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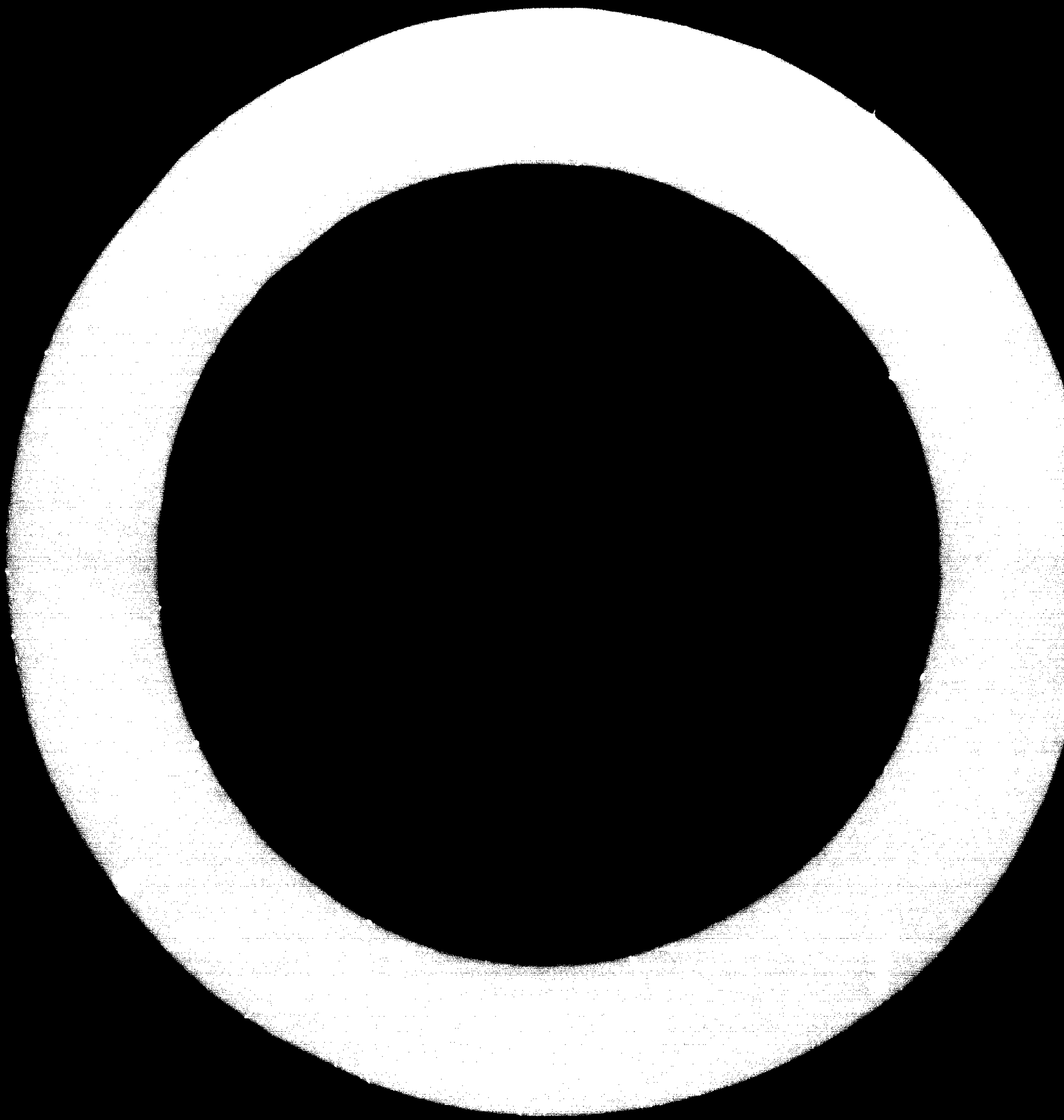

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ORE EXPLORATION AND EXPLOITATION - INTERMEDIATE SCALE

by

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SUMMARY

As basis of the realisation of iron ore projects the existence of a market for the products is required. This market may be worldwide for certain iron ores. Recent development of ore sources and metallurgy show that only ores or concentrates of high chemical and physical qualities have a chance to be sold on the world market.

Calculations of pig iron costs indicate that the cost advantage of high quality blast furnace feed generally cannot be balanced by lower prices of low quality ores.

Ore exploration is described exposing the different phases of field work concerning surface reconnaissance and underground sampling, material testing and technical planning. The necessity of cost estimations of the proposed plants and operations accompanying each phase of research is emphasized.

General viewpoints for the financing and the realization of iron ore projects are discussed.

The role of technical consultants is pointed out, especially in connexion with the organization of governmental enterprises in iron ore. Independent technical and economical control should be guaranteed also in any case.

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1. <u>Bases of the realization of Iron and Steel projects on intermediate scale</u>

1a <u>Market Conditions</u>

Iron and steel as basic industrial materials greatly helped to form the existent picture of modern industries. Steel consumption figures per head are good indicators of the industrialization of a country.

The figures of the consumption in iron and steel and the important differences still existing between countries of different economic development status are known.

Thus the conclusion can easily be drawn that by an increase of the iron and steel consumption the desired progress in industrialization is indicated.

The question how to pay for such an increase is closely connected to the question how to raise the necessary foreign currency for importing iron and steel products. Consequently the possibilities of home resources and of the own production of iron and steel are approached. There exist several economic requirements however that must be fulfilled before such a project can be realized.

Sound economic development demands supply of industrial products at prices which can compete with those of other countries. Therefore all consideration should be concentrated on the problem to what costs a projectd plant could produce.

A market survey investigating as well inland consumption as export possibilities is serving as basis for the capacity determination and for the determination of production cost limits. The great variety of iron ores in grade and type still serving as raw material for iron and steel production has stimulated in the past many projects which prove to be economically unfeasible in a future, governed by low cost production on the basis of high grade iron ores or concentrates.

Exportation of iron ore can therefore only be taken into account if highest quality and low costs of production and transportation guarantee competing prices on the world market.

The iron ore projects realized in developing countries during the past decade and commencing to feature ore prices on the market today underline this trend. Cheap production costs by open cast mining of high grade ore in connexion with low transportation costs to a suitable harboursite originated a series of large scale exploitations for export in unindustrialized areas which became or are becoming in consequence centres of industrial activities. The examples of Canada, Venezuela, Peru and Brazil, of Mauretania, Sierra Leone and Liberia may be cited.

Medium sized projects find their place there, where insufficient ore quality or tonnage reserves or high production costs are prohibitive for meeting the world markets competition. They are destinated to serve a local market at costs which are not significantly different from those of imported products. In the case of less populated countries this market can and should possibly comprise neighbouring countries.

Close co-operation of areas with similar economic conditions in the planning and realization of such projects is by far more favourable than national projects without sufficient market background.

1b <u>Material basis</u>

It has been pointed out that only high grade iron ores or concentrates of 60% or more have a chance today to supply a wider market. Therefore an ore of this quality is preferably required before starting any iron and steel project. This statement, however, is not in accordance with the actual practice in existing plants. In France, Britain, West Germany, in Russia and in many other countries plants are using low grade ores of 30% iron, which may be upgraded by beneficiation and thermal treatment to 40% Fe. Recent investigations based on calculations of coke consumption and cost figures, however, have proved that the transformation of such ores into pig iron in the blast furnace process is too costly to be balanced by cost advantages of the ore itself. Some examples for production costs are cited in table 1. Regarding the difference in production costs for pig iron between the ore of 29% Fe and that of 67% Fe it is evident that per ton of pig iron $ 18 must be saved by cheaper ore to produce pig iron from both ores at the same costs.

This means however a necessary cost advantage of the low grade ore which apparently cannot be achieved as long as the high grade ore is sold for $ 12-14 per ton. Therefore utmost care must be taken not to start projects on ore that for all future prohibits an economic activity.

The kinds of ore to be taken into consideration are such which are enriched by natural processes already as it is the case in many African and South American deposits, derived from quartz banded iron ores and occurring within such horizons or deposits believed to be of magmatic origin as in Northern Sweden, or near the Pacific coast of South and Middle America. While the world reserves of the first group, known so far can be estimated in the order of 25 billion tons in all continents, those of the second type reach scarcely 3 billion tons.

The single deposits of the first category form often masses of 100 million tons and more, while the deposits of the second type normally occur in small lenses, rarely exceeding 10 million tons of ore.

There exists however a third category of iron ore, quartz banded iron ores, a group which is also known as itabirite or taconite, containing billions of billions of tons with iron contents of 25 to 35%, that can be enriched by beneficiation processes and is providing a growing percentage of the present ore consumption. Concentrates of this ore, as produced in Canada, Scandinavia, Western Africa, are characterized by high chemical quality and after agglomeration, especially in the form of pellets, by excellent physical properties.

Iron ore therefore that is occurring with more than 60% or which can be enriched by cheap beneficiation processes has a good chance to form an economical sound basi for a production of iron and steel or even to be exported if the transportation co..s to the centres of consumption are not prohibitive.

1c <u>Conduction of preparatory work</u>

A market analysis taking into consideration the local requirements of iron ore, the possibilities to sell ore abroad as well as to buy foreign ore must be carried out by experts, acquainted with the international iron ore situation. Consulting companies carrying out such surveys exist in Europe as well as in North America. The advantage of such a report lies in the strict economic viewpoints that are applied.

The necessary information for such a report is to be supplied preferably by a local planning staff, comprising economists who are well familiar with a country's economic situation, transportation conditions, labour, material prices, a.s.o.

A market study can be completed within 2 to 3 months. It forms the basis for further decisions how to proceed with a project.

2. <u>Ore exploration intermediate scale</u>

Ore exploration is always aimed to prove quantities and qualities of ore of which certain parts, normally surface outcrops are known. Due to the fact that in almost all cases surface ore has undergone alterations and that only suppositions exist as to the volume of ore bodies, surprising results of intense fieldwork are abundant. Just as frequent is, however, the reluctance of planning authorities to change original assumptions. To prove in each stage of exploration the economic feasibility of a project, the exploration work should therefore continuously be accompanied by economic calculations, based always upon the most recent information, and providing the possibility to stop a project not spending useless money. This is true for projects in any scale.

2a **Organization of exploratory activities**

Complete exploration work includes thus as well technical as economical research. The technical part can be grouped into -

investigation of the ore;

technical planning of mining and beneficiation;

cost estimation of mining and beneficiation.

First, attention is directed upon the deposit itself and its reconnaissance. This work of geological research normally starts from the surface and proceeds into the depth.

For a medium-sized operation, aimed to prove reserves of ore or concentres in the order of 10 to 25 million tons, to supply a medium sized steel plant, producing 200,000 to 500,000 t of steel the first investigations comprise geological mapping, based on topographical information, sampling and eventually geophysical groundwork. A basic topographical information is required.

If, for this information new maps have to be established, this may be done preferably from aerial photographs. The aerial survey of the outcrop areas can be combined with a geophysical survey which in the case of iron ore may be restricted to aeromagnetics. Geophysical methods may indicate covered ore bodies. Such preliminary information has to be confirmed, however, by ground investigations.

The planning staff of this first phase should include engineers or geologists who are well acquainted with prospecting, geological mapping, surface sampling, organisation of geological field work, setting up of camps, organization of prospecting teams, etc. Field laboratories for chemical or preparation tests are normally not required, due to the fact that reliable laboratories can be reached in most cases within a reasonable time. The great importance of the exactness of analyses, on which all further calculations are based, must be stressed in this connexion.

The administration requires personnel, acquainted with provisional storage of supply and material, with transportation facilities, etc.

Many governmental and private teams have during the last decades carried out such field work in all parts of the world. For many of the different branches of the activities specialized firms and institutions are available. This applies for air-borne surveys, for beneficiation test and for chemical analyses, for geological mapping and for mineralogical examinations. There are, however, from the very beginning personalities needed who understand all these activities and are able to co-ordinate and to direct them. Such general consultants who are as well familiar with the economical as with the technical aspects of an undertaking can be found in consulting engineering companies.

2b Exploration activities

2b (i) Topographical information

Topographical maps are the fundament of all geological and geophysical work.

Normally two kinds of maps are required. One is concerning a wider area, in which prospecting is carried out. Depending upon the type of deposits, this can be any surface between 50 and 1,000 km^2. Large scale maps of 1 : 10,000 to 1 : 25,000 can be obtained easily from aerial photographs with a high grade of exactness. Geological detail mapping of ore deposits requires topographical maps 1 : 1,000 to 1 : 2,000. They can also be reproduced from aerial photographs. Often the photographs themselves serve as charts on which the mapping is done. Such procedure demands however later topographical corrections and can be considered as improvisation only. The following pictures show the aerial photographs and a contour map of the same area, which were produced in scale 1 : 1,000 and served as base for geological mapping, as shown in the last picture (picture 1a, 1b).

Aerial photographs constitute the quickest and most modern way to procure topographical maps. Sometimes, however, it may pay to use ground methods for this purpose. To work with chain and compass as it was done in early prospections throughout the world is not to recommend in most cases of iron ore prospection due to the possible magnetic properties of the ore.

The plane-table however constitutes a mean of topographical mapping, by which an area of about 20 km^2 can be covered per month by a team consisting of one surveyor and two helpers.

If the mapping geologist is carrying out this work himself, the combination of topography and geology is simplifying the task.

For greater areas normally an airborne survey is much cheaper than topographical ground surveys.

2b (ii) Geological reconnaissance, geophysical prospecting

Since surface work is normally cheaper than underground exploration it should be extended as far as possible. Surface conditions however greatly differ according to climatic conditions.

Some pictures may illustrate this variety. The thin and scarce cover of soil and plants over iron ore outcrops in sub-arctic climate in Canada (picture 2), in mountainous areas in Norway (picture 3) as well as in the waterless Salt Range Mountains in Pakistan (picture 4) result in a great number of ore and rock exposures which enable a great deal of mapping without trenching or pitting.

The contrary applies for areas with rich vegetation where normally prevail weathering and more or less deep riching lateration of the outcropping rocks. Pictures from the Eastern part of the Congo Republic (picture 5) and from Thailand (picture 6) show such conditions. As support of surface findings geophysics and geochemistry may be applied. The simplest geophysical method, used to outline iron ore deposits are magnetic measurements. Applied on magnetite deposits as airborne methods they can indicate areas, on which further ground work should be concentrated. By application of ground methods the borders of outcropping but not exposed ore bodies may be located under a cover of overburden.

The first geological reconnaissance is a task of great important for a project. It requires much more experience to judge the possibilities of an ore prospect without much exploration work undertaken than to pursue a very complete exploration programme, answering all questions by investigations. Such a programme is certainly a necessary phase of a project. The first reconnaissance work, however, will prepare the necessary decision if detailed investigations should be undertaken or not. Of great help in the first reconnaissance phase is the possibility to classify a deposit after genetic view-points. Knowing if an ore outcrop belongs to an itabiritic ore, to a magmatic deposit or to an oolotic ore is most important for the conclusions concerning surface alteration, characteristics of unweathered ore, possibilities of continuation of the outcrop a.s.o.

2b (iii) Surface and underground exploration

To support geological reconnaissance as well as mapping, surface digging has often to be undertaken to expose unweathered surfaces of ore and bedrock.

This is normally realized by digging trenches or pits. Though modern machinery is available for such work, it is normally carried out without such investment, in using local labour.

In covered areas a network of openings guarantees the best way of preparing a geological map.

As mechanical help motor drills may be used for trenching and sinking of pits, machines, which can be transported by two men and which drill holes of 35 mm diameter into any kind of rock to be blasted.

Underground exploration comprises drilling, tunnelling and sinking of shafts.

Drill holes are the most applied methods to gain underground information. A great variety of drilling machines are on the market. It pays in any case to entrust the operation of such machinery to specialists, which are available as teams from specialised companies.

Local drillers can be trained by experienced men. Drilling on iron deposits is normally carried out to gain drill cores from which qualitative conclusions on the ore character can be drawn. Experience has shown that for such information normally thin cores of 2 - 4 cm diameter are sufficient. Though often more material is required e.g. for beneficiation tests, the higher cost for larger drill core diameters are in no way balanced by the additional information gathered (pictures 7 and 8).

Core drilling should at least result in 80% core recovery. Otherwise the protection against misinterpretation of the drilling results is not sufficient. A new method of core evacuation, the wire line drilling, by which the core is drawn without removing the drill rods has increased the drilling speed considerably. In the MISIPA project a North American drilling company reached an average of 20 m per day in depths down to 350 m in two shifts with this method.

Cores should principally be splitted, one half serving as reference and remaining untouched, the other half being used for material testing, as analyses a.s.o.

Tunnelling is carried out in cases of topographical favourable conditions, to assure tonnage reserves in long stretched ore bodies or to gain fresh material in larger quantities. For tunnels with more than 20 m of length rail haulage is required. Mining technique normally requires a compressor to mine by pneumatic picks or hammers. Artificial aeration, lamps, supports and transportation equipment are required (picture 9).

For shaft sinking down to 20 m primitive means may be applied as hand winches for material handling. Deeper shafts normally demand high investments and are not advisable in the exploration phase of a project.

2b (iv) <u>Material testing</u>

First requirement for testing the ore of a prospective deposit is a very careful sampling. Target of all sampling is the collection of representative material that can serve for analyses and tests. If sufficient surface exposures are existing a sampling pattern may be spread over the deposit. Samples, taken by trenching are very useful. Applied on layered deposits, such trenching ought to be carried out perpendicularly to the bedding, work which requires careful examination of the deposit's structure. In case of structureless ore masses a network of sampling spots should allow a statistic evaluation.

Surface alteration of iron ore deposits may concern oxydation of magnetite and alteration into hematite, oxydation and solution of sulfides, limonitisation of gangue minerals, of iron carbonate, solution of gangue minerals. All these processes are changing the chemical and partly the physical properties of the ore.

There even exist iron ores, derived from the weathering of rocks in lateritic deposits. In all these cases the statement of the characteristics of the unaltered material and of the borderlines between ore and rock are of utmost importance. Therefore samples of fresh ore from unaltered parts must be taken. This may be done by drilling or by tunelling. In both cases it should be tried to eliminate accidental factors in applying a statistic pattern of sampling spots, that is of drill holes or of tunnels. When the general characteristics of a deposit are known, larger single samples can be taken from one spot, as they are needed for beneficiation tests. It should, however, in all cases be known, for which part of a deposit such samples are representative.

A picture illustrates a sampling shaft in Patagonia and its position in the deposit. Its aim was to reach unweathered ore (picture 10).

In testing the material the following questions are to be answered:

> chemical compositions of the ore by chemical analyses
> physical properties of the ore as density, friability and so on
> by density tests, screen analyses a.s.o., type of ore, status
> of weathering, ore and gangue minerals, indications for bene-
> ficiation by microscopic analyses. beneficiation properties by
> beneficiation tests, other metallurgical characteristics as
> agglomeration, reducibility a.s.o.

Specialized laboratories are existing for all these tests. For a testing schedule and the extent of a tests application a central planning is advisable.

2c Technical planning

Based on the information, received by the exploration of a deposit and by the results of material testing the technical planning comprises:

- processes to be applied;
- machines to be used;
- plant location and auxiliary facilities;
- needed labour to be employed;
- timing.

In many cases several technical possibilities have to be taken into consideration. Cost calculations will decide on the most economic solution.

Modern iron ore development comprises nearly exclusively open cast mining. The reasons are evident, low costs. To mine a ton of ore in a good organized mine costs about $ 0,5-0,8 per ton direct operating costs. On the other hand underground mining is always more expensive. The costs however are highly dependent upon local conditions.

Labour costs constitute in many countries the highest part of the total costs. There, however, enormous differences are existing. Planning may take into account a higher percentage of human labour which means less investment in machinery, if wages are as low as in many African and Asian countries. Still today miners may receive in those areas not more than $ 0.5 per day while in Northern America wages are up to $ 20 per day. On planning new plants, reasonable wages should however be anticipated, for such future centres of industry will demand a sufficient standard of living for everybody employed there.

In underground operations the efficiency of one man may vary between 6 and 20 t/day in technically good equipped mines, depending upon the methods applied and on the possibilities offered by the deposit. In any case however underground mining costs at least 2 to 3 times more than open cast mining, in many cases 4 to 5 times more.

Beneficiation of iron ore today is limited to two methods, if enrichment from low grade ore to high grade concentrates is considered. These methods are magnetic beneficiation with low intensity for magnetite ores and with high intensity for certain hematite ores and gravity concentration, normally with spirals, for coarse grained ores (picture 11), magnetitic as well as hematitic. In case of beneficiation plants a pilot operation, testing the [illegible] kinds of ore of a deposit with capacities of 5 to 20 t/h with different methods may pay (picture 12). Beneficiation plants are to locate near the ore deposit in order to diminish the amount of transportation, while agglomeration plants may be situated near a harbour or near the reduction plant.

2d Cost estimations

Cost estimations have to cover investment costs and operating costs.

It is interesting to note that especially in the case of investment costs the first calculation often covers only half of the actual investment. Reason for this is the fact that first estimations normally take into account only direct costs for plants and equipment, neglecting such items as financing costs, preproduction interest, planning costs, legal costs, working capital a.s.o.

There are two kinds of making up cost estimations, both of which are to be pursued in serious considerations: One is the comparison with costs of similar projects, naturally providing only very crude figures but useful for the first estimates, the other one is the careful addition of cost figures for all phases and branches of an enterprise.

It may be of interest to note some general figures as to the investment costs of mining projects per ton of annual capacity. For open cast mining including all costs of equipment, construction, financing, preproduction, expenses, the investments, excluding transportation facilities over long distance, harbour facilities, etc. range between $ 15 and 20 per ton of annual capacity. Plants, comprising beneficiation facilities for magnetic or gravity separation or any combination of them require investments in the order of $ 30 to $ 35 per ton of annual capacity.

Underground investments are highly dependent upon the requirements of the deposit. While in open pit mining the costs for machinery form the greatest part of the investments in underground development the openings, shafts and tunnels constitute a relatively important portion. To sink a shaft for a capacity of 500,000 t/year may cost $ 1500 - 2000 per m in depths down to 200 m. A shaft, designed for 3 million tons yearly capacity is requiring $ 5000 per m down to 900 m depth.

The real difference in costs between opencast and underground mining exists in operating costs. As already pointed out, direct operating costs in opencast mining may amount to $ 0.5 - 0.8 per ton. Including all general costs, capital costs a.s.o. costs for mining in open pit may sum up to $ 1.5 - 2.0 per ton of ore. In underground mines, however, costs figures of $ 5 to 7 per ton of ore are normal. Reasons are the smaller mining faces, greater percentage of labour needed, smaller units for drilling, loading and transportation and complicated horizontal and vertical haulage.

2c Exploration costs

For medium sized explorations which are designed to prove 10 to 30 million tons of ore the costs depend highly upon the kind of deposit which is to be investigated. While costs of mapping, of surface sampling, of feasibility reports and of material testing stay more or less the same for different deposits, the amount of drilling to be completed before the realization of a project may be considered as economically sound is influencing the costs to a great part.

The different costs can be estimated as follows:

First phase (Preliminary information)

Market analysis as pointed out above	
Topographical maps 1 in 25,000 for 500 km² from airborne surveys	$ 20 000 - 30 000
Topographic maps 1 in 1,000 for 50 km²	$ 60 000 - 80 000
Geological mapping 20 km²	$ 50 000 - 100 000
Sampling and chemical analyses	$ 15 000 - 20 000
Beneficiation tests, small scale and mineralogical investigation	$ 5 000 - 10 000
First feasibility study including cost estimations	$ 8 000 - 15 000
	$ 20 000 - 40 000
	$ 170 000 - 300 000

Second phase (Thorough investigation)

These costs cannot be estimated as detailed as those of the first phase. Such factors as distance of the deposit from the next transportation facility, manner of men and material transportation, possibilities of housing for the field crew, drilling equipment, water supply, roads, air strips, docks and so on can mean very different costs.

Very approximately it may be estimated that this phase of exploration includes fieldwork for

0.5 - 2.0 Mio $

As already pointed out, in any case the results of this work should be evaluated in taking them into account in a new feasibility calculation. Thorough material testing comprehending beneficiation tests, if necessary, large scale sampling of some hundred tons, complete the required information. If well organized and carried out by experts, all this additional work may be completed for

0.2 to 1.0 Mio $

This does not include the costs for construction of a pilot plant.

The end of this phase is the decision whether to realize the project or not.

3 Ore exploitation intermediate scale

3a Financing

The positive decision to start an ore project after promising results of the exploration work, market considerations and cost estimations is followed by securing the financing of the project.

The best way to assure financing is to provide for ore sales for a sufficient long period. There exist long term contracts between iron ore enterprises and steel producers which enabled the financing on the base of ore prices, which are continuously adapted to the requirements of capital amortisation.

In other operations ore consumers are main shareholders and therefore financing themselves.

Government financing is another possibility.

3b Plant construction

Construction begins with issuing of tenders. The preparation of the tenders should be conducted by persons who are well familiar with the technical details, on which the cost estimations were based. A technical bureau should be set up by the ore company or may be provided by a general consultant.

The construction phase comprises in open pit mines stripping operations, in underground mines sinking of shafts and completion of tunnels, road construction, often railway construction a.s.o.

Underground openings require their time, depending upon the progress which can be attained in shafts and tunnels. While for shaft sinking in hard rock an average of 30 m/month may be assumed, the highest efficiency in tunnelling may be 100 m per month, this however with total mechanization of drilling, loading and transportation.

The construction time of an open pit operation medium scale, may be estimated to reach 1 to 2 years for preparing road construction, open pit buildings, maintenance shops, loading station, stock piles a.s.o.

Underground operations are highly dependent upon the kind of openings to be performed before starting production. Normally 2 to 3 years are required. In many cases not the mines themselves, but the construction of transportation ways as railroads and harbours are decisive for the construction period.

The construction time for beneficiation plants is highly dependent upon the time of delivery for machinery and equipment, which may amount to one year for certain specially fabricated parts of a plant.

3c Starting up period

The starting up period is a critical phase of any project. It is the time when the processes, worked out by planning and the assumptions made, have to prove their justification.

Therefore often the planning and constructing institution is entrusted with the starting up before handing over a plant.

For engines and flowsheets the working conditions should be quite clear before starting up large scale operation.

The most uncertainties are existing normally with respect to the ore itself. As well the ore quality on any point of the deposit as the ore rock contacts are more or less subdue to suppositions until operations are opening up the deposits.

Therefore the starting up period includes more or less always changes which need trained personnel to be carried out.

4. Organization of governmental institutions, directing exploration and exploitation programmes

There are three fields in which must be worked before realisation of a project:

geological science;

technical planning and construction;

economical research and co-ordination.

In many countries central governmental institutions are responsible for the industrial development. They normally cannot employ teams for all fields of activity, covered by such an institution. But they should have experts, at least able to judge upon the possibilities of a project and able to organize development work.

Geological institutes as they are traditionally existing in many industrialised countries should necessarily work in developing areas with strictly practical aspects. The geological engineer is to be preferred to the scientist.

The most important sections of a geological institute with respect to the development of raw material sources are chemical and mineralogical laboratories, equipped to carry out reliable material analyses.

The geological department should be headed by an experienced geological engineer. The outfit should include vehicles for field work, camping equipment, designing material, equipment for sample taking, including portable drilling machines.

meration plants may be situated near a number of ...

In the case of areas of countries which are rich in different minerals, a beneficiation test station may pay, which might be connected with a technical university.

To buy large drilling equipment or heavier machinery for exploration work pays only in case of very comprehensive programmes.

Such equipment might be rented from specialized firms, who also may carry out the exploration work.

The employment of experts by any governmental development institution cannot be overemphasized. In the past many projects in the iron and steel industry have been promoted for political or personal reasons without real economical background. There should at least exist someone who is able to judge upon the economic aspects properly.

Table 1

Precalculated production costs for pig iron in blast furnace under equivalent technical conditions

Type of ore	Analysis % Fe	SiO$_2$	CaO	kg slag produced per kg pig iron	kg limestone required per kg pig iron	kg coke required per kg pig iron	kg ore required per kg of pig iron	costs *) of production per kg pig iron /t
Oolite, limonitic	29	9	19	1.10	-	0.94	3.28	40
Oolite, chamositic magnetitic	49	8.9	2.6	0.68	0.40	0.89	1.94	32
Magnetite	60	4.1	6.4	0.32	0.03	0.74	1.58	26
Hematite	67	0.4	0.2	0.11	0.09	0.69	1.42	22

*) Costs are based upon prices for coke, limestone, handling a.s.o. as valid in Western Germany.

Figures

Fig. 1a Aerial Photograph, covering 0.3 km^2

Fig. 1b Topography and geology of the same area

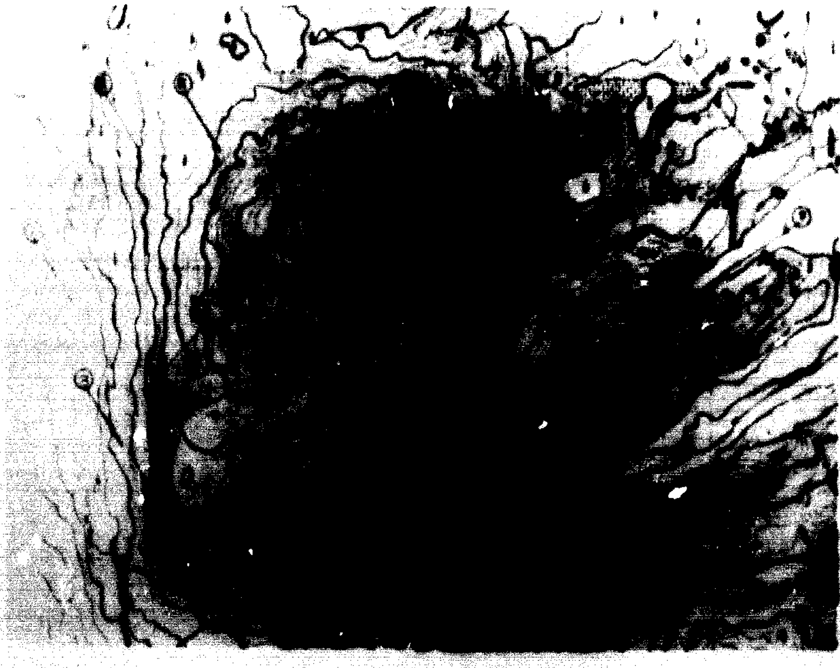
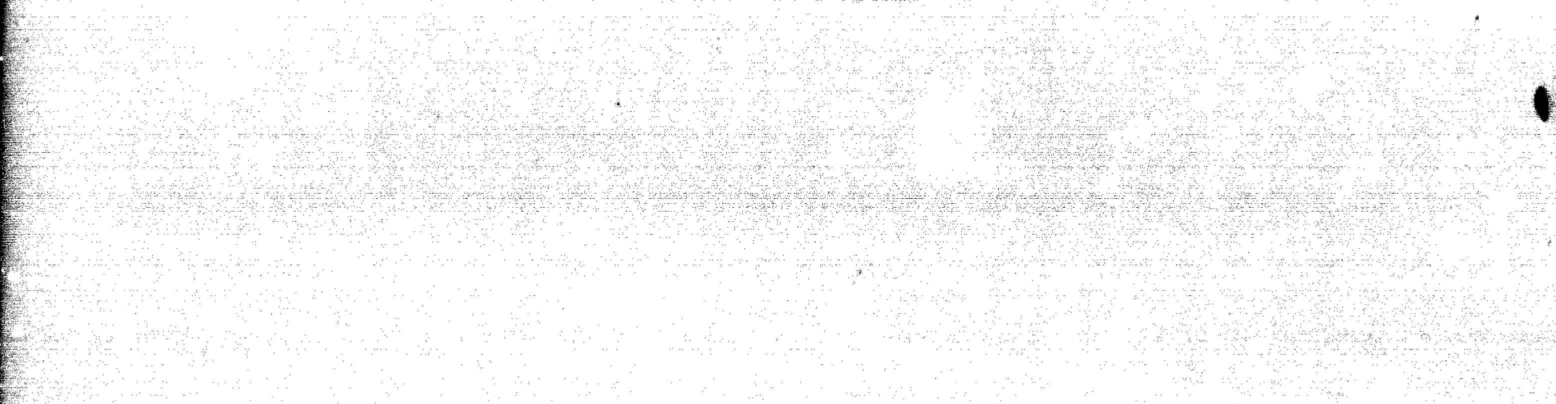


Fig. 2 Iron ore horizon
Northern Canada



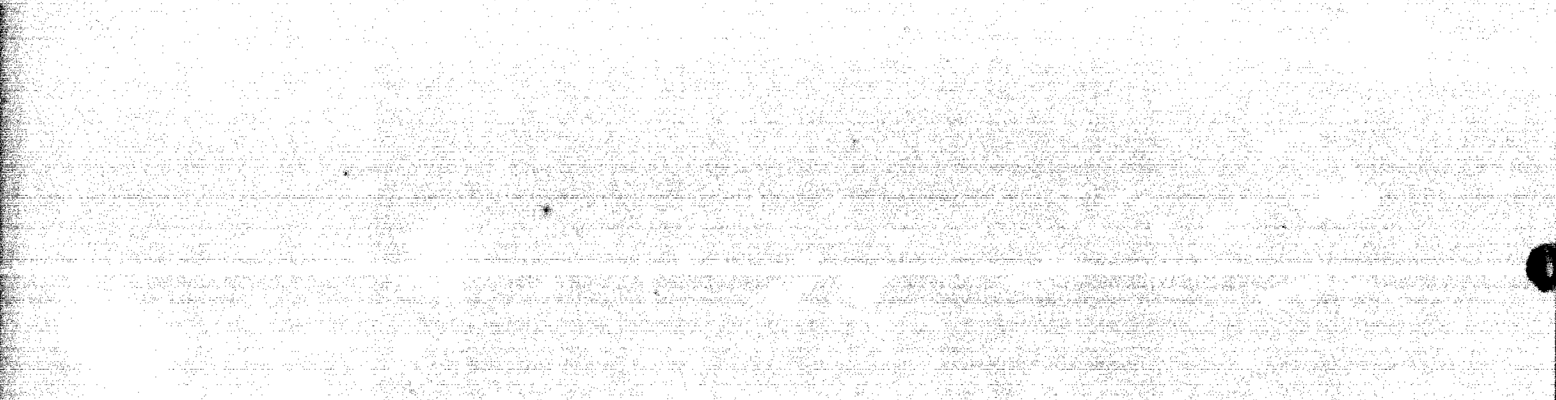


Fig. 3 Iron ore horizon
Northern Norway

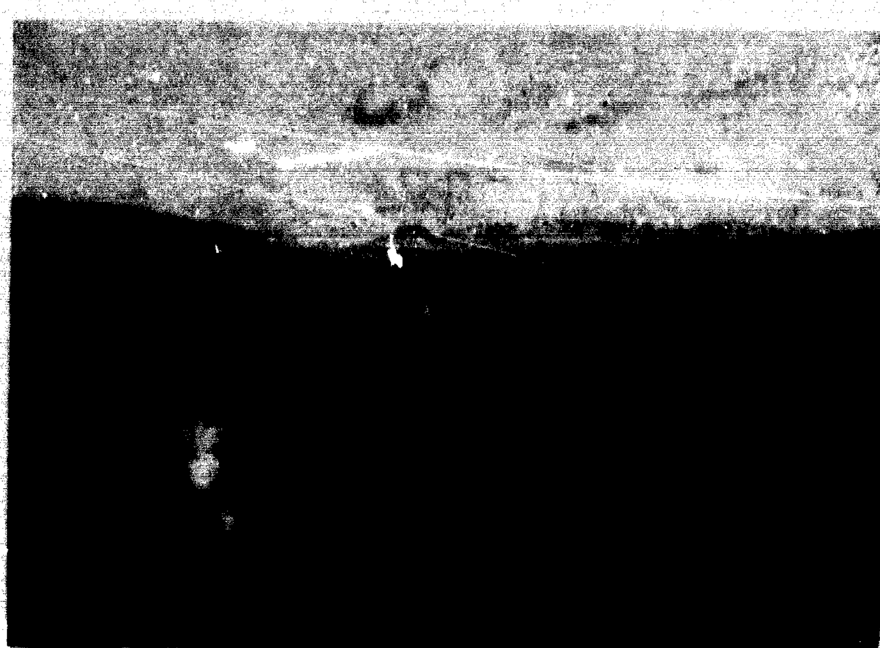


Fig. 4 Iron Ore Beds
Salt Range, Pakistan

Fig. 5 Primary Forest Covering Ores,
Maniema, Congo

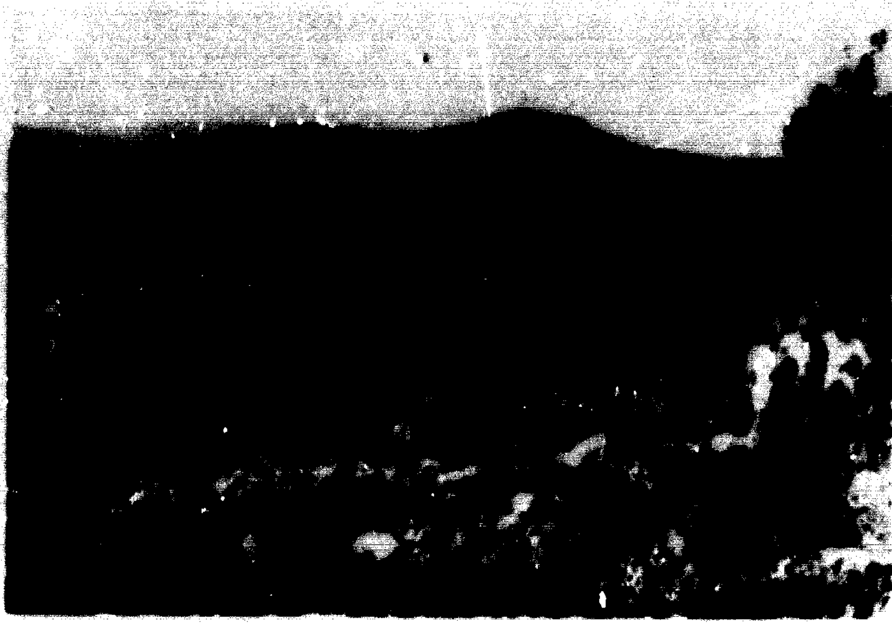


Fig. 6 Bamboo Forest over Iron Ore,
Thailand

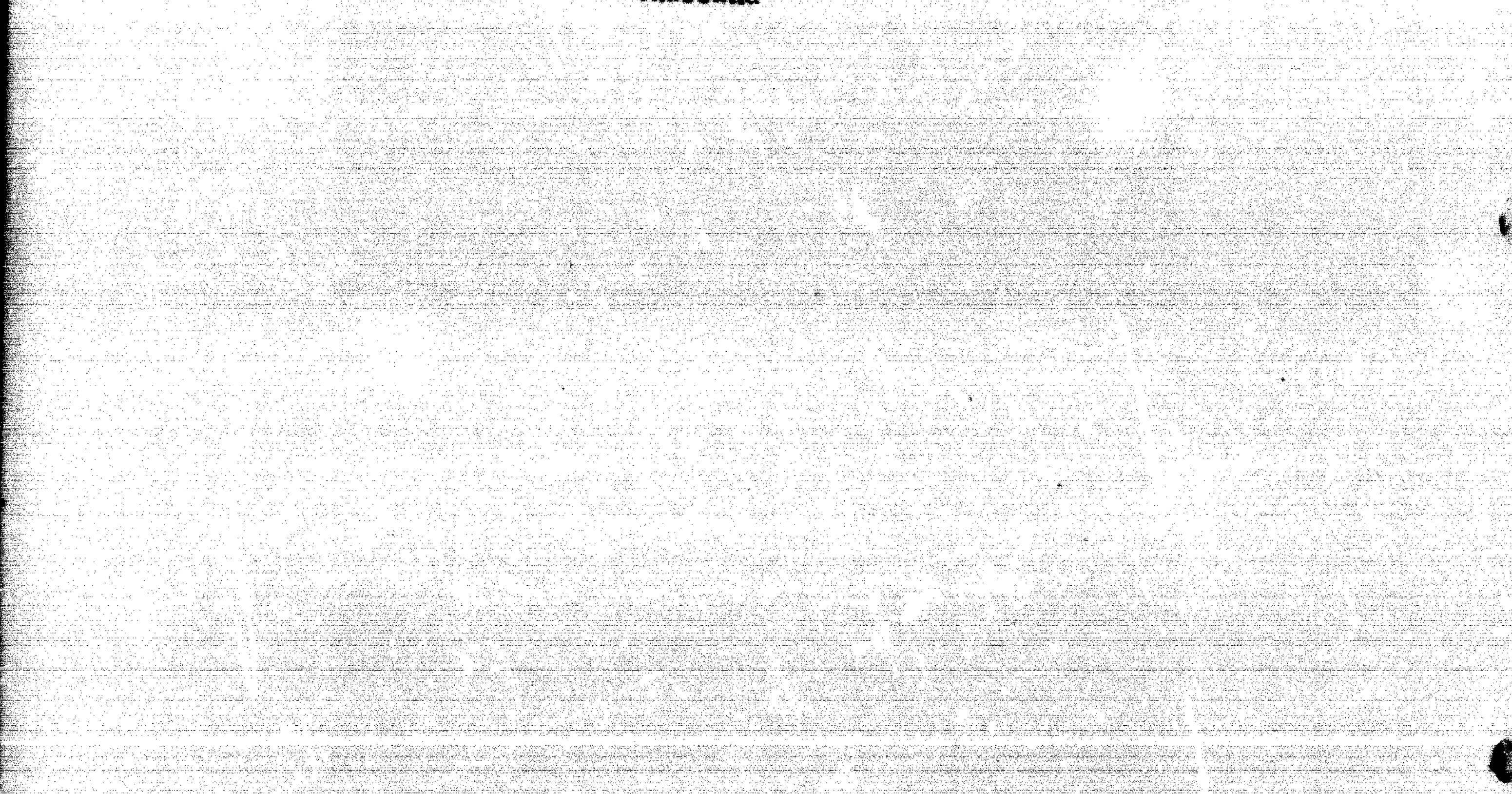


Fig. 7 Diamond drilling on Iron Ore
in Primary Forest

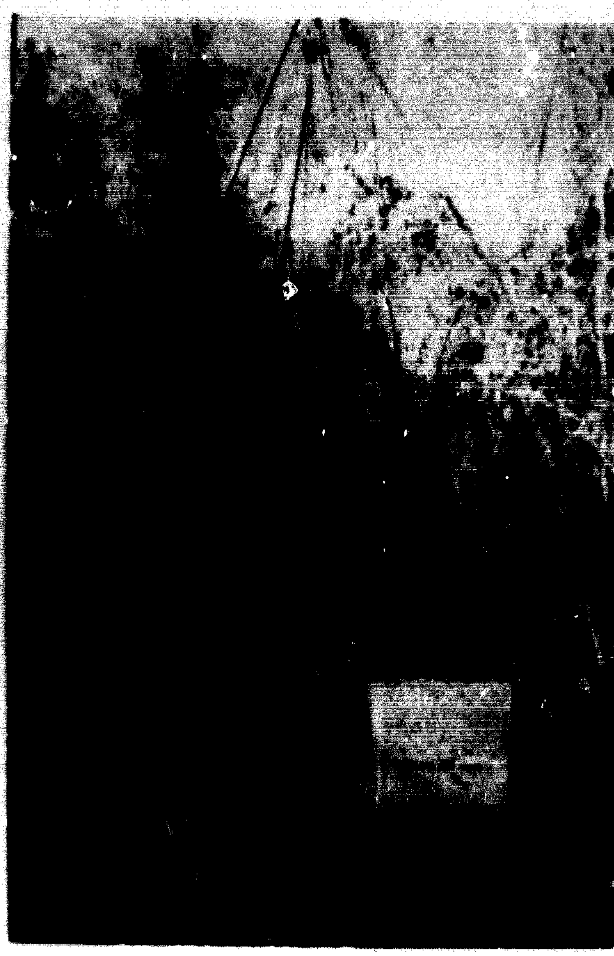


Fig. 8 Diamond Exploration Drilling, Norway

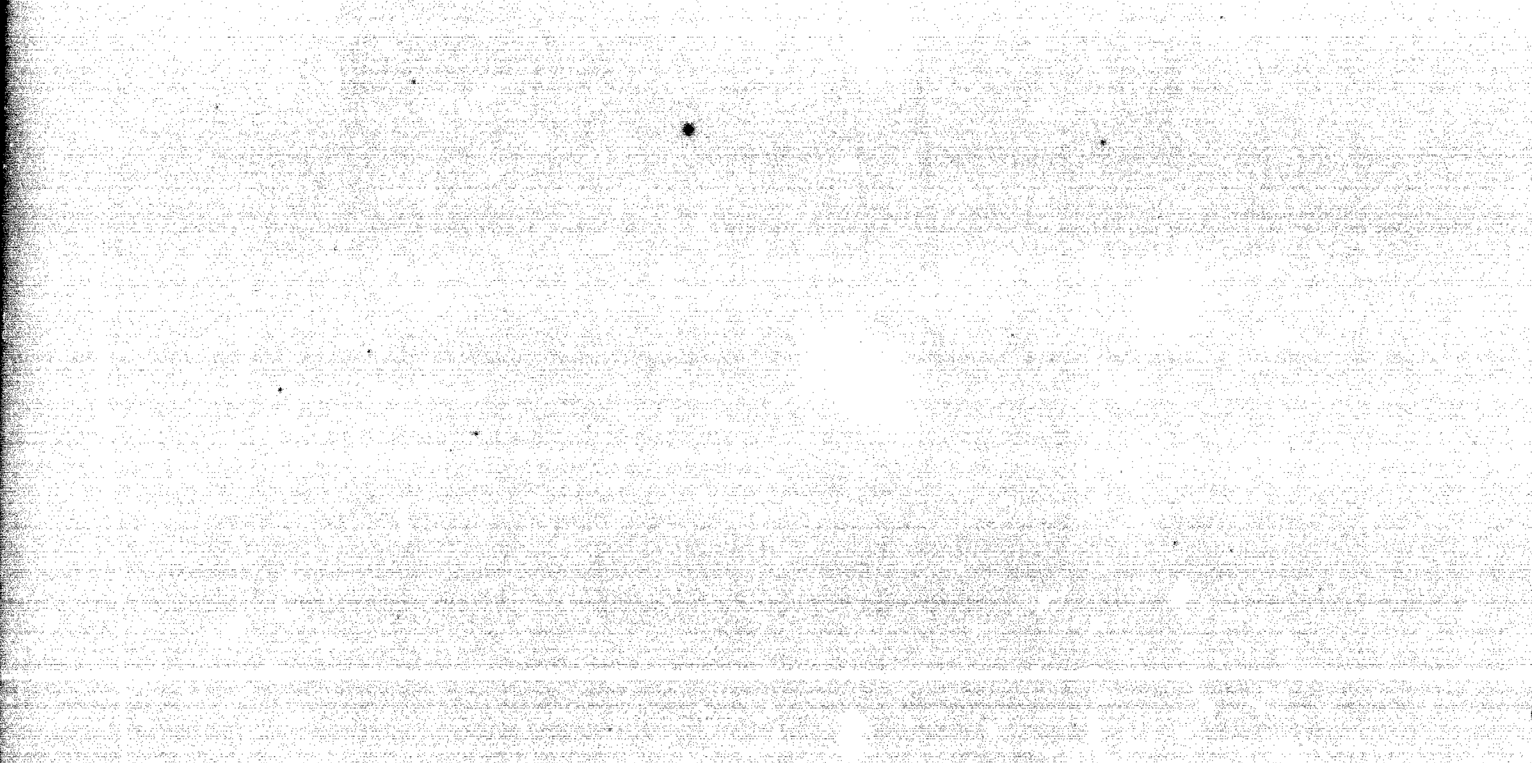


Fig. 9 Tunnelling in Iron Ore Deposit, Thailand

Fig. 10 Geological Section of Sampling Pit, Argentine

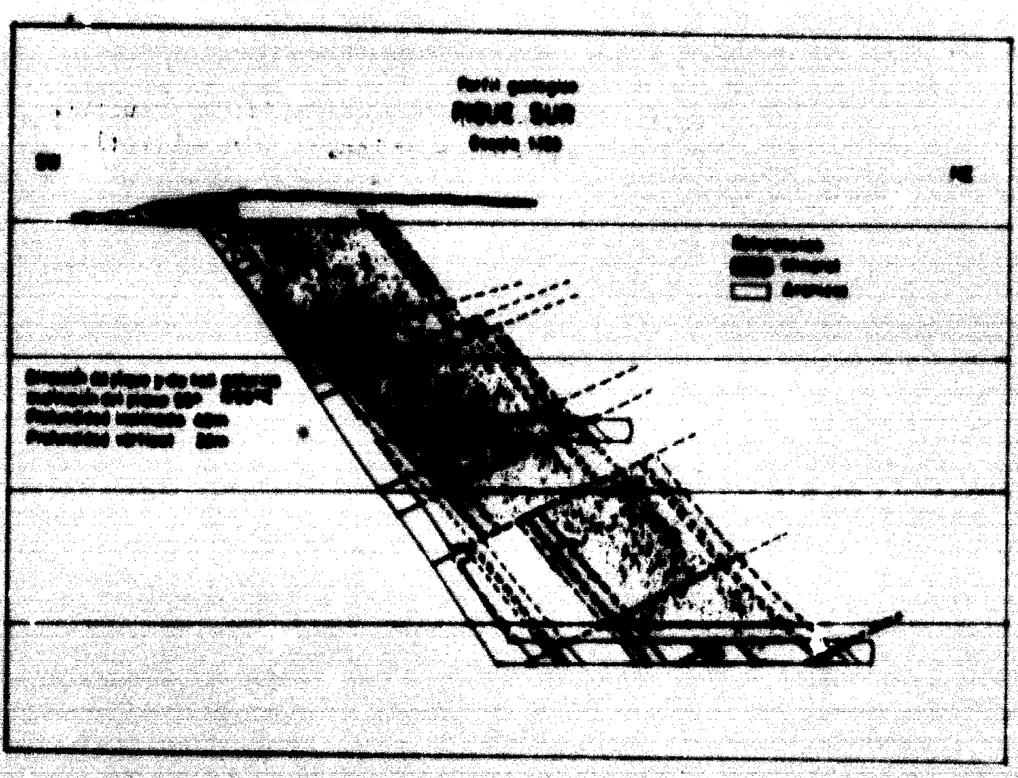


Fig.11 Coarse Grained Hematite in Quartz, Polished Section, enlarged 10:1.

Fig. 12 Pilot Plant Wabush Iron Ore Project, Canada