LITHO AND STREAM SEDIMENTS GEOCHEMICAL INVESTIGATION FOR BASE AND PRECIOUS METAL IN TIMARGARA, MAIDAN AND JANDUL AREA, DISTRICT DIR, NORTHERN PAKISTAN

BY

ALI SARWAR

NATIONAL CENTRE OF EXCELLENCE IN GEOLOGY
UNIVERSITY OF PESHAWAR

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APPROVED BY

(Supervisor)
Dr. M. Tahir Shah
Associate Professor
NCE in Geology
University of Peshawar

(External Examiner)
Dr. Abdul Khaliq
Senior Geologist
Hard Rock Division
Atomic Energy Commission
Peshawar

(Director)
National Centre of Excellence in Geology
University of Peshawar

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ABSTRACT

The area of study (about 900 sq. km.) is a part of the Kohistan island arc in the northern part of Pakistan. The Kohistan island arc, which is a part of Kohistan-Ladakh island arc, represent a cross section through an intra-oceanic island arc sequence which develop as a result of the northward subduction of Neotethyan oceanic lithosphere during late Jurassic and Cretaceous time. It is bounded by the ,main Mantle Thrust (MMT) in the south and Main Karakoram Thrust (MKT) or Shayok suture in the north in the Pakistani terrane.

The area of study is located immediately north of the MMT in Dir district. It has a complex geology and is mainly composed of amphibolites, metadiorites and metagabbro-norites, metagranodiorites, metagranites and metavolcanics with subordinate amount of hornblendites, ultramafites and tonalites. The area has been investigated for preliminary geology, however, no detail geochemical investigation has been carried out for precious and base metals mineralization. This study has main emphasis on the rocks and stream sediments (both pan concentrates and -80 mesh fine fraction) geochemical survey for gold and base metals in order to delineate areas likely to contain mineralization and be worthy of follow-up work.

The area has been divided into 56 drainage cells ranging from 2-50 km^2 with an average density of about one site per 15 km^2. From each cell a pan concentrate and -80 mesh fine fraction were collected for geochemical analyses of Au, Ag, Cu, Zn, Pb, Co, Ni, and Cr,

by atomic absorption. The visible gold as piece, speck and color was identified in the pan concentrates at the site. The floats were also examined for alteration and other geological phenomenon at each site. The pan concentrates are dominantly composed of magnetite whereas zircon, quartz, pyroxene, garnet, hornblende, feldspar, tourmaline, chromite and rock fragments occur as minor constituents.

The geochemical data for rock samples, pan-concentrates and fine fractions of stream sediments have been displayed and evaluated by considering various geostatistical methods. Geochemical maps have also been prepared on the basis of single and multi-eliments consideration in order to pin point areas of most interest. These studies show that pan-concentrates have higher concentration of all the elements as compared to that of fine fraction. These elements are silicate bounded rather than sulfide bound in stream sediments. The higher concentration of Cu, Pb, Zn, Ni, Cr, Co and Ag could be related to the bed rock rather than to specific mineralization in the area. The anomalous gold, however, could not be directly related to the bed rock but it could possibly be related to the existence of gold-bearing mineralization in the North and north-eastern part of Samarbagh area, the detail geochemical survey is, therefore, recommended for follow-up in the region.

CHAPTER 1

INTRODUCTION

Location and Accessibilty

The area of study covers about 900 Sq Km and is situated between latitude 34° 47 N to 35° N and longitude 71° 34 E to 71° 55 E in Dir district, northern Pakistan (Fig.1). It covers most part of the Jandul valley (Toposheet No.38 N/9) and Timergara and Midan area (Toposheet No38 N/13). Timergara and Samarbagh are the main towns in the area and are located about 190 Km north of Peshawar and 85 Km south -west of Dir . The main access to the area is along Peshawar- Chitral and Peshawar -Bajaur roads. A number of metalled and un metalled roads connect various localities of the Timargara and Samarbagh areas. Most part of the thesis area is accessible by two main metaled roads which are joining the Timargara and Samarbagh towns within the thesis area. One is passing through the Lal Qala while another is passing through the Tora Tiga and Munda areas (Fig.1).

Topography and drainage

The study area has moderate to high relief . The central, north-eastern and north-western portion of the area has high relief while the south-eastern and south western part of the study area is occupied by smaller hillocks. There are a number of peaks, e.g. Shahi,

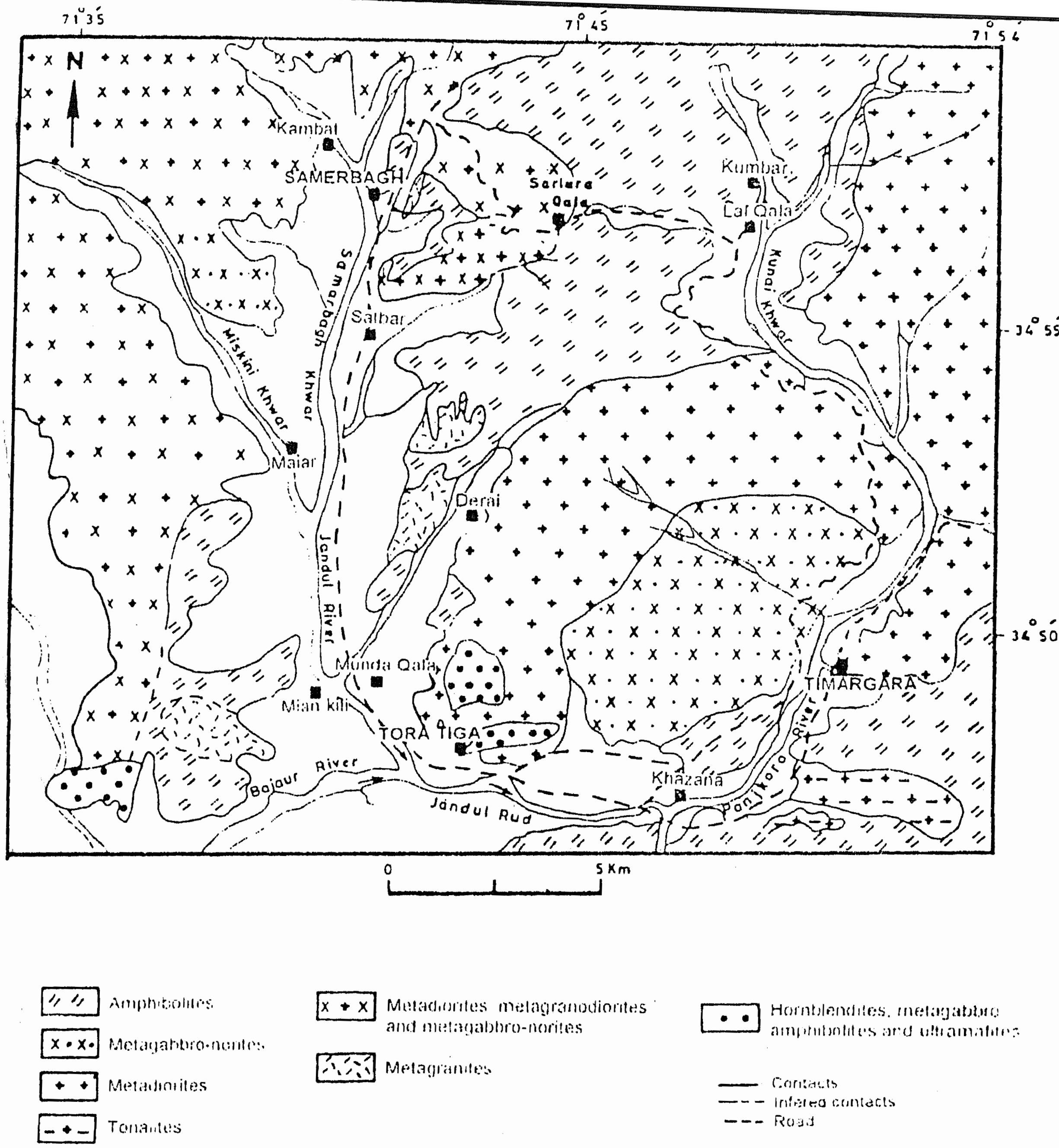


Fig. 1. Geological map of the Timargara and Samarbagh areas, District Dir,N.W.F.P., Pakistan (Modified after Kakar et al., 1971, Chaudhry et al., 1974 and Butt et al., 1981)

Sarlara, Kwarai having height of 3201m, 1871m and 2329m respectively. Steep walled valleys with slope of more than 45° are the common topographic features of the area. Topographically the northern and central part of the area is characterized by sharp and steep dipping ridges bounded by sloping features in two direction.

The area generally drains into the Panjkora river by various streams (i.e. Samarbagh, Miskini and Kunai streams). In western part of the study area, two big streams such as Samarbagh khwar and Miskini khwar join each other near Mayar and flow downward towards Munda Qala in the south. It then joins the main Bajaur khwar near Mund Qala. The Bajaur khwar is flowing towards east and fall into the Panjkora river near Khazana village (Fig.1). The north-eastern part of the area is drained into the Kunai khawar. This stream flows downwards and fall in to the Panjkora river in the south. The area around Timergara is directly drained into Panjkora river by various small streams. Most of the steams of the area are seasonal, except few, and carry sufficient discharge during rainfall. The drainage system of the area is flat bottomed and most of the streams join each other at acute angles, producing dendritic drainage pattern. However, Radial pattern has also been noticed around high altitudes.

Vegetation

The mountains as well as the valleys are thinly covered with different types of trees. Pinus, abes, pendrow, deodara grow above an altitude of three thousands meters. The hill slopes are covered with the wild bushes and grass. Beside these, fruit trees like walnut, mulbery, pear, peaches, apricot etc. also grow in the area. The plain areas and valleys are mostly cultivated for wheat, barley, sugar cane, maiz and rice.

Climate

The study area lies in the sub tropical continental high land zone. The low land area like Timergara has the hot & dry summers temperature rise upto 38°C and the cold winter temperature drop to freezing, while the up land areas such as Sumerbagh and Midan have warm summer and cold winter. The coldest months are December to February during which the temperature in certain valleys reach to freezing temperature. The high peaks (e.g. Kwarai, Sarlara and Shahi etc.) are generally covered with snow during the months of December to February every year. No meteorological record of the study area is available but according to the nearest meteorological station at Chakdara, the rain fall in the region varies from 33 to 47. Most of the rainfall occurs during winter, especially in March. Mostly precipitation occurs from t he snow during the winter season.

SCOPE AND PURPOSE OF INVESTIGATION

The area of study lies in the north-western portion of the Kohistan island arc. The arc type set up and the associated calc alkaline magmatism in Dir and Swat Kohistan (Majid & Paracha, 1980, Majid et. al., 1981; Hamidullah et. al., 1990; Shah, 1991, Shah et al., 1994) by itself forecast the existence of various types of mineral deposits, especially epithermal gold and volcanogenic massive sulfide deposits. The calc-alkaline magmatism is indicative of producing geochemical anomalies for the base metals, especially copper (Cu), Lead (Pb) and zinc (Zn) associated with basic and acidic igneous rocks. It is now determined by the modern research that various metallogenic provinces throughout the world are originated in specific tectonic setting. The massive sulfide deposits, the porphyry type deposits and epithermal precious metal deposits are mostly associated with magmatism in island arc type of setting. The significant enrichment of sulfur in acid to intermediate volcanic rocks can give rise to various sulfide deposits. These sulfide deposits in turn can develop strong indications of the existence of various other precious metal deposits, especially gold (Au) and silver (Ag) in the adjacent areas. The occurrence of hydrothermal copper mineralization in Dir area (Shah, 1991; Shah et al., 1994) indicates that the area has capability of producing base and precious metal potentials associated with already known copper mineralization elsewhere in the world. Keeping in view the above mentioned facts, the regional scale preliminary geochemical investigation in Dir and Swat Kohistan area is very necessary. This study is the part of this scenario. The detailed geochemical investigations of rocks and stream sediments of the study area has, therefore, been intended to carry out in order to accomplish the following aims and objectives:

- Collection of proper samples of rocks and stream sediments (both pan concentrates and fine fractions) from the study area.

- To determine the base metals (Cu, Pb, Zn, Ni, Cr, & Co) and precious metals (Au & Ag) in the rock and stream sediment samples.
- Preparation of geochemical maps of the study area on the basis of stream sediment survey.

- Delineation of various anomalous zones on the basis of geochemical studies in the area.

PREVIOUS WORK

The first preliminary work of Hyde (1915) in district Dir is the land mark for the subsequent geoscientists working in the area. Ahmad (1962) has reported uneconomic cooper mineralization along quartz veins in Barwa, Kambat and Usheri areas. Jan et. al. (1969) worked on corundum-bearing and related rocks around Timergara. Khan (1969) mapped a 9 sq.km body of hornblendite in Assegai village near Rabat in Timergara quadrangle. Kakar et. al. (1971) presented a detailed geological map of Jandul valley for the first time. They have divided the rocks, from young to old, as hornblendites, pyroxenites, peridotites, diorites and amphibolites. They also presented petrographic account of the rocks of the area. Their map and nomenclature of the rocks are, however, modified during this study. Engineers Combined Limited (ECL) in 1978 has presented the preliminary investigation of minerals of the Dir and Swat areas. The detailed petrological studies of the Tora Tigga ultramafic complex (lies in the southern middle portion of the study area) are given by Banaras et. al. (1982), Jan et. al. (1983) and Jan and Tahirkheli (1990). A review of the geology of the areas west of western syntaxial bend of Himalaya in Dir district and adjoining areas, including part of the thesis area, is presented by But et al. (1980).

Further north near Dir the petrographic and geochemical studies are carried out on the rocks of the Dir Group of Tahirkheli (1979) (1982) especially, the metavolcanic rocks by Hamidullah et. al. (1990), Shah (1991), Shah and Hamidullah (1993), Shah et al. (1994) and

Sullivan et. al. (1992). The geology of the adjoining areas of thesis area is also given by Khan and Saleemi (1972), Arbab and Khan (1973), Chaudhry et. al. (1974) and But et al. (1980).

All these studies are based mainly on the geology and geochemistry of the rocks. No stream sediment geochemical investigations are carried out in the area. However, Sarhad Development Authority (SDA) has recently started stream sediment geochemical investigations of Dir and Swat region.

CHAPTER 2

REGIONAL GEOLOGICAL SETTING

Rocks of the thesis area are a part of the Kohistan island arc. This whole terrane is, therefore, discussed in the context of plate tectonic and related events responsible for the generation of various types of rocks and related mineral deposits in the region.

Geology and tectonic setting of the Kohistan arc terrane

The Kohistan arc terrane of northern Pakistan (Fig.2) occupies an area of about 36000 Km^2 between the higher Himalayas in the south and Karakoram-Hindukush in the north. It is a part of the Kohistan-Ladakh island arc, which represents a cross section through an intra-oceanic island arc sequence which developed as a part of the northward subduction of Neotethyan oceanic lithosphere during late Jurassic and Cretaceous times (Honegger et al., 1982; Tahirkheli and Jan, 1979; Searle et al., 1987). This arc mainly comprises diverse suite of volcanic, plutonic, and subordinate sedimentary rocks which are variably deformed and metamorphosed. The Kohistan arc is separated from the Ladakh arc by the N-S trending Nanga Parbat Haramosh dome (Zeitler, 1985). The Kohistan island arc is bounded by major fault structures from all sides; it is separated from the Karakoram plate in the north by Northern or Shyoke suture or Main Karakoram Thrust (MKT), from Indian plate in the south by the Indus suture or Main Mantle Thrust (MMT) and from the Nanga Parbat- massif in the east by the Raikot fault (Fig.2) The Karakoram plate consists of Paleozoic and subordinate Mesozoic sediments into which the Khunjarab- Wakhan- Tirichmir granitoids of the Jurassic to

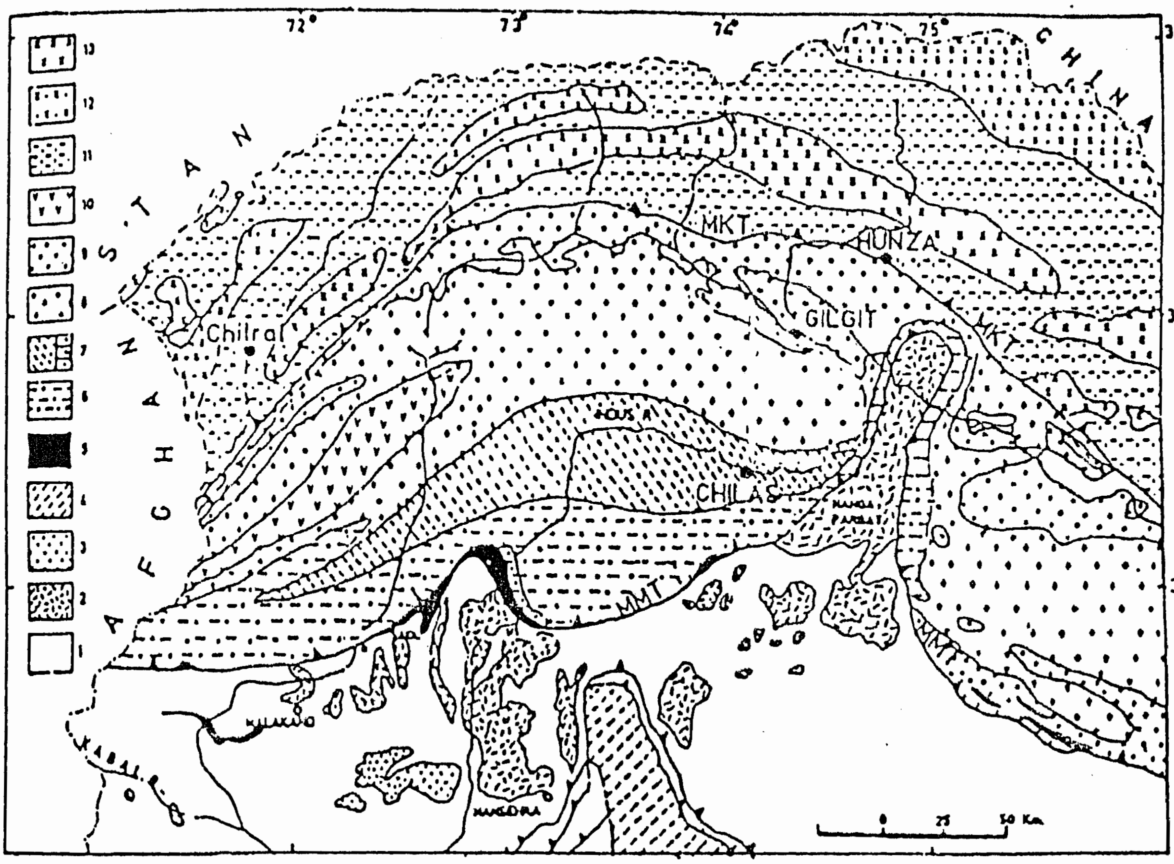


Figure 2 . A simplified geological map of northern Pakistan. (1) Precambrian to Mesozoic sedimentary rocks of the Indo-Pakistan plate; (2) Precambrian to Cambrian granitic rocks; (3) Permo-Triassic alkaline to subalkaline igneous rocks; (4) Middle Tertiary clastic sediments; (5) Ultramafic ophiolite; (6) Amphibolite belt; (7) Chilas-Jijal mafic complexes; (8) Kohistan-Ladakh (Transhimalayan) granitic rocks; (9) Cretaceous sediments and volcanics of Yasin; (10) Creto-Eocene sediments and volcanics of Kalam-Dir area; (11) Sediments and metasediments of the Karakoram plate; (12) Khunjrab-Wakhan-Tirichmir granites; and (13) Karakoram granitic belt. MMT: Main Mantle Thrust; MKT: Main Karakoram Thrust. (Jan et al., 1984).

Cretaceous and the Karakoram batholiths of Cretaceous to Tertiary age are emplaced (Debon et al., 1987). The Indian plate is made up of Precambrian to Cambrian basement and Paleozoic to Mesozoic and Tertiary cover. Several episodes of plutonic activity ranging from Precambrian to Permo-Triassic and even Himalayan age have been recorded in the Indian plate margin in northern Pakistan (for detail see Chamberlain et al., 1991; Jan and Karim, 1990; LeFort et al., 1980; Shams, 1983).

The Kohistan arc terrane is known universally for its excellent exposures of a more or less complete island arc crust including rocks from the top sedimentary cover to those at the Moho (Tahirkheli et al., 1979; Jan, 1980; Bard et al., 1980; Coward et al., 1985; Miller and Cristenson, 1994). Broad aspects of the tectonic evolution of the terrane are now reasonably well constrained as a result of reconnaissance mapping, structural analyses and radiometric dating in the last decade or so.

Recent tectonic models for the development of north western Himalayas suggest that the initial separation of the Indian plate from the Gondwanic continent occur at about 120 Ma ago in Early Cretaceous (Powell, 1979). Its rapid movement relative to Australia/Antarctica, with the average rate of 15 cm/year, took place within 80 Ma to approximately 53 Ma (Powell, 1979) until it collided with Eurasia during the Early Tertiary (LeFort, 1975; Molnar and Tapponnier, 1977; Powell, 1979; Klootwijk et al., 1992;).

The Indus-zangbo Suture (IZS) which represent the collisional boundary in the southern Tibet, bifurcate further west into MKT (Northern or Shyoke suture) and MMT (Indus suture) in the Pakistan domain (Fig.2).

These two sutures have been regarded to enclose the Kohistan island arc. This arc became a continental Andean type margin in front of the Asiatic plate after the closure of a small back arc basin along the Northern suture or MKT in the period between 100 and 73 Ma. Further northward subduction of the Tethyan lithosphere resulted in the final closure of the Tetheys ocean and under thrusting of the Indo-Pakistan plate beneath the Asiatic plate during 50 to 40 Ma along the MMT on the southern side of the Kohistan-Ladakh arc (Powell, 1979; Searle, 1983; Tahirkehli, 1983; Searle et al., 1987; Petterson and Windley, 1985; Pudsey, 1986; Pudsey et al., 1985; Coward et al., 1986; Treloar, 1989; Klootwijk et al., 1992). Both the sutures are characterized by discontinuous out crops of ophiolites and melanges and in the case of MMT, blueschist and high pressure granulites (Jan and Howie, 1982; Jan, 1991).

In a north-south section, between MKT and MMT, across the Kohistan arc terrane the following major lithologies are reported.

Yasin group: Ivanac et al. (1956) has assigned the name Yasin Group to sediments with volcanic suit of lavas, tuffs and agglomerates near village of Yasin in the north central part of the Kohistan terrane. Tahirkheli (1979;1982) used the term Yasin Group only for the sedimentary part and include the volcanic component into Rakaposhi volcanic group. Further detail work has been carried out by Pudsey et al. (1985) and Pudsey (1986). According to them the deterital sediments of Yasin Group are of deep water origin probably deposited in a back-arc or Intra-arc basin.

Chalt volcanics: The Chalt volcanics are also known as the Rakaposhi volcanic group (Tahirkheli, 1979; 1982). These Cretaceous and possibly Late Jurassic, pillowed volcanics, tuffs, pyroclastics and minor calcareous rocks underly the Yasin Group. Brief description of these volcanics is given in Ivanac et al. (1956), Tahirkheli (1979; 1982), Coward et al. (1982), Petterson et al.(1990) and Petterson and Windley (1991). These workers suggest that these volcanics are subduction- related high-Mg tholleitic andesites, boninites, calc-alkaline andesites and dacite-rhyolite, metamorphosed to greenshist facies (Ivanac et al., 1956; Petterson and Windley, 1985; Petterson et al., 1990).

Kohistan-Ladakh granitic belt (Kohistan Batholith): The presence of Major belt of granitic rocks in the northern part of Kohistan terrane was identified by Tahirkheli and Jan 1979 and Jan et al. (1981) which was later termed as the Kohistan batholith by Petterson and Windley (1985) and Coward et al. (1986). This belt comprises undeformed or mildly deformed intermediate to felsic plutonic rocks.

Chilas complex: Chilas complex is a larger mafic to ultramafic body occupying the middle part of the Kohistan terrane for a distance of about 300 Km between Dir in the west and Nanga parbat in the east (Jan et al., 1984; Khan et al., 1989). The body is internally coherent and attains a maximum width of about 40 Km in the central parts of the terrane. More than 85% of the Chilas complex is made up of gabbro-norites, with some hypersthene quartz diorites, gabbro and troctolites (Jan et al., 1984; Khan et al 1989; 1993)) In the Chilas area the pyroxene quartz-diorite are the dominant rock types intruding the amphibolites in the north and south of the complex. Khan and Jan (1992) suggest intrusive relationships between the Chilas Complex and the southern (Kamila) amphibolite belt.

A calc-alkaline composition and Island arc/back arc setting of magma generation have been suggested for the Chilas complex on the basis of mineral (Jan and Hawie, 1983; Khan et al., 1989) and whole-rock chemistry (Khan et al. 1989; 1993).

Southern (Kamila) amphibolite belt: Southern amphibolite belt has a vast distribution in southern Kohistan. Previously, it was considered to occupy the entire southern part of Kohistan terrane between the MMT in the south and the southern contact of Chilas complex in the north. The recent mapping has revealed that this amphibolite belt is in direct contact with the MMT only in the extreme eastern and western part of the Kohistan terrane. These amphibolites have been referred to as southern amphibolites (Jan, 1979; Bard et al., 1980) or more commonly as the Kamila amphibolite belt (Coward et al., 1982, 1986; Jan 1988). Southern amphibolite belt comprises a complex assemblage of lithologies. Two rock types are predominant. Fine- to medium grained amphibolites are the most predominant rock types in the eastern part of the belt exposed in the southern tributaries of the Indus river. In the central and western part of the belt the proportions of the medium grained amphibolites become relatively subordinate at the expense of medium- coarse grained amphibolites. Both the varieties are derived from volcanic precursors (Jan, 1979; 1988; Khan et al., 1983).

Jijal-Patan complex: The Jijal-Patan complex is a tectonic wedge of ultramafic- mafic plutonic body, covering about 150 km area to the north of MMT along the Indus river (Jan and

Howie, 1981; Jan and Windley, 1990; Miller et al., 1991). It is divisible into lower ~4 km thick succession of layered ultramafic rocks and upper 7 Km thick succession of garnet granulites. The ultramafics, and garnet granulites are derived from feldspathic peridotites, pyroxenites, troctolites, olivine-gabbro and gabbro-norites. These presumably represent cumulates in the roots of the Kohistan arc. Thermo-barometry based on the composition of the coexisting minerals suggests that the granulite were equilibrated during high pressure metamorphism at depth of about 30-40 km (for detail see Bard, 1983; Jan and Howie, 1981). Yamamoto (1993) related the high pressure granulites facies metamorphism to the Kohistan-Asia collision.

Spat mafic-ultramafic complex: High pressure Jijal Complex occupies the hanging wall of the MMT only in the Indus valley. The MMT is overlain by Sapat ultramafic- mafic complex in Kaghan valley which comprises ultramafic and gabbroic rocks, metamorphosed to epidote-amhibolite to greenshist facies and lack garnet. The complex, in Spatgali area upper Kaghan, contains about a Kilometer thick body of serpentinized dunites and peridotites at its base. Upsection, the ultramafic body is overlain by a zone of layered gabbro-norites, anorthosites and peridotites (for detail see Jan et al., 1990).

Dir group: A 15-20 km wide and more than 120 km long belt of slates and volcanic rocks (Dir Group, Tahirkheli, 1979) stretches in a NE-SW trend across the Dir and Swat valley in western Kohistan. On the basis of paleontalogical and radiometric evidence the rocks have been assigned Late Paleocene- Early Eocene age (Kakar et al., 1971; Khan, 1979; Treloar et al; 1989; Sullivan et al; 1993). This group has been divided into two units, Baraul Banda Slate Formation and Utror Volcanic Formation. The Baraul Banda Slate Formation is about three

Kilometers in thickness and comprises 30-70m thick basal succession of conglomerates, breccia and pebbly sandstone overlain by ~2500m thick succession of thinly bedded-laminated sandstone, siltstone and mudstone (Sullivan et al., 1993). The Utror Volcanic Formation is compresed of basalt, basaltic-andesite, andesite, dacite, rhyolite, pyroclastic breccia and tuff of calc-alkaline nature (Majid and Paracha, 1980; Majid et al., 1981; Shah and Hamidullah, 1993; Shah et al., 1994; Sullivan et al., 1993). Coward et al. (1982, 1986; 1987) regarded this succession as island arc sequence, to have formed due to north ward subduction in Late Jurassic to Early Cretaceous, and the deformation and metamorphism to be related to the closure of the MMT. The continued subduction and crustal anatexis gave rise to the Kohistan batholith and Dir Kalam group (Petterson and Windley, 1985; Sullivan et al., 1993).

CHAPTER 3

LOCAL GEOLOGY

The thesis area is located immediately north of the Main Mantle Thrust (MMT). It is mainly composed of metamorphic, plutonic and volcanic rocks which could be the part of the north-western extention of the southern Kamila amphibolite belt of Jan et al. (1979; 1988). The geology of the area has been described by Kakar et al. (1979), Chaudhry, et al. (1974), Butt, et al. (1980) and Jan, et al. (1983).

This work is mainly concerned with the geochemical investigation of the area. Therefore, limited number of samples have been collected during field work from the various rock exposures, already mapped by Chaudhry et al. (1974), Butt et al. (1980) and Kakar et al. (1971). During this prelimnary study it was felt that the area has a complex geology and the mapping which is done before need further modification. During this study some modifications in regard to nomenclature, based on field and petrographic studies (not presented here but are given in Shah et al., in press) are made in order to emphasis that further detail petrographic work is needed to be carried out in the area. On the basis of petrography and field textures the following grouping is made (see Fig. 1).

1. Timergara complex
2. Sumergagh complex
4. Tora Tiga complex

TIMERGARA COMPLEX

The rocks of the complex are exposed in central and north-eastern portion of the study area (Fig. 1). This complex is mainly composed of amphibolites, metadiorite and metagabbro-norites with lesser amount of metagabbro, metagranodiorites, quartz diorites, tonalites and volcanics.

Amphibolites

On the basis of field observations the amphibolites of the area are distinguished as Banded amphibolites (para amphibolites) and are shown in figure 1. The main exposures of banded amphibolite unit is exposed in the southern and northern part of the thesis area. However, minor sheets and lenses are also exposed in the central part of the area (Fig.1). The general strike of the amphibolites changes from east-west in the southern parts to north-east in the north and central parts of the area. These types of amphibolites in other parts of the Dir district are termed as Northern Dir amphibolits (para-amphibolites) by Chaudhry et. al. (1974). These rocks are distinctly banded and schistose. The foliations are parallel to the layering, generally trending NE-SW. There are alternate dark and light colored bands. The dark colored bands have amphibole in higher concentration while the falsic phases (plagioclase and quartz) along with pink coloured garnet are concentrated in the light color bands. At places the bands of cherty material up to 2 inches thick are also noticed. These rocks are intruded by dioritic, aplitic and mafic dikes. The diorite intrusion in the from of small plugs are also present, which contain xenoliths of banded amphobolites. The diorite intrusions are, however, very much weathered, sheared and altered within this amphibolite. Bedded quartizites up to 2m thick and more than 20 meter long are also exposed within this unit at various places. At one place near Kombar bazar the green colored metavolcanics are exposed within this unit.

The banded amphibolites are very much sheared deformed and show development of micro folds, especially recumbent and chevron folds, near Sarlara Qala which indicate the existence of thrust fault in the vacinity (not marked on the map). However, local faulting, folding and shearing is the common feature of these amphibolites. The banded amphibolites in the southern parts are also intruded by the plutonic rocks of tonalite composition and are shown in figure 1.

There are isolated outcrops of banded amphibolites in the north-east of Samerbagh (Fig. 1). These out crops are in contact with porphyritic augen gneiss. The amphibolite in this zone are intensively deformed and stretched. In the central part of the thesis area (e.g. near Charmang and Jabagai area), these amphibolites are intruded by granititic rock which resulted in the formation of hornblende in the form of veins.

Metadiorite and metagabbro-norite unit

The metadiorite and metagabbro-norite are previously shown as diorite and norite units on the map of Chaudhry et al., (1974) and Butt et al. (1981). However, both previously named diorite and norite are renamed as metadiorite and metagabbro-norite respectively in the present study (Fig. 1).

Metadiorite: Metadiorites are massive in hand specimen and have medium-to coarse grained texture. These are dark gray to greenish gray on fresh surface and dirty dark brown on weathered surface. Plagioclase hornblende and quartz can very readily identified in hand specimens.

Metagabbro-norite: Metagabbro-norites and the metagabbros are not easily distinguished in the field and are, therefore, shown as single unit on the map (Fig. 1). At some placed these rocks appears as homogeneous amphibolites in the field because of the development of high concentration of hornblende during metamorphism. These rocks are medium to course grained having well developed foliations. In handspecimen these are massive dark gray colored rocks on fresh surface while light brown to yellowish brown on weathered surface. Plagioclase and hornblende are clearly recognizable in hand specimens.

Both the metadiorite and metagabbro-norites are having many similar features and are, therefore, discussed together as follows. The general trend of foliations of these units is NE-SW which, in turn, is in general conformity with the regional trend of the southern (Kamela) amphibolite belt. These rocks are intruded by hornblendite, aplite and micro-dioritic dikes and quartz veins. Where ever the rock has these intrusions, it has attained maximum weathering and alteration on both sides of the intrusion. At certain places, the alteration is so intense that the rock is hardly recognizable. Shearing along local faults is the common feature of these rocks. In these shears zone the rock shows alteration to epidote which is present as a fractured filled material in the form of a net work of microveins. The quartz veining is also noticed within the shear zones. Occasionally dark patches (about less than 30cm thick) containing >90% amphibole, are present within the metagabbro-norite.

Metavolcanics

Patches of volcanic rocks and volcanic porphyry dikes are exposed in the thesis area. A green colored metavolcanic rock exposure (metamorphosed to greenshist facies) is present within the banded amphibolites near Kumber bazar in the north-eastern portion of the thesis area (not shown in map). The rock is foliated and at places developed schistocity. These volcanics are intruded by dioritic dikes. These dikes have chilling and alteration effects on both sides within these volcanics and also have xenoliths of metavolcanics in them. The rock is mostly altered to epidote and chlorite. Occasionally, the epidotization is so intense that the rock attained patchy appearance. The micro veins containing limonite, chalcopyrite and pyrite are also noticed. Various other exposures (unmapable) are also present further north.

SAMARBAGH COMPLEX

This complex is widely exposed in the Jandul valley, covering most of the western and north-western part of the thesis area. The rocks of this complex are extended to Afghanistan in the north-western part and to Bajaur agency in the south-western part of the study area. This complex is mainly composed of metadiorites and metagabbro-norites with subordinate amount of norite, gabbro, granodiorites, metagranites, metavolcanics and porphyry dikes (Fig. 1). Field aspects of various rocks of the complex are discussed as follows.

Metadiorites, metagranodiorite and metagabbro-norite unit

Metadiorite and metagabbro-norite are previously shown as diorite and norite units on the map of Kakar et al., (1971). During this study it was found that the rocks maped as a single diorite unit by Kakar et al., (1971) are not only the diorites but these are making a complex of mainly metadiorite, metagranodiorite and metagabbro-norite with lesser amount of metanorite and metagabbro. These rocks are, therefore, grouped into metadiorite, metagranodiorite and metagabbro-norite unit during this study (Fig. 1). A detail mapping is, however, required to map these rocks as separate units.

Metadiorite and metagranodiorite: In field it is difficult to differentiate the metadiorite from metagranodiorite and meta-quartzdiorite. Field features of these rocks are , therefore, described together. Two varieties, leuco and mala, of meta-diorites are recognized in the field. The leuco diorites are light colored and are exposed mainly on the eastern side of the Miskini Khawar while mela diorites (containing pyroxenes) are dark colored and widely exposed in the western part of the Miskini Khawar. Both the varieties are medium- to course-grained having well developed foliation. These rocks near Sarlara Qala are highly deformed and sheared. The occurrence of quartz veins is the common feature of these deformed metadiorites. The metadiorite exposures south-east of Samarbagh and north-east of Satbar (Fig.1) are fine-to medium-grained, having unique banded structures of alternate mafic and felsic phases. These bands are deformed and exhibit micro folding. These could be primary igneous features or may be formed due to metamorphic segregation. These rocks are also intruded by pegmatitic veins, containing hornblende crystals of <cm long. These veins are both concordant and disconcordant to the layering/ banding. Iron-bearing phase (probably pyrite) is disseminated through out the rock which imparts reddish brown color to the weathered surface, due to oxidation, at places. The whole structural pattern in this area is extremely complicated and local faults can be seen in small intervals. These structural complications suggest the existence of thrust fault in the vicinity (not shown on the map).

Metagabbro-norite: The largest metagabbro-norite body in the thesis area is exposed near Mayar at Gamber (Fig.1). These are described as norite by Kakar et al., (1971). At this locality, these rocks have upper gradational contact with metadiorits and are intruded by the swarm of porphyry dikes extending in the east and west directions. These rocks are medium- to coarse-grained and are topographically distinct for their rusty dark brown weathered surface. At places, these rocks have developed foliation. In hand specimens the plagioclase clinopyroxene, orthopyroxene and hornblende are easily distinguished.

Metagranites

The mapable units of meta-granitic rocks are exposed within banded amphibolites near Jabagai hills in the centeral part of the thesis area (Fig. 1). These are light colored, coarse-grained granites with well developed fabrics. At places, it is intensively faulted, folded and cut by quartz and pegmatitic veins. There are other small intrusions of granite within this complex and are not shown in the map (Fig. 1).

TORA TIGA COMPLEX

Hornblendite, metagabbro, amphibolite and ultramafite units

The rocks of the Tora Tiga complex ,exposed in the southern central part of the thesis area, are well described both petrographicaly and geochemically by Banaras et al., (1982), Jan et al., (1983) and (1990). The geology of the rocks of the complex is extracted from Banaras et al., (1982), Jan et al., (1983) and is described as follows: This complex is mainly composed of amphibolites, metagabbros, ultramafics, hornblendites and other minor dikes and veins. The metagabbros occur in the southern part of the complex. These are the medium-to course-grained, homogeneous, gneissosed rocks. These carry dikelets and veins, as well as patches of hornblendite. These rocks grade into banded amphibolites in the central part of the complex. The contacts of the metagabbros with the lower lying ultramafics are sharp and locally sheared. The banded amphibolites form linear belts between the metagabbros and the garnet-amphibolites. The banded amphibolites are characterized by alternate light and dark colored bands with fine to medium grained texture. These can be the part of the main banded amphibolite unit exposed in the north-eastern and southern part of the thesis area. The garnet-amphibolites are similar to the metagabros with the exception of garnet porphyroblasts of varying dimension. Two main hornblendite exposures are present at Tora Tiga and Hashim village while numerous patches of variable size are present in other parts of the complex.

These hornblendites have sharp contact with metagabbro and amhibolites while their contact with the ultramafic rocks is gradational. The hornblendites are characterized by a heterogeneous textures. The predominant coarse-grained texture varies to medium-grained or locally pegmatitic. The presence of felsic dikes is another characteristic feature of these hornblendites . Among ultramafic rocks the olivine ultramafites and pyroxene ultramafites can easily be distinguished. The olivine ultramafites include various types of peridotites, dunites and serpentinites. These rocks occur as elongated to subcircular bodies, or small irregular patches. These are generally medium- grained, dark green, hard compact and vitreous when fresh; light green or gray and greasy when surpentinized. The pyroxene-ultramafites are the second most abundant ultramafites and occur as east-west trending bodies. These are hard and massive rocks, generally medium-grained, though coarse- and fine-grained varieties are also found locally. Besides, these rocks many felsic dikes and veins are present in various parts of the Tora Tiga Complex. These dikes have porphyroblasts of hornblende, plagioclase and quartz embedded in the abundant fine grained matrix.

CHAPTER 4

METHODOLOGY

A. FIELD METHODS

a. Collection of rock samples

Representative grab samples (≅ 2-4 kg) were hammered through the rock exposures in the field. Both fresh and weathered rock samples were collected in different sample bags. The crushed material along various sheared zones were also collected for base and precious metals determination. These samples were properly numbered in the field and brought to the laboratory for further analyses.

b. Collection of stream sediments

The drainage sample sites and associated drainage cell (catchments) were outlined on topographic maps and transfered onto the base maps. The cells sizes were kept 2-50 square kilometers and check samples along main drainage were taken to cover an area which is not represented by singal cell such as small drainages and the slopes along the main drainage samples. At each location a keen examination of stream floats (transported rock fragments) was made and local geology was noted. Heavy mineral pan- concentrates and fine sediment (-80 mesh) samples were collected for subsequent geochemical analyses for various target and indicator metals. All samples were assigned unique number. The details of relevant samples and geological observations were recorded on site and are given in appendix.

Pan concentrate samples: A standard volume (about 20 Kg of < 7mm) of stream sediments were collected from at least three natural heavy mineral spots along the active streams. These sediments were than panned in plastic panning dishes and reduced the volume to about 50-100 g containing heavy mineral concentrates. These pan-concentrates were then transferred to self- sealed plastic bags for detailed mineralogical and geochemical studies. Before transferring into plastic bags, these concentrates were examined closely with a pocket microscope for visible gold as well as other ore-indicators and necessary minerals. The visible gold was divided into different sizes such as piece (>0.5mm), speck (0.5-0.3mm) and color (<0.3mm). The presence or absence of gold along with other recognizable heavy minerals are recorded at the site (see appendix). These have helped in comparing field observations with the analytical data obtained through laboratory.

Fine fraction (-80 mesh): Fine stream sediment sample at each site was collected from at least three locations in active drainage channel. Among these two were from heavy mineral traps and one from low energy/fine sediments area of drainage sample site. These fine sediments were collected about 100-200 gm of (-80 mesh) material for subsequent chemical analyses. Each fine stream sediment sample was transferred to plastic bag and properly numbered.

Stream floats: At each sample site stream float (transported rocks and mineral fragments) were closely examined in hand spacemen by the magnifying lens to identify rock types, alteration and mineralization that have come from within the particular drainage cell represented by that stream sediment sample site. The observations were recorded for further interpretation and mapping purposes. The detail is given in appendix.

Field data recording

The following observations were recorded for each sample site during the filed (given in appendix):

1. Sample Number
2. Sampling interval
3. Prospect/location
4. Map sheet Number
5. Sample site latitude/longitude
6. Drainage Characteristics
7. Grid reference
8. Description of float
9. Pan mineralogy
10. Visible Gold content
11. Visible Gold Description

B. LABORATORY METHODS

Crushing and pulverizing of rock samples

Various types of rocks collected during field from the study area were thoroughly checked for their extensive alteration and weathering. Representative samples were then selected for further experimental work. The rock samples were crushed in Jaw crusher and then the crushed chips were pulverized in a tungsten carbide ball mill to - 75 micron (200 mesh size) with a quartz flush between samples. A portion of individual sample was collected after proper quartering and coning. During this whole process greater care was practiced to avoid contamination. The powdered samples were stored in the air tight glass bottles. These bottles, after removing the lids, were kept in the oven at 110 °C for two hours in order to remove the moisture.

Preparation of stock solutions

1. Stock Solution A

HF + HNO_3 digestion method: Accurately weighed 0.500 g of finely powdered sample, each of both rocks and stream sediments, was taken in a 100 ml teflon beaker. 5ml of hydrofluoric acid (HF) was added to it and was kept on hot plate at a temperature of approximately 75°C. After 10 minutes about 15 ml of concentrated HNO_3 was added and the heating was continued until complete dryness. 3N HCl was added to the residue and was heated until the maximum dissolution of residue. The volume was made to 50 ml with 3N HCl and was stored in polythene bottle. This solution was then used for trace elements determination by using atomic absorption spectrophotometer (AA).

2. Stock Solution B

Aqua Regia digestion method for gold: 10-20 g each of rock and stream sediment powder sample was weighed in the 200 ml Pyrex beakers. 50 ml of aqua regia was added to it and was heated for about half an hour at low heat. After half an hour about 35 ml of deionized water (D.I) was added. Heating and evaporation was continued until about 50 ml solution was left in the beaker. The whole beaker contents were then filtered in a test tube. The residue and beaker was washed several times with 6N HCl and the contents were collected in the test tube. This filtrate was of about 50 ml volume. The whole filtrate was then transferred to a 250 ml seperatory funnel. In order to keep the normality of filtrate to 6N, about 50 ml of D.I. water was added to it. Then 10 ml of Methyle Isobutyle Ketone (M.I.B.K.) was added to the separatory funnel. The funnel was then shaked for 6-8 minutes on automatic flask shaker. The lower layer was removed and 20 ml of 0.2N HCl was then added to the M.I.B.K in the funnel and was shaked for about 5 minutes more. The most probable interference of Fe was removed by this process. The M.I.B.K was collected and stored in glass test tube for further determination of gold on atomic absorption.

No. 32-C

Trace elements determinations

Both the rocks and stream sediment samples were analyzed for Cu, Pb, Zn, Ni, Cr, Co, Ag, and Au, by using partly Perkin Elmer 3300 (equipped with graphite furnace) and partly SP-191 Pye Unicam atomic absorption spectrophotometer in the geochemistry laboratory of the Centre of Excellence in Geology, University of Peshawar. The detail procedure and instrumental setting is given as follows:

Determination of nickel (Ni)

Instrument: SP 191 PYE UNICAM Atomic Absorption spectrophotometer

Instrument conditions:

Mode	Absorption
Wavelength	232nm
Slit width	0.2nm
Fuel flow	1.0 l/min
Air flow	4.5 l/min

1: Standard stock solution of 1000 ppm: 1g of Ni metal was dissolved in a minimum volume of(1:1) HNO_3 and was diluted to 1 litre with deionized water.

2. Standard stock solution of 100 ppm: 10 ml from 1000 ppm stock standard solution was transferred into a 100 ml volumetric flask and was made to the mark with deionized water.

3: Working standards: 0.5, 1, 2, 4 ppm standard solution were prepare by taking 0.5, 1, 2 and 4 ml from 100 ppm standard solution into a series of 100 ml volumetric flask and was made to the mark with deionized water.

Procedure: The atomic absorption spectrophotometer was set according to the above mentioned conditions. Ni cathode lamp was turned ON and allowed to warm up for 10 minutes. After warming up of cathode lamp, the air acetylene flame was ignited. The instrument was calibrated and standardized with working standards of 2 and 4 ppm. All the working standards were then run as unknown to verify the standardization. Stock solution of certified standards was run and the results were compared with the certified values. After making sure that the result of the certified standards were within the confidence limit, the sample's stock solutions A were then aspired into the flame and the Ni concentration of each sample was noted. The Ni contents in ppm were calculated according.

Determination of chromium (Cr)

Instrument: SP-191 PYE UNICAM Atomic Absorption Spectrophotometer

Instrument conditions

Mode	absorbence

Wavelength	357.9nm
Slit width	0.2nm
Fuel flow	1.5 l/min
Air flow	4.5 l/min

1: Standard stock solution of 1000 ppm: 3.735g of K_2CrO_4 was dissolved in deionized water and diluted to one litre with deionized water.

2. Standard stock solution of 100 ppm: 10ml of 1000ppm standard stock solution was taken in 100 ml volumetric flask and was made to the mark with deionized water.

3. Working standards: 0.5, 1, 2, 4 and 8 ppm of working standards were prepared by taking 0.5, 1, 2, 4 and 8 ml from the standard stock solution of 100 ppm in a 100ml volumetric flask and was made to the mark with deionized water.

Procedure: The atomic absorption spectrophotometer was set according to the above mentioned conditions. Cr cathode lamp was turned ON and let it to warm up for 10 minutes. After warming up of cathode lamp the air acetylene flame was ignited. The instrument was calibrated and standardized with working standards of 4 and 8 ppm. All the working standards were then run as unknown to verify the standardization. Stock solution A of certified standards were run through the instrument and the results were compared with the certified values. After making sure that the results of the certified standards were within the confidence limit, the sample's stock solutions A were then aspired into the flame and the Cr concentration of each sample was noted. The Cr contents in ppm were calculated.

Determination of cobalt (Co):

Instrument: SP 191 PYE UNICAM Atomic Absorption Spectrophotometer.

Instrument conditions:

Mode	Absorption
Wave length	240.7 nm
Slit width	0.4 nm
Fuel flow	0.9 l/min
Air flow	4.5 l/min
Burner height	10 mm

1: Standard stock solution of 1000 ppm: 1.0 g of cobalt metal was dissolved in 30 ml of (1:1) HCl and was diluted to one litre with deionized water.

2. Standard stock solution of 100 ppm: 10ml of 1000 ppm stock solution was taken in 100 ml volumetric flask and was made to the mark with deionized water.

3. Working standards: 0.5, 1, 2, 4 and 8 ppm of working standards were prepared by taking 0.5, 1, 2, 4 and 8 ml from 100 ppm standard stock solution in a series of 100 ml volumetric flasks and made to the mark with deionized water.

Procedure: The atomic absorption spectrophotometer was set according to the above mentioned conditions. Co cathode lamp was turned ON and let it to warm for 10 minutes. After warming up of cathode lamp the air acetylene flame was ignited. The instrument was calibrated and standardized with working standards of 4 and 8 ppm. All the working standards were then run as unknown to verify the standardization. Stock solution of certified standards were run through the instrument and the results were compared with the certified values. After making sure that the results of the certified standards were within the confidence limit, the sample stock solutions A were then aspired into the flame and the Co concentration of each sample was noted. The Co contents in ppm were calculated.

Determination of copper (Cu)

Instrument: SP 191 PYE UNICAM atomic absorption spectrophotometer.

Instrument conditions

Mode	Absorption
Wave length	325.8nm
Slit width	0.4nm
Fuel flow	1.0 l/min
Air flow	4.5 l/min
Burner height	10 mm

1. Standard stock solution of 1000 ppm: 1 g of copper metal was dissolved in 30 ml of (1:1) HNO_3 and was made to the volume of one litre with deionized water.

2. Standard stock solution of 100 ppm: 10 ml of 1000 ppm standard stock solution was taken in 100 ml volumetric flask and was made to the mark with deionized water.

3. Working standards: 0.5, 1, 2, 4 and 8 ppm of working standards were prepared by taking 0.5, 1, 2, 4, and 8 ml from 100 ppm standard stock solution into a series of 100 ml volumetric flasks and made to the volume with deionized water.

Procedure: The atomic absorption spectrophotometer was set according to the above mentioned conditions. Cu cathode lamp was turned ON and let it to warm up for 10 minutes. After warming up of cathode lamp the air acetylene flame was ignited. The instrument was calibrated and standardized with working standards of 4 and 8 ppm. All the working standards were then run as unknown to verify the standardization. Stock solution A of certified standards were run through the instrument and the results were compared with the certified values. After making sure that the results of the certified standards were within the confidence limit, the sample stock solutions A were then aspired into the flame and the Co concentration of each sample was noted. The Co contents in ppm were calculated.

Determination of lead (Pb):

Instrument: PERKIN ELMER 3300 Atomic Absorption Spectrophotometer.

Instrument conditions:

mode	absorption
Wavelength	217 nm
Slit width	0.4 nm
Fuel flow	0.9 l/min
Air flow	4.5 l/min
Burner height	10 mm

1. **Standard stock solution of 1000 ppm:** 1.598 g of lead nitrate $Pb(NO_3)_2$ was dissolved in 1% HNO_3 and was diluted to 1 litre with deionized water.

2. Standard stock solution of 100 ppm: 10 ml of 1000 ppm standard stock solution was taken in 100 ml volumetric flask and was made to the volume with deionized water.

3. Working standard solutions: 0.5, 1, 2, 4 and 8 ppm of working standards were prepared by taking 0.5, 1, 2, 4 and 8 ml of 100 ppm stock solution in a series of 100 ml volumetric flask and volume was made to the mark with deionized water.

Procedure: The atomic absorption spectrophotometer was set according to the above mentioned conditions. Pb cathode lamp was turned ON and allowed to warm up for 10 minutes. After warming up of cathode lamp the air acetylene flame was ignited. The instrument was calibrated and standardized with working standards of 4 and 8 ppm. All the working standards were then run as unknown to verify the standardization. Stock solution A of certified standards were run through the instrument and the results were compared with the certified values. After making sure that the results of the certified standards were within the confidence limit, the sample stock solutions A were then aspired into the flame and the Pb concentration of each sample was noted. The Pb contents in ppm were calculated.

Determination of silver (Ag)

Instrument: PERKIN ELMER 300 Atomic Absorption Spectrophotometer.

Instrument conditions:

Mode	Absorption
Wavelength	28.1 nm
Slit width	0.4 nm
Fuel flow	1.l/min
Air flow	5 l/min
Burner height	10 mm

1. Standard stock solution of 1000 ppm: 1.575 g of silver nitrate ($AgNO_3$) was dissolved in 100 ml of deionized water and was transferred to 1 litre volumetric flask. The volume was made to the mark with deionized water.

2. Stock solution of 100 ppm: 10 ml of 1000 ppm standard stock solution was taken in 100 ml volumetric flask and was made to the volume with deionized water.

3. Working standard solutions: 0.5, 1, 2, 4 and 8 ppm solution were prepared by taking 0.5, 1, 2, 4 and 8 ml from 100 ppm standard stock solution in a series of 100ml volumetric flasks and the volume was made to the mark with deionized water.

Procedure: The atomic absorption spectrophotometer was set according to the above mentioned conditions. Ag cathode lamp was turned ON and let it to warm up for 10 minutes. After warming up of cathode lamp the air acetylene flame was ignited. The instrument was calibrated and standardized with working standards of 4 and 8 ppm. All the working standards were then run as unknown to verify the standardization. Stock solution A of certified standards were run through the instrument and the results were compared with the certified values. After making sure that the results of the certified standards were within the confidence limit, the sample stock solutions A were then aspired into the flame and the Ag concentration of each sample was noted. The Ag contents in ppm were calculated.

Determination of zinc (Zn)

Instrument: SP 191 PYE UNICAM Atomic Absorption Spectrophotometer

Instrument conditions:

Mode	Absorption
Wavelength	213.9nm
Slit width	0.4nm
Fuel flow	1 l/min
Air flow	5 l/min
Burner height	10 mm

1. Standard stock solution of 1000 ppm: 1 g zinc metal was dissolved in about 20 ml of (1:1) HCl and was diluted to 1 litre with deionized water.

2. Standard stock solution of 100 ppm: 10 ml of 1000 ppm standard stock solution was taken in 100 ml volumetric flask and was made to the volume with deionized water.

3. Working standard solution: 1, 2, 4 and 8 ppm working standard solutions were prepared by taking 1, 2, 4 and 8 ml of 100 ppm standard stock solution in a series of 100 ml volumetric flasks. The volume in each flask was made up to the mark with deionized water.

Procedure: The atomic absorption spectrophotometer was set according to the above mentioned conditions. Zn cathode lamp was turned ON and allowed it to warm up for 10 minutes. After warming up of cathode lamp the air acetylene flame was ignited. The instrument was calibrated and standardized with working standards of 4 and 8 ppm. All the working standards were then run as unknown to verify the standardization. Stock solution C of certified standards were run through the instrument and the results were compared with the certified values. After making sure that the results of the certified standards were within the confidence limit, the sample stock solutions C were then aspired into the flame and the Zn concentration of each sample was noted. The Zn contents in ppm were calculated.

Determination of gold (Au)

Instrument: PERKIN ELMER Atomic Absorption Spectrophotometer

Instrument conditions:

Mode	Absorption
Wave length	242.8 nm
Slit width	0.4 nm
Fuel flow	0.9 l/min
Air flow	4.5 l/min

1: **Hydrobromic acid**, concentrated (48%).

2: **Hydrobromic acid - 10 % bromine solution:** Diluted 10 ml of bromine to 100 ml with concentrated hydrobromic acid.

1. Gold stock solution of 1000 ppm: 1 gram of pure gold was dissolved in aqua regia and was diluted to one litre with 10% HCl in a volumetric flask.

2. Standard stock solution of 100 ppm: 10 ml of 1000 ppm standard stock solution was taken in 100 ml volumetric flask and the volume was made to the mark with deionized water.

3. Standard stock solution of 10 ppm: 10 ml of 100 ppm standard stock solution was taken in 100 ml volumetric flask and the volume was made to the mark with deionized water.

4. Working standards: 0.5, 1, 2, 4 and 8 ppm working standards of gold were prepared by taking 1, 2, 4,8 and 16 ml of 10 ppm standard stock solution in test tubes and diluted to

20 ml with deionized water. O.22 ml of HBr 10% bromine solution was added to each test tube. It was followed by the addition of 10 ml MIBK. The solution was then shaked for 5 minutes and was centrifuged. The MIBK layer was separated and kept for further determination.

Procedure: The atomic absorption spectrophotometer was set according to the above mentioned conditions. Au cathode lamp was turned ON and allowed to warm up for 10 minutes. After warming up of cathode lamp the air acetylene flame was ignited. The instrument was calibrated and standardized with working standards of 4 and 8 ppm. All the working standards were then run as unknown to verify the standardization. Stock solution B (MIBK solution) of certified standards were run through the instrument and the results were compared with the certified values. After making sure that the results of the certified standards were within the confidence limit, the sample stock solutions B were then aspired into the flame and the Au concentration of each sample was noted. The Au contents in ppm were then calculated.

CHAPTER 5

RECONNAISSANCE GEOCHEMICAL EXPLORATION BASED ON LITHO & STREAM SEDIMENTS STUDY

General statement

Reconnaissance mineral exploration commonly begins with a geochemicl survey using various stream related material from widely spread sediment catchment areas. It is anticipated that stream detritus will contain specific indicator elements from any mineralization in the catchment area. Satisfactory results are normally obtained from stream sediments fines, especially for base metals. However, in the areas of extreme relief the fine fraction may not provide satisfactory anomaly/back ground contrast.

The intensity of drainage anomaly is a function of the amount of material eroded or leached from the catchment area, minus what has been precipitated from ground water below the surface, accumulated in overburden, or carried past the same site. A strong anomaly may, therefore, mean (i) a very large area of low grade mineralization, (ii) Swarms of very small deposits of high grade metalliferous material, (iii) small deposits of weakly mineralized but highly fractured rock that is usually accessible to leaching action of circulating ground water, or (iv) one or more deposits of ore grade. If the anomaly is clastic in origin, possibility (iii) is unlikely, but the other possibilities can not be distinguished; conversely the absence of a strong anomaly does not necessarily mean the absence of an ore body. Just as commonly, the absence of an anomaly may be caused by either dilution to precipitation of the metal some where along the drainage system between the source and the sample site.

Chemical elements in stream sediments may be found (1) as constituent of primary rock forming minerals, (2) as minerals formed during weathering, (3) as minerals typical of mineralization, (4) as ion adsorbed onto colloidal particles and clays and (5) in combination with organic mater (Rose, 1975). The characterization of these sources can be evaluated by the type of material collected from streams. The material of different media such as heavy mineral concentrates and fine fraction of <177mm (-80 mesh) show important chemical differences as these media are subjected to different influences, and underlies different geological textures (Davenport 1990; Bellehumeur et. al., 1994). Keeping these criterion in mind, the present study is also based mainly on the geochemical investigations of heavy mineral concentrates and fine fractions of the stream sediments. In order to compare the stream sediment anomalies with the rocks of the area, the geochemical investigation of various rocks exposed in the catchment area were also carried out. The main objective of this reconnaissance geochemcial survey in the area is to find areas likely to contain mineralization and be worthy of follow-up work.

Sample collection and analyses

Stream sediments were collected from fifty six sites covering an area of about 900 km^2 in Timergara and Samarbagh areas of southern Dir. The surface areas of the catchment basins (cells) vary considerably, but most of the samples were collected at the out flow sites of catchment basins ranging from 2 to 50 km^2 (Fig 3a & b)). The average sample density was about one site per 15 km^2. Two samples were collected at each site: (a) pan-concentrate stream sediments and (b) fine fraction (-80 mesh) of stream sediments. The pan concentrate samples were obtained by sieving to <850mm (-20 mesh) and the heavy minerals concentrates were prepared by panning. The fine fractions were obtained by sieving the clay size material to <177mm (-80 mesh) size from the same site. The details of the procedure are given in the chapter 4.

Both pan-concentrates and fine fractions of stream sediments were digested in weak (HNO3) and strong (aqua regia) acids in the laboratory. The digested solutions were then used for the determination of Au, Ag, Pb, Zn, Cu, Ni, Cr & Co by using Atomic Absorption spectrophotometer both in the Geochemistry Laboratory of NCE in Geology, University of Peshawar and the Mineral Testing Laboratory of the SDA, Peshawar. The details of the analytical procedures are given in the chapter 4.

In order to enable comparative interpretation, the normalization of pan-concentrate data is very necessary, especially in the case of those elements which have nugget effects (e.g. gold). The normalization is also very necessary because the concentration factor, reflected in the weight of the final concentrates, varies with the amount of heavy minerals present at the same site. However, for fine fraction the normalization is not important. The pan-concentrate data (i.e. Au, Ag, Pb, Zn, Cu, Ni, Cr and Co) of the studied samples have, therefore, been normalized to 100 g and the result are shown in table 1. This normalized data are then used during interpretation. A summarized statistical geochemical

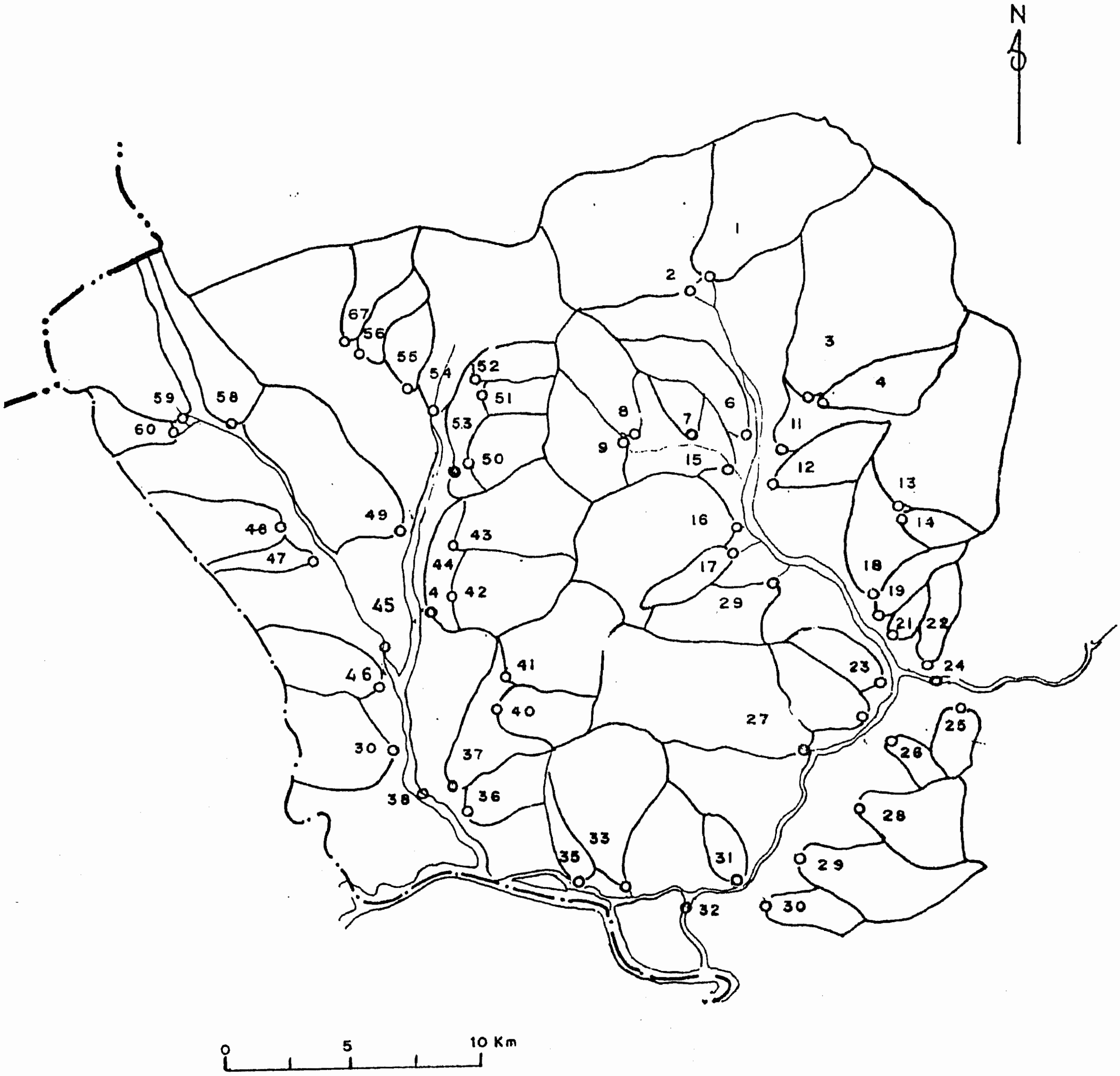


Fig. 3a. Map showing sample numbers along with sample sites and drainage basins of the study area.

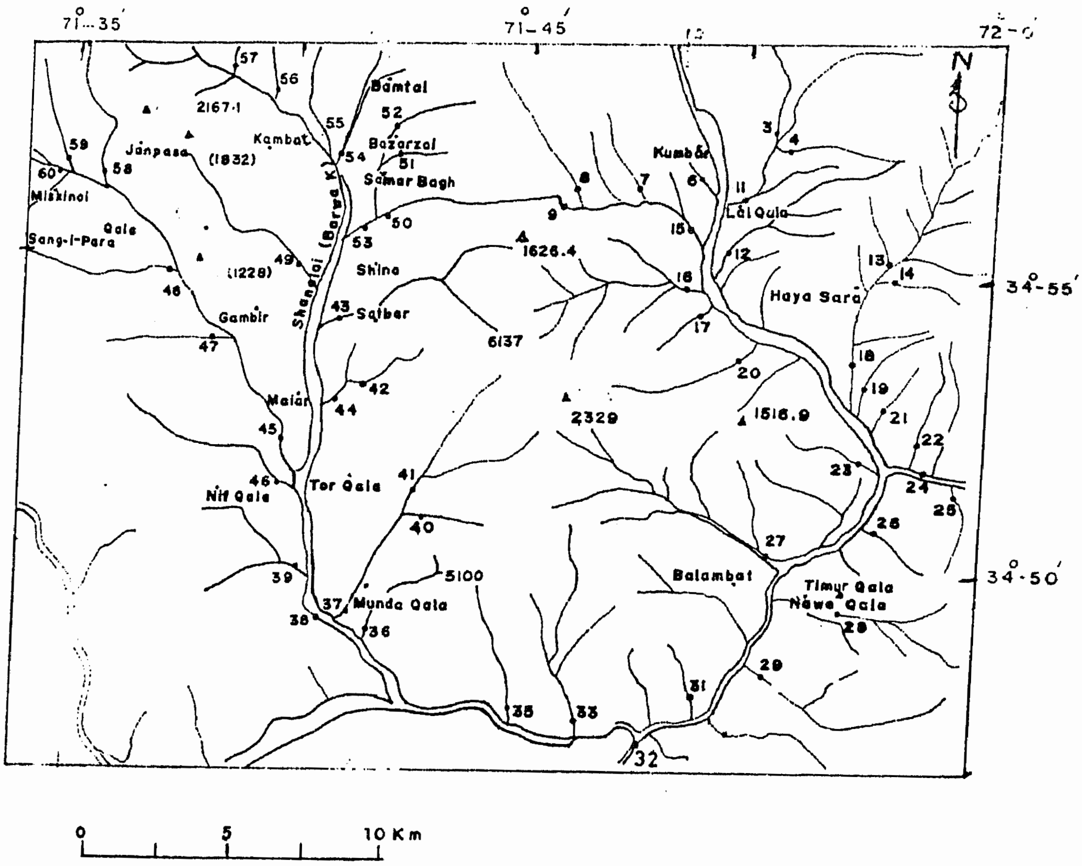


Fig. 3b. Map showing drainage pattern and location of sample sites of the study area.

data of the pan concentrates is given in table 2. The fine fraction geochemical data along with summery statistics are also given in table 3 and 4 respectively.

Float and pan concentrate study

Float study: Float study is very useful in the areas where there is a thick vegetation cover and the rock exposures are hardly exposed. The study area is not of this type. The rocks are well exposed and the geology is very well studied by collecting rock samples from the exposures. However, during the present study the float at each steam sediment sample site was studied and the float geology has been given in the appendix. These floats are mainly of metadiorite, metagranodiorite, granite gneiss, metagabbro-norite and amphibolite. However, in some streams floats of quartz pegmatites, hornblendite, applite dike rock, quartz vein material, pyroxenite and volcanics etc. are also found along with the above mentioned main float types.

Pan-concentrate : Mineralogy of the pan-concentrate samples was carried out under the binocular microscope in the Mineral Testing Laboratory of SDA, Peshawar (see appendix). More emphasis was given to the identification of gold in the form of pieces, specks and colors in each pan-concentrate sample. The pan-concentrates are dominantly (>60%) composed of magnetite. Zircon, quartz, pyroxene, garnet, hornblende, feldspar, tourmaline, chromite, pyrite and rock fregments occur as minor constituents (see appendix).

Table 1 Geochemical data of the stream sediments pan concentrate from Timargara and Samar Bagh areas, southern Dir.(All values are in ppm)

S.No.	Au	Ag	Pb	Cu	Zn	Co	Ni	Cr
PC1	0.05	0.50	8	65	73	47	25	103
PC2	0.05	0.50	5	31	32	22	19	128
PC3	2.46	0.50	8	72	82	60	50	239
PC4	0.05	0.50	9	78	80	61	57	244
PC6	0.10	0.50	6	55	34	40	24	160
PC7	0.05	0.50	8	86	63	45	76	570
PC8	0.59	0.50	12	90	100	68	104	602
PC9	0.99	0.50	9	95	98	58	86	398
PC11	0.07	0.71	7	38	42	24	14	47
PC12	0.98	0.50	13	99	72	57	53	242
PC13	0.85	29.00	8	98	65	97	63	301
PC14	0.56	0.50	8	110	68	78	61	279
PC15	0.06	2.31	6	83	33	15	13	129
PC16	0.04	0.50	72	18	24	16	13	83
PC17	0.07	0.50	7	32	42	27	24	270
PC18	0.05	0.50	5	48	34	40	23	79
PC19	0.03	0.50	5	16	16	10	22	118
PC20	0.06	0.50	5	19	25	13	13	152
PC21	0.76	0.50	9	120	76	82	58	230
PC22	0.06	0.50	6	28	38	19	15	135
PC23	0.07	0.50	7	30	31	13	30	137
PC24	0.58	0.50	6	19	26	17	17	83
PC25	0.05	0.50	5	41	31	25	25	113

(continued table 1)

S.No.	Au	Ag	Pb	Cu	Zn	Co	Ni	Cr
PC26	2.54	0.50	5	51	43	16	17	105
PC27	0.05	0.50	5	16	31	15	24	186
PC28	0.27	0.50	8	43	50	68	52	142
PC29	0.59	1.29	102	429	32	41	36	139
PC31	0.04	0.50	145	40	27	20	26	125
PC32	1.56	1.07	11	105	85	43	51	320
PC33	0.04	0.50	5	8	27	16	22	139
PC35	0.06	0.50	88	33	37	21	61	201
PC36	0.04	0.50	5	32	25	19	21	108
PC37	0.10	1.02	10	65	55	35	29	117
PC38	0.63	1.31	13	39	66	39	100	603
PC39	0.05	0.50	5	15	29	15	41	465
PC40	0.47	0.50	17	173	72	48	50	89
PC41	0.05	0.50	12	90	80	85	43	241
PC42	0.94	0.50	15	93	79	53	50	147
PC43	0.05	0.50	18	94	81	51	41	152
PC44	3.47	1.04	10	36	59	40	71	585
PC44	0.21	2.09	21	63	80	59	21	105
PC46	0.49	1.29	13	36	52	28	77	851
PC47	0.09	0.85	9	19	51	26	70	530
PC48	0.04	0.50	11	10	14	10	49	620
PC49	0.09	0.89	9	37	36	28	75	1068
PC50	2.94	0.50	8	96	76	56	43	155
PC51	0.83	0.50	12	101	92	61	50	172
PC52	0 84	0.50	9	98	83	43	59	296
PC53	0.51	1.60	16	48	73	48	16	96
PC54	6.15	0.79	8	32	38	27	97	809
PC55	1.87	0.76	8	35	33	26	56	668
PC56	5.40	0.50	48	43	25	32	40	417
PC67	4.32	0.95	10	89	40	25	53	504
PC58	0.21	0.50	5	16	28	13	24	265
PC59	0.06	0.50	6	25	38	16	29	208
PC60	0.05	0.50	5	17	32	15	37	422

Table.2 Summery statistics for the stream sediment pan concentrates from Timargara and Samarbagh area, southern Dir.

	Au	Ag	Pb	Cu	Zn	Co	Ni	Cr
N	56	56	56	56	56	56	56	56
AVG	0.78	1.20	16.01	62.49	50.96	36.98	43.11	284.23
VAR	1.80	14.47	668.25	3732.97	557.36	467.26	567.31	51076
STD	1.34	3.80	25.85	61.10	23.61	21.62	23.82	226.00
CV	1.72	3.18	1.61	0.98	0.46	0.58	0.55	0.80
MAX	6.15	29.00	144.70	428.60	100.00	97.20	103.60	1067.5
MIN	0.03	0.50	5.00	7.81	14.26	9.98	12.51	46.69
D.L.	0.05	0.50	5.00	5.00	5.00	5.00	5.00	5.00
C.A.	0.004	0.07	13	55	70	25	75	100

N, number of samples; AVG, average (mean); VAR, variance;
STD, standard deviation; CV, coefficient of variation;
MAX, maximum value; MIN, minimum value; D.L., detection limit;
C.A., crustal abundance.

Table.3. Geochemical data of stream sediment fine fraction from Timargara and Samar Bagh areas, southern Dir. (All values are in ppm)

S No.	Au	Ag	Pb	Cu	Zn	Co	Ni	Cr
SS1	0.05	0.5	5	32	38	17	15	60
SS2	0.05	0.5	5	22	38	10	17	30
SS3	0.05	0.5	8	41	95	20	30	89
SS4	0.05	0.5	7	45	71	14	18	65
SS6	0.05	0.5	5	30	40	12	15	35
SS7	0.76	0.5	8	38	80	20	81	83
SS8	0.05	0.5	5	34	80	30	32	108
SS9	0.05	0.5	7	46	95	26	28	112
SS11	0.05	0.5	5	24	37	14	13	38
SS12	0.72	0.5	7	51	96	35	30	78
SS13	0.05	0.5	7	47	78	27	32	76
SS14	0.05	0.5	6	52	76	23	26	68
SS15	0.05	0.5	5	22	39	10	18	60
SS16	0.05	0.5	5	23	45	11	13	34
SS17	0.05	0.5	11	27	35	12	12	40
SS18	0.05	0.5	5	28	42	16	17	87
SS19	0.05	0.5	7	40	51	17	37	94
SS20	0.05	3.0	16	28	49	14	18	60
SS21	0.48	0.5	13	31	103	34	32	298
SS22	0.05	0.5	6	25	48	16	27	60
SS23	0.05	0.5	5	35	43	15	32	70
SS24	0.05	0.5	6	28	44	13	17	48
SS25	0.05	0.5	5	26	58	16	27	92

(continued table 3)

S.No.	Au	Ag	Pb	Cu	Zn	Co	Ni	Cr
SS26	0.05	0.5	6	46	53	15	29	70
SS27	0.05	0.5	5	23	39	9	25	48
SS28	0.05	0.5	5	28	45	12	37	70
SS29	0.05	0.5	5	18	42	11	30	68
SS31	0.05	0.5	5	45	49	15	33	54
SS32	0.05	0.5	5	22	39	9	25	70
SS33	0.05	0.5	5	28	41	10	23	54
SS35	0.05	0.5	5	39	42	16	58	150
SS36	0.05	0.5	5	27	48	13	25	56
SS37	0.05	0.5	5	19	37	10	21	50
SS38	0.05	0.5	5	22	34	7	23	70
SS39	0.05	12.0	20	35	32	10	30	120
SS40	0.05	0.5	15	38	80	30	32	113
SS41	0.05	0.5	17	39	94	43	40	112
SS42	0.5	0.5	13	31	117	36	32	84
SS43	0.56	0.5	16	33	127	32	31	78
SS44	0.05	0.5	5	20	42	10	20	65
SS45	0.05	3.6	6	40	52	12	27	105
SS46	0.05	0.5	5	22	38	9	17	90
SS47	0.05	0.5	5	22	35	7	23	70
SS48	0.05	0.5	5	26	32	11	25	120
SS49	0.05	0.5	5	32	25	10	16	98
SS50	0.05	0.5	14	42	108	26	34	89
SS51	0.05	0.5	16	38	84	24	34	73
SS52	0.74	0.5	18	40	93	28	32	80
SS53	0.05	0.5	5	24	50	11	22	80
SS54	0.05	0.5	5	43	53	13	30	108
SS55	0.05	0.5	5	58	40	14	24	106
SS56	0.05	0.5	5	74	43	14	24	80
SS57	0.05	0.5	7	39	46	12	18	93
SS58	0.05	0.5	21	36	53	11	18	74
SS59	0.05	0.5	8	25	58	10	21	62
SS60	0.05	0.5	5	37	45	12	24	114

Table. 4. Summery statistics for the stream sediment fine fraction from Timargara and Samarbagh area, southern Dir.

	Au	Ag	Pb	Cu	Zn	Co	Ni	Cr
N	56	56	56	56	56	56	56	56
AVG	0.11	0.74	6.88	33.68	57.09	16.74	26.61	81.41
VAR	0.03	2.46	24.51	118.48	609.61	72.71	121.48	1492.6
STD	0.18	1.57	4.95	10.88	24.69	8.53	11.02	38.63
CV	1.65	2.12	0.72	0.32	0.43	0.51	0.41	0.47
MAX	0.76	12.00	21.00	74.00	127.00	43.20	81.00	298.00
MIN	0.05	0.00	0.00	18.00	25.00	7.00	12.00	30.00
D.L.	0.05	0.50	5.00	5.00	5.00	5.00	5.00	5.00
C.A.	0.004	0.07	13	55	70	25	75	100

N, number of samples; AVG, average (mean); VAR, variance;
STD, standard deviation; CV, coefficient of variation;
MAX, maximum value; MIN, minimum value; D.L. detection limit;
C.A., crustal abundance.

Gold in the form of pieces (>0.5mm), specks (0.5-0.3mm) and colors (<0.3mm) is identified in certain streams mainly in the north eastern and north western portion of the studied area as shown in figure 4. Gold in the form of pieces (>0.5mm) has been observed in few pan concentrates of the study area. However, no nugget of gold has been noticed in the pan-concentrates. The specks and colors are generally angular to sub angular, some time subrounded in roundness, irregular to rectangular in shape and bright yellow in color. The detail mineralogy and texture of the pan concentrates are given in appendix.

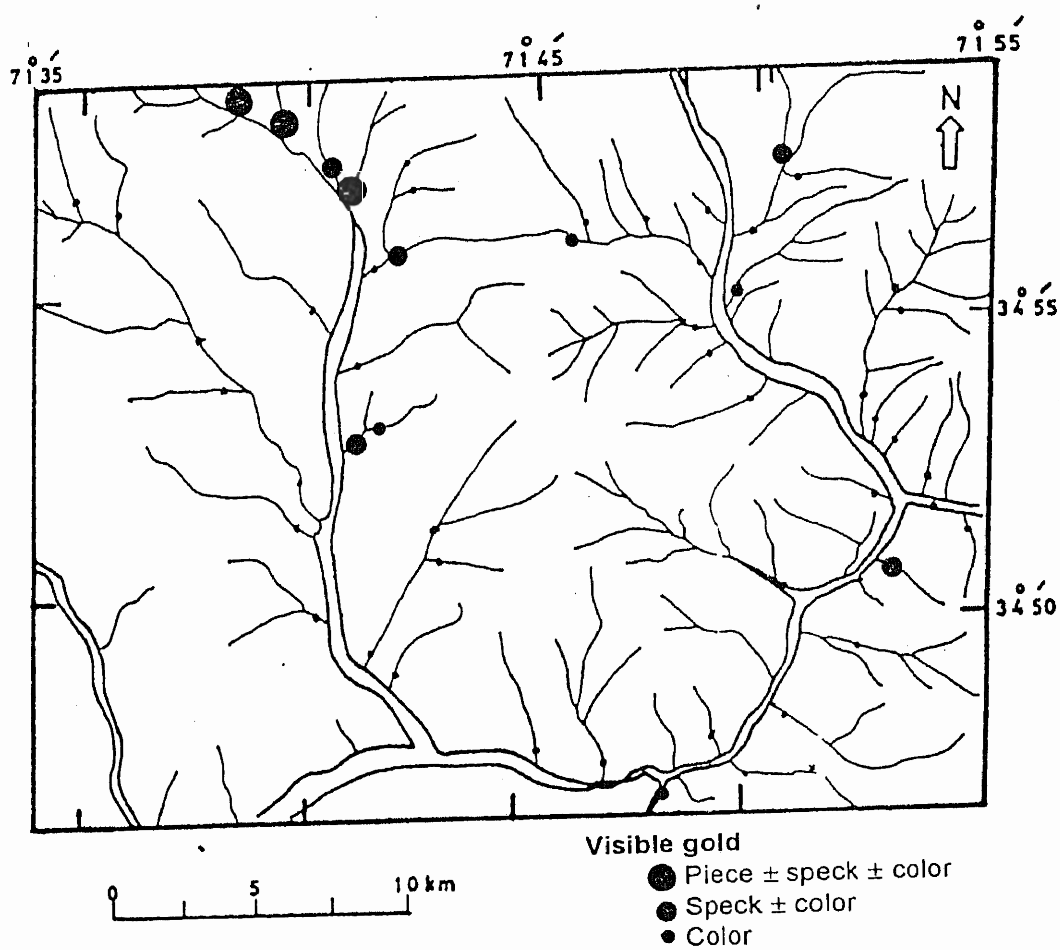


Fig. 4. Distribution map of visible gold of the study area.

INTERPRETATION OF GEOCHEMICAL DATA

In geochemical mapping and exploration studies, very heterogeneous geological environments are often sampled. Changing geological units, weathering and climatological conditions are continuously refining and modifying the geochemcial background values. In soil and stream sediment surveys, the informations concerning rock materials and their transportation effects are of greater concern. Consequently, the basic problems of data processing in geochemical exploration and mapping concern the determination of different geochemical backgrounds, thresholds and discrimination between background and anomalies. In most cases it is not possible to extract the relevant information related to surrounding rocks and mineralization from the analytical data of single element. For this purpose multielement analyses are required for routine determination. Besides the need for a well established geochemical background, sophisticated statistical methods are helpful in reducing and interpreting the resulting data sets. Reviews of useful statistical methods are given in Howarth (1983) and in Rock (1988).

In the exploration geochemistry the terms "threshold and geochemical anomaly" are most commonly used. Threshold is the concentration of an indicator element above which a sample is considered anomalous. In other words threshold is the upper limit of normal background fluctuation, any higher values are anomalies, and lower values are background. A geochemical anomaly can be termed as deviation from the norm. More specifically it can be defined as departure from the geochemical patterns that are normal for a given area of geochemical environment. Those anomalies which are directly related to the mineralization are known as the significant anomalies and those superficially similar anomalies unrelated to ore are termed as non-significant anomalies. These could be the scavenging of metals by limonitic or manganiferous accumulations, artificial contamination by mining, industrial or agricultural activities.

The interpretation of geochemical data involves consideration of multiple population of data. In data from a survey, a log-normally distributed population of background samples may constitute one population. Samples near ore and affected by dispersion involving the ore can be considered as second population. Samples related to certain rock types or unusual aspects of the environment may define additional populations.

A variety of methods have been devised for extracting an anomalous population out of composite population during the interpretation of data in geochemical exploration (Lepertier, 1969; Sinclair, 1974, 1976; otsn et al., 1948; Tennant and White, 1959). The methods of Tennant and White (1959) and Sinclair (1974, 1976) have been used during this study. These methods seem to be most excellent in theoretical consideration, for the data processing during this study. The procedure of the data processing is as follows:

1. First of all the data was ranked (arranged) in order of increasing magnitude.

2. The data was divided into specific intervals of uniform width by a common formula: [K]=10.log10N: where [K] is the largest integer (number of intervals) contained in the right hand expression, and N is the number of observations.

3. The interval width was determined by dividing the largest value of the indicator element by the value of [K] and the value obtained was rounded to a whole number. The interval width obtained by this method was further synthesized and final value, very close to the first, was selected as an interval width. This is evident from tables 5 & 6.

4. The class frequency, relative frequency, cumulative frequency and cumulative relative frequency (%) were calculated for each element (Tables 5 & 6).

5. The cumulative frequency curve was constructed by plotting cumulative frequency distribution vs logarithmic concentration on a log-probability paper for each element (Figs. 5 & 6).

6. A cumulative frequency distribution curve was subdivided into several parts at break points. In other words the mixture of two or more normal populations plot as linear segments separated by curved segments containing an inflection point. This resulted in S-shaped curve, representing two log-normal populations (Figs. 5 & 6).

7. Besides the cumulative frequency curve (Fig. 5 & 6) the histograms of each element for both pan concentrates (Fig. 7) and fine fraction (Fig. 8) are also constructed.
8. Considering both these frequency distribution diagrams and other factors, a nominal threshold value for each indicator element has been selected during this study, which indicate the upper limit of the background values.

9. The data above threshold for each element are divided into low order and high order anomalous values by considering the frequency distribution diagrams.

10. Both background along with low order and high order anomalous values for each element are plotted on each stream site, for both pan-concentrates (Fig. 9) and -80 mesh stream sediment samples (Fig. 10), on a topographic map.

DISPLAYING AND EVALUATION OF DATA

The chemical data, obtained by analyzing the rock samples and pan concentrates and fine fractions of stream sediments and rocks, have been displayed and evaluated by using single element and multielements diagrams in order to pin point areas of most interest.

(A) Single element presentation

Basic statistics, cumulative frequency curve and histograms of each element are shown in tables 5 and 6, figures 5 and 6 and figures 7 and 8 respectively. The distribution maps of each element on the basis of its concentration in pan-concentrate and fine fraction (-80 mesh) are prepared and are shown in figures 9 and 10 respectively. The results are discussed as follows:

Table.5. Statistacal data calculated for the construction of cumulative frequency curve for various elements determined in pan cocentrates of the studied area.

GOLD (Au)

1		2	3	4	5	6
0.00	0.50	0.25	34	61	34	61
0.50	1.00	0.75	14	25	48	86
1.00	1.50	1.25	0	0	48	86
1.50	2.00	1.75	2	4	50	89
2.00	2.50	2.25	1	2	51	91
2.50	3.00	2.75	1	2	52	93
3.00	3.50	3.25	1	2	53	95
3.50	4.00	3.75	0	0	53	95
4.00	4.50	4.25	1	2	54	96
4.50	5.00	4.75	0	0	54	96
5.00	5.50	5.25	1	2	55	98
5.50	6.00	5.75	0	0	55	98
6.00	6.50	6.25	1	2	56	100

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

SILVER (Ag)

1		2	3	4	5	6
0.00	1.50	0.75	52	93	52	93
1.50	3.00	2.25	3	5	55	98
3.00	4.50	3.75	0	0	55	98
4.50	6.00	5.25	0	0	55	98
6.00	7.50	6.75	0	0	55	98
7.50	9.00	8.25	0	0	55	98
9.00	10.50	9.75	0	0	55	98
10.50	12.00	11.25	0	0	55	98
12.00	13.50	12.75	0	0	55	98
13.50	15.00	14.25	0	0	55	98
15.00	16.50	15.75	0	0	55	98
16.50	18.00	17.25	0	0	55	98
18.00	19.50	18.75	0	0	55	98
19.50	21.00	20.25	0	0	55	98
21.00	22.50	21.75	0	0	55	98
22.50	24.00	23.25	0	0	55	98
24.00	25.50	24.75	0	0	55	98
25.50	27.00	26.25	0	0	55	98
27.00	28.50	27.75	0	0	55	98
28.50	30.00	29.25	1	2	56	100
30.00	31.50	30.75	0	0	56	100
31.50	33.00	32.25	0	0	56	100

1 = class interval
2 = Mid Point
3 = frequency

4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

COPPER (Cu)

1		2	3	4	5	6
0.00	25.00	12.5	13	23	13	23
25	50	37.5	18	32	31	55
50	75	62.5	6	11	37	66
75	100	87.5	13	23	50	89
100	125	112.5	4	7	54	96
125	150	137.5	0	0	54	96
150	175	162.5	1	2	55	98
175	200	187.5	0	0	55	98
200	225	212.5	0	0	55	98
225	250	237.5	0	0	55	98
250	275	262.5	0	0	55	98
275	300	287.5	0	0	55	98
300	325	312.5	0	0	55	98
325	350	337.5	0	0	55	98
350	375	362.5	0	0	55	98
375	400	387.5	0	0	55	98
400	425	412.5	0	0	55	98
425	450	437.5	1	2	56	100

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

ZINC (Zn)

1		2	3	4	5	6
0	5	2.5	0	0	0	0
5	10	7.5	0	0	0	0
10	15	12.5	0	0	0	0
15	20	17.5	2	4	2	4
20	25	22.5	3	5	5	9
25	30	27.5	4	7	9	16
30	35	32.5	10	18	19	34
35	40	37.5	6	11	25	45
40	45	42.5	4	7	29	52
45	50	47.5	1	2	30	54
50	55	52.5	3	5	33	59
55	60	57.5	0	0	33	59
60	65	62.5	2	4	35	63
65	70	67.5	2	4	37	66
70	75	72.5	4	7	41	73
75	80	77.5	7	13	48	86
80	85	82.5	5	9	53	95
85	90	87.5	0	0	53	95
90	95	92.5	1	2	54	96
95	100	97.5	2	4	56	100

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

LEAD (PB)

1		2	3	4	5	6
0	10	5	38	68	38	68
10	20	15	12	21	50	89
20	30	25	1	2	51	91
30	40	35	0	0	51	91
40	50	45	1	2	52	93
50	60	55	0	0	52	93
60	70	65	0	0	52	93
70	80	75	1	2	53	95
80	90	85	1	2	54	96
90	100	95	0	0	54	96
100	110	105	1	2	55	98
110	120	115	0	0	55	98
120	130	125	0	0	55	98
130	140	135	0	0	55	98
140	150	145	1	2	56	100

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

NICKLE (Ni)

1		2	3	4	5	6
0	5	2.5	0	0	0	0
5	10	7.5	0	0	0	0
10	15	12.5	5	9	5	9
15	20	17.5	4	7	9	16
20	25	22.5	11	20	20	36
25	30	27.5	4	7	24	43
30	35	32.5	0	0	24	43
35	40	37.5	3	5	27	48
40	45	42.5	4	7	31	55
45	50	47.5	5	9	36	64
50	55	52.5	4	7	40	71
55	60	57.5	4	7	44	79
60	65	62.5	3	5	47	84
65	70	67.5	1	2	48	86
70	75	72.5	2	4	50	89
75	80	77.5	2	4	52	93
80	85	82.5	1	2	53	95
85	90	87.5	1	2	54	96
90	95	92.5	0	0	54	96
95	100	97.5	1	2	55	98
100	105	102.5	1	2	56	100

1 = class interval
2 = Mid Point
3 = frequency

4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

CHROMIUM (Cr)

1		2	3	4	5	6
0	50	25	1	2	1	2
50	100	75	5	9	6	11
100	150	125	16	29	22	40
150	200	175	6	11	28	51
200	250	225	7	13	35	63
250	300	275	4	7	39	70
300	350	325	2	4	41	74
350	400	375	2	4	43	77
400	450	425	2	4	45	81
450	500	475	1	2	46	83
500	550	525	1	2	47	85
550	600	575	2	4	49	88
600	650	625	3	5	52	93
650	700	675	1	2	53	95
700	750	725	0	0	53	95
750	800	775	0	0	53	95
800	850	825	1	2	54	97
850	900	875	1	2	55	99
900	950	925	0	0	55	99
950	1000	975	0	0	55	99
1000	1050	1025	0	0	55	99
1050	1100	1075	1	2	56	101

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

COBALT (Co)

1		2	3	4	5	6
0	5	2.5	0	0	0	0
5	10	7.5	2	4	2	4
10	15	12.5	7	13	9	17
15	20	17.5	8	14	17	31
20	25	22.5	5	9	22	40
25	30	27.5	6	11	28	50
30	35	32.5	3	5	31	56
35	40	37.5	3	5	34	61
40	45	42.5	4	7	38	68
45	50	47.5	3	5	41	74
50	55	52.5	2	4	43	77
55	60	57.5	5	9	48	86
60	65	62.5	2	4	50	90
65	70	67.5	2	4	52	93
70	75	72.5	0	0	52	93
75	80	77.5	1	2	53	95
80	85	82.5	2	4	55	99
85	90	87.5	0	0	55	99
90	95	92.5	0	0	55	99
95	100	97.5	1	2	56	100

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

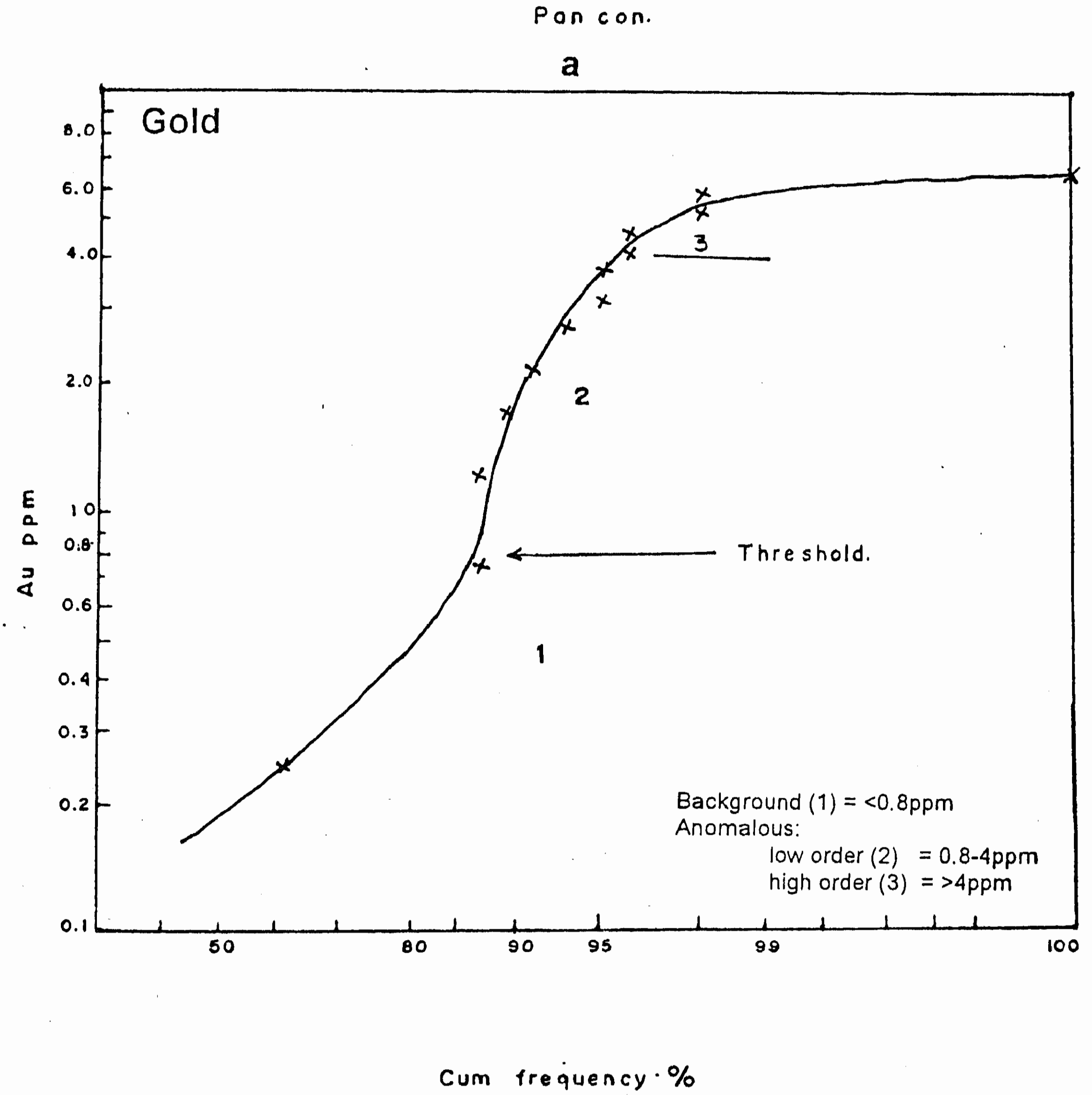
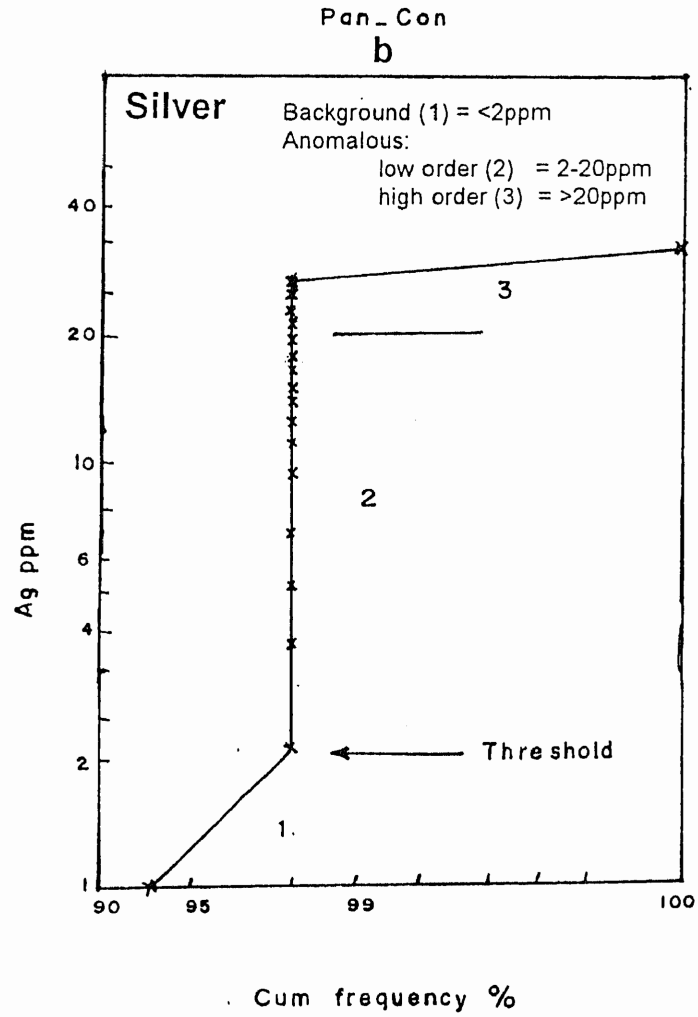
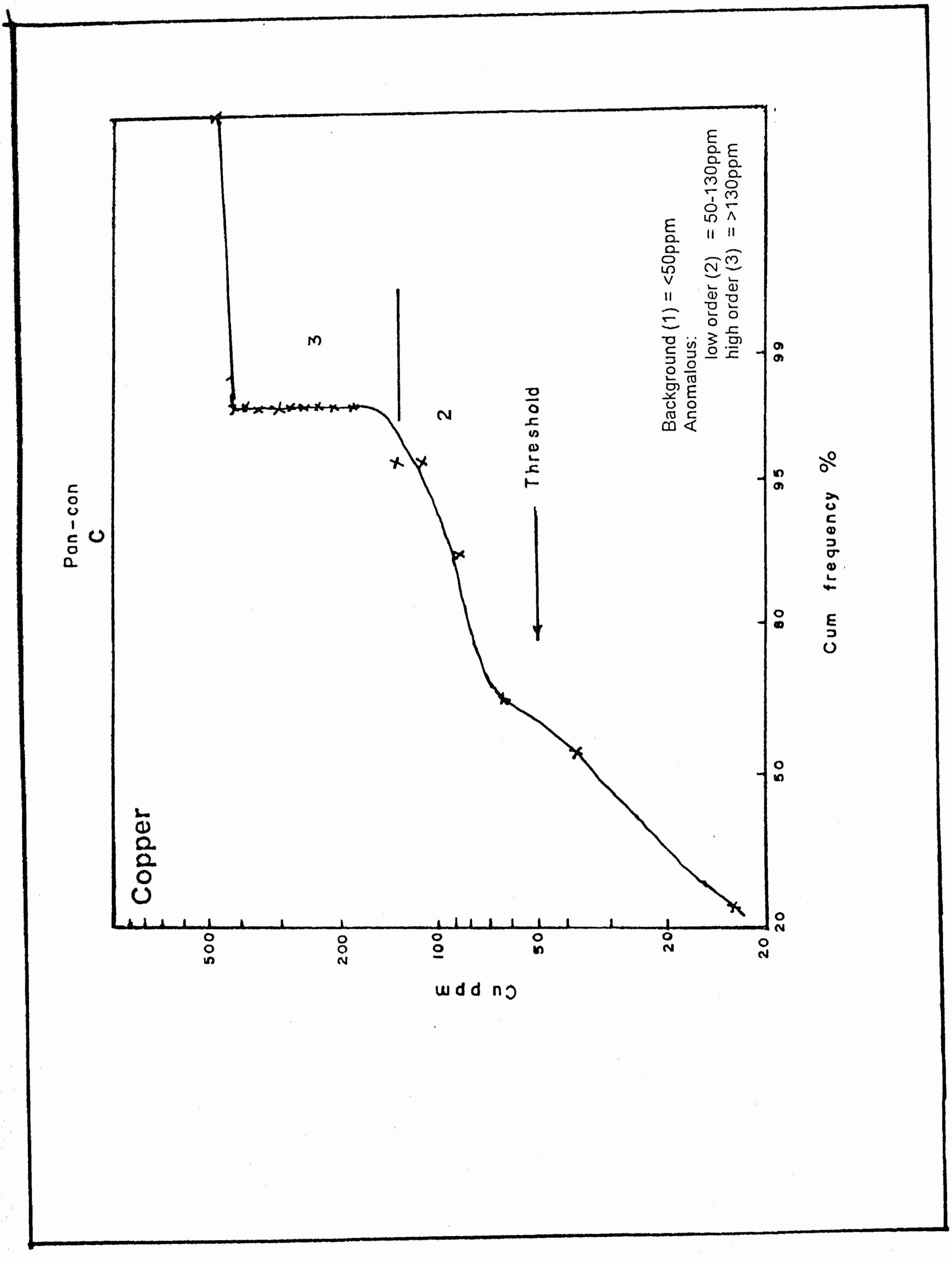
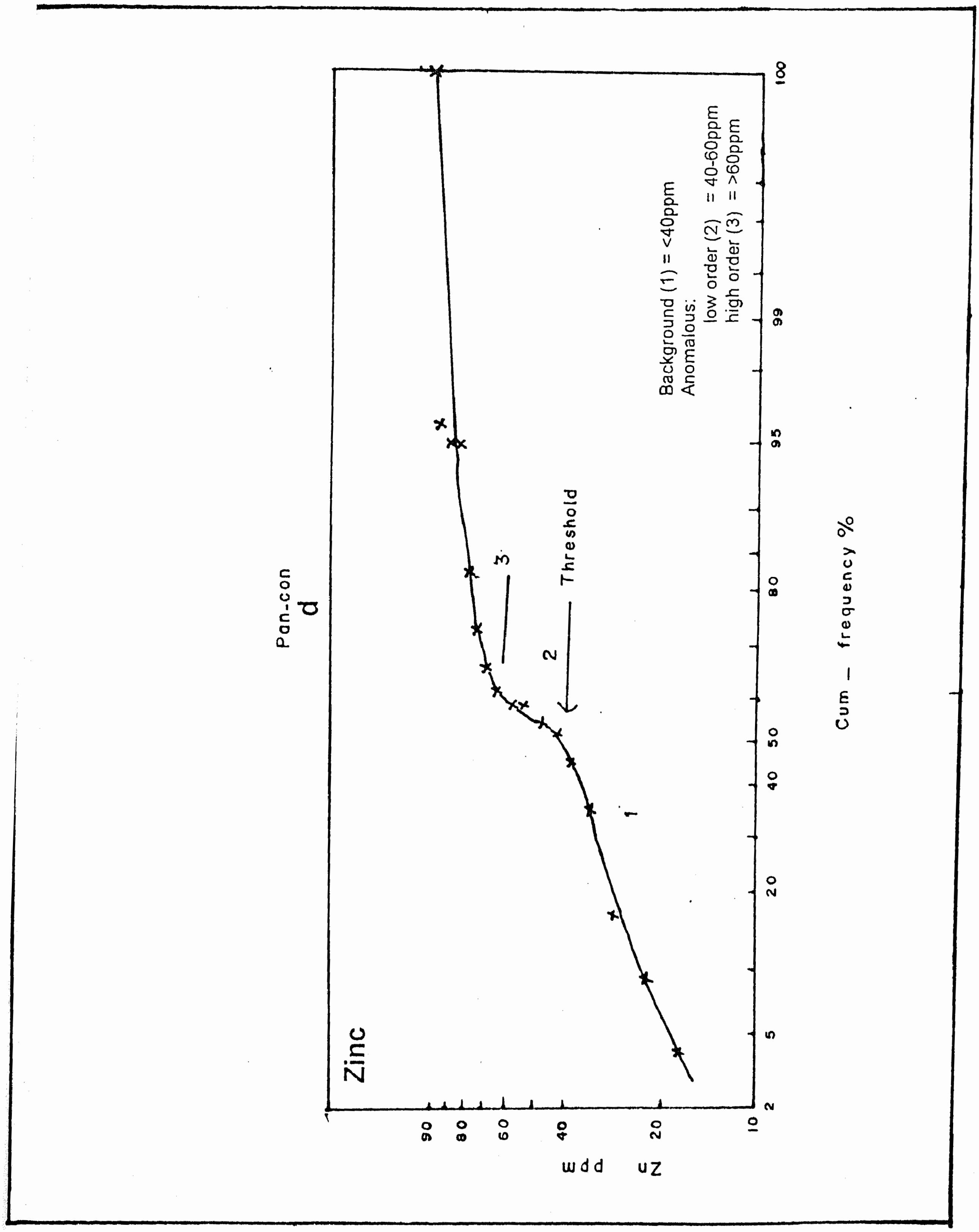


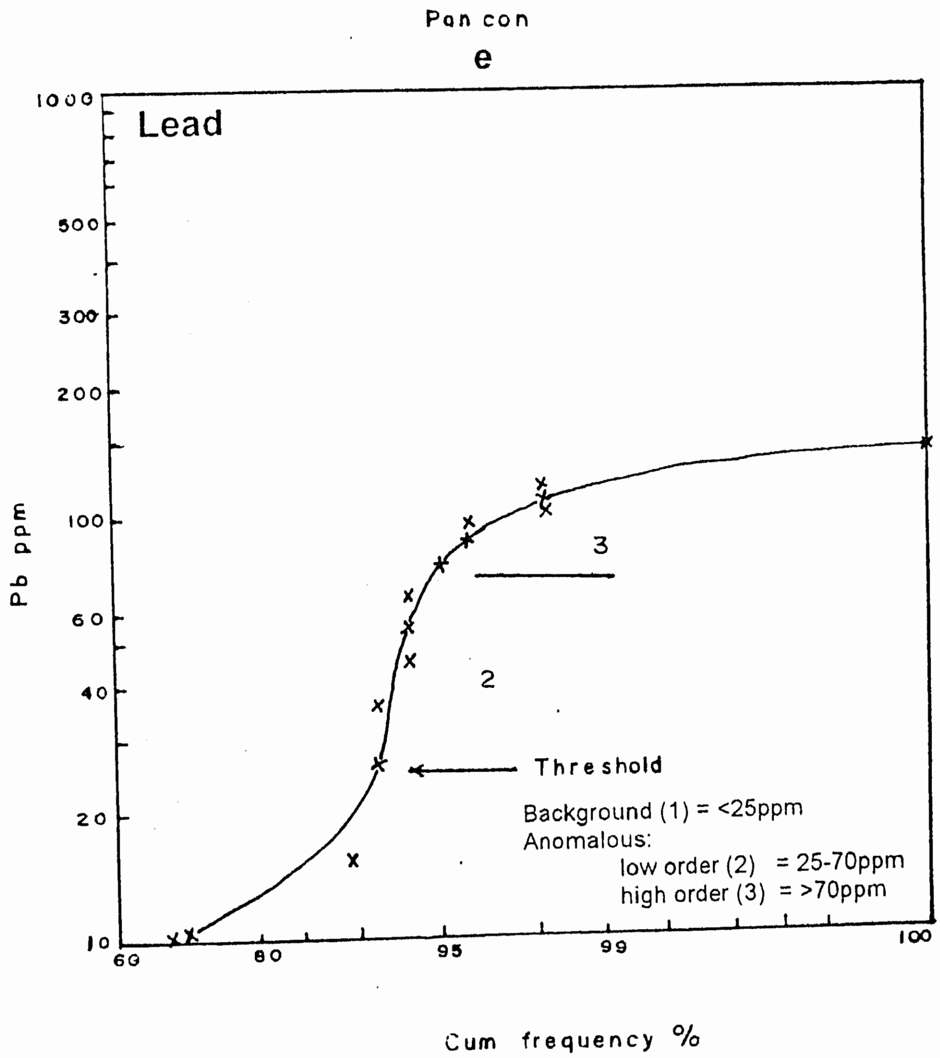
Fig. 5. Cumulative frequency curves for Au, Ag, Cu, Zn, Pb, Ni, Cr and Co for the pan concentrates of the study area.


Pan_Con
b
Silver
Background (1) = <2ppm
Anomalous:
low order (2) = 2-20ppm
high order (3) = >20ppm
3
2
1.
Threshold
Ag ppm
40
20
10
6
4
2
1
90
95
99
100
Cum frequency %



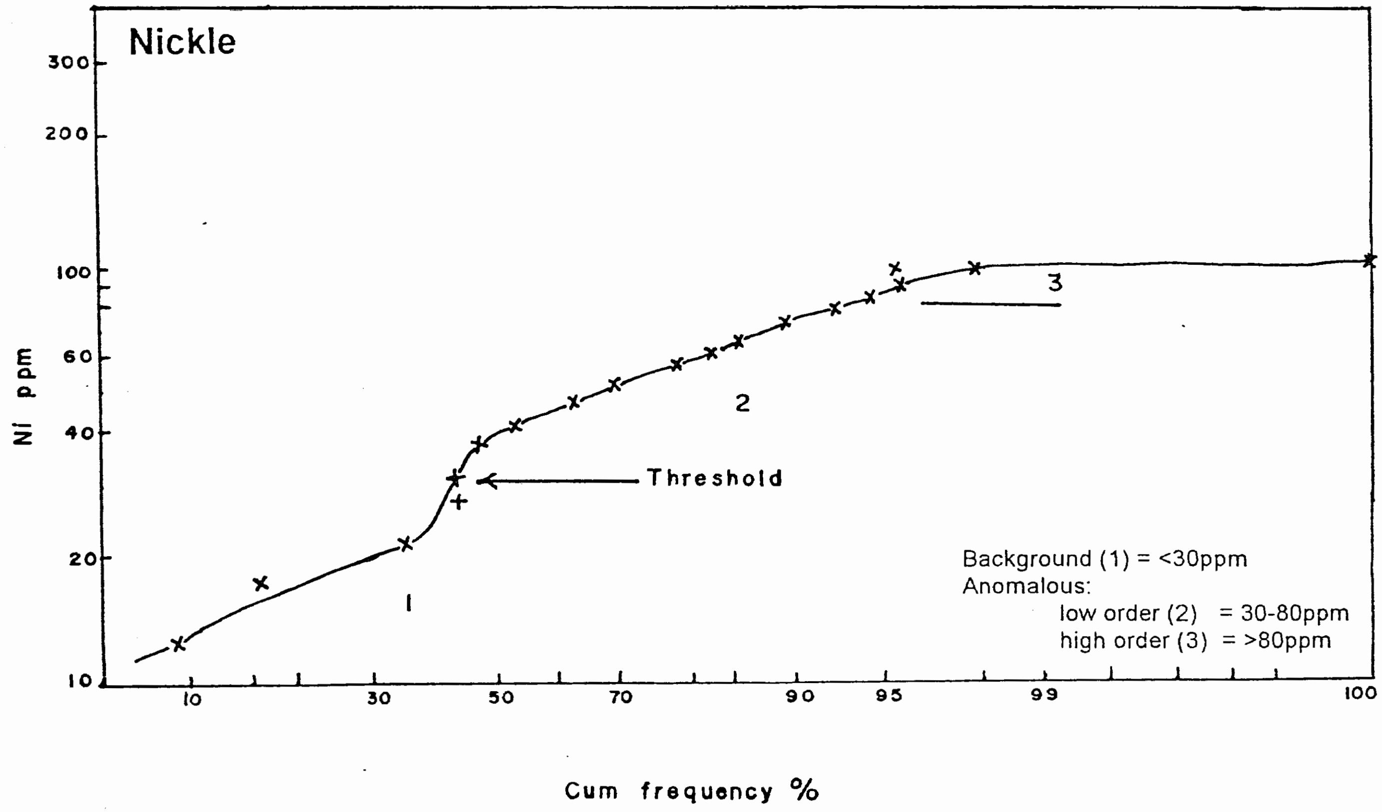
Pan-con
C
Copper
Cu ppm
500
200
100
50
20
20
20
50
80
95
99
Cum frequency %
Threshold
3
2
Background (1) = <50ppm
Anomalous:
low order (2) = 50-130ppm
high order (3) = >130ppm


Pan-con
d
Zinc
Threshold
1
2
3
Background (1) = <40ppm
Anomalous:
low order (2) = 40-60ppm
high order (3) = >60ppm
Cum _ frequency %
Zn ppm

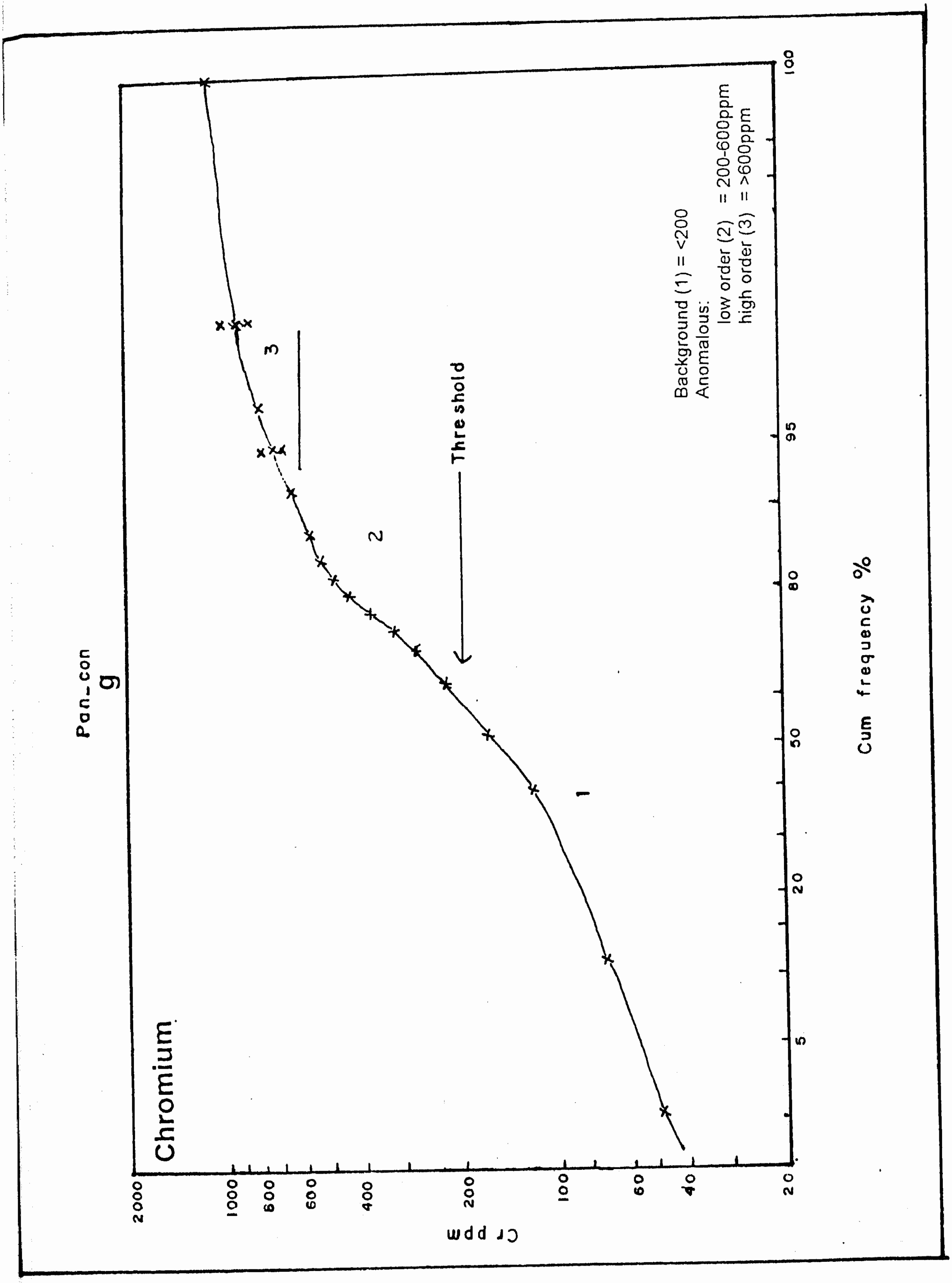

Pan con
e
Lead
1000
500
300
200
100
60
40
20
10
Pb ppm
60
80
95
99
100
Cum frequency %
3
2
Threshold
Background (1) = <25ppm
Anomalous:
low order (2) = 25-70ppm
high order (3) = >70ppm

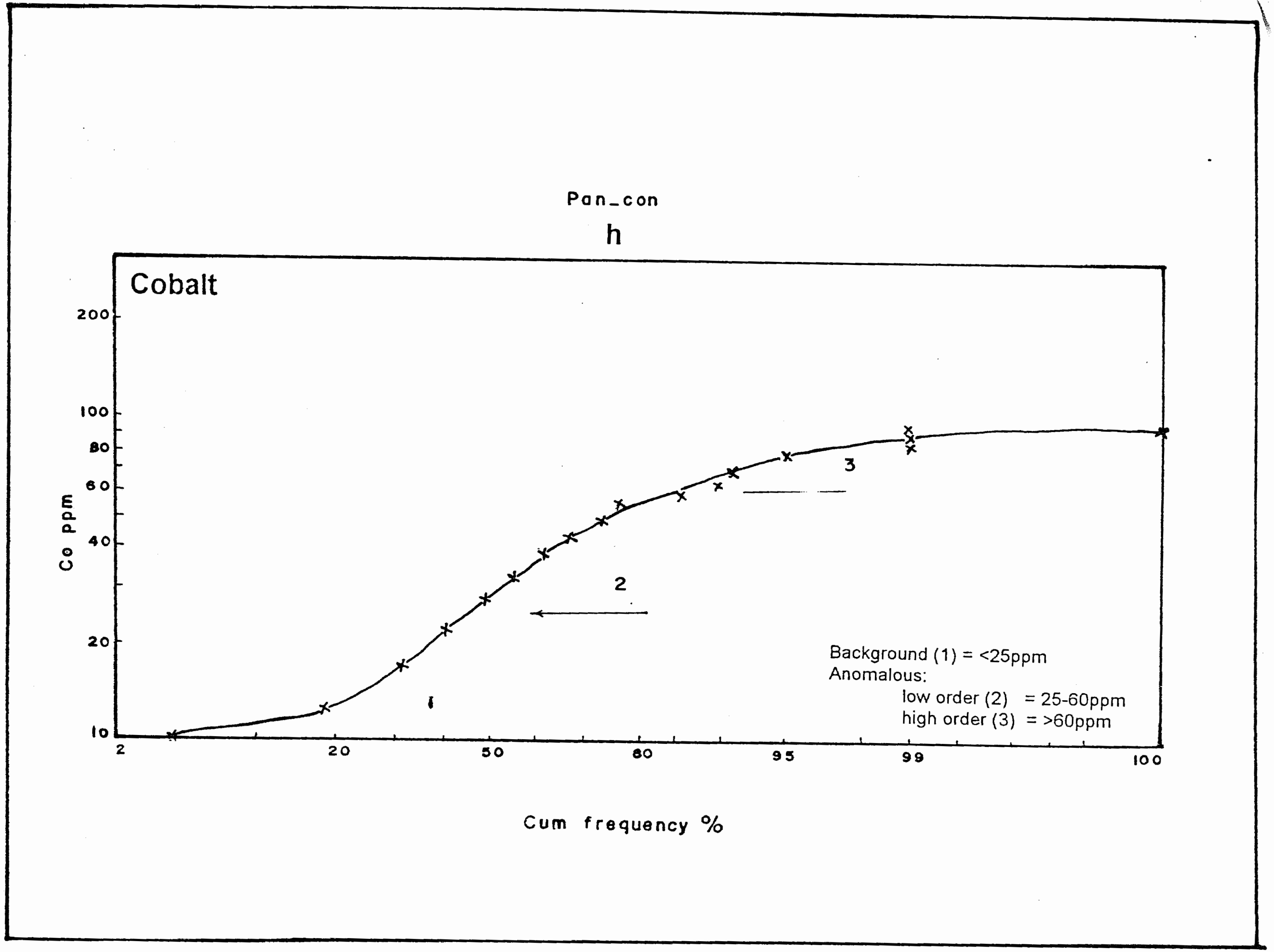
Pan_con

f



Nickle
Ni ppm
300
200
100
60
40
20
10
10
30
50
70
90
95
99
100
Cum frequency %
1
2
3
Threshold
Background (1) = <30ppm
Anomalous:
low order (2) = 30-80ppm
high order (3) = >80ppm


Chromium
Pan_con
g
Cr ppm
2000
1000
800
600
400
200
100
60
40
20
Cum frequency %
5
20
50
80
95
100
Threshold
1
2
3
Background (1) = <200
Anomalous:
low order (2) = 200-600ppm
high order (3) = >600ppm



Pan_con
h
Cobalt
Co ppm
200
100
80
60
40
20
10
2
20
50
80
95
99
100
Cum frequency %
1
2
3
Background (1) = <25ppm
Anomalous:
low order (2) = 25-60ppm
high order (3) = >60ppm

Table 6. Statistacal data calculated for the construction of cumulative frequency curve for various elements determined in fine fraction of the studied area.

GOLD (Au)

1		2	3	4	5	6
0.00	0.05	0.025	50	89	56	89
0.05	0.10	0.075	0	0	50	89
0.10	0.15	0.125	0	0	50	89
0.15	0.20	0.175	0	0	50	89
0.20	0.25	0.225	0	0	50	89
0.25	0.30	0.275	0	0	50	89
0.30	0.35	0.325	0	0	50	89
0.35	0.40	0.375	0	0	50	89
0.40	0.45	0.425	0	0	50	89
0.45	0.50	0.475	1	2	51	91
0.50	0.55	0.525	1	2	52	93
0.55	0.60	0.575	1	2	53	95
0.60	0.65	0.625	0	0	53	95
0.65	0.70	0.675	0	0	53	95
0.70	0.75	0.725	2	4	55	98
0.75	0.80	0.775	1	2	56	100

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

SILVER (Ag)

1		2	3	4	5	6
0.00	0.50	0.25	53	95	53	95
0.50	1.00	0.75	0	0	53	95
1.00	1.50	1.25	0	0	53	95
1.50	2.00	1.75	0	0	53	95
2.00	2.50	2.25	0	0	53	95
2.50	3.00	2.75	1	2	54	96
3.00	3.50	3.25	1	2	55	98
3.50	4.00	3.75	0	0	55	98
4.00	4.50	4.25	0	0	55	98
4.50	5.00	4.75	0	0	55	98
5.00	5.50	5.25	0	0	55	98
5.50	6.00	5.75	0	0	55	98
6.00	6.50	6.25	0	0	55	98
6.50	7.00	6.75	0	0	55	98
7.00	7.50	7.25	0	0	55	98
7.50	8.00	7.75	0	0	55	98
8.00	8.50	8.25	0	0	55	98
8.50	9.00	8.75	0	0	55	98
9.00	9.50	9.25	0	0	55	98
9.50	10.00	9.75	0	0	55	98
10.00	10.50	10.25	0	0	55	98
10.50	11.00	10.75	0	0	55	98
11.00	11.50	11.25	0	0	55	98
11.50	12.00	11.75	1	2	56	100

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

COPPER (Cu)

1		2	3	4	5	6
0	5	2.5	0	0	0	0
5	10	7.5	0	0	0	0
10	15	12.5	0	0	0	0
15	20	17.5	3	5	3	5
20	25	22.5	12	21	15	27
25	30	27.5	10	18	25	45
30	35	32.5	8	14	33	59
35	40	37.5	10	18	43	77
40	45	42.5	7	13	50	89
45	50	47.5	2	4	52	93
50	55	52.5	2	4	54	96
55	60	57.5	1	2	55	98
60	65	62.5	0	0	55	98
65	70	67.5	0	0	55	98
70	75	72.5	1	2	56	100

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

ZINC (Zn)

1		2	3	4	5	6
0	5	2.5	0	0	0	0
5	10	7.5	0	0	0	0
10	15	12.5	0	0	0	0
15	20	17.5	0	0	0	0
20	25	22.5	0	0	0	0
25	30	27.5	1	2	1	2
30	35	32.5	0	0	1	2
35	40	37.5	5	9	6	11
40	45	42.5	10	18	16	29
45	50	47.5	11	20	27	48
50	55	52.5	6	11	33	59
55	60	57.5	5	9	38	68
60	65	62.5	3	5	41	73
65	70	67.5	0	0	41	73
70	75	72.5	0	0	41	73
75	80	77.5	1	2	42	75
80	85	82.5	5	9	47	84
85	90	87.5	1	2	48	86
90	100	95	0	0	48	86
100	105	102.5	5	9	53	95
105	110	107.5	1	2	54	96
110	115	112.5	1	2	55	98
115	120	117.5	0	0	55	98
120	125	122.5	1	2	56	100
125	130	127.5	0	0	56	100

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

LEAD (Pb)

1		2	3	4	5	6
0	1	0.5	0	0	0	0
1	2	1.5	0	0	0	0
2	3	2.5	0	0	0	0
3	4	3.5	0	0	0	0
4	5	4.5	31	55	31	55
5	6	5.5	4	7	35	63
6	7	6.5	6	11	41	73
7	8	7.5	3	5	44	79
8	9	8.5	0	0	44	79
9	10	9.5	0	0	44	79
10	11	10.5	1	2	45	80
11	12	11.5	0	0	45	80
12	13	12.5	2	4	47	84
13	14	13.5	1	2	48	86
14	15	14.5	1	2	49	88
15	16	15.5	3	5	52	93
16	17	16.5	1	2	53	95
17	18	17.5	1	2	54	96
18	19	18.5	0	0	54	96
19	20	19.5	1	2	55	98
20	21	20.5	1	2	56	100

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

NICKLLE (Ni)

1		2	3	4	5	6
0	5	2.5	0	0	0	0
5	10	7.5	0	0	0	0
10	15	12.5	5	9	5	9
15	20	17.5	11	20	16	29
20	25	22.5	13	23	29	52
25	30	27.5	11	20	40	71
30	35	32.5	11	20	51	91
35	40	37.5	3	5	54	96
40	45	42.5	0	0	54	96
45	50	47.5	0	0	54	96
50	55	52.5	0	0	54	96
55	60	57.5	1	2	55	98
60	65	62.5	0	0	55	98
65	70	67.5	0	0	55	98
70	75	72.5	0	0	55	98
75	80	77.5	0	0	55	98
80	85	82.5	1	2	56	100

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

CHROMIUM (Cr)

1		2	3	4	5	6
0	20	10	0	0	0	0
20	40	30	5	9	5	9
40	60	50	10	18	15	27
60	80	70	19	34	34	61
80	100	90	10	18	44	79
100	120	110	10	18	54	96
120	140	130	0	0	54	96
140	160	150	1	2	55	98
160	180	170	0	0	55	98
180	200	190	0	0	55	98
200	220	210	0	0	55	98
220	240	230	0	0	55	98
240	260	250	0	0	55	98
260	280	270	0	0	55	98
280	300	290	1	2	56	100

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

COBALT (Co)

1		2	3	4	5	6
0	3	1.5	0	0	0	0
3	6	4.5	0	0	0	0
6	9	7.5	5	9	5	9
9	12	10.5	19	34	24	43
12	15	13.5	11	20	35	63
15	18	16.5	6	11	41	73
18	21	19.5	2	4	43	77
21	24	22.5	1	2	44	79
24	27	25.5	4	7	48	86
27	30	28.5	1	2	49	88
30	33	31.5	3	5	52	93
33	36	34.5	2	4	54	96
36	39	37.5	1	2	55	98
39	42	40.5	0	0	55	98
42	45	43.5	1	2	56	100

1 = class interval
2 = Mid Point
3 = frequency
4 = relative frequency (%)
5 = cumulative frequency
6 = relative cumul. frequency (%)

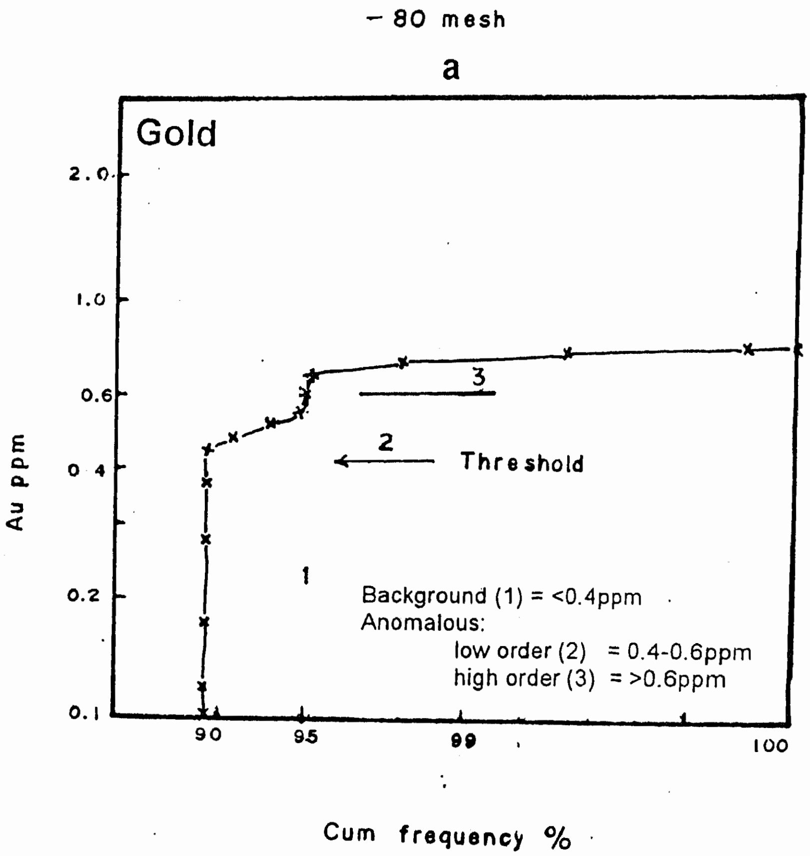
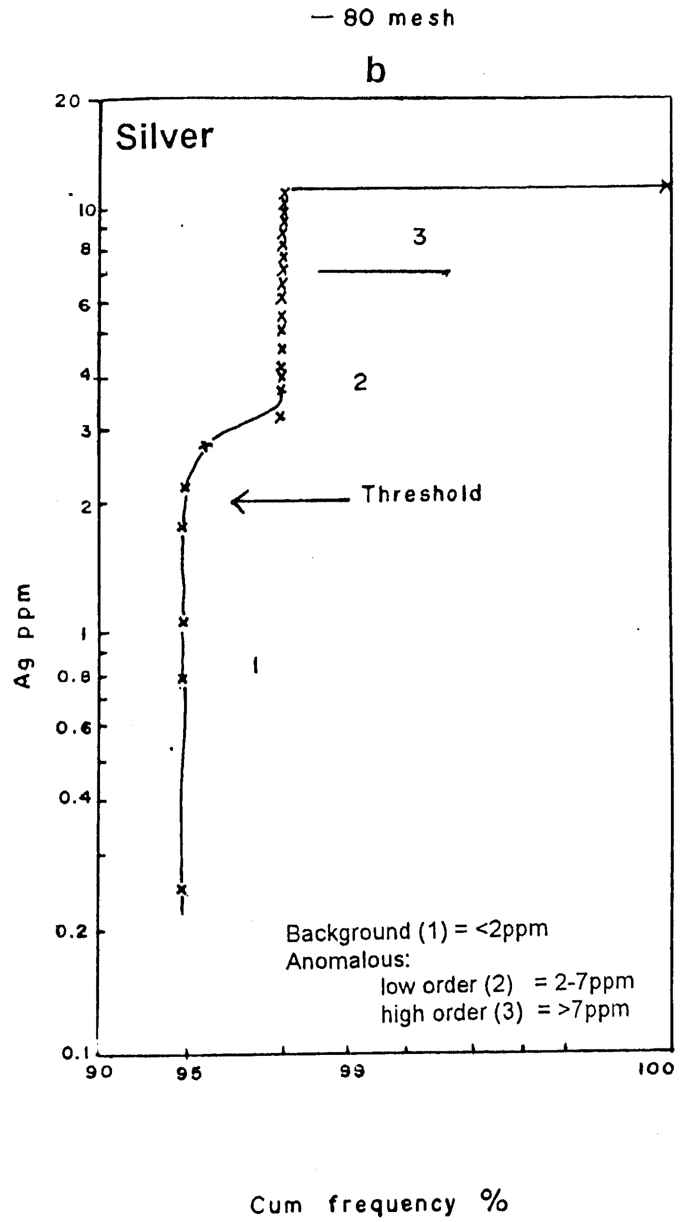
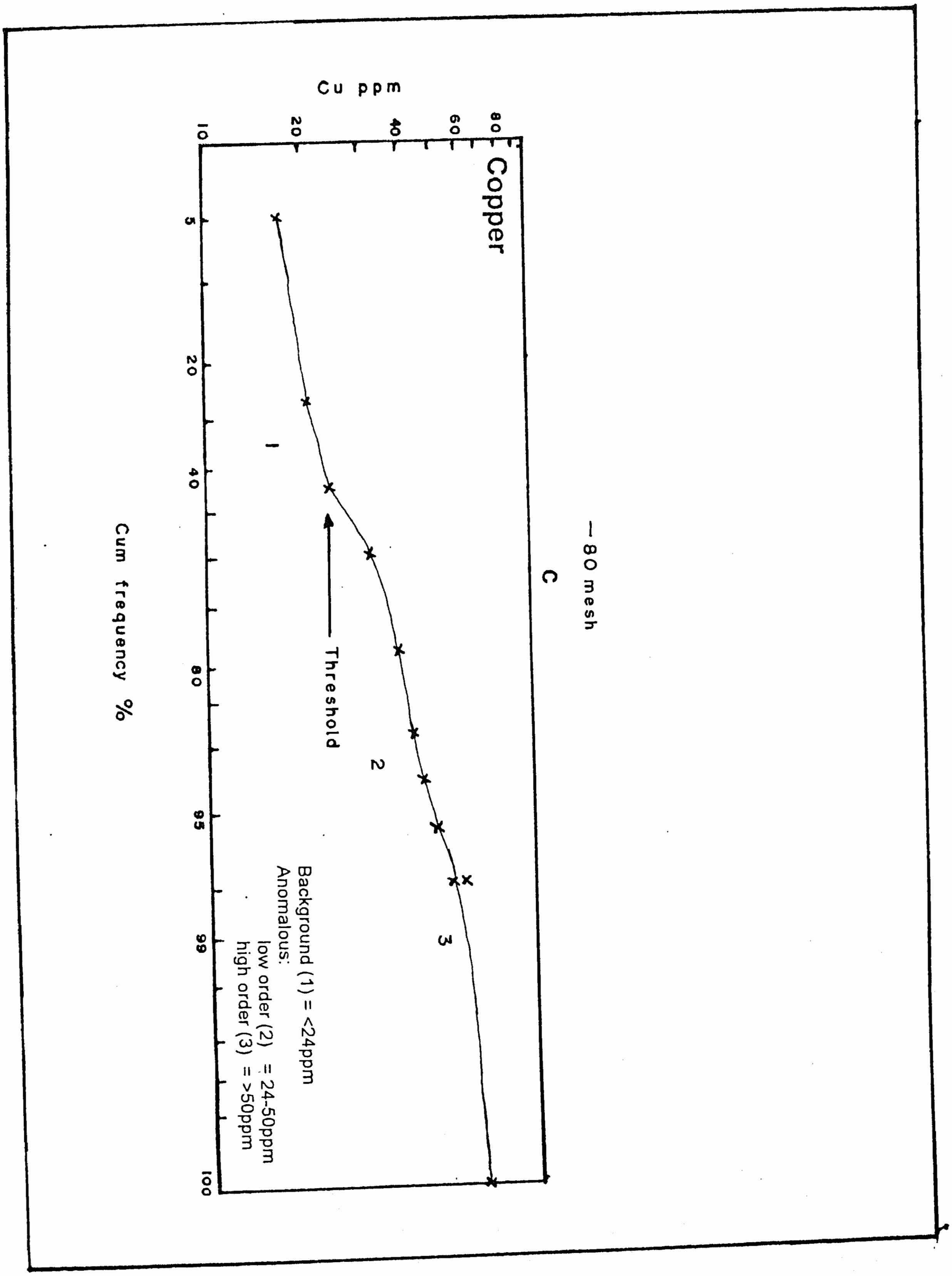


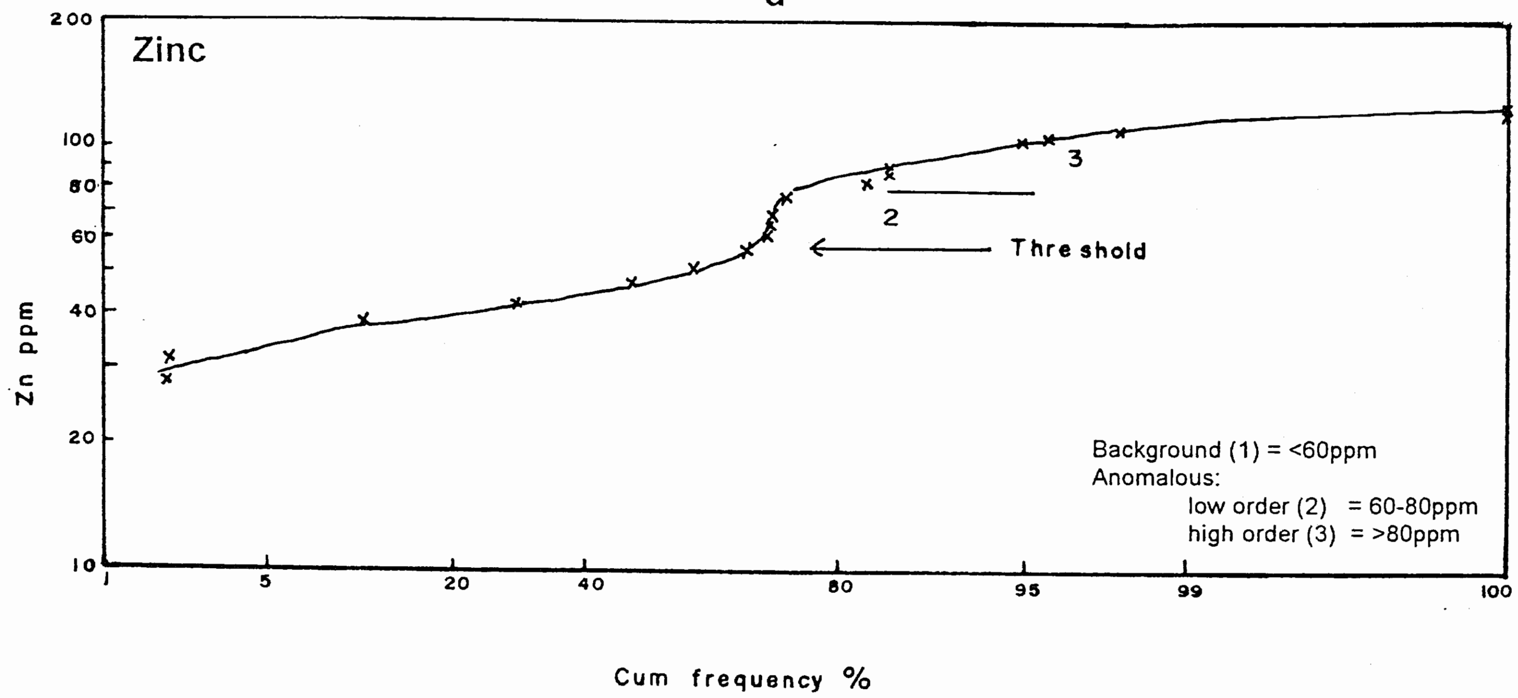
Fig. 6. Cumulative frequency curves for Au, Ag, Cu, Zn, Pb, Ni, Cr and Co for the fine fractions (-80 mesh) of the study area.

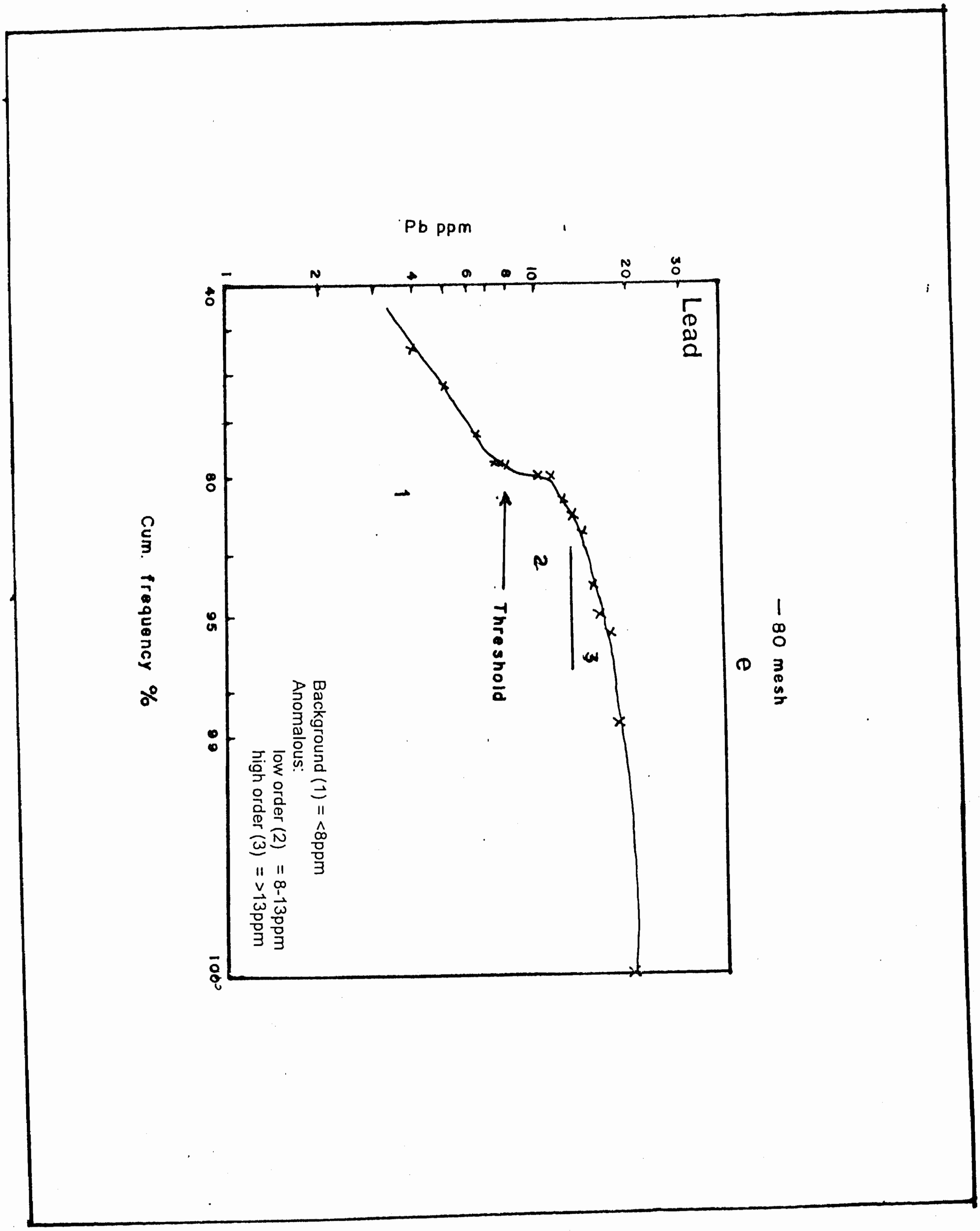

— 80 mesh
b
Silver
Ag ppm
20
10
8
6
4
3
2
1
0.8
0.6
0.4
0.2
0.1
90
95
99
100
3
2
1
Threshold
Background (1) = <2ppm
Anomalous:
low order (2) = 2-7ppm
high order (3) = >7ppm
Cum frequency %

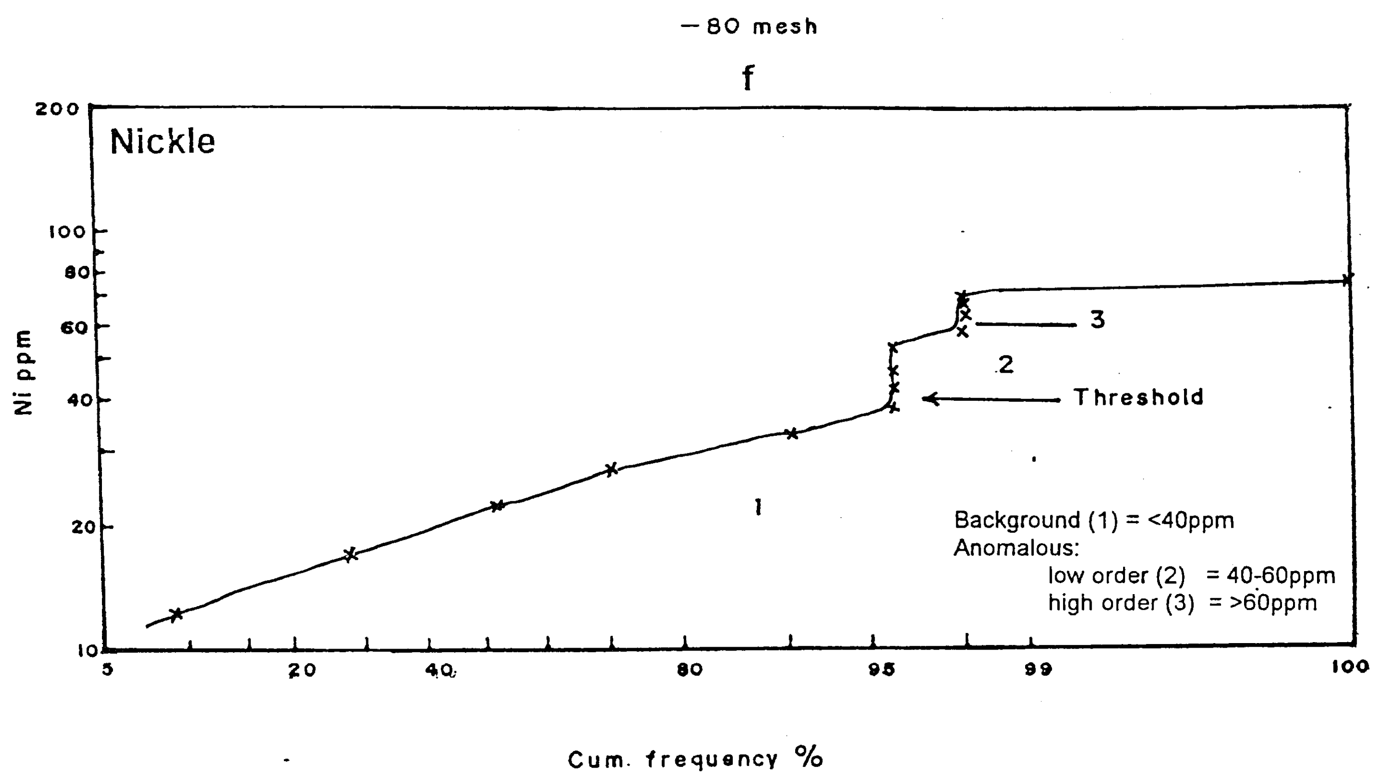

-80 mesh
C
Copper
Cu ppm
Cum frequency %
Threshold
Background (1) = <24ppm
Anomalous:
low order (2) = 24-50ppm
high order (3) = >50ppm

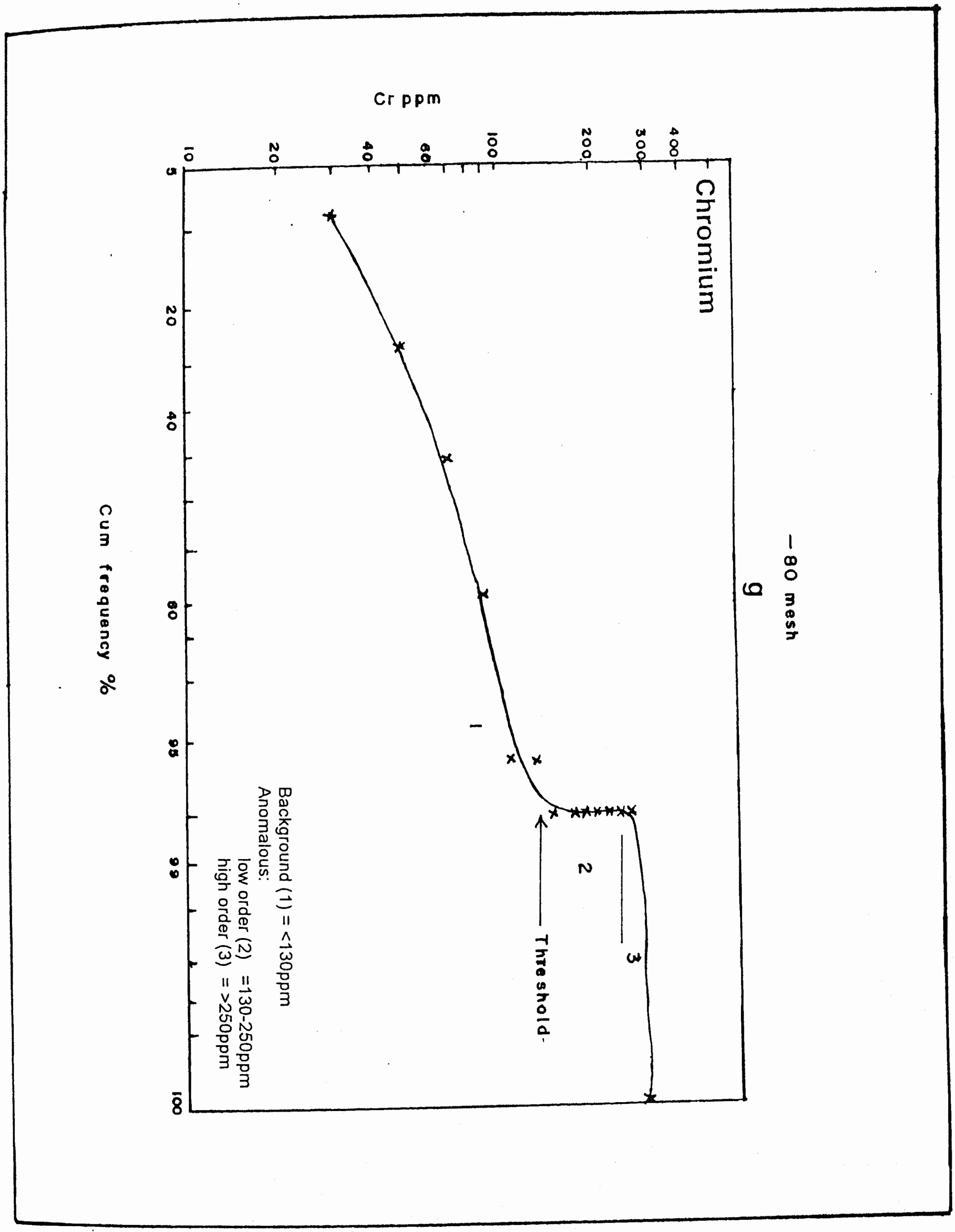
— 80 mesh

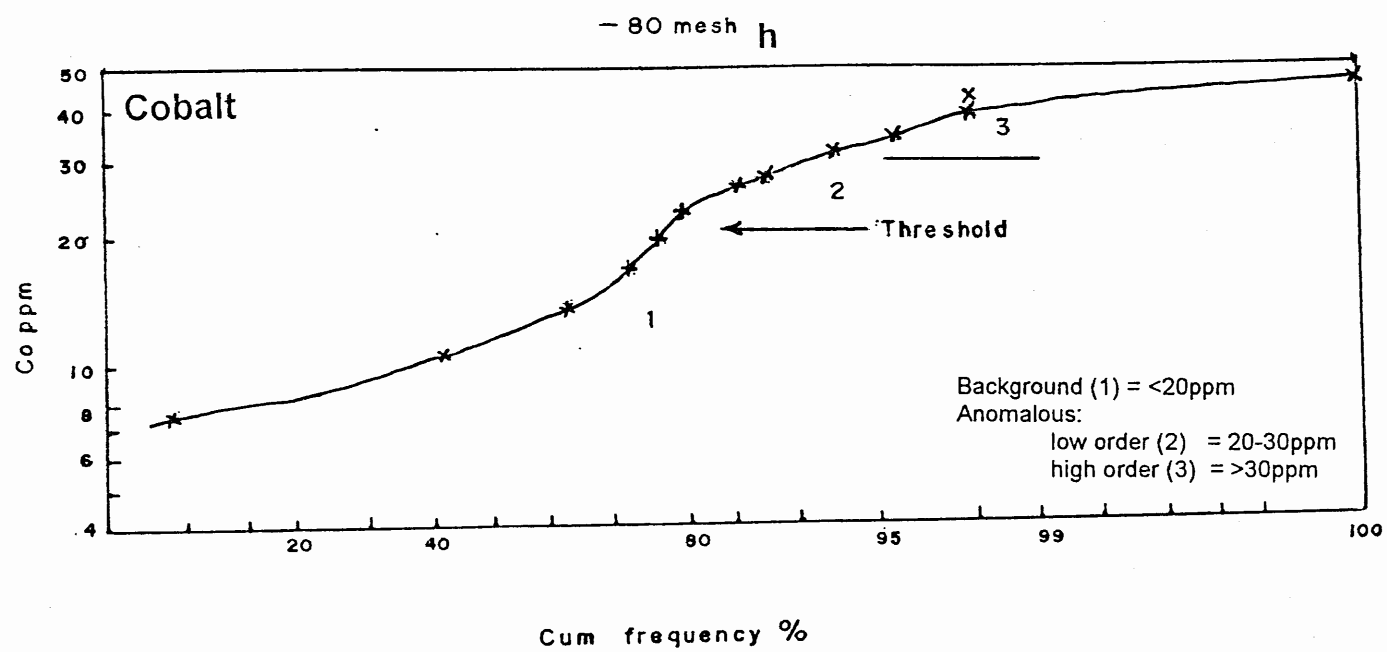
d


Zinc
Zn ppm
200
100
80
60
40
20
10
1
5
20
40
80
95
99
100
Cum frequency %
2
3
Thre shold
Background (1) = <60ppm
Anomalous:
low order (2) = 60-80ppm
high order (3) = >80ppm

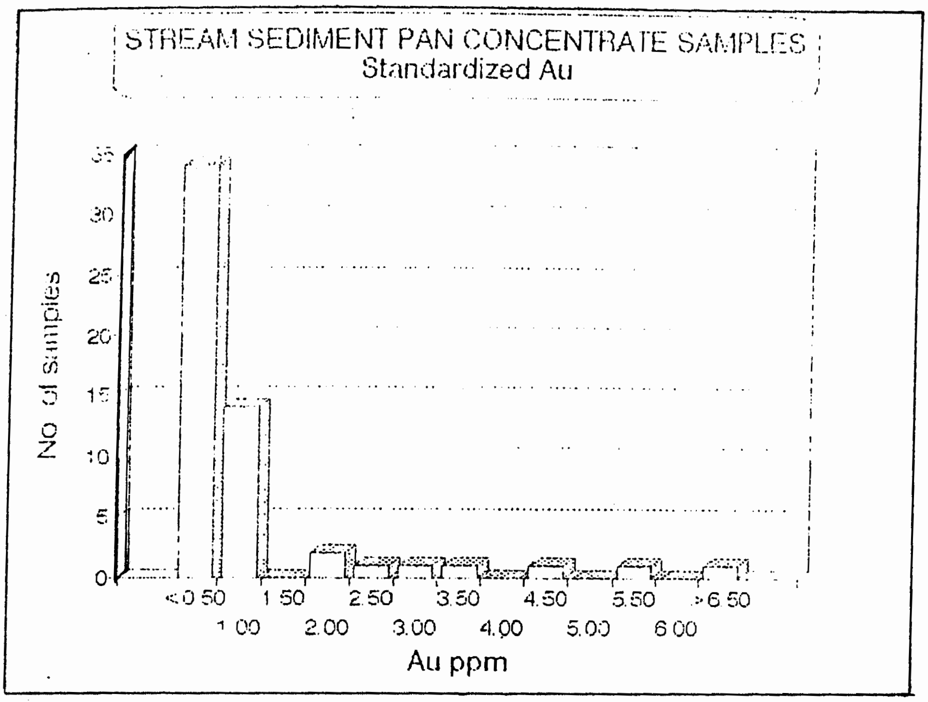

Lead
e
−80 mesh
Pb ppm
1
2
4
6
8
10
20
30
40
80
95
99
100
Cum. frequency %
1
2
3
Threshold
Background (1) = <8ppm
Anomalous:
low order (2) = 8-13ppm
high order (3) = >13ppm


—80 mesh
f
Nickle
Ni ppm
200
100
80
60
40
20
10
5
20
40
80
95
99
100
Cum. frequency %
1
2
3
Threshold
Background (1) = <40ppm
Anomalous:
low order (2) = 40-60ppm
high order (3) = >60ppm


Chromium
-80 mesh
g
Cr ppm
10
20
40
60
100
200
300
400
Cum frequency %
5
20
40
80
95
99
100
Background (1) = <130ppm
Anomalous:
low order (2) =130-250ppm
high order (3) = >250ppm
Threshold
1
2
3


- 80 mesh h
Cobalt
Co ppm
50
40
30
20
10
8
6
4
20
40
80
95
99
100
Cum frequency %
1
2
3
Threshold
Background (1) = <20ppm
Anomalous:
low order (2) = 20-30ppm
high order (3) = >30ppm

a



b

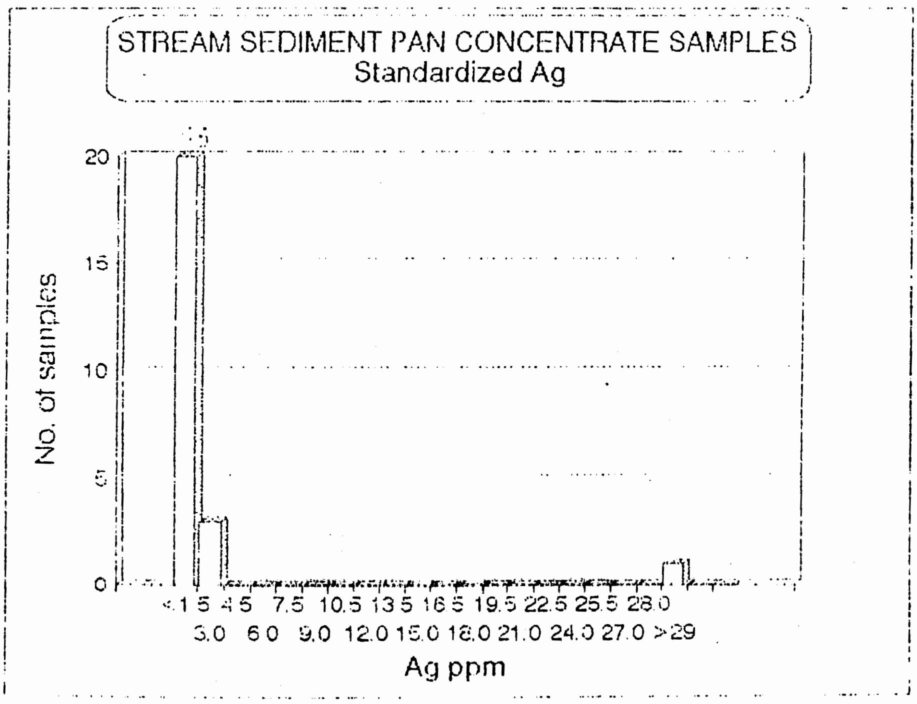
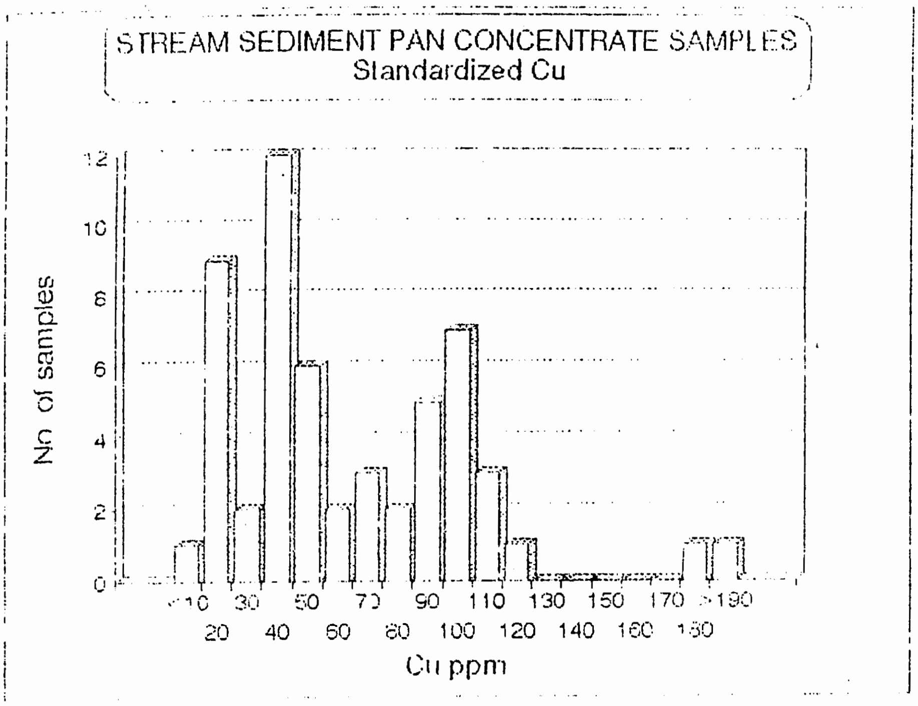
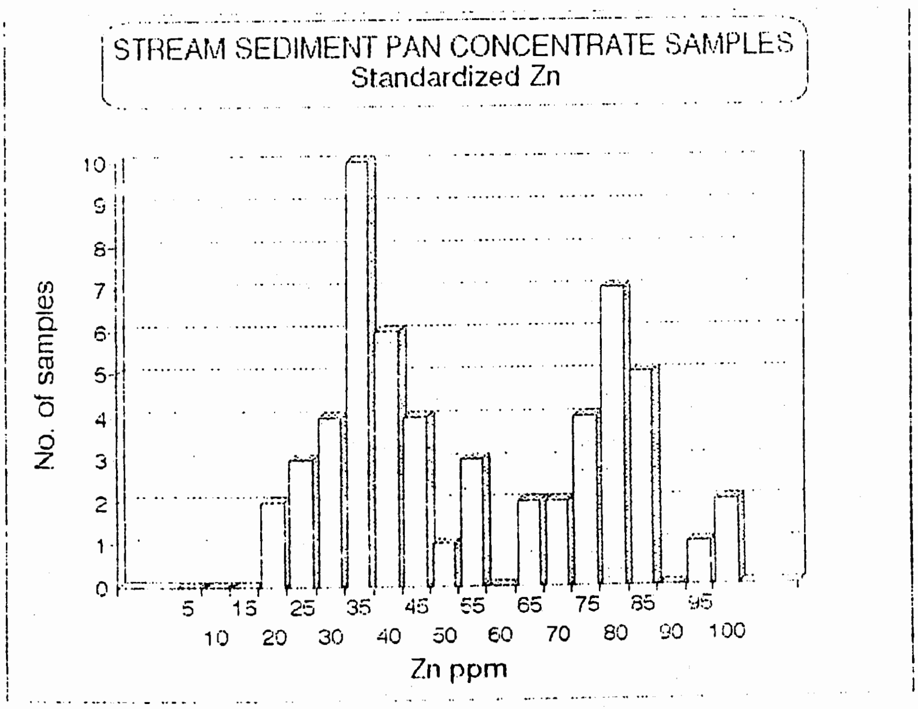


Fig. 7. Frequency histograms for Au, Ag, Cu, Zn, Pb, Ni, Cr and Co for the pan concentrates of the study area.

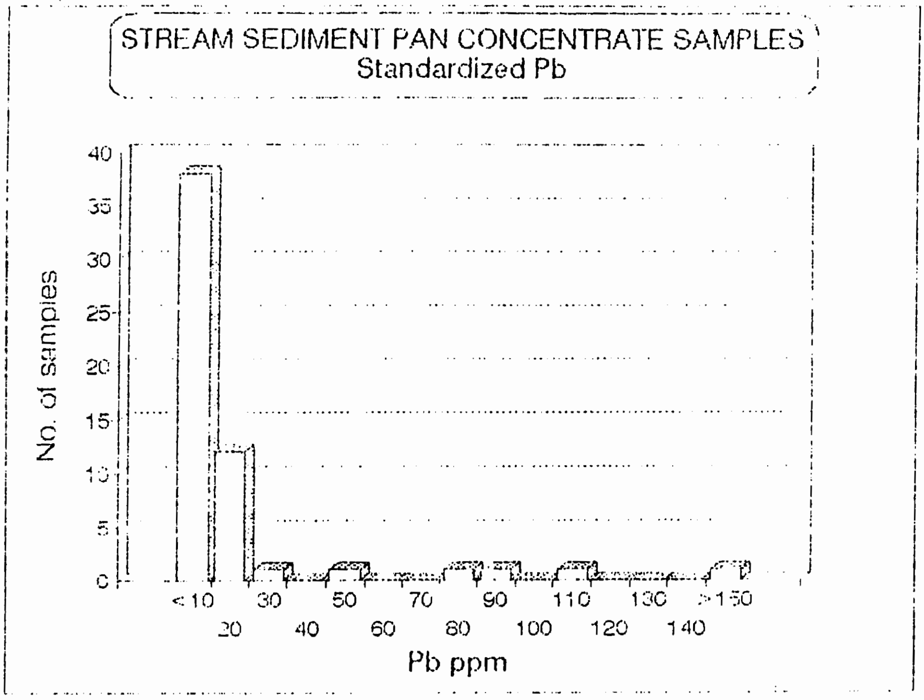
c


STREAM SEDIMENT PAN CONCENTRATE SAMPLES
Standardized Cu
No. of samples
Cu ppm
<10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
>190

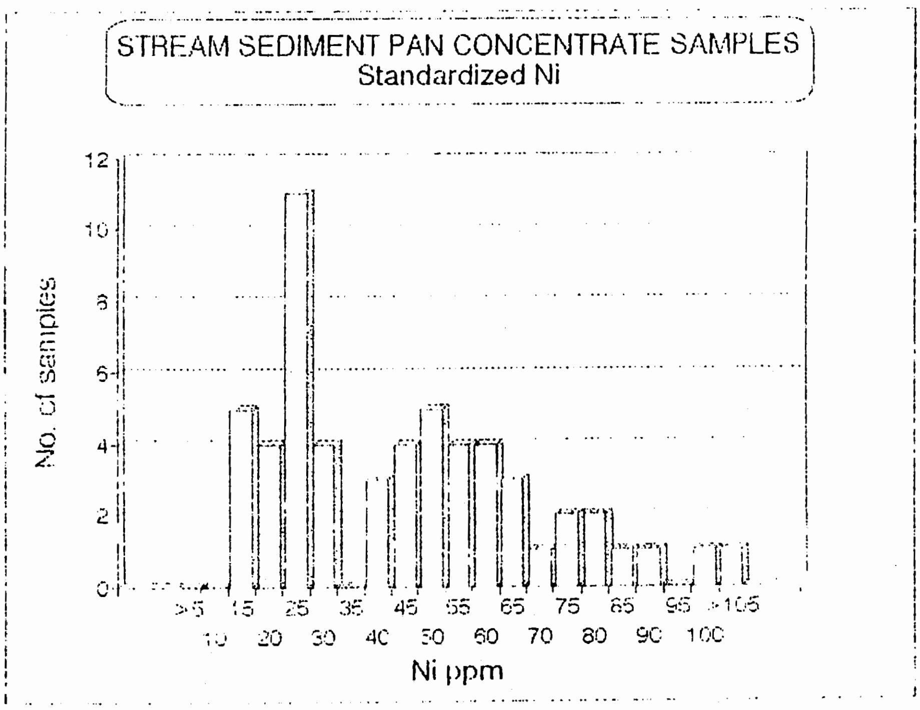
d


STREAM SEDIMENT PAN CONCENTRATE SAMPLES
Standardized Zn
No. of samples
Zn ppm
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100

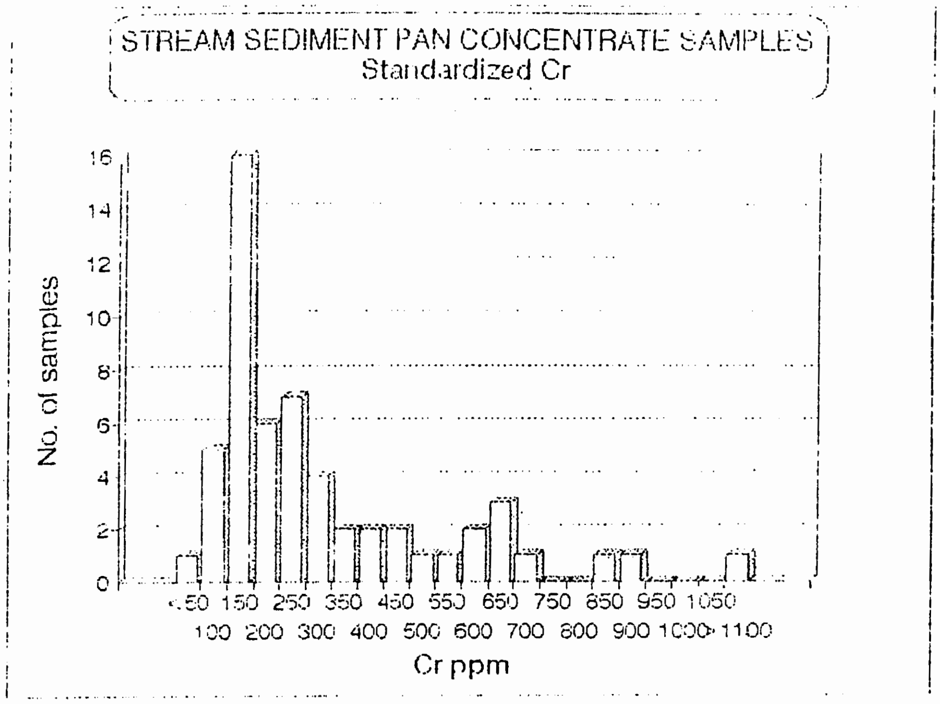
e


STREAM SEDIMENT PAN CONCENTRATE SAMPLES
Standardized Pb
No. of samples
0
5
10
15
20
25
30
35
40
<10
30
50
70
90
110
130
>150
20
40
60
80
100
120
140
Pb ppm

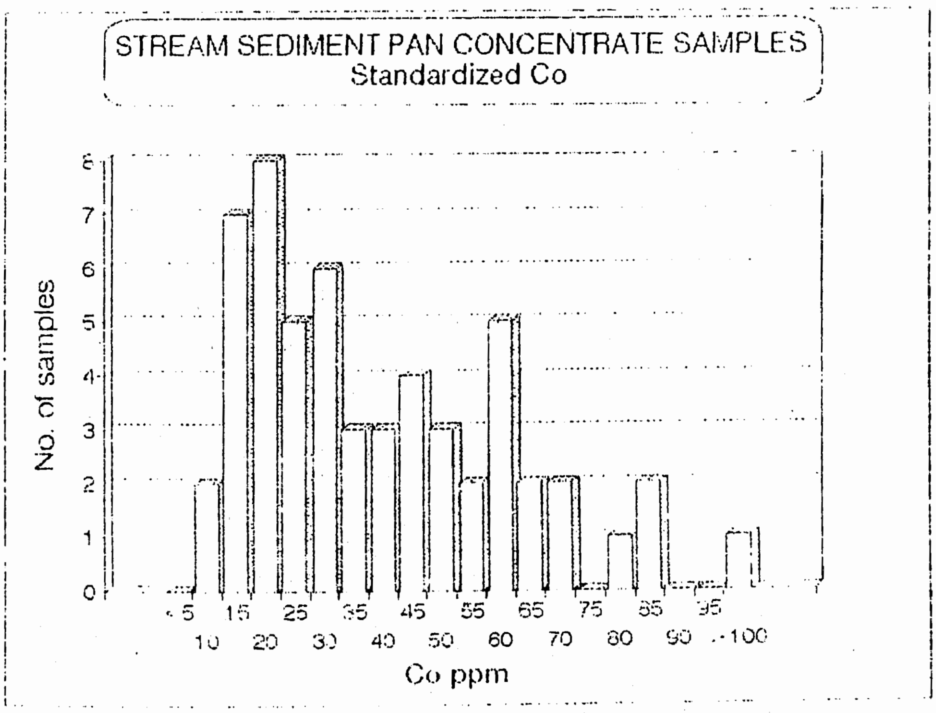
f


STREAM SEDIMENT PAN CONCENTRATE SAMPLES
Standardized Ni
No. of samples
0
2
4
6
8
10
12
>5
15
25
35
45
55
65
75
85
95
>105
10
20
30
40
50
60
70
80
90
100
Ni ppm

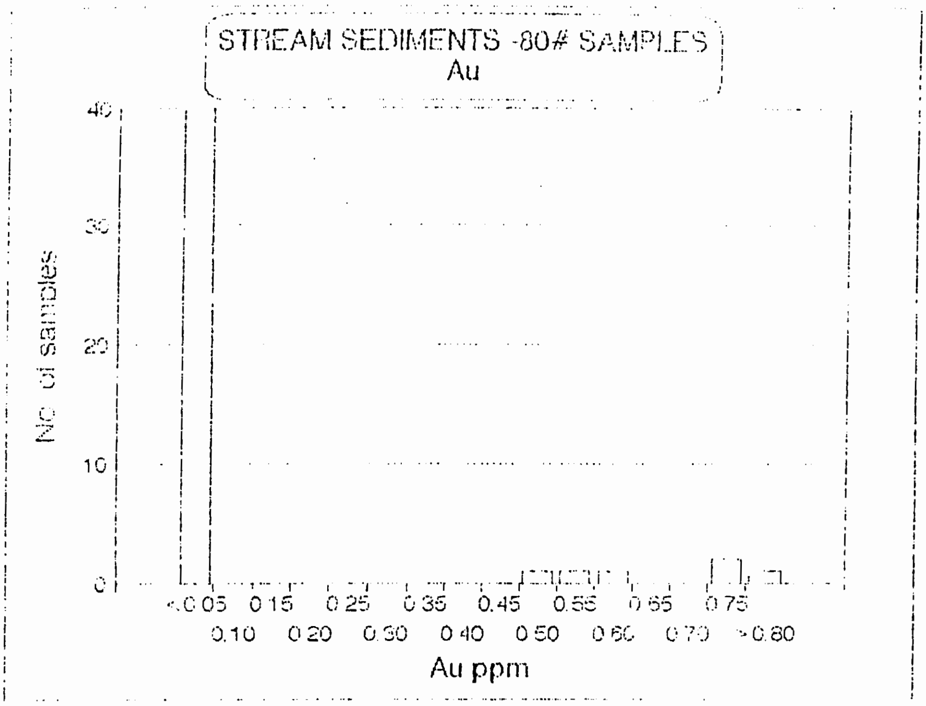
g


STREAM SEDIMENT PAN CONCENTRATE SAMPLES
Standardized Cr
No. of samples
0
2
4
6
8
10
12
14
16
<50 150 250 350 450 550 650 750 850 950 1050
100 200 300 400 500 600 700 800 900 1000 >1100
Cr ppm

h


STREAM SEDIMENT PAN CONCENTRATE SAMPLES
Standardized Co
No. of samples
0
1
2
3
4
5
6
7
8
<5 15 25 35 45 55 65 75 85 95
10 20 30 40 50 60 70 80 90 >100
Co ppm

a



b

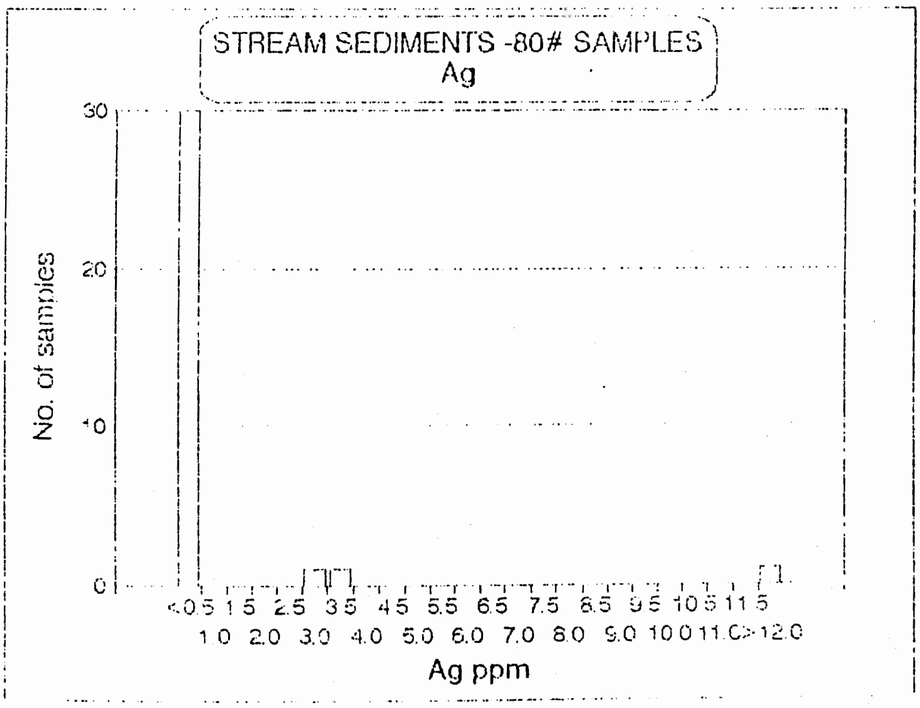
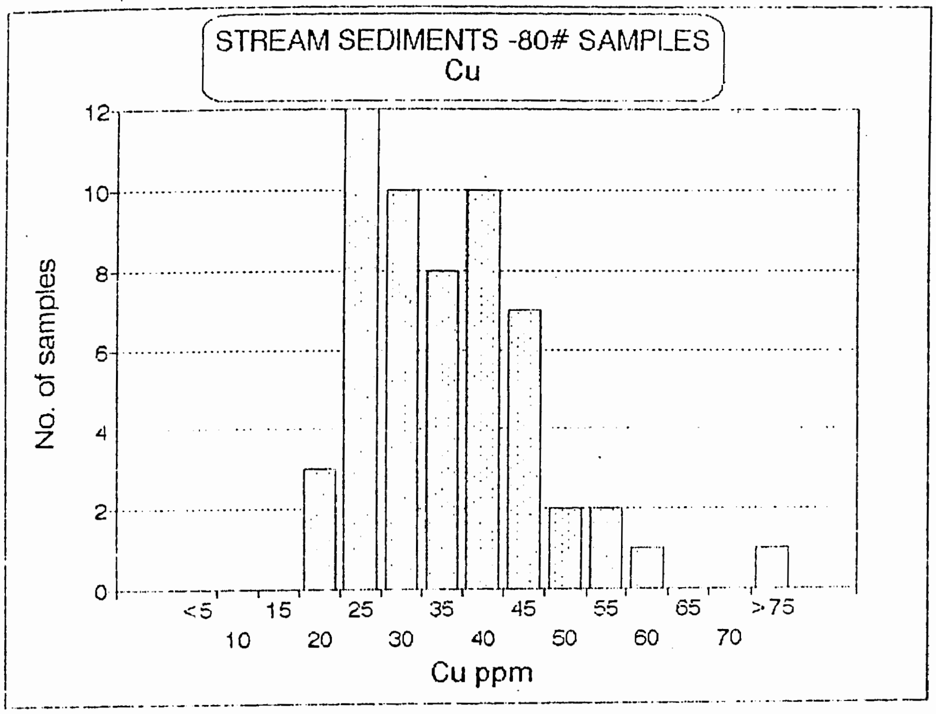
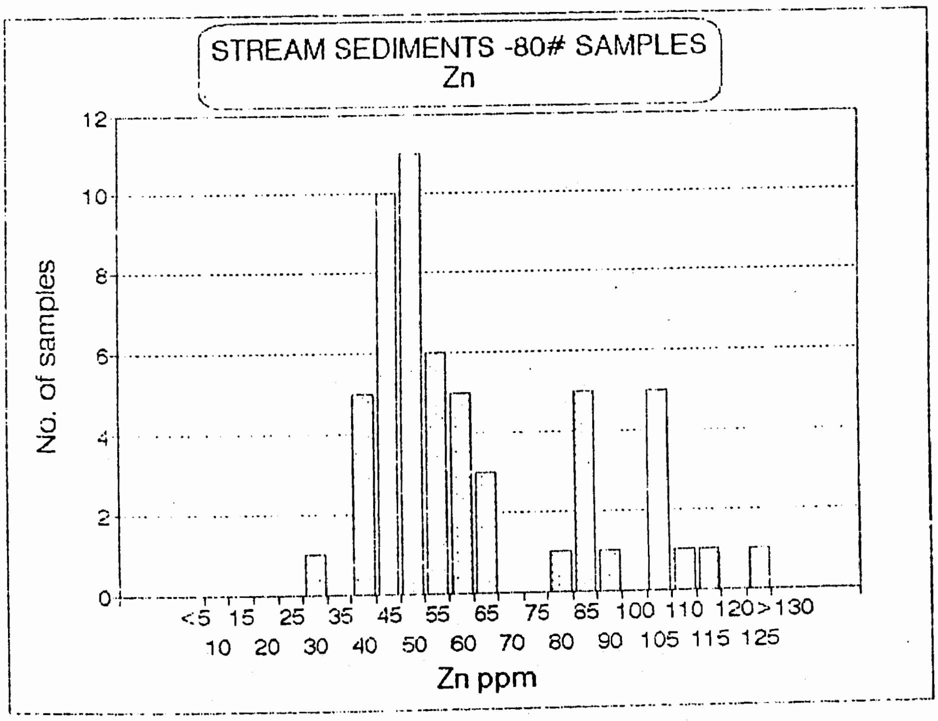


Fig. 8. Frequency histograms for Au, Ag, Cu, Zn, Pb, Ni, Cr and Co for the fine fractions (-80 mesh) of the study area.

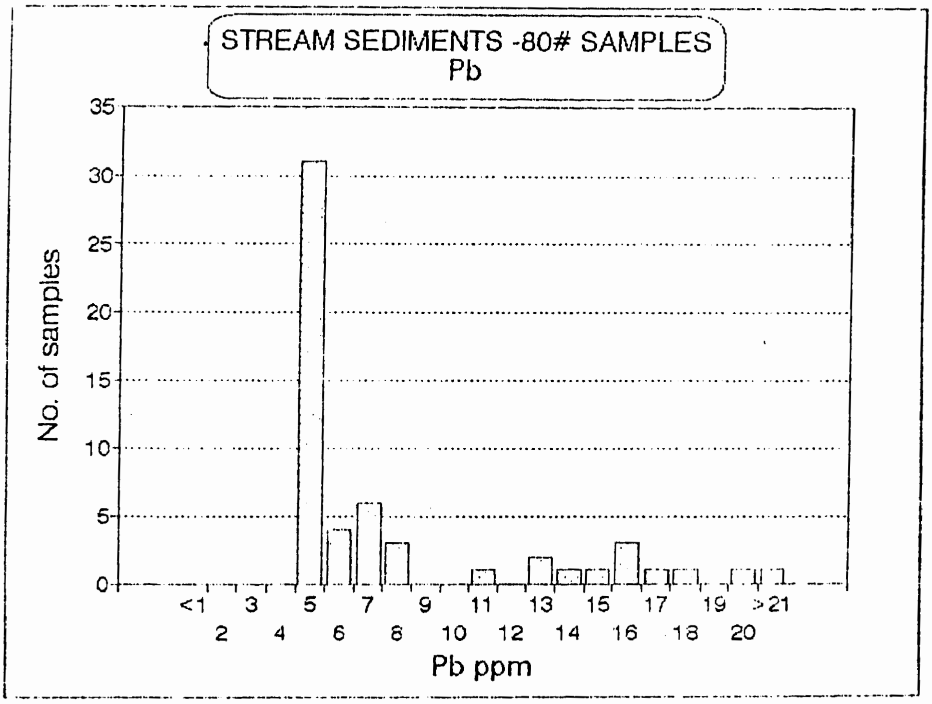
c


STREAM SEDIMENTS -80# SAMPLES
Cu
No. of samples
0
2
4
6
8
10
12
<5
15
25
35
45
55
65
>75
10
20
30
40
50
60
70
Cu ppm

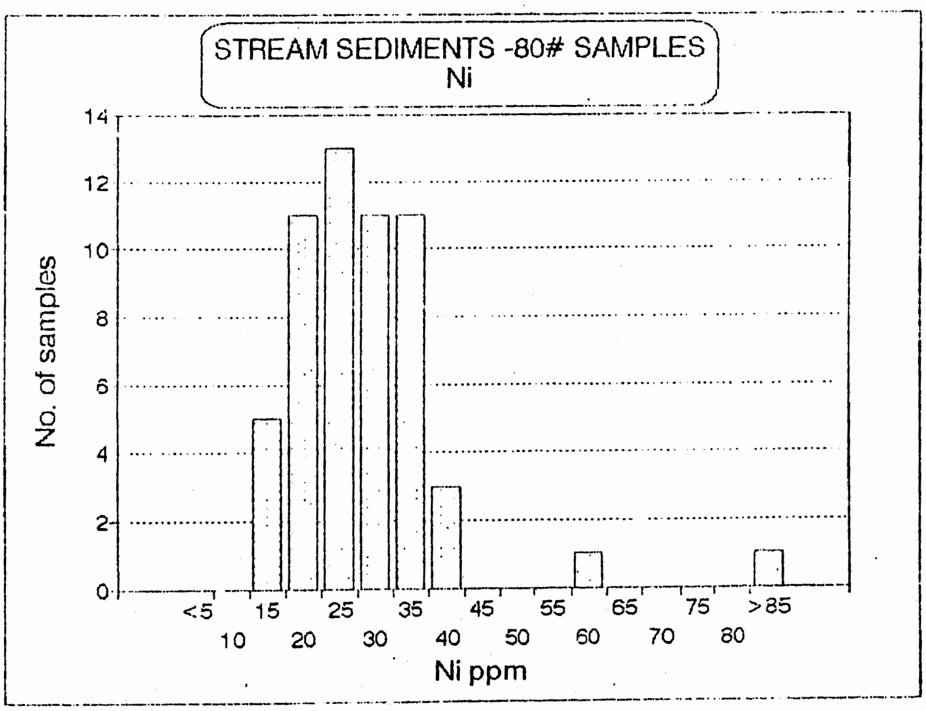
d


STREAM SEDIMENTS -80# SAMPLES
Zn
No. of samples
0
2
4
6
8
10
12
<5
15
25
35
45
55
65
75
85
100
110
120
>130
10
20
30
40
50
60
70
80
90
105
115
125
Zn ppm

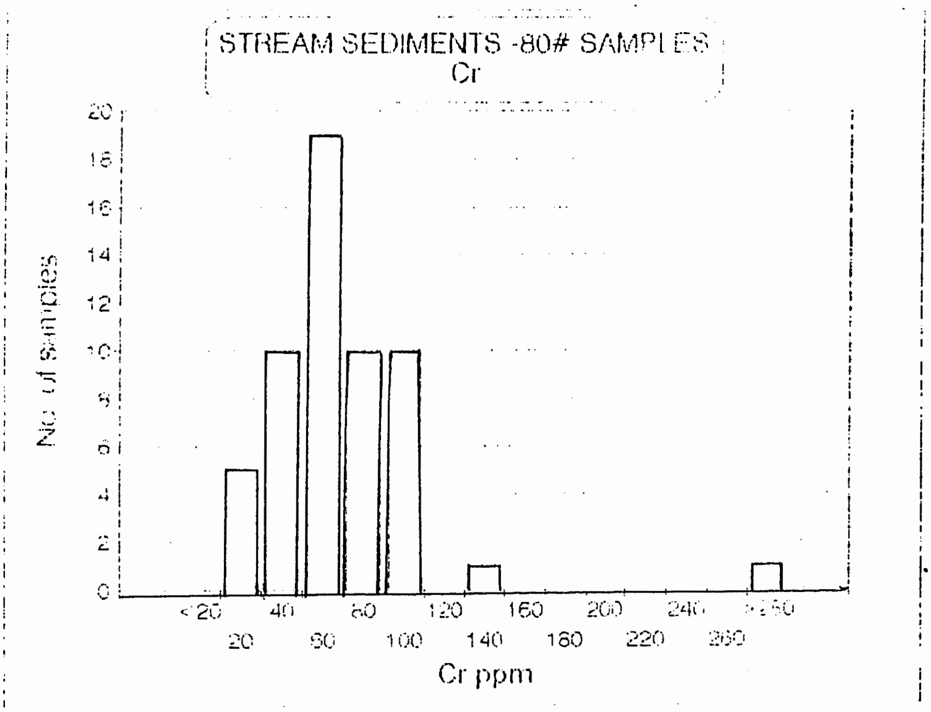
e


STREAM SEDIMENTS -80# SAMPLES
Pb
No. of samples
35
30
25
20
15
10
5
0
<1
3
5
7
9
11
13
15
17
19
>21
2
4
6
8
10
12
14
16
18
20
Pb ppm

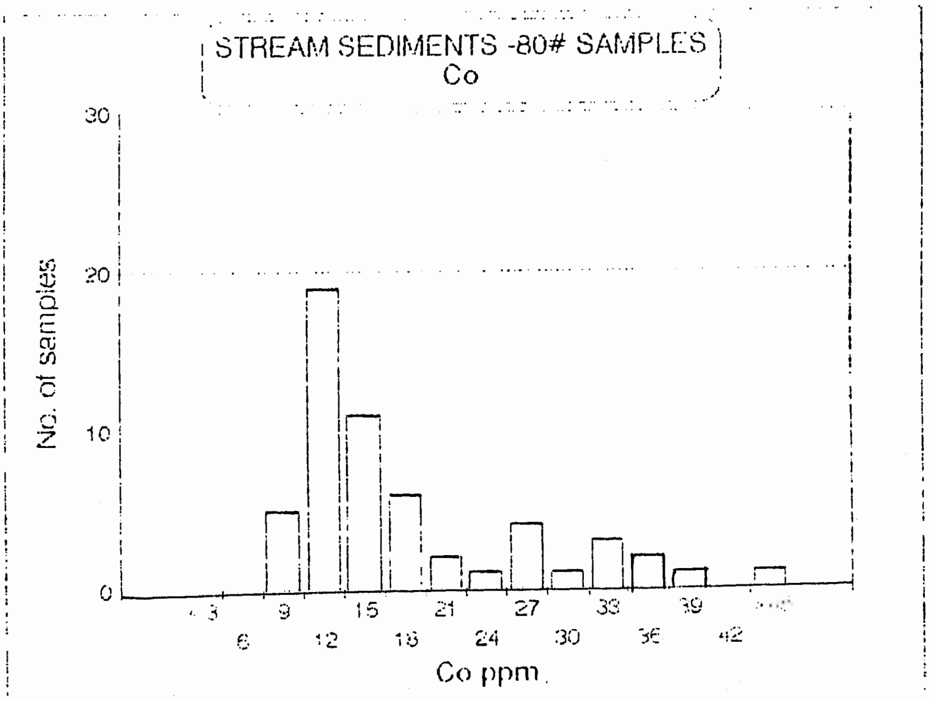
f


STREAM SEDIMENTS -80# SAMPLES
Ni
No. of samples
14
12
10
8
6
4
2
0
<5
15
25
35
45
55
65
75
>85
10
20
30
40
50
60
70
80
Ni ppm

g


STREAM SEDIMENTS -80# SAMPLES
Cr
No. of samples
Cr ppm

h


STREAM SEDIMENTS -80# SAMPLES
Co
No. of samples
Co ppm

GOLD (Au): Gold has a major population break at 86th percentile in the pan-concentrate (Fig. 5a) and 89th percentile in the fine fraction (Fig. 6a). The background, low order and high order anomalous intervals of <0.8 ppm, 0.8-4ppm and >4ppm respectively are selected for the pan-concentrates while <0.4ppm, 0.4-0.6ppm and >0.6ppm respectively are selected for the fine fraction of the stream sediments. The distribution maps for gold in both pan-concentrate and fine fraction are also prepared and are shown in figures 9a and 10a respectively. The distribution map of pan-concentrate (Fig-9a) shows a wide geographical distribution of enhanced Au values (up to 7ppm) as compare to that of fine fraction (Fig. 10a). The highest, localized, Au values are found in the north and north-east of Kambat village near Sumerbagh, where metadiorite, metagranodiorite and metagabbronorite of the Samerbagh complex are exposed. The gold concentration in these rocks ranges from 0.000ppm to 0.009ppm in metadiorite, from 0.000ppm to 0.004ppm in granodiorite and from 0.000ppm to 0.007ppm in gabbronorite (Table 7). Minor gold enhancement is also observed in certain streams in north-eastern portion of the study area in the vicinity of Lal Qala (Figs. 3b & 9a), where mainly the metadiorite and amphibolites of the Timergara complex are exposed. Other streams having low order anomalous values are also shown in figure 9a.

Considering the low order and high order anomalous values of gold, the area north of Samarbagh can be pinpointed as a source of gold anomaly in the stream sediments pan-concentrates. It seems that the rocks of the area are not cotributing the high anomaly of gold in pan-concentrates. But this anomaly could be related to a specific type of mineralization, most probably in the form of quartz veins.

SILVER (Ag): About 72% of pan concentrate and 95% of the fine fractions of steam sediments in the area are below detection limit (<0.5 ppm). By considering the frequency distribution (Figs. 5b & 6b) and histogram (Figs. 7b & 8b), the background, low order and high order anomalous values of <2ppm, 2-20 ppm and >20ppm respectively in pan concentrate and <2ppm, 2-7 ppm and >7ppm respectively in fine fraction are selected. Figure 9b & 10b are the distribution maps of silver in the area. The distribution pattern of silver in both pan concentrates and fine fraction is very different. However, one sample near Mayar show low order anomaly in both the fractions (see Figs. 9b & 10b). Silver concentration in all the rock samples (Table 7) of the study area have the values below the detection limit (<0.5) and , therefore, indicate no contribution in regard to silver.

COPPER (Cu): By considering the frequency distribution of copper (Figs. 5c & 6c) and histograms (Figs. 7c & 8c) the values of 50ppm and 24ppm are treated as the nominal threshold value for pan-concentrate and fine fraction respectively. The values of 50-130 ppm and >130 ppm are considered as low and high order anomaly respectively in pan-concentrates and 24-50ppm and >50 ppm as low and high order respectively in the fine fraction. The distribution maps of copper for both pan-concentrates and fine fractions are shown in figures 9c & 10c respectively. The low order anomaly of copper in the fine fraction is widely distributed through out the study area as compared to the pan-concentrates. Three streams, two in the northern part of Kambat and one south of Lal Qala, have high order anomalous copper concentration in the fine fraction (Fig.10c). Two streams have high order anomalous concentration in pan-concentrates as shown in figure fraction. The distribution maps of copper for both pan-concentrates and fine fractions are shown in figures 9c & 10c respectively. The low order anomaly of copper in the fine fraction is widely distributed through out the study area as compared to the pan-concentrates. Three streams, two in the northern part of Kambat and one south of Lal Qala, have high order anomalous copper concentration in the fine fraction (Fig.10c). Two streams have high order anomalous concentration in pan-concentrates as shown in figure 9c. Both pan-concentrate and fine fractions have, to some extent, similar distribution pattern of copper.

Low to high order anomalous values of copper, though not really high, could be attributed to the rocks of basic to intermediate composition (diorite, gabbronorite, amphibolite etc.) in the area where the Cu is ranging from about 30-140 ppm (Table 7). This suggest that the Cu anomaly in stream sediments is not related to a specific type of mineralization.

ZINC (Zn): A threshold value of 40 ppm for pan-concentrate and 60 ppm for fine fraction has been determined by considering the frequency distribution diagrams (Figs. 5d & 6d) and histograms (Figs. 7d & 8d). The low and high order anomalous values are 40-60 ppm and >60 ppm respectively in the pan-concentrates and 60-80 ppm and >80 ppm respectively in the fine fraction. The distribution pattern of Zn in figure 9d &10d indicates that it has generally high order anomalous values in both pan-concentrate and fine fraction of many streams of the studied area. Both pan concentrates and fine fractions have more or less similar distribution patterns for Zn. The concentration of zinc in various rocks of the studied area are ranging from 15 to 90 ppm (Table 7). This suggest that the anomalous values, though not really high, in stream sediments could be contributed by the rocks rather than by the specific type of mineralization.

LEAD (Pb): The frequency distribution of Pb in the form of frequency curves (Figs. 5e & 6e) and histograms (Figs. 7e & 8e) suggest nominal threshold value of 25 ppm in the pan concentrate and 8 ppm in fine fraction. The distribution pattern of Pb in figures 9e & 10e shows that certain streams in the Jandul valley (western half) of study area have high order anomalous values of Pb in fine fraction while few streams in eastern half are also having high and low order anomalous values in the pan-concentrates. Both the pan concentrate and fine fraction have different distribution pattern for Pb.

Various rocks of the study area have lead in the range of 20 to 55 ppm (Table 7). This suggest that the anomalous values of lead in the stream sediments, though not high, can be related to the various rock types and not to the specific type of mineralization in the area.

NICKEL (Ni): The frequency distribution (Figs. 5f & 6f) and the histograms (Figs. 7f & 8f) of Ni suggest that the nominal threshold value in pan-concentrate is 30 ppm while in fine fraction, it is 40 ppm. Low and high order anomalous values are 30-80 ppm and >80ppm respectively in pan-concentrates and 40-60 ppm, and >60 ppm respectively in the fine fraction of stream sediments. The concentration of nickel for each sample site in both pan-concentrates and fine fractions are plotted on the distribution diagrams (Figs. 9f

&10f). The distribution pattern of Ni in pan concentrates (Fig. 9f) shows a wide distribution of low order anomaly of Ni in the streams of the study area while the distribution pattern of fine fractions shows no anomaly in these streams. The high order anomaly in both pan-concentrates and fine fraction is restricted to three streams west of Lal Qala and a stream near Kambat in the study area (see Figs. 9f & 10f).

CHROMIUM (Cr): A threshold values of 200 ppm of Cr in pan-concentrate and 130 ppm in fine fraction have been selected after consulting the frequency distribution diagrams (Figs. 5g & 6g) and histograms (Figs. 7g & 8g). The low order and high order anomaly of Cr is distinguished as 200-600 ppm and >600 ppm respectively in pan concentrates and 130-250 ppm and >250 ppm respectively in fine fraction. The data has been presented on the distribution diagrams (Figs. 9g & 10g). The distribution pattern of pan concentrates (Fig. 9g) is different from that of the fine fractions (Fig. 10g). Many streams in the western half of the area are anomalous while few streams in the north-eastern portion of the study area show low to high order anomaly in the pan-concentrates. However, only two streams have high order anomaly in the fine fraction while rest of the streams have the background values.

Cr and Ni distribution maps are analogous. Their high order anomaly in the area west of Lal Qala, in the north-eastern portion of the study area, is due to the presence of small exposure (10-15m thick; not-shown on the geological map) of ultramafic rock. The low order anomalous values of Cr and Ni in the western half of the study area can be attributed to the presence of metagabbro and metagabbro-norites of the Samarbagh and

Tora Tiger complexes (Fig. 1). The high order anomalous values (maximum of 1068 ppm) of Cr in this region may indicate the occurrence of ultramafic rocks. Nickel is, however, having low order anomaly in this region, except in two streams one near Kambat and another west of village Munda Qala. Basic to intermediate rocks of the study area have Ni in the range of 10 to 90 ppm and Cr in the range of 10 to 160 ppm (Table 7). The ultramafic rocks of the area are not analyzed during this study, however, Jan and Tahirkheli (1990) have reported Ni upto 1174 ppm and Cr upto 5586 ppm in the ultramafic rocks of the Tora Tiga complex of the study area. It is, therefore, suggested that the spread of enhanced Cr and Ni through out most part of the studied area could be related to the bed rocks and not to a specific mineralization.

COBALT (Co): The frequency distribution of Co suggested a nominal threshold values of 25 ppm in pan-concentrate (Figs. 5h & 6h) and 20 ppm in fine fraction of stream sediments (Figs. 7h & 8h). The low and high order anomalous values for Co in pan-concentrate are distinguished as 26-60 ppm and >60 ppm respectively while for fine fraction, these are considered as 20-30 ppm and >30 ppm respectively. The pan concentrate distribution pattern for Co (Fig. 9h) shows that most streams in the western part of the study area while some streams in the eastern part of the study area are low order anomalous. However, two streams in the western half and few streams in the eastern half of the study area are having high order anomalies in the pan-concentrates (Fig. 9h). Instead of few streams, the rest of the streams of the area have back ground values in the fine fractions of the stream sediments (Fig. 10h). The distribution pattern of Co in both the fractions (i.e. pan concentrate and fine fraction) are, therefore, not similar. Various

Table.7. Trace element data of the rocks from Timargara and Samarbagh areas southern Dir, N.W.F.P.

Metadiorite S.No.	Zn	Pb	Cu	Ni	Cr	Co	Ag	Au
TMG1	68	47	44	68	56	63	<0.5	0.004
TMG3	78	44	44	54	55	63	<0.5	0.007
TMG4	63	46	104	52	61	59	<0.5	0.007
TMG5	67	35	59	32	45	65	<0.5	0.009
TMG6	51	32	86	30	32	63	<0.5	0.003
TMG114	60	32	70	24	34	63	<0.5	0.005
TMG115	61	30	48	38	43	58	<0.5	0.008
TMG117	95	39	56	35	52	61	<0.5	0.006
TMG118	88	34	90	25	36	64	<0.5	0.006
TMG119	78	42	70	31	33	52	<0.5	0.007
SMR45	97	40	88	56	48	67	<0.5	0.000
SMR47	64	51	51	52	50	66	<0.5	0.002
SMR48	64	46	45	52	48	59	<0.5	0.005
SMR49	68	37	62	59	48	60	<0.5	0.000
SMR50	62	37	36	57	51	67	<0.5	0.000
Metagranodiorites								
SMR24	43		52	16	24	71	<0.5	0.003
SMR25	30	40	56	15	13	93	<0.5	0.004
SMR26	15	35	44	12	8	56	<0.5	0.000

(cotinue table7)
Metagabbro-notites

S.No.	Zn	Pb	Cu	Ni	Cr	Co	Ag	Au
TMG28	67	31	46	52	69	58	<0.5	0.000
TMG29	69	32	73	49	79	62	<0.5	0.000
TMG30	62	41	54	77	114	61	<0.5	0.000
TMG31	71	52	64	51	84	65	<0.5	0.004
TMG33	78	53	42	41	62	64	<0.5	0.006
TMG35	68	43	45	59	56	47	<0.5	0.003
SMR37	75	40	77	92	105	68	<0.5	0.006
SMR38	65	36	75	86	102	67	<0.5	0.007
SMR39	84	55	59		96	70	<0.5	0.002
SMR40	81	44	59	59	98	67	<0.5	0.000
SMR41	88	47	60	66	100	51	<0.5	0.000
SMR42	77	48	74	67	100	58	<0.5	0.004
SMR51	53	52	48	86	160	71	<0.5	0.005
SMR53	59	43	49		105	68	<0.5	0.000
SMR54	70	47	43	76	142	66	<0.5	0.004
SMR55	61	29	28	66	127	58	<0.5	0.004
SMR56	71	50	57	49	64	54	<0.5	0.007
SMR57	67	38		48	73	64	<0.5	0.008
SMR58	53	34	62	74	97	52	<0.5	0.000
SMR59	63	44	59	52	69	71	<0.5	0.004
Metagranites								
SMR99	29	22	38	12	14	57	<0.5	0.002
SMR103	22	31	39	17	12	73	<0.5	0.004
SMR104	26	42	43	15	12	62	<0.5	0.005
SMR108	15	33	50	14	13	62	<0.5	0.002
SMR109	16	29	41	13	15	66	<0.5	0.000

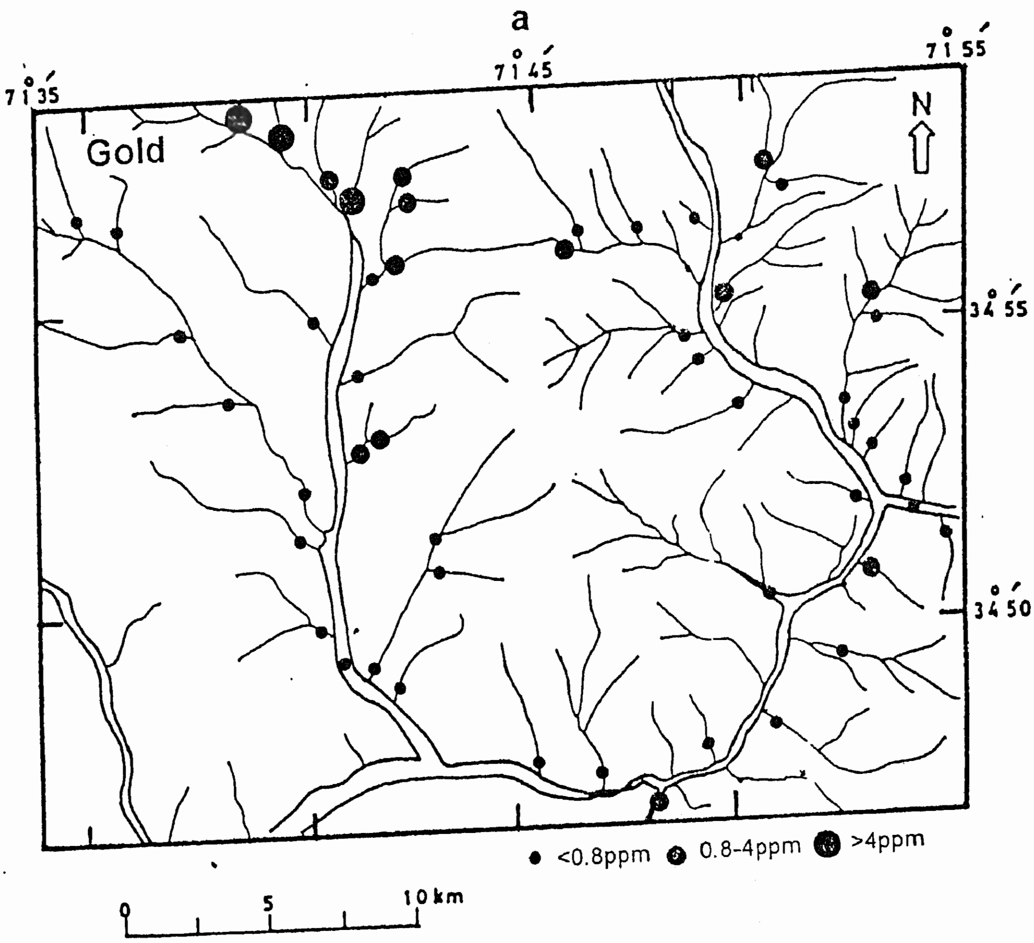
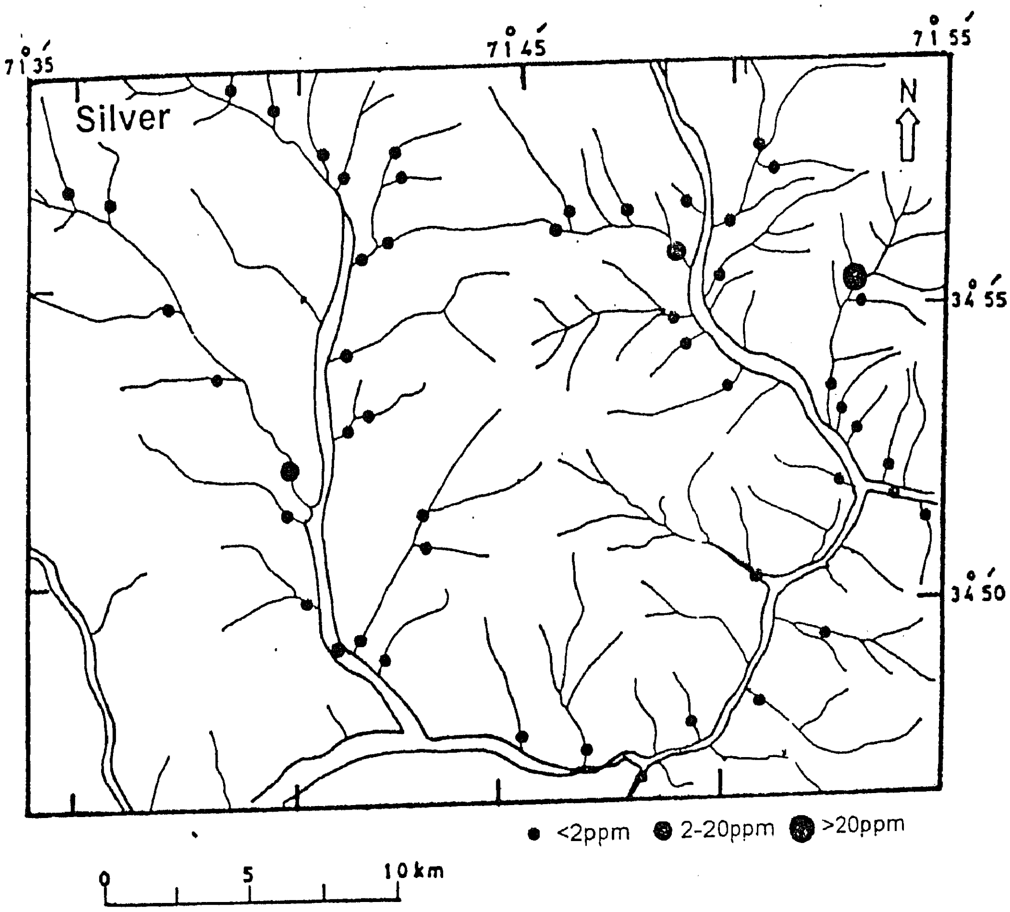
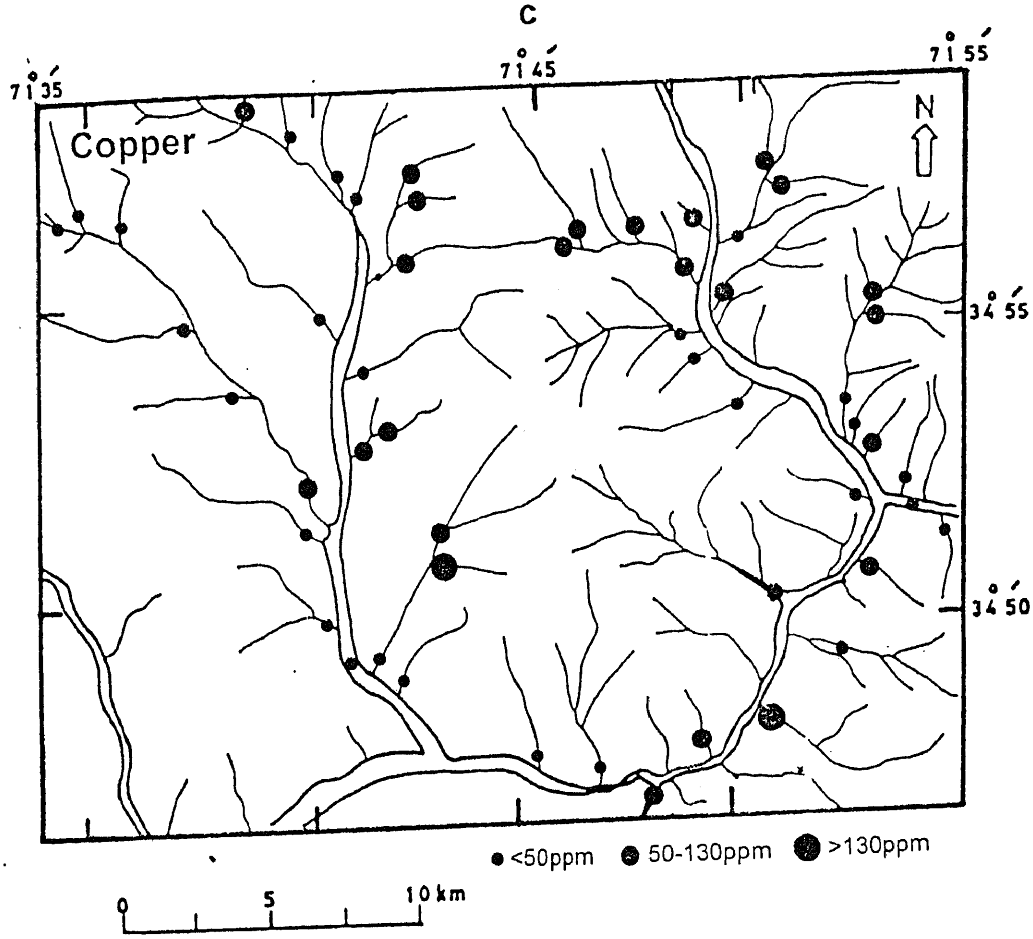


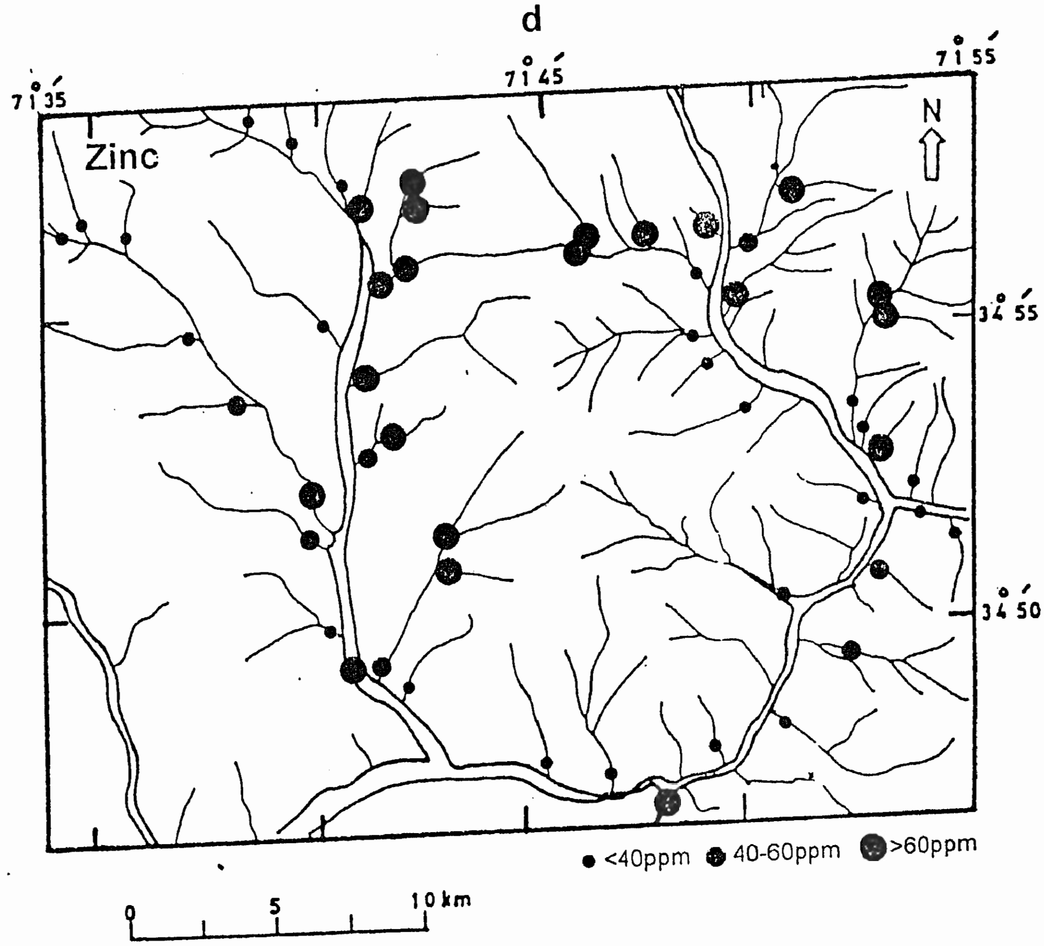
Fig. 9. Distribution map of Au, Ag, Cu, Zn, Pb, Ni, Cr and Co for the pan concentrates of the study area.

b

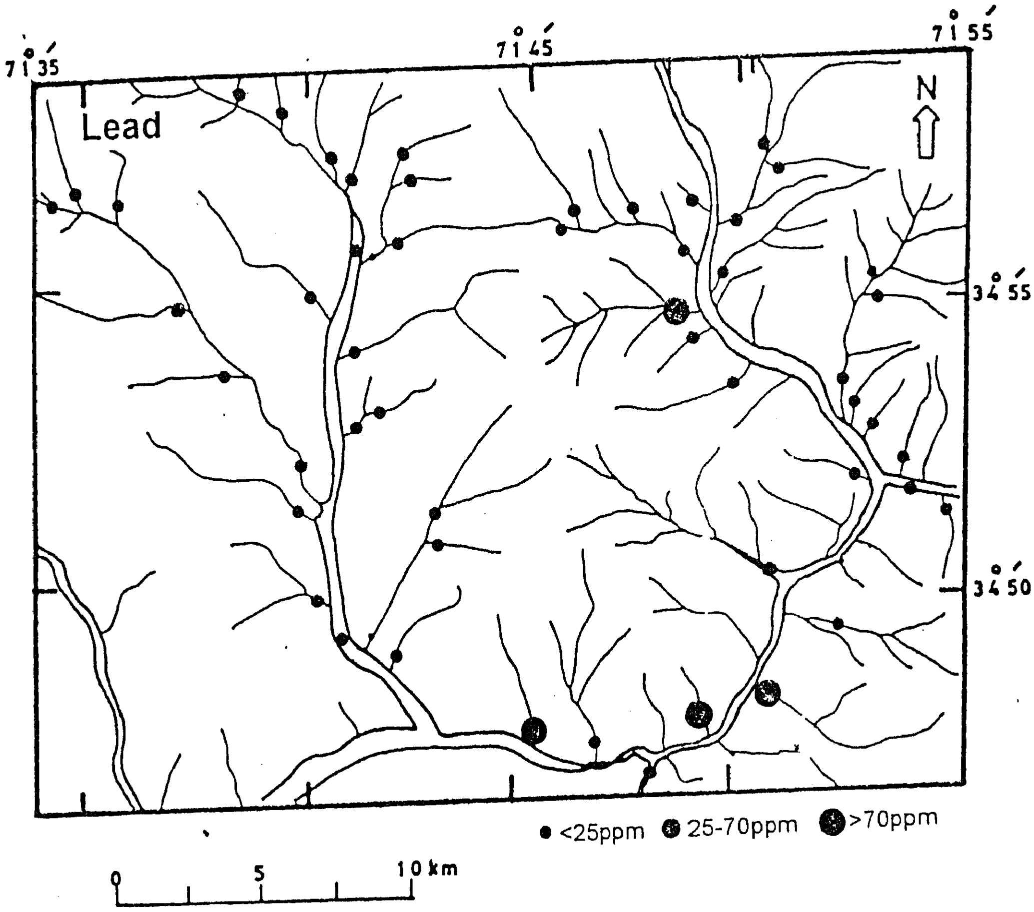


C

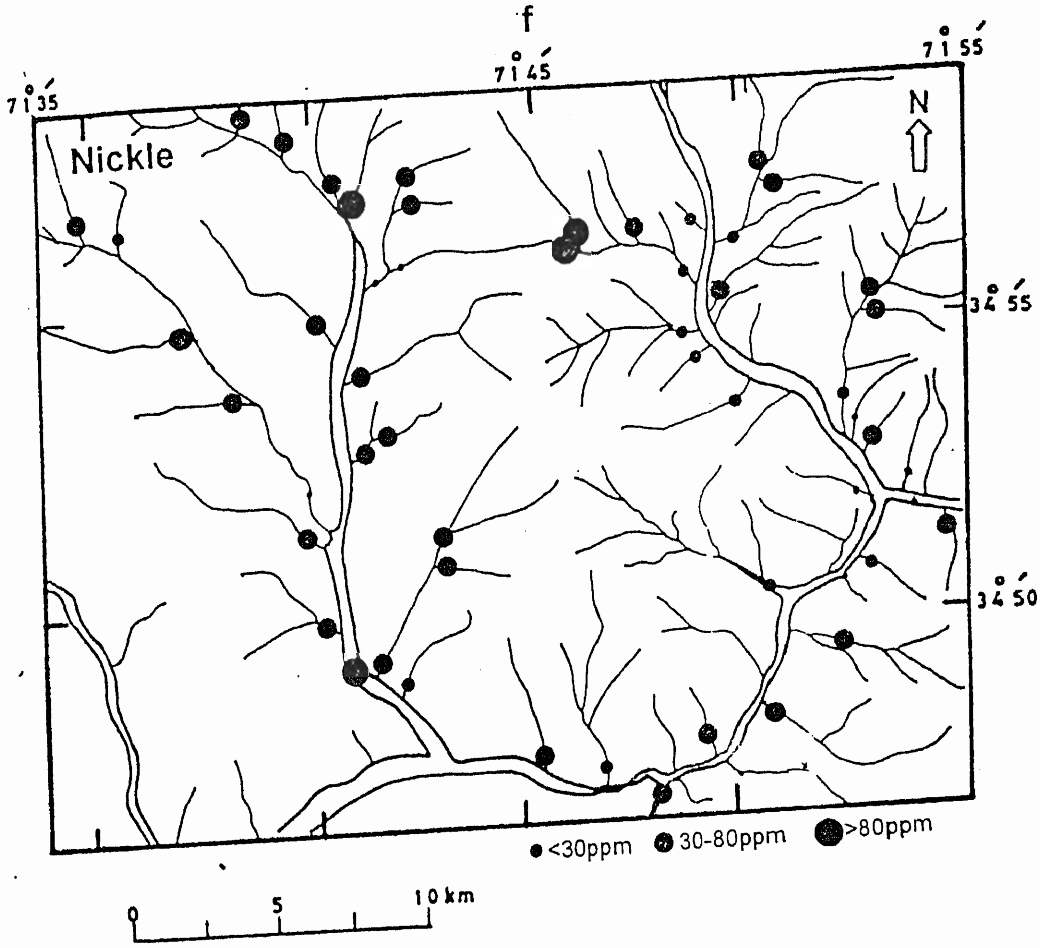

71°35'
71°45'
71°55'
34°55'
34°50'
Copper
N
<50ppm
50-130ppm
>130ppm
0
5
10 km


d
71°35'
71°45'
71°55'
Zinc
N
34°55'
34°50'
• <40ppm
40-60ppm
>60ppm
0
5
10 km

e

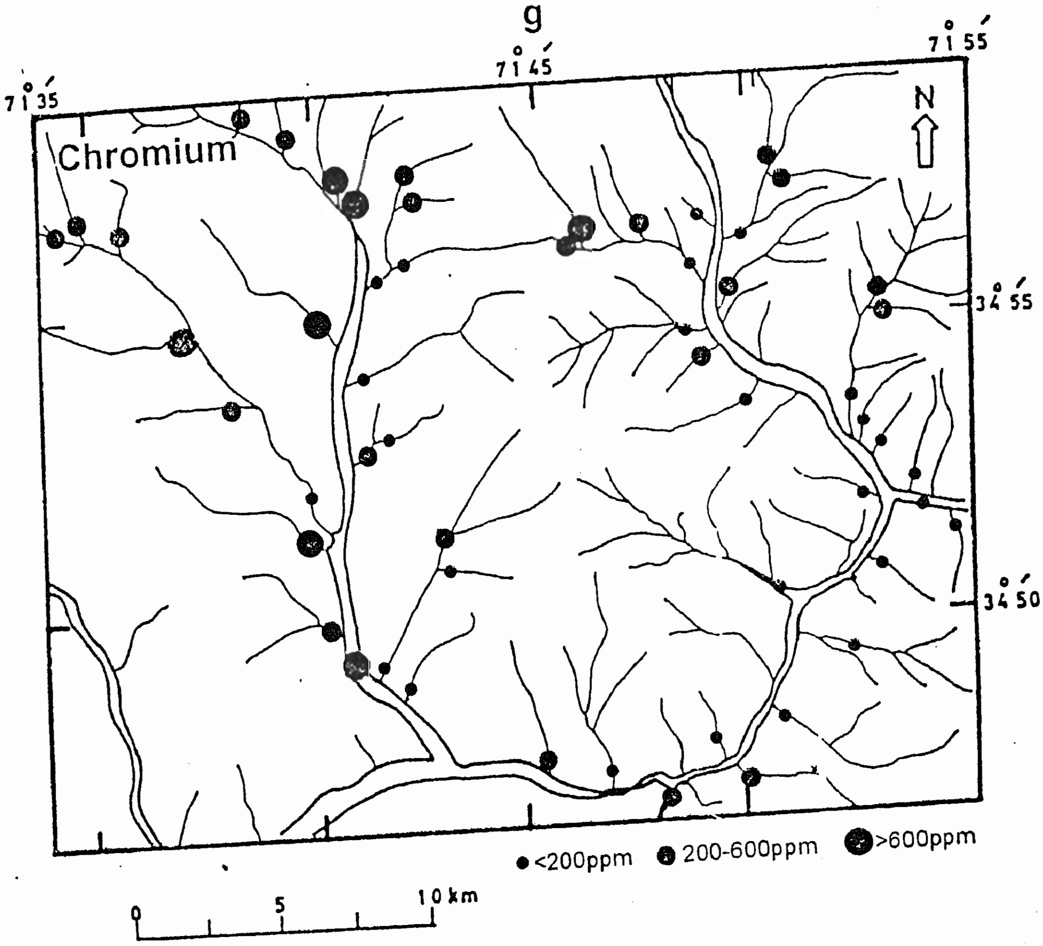


f

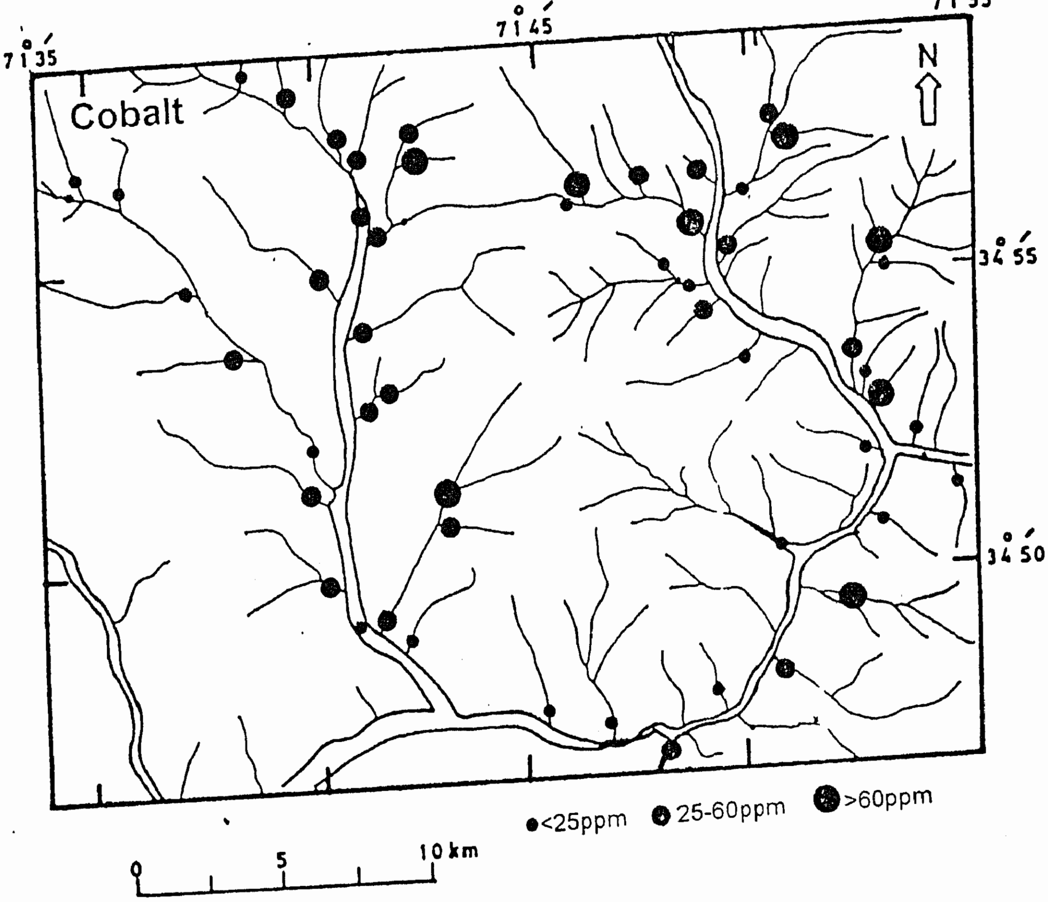


71°35′
71°45′
71°55′
N
Nickle
34°55′
34°50′
• <30ppm
30-80ppm
>80ppm
0
5
10 km

g


71°35'
71°45'
71°55'
Chromium
N
34°55'
34°50'
• <200ppm
200-600ppm
>600ppm
0
5
10 km

h



71°35'
71°45'
71°55'
34°55'
34°50'
Cobalt
N
•<25ppm
25-60ppm
>60ppm
0
5
10 km

a

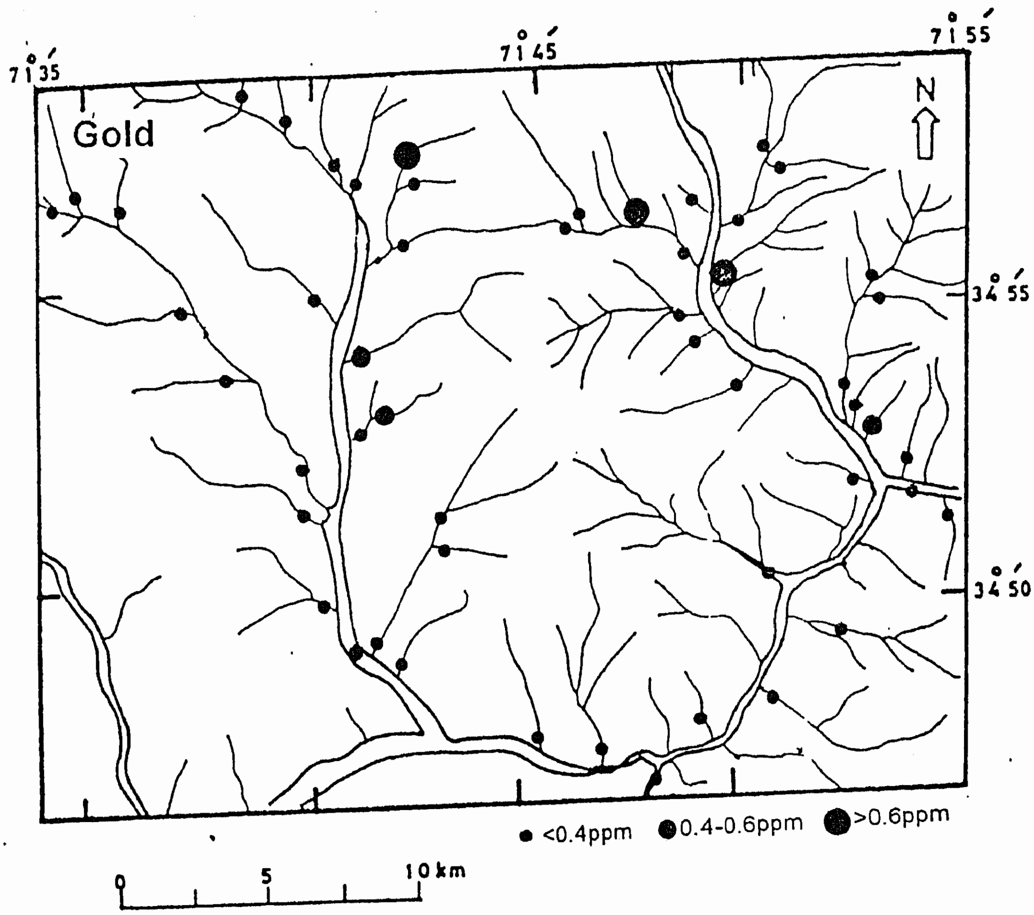
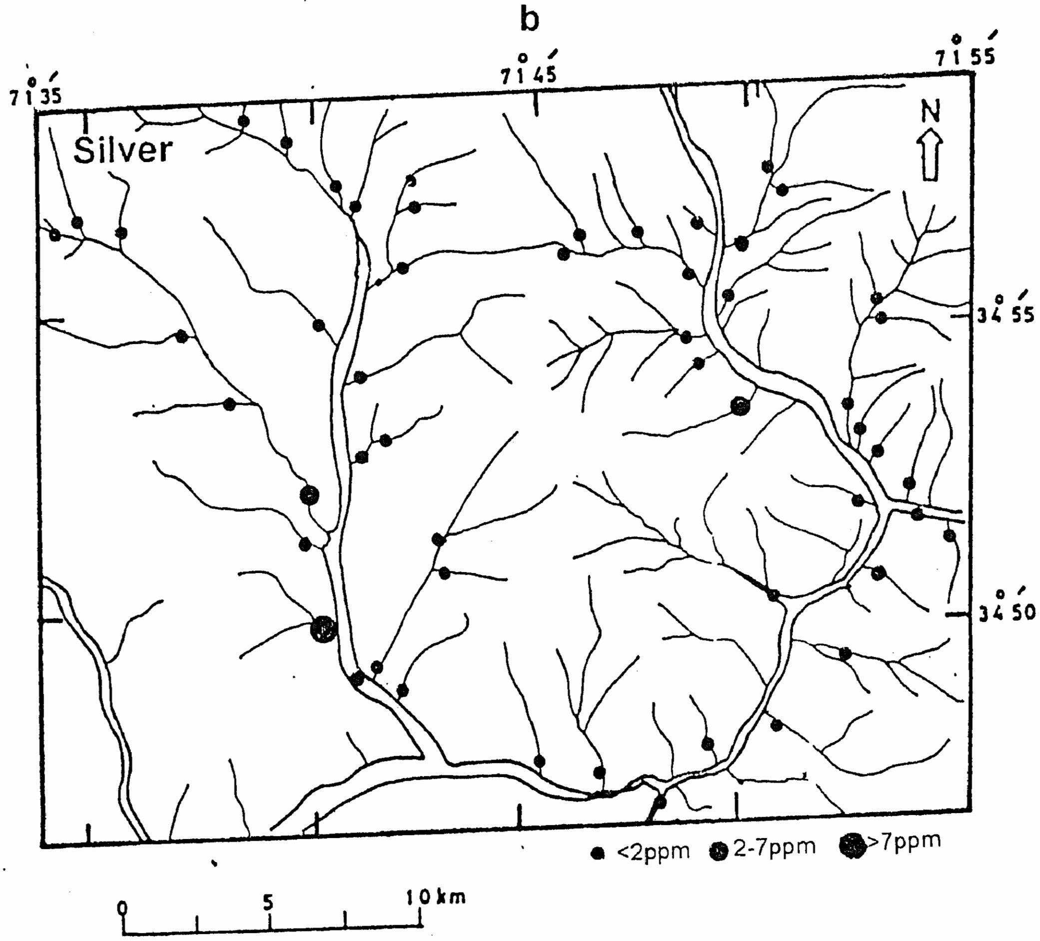
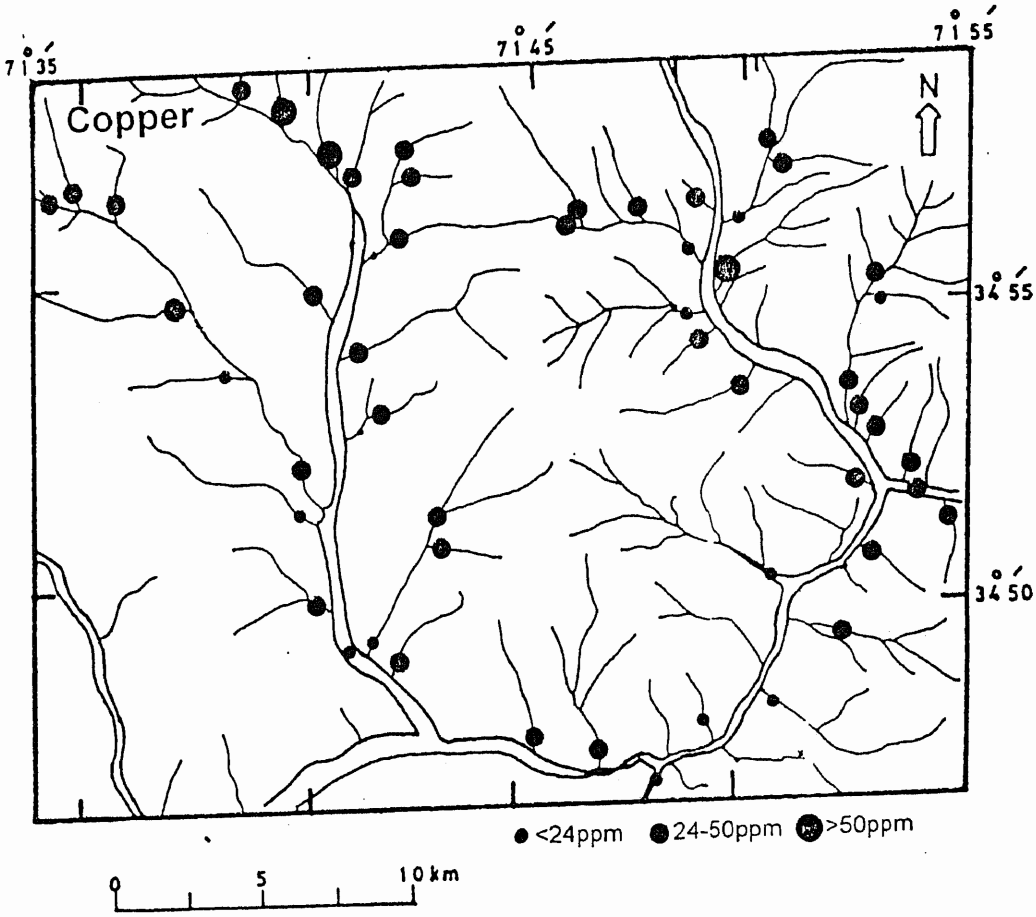


Fig. 10. Distribution map of Au, Ag, Cu, Zn, Pb, Ni, Cr and Co for the fine fractions (-80 mesh) of the study area.

b

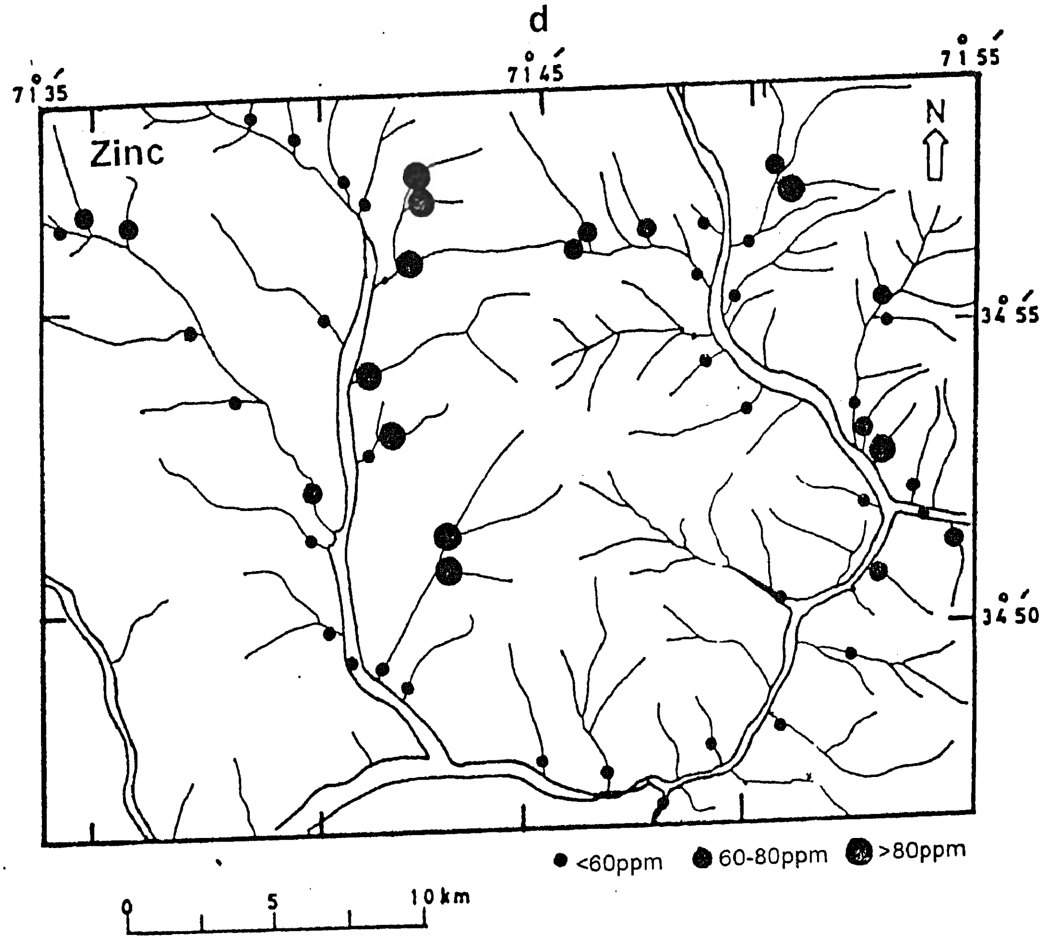


c

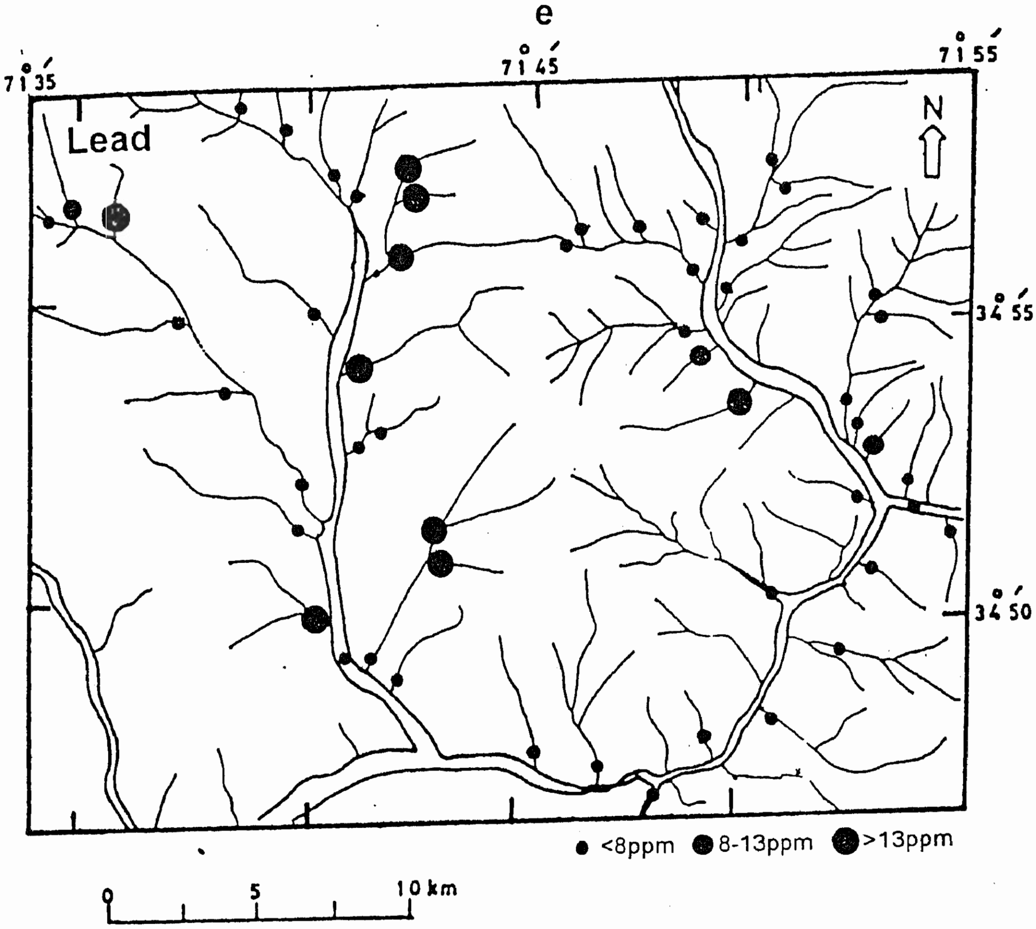


71°35'
71°45'
71°55'
Copper
N
34°55'
34°50'
● <24ppm ● 24-50ppm ● >50ppm
0 5 10 km

d



e



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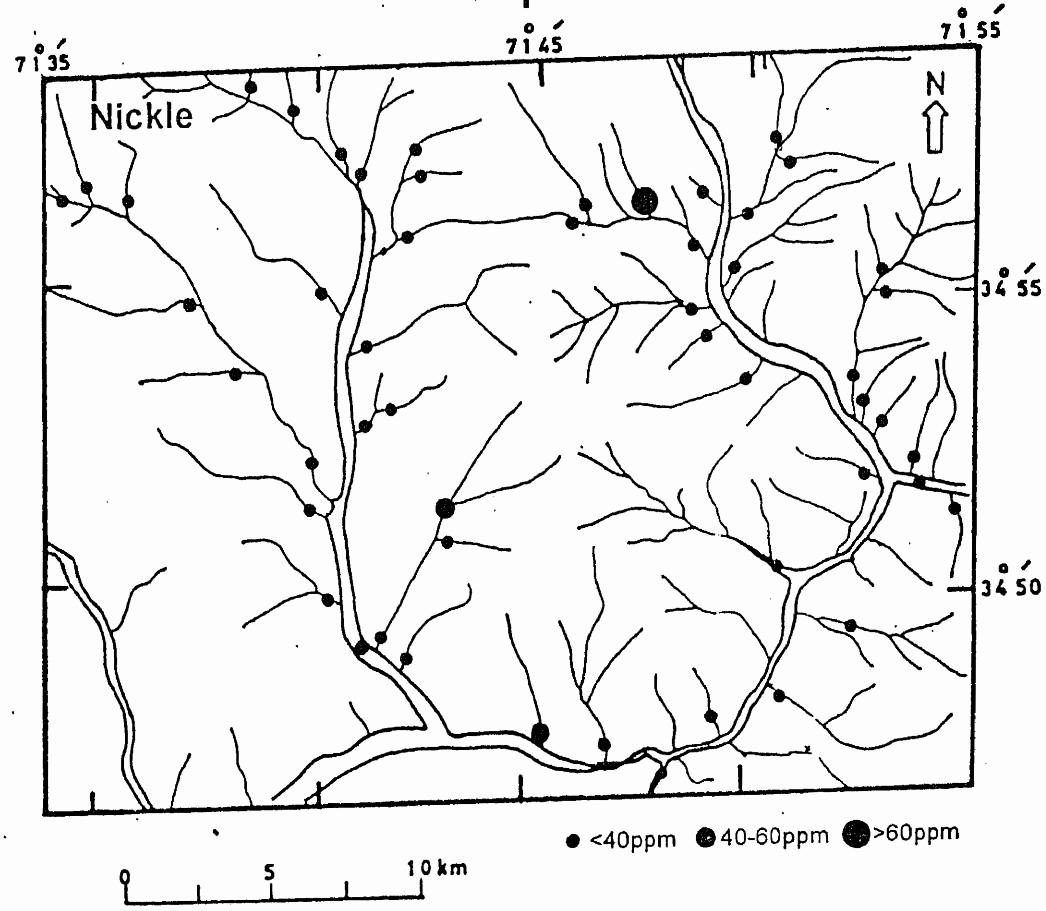
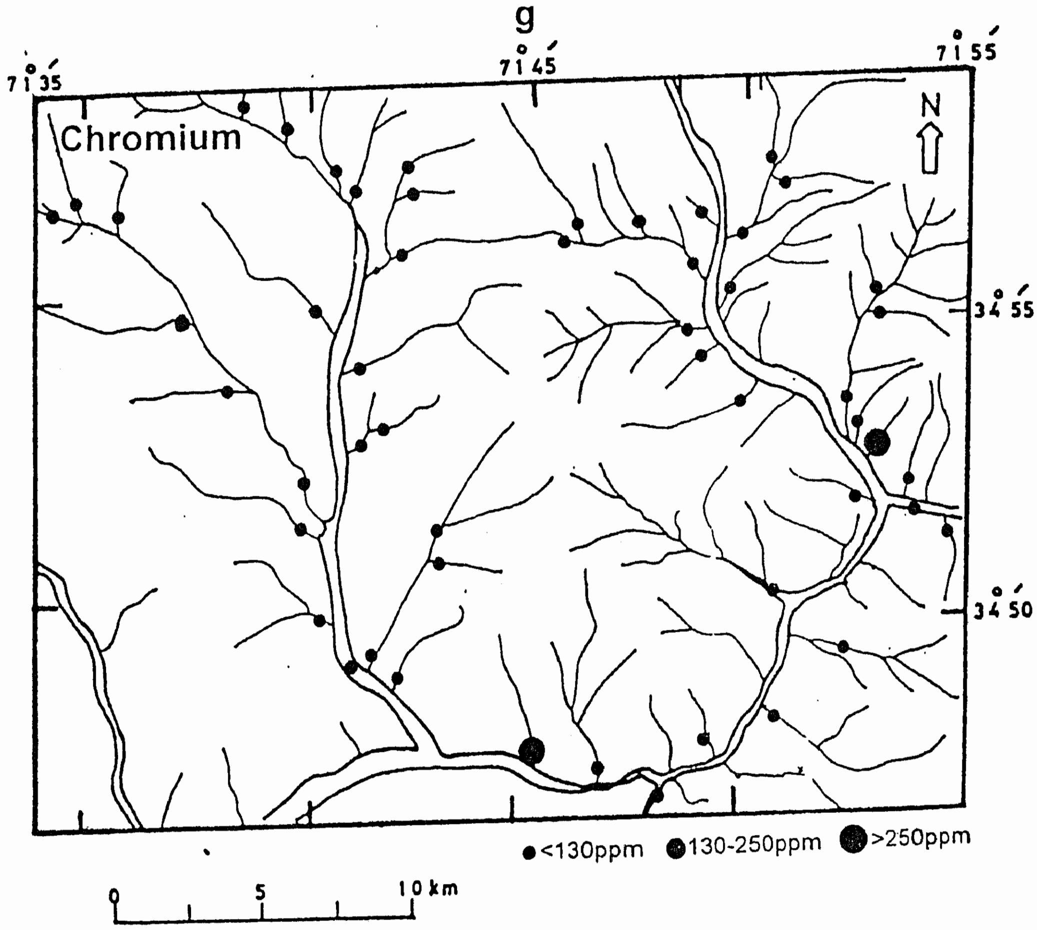
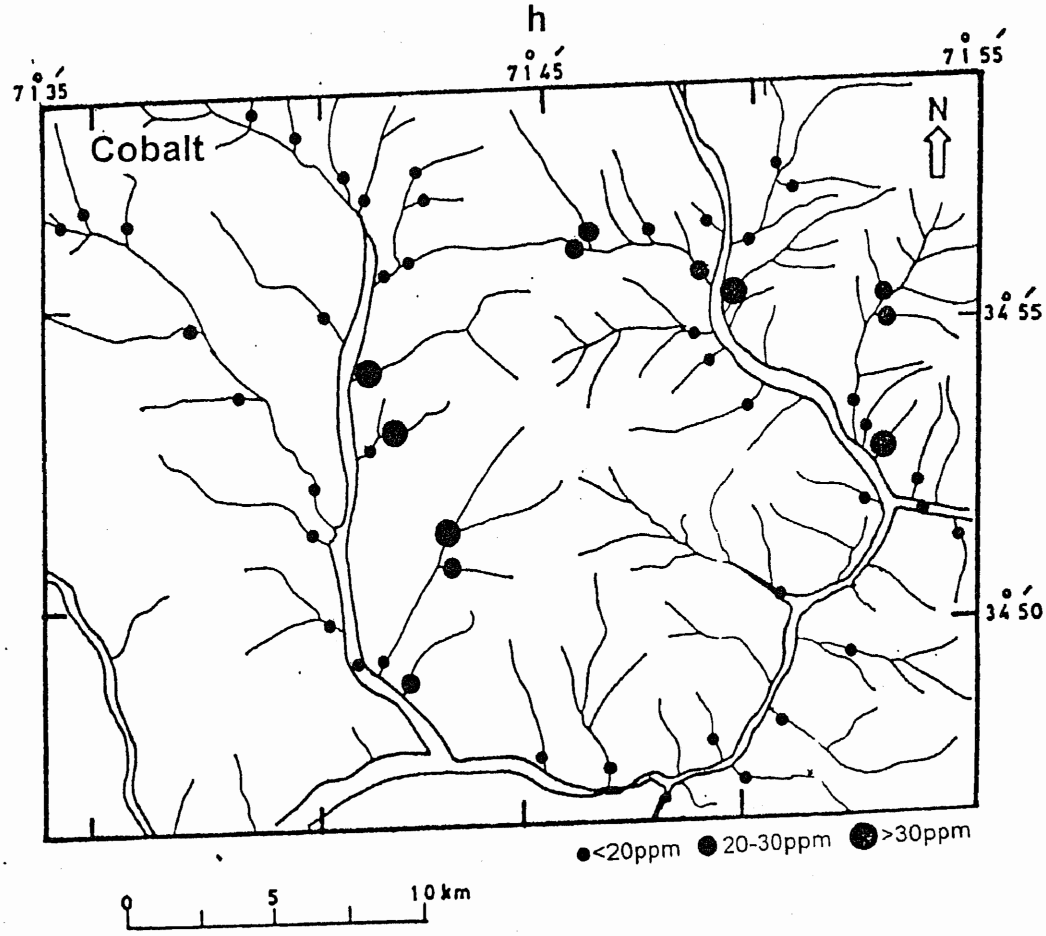

71°35'
71°45'
71°55'
Nickle
N
34°55'
34°50'
• <40ppm
40-60ppm
>60ppm
0
5
10km


g
71°35'
71°45'
71°55'
Chromium
N
34°55'
34°50'
<130ppm
130-250ppm
>250ppm
0
5
10 km

h


71°35'
71°45'
71°55'
34°55'
34°50'
N
Cobalt
●<20ppm ●20-30ppm ●>30ppm
0 5 10km

rocks of the study area have Co in the range of 50 to 95 ppm (Table 7). The spread of Co anomalies in the area, therefore, suggest that these anomalies are generated by the existing rocks and may not be attributed to the specific mineralization.

By considering the single element distribution pattern of both pan-concentrates and fine fractions, it can be concluded that Cu, Pb, Zn, Ni, Cr, and Co might be expected to reflect the bed rock geology of the area.

(B) Multi-elements Presentation

For the multi-elements presentation of the stream sediment data a SCORSUM technique of Chaffe (1983) has been used. According to this technique the full range of chemical data for each element of interest in both pan-concentrations and fine fractions have been divided into three categories of background, low and high anomalous values as in the case of single element presentation. For simplicity the same background, low and high order anomalous values are taken as those obtained through the cumulate frequency curves and histograms plotted during the displaying of single element data in the previous section. The data is summarized in table 8 . The background, low and high order anomalous values are scored here as 0, 1 and 2 respectively. The original chemical data set for each element ,in both pan-concentrates and fine fractions, is transferred to a matrix of anomaly scores as shown in table 9. All of the anomalous elements and their concentrations for both pan concentrates (denoted as PC) and fine fractions (denoted as SS) for the study area are displayed on drainage map (Fig. 11). This map serves as a compilation sheet to be used for manually calculating the SCORESUM for each site. The scores obtained for each element are then summed (SCORESUM) for each site and are given in table 9. These SCORESUMS (shown in circle) along with the scores of individual medium are then plotted on a summery drainage map (Fig. 12).

Various cells (catchment areas) in the studied area have been identified / marked as anomalous on the basis of SCORSUM technique as shown in figures 11 & 12. These anomalous areas mostly lie on the eastern side of the Samarbagh khawar (stream) and also in the north-eastern portion of the study area. These anomalous areas have anomalies for Zn, Ni, Cr, Co and some time Cu (Fig. 11). However, in certain cells, especially in the north and north-eastern parts of Samarbagh, the Au is anomalous from low order to high order. These areas, therefore, have potential for the gold mineralization. Thus this map is very useful in delineating the anomalous areas which could further be evaluated for any kind of mineralization.

The concentration of various elements and summary statistics for both fine and heavy fractions of the stream sediments in tables 1, 2, 3 and 4 show that about 93% of Au and 95% of Ag in the fine fractions and 32% of Au and 82% of Ag in the pan-concentrates are equal or below the detection limit. The rest of the elements (i.e. Cu, Pb, Zn, Ni, Cr, & Co) are above the detection limit. Tables 5 and 6 and the frequency distribution diagrams (Figs. 5, 6, 7 & 8) further exhibit that the fine and heavy fractions have very different background levels. Most of the analyzed elements including base metals have enrichment in the heavy fractions, especially Au and Cr are highly enhanced in the pan concentrates relative to fine fraction of stream sediments in the study area. Generally, base metals occur in silicate and sulfide phases of bed rocks of which silicates are more stable than sulfides in the stream environment. Therefore, mostly the surficial processes cause concentration of these metals in the fine fractions which are derived from the less resistant minerals such as sulfides. The less concentration of even Cu, Pb & Zn in the fine fractions of the studied samples is, therefore, unlikely as these metals are usually concentrated in the fine fractions of the stream sediments. The abundance of Au, Cr, and Ni in the pan concentrates is obvious because of the presence of gold in the form of pieces, specks and colors and Ni and Cr-bearing minerals such as pyroxene, olivine and chromite etc. and also the rock fragments (see appendix).

There could be many causes for such type of unlikely behaviour of these metals. These could be: 1) Due to extreme relief of the area, the surficial weathering and erosional processes are less effective in the area. This might not have given a chance to these metals to concentrate as fine fraction of <177 mm (-80 mesh) and may have remained in the coarser fraction of the stream sediments; 2) These metals could be silicate bound (i.e. found in the resistant minerals) rather than sulfide bound in the stream sediments; 3) dissolved and particulate trace elements may fluctuate widely depending on seasonal flow rate. It is most probable that due to the individual effect or combined effect of the above mentioned factors, the fine fraction of stream sediments in the area do not provide adequate anomaly / background contrast to satisfy the requirement imposed by the sample density. However, pan-concentrates could

be the right medium to pin point areas of interest (especially for gold) in the area of study.

Table.8. Summery of background and anomalous range for eight elements in 56 samples, each of pan-concentrates and fine fraction (-80 mesh), of the stream sediments of the studt area.(all values are in ppm)

Element		Background values score = 0	% of sample	Anomalous samples low order score = 1	high orde score = 2
Au	PC	<0.8	74	0.8--4	>4
	SS	<0.04	91	0.4--0.6	>0.6
Ag	PC	>2	95	2--20	>2.0
	SS	>2	95	2--7	>7
Cu	PC	<160	96	160--300	>300
	SS	<24	23	24--50	>50
Pb	PC	<25	91	25--70	>70
	SS	<8	79	8--13	>13
Zn	PC	<40	48	40--60	>60
	SS	<50	59	50--80	>80
Ni	PC	<23	25	24--80	>80
	SS	<24	39	40--60	>60
Cr	PC	<170	45	170--600	>600
	SS	<150	98	150--250	>250
Co	PC	<20	29	20--60	>60
	SS	<13	50	13--30	>30

PC = pan-concentrates
SS = -80 mesh sample

Table.9. The individual anomaly score for each element along with the SCORESUM of both pan-concentrates and fine fraction (-80 mesh) for the drainage cells of the study area.

Sample No	Au	Ag	Cu	Pb	Zn	Ni	Cr	Co	SCORESUM
PC1	0	0	1	0	1	1	0	1	4
SS1	0	0	1	0	0	0	0	0	1
PC2	0	0	0	0	0	0	0	0	0
SS2	0	0	0	0	0	0	0	0	0
PC3	1	0	1	0	2	1	1	1	7
SS3	0	0	1	0	2	0	0	0	3
PC4	0	0	1	0	2	1	1	2	7
SS4	0	0	1	0	1	0	0	0	2
PC6	1	0	1	0	0	0	0	2	4
SS6	0	0	1	0	0	0	0	0	1
PC7	0	0	1	0	2	1	1	1	6
SS7	2	0	1	0	1	2	0	0	6
PC8	0	0	1	0	2	2	2	2	9
SS8	0	0	1	0	1	0	0	1	3
PC9	1	0	1	0	2	2	1	1	8
SS9	0	0	1	0	2	0	0	1	4
PC10	0	0	0	0	1	0	0	0	1
SS10	0	0	0	0	0	0	0	0	0
PC12	1	0	1	0	2	1	1	1	7
SS12	2	0	2	0	2	0	0	2	8
PC13	1	2	1	0	2	1	1	2	10
SS13	0	0	1	0	1	0	0	1	3
PC14	0	0	1	0	2	1	1	2	7
SS14	0	0	2	0	1	0	0	1	4
PC15	0	1	1	0	0	0	0	0	2
SS15	0	0	0	0	0	0	0	0	0

(continued table9)

Sample No	Au	Ag	Cu	Pb	Zn	Ni	Cr	Co	SCORESUM
PC16	0	0	0	2	0	0	0	0	2
SS16	0	0	0	0	0	0	0	0	0
PC17	0	0	0	0	0	0	1	1	2
SS17	0	0	1	1	0	0	0	0	2
PC18	0	0	0	0	0	0	0	1	1
SS18	0	0	1	0	0	0	0	0	1
PC19	0	0	0	0	0	0	0	0	0
SS19	0	0	1	0	0	0	0	0	1
PC20	0	0	0	0	0	0	0	0	0
SS20	0	0	1	0	1	0	0	0	2
PC21	0	0	1	0	2	1	1	2	7
SS21	1	0	1	1	1	0	2	2	8
PC22	0	0	0	0	0	0	0	0	0
SS22	0	0	1	0	0	0	0	0	1
PC23	0	0	0	0	0	0	0	0	0
SS23	0	0	1	0	0	0	0	0	1
PC24	0	0	0	0	0	0	0	0	0
SS24	0	0	1	0	0	0	0	0	1
PC25	0	0	0	0	0	0	0	0	0
SS25	0	0	1	0	0	0	0	0	1

(continued table.9)

Sample No	Au	Ag	Cu	Pb	Zn	Ni	Cr	Co	SCORESUM
PC26	1	0	1	0	1	0	0	0	3
SS26	0	0	1	0	0	0	0	0	1
PC27	0	0	0	0	0	0	1	0	1
SS27	0	0	0	0	0	0	0	0	0
PC28	0	0	0	0	0	1	0	2	3
SS28	0	0	1	0	0	0	0	0	1
PC29	0	0	2	2	0	1	0	1	6
SS29	0	0	0	0	0	0	0	0	0
PC31	0	0	0	2	0	0	0	0	2
SS31	0	0	1	0	0	0	0	0	1
PC32	1	0	1	0	0	1	1	1	5
SS32	0	0	0	0	0	0	0	0	0
PC33	0	0	0	0	0	0	0	0	0
SS33	0	0	1	0	0	0	0	0	1
PC35	0	0	0	2	0	1	0	0	3
SS35	0	0	1	0	0	1	0	0	2
PC36	0	0	0	0	0	0	0	0	0
SS36	0	0	1	0	0	0	0	0	1
PC37	0	0	0	0	1	1	0	1	3
SS37	0	0	0	0	0	0	0	0	0
PC38	0	0	0	0	2	2	2	1	7
SS38	0	0	0	0	0	0	0	0	0
PC39	0	0	0	0	0	1	1	0	2
SS39	0	0	1	2	0	0	0	0	3
PC40	0	0	1	0	2	1	0	1	4
SS40	0	0	1	2	1	0	0	1	5

(continued table.9)

Sample No	Au	Ag	Cu	Pb	Zn	Ni	Cr	Co	SCORESUM
PC41	0	0	1	0	2	1	1	2	7
SS41	0	0	1	2	2	0	0	2	7
PC42	1	0	1	0	2	1	0	1	6
SS42	0	0	1	1	2	0	0	2	6
PC43	0	0	1	0	2	1	0	1	5
SS43	0	0	1	2	2	0	0	2	7
PC44	1	0	0	0	1	1	1	1	5
SS41	0	0	0	0	0	0	0	0	0
PC45	0	1	1	0	2	0	0	1	5
SS45	0	1	1	0	0	0	0	0	2
PC46	0	0	0	0	1	1	2	1	5
SS46	0	0	0	0	0	0	0	0	0
PC47	0	0	0	0	1	1	1	1	4
SS47	0	0	0	0	0	0	0	0	0
PC48	0	0	0	0	0	1	2	0	3
SS48	0	0	1	0	0	0	0	0	1
PC49	0	0	0	0	0	1	2	1	4
SS49	0	0	1	0	0	0	0	0	1
PC50	1	0	1	0	2	1	0	1	6
SS50	0	0	1	2	1	0	0	1	4
PC51	1	0	1	0	2	1	0	2	7
SS51	0	0	1	2	2	0	0	1	6
PC52	1	0	1	0	2	1	1	1	7
SS52	2	0	1	2	2	0	0	1	8
PC53	0	0	0	0	1	0	0	1	2
SS53	0	0	0	0	0	0	0	0	0
PC54	2	0	0	0	0	2	2	1	7
SS54	0	0	1	0	0	0	0	1	2
PC55	1	0	0	0	0	1	2	1	5
SS55	0	0	2	0	0	0	0	0	2
PC56	2	0	0	1	0	1	1	1	6
SS56	0	0	2	0	0	0	0	0	2
PC57	2	0	1	0	0	1	1	0	5
SS57	0	0	1	0	0	0	0	0	1
PC58	0	0	0	0	0	1	1	0	2
SS58	0	0	1	2	0	0	0	0	3
PC59	0	0	0	0	0	1	1	0	2
SS59	0	0	1	0	0	0	0	0	1
PC60	0	0	0	0	0	0	0	1	1
SS60	0	0	1	0	0	0	0	0	1

PC = pan-concentrates

SS = -80 mesh sample

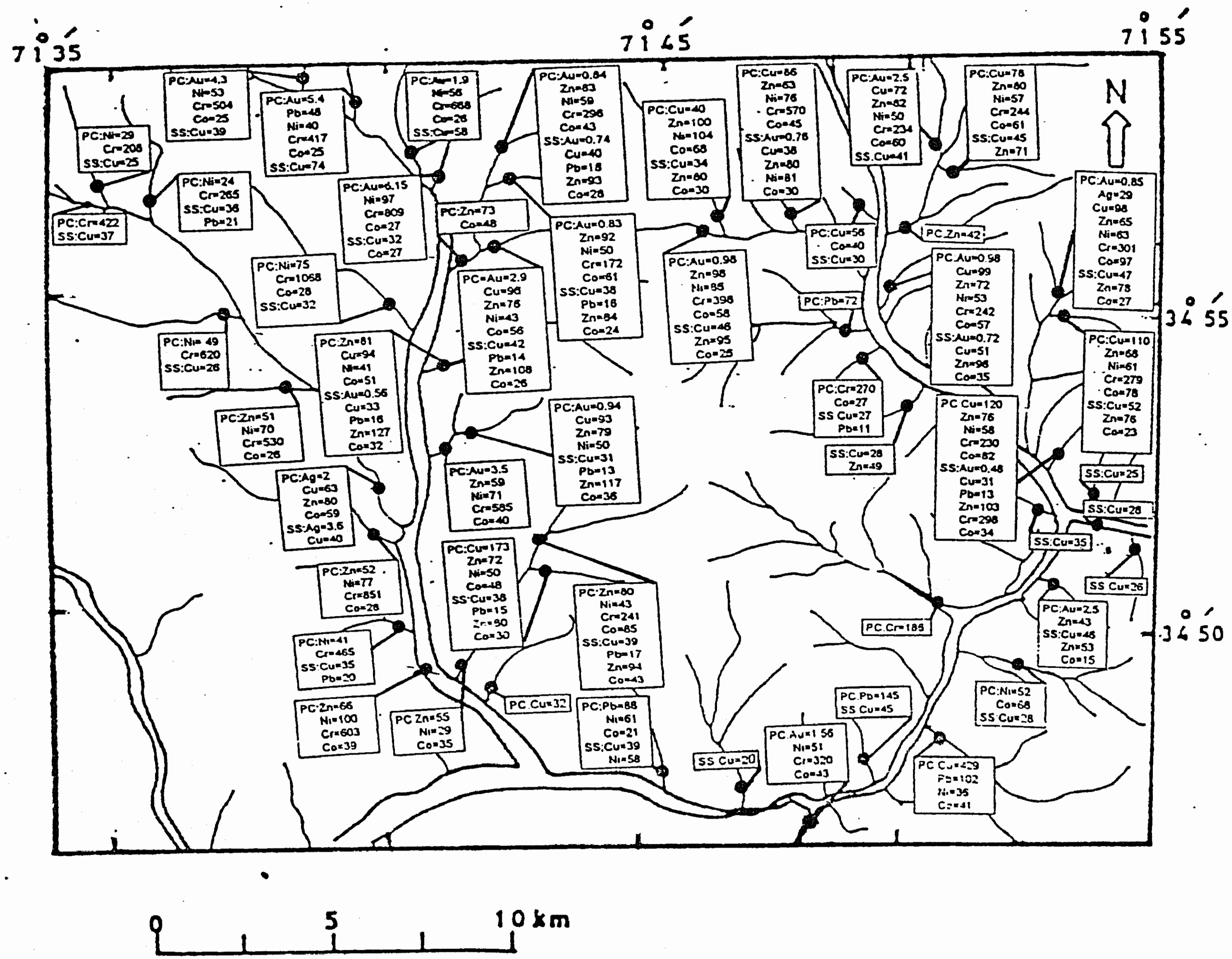


Fig. 11. Map showing streams and anomalous elements in both pan concentrates and fine fractions (-80 mesh) of the study area. PC = pan concentrate samples; SS = fine fraction samples. If a sample has no anomalous elements, only dot is shown.

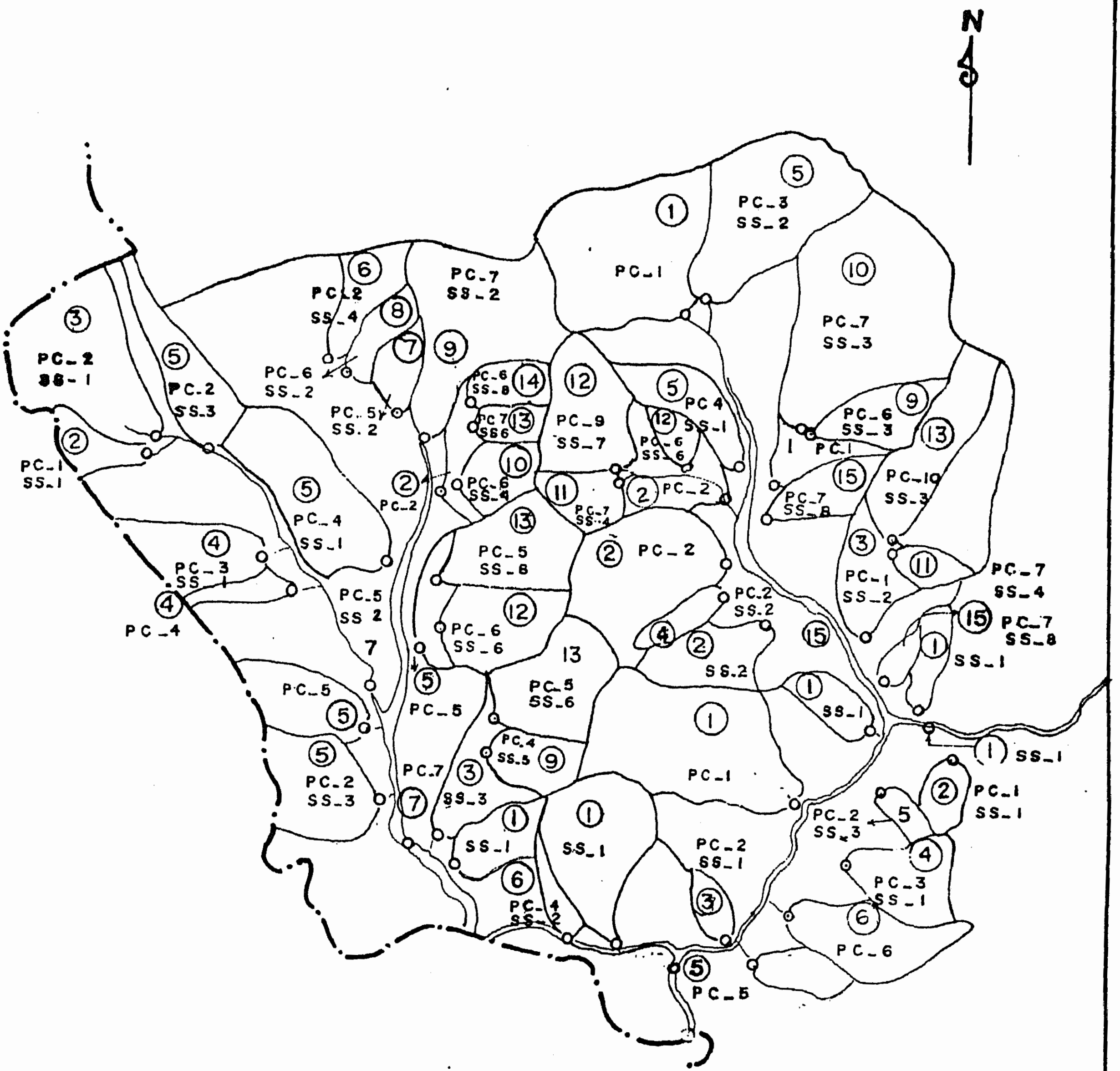


Fig. 12. Map showing sample sites, drainage cells and SCORESUMS for the pan concentrates and fine fractions (-80 mesh) of the study area. PC = Pan concentrates SCORESUM; SS = fine fractions (-80 mesh) SCORESUM. Number in circle is the sum of SCORESUMS for the two media. Small open circles indicate sample sites.

CONCLUSIONS

- The area of study has been divided into three complexes 1) Timargara Complex, 2) Samarbagh Complex and 3) Tora Tiga Complex on the basis of field and petrographic studies.

- The area is mainly composed of metadiorites, metagabbro-norites and amphibolites with lesser amount of metagranites, meta volcanics, aplite dikes, tonalites, hornblendites and ultramafites.

- The geochemical studies of the rocks of the area show no any kind of anomaly in regard to base metals and precious metals.

- The floats dominantly consists of fragments of metadiorite, metagabbro-norites and amphibolites with subordinate amount of quartz pegmatites, hornblendites, aplite dike rocks, quartz vein material, pyroxenite and metavolcanics.

- The pan-concentrates are dominantly composed of magnetite with lesser amount of quartz, zircon, pyroxene, garnet, hornblende, feldspar, tourmaline, pyrite, chromite and rock fragments.

- The pan-concentrates have higher concentration of all the elements (i.e. Au, Ag, Cu, Pb, Zn, Ni, Cr and Co) as compare to that of fine fraction (-80 mesh).

- Though Cu, Pb, Zn, Ni, Cr and Co are anomalous in the pan-concentrates of the stream sediments but it could be related to the bed rocks rather than to specific type of mineralization in the area.

- The anomalous gold, however, could not be directly related to the bed rocks. Its high order anomaly (both as visibly and Geochemically) suggest that the area north and northeast of Samarbagh has the potential for gold mineralization, probably in the form of quartz veins etc.

- It is, therefore, recommended that further detail geochemical study in regard to follow-up for gold mineralization should be carried out in the area north and northeast of Samarbagh.

- This study suggest that the base metals are generally silicate-bound rather than sulfide-bound in the stream sediments.

REFERENCES

Ahmad. W.. 1962. Copper showings in the Usheri region, Dir, Pakistan. Geol. Surv. Pak. Min. Inf. Circ. No..8. 14.

Arbab. M.S.H. & Khan, R.N., 1973. Geology of Dir and Northern part of Timergara Quodranle. N.W.F.P. Pakistan . Geol. Surv. Pak. Inf. Rel. No.49.

Bard. J.P.. Maluski, H., Matte, P, & Proust, F., 1980. The Kohistan sequence, crust and mantle of an abducted island arc. Geol. Bull. Univ. Peshawar, 13, 87-93.

Bard. J.P.. 1983. Metamorphic evolution of obducted island arc; Example of the Kohistan sequence (Kohistan) in the Himalayan collided range. Geol. Bull. Univ. Peshawar, 16, 105-184.

Bellehumeur. C.. Marcotte. D. & Jebrak, M., 1994. Multi-element relationship and spatial structures of regional geochemical data from stream sediments, south-western Quebec, Canada. J. Geochem. Explor. 51. 11-35.

Butt. K.A.. Chaudhry. M.N. & Ashraf, M., 1980. An Interpretation of petrotectonic Assemblage west of western Himalayan syntaxis in Dir District and adjoining Areas in northern Pakistan. Geol. Bull. Univ. Peshawar. 13. 79-86.

Chaffee. M.A.. 1983. Scoresum- Atechnique for displaying and evaluating multi-element- geochemical information. with examples of its use in regional mineral assessment programs. J. Geochem. xplor. 19. 361-381.

Chamberlain. C.P.. Zeitler. P.K.. & Erickson, E., 1991. Constraints on the Tectonic evolution of the northwestern Himalaya from Geochronologic and petrologic studies of Babusar Pass. Pakistan. J. Geol. 18. 354-357.

Chaudhry. M.N. and Chaudhry. A.G. 1974. Geology of Khagram area, Dir district. Geol. Bull. Punjab Univ. 11. 21-44.

Coward. M.P.. Jan. M.Q., Rex, D.C.. Terney, J., Tahirwall. M. & Windley. B.F.. 1982. Geotectonic framework of the Himalaya of N.W. Pakistan: J. Geol. Soc. London. 139, 299-308.

Coward. M. P. Windley. B.F., Broughton, R.D., Luff, I.W; Petterson, M.G; Pudsey, C.J., Rex, D.C. & Khan. M. A.. 1985. Collision tectonic in the NW Himalayas. In: Collision tectonics (M.P. Coward & A.C. Ries eds.). Geol. Soc. London, Spec. Publ. 19, 203-219.

Coward. M.P., 1986. A section thorugh the Nanga parbat syntexis, Indus valley Kohistan Geol. Bull .Univ. Peshawar. 18. 147-152.

Coward. M.P. & Butler, R.W.H.. Khan, M.A. & Knippe, R.J., 1987. The tectonic history of Kohistan and its implications for Himalayan Structure. J. Geol. Soc. London, 144, 377-391.

Davenport. P.H: 1990. A comparison of regional geochemical data from lakes and streams in northern abrador: implications for mixed-media geochemical mapping. J. Geochem. Explor. 39, 117-151.

Debon. F.. & Le Fort, P., Dautel, D., Srnet, J. Zimmermann, J.L., 1987. Granites of western Karakorm and northern Kohstan (Pakistan): A composit Mid cretaceous to upper Ecnozoic magmatism. Lithos, 20, 19-40.

Hamidullah, S. & Islam, F. & Farooq, M., 1990. Petrology and goechemistry of the western part of the Dir Ignious complex, Kohsitan island arc. Northern Pakistan. In: Geology and Geodynamic evolulion of the Himalayan collision zone (Sharama, K.K. ed.). Phys. Chem. Earth, 17, 31-46.

Hamidullah. S., Shah, M.T., 1993. Textural and minerchemical significance of hornblendes from an andesite at Dir Kohsitan arc, N. Pakistan. Geol. Bull. Univ. Peshawar, 26, 45-58.

Honegger. K., Dietrich. V., Frank. W., Gansser, A., Thani, M. & Trommsdorff. V., 1982 Magmatism and metamorphism in the Ladakh Himalaya (the Indus Tsangpo sutur zone). Earth Planet. Sci. Letters 60, 253-292.

Howarth. R.J., 1983. Statistics and data analysis in geochemical prespecting. In: Handbook of Exploration Geochemistry (G.J.S. Govett. ed.). Elsevier, Amsterdam, 2, 437 pp.

Hyden. H.H., 1915. Notes on the geology of Chitral Gilgit and Pamirs. Geol. Surv. India, 45, 271-335.

Ivanac. J.F., Traves. D.M.. & King, D., 1956. The Geology of the NW portion of the Gilgit Agency. Rec. Geol. Surv. Pakistan, 3,1-27.

Jan. M.Q.. Kempe. D.R.C. & Tahirkheli, R.A.K., 1969. The Geology of corundum bearing and related rock around Timergara. Geol. Bull. Univ. Peshawar, 4, 82-89.

Jan. M.Q.. 1979. Petrography of pyroxene granulites from northern Swat and Kohistan. Geol. Bull. Univ. Peshawar. 11, 65-87.

Jan. M.Q.. Khan M.A.. Tahirkheli. T. & Kmal, M.. 1981. Tectonic subdivision of granitic rocks of north Pakistan. Geol. Bull. Univ. Peshawar. 14, 1-28.

Jan. M.Q.. & Howie. R.A.. 1981. The mineralogy and geochemistry of the metamorphosed basic and ultrabasic rocks of the Jijal Complex, Kohistan, NW Pakistan. J. Petrolgoy 22, 85-126.

Jan. M.Q.. & Howie. R.A.. 1982. Hornblendie amphiboles from basic and intermediate rocks of Swat-Kohistan. northwest pakistan. Amer. Mineral. 67, 1155-1178.

Jan. M.Q.. Banaras, M., Ghani, A., & Khan, M. A., 1983. The Tora Tigga ultramafic complex, southern Dir District. Geol. Bull. Univ. Peshawar, 16, 11-29.

Jan. M.Q.. 1988. Geochemistry of amphibolites from the southern part of the Kohistan arc, N Pakistan. Mineral. Mag. 52. 147-159.

Jan. M.Q.. Khattak. M.U.K.. Parvez. M.K.. Windley, B.F., 1989. The Chilas stratiform complex: fied and mineralogical aspects. Geol. Bull. Univ. Peshawar, 17. 163-69.

Jan. M.Q.. & Karim, A.. 1990. Continental magmatism related to Late Palaeozoic-Early Mesozoic Rifting in northern Pakistan and Kashmir. Geol. Bull. Univ. Peshawar, 23, 1-25.

Jan. M.Q.. & Windly. B. F.. 1990. Chromium spinel-silicate chemistry in ultramafic rocks of the Jijal complex. Northeast Pakistan, J. Petrolgoy, 31, 667-715.

Jan. M.Q.. 1991. High pressure metamorphic rocks from the Himalaya and other tectonic- a review. In: Geology and Geodynamic evolulion of the Himalayan collision zone (Sharama, K.K. ed.). Phys. Chem. Earth. 18, 329-343.

Kakar. S.K., Badshah, M.S., & Khan, J. 1971. The geology of the Jandul valley, western Dir. Geol. Bull. Univ. Peshawar. 6. 54-73.

Khan. R.N.. 1969. Geology of Timergara Quadrangle, Dir. NW Pakistan. Geol. Surv. Pak. unpublished.

Khan. R.N. & Saleemi. B.A. 1972. Geology of Kotegram and Akhagram Quard range, District Dir and Swat. NWFP Pakistan. Geol. Surv. Pak. Inf. Rel. No.80.

Khan. M.A.. Jan. M.Q.. Windley. B.F.. Tarney, J. & Thrilwall, M.F., 1989. The Chilas ultramafic mafic ignous complex of the Kohstan island arc in the Hamalaya north Pakistan. Geol. Soc. Am. Sp. paper 232. 75-94.

Khan. M.A. & Jan. M.Q.. & weaver. B.L., 1993. Evolution of the Lower arc crust in Kohistan N. Pakistan: Temporal arc magmatism though early, mature and intra arc rift stages. In: Treloar. P.J., spec. Publ. Geol. Soc. London. 74.

Kloot Wijk. C.T.. & Gee. J.S.. Pearce, J.W., Smith, G.M., & Mc Fadden, Ph.L, 1992. An early India-Asia contact: Paleo magnetic constraints from Ninetyeast Ridge, OPD leg. 121. Geology 20, 395-398.

LeFort. P.. Debon. F.. & Sonet. J.. 1980. The "Lesser Himalaya" cordirite grainite belt: Typology and age of the pluton of Mansehrah. Pakistan; proceedings international Geodynamics confrence. Geol. Bull. Univ.. Peshawar. Spec. Issue, 13, 51-61.

LeFort. P.. 1975. Himalayas: the collided range; present knowledge of the continental arc. Am-J. Sci. 275A. 1-44.

Lepeltier. C: 1969. A simplified statistieal treatment of geochemical data by graphical representation. Econ. Geol. 64. 538-550.

Majid. M. & Paracha, F.a., 1980. Calc-alkaline magmatism at destructive plate margin in N.Pakistan. Geol. Bull. Univ. Peshawar. 13. 109-120.

Majid. M.. Shah. M.T.. Latif. A: Aurangzeb: Kamal, M., 1981. Major element abundances in the Kalam Lauas . Geol. Bull. Univ. Peshawar. 14, 45-62.

Molnar. P., & Tapponnier. P., 1977. The collision between India and Eurasia: Scientific American, 236, 30-41.

Otsu. H.. Kubotta. R. & Matsuda, Y., 1984. Partition of statistical frequency distribution of geochemical data. Min. Geol. 34, 51-56 (Japanese with English abstract).

Petterson. M.G. & Windley, B.F. 1985. Rb-Sr dating of the Kohistan arc batholith in the Transhimalayan of of the North Pakistan and tectonic imlications. Earth Planet. Sci. Lett., 74, 45-57.

Petterson. M.g. & Windley, B.F. & Luff, I.W., 1990. The Chalt valcanics, Kohistan, N. Pakistan High-Mg tholeites and low Mg calc-Alkaline volcanism in a cretaceous island arc. In: Geology and Geodynamic evolulion of the Himalayan collision zone (Sharama, K.K. ed.). Phys. Chem. Earth, 17. 19-30.

Petterson. M.G. & Windley. B.F., 1991. Changing source regions of magmas and crustal growth in the Trans-Himalayas: Evodence from the chalt volcanics and Kohistan batholith Kohistan, N. Pakistan. Earth planet. Sci. Lett., 102, 326-341.

Powell. Mc A. 1979. A Speculative tectonic history of Pakistan and surroundings: Some constraints fromt he Indian ocean. In: Geodynamics of Pakistan (A. Farah and K.A. DeJong, (eds). Geol. Surv. Pak. Sp.Publ. 5-24.

Pudsey. C.J., Coward. M.P., Luff, I.W., Shackleton, R.M., Windley, B.F. & Jan, M.Q., 1985. Collision zone between the Kohistan are and the Asian plate in NW Pakistan. Trans. R. Soc. Edinb: Earth Sci. 76. 643-479.

Pudsey. C.J., 1986. The northern suture, Pakistan: margin of a cretaceous island arc. Geol. Mag; 123, 405-423.

Rock. N.M.S: 1988. Numerical Geology, Lecture notes in earth sciences, Springer, Berlin, 427 pp.

Rose. H.W., 1975. The mode of occurrence of trace elements in soils and streams sediments applied to geochemical exploration. In: Geochemical Exploration (I.L. Elliott and W.K. Fletcher, eds.), Elsvier Amsterdem, 891-905.

Searle. M.P., 1983. Stratigraphy. Structure and evolution of the Tibetan-Tethys zone in Zanskar and the Indus sture zone in the Ladakh Himalaya. Trans. Roy. Soc. Edinb. 73, 205-219.

Searle. M.P., Windley, B.F., Coward, M.P., Cooper, D.J.W., Rex, D.C., Tingdong, L., Xuchang, X., Jan, M.Q.. Thakur, V.C. & Kumar, S., 1987. The closing of Tethys and Tectonic of Himalaya. Geol. Soc. Amer. Bull. 98. 678-7010.

Shah. M.T., 1991.Geochemistry, mineralogy and petrology of the sulfide mineralization and associated rocks in the area around Besham and Dir, Northern Pakistan unpublished. Ph.D. Thesis Univ. S. Carolina. Columbia.

Shah. M.T. & Jan. M.Q., 1993. Mineralogical constraints of the Shergarh Sar amphibolites. Allai Kohistan. northern Pakistan. Geol. Bull. Univ. Peshawar. 26, 59-73.

Shah, M.T., Shervais, J.W. & Ikramuddin, M., 1994. The Dir meta-volcanic sequence: Calcalkaline magmatism in the Kohstan arc terrance, northern Pakistan. Geol. Bull. Univ. Peshawar, 27, 9-27.

Shams, F.A., 1983. Granites of NW Pakistan. In: Shams, F.A., (ed.) Granites of Himalayas, Karakoram Hindukush. Inst. Geol. Punjab, Univ. Lahore, Pakistan, 75-121.

Sinclair, A.J., 1974. Selection of threshold in geochemical data using probability graphs. J. Geochem. Explor. 3, 129-149.

Sinclair, A.J., 1976. "Probability graphs" Assoc. Exploration Geochemists, Spec. Vol. No.4, 95pp.

Sullivan, M.A., Windley, B.F., Saumders, A.D., Haynes, J.r. & Rex. D.C., 1993. A palaeogeographic reconstruction of the Dir group: evidence for magmatic arc migration within Kohistan, N. Pakistan. In: Himalayan tectonics. CP. J. Treloar & M.P. Searl, eds). Spec. Publ. No.74 Geol. Soc. London, 139-160.

Tahirkheli, R.A., 1979. Geology of Kohistan and adjoining eurasian and Indo-Pakistan continents, Pakistan. Geol. Bull. Univ. Peshawar, 11, 1-30.

Tahirkheli, R.A.K., Mattaure, M; Proust, F., & Tapponnier, P; 1979. The India-Eurasia suture in northern Pakistan: Synthesis and interpretation of data on plate scale. In: Geodynamics of Pakistan (A.Farah, A. & K.A. DeJong, eds.) Geol. Surv. Pakistan, 125-130.

Tahirkheli, R.A.K., Jan, M.Q. & Majid, M., 1979. Geology of Kohistan, Karakoram Himalaya, northern Pakistan. Geol. Bull. Buniv. Peshawar 14, 189 p.

Tahirkheli, R.A.K., 1982. Geology of Himalaya, Karakoram and Hindukush in Pakistan. Geol. Bull. Univ. Peshawar, 15, 54 pp.

Tahirkheli, R.A.K., 1983. Geological evolution of Kohistan island arc on the southern flank of the Karakoram-Hindukush in Pakistan. Bollettino Geofisica Teorica Applicata 25, 351-364.

Tennant, C.B. & White, M.L., 1959. Study of the distribution of some geochemical data. Econ. Geol. 54, 1281-1290.

Treloar, P.J., Rex, D.C., Guise, P.G., Coward, M.P., Searle, M.P., Windley, B.F., Petterson, M.g., Jan, M.Q. & Luff, I.W., 1989. K-Ar and Ar-Ar geochronolgoy of the Himalayan collision on NW Pakistan: Constraints on the timing of suturing, deformation, metamorphism and uplift. Tectonics, 8, 881-909.

Yamamoto, H: 1993. Constraints metamorphic P-T-time paths of the Kohistan granulites and tectonics of the western Himalayas. J. Geol. Soc. London 150, 843-856.

Zeitler, P., 1985. Cooling history of the NW Himalaya Pakistan. Tectonics 4, 127-151.

APPENDIX

FIELD AND MICROSCOPIC STUDIES OF PAN-CONCENTRATES

SAMPLE No. 1

Location: Zimdara/Gal Khwar near Bandai village.
Span: 20 to 30 meter
Grid reference:
Gradient: Medium
Elevation: 1150 m
Boulder size: Less than 2 meter
Drainage Area: 24.37 $(Km)^2$
Float Geology: Amphibolite, Pagmatite, Hornblendite, Black volcanics, Quartz vein material.

Mineralogy: It is dominantly composed of magnetite >60%) with minor amount of rock fregments, feldspar, quartz, garnet, zircon, pyroxene, biotite and pyrite. No gold is visible.

SAMPLE NO.2

Location: Athrafi Khwar (Sheklai Khwar)
Span: 50 to 80 meter
Grid reference: 34N 71E
Gradient: Medium
Elevation: 1150 m
Boulder Size: Less than 2 meter
Drainage Area: 30 $(Km)^2$
Float Geology: Amphibolite, Pagmatite, Black volcanics, Hornblendite, Mica Granit, Quartz vein material.

Mineralogy: It is dominantly composed of magnetite (>60%) with minor amount of rock fregments, quartz, garnet, zircon, pyroxene, and pyrite. No golg is visible.

SAMPLE NO.3

Location: Loe Khwar or/Nawar Khwar at Markhani village.
Span: 150 meter
Grid reference: 34,58.0N 71,50.5E
Gradient: Medium
Elevation: 1060 m
Boulder size: Less than 2 meter
Drainage area: 41.87 Km^2
Float Geology: Amphibolites, Diorites, Granites, Granetic Gnessis, Hornblendite, Pagmatite, Norite, Quartz, Quartzite.

Mineralogy: It is dominantly composed of magnetite (>60%) with minor amount of rock fregments, quartz, garnet, zircon, pyroxene, and pyrite. Gold is present in the form of two specks having the following specification:

SPECK No. 1

Color: Medium yellow
Shape: Near rectangular
Form: Solid
Roundness: Subangular to subrounded.

SPECK No. 2

Color: Medium yellow
Shape: Near oval
Form: Solid
Roundness: Subrounded.

SAMPLE NO.4

Location: Adda Khwar at Markhani village.
Span: 10 meter
Grid reference: 34,57.9N 71,50.6E
Boulder size: Less than 1 meter
Elevation: 1080 m
Gradient: Medium
Drainage ara: 6.87 (km^2)
Float Geology: Amphibolite, Diorites, Granites, Quartz vein material, Pagmatite, Hornblendite, Norite.

Mineralogy: Magnetite is the dominant phase (>60%) with lesser amount of rock fregments, zircon, quartz,
garnet, hornblende, pyroxene and pyrite. Gold is not visible.

SAMPLE NO.6

Location:Kumbar Khwar near Kumbar village.
Span: 100 to 150 meter.
Grid reference: 34,57.4N 71,48.4E
Gradient: Medium to Gentle.
Elevation: 1080 m
Boulder size: Less than 1.5 meter.
Drainage Area: 10 $(Km)^2$
Float Geology: Amphibolites, Pagmatite, Green volcanics, Diorite, Hornblendite, Black volcanics, Quartz vein material.

Mineralogy: Magnetite is the dominant constituent (>55%) with minor amount of rock fragments, zircon,pyroxene,garnet and pyrite.Gold is not visible.

SAMPLE NO.7

Location: Bandagai Khwar at Parikas village.
Span: 10 to 15 meter
Grid reference: 34,57.2N 71,47.4E
Gradient: Medium
Elevation: 1020 m
Boulder size: Less than 1 meter
Drainage area:10 (Km^2)
Float Geology: Amphibolite, Diorite, Quartz., Aplite, Mata volcanics.

Mineralogy: Quartz and Zircon are the dominant phases (>55) with minor amount of rock fregments,hornblende, magnetite and pyrite. No gold is visible.

SAMPLE NO.8

Location: Ganga Khwar at Nimaz Kot village.
Span: 20 to 25 meter
Grid reference: 34,57.4N 71,40.1E
Gradient: Medium
Elevation: 1160 m
Boulder size: Less than 5 meter
Drainage area: 12.5 (Km^2)
Float Geology: Banded amphibolites, Diorites, Quartz vein material, Hornblendit, Granites, Pagmatite, Aptite.

Mineralogy: Quartz and Zircon are the dominant phases (>55) with minor amount of rock fregments,hornblende, magnetite, pyrite and chalcopyrite. No gold is visible.

SAMPLE NO.9

Location: Bawra Khwar at odigram. Malkhana village.
Span: 20 meter
Grid reference: 34,57.2N 71,45.9E
Gradient: Medium
Elevation: 1125 m
Boulder size: Less than 2 meter
Drainage area:3.12 Km^2
Float Geology: Banded Amphibolite, Hornblended, Diorites, Pagmatite, Quartz vein material, Quartzite, Aplite.

Mineralogy: Magnetite is the dominent phase (>65%)with minor amount of zircon, pyroxene, hornblende, quartz, garnet and pyrite. Gold is present in the form of two colors having the following specification:

Color No. 1
Color: Yellow
Shape: rectangulr
Form: solid
Roundness: subrounded

Color No. 2

Color: medium Yellow
Shape: near rectangulr
Form: solid
Roundness: subangulr

SAMPLE NO.11

Location: Akakhel Khwar near Dokrai village,
Span: 100 to 120 meter
Grid reference: 34,57N 71,49.6E
Gradient: Medium
Elevation: 1000 m
Boulder size: Less than 1.5 meter
Drainage Area: 46.87 $(Km)^2$
Float Geology: Amphibolites, Pegmatite, Black and Green valcanics, Hornblendites, Diorit.

Mineralogy: Magnetite is the dominent phase (>60%)with minor amount of rock fregments, feldspar, pyroxene, zircon, quartz, garnet, pyrite. No gold is visible.

SAMPLE NO.12

Location: Dokari Khwar at Gulgat village.
Span: 20 to 30 meter
Grid reference: 34,56.2N 71,49.5E
Gradient: Medium
Elevation: 1000 m
Boulder size: Less than 1 meter.
Drainage area:8.75 Km^2
Float Geology: Amphibolites, Diorites, Granites, Quartz vein material, Hornblendites, Norite, Pagmatite, volcanics.

Mineralogy: Magnatite is the dominant(>60%) while zirco garnet, quartz, hornblende, pyrite and rock fragments are the minor constituents. Gold is present in the form of one color.

Color No. 1

Color: bright yellow
Shape: angular
Form: Solid
Roundness: rectangulr

SAMPLE NO.13

Location: Lajbok Khwar at Manro Banda village
Span:20 to 30 meter
Grid reference: 34,55.6N 71,52.6E
Gradient: Medium
Elevation: 1255 m
Boulder size: Less than 4 meter
Drainage area:28.75 $(Km)^2$
Float Geology: Amphibolites, Granite, Pagmatite, Hornblendites, Quartz vein material.

Mineralogy: Magnetite is the dominant(>60%) while zirco garnet, quartz, hornblende, pyrite and rock fragments are the minor constituents. No gold is visible.

Sample No. 14

Location: Biari Khwar near Manro Band village.
Span: 10 to 15 meter
Grid reference: 34,55.5N 71,52.6E
Gradient: Medium
Elevation: 1160 m
Boulder size: Less than 5 meter
Drainage area: 2.5 $(Km)^2$
Float Geology: Amphibolites, Granite, Norite, Quartz vein material, Diorite, Pagmatite, Hornblendite.

Mineralogy: Magnatite is the dominant(>60%) while zirco garnet, quartz, hornblende, pyrite and rock fragments are the minor constituents. No gold is visible.

SAMPLE NO.15

Location: Shahkhali Khwar near Kotkai village.
Span: 20 to 25 meter.
Grid refernece: 34,56.6N 71,48.4E
Gradient: Medium
Elevation: 980m
Boulder size: Less than 2 meter.
Drainge Area: 31.25 $(Km)^2$
Float Geology: Amphibolite, Pagmatite, Quartz, Hornblendite, Red volcanics.

Mineralogy: Magnetite is the dominant constituent (>55%) with minor amount of rock fragments, zircon,pyroxene,garnet and pyrite.Gold is not visible.

SAMPLE NO.16

Location: Shadas Khwar at Maidan area.
Span: 20 to 25 meter
Grid reference: 34,55.4N 71,48.5E

Gradient: Medium
Elevation: 960 m
Boulder size: Less than 2 meter
Drainage Area: 22.5 $(Km)^2$
Float Geology: Diorite, Garnite, Quartz vein material, Amphibolite, Quartzite, Hornblendite, Tonalite, Black volcanics.

Mineralogy: Rock fragments are the dominant constituents (>60%) with minor amount of feldspar, zircon,pyroxene, garnet and pyrite.Gold is not visible.

SAMPLE NO. 17

Location: Takatak Khwar Maidan area.
Span: 15 to 20 meter
Grid reference: 34,54.8N 71,48.4E
Gradient: Medium
Elevation: 1000 m
Boulder size: Less than 2 meter
Drainage Area: 2.5 $(Km)^2$
Float Geology: Granodiorite, Diorite, Granite, Quartz vein material, Amphibolites.

Mineralogy: Magnetite is the dominant constituent (>60%) with minor amount of feldspar, zircon,pyroxene and pyrite.Gold is not visible.

SAMPLE NO.18

Location: Lajbok Khwar at Mula Cham.
Span:45 to 50 meter
Grid reference: 34,53.8N 71,51.9E
Gradient: Medium
Elevation: 880 m
Boulder size: Less than 2 meter
Drainage Area: 38.75 $(Km)^2$
Float Geology: Granodiorite, Diorite, Amphibolite, Hornblendite, Pagmatite, Quartz vein material, Granite, Black volcanic.

Mineralogy: Feldspar are the dominent phase (>60%)with minor amount of rock fregments, pyroxene, hornblende, magnetite, chromite, zircon, quartz and garnet. Gold is present in the form of one color having the following specification:

COLOR No. 1

Colour: Medium yellow
Shape: platy
Form: Solid, thick
Roundness: Rounded

SAMPLE NO.19

Location: Mohammad Nyazi Khawar at Rehanpur village.
Span: 12 to 20 meter
Grid refernece: 34,53.3N   71,52.1E
Grdient: Medium to Steep
Elevation: 840 m
Boulder size: 2.5 meter
Drainage Area: 3.75 $(Km)^2$
Float Geology: Granodiorite, Diorite, Granite, Amphibolite, Quartz vein material, Hornblendite, Pagmatite.

Mineralogy: Pyroxene and feldspar are the dominent phase (>55%)with minor amount of rock fregments, pyroxene, hornblende, magnetite, chromite, zircon, quartz and garnet. No gold is visible.

SAMPLE NO.20

Location: Sangolai Khwar
Span: 25 meter
Grid refernece: 34,54.2N   71,49.4E
Grdient: Medium to Steep
Elevation: 950 m
Boulder size: <2 meter
Drainage Area: 3.75 $(Km)^2$
Float Geology: Amphibolite, Granodiorite, Diorite, Granite, Amphibolite, Quartz vein material, Hornblendite, Pagmatite.

Mineralogy: Magnetite is the dominant constituent (>55%) with minor amount of rock fragments, zircon, feldspar, hornblende, pyroxene, chromite, garnet and scheelite.No visible gold

SAMPLE NO.21

Location: Giro Khwar at Rehanpur School.
Span: 10 meter
Grid reference: 34,52.8N   71,52.4E
Boulder size: Less than 2 1 meter
Elevation: 840 m
Drainage area: 2.5 $(Km)^2$
Gradient: Medium
Float Geology: Amphibolite, Hornblendite, Pagmatite, Quartz vein material, Granite

Mineralogy: Dominently composed of magnetite(>60%) with minor amount (1-15%) of Zircon,qurtz, hornblende and garnet. Among the ore phases magnetite and pyrite are distinguishable. Gold is not visible.

SAMPLE NO.22

Location: Barandu Khwar at Rehanpur School.
Span: 10 meter

Grid reference: 34,52.8N 71,52.4E
Boulder size: Less than 2 1 meter
Elevation: 830 m
Drainage area: 2.5 $(Km)^2$
Gradient: Medium
Float Geology: Amphibolite, Hornblendite, Pagmatite, Quartz vein material, Granite

Mineralogy: It has magnetite as the dominant phase (>55%) with minor amount of feldspar, zircon, pyroxene, biotite, scheelite and pyrite.Gold is not visible.

SAMPLE NO.23

Location: Barando Khwar between Khan Abad and Shahzadi village.
Span: 20 meter.
Grid reference: 34, 51.9N 71, 52.1E
Boulder size: Less than one meter.
Elevation: 800 m
Gradient: Medium
Drainage Area: 9.37 $(Km)^2$
Float Geology: Amphibolites,Diorite, Quartz vein material, Granodiorite, Granite, Hornblendite, Pyroxenite, Black volcanics.

Mineralogy: Magnetite is the dominant constituent (>60%) with minor amount of rock fragments, zircon,garnet and scheelite.No visible gold

SAMPLE NO.25

Location: Danrwa Khwar
Span: 20 meter.
Grid reference: 34, 51.9N 71, 52.1E
Boulder size: Less than one meter.
Elevation: 820 m
Gradient: Medium
Drainage Area: 8.37 $(Km)^2$
Float Geology:Amphibolites,Diorite, Quartz vein material, Granodiorite, Granite, Hornblendite, Pyroxenite, Black volcanics.

Mineralogy: Magnetite is the dominant constituent (>60%) with minor amount of rock fragments, zircon, feldspar, pyroxene, chromite, garnet and scheelite.No visible gold

SAMPLE NO.26

Location:Gurgia Khwar 100 meter from main road.
Span: 10 to 15 meter
Grid reference: 34,50.6N 71, 52.3E
Gradient: Medium
Elevation: 830 m
Boulder size: Less than 1 meter.
Drainage Area: 9.37 $(Km)^2$

Float Geology: Granodiorite, Amphibolite, Manzonite, Hornblendite, Quartz vein material, Granite, Pagmatite.

Mineralogy: Magnetite is the dominant constituent (>60%) with minor amount of rock fragments, zircon,garnet and scheelite.Gold is present in the form two colors and one speck having the following specification:

Specks No. 1

Color: bright yellow
Shape: sub angular
Form: solid
Roundness: subrounded

Color Nos. 1 & 2

Color: Medium yellow
Shape: Arborescent
Form: Solid, thick
Roundness:Rounded

SAMPLE NO. 27

Location:Anderi Khwar at 100 meter down from the main Timergara Maidam road.
Span:75 meter
Elevation: 750 m
Boulder size:less than 2 meter
Gridrefrence 34, 50.5N 71, 50.2E
Gradient: Medium
Drainage Area: 30.6 (Km2)
Float Geology: Granodiorite, Diorite, Tonolite, Biotite Granite, Hornblendite, Quartz vein material, Qtzite, Amphibolite, Norite.

Mineralogy: Magnetite is the dominent phases (>50%)with minor amount of rock fregments, zircon, Feldspar, quartz, epidote,chromite,pyroxene and garnet. No gold is visible.

SAMPLE NO. 28

Location:Timergara Khwar nea Kotko Shah village.
Span:120 meter
Elevation: 740 m
Gradient: Medium
Grid reference:34,49.2N 71,51.5E
Boulder Size: Less than 1 meter
Drainage Area: 10 (Km2)
Float Geology: Amphibolite, Hornblendite, Diroite, Feldspar, Quartz vein material, Granite,Granodiorite, Salphides, Tonalite.

Mineralogy: Magnetite is the dominent phase (>50%)with minor amount of zircon, feldspar, quartz, pyroxene, garnet and pyrite. No gold is visible.

SAMPLE NO. 29

Location: Khungi Khwar.
Eleuation: 720m
Span:10 to 15 meter
Gridrefrence 34, 48.1N 71, 50.0E
Gradient: Medium
Drainage Area: 15(Km2)
Boulder size: Less than 2 meter
Float Geology: Amphibolite, Diorite, Granodiorite Hornblendite, Granite, Quartz vein material, Sulphide with Cu, mineralization and miner meta volcanices.

Mineralogy: Magnetite is the dominent phase (>55%)with minor amount of rock fragments zircon, feldspar, quartz, pyroxene, garnet and pyrite. No gold is visible.

SAMPLE NO.31

Location: Qalagai Khwar near Qalagai Khazana village.
Span: 15 to 20 meter.
Grid reference: 34,47.6N 71,48.5E
Gradient: Medium
Elevation: 755 m
Boulder size: Less than one meter
Drainage Area: 3.12 $(Km)^2$
Float Geology: Amphibolite, Hornblendite, Granodiorite, Pagmatite, Tonalite, Garnet bearing Amphibolite, Ultramafics.

Mineralogy: Magnetite and feldspar are the dominant constituents (>55%) with minor amount of rock fragments, zircon, hornblende, pyroxene,biotite, chromite, and pyrite.Gold is not visible.

SAMPLE NO. 32

Location: Main Panjkor ariver
Span: 150 to 200 meter.
Grid reference: 34,47.6N 71,48.5E
Gradient: Medium
Elevation: 755 m
Boulder size: Less than one meter
Drainage Area: Main
Float Geology: Amphibolite, Hornblendite, Granodiorite, Pagmatite, Tonalite, Garnet bearing Amphibolite, Ultramafics.

Mineralogy: Magnetite is the dominent phases (>55%)with minor amount of rock fregments, zircon, quartz, chromite, volcanics, Hornblendite, Amphibolite, diorite, granodiorite, granites and pyroxene.Gold is present in the form of 9 colors having the following specsification:

Color Nos. 1, 2 &3
Color: bright yellow
Shape: near oval
Form: solid
Roundness: subrounded

Color Nos. 4,5, 6 & 7

Color: bright yellow
Shape: near pear
Form: solid
Roundness: subrounded

Color Nos. 8 &9

Color: yellow
Shape: scorpian like
Form: solid
Roundness: subrounded

SAMPLE NO. 33

Location: Garra Khwar
Elevation: 669 m
Span: 20 to 25 meter
Gradient: medium
Grid reference: 34,47.6N 71,45.6E
Boulder size: less than one meter
FloatGeology:Diorite,Granodiorite, Hornblendite, Gnessis, Quartz nmaterial,Peridotite.

Mineralogy: Magnetite is the dominent phase (>65%)with minor amount of rock fragments zircon, feldspar, quartz, peroxene, garnet and pyrite. No gold is visible.

SAMPLE NO. 35

Location: Garra Khwar
Elevation: 669 m
Span: 20 to 25 meter
Gradient: medium
Grid reference: 34,47.6N 71,45.6E
Boulder size: less than one meter
FloatGeology:Diorite,Granodiorite, Hornblendite, Gnessis, Quartz nmaterial,Peridotite.

Mineralogy: Magnetite is the dominent phase (>55%)with minor amount of rock fragments, zircon, feldspar, quartz, pyroxene, garnet and pyrite. No gold is visible.

SAMPLE NO.36

Location: Ghanam Shah Khwar Jandul area.
Span: 15 meter
Grid reference: 34,49.3N 71,41.6E
Boulder size: less than 1 meter
Elevation: 760 m
Gradient: Medium
Drainage Area: 4.37 $(Km)^2$
Float Geology: Amphibolite, Hornblendite, Qtzite, pagmatite, praxenite, Granite, Garnet, Amphibolite,

Mineralogy: Magnetite is the dominant constituent (>55%) with minor amount of rock fragments, zircon, hornblende,pyroxene and chromite.Gold is not visible.

SAMPLE NO. 37

Location: Uch khwar near Munda village.
Span:100 to 150 meter.
Elevation 780 m
Boulder size: Less than 2 meter.
Grid reference: 34,49.8N 71, 41.2E
Float Geology:Diorite, Granodiorite, Granites, Quartz vein material, Pyroxenite.

Mineralogy: Magnetite is the dominent phases (>60%)with minor amount of rock fregments, zircon, quartz, pyroxene, olivine, garnet and pyrite. No visible gold.

SAMPLE NO. 38

Location: Main Jandul Khwar near Main Kili village.
Span:200 to 300 meter
Elevation: 730 m
Gradient: Medium.
Grid reference: 34,49.7N 71, 41.5E
Boulder size: Less than 1 meter.
Float Geology: Diorite, Granodiorite, Rhyolite, Quartz vein material, volcanics, Mica Granite, Gnessis, Amphibolite, Volcanics aglomerate and breccia.

Mineralogy: Magnetite is the dominent phases (>65%)with minor amount of rock fregments, zircon, quartz,pyroxene,hornblende, beryl, chromite, garnet and pyrite. Gold is present in the form of gold having the following specifiction:

Speck No. 1

Color: bright yellow
Shape: irragular
Form: solid
Roundness: subangular

Speck No. 2

Color: bright yellow
Shape: oval
Form: solid
Roundness: subrounded

SAMPLE NO.39

Location: Dop Qala Khwar
Span: 20 to 25 meter
Grid reference: 34,54.8N 71,48.4E
Gradient: Gentle
Elevation: 780 m
Boulder size: Less than 6 inches
Drainage Area: 12.5 $(Km)^2$
Float Geology: Amphibolite, Granitic Gnessis, Quartz vein material, Pagmatite.

Mineralogy: Magnetite is the dominant constituent (>50%) with minor amount of rock fragments, zircon,pyroxene and pyrite.Gold is not visible.

SAMPLE NO. 40

Location: Gulo Tangai Sar village.
Span: 20 to 25 meter
Grid reference: 34,51.7N 71,41.4E
Boulder size: Less than 2 meter
Elevation: 840 m
Gradient: Medium
Drainage area: 15 Km^2
Float Geology: Amphibolite, Norite, Granite, Quartz vein material, Hornblendite.

Mineralogy: Dominantly composed of magnetite (%55) with minor amount rock fragments zircon, quartz vein material, chromite, pyroxene, garnet and pyrite. Gold is not visible.

SAMPLE NO. 41

Location: Shal Kandai Khwar at Khista Dehrai village.
Span: 70 meter
Grid reference: 34,52.3N 71,42.7E
Boulder size: Less than 3 meter.
Elevation: 875
Gradient: Medium
Elevation: 7.5 Km^2
Float Geology: Amphibolites, Granites, Grasiodiorite, Diorite, Hornblendites, Quartz vein material, Norite, Quartzite.

Mineralogy: Dominantly composed of magnetite (%55) with minor amount rock fragments, zircon, quartz vein material, chromite, pyroxene, garnet and pyrite. Gold is not visible.

SAMPLE NO.42

Location: Charmango Khwarr near Cham
Span: 15 to 20 meter
Grid reference: 34,54.2N 71,41.4E
Boulder size: Less than 1 meter
Elevation: 875 m
Gradient: Medium
Drainage area: 12.5 Km^2
Float Geology: Amphibolites, Diorites, Quartz vein material, Pegmatites, Hornblendites.

Mineralogy: It is dominantly composed of magnetite (>60%) with minor amount of rock fregments, quartz, garnet, zircon, pyroxene, and pyrite. Gold is present in the form one color having the following specification:

Color No. 1

Color: medium yellow
Shape: subangulr
Form: thick solid
Roundness: rounded

SAMPLE NO.43

Location: Swara Ghundlai Khwar. Near Qala village.
Span: 40 to 45 meter
Grid reference: 34,55.1N 71,41.3E
Gradient: Medium
Elevation: 880 m
Boulder size: Less than 2 meter
Drainage area: 12.5 Km^2
Float Geology: Amphibolites, Diorite, Granadiorites, Granitic Gnessis, Quatz vein material, Pegmatite, Hornblendites.

Mineralogy: Magnetite is the dominent phase (>55%)with minor amount of rock fregments, zircon, quartz and garnet.No gold is visible.

SAMPLE NO. 44

Location:Charmango Khawar near police chowki.
Span: 80 to 100 meter.
Gridreference: 34,53.5N 71,40.9E
Gradient: Medium

Elevation: 850 m
Boulder size: Less than 1 meter.
Drainage Area: 30.6 (Km^2)
Float Geology: Amphibolite, Banded amphibolites, Gniesses, Granite, Quartz vein material, Feldspar.

Mineralogy: Magnetite is the dominent phases (>60%)with minor amount of rock fregments, zircon, quartz,hornblende,chromite, garnet and pyrite.Gold is present in the form of two specks and two colors having the following specification:

Speck NO.1

Color: bright yellow
Shape: oval
Form: Solid
Roundness: subrounded

Speck NO.2

Color: bright yellow
Shape: pear shape
Form: Solid
Roundness: subrounded

Color 1 & 2

Color: bright yellow
Shape: near angular
Form: Solid
Roundness: subrounded

SAMPLE NO.45

Location: Mula Banda Khwar near Arif Qala village.
Span: 20 to 30 meter
Grid reference: 34,52.0N 71.39.4E
Gradient: Medium
Elevation: 800 m
Boulder size: Less than 1 meter
Drainge Area: 10.62 $(Km)^2$
Float Geology: Grano diorite, Diorite, Amphibolite, Hornblendite, Quartzite, Quartz vein material,Black volcanics.

Mineralogy: Magnetite is the dominant constituent (>60%) with minor amount of rock fragments, zircon,garnet and scheelite. Gold is not visible.

SAMPLE NO. 47

Location: Kotki Khwar
Elevation: 910 m
Span: 100 to 150 meter
Grid reference: 34, 54.7N 71, 37.8E
Gradient: Medium
Drainage Area: 2.5 $(Km)^2$
Boulder size: Less than 3 meter.
Float Geology: Diorite, Granodiorite, Volcanic braceia, Granite, Quartz vein material, feld spar, Rhyolit, volcanics.

Mineralogy: Magnetite is the dominent phases (>55%)with minor amount of rock fregments, zircon, quartz,pyroxene,hornblende, beryl, chromite, garnet and pyrite.No visible gold.

SAMPLE NO.48

Location: Bandichi Khwar at Main Banda village near Sangepara village.
Span: 40 to 50 meter.
Grid reference: 34,55.5N 71,36.9E
Gradient: Steep
Elevation: 1040
Boulder size: >1 m
Drainage Area: 10.62 $(Km)^2$
Float Geology: Diorite, Granodiorite, Biotite Granite, Quartz vein material, volcanics.

Mineralogy: Magnetite and garnet are the dominant constituents (>55%) with minor amount of rock fragments, zircon, feldspar, hornblende, pyroxene,biotite, chromite, and pyrite.Gold is not visible.

SAMPLE NO.49

Location: Shontala Khwar near Cham village.
Span: 30 to 40 m
Grid reference: 34,55.4N 71,40.0E
Gradient: Medium
Elevation: 920 m
Boulder size: Less than 2 meter
Drainage Area: 21 $(Km)^2$
Float Geology: Volcanics, Diorites, Granodiorite, Hornblendite, Pigmatites, Quartz vein material.

Mineralogy: Magnetite is the dominant constituents (>55%) with minor amount of rock fragments, zircon, feldspar, hornblende, pyroxene,garnet, chromite, and pyrite.Gold is not visible.

SAMPLE NO.50

Location: Manshi Khwar at Manshicham village.
Span: 10 to 15 meter
Grid reference: 34,57.0N 71,41.5E
Gradient: Medium

Elevation: 970 m
Boulder size: Less than 2 meter
Drainage area: 6.87 Km^2
Float Geology: Diorite, Granites, Granitic gnessis. Amphibolites, Hornblendite, volcanics, Pegmatite, Aplite, Micro granite.

Mineralogy: It is dominantly composed of magnetite (>60%) with minor amount of rock fregments, quartz, garnet, zircon, pyroxene, and pyrite. Gold is present in the form of three specks and one color having the following specification:

Specks No.1

Color: Bright yellow
Shape: Scorpion like shape
Form: Solid, compact
Roundness: Angular

Speck No.2

Color: Bright yellow
Shape: Near angular
Form: Solid
Roundness: Sub-angular

Speck No.3

Color: Bright yellow
Shape: Near angular
Form: Solid
Roundness: Subangular to sub-rounded.

Color No.1

Color: Bright yellow
Shape: Irregular shaped
Form: Solid
Roundness: Angular

SAMPLE NO.51

Location: Shar Kora Khwar at Tatar village.
Span: 20 to 25 meter
Grid reference: 34,58.4N 71,42.3E
Gradient: Medium
Elevation: 1140 m
Boulder size: Less than 3 meter
Drainage area: 3.12

Float Geology: Amhibolite, Diorites, Matavolcanics, Mata Diorite, Granites, Pegmatite, Maroon colour volcanics, Quartz vein material.

Mineralogy: Magnetite is the dominent phase (>55%)with minor amount of rock fregments, zircon, pyroxene, hornblende, quartz, garnet and pyrite.No gold is visible.

SAMPLE NO.52

Location: Bazarzai Khwar at Tatar village.
Span: 35 to 40 meter
Grid reference: 34,58.8N 71,42.2E
Gradient: Medium
Elevation: 1120 m
Boulder size: Less than 3 meter
Drainage area: 5.62 Km^2
Float Geology: Matavolcanics, Amphibolites, Quartz vein material, Granite, Granodiorite, Quartzites.

Mineralogy: Magnetite is the dominent phase (>65%)with minor amount of rock fregments, zircon, pyroxene, hornblende, quartz, garnet and pyrite.No gold is visible.

SAMPLE NO.53

Location: Manshicham Khwar (Samarbagh)
Span: 15 to 20 meter.
Grid reference: 34, 56.6N 71, 41.6E
Gradient: Medium
Elevation: 910 m
Boulder size: <1 m
Drainage Area: 20.6 $(Km)^2$
Float Geology: Rhyolite, Amphibolite, Granite, black volcanic, Green volcanics.

Mineralogy: Magnetite is the dominant constituent (>60%) with minor amount of rock fragments, zircon,garnet and scheelite. Gold is not visible.

SAMPLE NO.55

Location: Berarai khwar (Samarbagh)
Span: 15 meter.
Grid reference: 34, 58.4N 71, 40.2E
Gradient: Medium
Elevation: 1040 m
Boulder size: <2 m
Drainage Area: 5.4 $(Km)^2$
Float Geology: Diorite, granodiorite, volcanics quartz vein material and Amphibolite.

Mineralogy: Magnetite is the dominant constituent (>55%) with minor amount of rock fragments, zircon, feldspar, hornblende, pyroxene, chromite, garnet and scheelite.Gold is present in the form of one speck and two colors having the following specification:

Color No. 1 & 2

Color: bright yellow
Shape: thin, flaky
Form: bolid, thick, pitted
Roundness:rounded

Speck No.1

Color: Bright yellow
Shape: rounded
Form: solid
Roundness: roundedlor

SAMPLE NO.56

Location: Darangal Khwar near Tia village.
Span: 20 to 30 meter
Grid reference: 34,49.2N 71.38.9E
Gradient: Steep
Elevation: 1200 m
Boulder size: Less than 2 meter
Drainage Area: 6.87 $(Km)^2$
Float Geology: Diorite, Granodiorites, volcanics, black color rock having abundent Amphibolite,Biotite granites, Hornblendite, Quartz vein material.

Mineralogy: Magnetite is the dominant constituent (>50%) with minor amount of rock fragments, zircon, hornblende,pyroxene and chromite.Gold is present in the form of one piece and two colors having the following specification:

Piece No. 1

Color: medium yellow
Shape: subrounded
Form: solid
Roundness: subrounded

Color No. 1 & 2

Color: Medium Yellow
Shape: Rounded
Form: Solid, thick
Roundness:Almost rounded

SAMPLE NO.57

Location: Loi Khwar/Gawardesh Khwar near Bota Khwar.
Span: 30 to 40 meter

Grid refrence: 34,59.6N 71,38.5E
Gradient: Medium to Steep
Elevation: 1100 m
Boulder size: 5 to 8 meter
Drainage Area: 4.37 $(Km)^2$
Float Geolgy: Diorite, Granodiorite,Volcanic of various type.

Mineralogy: Magnetite is the dominant constituent (>65%) with minor amount of rock fragments, zircon,pyroxene and pyrite.Gold is present in the form of one piece and one speck having the following specification:

Piece No.1

Color: bright yellow
Shape: subrounded
Form: solid
Roundness: subrounded

Speck No. 1

Color: Medium Yellow
Shape: Rounded
Form: Solid, thick
Roudness:subrounded

SAMPLE NO.58

Location: Pitao Khwar Miskini dara Jandul area.
Span: 15 meter
Grid reference: 34,57.4N 71,35.5E
Gradient: Steep
Elevation: 1640 m
Boulder size: >3 m
Drainage Area: 10 $(Km)^2$
Float Geology: Diorite, Granite, Gabbro, Tonalite, Valcanic braecia, Qtzites.

Mineralogy: Magnetite and zircon are the dominant constituents (>55%) with minor amount of rock fragments, feldspar, hornblende, pyroxene,biotite, chromite, and pyrite.Gold is not visible

SAMPLE NO.59

Location: Loi Khwar north of Maskini bazar.
Span: 40 meter
Grid reference: 34,57.8N 71,34,3E
Gradient: Medium
Elevation: 1770 m
Boulder size:4 meter
Drainage Area:19.37 $(Km)^2$
Float Geology: Diorite,Grandiorite, Granite, Valcanics braecia, Volcanics.

Mineralogy: Magnetite and zircon are the dominant constituents (>55%) with minor amount of rock fragments, feldspar, hornblende, pyroxene, biotite, chromite, and pyrite.Gold is not visible

SAMPLE NO.60

Location: Suki Khwar situated between Darbar village and on Meskini village.
Span: 50 to 60 meter.
Grid reference: 34,57.5N 71,34.0E
Boulder size: Less than 2 meter
Elevation: 1640 m
Gradient: Steep
Drainage Area: 5.62 $(Km)^2$
Float Geology: Granodiorite, Tonolite, Diorite, Quartz vein material, volcanics,granite, Volcanic braecia.

Mineralogy: Magnetite and zircon are the dominant constituents (>55%) with minor amount of rock fragments, feldspar, hornblende, pyroxene, biotite, chromite, and pyrite.Gold is not visible.