At two places in the crystalline limestone terrain in the northeastern part of the area, rocks consisting mainly of wollastonite accompanied by quartz, muscovite and iron minerals are distributed in a small extent. Although it is strongly possible that the rocks might be the skarn because of the presence of dykes and stocks of granite in the vicinity, it is also possible that it might be the product from limestone subjected to regional metamorphism.

No distribution of useful metallic minerals has been observed.

(4) Limonite

Distribution of limonite ore was observed in four places from the central to the northeastern part of the area. These are chemically precipitated deposits distributed in the flat, dried up swampy areas in small amount. These are not likely to form an ore deposit of a significant scale.

3-4-2 Detailed Survey Area (Telot Chrome, Nickel and Gold Deposits)

(1) Situation and Access

The deposits are situated in the Telot area in West Pokot District at N 1°36' latitude and E 35°23' longitude in the southwestern part of the Sekerr Mountains. The altitude is 2,200 to 2,400 meters above sea level.

The route to the ore deposits is as follows: to drive along the National Highway A-1 from Kitale to Marich Pass through Ortum (100 km, one hour and a half). Then enter the uphill road by four-wheel drive vehicles at the junction about three kilometers to the north of Marich Pass. To ascend the steep cliff about nine hundred meters high, and to reach Telot (approximately 15 km, one hour). The deposits can be reached hiking along the broken motor road constructed for exploration (30 minutes to one hour).

(2) History of Exploration

The chromium and nickel deposits at Telot were first discovered in 1956. Since then exploration has been carried out by organizations like New Consolidated Gold Field Ltd. of South Africa, Department of Mines and Geology of Kenya and Japanese consortium constituted by Nippon Kokan KK., Kokan Kogyo KK. and C. Itoh and Co. Ltd. The outline and conclusion of these exploration works are shown in Table 3-2.

On the other hand, although it is said that the gold deposit has been mined since before independence of Kenya in 1963, there are not any description for the gold deposit in those exploration reports mentioned above, and it is thought that the panning of gold became active in recent years.

Table 3-2 Summary of Exploration work for Telot Cr, Ni, Au, Deposits

Item \ Investigator	New Consolidated Gold Fields Limited	Department of Mines and Geology	Nippon Kokan K.K. Kokan Mining Co., Ltd. C. Itoh & Co., Ltd.	MMAJ & JICA (Phase I)
Period of Investigation	April 1957 ~ March 1958	Dec. 1967 ~ Sept. 1968	April 1976 ~ May 1977	Oct. 1983 ~ March 1984
Road Construction	Landrover Truck 7 mile (11.26 km)			
Road Repairment, Improvement		7 mile (11.26 km)	14 km	
Topographic Survey	Grid-line control	Picketting 3,000ft x 6,000ft 200-foot grid		
Geological Survey	120 mi^2 (310 km^2)	About 3 km^2 (?)	20 km^2	120 km^2 (Semi-Detailed Survey)
Geophysical Survey		Grand Magnetic Survey 32,000 line feet, 100-foot interval		
Excavation Work: Trench	5,800 Cubic Yards ($4,434\ m^3$)	500 feet Av. width 3 ~ 4 ft Av. depth 5 ~ 6 ft	1,380 m	Clearing of old Trenches
Excavation Work: Pit			67 pits	
Excavation Work: Tunnel			122.80 m	
Diamond Drill Hole		11 winkle DDHs (Total 289 ft)	11 DDHs (Total 412.07 m)	
Analysis	319 soil samples for Ni, Co Some Cr-Ore	58 samples for Cr, Ni	46 samples for Cr, Fe, Ni, Au, Ag, Pt	206 soil samples for Cr, Ni, Co, V, Pt, 61 soil samples for Au 6 samples for Au, Ag 20 samples for Cu, Pt, V, Fe, Al 21 samples for Co, Ni, Cu
Main Targets	Chrome, Nickel	Chrome, Nickel	Chrome	Chrome, Nickel, Gold
Ore reserves of chromite deposit	Total tonnage proved 3,000 tons	Proven reserves 13,000 Long tons Probable reserves 6,500 Long tons Possible reserves 40,000 Long tons Average grade 49.17% Cr_2O_3 Average Cr/Fe ratio 3.12/1	Main ore body 3,600 tons Total of float ore 3,800 tons Grand total of proved reserves 7,400 tons Probable ore reserves 1,000 tons Proved + Probable 8,400 tons 48% Cr_2O_3	The reserves of a single body might be in the order of few to several thousand tons.
Ore reserves of nickel deposit	Total tonnage 8,000,000 tons Averaging a little over 1.0% Ni.	Probable indicated reserves 5,333,000 Long tons Grade slightly more than 1% Possible indicated reserves 14,425,000 Long tons Average grade 0.7% Ni.	No calculation	No calculation
Conclusion	The prospect does not appear to be economic at ruling prices.	Further development work in order to increase proven chromite reserves and to up-grade present possible indicated reserves to category of proven reserves of nickel is justified.	The development of telot chromite deposit will not be profitable. Exploitation of nickel ore will not be economical.	Further detailed geochemical and geological exploration works for nickel and gold mineralization are recommended.

The survey programme initiated in 1983 for the first year of the project, in which a Semi-Detailed survey including geological survey and geochemical prospecting were conducted for purposes of mainly nickel and chromite deposits. The area consists of 120 km^2 containing the serpentinite body and talc schist, the host rocks of the deposits. As a result, nickel ore of up to 2.79 percent in nickel grade was obtained in the nickel deposit, and it was concluded that it was necessary to know the size and the shape of ore bodies with economical value in the known ore deposits.

Regarding the gold deposit, a notable geochemically anomalous zone extending north was defined around and in the present panning site used by the local residents, which led to the judgement that it was necessary to introduce the exploration of the higher order.

As regards the chromite deposit, detailed survey including drilling had been completed, and the result led to the conclusion that the chromite deposit has a low economical value, mainly because of the small amount of ore reserves (Table 3-2). The same conclusion was reached as a result of 1st phase survey.

Based on the reasons given above, it was decided to carry out a detailed survey for gold and nickel deposits in the second year of the survey programme.

(3) Gold Mineralization

Outline

On the ridge three to four kilometers to the north of the chromite deposit, surface soil and weathered rock are mined manually by the local residents. These soils are transported to a creek with flowing water, where gold is recovered by panning.

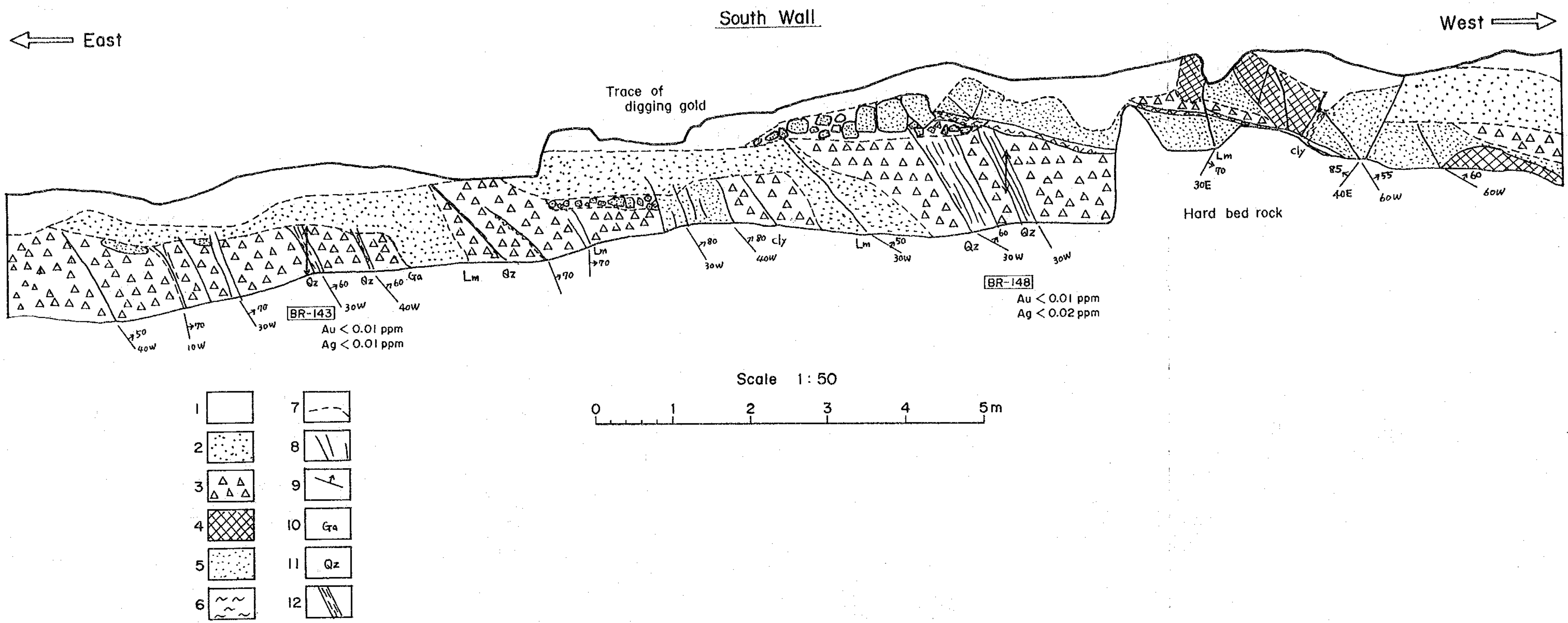
Mining is being carried out in a try and error method. The high grade parts have been dug down to a depth of five meters. The transportation is conducted only by man-power, and the ore is transported for five kilometers from the most distant working face.

It is said in general that several hundred kilogrammes of soil are treated by a miner per day and that a person of an excellent performance recovers one gramme of gold per week. The estimation of the minable grade based on oral conversation leads to the calculation that it is about 0.5 gramme per ton and that the grade of the crude ore would be about one gramme per ton when the recovery of panning is taken into consideration.

At the present site, a considerable area of the surface has been excavated, thus the working faces tend to move southwards.

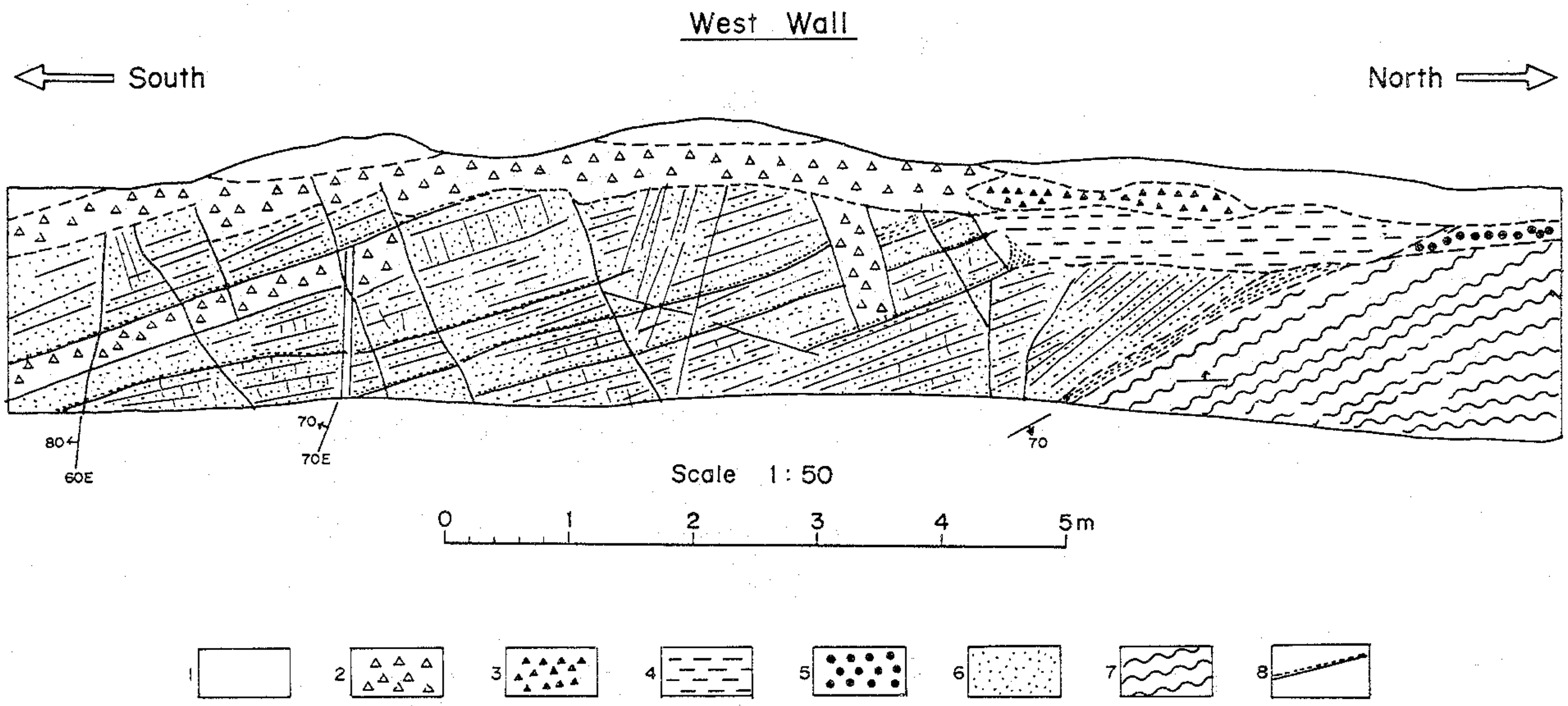
Geology

As a result of geological survey along the survey lines set up for geochemical prospecting, it became clear that the area of mining is within the silicified zone, that the silicified zone shows



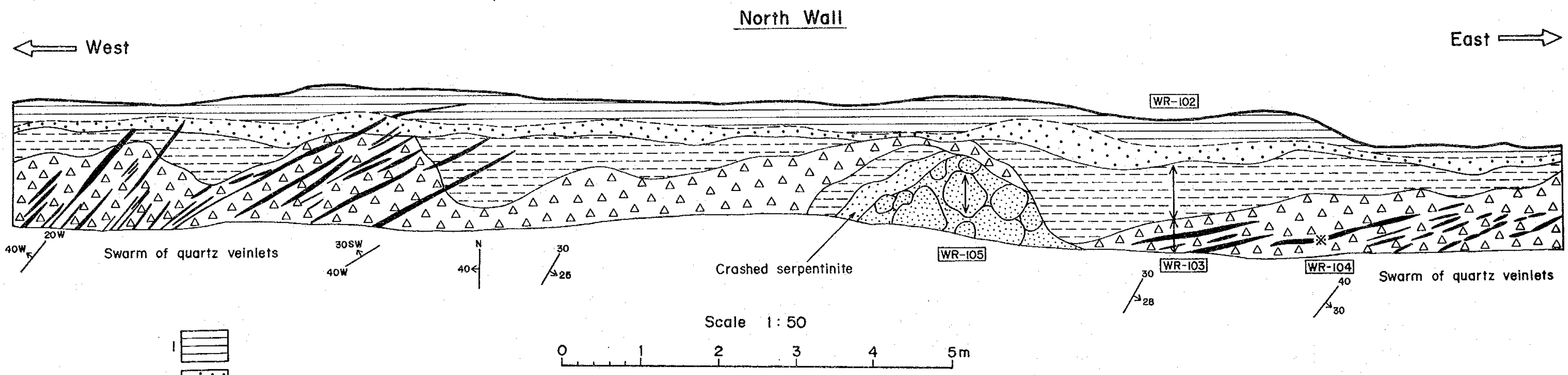
1. Bluish brown sandy soil and gravel with grass roots
2. Reddish brown sandy soil
3. Sand and gravel composed of serpentinite
4. Fresh hard serpentinite
5. Weathered earthy serpentinite
6. Chlorite schist
7. Boundary of rocks or soil horizon
8. Joint or cracks
9. Dip & strike of joint
10. Garnierite stain
11. Quartz vein
12. Silicified zone

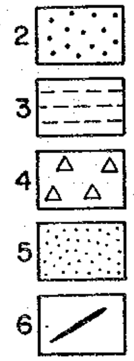
Fig. 3-8 Geological Sketch of J-14 Trench



1. Bluish brown sandy soil and gravel with grass roots
2. Pale brown~partly reddish brown strongly decomposed serpentinite, earthy
3. Serpentinite breccias
4. Reddish brown horizone, clay rich
5. Breccias of chlorite schist
6. Serpentinite partly silicified
7. Chlorite schist
8. Crack with clay

Fig. 3-9 Geological Sketch of L-18 Trench





1. Pale brown soil and breccias of talc with dense development of gtass roots
2. Pale brown soil and breccias of talc
3. Orange brown, partly light brown homogeneous soil
4. Reddich brown soil with abundant talc breccias
5. Serpentinite blocks, strongly silicified
6. Quartz vein

Assay Result

Sample No	Au(ppm)	Ag(ppm)
WR-102	<0.01	<0.2
WR-103	<0.01	<0.2
WR-104	<0.01	<0.2
WR-105	<0.01	<0.2

Fig. 3-10 Geological Sketch of M-16 Trench

a remarkable extension in the direction of north to south, and that the main part is at the central part of the serpentinite with a width of up to 350 meters (Fig. 4-12).

Mining work of gold led to a conclusion that soils containing fine-grained siliceous materials was relatively high in gold content. It was therefore concluded that the gold mineralization is related to silicification.

As a result of observation and examination of trenches and pits, and the surface geological survey, siliceous materials in the silicified zone are as follows.

(a) Chalcedonic Quartz Vein

Two modes of occurrence are observed. One is within serpentinite and talc schist in lenticular to bedded form, and has a width of several centimeters to several tens of centimeters, and is parallel with the structure of the country rocks (strike : NNW-SSE, dip : mainly west), and the other is network type and porous.

(b) White Quartz Vein

Two modes of occurrence are observed. One is the veinlets (0.1 mm to several mm in width) occurring reticularly in serpentinite and talc schist, and the other is the veinlets (1 mm to several cm in width) showing in form of vein.

(c) Silicified Serpentinite

It is several meters to several tens meters wide, extending north-northwest. The rock is greyish white to pale brown, and very hard, often forming a protrudent topography.

(d) Silicified Talc Schist

It occurs in talc schist in a lenticular form, from several centimeters to several meters wide.

Laboratory tests were made for the siliceous materials and silicified rocks as described below.

(a) Chemical Analysis

Table 3-3 shows the result of chemical analysis of 20 samples of siliceous materials and soils analysed for gold and silver.

Only 0.07 ppm of gold was detected in the soil which contains siliceous material. Silver was detected at the value of 1.0 ppm in the same soil sample. It is noteworthy that it was detected at 2.5 ppm in a chalcedonic quartz vein. This is consistent with the results of the survey in the first year. The content of silver above the detection limit was shown in only two samples of agate-like chalcedonic quartz vein. It is a possibility that chalcedonic quartz is the silicified material to be related to the mineralization of gold and silver.

(b) Microscopy of Polished Section

As a result of microscopic observation of the same samples of chalcedonic quartz vein (Table A-2), tiny particles of gold grain was confirmed, which supports the hypothesis mentioned above.

(c) X-Ray Diffraction

Table A-3 shows the result of X-ray diffraction of silicified talc schist distributed in the vicinity of the chalcedonic quartz vein mentioned above, in which only talc and quartz were detected and no other alteration minerals were confirmed. No pyrite nor clay minerals related to hydrothermal alteration were observed with the naked eye in the silicified zone at Telot. And the result shows that no such strong alteration to help form pyrite and clay minerals did take place in the silicified zone.

Discussion on Mineralization

It is an important fact that the gold mineralization at Telot is closely related to the silicified parts of serpentinite and talc schist, that the main part of the silicified zone continues for two kilometers northwards with a width of about 350 meters, and that most of the samples with geochemically anomalous values of gold described later (Chapter 4) are contained in the zone with 350 meter width.

According to the result of geological survey, the distribution of lenticular talc schist is often observed within fractured parts in serpentinite and along faults.

On the other hand, occurrence of talc schist is often observed, and at the same time, strong silicification is also observed in pits and trenches excavated in the silicified zone in the central part (e.g. M-16 trench).

It seems therefore that the silicified zone includes a series of faults and fractured zones, suggesting that gold mineralization associated with silicification took place through the faults and the fracture zones.

Although gold deposits associated with ultrabasic rocks are observed everywhere in the world, the origin of gold has not necessarily been made clear.

There are two points of view about it; one is that gold is contained primarily in ultrabasic rocks, and the other is that it was introduced by tectonic movement such as faulting and fracturing (Boyle, 1979).

Since both the gold deposit of Telot and the gold deposit found in the upper reaches of the Endogh River (report of the first year) are emplaced in serpentinite or talc schist accompanied with the ultrabasic rock, and taking into account that both deposits are contained in the same tectonic zone, it can be interpreted that the primary gold which had been contained in the ultrabasic rock might be concentrated by the effect of tectonic movement in the formation of Telot gold deposit.

Ore Reserve and Grade

Ore reserve is to be calculated on the assumption that open pit method is applied for mining operation. Suppose that the mineralized zone occupies a maximum extent in the silicified zone

Table 3-3 Result of Chemical Analysis (Ore), for Au Ore

Sample No.	Au (ppm)	Ag (ppm)	Location*	Remarks
BR-9	<0.01	<0.2	L-20 Surface	Brown limonite stained silicified serpentinite
BR-130	<0.01	<0.2	J-14 Pit	Khaki soil with decomposed serpentinite breccia
BR-143	<0.01	<0.2	J-14 Trench	Khaki soil with film veinlets of amorphous quartz
BR-148	<0.01	<0.2	ditto	ditto
BR-150	<0.01	<0.2	L-18 Trench	Brown soil with decomosed serpentinite breccia
CR-13	<0.01	<0.2	R-15∿R-16	Agate like amorphous quartz vein with boxwork of limonite
CR-22	<0.01	2.5	T-15 Surface	Chalcedonic quartz vein
CR-31	<0.01	<0.2	Z-8 Surface	Brown limonite stained silicified serpentinite
CR-99	<0.01	<0.2	I-18 Surface	Brown soil with fine talc breccia
WR-15	<0.01	<0.2	L-19 Surface	Porous quartz veinlents
WR-16	<0.01	<0.2	L-17 Surface	Strongly silicified serpentinite
WR-102	<0.01	<0.2	M-16 Trench	Orange brown soil, talc schist origin
WR-103	<0.01	<0.2	ditto	Reddish brown soil, talc schist origin
WR-104	<0.01	<0.2	ditto	Silicified talc schist
WR-105	<0.01	<0.2	ditto	Strongly silicified rock (talc schist origin?)
WR-112	<0.01	<0.2	M-8 Pit	Silicified serpentinite (vein-like)
WR-127	<0.01	<0.2	L-11 Pit	Quartz vein
WR-128	<0.01	<0.2	M-16 Pit	Thin quartz veinlet
WR-181	<0.01	<0.2	K-15∿K-16	Silicified leached serpentinite
WR-182	0.07	1.0	K-13∿K-14	Yellowish green soil with fine siliceous material

*Ref. Plate 9; Location Map of Pits, Trenches, Soil samples and Tested Samples shown by the gold content above the detection limit of geochemical samples, the area is 350 m x 2,000 m = 700,000 m^2.

If it is assumed that the depth of the weathered zone which is easy to mine is 10 meters and that the specific gravity of ore is 2.5, the ore reserve is 700,000 m^2 x 10 m x 2.5 = 17,500,000 tons.

The grade is estimated to be about one gramme per ton at the high grade part. However, average grade for the whole reserve is considered to be considerably lower than 0.5 gramme per ton taking the result of geochemical prospecting into consideration. This is fairly low as compared with the average grade of the operating open pit mines in the world, which is 0.1 oz/ton = 3 gr/ton.

Therefore it is considered that the deposit is not suitable for systematic mining on a large scale.

(5) Nickel Mineralization

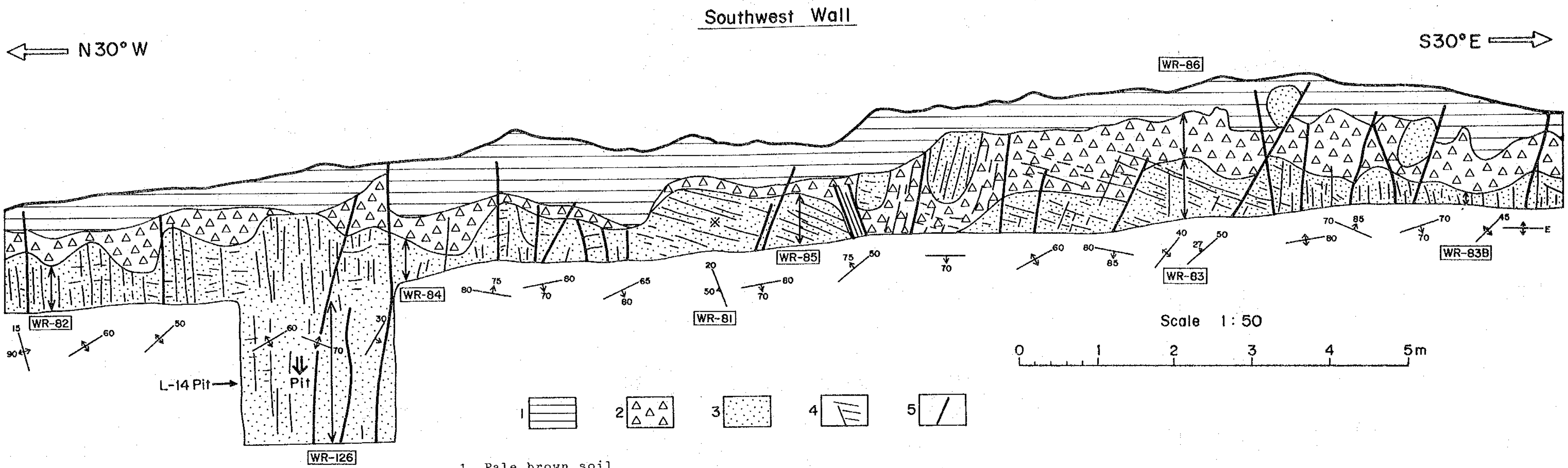
Geology

Fig. 3-11 to 3-13 shows geological sketch of the trenches excavated for the survey of the nickel deposit, and Fig. A-1 to A-30 shows that of the pits. The compilation of these sketches and the result of surface geological survey led to produce a typical columnar section of the Telot nickel deposit which is shown in Fig. 3-14.

Nickel ore bodies with a Ni content of more than 10,000 ppm and with a sizable extent are considered to locate in four places, taking account of the assay results of the ore samples obtained on the surface, those of the ore samples from the trenches and pits, and those of the soil samples for geochemical analysis showing more than 5,000 ppm of nickel content. Fig. 3-15 shows such places as Gold Hill, Chrome Ridge, Main Ridge and Golf Links. Among these, the Main Ridge was not confirmed in the present survey, but it was added from the results of the geochemical prospecting (Fig. 3-16) conducted by New Consolidated Gold Fields Ltd.

The areas between these mineralized zones are considered to be part with weak primary mineralization, or places where nickel mineralized zones were eroded out as a result of weathering and erosion.

The values of anomalies obtained as a result of the current geochemical survey (Chapter 4) are generally low in grade and small in extent as compared with the areas showing more than 7,000 ppm of nickel content which were suveyed by New Consolidated Gold Fields Ltd. (1956). The reason is likely to be that, in the latter case, the samples might have been taken at depth reaching the nickel enrichment zone, whereas, in the former case, the same samples which were used for gold geochemical analysis were analysed, and the depth of sampling

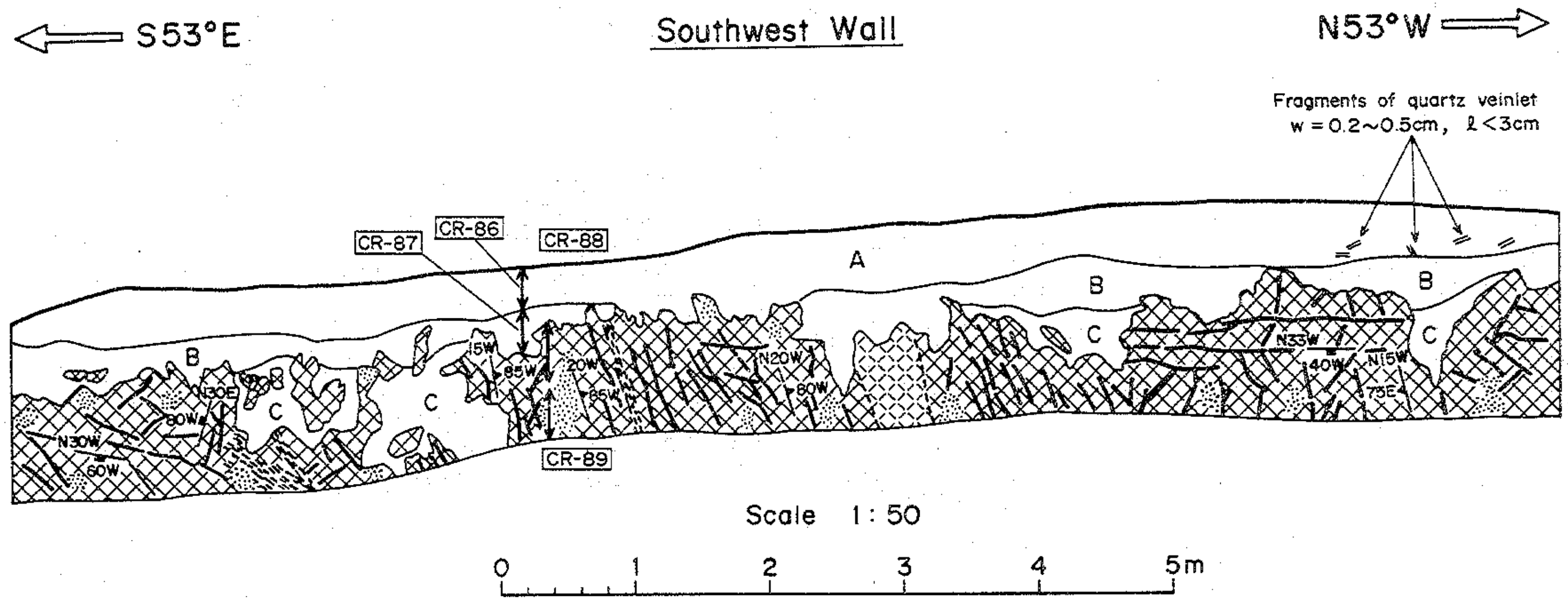


1. Pale brown soil
2. Strongly decomposed serpentinite (structure invisible)
3. Weathered serpentinite (structure visible)
4. Joint
5. Fissure

Assay Result

Sample No	Ni(ppm)	Co(ppm)	Cr(ppm)	Fe(%)	MgO(%)	SiO_2(%)
WR-81	21000	240	2700	6.60	28.2	39.0
82	10000	250	2600	5.55	23.0	40.4
83	11000	330	2800	8.10	25.8	45.2
83B	11400	290	2900	6.45	16.0	41.8
84	11500	400	3800	13.05	20.8	45.1
85	20000	330	2700	7.05	30.0	41.9
86	16000	330	2700	7.50	14.0	43.2
126	7200	330	2100	6.00	28.8	43.3

Fig. 3-11 Geological Sketch of L-14 Trench



Serpentinite
Silicified serpentinite
Schist sity
Joint
Assayed sample No.

Garnierite stain along cracks
Sheared serpentinite
Cracks in serpentinite

A. Brown soil (A horizon) with gravels of serpentinite, silicified serpentinite talc schist and chlorite schist

B. Reddish brown soil (B horizcn) with fragments of serpentinite and silicified serpentinite

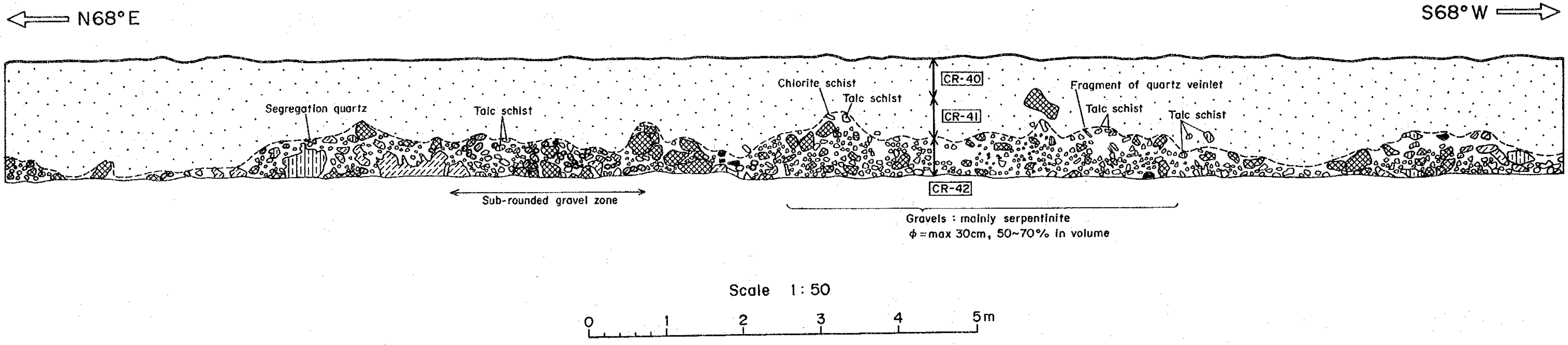
C. Brown soil (C horizon?) with fragments of serpentinite and silicified serpentinite

Assay Result

	Ni(ppm)	Co(ppm)	Cr(ppm)	Fe(%)	MgO(%)	SiO_2(%)
CR-86	4300	680	10000	9.45	21.0	37.7
87	4900	570	4500	9.00	27.2	43.5
88	7400	220	3200	5.40	26.0	48.2
89	9200	440	2900	6.75	14.2	40.2

Fig. 3-12 Geological Sketch of R-18 Trench

Southeast Wall



Hard porous brown soil

Sub-angular~Sub-rounded poligenetic gravel zone

Schistosed serpentinite

Silicified serpentinite

Chlorite schist

Talc schist

Assay Result

Sample No	Ni(ppm)	Co(ppm)	Cr(ppm)	Fe(%)	MgO(%)	SiO_2(%)
CR-40	2700	240	3300	11.25	11.0	43.5
CR-41	2700	260	2600	10.60	10.6	43.0
CR-42	2800	220	3100	8.10	8.3	40.6

Fig. 3-13 Geological Sketch of FF-31 Trench

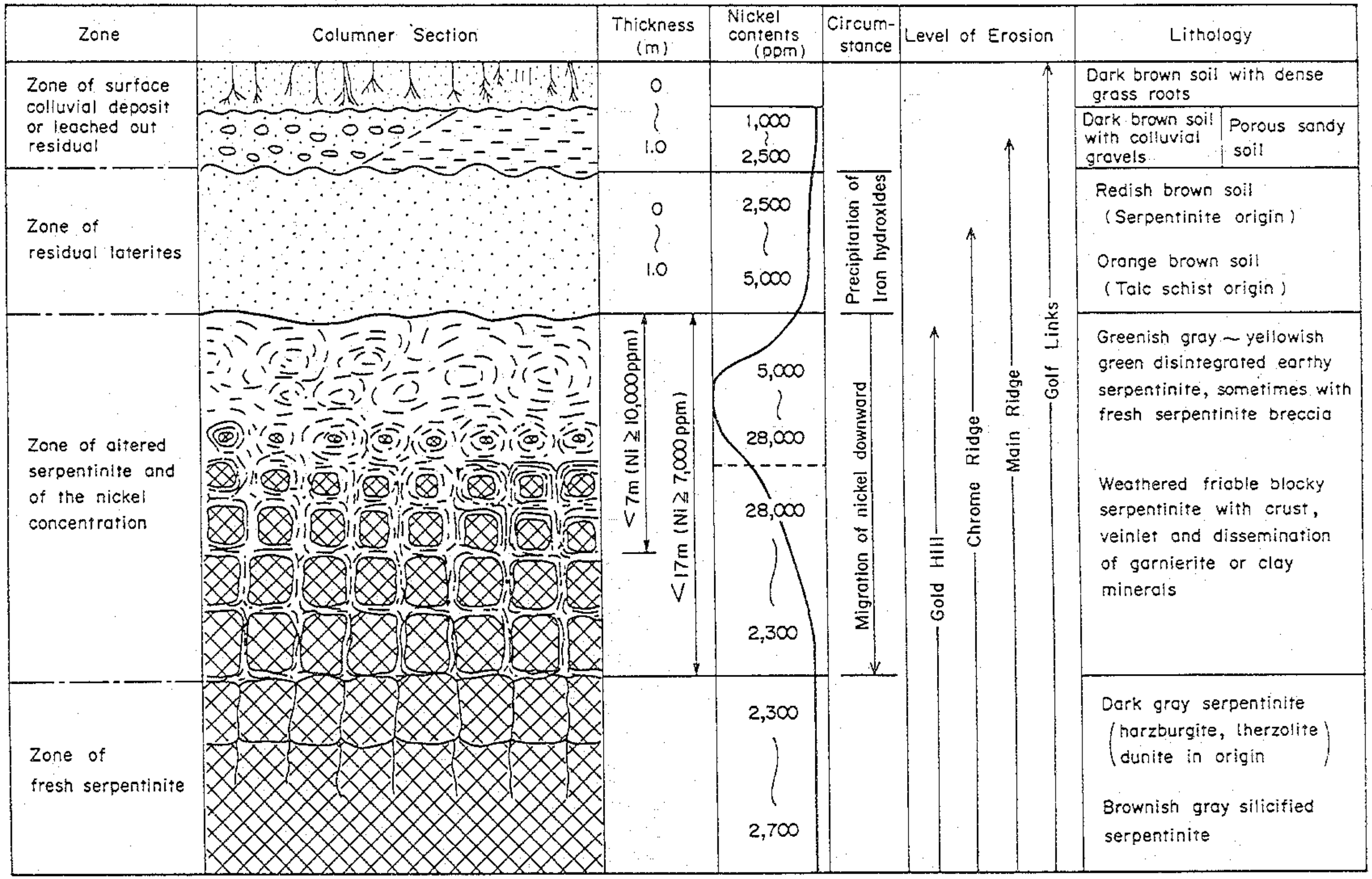


Fig. 3-14 Generalized Profile of Telot Garnierite Deposit

Fig. 3-15 Nickel Ore Bodies and Location of Pits and Trenches

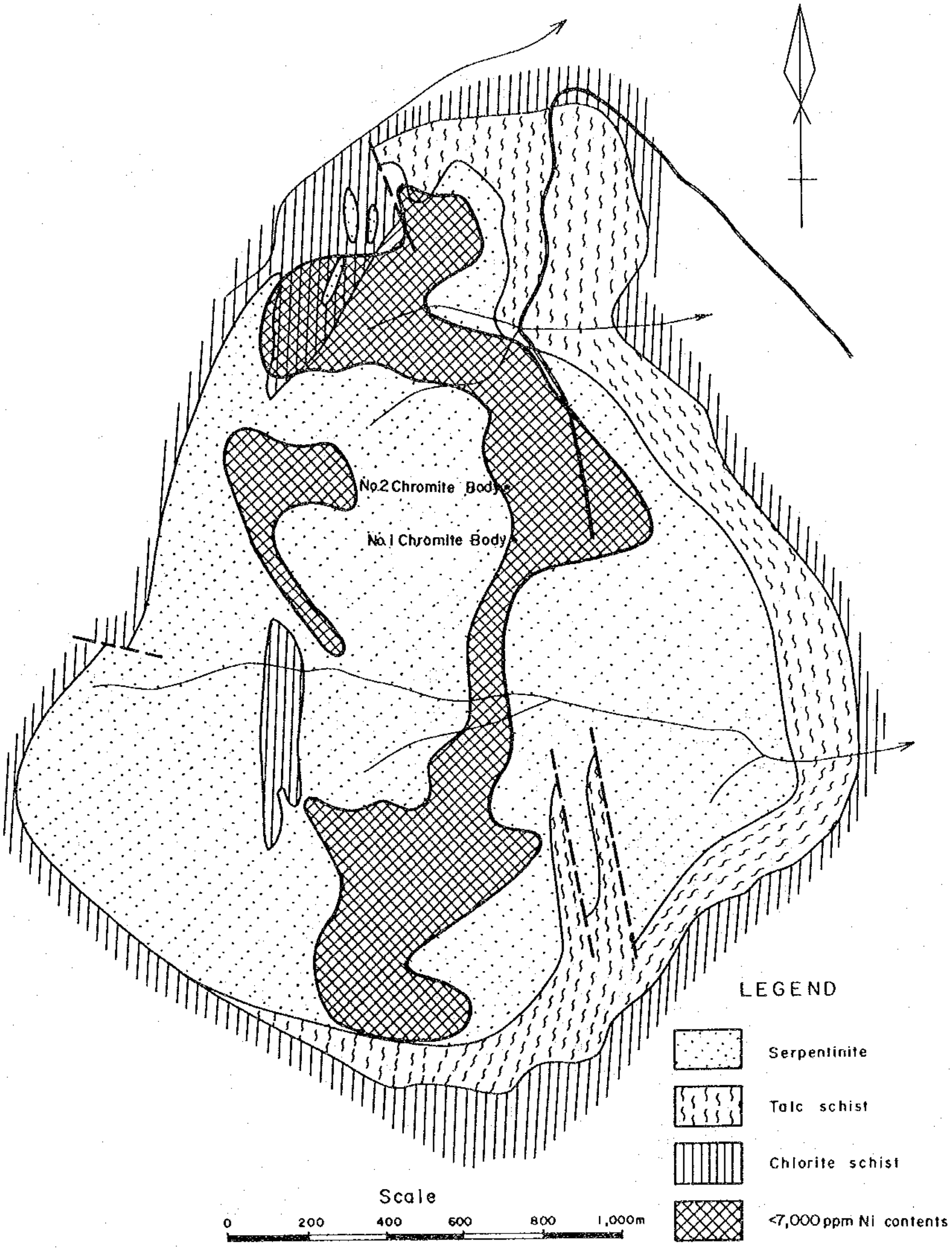


Fig. 3-16 Geochemical Anomalies in the Telot Area
(After New Consolidated Gold Field Ltd.)

was at relatively shallow colluvial zone or within zone of leaching above the nickel enrichment zone.

Geology of the mineralized zones is as follows.

(a) Gold Hill (the surface area: approximately 100,000 m^2)

The altered nickel enriched serpentinite containing a large amount of garnierite is exposed on the surface, and the samples for geochemical survey and the ore samples obtained from the surface include those of high nickel grade. This is the mineralized zone showing the most advanced erosion among the four zones.

(b) Golf Links (the surface area: approximately 180,000 m^2).

A very gently inclined flat landform extends on the eastern side and it is considered to correspond to a relic topography of the eroded surface of peneplain, which has been named "Cherangani plane" (McCall, 1964) from the altitude above sea level. The nickel enrichment zone occurs at a depth more than one meter below the colluvial surface bed, on which an eroded reddish brown soil with an irregular thickness is present, or lacking.

(c) Chrome Ridge (the surface area: approximately 100,000 m^2)

Chromite deposits are contained in the rocks of this area. The topography is a little steeper than that of the Gold Hill. Thin surface soil less than 0.5 meter thick covers the eroded reddish brown soil bed or the nickel-rich altered serpentinite.

(d) Main Ridge (the surface area: approximately 50,000 m^2).

The landform is a little more gentle than that of the Gold Hills. Weathered serpentinite 0.5 meter thick is distributed underneath the humus soil zone about 0.5 meter thick. The nickel enriched altered serpentinite occurs below the weathered serpentinite.

Characters of Nickel Ore

The nickel ore in the mineralized zone is classified in the following categories.

(a) Earthy altered serpentinite
(b) Blocky weathered serpentinite
(c) Film-like veinlets and fissure-filling material
(d) Reddish brown soil
(e) Dissemination or crust in relatively fresh serpentinite

(a) and (b) correspond to the C-horizon of the classification of soil, often showing the values of more than 10,000 ppm Ni, and accompanied by (c) of high-grade in many cases. (d) corresponds to the B-horizon in the classification of the soil profile, and it is a part with a high concentration of iron hydroxide. The nickel grade is 2,500 to 5,000 ppm in general, showing a low grade except for only one example which showed a value of 8,000 ppm. Although (e) is high in grade locally, but considerably low in bulk.

Table 3-4 Result of Chemical Analysis for Nickel Ore

Sample No.	Location*1	Depth (m)	Type of Ore (Rock) *2	Assay Results						Other Test*3
				Ni(ppm)	Co(ppm)	Cr(ppm)	Fe(%)	MgO(%)	SiO_2(%)	
BR 14	K-13 S	0	Strongly weathered serp. with garnierite	13,000	240	2,200	6.15	32.5	41.2	
81	DD-15 S	0	ditto	10,600	240	1,900	5.25	35.8	40.3	
120	J-20 P	0.6∿0.8	Pale brown talc-soil	3,700	330	2,100	6.15	20.8	56.3	
123	K-17 P	0.8∿1.1	Reddish brown soil with silicified serp. breccia	4,200	290	4,400	8.55	14.0	56.1	
126	M-20 P	1.1∿1.5	Strongly weathered silicified serp.	5,900	270	3,500	8.55	28.8	39.8	
128	P-20 P	0.2∿1.0	Strongly weathered talc schist	4,300	250	2,100	6.45	16.6	59.9	
130	J-14 P	1.3∿1.5	Khaki soil	4,500	320	2,600	7.95	28.0	45.0	Au-Ag
131	D-14 P	0.3∿0.7	Strongly weathered earthy talc schist	3,200	460	4,500	10.65	20.6	47.3	
134	A-12 P	0.8∿1.2	Brown soil (talc-schist origin)	6,000	1,020	8,400	16.65	17.4	41.0	
137	V-19 P	0.9∿1.3	Reddish brown weathered disintegrated serp.	7,700	240	2,500	6.60	19.8	41.5	
139	S-20 P	0.5∿0.8	Yellowish green weathered serp.	9,500	250	2,700	6.60	30.8	42.2	
140	ditto	1.6∿1.8	Cream yellow strongly weathered serp.	8,000	220	1,900	4.95	24.8	55.6	
CR 40	FF-31 T	0∿0.5	Brown porous hard soil, upper zone	2,700	240	3,300	11.25	11.0	43.5	
41	ditto	0.5∿1.0	ditto lower zone	2,700	260	2,600	10.25	10.6	43.0	
42	ditto	1.0∿1.5	Colluvial ∿ alluvial gravel layer	2,800	220	3,100	8.10	8.3	40.6	
54	BB-26 P	1.2∿1.6	Yellowish green strongly weathered serp.	10,900	250	2,200	6.90	26.8	41.0	
64	BB-14 P	0∿0.4	Brown porous soil	6,400	270	2,800	10.80	18.0	36.6	
65	ditto	0.4∿0.7	Reddish brown soil	7,200	290	2,400	11.40	15.2	37.1	
66	ditto	0.7∿1.5	Pale brown ∿ white weathered schistosed serp.	3,500	220	2,000	5.70	13.2	42.7	
82	Y-14 P	0.7∿0.8	Reddish brown soil	4,700	420	6,700	14.40	14.6	37.3	
83	ditto	0.8∿1.2	Reddish brown soil with serp. breccia	4,600	660	5,600	12.30	28.0	36.7	
84	ditto	1.2∿1.5	Light brown soil with serp. breccia	3,900	540	4,100	8.40	28.8	39.0	
85	ditto	1.1∿1.5	Weathered serp. with yellow mineral on surface	5,200	210	2,200	4.50	33.0	44.1	X-R
86	R-18 T	0∿0.3	Brown surface soil	4,300	680	10,000	9.45	21.0	37.7	
87	ditto	0.3∿0.6	Reddish brown soil	4,900	570	4,500	9.00	27.2	43.5	
88	ditto	0.4∿0.9	Weathered yellowish green serp.	7,400	220	3,200	5.40	26.0	48.2	
89	ditto	0.9∿1.3	ditto	9,200	440	2,900	6.75	14.2	40.2	
WR 18	L-15 S	0	Pale green weathered serp.	9,000	190	2,200	5.40	31.0	41.1	
19	L-13 S	0	Dark gray weathered serp.	4,300	440	2,200	5.25	25.2	40.7	
41	O-12 S	0	Gray fresh serp.	2,700	190	1,500	4.50	31.6	39.6	X-R
46	O-15 S	0	Weathered yellowish green serp.	9,100	460	1,900	5.55	34.8	41.8	
81	L-14 T	1.0	Strongly weathered garnierite rich serp.	21,000	240	2,700	6.60	28.2	39.0	X-R
82	ditto	0.8∿1.4	Yellowish green weathered serp.	10,000	250	2,600	5.55	23.0	40.4	
83	ditto	0.9∿1.7	ditto	11,000	330	2,800	8.10	25.8	45.2	X-R
83B	ditto	1.2∿1.4	ditto	11,400	290	2,900	6.45	16.0	41.8	
84	ditto	1.0∿1.6	ditto	11,500	400	3,800	13.05	20.8	45.1	
85	ditto	0.6∿1.3	Strongly weathered garnierite rich serp.	20,000	330	2,700	7.05	30.0	41.9	
86	ditto	0.3∿0.9	Greenish grey strongly weathered earthy serp.	16,000	330	2,700	7.50	14.0	43.2	
113	M-8 P	0.8∿1.1	Light orange brown soil	4,100	400	4,700	12.00	10.8	40.5	
114	P-10 P	0.5∿0.9	Weathered silicified serpentinite	2,700	280	3,200	6.45	31.8	40.0	
115	ditto	0.9∿1.6	Weathered serp. with yellowish green mineral	5,000	300	2,400	6.15	14.2	40.6	
119	P-14 P	1.4∿1.7	Pale grey silicified schistosed serp.	2,400	260	1,100	3.00	33.4	49.6	
121	L-11 P	1.2	Grey weakly weathered serp.	4,600	260	1,400	3.75	37.6	42.4	
122	ditto	1.0∿1.6	Weathered greenish brown serp.	9,400	340	2,300	7.35	38.0	38.0	
123	ditto	0.6∿1.0	Strongly weathered orange brown serp.	13,200	390	3,600	8.40	31.4	39.5	
124	ditto	0.4∿0.6	Decomposed bleached serp.	2,300	240	1,500	3.15	36.0	43.1	
126	L-14 P	2.1∿3.6	Strongly weathered pale greenish grey serp.	7,200	330	2,100	6.00	28.8	43.3	X-R
131	U-14 P	1.1∿1.6	Weathered, disintegrated serp.	2,900	270	4,000	4.80	23.6	42.9	
176	O-21 S	0	Fresh serpentinite	2,400	310	1,700	4.50	36.4	35.1	
182	K-13∿14 S	0	Greenish brown weathered earthy serp.	9,000	480	4,000	10.35	26.0	42.8	Au-Ag X-R

*1 P: Pit, T: Trench, S: Surface, Ref: Plate ....., *2 Serp.: serpentinite

*3 Au-Ag: Chemical Analysis for Au and Ag, X-R: X-ray diffractive analysis, TS: Thin section

The nickel mineral is pale green to pale reddish brown, found in form of powder or veinlets. That which is contained in the soil of serpentinite is greenish brown in colour.

For the purpose of identifying the nickel minerals, five ore samples of different grades were tested by X-ray diffraction method, and for identifying the principal minerals of serpentinite, a rock sample of fresh serpentinite was tested by the same method. The results are as shown in Table A-3.

The fresh serpentinite mainly consists of antigorite, olivine and chromite, accompanied by pyroaurite. Pyroaurite is the secondary alteration mineral of serpentine minerals.

The nickel ores consist of antigorite or garnierite, montmorillonite, chromite and quartz. The veinlet-like green part contains illite and illite-montmorillonite mixed-layer minerals. Antigorite can not be distinguished from garnierite by X-ray diffraction, but it is likely that these samples consist mainly of antigorite, being accompanied by garnierite, or they are composed of garnierite with low nickel content judging from the assay values of the samples (Ni: 7,000 to 21,000 ppm).

Results of microscopic observation of the polished sections of nickel ore is shown in Table A-2.

Grade

The assay values for the samples of nickel ore and unaltered serpentinite 50 in total such as Ni, Co, Cr, Fe, MgO and SiO_2 are shown in Table 3-4, and statistic values and correlation coefficients between the components analyzed are shown in Table 3-5 and Table 3-6 respectively.

Table 3-5 Statistic Values of Analytical Element

Elements	Unit	Number of Samples	Maximum Value	Minimun Value	Mean	Standard Deviation	m + 2σ
Ni	PPM	50	21000	2300	7044.00	4334.80	15713.60
Co	PPM	50	1020	190	339.20	149.44	638.07
Cr	PPM	50	10000	1100	3128.00	1654.09	6436.18
Fe	%	50	16.65	3.00	7.60	2.90	13.41
MgO	%	50	38.00	8.30	24.28	8.16	40.60
SiO_2	%	50	59.90	35.10	42.70	5.10	52.89

Table 3-6 Correlation Coefficients

	Ni	Co	Cr	Fe	MgO	SiO_2
Ni	1					
Co	-0.079	1				
Cr	-0.120	0.773	1			
Fe	-0.026	0.625	0.716	1		
MgO	-0.161	-0.103	-0.328	-0.519	1	
SiO_2	-0.137	-0.205	-0.199	-0.207	-0.155	1

5% significance level : 0.277

Among the 50 samples, the ore samples taken from each ore body i.e. Gold Hill, Chrome Ridge and Golf Links were used for calculation of the average grade. The result is shown in Table 3-7.

Table 3-7

Contents / Ore Body	Ni (ppm)	Co (ppm)	Cr (ppm)	Fe (%)	MgO (%)	SiO_2 (%)
Gold Hill	10,600	340	2,600	6.94	30.0	41.6
Chrome Ridge	7,900	290	3,000	6.48	23.4	44.8
Golf Links	7,000	320	3,000	8.15	25.8	39.4
Average	8,500	320	2,900	7.19	26.5	41.9

Among these three ore bodies, the Gold Hill ore body is the highest in nickel grade while the other two are relatively low. This is likely to be due to the fact that enrichment zone is exposed on the Gold Hill area, whereas overburden is relatively thick at other bodies, having led to less frequency of taking samples of the nickel enriched part lower.

However, the nickel grade in the two ore bodies is estimated to be about 10,000 ppm and is similar to that of Gold Hill when to refer to the results of trenching in the past, and it is considered that the grade will be Ni + Co = 1.1% approximately in all the three ore bodies. This value is fairly low as compared with the grade (Ni + Co > 2.0%) of nickel deposits of the same type in operation in other part of the world.

It is desirable that the garnierite ore has the composition such as Co < 0.05%, Fe < 15%, MgO < 20%, SiO_2 < 40% and Cr < 0.05% (Yoshida, 1978). Especially it is said that the ores of low magnesia and low silica are favorable for extraction and smelting of nickel. The values of MgO and SiO_2 in the Telot nickel deposit are 26.5% and 41.9% respectively, and it can be said that the ore is rich in MgO and SiO_2 content.

Ore Reserves

Since no systematic sampling and analysis for calculation of ore reserve has been made in the current survey, reliable data to estimate the depth of mineralization is also not available. Any basis for further revision of the results of calculation of ore reserve performed by the Department of Mines and Geology who revised the calculation conducted earlier by the New Consolidated Gold Fields Ltd., is not there.

The assumption of the depth by the Department of Mines and Geology was based on the results of drilling, which is considered to be accurate to a considerable extent. Further, the extent of mineralized zone and the area set up are almost the same as those obtained in the current survey. It can be said, therefore, that the calculation of the ore reserve by the Department of Mines and Geology might be reasonable. However, because the topography of the mineralized zone is fairly steep and because the mineralized zone would not always show a regular zonal arrangement from the evidences observed in the pits and trenches, more investigation would be required for a more accurate calculation of ore reserve and grade.

CHAPTER 4 GEOCHEMICAL SURVEY

4-1 Outline of the Geochemical Survey

4-1-1 General Remarks

Geochemical survey was performed with the purpose of detecting geochemical anomalies caused by mineralization and of obtaining basic data for mineral exploration in the next phase of the project.

The second phase investigation comprises regional survey and detailed survey. The area of regional geochemical survey is 770 km^2 and same to that of the regional geological survey. Although no mineralization except a small scale placer gold deposit along the Moiben river has been known, the area was selected for the survey for two reasons. One is that the geology and the geological structure relating to mineral occurrences of gold, copper, chromium etc. in the area of first phase programme were thought to continue into the area of second phase. The other is that a skarn float was collected in the area of the second phase during the first phase survey. In the regional survey, 709 stream sediment samples were collected and analysed for five elements, Au, Cu, Zn, F and Cr. The area of detailed geochemical survey, 3 km^2, is included in the detailed geological survey area, covering the Telot serpentinite body in which chromite, garnierite and eluvial gold deposits occur. The area was selected for follow up in order to evaluate the gold and nickel mineralizations. For this purpose, a grid system with 100m x 50m unit was designed, and 607 soil samples were collected for analysis of Au, Ni and Cr.

Table 4-1 lists the number of geochemical samples, analytical elements and so on.

4-1-2 Sampling and Sample Preparation

The localities of geochemical samples are shown in Plate 9 (Regional Survey Area) and Plate 10 (Detailed Survey Area).

In the Regional Survey Area, about 50 grammes each of stream sediment samples screened under 80-mesh were collected from almost all tributaries at their bifurcations from major drainages systems. Screening could have been done at the place with water because sufficient running water was found even in a very small tributary. In the Detailed Survey Area, 500 to 800 grammes each of soil samples were collected from the intersections between 36 longitudinal survey lines with 50 m intervals and 35 latitudinal survey lines with 100 m intervals. In general, soils of B horizon were taken, but in case B horizon was lacking or too deep to take, soils of A or C horizon were sampled.

The stream sediment samples in craft paper envelope were dried in the sun as they are. The soil samples were crushed fingers or mallet after drying and screened under 80-mesh.

About 50 grammes of screened soil samples were taken for analysis.

4-1-3 Assay Method

Table 4-2 gives the detection limit and assay method for each analytical element.

4-1-4 Data Processing

The analytical results were converted into logarithmic figure, then univariate statistical analysis was carried out for the data of regional survey area and detailed survey area separately.

To determine the threshold value which devides the analytical values into two groups, anomalous and background, following standards were applied.

Standard 1 : In case the cumulative frequency distribution curve shows a break caused by the anomalous population, the threshold value will be determined by the frequency distribution obtained by using Chebychev function approximating the cumulative frequency distribution and its first derivative. This is a new method to calculate the statistical frequency distribution of geochemical data proposed by H. Otsu et al. (1983). However, if the value of $\bar{x} + 2\sigma$ ($\bar{x}$: mean, σ: standard deviation) is considerably smaller than the threshold value obtained by the method above mentioned, the value of $\bar{x} + 2\sigma$ will be selected as the threshold value.

Standard 2 : If it is hard to extract the anomalous population from cumulative frequency distribution curve, the threshold value will be determined as $\bar{x} + 2\sigma$. This means that the data belonging to anomalous population are none or very few.

Standard 3 : For the elements i.e. Au of which analytical data are mostly under the detection limit, 2.27 percent of number of all the samples will be selected from high value side, and the threshold value will be fixed as the minimum value in the selected data. The ratio, 2.27 percent signifies the proportion over $\bar{x} + 2\sigma$ in a normal distribution.

The computer calculates down to 7 decimal places, therefore the values of $\bar{x} + n\sigma$ (n = 1, 1.5, 2, 3) shows a little difference from the values calculated by the values of $\bar{x}$ and σ on the tables.

4-2 Regional Survey Area

4-2-1 Statistic Values and Distribution

Table 4-4 shows the statistic values of analytical elements. The analytical results of Au are mostly under the detection limit (0.01 ppm) therefore the results were omitted from statistic treatment. The analytical results of Cr and F under detection limit were also omitted.

Histgrams and cumulative frequency distribution curves for the elements are illustrated in Fig. 4-1 and Fig. 4-4. The histgrams were drawn after dividing the range into 20 classes for each element.

4-2-2 Correlation of Elements

Table 4-5 gives the correlation coefficients between the elements and |R| values of significance test. The analytical data under detection limit were excluded from the calculation. Numbers of paired samples used for the calculation are written under each correlation coefficient.

Scatter diagrams are presented in Fig. 4-8.

The correlation coefficients between Cu and F is less than corresponding |R| value, consequently the correlation between them is lacking with significance level of one percent. Other correlations showing positive one are affirmative with significance level of one percent judging from the results of comparison between the coefficients and the |R| values. The correlation coefficient between Cu and Zn, namely 0.704 reveals highly positive correlation, and those between Cr and Zn (0.401) and between Cr and F (0.374) show moderately positive correlation.

4-2-3 Selection of Threshold Values

Threshold values were selected as follows on the basis of the standards described earlier, and are listed in Table 4-6.

- Au : Threshold value was determined by the standard 3.
- Cu,Zn : Threshold values were determined by the standard 2. Almost straight cumulative frequency distribution curves mean no existence of anomalous population extractable.
- Cr, F : Threshold values were determined by the standard 2 and are the values of $\bar{x} + 2\sigma$.

Anomalous values were classified further into three groups such as AA-grade, A-grade and B-grade. This classification was done by use of the values of $\bar{x} + 2.5\sigma$ and $\bar{x} + 3\sigma$ for Cu and Zn, by the theoretical proportion of samples over $\bar{x} + 2.5\sigma$ and $\bar{x} + 3\sigma$ in a normal distribution for Au. In the case of Cr and F, two frequency distributions of anomalous population were extracted and the values deviding background population, lower value anomalous population and higher value anomalous population were used for the classification.

4-2-4 Interpretation of Geochemical Anomalies

Fig. 4-11 and Plate 7 give the distribution of anomalous smaples and anomalous zones. Interpretations of geochemical anomalies for each element are as follows.

(1) Au

An anomalous zone, namely, Kipnai anomalous zone (Au: 0.03 - 1.30 ppm) can be distinguished. The zone has three anomalous samples with maximum values and second one for Au. No geological evidence which can be related with gold mineralization and no panning works for placer gold have been known in the area. This anormaly may suggest that the area has a possibility of a productive placer gold deposit which can be worked on a small scale.

Other seven anomalous samples are distributed sporadically, and the relation to gold mineralization is unknown. Although a few gold panners have been working along the upper stream of Moiben river, there is no anomalous zone but two B-grade anomalous samples (Au: 0.04 and 0.05 ppm) have been obtained.

(2) Cu

An anomalous zone was extracted for copper.

Threshold value, 30 ppm and the maximum value, 60 ppm are not high values, in comparison with the copper content in rocks shown in Table 4-3. A cumulative frequency distribution curve for Cu is a straight line which indicates that no anomalous value which could be separated from the curve from the analytical values. Consequently it may be that the anomalies of Cu were not caused by any mineralization.

Many anomalous samples are distributed in the northeastern part of the area where hornblende gneisses are widely exposed . Since the copper content in basic rock is high, for instance 72 ppm on an average in basalt and gabbro, the anomalies appear to reflect the distribution of hornblende gneisses.

A zone near kapyeko where seven anomalous samples are relatively close is named as the Kapyeko Cu anomalous zone (Cu: 30 - 60 ppm), but the causality to the existence of hornblende gneisses can only be estimated.

(3) Zn

Anomalous samples are distributed sporadicaly and no anomalous zone was extracted.

Judging from the following respects, it can be concluded that greater part of anomalies of Zn did not originate from any mineralization but in hornblende gneisses like in the case of copper. Threshold value, 138 ppm and the maximum value, 200 ppm are not so high value as to indicate mineralizaton compared with zinc content in rocks shown in Table 4-3, and the content in basic rock, 94 ppm in basalt and gabbro, is high value in general. As indicated by the high positive correlation (r = 0.704) between Cu and Zn, cumulative frequency distribution curve for Zn is almost straight like it is for Cu, and the 60 percent of anomalous samples is distributed in the northeastern part of the area where hornblende gneisses are exposed.

(4) Cr

Almost all anomalous samples are concentrated in three areas and form distinct anomalous zones which have been named Noliewer, Kapsangar and Tenden Cr anomalous zone from north to south.

Noliewer Cr anomalous zone (CR: 208 - 590 ppm) containing an AA-grade, six A-grade and three B-grade anomalies extends more than 7 km in the NW-SE direction in upper stream of Tangasia river. The northern extention of the zone is cut by the boundary of the survey area. No ultrabasic rock but hornblende gneisses are distributed in the zone and chromium content in basic rock is high as the value in Table 4-3 and as the values 340 ppm in gabbro by Goldschmidt (1937) and 410 ppm in gabbro-dolerite by Sahama (1945), it seems that these anomalies are caused by hornblende gneisses containing relatively high chromium content.

Kapsangar Cr anomalous zone (Cr: 213 - 360 ppm) is about 4 km to the southwest of Kapsangar, extending 5 km in the NNW-SSE direction. An A-grade and six B-grade anomalies are found in the zone and the geology is composed of hornblende gneisses and porphyroblastic gneisses. At least some of the anomalies must reflect the distribution of hornblende gneisses.

Tenden Cr anomalous zone (Cr: 288 - 759 ppm) containing an AA-grade, two A-grade and three B-grade anomalies is 1 km to the northeast of Tenden. The relationship between the anomalies and geology is uncertain, but because no ultrabasic or basic rock has been noted in the area and three copper anomalies are distributed in it, the anomalies may caused by part of bed containing relatively high heavy metal content.

(5) F

A distinct anomalous zone named Kapsangar F anomalous zone (F: 288 - 759 ppm) is 4 km to the southwest of Kapsangar. The zone is elliptical in form extending to almost north-south with long axis of about 4 km and width of about 1 km. All anomalous samples except one A-grade anomalous sample are in the zone.

The values of anomalous samples are not so high as to connect them to some mineralizations or alkaline igneous rock in comparison with F content in ordinary rocks given in Table 4-3.

In the first phase report, Ortum F anomalous zone (F: 920 - 3,475) was thought to be caused by some effects of ultrametamorphism. That idea may be applicable to the Kapsangar F anomalous zone, since potash feldspar porphyroblastic gneisses which seem to be the product of ultrametamorphism are distributed mainly in the zone.

4-3 Detailed Survey Area

4-3-1 Statistic Values and Distribution

Table 4-7 lists the statistic values of analytical elements. Mean and standard deviation of Au are not calculated because analytical results of Au are mostly under the detection limit. Table 4-8 and 4-9 show the statistic values for Cr and Ni classified according to parent rocks of soil samples such as all serpentinite, no-silicified serpentinite, silicified serpentinite, talc schist and amphibole schist (including chlorite schist and hornblende gneiss).

Histgrams and cumulative frequency distribution curves for the elements are shown in Fig. 4-1 and Fig. 4-5. Analytical values over detection limits were used for the figures.

Fig. 4-2, 4-3, 4-6 and 4-7 give histgrams and cumulative frequency distribution curves for Cr and Ni classified according to parent rocks mentioned above.

4-3-2 Correlation of Elements

Table 4-10 gives the correlation coefficients for the elements and $|R|$ values of significance test. Analytical values over detection limits were used for the calculation and the numbers of paired samples calculated are written under each correlation coefficient.

Scatter diagrams are shown in Fig. 4-9.

As the result of significance test, the correlations between Au and other two elements are negative and that between Cr and Ni is affirmative in significance level of one percent. The very high correlation coefficient between Cr and Ni, namely 0.879, reveals very strong positive correlation..

Table 4-11 lists the correlation coefficients between Cr and Ni classified according to the parent rocks. The fact that the correlation coefficients are over 0.77 in the case of no-silicified serpentinite, talc schist and amphibole schist, and that of silicified serpentinite is low as 0.449, indicates the different manner of mobilization of Cr and Ni under the condition of hydrothermal alteration.

4-3-3 Selection of Threshold Values

Threshold values were selected as follows based on the standards, and are shown in Table 4-12.

Au : Threshold value was determined by the standard 3.

Cr : Breaks on the cumulative frequency distribution curve indicate that the analytical data can be divided into two main populations. One is medium to high content population with proportion of 80 to 85% consisting mainly of samples whose parent rock is serpentinite. The other is low content population with proportion of 15 to 20% consisting mainly of samples whose parent rock is amphibole schist. However the curve in high content side is nearly straight and the existence of anomalous population is negative. Accordingly, threshold value was determined by standard 2, but in this case mean ($\bar{x}$) and standard deviation (σ) applied were not that of all samples but that of 323 samples whose parent rock is serpentinite.

Ni : The cumulative frequency distribution curve with clear breaks shows that the analytical data consist mainly of three populations, namely, very high content population with proportion of 4% ± reflecting anomalous samples, medium to high content population with proportion of 84% ± reflecting mainly serpentinite as parent rock and low content population with proportion of 15% ± reflecting mainly amphibole schist as parent rock. Consequently threshold value was determined by standard 1, and is the value determined by the frequency distribution.

Anomalous values of Ni were classified, further into three groups such as group of AA-grade, A-grade and B-grade bordered by the values of $\bar{x} + 2.5\sigma$ and $\bar{x} + 3\sigma$. For Au, this classification was done based on the theoretical proportion of samples over $\bar{x} + 2.5\sigma$ and $\bar{x} + 3\sigma$ in a normal distribution.

Since the number of samples over threshold value is not so big, high values in the background population are selected as high-background values. The values of Cr and Ni are limited by the values of $\bar{x} + 1.5\sigma$ and $\bar{x} + 2\sigma$, and the value of Au is bordered by threshold value and detection limit.

These values are also shown in Table 4-12.

4-3-4 Interpretation of Geochemical Anomalies

Plate 8 and Fig. 4-12 show the distribution of anomalous and high-background value samples, the excavated area for eluvial gold, silicified serpentinite, chromite and garnierite occurrences and the inferred zone of gold mineralization.

The following are the interpretation of geochemical anomalies for each element.

(1) Cr

No anomalous sample is extracted as same as the result of geochemical survey for the Semi-detailed Survey Area A in phase

I. All high-background value samples (Cr: 4,800 - 5,500 ppm) except one sample are in the Golf Links area, and further eight samples are concentrated around the point CC-15. However, no occurrence of chromite has been noted in the area. On the contrary, only one high-background value sample (Cr: 5280 ppm) was obtained in the area where chromite ore bodies and floats are distributed. The fact may be explained as follows: the resistivity of chromite for weathering is so strong that very few grains of chromite under 80 mesh are produced, resulting in rare appearance of anomaly for Cr.

Some values of chromium content in ultrabasic rock have been reported and are as high as 2,980 ppm by Turekian (1977), 3,440 ppm in dunite by Goldschmidt (1937) and 4,000 to 9,400 ppm in serpentinite or peridotite emplacing chromite deposits by Bamba (1963). It seems that the concentrical distribution of high-background values in Golf Links area is caused by the residual soil of serpentinite containing much chromium.

(2) Ni

Two each of AA-grade and A-grade anomalous samples (Ni: 7,800 - 9,400 ppm) are in or near the known mineralized area of garnierite, showing good relationship betweeen them. Other three anomalous samples (Ni: 5,600 - 10,000 ppm) are distributed separately and the feature possibly means local concentration of Ni near the surface.

Nickel minealization in deeper zone, under the depth of about 50 cm, was not detected during the geochemical survey because the depth of soil samples was limited in shallow surface zone. Consequently evaluation of nickel mineralization is difficult and can not be done using only the result of geochemical survey. It shoud be done by adding the data from pits, trenches, shallow drillings and so on.

No existence of anomalous sample in the area where a sample with maximum value (Ni: 26,400 ppm) was collected in phase I, suggests that the anomaly is very local one.

(3) Au

Many anomalous samples (Au: 0.12 - 0.75 ppm) and high-background value samples are distinctly distributed in a zone trending N-S. The anomalous zone is almost bordered by the E and Y survey lines and by the No. 12 and No. 19 survey lines with a length of 2,000 m in the N-S direction and the width of 350 m in the E-W direction. 88% of the total number of the anomalous samples and 69% of high-background value samples are within this zone. Further, 50% of anomalous samples and 41% of high-background value samples are distributed in the northern half of the zone bordered by the I and O survey lines with the length of 600 m in the N-S direction. About one-third of the soil samples show gold content over detection limit in the northern half of the zone. It shows a good relationship between the results of geochemical survey and geological survey and the area digged for eluvial gold is entirely included in the northern half of the zone.

Fig. 4-10 shows mutual relationship between gold mineralization and silicification observed mainly in serpentinite. The parent rock of 53% of the samples with gold content over detection limit is silicified serpentinite. Also a few minute grains of native gold was confirmed in chalcedonic quartz vein emplaced in the silicified serpentinite under microscopic observation of a polished section (sample CR-22).

The very low correlation coefficients between Au and Cr or Ni, 0.095 and 0.091 means no correlation between them, and it might be caused by the epigenetic character of gold mineralization.

The anomalous zone and silicified serpentinite zones are mostly included in the central zone of the Telot serpentinite body trending in the N-S direction. Large and strongly silicified zones are particularly distributed in the anomalous zone.

In conclusion, new productive area for eluvial gold can be expected in the southern half of the anomalous zone judging from the distribution of anomalous samples, high-background value samples, silicified zones and the excavated area for eluvial gold.

Table 4-1 List of Geochemical Samples

Area	Number of Stream Sediment Samples	Number of Soil Samples	Analytical Elements	Area Covered km^2	Sampling Density (Piecies/km^2)
Regional Survey Area	709	-	Au, Cr, Cu, Zn, F	770	0.9
Detailed Survey Area	-	607	Au, Ni, Cr	3	202

Table 4-2 List of Detection Limits and Assay Method

Material	Element	Detection Limit	Assay method	Remarks
Stream Sediments	Au	0.01 ppm	AA	Aqua Regia digestion, extracted into MIBK
	Cr	5 ppm	do.	HF/Aqua Regia total digestion
	Cu	1 ppm	do.	do.
	Zn	1 ppm	do.	do.
	F	10 ppm	Ion Electrode	NaOH fusion
Soils	Au	0.01 ppm	AA	Aqua Regia digestion, extracted into MIBK
	Cr	10 ppm	do.	Na_2O fusion or HF/Aqua Regia total digestion
	Ni	1 ppm	do.	HF/Aqua Regia total digestion

AA: Atomic Absorption Measurement

Table 4-3 Content of Elements in Rocks

Element Unit	Au ppm	Cu ppm	Zn ppm	Cr ppm	F ppm	Reference
Earth's Crust	0.004	55	60	100	620	Clake number
Ultramafic Rocks	0.0032	42	58	2,980*	20	No mark: Wedepohl, "Handbook of Geochemistry" (1969-1978) * : Turekian (1977)
Basalt and Gabbro	0.0032	72	94	170*	420	
Granite	0.0023	12	51	4.1*	810	
Sandstones and Quartzites	0.005	10	40	35*	280	
Shale	0.004	42	100	90*	680	

Table 4-4 Statistic Values of Analysed Elements, Regional Survey Area

Element Unit	Au ppm	Cu ppm	Zn ppm	Cr ppm	F ppm
Number of Samples	709	709	709	709	709
Number of Samples Under Detection Limit	699	0	0	15	3
Maximum Value	1.3	60	200	680	759
Minimum Value	<0.01	1	4	<5	<10
Mean ($\bar{x}$)	-	9.4	46.7	43.4	82.0
Standard Deviation (S.D. in Log figure)	-	0.254	0.235	0.313	0.262
$\bar{x}$ + 2 S.D.	-	30	138	183	274
$\bar{x}$ + 2.5 S.D.	-	41	181	263	371
$\bar{x}$ + 3 S.D.	-	55	237	377	502

Table 4-5 Correlation Coefficients, Regional Survey Area

	Cu	Zn	Cr	F
Cu				
Zn	0.704 (709)			
Cr	0.262 (692)	0.401 (692)		
F	0.082 (706)	0.308 (706)	0.374 (689)	

( ) Number of paired sampels calculated

R(φ,e)
φ: degree of freedom
e: significance level

|R| (687,0.01) = 0.098
|R| (690,0.01) = 0.098
|R| (704,0.01) = 0.097
|R| (707,0.01) = 0.097

Table 4-6 Thresholds and Classification of Anomalous Values, Regional Survey Area

Unit: ppm

Element	Anomalies			Threshold
	Grade AA	Grade A	Grade B	
Au	Au≥1.30 (1)	1.30>Au≥0.09 (3)	0.09>Au≥0.01 (6)	0.01
Cu	Cu≥55 (2)	55>Cu≥41 (5)	41>Cu≥30 (13)	30
Zn	- (0)	Zn≥181 (2)	181>Zn≥138 (12)	138
Cr	Cr≥525 (3)	525>Cr≥295 (10)	295>Cr≥183 (14)	183
F	F≥550 (2)	550>F≥339 (3)	339>F≥274 (3)	274

( ) Number of samples

Table 4-7 Statistic Values of Analysed Elements, Detailed Survey Area

Element Unit	Cr ppm	Ni ppm	Au ppm
Number of Samples	607	607	607
Number of Samples Under Detection Limit	0	0	562
Maximum Value	5,500	10,000	0.75
Minimum Value	40	60	<0.01
Mean ($\bar{x}$)	1,515	1,624	-
Standard Deviation (S.D. in Log figure)	0.373	0.401	-
$\bar{x}$ + 2 S.D.	8,451	10,308	-

Table 4-8 Statistic Values of Cr by Parent Rocks, Detailed Survey Area

Unit: ppm

Parent Rock	Serpentinite (All)	No-Silicified Serpentinite	Silicified Serpentinite	Talc Schist	Amphibole Schist
Number of Samples	323	133	140	72	88
Maximum Value	5,500	5,170	5,250	3,990	2,640
Minimum Value	100	100	400	480	40
Mean ($\bar{x}$)	2,210	2,045	2,200	1,554	458
Standard Deviation (S.D. in Log figure)	0.222	0.267	0.168	0.216	0.383
$\bar{x}$ + 2 S.D.	6,148	6,990	4,765	4,194	2,672

Table 4-9 Statistic Values of Ni by Parent Rocks, Detailed Survey Area

Unit: ppm

Parent Rock	Serpentinite (All)	No-silicified Serpentinite	Silicified Serpentinite	Talc Schist	Amphibole Schist
Number of Samples	323	133	140	72	88
Maximum Value	10,000	9,000	8,400	3,460	3,380
Minimum Value	160	160	520	270	60
Mean ($\bar{x}$)	2,469	2,198	2,592	1,948	392
Standard Deviation (S.D. in Log figure)	0.184	0.204	0.152	0.208	0.450
$\bar{x}$ + 2 S.D.	5,765	5,621	5,228	5,088	3,121

Table 4-10 Correlation Coefficients, Detailed Survey Area

	Cr	Ni	Au
Cr			
Ni	0.879 (607)		
Au	0.095 (45)	0.091 (45)	

R(ϕ,e)
ϕ: degree of freedom
e: significance level

|R| (43,0.01) ≈ 0.380
|R| (605,0.01) ≈ 0.104

( ) Number of paired samples calculated

Table 4-11 Correlation Coefficients between Cr and Ni by Parent Rocks, Detailed Survey Area

	Serpentinite (All)	No-silicified Serpentinite	Silicified Serpentinite	Talc Schist	Amphibole Schist
Correlation Coefficient (Cr-Ni)	0.636 (323)	0.770 (133)	0.449 (140)	0.779 (72)	0.852 (88)

( ) Number of paired samples calculated

R(ϕ,e)
ϕ: degree of freedom
e: significance level

|R| (70,0.01) = 0.302
|R| (131,0.01) = 0.223
|R| (321,0.01) = 0.143
|R| (86,0.01) = 0.273
|R| (138,0.01) = 0.217

Table 4-12 Thressholds and Classification of Anomalous Values, Detailed Survey Area

Unit: ppm

Element	Anomalies			Threshold	High-background Value
	Grade AA	Grade A	Grade B		
Cr	-	-	-	6,150	6,150>Cr≥4,762 (12)
Ni	Ni≥8,811 (3)	8,811>Ni≥7,128 (3)	7,128>Ni≥5,370 (1)	5,370	5,370>Ni≥4,665 (3)
Au	Au≥0.75 (1)	0.75>Au≥0.40 (3)	0.40>Au≥0.12 (12)	0.12	0.12>Au≥0.01 (29)

( ) Number of samples

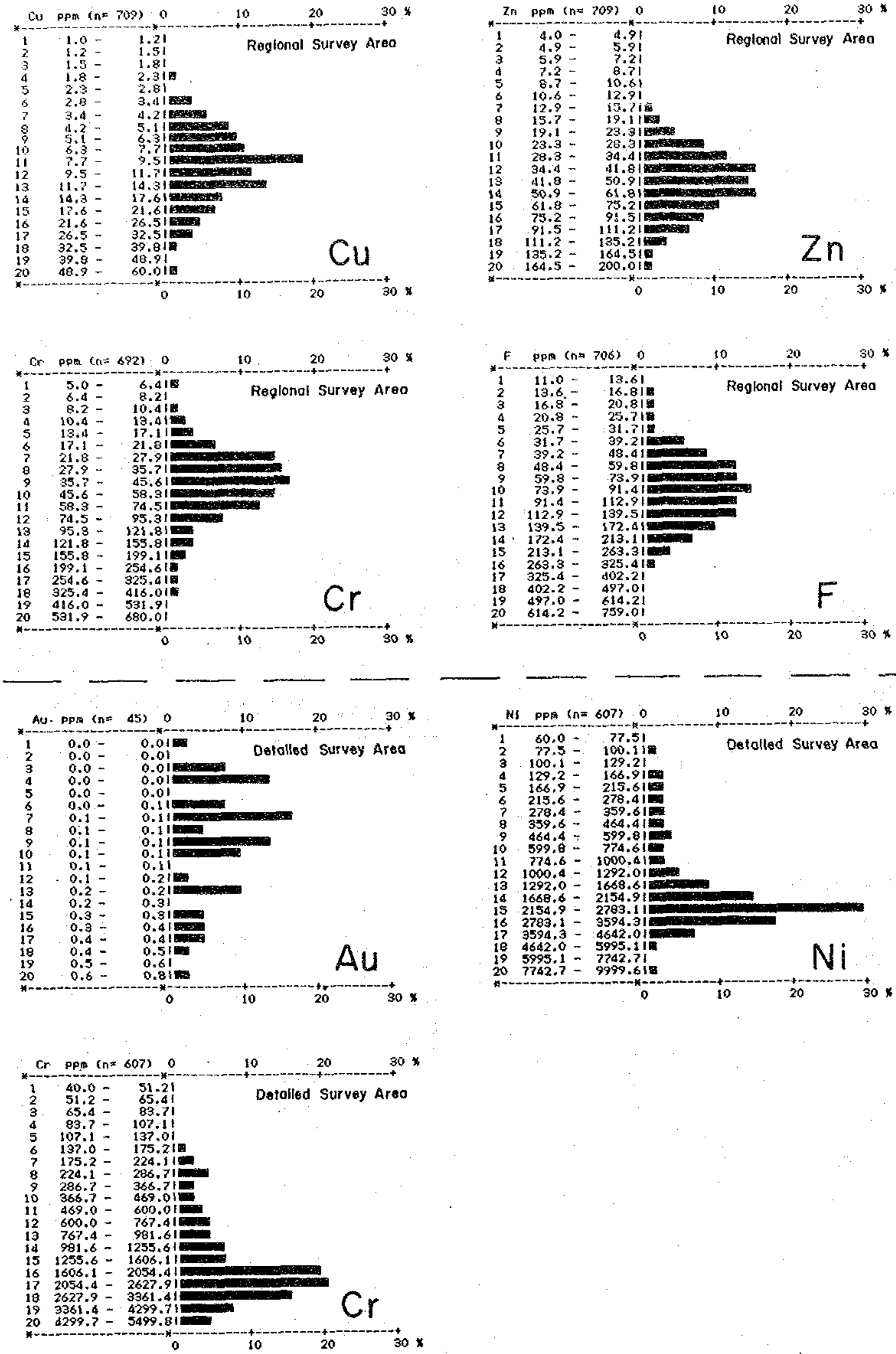


Fig. 4-1 Histgrams for Analytical Elements

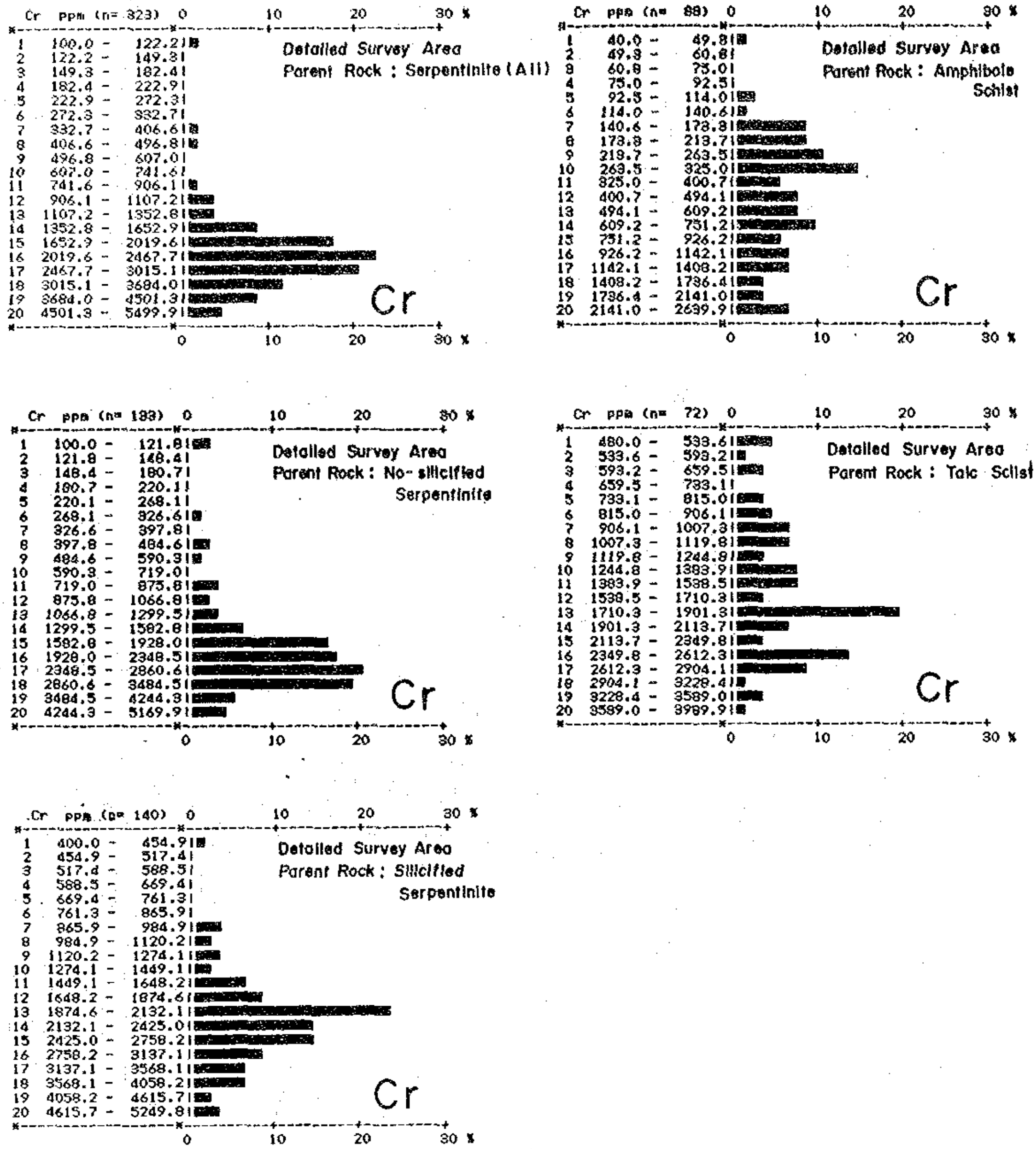
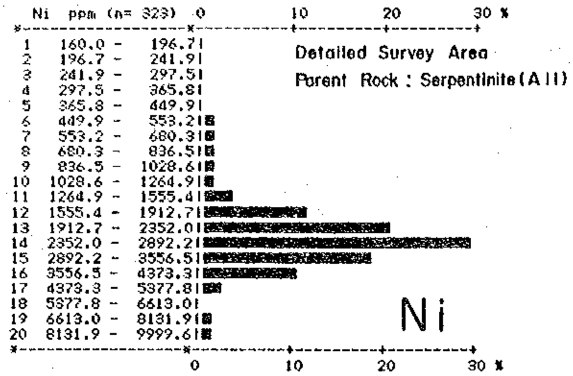
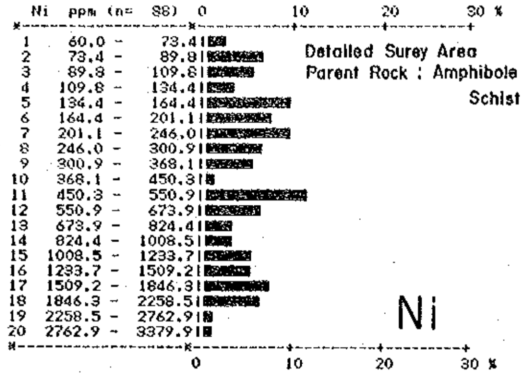
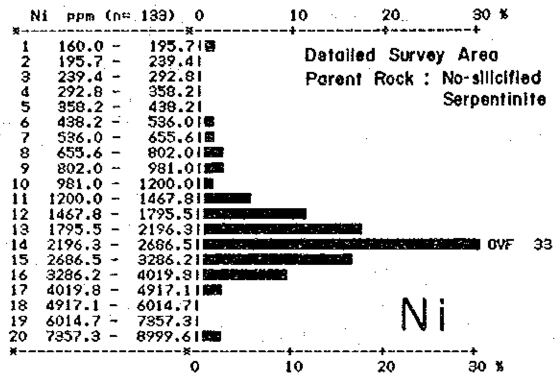
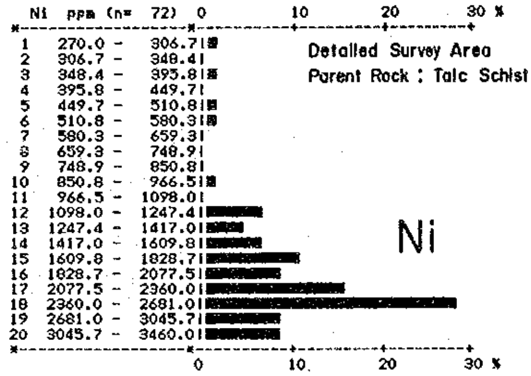


Fig. 4-2 Histgrams for Cr by Parent Rocks, Detailed Survey Area









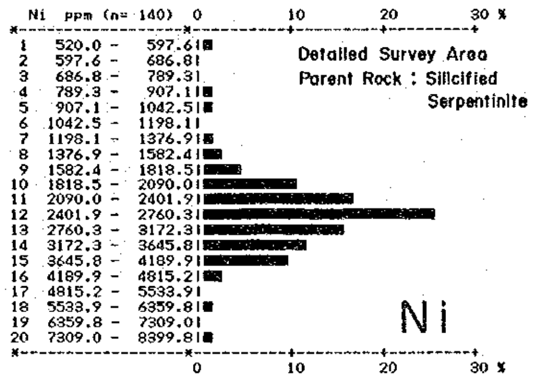


Fig. 4-3 Histgrams for Ni by Parent Rocks, Detailed Survey Area

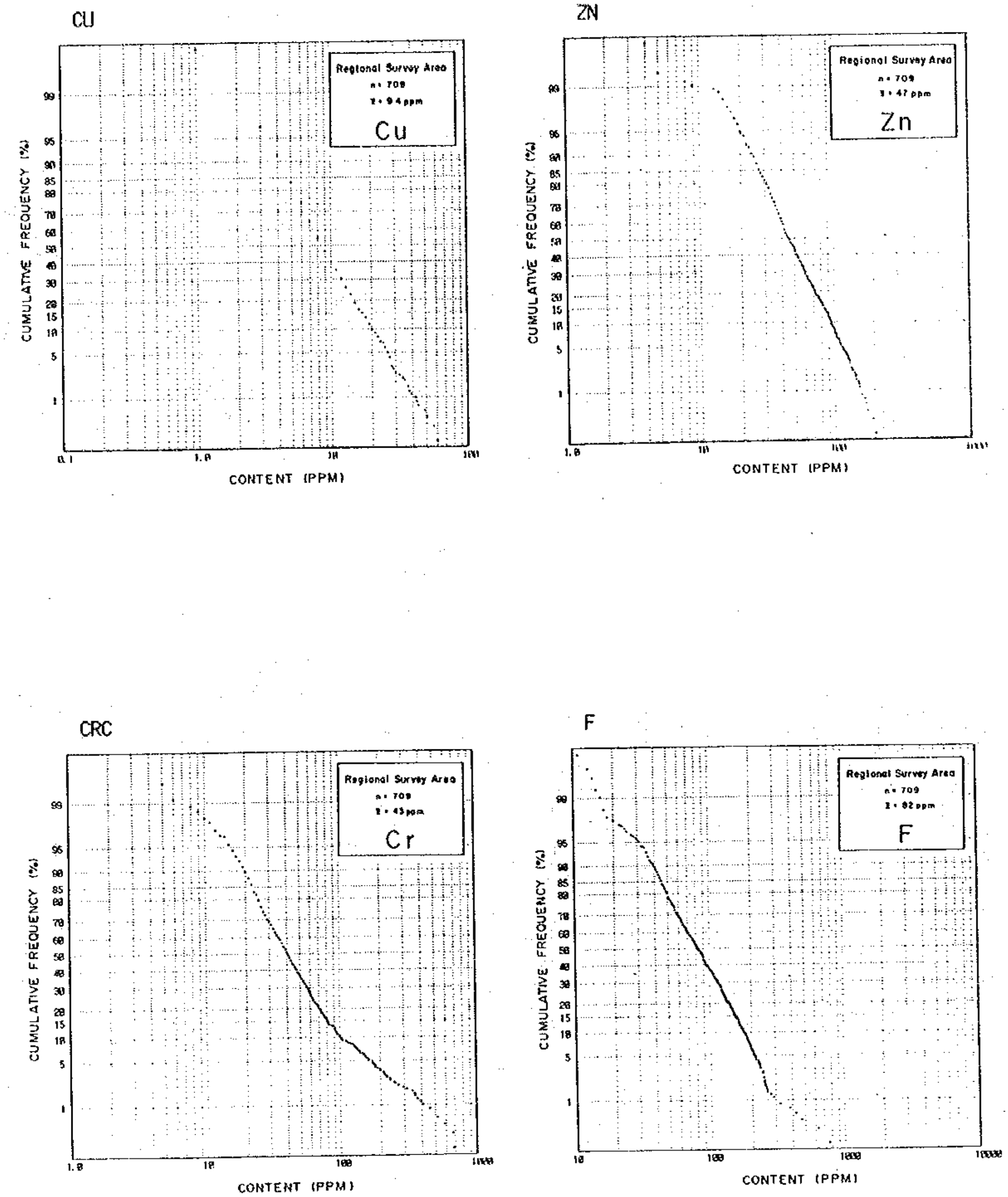
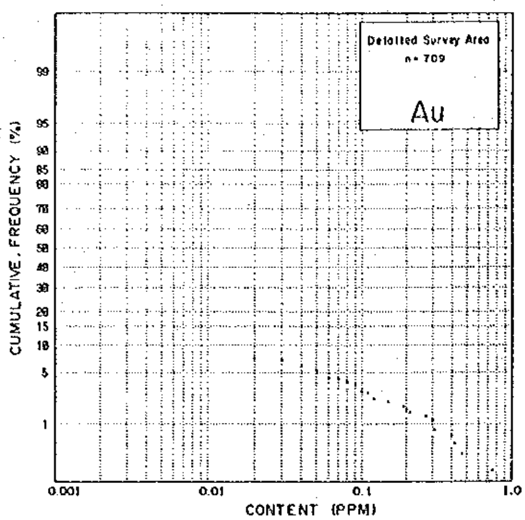
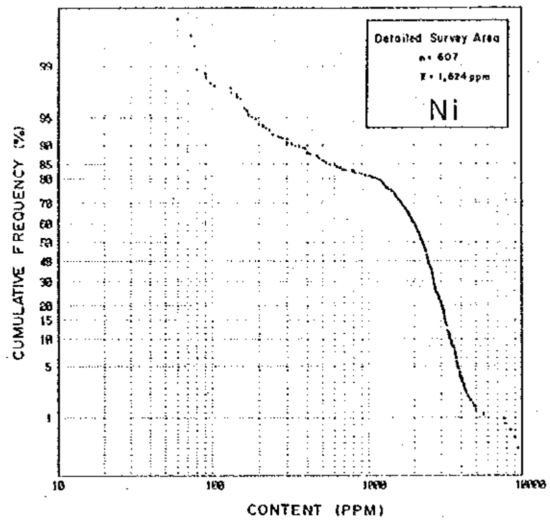


Fig. 4-4 Cumulative Frequency Distribution Diagrams for Analytical Elements, Regional Survey Area

AU



NI



CRD

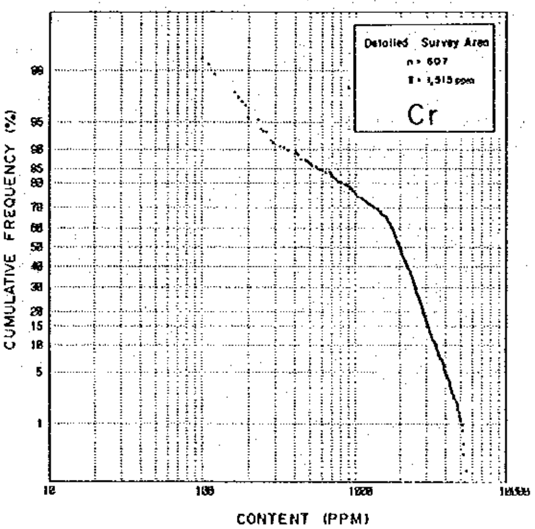


Fig. 4-5 Cumulative Frequency Distribution Diagrams for Analytical Elements, Detailed Survey Area

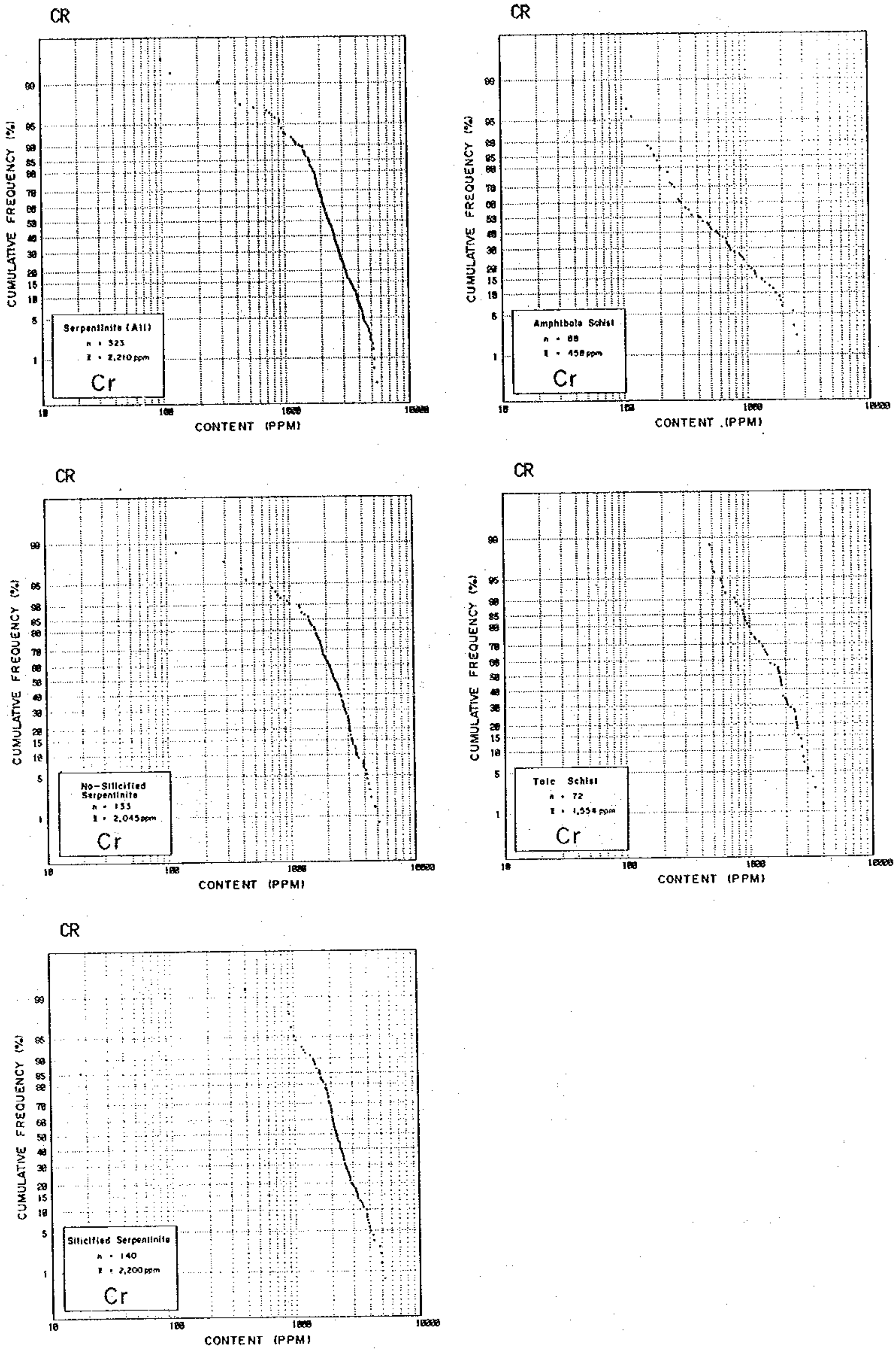


Fig. 4-6 Cumulative Frequency Distribution Diagrams for Cr by Parent Rocks, Detailed Survey Area

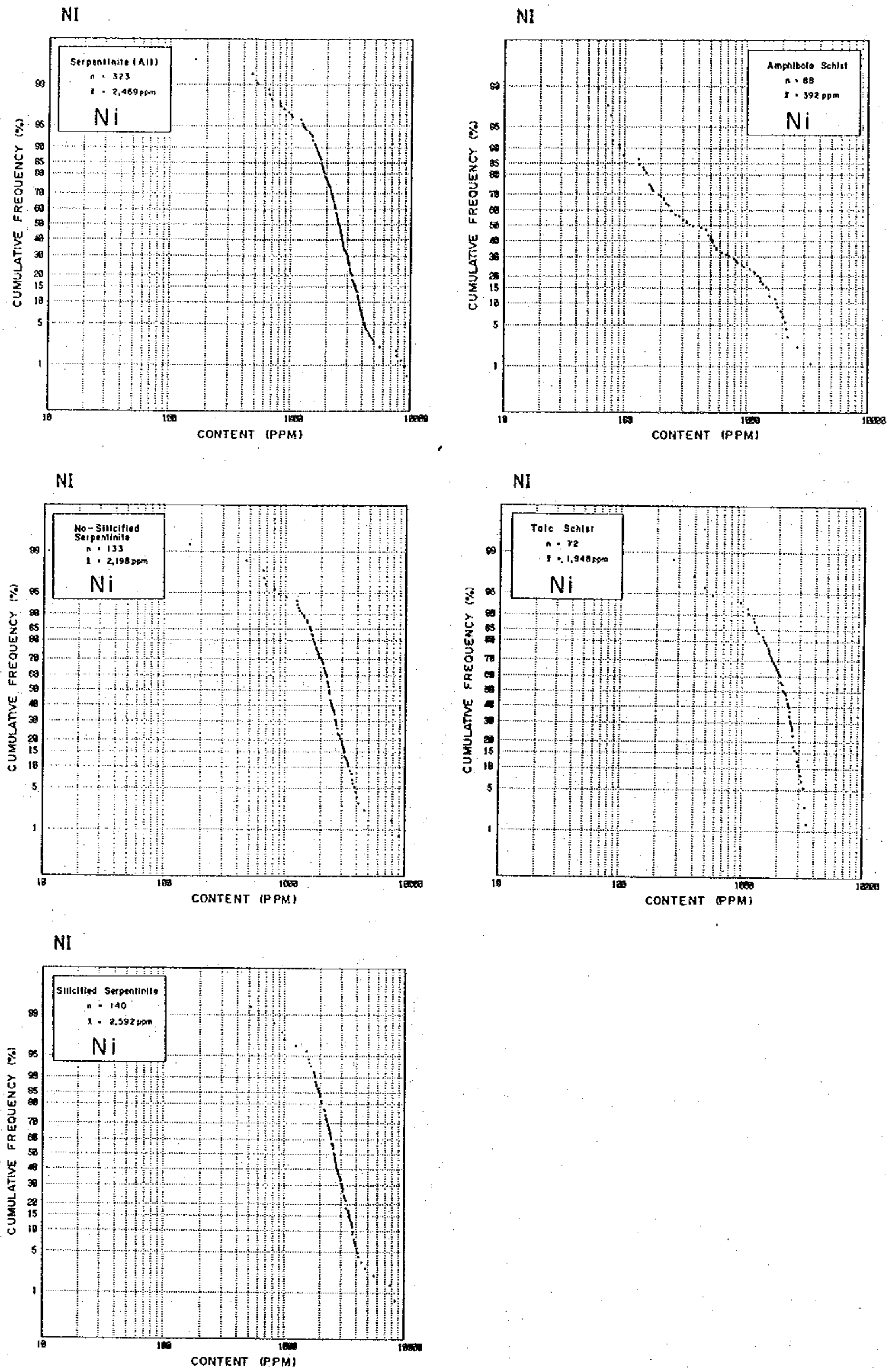


Fig. 4-7 Cumulative Frequency Distribution Diagrams for Ni by Parent Rocks, Detailed Survey Area

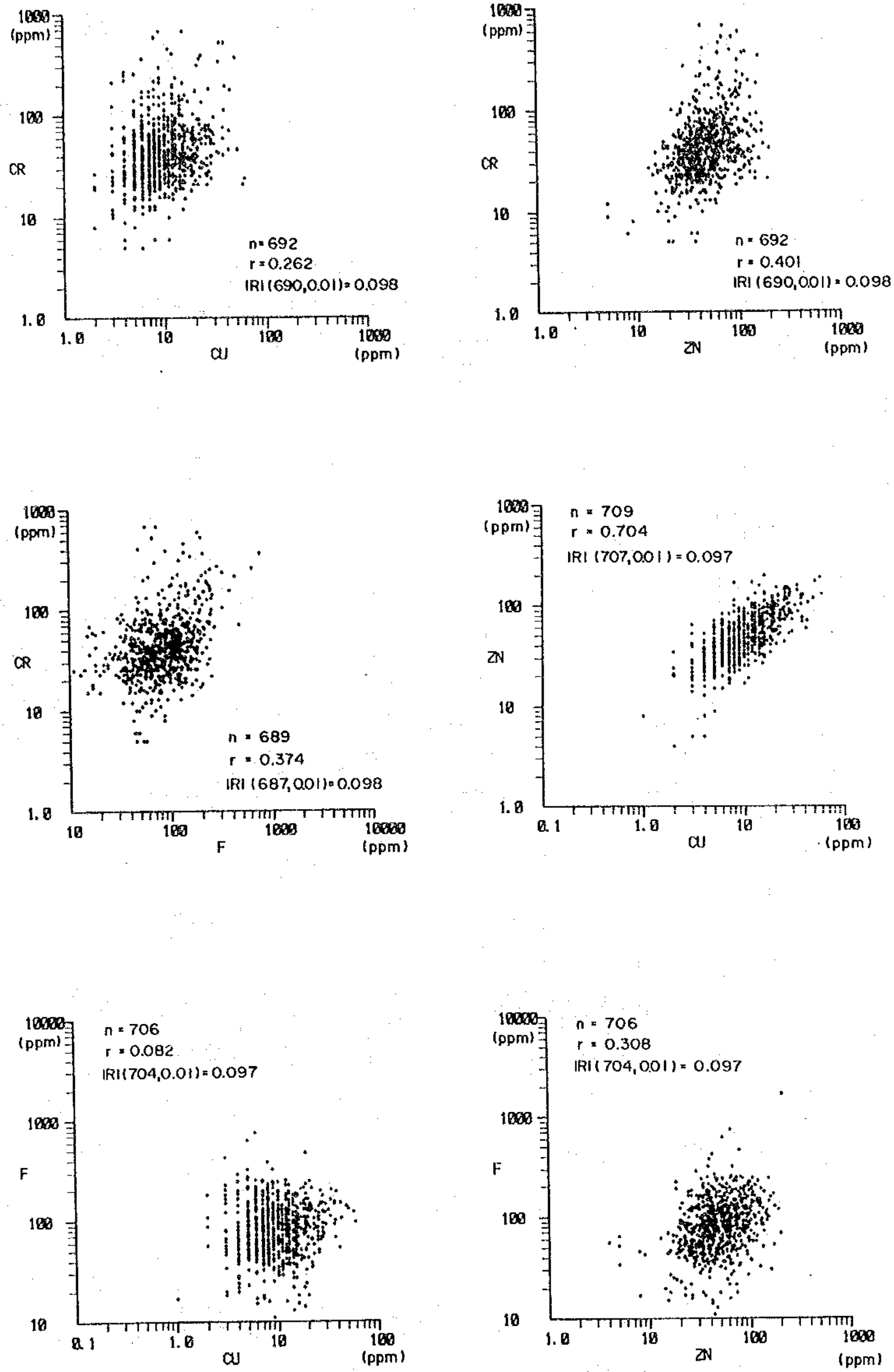


Fig. 4-8 Scatter Diagrams, Regional Survey Area

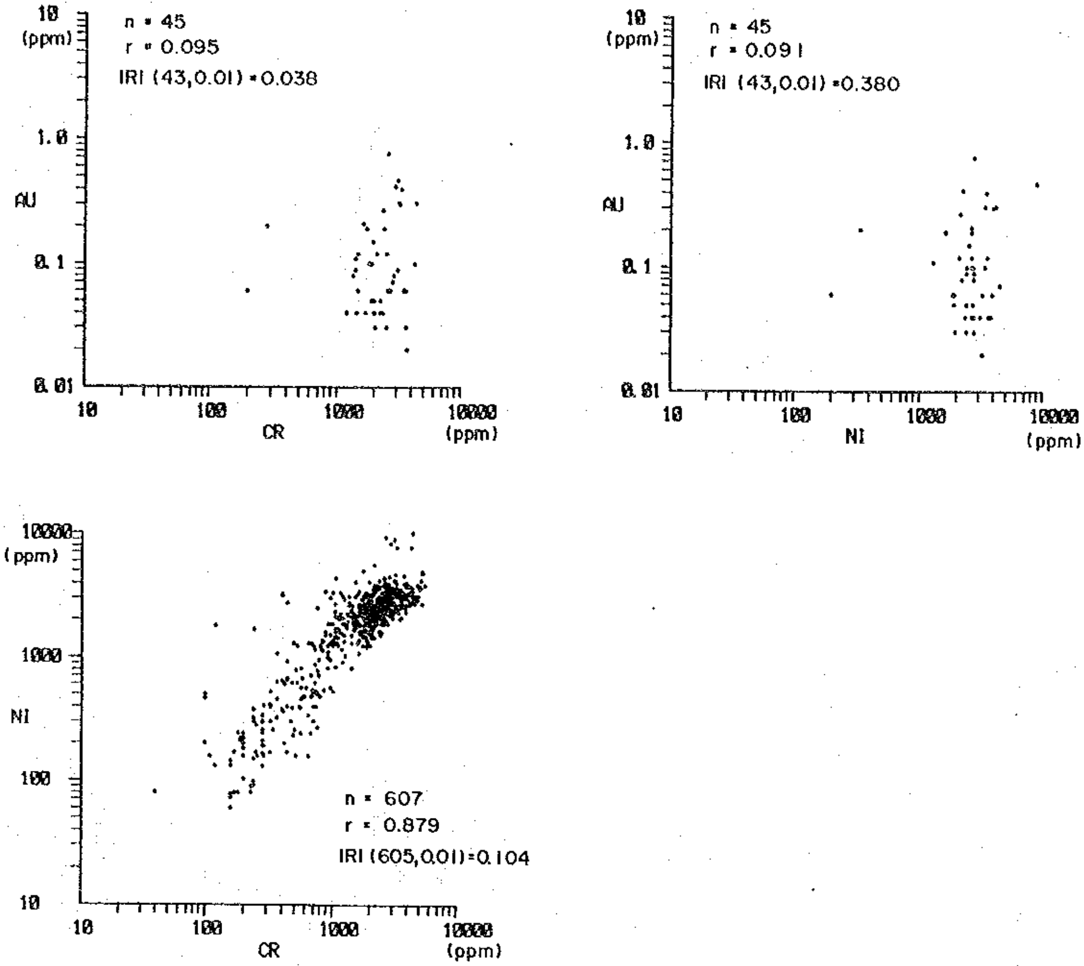


Fig. 4-9 Scatter Diagrams, Detailed Survey Area

Parent Rocks	Number of Samples
Silicified Serpentinite	17
No-silicified Serpentinite	9
Talc Schist	5
Amphibole Schist	1
Total	32

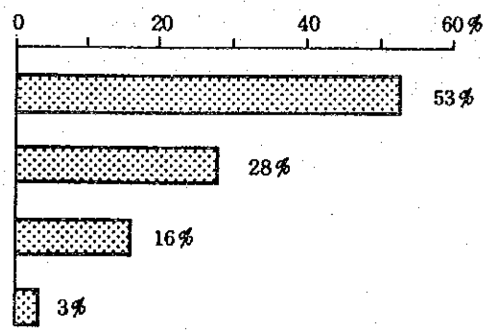
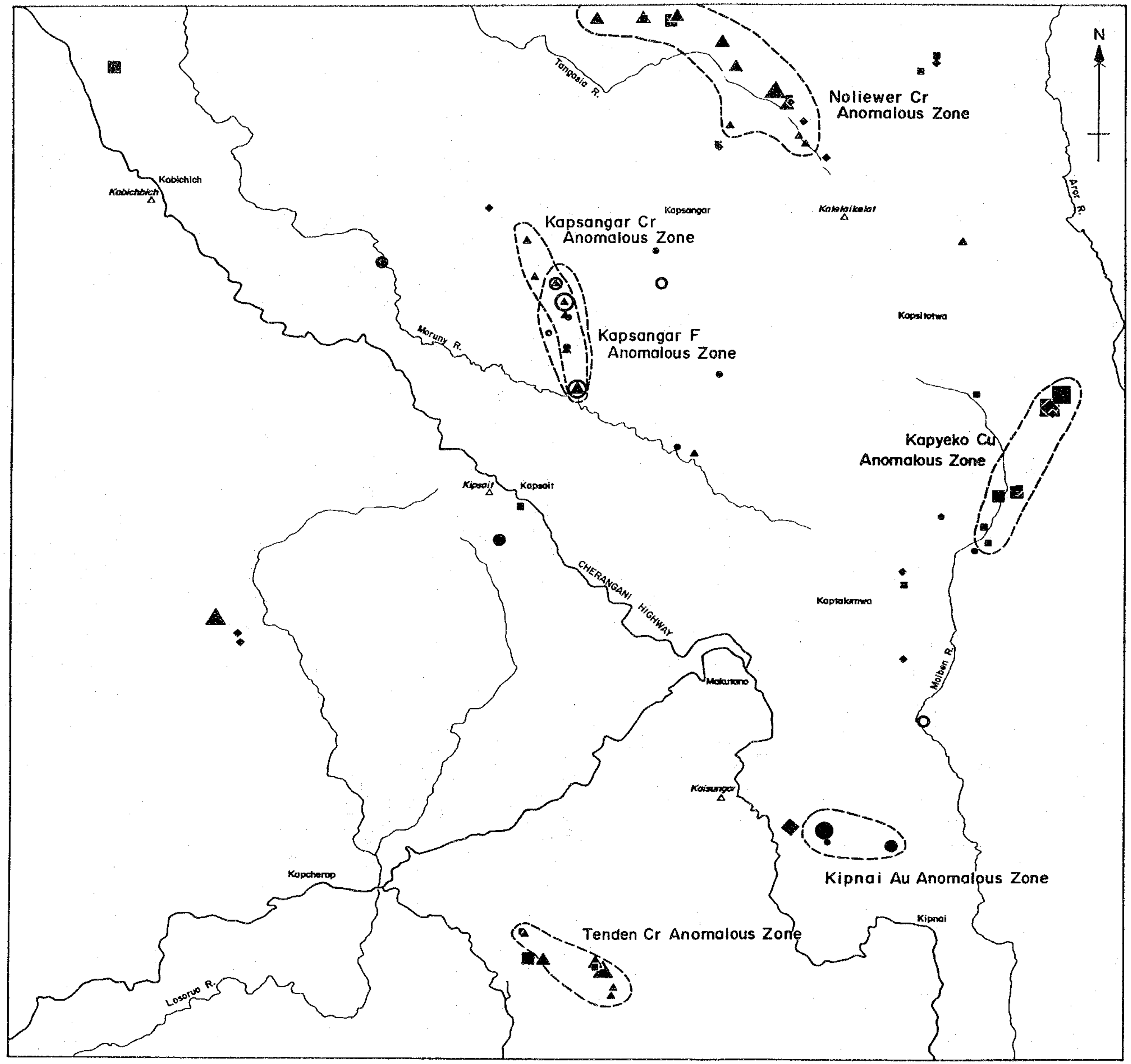


Fig. 4-10 Histgram of Parent Rocks of Soil Samples with The Gold Content over Detection Limit, Detailed Survey Area



LEGEND

Au max = 1.3 (Unit : ppm)

AA Grade Anomaly	● ≧ 1.30	n = 1
A 〃	1.30 > ● ≧ 0.09	n = 3
B 〃	0.09 > ● ≧ 0.01	n = 6

Cu x̄ = 9.4 , max = 60 (Unit : ppm)

AA Grade Anomaly	■ ≧ 55	n = 2
A 〃	55 > ■ ≧ 41	n = 5
B 〃	41 > ■ ≧ 30	n = 13

Zn x̄ = 47 , max = 200 (Unit : ppm)

A Grade Anomaly	◆ ≧ 181	n = 2
B 〃	181 > ◆ ≧ 138	n = 12

Cr x̄ = 43 , max = 680 (Unit : ppm)

AA Grade Anomaly	▲ ≧ 525	n = 3
A 〃	525 > ▲ ≧ 295	n = 10
B 〃	295 > ▲ ≧ 183	n = 14

F x̄ = 80, max = 759 (Unit : ppm)

AA Grade Anomaly	○ ≧ 550	n = 2
A 〃	550 > ○ ≧ 339	n = 3
B 〃	339 > ○ ≧ 274	n = 3

x̄ : mean value , max : maximum value , n : number of samples

Anomalous Zone

0 5 km

Fig. 4-11 Geochemical Anomaly Map, Regional Survey Area

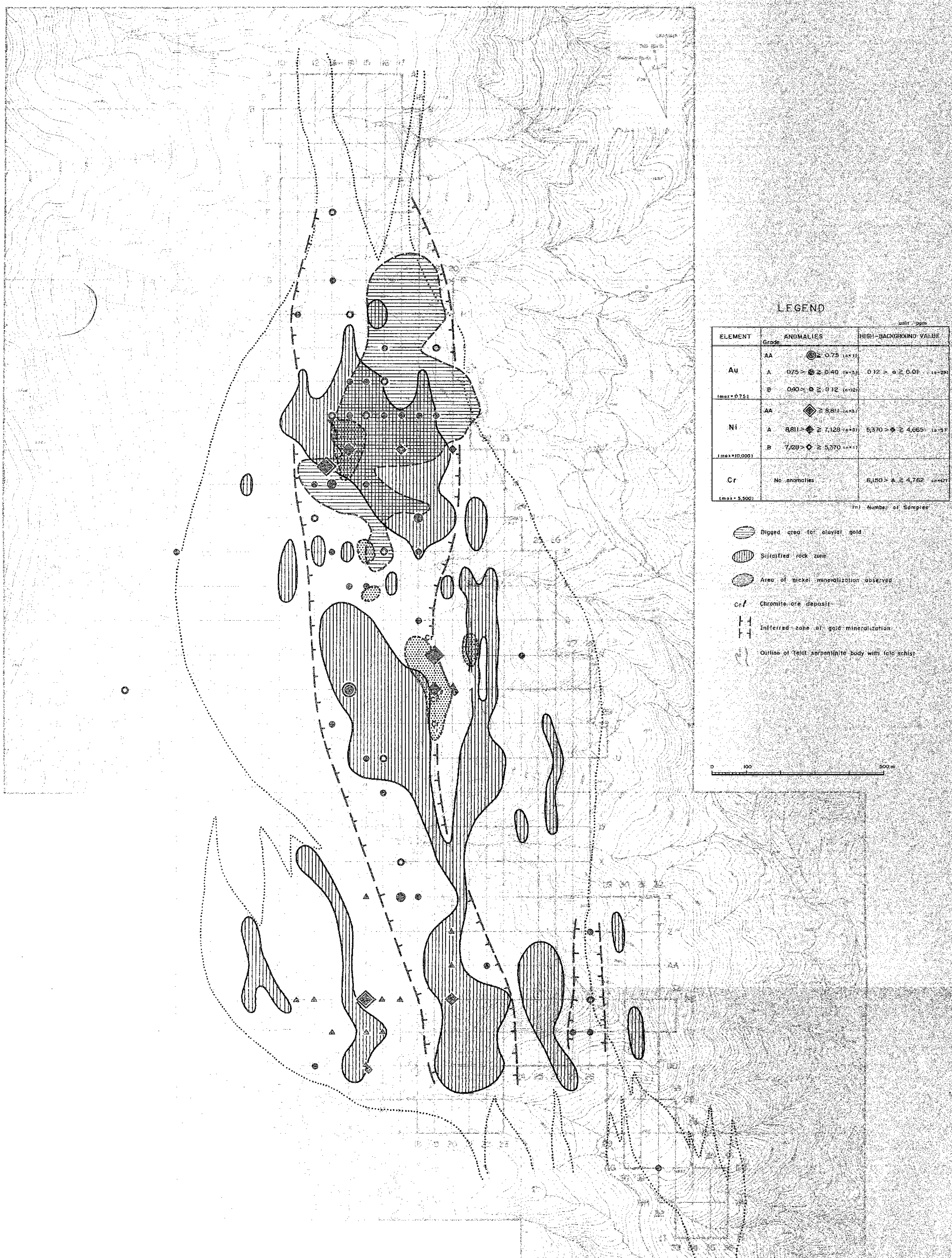


Fig. 4-12 Interpretaion Map for the Result of Geochemical Survey, Detailed Survey Area

CHAPTER 5 CONCLUSION

The following conclusions are reached based on the geological and geochemical surveys.

5-1 Regional Survey Area

(1) The area belongs to the Mozambique Orogenic Belt. The geology consists mainly of the regional metamorphic rocks belonging to amphibolite facies called the Mozambique belt metamorphic rocks, accompanied by dykes and stocks of granite and granodiorite of a small scale.

(2) The Mozambique metamorhpic rocks consist of such rocks like gneisses and quartzite derived from the sedimentary rocks of pelitic to psammitic origin and gneisses of basic volcanic rocks in origin which are controlled by the overturned folds trending north-northwest to north.

(3) Only a small-scale panning site of placer gold is found as a known ore deposit along the uppermost reaches of the Moiben river in the eastern part of the area. Although the gold is mined by a small number of local residents, it was not detected by the geochemical survey leading to a judgement that the mineralization of gold is weak.

(4) Skarnization zones and silicification zones were observed as showings. The skarnization zones are locally distributed in crystalline limestone at the contact with the dykes or stocks of granite in the northeastern part of the area, which is small in scale and no useful minerals were observed. A silicification zone extending for two kilometers was confirmed in the northeastern part of the area. Microscopic observation revealed only the presence of a small amount of tiny particles of chalcopyrite and gold, but geochemical prospecting did not detect any anomaly This leads to the judgement that the scale of mineralization is not large.

(5) The geochemical survey resulted in extracting only a small-scale gold anomaly in the southwestern part of the area. This anomalous zone can be a panning site for placer gold which the local residents could excavated on a small scale.

5-2 Detailed Survey Area

(1) The geology of the area is composed of hornblende gneiss, green schist, quartzite and biotite gneiss which belong to the Mozambique belt metamorphic rocks, and serpentinite and talc schist derived from ultrabasic rocks which intruded into the metamorphic rocks.

(2) Serpentinite and talc schist are distributed along the axial part of the syncline in the Mozambique metamorphic rocks which show a trend of N-S to NNW-SSE. Many faults of N-S to NNW-SSE systems are inferred centreing on the area of metamorphic rocks, showing a character of tectonic zone.

(3) The garnierite, eluvial gold and chromite deposits are emplaced in the serpentinite (Telot serpentinite body).

(4) The nickel deposit is in form of garnierite formed by processes of weathering and residual process, forming sizable mineralized zones in four places.

The calculation of ore reserves conducted by the Department of Mines and Geology of Kenya (presently Mines and Geological Department) gives about five million tons (a little more than one percent in nickel content) of probable ore reserves and about fourteen million tons (0.7 percent in nickel grade) of possible ore reserves, which are considered to be reasonable on the basis of the result of survey of this phase. However, in the nickel ore deposits of this kind elsewhere in the world (for example, in New Caledonia), the ore reserves are several tens million tons with nickel grade of two to three percent, and the ores with more than two percent are mined and shipped.

The Telot nickel deposit is low in nickel grade and scanty in ore reserves. Moreover, the deposits are situated far away from the coast for shipment and infrastructure conditions need to be improved. Therefore, it does not appear to warrant further exploration work.

(5) The eluvial gold deposits are contained in the silicified zone extending for two kilometers towards north with a width of 350 meters in the E-W direction, in the central zone of Telot serpentinite body, which is almost consistent with the geochemical anomalous zone of gold. The gold mineralization appears to be closely associated with chalcedonic quartz veins. The results of analysis of silicified rocks confirm this association.

The gold content in the high grade parts of the deposit is estimated to be approximately 1 g/ton, leading to the judgement that the deposit can not be operated by a systematic mining method. However, it is expected that the area to the south of the present mining site, currently being mined by hand by the local residents, where silicified zone and the geochemical anomalous zone are overlapping, would be the next mining site for them.

(6) The ore reserve of the chromite deposit is calculated to be 8,400 tons (Cr_2O_3: 48%) of both proved and probable ore reserves altogether by the past exploration work including diamond drill holes. The deposit is high in chromium grade and

suitable for open pit mining, but scanty in ore reserves, so that the deposit would be acceptable for mining on a small scale for a short time when domestic demand for chromite arises in Kenya, depending on the market conditions.

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