytau Stock, and other tungsten and gold ore showings by Sarytau Intrusives.

(3) Consideration of regional geology and geologic structures

Tungsten and gold ore deposits in the Survey Area are related to the Carboniferous to Permian granitic intrusions, and are mainly hosted by Karashakh and Kokpatas Formations of Proterozoic age. Therefore, it is important to study the two formations.

Karashakh Formation is characterized by abundance of metamorphosed basalt and andesite, and by more intense metamorphism than upper formations. While Kokpatas Formation consists of quartzites and sandstones intercalated with dolomites and limestones. However, it is difficult to distinguish the two formations by Landsat image interpretation, due to the fact that both formations are metamorphosed and deformed to show similar topographic features. However, it also is interpreted that the difference of two formations is caused only by facies change based on a large scale geologic map (V.H. Ushakov,1994). Another geologic map of the scale 1 200,000 that cover the most part of the Survey Area(A.N.Buhalin,1989) does not classify the two formations, although they are correlated to the Ordovician to Silurian age. It is difficult to understand geology and geologic structure in the Survey Area because fossils are scarce in the formations. Geologic structures are so complicated that late Proterozoic, and Silurian to Devonian fossils occurs in adjacent strata, which can be interpreted as olistromes.

(4) Characteristics of hydrothermal alteration and effectiveness of alteration extraction by Landsat images

As results of ground truth, following characteristics have been confirmed on the ore deposits and showings in the Survey Area.

- Clay minerals as results of hydrothermal alteration occur scarcely in the Sarytau and the Sautbay tungsten ore deposits. At Sarytau, surface is covered by the aeolian sand and rock exposures are poor.
- Chlorite and sericite occur with iron oxides at the gold ore showings in the Survey area. Although exposures of the gold ore showing is generally narrow, probably due to the surface cover is thin and it appears that floats have not moved far away from the original outcrops because they shows similar alteration and oxidation to the surrounding outcrops.
- Hydrothrmal alteration and iron oxides are not widespread at Turbay gold ore deposits, and have not been extracted by the images analysis.

The gold ore deposits in the Survey Area are classified into two types: low sulfide type as in Turbay and high sulfide type as in Kokpatas ore deposits. The Turbay is of quartz stockwork type and does not accompany much sulfides, while Kokpatas deposits contain substantial amount of pyrite and pyrrhotite.

The alteration zones of high sulfide type have been extracted for which spectral analysis is effectively applied. On the other hand, spectral analysis for the purpose of extraction of alteration zone may be less applicable for the low sulfide type ore deposits since iron oxide zone is poorly developed.

(5) The roles of geophysical methods in the Survey Area

The roles of previously used and proposed geophysical methods in mineral exploration in the survey area are summarized as follows:

①Most known ore deposits in the area are near granitic rocks and are associated with magnetic anomalies.

②Granitic rocks are less dense than host rocks and produce clear low gravity anomalies.

③Magnetic surveys can effectively delineates the location of contacts of intrusive rocks with host rocks. Magnetic anomalies are often observed near the ore deposits and showings of both skarn type and vein type as they contain pyrrhotite. Magnetic survey will provide the useful information in mineral exploration of this area.

④Gravity and magnetic surveys have been used successfully and extensively in this area. In addition to these methods, extensive use of electrical and electromagnetic survey methods will help to clarify details of ore fields.

(6) Subjects of the exploration

The Survey Area has been explored for a long time and almost all significant ore showings may have been prospected by some methods before. However, recent discovery of the Bulutkan ore showings indicates that there is a potential for exploration in the Survey Area. To establish future guidance for exploration, following must be revealed.

①Main tungsten deposits are of skarn type. That means contact zones of intrusive rocks and carbonates are the target of exploration. The stratigraphic position of the carbonates rocks may be established. However, data on the structural control of ore emplacement are not available. It is less common that the carbonate layers are uniformly metasomatized. Ore deposits are often emplaced at anticlinal or synclinal axis or intersections of fractures and limestones. Therefore, it is important to analyze the structural control of ore deposits in detail.

It is expected that detailed geologic structures will be revealed by conducting existing data compilation and mapping using Landsat image.

②Other geologic issues such as lithological facies changes among the Karashakh, Kokpatas and Khodjaakhmet formations, Kokpatas antiform and exsistence of apparent overturned folding may be revealed.

Extracting the alteration zones by LANDSAT imagery analysis is presumed to be effective for the high sulphide type gold deposit.

Judging from the distribution of ore deposits, ore showings and the alteration zones, an ore zone of NW-SE direction including the possible alteration zones near Sautbay deposit(W) and Bulutkan ore showing(Au) and the another ore zone of NNW-SSE direction from Kokpatas deposit(Au) to the south-western part of Okjetpes deposit(Ag) are extracted as potential exploration areas for the high sulphide type gold deposit.

(7) Ore reserve estimation of Sautbay and Burgut deposits

The total ore reserve of Sautbay and Burgut deposits is 25,885 thou. tons with cutoff grade of 0.05%(WO_3). The average grade of WO_3 is 0.27%, and that of Au is 0.24 g/t. Ore resere estimate in the scheduled open pit (mostly No.1 ore body up to 150m deep) is 2,621 thou. tons with average grade of WO_3-0.35%, Au-0.13 g/t.

The ore grade of the skarn type ore body which has been mined since 1980 in the western countries (USA, Canada, Australia, South Korea, Turkey, and etc.) is more than

WO_3 0.5% in the deposit of open pit mining and more than 1% in case of underground mining. Such mines are sometimes enforced to close and resume again due to the change of market price of tungsten.

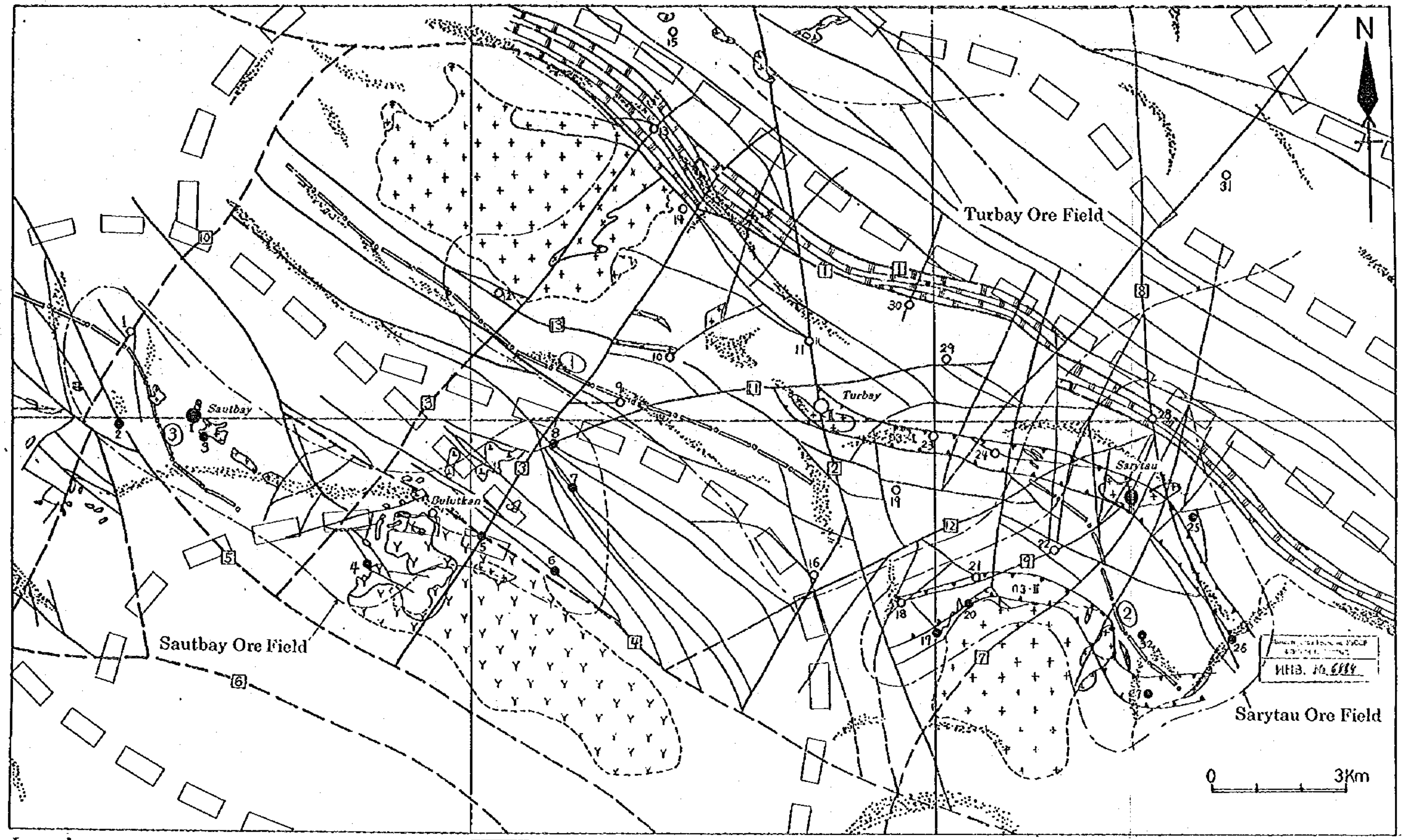
(8) Bulutkan ore showing

As a result of data compilation, Bulutkan ore showing(Au) was extracted as a promising area for further exploration.

About 70 holes of non-coring drilling have been done aiming at a part of ore showing up to 70m deep, and a high grade gold ore body has abready been confirmed. The ore body is traced to the north-west direction more than 100m with thickness of maximum 30m and extends more than 70m deep. Using the result of chemical analyses of samples on trenches and non-core drillings as a basis, a rough estimate of ore reserve was calculated.

The reserve is 342 thou. tons and the average grade of Au is 6.9 g/t. The metal contents of Au is about 2.3t. As a result of check analysis of sludge samples of drill hole C-3361, high gold concentration of this ore body was confirmed (length of sludge-22m, average grade-Au 29.2 g/t). It is necessary to execute coring drillings aimig at the lower part of ore body to confirm the shape, structure and downward continuity of the ore body and to provide useful information for further investigation. From the result of route prospecting, distribution of 4 zones (width of 20-150m) of brecciated, ferrugenous silicified metasomatites are presumed in the eastern part of this ore body.

These oxidized formations form the zone with width of 600-700m and length of 4.5km. Wide potential exploration area for gold mineralization is expected in this ore showing.



Legend

magmatic formations
a: exposed b: assumed by geophysical data

- granodiorite, adamellite
- alkaline granite
- syenite-diorite, gabbrosyenite, gabbro diorite
- gabbro, gabbro-diorite, diorite

anticline
1: Turbay 2: Sarytau 3: Sautbay

● Tungsten I: Sautbay III: Sarytau
○ Gold II: Turbay

tectonic ridge forming Turbay fault

very high permeability zone

fractured disturbance
a: large b: small c: assumed

1: Turbay abyssal fault 2: Central Turbay
3: West Turbay 4: North Sautbay
5: South Sautbay 6: Okjetpes
7: East Okjetpes 8: East Sarytau
9: Sarytau 10: West Sautbay
11: Central Turbay 12: West Sarytau
13: North Akkoi and others

most intensive linear elements of magnetic, gravity and electric fields, dividing geological blocks

axis of most intensive positive anomaly of magnetic field (Δ Tloc)

Ore Field

(after A.P. Cheshuin; 1994)

● Tungsten 2: Saghinkan 3: Burgut 4: South East Sautbay 5: Kizilkashkar 6: Sautbay Group of Points 7: East Sarydjoy 8: West Sarydjoy 17: Kazgan 20: West Kazgan 25: Bektash 26: Katirtas 27: East Kazgan 32: South Bektash

○ Gold 9: Central 10: Central Turbay 12: South Turbay 13: North Turbay 14: Nea-Contact 15: Daikovoe 16: Kayansai 18: East Akkoi 19: Akkoi 21: South Sarytau 23: East Turbay 24: Kurgantau 29: Karatau 30: North-East Turbay 31: Taraubay

○ Silver with Gold 1: Koktash 22: Central Sarytau
○ Copper 28: North Sarytau

Fig. II-5-1 Summary of the Compilation

Part III CONCLUSION AND RECOMMENDATION

Chapter 1 Conclusion

(1) Geology of the Southern Bukantau Area including the Survey Area is composed of the basement formation of Proterozoic Riphelan to Vendian Series, groups of Paleozoic and Mesozoic and Cenozoic which unconformablly overlay on the basement formation (Fig.I-3-1). Granites and dykes of late Carboniferous to late Permian intruded into the groups of Proterozoic and Paleozoic.

Proterozoic group consisting of schist, quartzite, limestone, dolomite, shale and sandstone are classified into the four formations of Karashakh, Kokpatas, Khodjaakhmet and Koksai from lower to upper horizons with total thickness of over 3,000m. Among them, Kokpatas Formation and Karashakh Formation are the host rock of those ore deposits of tungsten skarn, gold silver quartz vein and metasomatic deposits in this area.

Systems of Ordovician, Silurian and Devonian of Paleozoic Era spread out in the survey area.

The system of Ordovician, consisting of slate, shale, sandstone, pyroclastics is occupying the northwest periphery of the Survey Area.

The system of Silurian is exposed in the southeast of Okjetpes which consists of alternation of shale and sandstone.

Kokpatas antiform of NNW-SSE direction is passing through Kokpatas toward Okjetpes. Limestone, shale and dolomite of lower Carboniferous period crop out as a window in the center of the antiform structure around Kokpatas.

Limestone, dolomite, shale and sandstone of Devonian to middle Carboniferous age are exposed as a window in Okjetpes area, the southeast extension of the antiform structure. Gold silver quartz veins are hosted in the formations of Devonian to Carboniferous.

Surrounding Proterozoic and Paleozoic rocks exposed are the marine sediments consisting of shale and sandstone of Cretaceous to Eocene age, and continental sediments consisting of conglomerate, sandstone and mudstone of Oligocene to Quaternary age.

Dominant intrusive rocks are the Altyntau Intrusives (granite), the Kokpatas Intrusives (granite-adamellite), the Turbay Intrusives (granite), the Sarytau Intrusives (granodiorite), the Sautbay Intrusives (monzonite to granosyenite). All intrusive rocks have intruded during late Carboniferous to early Permian age.

Dykes of diorite, gabbro, lamprophire and quartz syenite crop out in the area.

(2) Ore deposits and showings of tungsten, gold, silver and copper are located in the Survey Area. Twenty four ore deposits and showings have been detected in the Phase I (Fig.II-1-2, Table II-1-2).

They are divided into the following four ore fields.

1) Sarytau ore field

① Tungsten skarn・stockwork deposits (Sarytau deposits, Katirtas showing)

② Gold skarn deposits (South Sarytau showing)

③ Gold・silver・sulfide quartz vein (Central Sarytau showing)

④ Gold・silver・copper quartz vein (North Sarytau showing)

2) Sautbay ore field

① Tungsten skarn deposits (Sautbay deposits, Saghinkan showing, Burgut showing)

② Gold quartz vein・metasomatic deposits (Bulutkan showing)

3) Turbay ore field

① Gold stockwork・metasomatic deposits (Turbay deposits, East Turbay showing, South Turbay showing)

② Gold・silver・sulfide quartz vein (West Turbay showing)

4) Okjetpes ore field

① Silver・carbonate quartz vein・stockwork deposits (Okjetpes deposits)

② Gold quartz vein (Barhanny showing)

Tungsten skarn deposits are the stratiform type in carbonate rock intercalated mainly in Karashakh Formation and Kokpatas Formation of upper Proterozoic age and poorly developed both in Koksai Formation and Khodjaakhmet Formation. Ore shoots are frequently formed within 50-100 m rarely 200 m from the boundary of granitic intrusives.

Tungsten stockwork deposits occur commonly in granitic intrusives and occasionally in the host rocks. They are comprised of vein-veinlets emplaced in a fractured zone.

Previously known important gold・silver mineralization is observed in Turbay deposits of Turbay ore field and East Turbay showing. The mineralization is structurally controlled by NW-SE trending the Central Turbay zone of permeability

(Turbay Ore Zone).

Localization of other gold・silver deposits and showings are also controlled by the fractures of NW-SE, NE-SW and NNW-SSE.

Study of the existing data has revealed that Bulutkan showing is promising and worthy to conduct further exploration. Drilling of 70 non-core drillings has been carried out in the area and an area of gold mineralization has been already detected.

Size of the gold deposit is 30 m thick, 100 m long and extends over 70 m to the depth. Based on the assay data of the trenches and drillings, the ore reserves of 342,000 tons with Au 6.9 g/t (Au contents 2.4 tons) were estimated.

There is an enough room for further exploration around this showing.

(3) The existing data about Sautbay and Burgut deposits were collected and ore reserves of the two deposits were estimated by using personal computer.

MicroLYNX Plus, a software fit for estimation of vein type deposits, released by Lynx Geosystem Inc. of Canada, was used in ore reserve estimation. All of the data which are necessary for ore reserve caluclation were inputted into MicroLYNX. The characteristics of WO_3 and Au distributions in 3-D space were examined by analyzing the data geostatistically. In order to estimate the grades of the target components, a 3-D block model was created, and the average grades of WO_3 and Au in each block were estimated individually by Kriging interpolation method based on the result of variogram analyses.

The total ore reserve of Sautbay and Burgut deposits is 25,885 thou.tons with the cutoff grade of 0.05%(WO_3). The average grade of WO_3 is 0.27% and Au is 0.24g/t. The metal contents of the two components are about 70 thou.tons(WO_3) and 6 tons(Au) respectively.

Comparison of our estimate with that of Sarydjoy report was made. Both of the methods provided almost the same ore reserve of about 2,600 thou.tons (cutoff grade 0.05%WO_3) in the scheduled open pit (up to 150m deep) of Sautbay deposit. Although the average grades of WO_3 and Au are a little lower than those of Sarydjoy report, the two results can be considered to be practically the same.

In case whole area of Sautbay and Burgut deposits, however, significant differences were observed not only in the tonnage of ore but also in the average grades of ore between two results.

The ore grade of workable skarn type tungsten mines in the western countries (USA, Canada, Australia, South Korea, Turkey and etc.) is at least 0.5%WO_3 in open pit mining and 1%WO_3 in underground mining. Comparing with this, the ore grade of Sautbay and Burgut deposits is considerably lower. The margiral workable ore grade, however, is variable depending upon the size of ore deposits and various factors of mining cost. Therefore it is necessary to make a prefeasibility study in order to find out the possibility of developing these ore deposits.

(4) The roles of previously used geophysical methods in mineral exploration in the Survey Area are summarized as follows :

① Most of the known ore deposits in the area are located near granitic rocks and are associated with magnetic anomalies.

② As the densities of granitic rocks are lower than the other host rocks, granitic rocks form low gravity anomalies. Therefore gravity survey is effective to assume the location, depth and extent of intrusives including crypto-batholith.

③ Magnetic survey can effectively delineates the contacts of intrusive rocks with host rocks. Magnetic anomalies are often observed near the ore deposits and showings of both skarn type and vein type as they sometimes contain pyrrhotite. Magnetic survey will provide the useful information in mineral exploration of this area.

④ Gravity survey and magnetic survey have been applied successfully and extensively in this area. In addition to these methods, electrical survey and electromagnetic survey are to be conducted in the further exploration that will provide important information about ore deposits.

(5) Result of satellite imagery analysis revealed that the lineament of each area shows particular direction. The lineaments of E-W and NE-SW~ENE-WSW directions are dominant in the north to northwestern part of the area, and lineaments of E-W direction are longer in length. The lineaments of N-S~NNW-SSE and NE-SW~NNE-SSW directions are dominant in the central to western part of the area. In the eastern part of the area lineaments of NE-SW and WNW-ESE~E-W directions predominate.

The NE-SW lineaments in Sarytau, Turbay, Sautbay deposits and Bulutkan ore showing have not been confirmed that they correspond to the faults because of rock exposures are limited and snow fall at the time of survey. However, existence of the faults has been inferred by the facts of development of shear zones, linear drainages pattern and existence of fault scarps. Turbay fault and Eastern Okjetpes fault are well coincide with a lineament which have been extracted by photogeologic interpretation of the images.

(6) Eighteen geologic units were identified in the Survey Area by satellite imagery interpretation. Among them, six units are correlated to the older metamorphic~sedimentary rocks distributed in the mountainous area, nine units are correlated to the younger unconsolidated~loosely consolidated sediments and three units are correlated to the Carboniferous~Permian intrusive rocks.

Ground truth has revealed that the geologic units obtained by the image analysis had been correctly classified and reflect lithology. Therefore photogeological interpretation map is used as a base map for further analysis with minor changes.

Turbay Intrusives were classified as the sedimentary rock unit OCa. The ground truth survey has revealed that exposures of granitic rocks are limited along narrow drainages and the wide flat area was covered by Quaternary unconsolidated deposits. Therefore, the area does not show granitic features in topography, and the exposures of the granitic rocks are not enough to be identified as granite by the image analysis.

The symbols of geological units were changed : unit Ca was changed to R-Ca, unit OCa was changed to R-OCa since those units are correlated to Proterozoic group. However, the unit OCa at Okjetpes is correlated to Devonian to Carboniferous, therefore the symbol was changed to DCa.

(7) Seventeen areas of alteration zone are selected by the spectral analysis of the images.

The alteration zones which have been extracted by spectral analysis may indicate high sulfide type gold mineralization. On the other hand, the spectral analysis for the purpose of extraction of alteration zone may not be very effective for the low sulfied type mineralization since development of iron oxide zone is poor.

(8) Judging from the distribution of ore deposits, ore showings and the alteration zones, an ore zone of NW-SE direction including the alteration zones near Sautbay deposit(W) and Bulutkan ore showing(Au) and the another ore zone of NNW-SSE direction from Kokpatas deposit(Au) to the south-western part of Okjetpes deposit(Ag) are expected as potential exploration areas for the high sulphide type gold deposit.