The
Institution of Engineers (India),
Nagpur Centre
North Ambazari Road, Nagpur

Papers for Discussion

AT THE
TWENTYSECOND ANNUAL GENERAL MEETING
4th JANUARY 1969
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Nagpur Centre
North Ambazari Road, Nagpur

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TWENTYSECOND ANNUAL GENERAL MEETING
4th JANUARY 1969

With Best Compliments from :

EDAL JAL CASSAD
Honorary Secretary
THE INSTITUTION OF ENGINEERS (INDIA)
NAGPUR CENTRE
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Improving the Quality of Technical Education in Polytechnics

Shri N. G. Wagh, Principal, Government Polytechnic, Jalgaon.

Abstract of the Paper

After the advent of Independence tremendous expansion has taken place in facilities for technical education. Number of Engineering Colleges, Polytechnics, Industrial Training Institutes are opened in the last 20 years. Due to the rapid expansion and the non-availability of highly qualified teaching staff in adequate number and the necessary equipment the standard of education in the Technical Institutions has deteriorated. The paper deals with the steps to be taken to improve the standard of education in Polytechnics.

The reasons for the deterioration in the quality or standard are briefly discussed. The effect of the important factors like teacher, student, equipment, text books, audiovisual aids, examination system on the quality of education is separately discussed. Each of these factors has a great influence in this respect.

Technical Education is not complete unless the theoretical training imparted in the Institution is combined with the practical experience in the industries. In this respect Industry has to play a very important role of providing practical training to the students passing out from the Polytechnics. The need for co-ordination between Technical Institution and the Industry is stressed in the paper. While discussing all these factors suggestions are made for improving the quality of education in the Polytechnics.
Improving the Quality of Technical Education in Polytechnics

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Before Independence there were very few Institutions all over India imparting Technical Education. The British regime did not encourage technical education with the result that by and large brilliant students were not attracted to Engineering Courses. After the advent of Independence in 1947 Government decided to improve the lot of the people of the country and to achieve this, undertook a gigantic programme of construction of dams for irrigation, Electricity generation, steel plants, Fertiliser plants etc. Trained technical man power was required to man these projects and since the number of technically qualified persons was very small, acute shortage of technical personnel was felt. To tide over this difficulty, number of Technical Institutions like Engineering Colleges, Polytechnics, I. T. I's were planned and they were started in the various parts of the country. Prior to 1947 there were very few Engineering Colleges in the Maharashtra State where Degree as well as Diploma Education was imparted.

These Institutes had a small intake capacity. Since jobs were not available and chances of promotion were difficult, the teachers in these Institutes had to work very hard to maintain a high standard. In the Second Five Year Plan the diploma institutes were separated from the degree institutes and the institutes giving diploma education were called Polytechnics. The subject matter of this paper is confined only to the education in the Polytechnics.

Need for Improving the quality of education in Polytechnics.

For the expansion of technical education large number of Institutes were set up. The intake capacity of the Institutes was also raised. Generally the Institutes were opened to provide instructional facilities for an Intake capacity of 180 students (60 Civil, 60 Mechanical and 60 Electrical). It became necessary to recruit staff for these various Institutions. Due to the availability of better scales in the Industry better people were attracted to the Industry with the result that in many Technical Institutions teaching
staff of a high standard was not available in sufficient number. The outlay of Technical Institution is quite big and some of the equipment is required to be imported. Due to these difficulties of getting equipment the institutions were not equipped fully for quite a long time. Thus due to the non-availability of the properly qualified adequate staff and the necessary equipment, the quality of education in Polytechnics started deteriorating. Since expansion has taken place on a very large scale, it is necessary to take steps to improve the quality of education in these Institutes.

In this connection the part played by each of the following factors will have to be considered:—

1. Teacher.
2. Student.
3. Equipment.
5. Audiovisual Aids.

1. Teacher:—

Properly qualified conscientious teacher is a backbone of any educational Institution. The teacher has not only to pass on a bundle of knowledge to the student but his role is to make the student think independently, develop in the student the ability to solve problems and see that he becomes a responsible citizen. An ideal teacher must have a deep knowledge of a subject and must be able to transmit that knowledge to the students properly. This requires good power of expression, command over the medium of instruction and ability to interest the students. A technical teacher to be successful should have practical experience in the outside field. It has been observed that if a bad teacher is analysed his defect lies in the shallowness of his knowledge. To improve the standard of teachers a technical teacher training college is opened in our State at Karad where a systematic scheme to train technical teachers is planned. The knowledge of the teacher is improved and he is taught the methods of teaching, psychology of teaching etc. He is also given an opportunity to work in the industry for some period to enable him to gain practical experience. It is necessary that these facilities of technical teacher training should be expanded as much as possible to train the existing teachers as early as possible. The teachers should be encouraged
to attend refresher courses and seminars. They should be allowed consultancy practice. This will broaden their outlook and will help in making their knowledge deep.

(2) **Student:**—

It is not correct to put blame entirely on the teacher for the poor standard of education. One of the factors is the unsatisfactory product which comes to the technical institution. The student who comes to technical institution is not properly equipped in many cases. He lacks sincerity and does not want to put in sincere hard work. Generally his command over the language is not satisfactory; with the result that an average S. S. C. student finds technical courses difficult. The solution to this problem is to modify the admission qualifications and also to see that the student who takes up a course in a Polytechnic is properly trained upto the High School stage. In the Semester System the weekly tests should be held and the performance at these weekly tests should be taken into consideration at the time of the final examination.

(3) **Equipment:**—

Technical Institutions must be fully equipped It is necessary to take steps to fabricate the equipment at the Institution or in production Centres. Students should be given ample opportunity to visit the Industries and study the machines and processes where it is not possible to provide these facilities in the Institution.

(4) **Text Books:**—

The standard of English of the students in the Polytechnics is very poor. At the same time it is difficult to suggest one single text book which will cover the syllabus in some subjects. The students are not able to follow the text books written by foreign authors. It is high time that text books should be written by the Board or the Universities to cover the syllabus of the course and such text books should be prescribed to the students.

(5) **Audiovisual Aids:**—

Occupy a very prominent place in the modern education. Instead of a poor teacher teaching to the students it is better to tape record the lectures of a first class teacher and teach the students with the help of this tape record. If such lectures are tape recorded and the students are made to learn from these lectures they will get the benefit of ideal teachers. This is bound to improve their standard. In this
connection film Institute of India can also help the technical Institutes. Modern processes and equipment etc. in some subjects can be filmed by the Institute and these films can be shown to the students. Instead of a teacher explaining some things with the help of sketches drawn on the black board it will be beneficial to the students if these things are shown to them through the films.

(6) Examination System:

In the recent years the system of evaluating the ability of a student has become very complex. We are following examination system which was in vogue during the British days. This system tests only the memory of the student. It lacks the power of ascertaining whether the student has really acquired the knowledge of the subject or otherwise. Due to the system of option a student can get a first class without knowing some of the portion of the subject and so a first class career does not necessarily mean master over the subject. It is high time that the examination system should be properly re-oriented to test the real ability of the students.

No technical education can be complete unless there is a proper combination of the theory taught in the Institute with the practice in the Industry. Educational Institutions can not be expected to provide facilities for practical experience. Only the fundamentals in Engineering can be taught at a Technical Institution. It is the Industry who must provide necessary facilities for the practical training of the students who pass out from the technical Institutions. Unless there is a proper co-ordination between a technical Institute and Industry, production of high quality technician is not possible. It is, therefore, necessary that some steps should be taken immediately to effect this co-ordination between the technical Institutions and the Industry to achieve the desired result.
Development of Irrigation In Vidarbha In Pre-Plan Period and Lessons to be Learnt Therefrom

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INTRODUCTION

1. Object of the Paper:—

While dealing with the investigations of irrigation projects for the preparation of the IVth Plan, the study of the irrigation in the past was taken up to understand the background of the present stage of irrigation in Vidarbha and to see whether the present planning is a logical extension of the previous mode of development. This study revealed certain interesting features which, it is thought, would be interesting to others. An attempt has therefore been made in this short paper to bring out those aspects and suggestions have also been made about the lessons which should prove useful if they are kept in mind while developing the future proposals.

2. Constitution and changes in the Boundaries of the Region:—

The Central Provinces was constituted as a province in 1862. The first important alterations in its boundaries was the transfer of the district of Sambalpur to Bihar and Orissa in 1905 and the amalgamation of Berar consisting of four districts i.e. Buldhana, Akola, Amravati and Yeotmal with the Central Provinces in 1903. In November 1956 the State Re-organisation took place and the eight Marathi speaking districts (Chanda, Bhandara, Nagpur, Wardha, Yeotmal, Amravati, Akola & Buldhana) came to be amalgamated with the then bilingual Bombay State. In 1960, separate State consisting of 26 Marathi speaking districts came to be formed and has been named as the State of Maharashtra. This is the third largest State in the Indian Union both in respect of area and population. The geographical area of this State is 765 lac acres and the population is 3.96 crores according to 1961 census. The State can be divided into 4 natural regions such as Kakan Coastal Strip, Western Maharashtra,
Marathwada Region and Vidarbha:

The last region which is the subject of the present paper consists of 8 districts, four of which were previously known as Berar and the other four were taken to come from the very old Central Provinces. The geographical area of the Vidarbha is 236 lac acres (i.e. 30.91% of the State) and the population is 923 lac (23.33% of the State). The total cropped area is 120 lac acres, out of which at present about 6% is under irrigation against the target of about 26 to 28%.

3. Rainfall, Soils and Agroclimatic Zones:

3-1. The districts Buldhana, Akola, Amaravati, Yeotmal & Wardha, major portion of Nagpur & Western Part of Chanda lie in the assured rainfall zone having 30° to 50° rainfall and the rest portion viz., some portion of Nagpur District, the whole of the Bhandara District and Eastern part of the Chanda District) lie in the moderately high rainfall having 50° to 75° rainfall. The distribution of the rainfall over the seasons is however at times not congenial to the growth of crops.

3-2. The soils are derived from the Deccan Trap Rock of volcanic origin in all districts except Chanda and Bhandara. The soils in Chanda and Bhandara Districts are derived from mixed granite, gneiss and schist converted into laterite due to constant action of heavy rainfall and vegetation.

3-3 According to the agroclimatic zones the Vidarbha area falls under four zones. They are as under:

i) Assured rainfall with Kharif cropping—
   Buldhana, Akola & Amravati Districts.

ii) Moderately high rainfall with trap soils—
   Yeotmal, Wardha & major portion of Nagpur District.
   (Western Part).

iii) Moderately high rainfall with soils from mixed rocks—
   Eastern strip of Nagpur District, Western half of Bhandara District & Western Part of Chanda District.

iv) High rainfall zone with soils from mixed rocks—
   Eastern parts of Bhandara & Chanda Districts.
HISTORY OF IRRIGATION IN VIDARBHA

4. Famine & Scarcity:—

The State Irrigation in this region owes its origin to the recommendations of the Irrigation Commission (1901-1903). This Commission was appointed in pursuance of the recommendations of the Famine Commission of 1898, whose views were endorsed by the subsequent Famine Commission of 1901. Upto 1896-97 it continued to be the general belief that the agricultural practice in this region was practically secured by reason of the regularity of the rainfall and its favourable position with respect to the Bombay or South West monsoon current and that of the Bengal or North East monsoon current. Its hills and forest are of immense assistance in condensation and that helps to avoid distress. But this impression was banished when the famine of 1899-1900 occurred preceding with series of two years of short rainfall. The Famine Commission (1880) remarked that among the means that may be adopted for giving direct protection from famines arising out of drought, the first place must unquestionably be assigned to the work of irrigation. This was more so, because in those days easy, quick and extensive means of communication and transport were not available for movement of food stuff from one part of the country to the other.

5. Recommendations of the Irrigation Commission (1901-03):—

Prior to the introduction of reforms in 1927, the subject of irrigation was under the control of the Central Government and construction of every irrigation work used to require the sanction of the centre. Till the country was hard hit by famines the policy of the centre was to allow only construction of productive works and as it was difficult to get irrigation works of productive nature in this area, as then defined, there were no State irrigation works. It was observed by the Commission that though the total amount of rainfall was usually sufficient, it was seldom satisfactorily distributed throughout the season and was particularly liable to fail in all the important months of September and October and that in the latter months it was, as a rule insufficient for the better qualities of rice. It drew the conclusion that the first and chief value of irrigation would be to correct irregularities in the distribution of the rainfall and more especially supplement deficiencies of the late rain. The commission further stated that in considering the field which existed for the construction of State Irrigation Works in the Central Provinces, it was reluctant to recommend construction of expensive works in any tract where their utility cannot be justified by existing agricultural practice in that tract. Even then in many
cases before irrigation can be developed, local prejudices would have to be overcome and cultivator taught how to grow and how to irrigate new classes of crops. The commission however suggested that the change of irrigation should be limited to that area for which the available supply of water is sufficient to afford real and substantial protection. It was also observed that the most promising field for the extension of irrigation by Government works might be said to comprise the rice tracts of Wainganga and Chattisgarh districts, of Seoni and Nagpur. The Commission therefore recommended the construction of experimental works costing Rs. 300 lakhs in aggregate, over a period of 20 years. The commission recommended that the experiment should not be confined to rice districts. It mentioned the possibility of cultivation of rice in areas where it was not then grown and also referred to the possibilities of irrigation of wheat. Under these schemes the construction of Khairabundha, Asolamendha, Naleshwar, Ghorajhari, Ramtek tank works and few other were taken. These various works were completed during the period of 1910 to 1920. Out of these, four were from Chanda, four were from Bhandara and one work from Nagpur district. Sixteen minor works were also completed during this period out of which four were from Bhandara district and remaining twelve were from Chanda district. No irrigation works were constructed in the remaining five districts of Wardha, Amravati, Yeotmal, Akola & Buldhana. The commission did not contemplate the construction of State Irrigation works in Berar on any appreciable scale nor did they consider it possible to provide irrigation to an extent at all sufficient for the adequate protection of the ordinary staple crop in that area in a year of severe drought.

6. **Complete Vs. Partial protective system:**

In May 1906 a case was made out by the Chief Commissioner of the province that the programme should be extended to other parts of the province and the policy of going only for protective works require reconsideration. The advantage of these works should not only be restricted to an area which can be fully protected in a dry year but should secure a fair crop over as large an area and to as many cultivators as possible. Ultimately Mr. Craddack came out with a proposal that works should be designed to irrigate as much of the areas which they command as the area to which they can give two waterings when the tank is full. It was considered that it was useless to store up water for severest droughts that have ever been experienced and waste water in other years. This decision to abandon the completely protective system and to adopt the system of partial protection based on the irrigation of area to which a work, when full, could give two waterings led to the revision of all the works then
under construction and this is how the canal system of Ramtek, Asolamendha, Ghodajhari etc. were extended to more than three times the areas to which their water would be sufficient according to the conservative method of planning.

7. **Poor response from cultivators:**

There was increase in cost of works as executed compared with original estimates. This was largely due to the great rise in the cost of plant, materials and labour which occurred during and after the First World War. Another reason was the extension of canals to irrigate very much greater areas in accordance with the policy of partial protection. It was however experienced that there was no proper response from cultivators and the works, which were anticipated to be productive also proved to be unproductive. This situation was a great set back to the enthusiasm then shown by the Government in undertaking construction of irrigation works.

8. **After the provincial autonomy:**

After the transfer of the subject of the irrigation to the provinces from the centre, a review was taken by the Central Provinces Irrigation Committee (1927-1929) and it came to the conclusion that it would have been better pleased had it been able to recommend a forward policy of new construction but though it appreciated the value of irrigation it regretted that the results secured did not justify its doing so. It came to the conclusion that the no new works should be undertaken until the areas commanded by existing works are fully developed. Similarly no state works should be constructed in Berar unless it is anticipated that the return from them would be satisfactory. Thus a great hault was put to the advancement of construction of new irrigation works even after the provincial autonomy was brought into force.

9. **Grow more food campaig after world war II:**

With the acute food shortage as an aftermath of world war II, the State Government under their grow more food compaign started the schemes of construction and repairs of small village tanks and about twelve works were completed between 1949 to 1956. Out of these twelve works, four were from Bhandara District, four from Amravati and two each from Akola and Buldhana Districts.

10. **Position of the planning of the development plan:**

While preparing the outline of development plan of Central Provinces and Berar in March 1945, it was mentioned that experience of Irriga-
tion Projects in the province was unhappy from a financial point of view and according to prewar standards, most projects were failures. Moreover though it was recognised that such projects would increase the wealth and prosperity of the province they had to be shelved on the basis of priority for want of money. Thus the position of the time when the planning of the Development Plan was undertaken, was not at all encouraging.

**TYPES OF IRRIGATION**

11. Three types of irrigation works:—

The projects of irrigation can be divided under three types of works taking the cost as a criteria for division. They are—

i) **Minor Irrigation.**

ii) **Medium Irrigation.**

iii) **Major Irrigation Projects.**

We will try to examine evolution of each type one by one.

11.1 **Minor irrigation works:**—

Under this category in the by gone days the activity was restricted to the private agency. The Ex-Malguzari Tanks which are constructed in Bhandara, Chanda and Nagpur Districts form a great assets to Maharashtra State. There are thousands of Malguzari tanks in the districts. Individually these tanks are small but their total irrigation potential is large and hence they are an important source of minor irrigation. Most of these tanks appear to have been constructed about 250 to 300 years ago. It is not exactly known as to how these tanks came to be constructed initially but it appears that in many cases certain forest areas were allotted to the people for habitation and cultivation through the agency of an enterprising person named as “Patil” who arranged to colonize village families from various places. The “Patil” used to get a commission on the assessment and he used to pool together labourers of the village for Nistar works. Thus these tanks or bunds might have been constructed as a protection against the shortage of drinking water in hot weather season. It was experienced that the rice crop would fail frequently due to failure of timely rains, so these tanks came into existence for supplementing water required for rice fields. Subsequently with the growing need of cultivating rice crop these tanks were constructed practically every where without the consideration of technical or economical aspect. Most of the tanks are situated in very flat basins and hence the length of the bund is abnormally more. This is one of the reasons why the renovation of tanks are being found financially infeasible. Consequent on abolition of proprietary
rights in 1950, all Malguzari Tanks irrigating fields of groups of cultivators came to be vested in Government. The maintenance and operation of these tanks before the abolition of proprietary rights was a simple affair being managed by the beneficiaries whose efforts used to be co-ordinated by Malguzars.

11.2 Medium & Major Irrigation Works:—

Majority of irrigation works which were constructed in the past, in the Vidarbha, fall under category of “medium” projects and the remaining under “minor works.” There are very few sites for major irrigation projects. They present the difficulty of huge submergence due to flat lie of the country. They not only involve huge investment but also pose problems of foundation. Naturally whatever works constructed in the past, were mainly restricted to medium projects and minor ones. Even now with the present planning it seems that the Vidarbha Region is an area suitable mainly for Medium size projects.

IRRIGATION AND ENGINEERING PRACTICES : & LESSONS TO BE LEARNT THEREFROM

12. Crop Pattern:—

The cropping pattern is largely influenced by variety of soils and climate conditions of the region. Taking these factors into account, the Vidarbha area has been broadly divided into four agroclimatic zones as already explained. On these basis Chanda, Bhandara and part of the Nagpur district are suitable for growing rice. The rest of the Vidarbha is suitable for cotton, wheat, and millets. Any deficiencines in the distribution of rainfall affect very adversely the rice crop. Under such circumstances, the yield of the crop goes down so low that at times it has to be taken as good as failed. While in the case of wheat the deficiency is not so material as the excess of rainfall is. This crop is comparatively tender and get adversely affected with a little excess of rainfall. The cotton and millets are comparatively sturdy crops and can stand variations of rainfall without getting severely affected. Thus when the Government was developing irrigation as a protective measure, it was but natural that it had given preference to the rice areas. That is why all the irrigation works constructed in the past are concentrated in Chanda, Bhandara and part of the Nagpur Districts. As regards the extension of the irrigation to the other part, particularly for growing wheat, experiments were made by providing water for it. For instance, the Mahanadi Project and the Tandula Project and on a smaller scale the Wainganga project were designed to give water
to wheat in the rabi season. The public did not utilize these provisions as they could get one or two showers during the winter season which could thrive the crop of wheat. Thus this experiment failed completely and Government gave up the idea of extending the irrigation to the other parts where irrigation would have predominantly been used for rabi crops, mainly consisting of wheat. As regards the existence of irrigation in rice tracts it was not under demand due to the existence of thousands of Malguzari tanks. Non-availability of additional land for cultivation because of the extensive forest in that area was another reason for the stagnation. In the circumstances explained above, it will be noticed that the crop pattern which was developed was only a monotype. The tendency of the cultivators was to have only one crop and that has been found to continue even now. The present crop pattern consists of multicrops, in order to take full advantage of the water potential and assure monetary success. But due to static tendency of the cultivators, there is more danger of remaining these storages unused for a considerable period and thus locking up the capital without return. This is a very undesirable feature particularly when the object of the planning is to raise the economic level of the people mainly dependent on agriculture. This situation thus leads to the necessity of developing the planning in stages. Most of the projects sites are suitable only for earthen dams. These are however not generally suitable only for construction in stages when the projects are of medium size and also when gates are to be avoided. The only way left is therefore to take first a few works well distributed all over the area instead of going for irrigation works everywhere and then take others when the demand for them is justified on the basis of the experience on those which are constructed.

13. Design of waste weirs:—

In the Central Provinces, the designs of waste weirs used to be based on the tables prepared by Captain A. E. Garret. The main characteristic of this method is that, it allows for flood absorbing capacity of the tank in working out the length of the waste weir required. The discharges of the flood used to be worked out for two types—one, for spates based on Dicken's formula \(1 = 1400 \text{ M}^2\) and second, for prolonged flood based on intensity of rain with a sliding scale depending upon the size of the catchment. The longer length given by these two formulae used to be adopted for construction. The water spread of the lakes are generally considerable due to the flat country and thus provide for a sizeable capacity for flood absorption. The designs based on these considerations of flood absorption capacity lead to considerable economy. This was a practice adopted by
the Central Provinces over a long period of more than 50 years and was considered to be acceptable. The present method of working out the flood discharges by Inglis formula which gives nearly double the discharges that of Dicken's and further ignoring the flood absorbing capacity of the tank, on the score of a factor of safety, makes the projects costly. As a justification of this method, some failures of a few tanks which took place in the monsoon of 1959 are quoted. It is however felt that the whole method should be re-examined again and necessity of ignoring the flood absorbing capacity should be got reaffirmed. Some of these damages in that year may not be attributable to the practice of allowing for the flood absorbing capacity. If at all, necessity of a further factor of safety is necessary it can be assured by providing breaching sections at suitable locations. The crops engineers of U. S. A. have developed a practice of providing spillway capacities on the premise that structural damage may be accepted during the passage of the floods in excess of design floods provided that the security of the dam is not jeopardized and loss of property, if any, is economically acceptable as against the capital investment, required for passing the maximum possible flood. As already explained above, Vidarbha is the area for medium projects and criteria suggested above would definitely help to make these projects economically attractive without the introduction of any unsound proposition. The suggestion is particularly based on the long standing practice of this region itself.

14. Free Board:—

The lakes in the Vidarbha area are all land locked, generally surrounded by hills and we seldom get very high gales near the hills. The practice in C. P. was to provide a free board of five feet above the H. F. L for a height of dam of 25 feet upto H. F. L and 6 feet for a height above 25 feet of dam. The dams with the free board provided as above in the C. P. were never found to have been over topped. The present practice of providing free board ranging from 5' to 8' is rather on a higher side and needs to be reexamined for the sake of possible economy.

15. Dead storage for silting:—

One of the retired Deputy Chief Engineers from M. P. has stated that they have constructed in the state a large number of reservoirs as long as 50 years. Observations have been made in general on all of them during the last 10 years and finally it has been reported there is no silting worth the name. A provision of, not more than 5 to 10 percent of the
total capacity of the reservoir should suffice as a provision for a silt pocket. Thus the present practice of providing silt pocket on the basis of Dr. Khosla's formula requires reconsideration. This matter is however very difficult for the decision for want of authentic data covering a long period.

16. Depth for cut off:—

The general practice followed in the C. P. was to provide for a narrow cut off trench refilled with impervious materials in the form of a puddle. The depth of the puddled trench was generally taken to be half the depth of the H. F. L. of the lake over the ground level. This method would normally provide a horizontal creep length as 6 times the depth of water, allowing that the horizontal permeability is 4 times that of the vertical permeability. It was considered that when the water has creeped through a length 6 times the head it would have lost all the head and the velocity at the end where it emerges will be nil or negligible. In the case of extremely expensive deep cut off, the partial cut off used to be provided, as in that case, it was taken that the creeping water would not be able to carry away the material along with it. The present practice is to provide nearly double the depth as compared with the practice used to be followed previously in this region. The deeper depth of cut off increases the cost considerably which might probably be reduced without any danger to the utility of the dam.

CONCLUSION

17. Certain of the practices which used to be followed previously in this region in respect of construction of irrigation dams need to be studied and adopted while preparing new irrigation projects. They are likely to lead to some economy without any danger to the dams. The real success of irrigation venture will however depend upon the co-operation of the cultivators in utilising the water potential created from time to time. The stoppage of advancement in irrigation, in the past, is mainly due to lack of enthusiasm in utilising the storages created. It is hoped that due to all round awakening for raising the economic level, the discouraging experience of the past would not be repeated.
Bazaar Centre From its Utility Point
C. D. Kale, A. M. I. E. & B. V. Aghashe,

In an industrially developing cities, bazaar and shopping centres have become a very urgent and utmost necessity. It is always observed that the bazaars and the shopping centres now existing in many of the cities are in a very hopeless state of conditions. Whatever is being done in some of the cities seems to have not been scientifically dealt with.

In exhibitions bazaars and shopping centres with great rush of people and their transactions of their safe sellable goods create a lot of chaos and confusion due to improper arrangement caused by unscientific position of shops. This results in complete mis-management of exhibitions or shopping centres or bazaar.

Addition to these things there is no parking space for vehicles, similarly no space is provided for playing for very small children when elders are busy in shopping.

As in many cities availability of space for shops is very small and when you cannot avoid flow of people during busy hours, ideal bazaar centres is thought to be a prime necessity.

We have come across such hardships in Nagpur where there are exhibitions of high orders performed every year. There is a weekly bazaar held every day in one of the precincts of Nagpur City. In the same way for daily shopping there are near about 30 to 35 centres located in Nagpur City. Every where great rush is observed specially at exhibition and makes it difficult for every visitor to observe the show or make his purchases. The depth of rush some times goes to 6 person deep. Therefore we have thought of a very ideal bazaar-cum-exhibition centre from our own point of views.

Salient features of these are

1. The plan shows the details. It covers 200'x200' plot area. If required, multiple of the above can be thought depending on the requirement of the town with availability of space, in series or in different localities.
LAY-OUT OF ECONOMIC & IDEAL BAZZAR CENTRE
2. The plan maintains proper ventilation for shopkeepers and public.

3. Show room space for each shop is more. This allows the shopkeeper to exhibit his items of his goods to a number of customers at a time. This reduces the depth of standing persons infront of shops. This helps early movement for customers.

4. Hexagonal type of arrangement gives smooth circulation of traffic avoiding sharp curves and corners. The central core behind the shops is utilised for washing of vegetables, opening of sealed boxes, throwing the dirt, there by keeping the frontage of the shops clean. A gallery in the fornt provides safety from rains and sun for the public when customers are to shop in summer or in rainy season. Residential accommodation for shopkeepers is provided at top so that customers can avail the services of the shopping centre even at odd hours of the day or night. 

(This is specially required where three shifts of mills, factories and railways are run throughout a day. Similarly for medical, marriages, events of deaths these services are very badly felt).

5. Parking space at the centre as shown will avoid traffic jams. Parks for children of customers gives safety from accidents.

6. Provisions of overhead passage will avoid pedestrian road crossing while moving from one shopping centre to the other.

7. By providing proper lighting arrangements some expenditure is reduced due to hexagonal arrangement and that bazaar is illuminated.

8. By providing 10'-O" space in front of the sub-centre we are avoiding rush of customers from the road way by allowing the vehicles of the customers, if any, to approach as near as possible by parking them in the centre.

9. The circular stair in the centre provides inside way to residences and also avoids the animals to enter the boundary of shops.

10. The other facilities of water, fire brigade can be suitably introduced in the children playing spaces for public and very near to central core for shopkeepers.

11. If more accommodation is necessitated one more floor can be provided.

12. Technically the design provides very excellent situation for the following:

   (a) Architecturally very pleasing.

   (b) Structurally sound due to interlocking of walls.
(c) Making all the walls load bearing walls and that dead walls to a minimum.

(d) By providing necessary beams depth of slab is reduced to $4\frac{1}{8}$ though the maximum span of the room is 18'-0". The maximum span for slab is 11'-0" and minimum 6'-0" for this reinforcement can be suitably varied.

(e) We know that for minimum length of wall to get maximum area square room is an ideal arrangement. But in the plan shown, the hexagonal arrangement gives the same length of wall for nearly same area but in addition to this it provides an extra enclosed area of 43 sft. (for this plan only) which does not require any additional structure.

(f) For wind aspect fan, lights are provided. If expansion is required, for the structure, it is possible in every direction.

13. The idea of the bazaar centre is not a new one. Many of us must have seen that there are so many old temples with many offsets in a particular way or the other. These offsets are given only to add for the circumferencial area and use this area to have different types of idols. (Generally of Gods and other different occasions of wars etc). This gave the architectural appearance also. In addition to this it gave the structure an extra fixidity and brought the highest point to a minimum as required for the temple. This quality is made use of in thinking of this bazaar centre.

14. In addition to above points it is thought necessary to note here that people will get nearly all the required materials at one place if the shops are arranged in that way or for possible requirements. This arrangement can be done by allowing different shops one after the other in the hexagonal place or by arranging same types of shops in one hexagonal system and arranging hexagonal system as shown in plan or in different series only if the market required is of larger capacity.

This will beautify the centre and also distribute the number of persons coming to market in different shops for the purchase of the same goods. As the shops will be very near to each other the rates will also be the same all where and will not vary. The only idea of the Govt. Market (to have minimum rates with profits) should be bourned in mind by the shop keepers.

If this is done the markets will be ideal and will continue to run efficiently.
SPACE AGE WELDING TECHNIQUES

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Abstract:

The phenomenal progress in the field of nuclear engineering and space technology would not have been possible but for the parallel advances in engineering techniques. The technique which contributed most to the new ventures is welding. The technique in itself is undergoing a revolution and the new techniques like electron beam and Laser welding are just short of becoming regular welding tools in the simplest of the workshops in the developed countries. Recent advances in the technology of welding such as electroslag, friction, high frequency resistance, ultrasonic, electron beam and Laser welding have been briefly outlined here.

Introduction:

Welding comes as an age-old technique of metal fabrication and today it is almost an indispensable tool in general engineering. Fabrication by welding usually leads to simpler designs improved economy, performance and reliability, particularly in large fabrications. In industries such as chemical engineering and conventional power-generation where higher temperature and pressure conditions prevail, welding is indispensable for fabrication. Further, the rapid advances in space technology and nuclear engineering owe a great deal to the improved welding techniques.

There had been a remarkable development in the welding processes during last decade and many of the newer processes depend for heat generation on physical principles other than the conventional electric arc or combustible gas mixtures. It is therefore interesting to look into these developments as they occurred.
FIG. 4. PRINCIPLE OF ELECTRO SLAG WELDING.

CONTINUOUSLY FED ELECTRODES

GUIDE OSCILLATED ACROSS GAP

PLATE

MOLTEN SLAG BATH

ELECTRODE GUIDES

WATER COOLED COPPER SHOES

MOLTEN WELD METAL

SOLIDIFIED WELD METAL
Electroslag Processes:

The principle of this process is different from the normal flux processes, which utilize arc with the slag only for shielding, in that in the electroslag process the synthatic slag serves as a resistance heating media to melt the continuously fed electrode, and no arc is present.

Fig. 1, depicts the principles of electroslag process. The plates to be welded are prepared so as to have plain square edges and the metal and slag bath contained between two water-cooled copper shoes is moved up the joint with the welding head.

The process is especially useful in welding of thick sections like pressure vessels and boiler drums. This process results in large savings in welding time as compared to the conventional processes. In the fabrication of pressure vessels the process can replace the conventional forging techniques with considerable economy.

Upto 3 in. thickness a single electrode wire is used which is oscillated through the gap during welding. For thicker sections multiple electrode wires are used.

One of the main problems in electroslag welds is the coarse grain size of the as cast structure which results in low impact resistance. However the structure can be refined by normalizing treatments or by the addition of grain refining inoculants to the weld pool. A further problem is the grain-coarsening in the heat-affected zone which is particularly severe in electroslag process because of high heat input coupled with low welding speed, resulting in a wider heat-affected zone. However, satisfactory properties can be obtained and the process is rapidly becoming established for welding large fabrications.

A variation of the electro slag process is the 'consumable nozzle' process as shown in fig. 2. In this process a fixed wire feed head is used and the wire is guided into the joint by a rigid concentric guide or nozzle. As the guide melts by resistance heating of the slag bath, the level of the molten metal and slag bath rises and fills the joint. The copper shoes are moved up manually by placing a second shoe above the first and so on until the weld is complete.

The main feature of the consumable nozzle electro-slag process is that it involves much simpler mechanisms and also that it is less expensive than conventional electroslag process. However, consumable nozzle process is used for fabrications of smaller and thinner sections than those.
FIG. 2. **PRINCIPLE OF CONSUMABLE NOZZLE ELECTRODE SLAG WELDING**
done by conventional electro slag process. The properties of the weld are similar in both the processes.

**Friction Welding**

This is a simple process and consists of rotating a component held in a chuck at a speed of about 2,000 rpm under applied pressure against a stationary component held in another chuck. The friction developed generates heat and initiates bonding. When this starts the rotating head is braked and the previously fixed head released and accelerates up to the speed of decelerating head. Increased pressure is then applied to effect a forging cycle.

This process is unique firstly because no fusion is present and no liquid phase exists and secondly no external sources of heat are used. Compared with its nearest 'rival', flash butt welding, it results in about 75% power savings.

Friction welding process produces an ideal weld. It does not involve any as-cast structure and all the complications arising from the as-cast structure are eliminated. The intimate contact of the surfaces eliminates contamination from atmosphere and alloy losses do not occur. Temperature gradients are very shallow due to the gradual spread of heat into the workpiece, which makes its application to hardenable steels attractive and holds promise for dissimilar metal joints. At present the application of this process is limited to welding of 1 sq. in cross section because of the difficulty in developing adequate braking mechanisms for larger sections.

**High-Frequency Resistance process**

In this process the high-frequency alternating current is brought in direct contact with the object instead of through a transformer as induction heating. The current flows through the object in the path of least inductance instead of in the path of least resistance and the object is heated to the required temperature.

Fig. 3 illustrates the basic principles of the process. When a low frequency current (say 60-cycley) is applied to the metal piece through the contacts, the current would flow through the contact in an uniform way, and would cause the metal to be heated more or less depending on the electrical resistivity of the metal. However, when a high-frequency voltage is applied it is possible to have almost no flow directly between the
Fig. 3. High-frequency resistance heating on the surface of a metal plate.

Fig. 4. High-frequency welding of tubing.

Contact shoes (to high-frequency source)

Leads to power

Plate

Current path in water-cooled conductor

Current flow

Direction of travel

Squeeze

Weld

Current path in water-cooled conductor

Dotted line path of current in plate

High-frequency power source

Metal plate

Current path on metal plate

High-frequency power surface
FIG. 5 A TORSIONALLY DRIVEN RING-WELD SYSTEM.
contacts and the major part of the current could be directed to flow the longer distance between the contacts over the path of lowest inductance, which is the path closest to the return conductor of the circuit. This is the basis of the high frequency resistance welding.

Fig. 4 shows the seam welding of pipe by high-frequency resistance. The edges of continuously formed steel strip are pressed together by the squeeze rolls. As this occurs, a small angle is formed with the weld joint at the apex and the two edges at the sides. When high-frequency current is applied through the contacts just in advance of the squeeze rolls, there will be two current paths (i) from one contact around the back of the tube to the other contact and (ii) from one contact along one leg of the angle to the apex and back the other leg to the other contact. The major part of the current takes the path of least inductance, that is, between the two legs and the angle, thus heating the two edges and the weld results when the edges are squeezed together.

A current of 45,000 cycles per second is generally used for resistance welding. At this frequency the current flows through only a few thousandths of an inch deep consequently reducing the heat affected zone. Butt, tee, and lap joints can be conveniently made by this process. The welds made by this process give excellent properties and the weld strength is as good as that of the base metal. The ductility and impact strength are also comparable with that of the parent metal.

The main features of this process are, no filler material is added to the weld joint, the finished weld contains no cast structure, extremely small heat affected zone, as the weld is in compression during cooling which eliminates shrinkage cracks, dissimilar metals and alloys can be joined, and the weld can be made at high speeds resulting in greater economy.

The process has a potential future in welding of high-strength materials and some of the more difficult to-weld materials such as Aluminium alloys, stainless steels, molybdenum columbium tantalum and tungsten alloys.

However, the application of this process is limited by the fact that it is continuous and completely automatic. It cannot be used for intricate shapes and small jobs. Also since the depth of the current flow is very small the girth welds in pipe tubing and similar objects cannot be made by this process.
FIG. 6 ELECTRON BEAM WELDING
Ultrasonic Welding Process:

Almost any type of weld including spot welds, ring welds, seam welds and area welds, is possible by this process. The critical part of an ultrasonic welding machine is the transducer-coupling system which converts high-frequency electrical power into acoustic power and delivers it to weld zone. The coupling system must be designed to match the frequency of the transducer which is usually a stack of nickel alloy laminations.

For a satisfactory performance of the transducer-coupling system it must firstly be insensitive to force, i.e. when force is applied to the weldment there should be no significant shift in the resonant frequency of the system and secondly it must lose relatively little energy through its mounting system. Mounting systems which are insensitive to a force of 100 tons are now developed.

Fig. 5 illustrates the transducer-coupling system for torsionally driven ring-weld system which produces continuous annular welds with a single weld power interval. Unlike other processes the ultrasonic welding produces a variety of metallurgical phenomena. The interfacial heating associated with vibratory energy may give rise to local working effects along the surfaces, the plastic metal may extrude through the joints, under certain circumstances the temperature effect may result in recrystallized and annealed structure. Further complication may arise in welding of alloys because of the anomalous diffusion effects.

Ultrasonic welding has been found useful in welding aluminium and its alloys high temperature dispersion strengthened materials and welding of small fragile components like transistors and other semiconductor devices.

Electron Beam Welding:

Since its first discovery in 1957, the focused electron beam as a source of intense energy, has been put to many applications including melting and welding. Utilization of electron beam in joining has now become a standard practice and it is no wonder if one hears that the Apollo astronauts will be carrying a battery operated portable electron gun into the space.

Initial interest in the focused electron beam process was mainly for the welding of refractory metals and pressurizing of the nuclear fuel element case onto the uranium fuel element in which gaseous contamina-
FIG. 7. PRINCIPLE OF LASER WELDING
tion and oxidation of the weld has an adverse effect. However, the improved focusing techniques and deeper penetration with high depth-to-width ratio have increased the potential of the electron beam process considerably.

Fig. 6 shows a typical electron beam welding set up. The electrons are emitted from a cathode maintained at a high negative potential relative to the earthed work piece. The voltage of a commercial equipment can be upto 150 KV. The focusing of the electron beam is achieved by magnetic lenses. Additional magnetic defectors can be incorporated for better focusing. The whole assembly must be operated under high vacuum (10^5 mm Hg.) since electrons cannot travel far in gaseous atmospheres. This is the main disadvantage of electron beam and the requirement of a vacuum chamber has restricted its use to small workpieces. Larger vacuum chambers involve higher capital investments.

The important feature of the electron beam weld is the high depth-to-width ratio which results from very high energy density of the order of 10^7 watts per sq. cm resulting from the fine spot size. Welds which are crack susceptible even under submerged arc, can be welded without cracks by the electron beam technique. Strength comparable to the parent metal are common in this process. The heat affected zone is very small and is of particular advantage in welding materials like ausformed steels that undergoes damage in the heat affected zone in the conventional processes. Since the fusion zone is also very thin, the stress arising due to solidification are less than in normal methods and this is of particular interest in aircraft industry where design considerations are not very flexible.

Attempts are now being made to overcome the limitation imposed by vacuum requirements in electron beam welding. "Out-of-Vacuum" electron beam welding units are now being developed. In the out-of-vacuum equipment, the electron beam is produced and focused within the vacuum chamber and it is then allowed to pass through a series of orifices in differentially pumped chambers into air or inert gas at atmospheric pressure. However, since the electron beam cannot travel large distances in gaseous atmospheres the working distance is limited. Also the beam gets defocused and loses considerable power through collision with the atmosphere resulting in a reduced depth to width ratio. However the welds produced are comparable to that of the vacuum electron beams.

The electron beam welding technique has now become a standard practice and we know exactly what properties can be expected from
electron beam welds. Today electron beam welding has become a part of the specification in more than one set of nuclear fuel elements. Electron beam is also used in joining electronic components. Some of the problems in space technology such as joining of tungsten and its alloys are now being overcome with the help of this process.

It is reported that the astronauts in the Apollo space ship will now be carrying a battery operated portable electron beam welding set thus paving the way towards the realization of a dream in which the spacemen with electron guns in their hand, welding their residences in the outer space where they will need no vacuum pumps.

Laser Beam Welding:

The laser (light amplification by stimulated emission of radiation) or Optical maser has made available to the materials engineer a new and powerful tool. The electromagnetic radiation from the solid-state lasers is the most intense from of radiant energy ever developed by man. Laser as a heat source can be utilized in a broad range of applications including metal cutting and joining.

Fig. 7 illustrates the working principles of a ruby laser. The cylindrical ruby crystal seeded with chromium ions is energised by a xenon electronic flash in a reflecting enclosure called the pumping source. The strong green light of the xenon flash causes the chromium ions to emit a photon of red light. This photon may strike another chromium ion in the excited state causing it in turn to emit a photon in the same direction and in phase with the colliding photon. The ends of the ruby crystal are silvered so that the light wave is reflected to and fro along the crystal exciting more chromium ions and causing considerable light amplification. The amplified beam is eventually emitted from the output end of the rod which is made less reflecting than the back end. The coherent beam emerging out of the crystal can be focused with much greater provision than the ordinary light and can be used as an intense source of energy. The energy release that can be produced by a laser is of the order of $10^7$ watts per square centimeter and is the same as possible by an electron beam. The laser is an excellent source of welding energy and the high intensity of the radiation it is possible to weld even the most refractory metals. As it can operate in any atmosphere greater source-to-workpiece distances are possible, making welding in inaccessible positions possible. Laser beams can be readily focused by optical means and can give the same penetration characteristics as electron beam. However, lasers cannot be operated continuously but only in pulses of a few micro-seconds duration. But
even this fact could be utilized advantageously in refractory metals to eliminate the grain growth in the heat affected zone. The fusion zone is extremely small and is about 40% of the joint depth.

At present laser welding is confined to miniature components such as in electronic circuits. Laser has an advantage here, being able to produce very small, accurately positioned welds. However, because of the high heat intensities laser may result in surface boiling of the metal if it is not controlled properly.

Conclusion:

An attempt has been made to highlight some of the important features of the newly developed welding techniques. The development in welding processes in recent years have been rapid and the potential of each process is increasing at a rapid rate. The processes like high frequency resistance welding and ultrasonic welding are restricted in their application to large components which can be welded in a continuous operation. Friction holding is restricted to small components because of the difficulty in producing adequate braking systems for larger components. The high vacuum requirements of electron beam have been overcome to some extent and more progress is expected in coming years. The laser beam welding seems to be an ideal process for small and big components as it can operate in any atmosphere.

References:

Export trade of Indian ferromanganese
Problems and outlook

By

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The present installed capacity of high carbon ferromanganese in India is approximately of the order of 200,000 tonnes per annum. It was visualised, while setting up various units of production, that nearly 100,000 tonnes of it could be consumed by the Steel plants in the country and the rest will find an outlet in the international market. Unfortunately, none of these objectives could be achieved. All steel plants, together were able to consume about 83,000 tonnes of ferromanganese during the year 1967. The performance in the export markets has been below expectations. It has been possible to export only a small quantity of ferromanganese, about 15,000 tonnes to United States of America during 1966. The position improved slightly during the year 1967 when about 9,000 tonnes was also exported to the Japanese market. It will be seen from this analysis that the internal consumption of ferromanganese has not lagged far behind the anticipations, but the export trade has been all along extremely sluggish and, in fact, the target fixed for export was unrealistic.

While taking stock of the current situation, this paper analyses the possible future demand of Indian ferromanganese in various world markets.

Export performance of Indian ferromanganese and factors inhibiting increased exports

Cash sales of Indian ferromanganese in the international market has all along been very insignificant. Some sizeable exports were made during the year 1960 and 1961 due to wheat barter arrangements negotiated by the State Trading Corporation of India with the Government of United States of America. Following the barter arrangements the exports suddenly fell to 9,186 tonnes in 1962 from a figure of 66,359 tonnes in
GRAPH SHOWING PRODUCTION, EXPORTS & INTERNAL CONSUMPTION OF FERROMANGANESE IN INDIA DURING THE YEAR 1963-67

TONNES

160,000

140,000

120,000

100,000

80,000

60,000

40,000

20,000

0

1961 and further declined to 4,189 tonnes in 1963. Contracts, mostly barter type, negotiated by the Minerals and Metals Trading Corporation of India with the Governments of United States of America, United Kingdom, Australia and West Germany, again gave a fillip to the export trade and the export figures during the years 1964 and 1965 stood at 91,210 and 58,569 tonnes respectively. With the conclusion of these contracts, the exports fell again sharply to 15,390 tonnes during the year 1966. Almost all the quantity was exported to United States of America. There has been a slight increase in the exports during the year 1967. In addition to about 15,000 tonnes of exports to the United States of America, another 9,000 tonnes could find place in the Japanese market during the year 1967.

The reasons for shortfalls in exports are many and varied. A few of them are discussed in the following paragraphs in some detail.

(1) Production costs.

A high cost of production appears to be one of the major factors which limits the export trade of ferromanganese. Expenditure on electricity, manganese ore and overheads form the major chunk of the overall production costs. Ferromanganese is a power intense industry. In Indian conditions consumption of electricity per tonne of ferromanganese varies from 2,680 units (K W. H.) to about 3,600 units. A variation of 1 nP. per unit might result in a reduction of Rs. 30-35 per tonne in the production cost. Actual variation in the cost of electrical energy is much higher than 1 nP. the rate in Maharashtra being 6.5 nP and that in Orissa 4 nP. It is generally seen that the plant based on hydral power have lower rate of electricity tariff and those based on thermal power have relatively higher rates. Under identical conditions the difference in the cost of electrical energy alone will result in a difference of cost of production to the extent of about Rs. 75-80. It is also seen that there is a large variation in the actual consumption of electrical energy in various plants. If the rate of consumption is kept at the minimum, there could be a saving of 500-900 units which will amount to Rs. 48-58 in terms of further savings. There is thus need to reduce the consumption of electrical energy and also to reduce the unit cost of electrical energy. Actual electrical rate tariffs prevalent in other countries of the world which are our competitors, in the international market are not readily available but there is reason to believe that in countries like South Africa and Norway the cost on account of electrical energy forms only a negligible part of the overall production costs. The other major items in the cost of production are (a) cost of manganese ore, and (b) overheads on account of management, marketing and depreciation. Ferromanganese plants in India are generally operating on an
average of 65% of their rated capacities. If the production is increased to the rated capacity there is likelihood of saving in the cost on account of overheads. The extent to which production could be increased is difficult to answer. The average annual production and consumption of ferromanganese in the country during the period 1963-67 are 133,000 tonnes and 81,000 tonnes respectively, leaving about 52,000 tonnes for exports per year. The maximum internal demand during the period was of the order of 87,000 tonnes and assuming that there may not be any substantial increase in production of steel before 1973-74, the internal consumption during the next 2-3 years may not far exceed 87,000 tonnes. Under these conditions if the plants are to operate at 90% of their rated capacity, the annual production will be of the order of 1,80,000 tonnes, leaving a balance of 93,000 tonnes to be disposed off in the export market. On account of the high cost of present production and the indicated trend of export, it is unlikely that export of this magnitude will be realised. Government is understood to have, under consideration, two steps designed to promote export. Firstly, ferromanganese export need not be canalised through the MMTC and, secondly, a scheme of grant of a reasonable rate of subsidy for a stated tonnage of ferromanganese is under active consideration. The impact of these need close examination and if their purpose is realised, the production of ferromanganese can be increased, which will lower the production cost.

The bill on account of manganese ore may be reduced, either by reducing the rate of ore consumption or by reducing the unit price of ferromanganese ore. Reduction in the manganese ore rate is possible in those plants which use the so-called fluxless process if they change over to the fluxing process. In India fluxless process is not being used. If there is a switch over to the fluxless process, there may be considerable savings in terms of consumption of electricity of the order of about 900 units per tonne of ferromanganese produced. The productivity of the furnaces will also improve. The only snag is that slag containing 25-40% manganese is produced, which has to be economically disposed off. Flux requirements are lower but there is relatively a higher consumption of manganese ore. If the production of silico manganese is taken up where the high manganese slag can be used, the fluxless method may prove quite economical.

(2) Quality of ferromanganese.

Ferromanganese exported from India is of high carbon variety. It is seen, however, that the quality suffers from certain drawbacks. The
detailed specifications of the ferromanganese imported by principal importing countries of the world is not available. It appears that the Indian ferromanganese generally does not come up to the international standards in respect of manganese and phosphorous content. In most of the plants the manganese content of ferromanganese is below 76 percent. Phosphorous content is invariably high, i.e. 0.30 percent. South Africa is an important competitor in the international market. The manganese content of South African ferromanganese varies from 77 to 80 percent. Phosphorous is remarkably low of the order of 0.054 percent. India appears to be at a disadvantage with regard to the quality of ferromanganese.

The manganese ore ideally suited for the production of ferromanganese should have a ratio of Mn:Fe of about 7:5 or more and phosphorous content less than 0.15 percent. The ratio of manganese and iron in Indian ores is generally 5:6 and phosphorous content is never less than 0.1 percent. This handicap ultimately affects the quality of ferromanganese. Our manganese resources with ideal specifications are rather insignificant. Phosphorous content in ores is low in those areas where manganese-iron ratio is also low. The best ore in India, the Oriental Mixture, has a ratio slightly less than 7 and since the ratios of ores in Bihar, Orissa and Mysore are generally still lower and the feasibility of blending with the imported ores of much higher ratios is ruled out, the only way is to explore the feasibility of supplying beneficiated ores or agglomerates. This is a long term measure. A possible field in this direction is to reduce the iron content of the high grade fractions of the ores from Bihar and Orissa and feed them to the ferromanganese plants with or without blending with the higher grade medium phosphorous ores from Madhya Pradesh and Maharashtra.

**Dimension of trade in major international markets and the possibilities of augmenting exports from India in those markets**

The total world market of ferromanganese, mostly high carbon, was of the order of about 7,67,000 tonnes during the year 1966 as against the total world production of about 3.4 million tonnes. From the point of view of major consuming centres, the important groups are (1) North America, mostly U S A. (2) Western Europe, mostly countries comprising European Common Market, i.e. France, Germany (Federal), Italy, Belgium-Luxemburg and Netherlands. In addition, United Kingdom is also a very important market for ferromanganese. (3) U. S. S. R. and (4) Japan. The major exporter countries of ferromanganese of the world
are U. S. S. R., Germany (federal), France, Norway and Union of South Africa.

The supplies from U. S. S. R. meet the requirements of most of the countries constituting the communist bloc. U. S. S. R is the leading producer of manganese ore are in the world and the resources of manganese ore are considerable in this country. Production of ferromanganese in U. S. S. R. during the year 1966 was of the order of about 800,000 tonnes.

The location of Germany (Federal), France and Norway is such that it conveniently meets almost all the requirements of Western Europe. The only outside country of importance, which enters this market is Union of South Africa. The position of U. S. A. is somewhat different and from the discussions it would appear that India can hope to increase her exports in this market. The only other country where exports could be increased from India is Japan as would be seen from the factors analysed in the subsequent paragraphs. It may be mentioned that Australia is also increasing her production of ferromanganese and in due course of time may become a keen competitor in many world markets, especially Japan.

The situation in major world markets of ferromanganese are analysed below.

(a) U. S. A.

U. S. A. being the world's biggest steel producer is also the largest ferromanganese producer. Its production of ferromanganese of various grades touches the mark of one million tonne. In addition, it also imports sizeable quantities of ferromanganese from other countries. During the year 1966, U. S. A. imported about 230,000 tonnes of ferromanganese. In order of importance, the sources of supplies were France, West Germany, South Africa, Belgium, Luxembourg, United Kingdom, Norway, Japan, Australia and India. There are a host of other countries such as Canada, Sweden, Spain, Italy, Yugoslavia, Brazil, etc. which also export small tonnages to the U. S. A. Occasionally U. S. A, has been lifting Indian ferromanganese in large quantities against certain special trade agreements such as the Wheat Barter arrangements in 1964 when exports from India to the United States reached a figure of 91,000 tonnes. In regular channel of trade, however, the exports from India to the United States have been meagre at about 15,000 tonnes in 1967. While planning the export targets of ferromanganese, it was visualised that U. S. A will be the most important market for Indian ferromanganese but this aspiration could not be
fulfilled, mainly on two accounts, i.e. (1) The quality of Indian ferromanganese is inferior, both in respect to manganese and phosphorous contents. Most of the imports into U. S. A. reflect manganese content 76 percent and above. The quality produced in India, as will be seen, has manganese content below 76 percent. The phosphorous content in Indian ferromanganese is 0.3% but it is understood that the U. S. A. steel producers need phosphorous up to a maximum limit of 0.25 percent. At one stage, it was pointed out by U. S. A. steel producers that during stock-piling Indian ferromanganese disintegrates due to the high content of phosphorous. There is no information regarding phosphorous content of the ferromanganese imported into the United States from other sources excepting that from Union of South Africa whose phosphorous is as low as 0.054 percent. The manganese content is as 79 percent. (2) The Indian ferromanganese is in competitive with respect of price also. The c.i.f. value per tonne of ferromanganese in United States from France, West Germany, South Africa, Belgium–Luxemburg, U. K. and Norway varied from Rs. 621/- (from Norway) to Rs. 808/- (from U. K.) during the year 1966. The value from India stood at about Rs. 1,000/- per tonne. The published prices in June 1968 of imported standard grade ferromanganese analysing 74–76% manganese (Pitsburg) stood at Rs. 1,080–1,110 per tonne. If these figures are co-related with our cost of production, it will be seen that unless the cost is reduced appreciably, the Indian ferromanganese in United States market has no future whatever. The recent subsidy which the Government has granted to this industry might alleviate this position, and its results are to be watched with great interest. There was recession in the steel industry of U. S. A., the production of raw steel during the year 1967 being of the order of 127 million tons quoted by Mining Journal, January 12, 1968, The U. S. Steel industry, however, appears to have recovered during the year 1968 and an average monthly production of 12.43 million tons has been predicted by the Chairman of Republic Steel Corporation according to the Mining Journal. On this basis, the steel production during 1968 may be of the order of 149.00 million tons (151.3 million tonnes). This trend indicates growing imports of ferromanganese in this important international market. If the prices and quality of Indian ferromanganese are competitive, there is no reason why India cannot augment her exports into the United States of America.

(b) Japan.

The ferromanganese industry of Japan is well-organised. Besides meeting internal demands, about 15,000 tonnes of it finds outlet in the
world market at present. The imports have so long been insignificant. Apparently, Japan may not look to be a potential market for ferromanganese, but the important point about Japan is that its steel production is bouncing up every year. During the year 1968 there is slight recession in its steel industry, especially during the latter half of the year. But according to Japan Commerce Daily of April 18, 1968, plans of steel production for 1971 are very ambitious. A capacity of the order of 100 million tonnes of crude steel is likely to be created with an ultimate production of 75 million tonnes. Although the current requirements of ferromanganese are almost entirely met with from internal sources, it is doubtful if the ferromanganese producers will be able to keep up the growing requirements of the steel industry. As reported by Indian Embassy in Tokyo, the present production (from April, 1965 to March, 1967) of high carbon ferromanganese in Japan is of the order of 273,000 tonnes, out of which small quantity of the order of 5,000 tonnes is exported to other countries. It has also been reported by the Embassy that there are plans to enhance ferromanganese production in Japan. But if the steel production plan visualised for 1971 is realised, the requirements of high carbon ferromanganese will increase considerably, and in due course of time the present levels of production in Japan may have to be doubled. There is no doubt that the shortage of ferromanganese for steel industry has already started to be felt in Japan. Enquiries from M/S Mitsubishi Shoji Kaishe Ltd., one of the largest dealers in ferro alloys in Japan reveal that Japan imported ferromanganese with the following constituents from India only for the first time totalling 12,500 tonnes during the fiscal year, 1967-68 because domestic production capacity of the same could not meet the demand resulting from brisk expansion of iron and steel industry.

| Mn   | 73-78%       |
| Si   | 2.0% below   |
| C    | 7.3% below   |
| P    | 0.40% below  |
| S    | 0.03% below  |
| Fe   | Balance      |

The purchase was made at Rs. 840-862.50 per tonne c i f. Japan.

The conclusion that can be arrived at, on the basis of the above information, is that there is good scope for Indian ferromanganese to find market in Japan. The quality of ferromanganese produced in Japan is comparable to our own product as will be revealed from the following analysis of the Japanese ferromanganese sent to this department by Indian Embassy in Tokyo.
Mn = 73-78%
C = 7.3% below
Si = 1.2% below
P = 0.40% below
S = 0.02% below
Fe = Balance

The price offered, however, is not attractive considering the production cost of the Indian ferromanganese.

(c) U. K.

The British Steel Corporation have reported to the Indian High Commission, London to whom a reference was made by this department, that at present there is an excess of ferromanganese production in United Kingdom, and the imports are likely to be of limited tonnages, mainly from traditional suppliers. The production of ferromanganese in U. K. during the year 1965 stood at 1,775,000 tonnes. The plant capacity for high carbon ferromanganese is estimated at about 200,000 tonnes approximately. The imports of high carbon ferromanganese during the year 1967 was of the order of 51,000 tonnes only, mainly from South Africa followed by Norway. The price for imported ferromanganese standard grade is quoted at Rs. 909 by the Metal Bulletin.

The prospects of ferromanganese exports into U. K. will depend on her steel production. The British Steel Industry is undergoing a period of recession. Estimated production of crude steel during the year 1968 may be placed at 25 million tonnes on the basis of January-March production of 6.24 million tonnes reported by the Metal Bulletin dated April 19, 1968.

It appears reasonable to conclude that the present level of imports into U. K. is likely to continue in future years. The chances that India can capture a part of these imports are rather bleak. It is reported that South Africa which is the chief supplier of high carbon ferromanganese to U. K. offers more advantageous terms than any other country, both in respect of price and quality.

(d) European Coal and Steel Community.

During the year 1968 the E. C. S. C. countries are likely to produce 97.3 million tonnes of crude steel compared to 90.4 million tonnes in 1967 and 86.3 million tonnes in 1966, as per the information given by Metal Bulletin of August 9, 1968 and Mining Journal of September 15, 1968.
The Western Europe, excluding United Kingdom, imported about 300,000 tonnes of ferromanganese during the year 1966 out of which about 2,500,000 tonnes were imported by E. C. S. C., comprising West Germany, France, Italy, Belgium, Luxemburg and Netherlands. The E. C. S. C. Countries appear to be a very important international market for ferromanganese. But most of the requirements of this part of the world is met by France, Germany (federal), Norway and South Africa. The production of ferromanganese in France during the year 1966 was roughly of the order of 300,000 tonnes, out of which it exported about 188,000 tonnes. Similarly, the production in Germany (Federal) and Norway was 295,000 tonnes and 252,000 tonnes respectively during the year 1968. The exports stood at 91,000 tonnes and 114,000 tonnes during the above period from these countries. France and Germany (Federal) are members of European Coal and Steel Community and European Common Market and thus they have added advantage for exports of their ferromanganese to other member countries. Besides, the countries of West Europe are closely packed together and this alloy is available next door in France, Germany (Federal) and Norway. In addition, these producer countries of ferromanganese are close to the manganese fields of the African Continent. The quality of manganese ore produced in various countries of Africa is very high with respect to Mn:Fe ratio and phosphorous content.

The only other country of any significance, which enters the West European market from outside is the Union of South Africa. Although South Africa is located at a long distance with reference to these markets, the quality of ferromanganese is so good that it is in good demand all over the world, i.e. U. S. A., U. K., E. C. S. C. countries etc. The analyses of South African ferromanganese as reported by the Metal Bulletin, Special Issue Summer 1968 is given below.

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<th>(a) Electric furnace grade</th>
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<tr>
<td>Mn</td>
<td>79-9%</td>
<td>77-1%</td>
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<td>C</td>
<td>6-89%</td>
<td>6-70%</td>
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<tr>
<td>Si</td>
<td>0-29%</td>
<td>0-77%</td>
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<tr>
<td>P</td>
<td>0-154%</td>
<td>0-058%</td>
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<tr>
<td>S</td>
<td>0-013%</td>
<td>0-015%</td>
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High Carbon Ferromanganese
The ferromanganese plants are located in New Castle and Vereeniging and are operated by African Metals Corporation (AMCOR). We do not have enough information about the structure of AMCOR but it is understood that Western European countries as well as United States have a share in it. The ore supplies to these plants come from Postmasburg and AMCOR owns a substantial interest in the mining venture also. Postmasburg manganese ores are reported to have very high Mn:Fe ratio and abnormally low phosphorous, which ultimately results in the production of ferromanganese of the type indicated above.

Under the circumstances explained above, it is rather difficult for India to make any headway in her exports of ferromanganese to the West European countries.

CONCLUSIONS

The conditions obtaining in various consuming markets of ferromanganese, discussed in some detail in this paper, suggest that the chances of augmenting the exports of Indian ferromanganese into the world trade are not bright. The U. S. S. R. is one of the leading producer of ferromanganese and its manganese resources of appropriate quality are enormous in size. All the requirements of U.S.S. R., present and future, as also those of most of the East European countries can be conveniently met with from the production in U. S. S. R. itself.

The Western Europe produces almost all of its requirements from the ores imported from various sources. The only outside country of any significance entering this market is the Union of South Africa. The South African ferromanganese is preferred all over the world because of its very high quality and competitive price.

The requirements of U. S. A. are likely to increase considerably in future years in relation to its steel production. There is a good chance for India to export more of ferromanganese into this market, provided prices and quality of Indian ferromanganese is made competitive.

The other important country where exports could be increased in future years is Japan, which is expanding its steel industry very briskly. Japan has already started to turn to India for ferromanganese as the indigenous production of this alloy could not cope up with the requirements of the steel industry during the year 1967. The
steel expansion programmes in Japan are ambitious and it is time that India should make efforts to increase her exports into this market, both from short and long range point of view. Incidentally, it may be mentioned that Australia is fast coming up in her manganese ore and ferromanganese production and it might prove a keen competitor in the Japanese market.

The other prospective markets of Indian ferromanganese in limited quantities could be the other Asian countries, as and when they begin or increase their steel production.
Undergraduate Teaching Vis-A-Vis Research and Post-Graduate Teaching in Engineering Colleges in India

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These days much is being talked of research and post-graduate courses in almost every engineering college. A good teacher devoted entirely to his job of teaching the undergraduate classes is considered to lack something vital, if he has no research project to talk about, or no post-graduate course to run or participate in. Similarly a College is considered inferior if it lacks these things. At the same time, there is a tendency to rate a person who can claim that he is doing research or conducting a Post-graduate course higher than the sincere Undergraduate teacher, regardless of what attention the former devotes to his undergraduate teaching or how he carries his teaching work load (which by virtue of his being a postgraduate teacher is much lower for him) or the sort of lecture he delivers to his undergraduate students. I think it is about time now when it is necessary to take a second look at this question and think of how the position ought to be.

That raises the fundamental question as to what the main job of the average teacher in an engineering college or rather that of the colleges themselves is or must be. It is clear that the main job of the engineering colleges is to turn out engineering graduates who would handle efficiently and confidently the industries of the country, i.e. who would handle jobs of construction, maintenance, erection, production, planning or execution. In short, it should be to maintain and raise the standard of the finished product to make it more acceptable to industry. The jobs involving design and research form only a small percentage of the sum total of all engineering jobs and hence only a few engineers specialised in these two branches are needed at any time.

Considering the output of the various I. I. T S. and the P. G. courses at some colleges, production of this category of engineering personnel as regards quantity can be said to be well or more than cared
for today. If it is accepted that the bulk of the product of engineering colleges is eventually going into execution jobs which do not require the higher technical knowledge of today's Masters' degree holders, it follows that the main job of the faculty of an engineering college is to concentrate on undergraduates and train them in such a way that their fundamental ideas are clarified, they understand the relationships between the broad sub-branches of the field of engineering they have chosen and also the relationships with the other branches for handling jobs of their own field. The question of training a large percentage of students not to speak of bulk of them for research or for P. G. Courses, simply does not arise. Besides, the country cannot afford this expenditure and is not expected to be in a position to do so for quite some time more.

Now let us turn to the matter of research. What is research in the first place? Oxford dictionary defines it as "careful search or inquiry after or for" or "Endeavour to discover new facts etc. by scientific study of a subject, course of critical examination".

If 'careful search' is taken as the only meaning of the word research, it would certainly be acceptable to all and every teacher in engineering could be expected to conduct such research, i.e. careful search in whatever job he does, e.g. for teaching a subject better, he would always be expected to consult books or try to spot out actual things in the field which would clarify a point in the minds of students or to devise a new apparatus. This definition however is by-and-large irrelevant in the context of what goes on generally in the name of research as prevalent now and it is to this concept of research that objection can be taken. The primary objection to much of the research work is regarding choice of the subject, which generally is so obscure that there is hardly any application thereof to industry, immediately or in foreseeable future. Sometimes, the apparatus devised is so ridiculous in relation to the objective of the experiment that one wonders what value the results would have and to what extent they would be realised in practice. The author found that some laboratories in U. S. A. and U. K. also are not free from this defect.

For those who are prepared to do research without allowing their undergraduate teaching to suffer, let us define research as critical study of some process in the engineering industry, may be regarding materials and their arrangements, the way to obtain that arrangement etc. with a view to achieve economy or get higher production. The more fundamental type of research having no immediate application or with application at a doubtful date in future, may be entrusted to the institutions primarily devoted to research.
It is now necessary to see that pre-requisites are necessary before effective and useful engineering research of the above type may be conducted.

1. Personnel: This is the most important single factor in research. It will be agreed that research is not every man's meat. Apart from possession of knowledge and thirst for it, the research worker must have aptitude and devotion to research. It is not a job which can be lightly undertaken and handled. Further, for undertaking research on a problem, it must be spotted out and understood. Many of the present staff members in engineering colleges, have hardly any experience in industry. It is therefore, extremely difficult for them to fully understand problems on which they desire to carry on research.

2. For fabricating the experimental set-ups and making modifications in it, adequate workshop facilities, good craftsmen and tools are necessary. There are seldom available together.

3. Library facilities: Excellent library facilities are essential and generally adequate facilities exist at many colleges.

4. Collaboration with Industry: Evidently the most urgent problems to select are those which industry (particularly that in the region) faces and unless there is close collaboration, obtaining of the problems, will be difficult and the type of solution desired will not be known.

5. Time available: It must be realised that research is not a job to be handled lightly or in spare time. If a teacher has been allocated full teaching load and is keen to make a good job of his teaching work, it is impossible for him to find time and concentrate on his research. With the introduction of new and numerous elective subjects and concept of projects in many Universities, the teaching staff have got to put in tremendous work to get conversant with these to do justice to teaching of these electives and handling of the projects.

6. Cooperation to a research worker from colleagues in his own department and the other departments in the College: Research is a result of team work and it is now fully accepted that the days of a lone Einstein or Newton making big discoveries are over. Any research project needs the services of several types of people and in the absence of prompt help from other colleagues on quick headway is possible for anyone.

As it is rare to have a combination of all these features at one place or for any one individual today, the futility of expecting all or most teachers to do research work will be appreciated. The position is certainly
not ripe for these things today, which is likely to continue for quite some time more.

As already stated, the need for excellence in teaching cannot be overemphasised. Good teaching involves a host of things—painstakingly prepared lectures, and notes giving clear and correct conception of the subject and above all creating in the student an interest in the subject, initiative for study and thirst for knowledge. A teacher's ability and calibre must be judged primarily from these conditions. Sometimes an argument is put up that participation in research activities i.e. (research in the prevalent sense) is a pre-requisite for good teaching. However, experience of students lends no support to this contention. A good research worker is necessarily not a good teacher and vice-versa.

If we compare the state of affairs prevailing in industries in this respect, we shall see quite a different picture. In an industry, the engineer is judged by the output of his work in relation to quality, quantity and rate. No body expects him to do any research in addition. It is therefore not understood why an engineering teacher is singled out and considered useless if he does no research but is otherwise an excellent teacher.

There is another important factor which has not been mentioned in this connection so far and looking to the developments in the country today, this factor may become the dominating one in the near future—that is the view of the students' body in this matter. With the increasing consciousness regarding their rights they are sure to demand higher quality of teaching regardless of whether the teacher does any research or not. When this happens, a teacher who is unable to deliver his teaching goods well, no matter what research he does is bound to find disfavour with the students— as a teacher in any case.

For these reasons it is felt that the trend towards encouraging research at the cost of teaching needs to be reversed. If this is not done by teachers and administrators it might be forced upon every one by student body. It is therefore very necessary to encourage good teachers devoted to their teaching work and to draw attention of his colleagues to the primary need to do so.
Problem after problem

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SYNOPSIS

1.0 In this paper the author has tried to bring out a few of the typical but unusual problems encountered during the construction of an earthen dam, a major Irrigation Project in Bhandara district of East Vidarbha viz. the Itiadoh Project.

2.0 The author has briefly described here how the problems have been overcome.

1.0 The title of this paper sounds somewhat unusual. But the author feels that it is not possible to choose a more appropriate title than this. An attempt is made in this article to bring out some of the important problems met with during the states of investigation and construction of the ITIADOH DAM in the Bhandara district. At the outset it may be clarified that the construction of the dam is yet to complete. It will take a couple of years to achieve final completion of the dam.

2.0 The brief details of the ITIADOH irrigation project are described below in order to indicate the magnitude of the project and the significance of the dam work in the entire project.

2.1 The river Garvi is a tributary of the Wainganga in the Godawari Basin. It has a catchment of 705 sq. Kkm. (272 sq. miles), with a capacity of yielding 319 MM³ (11250 mcft.) of water at 75% dependability. The average rain fall in the catchment is 1338 mms. (52-50) inches. The principal crop under irrigation will be paddy to the extent of 50,000 acres (20,235 hectares). Out of the remaining irrigation of 24,500 acres (9920 hectares), about 7000 acres (2833 hectares) will be sugarcane and the rest will be seasonals.

2.2 The dam proposed across Garvi river is an earthen dam having a central impervious soil core and casing of pervious material on either side. The surplussing arrangements consist of a fall over the surface of a
rock barrier on the left flank dressed to a slope of 0.8 to 1 and lined with concrete. The fall is through a height of about 80 ft. The energy at the foot of this fall is dissipated in a lined stilling basin of cement concrete extending for a length of about 200 ft. from the foot of the fall. The outlet is located in a rock cut on the right flank, which is filled with a masonry gravity section. This masonry dam abuts the natural hills on the right side and forms an envelope junction with the earthdam on the left side.

3.0 Prior to carrying out detailed survey and investigations to ascertain the feasibility of building an earthen dam at Gothangaon, studies on topo sheets were carried out. These studies offered a very good and tempting site since the gorge was narrow and the area to be submerged was mostly forest (please see sketch No. 1). There is adequate command to utilise the water potential created by the storage dam. There were, however, a number of problems to be tackled before undertaking the actual work. These have been briefly described below:—

4.0 The village nearest to the site of the dam is Gothangaon and the nearest town, Sakoli, a tahsil headquarter. All the distance from Sakoli to Gothangaon had to be “treked” either in a bullock cart or on horse-back. There were no roads. The cart tracks were unfordable at many places even for jeeps. Gothangaon is actually a hamlet with a few shanty huts. The area is thickly wooded and has abundant wild life. There were instances of personnel posted for this work offering either to resign or proceed on long leave because of these abhorrent conditions.

5.0 The tank basis survey was completed by the erstwhile Madhya Pradesh Government and the project estimates were submitted to the Central Government. After the reorganisation of States in 1956 the project area was included in the Bilingual State of Bombay. The project was re-examined and as a result of further studies, the project was further revised to improve its scope.

6.0 When construction was commenced some additional ‘trial bores were drilled along the dam line to more precisely locate the rock ledge along the dam line. Surprisingly enough the bores taken between ch 12 and ch. 13 did not reveal the presence of rock even upto 80 ft. depth below ground level (please see sketch No. 2). At other locations, the width of rock band varied from 30 ft to 150 ft. The rock encountered were quartzite and hence drilling in it was quite expensive. The rock was so abrasive that at places we could hardly drill 2.5 to 3 metres with one diamond drill bit. These investigations revealed that the rock dips almost
vertically on both sides of its widthwise extent. The rock profile below the overburden somewhat resembled the back of a crocodile. (please see sketch No. 3A & 3B). It can thus be imagined how it was difficult to align the dam along this crocodile’s back. This peculiar profile of the bedrock was later got confirmed by carrying out geophysical studies through the C. W. P. R. S. and the Geological Survey of India. It was also revealed that the bed rock is full of fissures and cracks. Since this was the only rock band on which the dam cut off could rest, it was imperative to devise ways & means to render this band impervious to passage of water. This item itself developed into a problem of substantial proportions. The depths to which the grouting was to be done had to be decided after a very careful study of the nature of rock fissures and the extent to which grouting of this rock would be necessary.

7°0 When the cut off trench was excavated upto the quartzite rock band and the rock surface was carefully examined, it was noticed that the rock was not only badly cracked and fissured but it had developed long tunnel like cavities at places. These cavities had, therefore, to be opened and backfilled with concrete or impervious material, depending upon their size and extent.

8°0 The Garvi river is full of coarse grained quartzite sand deposits at the dam site and almost along its course on the upstream. It was therefore a natural choice to use this cheap river sand for the upstream and downstream casing zones of the dam. When the sands were laid in layers in the casing zone, their compaction became a problem. Ordinary smooth roller was tried with little success. Use of a vibratory rollers was also considered but was not found to be of any great advantage. Rolling by a heavy track tractor over saturated sand layer was found to be comparatively cheap & adequate.

9°0 The problem of securing a sufficient supply of machinery at the project site getting their spares in adequate quantity and finally getting output from the machinery to desired standards is well known everywhere. But the gravity of this problem was more acutely on this project firstly because of its location at an out of the way place at one end of the State and secondly because of the dearth of foreign exchange.

10°0 Since the outlet and the cannal were on the right flank of the river, the spillway was located on the left flank to avoid costly cannal crossing. The rock on this flank too was a narrow band of quartzite rock. The rock in the portion where the spillway has been located was at a fairly high elevation and a portion of the hill was cut into
rock to form an approach channel at the end of which a small masonry bar in the form of an ogee is proposed to be constructed. In continuation of the downstream profile of this ogee, the rock-mass is cut at a slope of 0.8 to 1 for a depth of about 80 ft. below the crest level. This face of the rock is proposed to be lined with concrete, which will be sufficiently anchored into the mass of rock behind it, to form the downstream face of the spillway. Beyond this rock bar, on the downstream of it, there is deep overburden of clayey soil formed by disintegration in situ of the parent granite. Since the quartzite rock is a badly fractured structure, it is proposed to provide a deep grout curtain (3 rows in succession 6' to 8' apart) in this rock. To relieve the uplift pressures that might escape the curtain, vertical drainage holes 4" diam, at about 10 ft. centres, connected to horizontal runners at two different elevations on the downstream face of the cut rock, leading the intercepted drainage outside the spillway portion are proposed.

11.0 The discharging capacity of the spillway at MWL is 1928 M³/sec (68100 cusecs). The length of the weir is 85 meters (280 ft). This gives an intensity of discharge of about 240 cusecs per ft, falling through a height of about 80 ft. Since there is a deep clayey overburden immediately downstream of the toe of the spillway, the design of dissipation arrangements posed a sizeable problem. A dented apron 150 ft long, with an R. C. C. end weir followed by a secondary apron 70 ft. long and a launching apron of crated rubble extending for a length of 60 ft. beyond this secondary apron is proposed. The apron level is determined on the consideration of feasibility of excavation in Koalinite clay under subsoil water and the requirements of efficient hydraulic behaviour of the structure.

12.0 The problem of anchoring the apron slab against uplift pressures is proposed to be tackled by providing bulb-anchors in the clay below. The pore pressures in the clay are proposed to be reduced by providing sand drains. The spray walls of the spillway will be R. C. C. counterforted retaining walls subjected to heavy earth pressures.

13.0 The spillway work involves about 14,000 m³ of R. C. concrete (500,000 cfts.). The earth dam filling in the gorge portion will be about 15 mcf. The spillway concrete is being planned to be done departmentally this year and earthwork in the gorge will be done next year.

14.0 The author is thankful to Shri Kulkarni who examined this script and made valuable suggestions.
CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEY

OTTAWA

Mineral Resources Internal Report

MRI 171/63

NONFERROUS MINERAL EXPLORATION

By

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Indian Bureau of Mines

Mineral Resources Division

December, 1962
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INTRODUCTION

This report is one of a series of projects completed during a period of study with the Mineral Resources Division, Department of Mines and Technical Surveys, Canada under a Colombo Plan award administered by the External Aid Office of the Canadian Department of External Affairs.

The report deals with procedures followed in North America in mineral exploration with special reference to non-ferrous metals. The part played by government departments, commercial survey companies and mining companies is outlined. A chapter is also devoted to problems of expenditures on exploration.

It is anticipated that this small piece of research work may be of help in planning exploration programmes in India.

Author's visits to the leading commercial survey companies; some mining companies; British Columbia, Saskatchewan, Ontario and Quebec geological sciences departments, arranged by the Mineral Resources Division were of considerable help. Guidance and assistance received from Mr. R. B. Toombs, Head of the Mineral Economics Section and other officers and staff of the Mineral Resources Division is heartily acknowledged. The author is indebted to officers of the Geological Survey of Canada for assistance relative to Chapter III.

SUMMARY

During recent decades the mining industry has been facing a great transition in exploration. The pioneer era of numerous outcrop discoveries is no more. At present many common metals are being sought in blind orebodies which show no trace at the surface. This calls for the application of modern scientific tools in exploration rather than dependence on old-time prospectors.

Procedures Used by Commercial Survey Companies

A complete exploration programme is generally tackled by a survey company in the following sequence:

1. Simultaneous flying of colour and black and white aerial photography of the area;

2. Geologic interpretation of the aerial photography;

3. Field-checking and editing of the photogeologic interpretation;

4. Combined airborne magnetometer and scintillometer geophysical survey of the area;
5. Geological interpretation of the airborne geophysical data;

6. Geochemical survey comprising the selection and analysis of selected alluvium, rock chip and water samples;

7. Reconnaissance geologic mapping in areas selected from the history of the area, photo-interpretation, airborne geophysical data and the geochemical data;

8. Reconnaissance ground geophysical surveys, including the use of ground magnetometer in areas selected from the results of steps 1 to 7.

9. Detailed geological mapping at a scale of 1:5,000 in areas selected from the results of steps 1 to 8;

10. Diamond drilling on specific targets selected from the previous steps.

Details of the structure, functions and some recent mineral development work of Hunting Survey Corporation Limited, Spartan Air Services Ltd. and Canadian Aero Services Ltd. are included.

**Procedures Used by Mining Companies**

A mining company engages itself in exploration activity in the following way:-

1. By purchasing mineral prospects from a prospector or a syndicate;

2. By purchasing mineral property from a company engaged in exploration work only;

3. By employing trained prospectors;

4. By organizing prospecting programmes on a large scale.

The role of each of the above is given. Organized prospecting programmes by larger companies is tending to be the most predominant procedure in view of the new techniques of exploration and large investment. **Joint exploration ventures** for domestic and foreign deposits is a common procedure in the United States.

The work of some major companies of Canada such as International Nickel Company of Canada Ltd., Falconbridge Nickel Mines Ltd. and The Consolidated Mining and Smelting Company of Canada Ltd. is given.

The exploration work leading to the discovery of Pine Point lead-zinc deposits, Lynn Lake nickel deposits and Craigmont Copper deposits, is outlined.
Government Procedure

The government does not involve itself directly in mineral exploration. But it does provide base-maps of all types from which intelligent exploration programmes may be planned. Also research and testing facilities are provided. The use of photogeology and aeromagnetic maps in mapping is common. Helicopter operations have made it possible to cover large inaccessible areas for mapping. These methods are described. Research work in geophysics and geochemistry being carried out in the Geological Survey of Canada is outlined. The survey has also taken up the study of Canadian Metallogenic provinces. Large scale mapping on 1" = 1 mile scale of promising deposits is also done by the Survey. Provincial departments compile maps of various mining districts on 1" = 500 ft.

Expenditures on Exploration

Cost categories of an exploration programme and cost figures for most of the exploration methods are given. Additional Free World statistics of geophysical activities such as man-power utilization and expenditures are shown in tabulated form.

The cost of exploration varies directly as the anticipated value of the discovery and the probability of making the discovery. Callaway's formula $C = RN$ is discussed where $C$ = the maximum amount that can be spent economically on a given exploration project.

$R$ = the estimated probability success which is expressed as a fraction whose numerator is the number of discoveries and whose denominator is the total number of attempts to make a discovery.

$N$ = Discounted net value of the return.

Government Incentive for Exploration

Legal, financial and technical incentives given by the Canadian and United States governments are analysed. Mining legislation and taxation are briefly discussed and more fully dealt with in a separate report prepared by the author. Mention is made of depreciation, depletion, pre-production allowances and tax exemptions. Financial assistance given to prospectors and loans given to private companies are shown to be of significance. Government participation in building roads, rail roads, air-strips etc. is described.
CONCLUSIONS

Search for "blind orebodies" calls for re-orientation of exploration management and technique.

Smaller companies will do little in modern exploration. This activity is tending to be concentrated into larger firms with capacity for large investment and maintenance of efficient exploration personnel. Joint ventures in exploration are also becoming common.

It is advantageous to prepare regional geological, metallogenic, geochemical and geophysical maps and evolve hypotheses of ore-localization for testing. This narrows the area for detail examination, which may consist of large scale mapping, ground geophysics and geochemistry followed by drilling. The suitability of a geophysical or geochemical method will depend on the nature of the problem. These methods at present, however, are ineffective beyond a few hundred feet.

The technique of geological mapping has considerably improved during the recent years. Increasing use is being made of photogeology and aeromagnetic maps.

Exploration may be conducted over large areas testing all possible ore indicators, and finally locating the deposits by diligent skimming process.

It is essential to keep a tab on investment and possible return. Every expenditure must have a justification. It is necessary to re-assess the situation at every stage and resort to progressive expenditure as explained in Chapter IV.

The government should provide conducive mining laws to attract private capital and give necessary tax incentives, particularly those measures which permit a mining company to obtain early and complete recovery of its capital investment.
CHAPTER I

PROCEDURES USED BY COMMERCIAL SURVEY COMPANIES

The survey companies in Canada are specialized agencies in the fields of photogrammetry, soils, geology, forestry, geophysics, route and site location, geodesy, surveying and cartography. The equipment used includes precise, new aerial cameras, stereoplotting instruments, electronic computers, magnetic, electrical, seismic and resistivity sets and electronic surveying instruments.

In the mineral exploration field the methods used by these Canadian companies are largely based on photogeology and geophysics. However, the actual type and amount of work depends on the terms of their contracts with mining companies and government departments, both within and without the country. Their services are very much sought after in foreign countries so much so that many subsidiary companies have sprung up in various parts of the world.

It may be noted that these survey companies do not hold claims or leases in any area. They render their services on behalf of their clients.

A complete exploration programme is generally tackled by a survey company in Canada in the following sequence:

1. Simultaneous flying of colour and black and white aerial photography of the area;

2. Geological interpretation of the aerial photography;

3. Field-checking and editing of the photogeologic interpretation;

4. Combined airborne magnetometer and scintillometer geophysical survey of the area;

5. Geological interpretation of the airborne geophysical data;

6. Geochemical survey comprising the selection and analysis of selected alluvium, rock chip and water samples;

7. Reconnaissance geologic mapping in areas selected from the history of the area, photo-interpretation, airborne geophysical data and the geochemical data;

8. Reconnaissance ground geophysical surveys, including the use of ground magnetometers and Afmag equipment in areas selected from
the results of steps 1 to 7;

9. Detailed geological mapping at a scale of 1:5,000 in areas selected from the results of steps 1 to 8;

10. Diamond drilling on specific targets selected from the previous steps.

The combination of photogeology, airborne geophysics, geochemistry, geologic mapping and ground geophysics narrows the search and the subsequent drilling to the area of maximum commercial potential. However it is only rare that the commercial survey companies are asked to perform all the steps.

The details of the structure and functions of the chief survey companies in Canada are given below:-

**Hunting Survey Corporation Limited**

**Structure**

Head Office: - 1450 O'Connor Drive,
              Toronto 16, Ontario.

President and Director: - D. N. Kendall
Vice-President and Director - Marketing: - W. H. Godfrey
Director and General Manager: - D. C. MacKay

Hunting Survey Corporation Ltd. is a private company incorporated under the laws of Canada. It is one of the world wide Hunting Group of Survey Companies. It may be noted that International Hunting Group consists of an extensive complex of companies engaged in the fields of shipping, oil-marketing, manufacture, aviation, air, ground and resource surveys.

The survey side of the business has two main bases, England and Canada. The London based companies have associations throughout Europe and Africa, while the Canadian company has branches in the United States and Latin America. The Canadian company was formed in 1960 to integrate the services of three former companies in the group, namely, The Photographic Survey Corporation Ltd., Hunting Air-borne Geophysics Ltd, and Hunting Technical and Exploration Services Ltd. Total staff of the company exceeds 350 of which one-fifth are professional scientists and engineers including geologists, geophysicists, forestors, agriculturists, physicists and civil engineers.

The company is equipped with the latest photogrammetric survey and geophysical instruments and operates some 20 aircraft.
Services

Air Operations - Aerial photography, air-borne geophysics, control surveys with Airborne Profile Recorder (APR) and electronic distance measurement, helicopter services, air transport.

Survey Operations - Geodetic surveys, control surveys, photogrammetric maps and mosaics, topographic surveys, cadastral surveys, tax mapping, engineering surveys, route location, earth-quantities, micro-wave path proving, pipeline surveys.

Geophysical Surveys - All types of airborne and ground geophysical surveys and interpretation including airborne and ground magnetics, airborne and ground electromagnetics, gravity, shallow seisms, water-borne seisms, induced polarization, resistivity, Afmag, Turam, Ronka.

Resources Surveys - Geological services, forestry, soil surveys, land use and land capabilities surveys, hydrology.

Some Examples of Work Related to Mineral Development

(a) The Canadian Arctic

In 1958 the company was awarded a contract by the Canadian Department of Mines and Technical Surveys to photograph 220,000 square miles stretching from Frobisher on Baffin Island to the most northerly tip of the American continent on Ellesmere Island. This was successfully completed in three years using two B17 Flying Fortress aircraft with logistic aircraft support. The operation called not only for the provision of air-photography, using the latest precision cartographic cameras, but also for the obtaining of a simultaneous Airborne Profile Recorder (APR) record, to provide vertical control for subsequent mapping.

(b) Ceylon and Pakistan Resources Surveys

In 1952 the Canadian government, under Colombo Plan, agreed to support a resources survey of West Pakistan to cost over $3,000,000, and subsequently in 1955 a similar operation was started for Ceylon. The Pakistan Survey called for geological mapping of 160,000 square miles and for a land use and soil survey of 110,000 square miles. The first step was obtaining aerial photography of the whole of the West Pakistan, some 298,000 square miles. This was followed by four years of photographic interpretation and field work. Finally there was a two year period of compilation and map printing. A geological map on 1" = 4 miles scale was compiled.

In Ceylon the first step was aerial photography of the whole country followed by land and water resources surveys which also included geology. In support of geology, airborne and ground geophysical surveys assisted in evaluating economic possibilities.
(c) The Mattagami Mines Project

In April 1957 Hunting Survey Corporation was commissioned by the Mattagami Syndicate to carry out an airborne geophysical survey of a six hundred square mile area of Northwestern Quebec.

The survey was carried out using a Canso aircraft fitted with a Gulf airborne magnetometer and with the Hunting electromagnetic system measuring phase shift at two frequencies, 400 C. P. S. and 2,300 C. P. S. Flight line spacing was 1,320 feet and flying height 500 ft. The flying was completed in five days. A strong magnetic and electromagnetic anomaly was drilled which proved massive sulphides of zinc, copper and silver under 50 ft. of clay. Subsequent intensive exploration has revealed four additional orebodies in the immediate vicinity of the discovery. Total tonnage is now 30,000,000 tons grading 12% zinc, 75% copper, 0.02 oz gold and 1.25 oz silver. A little further afield three more promising discoveries have been made.

(d) Resources Development, Chile and Peru

A main planning objective of the Peruvian Government is the development of a region called "Peru via". This covers 100,000 square kilometers lying on the east slopes of the Andes. The ground height in the area varies from 1,500 ft. (450 m) to 15,000 ft. (4,500 m), giving a considerable range of soil and climatic conditions. The company's work in the area entails aerial photography, provision of control, topographic mapping, selection of access routes, geology, forestry and soils mapping and hydrology.

The company's work in Chile has included the obtaining of part of the air photography, airborne geophysics and photo interpretation.

(e) Operation Overthrust

Operation overthrust is a compilation at a scale 1" = 1 mile of aerial photography and geology over an area of 350,000 square miles extending from Lake Winnipeg to Lake Misstassini, Canada. It is primarily an attempt to provide a bibliography of geological data compiled to-date and to integrate this information with the result of geological interpretation of aerial photography over the same area. Approximately 15,000 photographs were examined stereoscopically and the observed structural data transferred to translucent overlays and to mosaics. In editing this data down to 4 miles and again to 8 miles to one inch, a number of interesting regional structural anomalies have been observed which may add to the knowledge of the tectonics of Canadian Shield.

(f) Aeromagnetic Survey of a Part of the Canadian Shield

The company is carrying out the above work on behalf of the Department of Mines and Technical Surveys.
Spartan Air Services Limited

Structure

Head Office: - P. O. Box 3508, Station C, Ottawa, Canada.

President: - W. P. McGill
Vice-President: - J. A. Roberts
Associate Companies: - Toronto, Calgary, Nairobi, London

Spartan Air Services Ltd. was formed in 1946. Formerly it was an aerial photography company with only eight employees. Now it employs over 400 personnel and operates more than 50 aircraft and helicopters. Its associate and subsidiary companies work in Calgary, Toronto, Nairobi and London.

Services

**Helicopters** - Charter and contract flying, flight instructions, Bell helicopter maintenance and repair.

**Engineering** - Airborne geophysical surveys mainly magnetometer, electromagnetometer and scintillometer; aerial photography; photogrammetry; photo interpretation; resource surveys including structural geology, forest inventory and overburden and soil analysis; land use surveys; cadastral surveys; electronic surveys including high precision shoran and airborne profile recording; tellurometer surveys; photo-lab processing and photographic reproduction.

**Examples of Work Related to Mineral Development**

The company's experience includes:- 3,100,000 square miles of photography in Canada, U. S. A., Colombia, Trinidad, Honduras, British Guiana, Malaya, Kenya and the Caribbean.

1,400,000 line miles of airborne geophysical survey in Canada, U. S. A., India, Malaya and the Phillipines.

40,000 hours of helicopter flying in Canada and Kenya.

1,300 miles of route and site survey for rail-roads, highways and micro-wave relay chains in Canada.

Spartan has played a major role in locating important iron ore finds in Ontario, Quebec and Labrador. It has also defined the Allard Lake ilmenite deposits and contributed substantially to Canada's nickel exploration.
The new centre of Canadian Aero is located in a 25,000 sq. ft. building near Uplands Airport, Ottawa, Canada.

Founded in 1948 it offers a broad survey capability in Canada and abroad. The company is an affiliate of Litton Systems (Canada) Limited and is part of the Aero Group with associated companies in Madrid, Tehran, Sydney, and Philadelphia. Its subsidiaries include Canadian Aero Mineral Survey Limited, Toronto and Service Aéronautique Canadien du Quebec Limitée, Montreal.

The services of the company include aerial exploration for minerals and engineering projects. The company has more than 2,000,000 line miles of experience in aerial surveys for oils and minerals around the world. At present the company is working in Surinam, British Guiana, Mexico, Ireland, England, Australia, Turkey and Egypt. The work essentially consists of photogrammetry, photogeology and geophysics.

A brief summary of Aero services capabilities as an organization is as follows:

1. Preliminary studies of engineering soils and geology for highway location, by photo interpretation, geophysical and field methods.

2. Consultants for planning surveys and maps.

3. Aerial photography: high altitude for reconnaissance; low altitude for detailed mapping; oblique photos and phot-maps for public relations use.

4. Mapping on larger or smaller scale, with engineering accuracy, to establish highway centre line, cross sections and profiles, engineering and construction information.

5. Detailed studies of engineering soils and geology for highway design-drilling, sampling, testing and engineering reports.

6. Geodetic surveys to establish positions and bench marks.

7. Property surveys and detailed surface and sub-surface surveys and investigations.

8. Relief models for special displays and presentation.

To perform this work the company has available a good staff of professional engineers and technicians. They are specialists in the fields of photogrammetry, soils, geology, forestry, geophysics, route and site location, geodesy, surveying and cartography as applied to a wide variety of engineering requirements. The equipment used includes precise, new aerial cameras,
stereoplotting instruments, electronic computers, seismic and resistivity sets and electronic surveying instruments.

CHAPTER II

PROCEDURES USED BY MINING COMPANIES

A mining company engages in exploration activity in the following way:-

1. By purchasing mineral prospects from a prospector or a syndicate.

2. By purchasing mineral property from a company engaged in exploration work only.

3. By employing trained prospectors.

4. By organizing prospecting programmes on a larger scale.

Each of the above is described below in a greater detail.

1. Individual Prospectors or Syndicates

An individual prospector used to finance himself or was provided with a 'grubstake' by a backer on the condition that the supplier would have half interest in anything found. The grub-stake meant the provision of groceries or the money to purchase them. The British Columbia provincial government still grants grub-stakes up to $300 for food, shelter and clothing plus $200 travelling expenses. No interest, however, is retained by the government in any discovery made by a grub-staked prospector who is free to stake claims and dispose of them as he desires. The grub-stake supplied by a backer is not popular now as the expense of travel and equipment tends to make this prohibitive. This has given place largely to syndicates, several backers joining to pay the expenses of one prospector or more. The prospectors are experienced in the art of prospecting.

In an ordinary syndicate the money required is estimated and divided into equal units. The members may take an equal or unequal number of units and the prospector is apportioned the share agreed upon. In the event of success the claims might be sold and the proceeds apportioned on the basis of the number of units held by the members. If it is decided to form a company, each unit would be exchanged for a certain number of shares in the company.
The syndicate generally does not have financial and technical resources to undertake more than the preliminary exploration of a prospect. The mining companies on the other hand, are qualified to do such work.

Most mining companies are anxious to acquire promising prospects, but they do not buy a prospect outright because of the risk involved in it. The usual procedure is to take an option by a legal agreement on payment of certain cash. The company then undertakes exploration work for a certain period of time, after which it may either abandon the property or buy it for a specified sum in cash or a specified number of shares, or both.

Several companies interested in acquiring prospects employ scouts who tour mining camps and prospecting fields, keeping in touch with prospectors and discoveries.

2. Companies Engaged in Exploration Work

There are some companies which specialize in acquiring prospects, exploring them and, if the results are successful, selling them to mining companies. But such companies are not many. This procedure does not appear to be very common although some companies have been very successful in this type of activity.

3. Employment of Trained Prospectors by Mining Companies

Many mining companies employ experienced prospectors in the hope that they will discover new deposits to increase the holdings of the company or to take the place of the parent mines when they become exhausted. In addition to monthly salaries, the prospectors are supplied with all necessary equipment, groceries and funds for travelling. Very little supervision is exercised on their work. In the event of a discovery the company usually pays a specified bonus that meets certain specifications, or gives the prospector a certain share in the profits from a discovery that eventually proves productive.

4. Organized Prospecting Programmes

The tendency now is to have organized prospecting schemes by the companies. Many companies have experienced geological staff but few of them have the adjunct departments such as geophysics and drilling. For these methods of exploration, contract services are given to the companies or firms which specialize in them.

Organized prospecting is conducted in a favourable area without acquiring ground beforehand, or on concessions or groups of claims under the supervision of an experienced geologist who may be assisted by other geologists or engineers. Actual prospecting is done by teams each composed of two experienced prospectors or of one experienced man and one trainee. Payment is generally by salary but there is usually some form of incentive bonus. The
supervisor selects an area which is prospected by a team. The supervisor visits the area and either instructs the team how to continue in that area or moves them to another. Ordinary prospecting is combined with geological mapping, geophysical surveys or some of the other special methods of prospecting.

It appears worthwhile to give below the details of the work of the geological departments of some of the leading mining companies of Canada.

International Nickel Company of Canada Limited,

Geological Department

The geological department consists of two divisions: mine geology which serves all operating mines; and exploration and research which handles all surface and laboratory work.

Mine Geology

The duties of the geological staff at each mine are (i) to provide the necessary geological information for efficient mining, (ii) to discover new facts about ore localization, and (iii) to use the new information in the search for ore in the given mine. Mine exploration consists of (i) reconnaissance exploration, (ii) development exploration, and (iii) routine exploration. Reconnaissance exploration is directed to prove the lateral and downward extension of orebodies by diamond drilling. Development exploration affords the basis for the detailed delimitation and opening up of the orebodies. Routine exploration consists of miscellaneous diamond drilling to outline ore irregularities disclosed in the course of stoping.

Exploration and Research

For areas outside Sudbury district, complete information is kept and examined and field trips are arranged for the examination of promising properties. Samples received from prospectors are assayed and the results determine the advisability of visiting the property and of carrying on exploratory work.

Examination of properties in the Sudbury district generally involves the re-mapping of known showings on a large scale.

The first step toward exploring any promising prospect is mapping of the area directly on aerial photographs covered with a thin film of acetate. If the geological conditions warrant expenditure, magnetometer studies are then carried out. Anomaly contour maps are prepared on the same scale as the geological map. The maps are superimposed over each other to determine if an anomaly is significant. The area is searched for possible outcrops which may have been missed in previous mapping. A plane table map on a scale of 100 ft. to the inch is made of the chosen area and any significant
features found are tied in the regional map. The drilling is then laid out to
cross-cut the ore-bearing structure to the best advantage.

Research ranges from questions of pure science to specialized
problems of local interest. Genesis of Sudbury ores and the effective application
of accumulated knowledge to the discovery of additional occurrences is
the focal point of research.

Falconbridge Nickel Mines Limited
Geological Department

The geological department consists of two divisions: mine geology
and exploration.

Mine Geology

The duties of the staff in this department consists of providing
technical geological direction for the mine production staffs, preparing ore
statistics and reports for management, supervising and directing geological
exploration and maintaining the records for this work.

Exploration

In addition to the routine work related to mining, the department
conducts a continuing programme of exploring the norite foot-wall zone on its
claims around the irruptive in Sudbury. Exploration in the outlying districts
is also conducted. Geological mapping followed by magnetometer and elec-
tromagnetic surveying and diamond drilling is the sequence maintained in explora-
tion.

The Consolidated Mining and Smelting Company of
Canada Limited, Geological Department

The geological department consists of two groups, namely, those
working at the mine and those exploring the new prospects.

Mine Geology

The duties are to maintain grade controls, establish the limits
of mining, prepare ore reserve estimates and, in general, assure that all
pertinent geological data are collected, recorded and utilized.

Exploration

The duties are to initiate and conduct aerial studies, provide
gеоlоgісаl guidance on specific projects and employ geophysical methods. The
exploration unit assesses the chances of success in any exploration venture.
The exploration unit has regional offices and each region is looked after by exploration engineers. The exploration engineers in charge of each district with their staffs, examine properties and supervise prospecting and the initial development of properties. The main geological division plans and directs the necessary geological or geophysical programmes on properties being explored and also takes an active part in all phases of exploration.

Examples of Mining Company Exploration Programmes Leading to Mineral Discoveries

Pine Point Lead-Zinc Deposits

The ore showings near Pine Point on Great Slave Lake have been known since 1898. During the years 1928-30, the Consolidated Mining and Smelting Company of Canada Limited and Ventures Limited joined Northern Lead-Zinc Company in exploration of these deposits and about 21,000 feet of churn drilling was done but this work did not prove new orebodies in an assumed favourable geological setting, and hence the property was considered of minor interest.

In 1945 the property was again examined by the Consolidated Mining and Smelting Company of Canada, Limited and the ore showings were noted to resemble the productive orebodies in the Tri-State and other United States shallow lead-zinc fields. Mapping revealed a transcurrent fault along the south shore of the lake which, on extension, would pass near the Pine Point lead-zinc orebodies if it were projected some 50 miles west-southwest. Since there were several small lead-zinc showings near the fault it was assumed that along its length there was a lead-zinc mineral province. The area was taken on concession and exploration was directed to prove the hypothesis.

Exploration began with the drilling of cross-sections at three miles intervals along the inferred belt of mineralization, the holes on each line being about 1,000 ft. apart. The belt was explored for a length of 22 miles. Drilling provided information on the regional structure, outlined the belt more closely and indicated that the best mineralization was in the coarse dolomite member. Cross-sections were then drilled at intervals of one mile and parts of the area were filled in to give grids of hole at 1000 ft. intervals. At the same time close drilling was done at 50 to 200 ft. intervals around some of the holes that gave ore-intersections. This confirmed the general stratigraphic control of the ore. It also indicated that some of the orebodies tend to follow structural depressions and occur essentially as sheets, while others are much thicker in relation to their width and are probably related to fracture zones.

The result of the work has outlined a 22 mile long and 2-4 miles wide mineralized belt.
Lynn Lake Nickel Deposit

In 1941, Austin McVeigh, a prospector of Sherritt Gordon Mines, Limited, discovered a patch of fairly massive pyrrhotite with a little chalcopyrite near Lynn Lake. The analysis of the sample showed less than 1 per cent copper, better than 1.5 per cent nickel and no precious metals. The rock knoll was fine-grained gabbro, 200 ft. in diameter and rose about 20 ft. above the level of the surrounding muskeg. The sulphide showing was 4 feet in length and 2 feet in width. There were no other outcrops and the surrounding expanse of swamp and muskeg left plenty of room for imagination.

The area was prospected with a Tiber magnetometer which showed some anomalies. Further magnetometric work was done on strong anomaly area. Drilling started on the big anomaly at Ralph Lake. Three holes were drilled but in every case it was found that the anomaly was due to lenses of magnetite in quartzite. Drilling equipment was then moved to Lynn Lake to investigate the weak anomalies which had been picked up earlier. Drilling started on the best looking of the three anomalies, which was located in a swamp to the north of the rock knoll on which the original find had been made. This hole was drilled to the west at an angle of 45° to a depth of 470 feet. The core showed sparsely disseminated sulphides, chiefly pyrrhotite with a little chalcopyrite, obviously much below ore grade. A second hole was started 250 ft. to the north but was abandoned due to caving. The third hole was a vertical hole in the anomaly. This hole located the upper A orebody, giving an intersection of obviously good grade ore. The hole was completed at a depth of 445 feet. The area was then staked by the company. Later development of the Lynn Lake orebodies was more or less routine. Geophysical surveys, both magnetic and electromagnetic, located all the sulphide deposits which came within two to three hundred feet of surface. One or two diamond drill holes in each anomaly were sufficient to determine whether or not the sulphides were nickel bearing. The nickel-copper deposits were then outlined by closely spaced diamond drill holes, followed in most cases by subsequent underground development work. Total reserves of Lynn Lake of 14,055,000 tons averaging 1.22% nickel and 0.6% copper were established. Fort Saskatchewan nickel refinery is based on production from Lynn Lake mine.

Craigmont Copper Mine, British Columbia

The area was held under claim by Craigmont Mines. Preliminary work was done in 1954 but due to lack of funds further work could not be continued. In 1956 funds were raised and some trenching work was carried out which showed copper values around 0.8%. Finally a soil sampling programme was carried out in a selected area. Subsequent to soil sampling a reconnaissance, magnetometer survey was carried out which indicated an anomaly. Drilling was then started and two holes were drilled to a shallow depth to investigate mineralization north of the magnetic anomaly. The results were poor and the company was running short of money. It was decided to drill one hole on the magnetic anomaly. It was a vertical hole and showed mineralization comprising hematite, magnetite and chalcopyrite at a depth of 340 ft. and continued
to the end of the hole at a depth of 497 feet. The 157 ft. averaged 1.01% copper, including 50 ft. which ran 2.22% copper. Subsequently two vertical holes showed long sections of low grade mineralization. For instance hole No. 4 encountered 450 ft. averaging 0.82% copper. A hole then was started at about 500 ft. west of No. 4 hole. It encountered 530 ft. of continuous mineralization averaging 2.23% copper. The company's financial position at this stage was very bad. Due to the success of drilling programme, Canadian Exploration participated in the venture and the financial difficulties were thus eased. Drilling was resumed in 1957. Hole No. 15 encountered 640 ft. of continuous ore averaging 4.4% copper. The mine has gone into production now with the participation of several other companies.

Development of Dufresnoy Property, Quebec

The Continental Copper Mines, Limited has started exploration of the above area this year. Induced polarization and resistivity surveys have been carried out to test sulphide concentration down to a depth of about 1,600 feet. The survey, performed by Hunting Survey Corporation Limited, outlined two favourable areas for which a diamond drilling programme is recommended. In the south area, the survey outlined two I.P. anomalies, described as Zones A & B, at estimated depth of 500' and 800'. In the North area, one I.P. anomaly, designated as Zone C has been located. A drilling programme is being planned.

The purpose of giving this example is to focus attention on the depth factor which may be relevant to the Indian situation.

CHAPTER III
GOVERNMENT PROCEDURES

None of the government departments, either provincial or federal, involve themselves directly in mineral exploration except in cases of emergency. This field in Canada has been entirely left to the private sector. But the government departments, especially the federal government, contribute a great deal to the search and discovery of mineral deposits indirectly. This indirect relationship stems from the nature of job performed by these departments.

Geological Survey of Canada

The Geological Survey of Canada, a branch of the Department of Mines and Technical Surveys, is most closely connected with prospecting.
Geological Mapping

A geological map is a basic requirement for any mineral exploration party. The Geological Survey is charged with the responsibility of mapping and interpreting Canada's geology and making such information available to the public as rapidly as possible. Reconnaissance maps are prepared on 8 miles to the inch and 4 miles to the inch scale, while the detailed maps are prepared on 1 mile to the inch scale.

In effecting more coverage of area and achieving more precision, the science of geological mapping has undergone considerable change during the recent years. Greater use is being made of photogeology, helicopter operation and aeromagnetic surveys.

Photogeology

Photogeology, in its proper perspective, demands the application of accepted geologic principles to the study of aerial photography. It involves the recognition of rock types, delineation of individual beds and horizons to the greatest degree the photo will permit, measurement of attitudes by photogrammetric means, and the cohesion of these into a consistent and compatible picture. The main factors involved in the analysis of a photograph are the following:

**Topography** - Variations in topography are easily recognized on a photograph and many useful facts can be inferred from the details of topography.

**Drainage** - A drainage system is an easily discernible feature on a photograph and is an important clue in the interpretation of photographs.

**Erosion** - Erosion characteristics are useful in identifying broad soil types and in determining geologic contacts, thickness of overburden and the rock types themselves.

**Tone** - Tone is influenced by the type of vegetation, drainage etc. Thus it may serve to delineate geologic and geomorphic units. Relative tones must be considered, because of slight differences in exposure and developing.

**Vegetation** - Vegetation can often be of help in determining soil types, soil texture and rock types, by a physically or chemically influenced affinity or aversion to a rock or soil by a plant or tree.

The above aspects are looked for by the geologist, on the stereo pair, in the study and identification of a surface geological feature or land form and the nature of the rock or structure on which it is developed or which it characterizes.
In the field, mapping of an area is done directly on aerial photographs covered with a thin film of acetate.

Helicopter Operations

Geological mapping with the aid of helicopters is a new method. In 1952, it was tried in Canada by the Geological Survey of Canada and is now in use for reconnaissance mapping of the remote areas in the north where conventional methods prove to be laborious, time-consuming and expensive.

Initially the technique was used in areas presenting the minimum of operational and terrain problems to demonstrate its suitability and then adapt it to more difficult conditions.

Operations Keewatin (1952), Baker (1954), and Thelon (1955) were successfully completed. The two helicopters of each project (two Hiller 360 on Operation Keewatin, and two Bell 47D-1 on each of Operations Baker and Thelon) were used solely as low-flying observation platforms, enabling the geologists to make their observations from aircraft rather than from canoes or on foot. For greater detail, the geologists were flown a few feet off the ground or were landed to make observations. The aerial traverses radiated outward from each operating camp. About 185,000 square miles were mapped by the three operations, at an average cost of about $2.63 a square mile ($=Rs4.37). The amount of work performed in three field seasons would have taken 40 party-years by conventional methods.

In operation Franklin (1955) 100,000 square miles area was mapped at 1 inch to 8 miles scale. The operation required range and load carrying aircrafts and had to be capable of landing where and when required on islands devoid of lakes or landing fields. Two Sikorsky S-55 helicopters were used. Cost per square mile came to slightly more than $3.00.

In 1954 a Bell helicopter was used by a party assigned to 1-mile mapping in northern Cape Breton Island. The aircraft was mainly used for transportation of geologists and the time thus saved enabled them to do in one season what would otherwise have required four to six.

A thirty day trial was made for a helicopter assisted mapping in the Pitt Lake area near Vancouver on 4-mile to the inch scale. The experience gained was later applied in planning Operation Stikine (1956). It required mapping of about 25,000 sq. miles of northwestern British Columbia on a scale of 1 inch to 4 miles. The area included a variety of terrain. Five separate mapping parties and one administrative party were organized, each equipped with two way radio. Each field party used its own working technique to fit the peculiar geological and geophysical requirements of the area allotted to it. A wide variety of operational experience was thus obtained for comparison, evaluation and adaptation for future mapping projects in the mountains. Aircrafts were used mainly for transportation. The work was done at a considerable speed but the map produced was more erratic than it would have been.
had the mapping been done more slowly by a number of smaller parties working by conventional methods. Current plans for other major helicopter-assisted projects in the western Cordillera are to extend these projects over two or more field seasons, to obtain readily accessible and key geological data during an initial reconnaissance season with support from light, relatively inexpensive, fixed wing aircraft, and thereafter to make full use of helicopters to map rapidly the remaining less accessible areas by applying the key data obtained during the previous reconnaissance season. These proposed modifications are expected to result in better economy and increased quality, at some sacrifice in speed.

The objectives of operation MacKenzie (1957) were to obtain and collate precise stratigraphic data from appropriate points throughout the river basin and adjacent mountains and to prepare geological maps of the plain areas on scale of 1 inch to 8 miles and the mountains on a scale of 1 inch to 4 miles. The helicopters were used for traverses and transportation. About 100,000 square miles were mapped and approximately 225,000 feet of stratigraphic section measured and studied in detail. The cost came to about $1.68 a square mile.

In the operation Fort George certain modifications were made in helicopter mapping. Only one helicopter with three geologists was used. The coverage was 35,000 square miles instead of 60,000 square miles each field season. Instead of radial flights, parallel flights at 6 miles interval were introduced. The cost came to $2.03 a square mile. Although the coverage was low, it was possible to assemble and compile geological data as rapidly as it accumulated. The system of parallel traverses achieved excellent uniformity of geological coverage.

The above are some examples of major helicopter mapping projects in Canada. The usefulness of the technique has been proved beyond doubts. As far as the logistics are concerned, it is believed that no overall advantage would be gained by using larger parties or more than two helicopters to a party. Better results at equal or less cost might be had from relatively modest parties of simple flexible organization, taking full advantage of a season or two of preliminary reconnaissance prior to the expensive helicopter phase.

**Geophysics**

The federal government has in hand an $18 million aeromagnetic survey programme of the Canadian Shield. The expenses are to be shared equally by the federal and the provincial governments concerned. The project will take twelve years to complete and cover 1,800,000 square miles and involve 3,600,000 line miles of flying. The survey work has already started and the commercial survey companies have contracted to carry out the work. Aeromagnetic maps have proved of great help to geologists for mapping purposes. The geophysical section of the Geological Survey of Canada makes available to the geologists the results of aeromagnetic surveys
in an area before the geologists start mapping in that area. The information gained from aeromagnetic surveys and used in conjunction with the results of ground geological surveys is useful in delimiting those areas favourable for mineral occurrences. During the past decade aerial surveys on a much smaller scale have brought to light the base-metal wealth of the Mattagami area of Western Quebec and the large iron ore deposits at Marmora in southeastern Ontario.

Two additional aeromagnetic surveys not connected with the above have been carried out. One of these, comprising some 30,000 line miles covered an area in the high Arctic extending some 200 miles out over the Continental Shelf north of Ellef Ringnes Island and south an equal distance to just north of Bathurst Island. The purpose of this survey, which is to be carried out on a contract basis in connection with the Continental Shelf Project, is to assist in exploring the geology of the area, and to provide general background data for possible future exploration by industry. The data obtained from out over the Shelf are of long term scientific interest and will aid in understanding the geology of the arctic basin and its relationship with that of the North American Continent.

The second project is to test the feasibility of conducting aeromagnetic surveys in areas of steep topographical relief, using special magnetometer equipment developed by the Geological Survey of Canada.

The geophysicists of the Geological Survey of Canada are working on aeromagnetic interpretation, palaeomagnetism and magnetic properties of rocks, seismic reflection and refraction, electrical studies for ground water and radio frequency measurements as a means of mapping near surface conductivity.

The geophysicists of the Survey cover two aspects of work in aeromagnetic interpretation: interpretation of aeromagnetics over sedimentary basins, which is largely a matter of mathematics, and interpretation over areas of intrusives and metamorphic rocks. Reference has been made to the magnetometer equipment developed by the geophysical section for use in areas having steep topographical relief. Research is also continuing on a method to do away with the weighty and bulky transmitting coil required in airborne electromagnetic methods.

**Geochemistry Applied to Mineral Exploration**

Geochemistry is a valuable complement to geological mapping, and is an important modern technique for the exploration of metalliferous deposits and oil and gas pools. The basic principle of geochemical prospecting is the detection of dispersion patterns. Essentially the methodology in an operation consists of the following:—*

(1) Orientation survey in the vicinity of known ore-deposits to find clues to the type of expected anomaly, the most effective geometric pattern for sampling, maximum spacing and the likely expenditure on the survey.

(2) The adoption of that sampling pattern which would fit the geometry of the expected anomalies.

(3) Spacing of samples such that no anomaly is overlooked.

(4) The choice of constituents to be determined in a sample.

(5) Preparation of a geochemical map plotting (i) spurs and crests of ridges (ii) drainage of the area (iii) sample locations (iv) values of the samples (v) simple geological information. If possible the geochemical data should be contoured by drawing isograds or lines of equal composition. It is commonly found that the only useful contour that can be drawn on a geochemical plan is the threshold contour separating areas of anomalous values from areas of background values.

(6) Finally the interpretation of the map which depends on answering the following questions:

(i) How do the anomalies form?

(ii) What is the threshold value of the anomaly?

(iii) What can cause false anomalies?

During recent years geochemical prospecting has been followed quite actively in Canada, although, in the beginning it was thought to be ineffective due to the preponderance of glacial drift. Many mining companies now employ this method in metal exploration. The Geological Survey of Canada is engaged in developing field and laboratory methods for geochemical prospecting.

In the laboratory, research is continuing to develop new chemical and spectrographic methods of analysis and to improve the accuracy range, sensitivity and speed of existing methods. Some of the basic research have been listed in Chapter V.

In the field, the work done in Nova Scotia has helped directly to define geographical areas and geological environments for base-metal prospecting. The fundamental geochemical studies carried out in the Yellowknife area of Northwest Territories helped to assess the source of gold and other elements
and the process causing their concentration in ore-bodies in the area. A party has recently carried out a study of the distribution of uranium in natural waters in an area of about 1,000 sq. miles around Bancroft, Ontario. High values obtained in waters sampled near uranium ore-bodies decrease rapidly to background levels away from the ore-bodies and offer narrow targets for prospecting. Geochemical prospecting methods for petroleum and natural gas have been studied with the collection of samples over oil and gas pools in southern Ontario and Alberta. Preliminary laboratory analysis of some of the samples by gas chromatography indicated anomalous amounts of hydrocarbons in the soil above a gas pool in southwestern Ontario and thereby provided hope for the success of the method as a prospecting tool.

Economic Mineral Deposits Investigations

The Geological Survey of Canada also conducts detailed studies of certain mineral deposits and publishes the results of investigation in the form of bulletins. The provincial governments are, however, at present more concerned with this detailed type of work. Most of their mapping is done on 1" = 1 mile scale with large scale mapping of selected areas on 1" = 500 ft. or 1" = 1000 ft. An interesting and useful feature of the work is that done by various resident-geologists in a province. They compile a geological map of their districts on 1" = 500 ft. scale. Compilation is done on the basis of field mapping and information gathered from the working mining companies in the area. Compilation is a continuous process to keep the map up to date.

Study of Canadian Metallogenic Provinces

The study of metallogenic provinces has been taken up by the Geological Survey of Canada and a preliminary study has already been completed. The concept is that the concentration of a metal or metals in a particular region is not an accidental phenomenon but could be explained scientifically on the basis of various geological processes. This type of research will result into outlining suitable environments of ore localization and will aid mineral exploration. At present the study is directed towards preparing maps showing the occurrences of an individual metal and then preparing a composite map of various metals. The scale of the map is 1" = 120 miles, the same as the one for the geological map of Canada. Linking up the occurrences with geology, certain important conclusions could be reached regarding ore localization. The theory of metallogenic province could further be developed by detailed sampling and field work which will be of great help in mineral exploration.
CHAPTER IV
EXPENDITURES ON EXPLORATION

There are certain terms in use in the mining industry which will have to be clarified before examining the financial implications of an exploration programme. The United States Bureau of Mines offers the dictum that 'Prospecting is the search for ore, and exploration is the work involved in gaining a knowledge of the size, shape, position and value of an orebody. Development is the preparation of a mine for ore extraction'. It is difficult, however, to draw a hard and fast line of demarcation between 'Exploration' and 'Prospecting'. The best definition of exploration appears to be that offered by Dewar\textsuperscript{1} - "The whole gamut of activities relating to the acquisition of knowledge essential for exploitation of mineral wealth constitutes mineral exploration. These activities can be conveniently divided into a number of stages such as regional reconnaissance surveys, detailed investigation of mineralized districts, preliminary appraisal of prospects and detailed exploratory and proving operations in selected prospects". In this definition prospecting and exploration have been merged together and this is logical both scientifically and for cost accounting purposes. It is also necessary to pin-point the dividing line between 'exploration' and 'development' for the purposes of cost-accounting. A practical criterion given by Preston\textsuperscript{2} appears to be adequate - "Probably the most satisfactory theoretical standard here would be to include as exploration costs all expenses, other than purchase or long term leasing of mining sites, which are made in advance of the management decision which establishes the size of the capital plant and the annual output of the mine. Once this decision is taken, then further activities can be thought of as the preparation of the site for operations at this stated rate, and thus constituting development rather than exploration".

Exploration activities in an operating mine directed to "develop a ton of reserves for every ton mined" are considered expenses of capital maintenance and not as cost of exploration.

Cost Categories

The following, then, will be the broad cost categories in a mineral exploration programme.

(1) Surveying and mapping (aerial and ground)
(2) Aerial photography
(3) Interpretation of photographs

\textsuperscript{(1)} 'Exploration Methods' by H. R. Dewar, Director Indian Bureau of Mines

\textsuperscript{(2)} Exploration for non-ferrous metals, by Lee E. Preston, Resources for the Future Inc.
(4) Geophysical (air and ground) and Geochemical Surveys,

(5) Detailed geological mapping on ground of a selected area on a large scale.

(6) Drilling

(7) Trenching: hand and machine

(8) Test Pitting

(9) Drifting and cross-cutting

(10) Rehabilitation and preparatory work

(11) Road Building

(12) Trail Building

(13) Surface Clearing

(14) Sampling

(15) Shaft sinking (raises and winzes)

(16) Other work

(17) Reports

All the above categories may not be pertinent in a particular exploration programme. This will depend on the designing of the programme which, in turn, depends on geological and economic factors.

Cost figures of most of the exploration methods are shown in Tables 1 and 2. In many under-developed countries, drilling is resorted to after initial surface mapping. In such cases a usual method of estimating costs of specific exploration projects is to estimate direct-drilling cost plus 50 per cent. But the recent innovations in exploration techniques covering large areas have tended to decrease the importance of drilling costs. These innovations are geophysics, geochemistry and photogeology. No doubt, it is cheaper to dig one hole than to conduct an air and ground survey over a large area, but the unit cost of discovering deposits by survey methods is likely to be considerably less than the unit cost of finding the same deposits by more or less random digging.

Tables 3 - 6 give important data of man-power utilization and expenditures in the Free World in geophysical activities, both surveying and
research. Table No. 3 indicates that on a man–month basis, an average of 664 professionals and technical persons were employed in mining geophysics in 1960, expenditure for geophysical exploration and research amounting to $10,974 million. This table also indicates that the United States utilized the most man–power with 2,010 man–months (168 persons) followed by Europe, Japan, Canada and Latin America in that order. Table 4 shows that more man–months were employed in geochemical exploration and research than any other method. An average of 117 professional and technical persons were employed in the use of this method. It may be noted that government activity accounted for a larger share of the geochemical total. Geochemical method was followed by resistivity and induced polarization techniques, seismic method, gravity, electromagnetic, ground magnetic, aeromagnetic, self-potential and radioactivity in that order. The aeromagnetic method with a relatively high expenditure per man–month ranked first and accounted for an estimated outlay of $2,504 million. This was followed by geochemical, resistivity and seismic methods. It may also be noted that the number of man–months utilized by government organizations accounted for 61.4% of the total Free World man–power utilization in 1960 but only 34.3 per cent of total expenditures. This is due to high employment of personnel in government departments and lower expenditures per man–month.

Canada has one of the most active exploration activities in the world. Table Nos. 7, 8 and 9 contain cost figures of metal prospecting and diamond drilling statistics of Canada. The cost of metal exploration has increased from about $6,415 million in 1949 to $43,55 million in 1960. Exploration by copper–gold–silver mining companies accounts for the largest expenditure followed by nickel–copper mines; silver–lead–zinc mines; miscellaneous metals (iron, uranium, molybdenum, etc.) and gold mines in that order. Expenditures on exploration for oil and natural gas are not shown but in recent years they have been much larger than those for metals, averaging about $70 million per year. This is a minimum estimate as it relates to capital expenditures only.

Optimum Expenditure on Exploration

It will be seen from the above that the time–honoured method adopted by prospectors of combing the ground in the hope of 'striking it rich' is being largely replaced by modern scientific methods of geophysics, geochemistry, photogeology and drilling. This is due to the fact that more efforts are necessary in locating blind orebodies. As Slichter put it — "During recent decades the mining industry has been facing a great transition in prospecting. The transition is from the pioneer era when discoveries in outcrop were

(3) Geophysics applied to prospecting for ores, by L. B. Slichter, Economic Geology 50th Anniversary Volume.
relatively easy, and numerous, to the present, when many common metals must be sought in blind orebodies which show no trace at the surface. In petroleum prospecting this transition is far along. Exploration for concealed oil structures at great depth, with elaborate systems of scientific tools, is the accepted routine. In mining the problems are different and often more difficult; and the transition is still in an early stage."

In the United States today there is small chance of finding a base-metal in outcrop. This statement is a tribute to the thoroughness with which prospectors have searched accessible outcrops everywhere - the statement soon will be applicable to a wider category of metals, and to the earth as a whole. Yet for each orebody visible in outcrop, many are concealed by overburden. Only a small fraction of the orebodies available for discovery have been found. Even though the geochemical and geophysical methods have a range of only a few hundred feet, they make available an enormous volume of ground for exploration. Success in exploring this 'enormous volume of ground' would greatly increase the world's available supply of metals.

The nature of exploration problems and the techniques adopted to solve them call for well coordinated exploration programmes over larger areas to evolve hypotheses based on the study made in the area and to test them. This necessitates large exploration expenditure which is beyond the scope of a smaller company. Either the government itself or larger companies would be most suitable to do the job. Before resorting to large expenditure there will be more and more questions regarding the justification for the expenditure i.e. expenditure versus returns. It must be recognized at the outset that exploration is a high-risk enterprise and therefore investment returns are difficult to predict. Yet it is necessary to identify pertinent factors which will justify exploration expenditure and prevent wasteful expenditures of money. Not much work appears to have been done in this field. Recently Callaway has made an attempt to express by formula the factors determining permissible cost of exploration.

**Callaway's Formula**

The cost of exploration varies directly as the anticipated value of the discovery and the probability of making the discovery. Mathematically,

\[ C = RN \]

where \( C \) = the maximum amount that can be spent economically on a given exploration project.

\( R \) = the estimated probability success which is expressed as a fraction whose numerator is the number of discoveries and whose denominator is the total number of attempts to make

---

a discovery.

\[ N = \text{Discounted net value of the return.} \]

It is contended that the above formula should not be expected to give final mechanical answers with regard to exploration expenditure. But it is capable of classifying exploration projects into their relative positions of worthiness.

**Identification of Parameters \( R \) and \( N \):**

1. **Probability Success \( (R) \)**

This will be governed by the geologic factors. It will be necessary to examine diligently all the work done in the area. If it is found that the district has been examined more thoroughly in the past and the factors governing ore localizations are known, \( R \) will increase say at 1/20. If it is a virgin area or not much work is done in the area, \( R \) will have to be placed at say 1/500. Geological judgment will determine \( R \).

2. **Net Value \( (N) \)**

It is true that a hidden orebody can not be accurately evaluated but a study of the population density of mines in the region and the distribution of mines in respect to value or size will often disclose enough pertinent facts to infer a value for such orebodies that may remain, as yet, undiscovered.

**Progressive Expenditure**

It will be seen from the above that the parameters \( R \) and \( N \) are purely hypothetical in the initial stage. Hence their values should be determined with caution. This will result in a small permissible expenditure, perhaps, sufficient to test important ore indicators. After this phase of investigation, if the value of \( R \) and \( N \) increases, further expenditure will be calculated on the basis of the following formula:

\[ C_1 = R_1 N_1 - C \]

\( C_1 = \text{Permissible expenditure after reassessment.} \)

\( R_1 = \text{New probability success.} \)

\( N_1 = \text{New net value.} \)

\( C = \text{Amount already spent.} \)

Perhaps the above phase will further increase \( R \) and \( N \) and the permissible expenditure now arrived at may permit employment of geophysics and other modern tools of exploration.
The progressive re-assessment and expenditure will continue till the value of the deposit (N) is sufficiently established to justify the setting out of output goals and the construction of surface and underground facilities for regular production. Thus R = 1 may be said to mark the boundary between exploration and development.

**TABLE 1**

<table>
<thead>
<tr>
<th>Method</th>
<th>Cost (U. S. $)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aditng</td>
<td>26 per foot of which roughly 1/3 r. d. is labour cost</td>
<td></td>
</tr>
<tr>
<td>Shaft sinking</td>
<td>200 per foot with labour cost one third</td>
<td></td>
</tr>
<tr>
<td>Drilling</td>
<td>50 per foot to 25 per foot*</td>
<td>up to 1,000 ft. depth</td>
</tr>
<tr>
<td>Chrun drilling</td>
<td>2 per foot to 5 per foot</td>
<td></td>
</tr>
<tr>
<td>Diamond drilling</td>
<td>2 per foot to 8 per foot</td>
<td></td>
</tr>
<tr>
<td>Geothermal (Ground)</td>
<td>100-150 per line mile</td>
<td></td>
</tr>
<tr>
<td>Magnetic (Air)</td>
<td>Contract work for 6-10 per line mile, but company costs may be as low as $1 per mile</td>
<td></td>
</tr>
<tr>
<td>Magnetic (Ground)</td>
<td>up to 150 per line mile. For a large reconnaissance utilizing various magnetic techniques costs may vary widely but $10 per acre is typical</td>
<td></td>
</tr>
<tr>
<td>Seismic (Ground)</td>
<td>300 per day for ten observations</td>
<td></td>
</tr>
<tr>
<td>Gravational (Ground)</td>
<td>10-50 per observations, up to 60 observations per day</td>
<td></td>
</tr>
<tr>
<td>Geochemical</td>
<td>5 per observations, about 20 observations per man day; 200-500 per sq. mile</td>
<td>One of the cheapest ground methods</td>
</tr>
<tr>
<td>Radioactivity (Air)</td>
<td>6-10 per line mile</td>
<td>May be cheapest aerial method, but cost vary widely</td>
</tr>
</tbody>
</table>
Table 1 - continued

<table>
<thead>
<tr>
<th>Method</th>
<th>Cost (U.S. $)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical (Air)</td>
<td>10-20 line mile</td>
<td></td>
</tr>
<tr>
<td>Electrical (Ground)</td>
<td>450 per day, up to 1,000 per sq. mile</td>
<td></td>
</tr>
</tbody>
</table>

1 U.S. dollar = 4.75 Indian Rupees.
* A recent tabulation gives a range of $0.50 - $10.00 per foot.

TABLE 2

Representative Aerial Survey and Airborne Geophysics Cost Estimates for a Country 200,000 sq. miles in Area

<table>
<thead>
<tr>
<th>Method</th>
<th>Cost per sq. mile (U.S. $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aerial photography of the whole area at scale 1:40,000</td>
<td>5.00</td>
</tr>
<tr>
<td>2. Base map at 1&quot; = 1 mile or 1:50,000 planimetry only including the establishment of some control</td>
<td>4.00</td>
</tr>
<tr>
<td>3. Compilation of all known geology and photogeological interpretation of the whole area</td>
<td>2.50</td>
</tr>
<tr>
<td>4. Field investigations to establish rock types together with subsequent report compilation and laboratory tests</td>
<td>5.00</td>
</tr>
<tr>
<td>5. Airborne geophysical flying, including aeromagnetics and airborne scintillation contour and including interpretation of the results and compilation onto geological maps @ $25 per sq. mile, but since only 10% of the area is to be flown overall cost per sq. mile.</td>
<td>2.50</td>
</tr>
<tr>
<td>Total</td>
<td>= 19</td>
</tr>
</tbody>
</table>

1 U.S. dollar = 4.75 Indian Rupees.
### TABLE 3

Free World Mining Geophysical Activity in 1960 by Geographical Areas

<table>
<thead>
<tr>
<th></th>
<th>Manpower Utilization Man Months</th>
<th>Expenditures Millions $ (U.S.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Govt.</td>
<td>Pvt.</td>
</tr>
<tr>
<td>United States</td>
<td>1,208</td>
<td>802</td>
</tr>
<tr>
<td>Europe</td>
<td>1,234</td>
<td>639</td>
</tr>
<tr>
<td>Japan</td>
<td>1,622</td>
<td>-</td>
</tr>
<tr>
<td>Canada</td>
<td>455</td>
<td>700</td>
</tr>
<tr>
<td>Africa</td>
<td>19</td>
<td>857</td>
</tr>
<tr>
<td>Australia</td>
<td>349</td>
<td>18</td>
</tr>
<tr>
<td>Latin America</td>
<td>1</td>
<td>59</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4,888</td>
<td>3,075</td>
</tr>
<tr>
<td><strong>Per cent of Total</strong></td>
<td>61.4</td>
<td>38.6</td>
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</table>

### TABLE 4

Free World Mining Geophysical Activity in 1960 by Method Utilized

<table>
<thead>
<tr>
<th></th>
<th>Manpower Utilization Man Months</th>
<th>Expenditures Million $ (U.S.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Govt.</td>
<td>Pvt.</td>
</tr>
<tr>
<td>Geochemistry</td>
<td>1,066</td>
<td>340</td>
</tr>
<tr>
<td>Combined resistivity¹</td>
<td>631</td>
<td>703</td>
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<tr>
<td>Seismic</td>
<td>693</td>
<td>343</td>
</tr>
<tr>
<td>Gravity</td>
<td>557</td>
<td>279</td>
</tr>
<tr>
<td>Electromagnetic</td>
<td>352</td>
<td>425</td>
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<tr>
<td>Ground Magnetic</td>
<td>311</td>
<td>460</td>
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<tr>
<td>Aeromagnetic</td>
<td>331</td>
<td>333</td>
</tr>
<tr>
<td>Self Potential</td>
<td>455</td>
<td>110</td>
</tr>
<tr>
<td>Radioactivity</td>
<td>390</td>
<td>42</td>
</tr>
<tr>
<td>Other</td>
<td>102</td>
<td>40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4,888</td>
<td>3,075</td>
</tr>
<tr>
<td><strong>Research Portion</strong></td>
<td>2,817</td>
<td>342</td>
</tr>
</tbody>
</table>


(1) Includes resistivity and induced polarization. Geophysical activity includes survey research.

(2) Figure appears small, perhaps, due to inadequate coverage.

= U.S. dollar = 4.75 Induan Rupees.
### TABLE 5

Free World Mining Geophysical Activity - 1960

<table>
<thead>
<tr>
<th></th>
<th>Manpower Utilization</th>
<th>Expenditures</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Govt.</td>
<td>Pvt.</td>
<td>Total</td>
</tr>
<tr>
<td>Mining</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surveys</td>
<td>2,071</td>
<td>2,733</td>
<td>4,804</td>
</tr>
<tr>
<td>Research</td>
<td>2,817</td>
<td>342</td>
<td>3,159</td>
</tr>
<tr>
<td>Total</td>
<td>4,888</td>
<td>3,075</td>
<td>7,963</td>
</tr>
<tr>
<td>Per cent Research</td>
<td>57.6</td>
<td>11.1</td>
<td>039.7</td>
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</table>

### TABLE 6

Free World Mining Geophysical Surveys - 1960

<table>
<thead>
<tr>
<th></th>
<th>Manpower Utilization</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Govt.</td>
</tr>
<tr>
<td>Total Mining Surveys</td>
<td>2,071</td>
</tr>
<tr>
<td>Contract Portion</td>
<td>54</td>
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<tr>
<td>Per cent contract</td>
<td>2.6</td>
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</table>

### TABLE 7

Cost of Prospecting by Metal-mining Industry in Canada, by Province and Types of Operations, 1960 and 1959 ($)

<table>
<thead>
<tr>
<th></th>
<th>1960</th>
<th>Copper-</th>
<th>Silver-</th>
<th>Nickel-</th>
<th>Miscellaneous</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gold Operations</td>
<td>Gold Mines</td>
<td>Gold-Silver Mines</td>
<td>Cobalt Mines</td>
<td>Lead-Zinc Mines</td>
<td>Copper Mines</td>
</tr>
<tr>
<td>Newfoundland</td>
<td>-</td>
<td>28,092</td>
<td>385,623</td>
<td>354,094</td>
<td>-</td>
<td>686,499</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>16,686</td>
<td>91,703</td>
<td>186,350</td>
<td>17,057</td>
<td>-</td>
<td>2,587</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>-</td>
<td>286,612</td>
<td>809,925</td>
<td>669,586</td>
<td>-</td>
<td>9,327</td>
</tr>
<tr>
<td>Quebec</td>
<td>-</td>
<td>1,525,247</td>
<td>7,696,468</td>
<td>3,068,141</td>
<td>590,134</td>
<td>2,103,458</td>
</tr>
<tr>
<td>Ontario</td>
<td>42,440</td>
<td>914,549</td>
<td>3,763,158</td>
<td>26,805</td>
<td>99,036</td>
<td>2,832,077</td>
</tr>
<tr>
<td>Manitoba</td>
<td>-</td>
<td>248,231</td>
<td>2,649,070</td>
<td>11,491</td>
<td>5,171,145</td>
<td>27,655</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>-</td>
<td>2,364</td>
<td>575,099</td>
<td>20,322</td>
<td>462,622</td>
<td>18,061</td>
</tr>
<tr>
<td>Alberta</td>
<td>31,865</td>
<td>-</td>
<td>904</td>
<td>64,643</td>
<td>-</td>
<td>630</td>
</tr>
<tr>
<td>British Columbia</td>
<td>5,319</td>
<td>228,824</td>
<td>2,508,003</td>
<td>845,280</td>
<td>2,465</td>
<td>230,801</td>
</tr>
<tr>
<td>Northwest Territories</td>
<td>481,939</td>
<td>226,046</td>
<td>371,537</td>
<td>352,938</td>
<td>657,680</td>
<td>2,090,140</td>
</tr>
<tr>
<td>Yukon Territory</td>
<td>22,495</td>
<td>6,990</td>
<td>304,612</td>
<td>81,150</td>
<td>-</td>
<td>31,586</td>
</tr>
<tr>
<td>Canada</td>
<td>118,805</td>
<td>3,814,541</td>
<td>19,105,258</td>
<td>26,805</td>
<td>5,602,547</td>
<td>9,411,381</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>1959</th>
<th>Copper-</th>
<th>Silver-</th>
<th>Nickel-</th>
<th>Miscellaneous</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gold Operations</td>
<td>Gold Mines</td>
<td>Gold-Silver Mines</td>
<td>Cobalt Mines</td>
<td>Lead-Zinc Mines</td>
<td>Copper Mines</td>
</tr>
<tr>
<td>Newfoundland</td>
<td>-</td>
<td>49,646</td>
<td>33,117</td>
<td>251,038</td>
<td>-</td>
<td>568,805</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>468</td>
<td>54,283</td>
<td>90,252</td>
<td>2,007</td>
<td>-</td>
<td>8,680</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>17,577</td>
<td>275,593</td>
<td>310,385</td>
<td>73,113</td>
<td>-</td>
<td>9,513</td>
</tr>
<tr>
<td>Quebec</td>
<td>-</td>
<td>1,707,344</td>
<td>13,966,818</td>
<td>42,202</td>
<td>205,726</td>
<td>626,542</td>
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<tr>
<td>Ontario</td>
<td>-</td>
<td>1,203,466</td>
<td>3,184,028</td>
<td>45,281</td>
<td>75,738</td>
<td>2,146,916</td>
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<tr>
<td>Manitoba</td>
<td>-</td>
<td>126,883</td>
<td>2,395,300</td>
<td>400</td>
<td>8,442</td>
<td>5,264,027</td>
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<tr>
<td>Saskatchewan</td>
<td>-</td>
<td>28,211</td>
<td>408,794</td>
<td>17,724</td>
<td>188,509</td>
<td>143,202</td>
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<td>Alberta</td>
<td>32,500</td>
<td>-</td>
<td>2,605</td>
<td>44,348</td>
<td>-</td>
<td>-</td>
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<tr>
<td>British Columbia</td>
<td>3,413</td>
<td>76,945</td>
<td>1,436,069</td>
<td>737,916</td>
<td>1,043</td>
<td>280,293</td>
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<td>14,424</td>
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<td>77,094</td>
<td>-</td>
<td>2,368</td>
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<td>3,649,286</td>
<td>22,226,933</td>
<td>87,883</td>
<td>1,559,613</td>
<td>8,512,264</td>
</tr>
</tbody>
</table>

* Includes iron-, uranium-, and molybdenum-mining, etc.

Note: The amounts shown are the expenditures incurred by mining companies, as classified by their main type of metal-mining activity. These expenditures, however, apply to prospecting conducted by such companies in all sectors of the mineral industry. If, for example, a company whose chief activity is gold-quartz-mining expends funds on prospecting for lead and zinc, such expenditures are included in the column headed 'Gold Mines' in the foregoing tabulation.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1949</td>
<td>66,304</td>
<td>3,211,201</td>
<td>549,015</td>
<td>37,042</td>
<td>952,266</td>
<td>586,329</td>
<td>1,013,022</td>
<td>6,415,179</td>
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<tr>
<td>1950</td>
<td>60,550</td>
<td>2,758,669</td>
<td>801,388</td>
<td>86,010</td>
<td>575,322</td>
<td>614,377</td>
<td>456,951</td>
<td>5,353,267</td>
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<tr>
<td>1951</td>
<td>21,106</td>
<td>2,414,004</td>
<td>1,194,546</td>
<td>36,119</td>
<td>968,244</td>
<td>3,123,263</td>
<td>1,419,157</td>
<td>9,176,439</td>
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<td>1952</td>
<td>11,805</td>
<td>2,566,981</td>
<td>1,740,207</td>
<td>105,902</td>
<td>2,268,355</td>
<td>5,124,466</td>
<td>1,760,458</td>
<td>13,578,174</td>
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<tr>
<td>1953</td>
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<td>2,514,501</td>
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<tr>
<td>1954</td>
<td>35,240</td>
<td>3,399,755</td>
<td>3,188,890</td>
<td>24,733</td>
<td>6,843,897</td>
<td>6,785,804</td>
<td>6,536,916</td>
<td>26,815,235</td>
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<tr>
<td>1955</td>
<td>24,804</td>
<td>1,470,643</td>
<td>7,147,498</td>
<td>86,524</td>
<td>3,192,248</td>
<td>8,344,186</td>
<td>6,662,638</td>
<td>26,928,541</td>
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<tr>
<td>1956</td>
<td>31,620</td>
<td>4,264,955</td>
<td>18,315,885</td>
<td>111,102</td>
<td>3,571,201</td>
<td>13,310,337</td>
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<td>48,400,259</td>
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<tr>
<td>1957</td>
<td>75,468</td>
<td>3,370,252</td>
<td>17,545,591</td>
<td>9,065</td>
<td>2,781,917</td>
<td>12,220,660</td>
<td>18,421,466</td>
<td>54,424,419</td>
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<tr>
<td>1958</td>
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<td>2,246,360</td>
<td>10,239,495</td>
<td>10,396</td>
<td>1,351,065</td>
<td>13,894,699</td>
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<td>8,512,264</td>
<td>6,916,517</td>
<td>43,017,635</td>
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<td>1960</td>
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<td>19,105,258</td>
<td>26,805</td>
<td>5,602,547</td>
<td>9,411,381</td>
<td>5,474,273</td>
<td>43,553,610</td>
</tr>
</tbody>
</table>

* Includes iron-, uranium-, and molybdenum-mining, etc.

Note: See the general footnote for Table 7.
<table>
<thead>
<tr>
<th>Year</th>
<th>Footage Drilled</th>
<th>Income from Drilling ($ millions)</th>
<th>Average Number of Employees</th>
<th>Total of Salaries and Wages ($ millions)</th>
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</thead>
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<tr>
<td>1950</td>
<td>8,006,747</td>
<td>9.5</td>
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<td>12.4</td>
<td>2,431</td>
<td>6.0</td>
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<tr>
<td>1952</td>
<td>5,180,783</td>
<td>14.7</td>
<td>2,345</td>
<td>7.1</td>
</tr>
<tr>
<td>1953</td>
<td>5,258,870</td>
<td>15.8</td>
<td>2,238</td>
<td>7.1</td>
</tr>
<tr>
<td>1954</td>
<td>5,639,574</td>
<td>15.9</td>
<td>2,352</td>
<td>7.8</td>
</tr>
<tr>
<td>1955</td>
<td>6,443,641</td>
<td>21.4</td>
<td>2,840</td>
<td>9.9</td>
</tr>
<tr>
<td>1956</td>
<td>7,840,670</td>
<td>27.6</td>
<td>3,415</td>
<td>12.6</td>
</tr>
<tr>
<td>1957</td>
<td>6,296,128</td>
<td>21.2</td>
<td>2,951</td>
<td>10.8</td>
</tr>
<tr>
<td>1958</td>
<td>4,426,594</td>
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<td>1,717</td>
<td>6.9</td>
</tr>
<tr>
<td>1959</td>
<td>5,435,971</td>
<td>17.9</td>
<td>1,902</td>
<td>8.0</td>
</tr>
<tr>
<td>1960</td>
<td>5,521,211</td>
<td>17.1</td>
<td>1,912</td>
<td>8.0</td>
</tr>
</tbody>
</table>

* Drilling operations conducted by contractors who employed diamond drills only, which were used chiefly in testing metalliferous deposits.
CHAPTER V
GOVERNMENT INCENTIVES FOR EXPLORATION

Exploration in Canada has been, historically, the function of private enterprise. This system has worked very well under the government's policy of providing all possible incentives in the development of mineral resources. This section deals with only those incentives which are provided for mineral exploration.

The incentives given by the government may be divided into the following categories:

(1) Legal
(2) Financial
(3) Technical

(1) Legal

Generous and simple laws governing the disposition of mineral rights may be termed legal incentives. In accordance with the British North America Act of 1867 mineral rights are vested in the various provinces of Canada with the exception of the federally-administered Yukon and Northwest Territories, Indian reservations and National Parks. Each province has its own set of mining laws and they differ in detail. However, they all have a common goal of creating a situation which provides for most advantageous exploitation of mineral resources.

The basic requirement of the security of land tenure is fully assured. This is a very important aspect in a system where private enterprise is involved. The method of acquiring mineral rights is by staking. Canadians, other British subjects, and aliens over 18 years of age and having a prospector's licence have the right to stake. Staking can be done anywhere except in National parks and Indian reservations. After staking a claim, the rights are protected for a period of five years subject to performing specified assessment work. Initially the rules restricted the area of claims but in most of the provinces rules are being revised to include larger tracts of land taking into consideration the modern exploration techniques. A few of the provinces have already revised their rules. Mining on a claim can be started after obtaining a lease, concession or permit which is renewable. Absolute title to mining claims can be obtained by bringing claims to patents in a few provinces. Fees of application, rentals and royalties are moderate.

(1) Mining Taxation and Legislation in Canada by A. M. Hussain.
(2) **Financial**

(a) **Taxation**

Federal Income Tax Act provides substantial direct encouragement by giving (a) three years tax exempt period for new mines, (b) allowances for pre-production cost, (c) depletion and depreciation allowances, etc. Special income tax deductions are also provided if needed in special projects. Recently the Act has been amended to encourage the further processing of minerals and to encourage product research. No export taxes are levied on Canadian minerals or mineral products. Similar encouragement is given by the provinces. The provincial governments are also empowered to levy direct income tax but, in fact, the federal government collects the provincial share of corporate income tax on behalf of most of the provinces under the same incentive provisions.

Royalty or mining tax is levied on production or profits. While calculating the profit exploration expenditures are deductible. Some of the provinces grant a three year period of exemption from royalty and mining taxes. This benefit is in addition to the three year period of exemption from corporate income taxes.

(b) **Assistance to Prospectors**

Most of the provinces in Canada provide assistance to prospectors by giving them financial help such as a 'Grub Stake' and short instructions in prospecting methods. Grub-Stakes in British Columbia, for example, are granted with the object of maintaining the search for mineral occurrences with mine making possibilities. No interest is retained by the government in any discovery made by a grub-staked prospector who is free to stake claims and dispose of them as he desires. However these grants are not intended for the purpose of exploring mineral occurrences already found. Grub-stakes up to $300 for food, shelter and clothing, plus $200 travelling expenses are available to a limited number of fully qualified prospectors who undertake to prospect in areas considered favourable and selected in accordance with a long range plan for the development of the province. Prospectors are required to keep records and to plot the area prospected on a suitable map. Free assay facilities are provided to the prospectors. Application for grub-stakes are considered every year.

In Saskatchewan, the Prospector's Assistance Plan consists of providing transportation, basic camping and prospecting equipments to the prospectors. Rock drills, outboard motors and geophysical instruments are not included. Relevant maps and reports are provided free of charge and geological advice is available from government geologists before the field season or on servicing flights. Each participant may record 18 claims.

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(2) For details the report "Mining Taxation and Legislation in Canada" by A. M. Hussain may be referred.
free of charge and 12 free assays are provided for each party. Credit with the supplier of the party's choice will be provided for food at the rate of $2.00 per man/day. Extras are the responsibility of each participant. Participants may prospect anywhere in Saskatchewan's Precambrian Shield, subject to any local reservations which may be in force. A party must consist of two men having a valid miner's license and they are required to be in the field for 100 days at least. A bond of $100 is deposited with the government. This is refundable. Prospectors must maintain a diary which is deposited with the government after the completion of work. Prospectors retain full rights to any claim they may stake. The government is not obliged in anyway to option or purchase these claims. There is no limit to the number of years in which assistance may be received, but application must be made each year and will be judged in conjunction with those of other applicants.

Most provinces give short instruction courses to prospectors. In Saskatchewan, for example, the Geology Division organizes an annual three week training course at La Ronge for prospectors. This consists of approximately two weeks of daily lectures on such subjects as elementary geology, minerals and rocks, ore-deposits, prospecting procedure and modern prospecting equipment. The final week is devoted to practical exercises in the field including the use of the compass, handling a canoe, rock-drill and explosives, staking a claim and visiting mineral showings. Approximately five applicants are selected to attend each year. The registration fee for the course is $10.00 and, in addition, a $25.00 bond must be posted on acceptance.

(c) Transportation

The cost of the construction of roads, railroads, air-strips, power facilities, docks, harbours and housing in connection with the development of mineral resources is shared by the federal government, provincial governments and industry.

For the opening up and development of potential mining areas the Government of Canada has instituted a "Road to Resources" programme. In this programme the federal government made $71/2 million available to each province if the province would spend an equal amount on the construction of roads for the development of natural resources. If the mining access roads are built with a view to negotiating and developing areas in general, the cost is shared equally between the concerned provincial government and the federal government. If the access road is built to approach a particular property belonging to a company, the cost is equally shared between two governments and the company.

(d) Geophysical Surveys

Recently the Federal Government has commenced an aeromagnetic survey of the Canadian Shield. The work is being done by private commercial survey companies on contract basis. The cost of the survey is shared equally
between the federal and provincial government concerned, where the survey is in a province. In the Northwest Territories the total cost is borne by the federal government.

Some provinces bear 25% of the cost of a geophysical survey if such a survey is conducted by private mining companies. This is to stimulate exploration.

(e) **Loans from Industrial Development Bank**

The Industrial Development Bank was established by the Canadian Parliament in 1944. Initially its activities were restricted to a few specified business categories. At present, however, it helps finance small and medium size Canadian businesses of almost every type. But the IDB steps in only when it is satisfied that required financing is not available from other sources on reasonable terms and conditions. The Bank's function is to supplement the services of other lenders. Most of the loans approved by the Bank are for amounts of less than $100,000. The Bank also makes larger loans, but the larger the amount required, the greater may be the possibility that the financing is available elsewhere on reasonable terms and conditions, such as from other lenders or by public financing. Current interest rate normally applied to new IDB loans is 7% per annum, calculated on the daily outstanding balance. The repayment of loan is usually by way of monthly instalments of principal and interest. The length of period is tailored to suit the circumstances. Experience has shown that loans can be repaid within a range of about seven to ten years.

At present the activity of the Bank in the mineral industry field is not very significant. In 1962 out of 2,085 loans made only 28 pertained to mines (and milling), quarries and oil wells. This amounted to about $1.5 million out of the total value of about $92 million. It is anticipated that the Bank's activities will enlarge in the mining field in due course of time.

(3) **Technical**

The chief role of the government is to provide basic geological data for the use of private enterprise and also provide raw material testing facilities and research. Government procedures in mineral exploration have been dealt in detail in Chapter III.

The technical agency of the federal government providing most active assistance in exploration is the Geological Survey of Canada.

Besides what has already been mentioned about the Geological Survey of Canada in Chapter III, the following basic research projects of the Survey are also of significance in mineral development.
(a) **Geophysics**

(1) **Electromagnetic Radiation Studies**

The propagation of electromagnetic waves and pulses is influenced by the earth's material and moisture in the ground. The study of this effect will be valuable in the understanding and interpretation of electrical and electromagnetic data in terms of geology. One immediate application appears to be the tracing of groundwater aquifers.

In this project the Survey is engaged in theoretical, scale-model measurements, instrumentation and field work.

(2) **Gamma-ray Spectrometer Studies**

The aim of this project is a laboratory study of gamma-ray emission spectra prior to measurements on rocks in the field, investigation of the fall of spectra with increasing air distance and the significance of diurnal variations in the gamma field of the earth.

(3) **Paleomagnetic Studies**

These studies are designed to measure the direction of remnant magnetism in rock samples as a means of determining the direction of the earth's magnetic field during geologic history. This will help in solving stratigraphic and structural problems. Paleomagnetic data on some Sudbury specimens indicate that the norite was emplaced into a gently dipping structural basin and subsequently folded into its present position.

(b) **Geochemistry**

Basic research in geochemistry include the following:

(1) Isotope chemistry of sulphur in rocks and minerals.

(2) Lead- and sulphur-isotope geology of Keno and Galena Hills, Yukon.

(3) Isotope studies of sulphur from Canadian petroleum deposits.

(4) Radiocarbon dating.

(5) Chemical and spectrographic analyses of rocks and minerals.

(6) Investigation of recent methods for determining ferrous iron in rocks and minerals.
(7) Origin of sulphides in radioactive conglomerate.

(8) Isotopic study of Canadian ore leads.

(9) Magnesium-isotope studies.

(10) Age determination of rocks and minerals.

(11) Study of trace-element absorption by silicates.

(c) Mineralogy and Petrology

(1) Composition of olivine grains

(2) Rare mineral studies

(3) X-Ray spectrographic methods

(4) Study of micas

(d) Mineral Processing and Metallurgy

Brief reference of the activities of the Mines Branch, Department of Mines and Technical Surveys appears appropriate in this place. This branch has assisted in the development of Canada's mineral resources by carrying out applied research and technical services for industry and for other government agencies. It has also been developing a programme of long-range, fundamental research aimed at increasing the growth and efficiency of the Canadian mineral industry. Although not directly concerned with exploration in the first instance, the Mines Branch offers valuable services to industry once the mine development stage has been reached.

The Extraction Metallurgy Division of this branch is responsible for basic and applied research in extraction metallurgy. Considerable work is being done in the application of hydrometallurgical and pyrometallurgical procedures. Some of the important work includes hydrometallurgical research on uranium and gold, pyrometallurgical research on iron ores and niobium and certain corrosion problems.

The Fuels and Mining Practice Division is engaged in the following broad areas of research:

Coal - Evaluation of coal and peat resources. Engineering research on cleaning and agglomeration for market requirements and in combustion and metallurgical use.
Petroleum and Gas - Evaluation of crude oils and natural
gas, fundamental research on hydrocarbon materials,
research in refining of low-grade crude and bitumen.
Combustion research with oil and gas.

Mining and Rock Physics - Research in ground mechanics
and respirable dust. Fundamental research on
physical properties of geologic materials.

Safety in Relation to Explosion Hazards - Test work and
research on explosives, electrical effects in ex-
plosive gas and vapour mixtures, and explosibility
of dust, all with a view to the users' and public
safety.

The Mineral Processing Division cooperates with industry in
bringing new mines into production and in improving existing operations,
where technical aid in milling and treatment of ores, minerals and mineral
products, both metallic and industrial, is required. The work in industrial
minerals field is divided into the following categories:

(1) Research and investigation towards improved processing
and products.

(2) Technical assistance to industry requiring laboratory
participation.

(3) Survey of resources, treatment and industrial applica-
tion of these minerals in Canada.

(4) Technical consultation on specific problems for industry
and other government agencies.

In the metallic minerals field, investigations into practical
problems of processing of both ferrous and nonferrous ores are carried out.
For the ferrous group the work involves the use of magnetic separation,
flotation and table concentration. In the nonferrous field, investigations
on lead, zinc, copper and other base metal ores are conducted using flotation,
jigging, and table concentration. In the case of precious metal ores the ap-
proach is by testing the effects of amalgamation, flotation and cyanidation.

The work of the Mineral Sciences Division includes mineralogy,
physical chemistry, physics and analytical chemistry. Applied and fund-
damental research in physical metallurgy covers many metals and alloys.
CHAPTER VI
EXPLORATION IN THE UNITED STATES

(1) Government Policy and Participation

Like Canada, exploration activities in the United States are almost entirely carried out by the private sector with government providing necessary legal, financial and technical stimulation, although the details of these measures may vary widely between the two countries.

An important point to bear in mind is the outward flow of capital and technical know-how from the United States to other countries in the mineral development field. This is due to various economic and political reasons. In the total foreign outlays, expenditures on mineral exploration are quite important. However, in this section, only policy measures having direct bearing on the exploration of domestic deposits will be considered.

(a) Disposition of Mineral Rights

Mineral titles generally form part of the surface titles unless and until severed. The titles are governed either by Federal law or State law depending upon whether the mineral property sought is owned by the Federal Government, the States, or individuals. At present the most important federal laws are (1) the Mining Law of 1872 governing lode and placer claims of metalliferous minerals, including uranium, (2) the amended Mineral Leasing Act of 1920 that covers all deposits of coal, phosphate, sodium, potassium, oil, oil-shale, or gas, (3) the Outer Continental Shelf Lands Act of 1953 that permits the development of minerals in the Outer Continental Shelf by Government Lease, and (4) the Multiple Use Acts of 1954 and 1955 that allows joint use of the same tracts of public lands for mineral and non-mineral development.

The States have followed various patterns in their mineral laws but generally the laws are modelled after the federal laws. Individually owned lands are governed by the laws of each State relating to property titles, sales and conveyances, leases, licences and contracts.

Disposition of mineral rights for metal and placer deposits is governed by the location system although leasing system is provided for oil, gas and coal and some other non-metallics. Only the systems providing for lode claims will be dealt with here.

Only the citizens of United States are entitled to acquire rights to public mineral lands. A discovery is the pre-requisite to a valid location.

In the case of a lode or vein a valid location can be made only of the top or apex of the vein. If the apex is located, the locator is granted an extra-lateral right to follow the vein on its dip through the side-lines under adjoining property. The end-lines of the claim that traverses the lode must be parallel.

After discovery the next step is marking the boundary on the surface. Each lode location may not exceed 1,500 ft. in length along the vein or lode nor more than 300 ft. on each side of the vein on the surface. Mineral claims may be recorded in the local land office. The number of claims that may be located is unlimited. To keep the claim valid at least $100.00 worth of development work must be done each year. The locator may obtain a patent of ownership by spending $500.00 upon improvements, paying a fee of $5.00 an acre and having the claim surveyed.

No royalties of any kind are levied on the production of any patented or unpatented mining claims under the 1872 Act.

(b) Federal Income Tax

Depletion Allowance - Three methods of calculating the depletion allowance are possible (1) cost depletion*, (2) adjusted depletion**, (3) percentage depletion. The maximum sum which can be recovered through (1) and (2) is the original expenditure of the mine. Once this stage is reached percentage depletion may be continued till the rest of the life of the mine.

The maximum percentage which the depletion deduction may bear to net income is 50 per cent. For eighteen metallic ores, including those of lead and zinc mined domestically, bauxite and uranium, the percentage of gross income deductible for depletion is set at 23 per cent. For copper, iron ore, and non-domestic mines of lead, zinc and other non-ferrous metals the limit is 15 per cent. Gross and net income for depletion purposes include only the imputed income from mining and treatment process up to smelting.

The effect of depletion deduction has been to reduce the total tax payments of non-ferrous mining companies by 35 to 40 per cent a year.

Expensing - Exploration expenditure is deductible as current expenses up to $100,000 per taxpayer per year and up to four years for any one property. Development capital expenditures may be deducted as expenses without limit. In either case the taxpayer retains the option of recovering expenditure through cost depletion. The deduction of exploration and development expenses,

* Cost depletion = \( \frac{\text{Initial Cost}}{\text{Reserves}} \) = amount/ton

** Adjusted depletion = \( \frac{\text{Initial Cost} - \text{Previous depletion}}{\text{Reserves}} \) = amount/ton
however, does not revoke the privilege of percentage depletion.

(c) Tariff, government purchase contracts and stockpiling

These measures are intended to maintain or increase prices for the purpose of protecting domestic industries. Tariff legislation has efficiently produced a differential between domestic and international metals prices. But this means is resorted to only after serious domestic overproduction has occurred. The stockpiling programme has resulted in maintaining or raising the prices by removing surplus supplies from the market. Higher and stable price pattern stimulates investment in search for domestic orebodies.

(d) Government Exploration

Although the government does not directly involve itself in mineral exploration, the work of the Geological Survey and the Bureau of Mines goes a long way in helping exploration parties. The historic role of the Geological Survey has been the scientific study of terrain for mineral development. The studies of operating and developing mines by the staff of the Bureau of Mines have contributed similarly to the expansion of metals production by private industry. Besides, some of the work done by these departments required direct involvement. Exploration and development loan programmes may also be mentioned in this connection.

The following four government programmes are summarized below to assess government's participation in exploration. The first three have already terminated but nevertheless they throw light on the mechanism of government activity.

Strategic Minerals Development Programme (1939-49) - In this programme the Bureau of Mines was authorized to investigate deposits of seven strategic minerals in order to develop in-ground low grade reserve stock. During World War II the programme was enlarged to include nearly all industrial minerals for immediate production possibilities. The whole programme cost the Federal Government $30 million. The result was that 78 per cent of the deposits physically explored developed significant tonnages. The entire programme operated only upon projects passed over by private industry because of low values of expected results. The return of the investment may be gauged from the following:— "The most notable commercial deposit indicated by the programme is the San Manuel Copper deposit in Pinal County, Arizona. This is a porphyry type deposit containing more than 460 million tons of ore averaging approximately 0.8 per cent copper. Annual output of 140 million pounds of copper and 6 million pounds of molybdenum is anticipated. Disregarding the values in molybdenum and anticipating a price-cost spread of 4 cents per pound of copper, a rough estimate may be made that the profits of San Manuel alone (approximately $5 million annually) discounted to the present at 6 per cent, would aggregate over $30 million within eight years. That is, that the single large copper deposit developed by this programme could pay the costs of the entire programme in 33 minerals within
an eight year period of satisfactory market conditions".

Premium Price Plan (1942-47) - This plan was instituted to stimulate production in excess of quota, based on 1941 production, for domestic copper, lead and zinc mines. The exploration premium was part of the total plan and was established in 1946 and operated for only one year. Premiums were paid only to producing mines and for projects from which output was expected prior to December 31, 1947. Medium-sized companies are reported to have developed sizeable reserves under this programme.

Defense Minerals Exploration Administration (1951-58) - The purpose of this programme was to encourage exploration of domestic sources of strategic and critical metals and minerals. The government entered into contracts with private companies contributing a part of the costs for exploration work for certain mineral deposits. The percentage of government participation varied from 50 to 75 per cent. The 50 per cent limit was applied to the major non-ferrous metals.

The procedure of DMEA was as follows:-

1. Upon application by the private company the property was inspected by government geologists and engineers.

2. If the property was favourable, DMEA entered into agreement with the company specifying the work to be done and government participation with repayment out of royalties guaranteed by a contractual lien upon the property.

3. All work was done by the private contractor under government supervision.

4. If it was found that sufficient reserves have been proved to start production, the project was "Certified". If otherwise, the project was "Terminated Without Certification". The government retained no claim or lien against the property. Contracts were cancelled or terminated unilaterally by the DMEA. Any production marketed from projects either in force or certified was subject to royalty payments to the government.

During more than seven years of operation, a total of 1,159 contracts were executed valued at $56.8 million, and the government funds committed total $33.5 million. This programme resulted in the opening of a number of new or abandoned mines, increase in production and knowledge of mineral reserves.

Office of Mineral Exploration (1958 - Present) - On the expiry of the DMEA programme its activities were transferred to a new permanent programme under the office of Minerals Exploration, established in September, 1958. The purpose and administrative procedure of this plan is same as that of DMEA. The principal differences, however, are, first, that OME loans
accumulate interest from the date Federal Funds are made available to the contractor and, second, that the applicant must establish the non-availability of loan from commercial private sources and his own inability to carry out the work on his own. The interest to be charged is not fixed, but it should not be lower than that the Treasury has to pay plus 2 per cent to cover costs of operating the agency. If no production occurs, no repayment is required. Contracts under this plan are limited to a maximum of $250,000 of government participation.

(2) Company Procedures

Exploration has entered a new phase since World War II. Till then it was considered a sort of luxury to be indulged in only when times were good. The reliance on prospectors is tending to disappear. This is obviously due to the reason that surface outcrop showings have been investigated in most parts of the country. Mineral exploration is directed to discover 'blind deposits'. Although drilling, flotation and selective flotation techniques were known in the early part of this century, the application of the new techniques in metal exploration such as photogeology, geophysics and geochemistry did not become widespread until the early fifties. The inescapable new methods require larger areas, large investment and efficient technical know-how. As a result, exploration is increasingly going into the hands of larger firms who maintain exploration departments and research establishments. There is a growing tendency among the firms to take up exploration work as a joint venture both within and without the country. The exploration methods followed by companies are similar to those already described for Canadian mining and survey companies.
Physical And Chemical Characteristics Of Manganese Ores

By A. M. Hussain, M.Sc.*

It is essential to know the physical and chemical characteristics of manganese ores to evaluate and examine the suitability of the ore for various industries. It would help in directing attention to the problems of supply and demand and the connected intricacies more rationally. The data available at hand are certainly by no means exhaustive. Nevertheless, they enable an ardent scholar to come to grips with the general situation and evolve a picture enabling him to recognise the problems of the manganese ore industry in India, and the export trade. The analyses of the U.S.S.R., Brazil, and Ghana deposits which are the main competing countries have been given. The analysis of Indian ores of all the localities have been elaborately dealt with.

1. U.S.S.R.

Physical

The physical nature of the Russian ores are, on the whole, soft. The Tchiaturi ores distinther into fine. The Nikopol ores are, however, coarser and cleaner, but of low grade which require concentration. A general screen analysis of Russian ores is given below:

<table>
<thead>
<tr>
<th>Size</th>
<th>Percentage</th>
<th>Size</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot;</td>
<td>Nil</td>
<td>1&quot;</td>
<td>5½</td>
</tr>
<tr>
<td>3&quot;</td>
<td>Nil</td>
<td>3½&quot;</td>
<td>15</td>
</tr>
<tr>
<td>2&quot;</td>
<td>Nil</td>
<td>6½&quot;</td>
<td>18</td>
</tr>
<tr>
<td>10 mesh</td>
<td>18</td>
<td>60 mesh</td>
<td>1</td>
</tr>
<tr>
<td>20 mesh</td>
<td>12⅔</td>
<td>—100 mesh</td>
<td>2⅔</td>
</tr>
<tr>
<td>65 mesh</td>
<td>2⅔</td>
<td>-</td>
<td>—</td>
</tr>
</tbody>
</table>

Chemical

Percentage Analysis of Tchiaturi ores

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Unwashed</th>
<th>Washed</th>
<th>Peroxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn</td>
<td>11.8</td>
<td>18.8</td>
<td>1.5</td>
</tr>
<tr>
<td>MnO2</td>
<td>63.1</td>
<td>62.4</td>
<td>82.2</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>1.5</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>SiO₂</td>
<td>10.9</td>
<td>6.9</td>
<td>6.4</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>0.36</td>
<td>0.33</td>
<td>0.47</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>0.9</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>CaO</td>
<td>1.9</td>
<td>1.4</td>
<td>1.7</td>
</tr>
<tr>
<td>H₂O</td>
<td>5.1</td>
<td>5.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Equivalent to</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td>49.02</td>
<td>53.97</td>
<td>53.11</td>
</tr>
<tr>
<td>Fe</td>
<td>1.07</td>
<td>0.89</td>
<td>0.81</td>
</tr>
<tr>
<td>P</td>
<td>0.14</td>
<td>0.15</td>
<td>0.22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn (dry)</td>
<td>45.00</td>
</tr>
<tr>
<td>Fe (dry)</td>
<td>5.00</td>
</tr>
<tr>
<td>SiO₂ (dry)</td>
<td>7.50</td>
</tr>
<tr>
<td>Al₂O₃ (dry)</td>
<td>7.50</td>
</tr>
<tr>
<td>P</td>
<td>0.10</td>
</tr>
<tr>
<td>Moisture (metal)</td>
<td>10.50</td>
</tr>
</tbody>
</table>

The manganese content of the Brazilian ores is high. The Amapa deposits average 50% Mn. Mn: Fe ratio is also high, as much as 12:1. But slag forming constituents i.e. SiO₂ + Al₂O₃ are high and moisture content is also high. It is also reported that the ores contain objectionable impurities of non-ferrous metals (Cu 0.08%; Pb 0.02%; Zn 0.03%; As 0.14%).

* Of Indian Bureau of Mines, New Delhi.
3. GHANA

A general screen analysis of the Ghana ore is given below:

<table>
<thead>
<tr>
<th>Size</th>
<th>Percentage</th>
<th>Size</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot;</td>
<td>0</td>
<td>10 mesh</td>
<td>8</td>
</tr>
<tr>
<td>3&quot;</td>
<td>0</td>
<td>20 mesh</td>
<td>6</td>
</tr>
<tr>
<td>2&quot;</td>
<td>4</td>
<td>65 mesh</td>
<td>4</td>
</tr>
<tr>
<td>1&quot;</td>
<td>5</td>
<td>100 mesh</td>
<td>4</td>
</tr>
<tr>
<td>¾&quot;</td>
<td>26½</td>
<td>—100 mesh</td>
<td>1½</td>
</tr>
<tr>
<td>½&quot;</td>
<td>30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chemical

**Analysis of Ghana Manganese Ores**

<table>
<thead>
<tr>
<th>Grade</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>MnO₂</td>
<td>94.98</td>
<td>86.08</td>
<td>78.71</td>
<td>68.57</td>
</tr>
<tr>
<td>Mn</td>
<td>2.08</td>
<td>3.20</td>
<td>3.88</td>
<td>3.51</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0.14</td>
<td>2.29</td>
<td>5.72</td>
<td>11.01</td>
</tr>
<tr>
<td>SiO₂</td>
<td>0.30</td>
<td>2.45</td>
<td>4.60</td>
<td>3.55</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>0.29</td>
<td>0.25</td>
<td>0.24</td>
<td>0.32</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>0.87</td>
<td>1.96</td>
<td>3.14</td>
<td>4.43</td>
</tr>
<tr>
<td>CaO</td>
<td>0.03</td>
<td>0.25</td>
<td>0.29</td>
<td>0.60</td>
</tr>
<tr>
<td>MgO</td>
<td>Trace</td>
<td>Trace</td>
<td>0.16</td>
<td>0.29</td>
</tr>
<tr>
<td>BaO</td>
<td>0.02</td>
<td>0.07</td>
<td>0.10</td>
<td>0.18</td>
</tr>
<tr>
<td>S₀</td>
<td>0.04</td>
<td>0.02</td>
<td>0.10</td>
<td>0.21</td>
</tr>
<tr>
<td>TiO₂</td>
<td>Trace</td>
<td>0.09</td>
<td>0.10</td>
<td>0.18</td>
</tr>
<tr>
<td>H₂O + CO₂</td>
<td>0.70</td>
<td>3.32</td>
<td>2.65</td>
<td>4.87</td>
</tr>
<tr>
<td>C₁₀O₈</td>
<td>Trace</td>
<td>Trace</td>
<td>0.10</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Total 99.45 99.98 99.79 99.92

Equivalent to

<table>
<thead>
<tr>
<th>Mn</th>
<th>61.65</th>
<th>56.90</th>
<th>52.77</th>
<th>46.08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>0.10</td>
<td>1.60</td>
<td>4.00</td>
<td>7.70</td>
</tr>
<tr>
<td>P</td>
<td>0.126</td>
<td>0.11</td>
<td>0.11</td>
<td>0.14</td>
</tr>
<tr>
<td>SiO₂</td>
<td>0.30</td>
<td>2.45</td>
<td>4.60</td>
<td>5.55</td>
</tr>
</tbody>
</table>

4. SOUTH AFRICA

The screen analyses of ore imported into U.S.A. are given below:

<table>
<thead>
<tr>
<th>Size</th>
<th>Percentage</th>
<th>Size</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot;</td>
<td>8</td>
<td>10 mesh</td>
<td>1</td>
</tr>
<tr>
<td>3&quot;</td>
<td>13</td>
<td>20 mesh</td>
<td>1</td>
</tr>
<tr>
<td>2&quot;</td>
<td>20</td>
<td>65 mesh</td>
<td>1½</td>
</tr>
<tr>
<td>1&quot;</td>
<td>32</td>
<td>100 mesh</td>
<td>1½</td>
</tr>
<tr>
<td>¾&quot;</td>
<td>12</td>
<td>—100 mesh</td>
<td>4</td>
</tr>
<tr>
<td>½&quot;</td>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

South African ores are very hard and require to be crushed. This is claimed to be important since the ore can withstand preparation, transport and storage without breaking into fines.

(Chemical Analysis of Postmasburg ore appears below)

5. INDIA

The Indian ores show wide variability in their composition. In general, however, the ores are fairly hard and lumpy and easily reducible. These characters are favourable for furnace requirements and are unmatched by the ores of other competing countries. The following is the sieve analysis of the Indian ores imported into U.S.A.

<table>
<thead>
<tr>
<th>Size</th>
<th>Percentage</th>
<th>Size</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot;</td>
<td>15</td>
<td>10 mesh</td>
<td>4</td>
</tr>
<tr>
<td>3&quot;</td>
<td>12½</td>
<td>20 mesh</td>
<td>½</td>
</tr>
<tr>
<td>2&quot;</td>
<td>16½</td>
<td>65 mesh</td>
<td>1</td>
</tr>
<tr>
<td>1&quot;</td>
<td>20</td>
<td>100 mesh</td>
<td>½</td>
</tr>
<tr>
<td>¾&quot;</td>
<td>17</td>
<td>—100 mesh</td>
<td>4</td>
</tr>
<tr>
<td>½&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Chemical**

**ANALYSIS OF POSTMASBURG ORE**

<table>
<thead>
<tr>
<th>Grade</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn</td>
<td>50-4</td>
<td>48-56</td>
<td>45-43</td>
<td>42-36</td>
<td>35-28</td>
</tr>
<tr>
<td>Fe</td>
<td>5-9</td>
<td>11-14</td>
<td>13-17</td>
<td>13-24</td>
<td>20-32</td>
</tr>
</tbody>
</table>

**Bulk analysis**

<table>
<thead>
<tr>
<th>Mn</th>
<th>52.21</th>
<th>50.38</th>
<th>48.95</th>
<th>47.22</th>
<th>45.93</th>
<th>43.28</th>
<th>42.97</th>
<th>40.14</th>
<th>36.68</th>
<th>34.40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>8.67</td>
<td>10.14</td>
<td>10.02</td>
<td>11.92</td>
<td>12.42</td>
<td>15.33</td>
<td>16.03</td>
<td>19.51</td>
<td>18.75</td>
<td>21.30</td>
</tr>
<tr>
<td>SiO₂</td>
<td>3.90</td>
<td>3.05</td>
<td>3.40</td>
<td>2.29</td>
<td>2.87</td>
<td>2.77</td>
<td>2.45</td>
<td>2.78</td>
<td>2.80</td>
<td>3.21</td>
</tr>
<tr>
<td>P</td>
<td>0.049</td>
<td>0.055</td>
<td>0.045</td>
<td>0.035</td>
<td>0.044</td>
<td>0.043</td>
<td>0.040</td>
<td>0.060</td>
<td>0.039</td>
<td>0.034</td>
</tr>
</tbody>
</table>
The chemical analysis varies widely. The analysis of both the high grade and low grade deposits have been indicated below with the intention that concerned scientists might be attracted to size up the problems of beneficiation, etc. Generally speaking the Indian ores have low Mn: Fe ratio and high phosphorus, characters adverse for the production of ferro-manganese. The manganese-iron ratio of Indian ore is 7 : 1, against the Caucasian ore ratio of 60 : 1, Ghana 10 : 1 and Brazil 12 : 1.

**Rajasthan**

The following is the analysis of the representative samples of the despatches of Rajasthan ores made during the past few years. The important point to note is the relatively low phosphorus content of the ores viz. below 0.15%. Though the manganese content is not very high, the Mn-Fe ratio in several places is quite suitable for the manufacture of standard grade ferro-manganese. The ores are rather high in silica.

### Analysis of Rajasthan Ores

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Location of ore</th>
<th>Mn</th>
<th>Fe</th>
<th>SiO₂</th>
<th>P</th>
<th>A₁₂O₃</th>
<th>Mn</th>
<th>Fe ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Deberi, Udaipur Dist.</td>
<td>35.68</td>
<td>5.04</td>
<td>21.16</td>
<td>0.288</td>
<td>—</td>
<td>7.1</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Sardarpur (Nathdwara) Udaipur District.</td>
<td>31.21</td>
<td>7.66</td>
<td>6.34</td>
<td>—</td>
<td>—</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Ital, Banswara Dist.</td>
<td>42.77</td>
<td>3.71</td>
<td>18.29</td>
<td>0.1147</td>
<td>3.33</td>
<td>11.5</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Talwara,</td>
<td>44.47</td>
<td>1.78</td>
<td>4.18</td>
<td>0.0319</td>
<td>3.97</td>
<td>25.0</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Talwara,</td>
<td>48.7</td>
<td>0.5</td>
<td>0.4</td>
<td>0.014</td>
<td>0.40</td>
<td>97.4</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Talwara,</td>
<td>41.65</td>
<td>4.78</td>
<td>2.18</td>
<td>0.0337</td>
<td>1.90</td>
<td>8.7</td>
<td></td>
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<tr>
<td>7.</td>
<td>Talwara,</td>
<td>41.25</td>
<td>5.99</td>
<td>2.39</td>
<td>0.033</td>
<td>1.10</td>
<td>8.9</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Sagan,</td>
<td>40.71</td>
<td>13.32</td>
<td>10.39</td>
<td>0.3008</td>
<td>2.12</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Ital,</td>
<td>41.73</td>
<td>3.09</td>
<td>25.81</td>
<td>0.1402</td>
<td>—</td>
<td>13.5</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Ital,</td>
<td>44.91</td>
<td>4.30</td>
<td>16.87</td>
<td>0.138</td>
<td>3.08</td>
<td>10.5</td>
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</tr>
<tr>
<td>11.</td>
<td>Ital, Banswara Dist.</td>
<td>44.91</td>
<td>3.55</td>
<td>16.60</td>
<td>0.0814</td>
<td>3.05</td>
<td>12.7</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Ital,</td>
<td>46.53</td>
<td>2.98</td>
<td>13.19</td>
<td>0.1481</td>
<td>2.47</td>
<td>15.9</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Ital,</td>
<td>45.72</td>
<td>3.72</td>
<td>14.67</td>
<td>0.1245</td>
<td>2.80</td>
<td>12.3</td>
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</tr>
<tr>
<td>14.</td>
<td>Thikhi (Nathdwara) Udaipur District.</td>
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<td>—</td>
<td>10.4</td>
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<tr>
<td>15.</td>
<td>Ramel,</td>
<td>51.7</td>
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<td>2.25</td>
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<td>—</td>
<td>24.6</td>
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</tr>
<tr>
<td>16.</td>
<td>Sironia, Banswara Dist.</td>
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<td>3.66</td>
<td>18.26</td>
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<td>3.14</td>
<td>12.1</td>
<td></td>
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<tr>
<td>17.</td>
<td></td>
<td>43.09</td>
<td>3.18</td>
<td>20.78</td>
<td>0.0392</td>
<td>3.35</td>
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<td></td>
</tr>
<tr>
<td>18.</td>
<td></td>
<td>43.6</td>
<td>2.99</td>
<td>22.98</td>
<td>0.0751</td>
<td>2.60</td>
<td>14.6</td>
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</tr>
<tr>
<td>19.</td>
<td></td>
<td>45.28</td>
<td>2.94</td>
<td>20.07</td>
<td>0.0706</td>
<td>2.70</td>
<td>15.4</td>
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</tr>
<tr>
<td>20.</td>
<td></td>
<td>40.64</td>
<td>3.60</td>
<td>26.73</td>
<td>0.0818</td>
<td>2.97</td>
<td>11.3</td>
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<tr>
<td>21.</td>
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<td>42.79</td>
<td>3.79</td>
<td>21.57</td>
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<tr>
<td>22.</td>
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<td>42.59</td>
<td>4.47</td>
<td>20.75</td>
<td>0.110</td>
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<td>9.5</td>
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</tr>
<tr>
<td>Sl. No.</td>
<td>Location of ore</td>
<td>Mn.</td>
<td>Fe.</td>
<td>SiO₂</td>
<td>P</td>
<td>Al₂O₃</td>
<td>Mn/Fe ration</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>----------------</td>
<td>-----</td>
<td>-----</td>
<td>------</td>
<td>----</td>
<td>-------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>Sagwa Dist.</td>
<td>31.70</td>
<td>3.70</td>
<td>38.88</td>
<td>0.1934</td>
<td>5.35</td>
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<tr>
<td>24.</td>
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<td>35.1</td>
<td>3.20</td>
<td>36.35</td>
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<td>7.75</td>
<td>10.97</td>
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<tr>
<td>25.</td>
<td>&quot;</td>
<td>34.6</td>
<td>3.336</td>
<td>36.20</td>
<td>0.0741</td>
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<td>10.3</td>
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<tr>
<td>26.</td>
<td>Sagar Lankai</td>
<td>40.16</td>
<td>16.24</td>
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<td>3.63</td>
<td>2.47</td>
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<tr>
<td>27.</td>
<td>&quot;</td>
<td>42.93</td>
<td>11.67</td>
<td>8.52</td>
<td>0.09</td>
<td>3.06</td>
<td>3.7</td>
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<tr>
<td>28.</td>
<td>Pandwal</td>
<td>34.92</td>
<td>13.71</td>
<td>17.33</td>
<td>0.26</td>
<td>—</td>
<td>2.5</td>
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<tr>
<td>29.</td>
<td>Tambeshra</td>
<td>38.18</td>
<td>2.83</td>
<td>30.76</td>
<td>0.1112</td>
<td>2.67</td>
<td>14.7</td>
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<tr>
<td>30.</td>
<td>&quot;</td>
<td>41.20</td>
<td>2.80</td>
<td>27.70</td>
<td>0.180</td>
<td>1.00</td>
<td>13.4</td>
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<tr>
<td>31.</td>
<td>Kalakhunta</td>
<td>40.82</td>
<td>4.50</td>
<td>24.85</td>
<td>0.112</td>
<td>3.57</td>
<td>9.0</td>
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<tr>
<td>32.</td>
<td>Itala</td>
<td>35.67</td>
<td>4.13</td>
<td>29.68</td>
<td>0.3345</td>
<td>—</td>
<td>11.1</td>
<td></td>
</tr>
<tr>
<td>33.</td>
<td>&quot;</td>
<td>57.00</td>
<td>5.03</td>
<td>13.19</td>
<td>0.139</td>
<td>3.65</td>
<td>11.1</td>
<td></td>
</tr>
<tr>
<td>34.</td>
<td>&quot;</td>
<td>43.52</td>
<td>2.79</td>
<td>22.75</td>
<td>0.130</td>
<td>3.18</td>
<td>15.6</td>
<td></td>
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<tr>
<td>35.</td>
<td>&quot;</td>
<td>34.74</td>
<td>2.60</td>
<td>29.62</td>
<td>0.21814</td>
<td>3.14</td>
<td>11.0</td>
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<tr>
<td>36.</td>
<td>&quot;</td>
<td>39.07</td>
<td>2.42</td>
<td>31.13</td>
<td>0.147</td>
<td>2.50</td>
<td>16.1</td>
<td></td>
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<tr>
<td>37.</td>
<td>&quot;</td>
<td>40.85</td>
<td>2.42</td>
<td>28.28</td>
<td>0.134</td>
<td>3.33</td>
<td>16.8</td>
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<tr>
<td>38.</td>
<td>Talwara</td>
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<td>1.00</td>
<td>0.85</td>
<td>0.024</td>
<td>2.5</td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>

**Madhya Pradesh**

Good grade deposits in this State are located in Balaghat and Chhindwara districts. Deposits of less importance occur in Jhabua and Jabalpur districts. The characteristic feature of Madhya Pradesh ores is their lumpy, hard and compact nature. They are preferred to softer ores and are in high demand.

The ores are generally mixed at the port to obtain the required grade and are sold under trade names i.e. Bawanthari mixture, oriental mixture etc.

Complete data are lacking regarding the analysis of ores of various localities. Approximate variations are shown below district-wise, but the marginal ores may vary widely from these figures.

**Balaghat**

The chemical analyses of 13 samples from different mines in this district gave the following range.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>49.08 to 54.51%</td>
</tr>
<tr>
<td>Iron</td>
<td>5.28 to 9.10%</td>
</tr>
<tr>
<td>Silica</td>
<td>1.62 to 6.02%</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.04 to 0.24%</td>
</tr>
<tr>
<td>Moisture</td>
<td>0.12 to 0.85%</td>
</tr>
</tbody>
</table>

The low grade ore extracted at Maragpur, Balaghat district would have the following analysis:

<table>
<thead>
<tr>
<th>Mn%</th>
<th>Fe%</th>
<th>P%</th>
<th>SiO₂%</th>
<th>Al₂O₃%</th>
<th>Ba%</th>
<th>Cao%</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.45</td>
<td>2.19</td>
<td>0.098</td>
<td>17.72</td>
<td>8.51</td>
<td>2.08</td>
<td>2.30</td>
</tr>
</tbody>
</table>
Chhindwara District

The chemical analyses of nine samples from different mines gave the following analysis range:

- Manganese: 48.95 to 54.97%
- Iron: 5.00 to 11.77%
- Silica: 4.98 to 10.63%
- Phosphorus: 0.06 to 0.28%
- Moisture: 0.00 to 1.27%

The low-grade ore extracted at Kachhidhana, Chhindwara district would have following analyses:

- Manganese: 41.60%
- Iron: 8.46%
- Phosphorous: 0.20%
- Silica: 14.60%

Jhabua District

The reef ore analyses are the following:

- Manganese: 40-44%
- Iron: 10-11%
- Silica: 10%
- Phosphorus: 0.25-0.3%

Jabalpur District

Analysis of three samples gave the following range:

- Manganese: 34.53 to 56.80%
- Iron: 1.60 to 10.30%
- Silica: 1.40 to 4.79%
- Phosphorus: 0.30 to 0.46%
- Moisture: 0.32 to 0.90%

ANDHRA PRADESH

Occurrences of manganese ores are concentrated in Chipurupalli and Salur taluks. The manganese content of the ores of commercial grade varies from 40-55%. The deposits are, however, mostly third grade and they contain high phosphorus. The ores generally are required to be blended with high grade ores for export.

**Analyses of ores from Andhra Pradesh**

<table>
<thead>
<tr>
<th>Locality</th>
<th>Manganese</th>
<th>Iron</th>
<th>Silica</th>
<th>Phosphorus</th>
<th>Aluminium</th>
<th>Ba</th>
<th>CaO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Kodur mines</td>
<td>45-55</td>
<td>5-10</td>
<td>2-5</td>
<td>0.20-0.30</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Garividi (detrital ore)</td>
<td>42-99</td>
<td>16.63</td>
<td>3.66</td>
<td>0.14</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Garbhan main quarry</td>
<td>40-49</td>
<td>7-15</td>
<td>3-10</td>
<td>0.35-0.55</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Perapi, near Chipurupalli Rly. Station (Boulders)</td>
<td>26.68</td>
<td>14.72</td>
<td>16.66</td>
<td>0.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avagudem workings near Chipurupalli Rly. Station</td>
<td>39.41</td>
<td>13.30</td>
<td>4.73</td>
<td>0.44</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avitambalasa Workings</td>
<td>30-40</td>
<td></td>
<td></td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Sonapuram, Salur taluk</td>
<td>40.54</td>
<td>13.60</td>
<td>3.40</td>
<td>0.200</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Mamidipalli (Itala Mamidipalli) Salur taluk</td>
<td>32.21</td>
<td>15.20</td>
<td>10.30</td>
<td>0.482</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bamkuruvulasa, Salur taluk</td>
<td>46.98</td>
<td>9.10</td>
<td>4.50</td>
<td>0.48</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Peddapadam &amp; Markonda-putta, Salur</td>
<td>30-40</td>
<td>12-15</td>
<td></td>
<td>0.20 to (SiO₂ &amp; Al₂O₃) 0.30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remarks:
- It is estimated that about 2 million tons of ore with 20-25% Mn. may be available in the dump.

Notes:
- The analysis given is that of commercial grade ore. The average grade of ore belongs to 3rd grade analysing about 38-40%. Mn. Dumps are estimated to contain about a million tons of ore containing 25-30% per cent manganese.
MYSORE

The manganese ores of Mysore State are generally second and third grade. Iron is generally high and seems to be combined with manganese both mechanically and chemically. Silica and phosphorus are remarkably low.

The analyses of Sandur ores mined by The Sandur Manganese and Iron Ores (P) Ltd. are given below:

**Grade “Sandur A”—38—40% Mn.**

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese oxide (MnO₂)</td>
<td>58.86%</td>
</tr>
<tr>
<td>Manganese Oxide (MnO)</td>
<td>7.10%</td>
</tr>
<tr>
<td>Ferric Oxide (Fe₂O₃)</td>
<td>23.40%</td>
</tr>
<tr>
<td>Silica (SiO₂)</td>
<td>1.23%</td>
</tr>
<tr>
<td>Phosphoric Anhydride (P₂O₅)</td>
<td>0.064%</td>
</tr>
<tr>
<td>Sulphuric Anhydride (SO₃)</td>
<td>Nil</td>
</tr>
<tr>
<td>Alumina (Al₂O₃)</td>
<td>6.16%</td>
</tr>
<tr>
<td>Calcium Oxide (CaO)</td>
<td>0.21%</td>
</tr>
<tr>
<td>Combined Water (H₂O)</td>
<td>6.88%</td>
</tr>
<tr>
<td>Magnesia (MgO)</td>
<td>Trace</td>
</tr>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>Trace</td>
</tr>
<tr>
<td>Copper, Cadmium, Lead, Arsenic, Antimony, Zinc etc.</td>
<td>Nil</td>
</tr>
</tbody>
</table>

**Grade “Sandur B”—20-32% Mn.**

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese dioxide (Mn₃O₅)</td>
<td>48.90%</td>
</tr>
<tr>
<td>Ferric Oxide (Fe₂O₃)</td>
<td>35.32%</td>
</tr>
<tr>
<td>Alumina (Al₂O₃)</td>
<td>9.87%</td>
</tr>
<tr>
<td>Silica (SiO₂)</td>
<td>1.34%</td>
</tr>
<tr>
<td>Phosphoric Anhydride (P₂O₅)</td>
<td>0.057%</td>
</tr>
<tr>
<td>Calcium Oxide (CaO)</td>
<td>Trace</td>
</tr>
<tr>
<td>Sulphur</td>
<td>Nil</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Trace</td>
</tr>
<tr>
<td>Copper, Cadmium, Lead, Arsenic, Antimony, Zinc etc.</td>
<td>Nil</td>
</tr>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>Trace</td>
</tr>
<tr>
<td>Combined Moisture</td>
<td>The rest</td>
</tr>
</tbody>
</table>

**Physical Properties**

<table>
<thead>
<tr>
<th>Component</th>
<th>Size</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumps</td>
<td>4&quot; and above</td>
<td>55%</td>
</tr>
<tr>
<td>Rubbles</td>
<td>2&quot;</td>
<td>25%</td>
</tr>
<tr>
<td>Smalls</td>
<td>1&quot;</td>
<td>15%</td>
</tr>
<tr>
<td>Fines</td>
<td>Less than 1&quot;</td>
<td>5%</td>
</tr>
</tbody>
</table>

The ores in Shimoga assay Mn 35.53; Fe 20.74 and SiO₂ 1.86% with low phosphorus content. The Tumkur ores are reported to be high in Silica i.e. 15-20%.

The Mysore Iron and Steel Works, Bhadravati get manganese Ore from Kumsi and Gungrur mines in Shimoga district for the manufacture of ferro-manganese for their local use. The Manganese content in the ore falls short of by 4 to 6%.

A number of analysis from near Goida, North-Kanara district conducted by the Geological Survey of India, reveals that the grades of ore ranging from high grade manganese ore to highly ferruginous manganese-ores are present. The manganese content varies from 15.79% to 53.79%. Iron is generally high and seems to be combined with manganese both mechanically and chemically varying from 3.88 to 28.21%. Silica is low varying from 1.38 to 7.95%. In case of manganese breccia and gritty ores silica is somewhat higher going upto 12.30%. Phosphorous is very low varying from 0.02 to 0.114% and is well within acceptable limits.

**MAHARASHTRA**

What has been said in regard to Madhya Pradesh Ores, more or less, apply to Maharashtra Ores also. Nagpur and Bhandara deposits are, as a matter of fact, continuation of Madhya Pradesh deposits.

**Nagpur District**

The general grade of ore produced from this district contains the following:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>42-52%</td>
</tr>
<tr>
<td>Iron</td>
<td>5-7%</td>
</tr>
<tr>
<td>Silica</td>
<td>11-18%</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>0.18-0.26%</td>
</tr>
</tbody>
</table>

**Bhandara District**

The chemical analyses of 13 samples from different mines in this district gave the following range:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>49.00 to 54.07%</td>
</tr>
<tr>
<td>Iron</td>
<td>3.86 to 10.25%</td>
</tr>
<tr>
<td>Silica</td>
<td>2.08 to 6.50%</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>0.06 to 0.34%</td>
</tr>
<tr>
<td>Moisture</td>
<td>0.09 to 1.00%</td>
</tr>
</tbody>
</table>

Ratnagiri ores contain 30% Mn on the average.
GUJARAT

The following is the percentage composition of Panch-Mahal ores:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Grade</th>
<th>Pyrolusite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Manganese</td>
<td>48-50</td>
<td>46-47</td>
</tr>
<tr>
<td>Iron</td>
<td>4-5</td>
<td>5-7</td>
</tr>
<tr>
<td>Silica</td>
<td>6-8</td>
<td>9-11</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>0.23-0.26</td>
<td>0.24-0.28</td>
</tr>
<tr>
<td>MnO₂</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BIHAR & ORISSA

In Bihar manganese ores occur near Chaibasa. Generally, the ores are soft and rather waddy in nature—mostly of low grade associated with phyllitic and schistose rocks and contain jaspers veins. Ore with 30 to 44% manganese content is generally obtained by hand picking for export.

In Orissa the ores are generally mixtures of oxides and hydroxides of manganese and iron. The low phosphorous content of these ores is a note-worthy feature although ores high in phosphorous are also met with, especially in Patna District. Occasionally high grade metallurgical ores and in some places chemical or battery grade ores are also found.

Only 17% of the reserves of this state contain 45% and above manganese content. But the spongy nature of the ores and the infiltration of clay therein make them remarkably responsive to beneficiation tests. General low phosphorous content of the ores and their amenability to beneficiation are important points to be borne in mind.

Chemical analyses of some of the ores from Choraiajor Gangpur gave the following range:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Range</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>45.58 to 54.13%</td>
<td>45.31%</td>
</tr>
<tr>
<td>Iron</td>
<td>2.60 to 7.92%</td>
<td>6.59%</td>
</tr>
<tr>
<td>Silica</td>
<td>2.60 to 11.20%</td>
<td>4.41%</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>0.061 to 0.250%</td>
<td>0.117</td>
</tr>
</tbody>
</table>

Chemical analyses of several manganese ores from Keonjhar gave the following:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>38.0 to 58.85%</td>
</tr>
<tr>
<td>Iron</td>
<td>0.45 to 14.00%</td>
</tr>
<tr>
<td>Silica</td>
<td>0.78 to 6.00%</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>0.075 to 0.15%</td>
</tr>
</tbody>
</table>

Chemical analysis of several samples from Bonai gave the following range:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>36.15 to 59.00%</td>
</tr>
<tr>
<td>Iron</td>
<td>1.12 to 11.22%</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>0.011 to 0.18%</td>
</tr>
<tr>
<td>Silica</td>
<td>0.38 to 8.26%</td>
</tr>
</tbody>
</table>

A certain amount of the manganese ore is of low phosphorous type but it is of limited extent. An average of several chemical analyses of such ores is given below:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>57.01 %</td>
</tr>
<tr>
<td>Iron</td>
<td>1.93 %</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>0.0098 %</td>
</tr>
<tr>
<td>Silica</td>
<td>1.60 %</td>
</tr>
</tbody>
</table>

Chemical analyses of several typical samples of manganese ore from Gadshankar in Patna are given below:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>54.15 % 41.50 % 36.20 %</td>
</tr>
<tr>
<td>Iron</td>
<td>3.10 % 11.50 % 14.40 %</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>0.372 % 0.377 % 0.456 %</td>
</tr>
</tbody>
</table>

Chemical analysis of Kutungi deposits, Koraput is indicated below:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese</td>
<td>51.35 % 53.52 % 55.42 %</td>
</tr>
<tr>
<td>Iron</td>
<td>5.02 % 3.91 % 1.12 %</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>Nil        0.02 % 0.01 %</td>
</tr>
<tr>
<td>Insol</td>
<td>3.30 % 1.86 % 7.08 %</td>
</tr>
</tbody>
</table>

Analyses of some low grade manganese ore samples on which beneficiation tests have been carried out by the Indian Bureau of Mines and National Metallurgical Laboratory.
<table>
<thead>
<tr>
<th>Location</th>
<th>Mn%</th>
<th>Fe%</th>
<th>Si₈%</th>
<th>Phosphorus</th>
<th>Al₂₀⁺</th>
<th>Ca¹</th>
<th>Mg²⁺</th>
<th>S</th>
<th>Ba⁶</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kachidhana mines, Chhindwara District M.P.</td>
<td>41.6</td>
<td>8.46</td>
<td>14.6</td>
<td>0.20</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Tirodi mines, Balaghat District M.P.</td>
<td>27.39</td>
<td>7.47</td>
<td>33.4</td>
<td>0.36</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Netra mine, Balaghat District M.P.</td>
<td>29.24</td>
<td>7.77</td>
<td>31.26</td>
<td>0.26</td>
<td>2.60</td>
<td>4.30</td>
<td>2.89</td>
<td>0.35</td>
<td>1.92</td>
</tr>
<tr>
<td>Mirajpur mine, Balaghat District, M.P.</td>
<td>34.45</td>
<td>8.19</td>
<td>19.72</td>
<td>0.098</td>
<td>8.51</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Kodur mines, Andhra Pradesh (Alluvial ore)</td>
<td>33.94</td>
<td>4.53</td>
<td>14.01</td>
<td>0.49</td>
<td>8.5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Marivalasa mines, Salur, Andhra Pradesh</td>
<td>28.63</td>
<td>12.68</td>
<td>18.44</td>
<td>0.20</td>
<td>6.19</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Kodur mines, Andhra Pradesh (Bed ore)</td>
<td>33.49</td>
<td>13.92</td>
<td>8.45</td>
<td>0.29</td>
<td>7.45</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Chipurupalli, Andhra Pradesh</td>
<td>25.82</td>
<td>10.89</td>
<td>25.16</td>
<td>0.13</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Shivarajpur mines, Gujarat</td>
<td>36.5</td>
<td>10.25</td>
<td>19.07</td>
<td>0.38</td>
<td>6.94</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Mansar mines, Maharashtra</td>
<td>32.67</td>
<td>10.13</td>
<td>27.48</td>
<td>0.46</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Nagri-goida, North Kanara, Mysore.</td>
<td>33.30</td>
<td>19.60</td>
<td>3.20</td>
<td>0.02</td>
<td>4.01</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Nagri-goida, (D grade ore) North Kanara, Mysore</td>
<td>34.71</td>
<td>18.49</td>
<td>3.93</td>
<td>0.03</td>
<td>6.70</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Papeli mines, North Kanara, Mysore</td>
<td>39.66</td>
<td>9.15</td>
<td>14.94</td>
<td>Trace</td>
<td>1.82</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Sandur, Mysore</td>
<td>30.18</td>
<td>21.9</td>
<td>0.99</td>
<td>0.03</td>
<td>12.40</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Keonjhar, Orissa, (Tisco ore) washed product</td>
<td>27.7</td>
<td>31.6</td>
<td>2.8</td>
<td>—</td>
<td>4.86</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Sagur, Orissa</td>
<td>29.06</td>
<td>17.98</td>
<td>1.78</td>
<td>0.052</td>
<td>14.40</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Siljora, Keonjhar Dist, Orissa</td>
<td>37.55</td>
<td>12.46</td>
<td>7.56</td>
<td>0.086</td>
<td>6.45</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Karwal mines, Orissa</td>
<td>31.37</td>
<td>24.73</td>
<td>3.68</td>
<td>0.44</td>
<td>2.75</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Banswara Distt.</td>
<td>38.82</td>
<td>5.0</td>
<td>21.58</td>
<td>0.15</td>
<td>6.7</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Kamji mines, Banswara Distt.</td>
<td>21.74</td>
<td>14.23</td>
<td>3.46</td>
<td>0.58</td>
<td>1.89</td>
<td>18.72</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Itala mine, Rajasthan</td>
<td>33</td>
<td>5.8</td>
<td>34.08</td>
<td>0.18</td>
<td>5.1</td>
<td>—</td>
<td>—</td>
<td>0.055</td>
<td>—</td>
</tr>
<tr>
<td>Chhorbaoli Forests, Nagpur</td>
<td>35.10</td>
<td>10.85</td>
<td>14.24</td>
<td>0.43</td>
<td>8.13</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

INDIGENOUS SUPPLY OF MINERAL RAW MATERIALS—A VITAL ECONOMIC FACTOR IN THE INSTALLATION AND OPERATION OF STEEL PLANTS IN DEVELOPING COUNTRIES WITH SPECIAL REFERENCE TO INDIA

A. M. Hussain
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&

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Furnace charge of a steel plant is almost entirely made up of mineral raw materials. For this reason, the great industrial belts producing steel in important producer countries developed in proximity to mineral fields. Of late, however, the pattern of steel plant installations has undergone a change. Improved technology, transport systems and economic alliances have made it possible for a country to produce large quantities of steel even though it may itself lack in mineral resources. The thesis of the authors, however, is that the developing countries would have to plan steel plant installations based mostly on the indigenous availability of mineral raw materials and they will have to work out their production plans with this serious limitation in view. Improved technology has brought about a revolutionary change in the pattern of raw material consumption. The rigidity of conventional steel making processes regarding the quantity and quality of the ‘charge’ is no longer a bar in the wake of recent innovations in steel making. This development can be utilized by developing countries having poor quality of raw materials. Installation of steel plants with reference to available indigenous mineral raw materials and modern technological innovations has been discussed by the authors and pattern of steel plant locations in India in the next two decades has been projected on the above basis.

**Introduction**

Developing countries are making efforts to attain economic prosperity and become members of industrial societies of the
world by modernising their agriculture and attempting a simultaneous process of industrialisation. The major plank of their economic policy, for the attainment of this objective, will continue to be procurement of adequate quantities of steel either by indigenous production or by imports.

The international market of steel is quite easy. The world industry today is passing through a difficult and delicate phase. In the early 1960’s, due to profound technological reconstruction, steel production and consumption of the world reached exceptional levels. But this dynamism has now lost its force and most of the producer countries such as North American continent, Western Europe and Japan are leaning more on exports to sustain their levels of production. Viewed this way, it would appear that the developing countries would be in a convenient position to buy their steel needs from the international market. But it should not be ignored that these developing countries have, at their disposal, very meagre financial resources, especially the foreign exchange reserve, which could be utilised for the purchase of this commodity. It is interesting to note in this context that the better part of world exports of steel is made up of interchanges between the big manufacturing countries and not of exports to countries where steel production is inadequate. For example, the steel production of Japan is vitally linked with exports of sizeable quantity to other steel producing countries. During recent years, due to a decline in the steel exports to U.S. A., Japan is frantically exploring markets in other countries and it is even trying to expand its trade with China. The developing nations around Japan do not contribute much to the imports of Japanese steel. Japan is making continuous efforts to expand its exports to United States taking advantage of the high cost of American labour which may permit the Japanese steel to remain competitive in that market. Frequent labour strikes in United States’ steel industry could be another favourable factor to Japanese steel makers. This is not to say that Japan is not diversifying its exports in developing countries, but it is a matter of fact that without exports to United States and other industrialised countries, Japanese steel production would make but little headway.

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Having recognised that the developing nations are short of capital and they would not be in a position to import large quantities of steel for their industrial needs, the next alternative for them would be to make efforts to install steel plants in their own countries. As steel is a capital intense industry, requisite procurement of capital will again be a problem. But once a steel plant is installed, it will give multiple benefits and continuing drain on foreign exchange of developing countries will be obviated. The procurement of capital and other related factors has been discussed elsewhere in this paper.

Supply of indigenous mineral raw materials to the steel plants will be another vital factor for the developing nations. Due to tremendous advances made in transportation systems, it is now possible for a country, which is sufficiently industrialised and has at its disposal the modern shipping, port handling and other transport facilities, to install a steel plant and feed it from the raw materials imported from other countries. For example, the Japanese steel mills are based on iron ores transported from as far a distance as Itabira mine in Brazil and other sources such as Marampa deposit of Sierra-Leone, deposits in India and Australia’s Mount Newman deposits etc. For such a country as Japan, it is economical to import the mineral raw materials and smelt them in their furnaces but for the developing countries, who have not yet modernised their transportation systems, it would be uneconomical to follow the above pattern. These countries will have to plan their steel production on the mineral raw materials available with them. It is quite possible that many developing countries will be deficient in the requisite quality and quantity of ores. But they are in a happy position in the sense that they can draw upon the experiences of other industrialised nations, and make use of the advancements in steel metallurgy which now permits even lean ores to be used in the production of pig iron and steel.

**Basic factors for establishment of steel plants**

The developing countries will have to examine very carefully before setting up steel plants the various factors such as (i) capital finance, (ii) raw materials, (mineral ores, water, electricity, etc.), (iii) machinery, (iv) technical know-how, and (v) technical man-power.
The procurement of requisite capital for financing a steel plant is most difficult of all the factors listed above. Their own resources being inadequate, the developing countries will have to look forward to international organisations such as the World Bank, Inter-American Development Bank, Asian Development Bank and the United States Government Agency for International Development etc., besides direct help from other friendly countries. The President of the Chase Manhattan Bank, in his recent paper entitled "Economic Development: The Banking Aspects" has dealt with the problems of developing countries with reference to capital and man-power etc. The following extract from the editorial of "Mining Journal", London, dated October 6, 1967, on the above paper will be of interest in this context.

"It was pointed out that, as a whole, the developing nations have made notable economic advances in the past decade. The industrial output has doubled during this period, as has their mines' production. Steel production has tripled; while export earnings from this sector in the past two years alone have shown an annual increase of about 8 per cent; transportation systems in the developing countries have also expanded vastly. Most significant of all, perhaps, some of the developing nations such as Korea, Mexico and Thailand have achieved overall rates of economic growth far outstripping those prevalent in the industrialised nations.

Moreover, there is no visible reason why, in the years ahead, this kind of growth should not become the rule, rather than the exception. According to a recent study of Herman Kahn's Hudson Institute, it is entirely conceivable that by the end of this century the number of people living in poverty-stricken, preindustrial societies could be reduced from two-thirds of mankind to only one-eighth." Though this statement may seem wildly optimistic at first sight, it is solidly based upon a trend which the pessimists too often overlook: the remarkable progress of the new "science" of economic development.

Such development, in its present sense, only began to move out of the realm of academic discussion in 1949, when the World Bank first started to make sizeable loans to developing countries.
Since then, however, the World Bank organisation has been supplemented by other international bodies such as Inter-American Development Bank and the Asian Development Bank. On the national level, there are a number of agencies primarily or exclusively concerned with foreign aid, the largest being the U.S. Government's Agency for International Development. In addition, the resources of the major universities of Europe and America are constantly being used to further the technology of development. The number of men around the world with professional knowledge of economic development is now estimated at more than 100,000.

Rockefeller suggested in his address that the lessons so far learned can be reduced to three key propositions: (1) As a group, the developing nations do not suffer from a lack of national resources, but rather from their under-utilisation. (2) A major reason for this under-utilisation of resources lies in the fact that the developing nations are painfully short of capital. The World Bank estimate that they could usefully absorb $3,000-$4,000 million more in aid than they are currently receiving. (3) Even if capital is made available to a developing nation in massive quantities, it will not ensure economic progress. That will only occur if the capital is intelligently used, which involves making hard and sometimes unpopular decisions at every stage.

The above conclusions, among other things, point out that the funds available with the international organisations are inadequate to meet the needs of developing countries. This situation is further aggravated by the fact that recently the United States Government Agency for International Development has announced a cut of 50% in the loans proposed to be given to some developing nations. This trend is likely to continue in future years, due to growing internal responsibilities as also demand of a number of developing countries on the limited available finance. The non-availability of adequate capital will put serious limitation on planning of steel production in developing countries. These countries may, however, start plants with moderate capacities between 100 and 200 thousand tonnes a year which will involve investments of some 10 million dollars as compared with investments of between 500 and 600
million dollars required for an up-to-date full cycle plant capable of turning out over 2 million tonnes a year.

Apart from finance, the other equally important problem will be the procurement of technical-know how and technical manpower. The responsibility of supplying technical know-how and training of personnel should rest with established producers of steel. Why we say this with such an emphasis is due to the reason that both the established producers of steel and the developing nations, are in need of mutual help. The producers of steel are finding it increasingly difficult to sustain their production. If they help the developing nations, they will be, as a matter of fact, themselves derive considerable benefit by way of (i) the export of know-how, (ii) a continuous export of machinery and equipment and (iii) the tremendous possibilities of establishing trade relations through the training of personnel.

The other vital factor will be the indigenous procurement of mineral raw materials. An inventory of mineral resources required for steel plant must therefore be ready before steel production is planned. Most of the developing nations have already organised geological surveys in their countries. These surveys should be pressed into service and assigned priority work of measuring the reserves and grade of iron ores, manganese ores, limestone, dolomite, coal and refractory minerals. The process to be adopted in steel making will considerably depend on the quality of ores available in the country and also the type of steel needed. The quantity of mineral raw material available in a country will also have a significant bearing on the size of the plant. Those countries who have not organized geological surveys should do so without any further loss of time.

Mineral raw material consumption & steel metallurgy

Bessemer, Open Hearth, Duplex, Triplex, Electric and L. D. are the main processes of steel making. In recent years, there has been considerable interest in the many direct reduction processes that are not dependent on coking coal but usually produce a product for further refining in steel furnaces. No matter which series of processes is used, iron ore is essentially the only source of iron units. Compared with only 10 to 20 years ago
there is radical change in the concept of what constitutes an iron ore and from the point of view of developing countries it becomes an important point for consideration. Considering ore in the 1940's, North Americans were abundantly supplied with direct shipping hematites grading from 50 to 58 per cent iron. Europeans used lower grade ores of 28 to 32 per cent iron with self-fluxing features, supplemented with high grade magnetites grading in excess of 60 per cent iron. This was the general picture existing in those days. Today, most blast furnace operators want their ore charge to grade at least 58 to 60 per cent iron and possessing good structure. It is in this context that high grade pellets and sinters have assumed considerable importance. Pellets and sinters can be produced from low grade ores, after beneficiation, which were previously considered uneconomical. The deposits usually consist of magnetite or specular hematite in iron formation grading 25 to 38 per cent iron. The products grade 60 to 68 per cent iron. Such 'tailored ores' are now in much demand.

In Europe, the low grade deposits particularly in Britain and France are retaining their economic usefulness but with a decreasing margin over imported ores. Generally, least difficulty is experienced where blast furnaces are located adjacent to the mines. We do not know the latest position but sometime ago, reliable sources indicated that a factor that could have a marked effect on Lorraine ores in France will be the canalization of the Moselle River by 1966. This will permit barges, bringing overseas ores from Rotterdam to the Ruhr, to continue into the heart of the Lorraine fields and the steel industries of France and Luxembourg. In West Germany, many mines have been closed. The shift in emphasis from the Thomas steel making process using high-phosphorus material to basic oxygen process will be another factor influencing the market for European low grade ores. It has resulted in a decrease in imports of some high-phosphorus ores as produced in Sweden and at Wabana, Newfoundland.

Technical developments offer further change in the global picture analysed above. It will probably be only a few years before partially reduced ores or another form of metallic iron is produced for consumption in blast furnaces or cupolas to produce...
pig iron, or in steel furnaces as coolants or as supplements to quality scrap in the production of speciality steels.

The developing countries in Africa, Asia and Latin America can take advantage of the above metallurgical advancements. Fortunately many of them are rich in iron ore resources due to exploration and researches carried out after World War II. By the end of World War II, the United States of America experienced declining availability of traditional medium grade, direct shipping ores in the Lake Superior district. This resulted in two things, namely, a world-wide search for iron ore deposits in Africa, South America and Canada, and intensification of research in the beneficiation of low grade deposits. Both these efforts were amply rewarded. New discoveries of iron ore deposits were made in African and South American countries besides Canada and technique of pellet production was invented which enabled the working of low grade deposits. Thus most of the developing countries in Africa and South America have rich deposits of iron ore. But those which are short of it, particularly the Asian countries, should make good their deficiency by utilising low grade ores in the production of pellets and sinters for use in their steel plants. The use of sinters and pellets will also minimise the consumption of metallurgical fuel and fluxes.

Although iron ore is an international commodity and it can now travel as far a distance as 5,000 miles before it is consumed, it will not be possible for the developing countries to take advantage of this global movement. The reason is that these countries do not possess adequate receiving facilities at their ports, besides absence of modern internal transport systems. Specialised bulk ore carriers are the order of the day. In terms of ore carrying capacity, vessels of 50,000 and 60,000 tonnes are now not uncommon and larger boats are under construction. Capacities of 100,000 tonnes are now being mentioned as possible before 1970's. The other limitation will be the small capacity of their steel plants which will not permit imports in bulk.

Depending upon requirements, exclusive production of pig iron may also be planned by developing nations using low shaft furnace method. This method, in addition to other facilities, permits, in the main, the use of non-metallurgical fuel.

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Another development in steel metallurgy is the adoption of L. D. process in steel making. According to a recent survey carried out by Kaiser Engineers, the share of basic oxygen steel in the total world steel production has risen from about 4 per cent in 1960 to 22 per cent in 1966. In absolute terms, the increase during the period has been from 15 to 115 million tonnes. The basic oxygen process may account for about 40 per cent of the total world output by 1970.

This process itself is mechanically quite simple involving nothing more than the burning out of impurities and excess carbon in molten iron, scrap and flux by blowing oxygen into the puddle, under high pressure. It is claimed that this process combines the advantages of both Bessemer and open hearth processes without having their respective disadvantages. It has the lowest investment and capital cost of all steel making processes and its operating costs are 50 to 60 per cent of those incurred by O. H. process. This process permits consumption of basic refractories and the consumption rate is almost half that of other traditional processes. The process will suit the developing nations from the point of view of capital investment, raw material consumption and quality steel production.

Ferro-manganese is another important ingredient of steel making. About 10,000 tonnes of standard grade ferro-manganese is required for the production of one million tonnes of steel. Production of ferro-manganese requires availability of high grade manganese ore analysing 48 per cent manganese with 7:1 manganese: iron ratio and low phosphorus, below 0.1 per cent. A number of countries in Africa, South America and Asia possess good deposits of manganese. They should develop ferro-manganese industry and feed their other sister countries who lack in manganese resources. For example, India can cater to the needs of all Asian countries, without any difficulty. The developing nations who possess low grade deposits should take advantage of recent beneficiation techniques and use their ores for the production of ferro-manganese after up-grading.

**Future of steel industry in India**

It is considered appropriate to deal with the future of steel industry in India in some detail before concluding this paper, to serve as an illustration.
Before the pattern of future steel plant installation is predicted, it would be essential, in the first instance, to assess the demand for steel in the years ahead. The authors have made an attempt to evaluate the information available on the subject and arrive at a firm figure of steel and pig iron demand by the year 1980-81. Demand study is a specialised subject and very little work appears to have been done in this direction. The National Council of Applied Economic Research (NCAER) made an appraisal of steel demand in India for the period ending 1965-66 and 1970-71. The following methods for demand appraisal were examined by the NCAER:

(i) Historical analogy method

While applying this method, a particular country with a comparable stage of development is selected and its rate of growth of steel consumption is imputed to the economy under study.

In Japan, the consumption of steel increased by about 1.4 times over the period 1950-57 from 5.3 million tonnes in 1951 to 12.8 million tonnes in 1957. On this basis, India with 3.6 million tonnes of crude steel consumption in 1956, may be expected to consume approximate quantities of 8 million tonnes and 17 million tonnes of steel by 1961 and 1966, respectively. If the same logic is extended further, the consumption of steel may reach a figure of 37 million tonnes by 1970-71.

In U. K. the consumption of crude steel rose from 1.8 million tonnes in 1885 to 7.3 million tonnes in 1913, an increase of about 3 times during the 38-year-period or about 10 per cent per annum during the entire period. On the basis of this growth rate, India would consume 5.6, 8.9 and 13 million tonnes of steel by 1961, 1966 and 1970, respectively.

These examples show that the above method is inadequate for any precise demand forecast. It is difficult to find a country which is strictly comparable to another in any particular stage of development. In addition, the political, planning and productive systems also vary from one country to another.
(ii) **Industrial output method—an illustration**

If a relationship is established between per capita income and per capita steel consumption, a norm is obtained which can be applied for approximate forecast.

In U. S. A. between the period 1889 and 1983, the per head steel consumption increased by 4.85 times when per capita income rose by 88 per cent. The per capita income in India is also planned to be doubled by the end of the Fifth Plan period (1975-76). Imputing the same growth, the following figures of estimates have been arrived at by the NCAER:

<table>
<thead>
<tr>
<th>Population (million) at the end of year</th>
<th>Per capita national income (Rs.)</th>
<th>Per capita finished steel consumption</th>
<th>Total consumption of finished steel (million tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955-56</td>
<td>391.4</td>
<td>284.5</td>
<td>12</td>
</tr>
<tr>
<td>1960-61</td>
<td>430.8</td>
<td>312.9</td>
<td>19</td>
</tr>
<tr>
<td>1965-66</td>
<td>479.6</td>
<td>359.7</td>
<td>35</td>
</tr>
<tr>
<td>1970-71</td>
<td>527.8</td>
<td>410.8</td>
<td>56</td>
</tr>
</tbody>
</table>

*At 1952-57 prices*

The above method is also inadequate for demand estimates. Similar exercise with United Kingdom as base has given different estimates.

(iii) **Market approach method**

This method consists in dividing the country into various consumption sectors and assessing the requirements of each sector separately. Relevant data are lacking for Indian conditions and hence this method is not of much avail.

(iv) **Trend method**

Forecasts can be made on the basis of trend of steel consumption over a number of years. But this method cannot work well in a condition of quick changes. It may be of advantage for making short term forecasts, where forces acting towards changes are uniform.
(iv) End use method

The method consists in identifying final products of steel, listing the production targets of each product, and then evaluating their steel content to give an estimate of demand. The limitations of the method are that the targets of production of various products have to be assumed as achieved. Allowance has to be made for savings in steel consumption and substitution, if any. The export possibilities have also to be considered.

The NCAER has arrived at the following aggregate figures of demand for steel employing the end use method:

<table>
<thead>
<tr>
<th></th>
<th>1965-66</th>
<th>1970-71</th>
</tr>
</thead>
<tbody>
<tr>
<td>(in million tonnes)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Rolled mild steel</td>
<td>6.902</td>
<td>13.594</td>
</tr>
<tr>
<td>(ii) Ingot *</td>
<td>9.735</td>
<td>18.287</td>
</tr>
<tr>
<td>(b) Alloy &amp; special steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Finished</td>
<td>0.500</td>
<td>0.966</td>
</tr>
<tr>
<td>(ii) Ingot</td>
<td>0.834</td>
<td>1.610</td>
</tr>
<tr>
<td>(c) Pig iron (foundry grade)</td>
<td>2.006</td>
<td>3.462</td>
</tr>
</tbody>
</table>

The Council has further estimated steel demand by 1981 on the basis of relationship between past consumption of steel and increase in national income. Between 1951-61 the consumption of steel increased by 42 per cent. The national income is likely to grow and show an increase of 2.6 times by 1980-81. Corresponding to this, the steel demand should increase by about 8.1 times, i.e. 32 million tonnes of finished steel or 42 million tonnes of ingot steel. In addition, there could be exports of finished steel of about 5 million tonnes.

* The following ratios have been adopted for conversion from ingot to finished steel:
  Flat products - 69.0%, non-flat products - 78.0%, alloy and special steel - 60.0%.
In their publication entitled "Long Term Trends and Problems of the European Steel Industry", the United Nations have indicated that India would increase her demand of steel from 3.6 million tonnes in 1957 to 28.0 million tonnes by 1971–75. On the basis of this increase, the demand of steel in the year 1981 would be 43 million tonnes or 37 million tonnes depending upon when the 28-million-tonne figure is reached, in the year 1971 or 1975.

The total demand of steel in India in the year 1980–81 may be summarised as follows:

<table>
<thead>
<tr>
<th></th>
<th>Finished steel</th>
<th>Steel ingot</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. For internal consumption</td>
<td>32</td>
<td>43</td>
</tr>
<tr>
<td>2. For exports</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>50</td>
</tr>
</tbody>
</table>

In addition, a substantial quantity of foundry grade pig iron will have to be produced.

Although the above demand forecast tends to be somewhat theoretical, the analysis shows that India will have to undertake a bold and ambitious plan of steel production to meet her growing demands. When the present steel production is equated against the above projected demand, it seems almost impossible to make such a leap forward in a short time of about two decades. As has been discussed in this paper, there is a growing shortage of capital finance with the international organisation, which will be a limiting factor for the expansion of steel industry. If past performance could be a yardstick for projecting future developments, it would be seen that after a hard toil of the last two decades, India has been able to produce a little over 6 million tonnes of steel per year. Viewed this way, at best, we can visualise an additional production of about 10 million tonnes of steel by the year 1980–81. India is fortunate in having rich deposits of iron ore, manganese ore, limestone, dolomite, refractory minerals and also to an extent coal, which are required in steel metallurgy. Keeping in view the economic factors operating in the country, it would be reasonable to expect that most of MINES AND MINERALS
the production would come from the expansion of existing mills including the Bokaro steel plant, which has not yet come into production, and installation of one or two steel plants in Southern India, in Madras and Mysore. The production of foundry grade pig iron may not pose many difficult problems. The iron ore deposits are widespread in the country and it would be possible to plan a wide dispersal of pig iron plants in the States of Haryana, Rajasthan and Andhra Pradesh, using low-shaft furnace method, which permits non-metallurgical coal to be used in the production of pig iron.

As mentioned above, major portion of the projected additional production of 10 million tonnes per annum by the year 1980-81 would come from the existing steel mills including the Bokaro Steel Plant. The plant-wise distribution may be in the following order:

<table>
<thead>
<tr>
<th>Steel plant</th>
<th>Additional production in the year 1980-81 (in million tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bhilai</td>
<td>...</td>
</tr>
<tr>
<td>Rourkela</td>
<td>...</td>
</tr>
<tr>
<td>Durgapur</td>
<td>...</td>
</tr>
<tr>
<td>TISCO</td>
<td>...</td>
</tr>
<tr>
<td>ISCO</td>
<td>...</td>
</tr>
<tr>
<td>MISW</td>
<td>...</td>
</tr>
<tr>
<td>Bokaro</td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>Total 9</td>
</tr>
</tbody>
</table>

Installation of one new plant at Salem, Madras State, of the capacity of one million tonnes based on pellets produced from quartz magnetite ores of Salem and lignite briquettes from Nyveli may be visualised, which will account for the remaining production of one million tonnes.

The role of low-shaft furnace using non-metallurgical coal for the production of pig iron has been amply emphasised in this paper. The authors feel that a complex of low-shaft furnaces should be set up in various parts of the country for the
production of foundry grade pig iron. At present, there is only one plant at Barbil, Orissa, of the capacity of 30,000 tonnes per annum. More furnaces may be set up in Talcher industrial complex, Orissa, using non-metallurgical Talcher coals.

The State of Rajasthan owns ample resources of iron ore and limestone. It would be possible to set up a plant of the capacity of 100,000 tonnes per annum using lignite briquettes from Palana lignite deposits.

The State of Haryana can also plan to install a low-shaft furnace of a moderate capacity of 40,000 tonnes based on Mohindergarh iron ores and semi-anthracite coal from Kalakote, Jammu & Kashmir.

Similarly, the States of Andhra Pradesh and Maharashtra can conveniently plan to install pig iron plants as they have ample resources of iron ore and non-metallurgical fuel.

Possible locations of pig iron plants together with raw material supplies in the States of Haryana, Rajasthan, Maharashtra and Andhra Pradesh are given below:

**Haryana**

(i) Locality: Narnaul, distt. Mohindergarh, Haryana.

(ii) Capacity: 40,000 tonnes by applying low-shaft furnaces.

(iii) Sources of raw materials:

(a) Iron ore: Mohindergarh distt.

(b) Limestone: Ambala area.

(c) Reducing agent: Semi-anthracite coal from Kolkot.

(iv) Power: Hydro electricity from Bhakra Dam.

(v) Approach: It is an important Railway Station between Jaipur and Delhi (broad gauge).
Rajasthan

(i) Locality : Ringus, distt. Jaipur, Rajasthan.

(ii) Capacity : 100,000 tonnes from the low-shaft furnaces.

(iii) Sources of raw materials :

   (a) Iron ore : Morija in Jaipur district and Nathar-ki-pal, Udaipur district.

   (b) Limestone : Jodhpur area.

   (c) Reducing agent : Carbonized Palana lignite briquettes.

(iv) Power : Hydro electricity from Bhakra Dam.

(v) Approach : It is an important Railway Station between Jaipur and Narnaul (broad gauge).

Maharashtra

(i) Locality : Chanda, distt. Chanda, Maharashtra.

(ii) Capacity : 100,000 tonnes per annum.

(iii) Sources of supply of raw materials :

   (a) Iron ore : Chanda areas.

   (b) Limestone : Chanda distt. Yeotmal and Nagpur.

   (c) Reducing agent : Non-coking coal from Chanda and Nagpur.

(iv) Power : Thermal.

(v) Approach : Chanda is an important Railway Station in the Central Railway on Delhi-Madras Grand Trunk.

Andhra Pradesh

(i) Locality : Guntur.

(ii) Capacity : 100,000 tonnes based on low-shaft furnaces.
(iii) Supply of raw materials:
   (a) Iron ore: Guntur area and the adjoining parts.
   (b) Limestone: Guntur distt. and the adjoining areas.
   (c) Reducing agent: Non-coking coal from Singerani coal field.

(iv) Power: Hydro electricity from Nagarjun Sagar.

(v) Approach: It is a Railway Station on the main line.

Acknowledgement

The authors are indebted to Shri M. C. Basu, formerly Mineral Economist, Indian Bureau of Mines, for going through the paper and offering valuable suggestions.
EXPORT promotion is a major plank of our economic policy. During the Third Plan period the import bill is estimated to average Rs. 1,270 crores annually. This presupposes a higher export base, and the Plan rightly prescribes for an annual average export of Rs. 740 crores. The average annual exports during the Second Plan period were around Rs. 611 crores. Minerals and mineral products have, hitherto, contributed rather insignificantly to the export earnings. What is important, however, is the new dimensions noticeable in mineral trade and its vast future potentials. The export trade in minerals is being geared up on two planes, namely, (i) the export of manufactured products, such as ferro-alloys, iron and steel materials, alumina, aluminium, mica and heat and sound insulating mica bricks, refractory and ceramic materials and (ii) the export of surplus mineral commodities. Needless to say that the former is of recent origin commensurate with the establishment of various industrial units during the Second Plan. During the year 1960, the foreign exchange earnings by export of metals and alloys totalled Rs. 14 crores, out of which the share of ferrous metals was Rs. 13.8 crores. The export trade in mineral raw materials, though having a rich past, has acquired momentum recently with the planned exploitation of the mineral wealth. The opening up of large scale public sector mines and the installation of large beneficiation plants will prove useful in economic production and standardisation of grades. The foreign exchange earned by minerals in 1960 was about Rs. 51 crores as compared to Rs. 36 crores in 1951.

It may be noted, therefore, that a beginning on scientific lines has just been made and the promise of a great future lies ahead. The scale of production of various exportable minerals during the year 1960 and their current prices have been given in Table-I. Broad developments with special reference to export potentialities are described below.

IRON ORE

India is one of the richest countries of the world with regard to iron ore resources. The reserves of high grade ore alone are placed at 21,000 million tonnes.

There is a great demand for Indian ore in Japan and European countries. A number of agreements have been entered into between the various countries and the State Trading Corporation of India which is exclusively handling the exports of iron ore. Large scale mines capable of producing as much as 4 million tonnes of ore are being opened up in the public sector to meet the commitments. Transport facilities are being expanded to the maximum extent possible. Mangalore† is being developed as a major port on the west coast to meet the requirements of the European buyers who are interested in lifting ores from the ports nearest to them even though the grade may be low, freight being an important factor in cost structure.

Taking into consideration the demand and the production capacity, an export target of 12 million tons per annum is estimated to be achieved by the end of the Third Plan period. The export during the year 1960 was 3.43 million tonnes valued at Rs. 173 million. With the merger of Goa with the Indian Union, the export of iron ore will be increased to the tune of 6 million tonnes. This may also fetch a foreign exchange of about Rs. 35 crores annually.

IRON AND STEEL

During the Third Plan the development of the steel industry centres round the expansion of the three steel plants already commissioned during the Second Plan period and the erection of another plant at Bokaro. A capacity target of 10.2 million tonnes of mild steel ingots, 1.5 million tonnes of pig iron and 200,000 tonnes of alloy, tool and special steels is envisaged. The surplus quantity of 1.5 million tonnes of pig iron will be available for sale. During the year 1960 pig iron and sponge iron valued at Rs. 1.9 crores and iron and steel materials valued at about Rs. 8 crores were exported.

MANGANESE ORE

Manganese ore is known to the world market since long. In fact, the entire industry was till

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† With the acquisition of Goa, which has one of the finest harbours in the country, Mangalore’s development as a major port is likely to be put off.—Editor.
Table No. I: Scale of production of exportable minerals and their current prices.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Production in 1960</th>
<th>Current prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron-ore</td>
<td>10.68 million</td>
<td>Rs. 54.00/tonne — 65% Fe FOB Visakhapatnam, Reddi, Bombay and Kandia.</td>
</tr>
<tr>
<td>Manganese ore</td>
<td>1.20 million</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rs. 130 to 140/tonne — 46-48% Mn FOB Calcutta.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rs. 90 to 95/tonne — 42-44% Mn FOB Calcutta.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rs. 70 to 75/tonne — 38-40% Mn FOB Calcutta.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rs. 15 per long ton — 46-48% Mn FOB Visakhapatnam.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rs. 115 per ton — 44-46% Mn FOB — ditto.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rs. 85 per ton — 38-40% Mn FOB — ditto.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Price quotation July, 61)</td>
</tr>
<tr>
<td>Coal</td>
<td>52.59 million</td>
<td>Coal (Coking) Selected Grade A FOR Rs. 22.69/tonne.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grade B. Colliery Railway siding Rs. 21.70/tonne.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grade I. Colliery Railway siding Rs. 20.85/tonne.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coal (no-coking) Selected Grade A Colliery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Railway siding</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chromite</td>
<td>1,00,000 tonnes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rs. 140 to Rs. 145 per tonne—48% Cr₂O₃ Cr/F 2.81</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bauxite</td>
<td>387,000 tonnes</td>
<td></td>
</tr>
<tr>
<td>Mica</td>
<td>29,182 tonnes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mica (Block) C &amp; SS No. I FOB Calcutta Rs. 235/Kg.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F. S. No. I -do- Rs. 180/Kg.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G. S. No. I -do- Rs. 120/Kg.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stained No. I -do- Rs. 70/Kg.</td>
</tr>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Mica (Splitting) B. F. No. 4 -do- Rs. 25/Kg.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1st quality B. F. No. 5 -do- Rs. 18/Kg.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B. F. No. 6 -do- Rs. 8/Kg.</td>
</tr>
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<tr>
<td></td>
<td></td>
<td>Mica loose — 1st quality -do- Rs. 2.75 Kg.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd quality -do- Rs. 2.50 Kg.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesite</td>
<td>156,000 tonnes</td>
<td>Magnesite (raw) 45-46% Mgo Rs. 44.30/tonne F.O.B. Madras; magnesite (calcined) top grade Rs. 251.75/tonnes, First grade Rs. 209.00/tonne Service grade Rs. 157.47/tonne. Dead burnt Rs. 211.60/tonne FOB Madras. Kyanite 60-61% Al₂O₃ Rs. 264/tonne FOB Calcutta.</td>
</tr>
<tr>
<td>Kyanite and</td>
<td>20,156 tonnes</td>
<td></td>
</tr>
<tr>
<td>Sillimanite</td>
<td>8,483 tonnes</td>
<td></td>
</tr>
<tr>
<td>Soapstone</td>
<td>93,390 tonnes</td>
<td>Powder No. I Rs. 200.00/ton, No. 2 Rs. 150/ton, No. 3 Rs. 75/ton F.O.B. Calcutta.</td>
</tr>
<tr>
<td>Barytes</td>
<td>13,500 tonnes</td>
<td>Snow white (powder) Rs. 216.50/tonne; off colour Rs. 69.00/tonne F.O.B. Cuddapah.</td>
</tr>
<tr>
<td>Gypsum</td>
<td>997,000 tonnes</td>
<td></td>
</tr>
<tr>
<td>Ilmenite and</td>
<td>250,000 tonnes</td>
<td>Ilmenite. 58.59 % TiO₂ Rs. 73.16/tonne FOB Kolthottam (Kerala).</td>
</tr>
<tr>
<td>Rutile</td>
<td>982</td>
<td>Rutile. 94-96 % TiO₂ Rs. 984.20 Ex-factory (Chorwara).</td>
</tr>
</tbody>
</table>
recently dependent on export trade, witnessing boom periods as well as slump conditions depending on the tone of the world’s economic condition. During the Second Plan ferro-
manganese plants have come into operation in the country and have opened up avenues for the internal consumption of manganese ore. But as the resources of manganese ore in the country are bountiful, the planning is directed towards boosting up exports too. Indian ore is facing stiff competition in the world market from new sources of supply over which the consuming countries have either commercial or political control. Efforts are under way to reduce cost of production in the country by introducing scientific methods of mining. Large-scale beneficiation plants are proposed to be installed to ensure quality and conservation. It is anticipated that 1.5 million tonnes of ore can be exported annually as against the present export of 1.16 million tonnes valued at Rs. 14 crores (1960).

FERRO-MANGANESE

Ferro-manganese is being made in the country from the Second Plan period, both for internal consumption and for export trade. The present production of 86,000 tonnes will go up to 200,000 tonnes by the end of the Third Plan. A total quantity of about 43,000 tonnes was exported during 1960. This has to be gradually increased to about 100,000 tonnes annually during the course of the next few years. The analyses of different grades of ferro-manganese manufactured in the country are as follows:

<table>
<thead>
<tr>
<th></th>
<th>1st grade</th>
<th>2nd grade</th>
<th>Standard</th>
<th>2nd grade</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low phosphate</td>
<td>standard</td>
<td>low phosphate</td>
<td>standard</td>
<td>grade</td>
</tr>
<tr>
<td>Fe</td>
<td>12.71</td>
<td>14.91</td>
<td>12.54</td>
<td>14/17</td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td>80.15</td>
<td>78.31</td>
<td>77.30</td>
<td>75/77</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.15</td>
<td>0.263</td>
<td>0.20</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.008</td>
<td>0.020</td>
<td>0.020</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Si</td>
<td>0.69</td>
<td>0.36</td>
<td>1.35</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>6.30</td>
<td>6.15</td>
<td>6.15-7.00</td>
<td>6.5-7.00</td>
<td></td>
</tr>
</tbody>
</table>

MICA

India needs no introduction as the producer of the best variety of ‘Bengal Rudy’ and other varieties of muscovite and phlogopite mica. She has long established the world reputation as a monopoly exporter of quality mica of different sizes varying from Over Extra to Extra Special (164 sq. in.) to No. 5 or even less sizes. Recently, India has started manufacturing mica insulating (plates, rings, tubes etc.) and dry ground mica powder, for which export avenues are wanted and searched for. Mica insulating bricks manufactured in India is ideal for use as light weight insulating bricks up to a temperature of 1000°C and is a good substitute for vermiculite and diatomaceous earth insulating bricks.

The physical properties of Indian mica bricks are shown below.

India has sufficient reserves to maintain its export market for quite a number of years. Mica has been produced mainly for export purposes so far and the production can be increased according to the requirements. The rate of production has increased from 23,625 tonnes in 1955 to 29,182 tonnes in 1960.

COAL

India is fairly rich in her resources of coal and lignite which are estimated to be little over 31,000 million tons within a depth of 1,000 ft. The coal is mostly of the bituminous type and the calorific value of best quality goes about 7,000 calories. The moisture and the ash content vary considerably, ash from 11 to 13% in the selected grade coal and more than 18% in grade III coal. India, however, has got limited reserves of coking coal.

A total quantity of 52.59 million tonnes of coal was produced in the year 1960. By the end of the Third Five Year Plan a target production of 97 million tonnes annually is envisaged. This will mostly meet the requirements of home industries. A little quantity of coal is also exported to Pakistan, Burma and Ceylon. During the year 1960, 1.32 million tonnes were exported.

The Physical Properties of Indian Mica Bricks

<table>
<thead>
<tr>
<th>Grade</th>
<th>Density (lbs. per cft.)</th>
<th>Crushing strength (P. S. T.)</th>
<th>Thermal conductivity b.t.u. at 500°C</th>
<th>Max. Safe Tem. °C</th>
<th>Porosity %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>35 — 45</td>
<td>85 — 125</td>
<td>0.9 to 1.1</td>
<td>975</td>
<td>70 — 75</td>
</tr>
<tr>
<td>Medium</td>
<td>45 — 50</td>
<td>100 — 150</td>
<td>1.1 to 1.3</td>
<td>1000</td>
<td>70 — 75</td>
</tr>
<tr>
<td>Solid</td>
<td>50 — 60</td>
<td>150 — 230</td>
<td>1.3 to 1.5</td>
<td>1000</td>
<td>70 — 75</td>
</tr>
</tbody>
</table>
ILMENITE AND RUTILE

Ilmenite is widely employed for manufacture of titanium paints of brilliant whiteness. The rutile produced is quite suitable for manufacture of electrodes and also for use as a delustering agent for protection of nylon, rayon and terylene fibres from the action of sunlight. The TiO₂ percentage is above 55% in the Indian mineral.

India has great potentialities to feed the foreign buyers with ilmenite for quite a long time.

CHROMITE

The country is not quite rich in chromite deposits and the reserves are mostly required for her own requirements. However, fairly a large percentage of chromite produced in India is being exported and there may not be any difficulty in exporting about 30,000 tonnes of chromite every year from this country for sometime more. The chromite produced in India is usually of very high quality sometimes containing 50-53% Cr₂O₃. Usually Indian chromite is divided into two major grades, namely, High (above 47%) and low grade (below 47%) for this purpose.

KYANITE & SILLIMANITE

India is one of the largest producers of natural sillimanite which does not require any processing or calcining before use. Assam sillimanite is of world fame for its quality. It can be cut into different sizes and blocks and directly put into use. Indian sillimanite can stand very high temperatures, high abrasion and its co-efficient of expansion is much less so that it does not spall off in the furnace. Sillimanite can be supplied in blocks or sawn shapes (as per need of the furnace) or in fine powder and grain sizes. Typical ingredients are as follows:

<table>
<thead>
<tr>
<th>Sillimanite</th>
<th>94.85%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corundum</td>
<td>3.24%</td>
</tr>
<tr>
<td>Hematite</td>
<td>0.80%</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>0.45%</td>
</tr>
</tbody>
</table>

The presence of corundum improves its performance as a refractory.

India has richest deposits of Kyanite in the world located at Lapsa Buru, in Singhbhum district. Average alumina content of Lapsa Buru Kyanite deposits is fairly high, containing 61% Al₂O₃. Kyanite can be supplied from few inches in size to 1 ft. in length.

As a refractory, Indian sillimanite and kyanite can be utilised in different types of furnaces, as bricks, saggars, bonding and lining materials etc.

During the year 1960, 7831 tonnes of sillimanite and 26,000 tonnes of kyanite were exported from India.

MAGNESITE

India has ample reserve of magnesite about 96 million tonnes to meet the internal requirements as well as export demand. During 1960, 28,000 tons of magnesite was exported.

For use as a basic refractory, Indian magnesite is superb in quality. With more than 45% MgO, the magnesite has found wide utility in the manufacture of refractories, bricks, cupolas etc. India can supply dead burnt magnesite and peas required in steel industry. Both raw and calcined magnesite are exported.

BAUXITE

India is endowed with huge reserves of bauxite (30.8 million tonnes with more than 50 per cent Al₂O₃ or 254 million tonnes of all grades). In some varieties the Al₂O₃ content is more than 60 per cent. The mineral can be exported satisfying the specification of manufacturers of aluminium metal, refractory etc. India has launched an ambitious scheme of production of aluminium. 18,000 tonnes of metal are being produced at present and before the end of the Third Five Year Plan, the production is expected to be more than 83,000 tonnes. As such, the country will be in a position to export bauxite, alumina and aluminium metal. During the year 1960, 76,000 tonnes of bauxite were exported from India.

SOAPSTONE (Steatite)

The country has got fairly good reserves of soapstone specially in Rajasthan area. The extra white superior variety useful for cosmetic purpose or greenish ‘java-grade’ type and other types required as filler in rubber, paper and textile industries, are also available in the country in any quantity required by buyers. About 8,000 tonnes were exported during the year 1960.

BARYTES

Indian barytes with its high specific gravity and fineness, is highly suitable for use in oil-
well drilling muds. The snow-white barytes can cater to the need of the paint manufacturers. India can supply both the qualities in fairly large quantities. Middle-East countries are widely using Indian barytes for oil-drilling. The reserves of barytes has not been fully estimated but occurs in many parts of the country. About 25,000 tonnes of barytes was exported during 1960.

GYPSUM

A very large deposit in Rajasthan has been proved recently making a total reserves of 1,038 million tonnes in the country. Indian gypsum is of fairly high grade having more than 70% purity of which about 85% of the material is of more than 84% purity. So long there has been no export of gypsum, but, in view of the large reserves now proved, the prospects of export look bright.