INVESTOR INFORMATION PACKAGE
BUSINESS OPPORTUNITIES IN MINERAL SECTOR
OF KHYBER PAKHTUNKHWA, PAKISTAN

MALAKAND CHROMITE

Exploration Promotion Division
Directorate General Mines & Minerals
Minerals Development Department, Khyber Pakhtunkhwa, Pakistan

MAY, 1987

GOVERNMENT OF PAKISTAN
MINISTRY OF PLANNING AND DEVELOPMENT
PLANNING & DEVELOPMENT DIVISION
TECHNICAL ASSISTANCE PROJECT CELL

MINERAL SECTOR DEVELOPMENT STUDY
NORTH WEST FRONTIER PROVINCE
PAKISTAN

PRE-INVESTMENT PORTFOLIO
MALAKAND
CHROMITE PROJECT

MAY 1987

DAMES & MOORE
In association with
UNITED CONSULTANTS LIMITED
44-WARRIS ROAD, LAHOR
Tel: 412191/415136-37
Tlx: 44783 UCL PK

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

EXECUTIVE SUMMARY

The area between Sakhakot and Quila, in the Malakand ultramafic belt has been discovered to have a number of chromite orebodies. The SDA are currently exploring and defining orebodies with the view to mining them.

Ore from the orebodies found is too low in chromite and too high in silica to be sold as mined, and would have to be beneficiated to produce a saleable product. Beneficiation tests indicate a saleable quality concentrate could be produced.

For the purposes of developing generic potential mining and beneficiation costs, this portfolio assumed the presence of four small mineable orebodies that could be worked to produce 15000 tonnes of ore per year and a beneficiation plant in Peshawar that would produce 8300 tonnes of concentrate per year. This concentrate would have to be railed to Karachi to be exported. The international market would absorb this product to make such a project a profitable operation.

Exploration activity should be continued and enhanced in this area. More attention should be given to three dimensional analysis of the ore zones discovered through the use of diamond drilling, with the emphasis placed on defining mineable orebodies.

1.0 INTRODUCTION

This pre-investment portfolio is a result of the investigations, analysis and appraisals of the Malakand Chromite prospect areas carried out by consultants Dames & Moore International of Los Angeles, California, U.S.A., in Association with United Consultants Limited of Lahore, Pakistan, as part of their Agreement with the President, Islamic Republic of Pakistan, as represented by the Secretary, Planning and Development Division, Government of Pakistan, for a Mineral Sector Development Study of the North West Frontier Province, Pakistan.

The site work on this specific area involved a preliminary survey by a D&M geologist early in the twelve month study, a detailed study by a geologist and a mining engineer from D&M and geologists from the National Centre for Excellence in Geology, University of Peshawar, and extensive discussions with the Sarhad Development Authority geological project team based on site. Discussions with senior SDA management in Peshawar provided valuable input to this project.

Information helpful to the analysis and appraisal was provided by visits to other SDA exploration projects and to the SDA Kakul Phosphate Mine near Abbottabad.

This portfolio is not a feasibility study, but by assuming some specific conditions it attempts to outline those areas that will be critical in preparing a feasibility study when mineable orebodies are defined in the area.

2.0 GEOLOGICAL SETTING AND RESERVES

2.1 GEOLOGY

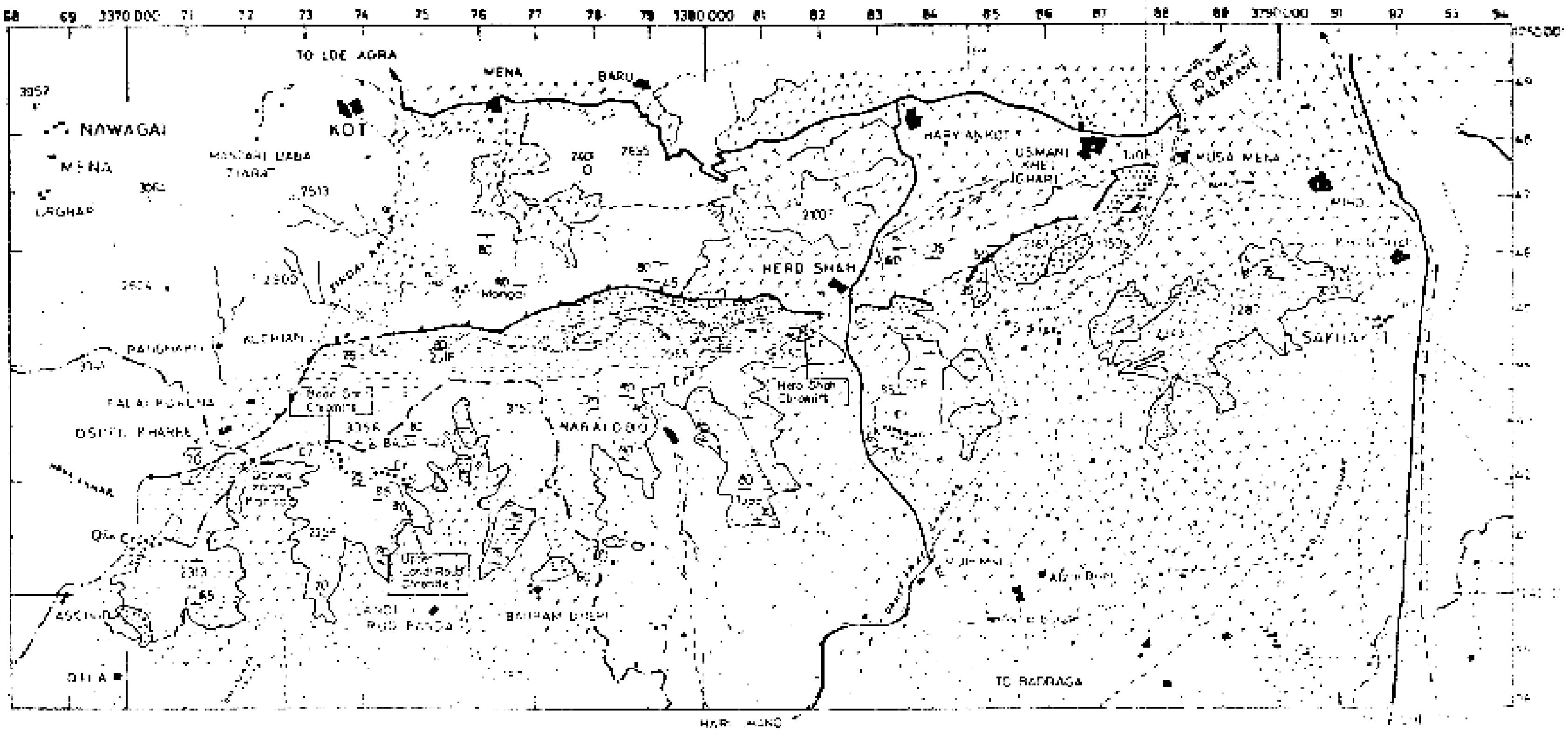
The Malakand chromite deposits lie about 65 kms north of Peshawar, within the Tehsil Charsadda and Malakand Agencies. The chromite bearing rocks occur in a belt up to 4.5 kms wide that extends westwards over 20 km from the town of Sakhakot to Qila. There is a railway line and a road to Darghai and existing gravel and dirt roads and tracks provide access to within one kilometre of most of the major known deposits.

The ultramafic complex forms a moderately steep, east-west trending range of hills which rise to elevations of almost 1000 metres above the northern edge of the Peshawar alluvial plain. Geological Survey of Pakistan topographic sheets No. 38 N/11 & N/15 at 1:50,000 scale cover the area.

The Upper Swat Canal passes within a few kilometres to the south east of the prospects, providing water to this relatively arid area. Groundwater probably could also be found in some of the alluvial-floored valleys.

Figure 2.1 shows the regional geology of the Malakand ultramafic belt. The chromite-bearing ultramafic complex of interest to this study extends over 20 km between Qila and Sakhakot and has been variously named as the Dargai, Hari Chand, Malakand, or Sakhakot-Qila ultramafic complex. Correlative rocks are found further west in the Utman Khel (Waziristan) ultramafic complex (Rafiq, 1984).

The ultramafic bodies have alpine-type characteristics which have close affinities to the Jijal ultramafics of the Kohistan Complex rather than the locally enclosing Paleozoic age metasediments of the Indo-Pakistan Plate. The Malakand ultramafic complex lies 20-25 km south of the Main Mantle Thrust. It is generally regarded as a klippe, (Tahirkheli, 1979



LEGEND

- ALLUVIUM
- HARZBURGITE DUNITE (CUMMULATE PERIDOTITE)
- METAMORPHIC PERIDOTITES
- SERPENTINITES WITH ASBESTOS & RODINGITE
- GABBROIC ROCKS
- META VOLCANICS WITH INTER-LAYERED GABBROIC SHEET
- META SEDIMENTARY SEQUENCE
- CHROMITE BODIES WITH DUNITE PATCHES
- ROAD AND RAILWAY LINE
- DIP & STRIKE, FAULT
- VILLAGES & PATH
- STREAM
- HEIGHTS

MINERAL SECTOR DEVELOPMENT STUDY NORTHWEST FRONTIER PROVINCE PAKISTAN	MALAKAND ULTRAMAFIC BELT LOCATION OF CHROMITE DEPOSITS	
Dames & Moore	1390-003-085	FIGURE 2

& Malinconico, 1982), although other structural interpretations can be made. Overall the complex has an ENE strike and generally steep northerly dip. Outcrop width is up to 4.5 km.

Internally, the ultramafic complex consists of harzburgite, peridotite, dunite, serpentinite, gabbroic rocks and minor rodingites and pyroxenite dikes. Over two-thirds of the complex is composed of harzburgite. The peridotite is more prevalent towards the margins of the complex. The dunite occurs as generally conformable lenses and horizons within both the harzburgite and the peridotites. These lithologies are most readily distinguished in the field on the basis of their respective weathering characteristics. The pyroxenites stand out in relief of the weathered surface. The chromite deposits usually are hosted within the dunites. Gabbroic rocks have been mapped towards the northern margin of the complex.

Faults and shears are ubiquitous throughout the complex and they are typically marked by zones of serpentinisation and commonly by magnesite veins. These zones are naturally recessive-weathering and are now marked by gullies. They should be easily identified on aerial photographs. Faults have caused considerable dismemberment of the chromite bodies.

2.2 EXPLORATION

The Geological Survey of Pakistan made the first comprehensive study and report of the geology of the ultramafic complex and its associated chromite deposits, (Rossman et al, 1970). They undertook large scale mapping at Qila, Hero Shah and parts of Landi Raud and Bada Sar prospects. Some drilling was undertaken at the Qila deposit.

PIDC/PMDC conducted some prospecting and grab sampling during 1973-74. During the period 1975-77 there was considerable selective mining of the readily accessible high grade ore from the deposits by various small private enterprises. The mining was done illegally under prospecting licence status only and commonly was poorly organised, primitive, wasteful and hazardous. Lower grade disseminated ores were left behind or discarded after hand-sorting. This mining ceased with the cancelling of leases and the loss of markets. PMDC submitted a PC-II scheme to the Government in February 1976. Fieldwork was conducted under a PC-I scheme between November 1976 and June 1977. Work under the phase II programme commenced in August 1977 and continued until July 1978. Details of any work by PMDC after this date are not available.

The PMDC exploration programme included the following:

* Geologic mapping at the scale of 1:12,000 conducted over the entire ultramafic complex. Aerial photograph enlargements were used as an aid in mapping.

* Detailed, tape and compass controlled, geologic mapping at scales of 1:600 and 1:300 for the Bajro Kanri, Hero Shah, Bada Sar, Qila, and upper and lower Landi Raud deposits. Mineralised outcrops were traversed and measured.

* Geologic cross section constructed on the basis of three traverses across the entire ultramafic complex. Additional detailed sections were prepared for individual deposits in order to support aditing and drilling proposals.

* Structural data collected for the whole complex and plotted at a scale of 1:12,500.

* Excavation and mapping of five adits, comprising a total of 239 metres, at the Bajro Kanri prospect.

* Assay sampling of most chromite occurrences in the area. This involved some 162 surface channel samples and 78 adit samples (of which 57 were analysed) from the Bajro Kanri adits.

* Collection of a total of 187 stream sediment samples for analysis of Ni and Co.

* Preparation and study of thin sections of samples from the various lithologies.

* Beneficiation studies on 10 tons of low grade ore from Bajro Kanri by PCSIR laboratories , Lahore.

* Magnetic survey of the Bajro Kanri and Hero Shah areas.

The SDA are currently working in the area under a PC-II scheme. This exploration effort has been directed towards the confirmation of reserves at Hero Shah and Upper Landi Raud. Maps showing the distribution of the chromite lenses and some of the important structures have been prepared at a scale of 1:1000 for each of the areas.

At Hero Shah, some 190 metres of aditing have been completed in one adit with several crosscuts. This adit has been mapped at a scale of 1:100. Much of the chromite exposed in the adit has been chip sampled but only a few assays have been completed.

At Upper Landi Raud, SDA are currently working on 3 adits on 2 separate lenses. The two adits on lens A have been sampled. Adit A-3 beneath lens B failed to intersect significant mineralisation.

The Japan Consulting Institute (1981) made a comprehensive study into the feasibility of utilising local magnesite and Malakand chromite for the production of chrome-magnesite refractory bricks.

2.2.1 Hero Shah

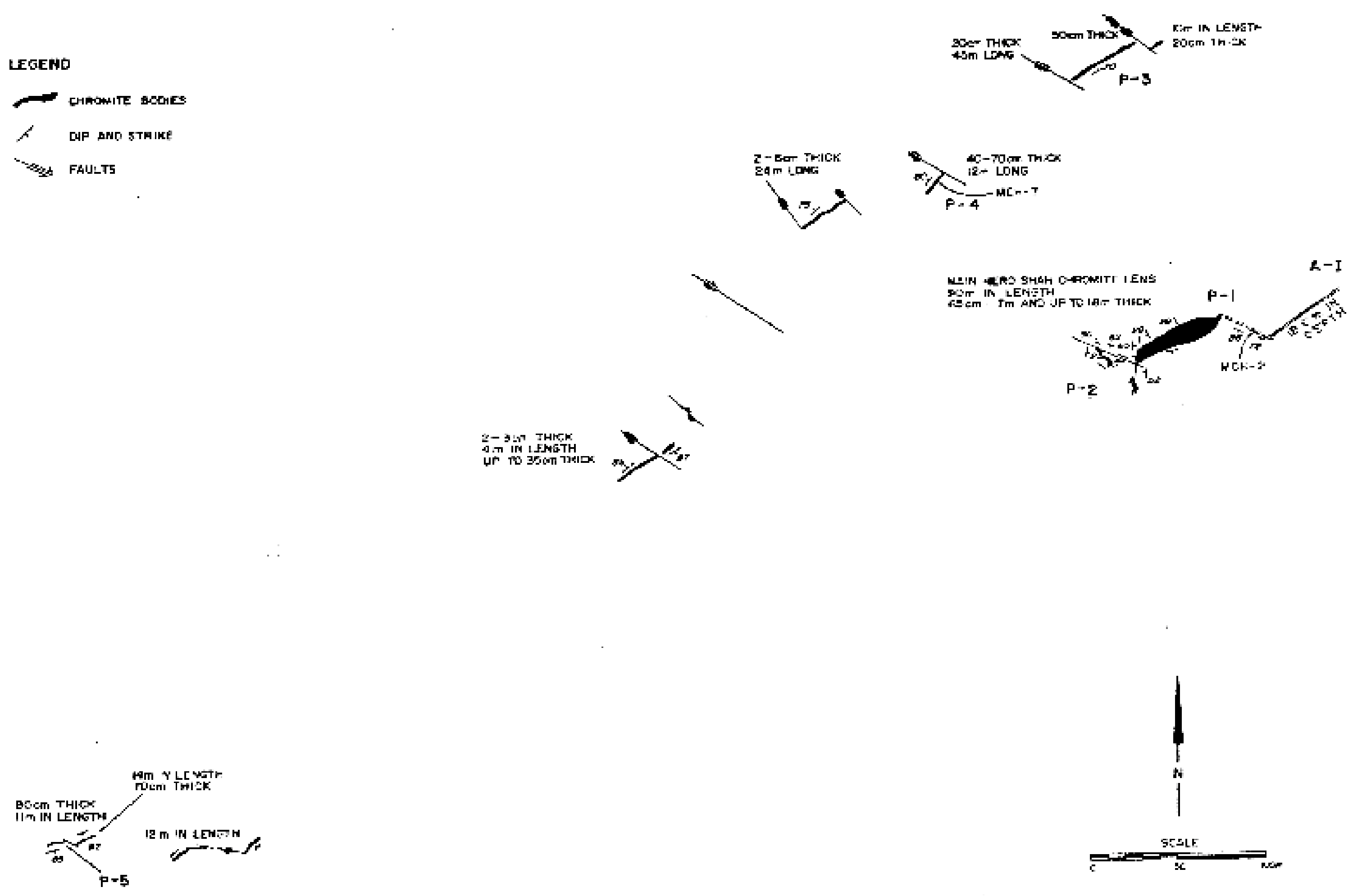
The Hero Shah prospect is situated 1.0 km southwest of Hero Shah. It can be readily reached by a fair weather track from the Hero Shah/Hari Chand Road.

Small open cast workings attest to some past mining of the higher grade ores. PMDC mapped and sampled the property. SDA have driven an adit with crosscuts to test the size and grade at a depth of about 15 metres below the main zone exposed at the surface.

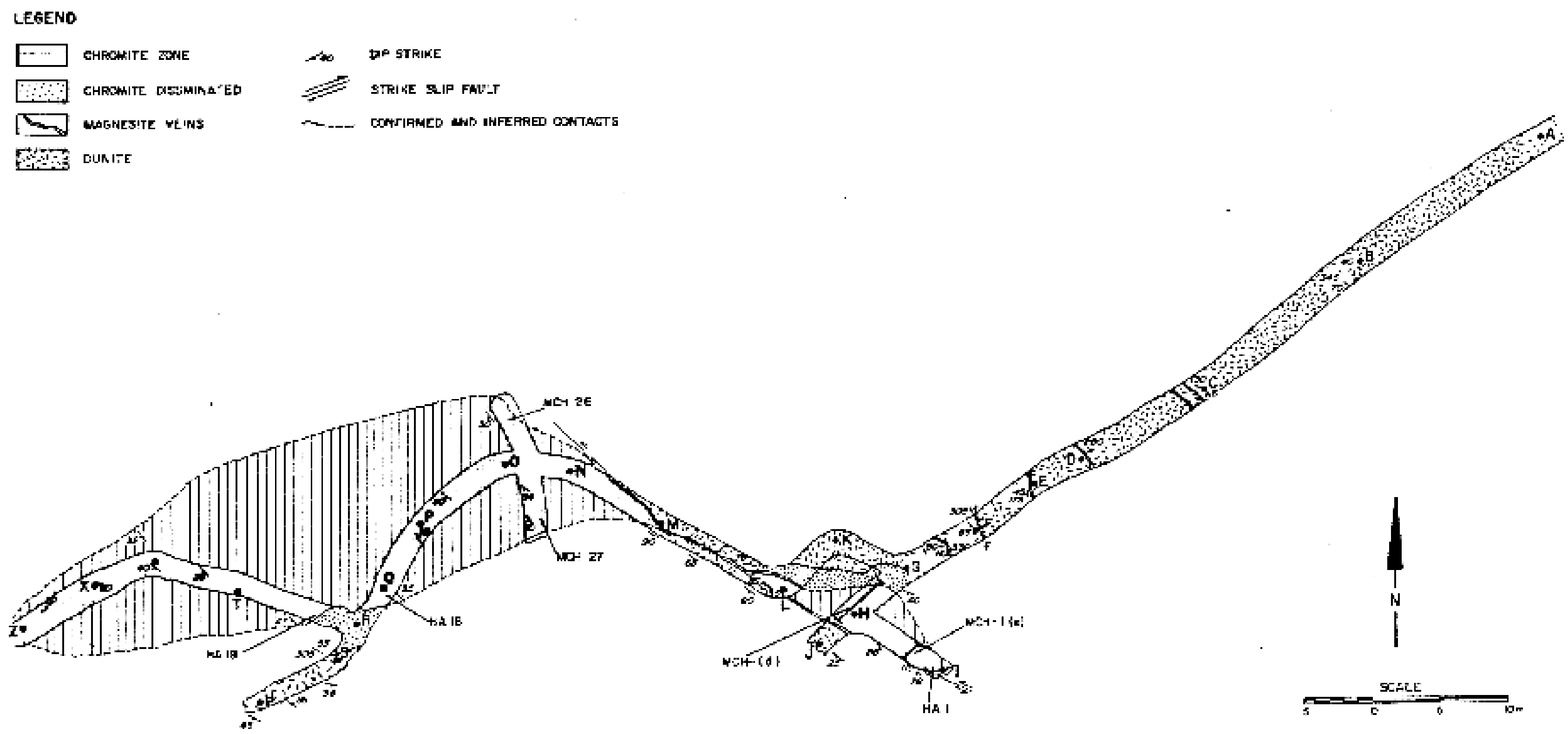
Several apparently isolated lenses of chromite are exposed in the Hero Shah area (Figure 2.2). They may represent the structurally dismembered sections of two previous sub-parallel horizons, with generally ENE strikes and steep northerly dips. Maximum width in the northern zone is only 90cm.

The main Hero Shah chromite lens is in the southern zone and is exposed over a strike length of at least 50 metres and a width of greater than 10 metres in both outcrop and in the SDA adit. The body has an overall ENE strike and apparently a steep northerly dip. By contrast the measured foliations in the rocks show a predominately NW trend. Faults and magnesite veins (filling fault zones?) also have this latter trend. The main lens is cut off at either end by strike-slip faults. The offset portions are much smaller than the main mass.

The main chromite lens is composed of fine to medium grained heavily disseminated, to locally massive, chromite ore. It is at least in part enveloped by lower grade disseminated chromite. The country rocks are dunite. Figure 2.3 shows the geology of the main lens in Adit A-1.



MINERAL SECTOR DEVELOPMENT STUDY NORTHWEST FRONTIER PROVINCE PAKISTAN	MALAKAND CHROMITE HERO SHAH CHROMITE BODIES (from SDA)	
Dames & Moore	1390-003-085	FIGURE: 22



NOTE: Samples HA1–HA19 taken at 2m intervals along adit

MINERAL SECTOR DEVELOPMENT STUDY NORTHWEST FRONTIER PROVINCE PAKISTAN	MALAKAND CHROMITE HERO SHAH GEOLOGY OF ADIT A-1 (from SDA)	
Dames & Moore	1390-003-085	FIGURE: 2.3

2.2.2 Upper Landi Raud

Access to this area is by way of a fair weather road to within a few hundred metres of the deposits. The two lenses of interest are exposed on either side of a dry valley. There are a number of small workings in the area, from which local miners have extracted all the easily won, high grade ore. The area was investigated by PMDC and has since been the subject of an aditing programme by SDA. They have sited two adits on lens A and one on Lens B. The relative locations of the two main lenses and the minor lenses are shown on Figure 2.4. There are no detailed plans or sections of the adits available as yet except for a sketch plan of Adit A-2 (Figure 2.5).

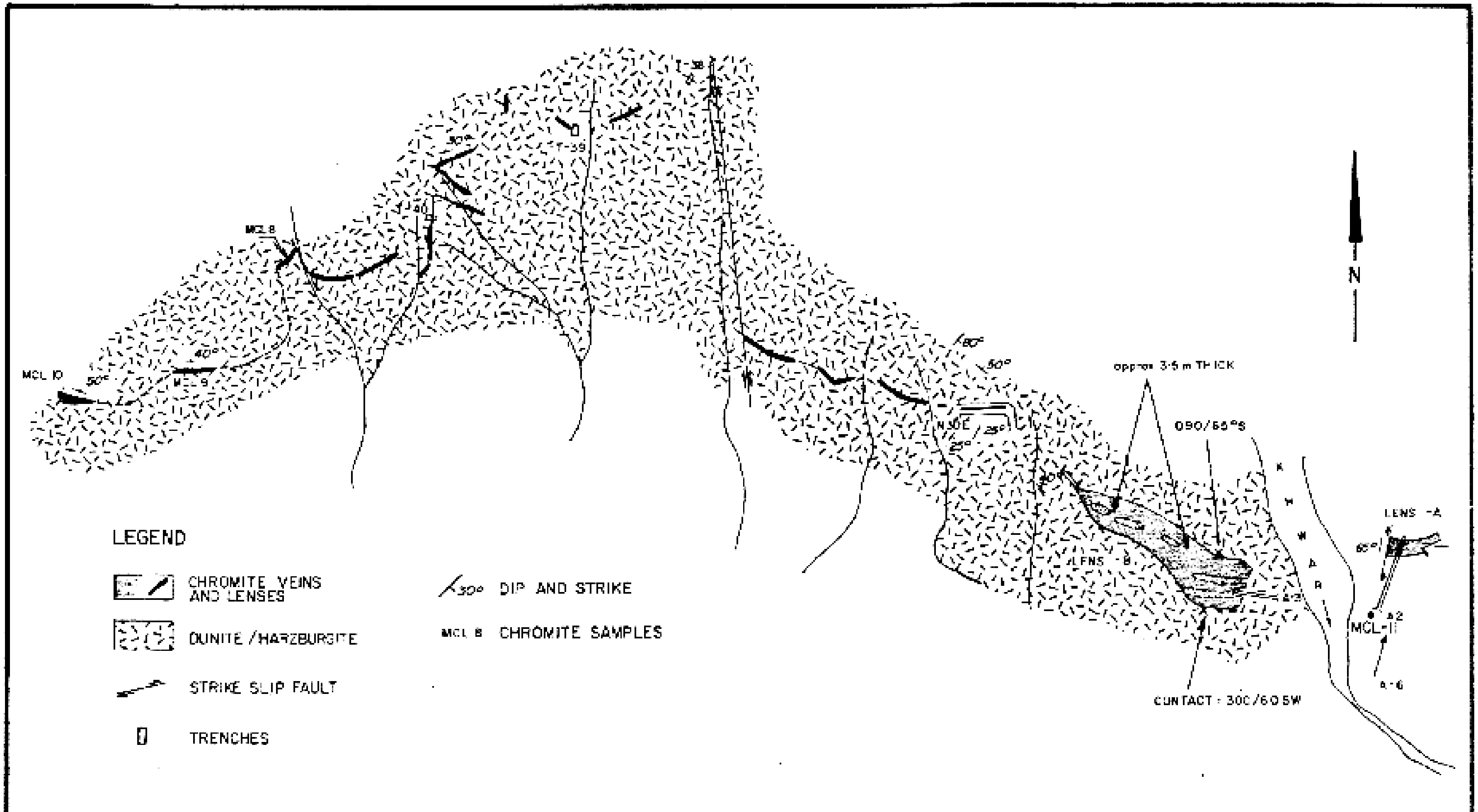
Lens A

Chromite lens A outcrops on the east side of the valley over a strike length of some 21 metres. It has an ENE-strike and a moderate to steep dip to the north. It is terminated at the west end by a NNE-trending high-angle fault. PMDC described the mineralisation as weakening towards the east end of the body. Maximum thickness at the surface is about 3.5 metres. The disseminated chromite is fine to medium grained.

The two adits driven by SDA, A-2 and A-4, have both intersected the lens at depth. The lower adit is sited 21 metres vertically (by altimeter readings) below the outcrop exposure. In A-4 however the dip is to the south. The widths of the lens in the adits have not yet been established, but it appears that the body maintains its strike extent.

Lens B

Chromite lens B is exposed on the ridge across the valley to the west from lens A. It may represent an off-faulted extension of the same zone. On the surface this lens appears much larger than Lens A with widths of the order of 20m but the grade is extremely variable. Though some high grade patches were noted locally there are also many



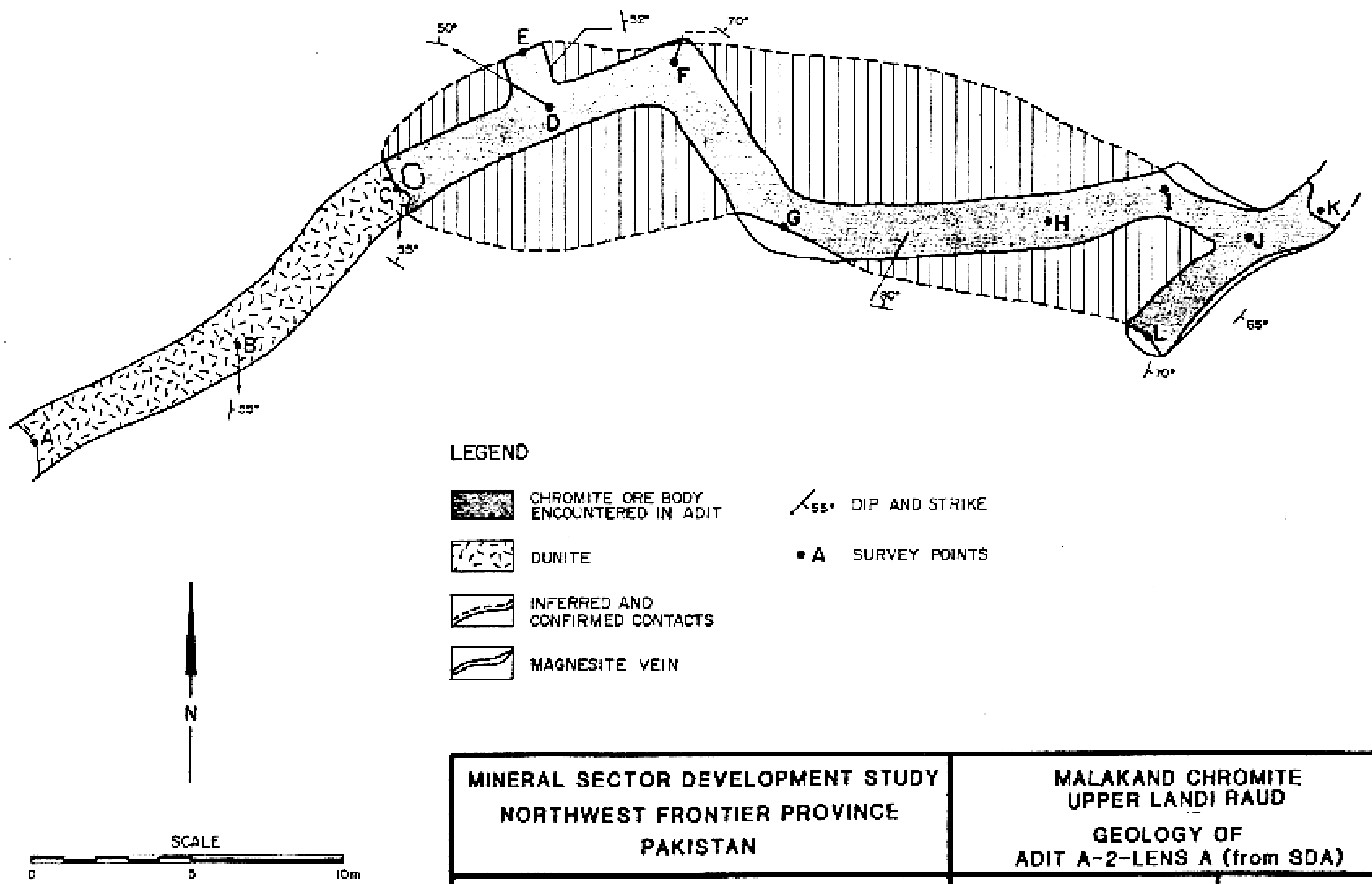
MINERAL SECTOR DEVELOPMENT STUDY
NORTHWEST FRONTIER PROVINCE
PAKISTAN

Dames & Moore

MALAKAND CHROMITE
UPPER LANDI RAUD
PROJECT GEOLOGY (from SDA)

1390-003-085

FIGURE: 2.4



MINERAL SECTOR DEVELOPMENT STUDY
NORTHWEST FRONTIER PROVINCE
PAKISTAN

Dames & Moore

MALAKAND CHROMITE
UPPER LANDI RAUD
GEOLOGY OF
ADIT A-2-LENS A (from SDA)

1390-003-085

FIGURE: 2.5

blocks/rafts of barren dunite within the body. Local miners have extracted all the easily won high grade ore. Chip samples MCL 13 to 16 were collected from a 20.7m traverse across the zone along the ridge crest and open cut exposures. Some dunite was included within this traverse. Thin low grade horizons of grapeshot chromite mineralisation were noted in the section just south of this traverse. This style of mineralisation is apparently unique to this area.

2.2.3 Bada Sar

The Bada Sar chromite deposit is located at about 800 metres elevation on a ridge west of Bada Sar peak. A road leads to within 300 meters of the deposit. A donkey trail provides the final access up the steep slopes to the deposit. Leases on this deposit are understood to be privately held.

According to PMDC (Sana-i-mehdi), lenticular bodies extend over at least 122 metres strike length, in a northeast - southwest direction. There has been extensive mining of the deposit in the past with 3 main quarries along this trend. The southern quarry exposes the largest lens, which has a length of 39.7 metres and a width of 3.6 to 19.8 metres. In the northern and central quarries the chromite bodies are only 3 to 4.5 metres wide.

There are stockpiles of chromite ore of variable grade at the end of the truckable road. The D&M/UCL field team inspected this material and collected a 100kg bulk sample and a random grab sample (BSB-1). Sample BS-1 was analysed by NCE and results are presented in Appendix 4.

2.3 SAMPLING AND ASSAY WORK

On the basis of existing analytical data, it is difficult to assess the grade of the various deposits. There is also considerable variation in results from different laboratories. From a consideration of all results and our visual inspection, it is estimated that the grade would be of the order of 30 percent Cr_2O_3 for the Hero Shah deposits and slightly less for the Upper Landi Raud deposits.

The ores have a relatively low Cr/Fe ratio of the order of 2:1 (iron rich) with high silica content. The relatively low grade of ±30 percent Cr_2O_3 combined with high silica content demonstrates the need for beneficiation to prepare a marketable product. The high iron may limit potential markets.

2.3.1 Hero Shah

PMDC made 4 channel sample traverses across the thickness of the lens (Sana-i-mehdi). Assays for the resulting 19 samples showed a range of from 7.8 to 38.5 percent CR_2O_3, 12.8 to 23.1 percent FeO and 6.6 to 31.2 percent Al_2O_3.

SDA have collected at least 19 chip samples from the adit and surface trenches, but have only assayed 7 of them. The results from different laboratories (Table 2.1) show extreme variation with SDA laboratory results being very low and the two PCSIR Laboratories reporting unusually high values. The one sample that they submitted to NCE, Peshawar, fell in between the two extremes.

Two grab and five chip samples were collected from the deposit by D&M/UCL geologists. The results for major oxides are present in Table 2.2.

SDA have not yet drawn any cross section for this deposit. They employed a surveyor to survey the adit and to mark the trace of the adit or the surface with rock cairns. However elevation data was either not recorded or was not readily available and the surface rock cairns were not labelled.

TABLE 2.1

MALAKAND CHROMITE DEPOSITS SDA EXPLORATION PROGRAMME
ANALYTICAL RESULTS FROM VARIOUS LABORATORIES

Sample No.	Location	Channel Length	Analysed by SDA Laboratories									Analysed by PCSIR Lab: Peshawar			Analysed by PCSIR Lab: Lahore	
			Cr_2O_3	FeO%	Al_2O_3%	MgO%	CaO%	SiO_2%	P%	Moisture%	Fe-Cr ratio	Cr_2O%	Fe_2O_3%	Al_2O_3%	Cr_2O_3%	Fe_2O_3%
MCH-1(d)	Heroshah Adit-1	5 mtrs.	6.5	11.74	8.83	-	-	-	-	-	-	-	-	-	46.80	17.60
MCH-1(e)	Heroshah Adit-1	3 mtrs.	-	-	-	-	-	-	-	-	-	48.77	13.35	26.28	-	-
MCH-2	Heroshah T-29	65 cm	4.31	10.52	13.34	-	-	-	-	-	-	-	-	-	44.91	17.20
MCH-7	Heroshah T-20	70 cm	7.38	12.92	14.47	-	-	-	-	-	-	-	-	-	49.70	18.40
HA-10	Heroshah Adit-1	2 mtrs	-	-	-	-	-	-	-	-	-	50.67	13.87	22.06	-	-
HA-18	Heroshah Adit-1	1 meter	-	-	-	-	-	-	-	-	-	40.11	20.13	28.50	-	-
HA-19	-do-	1 mtr.	30.38	15.16	21.80	7.58	Nil	12.56	Nil	0.30	1.96	36.88	15.36	-	-	-
MCH-2(a)	Landi Raud A-2(eastern cross cut)	11 mtrs	-	-	-	-	-	-	-	-	-	35.33	16.95	27.90	-	-
MCL-4	Landi Raud	13.5 m	-	-	-	-	-	-	-	-	-	49.00*	14.56	23.76	-	-
LA-1	Landi Raud Adit-2(along the whole length of A-2)	24.7 m	28.80	13.84	15.71	7.98	Nil	15.91	Nil	0.48	2.03	40.54	15.85	-	-	-
MCL-10	Landi Raud Chromite layer.	1.5m	32.35	14.43	16.57	9.57	Nil	16.84	Nil	0.39	2.19	48.57	15.89	-	-	-

*After beneficiation

-CONTINUED ON NEXT PAGE-

TABLE 2.1 Cond.

Sample No.	Location	Channel Length	Analysed by National Centre of Excellence in Geology Peshawar.							
			Cr_2O_3%	Fe_2O_3%	Mg O_3%	CaO%	Al_2O_3%	SiO_2%	P_2O_5%	Ig. Loss
LA-1	Landi Raud Adit-2 (along the whole length of A-2)	24.7 mtrs.	43.40	8.38	24.32	0.77	6.42	14.89	0.000	2.02
MCL-10	Landi Raud Chromite layer	1.5 mtrs.	34.91	11.01	26.31	1.39	5.12	17.58	0.00	0.77

TABLE 2.2

ANALYSES OF CHROMITE ORES COLLECTED BY D&M/UCL (ANALYSES BY NCE PESHAWAR)

SAMPLE	Cr_2O_3	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	P_2O_5	LOI(1000°C)	Sample Description
MCH-20	30.43	24.89	12.62	5.84	0.81	20.78	0.65	2.95	Grab from High grade dump at Adit 1
MCH-21	18.07	27.90	7.61	7.59	0.45	32.66	0.24	3.59	Grab from low grade dump at Adit 1
MCH-23	27.26	27.12	10.91	5.83	0.72	20.70	ND	4.12	5.0 m chip sample-surface
MCH-24	34.38	24.09	11.79	6.51	0.76	18.56	ND	1.81	5.0 m " " "
MCH-25	32.72	25.31	11.81	4.68	1.09	18.96	ND	3.67	5.7 m " " "
MCH-26	36.23	21.99	12.16	4.09	0.67	18.73	ND	2.51	2.5 m chip sample - N crosscut Adit1, Wend Main Lens
MCH-27	23.72	24.80	11.01	10.22	1.27	23.12	ND	4.39	4.0 m chip sample - S crosscut opposite MCH-26.
MCL-11	26.59	22.78	7.58	10.14	0.17	26.34	1.44	3.48	Grab from dump at Adit A-2

MCH = Hero Shah

MCL = Upper Landi Raud

ND = Not determined

The D&M/UCL geologist took two samples from which thin sections were cut on which petrographic examinations were done. The results of these are shown in Appendix 1.

2.3.2 Upper Landi Raud

Lens A

PMDC stated the average Cr_2O_3 content as 28.4 percent. An SDA 24.7m sample along the length of the mineralised zone in adit A-2 produced assays of 28.80, 40.54 and 43.4 percent Cr_2O_3 respectively from three different laboratories. They have sampled the lode in adit A-4 over 2m intervals but have not yet received the results.

Lens B

Adit A-3 was sited by SDA approximately 27 metres (by altimeter) below the ridge crest exposure, with the objective of proving the down-dip extent to the body. Only minor chromite has been intersected to date despite much weaving of the adit direction. Detailed surveying and mapping is required in order to determine whether it is a structural discontinuity or mis-direction of the adit which has caused the disappointment.

2.3.3 Bada Sar

There are stockpiles of chromite ore of variable grade at the end of the truckable road. The D&M/UCL field team inspected this material and collected a 100kg bulk sample and a random grab sample (BSB-1). Sample BS-1 was analysed by NCE and results are presented in Appendix 4.

Seven channel samples collected by PMDC from this property averaged 30.1 percent Cr_2O_3 (Sana-i-mehdi).

2.4 RESERVES

The Malakand chromite deposits are of the podiform alpine-type. Chromite mineral compositions cover most of the reported range for podiform bodies and unlike most alpine-type complexes there is a marked variation in the chemical composition of the chromite (Ahmed, 1984). These type of deposits are typically small and discontinuous thus making it difficult to estimate ore reserves with any great certainty.

Resource estimates have been made from a review of SDA and PMDC data and from our own field reconnaissance. Table 2.3 presents the consultants estimates. Further brief descriptions of the orebodies follow in the table.

There are insufficient data to enable calculation of chromite reserves (as opposed to resource estimates). In addition, mineable reserve estimates require definition of a mine plan. Assuming that sub-level stoping (similar to the Kakul phosphate mine) were the preferred method the mineable reserves would be of the order of 75 percent of insitu reserves.

Small scale development with limited capital costs could be envisaged on the basis of current exploration methods. However, any development necessitating high levels of capital expenditure would require more precise definition of orebody dimensions and grade variations. These data can only be provided through a drilling programme.

TABLE 2.3

SUMMARY OF INSITU RESOURCE ESTIMATES FOR MALAKAND CHROMITES

DEPOSIT	TONNAGE		GRADE
Hero Shah (Main Lens)	26,000	(1)	$\pm 30\% Cr_2O_3$
Upper Landi Raud			
Lens A	10,000	(2)	$\pm 30\% Cr_2O_3$
Lens B	70,000	(3)	
Sub Total - SDA Operations	106,000		
Bada Sar	100,000	(4)	$\pm 30\% Cr_2O_3$
TOTAL	206,000		

(1) Resources from surface to Adit level - no provision for resource at depth

(2) Little if any potential to prove additional resource

(3) Guesstimate only based on surface expression - adit A-3 failed to intersect zone.

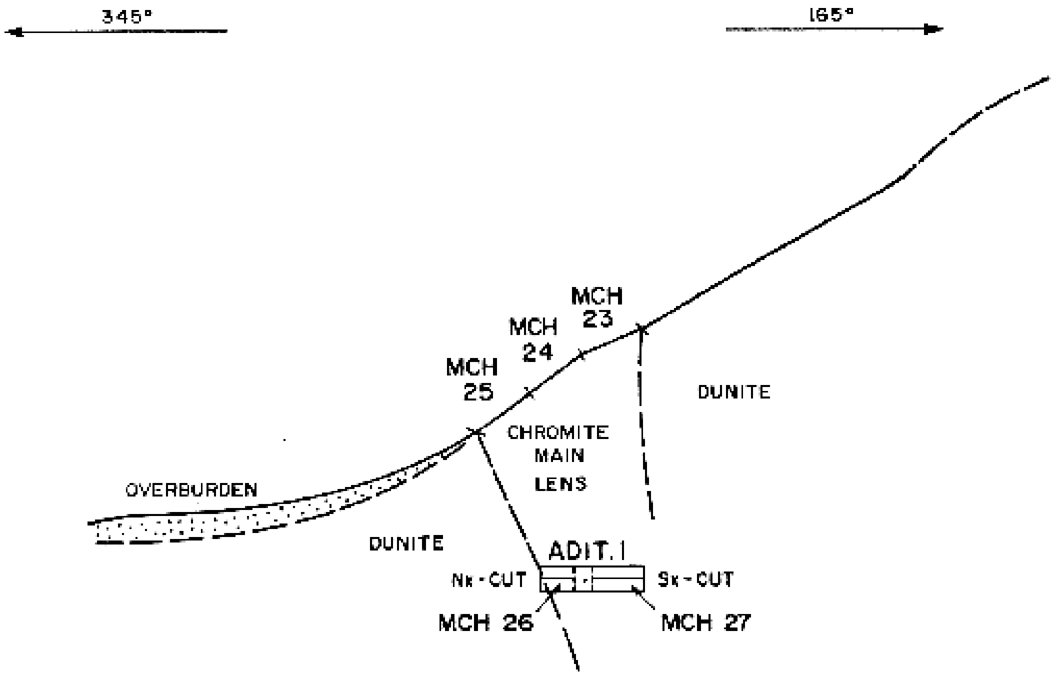
(4) PMDC estimate recalculated to S.G. of 4.0

2.4.1 Hero Shah

During the D&M/UCL field work, a tape and compass survey was conducted from the upper end of chip sample MCH-23 to the adit portal. Back sight checks indicated that there could be a few degrees error in the bearings due to minor amounts of magnetite in the underlying rocks. The corrected plan distance suggested the surface chip traverse to be above the new western cross cuts. Hence for the purposes of the cross section show in Figure 2.6 the assumption was made that the surface cairn by the north end of chip MCH-23 corresponded to this point in the adit. If this is correct, the north contact of the lens has a steep southerly dip at this point. The contact has not yet been reached in the south crosscut.

The elevation difference between the upper end of MCH-23, which is probably the highest exposure of chromite, and the adit portal was calculated from Brunton inclinometer readings to be 18.9m. Furthermore, the north end of MCH-25, which corresponds to ore of the lowermost exposures of chromite is only 11m. above the adit portal. As the MCH-23 to 25 chip traverse was made down a ridge and the adit probably has a slight upslope gradient, a realistic estimate of average vertical extent of chromite between the adit level and the surface is about 13m. This figure might be further reduced if weathered chromite does not come up to specifications.

Assuming a strike length of 50 metres and an average width of 10 metres, the volume of the main lens is : 50 X 10 X 13 = 6500 m_3. These figures require checking by accurate surveying of the deposit. Using a specific gravity of 4.0, the available tonnage above the main lens adit 1 is 6500 X 4.0 = 26,000 tonnes.



Mapped by: – Norm Corner 29 Oct. 1986

MINERAL SECTOR DEVELOPMENT STUDY NORTHWEST FRONTIER PROVINCE PAKISTAN	MALAKAND CHROMITE HERO SHAH MAIN CHROMITE LENS SKETCH SECTION	
Dames & Moore	1390-003-085	FIGURE: 2.6

This compares with a proved and probable reserve estimate by PMDC of 50,750 tonnes. Over 50,000 tonnes of ore might be available if the lens persists down-dip beneath the adit. The discrepancy results from the fact that PMDC included an estimate of reserves beneath the adit in totally unknown conditions.

2.4.2 Upper Landi Raud

Lens A

SDA made a tonnage estimate for lens A of 14,000 tonnes on the basis of 25m length, 4m width, 30m down-dip and a specific gravity of 4.6. The 4.6 specific gravity would only be realistic if the ore was solid iron or chrome-rich chromite and the 30m down-dip should be checked by surveying, though the body probably does extend below adit A-4. If figures of 25m length, 4m width, 25m down-dip extent, and a specific gravity of 4.0 are used the reserve estimate becomes 10,000 tonnes, which should be extractable via the existing adits.

This is a very small deposit with limited potential for the expansion of reserves. It is probably not rich enough to mine alone but it would probably be worth extracting in conjunction with any mining of lens B.

Lens B

PMDC claimed 24,000 tonnes of 30.4 percent chromite ore in this body. They used a thickness of only 3m which perhaps represents a higher grade portion of the zone. The consultant would guesstimate a tonnage potential of perhaps two to four times as much but with an overall lower grade.

2.4.3 Bada Sar

In the reserve summary by Faruqi (1981), the Bada Sar Body No 1 was ascribed reserves of 124,285 tonnes of proved and probable reserves. If a more realistic specific gravity of 4.0 was used this would change to about 100,000 tonnes.

Quarry walls from previous mining are grossly oversteepened, to the point of being overhanging. Thus any further mining would be an underground proposition but at least the steep slopes would facilitate adit- accessed underground mining.

3.0 MINING AND ENGINEERING STUDIES

3.1 DATA BASE REVIEW

There is, and has been, very little metallic mineral production in Pakistan, let alone NWFP. What production there has been has largely been from small private operators. This, unfortunately means there is no history of mining practices and costs on which a study of proposed operations and estimates of costs can be based.

Mining practices, manning, and costs must therefore be developed from first principles, augmented by whatever information is available. The SDA's PC-11 Scheme, Hazara Phosphate Exploration Project (Phase IV) was extremely helpful in estimating some mining costs, manning levels and manning costs. Other current SDA project documents also provided input for cost estimates.

Maps of the area available at the time of the study were only the 1:50,000 scale topgraphic sheets from the Surveyor General of Pakistan.

Three-dimensional information on the mineralised zones was very sparse. The SDA exploration team had surface mapping and some information from the driving of adits, with regards to structure, but assays from the adits were relatively few in number. The D&M/UCL geologist developed some vertical sections through the prospect areas based on the information available, and these were used in the estimates of ore reserves (Section 2.4).

There is a need for much more three-dimensional information of the mineralised zones at these sites (and other sites in the area that may be investigated) to determine early in the exploration programme the potential for worthwhile tonnage and grade in the prospect.

It is understood that the PMDC has additional information on some of the site, but this information was not made available to the consultant.

3.2 ASSUMPTIONS

The lack of historical data base on metallic mineral mining activity, and indeed the lack of defined orebodies in the Malakand Chromite prospect area means that many conditions and factors have to be assumed in order to develop a mineral exploitation scenario. The lack of specific information leads to generalised assumptions, and a generalised scenario.

For the purpose of this portfolio it is first assumed that there are mineable orebodies in the Malakand chromite prospect. They are not necessarily the sites described in Section 2.

For purposes of calculating mine establishment, development and mine operating costs, the assumed orebodies:

- are of a mutually similar small size;
- are mineable over a 50m length, a 60m height and a 5m width, and at 4.0 t/m^3 have an extraction potential of 53,500 tonnes employing sublevel open stoping mining techniques;
- are mineable at 15,000 t/y, not emplying any advanced mechanized mining techniques;
- are accessible by adit without the need for shaft sinking.

Additional assumptions, about the locale of the orebodies sites are:

- access and facilitiy provision is the same for all sites;
- three kilometres of road construction and power line construction are needed for each site;
- water supply, from the Upper Swat Canal, from the Jundai Khwar, or from wells is available within 2 kms of each site.

The orebodies are mine sequentially, with No. 2 orebody developed as No. 1 orebody is mined. No. 3 orebody utilised equipment moved from No. 1 orebody, and No. 4 orebody equipment from No. 2.

3.3 MINING OPTIONS

In general, the mining options for a vein deposit are one of the variants of cut and fill mining, open stoping or a caving method. There is insufficient data to choose an exact mining methodology, so it is assumed that ore and rock wall rock is of sufficient strength that sublevel open stoping can be employed.

The scale of mining operations can vary greatly. Given the assumed size and configuration of the orebodies, small scale mining would appear to be the best to get long term benefit from the develpoment. Capital and human resources are kept in balance for a long term project rather than used excessively for what could be a short term operation.

While is would be possible to mine out the orebodies faster, it would be necessary to have all orebodies defined at the start of development.

It is better to have the option to increase production once the project is underway if the circumstances and opportunity arise than it is to have to cut back if early optimistic forecasts become thwarted.

3.4 MINE DESIGN

The Technical Sector Review (TSR) report in this study has the following statement:

> "The decision to mine an orebody carries with it, axiomatically, the commitment to long-term employment of capital and manpower. Because of this commitment, the decision-maker can afford to (and should) spend a great deal of time and effort in evoloving the optimimum solution for the peculiarities of a specific case."

For the Malakand Chromite propsects, the 'peculiaraties of a specific case' cannot yet be defined. Consequently the designs that follow are in the nature of generic considerations and estimates and should not necessarily be construed as being 'the optimum solution'.

The reader is referred to the TSR report sections 7.1 to 7.6 relating to mine design criteria and concepts and to numerous mining and mine engineering texts that deal very extensively with these subjects.

3.4.1 General Estimates Used

General estimates on productivity and costs were developed from the consultants knowledge of mining practices, relevant information gained from field visits in NWFP and from SDA project costs and budgets.

- Access road construction will mostly be in the alluvial plain with hill road development. Cost is estimated to Be Rs50,000 per km.

- Electricity supply lines through this terrain would cost Rs 200,000 per km.

- Clearing and preparing a mine site for surface facilities would cost Rs 50,000 per hectare in the hilly terrain.

- Mining
  - development of a timbered haulage drift would average 0.5 metre per shift (m/s) for a three man crew.
  - development of a raise would average 0.5 m/s for a three man crew.
  - average pay per worker would be Rs 50 per day.

3.4.2 Site and Mine Development

The Chromite target areas ocur in a belt up to 4.5km wide extending westwards over 20km from the town of Sakhakot to Qila. Existing gravel and dirt roads and tracks provide access to within 1km of most of the major known targets.

For the purpose of this portfolio in devising a generic operation a typical road construction for access would be 3km, some of which would be in hilly terrain.

Site clearing and preparation would be required for mining services only, not for crushing or processing of ore. Three kilometres of power line would be needed, providing 250KVA to each site.

The site establishment and development asumed suitable for the mines is set out in Appendix 2.1 showing the access and major fixtures necessary. Capital estimates to set up the initial two sites are Rs 5.0 million with depreciation and amortization costs of Rs 46.7t. Capital required for sites 3 and 4 reduces to Rs 3.5 million, with depreciation and amortization costs of Rs 32.4/t on the tonnages mined from these sites.

The mining method projected for these orebodies is sublevel open stoping at a production rate of 50 t/d or 15,000 t/y. This gives a 14 year life to the four-orebody project, with 3.5 years production from each orebody.

Development of the orebody is projected to be by driving an access haulage adit on the production level, going through the bottom of the orebody. Subsequent development is then:

- a ventilation raise through to surface

- 2 raises 60m up either end of the orebody (assumed 50m apart)

- 5 sublevels at 12m intervals driven between the raises
- putting in draw points to the haulage level by coning out finger raises to the first sublevel and building chutes at the haulage level to control flow into the ore cars.

Mine development costs are set out in Appendix 2.2 at Rs1.0 million with amortisation costs of Rs19.2/t for each mine. Such a mining development lends itself to expansion or duplication within an orebody if more ore is proven.

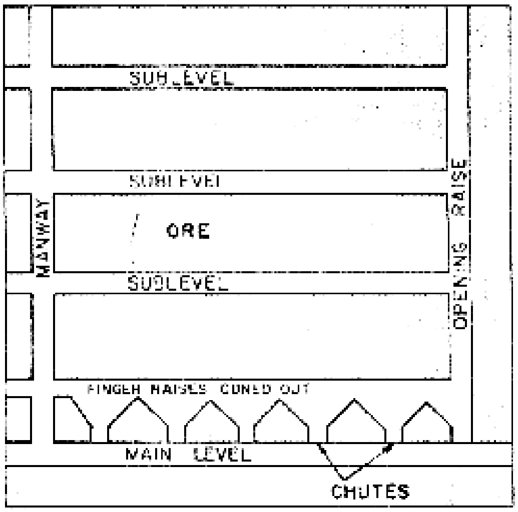
Assumptions and calculations for developing and costing a haulage drift are set out in Appendix 3.1. Time to develop to a stope ready for production stage is estimated at 2.5 years, using a 2 shift a day operation, 300 days per year. During this period approximately 8700t of ore should be produced, which could be stockpiled for the first 2 years, then drawn down to provide the necessary ore feed to the plant until the stope is ready for production. A production schedule for the four-mine project is shown in Appendix 3.6.

3.4.3 Mining Operation

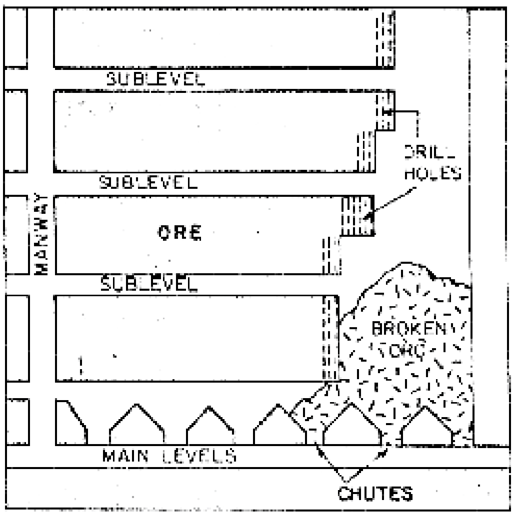
Mining at 15000t/y requires only one stope in production and a new stope, in this case a new mine, under development.

Sublevel open stoping is inherently a reasonably high productivity method once the development is done. One 3-man crew working 1 shift a day should be able to drill and blast out a ring of holes from a sublevel, and haul out ore equivalent to that blast in a 4.5 day cycle. Typical sections through a sublevel open stope are shown in Figure 3.4, illustrating the operation and sequence of operations.

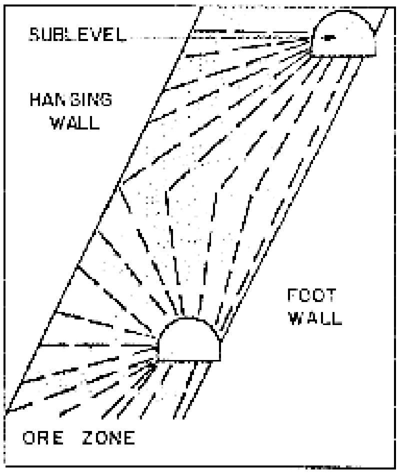
The assumptions, operations and calculations for ongoing mining are set out in Appendix 3.2, with costs of Rs29.9/t detailed in Appendix 3.3.



LONG SECTION
OPEN SUBLEVEL STOPING DEVELOPMENT



LONG SECTION
OPEN SUBLEVEL STOPING OPERATION



CROSS SECTIONAL VIEW OF DRILL HOLE PATTERNS OPEN SUBLEVEL STOPING

MINERAL SECTOR DEVELOPMENT STUDY NORTHWEST FRONTIER PROVINCE PAKISTAN	SUBLEVEL OPEN STOPING	
Dames & Moore	1390-003-085	FIGURE 3.4

All ore from the mine is hauled out in rocker cars and dumped at the portal. It is stockpiled by a front end loader which is also used to load the trucks that transport the ore to the crushing and beneficiation plant - assumed for this portfolio to be in Peshawar. Truck operating costs to deliver 50 tonnes of ore per day to Peshawar are detailed in Appendix 3.5.

The 44800 tonnes of ore from stoping operations pluc 8700 tonnes from mine and stope development is equal to just over 3.5 years production. On this basis a new mine must be developed every 3.5 years.

3.4.4 Equipment Selection

Equipment selection for such an operation is fairly simple because the operation is fairly simple. Drilling equipment is all air powered hand-held machines for drifts and raises, and bar mounted machines for stope drilling, loading and haulage on the haulage level is by air powered rail mounted overhead rockerloaders and battery locomotives pulling rocker dump cars and material movement in the sublevels is by air powered scrapers. The trucks to cart ore to the benefication plant would be a standard 10 tonne capacity with hydraulic dumping. Surface work would require a relatively small front end loader. The equipment list and costs are outlined in Appendix 2.3. Total cost is estimated at Rs 5.2 million and if depreciated over the project life, costs Rs 24.3/t.

3.4.5 Manning

Operation of the Malakand project will essentially always involve two sites at a time. A new mine will be under development while an existing mine is being stoped out. Because of the small scale of the operation, the manning required is also small. Production from the stope will require only one 3 man crew. Development of a mine will require two 3 man crews i.e., two shifts per day. One management and administration establishment would be used. For this portfolio it is assumed these people are based at the developing operation because that is where the major operational control is needed. Thus the management and administration group would move every 3.5 years to the next mine site.

Manning levels and classifications are set out in Appendix 3.4. They total only 9 underground operations workers and 31 management, administration, technical and surface workers. Costs of the underground operators are included in development and operating costs. The other 31 people have an annual cost of Rs565.2 thousand, or Rs37.7/t.

3.4.6 Cost Summary

Cost estimates to develop and mine the four-orebody Malakand project can be summarised as follows:

	Capital (Rs 000)	Rs/t
Site Establishment	8,520	39.8
Mine Development	4,140	19.3
Equipment	5,200	24.3
Direct Mine Operations		29.9
Ore Transport to Mill		26.3
Management and Administration		37.7
Infrastructure	140	2.9
	18,000	180.2

4.0 MINERAL BENEFICIATION STUDIES

4.1 DATA BASE REVIEW

As with mining of metallic ores, there is no history of processing metallic ores in Pakistan, consequently, no constructural, processing or costing structure to examine directly. The PCSIR has done some pilot studies on the concentration of chromite, and the consultant's knowlege of this work has been incorporated.

The process and structure described in this section come largely from the process tests done on the ore and the consultant's knowledge of plant designs to treat such ores.

Although much of the chromite ore mined worldwide can be used without any treatment, beneficiation is becoming increasingly important. Selective mining, hand cobbing and sorting, picking belts, wash screening, and wet classification have all been practised for many years where labour costs and ore grade permit. But more mechanised methods such as heavy media separation, gravity concentration using spirals, shaking tables etc, and electromagnetic and electrostatic separation are now being employed. All these methods separate chromite ore from silicate gangue but they have no effect on the relative amounts of chromium, iron, aluminium and magnesium as the oxides of these metals are in solid solution in the ore. To change the metal ratios, some form of chemical attack would be required.

4.2 PROCESS TESTING

Two bulk samples of chromite ore were taken by the D&M/UCL geologist and shipped to Australia for beneficiation testing by Australian Metallurgical and Mineral Testing Consultants (Ammtec) in Perth, Western Australia. Samples were taken from Hero Shah and Bada Sar. The results of that test work are included in Appendix 4.

PCSIR have also carried out beneficiation tests on ore from the area, using similar treatment as that employed by Ammtec, with comparable results. Concentrate grades from the tests were saleable products, but at low recovery rates. Recycling and regrinding of middlings would be necessary to improve overall recovery, but produces a finely ground product.

4.3 ASSUMPTIONS

As the mining operations were designed to allow for easy and rapid expansion of output if the circumstances call for it, so should the beneficiation plant be designed. In anticipation of potential increase in ore production, the capability to rapidly increase throughput is assumed built into the plant.

From the assays done, the ore feed to the mill is assumed to grade 27 percent chromite. From the process testing done, the concentrate grade is assumed to be 39 percent Cr_2O_3 and 25 percent Al_2O_3, with an 80 percent Cr_2O_3 recovery rate.

4.4 SITE ESTABLISHMENT

The beneficiation plant is assumed to be sited in Peshawar. It will be easy to build there, to obtain good management and staff, and to control operations. It will be convenient to the railway for shipping product out. Provision of support and infrastructure facilities will be simple, including the 700KVA electricity supply, and can be assumed to be covered in the capital cost summary in Appendix 5.3. An area of approximately 0.5 hectare would be sufficient for a plant of this size.

4.5 PROCESS AND DESIGN

Design criteria for the plant are listed in Appendix 5.1, and a flow sheet of the process follows as Figure 4.5.

The ore is crushed in a standard two stage crushing circuit and milled to 80 percent passing 200 um by closed circuit, single stage ball milling. The cyclone overflow is sent to a bank of spirals where a concentrate, middlings and tailings are produced. The tailings are discarded, the middlings are reground in a regrind mill and the concentrate is tabled. The regrind cyclone overflow is sent to a bank of cleaner spirals where a concentrate and tailings are produced. The cleaner spiral concentrate is tabled and cleaner spiral tailings are recycled to the head of the circuit. The table concentrates are thickened, filtered, dried and shipped while the table tailings are recycled to the regrind mill.

Concentrate production, at the rate of 33t/operating day is stockpiled before loading onto trains for shipment to Karachi port for export.

Tailings, produced at 27t/operating day are trucked from the plant to a landfill area by the trucks that bring in the ore from the mines.

Direct cost of processing is calculated in Appendix 5.2 to be Rs 73.0/t.

4.6 EQUIPMENT SELECTION

The processing equipment is detailed in Appendix 5.3. Together with all buildings and support facilities the total cost is estimated at Rs10.1 million, depreceiated at Rs47.1/t over the life of the four-mine Malakand project.

4.7 MANPOWER REQUIREMENTS

The manning projected for the beneficiation plant is set out in Appendix 5.4. Management, administration, operating and maintenance of the plant takes 29 people for a cost of Rs28.5/t.

4.8 COST SUMMARY

The cost of investment, depreciation, and operating the beneficiation plant are summarised as follows:

	Capital Rs(000)	Rs/t
Capital Investment	10090	
Depreciation over 14 year and 214000 tonnes		47.1
Direct cost of operation (excluding manpower)		38.8
Management, administration and labour		34.2
	10090	130.1

4.9 PRODUCTION AND VALUE

Annual production from the plant is projected to be 8300 tonnes of concentrate grading 39 percent chromite, at a cost of Rs308/t, FOB Peshawar. It is assumed that the concentrate can be sold on the export market.

Sale Price - FOB Karachi		US$60/t
	=	Rs1020/t
Freight and Handling		
Peshawar to Ship*		350
Cost of Product		300
Surplus before interest and tax		Rs 370/t

* This figure taken from SDA estimate of concessional rail freight rate and port handling charges for moving Jijal Chromite ore from Havellian to ship at Karachi.

5.0 INFRASTRUCTURE AND TRANSPORTATION

5.1 MINES

In addition to the underground workings, each mining operation requires its surface operating and support structures. For the Malakand chromite mines this support structure will be quite simple, as all crushing and ore beneficiation is handled away from the mine site. That leaves the facilities at the mine at mine office, change rooms, workshop, stores warehouse and yard, compressor facilities, locomotive battery charging facility, a small fuel tank, mine car dumping facility, and stockpile area. A small water tank, above the level of the mine workings should be installed to provide the necessary water.

It is envisaged that all sites would be similar, and a conceptual layout is shown in Appendix 2.2, figure A2.2.1. Land requirements for surface facilities should not be more than 0.5 hectare, plus the access road to the site and access for electricity and water lines.

Requirements for waste dumps will be small for these projected mines. The waste development is concentrated at the start of mine development, and can probably be used in the formation of the site foundation. Road construction to the mines is not expected to be onerous, as the area appears fairly dry, and much of the approach will be along the plain.

Constructing electric power lines should likewise be a simple operation, with a maximum of only 250KVA supply to a mine site.

Water supply is assumed to be available within 2km of the mines. Provision for piping, pumps and tank is made in the site establishment costs.

5.2 BENEFICIATION PLANT

The beneficiation plant is assumed to be in Peshawar so provision of services to support and power the plant would be a matter of dealing with the controlling authority for the provision of roads, electricity and water. Supply lines for these services should be short.

5.3 SUPPORT INFRASTRUCTURE

In addition to the infrastructure to support the mine and plant operations, there is often a need for services to support the people involved in a project.

At the mine sites there are expected to be only 40 people. It is not anticipated that housing would have to be provided, as it should be available within the surrounding area.

It is anticipated though that transportation will have to be provided for a number of workers. Provision is made for two mini-buses to transport men to and from the minesites. As calculated in Appendix 3.7, this would involve a capital outlay of Rs140,000 and annual operating costs of Rs33000/y.

It is not anticipated that any support of this nature would be provided in Peshawar for the beneficiation plant workers.

5.4 TRANSPORTATION ANALYSIS

The volume of material transported for the project would not be large-15000t/y ore from the mine sites to the plant in Peshawar, and 6700t/y of tailings from the plant to a land fill site by the same trucks that haul the ore.

It is assumed that all this material would move in the standard 10 tonne truck (with hydraulically tipping box) that is common in the NWFP.

6.0 MARKET CONSIDERATIONS

6.1 BENEFICIATION PLANT PRODUCT

The product from the beneficiation plant would be a chromite concentrate grading 39 percent Cr_2O_3. Chromite concentrate is a saleable commodity in the international market, with market values a function of Cr_2O_3 grade, combined Cr_2O_3 and Al_2O_3 grade, chrome to iron ratio, and sieve size of the product. The 8300 tonnes per year of concentrate produced from this project would have a cost of Rs 300/t at Peshavar, and Rs 650/t FOB vessel in Karachi.

6.2 MARKET ANALYSES

The principal consumers of chromite are the metallurgical, chemical, and refractory industries. Each of these consumer groups imposes quality requirements and specifications for the chromite it utilizes.

Chromium is used in the metallurgical industry to enhance hardenability, creep and impact strengths, and resistance to corrosion, oxidation, wear, and galling (Papp, 1986). The ores used by the metallurgical industry to produce ferrochromium, an intermediate product, have Cr_2O_3 contents of 45 to 56 percent and Cr:Fe ratios of 2.5 to 4.3. A standard composition of a metallurgical grade chromite is 48 percent Cr_2O_3 with a 3:1 Cr:Fe ratio. Charge grade chromium, made from chemical grade chromite, is being used to produce a lower grade ferrochromium suitable for use in argon oxygen decarbonization (AOD) and vacuum oxygen decarbonization (VOD) methods of making stainless steel (Mikami, n.d.).

Chromium-containing chemicals are used in chromium plating, etching, leather tanning, and drilling. The principal chemical produced is sodium dichromate, which serves as the basis for the production of chromic acid, basic chromium sulfate, tanning compounds, and chromium-based paints, dyes and pigments. (Papp, 1986). Sodium dichromate is produced from chemical grade chromite; which generally possess the following properties: Cr_2O_3> 44 percent, Cr:Fe about 1.5, and silica less than 3.5 percent (and most often, less than 2.5 percent).

The production of refractory brick and mortars, and ramming and gunning mixes by the refractory industry employs refractory grade chromite which traditionally has low Cr_2O_3 (30 to 40 percent), relatively high Al2O3 (25 to 32 percent), and a low Cr:Fe ratio (2.0 to 2.5:1) (Mikami, n.d.). While refractory bricks can contain up to 100 percent chrome, chromite is generally blended with magnesite to produce either chrome-magnesite (greater than 50 percent chrome) or magnesite-chrome (greater than 50 percent magnesite) bricks (Papp, 1986), with a typical mixture of 45 percent chrome and 55 percent magnesite.

The major application of chromite refractories is in iron and steel processing, non-ferrous alloy refining, glassmaking, and cement processing (Papp, 1986). Unlike applications in the metallurgical and chemical industries, the refractory industry uses chromite mineral directly (without the production of an intermediate product such as ferrochromium or sodium dichromate). Chromite is used in refractories to improve thermal shock and slag resistance, volume stability, and structural strength (Papp, 1986).

6.2.1 International Aspects

Whilst the world reserves base of chromite has been estimated in 1985 at 7.5 billion tons by the U.S. Bureau of Mines, the geographic distribution of these reserves is extremely uneven. About 84 percent of the world's chromite reserve base is found in the Republic of South Africa, Zimbabwe, Sudan and Madagascar. Outside Africa, the major reserves of chromite are found in the USSR (142 millon tons), Turkey (80 million tons), India (66 million tons), Finland and Philippines (32 million tones each), and Albania (22 million tons).

World mine production of chromite is estimated to have been about 10 million tons of Cr_2O_3 ores and concentrates, of which 6.1 million tons was produced in the non-Communist world. (EIU, 1987). Table 6.1 depicts the distribution of mine production between 1980 and 1985. As can be seen, South Africa, in terms of chromite ore and concentrate, produced over (54 percent of the total non-Communist world mine production (or one-third of total world production). The USSR produced a similar amount.

A large share (i.e., over 50 percent) of the world's chromite production is privately controlled, although some production in Greece, Turkey, India, and Finland, and all production in USSR, Cuba, Albania and Vietnam is state-controlled or owned. Among the major chromite producers, by country, are:

Country	Company
Albania	Government Owned
Brazil	Cia. de Ferro-Ligas de Bahia S.A.
	Cia. de Mineracao Serra de Jacobina S.A,
	Coitezerio Mineracao S.A.
	Cromita do Brazil S.A.
	Mineracao Vale do Jacurici S.A.
Finland	Outokumpu Oy (Government Owned)
India	Ferro Alloys Corp Ltd.
	Misrilall Mines Pvt. Ltd.
	Mysore Mineral Ltd.
	Orissa Mining Corp. Ltd. (Government Owned)
	Tata Iron and Steel Co.
New Caledonia	Inco Metals Co.
Philippines	Acoje Mining Co. Inc.
	Benguet Corp.
	Philchrome Mining Corp.
South Africa	Chrome Mines of South Africa Ltd.
	Chrome Corp. (S.A.) Pty. Ltd.

TABLE 6-1

WORLD PRODUCTION OF CHROMITE

(THOUSAND SHORT TONS, GROSS WEIGHT)

Country	1980	1981	1982	1983	1984	1985
Albania		783	744	755	794	909
Brazil		261	304	171	282	303
Cuba		23	30	37	41	44
Cyprus		11	3	0	0	0
Finland		454	380	271	492	500
Greece		27	32	30	68	68
India		369	374	465	466	610
Iran		35	45	55	55	55
Japan		12	12	9	8	13
Madagascar		110	49	50	66	66
New Caledonia		5	55	101	93	87
Pakistan		2	4	7	3	4
Philippines		484	355	294	286	284
Rep. South Africa		3,164	2,385	2,460	3,314	3,682
Sudan		28	21	22	22	22
Turkey		442	499	381	537	496
USSR		3,200	3,240	3,240	3,240	3,240
Vietnam		17	18	18	20	17
Yugoslavia		(a)	0	0	0	0
Zimbabwe		591	476	463	525	551
TOTAL		10,018	9,026	8,829	10,312	10,951

Source: U.S. Bureau of Mines, 1986

Notes: (a) less than 500,000 tons

	Lavino South Africa (Pty.) Ltd.
	Marble Lime and Associated Industries Ltd.
	Montrose Exploration Co. Ltd.
	Transvaal Consolidated Lands and Exploration Co. Ltd.
Turkey	Etibank (Government Owned)
	Bursa Toros Kroulari AS.
	Egemetal Madencilik AS.
	Sitki Kocman Mines
	Turk Maadin Sirketi AS.
	Haryi Ogelman Madencilik AS.
USSR	Government Owned
Zimbabwe	Rio Tinto (Zimbabwe) Ltd.
	Zimbabwe Alloys Ltd.
	Zimbabwe Mining and Smelting Co. (Pvt.) Ltd.

Whilst production of ferrochromium from chromite ores has historically been done in the more developed countries, the current trend has been for chromite producing countries to install furnace capacity for such production and, thus, reap the value added from downstream processing (Papp, 1986). Only two companies, Outokumpu Oy of Finland and Middleburg Steel and Alloys Holdings (Pty.) Ltd. of South Africa are vertically integrated (able to mine and smelt chromite and produce stainless steel).

In terms of worldwide demand for chromite, the OECD countries accounted for over 54 percent, whilst the USSR accounted for 23 percent. OECD consumers obtained chromium through imports of both chromite and chromium ferroalloys, secondary sources (recycling of scrap containing chromium), and stocks held by industry. Among these consumers, imports of chromium ferroalloys and metal are increasing in relation to chromite imports. This trend is largely the result of increases in ferrochromium production capacity by chromite producing countries, lower production costs by those producers, and avoidance of shipping costs associated with ores and concentrates.

Prices paid for chromite have remained relatively stable despite continued uncertainly regarding potential interruptions in the supply of chromite. The uncertainty regarding supply arises from the concentration of chromite reserves in countries that have been subject to serious internal and external conflicts and stresses. Continued unrest in South Africa and the adversarial posture between the United States and USSR have both caused concern over the possibility of supply interruptions. Should the supply of chromite from South Africa be cut, it is unlikely that output from other producers would be sufficient to meet demand. It should, however, be recognized that many countries (including the United States and Japan) maintain governmental stockpiles of both chromite and ferrochromium, as do many industrial consumers. In the event of a supply interruption, it is thought that these stockpiles may sufficiently meet demand until additional productive capacity and/or increased secondary recovery could add to supply. The maintenance of stockpiles and inventories has contributed to the stability of prices for chromite.

Recent (1980-85) price trends for chromite from Turkey and South Africa are shown in Table 6.2. Turkish chromite is generally 48 percent Cr_2O_3 and is suitable for metallurgical use. South African (Transvaal) chromite has a typical Cr_2O_3 content of 44 percent with no fixed ratio and is used extensively in the chemical industry. All grades of chromite can be used in the refractory industry although not for all grades of products. Albanian concentrates are quoted as having 51 percent Cr_2O_3.

TABLE 6.2

CHROMITE PRICES

(in dollars per tonne)

	1980	1981	1982	1983	1984	1985	1986
Transvaal Friable, Lumpy	55	55	55	55	55	50	43
Albanian Concentrates	-	-	-	-	68	84	nd
Turkish Lumpy	110	110	110	110	110	120	120

Note: Prices are presented in current US dollars, FOB.

Future world demand for chromium is forecast (by the U.S. Bureau of Mines) to grow at a rate of 4.5 percent per year until the year 2000. Based upon a 1985 demand load of 10,951 tons of chromite, this average annual growth rate would result in a demand for 22.4 million tons of chromite by 2000 (or a doubling of current demand). Several forecasts have suggested that demand would range from 20 million tons to 24.6 million tons in 2000. (Fischman, 1980; Leontief, 1983; and U.S. Bureau of Mines, 1980). The U.S. Bureau of Mines has suggested that, by 2000, demand would lie within a range of 17.5 and 32.6 million tons (Papp, 1986).

In terms of end uses, it is expected that chemical industry applications would account for 13 percent of demand in 2000, refractory uses for 4 percent, and that metallurgical uses (including fabricated metal products, machinery, transportation, and other uses) would account for the remaining usage. The increase in this latter category largely reflects increased use of stainless steel and other alloys required by high technology. Refractory uses are forecast to decline as the steel industry use of open hearth furnaces declines; glassmaking and cement kilns will likely be the major source of demand for chrome-based refractories. Use of chromium by the chemical industry is forecast to grow at an average annual growth rate of 3.5 percent. This increase will largely occur through increased use of pigments, drilling rods, catalysts, leather tanning, metal plating, and wood and water treatment.

In light of forecasts of demand for other metals, the consultant does not foresee achievement of the demand forecast by the U.S. Bureau of Mines. In light of the demand forecast for zinc, manganese, and other metals, and based upon historic patterns of demand growth, the consultant forecasts world demand for chromite to grow at an average annual rate of 1.5 percent, or to a level of 13.7 million tons in 2000. This lower forecast is also based upon the consultants expectation that the OECD countries will be risk averse and seek to increase substitution of chromium for other, more readily available materials.

As shown in Table 6.2, prices for chromite have remained stable and shown little increase since 1980 (the quoted price for South Africa Transvaal chromite decreased by 20 percent in current terms, while Turkish chromite increased by 9 percent). In the period 1985-2000, prices are not expected to increase in real terms unless an interruption in supply occurs that creates a temporary shortage of material. In part, the threat of a supply interruption is responsible for low expectations relative to price increases as such concerns appear to have fueled interest in exploration and development of new sources of supply (EIU, 1987). Also contributing to this low expectation of prices increasing is the increasingly competitiveness of the chromium processes and the trend toward processing within producing countries to capture the value added by downstream processing.

6.2.2 Domestic Aspects

The principal occurrences of chromite in Pakistan are located in the North West Frontier Province and Baluchistan. Production of chromite has been recorded in both provinces since 1975/76, as shown on Table 6.3. As can be seen, production of chromite has declined since the mid-1970's. Interestingly, production increased in 1982/83 and 1983/84, during the world economic recession, over production levels achieved in the period 1979/80 to 1981/82.

In terms of exports of chromite, approximately 6,000 tonnes were exported during 1982, none in 1983, and over 29,000 tonnes in 1984/85. Table 6.4 displays the quantity of chromite exported in 1984/85 by country of destination and value per tonne of exported chromite in both Rupees and U.S. dollars. These exports, in 1984/85, were valued at Rs. 29,292,000 (or Rs. 997 per tonne).

In addition, Pakistan imported chromium oxides and hydroxides in 1982/83, 1983/84, and 1984/85. Respectively, these imports were 30, 48, and 36 tonnes. In 1984/85, imported chromium products were valued at Rs. 118,000 (or Rs. 3,278 per tonne) and were obtained from the Netherlands. Early imports were obtained from West Germany and China (Foreign Trade Statistics, 1986 and U.S. Bureau of Mines, 1986).

As seen in Table 6.4, the average value of exported chromite in 1984/85 was Rs. 997 (or $59) per tonne. It has been reported that Jijal chromite (with greater than 48 percent Cr2O3 and a 2.8:1 ratio) was sold through Pakistan Trading Corporation for $70 per tonne (fob Karachi). Also, it is reported that negotiations are being conducted for the sale of 6,000 tonnes of Malakand chromite (40 percent Cr_2O_3 and 2.5:1 ratio) at an asking price of $60 per tonne.

6.2.3 Competitive Analysis

As long as Pakistan can produce good grade chromite ore or chromite concentrate at the costs projected in this portfolio, there should be an export market for the product. Import substitution is not an immediate prospect as the imports are an upgraded product and used in small qualtities, not warranting conversion facility investment. This situation could change if Pakistan were to develop its steel industry into the making of stainless and other speciality chromium steels.

TABLE 6.3

CHROMITE PRODUCTION - PAKISTAN

(tonnes, gross weight)

YEAR	NWFP	Baluchistan	Pakistan
1975/76	0	12,360	12,360
1976/77	2,115	7,900	10,015
1977/78	2,550	7,297	9,847
1978/79	3,204	1,681	4,885
1979/80	1,270	2,565	3,835
1980/81	0	1,108	1,108
1981/82	940	2,088	3,028
1982/83	230	4,257	4,487
1983/84	0	4,180	4,180
1984/85	0	3,090	3,090

Source: Statistical Yearbook, 1986

TABLE 6.4

CHROMITE EXPORTS 1984/85

Destination	Quantity (a)	Value/Tonne Rs	Value/Tonne $U.S. (b)
Bahrain	65	800	47
Bulgaria	5,060	1,000	59
China	5,000	1,175	69
Italy	1,839	913	54
Japan	4,700	1,287	76
Netherlands	2,704	1,201	71
Philippines	10,000	733	43
Average		997	59
TOTAL	29,368		

Source: Foreign Trade Statistics, 1986

Note: (a) quantity reported in metric tonnes

(b) assumes $1 (U.S.) = Rs 17

7.0 FINANCIAL CONSIDERATIONS

7.1 CAPITAL INVESTMENT

The initial investment needed to start the four-mine Malakand project is estimated to be Rs6.4 million to start the first mine and Rs 10.1 million to construct the beneficiation plant. An additional investment of Rs13.5 million would be needed to develop mines 2, 3, and 4 up the the 11th year of the project.

It is estimated that 34 percent of the initial capital would be foreigh exchang purchases, and 10 percent of the further investment. Total foreign exchange purchases of capital items over the 14 year life of the project are estimated, in 1986 terms, at Rs6.9 million.

7.2 OPERATING COSTS

Operation costs for the four mine Malakand project, from the various assumptions, estimations and calculations are summarised as follows:

	Production	Direct Operating		Capital	Total
	t/y	Rs(ooo)/y	Rs/t	Rs/t	Rs/t
Mining	15000	1409	93.9	83.4	177.3
Plant	15000	1095	73.0	47.1	120.1
Other		33	2.2	0.7	2.9
Total and averages	15000	2537	169.1	131.2	300.3
Concentrate produced	8300	2537	305.7	238.7	555.4

7.3 FINANCIAL APPRAISAL

The economic and financial viability of the project described in this portfolio is of course dependent on the many assumptions and estimates made in calculating the investments and operating costs, though these are believed to be conservative. The figures used, if financing and taxation charges are neglected, show an internal rate of return of 4 percent (Appendix 6).

It is worth noting that the transportation cost of concentrate from the plant to ship is the largest cost component of the analysis. Appendix 6 shows how much a change in this component can change the internal rate of return. Equally a change in market price would have a high impact on rate of return, but this is forecast to be relatively stable.

A project such as this would be beneficial in terms of foreign exchange income. For the estimates used, this income would be Rs 8.47 million per year, or Rs 118.5 million over the 14 year project.

7.4 PERIPHERAL ECONOMIC BENEFITS GENERATED

One of the major economic benefits from a chromite project such as this would be the earning of foreign exchange. Probably of equal benefit would be the skills and expertise gained by the developing and operating people on such a project. This increase in technological and management skills would assist the province and the country in future mining developments.

The establishment of mining activities in the Darghai area would increase the industrial base of the area, generating ancilliary businesses and helping to increase employment in the area.

8.0 RECOMMENDATIONS

8.1 CURRENT STATUS OF THE MALAKAND CHROMITE PROJECT

The SDA have a geological project team in the area, working under a Revised PC-11 Scheme, starting from December, 1986. Two areas are receiving the most attention currently, Hero Shah and Landi Raud.

There are as yet insufficient data to enable calculation of mineable ore reserves, but this data should be developed as exploration continues in the area. There are a number of mineralised target areas to be examined, and on the promise shown by current exploration the consultant has made a number of assumptions and developed a generic mining and beneficiation operation based on these assumptions:

- Mineable orebodies in the form of steeply dipping, small pods exist, with a mineable width of 5m, and an extraction potential of 53,500 tonnes per orebody. Four such orebodies are assumed.

- Mining can be done by sublevel open stoping techniques, at the rate of 15000 tonnes per year, with mine access by adit at the bottom of the orebody.

- The ore average 27 percent chromite and is amenable to beneficiation to produce a concentrate (39 percent chromite) of marketable quality in the world market.

8.2 EXPLORATION AND DEVELOPMENT

Notwithstanding the assumptions made concerning ore and orebodies for this portfolio, the critical recommendations for the Malakand project are to enhance the exploration activity.

The calculations on mining and beneficiating the ore have been based on assumptions and extrapolations made from the available knowledge and samples of the chromite exploration targets. There is some proven ore, but of indeterminate grade.

Recommendations are:

- Prove the ore at the known target areas. Diamond drilling is the preferred method of doing this. Once a mineralisation zone has been determined, a drilling programme on a grid pattern should be carried out to determine both geometry and grade of the orebody. The apparent small size and variable grade of the orebodies makes good definition of each orebody imperative. The short mining life of each orebody leave no leeway for expensive mining mistakes.

  An initial drill pattern on a 20 metre square grid is recommended, with infill drilling almost certainly necessary as the ore is outlined.

- Find more orebodies. The existing inferred reserve are insufficient to justify an exploitation and beneficiation programme. Proven mineable reserves in excess of 200,000 tonnes are considered the minimum required.

- Establish a beneficiation test programme to test all ore found for amenability to upgrading to a marketable concentrate. Tests on beneficiation compatibility of ores from different orebodies will be essential.

- Conduct detailed feasibility studies on the mining and beneficiating of proven ore. Effective and efficient operations are essential to the profitable mining of small orebodies, as there is little time or room to correct mistakes.

8.3 MINE DESIGN AND BENEFICIATION PROCESS

The mine design and beneficiation process in this portfolio are developed from numerous assumptions and are basically generic and simple to provide indications of structure, process and costs.

Detailed studies and designs will have to be done based on the specifics of the orebodies when they are proven.

The total scale of operations will have to carefully be assessed and will depend on the number of mineable orebodies found and the total amount of ore found. It is anticipated it will be relatively easy to expand ore production by duplicating operations, so the capacity to expand beneficiation capacity readily should be designed into the plant.

The beneficiation plant should be on a rail line to limit the number and different types of transport that have to be used for ore and concentrate.

8.4 INFRASTRUCTURE AND TRANSPORTATION

Developing a mining operation in an area will always require supporting infrastructure and transportation systems.

Road construction should be very simple for the most part, with only final access to mine sites being through hilly terrain. Trucking over these roads is expected to be 5 trucks (50t) per day over approximately 3.5 years for each mine site.

Construction of electric power lines should also be quite straight forward, as the power requirements are small - 250KVA per mine, and most of the land over which they are run will be drainage plain.

It is not anticipated that housing construction would be required for an operation of this size. Of the 40 people projected, some would be living in the area, and numerous villages in the area should provide the necessary housing.

Land acquisition is not considered to be a problem as the mines would be in the hills, and the areas unlikely to be under cultivation.

Infrastructure for the beneficiation plant is expected to be supplied as the plant is projected to be built in an industrial estate in Peshawar.

8.5 MARKET STUDIES AND DEVELOPMENT

There is currently a good international market for quality chromite ore or concentrate, and indeed Pakistan has been selling into that market for a number of years a high grade run-of-mine material. As set out in section 7, world demand for chromite is expected to grow slowly, but without much change in price. Malakand chromite concentrate should have ready sale into this market, at the price projected, US$60/tonne, which equates to recent Pakistani sales of the ore.

It will be necessary to keep good control on mining and beneficiating costs in such a time of stable prices. Negotiating the best possible rail freight charges and shiploading charges will be very important to the profitability of the project.

It is projected that all concentrate would go to export, as there is no domestic demand for this product, and the use of upgraded chromium products is too small yet to justify Pakastani facilities.

8.6 FINANCING ALTERNATIVES

Finance for the development of a project of this sort, particularly if under the auspices of a government sponsored body like the SDA, can come from a number of indigenous sources, including the Industrial Development Bank of Pakistan, the National Development Finance Corporation, and the Regional Development Finance Corporation.

Development of a project of the scale outlined in this portfolio is unlikely to attract any interest from mining companies or market oriented financing institutions outside Pakistan. Preparation of a good, realistic feasibility study is a pre-requesite to financing consideration by all the institutions canvassed by the consultant.

APPENDIX 1

PETROGRAPHIC STUDIES

PETROGRAPHIC ANALYSIS OF SAMPLES FROM THE HERO SHAH SITE

MCH - 28 Olivine Chromitite

This sample consists of chromite, olivine, serpentine and chlorite with traces of talc and magnesite. Chromite is brown. It is generally < 2 mm in grain size and contains a few silicate inclusions. Most grains show some alteration to black ferritchromite along fractures and grain margins, with accompanying chlorite. The olivine is strained, fractured, and along margins and fractures altered to serpentine. it is devoid of inclusions but in a few places there are vermicules of chromite in olivine. This intergrowth is unusual and confusing from petrographic point of view. The model composition of the rock is given in Table 1.

MCH-29 Chromitite

This rock consists of chromite, olivine, clino- and orthopyroxene, serpentine, and chlorite. It is medium grained and chromite grains reach up to 4 mm.

Chromite is brown but along grain boundaries and fractures it is altered to black ferritchromite. The alteration is minor but the chromite contains inclusions of silicate phases, particularly in the centre of the grains. Chlorite, and alteration product of chromite, is associated with ferritchromite. The silicates show local development of serpentine, thus some clinipyroxene grains look spongy. Although much cpx is "interstitial", optical continuity suggests that some may be poikilitic. Tiny inclusions of chromite occur in pyroxene but were not noted in olivine.

Modal composition of the rock is given in Table 1.

TABLE 1

MODAL COMPOSITION OF THE CHROMITITES BASED ON TWO THIN SECTIONS CUT AT 90° TO EACH OTHER

SAMPLE NUMBER	MCH 28	MCH 29
NUMBER OF POINTS COUNTED	731	1156
Chromite	45	54
Ferritchromite	2	10
Silicate inclusions in chromite	1	3
Olivine	36	10
Pyroxene	-	14
Serpentine + Chlorite	16	8

Note: As usual, oxide proportion under microscope may have been overestimated by 2 of 3% and silicates, particularly inclusions, may be underestimated.

APPENDIX 2

MALAKAND FOUR-MINE PROJECT

CAPITAL COSTS

A.2.1

Typical Site Establishment for Mining Operation suitable for 50t/d sublevel open stoping:

Item		Rs(000)
Establish road access	- 3km @ Rs 50,000	150
Clear site for Buildings portal etc.	- 0.5 hectare	50
Electrification	- line in 3km @ Rs 200,000	600
Water Supply	- 2km piping @ Rs 200/m	400
	- tanks and pumps	100
Office change houses and facilities buildings	- $160m^2$ @ Rs 1800	108
Workshop	- 20 m^2 @ Rs 1300	26
Stores	- 20 m^2 @ Rs 1800	36
Air Compressor House	- 10 m^2 @ 1000	10
Fitting out	- Offices, change house	50
	- workshops	50
Site Civil Works	- for dumps, stockpiles, waste rock disposal, stockpiles etc	200
Air Compressors	- 1 @ 375cfm	500
Sub Total		2280

Need two sites established at one time once second mine starts to be developed.

So capital input = 2 x Rs 2280 =		Rs 4560
10% Contingency		440
Total Initial Site Establishment		Rs 5000
Amortized over 2 mining operations of 53,500t each for 107,000/t Cost/tonne =		Rs 46.7/t

Additional Site Establishment Costs

Assume buildings move once to next mine site
Sites 3 and 4

	Rs(000)
As above	2280
Less buildings, fittings, compressor	(780)
Plus moving costs	100
Sub total	1600
10% contingency	160
Establishment cost for sites 3 and 4, each	1760
Amortized over 53,500t	Rs32.9/t

A.2.2

Mine Development

- to ready for production stage
- for 50t/d sublevel open stoping

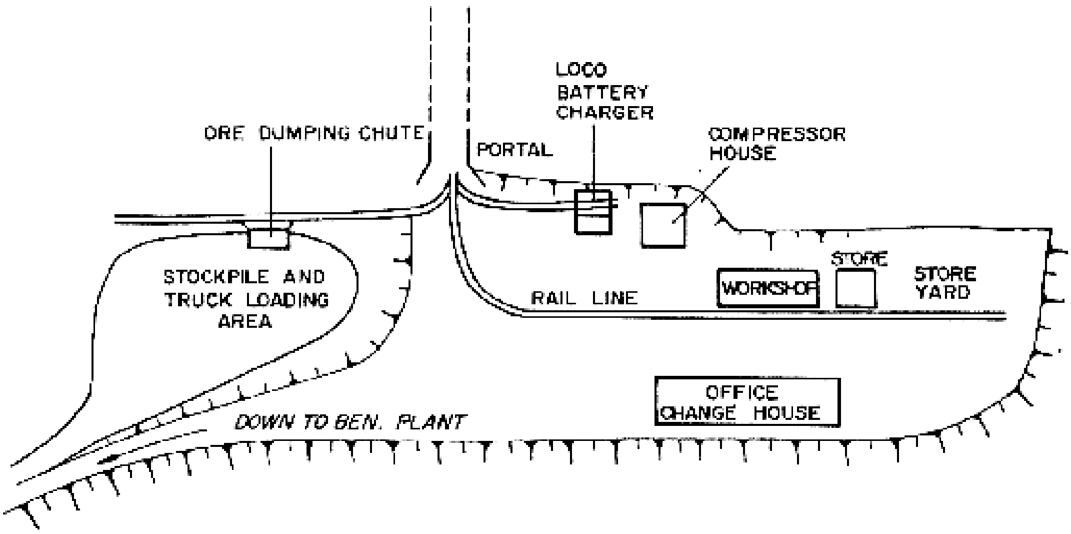
Item	Rs(000)
Adit access 200m @ Rs1860	372
Vent raise 90m @ Rs1200	108
Vent fan installed	20
Stope Development	
raises 2 x 60m @ Rs 1200	144
- Sublevels 4 x 50m @ Rs1000	200
- Top level development for ventilation 50m @ Rs1000	50
- Cone out for chutes $625m^3$	45
Subtotal	939
+ Contingency 10%	96
Total	1035

Amortized over 3.5 years and 53,500t = Rs 19.3/t

Mine Development timing and tonnage

Development	Time	Ore Produced
200m adit	200 days	50m x 5.6m^2 x 4t/m^3 = 1120t
90m vent raise	90	
Stope Development 120m raises	120 days	120m x 2.25m^2 x 4t/m^3 = 1080t
250m sublevels	250 days	250m x 4m^2 x 4t/m^3 = 4000t
Chute development	78 days	625m^3 x 4t/m^3 = 2500t
	738 days	8700t

Assuming 3 man crew, 2 shifts per day.



MINERAL SECTOR DEVELOPMENT STUDY NORTHWEST FRONTIER PROVINCE PAKISTAN	CONCEPTUAL MINE SITE LAYOUT

A.2.3

Equipment

for 50t/d sublevel open stoping

Item	Rs(000)
1 rockerloader	485
2 battery locomative set	1500
8 rocker cars	120
2 flat cars	20
1 slusher	500
3 air leg drills	51
2 long hole drills	60
2 plugger drills	30
18 cap lamp sets	33
3 10t trucks	1050
2 front end loaders	500
2 utility vehicles	350
Sub total	4731
+ contingency 10 %	469
Total	5200

Depreciation over 14 years and 214,000t = Rs 24.3/t

Low utilisation rate of equipment should ensure long life

APPENDIX 3

OPERATING PARAMETERS
AND
COSTS

A.3.1

Haulage drift costs

Cost of driving a drift

* Drift = 2.3 x 2.3m with timber sets every metre
* Drilling

15 holes/round - say 17m/m advance

drill steel = Rs1200/steel for 150m life

= Rs136/m

* Explosives

From SDA - explosive costs = Rs 100/ft of 6'x5' drift

For drift of area 57 sq ft

assume 50% increase in explosive cost = Rs 500/m

* Timber for support

assume Rs 730/t of timber

10kg/m length use 6.3m/set = Rs 46/m

* Labour

assume 0.5m advance/shift for 3 men

- drill, blast, muck out, install timber sets

@ Rs50/man shift = Rs 300/m

* TOTAL = Rs 982/m

use Rs1000/m

Cost of Haulage drift

* Driving drift and timbering = Rs1000/m
* Track

rail cost estimated to be Rs250/m for 22kg rail

for track = Rs 500/m

* Spikes, plates, switches estimate	= Rs 132/m
* Sleepers assume wood 10/10/80cm @ Rs 1000/t 56 sleepers/t and 3/m	= Rs 168/m
* Air and water pipe galvenized iron pipe per metre of drift	= Rs 30/m = Rs 60/m
* Cost of finished haulage drift	= Rs1860/m

A.3.2

50t/d Sublevel Open Stoping

Assume ore vein and stope is 5m wide
Sublevel is 2m x 2m on footwall, at 12m intervals
Area drilled by one ring of longholes = $56m^2$

Blasting - use 1.3kg explosive/m^3 ore
explosive loading densite = 1kg/m in 45mm hole

Drilling - with bar mounted percussion drill
drill 25 holes for 98m

Put rings 1 m apart
Load 73kg explosive/ring
Blast $56m^2$ x 1md x 4.0t/m^3 = 224t/ring
Have to blast 1 ring every 4.5 days

Drilling time

Set up		1.0 hour
Drill 98m @ 0.4m/min = 245 min.	- say	4.0 hours
Change holes 24 times x 5 min		2.0 hours
		7.0 hours

Assume 3 man crew, drill and blast 1 ring every 2 days, on 1 shift per day. The 224t of ore broken per ring can be hauled to the portal over 2 days.

Tonnage per stope

$56m^2$/ring x 50ml (50 rings) x 4 sublevels x 4.0t/m^3 = 44,800t
stope mining cycle = 44,800/50 = 896 days = 3 years

A.3.3

Mining Cost

- 50t/d sublevel open stoping

Drilling

98m/ring

- estimate detachable bit cost = Rs1200
  lasts for 150m
- estimate rods to drill up to 5.5m deep = Rs5000
  good for 900m

Cost/ring

· bits 98/150 x 1200	=	Rs 784	
rods 98/900 x 5000	=	Rs 544	
for 224/ring		Rs1328	Rs5.9/t

Explosives

· 73kg/ring x Rs40/kg	=	Rs2920	
· 25 detonators x Rs4		100	
- 70m electrice wire xRs5/m=		350	
for 224t		Rs3370	15.0

Haulage

· electricity			1.0

Manning

- Stope miners			
3 @ Rs50t/d	=	Rs 150	3.0

Sub total	24.9
Contingency 20%	5.0
Total direct mining cost	Rs29.9/t

A.3.4

Mine Management, Administration, Technical and Surface labourers
- for Malakand 2 site operations

Type	No	Salary/Month (Rs)	Total Month (Rs)
Manager/Mine Engineer	1	5400	5400
Clerk Typist	1	1000	1000
Accounts Officer	1	3300	3300
Clerk	1	1100	1100
Geologist	1	4400	4400
Ass't Mine Engineer	1	2700	2700
Surveyor	1	2000	2000
Surveyor Assistant	1	1100	1100
Mine Foremen	3	1500	4500
Transport Clerk	1	800	800
Drivers	3	1500	4500
Mechanics	3	1400	4200
Electrician	1	1300	1300
Technical Clerk	1	900	900
Draughtsman	1	1100	1100
Storekeeper	2	1000	2000
Yard Drivers/Workers	2	1000	2000
Watchmen	4	800	3200
Chowkidars	2		1600
	31		47100

Cost/tonne = Rs47100/1250t = Rs37.7/t

Underground Workers

Stope miners	3 men x 1 shift	3
Development cres	3 men x 2 shifts	6
		9

Costed into direct mining costs in A.2.4.

A.3.5

Trucking Operation

50t/d mine to mill (Peshawar)

70 km from mine to plant		
One truck does 2 trips/day	=	280km
Moves 20 tonnes/day		
Monthly, per truck	=	500t
	=	7000km
Use 3 trucks to move		1250t/mo

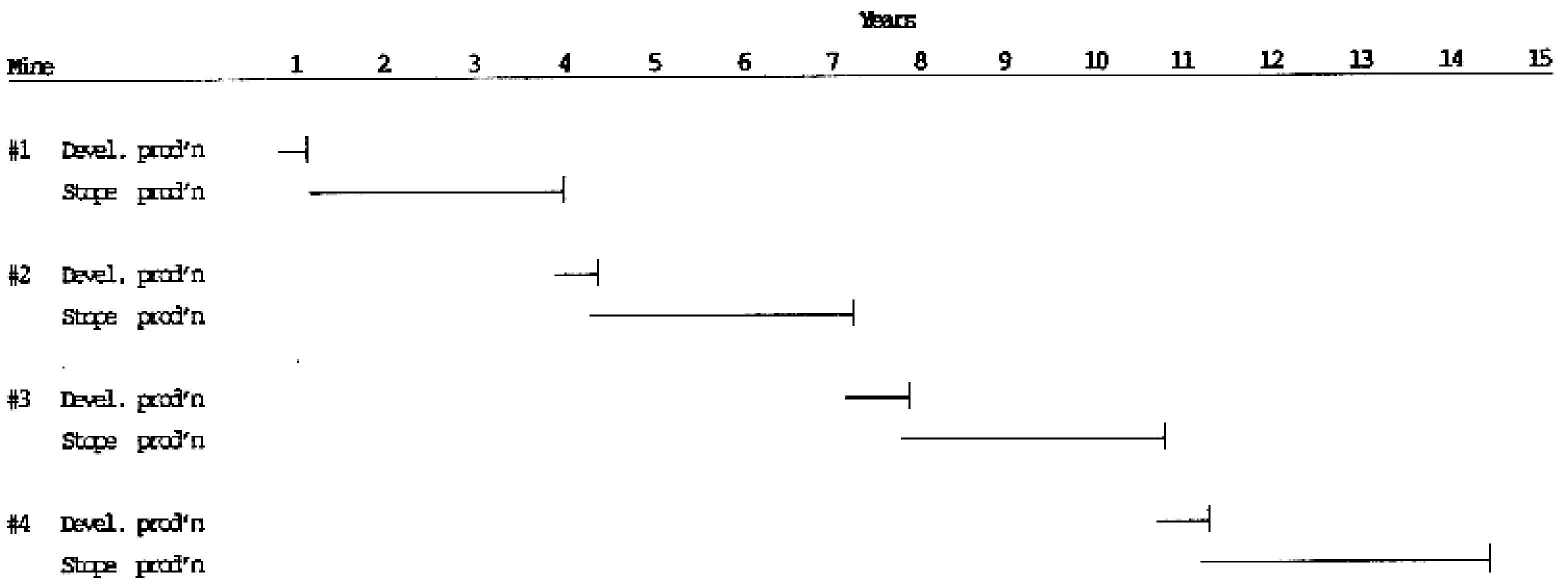
Cost per truck per month *

Fuel @ 4km/l and Rs3.0/l	Rs4376/mo
Maintenance	2000
Tyres	2580
Registration and taxes	1000
	9956
10% contingency	994
	Rs10950/mo
For 416.7t/mo/truck	= Rs 26.3/t

Drivers wages are already included in Manning costs, Appendix 2.5.

* Costs based on information from trucking operations in NWFP.

A.3.6 Four-Mine Development Production Schedule



A.3.7

Transport to Operations sites

Workers/staff have to be transported from surrounding towns to mine sites.

Total 40 people

Assume two minibuses are required, one to each site.

Assume each travels 40km/d

Running costs estimates

Assume 8km/l petrol @ Rs7.0/l

Tyres Rs3000/set of 4 - 30,000km

Km/mo	1000
Rs/mo	
Fuel	875
Repairs	150
Service	150
Tyres	100
Registration	100
	1375
No	2

Rs2750/mo x 12 = Rs33,000/y = Rs2.2/t

Capital Cost

Estimated at Rs 70,000 per unit

Depreciation charge = Rs0.7/t

APPENDIX 4

CHROMITE ORE PROCESSING

TESTWORK

Two samples of chromite ore from Hero Shah (MCH-BI) and from Bada Sar (BSB-1) were submitted for testing.

HEAD ASSAY (Percent)	MCH-BI	BSB-1
Cr_2O_3	27.6	33.2
Fe_2O_3	13.0	12.3
FeO	1.23	1.27
Al_2O_3	19.9	13.8
MgO	22.1	24.4
CaO	0.538	0.385
SiO_2	14.4	13.5
P_2O_5	<0.02	<0.02
% Loss on ignition	1.77	1.92

Testwork Procedure

The samples were ground to provide three milled products per sample. These products were minus 1mm, minus 0.5mm and minus 0.25mm respectively and after milling they were upgraded on a shaking table.

Results

Test results are compiled in Table A.4.4.1 (MCH-B1) and Table A.4.4.2 (BSB-1).

In each instance, it may be seen that as the grind becomes finer the amount of silica rejecting to the tailings increases : tabling material ground to minus 0.25mm results in 37.6 percent of the silica being rejected in the case of sample MCH-B1 and 53.8 percent in the case of sample BSB-1. Unfortunately, chromium shows the same trend, 16.0 percent and 18.1 percent of the Cr_2O_3 reporting to tailings with a grind of minus 0.25mm for MCH-B1 and BSB-1 respectively. Thus to achieve a low silica product, recovery will have to be sacrificed.

PCSIR Laboratories, Lahore, reportedly carried out beneficiation tests of a Malakand chromite sample of unspecified source or head grade, and using a similar treatment route as followed in the Australian work, with the exception that PCSIR used a slightly finer grind, produced the following concentrate (the minus 0.25mm results on MCH-B1 and BSB-1 are also shown for comparison).

Sample	PCSIR	MCH-B1	BSB-1
$\%Cr_2O_3$	45	39	47
FeO	16		
SiO_2	9	3.6	3.3
Al_2O_3	15	25	18
MgO	14	14	15

The PCSIR results are similar to those from BSB-1 for most constituents except silica which was rejected more successfully in the Australian test work. This is most encouraging as the Japan Consulting Institute found that Malakand chromite with 4.45 percent SiO_2 to be suitable for the production of chrome magnesite refractory bricks, whereas chromite with 15.7 percent and 23.6 percent respectively were not found to be suitable. Thus the concentrate from MCH-B1 with >60 percent combined Cr_2O_3 and Al_2O_3 and a silica level of less than 5 percent would seem to be suitable for refractory use (see specification for high aluminium ore in the introduction). The concentrate from BSB-1 would seem to meet the specifications for chemical grade material so there may be further uses for the Malakand chromite ore.

The concentrate grades show them to be saleable products but recovery in the table concentrate is low, only 22 percent of the Cr_2O_3 reports to the concentrate in the case of MCH-B1 and 21 percent in the case of BSB-1. However, the middlings in each instance contain about 60 percent of the Cr_2O_3 in the table feed.

Recycling the middlings will improve recovery but in order to keep the silica content low, it will probably be necessary to regrind the middlings.

TABLE 4.4.1

RESULTS WILFLEY TABLE CONCENTRATION CHROMITE SAMPLE NO. MCHB1

Grind Size	Product		CHROMIUM		SILICA		ANALYSES						
		Weight%	Cr_2O_3%	Dist.%	SiO_2%	Dist.%	Fe_2O_3%	FeO%	Al_2O_3%	MgO%	CaO%	P_2O_5%	LOI%
> 1MM	Concentrate	14.3	36.3	19.3	7.49	7.7	16.5		22.6	14.3	0.153	0.020	0.34
	Middling	73.2	26.6	72.4	13.52	71.4							
	Tailing	12.5	18.0	8.3	23.10	20.9							
		100.0	26.91	100.0	13.86	100.0							
> 0.5MM	Concentrate	32.2	39.1	33.5	4.79	8.2	16.7		23.5	13.7	0.144	0.020	Nil
	Middling	62.9	24.8	57.6	14.83	68.7							
	Tailing	13.9	17.4	8.9	22.68	23.1							
			27.09	100.0	13.59	100.0							
> 0.25MM	Concentrate	15.4	38.7	22.0	3.62	4.1	17.6		24.6	14.4	0.137	0.022	Nil
	Middling	61.0	27.6	62.0	13.22	58.3							
	Tailing	23.6	18.4	16.0	24.04	37.6							
			27.14	100.0	13.82	100.0							

TABLE 4.4.2

RESULTS WILFLEY TABLE CONCENTRATION CHROMITE SAMPLE NO. BSB1

Grind Size	Product	Weight%	CHROMIUM Cr_2O_3%	CHROMIUM Dist.%	SILICA SiO_2%	SILICA Dist.%	ANALYSES Fe_2O_3%	FeO%	Al_2O_3%	MgO%	CaO%	P_2O_5%	LOI%
> 1MM	Concentrate	26.9	42.9	35.4	7.62	14.0	15.3		16.0	17.7	0.100	0.02	0.13
	Middling	58.6	31.0	55.7	15.1	60.5							
	Tailing	14.5	20.1	8.0	25.7	25.5							
		100.0	30.62	100.0	14.63	100.0							
> 0.5MM	Concentrate	19.5	44.2	26.8	4.62	6.2	16.5		17.3	16.5	0.090	0.02	Nil
	Middling	62.0	31.8	61.4	14.6	62.5							
	Tailing	18.5	20.5	11.8	24.5	31.3							
		100.0	32.13	100.0	14.48	100.0							
> 0.25MM	Concentrate	15.2	46.6	21.4	3.30	3.4	15.6		17.9	15.3	0.085	0.02	Nil
	Middling	54.0	37.1	60.5	11.8	42.8							
	Tailing	30.8	19.5	18.1	26.0	53.8							
		100.0	33.12	100.0	14.88	100.0							

A.5.1

Chromite Plant - Design Criteria

General	
Annual operating days	250
Plant availability, %	25
Annual operating hours	1500
Plant capacity, t/h	10
Plant throughput, t/y	15000
Ore grade, % Cr_2O_3	27
Recovery. %	80
Concentrate grade, %Cr_2O_3	39
Concentrate grade, %Si_2O_3	25
Concentrate production, t/y	35370
Crushing Section	
Operating schedule, d/y	250
Operating schedule, d/wk	5
Operating scheudle, h/d	8
Availability, %	47
Annual operating, hours	945
Design capacity, t/h (dry basis)	15.9
Primary crusher feed size, mm	200x200
Crushed product, 80% minus, mm	11.0
Milling Sections	
Operating schedule, d/y	250
Operating schedule, d/wk	5
Operating scheudle, h/d	8
Availability, %	25
Annual oprating hours	1500
Plant capacity, t/h	10.0
Ball mill feed size, 80% minus, mm	11.0
Bond work index	19.0

Primary Cyclone overflow size, 80% minus, um	200
Primary Cyclone overflow density, % solids	30
Primary Cyclone underflow density, % solids	65
Regrind cyclone, overflows size, 80% minus, um	100
Regrind cyclone overflow density, % solids	30
Regrind cyclone underflow density, % solids	55
Gravity Section	
Operating schedule	As milling
Rougher spiral feed density, % solids	30
Cleaner sprial feed density, % solids	30
Table feed density, % solids	20
Overall recovery, %	80
Concentrate Handling Section	
Concentrate thickener underflow, density, % solids	60
Filter cake moisture, % H_2O	15
Dryer discharge moisture, % H_2O	8

Costs for equipment are based on P.C.S.I.R. report "Study on Substitution of Imported Minerals and Mineral Based Products (Phase 1)". Where no Pakistan prices have been found, Australian costs for equipment and consumables have been used.

A.5.2

Operating Costs

Power

Crusher Section

	Kw installed	Kw consumed
Primary Crusher Motor	22	18
Secondary Crusher Motor	50	40
Crusher Screen Motor	3	2
Conveyor and Feeder Motors	40	32
		92

Crusher operating time 945 h/year

Therefore Power Consumed Annually 86.9 MWh

Milling and Grinding Circuit

Primary Mill Motor	120	96
Primary Cyclone Feed Pump Motor	20	16
Regrind Mill Motor	50	40
Regrind Cyclone Feed Pump Motor	15	12
Assorted Small Motors	10	8
Shaking Table Motors	4	3
Tailings Pump Motors	20	16
		191

Concentrate Handling Section

Thickener Moter	2	2
Filter Motor	1	1
Vacuum Pump	12	10
Conveyor Motor	5	4
		17

Milling and gravity circuit operating time	1500 hour/year
Therefore Power Consumed	312.0 Mwh
Total annual power consumption	398.9 MWh
Cost of power	RS 1.0 Kwh
Therefore Annual power cost	Rs 399,000

Consumables

Annual	Consumption (kg/tonne)	Annual Consumption (tonnes)	Cost (R/tonne)	Cost (Rs000)
Grinding Media	1.2	18	600	108
Maintenance Materials	-	-	-	75

Summary of Operating Costs

Labour	Rs 513000
Power	Rs 399000
Consumables	R 183000
Total	Rs 1,095,000 or Rs 73.0 tonne/milled

A.5.3

Capital Costs

Mechanical Equipment

2

		(Cost Rs 000
Loading Bin	Capacity 50 tonnes	72
Belt Feeder	Capacity 16 t/l	50
Jaw Crusher	Size 355 x 510 mm	90
Secondary Cone Crusher	Size 610 mm	300
Crushing sizer screen	Size 914 x 1892 (single desk)	40
Fine ore bin	Capacity 25 tonnes	45
Belt conveyors	Capacity 16 t/h	180
Belt feeder	Capacity 10 t/h	40
Weighometer	Capacity 10 t/h	50
Ball mill	Size 1830 x 3050 mm	650
Primary cyclone feed pump	3/2 centrifugal pump	40
Hydrocyclone	250m	15
Automatic sampler	chain drive type	90
Regrind mill	size 1520 x 1830mm	350
Regrind cyclone feed pump	1 1/2 centrifugal pump	25
Regrind cyclone	200mm	15
Rougher spirals	3 x double round units	180
Cleaner spirals	3 x double round units	180
Shaking tables	2 x full sized units	180
Concentrate thickener	Size 4m diameter	25
Concentrate dryer	Capacity 130 t/day	600
	Total	3322

Buildings

Plant building	40' x 100' @ Rs 180/ft^2	= Rs 576000
Workshop	15' x 25' @ Rs 250/ft^2	= Rs 93750
Laboratory	15' x 20' @ Rs 250/ft^2	= Rs 75000
Office	15' x 20' @ Rs 250/ft^2	= Rs 75000
		Rs 819750

Capital Cost Summary

Mechanical equipment	Rs 3322000
Piping	Rs 5980000
Electrical and Instrumentation	Rs 664000
Civils	Rs 248000
Structural	Rs 166000
Building	Rs 820000
Laboratory Euipment	Rs 700000
Workshop Equipment, tools, office furnishings	Rs 500000
Total direct cost	Rs 7019000
Indirect Cost (25%)	Rs 1755000
Sub total	Rs 874000
Contingency (15%)	Rs 1316000
Total Estimate	Rs 10,090,000

A 5.4

Manning

Labour Operating

	Number	Daily Wage (Rupees)	Total Daily Wage (Rupees)
Plant Superintendent	1	170	170
Metallurgist	1	120	120
Chemist	1	80	80
General Foreman	1	100	100
Ships Foreman	1	75	75
Crusher Operators	2	50	100
Mill Operators	1	50	50
Gravity Section Operators	1	50	50
Concentrate Handling Operators	1	50	50
Laboratory Assistants	1	45	45
Sample Preparation Assistants	1	40	40
Labourers	2	30	60
Clerk Typist	1	40	40
	15		980

Maintenance

Maintenance Engineer	1	110	110
Foreman	1	80	80
Fitters	2	50	100
Electrician	1	50	50
Labourers	4	30	120
			460

Administration

Accountant	1	120	120
Clerk	1	40	40
Storekeeper	1	50	50
Labourer	1	30	30
Chowkidar	1	30	30
	5		270
			1710

Total Annual Wages	Rs 513000 /y
Over 15000 t/y	Rs 34.2 /t

APPENDIX 6

CASH FLOW PROJECTIONS

SIMPLIFIED CASH FLOW FOR CONCEPTUAL CHROMITE PROJECT AT MALAKAND

BASE CALCULATIONS

PRODUCTION YEARS	YEAR -2	YEAR -1	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12	YEAR 13	YEAR 14	YEAR 15	TOTAL
CAPITAL COSTS	(Rs 000)																		
MINE Site Establishment #1	500	1500	500																2500
#2					2000	500													2500
#3									2000	500									2500
#4												2000	500						2500
Mine Development #1		500	500	35															1035
#2					750	500	285												1035
#3									500	500	35								1035
#4												250	500	285					1035
Equipment	2000		3190						2000		3190								10380
BENEFICIATION PLANT		5000	5090																10090
BUSES	70			70					70		70								230
TOTAL CAPITAL COSTS	2570	7000	9280	105	2250	1000	285	0	4570	1000	3295	2250	1000	285	0	0	0		34890
OPERATING COSTS																			
MINE				1409	1409	1409	1409	1409	1409	1409	1409	1409	1409	1409	1409	1409	1409		19726
BENEFICIATION PLANT				1095	1095	1095	1095	1095	1095	1095	1095	1095	1095	1095	1095	1095	1095		15330
BUSES	16	16	16	33	33	33	33	33	33	33	33	33	33	33	33	33	33		510
TOTAL OPERATING COSTS	16	16	16	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537		35546
PRODUCTION Chromite Concentrate (t/y)				8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300	8300		
CASH FLOW PROJECTION																			
SALES REVENUE				5561	5561	5561	5561	5561	5561	5561	5561	5561	5561	5561	5561	5561	5561		
LESS CAPITAL COST	2570	7000	9280	105	2250	1000	285	0	4570	1000	3295	2250	1000	285	0	0	0		
LESS OPERATING COST	16	16	16	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537		
NET CASH FLOW BEFORE TAX	-2586	-7016	-9296	2919	774	2024	2739	3024	-1546	2024	-271	774	2024	2739	3024	3024	3024		
CUMULATIVE CASH FLOW BEFORE TAX	-2586	-9602	-18898	-15979	-15205	-13181	-10442	-7418	-8964	-6940	-7211	-6437	-4413	-1674	1350	4374	7398		
CUMULATIVE CAPITAL EXPENDITURE	2570	9570	18850	18955	21205	22205	22490	22490	27060	28060	31355	33605	34605	34890	34890	34890	34890		
INTERNAL RATE OF RETURN	4.0%																		

FINANCIAL PARAMETERS

EXCHANGE RATE - Rs/US$	17
CHROMITE CONC. PRICE - US$/tonne	60
FREIGHT & HANDLING - Rs/tonne	350

CHANGES IN FREIGHT AND HANDLING CHARGES

PRODUCTION YEARS	YEAR -2	YEAR -1	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12	YEAR 13	YEAR 14	YEAR 15	TOTAL
CASH FLOW PROJECTION																			
SALES REVENUE				5146	5146	5146	5146	5146	5146	5146	5146	5146	5146	5146	5146	5146	5146		
LESS CAPITAL COST	2570	7000	9280	105	2250	1000	285	0	4576	1000	3295	2250	1000	285	0	0	0		
LESS OPERATING COST	16	16	16	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537		
NET CASH FLOW BEFORE TAX	-2586	-7016	-9296	2504	359	1609	2324	2609	-1961	1609	-686	359	1609	2324	2609	2609	2609		
CUMULATIVE CASH FLOW BEFORE TAX	-2586	-9602	-18898	-16394	-16035	-14426	-12102	-9493	-11454	-9845	-10531	-10172	-8563	-6239	-3630	-1021	1588		
CUMULATIVE CAPITAL EXPENDITURE	2570	9570	18850	18955	21205	22205	22490	22490	27060	28060	31355	33605	34605	34890	34890	34890	34890		
INTERNAL RATE OF RETURN	0.9%																		

FINANCIAL PARAMETERS

EXCHANGE RATE - Rs/US$ 17
CHROMITE CONC. PRICE - US$/tonne 60
FREIGHT & HANDLING - Rs/tonne 400

CASH FLOW PROJECTION																			
SALES REVENUE				4731	4731	4731	4731	4731	4731	4731	4731	4731	4731	4731	4731	4731	4731		
LESS CAPITAL COST	2570	7000	9280	105	2250	1000	285	0	4570	1000	3295	2250	1000	285	0	0	0		
LESS OPERATING COST	16	16	16	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537		
NET CASH FLOW BEFORE TAX	-2586	-7016	-9296	2089	-56	1194	1909	2194	-2376	1194	-1101	-56	1194	1909	2194	2194	2194		
CUMULATIVE CASH FLOW BEFORE TAX	-2586	-9602	-18898	-16809	-16865	-15671	-13762	-11568	-13944	-12750	-13851	-13907	-12713	-10804	-8610	-6416	-4222		
CUMULATIVE CAPITAL EXPENDITURE	2570	9570	18850	18955	21205	22205	22490	22490	27060	28060	31355	33605	34605	34890	34890	34890	34890		
INTERNAL RATE OF RETURN	-2.6%																		

FINANCIAL PARAMETERS

EXCHANGE RATE - Rs/US$ 17
CHROMITE CONC. PRICE - US$/tonne 60
FREIGHT & HANDLING - Rs/tonne 450

CHANGES IN CHROMITE CONCENTRATE PRICE

PRODUCTION YEARS	YEAR -2	YEAR -1	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12	YEAR 13	YEAR 14	YEAR 15	TOTAL
CASH FLOW PROJECTION																			
SALES REVENUE				6972	6972	6972	6972	6972	6972	6972	6972	6972	6972	6972	6972	6972	6972		
LESS CAPITAL COST	2570	7000	9280	105	2250	1000	285	0	4570	1000	3295	2250	1000	285	0	0	0		
LESS OPERATING COST	16	16	16	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537		
NET CASH FLOW BEFORE TAX	-2586	-7016	-9296	4330	2185	3435	4150	4435	-135	3435	1140	2185	3435	4150	4435	4435	4435		
CUMULATIVE CASH FLOW BEFORE TAX	-2586	-9602	-18896	-14566	-12383	-8948	-4798	-363	-498	2937	4077	6262	9697	13847	18282	22717	27152		
CUMULATIVE CAPITAL EXPENDITURE	2570	9570	18850	18955	21205	22205	22490	22490	27060	28060	31355	33605	34605	34890	34890	34890	34890		
INTERNAL RATE OF RETURN	12.8%																		

FINANCIAL PARAMETERS

EXCHANGE RATE - Rs/US$ 17
CHROMITE CONC. PRICE - US$/tonne 70
FREIGHT & HANDLING - Rs/tonne 350

CHANGES IN CHROMITE CONCENTRATE PRICE

PRODUCTION YEARS	YEAR -2	YEAR -1	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12	YEAR 13	YEAR 14	YEAR 15	TOTAL
CASH FLOW PROJECTION																			
SALES REVENUE				8383	8383	8383	8383	8383	8383	8383	8383	8383	8383	8383	8383	8383	8383		
LESS CAPITAL COST	2570	7000	9280	105	2250	1000	285	0	4570	1000	3295	2250	1000	285	0	0	0		
LESS OPERATING COST	16	16	16	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537	2537		
NET CASH FLOW BEFORE TAX	-2586	-7016	-9296	5741	3596	4846	5561	5846	1276	4846	2551	3596	4846	5561	5846	5846	5846		
CUMULATIVE CASH FLOW BEFORE TAX	-2586	-9602	-18898	-13157	-9561	-4715	846	6692	7968	12814	15365	18961	23807	29368	35214	41060	46906		
CUMULATIVE CAPITAL EXPENDITURE	2570	9570	18850	18955	21205	22205	22490	22490	27060	28060	31355	33605	34605	34890	34890	34890	34890		
INTERNAL RATE OF RETURN	19.9%																		

FINANCIAL PARAMETERS

EXCHANGE RATE - Rs/US$ 17
CHROMITE CONC. PRICE - US$/tonne 80
FREIGHT & HANDLING - Rs/tonne 350

Minerals Development Department
Government of Khyber Pakhtunkhwa
Abdul Wali Khan Complex,
Civil Secretariat, Peshawar, Khyber Pakhtunkhwa

+92-91- 9223553

+92-91-9223551

Directorate General Mines & Minerals
Khyber Pakhtunkhwa
5 Khyber Road, Near Judicial Complex
Peshawar, Khyber Pakhtunkhwa

+92-91-9210275

+92-91-9211140

www.kpminerals.gov.pk www.Khyberpakhtunkhwa.gov.pk/Department/Mineral