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EDITORIAL

WHILST the response to the appeal of Mr. Hugh Picard for the I.M.M. Benevolent Fund has not come up to our expectations, it is, perhaps, as much as one can hope for, in view of the prevailing depression. It is certainly gratifying to note from this month's list that the appeal is receiving the attention of mining companies and their employees.

IT was announced last month that the Institution of Mining Engineers has awarded the "Mavor and Coulson" Travelling Studentship for 1932–33 to Mr. E. J. Kimmins, of Birmingham University. The studentship is worth £300 and the successful candidate is required to devote one year to the study of coal mining methods in Great Britain, the Continent of Europe, and either Canada or the United States.

SEVERAL new appointments to the Advisory Committee for the Metalliferous Mining Industry were announced towards the end of March. The new chairman, to succeed the late Mr. J. J. Burton, will be Mr. R. Arthur Thomas, while Mr. Burton's place as representative of the iron and steel industry will be taken by Mr. E. J. Fox. The new representative of the owners of iron ore mines and quarries is Major W. D. Barratt and Mr. E. Archer becomes secretary, following Mr. F. C. Starling.

THE new president of the American Institute of Mining and Metallurgical Engineers is Mr. Scott Turner, Director of the United States Bureau of Mines. Mr. Turner graduated from the University of Michigan in 1902 and received his E.M. from the Michigan College of Mines in 1904. Since then he has had extensive experience in various parts of the world, notably in Spitzbergen, and he was for several years consulting engineer to the Mining Corporation of Canada before joining the Bureau of Mines.

ELSEWHERE in this issue will be found a translation of certain extracts from a work by Professor Schneiderhöhn, of Freiburg,[1] in which his views on the geology of the copper belt of Northern Rhodesia are set out. The author has advised us that in the preparation of the material quoted the literature published up to May, 1930, was taken into consideration, but that no information published since that date has induced him to alter his views with regard to the genesis of the copper deposits of Northern Rhodesia and the Katanga.

AT the annual convention of the Canadian Institute of Mining and Metallurgy more light was shed by Dr. Charles Camsell on the ever-green topic of the mineral position of the British Empire. He drew attention to a survey made by the United States Department of Commerce which shows that the Empire considered as a unit has commercial control over 21 out of 28 of the essential raw-material metals and minerals. In contrast our own Imperial Institute in a recent report does not show the Empire in such a favourable position, but then it views the subject from the standpoint of political control. Thus petroleum, which is included in the former, is excluded from the latter. Dr. Camsell stressed the need for the compilation of a consolidated statement or mineral balance-sheet for the whole Empire, which he said was in course of preparation. With such evidence before the governments of the British Commonwealth at the forthcoming Ottawa conference the cause of Imperial unity should be further strengthened.

The Institution Meeting

The work of Sir Harold Carpenter on the internal structure of metals is already well known, but, although the greater part of his investigations have been devoted to finished metallurgical products, it is not too much to say that mining men have taken greater interest in the results of his labours since his attention has been turned to native metals. In 1928 the first-fruits of this aspect of his research were presented to the Institution of Mining and Metallurgy in the form of a paper, written in collaboration with Dr. S. Tamura, which embodied the results of an application of metallographic technique to the study of native metals. At the time it was only partially appreciated how much the work was likely to be of importance to economic geologists, although the authors themselves realized that the structure of the metals gave valuable

[1] "Mineralische Bodenschätze im Südlichen Afrika." Berlin: Nem-Verlag.

indications as to their past history. The subject was advanced a stage further in 1930, when, in conjunction with Dr. M. S. Fisher, Sir Harold once more brought the matter before the Institution, the investigation having been confined on this occasion to specimens of native copper. By this time it was generally realized how illuminating this type of research was likely to be as an aid to the elucidation of the problems of ore genesis and during the course of the discussion of this paper Dr. H. C. Boydell suggested that a similar study of specimens of native silver might be of even greater interest to practical geologists, as the subject of the origin of that metal was much more controversial than that of native copper. This suggestion was adopted and at last month's meeting of the Institution the first paper for presentation—" A Metallographic Investigation of Native Silver," by the same authors—drew an interested audience of mining geologists as well as metallurgists, and a second paper—" The Volumetric Assay of Gold," by Mr. W. Branch Pollard—proved an additional attraction to the latter, the time available proving all too short for those eager to take part in the discussions.

The study of native silver embodied in the paper by Sir Harold Carpenter and Dr. Fisher involved an examination of samples of the metal from deposits in various parts of the world, the specimens being investigated by metallographic means and by experiments in heat treatment. The authors have realized that the reactions by which native silver has been formed are fairly well understood by geologists, and that the new data are mainly useful for the light they throw on existing theories and for the help they may afford in determining the origin of any particular deposit. Briefly, they find that the metal is deposited by aqueous solutions of either meteoric or hydrothermal origin, and that when deposited by supergene or cool hypogene waters the structure of metals shows few, if any, traces of recrystallization. When, however, the structure is coarsely homogeneous, similar to that produced by annealing, it is considered that the metal has either been deposited from waters at a temperature above that of recrystallization (about 200° C.) or that the silver has subsequently been thermally metamorphosed. Most of the specimens seemed to show that more often than not the silver has been deposited from cool waters, although examples from Northern Rhodesia, Lake Superior, and Cobalt were deposited from hot solutions. At Lake Superior, where the silver is associated with native copper, it is interesting to note that both metals have been formed at a temperature within the range of 200° C. to 250° C. These notes will give some idea of the type of result which has been obtained from this work, and at the meeting, after the paper had been introduced by Sir Harold Carpenter, who had something to say of the differences between native copper and native silver, the discussion was opened by Dr. Desch, who, together with all the later speakers, congratulated the authors on the remarkable microphotographs they had prepared. Dr. Desch was followed by Dr. Sydney Smith, who compared one of the authors' specimens with a similar one collected by himself in Canada. Dr. W. R. Jones, in his contribution to the discussion, welcomed the fixation of additional points on a geological thermometric scale, although this speaker was reminded by Dr. J. A. L. Henderson that pressure conditions cannot be ignored in such research. Other speakers included Professors Bannister and Merrett, Dr. Fisher being able to reply to certain of their questions.

The discussion of the first paper of the evening somewhat curtailed the time available for Mr. Pollard to present his on the assay of gold, but the subject is of such interest that the written discussion will surely be followed very closely. It will suffice here to say that certain aspects of the method described by the author were first brought to the notice of members by a paper read in 1923, the present work being an amplification of the procedure then developed. The author's method, which is employed at the Cairo Mint and in the Alexandria Assay Office, originally involved solution of the assay in aqua regia, the gold being then precipitated as metal by a standard solution of mercurous nitrate. Various refinements have now been incorporated in the process, and it is considered that for certain purposes the wet assay has advantages over the dry method, an opinion tentatively shared by Dr. Sydney Smith, who opened the discussion on the paper and told something of his experiences in carrying out an analysis by this means. At any rate, it is possible to agree with the author that, in spite of the fact that it would be hard to improve on the fire assay of gold from the point of view of accuracy, the economies of time and expense promised by his method merit close examination.

Metallurgy and Engineering

At the recent annual general meeting of the Institute of Metals, on the occasion of his induction to the presidential chair, Sir Henry Fowler made some remarks which seem worthy of attention, particularly when he referred to the relations existing between metallurgy and engineering. Sir Henry from 1925 to 1930 occupied the position of chief mechanical engineer to the L.M.S. Railway, which he relinquished on his appointment as assistant to the vice-president for research and development, an appointment which lends additional weight to his pronouncements. After referring to the custom of the institute, whereby the president's chair is held successively by a producer of metals, a research metallurgist, and a user of metallurgical products—a most satisfactory arrangement—the new president dealt with the connexion between engineering and metallurgy, holding the view that no engineer can be said to be properly equipped for his work unless he has some knowledge of metallurgy. In this respect, of course, it will readily be admitted that the engineer's knowledge can hardly, in most cases at least, be expected to extend beyond a working acquaintance with the properties and strength of materials, whether cast or machined, and with the effects produced by heat and mechanical treatment. Sir Henry also emphasized the fact that no important discovery in metallurgy has been made but that a resultant advance in engineering practice soon became evident. The engineer is, in fact, constantly waiting on the metallurgist to provide him with those materials which make yet further conquests of the forces of nature possible. Witness, for example, the advance of the high-speed Diesel engine and the notable improvements in aero-engine design which made possible the building of the Schneider Trophy machines. Many more examples might be quoted tending to show that the engineer will generally be able to find an immediate use for all the new materials the metallurgist can find for him. The engineering profession, in fact, shows a definite tendency to recognize that its interests and those of the metallurgists run on parallel if not converging lines, as the president was gratified to record.

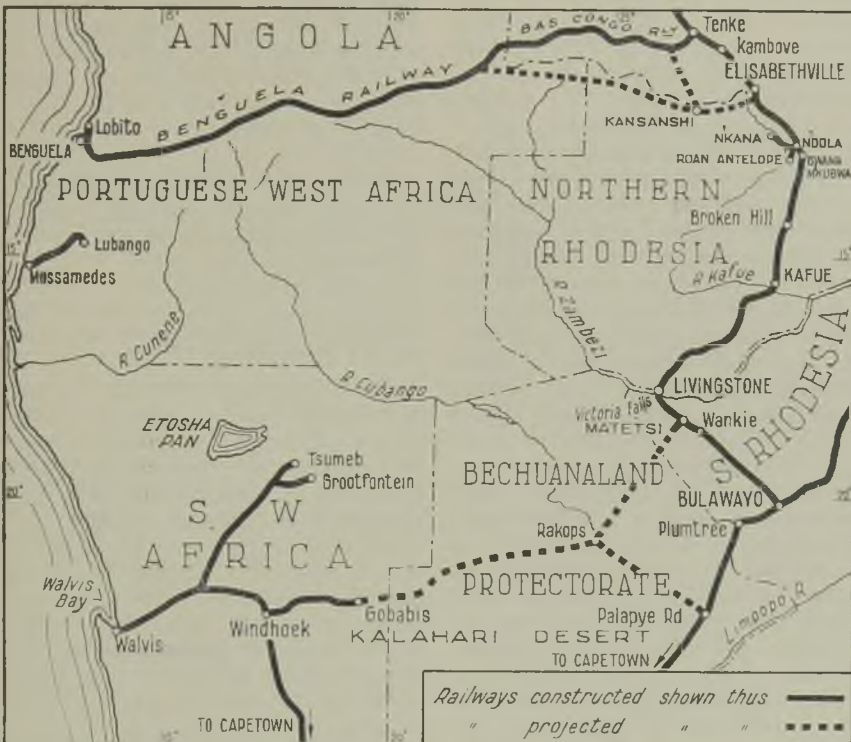
Sir Henry Fowler had, in addition, something to say about modern facilities for the teaching of metallurgy, as he was in no doubt that the advance of metallurgical education, as well as the growing importance of metallurgy generally, was largely responsible for the creation of a better understanding between the scientific and the so-called practical man. Nevertheless, it seems evident that there is a definite element of danger in this growth of educational facilities and that it has gone far enough, if not, indeed, already too far. It is possible that the sinking of available funds in the erection of teaching establishments which are really only a duplication of departments already in existence may starve the latter of endowments of which they are badly in need. It is impossible to overlook the fact that municipal pride is apt to demand at least an equality in its educational facilities with those of its neighbour, but there should be a wider understanding and it should be recognized that some of the new institutions resulting from these processes of civic expansion are unnecessary, inasmuch as adequate accommodation for students exists elsewhere.

The Development of the Kalahari

The development of Central African communications has always received special attention in these columns, the manner in which the traffic arteries have followed the pioneer, extending farther inland as mineral deposits have been discovered, throwing interesting light on the factors affecting the advance of civilization. Now, therefore, that details are available concerning reconnaissances made last year to test the possibilities of constructing a new railway link across the north of the Kalahari Desert it is possible once more to return to the subject. The projected line across the Kalahari is intended to join the railway systems of Southern Rhodesia with those of South-West Africa, thereby affording a direct outlet from the interior to Walvis Bay. It is stated that the results of the survey have been so favourable that the project has at last been brought into the realm of practical politics and the governments concerned have been urged to initiate a more extensive survey in order to confirm the results obtained by the first expedition and, more especially, to establish by boring operations the presence of adequate water supplies along the route.

Reference to the accompanying sketch map will show the route to be taken by the proposed new railway and it is important to note that the results of this first engineering survey seem to show that a line could be constructed with an easier gradient and which would have cheaper operating costs than those along the existing routes to Beira and Lobito Bay. In fact, the engineer in charge has expressed the view that Walvis Bay would be a more economical route than the other two even for traffic from Northern Rhodesia and the Katanga. It is important to remember, however, that there is but faint hope of the new line being able to develop

of artesian water has been extraordinarily rapid. In a recent paper read before the Geological Society of South Africa Mr. H. F. Frommurze has given a concise account of the flowing bore-holes in the Rehoboth, Gibeon, and Gobabis districts of South-West Africa. The first holes which gave flowing water in this area were drilled by the German Water Boring Department, while they were endeavouring to find out whether the Upper Karroo sediments were coal-bearing. After the War the area was further tested by the Irrigation Department of the South-West



much mineral traffic in its own area, judging by the present state of our knowledge of the local geology, and the real *raison d'être* of the new line lies in the hope, confidently expressed by the agricultural surveyors, that there exist ample supplies of artesian water below the desert sands. It is hoped by the opening up of these resources of underground water ultimately to render the country suitable for ranching purposes, and estimates have been prepared which envisage the area carrying about 1,700,000 head of cattle.

The development of the western edge of the Kalahari since the discovery of supplies

Administration, many more holes being drilled, as a result of which a strip of bush-covered sand, previously left to game and the Bushman, has been rendered habitable and potentially productive. The author of this paper has drawn several interesting conclusions as a result of his survey, among which it may be noted that he is of the opinion that a promising area for the striking of flowing water lies in the southern portion of the Aminuis Reserve and in the ground extending eastwards into Bechuanaland, an area which, if developed, will need such an outlet for its produce as the projected railway might provide.

REVIEW OF MINING

Introduction.—Mining conditions during the past month have shown little change. The decline in metal prices, due to the advance of sterling, has, however, proved somewhat disconcerting. Nevertheless, it is felt that at last matters are on the road to recovery, although it is recognized that it may be some time before they improve to any appreciable extent.

Transvaal —The output of gold on the Rand for March was 914,017 oz. and in outside districts 46,018 oz., making a total of 960,035 oz., as compared with 914,102 oz. in February, the March total representing a new monthly record. The number of natives employed on the gold mines at the end of the month totalled 214,024, as compared with 216,171 at the end of February.

The report of East Geduld Mines for 1931 shows the ore reserves at the end of the year to have been 3,750,000 tons, averaging 6·9 dwt. in value over a stoping width of 58 in. Stoping operations were commenced on July 1 last and up to the end of the year 231,700 tons of ore had been milled, the gold yield totalling 56,003 oz., worth £237,116. The working loss for the half-year's operations amounted to £33,035, although profits have been earned since September. The mine is expected to be in full swing by the middle of the year.

During 1931 the mill at the West Rand Consolidated Mines crushed 1,066,000 tons of ore, yielding gold to the value of £1,217,901. Working costs amounted to £984,879 and the working profit to £233,022. The indebtedness of the company to the General Mining and Finance Corporation, which at the end of 1930 amounted to £216,125, was repaid during the year. The estimated ore reserves at the end of the period under review amounted to 4,053,000 tons, averaging 5·6 dwt. in value over a stoping width of 45 in. The fire which occurred at the mine in June last, which resulted in a stoppage in the West Shaft section for six weeks, is responsible for the decrease of 21,000 tons in the ore crushed.

The report of the Meyer and Charlton Gold Mining Company for 1931 shows the ore milled, 206,120 tons, to be 7,280 tons less than in the previous year, owing to the stoppage in November last caused by the fire in the City Deep. The value of the gold produced was £207,868, while working costs amounted to £186,886, leaving a working profit of £20,982. The ore reserves at the end of the year were estimated to consist mainly of a few small blocks of South Reef, which have been opened up in claims leased from the City Deep, and, although certain high-grade pillars remain in the mine, it is regarded as evident that the end of its profitable l fe is not a long way off.

The accounts of the New Kleinfontein Company for 1931 show a working loss, after providing for development expenses, of £11,622. The ore milled totalled 611,200 tons and 124,487 oz. of gold was recovered, the total revenue being £531,993. The ore reserves at the end of the year were estimated to be 288,000 tons, averaging 4·93 dwt. in value over a stoping width of 53·01 in., as compared with 286,100 tons, 5·01 dwt., and 51·75 in. at the end of 1930. Development in the Apex mynpacht was resumed during the year and work so far accomplished has provided ore reserves which more than replace the tonnage mined from the section.

Details of the reports of the companies of the Johannesburg Consolidated group for 1931 will be found elsewhere in this issue. On the Randfontein Estates the development of the principal section of the mine is in a very interesting stage, the year's work having fully borne out the expectations of a progressive flattening of the dip of the reefs. It is now believed that beds are in the form of a large synclinal fold, which is cut out to the east by the Witpoortje fault, situated considerably east of the present working.

An accident to the rock hoisting engine at the No. 5 vertical shaft of the Consolidated Main Reef Mines, reported on March 9, was expected to interfere with the monthly output.

The accounts of Rand Mines, Ltd., for 1931 show a profit of £541,041, which, added to the balance of £428,817 brought in and £378 in respect of forfeited dividends, gives an available total of £970,236. Of this amount £409,030 has been distributed as dividends, equal to 80%, £63,083 expended in investments, and £31,412 has gone for taxation purposes, leaving a balance of £466,711 to be carried forward.

The report of Witpoort Gold Areas for 1931 shows the ore reserves to be 567,000 tons, of an average value of 6·2 dwt. over a stoping width of 41 ins. The position developed during the year shows the company to have been indebted to the General Mining and Finance Corporation to the extent of £90,000, while other commitments, for stores, etc., were also heavy. As the General Mining Corporation was disinclined to advance more money, the agreement with Brakpan mines, already noted in these columns, was entered into and at an extraordinary meeting held last month this was approved.

Shareholders of Brakpan Mines have been informed that in order to avoid appropriations from profits the board may decide to raise the funds required for the payments to the Witpoort company and for the development of the newly-acquired area by an issue of shares. For this purpose it will be necessary to increase the capital of the company and at meetings to be held in June and July next it will be proposed that the directors be given power to do this up to a maximum of £1,150,000.

Southern Rhodesia.—The output of gold from Southern Rhodesia during February was 45,032 oz., as compared with 42,706 oz. for the previous month and 42,818 oz. in February, 1931. Other outputs for February last were: Silver, 6,380 oz; coal, 44,928 tons; chrome ore, 2,647 tons; asbestos, 873 tons.

The report of the Globe and Phœnix Company for 1931 shows that 72,512 tons of ore was crushed, the gold recovered totalling 65,588 oz. The net profit for the year, including £37,214 brought in, amounted to £114,915. Dividends declared during the year absorbed £80,000, equal to 2s. per share, leaving a balance of £34,915 to be carried forward. The ore reserves at the end of the year were estimated to be 124,000 tons, containing gold to the value of £632,520, as compared with 126,300 tons, valued at £639,660, at the end of the previous year. The installation of new plant at the mine is said to be proceeding satisfactorily and it is hoped that it will be in full commission by the middle of the present year.

Northern Rhodesia.—Shareholders of the Rhokana Corporation were informed last month that the concentrating mill had started running on December 11 last and had been in successful operation ever since, metallurgical results being satisfactory and the tonnage capacity estimated to be considerably greater than the nominal figure. Smelting operations commenced on March 17, the first blister copper being shipped on March 21. Shareholders were reminded that the railway between N'Dola and N'Kana was not completed until May 26, 1930, so that eighteen months only were required to complete the mill and bring it into operation, while the first copper has been shipped in less than two years.

A circular to shareholders of the Rhodesia-Katanga Company gives details of the development work carried out by diamond drilling up to the end of 1931. This work is said to have fully confirmed the estimates of ore previously made, the grade having been raised from an average of 4·2% to 4·5% copper. It is further stated that pending an improvement in the price of the metal, work on the mine has been reduced to a minimum, being confined to two drill shifts per day in the north part of the mine, where the ore-bodies are at present undefined.

Australia.—It was announced last month that the Sulphide Corporation had decided to resume work on the Central Mine—which had been closed down since January, 1931, owing to low metal prices—on April 4.

Towards the middle of March details became available of the report of Mr. C. O. Lindberg on the Lake View and Star mine, which he visited on behalf of the New Consolidated Gold Fields, Ltd. Mr. Lindberg states that he is impressed by the continued favourable development results and the improvement in operating conditions. He points out that the Chaffers shaft is expected to be ready for service to the 1,600 ft. level in the present month and the cost of its enlargement, estimated at between £55,000 and £60,000, has been met out of profits. The conversion of the mill from dry to wet methods with flotation is expected to be completed shortly, when operating costs are expected to be reduced to 7s. 6d. per ton and total costs to about 23s. 9d. per ton. Mr. Lindberg adds that tribute production is on the decline and that it will probably cease entirely as the plant goes into production at the new rate of 30,000 tons per month.

The March circular to shareholders of the Wiluna Gold Corporation showed the new ore-body on the No. 2 West lode to have an indicated length of over 1,000 ft., the ore being free of antimony. Driving on the lode had been started. At the end of the month additional information was issued, a bore-hole west from the West lode at 554 ft. north on the 625 ft. level having encountered ore 51 ft. wide, averaging 44s. 6d. in value. At a point 342 ft. north driving on the lode had commenced and been carried for 52 ft. in ore averaging 54s. 6d. over a width of 7 ft. 3 in., the full width of ore not being exposed.

New Guinea.—It was announced last month by the Consolidated Gold Fields of South Africa that the dredge and power plant on the property of Bulolo Gold Dredging had started work on March 21 and that they were working satisfactorily.

India.—At extraordinary meetings of shareholders of the Balaghât and Nundydroog companies, held following the annual meetings this month, the sale of the Balaghât property to Nundydroog was approved. The terms of sale involve the payment of £40,000 in cash for the leases, workings, and certain plant, the payments to be spread over a period of nine months. For mining and milling the Balaghât ore reserves the Nundydroog Company will make a charge of 24s. per ton and, after deducting in addition from the net sale proceeds of bullion the 5% royalty due to the Mysore government and the cost of keeping the Balaghât mine free of water, the net profit will be divided as to 25% to Nundydroog and 75% to Balaghât. The former company will take over the assets and start work on the ore reserves on May 1 next.

Canada. — In the Supreme Court of Ontario judgment was given last month in favour of the representatives of British shareholders in the Yukon Consolidated Gold Corporation, in an action against Mr. Treadgold, a former president of the company. The judgment orders the return to the company for cancellation of 2,419,000 shares of the common stock and 15,000 preferred shares held by Mr. Treadgold and enjoins him from dealing in the shares until the cancellation is effected.

Spain.—During 1931 the Rio Tinto Company made a trading profit of £424,894, while the net profit was £100,185. After adding the amount of £384,367 brought in, there was an available total of £484,552, of which £81,250 has been distributed as dividends, equal to 5s. per share, leaving a balance of £403,302 to be carried forward. The report points out that conditions in Spain have been increasingly difficult, although the good relations between the company and its Spanish employees have been maintained.

Minerals Separation. — The report of Minerals Separation, Ltd., for 1931 shows a credit balance for the year of £33,948, against £54,658 for 1930. The balance brought forward was £28,972 and, after allowing for several other items, there was an available total of £72,462, of which £30,000 was distributed as dividends, equal to 15%. No dividend was received from the Australian company during the period under review, although an interim payment has been received for the current year.

Murex.—At an extraordinary meeting of Murex held this month the increase of the capital from £200,000 in 10s. shares to £250,000 by the creation of 50,000 preference shares of £1 each was approved. The new shares were offered to the shareholders at 21s. each.

Venture Trust.—An extraordinary meeting of the Venture Trust is to be held this month, when shareholders will be asked to approve the reduction of the share capital by writing 3s. 4d. off the value of the present 10s. shares. The reduced capital would then consist of 500,000 shares of 6s. 8d. and it will then be proposed that it be restored to £250,000 by the creation of a further 250,000 shares of 6s. 8d. each.

Union Corporation.—The accounts of the Union Corporation for 1931 show a net profit of £229,117, which, together with the £111,017 brought forward from 1930, gives an available total of £340,134. A dividend equal to 2s. 6d. per share will absorb £126,162 and £100,000 is to be placed to a special reserve, leaving a balance of £113,972 to be carried forward.

Consolidated Mines Selection. — During 1931 the Consolidated Mines Selection Company seriously felt the absence of a dividend on its large holding in the Anglo American Corporation of South Africa. The continued depreciation in the market value of holdings has been partly met by the transference of £20,000 from the reserve account, which is now exhausted. The book value of the company's holdings at the end of the year stood at £503,005, against a market value of £304,933, which the directors consider to be much below the true value. The profit and loss account shows that after writing £32,917 off the value of shares held the balance carried forward is £2,125.

Copper.—It was announced last month that at a meeting of copper producers held in New York it had been decided to reduce the output for the remaining nine months of 1932 to 20% of capacity. Shareholders of the companies operating in Northern Rhodesia have been informed that production will be reduced accordingly.

ELECTRICAL PROSPECTING FOR AURIFEROUS QUARTZ VEINS AND REEFS

By HELMER HEDSTRÖM

The author, who is connected with the Electrical Prospecting Company of Stockholm, pays particular attention to processes of "electrical trenching," which are undergoing extensive tests on several goldfields.

INTRODUCTION.—During the last few years a number of articles have appeared in mining periodicals on the use of electrical methods when prospecting for base metal ores. Very little has been published, however, on the application of these geo-electrical methods to other problems of mining geology, this being a comparatively recent development. The present article is intended as a brief description of part of this new development, namely of some new applications of those geo-electrical methods which are characterized by the determination of electrical potentials. These "potential methods" have previously been used almost solely for the locating of buried bodies of better electrical conductivity than the surroundings, for instance—pyritic ore-bodies. The new applications of these methods are used to locate or determine the distance to boundary planes between different rock formations. According to whether these boundary planes are nearly horizontal or nearly vertical, the new applications may be divided into the following two classes :—

(1) "Electrical drilling," which comprises the determination of thickness of overburden, depth to the ground water table, dip of slightly inclined sedimentary beds at moderate depth, etc. This process, which might possibly be of more interest, in general, to the civil engineer or hydrologist than to the mining engineer, has already been dealt with in several recent publications.[1]

(2) "Electrical trenching," comprising the locating of hidden contacts, fault planes, quartz veins, bankets, and reefs. This process should be of particular interest to mining men in these times of increasing activity in the field of gold prospecting. It is this application of the potential methods which is the special subject of the present article. Previously it has not been described in the literature, excepting in an article by G. F. Tagg in the MAGAZINE for September, 1930, and in the recent Report of the Imperial Geophysical Experimental Survey, where the problem of finding a vertical fault by the use of a four-electrode system has been discussed theoretically.

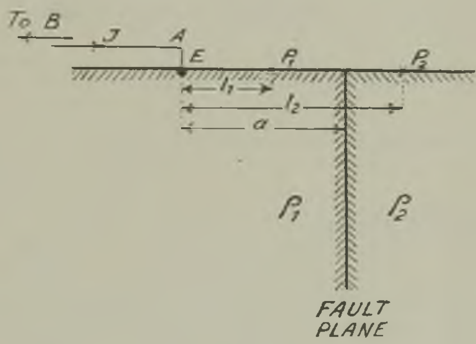


Fig. 1.

THEORETICAL CONSIDERATIONS OF "ELECTRICAL TRENCHING."—By "electrical trenching" an electric current is conveyed to the earth by means of two power electrodes, one of which (A in Fig. 1) is grounded in the area of investigation, while the other electrode (B) is placed so far away that it has practically no influence on the measurements. The electrical potential at the surface within the area of investigation will thus be caused solely by the electric current entering the ground at A, and the following relations will apply :—

If the strength of the current is called I and the electrical resistivity of the ground formation is called ρ_1, it is easy to prove that the electrode A will act as a "point-source"

[1] O. H. Gish : "Depths of Ground Water and other Subsurface Features indicated by Earth-Resistivity Surveys," *Terrestr. Magnetism*, 33, No. 3, 129–138 (1928).

Irving B. Crosby and E. G. Leonardon : "Electrical Prospecting applied to foundation problems," A.I.M.M.E., Tech. Publ. 131 (1928).

E. Lancaster Jones : "The Earth Resistivity Method of Electrical Prospecting," THE MINING MAGAZINE, June and July, 1930.

G. F. Tagg : "The Earth Resistivity Method of Geophysical Prospecting," THE MINING MAGAZINE, September, 1930.

E. G. Leonardon : "Electrical Exploration Applied to Geological Problems in Civil Engineering," A.I.M.M.E., Tech. Publ. 407 (1931).

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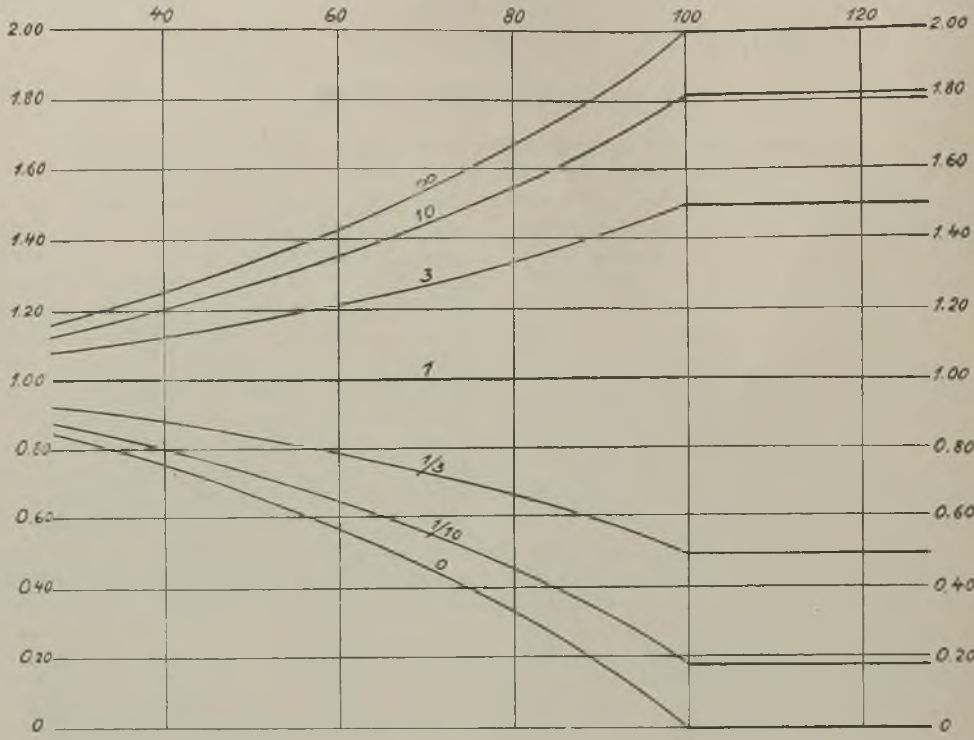


Fig 2

with a potential

$$E = \frac{I \cdot \rho_1}{2\pi} \quad . \; . \; . \; . \; . \; . \; . \; . \quad 1.$$

If the ground is homogeneous in all directions and to great depths the potential P at a point in a distance l from the electrode A will be

$$P = \frac{E}{l} = \frac{I \cdot \rho_1}{2\pi l} \quad . \; . \; . \; . \; . \; . \; . \quad 2.$$

The potential along a radius from A will thus decrease in inverse proportion to the distance from A. This " normal potential " distribution, however, will be disturbed by the presence of a vertical boundary plane (contact) to another formation with a different electric resistivity ρ_2, as shown in Fig. 1. The ensuing anomalous potential distribution in this case can be conveniently represented mathematically by application of Lord Kelvin's and Maxwell's " method of images."

By optical analogy we imagine that the boundary plane is acting as a mirror, partly reflecting and partly transmitting light from the point-source A. In the medium ρ_1 the expression for the potential will thus be composed of two parts, the first one due to the point-source E itself, and the second one due to the image which we suppose to have the strength kE, where k may be called the " reflection coefficient." At the point P_1 in Fig. 1, the potential will then be

$$P_1 = \frac{E}{l_1} + \frac{k.E}{2a - l_1} \quad . \; . \; . \; . \; . \; . \quad 3.$$

In the medium ρ_2 the potential at any point will be the same as if the ground were homogeneous, but the strength of the point source changed from E to another value E^1. (By optical analogy one may imagine that the point source E is seen dimly through the boundary plane.) At the point P_2 in Fig. 1 the potential will then be

$$P_2 = \frac{E^1}{l_2} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad 4.$$

At the boundary plane the potential must be the same whether computed from the expression 3 or 4. Consequently :—

$$\frac{E}{a} + \frac{k.E}{a} = \frac{E^1}{a}$$

or

$$E^1 = (1 + k).E \quad . \; . \; . \; . \; . \quad 5.$$

Further, the component of electric current passing through a certain small part of the boundary plane must be the same whether computed from the ρ_1-side or the ρ_2-side. This current can be expressed as the electric field $\frac{dP}{dl}$ (the derivative of the potential in respect to the distance), divided by the resistivity. Derivating the expressions 3 and 4 and putting $l_1 = l_2 = a$, we then get :—

$$-\frac{1}{\rho_1}.(1-k) = -\frac{1}{\rho_2}.(1+k)$$

$$k = \frac{\rho_2-\rho_1}{\rho_2+\rho_1} \quad . \; . \; . \; . \; . \quad 6.$$

and, from the expressions 3 and 4 :—

$$\frac{P_1}{E} = \frac{1}{l_1} + \frac{\rho_1-\rho_1}{\rho_2+\rho_1}\,\frac{1}{2a-l_1} \quad . \; . \; . \; . \quad 7.$$

$$\frac{P_2}{E} = \frac{1}{l_2}\cdot\left(1+\frac{\rho_2-\rho_1}{\rho_2+\rho_1}\right) \quad . \; . \; . \quad 8.$$

The reflection coefficient k thus varies from + 1 to − 1, according to whether the formation ρ_2 on the back side of the boundary plane offers a comparatively very high or a comparatively very low resistance to the passing of an electric current. In the first case the boundary plane acts as a totally reflecting mirror, in the second case as a totally reflecting " negative " mirror (the image in this case being of opposite strength to the point source E). For the same cases the " dimming coefficient " (1 + k) in expression 5 varies from 2 to 0.

Faults and Contacts.—By the use of the equations 7 and 8 the potential distribution can be computed along a profile of investigation that crosses a contact. Fig. 2 shows the results of such computations put together in a diagram. The boundary surface in this figure is supposed to be at a distance of 100 units of length from the power electrode. The potential values computed for observation points at different distances from the power electrode have been plotted against these distances, every value first having been multiplied by the corresponding distance. In other words, the plotted values represent the ratio between the computed potential and the normal potential, and thus represent the magnitude

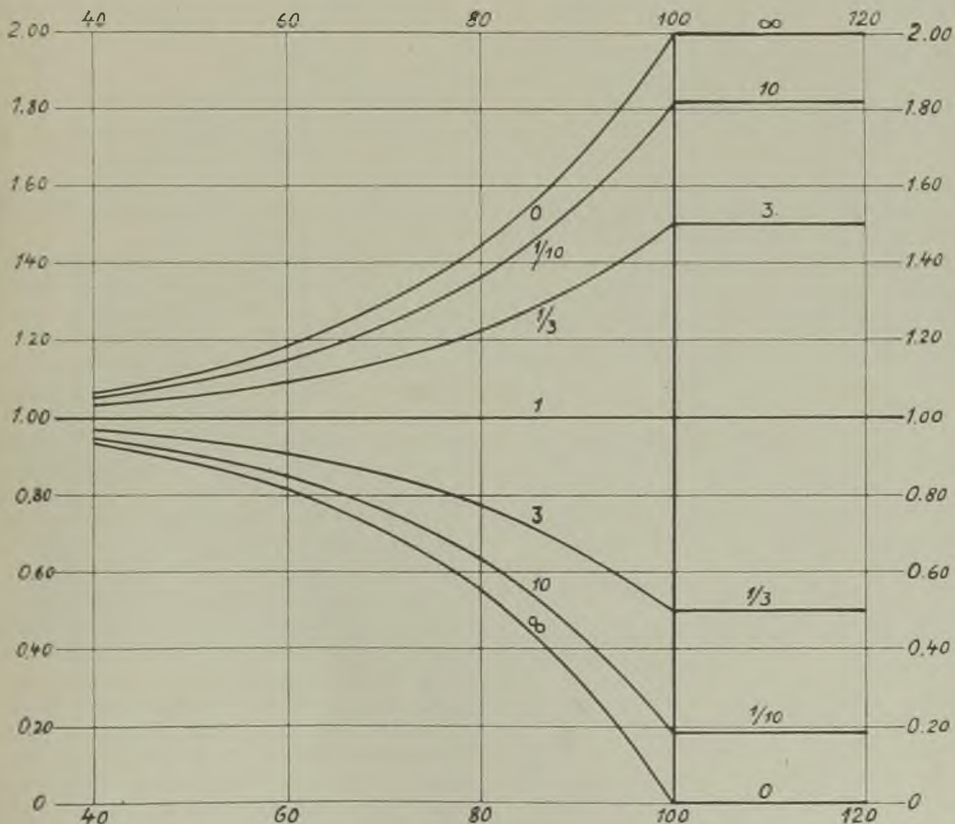


Fig. 3.

of the anomaly caused by the presence of the boundary plane. Different curves correspond to different ratios between the resistivities ρ_2 and ρ_1 on the two sides of the boundary plane.

The examination of the simple Fig. 2 discloses an important fact related to the method of locating vertical faults and contacts electrically. It shows that the anomaly in the potential at the boundary plane will amount to 50% of the possible maximum already for a resistivity ratio of 3 : 1, while for a resistivity ratio of 10 : 1 the anomaly will reach 82% of the possible maximal value. This means that a practical "saturation value" of anomaly is reached already at comparatively small resistivity ratios, and that the method consequently is very sensitive to small differences in resistivity on the two sides of the contact.

If, instead of the potential, the potential gradient or the electric field (potential drop per unit length), is calculated for the same conditions as in Fig. 2, we get, by derivation from the expressions 7 and 8, in respect to the distance l :—

$$-\frac{1}{E}\frac{dP_1}{dl}=\frac{1}{l^2}-\frac{\rho_2-\rho_1}{\rho_2+\rho_1}\cdot\frac{1}{(2a-l)^2} \quad . \; . \; . \quad 9$$

and

$$-\frac{1}{E}\cdot\frac{dP_2}{dl}=\frac{1}{l^2}\cdot\left(1+\frac{\rho_2-\rho_1}{\rho_2+\rho_1}\right) \quad . \; . \; . \; . \; . \quad 10.$$

for the conditions on the "front side" and the "back side" of the boundary plane, respectively.

Computing after the expressions 9 and 10 the electric field for different distances l and different values of the resistivity ratio $\frac{\rho_2}{\rho_1}$, and dividing the computed results with the normal electric field $\frac{1}{l^2}$, we get curves as those drawn in Fig. 3. This figure thus shows the computed electric field expressed in the normal electric field as unit, the value 1·00 representing the normal field and the other values the magnitude of "anomaly" caused by the presence of the contact. It is readily seen that the "saturation effect" discussed above appears also in this case, so that a comparatively large anomaly in the electric field is caused already for a comparatively small difference in the resistivities on the two sides of the contact. It will be noted that the magnitudes of these anomalies are the same as the potential anomalies shown in Fig. 2. Fig. 3, however, in contrast to Fig. 2, shows a discontinuity at the boundary plane. Thus in passing over the contact between two media with a resistivity ratio of 1 : 3, the electric field suddenly changes from a value equal to one half of the normal field to a value equal to 1·5 times the normal.

Quartz Veins, Bankets, and Reefs.—If the boundary plane in Fig. 1 is replaced by a sheet, of thickness b and resistivity ρ_3, as shown in Fig. 4, the potential distribution can be calculated in the following way.

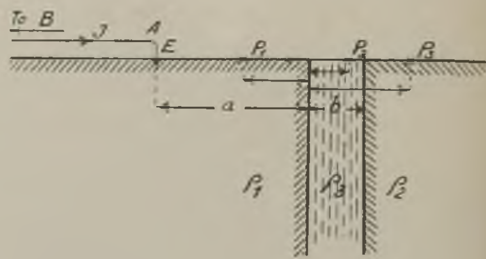


Fig. 4.

The "reflection coefficient" used above, $\frac{\rho_2-\rho_1}{\rho_2+\rho_1}$ we call ρ_{21}. The "reflection coefficient" of the opposite side of the same boundary surface, is then $\frac{\rho_1-\rho_2}{\rho_1+\rho_2}$ and may accordingly be called ρ_{12}, equal to $-\rho_{21}$. The corresponding "dimming coefficients" will be $1+\rho_{21}$ and $1-\rho_{21}$.

In the medium ρ_1, the potential will be due to the point source E and a series of images of E in the two boundary planes. Of these images the first one will be of the "strength" $E.\rho_{31}$ and will be placed at a distance a from the first boundary plane in analogy with equation 6. The second one, which is "dimmed" by the first boundary plane, then reflected in the second boundary plane and again "dimmed" when seen through the first boundary plane, will have the strength $E.(1+\rho_{31}).\rho_{23}.(1+\rho_{13})$, and will be at a distance $(a+2b)$ from the first boundary plane. Through double reflection of this second image in the two boundary planes a third image is added, which will have the strength $E.(1+\rho_{31}).\rho_{23}.(1+\rho_{13}).\rho_{13}.\rho_{23}$, and will be placed at a distance $(a+4b)$ from the first boundary plane. By repeated reflection in the two boundary planes we thus get an infinite series of images, which gives the following expression for the potential in a point on the surface of the medium ρ_1 at a distance x (numerically $\leq$ a) from the first boundary plane :—

$$P_1 = E \cdot \left\{ \frac{1}{a - x} + \frac{\rho_{31}}{a + x} + \frac{(1 - \rho_{31})^2 \cdot \rho_{23}}{a + x + 2b} + \frac{(1 - \rho_{31})^2 \cdot \rho_{23} \cdot \rho_{13} \cdot \rho_{23}}{a + x + 4b} + \frac{(1 - \rho_{31})^2 \cdot \rho_{23} \cdot \rho_{13}^2 \cdot \rho_{23}^2}{a + x + 6b} + \ldots \right\}$$

or

$$\frac{P_1}{E} = \frac{1}{a - x} + \frac{\rho_{31}}{a + x} + (1 - \rho_{31})^2 \cdot \rho_{23} \cdot \left(\frac{1}{a + x + 2b} + \frac{\rho_{13} \cdot \rho_{23}}{a + x + 4b} + \frac{\rho_{13}^2 \cdot \rho_{23}^2}{a + x + 6b} + \ldots \right) \quad 11.$$

If $\rho_1 = \rho_2$:—

$$\frac{P_1}{E} = \frac{1}{a - x} + \frac{\rho_{31}}{a + x} + (1 - \rho_{31})^2 \cdot \rho_{13} \cdot \left(\frac{1}{a + x + 2b} + \frac{\rho_{13}^2}{a + x + 4b} + \frac{\rho_{13}^4}{a + x + 6b} + \ldots \right) \quad 12.$$

By the same way of reasoning we get as an expression for the potential in a point on the surface of the medium ρ_3 at a distance x ($\leq$ b) from the first boundary plane :—

$$\frac{P_2}{E} = (1 + \rho_{31}) \left(\frac{1}{a + x} + \frac{\rho_{23}}{a - x + 2b} + \frac{\rho_{23} \cdot \rho_{13}}{a + x + 2b} + \frac{\rho_{23}^2 \cdot \rho_{13}}{a - x + 4b} + \frac{\rho_{23}^2 \cdot \rho_{13}^2}{a + x + 4b} + \frac{\rho_{23}^3 \cdot \rho_{13}^2}{a - x + 6b} + \ldots \right) \quad 13.$$

If $\rho_1 = \rho_2$:—

$$\frac{P_2}{E} = (1 + \rho_{31}) \left(\frac{1}{a + x} + \frac{\rho_{13}}{a - x + 2b} + \frac{\rho_{13}^2}{a + x + 2b} + \frac{\rho_{13}^3}{a - x + 4b} + \frac{\rho_{13}^4}{a + x + 4b} + \frac{\rho_{13}^5}{a - x + 6b} + \ldots \right) \quad 14.$$

At the surface of the medium ρ_3 we get for a point at a distance x ($\geq$ b) from the first boundary plane :—

$$\frac{P_3}{E} = (1 + \rho_{31})(1 + \rho_{23}) \left(\frac{1}{a + x} + \frac{\rho_{23} \cdot \rho_{13}}{a + x + 2b} + \frac{\rho_{23}^2 \cdot \rho_{13}^2}{a + x + 4b} + \frac{\rho_{23}^3 \cdot \rho_{13}^3}{a + x + 6b} + \ldots \right) \quad 15.$$

and if $\rho_1 = \rho_2$:—

$$\frac{P_3}{E} = (1 - \rho_{13}^2) \left(\frac{1}{a + x} + \frac{\rho_{13}^2}{a + x + 2b} + \frac{\rho_{13}^4}{a + x + 4b} + \frac{\rho_{13}^6}{a + x + 6b} + \ldots \right) \quad 16.$$

Computations after equations 12, 14, and 16 for a = 100 and different values of b and the resistivity ratio $\frac{\rho_3}{\rho_1}$ will give curves like those drawn in Fig. 5, where the plotted values represent the ratio between computed potential and normal potential, in the same way as in Fig. 3. The dotted curves refer to a resistivity ratio between the " vein " and " the country rock " of 3 : 1, the solid curves to a resistivity ratio of 10 : 1, the different values assumed for the width of the " vein " are 5, 10, 20, 40, 100, and so on.

A study of Fig. 5 reveals that the " saturation effect " mentioned above by the discussion of Fig. 2 exists also in this

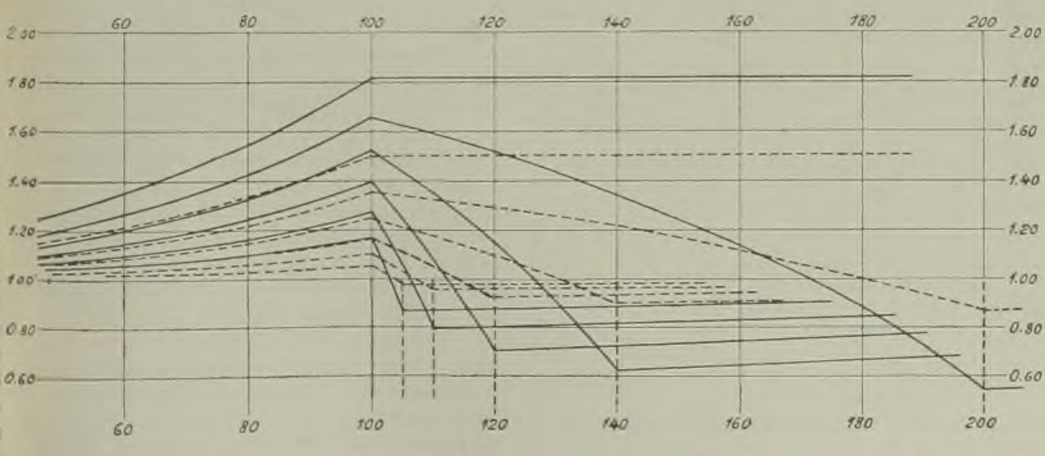


Fig 5.

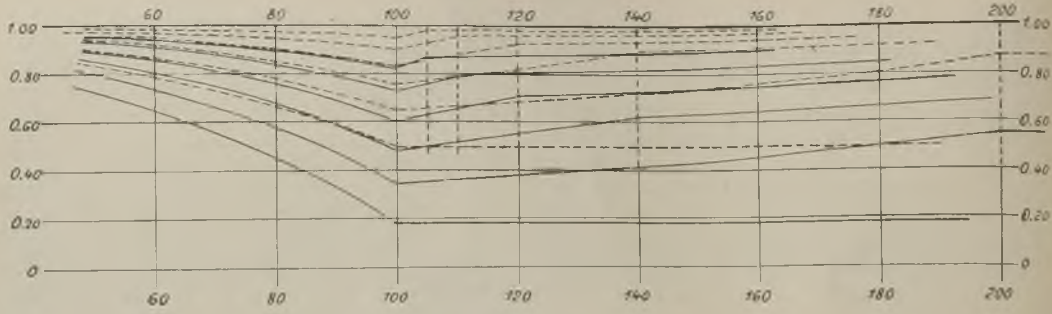


Fig. 6.

case, but only for large widths of the vein. For instance, at a width of 100 the increase of potential above the normal at the first boundary plane is 35% for a resistivity ratio of 3, 65% for a ratio of 10, 75% for a ratio of 20, and 100% for an infinite ratio. However, at a width of 10 the corresponding figures are 10, 27, 39, and 100%, showing that considerably higher resistivity ratios are needed in this case in order that the anomaly may approach its saturation value. In other words, the smaller the width of the vein the sharper the contrast will be between an anomaly caused by moderate resistivity ratio and high resistivity ratio.

Fig. 6 represents the same conditions as Fig. 5, with the exception that the resistivity ratios are inverted, that is, the "vein" is assumed to be a better conductor than the "country rock." It may be noted that the potential distribution on the back side of the vein is identically the same whether the resistivity ratio is 3 or $\frac{1}{3}$, 10 or $\frac{1}{10}$, etc.

Fig. 7 shows another way of representing the above results. Here the solid curves refer to the resistivity ratio 10, the dotted curves to the ratio $\frac{1}{10}$. The width of the vein is assumed constant $= 10$, and the different curves show the potential expressed in normal potential as unit, for different distances a to the power electrode. It may be noted that the magnitude of the anomaly increases when the power electrode approaches the vein.

If it is wished to study the electric field, instead of the potential, for the conditions shown in Fig. 4, it is possible to compute in the following way the electric field, expressed in normal electric field as unit: If the potential at a distance l from the power electrode is $\frac{P}{E}$, the electric field in the same point is $-\frac{1}{E}\cdot\frac{dP}{dl}$. As the "normal" field is $\frac{1}{l^2}$, the electric field expressed in this normal value as unit will be $-\frac{1}{E}\cdot\frac{dP}{dl}\cdot l^2$. If we call the function of l represented in Figs. 5, 6, and 7 for $F = \frac{P}{E}\cdot l$, we get :—

$$\frac{dF}{dl} = \frac{l}{E}\cdot\frac{dP}{dl} + \frac{P}{E}$$

Consequently, the electric field, expressed in the normal electric field as unit, will be :—

$$-\frac{1}{E}\cdot\frac{dP}{dl}\cdot l^2 = F - l\cdot\frac{dF}{dl}$$

The values F and $l\cdot\frac{dF}{dl}$ can both be taken out of Figs. 5, 6, and 7, where the ordinate values represent F, the distance from the power electrode is $= l$ and the tangent of the angle of slope of the curve is $= \frac{dF}{dl}$. (the product $l\cdot\frac{dF}{dl}$ will evidently be the same whether taken out of Fig. 5 or Fig. 7). If we now take as a measure of the magnitude of anomaly the electric field, in normal field as unit, over the centre of the vein, we can use values taken out of Fig. 5 and construct curves like those shown in Fig. 8.

A study of Fig. 8, in comparison with Fig. 5 shows that for small widths of the "vein" much larger anomalies will be obtained above the vein if the electric field is measured and expressed in normal field as unit, than if the potential is determined and compared with the normal potential. Fig. 8 also shows that for large widths of the vein high resistivity ratios do not give very much higher anomalies than comparatively small resistivity ratios, while for decreasing width of the vein the importance of higher resistivity ratios increases rapidly.

Possibilities of Application.—From the above theoretical investigations it is evident that a vertical contact, namely, a fault plane or a vein, which extends to the surface and is hidden only by a thin layer of overburden, can be readily located by potential determinations, provided that the resistivity ratios referred to above are sufficiently large. It is also evident that it is more advantageous to measure the potential drop per unit of length (potential gradient or electric field) than to determine the potential, since in this way much stronger indications will be obtained above a vein (except where the vein has infinite thickness, that is, in the case of a contact). The anomaly in this potential gradient, as Fig. 8 shows, decreases with increasing width of the vein and its minimum value can thus be obtained from the expression given in equation 7 for the potential gradient on the "back side" of a contact. This expression, divided by the "normal" potential gradient gives as the size of the minimum anomaly $1 + \frac{\rho_2 - \rho_1}{\rho_2 + \rho_1}$ or $\frac{2\rho_2}{\rho_2 + \rho_1}$, so that a 10% resistivity difference will give a minimum anomaly in the potential gradient of 5%, a resistivity difference of 20% will give an anomaly of roughly 10%, and so forth. Since now an anomaly of, for instance, 10% in the electric field constitutes quite a clear indication by an electric survey, it is thus evident that these measurements are a very sensitive means of detecting the presence of hidden contacts or veins. This is especially true when considering that the resistivities met with in nature show a very vivid variation between different rocks, so that the difference in resistivity between two adjacent formations is more likely to amount to several hundred per cent, than to only a few per cent. This is demonstrated in the table below, which gives some examples of the resistivities of different rocks :—

	Resistivity in ohm.-cm.
Base metal ores . . .	1–1,000
Clays, sands, alluvial deposits, drift, slope wash, soil . .	50–30,000
Shales, slates, sandstones, limestones	1,000–50,000
Crystalline schists, gneisses, igneous rocks . . .	20,000–1,000,000
Quartzites and quartz veins .	up to 15,000,000

While the good electric conductivity of base metal ores is due to conditions similar to those in metallic conductors, the ability of a normal rock formation to transmit electricity is due almost entirely to the moisture it holds in its pores and fissures. The electrical conductivity of this moisture, in turn, is due to the minute quantities of dissolved salts that it contains. The explanation of the large resistivity variations shown in the above table is thus that both the salinity of the moisture and the amount of moisture held per cubic foot vary considerably from one rock formation to another.

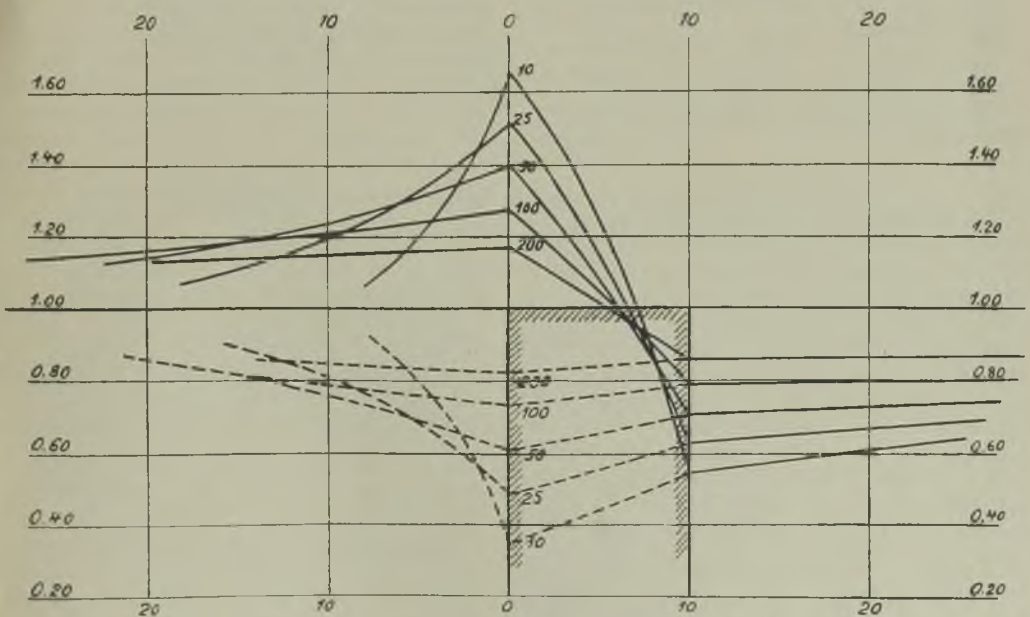


Fig. 7.

From the above considerations it follows that very good possibilities exist of locating hidden contacts and veins by "electrical trenching," under the conditions assumed above, that is, with very thin or non-existent overburden. It is evident that increasing thickness of the overburden will change the conditions in the electric field at the surface in such a way that the magnitude of the indications caused by quartz veins, etc., will decrease. This will especially be the case where the overburden has considerably lower resistivity than the underlying rock formations. By sufficient thickness of such an overburden one might expect that most of the electric current will travel through the overburden unobstructed by inhomogeneities in the underlying rocks, and that consequently no indications will be obtained from hidden quartz veins, etc.

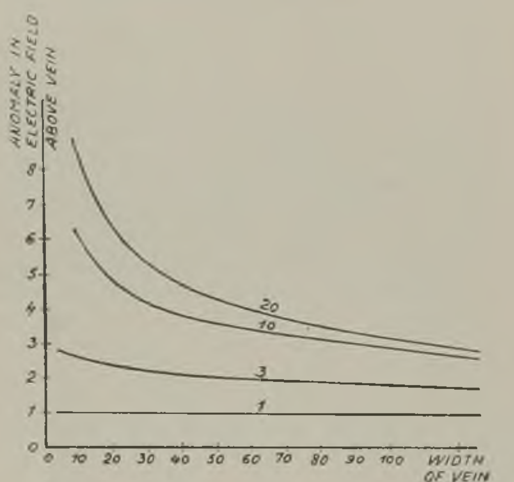


Fig. 8.

An investigation of this influence of the thickness and resistivity of the overburden is most conveniently done experimentally. The results from such experiments have shown that even under the extremely unfavourable conditions of 60 ft. of overburden with 40 times lower resistivity than the underlying rocks, a "non-conducting" quartz vein 6 ft. wide will still give a clear anomaly in the electric field at the surface of the ground. Under the same conditions but with the same resistivity for the overburden as for the underlying rocks, the indication of the quartz vein will be about ten times stronger. With decreasing thickness of the overburden, the anomaly will increase further up to the maximum value

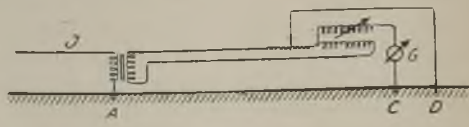


Fig. 9.

obtained when the overburden is non-existent or only a couple of feet thick.

For the conditions under which "electrical trenching" will most commonly be applied, that is, for thicknesses of overburden from a few feet up to, say, 100 ft., the method will thus generally be more than sufficiently sensitive for the detection of contacts or veins in the bedrock. As an example of this may be cited an instance from recent prospecting work on Sumatra, where an extension of a known auriferous quartz vein covered by more than 200 ft. of overburden gave a pronounced indication and was easily located by "electrical trenching."

Field Practice and Apparatus.—As already mentioned above, the electric current used by "electrical trenching" is conveyed to earth by means of a grounded electrode within the area of investigation. The other electrode needed to complete the circuit is grounded half a mile to a mile away and connected with the first electrode by means of a thin insulated wire, which is supplied with electric current from a small motor-generator. Alternating current of about 300 cycles is used, which for several practical reasons is to be preferred to direct current, while on the other hand the measurements with this low-frequency alternating current give very nearly the same results as with direct current. By means of special measuring apparatus the potential distribution is now studied along a straight line starting near the first-mentioned electrode and running away from both primary electrodes, across the anticipated strike of the contacts, faults or veins prospected for. If this "profile of survey" is made very long it will be advantageous to extend the cable line and move up the nearest primary electrode to the neighbourhood of the measuring

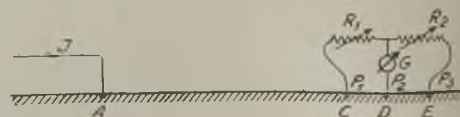
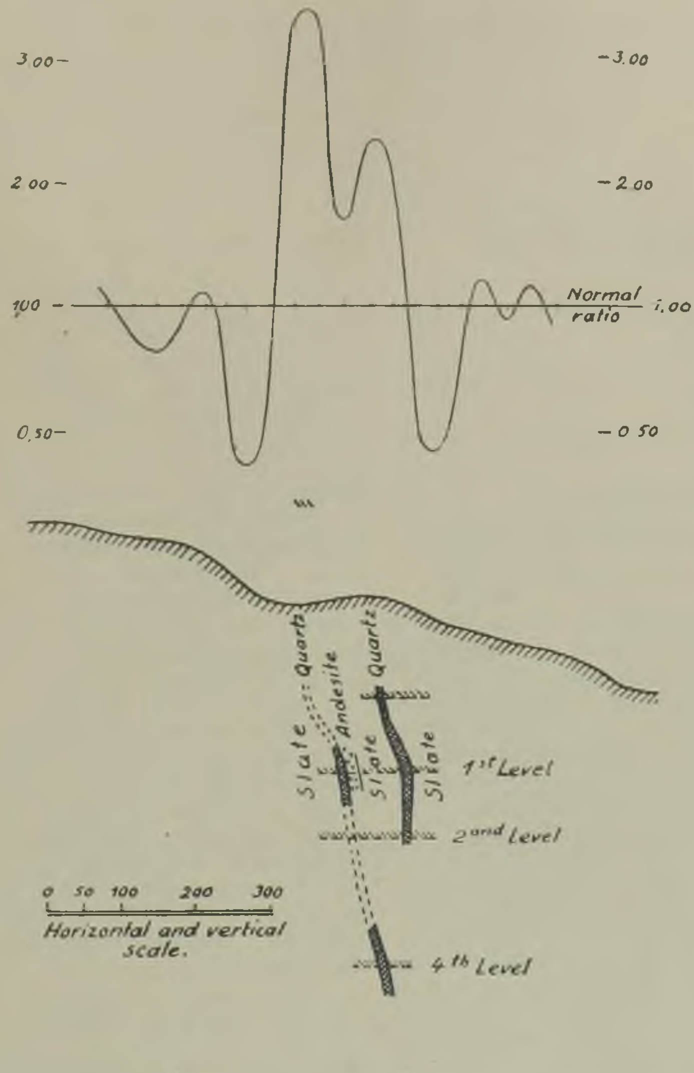


Fig. 10.



Geologic section and potential drop ratios along traverse over known gold - quartz veins.

Fig. 11.

apparatus, when the survey has proceeded to a distance of a few hundred yards from the first position of the electrode. Proceeding in steps in this way the desired length of profile is completed, the whole arrangement is then moved over to a parallel profile placed fifty yards or a few hundred yards away, according to the need for detail, and in this way the whole area of investigation is rapidly covered by straight line traverses electrically surveyed.

According to the theoretical considerations above the best way of studying the potential distribution along the profiles of survey is to measure the potential gradient. As an approximation to this the potential drop per unit of length or per, say, 30 ft., can be measured. This can be done by means of the Larsen compensator arrangement, which is schematically shown in Fig 9.

In this arrangement a secondary circuit is used, which is supplied by current from a transformer on the primary cable line. From a potentiometer and a variometer in the secondary circuit two variable auxiliary voltages can be taken out, which are used to compensate the potential drop between the pick-up electrodes C and D. (Compensation occurs when the indicating instrument G shows that no current is passing through it.) The two auxiliary voltages used have a phase difference of one-quarter cycle (90°), and as their strength can be varied at will it is evident that they can be used to compensate any potential drop of any phase that might occur. Since the strength of the auxiliary voltages varies in direct proportion to the primary current I, it is further easy to calibrate the arrangement in such a way that the readings give the measured voltage drops along the surface in semi-absolute units on the form $\frac{P_1 - P_2}{I}$. By multiplying these readings with $\frac{2\pi}{\rho_1}$ (see expression 1 above) one thus gets the expression $-\frac{1}{E} \cdot \frac{P_1 - P_2}{l_1 - l_2}$ which is an approximation of the expression used above for the electric field $-\frac{1}{E} \cdot \frac{dP}{dl}$.

A practical disadvantage of the above arrangement lies in the use of the long leads, which will be required between the primary circuit and the measuring arrangement, and which will hamper the survey. This drawback is eliminated if the arrangement shown in Fig. 10 is used, which measures the ratio between consecutive potential drops. By means of this "ratio compensator" or "ratiometer" it is evidently possible to determine, in successive steps, the relation between all potential drops along a profile of survey, and consequently to express the potential drop per unit of length all along the profile in the same arbitrary unit. This is all that is needed for the purposes of electrical trenching ; the fact that the semi-absolute values of the potential drops are not determined in this way is therefore no disadvantage.

This "potential drop ratio method" was first used in 1928 by the Imperial Geophysical Experimental Survey during its campaign in Australia, and the first descriptions of the method were published early in 1931. (Broughton Edge, *Nature*, January 3, 1931.) The ratiometer described by Edge in this article consists in principle of a bridge, as shown in Fig. 10, with two large variable resistances, R_1 and R_2. These resistances are adjusted until no current is flowing through the indicating instrument G. If the contact resistance at the pick-up electrode C is R_C and at E is R_E and the potential at the three pickup electrodes is P_1, P_2, and P_3, it then follows that

$$\frac{P_1 - P_2}{P_2 - P_3} = \frac{R_C + R_1}{R_E + R_2}$$

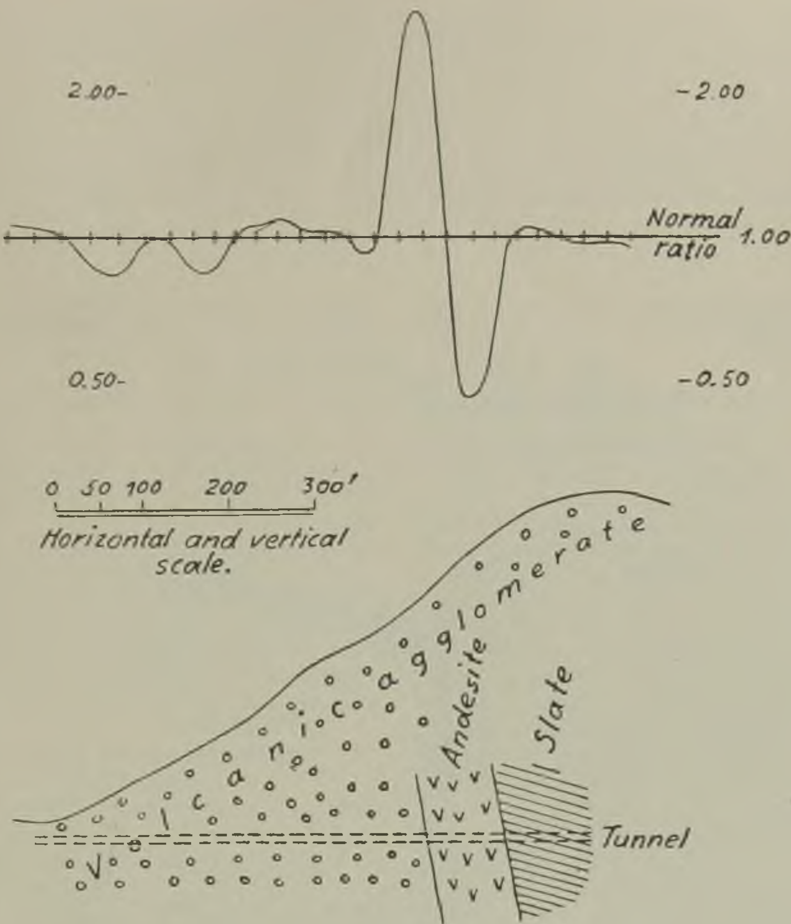
If the variable resistances R_1 and R_2 are kept sufficiently large in comparison with the contact resistances, the ratio between the two potential drops is given with sufficient accuracy by the ratio $\frac{R_1}{R_2}$. The errors arising from this approximation will, according to Edge, be negligible if a minimum value of 50,000 ohms is maintained in each arm of the bridge, since the contact resistances R_c and R_E will generally be less than a thousand ohms. It should be pointed out here, however, that dry and hard ground will often give much higher contact resistances than a thousand ohms and that it will often be difficult and time-wasting to bring these resistances down to the allowable value. Since by this method it is further impossible to know whether in the course of a survey the contact resistances in some places have happened to exceed the allowable, the risk for serious errors is always present.

It is, therefore, preferable to use the ratiometer or ratio compensator in the following way: After adjusting the two resistances R_1 and R_2 as before until the bridge is balanced, which we assume occurs for the resistance values R_1' and R_2', the resistance R_1 is readjusted to another value R_1'', whereupon the bridge is again balanced by adjustment of the resistance R_2 to a value R_2''. Instead of the expression above we then get :—

$$\frac{P_1 - P_2}{P_2 - P_3} = \frac{R_C + R_1'}{R_E + R_2'} = \frac{R_C + R_1''}{R_E + R_2''} = \frac{R_1' - R_2''}{R_2' - R_2''}$$

which shows that the influence of the contact resistances in this way is totally eliminated, so that the exact potential drop ratio is obtained as the ratio between the two resistance adjustments $R_1' - R_1''$ and $R_2' - R_2''$. The readings taken in this way are obtained very quickly and accurately once the bridge has been balanced, so that no objection exists against the method in regard to its speed and accuracy.

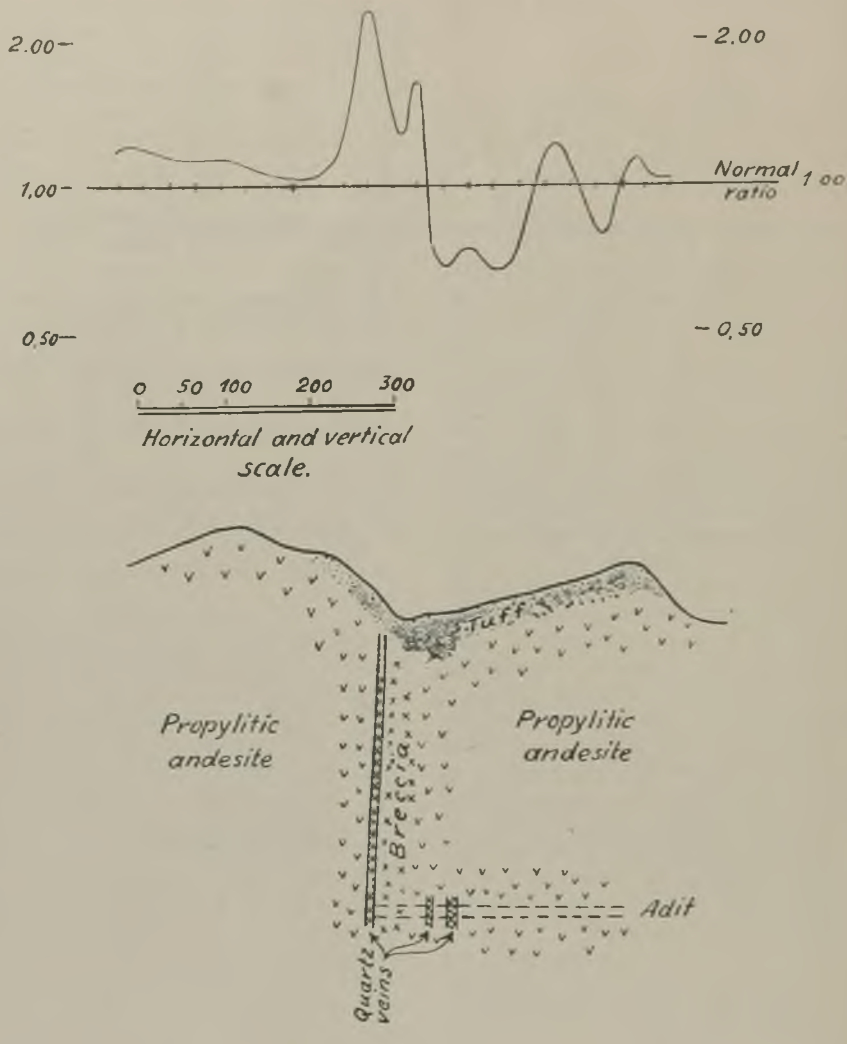
This ratio compensator method has first been described by Lundberg and Zuschlag in "A new development in electrical prospecting," A.I.M.M.E. Tech. Pub. No. 415. The elementary ratio compensator arrangement shown in Fig. 10 is, in the field instruments, augmented by provisions for the compensation of phase differences



Geologic section and potential drop ratios along traverse over known dyke and contact.

Fig. 12.

between the two potential drops, so that a sharp balancing of the bridge can be obtained under all conditions. In the ratiometer described by Edge, this is effected by the use of variable capacities in the two arms of the bridge, in the ratio compensator described by Lundberg-Zuschlag a variable inductance is used to create an out-of-phase voltage for compensation of the phase differences. In the latter arrangement the indicating instrument is a telephone, the impulses being stepped-up by means of a high-gain amplifier, which acts at the same time as a filter for overtones and, when using very low frequencies, as a frequency converter. The apparatus is light, and can be used almost everywhere, on lakes and moors as well as on dry ground, in thick woods or jungle as well as on open fields. The speed of a survey using such an outfit generally averages about 1,000–1,500 ft. of traverses per day, when the measurements proceed in steps of 30 ft. The personnel needed in addition to the observer is only five untrained helpers. Regarding the planning of the work and the interpretation of the results the same rule applies as for all geophysical work, namely that it should only



Geologic section and potential drop ratios along traverse over known gold - quartz veins.

Fig. 13.

be undertaken by experienced experts possessing the necessary knowledge of geology and physics.

Examples of Practical Results.—The process of "electrical trenching" has recently been used at the Lebong Donok gold mine on Sumatra, which is being worked on a wide, steeply dipping quartz vein, with liparite on the foot-wall side and hypersthene andesite and Miocene sediments in the hanging-wall. Fig. 11 shows the very pronounced electrical indications obtained over this deposit, in spite of the deep cover of overburden. In the figure the ratios between successive potential drops along the traverse have been plotted, as obtained by the ratio compensator apparatus referred to above. Fig. 12, which is from the same electrical survey, shows the electrical indication of a contact, as well as the geologic information obtained in a subsequent check tunnel which was driven on the electrical results. According to the mine management the results from the geo-electrical survey seem to agree very well with the geologic data from subsequent development work.

Fig. 14 shows an example of the results from "electrical trenching" at another gold mine on Sumatra, where the gold-bearing quartz veins were readily located electrically.

The method has also recently been used in Quebec, Canada, and in the Philippines in prospecting for auriferous quartz veins. From the locality on Luzon where such work is at present going on, the latest reports relate that electrical indications were obtained on traverses through the jungle, and that digging on these indications revealed remains of old workings from ancient gold mining activities.

PROSPECTING FOR ALLUVIAL DEPOSITS

By A. F. SKERL, A.R.S.M., B.Sc.

In this article the author, in the light of his own experience, makes special reference to the Northern Nigerian tinfield.

Alluvial deposits, including those containing minerals of economic value, are, of course, all derived from rocks existing previously to their formation and they may be broadly classified by their relation to the present or past drainage systems. Such a classification is set out in the following table and this omits all reference to those types of deposit termed eluvial and littoral.

Classification of Alluvial Deposits.—

Group A.—Related to the present river system :—

Class 1.—In the present river bed.

Class 2.—In side channels :—

(*a*) Higher than present adjoining river bed (terraces).

(*b*) Lower than or at the same level as the adjoining river bed.

Class 3.—In deserted valleys and channels, often not at once apparent from surface indications.

Group B.—Not related to present river system :—

Class 4.—Buried under alluvial, volcanic, æolian, or glacial accumulations.

Class 5.—Relics of ancient river systems destroyed by uplift.

Although possessing a common origin, alluvial deposits may, by subsequent natural occurrences, progress from one class to another ; for example, Class 1 by change of course of the river moves to Class 2. Should either Class 1, 2, or 3 be submerged by other deposits an entirely new river system may be formed having no relationship to the old. By strong upward earth-movement a new river system may be so rapidly developed that parts of the older may be left as elevated relics which, of course, tend to disappear as erosion proceeds.

Deposits so situated that they can be most profitably mined by underground methods may be termed "deep leads," and although it may be pointed out that fairly deep paywashes are won by open-cast methods and that many quite shallow deposits are worked by underground mining, the name suggests an underground method of ore extraction.

One or more of the above classes of alluvial deposit may be noted on any of the alluvial minefields of the world, and in N. Nigeria each is represented on the Plateau or on the Plains around. Briefly described, the geological history of the Nigerian Plateau, as interpreted by the Geological Survey of Nigeria, is as follows :—

1.—The intrusion of a Younger Granite into a series of metamorphic rocks already intruded by Older Granites.

2.—The mineralization of the Younger Granite and the adjacent older rocks more especially at the crown of the batholith.

3.—The erosion of the whole series with deposition of tinstone in a drainage system which became buried under a series of alluvial, volcanic, and eluvial accumulations (termed as a whole the Fluvio-Volcanic series).

4.—The elevation of the Plateau portion of the granite batholith and renewed erosion of the granite and Fluvio-Volcanic series, with re-deposition of tinstone along new drainage lines.

5.—Recent lava-flows covering large areas of the Plateau.

It is little wonder that the discovery of the rich deposits of the Plateau where the natural facilities for mining are greater, withdrew attention from those areas off the Plateau which had undergone but the first three of the above mentioned stages and consequently little reconcentration of their secondary deposits. For this reason there are to the north of the Plateau but few

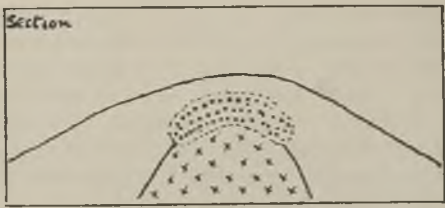


Fig. 1.

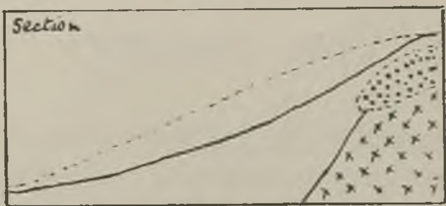


Fig. 2.

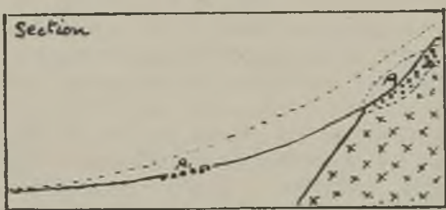


Fig. 3.

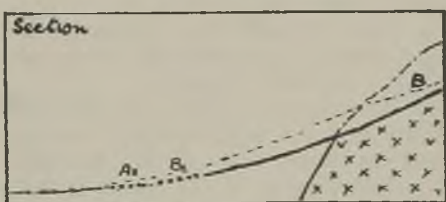


Fig. 4.

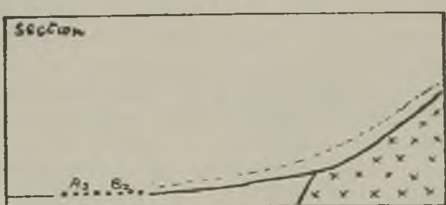


Fig. 5.

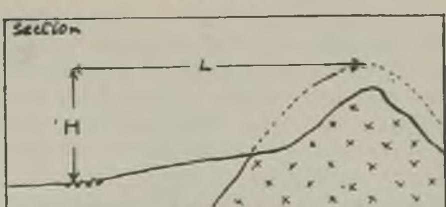


Fig. 6.

alluvial deposits the relation of which to the present river system cannot readily be seen.

Group A Deposits.—As may be known, random prospecting, though possibly quite cheap per foot, may be very expensive when measured by results, and it is therefore highly desirable that prospecting should at first be confined to places where there are chances of successfully locating payable ground conforming to one or other of the first three classes previously given.

A Class 1 deposit is usually first suspected on rivers running in or from the rocks known to carry mineral, and alluvials in the upper reaches of the rivers often lead from eluvial deposits just below the primary source. The finding of payable wash or even traces of mineral in the river bed leads to the quest for terraces or side channels, especially where the river leaves the hills, this being the most likely place for a flood plain at the head of which may occur the richest deposits. Flood plains with rich leads may also be situated in the hills.

When prospecting for Class 3 deposits, there is usually much less upon which to base operations. Sometimes a river bed will be found to carry mineral for some distance and then become unexpectedly barren. Search above the last occurrence of mineral may show where the river formerly flowed before diversion by choking or being beheaded by another river. In hilly country channel desertion often leaves a stream, albeit small, in the deserted channel, but where low gradients prevail the site may appear as a flat without any well-defined drainage.

Much has been written upon the "law of the paystreak" and many attempts have been made to evolve a formula sufficiently comprehensive to embrace the majority of alluvial deposits. It has been stated that the paystreak will occur at the head of the flood-plain, i.e. at the lower end of the valley where the river leaves the hills and enters the plain. Whilst this is often the case, other paystreaks quite as rich may occur out on the plain at some distance from the hills which have been denuded and cut back. The accompanying diagrams illustrate such a possibility.

Fig. 1.—This shows a dome with Younger Granite intruded into softer rocks and mineralized at the crown of the intrusion. (Figs. 2–5 have only one side of the dome shown.)

Fig. 2.—This shows incipient erosion by a river, and in Fig. 3 a part (A) of the

mineralized rock has been eroded and its ore contents deposited at A_1.

In Fig. 4 the remainder of the mineralized rock (B) has been eroded and its ore contents deposited at B_1 above A, which has meanwhile been moved downstream to A_2.

Fig. 5 shows the deposit (A_3B_2) to be now below flood-plain C at foot of hills. The downstream movement of AB will become slower as the river tends to reach its base line of erosion, or may even stop should the river find another course.

From general considerations of the geology of denudation by rivers, it is seen that whilst alluvial deposits may appear to occur haphazardly, in reality they represent but a few pages of the history of the river engendering them. Only in the simplest cases will the position of paystreaks be deduced with little preliminary prospecting.

The life of a river is largely bound up in its gradients and the character and structure of the rocks along its course, each of which varies either in time or place or both. When to these variants are added the effects of climatic changes, volcanic eruptions, and earth movements, the degree of complication of the life history of many of the rivers of N. Nigeria may be conceived. In so far as the flood-plain is usually a gradient-change-point, deposition of heavier particles may be expected, but not necessarily all the valuable heavy mineral will find a permanent resting place there. On the contrary, river spate will carry much mineral along the river course into regions of lower velocity where rolling is the main method of progression. From time to time a river may have changed its course and yet no indication of former channels may be apparent on the surface.

It is for these reasons that prospecting for payable alluvials is still largely a matter of trial and error, reduced, as much as possible, by the continued and careful correlation of all information as it is obtained. It must be borne in mind that present conditions may give no clear indication of the gradients prevailing at the time of the erosion of the primary deposit, and the altitude of this latter, where it may be deduced relative to the bedrock, may possibly reduce the region to be prospected. Much might be learnt from a compilation of vertical and horizontal displacements between the primary deposit and its payable secondary deposits in cases where these distances can be fairly accurately determined (Fig. 6), for the average of the minimum gradients so found should to a certain extent be constant, on the assumption that after a considerable time such low gradients are attained that movement ceases or results in the impoverishment of deposits by the gradual attrition and removal of ore particles. For tin in N. Nigeria off the Plateau the writer considers that distances of L greater than 30 H are unlikely to yield payable deposits.

There seems to be good reason to believe that desert conditions prevailed in N. Nigeria during geologically recent times. The two following cases of river diversion which occur on the properties of the Gold Coast Consolidated Lands Ltd., to whom the writer is indebted for permission to publish these notes, may be due to æolian accumulations, in part at least.

In the first (Fig. 7) the original course of the river is shown by the pay ground deposited in the flood plain at the mouth of the valley. Upon 6 ft. of river gravels and clays lie about 15 ft. of clay-loam, yellow to red in colour, and not clearly stratified. It contains no river gravel, but is sometimes gritty. About 6 ft. of this material must have been laid down before the present river channel A–B was available to the river.

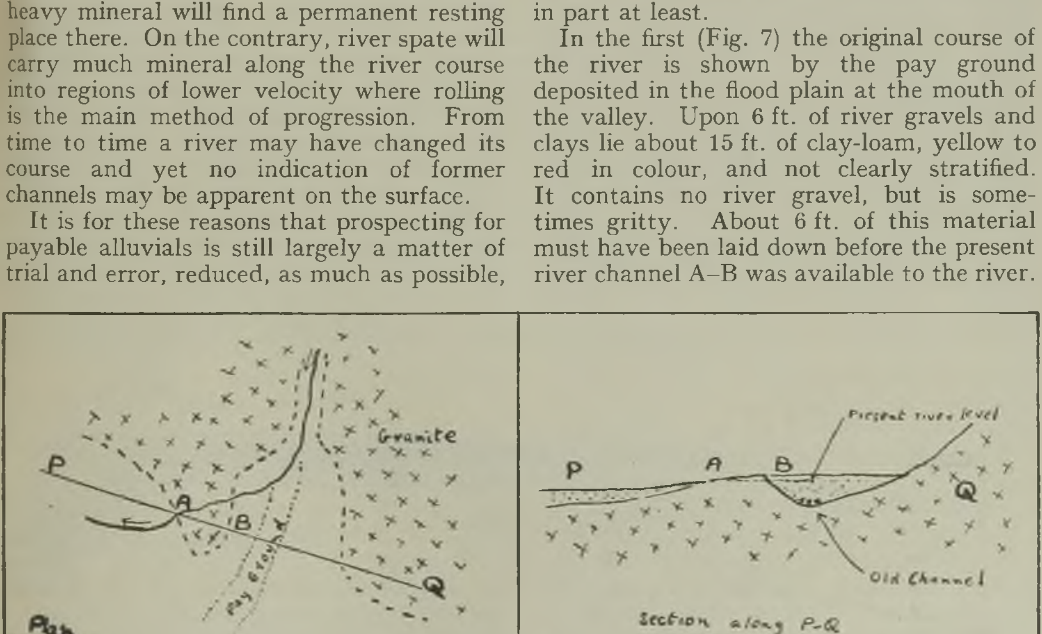


FIG. 7.

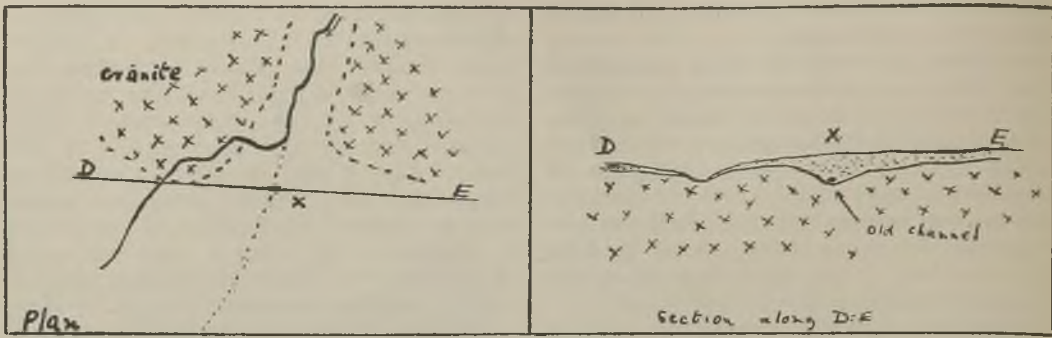


FIG. 8.

In the second case (Fig. 8) the river flows for nearly a mile in a fairly wide valley in which it had deposited a great deal of highly stanniferous alluvium. As soon as it left the valley, however, only traces of tinstone were found in or near the river bed. At X a small amount of payable wash was found, and pitting by lines below this across the direction of the valley above, proved a well-defined buried channel with typical river gravel, but unfortunately no payable wash was found. Here again, the overburden was loam-clay often as much as 20 ft. thick. In each case the flood-plain was found by pitting across the prolonged axis of the valley.

In the writer's opinion much that is described by the Geological Survey of Nigeria as rain-wash and rock decomposed *in situ*, is akin to the Loess of Eur-Asia. It extends over considerable areas of N. Nigeria, is remarkably constant in appearance, occurs at various heights, and apparently changes towards the North and East into the sands of the Sahara Desert, whence blow the dust-bearing winds of the dry season. There seems to have been a protracted period of dessication, when the lesser irregularities of the land-surface such as river channels, were largely obliterated by considerable depths of sand and dust. When the pluvial period resumed its sway the large hill-masses acted as primary watersheds and the main drainage lines lie between them as before, but the tributaries possibly found old channels inaccessible, and it is therefore possible that much tin-bearing wash may lie concealed especially in and around the Younger Granite hills north of the Plateau.

It sometimes happens that possible sites of deposit present an unfavourable aspect. For example, in one area, prospectors pitting through clay had found laterite resting upon bedrock. All succeeding pits reaching laterite were abandoned on the assumption that bedrock was directly below. The place was seen to be a likely site for an ancient river bed on the axis of a valley in the Younger Granite, and close to the contact between the Younger and Older Granites. Pitting across the prolongation of the axis of the valley located a lead under a top clay and bed of laterite formed at the underground water-table by the oxidation of ferruginous solutions arising from the decomposing bedrock. (See section, Fig. 9.) This deposit was drained by an adit and cross-cuts and the bedrock dried to become sufficiently firm

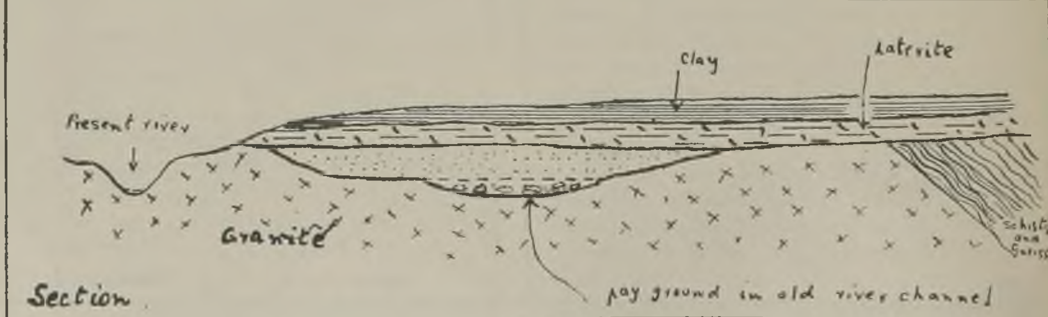


FIG. 9.

to permit the use of props. The laterite roof was very sound, and a long wall retreating method of mining gave complete extraction.

Group B Deposits.—The position of those secondary deposits not related to the present river system can often be only vaguely surmised. Only by the careful study of known deposits of this type and of their overburdens can the conditions under which others may be found be recognized.

PURPOSE OF PROSPECTING.—Prospecting for alluvial deposits has for its objects the finding of payable ore, its position, quantity, and grade. In firm ground which can be drained, quite low average overall values become payable if the mineral content is sufficiently concentrated. For example, 0·4 lb. per cu. yd. average overall, 60 ft. deep, all tinstone in wash 3 ft. thick might be profitably worked by underground methods, although the percentage mining extraction might not exceed 70 if timber were not used.

The values in dredging ground may be very small, but either the mineral contents must not be concentrated on a hard uneven floor or the bedrock must be soft. Other mechanical plants (excluding hydraulicking) usually require considerably higher average overall values according to the conditions.

In those forms of alluvial mining in which the wash is treated apart from the overburden it is of the utmost importance that its thickness and value be known beforehand. For example, assuming stripping overburden costs 5d. per cu. yd., and treating wash costs 1s. 8d. per cu. yard, and that the ground is 36 ft. deep, average overall content 1 lb. per cu. yd., and that the wash is in the one case 1 yard thick and in a second 3 yards thick, then, dealing with a column with base of 1 sq. yard :

Case I.—Overburden	11	yards at 5d.	.	55d.
Wash	1	,, at 20d.	.	20d.
	12	,,		75d.

Cost per lb. of tinstone—$6\frac{1}{4}$d.

Case II.—Overburden	9	yards at 5d.	.	45d.
	3	,, at 20d.	.	60d.
	12	,,		105d.

Cost per lb. of tinstone—$8\frac{3}{4}$d.

Rich washes at considerable depths, and those with hard overburden, are usually won by underground methods if possible. For example, assuming in the above case that the wash thickness, or mining width including all the wash, was $4\frac{1}{2}$ feet.—

Case III.—Overburden	$10\frac{1}{2}$	yards at 0d. .	0d.
Wash	$1\frac{1}{2}$	,, at 40d. say,	60d.
			60d.

Cost per lb. of tinstone 6·7d. assuming recovery 75%. The cost in this case is almost independent of the depth of the wash.

METHODS OF PROSPECTING.—*Trenching* is a good method in ground up to 15 ft. deep especially where the direction of the lead is fairly well known (e.g. in narrow valleys), as narrow, possibly rich, leads are almost certain to be picked up. *Paddocks* are sometimes made to obtain large bulk samples, but usually only after drilling has given good indication of values. This method is useful in very loose ground where other methods give uncertain results.

Drilling is the most suitable form of exploration in many cases, and is the only one possible where the ground is waterlogged throughout the year or is over 80 ft. deep, or is very loose wholly or in part, and for rainy season prospecting. Where, however, hard boulders occur in the alluvium and where there are very hard beds the ordinary hand operated drill is useless, often misleading as to bedrock, and power drills are necessary.

Pitting is the oldest method and is still very much used. Depths of 80 ft. and more have been pitted using simple manual hoisting gear. The ground must be firm, and not waterlogged.

Water is the chief obstacle to the use of this method, often not because of its quantity, but because in the confines of a pit it causes washing down of the sides. Quite loose sand can be pitted if there is no water, and care is taken to provide ladders. Running silt cannot be pitted through safely, although pitting "boys" sometimes pass through six inches or so of silt by letting it run out somewhat, and filling the cavity with grass-sods and leaves.

Lateral exploration from deep pits may make fewer pits necessary if the ground is sufficiently firm, but is only cheaper in deep ground as the cost per foot of tunnel is usually from 3 to 4 times the cost per foot of pitting to average depths, say 30 ft.

Often at the beginning of the pitting season the water table is too high for rapid progress. By paying the labourers on a scale in which the top few feet of a pit are paid at a rate less than the average rate per foot, pits may be sunk to the water table, left till it falls, and then continued. If paid at a uniform rate per foot " boys " often leave after digging a few feet and being paid for them. The alternative, no payment until finished, should not be used unless there is a fair chance of completion.

Pit (and drill) sites should be set out and surveyed simultaneously. Painting numbers on stones is very permanent, but not so rapid in the field as having short pegs with numbered metal plates nailed on. These can be prepared in camp from petrol tins, or better still, thin galvanized iron sheets, cut into suitable sizes.

The sampling or assay plan should be drawn to a scale sufficient to hold all useful information: and data, such as the following, should be kept in a register for future reference.

values. If it be known that the overburden is valueless a single groove sample over its whole depth is sufficient as a check; any suggestion of a top wash, however, should be carefully tested. From the pay dirt in the bottom three equidistant vertical groove samples should be taken. Though apparently laborious these checks are almost invaluable in some ground, and the total expense is little more than that for the first sample. In ground of almost uniform grade the values should agree fairly closely (and possibly for this reason such ground may need but one sample per pit) but for ground where the ore is in streaks or patches the average should be taken. In groove sampling it is essential that the volume of the dirt washed to obtain the sample be determined as accurately as possible by experiment for each kind of wash.

AREA............ LEASE NO.............

Pit No.	*Pitting Boy*	*Depth ft.*	*Paid s. d.*	*Date*	* *Sampling* *Overburden.*	*Wash.*
No. 5	Anglo	28	7 0	7/7/29	23 ft. @ Tr.	5 ft. @ 4·7, 8·9, 9·8 } Av. 7·8

Average Overall Value	*Tons Cassiterite*	*H.A.D. Surface*	*H.A.D. Bedrock*	*Remarks*
1·4	6·44*	136 ft.	108 ft.	

* "Area of influence" of pit 200 ft. by 50 ft.

The last two columns give contours of surface and bedrock, the former useful for leats, and the latter for drainage. Often in wide-flung scout prospecting the bedrock levels show where ore-bearing channels may be expected.

Overburden values should not be included in tonnage calculations unless the whole is to be treated. Usually some intermediate pitting is done to determine more exactly the boundary of the payable ground. This avoids useless expense of removing an overburden from poor wash. It is unusual for a deposit to have straight boundaries, and while " islands " of poor values in the deposit may be too small to leave unworked, the working of unprofitable ground on the outer boundary is rarely necessary or useful.

In the groove sampling of pits great care must be taken to avoid digging too much from near the bedrock, where the greater enrichment usually occurs. For this reason pits are best sunk 6 in. to a foot into bedrock before sampling, when a more even groove may be expected at the level of the highest

Commonly, the volume *in situ* and the volume when dug of the whole of the wash from one pit are compared, the former being expressed in cubic yards, and the latter by the number of " washing units," e.g. the washing unit may be the content of a marked calabash. The volume of this calabash can be standardized by reference to the weight of an equal volume of water.

Sampling by taking all or a portion of the wash dug from the pit is a very good method, but requires that the volume of the cylinder of wash extracted be known, and there is danger that unless the bedrock is entered for a short distance and the wash completely extracted the values found may be low because of rich wash left around the bottom of the pit. Also, an error of 5% in measuring the diameter of the cylinder of wash extracted would mean an error of approx. 10% in the wash value adopted.

Greater progress can be made if pitting boys work in pairs, each sinking the first few feet of his pit unaided and completing it with the help of his partner. Occasionally natives will pool their labour, and in deep pitting, especially where there is water, the extra assistance in bailing and hoisting is all-important.

Pitting has usually a footage per boy-day not less than that of drilling and is somewhat cheaper and therefore, where possible, is to be preferred. European supervision is less than that required for drilling, and whilst old picks and shovels are used for pitting, depreciation has to be allowed on drills. Pitting gives check samples at little extra cost; drilling requires another complete operation for each check.

The best spacing of holes cannot be expressed as a formula. It may be said that where the leads may be wide with respect to their length or where the direction of leads is unknown, prospecting by squares is best, but it is possible if the squares are too large to miss quite valuable ground, e.g. a square of 200 ft. of average overall content 1 lb. per cu. yd. and 30 ft. deep would contain nearly 20 tons. If the values warrant it, greater expenditure will usually be allowed, but counterbalancing this is the fact that larger deposits need fewer pits per acre to give a fair average result.

Some tin bearing ground is proved by 1 hole per 2 acres, but in recent years several mines in Malaya have reported that closer drilling of rejected ground has increased ore reserves. The Nigerian tinfields usually require from 4 to 16 holes per acre before ground can be considered proved.

GOLD IN ECUADOR

By H. L. HOLLOWAY

The author briefly describes the history of gold mining in Ecuador and goes on to say something of the origin of the placer deposits.

In the early days of the occupation of the Pacific Coast of South America by the Spanish conquistadores the kingdom of Quito, which now is part of the Republic of Ecuador, was famed for its richness in gold. History records that the king, Atahualpa, treacherously imprisoned by the Spaniards, offered to ransom himself by filling a council chamber with gold, which done, his captors afterwards put him to death. Yet in all the territory comprised in Ecuador to-day there is only one mine of any importance being worked for gold.

The question as to what were the sources of these early stores of the precious metal has been answered in several ways. By some it has been contended that the gold was the result of the slow accumulation of centuries, the winning of which was made possible, not by the richness of the mines, but by the availability of a large amount of practically slave-labour. By others it is held that rich placer mines did exist, but have been worked out. Others again have held that with the advent of the Spaniards the conquered people, fearing to awake further the cupidity of their captors by the winning of gold, ceased to extract it and the secret of the locations from which it was derived has been lost.

It seems certain that the gold won by the Incas was obtained almost entirely from placers. The large placer areas that are now known are as follows:—

1.—Those in the northern portion of the Province of Esmeraldas, watered by the Santiago River and its tributaries.

2.—Those in the district of Santo Domingo de los Colorados, situated in the western skirts of the Andes, in the Provinces of Pichincha and Leon.

3.—Those on the Napo River system, situated in the plains east of the Andes and E.S.E. of Quito.

4.—Those on the Santiago River system, east of the Andes, on the southern boundary of Ecuador with Peru (this Santiago being distinct from the river of the same name previously mentioned).

5.—Those on the Bobonaza River system, this river being a tributary of the Pastaza in the Amazonian basin.

6.—Those on the mountain plateau, in the Province of Azuay, the principal ones being at Collay, Ayon and Santa Barbara, Matanga, and on the Shingata River.

Minor placers occur in the Provinces of El Oro and Loja on a number of streams and also on some of the tributaries of the Guayas River in the Province of that name.

In the second half of the sixteenth century the Spaniards had developed considerable settlements for the winning of gold at Sevilla de Oro on the Upano, a tributary

of the Amazonian Santiago; at Mendoza on the Palora River, this a tributary of the Pastaza, and at several other points in what is now the Province of the Oriente. Sevilla de Oro is recorded as having had the considerable population of 25,000 souls, but the Indians, in one swoop, wiped out these settlements in the year 1599 so thoroughly that even the sites of them have been lost. Of the placer fields which sustained Sevilla de Oro and Mendoza nothing whatever is now known. The Indians in those parts are not gold winners and if the lost placers are re-found it will be by white men.

As to the origin of the known placers: In the province of Esmeraldas, towards the northern boundary with Colombia, there are large stretches of terraced alluvials, all more or less auriferous. Theodore Wolf, in his well-written and generally reliable work on the geology of Ecuador, holds that these placers were deposited by a river system that has now changed its orientation entirely and not by the Santiago River in its earlier development. This theory is based mainly on the fact that the old alluvial wash contains a considerable number of rocks derived from formations that only occur in the Central Andes, whereas the Santiago and its tributaries rise in the western slopes of the Western Cordilleras. The alluvial banks, even along the comparatively small tributaries, carry dioritic and porphyritic components, yet nowhere do the actual rivers touch within scores of miles of formations from which these could have been derived.

Wolf believes that the area now drained by the River Mira once discharged its waters much further to the south than at present, and that it was by that system that the alluvials were laid down. Certainly there is much in the arrangement of the banks to support this theory, for they extend from the tributaries of the Bogata in the north to the River Cayapas in the south, broken and irregular it is true, but never wholly absent.

It can be accepted that the bulk of the gold found in the present streams is derived from the erosion of these old alluvials, but there is nothing to rule out the possibility that the rivers traverse auriferous formations and themselves bring down a certain amount also. It is rare to find pieces of the original matrix adhering to the gold, but occasionally small nuggets found in the upper portion of the Cachavi are composed partly of a milky quartz and partly of metal. Prospecting for reefs in this area should first be confined to establishing whether or not the rivers in their upper courses above the alluvial banks are auriferous. If so the usual methods of following up indications would be adopted, but if the upper courses gave no showing of gold it would be for the prospector to establish the original derivation of the wash and to find which of its constituents has shed the gold. This, in the lack of geological knowledge of the country and the intense difficulty of travel in a forested and mountainous region with few roads, would call for considerable work and time.

In Santo Domingo de los Colorados the auriferous formations that have shed the gold in the placers are probably contained within the drainage area of the present streams and there prospecting should not be so difficult.

The Napo River placers undoubtedly originate from the eastern slopes of the range of mountains known as the Llanganates, situated to the east of the main Andes, S.S.E. of Quito. Legend credits this range as being one of the chief sources from which the Incas drew their supplies of the precious metal, but, leaving legend aside the greater number of the richer tributaries of the Napo rise in this entirely unexplored territory and the higher one ascends these auriferous streams the coarser becomes the gold.

In the Napo basin there are vast alluvial flats laid down by the present river and also terraces occurring on the higher levels, the origin of which it would be impossible to state without considerable study. All are auriferous and without doubt the old terraces do their share towards the enrichment of the present river, although the bulk of the gold is brought down from the upper waters, probably from reefs.

NATIVE WORKING ON A TRIBUTARY OF THE RIVER NAPO.

Two of the lower tributaries of the Napo which carry considerable gold are the Payamino and Coca Rivers. A spur of the Cordillera de Galeras stretches between these two rivers and, as only the tributaries that rise in this spur carry gold it is to be supposed that the source of the metal lies in auriferous formations contained in it. In this area either the early Spaniards or the Incas before them have done a good deal of work on the alluvial flats.

The auriferous tributaries of the Amazonian Santiago traverse in their upper courses, for the most part, a Palæozoic or earlier schistose formation, which is criss-crossed by quartz veins and stringers, and the probability is that it is these veins and stringers which carry the gold. The upper Zamora is an exception to this rule, for it cuts through igneous complexes containing well-defined quartz reefs. This river is, perhaps, the richest of all the larger ones in gold and its head-waters would bear thorough prospecting.

In the schist country, through which flows the Paute for the greater part of its upper course, there is little probability of striking concentration of gold in any one spot which would be sufficient for exploitation. At places one sees the commencement of tunnels which have been started in the schist and from which the natives claim to have taken quartz studded with gold, but samples from such tunnels when assayed usually show no more than a trace of the metal.

In the Bobonaza River system the gold is almost certainly of secondary derivation and it finds its way into the streams from the very ancient remnants of alluvial terraces with which the district is scattered. This view is based on the fact that many of the streams which are richest in gold—that is the Rotuna Grande and the Rotuna Chico, the Balsayacu, and the Sarayacu,—rise and flow entirely through late sedimentary formations, entirely free from igneous intrusions. The gold in these streams neither tends to enrich nor to become coarser upstream.

The Villano and Lliquino Rivers, which flow parallel to and slightly to the north of the Bobonaza, carry gold, the occurrence of which is similar to that in the last mentioned river. That the sources which feed the Villano and Lliquino rivers are distinct from those which feed the Bobonaza is proved by the difference in the ley of the gold and also by the fact that there occurs a trace of platinum in the Lliquino and in no other of the streams. It is probable that both the Lliquino and the Villano Rivers rise in volcanic country, but if the gold was brought down from the head-waters it should follow that as one ascended the streams it would become coarser and this is not the case. Many of the low hills in this district are capped with ancient alluvials, so much eroded that only remnants of them remain, and whence these alluvials came would be difficult in the extreme to ascertain. The prospector searching for primary sources in this district would be wasting his time.

Gold-Bearing Stream, Llanganates.

The mountain placers in Azuay Province are derived from the same schistose formation as those of the greater portion of the Amazonian Santiago, although there are here other metamorphic formations, principally quartzites, and some igneous intrusions. At Ayon and Santa Barbara, near the town of Sigsig, the gold won by the natives is coarse and sharp edged and certainly of quite local origin. The streams of Ayon and Santa Barbara have their sources in small lakes, high up the mountain sides and within a mile or two of the placers, and the schist is here cut by quartz veins of some size. Whether the gold is derived from these veins or from the stringers which cross and recross the formation in every direction a little prospecting should be able to determine. In the placers of Collay, near the town of Gualaceo, and those of Shingata, near the town of Nabon, the gold is considerably more waterworn. The country rock is again schist and it is probably the source of the gold.

The same schistose formation occurs on the western side of the Andes, in the Province of El Oro in the district of El Pasaje, and here again there are placers, although they are of little importance. The schist in this section is cut by numerous reefs of quartz, some of which are known to be auriferous.

In the Province of Loja the well-known gold-bearing district of Zaruma gives rise to many auriferous streams, among them being the Rivers Raspas, Colorado, and Tumbez. About six miles to the east of the town of Loja there has been found one of the few lode-gold mines worked by the Incas.

There are numerous other auriferous areas that have not been mentioned in this description of the gold occurrences of Ecuador, either because there is too little definitely known of them such—as is the case with those drained by the upper Aguarico and Sucumbios Rivers in the northern part of the Oriente—or because of their minor importance. There has been a certain amount of exploration work in the Provinces of Loja, Azuay, and El Oro, but for the rest the greater portion of the gold-bearing territory has not been prospected and it comprises what is practically a virgin field. The many placers attest the existence in the past of primary sources, which must have been of some magnitude to disseminate gold over such enormous areas, and it is not reasonable to believe that all such sources have now become exhausted.

The I.M.M. Benevolent Fund

The following further subscriptions to the Benevolent Fund of the Institution have been received in response to the appeal of Mr. Hugh Picard in the February issue of the MAGAZINE :—

Members at Rio Tinto	£33 17s. 0d.
W. Selkirk	£10 10s. 0d.
South Kalgurli Consolidated	£10 10s. 0d.
R. J. Lemmon	£5 0s. 0d.
H. C. Boydell	£4 8s. 0d.
T. Pryor	£3 3s. 0d.
G. W. Eaton Turner	£3 3s. 0d.
R. Goetz-Philippi	£2 2s. 0d.
L. E. Djingheuzian	£1 17s. 0d.
W. B. Pollard	£1 1s. 0d.
W. G. Wagner	£1 1s. 0d.
Amounts previously acknowledged	£35 14s. 0d.
Total	£112 6s. 0d.

LETTERS TO THE EDITOR

The Goldfields of Dutch West Borneo

SIR,—I have read with interest the article in your February issue by E. J. Vallentine on "The Goldfields of Dutch West Borneo," in which he draws attention to the possibilities which the so-called Chinese districts of Dutch West Borneo seem to offer to dredging with up-to-date plant of large capacity. The conclusion of Mr. Vallentine is that, in view of the marked advancement in dredging and other mining practice, the improvement in local conditions, and the growing demand for gold, this district deserves more attention to-day. Unfortunately the literature which Mr. Vallentine quotes is not up-to-date, and it may be of some value to observe that since the investigations mentioned by Mr. Vallentine several others have taken place which have thrown new light on the geology of the district.

Several Government mining engineers have done a lot of exploration work not mentioned by Mr. Vallentine, but details of which are to be found in the Yearbooks of the Mining Department of the D.E.I. In 1925 extensive exploration by the Government took place under the direction of Mr. de Kroes as to the up-to-date dredging of the goldfields intensively worked in the past by the Chinese immigrants, but the results were unsatisfactory. Therefore, notwithstanding the fact that the Chinese immigrants seem to have obtained an astonishing gold production in the past, the prospects of dredging in the districts mentioned do not look very bright at present. Still, where the production of alluvial gold has been stated to be a million ounces annually over several years it looks tempting to try to discover the primary deposits.

The question is: Are these primary deposits still present or have they all been eroded to the very roots? The Government engineers did not succeed in discovering any important lodes or veins bearing gold. The outcrops of rich veins may have been worked by the Chinese as far as they could with their primitive machinery and these ancient works may now be covered by the dense vegetation of the tropics, so that the possibility of the occurrence of veins and lodes is not exhausted. I feel, therefore, that the discovery of workable gold-bearing veins or lodes as well as low grade but extensive deposits may be regarded as possible still in the Chinese districts.

In conclusion, Mr. Vallentine mentions that a concession for a term of 75 years can be obtained on the production of proof that any specified metal or mineral can be produced at a profit. This is not quite correct, as a concession is granted as soon as it is proved that the specified metal or mineral occurs in a natural deposit from which its recovery is technically possible. This condition is far easier to fulfil.

P. M. Van Bosse.

The Hague,
February 20.

Hydraulic Pipe-Lines

Sir,—I read with interest Mr. Allen's article in your December issue on the cost of an electro-welded pipe-line. The following figures for a cold riveted, slip joint pipe-line, head 182 ft., recently installed may be of interest for comparison :—

Pipe made by Mechan ; 14 gauge, 5 ft. lengths, shipped nested to be riveted up into 15 ft. lengths on the site.

Pipe sizes . .	3,850 ft. of 15 in. diam.
	3,850 ft. of 13½ in. diam.
	250 ft. of 12 in. diam.
Total Length .	7,950 ft.

The pipe sections were landed from a small boat through heavy surf on to a beach in canoes, thence 6½ miles by river in canoes, followed by transport on men's backs for 6 miles to the site. First consignment landed on the beach December 10, 1930. Riveting started along pipe-line trace January 23, 1931. Water turned into pipe-line March 8, 1931. There were no leaks in riveted joints, although all done by entirely unskilled labour. In coupling slip joints one turn of baft with thick tar was put on before drawing the joint together with two bolts through the four lugs. A few small leaks at joints between pipe and bend were easily and quickly caulked.

Total cost, including supervision :—

Riveting 5 ft. lengths together to make 15 ft. lengths, coupling and caulking	$4,440·05
Cost per foot of completed pipe (riveting, coupling, caulking, and supervision)	54·6 cents
at 4·86 equivalent to	2s. 2¾d.

The average wage of labour was $1·25 U.S. currency per day at 4·86 equivalent to 5s. 1¼d.

F. W. Leighton.

Cucullo, Panama.
January 16.

BOOK REVIEWS

Lehrbuch Der Bergwirtschaft. By K. Kegel. Cloth, octavo, 653 pages, illustrated, with 95 statistical tables, and 20 specimen forms. Price RM. 48. Berlin : Julius Springer.

Mine economics in the broadest sense of the term would include world and national mineral resources, but such an all-embracing subject being so big, the author has wisely limited his work to those questions of more direct concern to the technical direction and to the mine officials, that is, to mining finance and mine management. Even so, a large book in eight sections has resulted, these sections treating successively : The bases of the mining enterprise ; the labourer in the mine ; the organization of his work ; the co-ordinating organization of the whole work ; the scheme of development and of winning ; the equipment on surface ; mine management ; and the valuation of mineral properties.

These eight sections do not all occupy an equal amount of ground, nor are they all of the same degree of independence. The first section deals with the three bases of mining enterprises : The natural basis, that is, a mineral deposit of economic value ; the legal basis, that is, mining rights, privileges, and responsibilities ; and the financial basis, that is, a financial structure proper to mining enterprises. Most attention is here given to the last basis, though since the financial structure depends so much upon the degree to which mineral reserves have become established, a book dealing with mining finance and mine management might well begin with the sampling and valuation of mineral deposits, a matter left over by the author for his final section.

The second section deals with the labourer as a human machine, laying stress upon one working underground. The influences of rhythm, physiology, psychology, instruction, in affecting performance are all fully discussed. This leads logically to the third section which, starting with an outline of time studies, takes up the different ways in which labour may be marshalled, individually, in parties, and in flowing order. Broadening this theme, the fourth section exposes the factors involved in co-ordinating the whole operations to obtain optimum efficiency of labour, of equipment, and of final result in terms of marketable product. These three sections, though in a way distinct, make one whole, namely, an exposition of such studies or investigations as when applied will indicate where betterment of result may be obtained; in other words, an outline of efficiency engineering.

The next section, the fifth and largest, deals with the applications of study results to the several mining operations, development, winning, haulage, and raising. It discusses the benefits of planning in advance, concentration of work, mechanization, and standardization. Much of this section is occupied by description of ordinary technical methods, as distinct from economics, this latter finding expression only in formulae and numerical illustrations. The cases given in illustration relate to the mining of beds of coal, copper, and potash, to the open-pit mining of lignite, and to the bore-hole winning of mineral oil.

The sixth section, which is relatively short, treats of the necessary items of the surface equipment, their nature, size, life, and layout. Here again the exposition is largely a technical description, though the economic aspect is entered by enumerating the considerations which are of economic weight. Here, also, the particular illustrations are drawn from German coal, lignite, and potash mines, and much is said about loading arrangements, marshalling yards, screening, washing, coking, and briquetting installations, steaming and electric-generating plants.

The seventh section deals with mine management in the general sense of the term, that is, the activities which aim to secure the optimum results from a launched and producing undertaking. Such management watches over the organization of the personnel, the layout and execution of the work, works costing, stores, labour, investment costs, depreciation, amortization, operating costs, and the general economy. It surveys also those studies and investigations, undertaken generally by specially allocated engineers, which have recommendations for betterments in view. In this section the analysis of expenditure and of work performed naturally receive considerable attention, and there is a wealth of useful specimen forms, tables, and graphs. The importance of an effective workshop to the general economy is emphasized by twenty pages and more being given to drawings and descriptions of representative workshops.

The eighth and final section is devoted, as already mentioned, to the examination and valuation of mineral deposits and mining enterprises. All the factors, favourable and unfavourable, to the making of profits, are discussed. The practical side of the establishment of mineral reserves receives limited attention. Not much is said about mine sampling, and nothing about the computation of the average value of mineral reserves, subjects which are of the greatest importance to precious-metal mining and to non-ferrous base-metal mining. Somewhat more attention is given to mineral contracts and marketing. Mining risks are discussed; and then the computation for present value is taken up. In this latter it is difficult to follow the reasoning which leads to the basic formula No. VI on p. 632 which differs fundamentally from British and American conclusions; as also it is to agree with the computations on pp. 634, 635, which result in a present value of M. 280,000 for a property which when provided with an equipment costing M. 1,000,000 to begin with and renewed at intervals of every 12 years will yield an annual profit of M. 360,000 for a life of 75 years; whereas the same property when provided with an equipment of three times the size and cost to begin with, renewed as before at intervals of 12 years, and yielding an annual profit of three times the amount for 25 years, one third of the previous life, would have a present value of M. 3,511,000, or more than 13 times as much as the previous present value, the rate of interest demanded on the investment being 8 %, and the safe rate of interest being 4%. It is true that present profit is the largest factor in present value, but it is far from being the preponderating factor that this comparison would indicate. A short statement of the benefits which rationalization would bring finishes the section and the book.

This book, while it practically confines itself to German mining and German authorities, is the first comprehensive work on mining finance and mine management from the economic view-point. As such it is heartily to be welcomed and the author is to be congratulated upon the completion of an arduous and pioneer task from which not only his students, but his colleagues and the mining profession will considerably benefit. The economic principles of mining operations demand study in the same detail as the technical principles.

S. J. TRUSCOTT.

☞ Copies of the books, etc., mentioned under the heading "Book Reviews" can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London, E.C.2.

NEWS LETTERS

BRISBANE

February 23.

Mount Isa.—Official returns for January show that the output of the Mount Isa mine is still steadily increasing, and that the full capacity of 2,000 tons of ore to be eventually dealt with daily is gradually being approached. The local mining warden states that when, in July next, the smelter reaches its full capacity, the output of bullion will be between 5,000 and 6,000 tons per month. The work in connexion with the Dwight-Lloyd sintering plant is well in hand and one machine is about to be put in commission. A start has also been made on the excavations for the new blast furnace. The portion of the original plant that had been reserved for the treatment of zinciferous ores, but which has not been used for that purpose, is being converted for the treatment of lead ores. In underground work the seven glory-holes on the Black Star section were operated continuously last month, but no new development was carried out on the lode. In the Black Star section the foot-wall chute rises on No. 3 level were completed, and the erection of chutes is in progress. The cross-cuts east and west from G 48 winze were completed to both walls of the Black Rock lode. The west cross-cut is being extended to the top of the rise from the No. 4 level sub-drive. Development by sub-level driving has been continued at No. 4 level. At G 40 section the west cross-cut met the foot-wall of the ore-body, and the mouth of the cross-cut is being stripped for track turnout. In the Rio Grande section, the drawing of the main lode south stope at No. 1 level has been continued. Two extra chutes were erected in the hanging-wall lode. At No. 4 level the main lode and the No. 1 hanging-wall lode north stopes, as well as the main lode north stope, were operated continuously during the month. The preparation of the No. 1 hanging-wall south stope was commenced. At the Urquhart (main haulage) shaft the tail-track drive was recommenced, while the diamond drilling at Crystalena No. 1 bore progressed steadily.

Lawn Hills Concession.—The first intimation received here that the Mining Trust had decided to give up the concession obtained from the Queensland Government over the Lawn Hills mines was found in the full report of the speech made by Mr. Leslie Urquhart at the last annual meeting. The announcement that the results of diamond drilling and other prospecting work had given no promise of the occurrence of large bodies of commercial ores, was received here with natural disappointment. The Mining Trust, it appears, had expended nearly $24,000 at Lawn Hills.

Gold Discovery in Queensland.—What promises to be an important discovery of gold has just been reported from North Queensland. The locality of the find is Mount Wandoo, situated in an old mining district 10 miles westerly from the terminus of the Chillagoe Railway at Mungana, which is 150 miles inland from the port of Cairns. At that place Mr. Alexander Macdonald, with others, has had about 30 men employed for some time in concentrated exploration and thorough testing work. Four shafts have been sunk, in all of which ore has been struck that gave very promising, but varying, assay results. There has been found a reef said to be remarkably rich in gold and silver. A battery is now in course of erection and what are estimated to be some remarkably rich lots of ore, totalling 150 tons, are at grass ready to be crushed. The find has not yet been officially reported to the Mines Department, but the Chief Government geologist (Mr. L. C. Ball), judging from the first results published in the Press, expresses the opinion that the outcrop is low grade, but that shoots of rich ore are being met with. Mr. Macdonald, who has had a long experience of mining in North Queensland, over a year ago obtained a concession from the Queensland Government over an area embracing several mines at and near Cardross, about ten miles from Mount Wandoo, intending to carry out mining on a large scale. According to a statement made by the Minister for Mines in the Legislature towards the end of last year, he must have obtained some capital, and has since been giving his attention to the Wandoo locality.

Murdoch Copper Process.—In 1930 a company called Cloncurry Copper, Ltd., took in hand the Vulcan copper mine, in the Cloncurry district, North Queensland, to try out the new Murdoch process for the treatment of copper ores. A considerable amount of money was spent in preliminary work at the mine and in the installation of the plant and a short time ago everything was ready for a start. It was officially reported that certain problems in the treatment of the ore had presented themselves but these, while causing some delay, were expected, after certain adjustments had been made, to be overcome. The company, however, has now been forced to cease operations for lack of funds and it is announced that it will not resume until additional capital has been raised. The Murdoch process is a leaching process, expected to be specially adaptable to the Cloncurry ores. Its distinctive feature, as compared with other leaching methods, is the use of lime for the precipitation of copper instead of scrap iron or electrolysis.

Great Boulder Proprietary.—In its last financial year, recently closed, the Great Boulder Proprietary, Ltd., showed satisfactory profits. This was due in a very large measure to the exchange premium on gold, also latterly to the enhanced price of gold. A dividend of 3d. per share ($12\frac{1}{2}\%$) has been declared in respect of operations during 1931. Profits which had accumulated in 1927 and 1928, when no dividends were paid, enabled the directors to pay a dividend of $12\frac{1}{2}\%$ in 1929 and in the succeeding year. There then remained a credit balance of £16,710. This sum, with the profit for the year, the actual amount of which has not yet been announced, has been sufficient to provide for the further $12\frac{1}{2}\%$ 1931 dividend, which will consume £21,875.

Taxation of Dividends.—The secretary of the Chamber of Mines of Victoria has notified members that dividends of gold-mining companies are now free from taxation in that State. A Bill giving this authority was passed on the last day of the session. This Bill provides for freedom from taxation from July, 1929. Any tax paid by companies since that date is to be refunded on application. Victoria is the last to fall into line in this respect with other Australian States and the Federal Government.

Shale Retorting in Tasmania.—The amalgamated shale-oil companies at Latrobe, Tasmania, are concentrating on production from shale at the Crozier retorting plant, where work is being carried on in three shifts. About 30 tons of shale is being treated daily. The plant is being run on close-costing conditions, and it is expected at the end of an investigation period of three months to show a balanced ledger, in the event of which it is intended to erect a plant capable of handling from 300 to 500 tons of shale daily. The whole of the output of petrol, amounting to 100 gallons a day, is being marketed in the district. The Railway Department is utilizing a big percentage of the fuel oil in the Launceston railway workshops, and the kerosene is being distributed throughout the State. Reports from the Railway Department on the fuel oil are extremely satisfactory, and it is stated that the bitumen manufactured is equal to, if not better than, the imported product, whereas tests have proved the petrol to be of a superior quality, with higher calorific value and giving greater mileage than the imported spirit.

JOHANNESBURG

March 2.

Luipaard's Vlei.—The Luipaard's Vlei Estate and Gold Mining Co. has applied to the Government for the leasing of the No. 5 (Midas) shaft section of the French Rand mine and preparations are well advanced for the re-equipping of the shaft, which is about 1,600 ft. deep. The shaft serves nine of the old French Rand workings and enabled a considerable tonnage of ore to be opened up on the portion of ground lying between the Luipaard's Vlei and Champ d'Or faults, which although faulted near the surface gave very high values. If the application for the lease is granted, the Luipaard's Vlei Company will obtain a considerable tonnage of known payable ground with an intact area, which gives promise of values considerably in excess of the present grade of the company. The ground has been lying dormant for over 20 years.

Randfontein Black Reef.—The Randfontein Estates Gold Mining Co. has suspended all work on the Black Reef series on what is known as the old Uitvalfontein Company's claims. The ground was purchased at auction during the latter part of 1928, when the entire claim holding of 589 claims of the Uitvalfontein Gold Mining

Company (Pty.), Ltd., was purchased from the liquidators for £2,000. During the following years 375 of these claims were allowed to lapse to Government and on the remaining 214 claims an extensive development programme was put in hand, resulting in the opening up of considerable tonnages on Black Reef of medium and low grade. Regular tonnages of Black Reef ore were crushed from these claims during the last two years, amounting to approximately 2,000 tons per month, which, combined with other Black Reef tonnages from the Battery Reef and other sections, gave a total of approximately 5,000 to 6,000 tons per month from these series. The reef lies horizontally at shallow depths over a large portion of the West Rand, and extends over great distances on other parts of the Transvaal. It is known to be an erratic gold carrier and, at the best of times, is only found in rich patches or pockets, of which the Uitvalfontein deposit is a good example. The acquisition of these claims by the Randfontein Estates was never looked upon as a big mining venture by that company, but merely as a business deal whereby an estimated profit could be quickly made and the ground then abandoned. Uitvalfontein has served this purpose and will very likely be open for pegging one of these days again.

Sabie Gold Mine Sold.—The assets of the Sabie (Transvaal) Gold Mining Co. (in liquidation), consisting of 442 claims and a reduction plant capable of treating 3,500 tons of ore per month, have been sold by public auction in Johannesburg for £1,125. The mine is in the Sabie district, adjoining Glynn's Lydenburg and the Transvaal Gold Mining Estates. During the three years up to 1929 the company milled 102,000 tons of ore and produced £126,000 worth of gold.

Congo Copper Developments.—It is reported from Rhodesia that improvements effected recently to the plant of the Union Minière du Haut Katanga will enable the company, when market conditions are normal, to increase its output from 82,000 tons to 150,000 tons without increasing its white staff or native labour force. The company is said to have discovered between Mokambo and Tshinsenda, on the Katanga Railway, a sulphide ore-body, which is believed to contain 115,000,000 tons of copper ore. As with the copper mines of Northern Rhodesia, retrenchment is now proceeding apace. At the end of January, nearly 150 men were discharged and sent back to Belgium from the Prince Leopold mine, Kipushi, and the Lubumbashi smelter. Like most of the employees of the Union Minière, these men were on contract with the obligation resting on the company to repatriate them as soon as their contracts expired, in the event of retrenchment becoming necessary. For this reason, the families concerned have not experienced such hardships as those discharged in the Rhodesian Copper Belt. At the Lubumbashi smelter, only one of the three furnaces is now operating, owing to the control now being exercised on the output of copper.

Gold Strikes in Rhodesia.—News has been received at Bulawayo of a reputedly rich gold strike on the property of the Luiri Gold Areas, Ltd., near Lusaka. Details are meagre, but it is said that the strike has been made in the neighbourhood of the Dunrobin, Matala, and Tanduma deposits. Another rich gold strike is reported to have been made in the Antelope gold belt, lying to the west of the Antelope mine, in the Bulawayo district. The new reefs include one 800 yd. long on the strike and 21 ft. in width which assayed up to 40 dwt. a ton in the preliminary tests. Further prospecting in the neighbourhood led to the discovery of several other virgin reefs, and nine more blocks of claims were pegged.

Rhodesia's Mineral Resources.—It has been suggested to the Government of Southern Rhodesia that it should form a central committee for the collection and tabulation of data relating to the mineral resources of the Colony in accordance with the agreement arrived at in 1930 at the Imperial Conference in London on the question of a review of the mineral resources of the Empire, and that it might be desirable to arrange for this central committee to represent both Northern and Southern Rhodesia, if this is feasible.

VANCOUVER

March 9.

Portland Canal.—Work on the Big Missouri property in the Portland Canal district has been suspended following the completion of the programme of diamond drilling by which Consolidated Mining and Smelting Co. of Canada, Ltd., has sought to outline the economic possibilities of the ore occurrence, which has been described as a mineralized enigma. Definite reports of the results of this work are not to hand, but the long continuance of the operations, and the extent of the work that has been carried out on the property has, from time to time, elicited appreciative comment upon the evident intention of the company to leave no stone unturned in its investigation. Consolidated Mining and Smelting Company acquired control of the property through a subsidiary organization entitled Buena Vista Mining Company, Ltd., and launched immediately upon the very thorough campaign of development that has now been suspended. The progress of this work has been watched with great interest in view of its importance to the district generally. Underground work includes over 2,200 ft. of cross-cutting, 3,600 ft. of driving, and many thousands of feet of diamond drilling; and in addition a concentrating plant was erected in 1930 with a capacity of 100 tons per day, in order to ascertain by careful run-of-mine sampling through the mill, whether the erratic distribution of values throughout the silicified porphyry zones, that was indicated by the diamond drilling, might be of commercial importance in relation to large-scale operations upon a low-grade ore-body.

Salmon River.—It is reported that a renewed attempt is to be made to develop ore on the Woodbine property in the Salmon River area. The history of this property has been the reverse of encouraging. It was brought to public notice about the year 1923 and was exploited later on the strength of the remarkable success attending the development of the Premier mine. At about this time reports were circulated of a rich ore-body having been developed, but subsequent careful sampling failed to show commercial values. The area is held to be one deserving of more prospecting work, especially in connexion with other mineralized zones along the strike of the Premier north-west zone. It is stated that a scheme of reconstruction is to be submitted to the shareholders of Woodbine Gold Mining Company, Ltd., under which further work is to be financed by Eastern interests.

Cariboo.—Placer mining operations on a large scale are foreshadowed by the acquisition by a Vancouver syndicate, headed by Brig.-Gen. J. Duff Stuart, of the properties in the heart of the Cariboo country, controlled hitherto by the John Hopp interests. All this ground lies in the Barkerville area and comprises the creeks and hydraulic claims from which the greater part of the production has been obtained in the more recent history of the Cariboo, including Lowhee creek, Stout's gulch, Mosquito creek, Forest Rose, Burns creek, and the famous Cameron claim that was being worked in 1863. The properties were amalgamated by John Hopp, formerly American manager for the English company that commenced hydraulicking operations in the field in 1907, and have been under the control of American capital since that time. The area is officially credited with a production of about $20,000,000·00, but it is generally recognized that in the earlier years a considerable recovery was not recorded. It is estimated that there are extensive areas of virgin ground where pay gravel may be expected at greater depth than has yet been worked. It is understood that active operations are to be commenced as soon as weather conditions permit and high hopes are entertained for an important increase in the production of placer gold from the Cariboo.

Omineca District.—Another placer mining area that is likely to come into prominence during the ensuing season is the Manson creek section in the Omineca district. Placer occurrences in this area are distinctly localized and are found, according to the Government engineer, in a strip of country about 55 miles in length and 15 miles in width extending in an east-west direction immediately south of the Omineca River from Boulder Creek on the east to Quartz Creek on the west. Coarse gold is found along the channels of Germansen and Manson Rivers and tributary creeks and nuggets up to 2·5 oz. in weight occur on bedrock in sections of old channels that are being worked. Consolidated Mining and Smelting Company has been testing by drill in one particular area, where several such sections occur along the banks of Slate Creek, and Germansen Placers, Ltd., has made extensive preparations for the hydraulic working of benches and old channels in the Germansen river valley. The origin of this gold is thought to be quite local.

Phillips Arm.—At a meeting of Morton Woolsey Consolidated Mines, held in Vancouver recently, a balance-sheet was presented in which current assets of $26,789, plus the ownership of the old Doratha Morton mine were offset against a total liability of $59,183. The Doratha Morton adjoining the Alexandria gold-quartz property on Phillips

Arm was acquired from the Yorkshire Trust Company. It came into prominence in 1898, when it was reported that a quartz ledge 100 ft. wide included a width of 25 ft., carrying average values in gold of about $10 per ton and the property was in fact credited with a production of about $100,000 that was recovered by cyaniding operations. Later investigations, however, proved that the claims of the management at that time were unduly optimistic and it would appear that values were confined to certain lenses of quartz in a wide silicified shear in the granitic country rock. Subsequent attempts to re-open the mine, after the original work was suspended and the treatment plant destroyed, have not been successful hitherto. The Morton Woolsey mine, in the Fort Steele district, adjoins the Snowflake, where the occurrence of stannite in a shoot of high-grade silver-lead ore gave rise to hopes in certain quarters of a commercial supply of tin a few years ago.

Bridge River.—In the Bridge River area the Lorne mill is now in operation and it is expected that the present capacity of 75 tons a day will be increased shortly to 100 tons. The estimated ore reserves at this mine are valued at around $300,000 and are confined mainly to one shoot on the King vein, where an amount of about 21,000 tons of ore of an average grade of $13 per ton has been blocked out. The monthly output for January from the Pioneer mine, valued at $54,000, showed a decrease due to power shortage, resulting from a break in the dam on the south fork of Bridge River, which put the hydro-electric plant out of commission, and operations had to be carried on with water power from Cadwallader Creek, as was being done previous to the hydro-electric installation. The company has declared a regular dividend payable April 1. Gold bullion is being shipped to Ottawa, where it is paid for in the equivalent of United States currency. The new three-compartment shaft, from which all future development will be carried out, is now down to a depth of over 300 ft. below the ninth level and it is reported that in this work some new veins were encountered carrying good values. Construction work on the new mill is progressing satisfactorily.

Wallace Mountain.—Announcement has been made of the payment of a dividend of 3 cents per share to shareholders in the syndicate owning the Highland Lass mine at Beaverdell. This property is controlled by the same interests that in 1930 acquired the famous Bell mine adjoining it, and the two properties are being operated under the same management. The mining of this exceptionally high-grade silver-lead ore which, owing to the complicated faulting systems, presents unusual problems in the case of all the mines of this camp, is especially difficult on the Highland Lass property, where the mineralized shear-zones in the rocks of the Wallace formation are found to feather out in an altered contact area. In spite of these handicaps, and of the low market price of the metal, three carloads of ore having a high silver content have been shipped since the commencement of the year, and the dividend now declared represents a return of about 24% on the purchase price of the property.

Reno Gold Mines.—During the past month the mill of the Reno gold mine at Salmo was totally destroyed by fire, representing a loss valued at $95,000 covered by insurance. Plans were under discussion for increasing the capacity of this treatment plant, by additional equipment, in view of the extremely satisfactory development of the mine and, although production will be halted temporarily, it is probable that the present disaster will not be without its compensations. The value of the production for the month of January was $27,300.

Cedar Creek.—An option has been acquired by Mr. Rice, vice-president of the United States Smelting and Refining Company, on the Cedar Creek placer property, which was purchased in 1930 by B. Boe from the Cedar Creek Mining Company. The origin of the gold occurrence on this property has been the subject of much discussion in the past, the bench on which the pay-streak is found being at a considerable elevation above the present drainage of the area. The gold is quite coarse generally, and in places it appears as though the pay gravel was rolled up in boulder clay, suggesting ice action upon a pre-glacial deposit. The pay streak follows, as pointed out by the Government engineer, a remarkably straight course, although bonanza values are not persistent. It is believed that this rich deposit was laid down originally by a stream of low gradient. The property has been tested recently by drilling and it is stated that the present purchase is the outcome of the results obtained.

TORONTO

March 18.

Porcupine.—The production of bullion by the mines of the Porcupine area during February was valued at $1,676,673, from the treatment of 258,797 tons of ore, as compared with $1,571,971 for January, when 274,095 tons were milled. The mill of the Hollinger Consolidated is handling about 5,000 tons of ore per day and active development is steadily increasing the ore reserves. An extensive programme of deeper mining is being carried out, the objective being 7,000 ft. or more. The inside winze from the 2,700-ft. level is being put down to the 6,000-ft. horizon, the present depth being over 4,000 ft. from the surface. On the completion of the winze both the central and main shafts will be put down in stages to the objective, 6,000 ft. The company is changing its system of stoping from the old "shrinkage," to "cut and fill," to avoid dilution. Ore conditions at depth on the Schumacher section are proving up well and some very high-grade ore patches have been opened up. The Dome Mines is milling about 1,500 tons of ore per day, its output in February being valued at $319,057, as compared with $319,736 in January and $291,841 in December. The recovery has been improved by recent changes at the mill. The company is stated to have opened an ore shoot on the 1,500-ft. level for a length of 600 ft. and a width of 35 ft., carrying high-grade ore. Ore is being taken out at a rate sufficient for mill requirements. Operations at the McIntyre-Porcupine have been curtailed by the burning out of the generator at No. 11 shaft. All mine development has been suspended until the damage has been repaired and hoisting through this shaft can be resumed. Vipond is making good progress with its big underground campaign and is pushing the drive into the old Porcupine Crown property. An ore zone has been encountered the extent and value of which have not yet been determined. The March will extend the scope of its operations, the old Ankerite mine, which is controlled by the March, having been dewatered and a cross-cut driven from the March to connect with the workings on the 700-ft. level of the Ankerite. The old mill of the Ankerite is being renovated and together with the March mill will be operated under the programme of development. At the Hayden a mill of 50 tons capacity is under construction and production is expected to commence early in April. At the annual meeting of the Coniaurum it was stated that although underground development had been attended with encouraging results and the mine had been paying its way there was not sufficient cash on hand to enable the continuance of a big deep development programme.

Kirkland Lake.—During February the mines of this camp yielded $1,817,887 in bullion from the treatment of 141,026 tons of ore, as compared with $1,991,993 the previous month from 148,793 tons of ore. The mill of the Lake Shore is treating between 2,200 and 2,400 tons of ore a day, with mill heads at between $16 and $17 per ton. Oil flotation is being installed in the main mill and it is understood that this system will considerably reduce the loss in tailings. The new tailing plant will be under the joint ownership of Lake Shore and Wright-Hargreaves. An outstanding feature of development at the lower workings is the opening up at the 2,300-ft. level of a mineral zone averaging 40 ft. in width, with a length of about 800 ft., carrying average values of $30 in gold. At the Wright-Hargreaves the new hoist, in connexion with the large and modern crushing plant recently installed, will enable the mine to supply the increased tonnage required by any future mill extension. At the lower workings values are declared to be well above the mine average and a number of high-grade sections have been recently opened up. Production at the Teck-Hughes is being well maintained. The deep development campaign is being actively carried on and it is anticipated that by the end of the summer a depth of 4,500 ft. will have been reached. Some high-grade ore is being opened up on the lower levels. The Sylvanite has completed the sinking of its main shaft to a depth of 3,000 ft. and lateral work will shortly be commenced on the levels between 2,000 and 3,000 ft. with the expectation that the same good values will be obtained on this horizon as were found on the adjoining Wright-Hargreaves. At the Barry-Hollinger cross-cutting is under way at the 1,875-ft. level to intersect the Nos. 8 and 9 vein systems and, should the results be satisfactory, mill capacity will be increased to about 300 tons per day, and the winze at the 1,000-ft. level will be raised to the surface, giving the mine two outlets. Moffatt-Hall is pushing work on the new 550-ft. level and has cross-cut the mineral zone. The ore appears to be of a good grade, running about the same value as on the upper levels.

Sudbury.—The annual report of the International Nickel Company for 1931 shows a net profit of $5,094,497 as compared with $11,770,060 in 1930. Sales of nickel in all forms, including nickel alloys, amounted to 55,739,047 lb., compared with 75,284,352 lb. the previous year. Copper sales decreased from 109,743,747 lb. to 96,919,677 lb. The company has put into operation the new Orford separation plant recently completed in conjunction with the new copper-nickel smelter at Copper Cliff, increasing the working force by about 200 men. This process was used at the refinery at Port Colborne, whence it was transferred to Copper Cliff on completion of the smelter and refinery there. The plant consists of cupolas and converters for the smelting of the nickel-copper matte, which is the product of the big smelter. Fumes from the new process will be dissipated through a 350-ft. stack on the cupola building. The Falconbridge Nickel Mines, Ltd., report a deficit of $252,642 for the year 1931, as compared with a deficit of $263,173 for 1930. Sales of nickel during the year amounted to 3,205,235 lb. or 52·6% of the year's total output of 5,306,222 lb. Stocks of nickel at the end of the year totalled 2,888,466 lb. and forward sales made for delivery in 1932 exceed this tonnage. During the year the smelter handled 109,520 tons of ore, and produced 4,363·2 short tons of matte, from which were recovered 2,569·4 tons of nickel and 1,033·5 tons of copper. The Treadwell Yukon will remove its mill from the Ellington property, work on which has been indefinitely abandoned, to its holding in the Pascalis district of north-western Quebec, where it will be operated as a test mill.

Rouyn.—The annual report of Noranda Mines for 1931 showed a total revenue from metal production of $10,506,233, as compared with $11,967,472 in 1930. Miscellaneous income amounted to $237,630, making a gross revenue of $10,743,863, against $12,418,736. Operating costs were $6,281,306, and after all deductions there remained a net profit of $2,374,041, compared with $3,842,115 in 1930. During the year the mill treated 765,544 tons of ore, concentrate, siliceous fluxing ore, and slag and produced 63,257,274 lb. of copper bullion. There were also produced 253,363 oz. of gold as against 117,393 oz. the previous year, and 558,801 oz. of silver, compared with 691,920 oz. in 1930. Ore reserves above the 1,975-ft. level are estimated at 10,960,000 tons, compared with 8,175,000 on December 31, 1930.

PERSONAL

ARTHUR R. ANDREW has been appointed professor of mining at the University of Otago, in succession to James Park.

JAMES P. BEST is returning from Nigeria.

J. COGGIN BROWN is returning from Burma.

E. W. BYRDE is returning to Nigeria.

CHARLES CAMSELL has been elected president of the Engineering Institute of Canada for the ensuing year.

STANLEY W. CARPENTER has left for Nigeria.

H. O. CRIGHTON has left for West Africa.

RICHARD DAVEY is home from Russia.

M. W. L. DEMPSTER is returning from the Gold Coast.

W. A. EDWARDS is returning from Chile in May.

ROWLAND C. FEILDING has returned from Canada and left for Central Europe.

AUBREY E. HORN is returning from Nigeria.

P. MERCER HUME is home from the Gold Coast.

J. JEFFREY is home from Spain.

V. F. STANLEY LOW is home from Panama.

J. R. MILLER is returning to Malaya.

HUMPHREY M. MORGANS is home from India.

ARTHUR E. PAGE is returning to Trinidad.

R. E. PALMER is leaving shortly for South America.

J. SCOTT PARK is returning from Nigeria.

THOMAS PRYOR is home from India.

REGINALD S. H. RICHARDS is returning from Portugal.

W. J. SHEPHARD has returned from West Africa.

FRANK N. SPETTIGUE is home from Spain.

H. LIVINGSTONE SULMAN is to be entertained at a dinner on the 20th inst., as an appreciation of his professional work in connexion with the flotation process.

S. L. TERRELL is returning to Uganda.

D. A. THOMPSON is home from the Gold Coast.

VERNON TURNER has returned from Uganda.

RUSSELL B. WOAKES is returning from India.

DUDLEY JOHN INSKIP, whose death is reported on March 28, whilst on his way home from the Channel Islands, was aged 54. He entered into partnership with J. A. Bevan in 1910, which was dissolved in 1929 owing to the latter's health. During part of this time he was manager of Mawchi Mines. He also reported on asbestos properties in Southern Rhodesia and the Transvaal and was for a time acting as Inspector of Mines to the Rhodesian Government.

TRADE PARAGRAPHS

Hadfields, Ltd., of East Hecla and Hecla Works, Sheffield, publish a leaflet describing their three-stage coal breakers, which are machines of the toothed roll type. The same leaflet also gives brief particulars of single, double, and four roll coal breakers.

Petters, Ltd., of Westland Works, Yeovil, have published a little booklet in which the case for the two-cycle engine versus the four-cycle is put. They are themselves one of the few manufacturers of two-stroke engines, including slow and high speed Diesel, in this country.

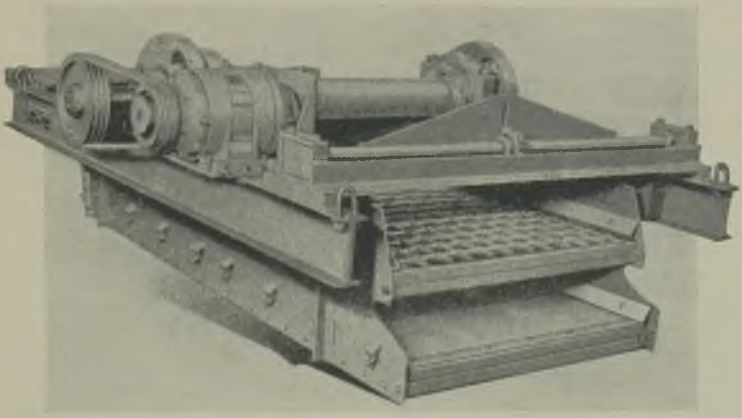
Ransomes and Rapier, Ltd., of Waterside Works, Ipswich, recently published a new catalogue describing their type 480 2-2¾ cu. yd. excavators, which are available as shovel, dragline, grab, crane, or pile driver for steam or electric drive. Details are also available of a new range of machines to which consideration will be given in these columns in a future issue.

Stein and Atkinson, Ltd., of 47, Victoria Street, London, S.W. 1, in the February issue of their publication *Modern Industrial Furnaces* deal entirely with a description of the Stein suspended furnace roof which it is stated is being generally adopted both in boilers and metallurgical furnace practice for uniform heat distribution, fuel economy, and reduced upkeep cost.

Carl Zeiss (London), Ltd., of Mortimer House, 37–41, Mortimer Street, London, W. 1, issue an attractive booklet covering some 25 pages describing their surveying instruments, which contains some notable new matter such as a simple level, a compass attachment for a level plane table, a simple telescopic Alidade, and three special types of tacheometer.

The Bureau of Information on Nickel of the Mond Nickel Co., Ltd., announce that their address is now Thames House, Millbank, London, S.W. 1. They also issue a further booklet in their series. This is devoted to heat-resisting alloys of nickel-chromium and nickel-chromium-iron and a further bulletin relating on this occasion to American and Continental practice in nickel deposition based on a paper read by one of the technical staff before a learned society.

Mining and Industrial Equipment, Ltd., of 11, Southampton Row, London, W.C. 1, report having received the following orders:—For England: One 4 ft. by 5 ft. one-surface Hum-mer electric screen for foodstuff, two 3 ft. by 5 ft. one-surface, type 31, Hum-mer electric screens for fireclay, one No. 0000 Raymond pulverizer for soap powder, and one 50 sq. ft. Rovac filter for caustic lime sludge. For the Dominions: One 4 ft. by 5 ft. one-surface, type 39, Hum-mer electric screen for coke.



EDGAR ALLEN–ALLIS-CHALMERS VIBRATING SCREEN.

Bruce Peebles and Co., Ltd., of Edinburgh, publish a booklet describing their synchronous induction motors. This is illustrated with examples of interest to mining men since they show the application to the driving of tube-mills, hammer-type rock breakers, and centrifugal pumps. The latter, installed in a fiery coal mine, is a 120 b.h.p., 3-phase, 50 cycle, 440 volts, 428 r.p.m. open type motor.

J. Rolland and Co., of Abbey House, 2 Victoria Street, London, S.W. 1, the representatives of **Fried. Krupp Grusonwerk, A.G.,** of Magdeburg Germany, send us a booklet covering some 80 pages and fully illustrated which gives detailed information with regard to Krupp wet cylinder mills. These include ball, pebble, and rod mills of both drum and tube types. Details are given of the various component parts including liners and grinding bodies.

Dings Magnetic Separator Co., of Milwaukee, Wis., U.S.A., have developed a new magnetic friction type clutch having contact faces on both sides of a spring disc which are "squeezed" between the magnet and armature elements when the coil is energized. In theory the effective transmission of this clutch is double that of a single friction contact face but in practice it has been proved to be approximately 75% more effective with the same magnet strength.

Edgar Allen and Co., Ltd., of Imperial Steel Works, Sheffield, publish a catalogue describing in full detail the Edgar Allen–Allis-Chalmers centrifugal vibrating screens. They are made in single, double, or treble decks, and one of the double deck type is shown in the accompanying illustration. This is also shown with the texrope drive guard removed. The vibrating mechanism consists of a heavy steel shaft carried on two over-size high-grade roller bearings mounted on the supporting frame in self-aligning dust-proof housings. This shaft carries on each side, just within the supporting frame, two heavy balance wheels, which are protected by steel housings. Between the balance wheels the shaft is turned eccentric for a short distance for the vibrating screen body bearings, which are of a special roller type carried in self-aligning dust-proof houses. The vibrating motion is positive and is equal over the entire screen surface. The screen is driven by a totally enclosed fan-cooled motor, the texrope drive shown in the illustration affording the transmission. The screen may be suspended from overhead supports by cables and springs or spring mounted. Screens and frames may be easily and quickly replaced and are both interchangeable and reversible. In the *Edgar Allen News* for March there is an article on primary rock crushers, which deals principally with the McCully gyratory crusher and also a description of a 12-ton ladle casting recently produced for the handling of copper matte in one of the Northern Rhodesian smelters.

Curchin and Watson, of Bevis Marks House, Bevis Marks, London, E.C. 3, who are now the London representatives of **Werf Conrad N.V.,** of Haarlem, Holland, have issued two publications giving information about Conrad DM and DMM rock drilling machines and Conrad DD 1 and DD 2 cable tool truck drillers. The former are light and easily transportable machines specially designed for underground drilling and prospecting work in mountainous or remote regions. They are core drills built on most modern lines including all-enclosed construction and the use of ball bearings and forged-steel heat-treated and ground gearings. The DD 1 and DD 2 fulfil a demand for a mobile and rapid drilling plant which can be operated by one man and are ideal for mineral prospecting, estimation of dredging ground, or blasting operations.

VICKERS PROJECTION MICROSCOPE

Cooke, Troughton, and Simms, Ltd., of 15-17, Broadway, London, S.W. 1, have taken over the manufacturing and selling rights of the Vickers works projection microscope, of which **Wild-Barfield Electric Furnaces, Ltd.,** have been appointed distributors. This valuable aid in the micro examination both of opaque and transparent substances is a most robust instrument and will carry specimens up to 50 lb. in weight. It contains all the usual microscope features and in addition, mounted as part of the instrument, is a camera for photographing the specimens. It is suitable for magnifications of from 3 to 5,000 diameters and is mounted on a large cabinet which contains all the essential accessories, thus the instrument is an entirely complete unit. The general arrangement is shown in the accompanying cross-section, Fig. 1, and the following is a brief description:—The instrument consists of a heavy cast iron block M through which passes vertically a large diameter hole, bored to take a heavy tube T. The upper end of the tube is fitted internally with an adaptor for the objective and externally is threaded to engage with a large diameter nut N. The under surface of the nut N rests upon the flat top of the block M, thereby supporting the tube T with its objective. Fine focussing is enabled by the partial rotation of N. Magnetic centring mounts are supplied which can be fitted to ordinary objectives of any make. The stage S is mounted upon a heavy cast iron stage support SS which latter engages with the microscope block M by means of sliding faces, its elevation being controlled by rack and pinion movement. C is a clamping spring and locking screw. The microscope is mounted upon a heavy cast iron camera case immediately above an adaptor which serves to carry a sliding microscope tube with projection eyepiece. The projected image of the object cast down by the inverted microscope is reflected by a rustless steel mirror to a projection screen PS mounted at a convenient angle for inspection, the camera length being adjustable by rotating the handle EH, which controls the elevation of the mirror. A removable hood H arranged above the projection screen excludes light during inspection or focussing. This hood may be swung out of position and the sliding visual tube V which carries a mirror and eyepiece is introduced into the optical axis of the microscope. Fig. 2 represents a front elevation of the microscope and shows clearly the illuminating arrangements. A bracket, with optical bench OB, is mounted at the right-hand side of the camera case. It carries a clockwork-driven arc lamp and also a pointolite lamp, either of which can be changed over instantly, according to requirements. The lamp condenser, with iris diaphragm, water trough, and colour screens, is also carried on this optical bench. A hole passing horizontally right through the body block M serves to house, on the right, a tube D, which carries a small iris diaphragm and field lens, and on the left, a sliding tube L, which is fitted with a vertical illuminator and centring screen. This system is, of course, for vertical illumination of opaque objects. The entire illuminating unit on optical bench OB can be elevated by means of a rack and pinion motion OH, to suit any type of illumination that may be required. On the right-hand side of the camera and projection screen PS is a comparison chamber and screen CS. This chamber is illuminated, and is used for viewing photomicro transparencies or autochrome transparencies of standard materials comparatively with the projected image of the object under inspection. The rotation of control handle CH enables the intensity of illumination or the transparency to be adjusted until it balances that of the projected image on the screen PS. By this means, it is possible to inspect test specimens of any class very rapidly, with great accuracy, and without the formality of taking too many

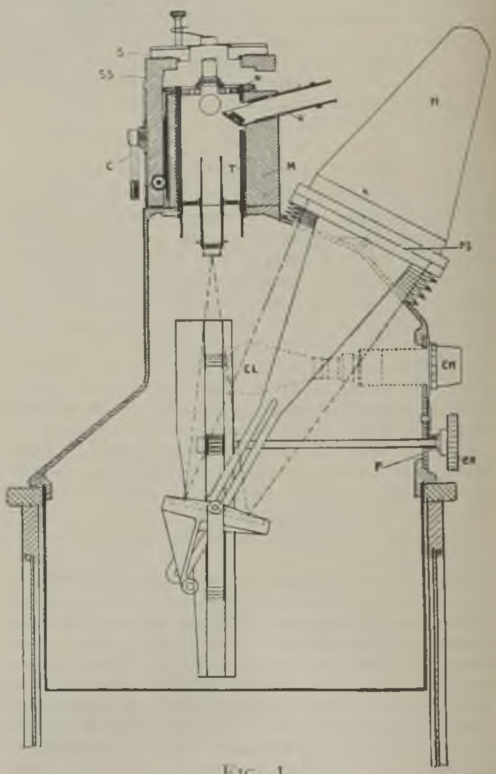


Fig. 1.

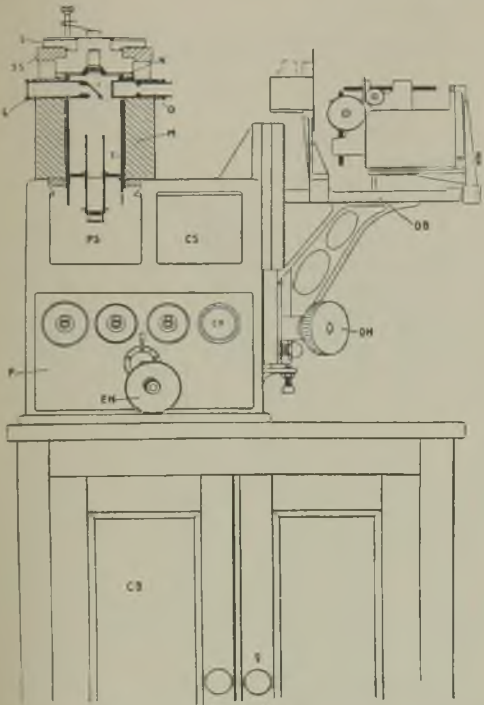


FIG. 2.

photographs. The control handle CH is also fitted with a graduated scale, which serves to indicate the exposure necessary when a photomicrograph is required. When the instrument is to be used with transmitted light, a mirror at 45° and stage condenser are attached above the object stage.

METAL MARKETS

COPPER.—March was a bad month for prices on the London Metal Exchange. Standard copper prices lost some ground, partly on account of the firmer sterling exchange, but partly also because of the continued poorness of demand. Quotations for electrolytic in America were erratic, but the cheaper sellers were eliminated during March and at the close Copper Exporters Inc. were quoting 6½ cents c.i.f. Europe for both general and custom sales. Producers have definitely decided to cut output to 20% of capacity and are reckoning that this will permit stocks to be reduced.

Average price of Standard Cash Copper: March, 1932, £33 1s. 9d.; February, 1932, £36 19s. 8d.; March, 1931, £44 17s. 2d.; February, 1931, £45 8s. 3d.

TIN.—Tin values sustained a very heavy loss last month, the decline being at first due to the rise in the sterling exchange, but it was greatly intensified by panicky stop-loss orders issued by stale "bulls." The statistical position underwent no appreciable change during March. Demand, on the whole, remained dull but stocks in the United States are believed to have been reduced. The producers associated in the output-curtailment scheme have been discussing a further "cut" of 8,420 tons (or one month's production) and it is believed this will be instituted soon.

Average price of Standard Cash Tin: March, 1932, £129 18s. 2d.; February, 1932, £139 4s. 7d.; March, 1931, £121 18s. 4d.; February, 1931, £118.

LEAD.—Prices fell severely during March, the absence of large-scale consuming interest and the firmness of sterling proving fatal to the maintenance of values, whilst sentiment was further weakened by a decline in the American quotation from 3·25 cents to 3 cents per lb. There is an impression in the market that both lead and spelter may eventually be transferred from the British tariff schedule to the free list.

Average mean price of soft foreign lead: March, 1932, £12 9s. 9d.; February, 1932, £14 11s. 3d.; March, 1931, £13 4s. 9d.; February, 1931, £13 9s. 11d.

SPELTER.—Despite evidence that the stocks held by the International Zinc Cartel are shrinking, sentiment has not been particularly strong and prices have given way in London, helped by easier advices at times from America and by the advance in sterling. The gold values of both spelter and lead are now at extraordinarily low levels. The suggestion is being mooted on the Continent that a zinc Customs *bloc* should be formed there as a reply to the British tariff. Germany, owing to trade friction, has locked out Canadian spelter by means of a prohibitive tariff.

Average mean price of spelter: March, 1932, £12 16s. 4d.; February, 1932, £14 1s. 7d.; March, 1931, £12 8s. 7d.; February, 1931, £12 9s. 11d.

IRON AND STEEL.—Sentiment on the British pig-iron market remained fairly cheerful during March, but business on the whole was quiet, despite the virtual exclusion of Continental pig-iron. Indian competition on the Scottish market, however, remains serious. Cleveland prices are steady, No. 3 foundry G.m.b. remaining at 58s. 6d. As regards British finished iron and steel, the close of March saw a slight improvement, but the position of the mills as a whole leaves much to be desired. It would not be surprising if one of the first decisions of the Tariff Advisory Committee was to increase the present import duty of 10% on foreign steel. The Continental steel market has continued to weaken and the extraordinarily cheap prices of foreign semis has created some interest amongst British consumers.

IRON ORE.—The iron ore position can only be described as serious. On the Continent ironmasters are overstocked with ore and have huge quantities due to them on contract for which they have no room and cannot pay. In this country a few odd cargoes change hands on the basis of about 16s. per ton c.i.f. for best Bilbao rubio.

ANTIMONY.—At the close of March, English regulus was quoted at £40 to £42 10s. per ton. Foreign regulus was in but scant demand; Chinese metal for forward shipment was, however, offered at £22 5s. c.i.f., whilst spot was nominally quoted at about £27 15s. ex-warehouse.

ARSENIC.—The market is not very active and prices are quite nominal. Cornish white is very scarce, whilst foreign material is uncertain, owing to exchange fluctuations, and quotations are made only against definite enquiries.

BISMUTH.—With sterling firmer the official price has been reduced to 4s. 6d. per lb for 5 cwt. lots and over, demand being quietly steady.

CADMIUM.—There is not a great deal moving, and prices are rather easier at about 2s. 2d., to 2s. 2½d. per lb.

LONDON DAILY METAL PRICES.

Copper, Tin, Zinc, and Lead per Long Ton; Silver per Standard Ounce; Gold per Fine Ounce.

	COPPER.				TIN.		ZINC (Spelter).	LEAD.		SILVER.		GOLD.
	Standard.		Electrolytic.	Best Selected.				Soft Foreign.	English.	Cash.	Forward.	
	Cash.	3 Months.			Cash.	3 Months.						
Mar.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	d.	d.	s. d.
11	32 18 9	33 3 9	36 10 0	35 10 0	130 15 0	132 7 6	12 13 9	12 10 0	14 10 0	18 1/16	18¼	113 8
14	33 13 9	33 16 3	36 17 6	—	129 16 3	131 8 9	12 13 9	12 12 6	14 10 0	18 7/16	18 9/16	114 0
15	33 6 10½	33 6 3	37 0 0	35 5 0	128 2 6	129 17 6	12 10 0	12 6 3	14 5 0	18¼	18⅜	114 0
16	33 8 9	33 6 3	37 0 0	—	129 16 3	131 8 9	12 3 9	12 3 9	14 5 0	18⅛	18¼	114 0
17	32 18 9	32 18 9	37 0 0	—	128 11 3	130 3 9	12 11 3	12 10 0	14 10 0	18	18⅛	114 5
18	33 13 9	33 13 9	37 0 0	36 10 0	130 5 0	132 0 0	12 18 9	12 10 0	14 10 0	18 3/16	18 3/16	114 4
21	32 14 4½	32 15 7½	36 17 6	—	127 8 9	129 1 3	12 12 6	12 2 6	14 5 0	17 13/16	17⅞	112 10
22	32 16 10½	32 19 4½	36 15 0	36 0 0	127 17 6	129 11 3	12 8 9	12 0 0	14 0 0	17¾	17 13/16	113 1
23	33 1 10½	33 4 4½	36 15 0	—	128 12 6	130 6 3	12 8 9	12 3 9	14 5 0	18 1/16	18 3/16	113 2
24	32 15 7½	32 18 1½	37 5 0	36 0 0	126 10 0	128 3 9	12 5 0	11 17 6	14 0 0	17 15/16	17 15/16	112 2
29	31 18 1½	32 3 9	35 15 0	34 10 0	118 3 9	119 11 3	11 7 6	11 11 3	13 10 0	17 11/16	17 11/16	108 11
30	31 13 9	31 15 7½	36 0 0	—	120 12 6	122 2 6	11 15 0	11 15 0	13 10 0	17⅞	17 15/16	110 5
31	30 18 1½	31 1 3	35 0 0	—	114 2 6	115 17 6	11 5 0	11 2 6	13 0 0	17⅝	17 11/16	109 1
Apr.												
1	29 16 3	30 1 3	34 0 0	32 15 0	106 15 0	108 7 6	10 15 0	9 17 6	12 0 0	17 7/16	17½	108 4
4	30 8 1½	30 11 10½	34 0 0	—	111 3 9	113 2 6	11 2 6	11 2 6	13 5 0	17⅝	17⅜	109 11
5	30 10 7½	30 9 1½	34 0 0	33 0 0	109 1 3	111 2 6	10 17 6	11 1 3	13 5 0	17¼	17 5/16	109 5
6	30 3 9	30 1 3	34 10 0	—	108 11 3	110 13 9	10 11 3	10 16 3	13 5 0	17	17 1/16	109 8
7	29 10 7½	29 10 7½	34 5 0	—	107 0 0	109 10 0	10 11 3	10 17 6	13 10 0	16 13/16	16⅞	109 0
8	29 5 0	29 8 9	34 5 0	32 10 0	105 3 9	107 13 9	10 16 3	10 18 9	13 10 0	16 13/16	16⅞	109 8
11	29 9 4½	29 14 4½	34 5 0	—	104 8 9	106 13 9	10 17 6	11 0 0	13 0 0	16 15/16	17	109 4

Cobalt.—The price of this metal is rather uncertain owing to the fluctuations in exchange rates, but the official quotation is 9s. per lb.

Cobalt Oxides.—Only limited quantities are changing hands, prices being about 5s. per lb. for black and 5s. 9d. for grey.

Chromium.—Metal is still 3s. per lb., with a moderate demand from the plating industry.

Tantalum.—Demand is slow and prices are quotably unchanged at £25 to £30 per lb.

Platinum.—Prices are still being adjusted to the dollar quotation and with the exchange moving so quickly alterations are made almost daily. Business is hampered and few sales have been effected. Refined metal at present is about £9 16s. to £10 1s. per oz.

Palladium.—An easier tone has been seen following the strength of sterling, about £4 15s. to £5 per oz. being the current quotation.

Iridium.—Prices can only be considered nominal in the region of £17 to £19 per oz. for sponge and powder.

Osmium.—About £16 to £17 per oz. represents the present value, demand being slow.

Tellurium.—Quotations are quite nominal on the basis of about 10s. per lb. (gold).

Selenium.—A quiet business continues in evidence at about 7s. 8d. to 7s. 9d. per lb. (gold.)

Manganese Ore.—The feature of the past month has been the conclusion of an arrangement between the Soviet Government and Belgian steel works, whereby the Soviet will place in Belgium a stock of fully 100,000 tons of ore, to be drawn upon by the Belgian steel works. Very low prices are mentioned in connexion with the deal, but definite information is lacking. Otherwise business is very slow. Best Indian ore stands at about 9¼d. to 9½d. per unit c.i.f. and good 48% Indian at 8½d. to 9d.

Aluminium.—Fears were entertained by the consuming industry during March that the home trade price would be advanced owing to the tariff affecting certain raw materials used in the reduction of aluminium and some covering purchases were made. So far, however, quotations remain unaltered at £95, less 2%, delivered, for ingots and bars.

Sulphate of Copper.—A rather easier tone has prevailed here, prices being about £18 10s. to £19, less 5%, for British material.

Nickel.—Owing to the firmness in sterling, prices have been reduced to £220 to £225 per ton, according to quantity. Demand, however, remains rather slow.

Chrome Ore.—The falling away in the Rhodesian output this year is evidence of the quietness of demand, but prices are upheld at about 80s. to 85s. per ton c.i.f. for good 48% Rhodesian ore and 100s. to 110s. for 55 to 57% New Caledonian.

Quicksilver.—Prices were advanced following the imposition of a duty, but the undertone of the market is none too strong, and spot material is obtainable at about £18 10s. to £18 12s. 6d. per bottle net.

Tungsten Ore.—The market has been stagnant and forward shipment from China is now offering at around 13s. per unit c.i.f.

Molybdenum Ore.—A quiet demand continues in evidence at around 37s. 6d. to 39s. per unit c.i.f. for 80 to 85% concentrates.

Graphite.—There is nothing much moving and prices are rather nominal at about £16 to £18 c.i.f. for 85 to 90% raw Madagascar flake, and £17 to £19 c.i.f. for 90% Ceylon lumps.

Silver.—The main feature of the silver market during the past month has been, of course, the decline in prices here as the result of the improvement in the international value of sterling. Spot bars were 19⅝d. on March 1, falling to 18¼d. on March 15 and closing at 17⅝d. on March 31. Strong efforts are still being made in the United States to secure an international conference on silver, leading bankers and industrialists in a number of countries having been invited to submit their views. It still remains doubtful, however, whether any such conference will be convened, at any rate with official support.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
March, 1931	869,331	41,667	910,998
April	840,259	42,078	882,337
May	867,949	42,330	910,279
June	855,073	42,677	897,750
July	872,198	44,645	916,843
August	870,822	45,603	916,425
September	872,053	43,971	916,024
October	900,353	44,760	945,113
November	855,102	45,408	900,510
December	877,178	46,175	923,353
January, 1932	890,688	46,096	936,784
February	869,711	44,301	914,012
March	914,017	46,018	960,035

TRANSVAAL GOLD OUTPUTS.

	February.		March.	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.
Brakpan	96,500	£151,833	104,000	£160,922
City Deep	77,500	20,473	83,000	21,486
Cons. Main Reef	68,500	23,019	67,500	22,804
Crown Mines	260,000	80,100	275,000	85,031
Daggafontein	31,000	£40,673	36,000	£59,014
D'rb'n Roodepoort Deep	47,000	15,448	49,500	16,133
East Geduld	51,000	15,436	56,000	17,265
East Rand P.M.	152,000	40,325	158,000	41,854
Geduld	81,000	25,932	85,300	26,923
Geldenhuis Deep	71,000	17,002	75,000	17,481
Glynn's Lydenburg	6,100	2,345	6,600	2,572
Government G.M. Areas	200,000	£389,510	208,000	£406,678
Kleinfontein	49,000	9,666	50,200	10,060
Langlaagte Estate	77,000	£107,180	80,000	£112,415
Luipaard's Vlei	31,100	7,823	33,500	8,377
Meyer and Charlton	17,200	£16,622	18,200	£17,804
Modderfontein New	161,000	63,080	167,000	66,336
Modderfontein B	72,500	20,495	76,000	21,495
Modderfontein Deep	43,000	20,922	44,800	21,715
Modderfontein East	72,000	21,101	73,500	21,549
New State Areas	82,000	£172,064	87,000	£180,742
Nourse	68,000	20,209	70,000	21,014
Randfontein	232,000	£267,286	240,000	£283,485
Robinson Deep	92,800	27,062	95,500	28,169
Rose Deep	59,600	12,785	62,500	12,986
Simmer and Jack	78,500	21,348	78,900	21,826
Springs	67,500	£148,264	68,800	£160,554
Sub Nigel	35,000	30,698	37,000	31,867
Transvaal G.M. Estates	17,100	4,918	18,300	5,175
Van Ryn	45,500	£42,748	49,000	£43,163
Van Ryn Deep	66,000	£93,300	67,000	£92,421
West Rand Consolidated	89,000	£100,718	95,000	£107,723
West Springs	73,800	£75,570	77,000	£81,584
Witw'tersr'nd (Knights)	62,000	£51,478	66,000	£55,684
Witwatersrand Deep	42,200	12,947	42,200	14,417

Values in S.A. currency.

COST AND PROFIT ON THE RAND, Etc.

Compiled from official statistics published by the Transvaal Chamber of Mines.

	Tons milled.	Yield per ton.	Work'g cost per ton.	Work'g profit per ton.	Total working profit.
		s. d.	s. d.	s. d.	£
Dec., 1930	2,661,200	28 6	19 9	8 9	1,160,548
January, 1931	2,721,316	28 3	19 8	8 7	1,171,456
February	2,481,600	28 6	20 1	8 5	1,045,980
March	2,718,400	28 2	19 9	8 5	1,151,017
April	2,592,800	28 7	20 1	8 6	1,105,711
May	2,751,400	27 10	19 6	8 4	1,149,105
June	2,698,100	28 0	19 7	8 5	1,140,399
July	2,771,400	27 10	19 6	8 4	1,155.466
August	2,799,800	27 10	19 5	8 5	1,159,382
September	2,765,400	27 10	19 5	8 5	1,162,355
October	2,870,800	27 8	19 3	8 5	1,210,743
November	2,726,720	27 10	19 5	8 5	1,144,208
December	2,793,900	27 10	19 5	8 5	1,173,732
January, 1932	2,880,500	27 5	19 4	8 1	1,163,434
February	2,775,400	27 8	19 6	8 2	1,133,212

NATIVES EMPLOYED IN THE TRANSVAAL MINES

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
March 31, 1931	207,239	13,436	4,106	224,781
April 30	206,770	13,242	4,030	224,042
May 31	207,109	13,305	3,689	224,103
June 30	207,209	13,286	3,345	223,840
July 31	208,155	13,512	1,817	223,484
August 31	209,409	13,563	1,705	224,677
September 30	209,424	13,276	1,626	224,326
October 31	208,987	13,061	1,517	223,565
November 30	209,270	12,882	1,429	223,581
December 31	211,552	12,260	1,402	225,214
January 31, 1932	215,752	12,394	1,598	229,744
February 29	216,171	12,177	1,363	229,711
March 31	214,024	12,009	—	226,033

PRODUCTION OF GOLD IN RHODESIA.

	1929	1930	1931	1932
	oz.	oz.	oz.	oz.
January	46,231	46,121	45,677	42,706
February	44,551	43,385	42,818	45,032
March	47,388	45,511	42,278	—
April	48,210	45,806	43,776	—
May	48,189	47,645	43,731	—
June	48,406	45,208	44,118	—
July	46,369	45,810	44,765	—
August	46,473	46,152	43,292	—
September	45,025	46,151	42,846	—
October	46,923	45,006	44,260	—
November	46,219	44,351	44,516	—
December	46,829	46,485	50,034	—

RHODESIAN GOLD OUTPUTS.

	February.		March.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	23,400	9,437	24,800	9,955
Globe and Phœnix	6,094	6,286	6,152	6,538
Lonely Reef	7,500	2,435	8,000	2,346
Luiri Gold	1,255	1,041	—	—
Rezende	6,100	2,428	6,500	2,597
Sherwood Star	4,600	£8,705	4,800	£7,930
Wanderer Consolidated	14,300	3,519	15,500	3,587

WEST AFRICAN GOLD OUTPUTS.

	February.		March.	
	Tons.	Oz.	Tons.	Oz.
Ariston Gold Mines	5,437	£9,569	—	—
Ashanti Goldfields	12,918	14,262	13,300	14,610
Taquah and Abosso	9,640	£13,137	10,799	£14,674

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Western Australia.	Victoria.	Queensland.
	Oz.	Oz.	Oz.
March, 1931	34,946	4,482	898
April	38,891	3,250	732
May	38,255	4,196	784
June	47,507	3,194	893
July	38,785	3,641	1,220
August	52,501	3,020	610
September	38,173	—	638
October	52,741	7,838†	1,031
November	53,869	4,758	1,428
December	49,215	—	1,224
January, 1932	44,037	—	916
February	44,672	—	—
March	47,108	—	—

† Sept. and Oct.

AUSTRALASIAN GOLD OUTPUTS.

	February.		March.	
	Tons	Value £	Tons.	Value £
Associated G.M. (W.A.)	4,921	5,105	5,597	5,504
Blackwater (N.Z.)	3,001	7,821	3,573	8,352
Boulder Persev'ce (W.A.)	7,074	14,845	7,315	15,215
Grt. Boulder Pro. (W.A.)	9,337	23,722	10,026	25,721
Lake View & Star (W.A.)	18,851	27,026	—	—
Sons of Gwalia (W.A.)	13,242	15,637	13,476	14,775
South Kalgurli (W.A.)	8,898	15,238	9,339	15,996
Waihi (N.Z.)	19,218	{ 6,094* 51,941†	—	{ — —
Wiluna	26,233	33,635	27,010	36,118

* Oz. gold. † Oz. silver.

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	February.		March.	
	Tons Ore	Total Oz.	Tons Ore	Total Oz.
Balaghat	3,000	2,101	2,950	2,105
Champion Reef	8,680	5,227	9,340	5,414
Mysore	15,379	6,609	16,600	7,160
Nundydroog	12,060	7,104	12,521	7,309
Ooregum	11,175	4,364	11,160	4,370

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	February.		March.	
	Tons	Value £	Tons	Value £
Chosen Corp. (Korea)	9,230	15,920	10,070	20,346
Frontino Gold (C'lbia)	3,430	17,133	3,160	16,628
Fresnillo	80,065	11,327d†	—	—
New Goldfields of Venezuela	6,485	1,815*	7,765	2,304*
Oriental Cons. (Korea)	8.214	70,067d	—	—
Remance	—	—	—	—
St. John del Rey (Brazil)	—	35,200	—	37,300
Santa Gertrudis (Mexico)	25,683	34,192d	—	—
Viborita	—	696	—	600
West Mexican Mines	1,500	23,000d	—	—

d Dollars. * Oz. gold. † Loss. ‡ To Jan. 16

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

Estimated at 72% of Concentrate shipped to Smelters. Long Tons.

July, 1931	4,757	January, 1932	3,014
August	5,375	February	2,132
September	2,449	March	3,064
October	3,282	April	—
November	2,488	May	—
December	3,222	June	—

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	January.	February.	March.
Ayer Hitam	29¾	—	119
Batu Caves	—	—	25
Changkat	90	75	47
Gopeng	32	7	60
Hongkong Tin	48¾	—	78¾
Idris Hydraulic	6¾	—	29¾
Ipoh	36	24¾	32½
Kampar Malaya	—	—	—
Kampong Lanjut	50	35	8
Kamunting	70	96	120½
Kent (F.M.S.)	15	—	14½
Killinghall	—	—	23
Kinta	20	—	30
Kinta Kellas	26¾	—	21½
Kramat Tin	85	85	105
Kuala Kampar	40	38	32
Kundang	—	—	—
Labat	14½	7¾	9½
Lower Perak	85	—	—
Malaya Consolidated	—	—	—
Malayan Tin	89¼	90¼	107¼
Malim Nawar	25	21	28
Pahang	125	125	125
Penawat	—	—	—
Pengkalen	14	—	74½
Petaling	155	90	190
Rahman	40⅕	40⅕	40⅕
Rambutan	4½	—	16
Rantau	11¾	17½	48
Rawang	30	52	40
Rawang Concessions	37	35	40
Renong	22½	28	28½
Selayang	17⅓	—	16½
Southern Kampar	—	—	126
Southern Malayan	113	3¼	119
Southern Perak	53½	11¾	41¾
Southern Tronoh	24	16	27
Sungei Besi	33	33	33
Sungei Kinta	22¼	16	25
Sungei Way	68½	—	71½
Taiping	17	14	19
Tanjong	12	19	45
Tekka	27	—	36
Tekka Taiping	40½	2	45
Temoh	—	—	—
Tronoh	52	80	43
Ulu Klang	—	12¼	—

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	January.	February.	March.
Anglo-Nigerian	53¾	10½	48½
Associated Tin Mines	230	129	235
Baba River	4⅞	—	4½
Batura Monguna	1¼	—	3
Bisichi	37	27	38
Daffo	5	2¼	—
Ex-Lands	56	34	45
Filani	3	—	—
Jantar	10	18	13
Jos	11¾	11½	—
Juga Valley	5½	8¾	8
Kaduna Syndicate	25	—	—
Kaduna Prospectors	11	—	—
Kassa	15	—	11
London Tin	150	143	135
Lower Bisichi	4	4	—
Naraguta Extended	—	—	—
Nigerian Consolidated	12	12½	7
Offin River	3½	3	2⅜
Ribon Valley	12	4¾	17
Tin Fields	—	4½	—
United Tin Areas	22½	—	24
Yarde Kerri	—	—	—

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	January.	February.	March.
Anglo-Burma (Burma)	28	17¼	18¾
Aramayo Mines (Bolivia)	130	134	141
Bangrin (Siam)	—	—	38¼
Beralt	30*	30*	31*
Consolidated Tin Mines (Burma)	95	95	103
East Pool (Cornwall)	49	46¼	—
Fabulosa (Bolivia)	47†	39†	47†
Kagera (Uganda)	18	20	—
Kamra	—	63	—
Malaysiam Tin	8½	8¾	8¾
Mawchi	200*	217*	—
Patino	907	813	813
Pattani	—	30¾	—
San Finx (Spain)	20*	16¾*	—
Siamese Tin (Siam)	25¼	25¼	100
South Crofty	49	51¼	54
Tavoy Tin (Burma)	55	27	46
Tongkah Harbour (Siam)	40	40	54
Toyo (Japan)	60¾	62	77½
Zaaiplaats	—	—	—

* Tin and Wolfram. † Tons fine tin.

COPPER, LEAD, AND ZINC OUTPUTS.

		Feb.	March.
Britannia Lead	Tons refined lead	3,316	—
	Oz. refined silver	208,550	—
Broken Hill South	Tons lead conc.	4,839	4,332
	Tons zinc conc.	4,914	4,569
Burma Corporation	Tons refined lead	5,880	5,880
	Oz. refined silver	490,000	500,503
Electrolytic Zinc	Tons zinc	—	—
Indian Copper	Tons copper	350	350
Messina	Tons copper	744	845
Mount Isa	Tons lead bullion	3,458	—
Mount Lyell	Tons concentrates	3,487	3,754
North Broken Hill	Tons lead conc.	—	5,510
	Tons zinc conc.	—	5,040
Rhodesia Broken Hill	Tons V_2O_5	35	40
	Tons V_2O_5 conc.	100	102
Roan Antelope	Tons concentrates	—	—
	Tons blister copper	3,082	2,054
San Francisco Mexico	Tons lead conc.	—	—
	Tons zinc conc.	—	—
Trepca	Tons lead conc.	3,191	3,739
	Tons zinc conc.	3,814	4,135
Villemagne	Tons lead conc.	352	—
	Tons zinc conc.	301	—
Zinc Corporation	Tons lead conc.	5,626	—
	Tons zinc conc.	4,267	—

IMPORTS OF ORES, METALS, ETC., INTO UNITED KINGDOM.

		January.	February.
Iron Ore	Tons	156,461	146,329
Manganese Ore	Tons	7,722	6,219
Iron and Steel	Tons	170,435	252,257
Copper and Iron Pyrites	Tons	20,606	34,029
Copper Ore, Matte, and Prec.	Tons	6,105	3,624
Copper Metal	Tons	8,499	16,878
Tin Concentrate	Tons	5,241	3,709
Tin Metal	Tons	900	979
Lead Pig and Sheet	Tons	21,363	31,737
Zinc (Spelter)	Tons	10,025	17,103
Zinc Sheets, etc.	Tons	800	3,010
Aluminium	Tons	643	2,355
Mercury	Lb.	119,173	158,018
Zinc Oxide	Tons	136	389
Zinc Ore	Tons	—	2,580
White Lead	Cwt.	9,430	19,899
Barytes, ground	Cwt.	23,842	63,179
Asbestos	Tons	532	2,163
Boron Minerals	Tons	1,362	745
Borax	Cwt.	20,731	33,190
Basic Slag	Tons	2,700	510
Superphosphates	Tons	5,145	20,302
Phosphate of Lime	Tons	37,255	33,692
Mica	Tons	149	104
Tungsten Ores	Tons	—	252
Sulphur	Tons	8,284	15,231
Nitrate of Soda	Cwt.	62,600	44,180
Potash Salts	Cwt.	97,723	297,097
Petroleum: Crude	Gallons	30,835,128	35,093,961
Lamp Oil	Gallons	26,215,960	20,818,181
Motor Spirit	Gallons	68,270,522	83,384,601
Lubricating Oil	Gallons	4,062,498	11,670,940
Gas Oil	Gallons	12,191,905	4,737,236
Fuel Oil	Gallons	38,061,304	42,083,451
Asphalt and Bitumen	Tons	9,368	10,377
Paraffin Wax	Cwt.	140,999	174,876

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

In Tons.

	January.	February.	March.
Anglo-Ecuadorian	18,038	14,555	16,057
Apex Trinidad	44,310	43,870	43,310
Attock	1,611	1,782	1,493
British Burmah	4,416	3,949	4,169
British Controlled	39,970	37,204	44,231
Kern Mex	984	927	1,109
Kern River (Cal.)	2,436	2,195	2,529
Kern Romana	564	282	174
Kern Trinidad	4,968	3,684	3,685
Lobitos	25,327	21,701	23,406
Phœnix	46,884	44,572	58,501
St. Helen's Petroleum	5,089	4,911	4,987
Steaua Romana	85,711	80,394	—
Tampico	2,678	2,579	2,893
Tocuyo	1,784	1,384	1,270
Trinidad Leaseholds	21,300	25,700	27,050

QUOTATIONS OF OIL COMPANIES' SHARES.

Denomination of Shares £1 unless otherwise noted

	Mar. 10, 1932.			Apr. 11, 1932.		
	£	s.	d.	£	s.	d.
Anglo-Ecuadorian		6	6		6	0
Anglo-Egyptian B.	1	5	6	1	2	6
Anglo-Persian 1st Pref.	1	5	0	1	4	9
,, ,, Ord.	1	17	6	1	15	0
Apex Trinidad (5s.)		10	6		9	9
Attock		12	6		11	3
British Burmah (8s.)		4	0		3	9
British Controlled ($5)		1	6		1	0
Burmah Oil	2	3	9	2	1	9
Kern River Cal. (10s.)		2	0		1	6
Lobitos, Peru	1	4	3	1	3	9
Mexican Eagle, Ord. (4 pesos)		7	0		6	3
,, ,, 8% Pref. (4 pesos)		7	6		6	0
Phœnix, Roumanian		4	6		3	3
Royal Dutch (100 fl.)	17	10	0	13	0	0
Shell Transport, Ord.	2	3	0	1	16	3
,, ,, 5% Pref. (£10)	9	15	0	10	0	0
Steaua Romana		5	6		4	6
Trinidad Leaseholds	1	5	6	1	3	9
United British of Trinidad (6s. 8d.)		2	6		2	0
V.O.C. Holding	1	4	6	1	0	0

PRICES OF CHEMICALS. April 9.

These quotations (some of which are affected by the devaluation of the pound sterling) are not absolute: they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.		19	9
,, 80%	,,	1	17	3
,, Glacial	per ton	59	0	0
Alum	,,	8	7	6
Aluminium Sulphate, 17 to 18%	,,	6	15	0
Ammonium, Anhydrous	per lb.		1	0
,, 0·880 solution	per ton	15	10	0
,, Carbonate	,,	27	10	0
,, Nitrate (British)	,,	16	0	0
,, Phosphate, comml.	,,	40	0	0
,, Sulphate, 20·6% N.	,,	7	0	0
Antimony, Tartar Emetic, 43/44%	per lb.			10
,, Sulphide, golden	,,			9
Arsenic, White (foreign)	per ton	25	10	0
Barium, Carbonate (native), 94%	,,	4	10	0
,, Chloride	,,	11	0	0
Barytes	,,	8	5	0
Benzol, standard motor	per gal.		1	4
Bleaching Powder, 35% Cl.	per ton	8	15	0
Borax	,,	16	10	0
Boric Acid	,,	26	10	0
Calcium Chloride, solid, 70/75%	,,	5	15	0
Carbolic Acid, crude 60's	per gal.		1	7
,, ,, crystallized, 40°	per lb.			6¾
Carbon Disulphide	per ton	30	0	0
Citric Acid	per lb.		1	1¼
Copper Sulphate	per ton	18	5	0
Creosote Oil (f.o.b. in Bulk)	per gal.			5¼
Cresylic Acid, 98–100%	,,		1	5
Hydrofluoric Acid, 59/60%	per lb.			6
Iodine	per lb.		19	7
Iron, Nitrate 80° Tw.	per ton	6	0	0
,, Sulphate	,,	2	0	0
Lead, Acetate, white	,,	38	0	0
,, Nitrate (ton lots)	,,	28	10	0
,, Oxide, Litharge	,,	28	10	0
,, White	,,	37	10	0
Lime, Acetate, brown	,,	7	0	0
,, ,, grey, 80%	,,	11	10	0
Magnesite, Calcined	,,	8	5	0
Magnesium Chloride	,,	5	10	0
,, Sulphate, comml.	,,	4	10	0
Methylated Spirit Industrial 61 O.P.	per gal.		2	0
Nitric Acid, 80° Tw.	per ton	23	0	0
Oxalic Acid	per cwt.	2	10	0
Phosphoric Acid. (Conc. 1·750)	per lb.			10
Pine Oil	per cwt.	2	5	0
Potassium Bichromate	per lb.			5
,, Carbonate, 96/98%	per ton	31	0	0
,, Chlorate	,,	34	0	0
,, Chloride 80%	,,	12	10	0
,, Ethyl Xanthate	per 100 kilos	7	10	0
,, Hydrate (Caustic) 88/90%	per ton	40	0	0
,, Nitrate	,,	31	0	0
,, Permanganate	per lb.			8½
,, Prussiate, Yellow	,,			8¼
,, ,, Red	,,		2	0
,, Sulphate, 90%	per ton	14	10	0
Sodium Acetate	,,	21	10	0
,, Arsenate, 45%	,,	20	10	0
,, Bicarbonate	,,	10	10	0
,, Bichromate	per lb.			4
,, Carbonate (Soda Ash) 58%	per ton	6	0	0
,, ,, (Crystals)	,,	5	5	0
,, Chlorate	,,	28	10	0
,, Cyanide 100% NaCN basis	per lb			8
,, Ethyl Xanthate	per 100 kilos	7	4	0
,, Hydrate, 76%	per ton	14	10	0
,, Hyposulphite, comml.	,,	9	2	6
,, Nitrate (ordinary)	,,	9	0	0
,, Phosphate, comml.	,,	13	10	0
,, Prussiate	per lb.			5
,, Silicate	per ton	9	10	0
,, ,, (liquid, 140° Tw.)	,,	8	10	0
,, Sulphate (Glauber's Salt)	,,	2	15	0
,, ,, (Salt-Cake)	,,	3	1	0
,, Sulphide Conc., 60/65%	,,	10	15	0
,, Sulphite, pure	per cwt.		14	0
*Sulphur, Flowers	per ton	10	10	0
,, Roll	,,	10	0	0
Sulphuric Acid, 168° Tw.	,,	4	5	0
,, ,, free from Arsenic, 140° Tw.	,,	3	0	0
Superphosphate of Lime (S.P.A. 16%)	,,	3	7	0
Tartaric Acid	per lb.		1	1
Turpentine	per ton	60	10	0
Tin Crystals	per lb.		1	0
Titanous Chloride	,,			10¾
Zinc Chloride	per ton	9	10	0
Zinc Dust, 90/92%	,,	20	0	0
Zinc Oxide (White Seal)	,,	35	0	0
Zinc Sulphate	,,	8	10	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD AND SILVER:	Mar. 10, 1932.			April 11, 1932.		
	£.	s.	d.	£	s.	d.
SOUTH AFRICA:						
Brakpan	3	13	9	3	6	3
City Deep		5	6		5	3
Consolidated Main Reef	1	2	0	1	0	6
Crown Mines (10s.)	5	5	0	4	17	0
Daggafontein	2	15	0	2	12	6
Durban Roodepoort Deep (10s.)		18	3		17	9
East Geduld	2	18	9	2	14	0
East Rand Proprietary (10s.)		13	9		12	6
Geduld	4	0	0	3	17	0
Geldbenhuis Deep		10	3		10	0
Glynn's Lydenburg		5	0		5	0
Government Gold Mining Areas (5s.	1	13	0	1	12	0
Grootvlei..	1	2	6	1	2	6
Langlaagte Estate	1	5	6		19	0
Meyer & Charlton	1	2	6	1	5	0
Modderfontein New (10s.)	2	7	6	2	3	9
Modderfontein B (5s.)		10	6		9	6
Modderfontein Deep (5s.)		17	0		17	0
Modderfontein East	1	13	9	1	11	6
New State Areas	2	7	6	2	8	9
Nourse		15	9		14	9
Randfontein	1	6	6	1	4	9
Robinson Deep A (1s.)		15	0		15	0
,, ,, B (7s. 6d.)		9	3		9	0
Rose Deep		6.	6		6	0
Simmer & Jack (2s. 6d.)		3	6		3	4
Springs	3	2	6	3	5	6
Sub Nigel (10s.)	3	15	0	3	15	0
Van Ryn		10	9		10	6
Van Ryn Deep	1	0	9		19	6
Village Deep (9s. 6d.)		2	6		2	6
West Rand Consolidated (10s.)		11	9		11	3
West Springs		12	3		11	9
Witwatersrand (Knight's)		8	6		7	0
Witwatersrand Deep		5	3		5	6
RHODESIA:						
Cam and Motor	1	8	9	1	8	9
Gaika		3	6		3	6
Globe and Phœnix (5s.)		14	6		14	3
Lonely Reef		16	3		16	3
Mayfair		4	6		4	6
Rezende	1	6	3	1	5	0
Shamva		1	0		1	0
Sherwood Starr (5s.)		13	9		13	9
GOLD COAST:						
Ashanti (4s.)	1	4	9	1	6	3
Taquah and Abosso (5s.)		5	0		4	6
AUSTRALASIA:						
Golden Horseshoe (4s.) W.A.		3	6		3	6
Great Boulder Propriet'y (2s.), W.A.		2	3		2	9
Lake View and Star (4s.), W.A.		9	9		9	7
Sons of Gwalia, W.A.		6	3		6	9
South Kalgurli (10s.), W.A.		16	0		15	6
Waihi (5s.), N.Z.		15	6		15	6
Wiluna Gold, W.A.		14	0		17	0
INDIA:						
Balaghat (10s.)		1	6		8	9
Champion Reef (10s.)		8	3		8	6
Mysore (10s.)		7	0		8	3
Nundydroog (10s.)		19	6		17	6
Ooregum (10s.)		2	6		3	0
AMERICA:						
Camp Bird (2s.), Colorado			6			3
Exploration (10s.)		1	6		1	6
Frontino and Bolivia, Colombia		16	3		16	9
Mexican Corporation, Mexico (10s.)		3	6		3	6
Mexico Mines of El Oro, Mexico		1	6		2	0
Panama Corporation		7	6		5	0
St. John del Rey, Brazil		18	0		18	6
Santa Gertrudis, Mexico		6	0		4	9
Selukwe (2s. 6d.), British Columbia		1	9		1	9
MISCELLANEOUS:						
Chosen, Korea		3	9		3	0
Lena Goldfields, Russia			6			6

COPPER:

Bwana M'Kubwa (5s.) Rhodesia		2	9		2	6
Esperanza Copper		13	9		13	9
Indian (2s.)		1	0		1	0
Loangwa (5s.), Rhodesia		1	9		1	6
Luiri (5s.), Rhodesia		3	3		2	6
Messina (5s.), Transvaal		6	0		5	0
Mount Lyell, Tasmania		16	0		15	6
Namaqua (£2), Cape Province		3	6		3	0
Rhodesia-Katanga		11	3		10	0
Rio Tinto (£5), Spain	17	17	6	12	10	0
Roan Antelope (5s.), Rhodesia		7	9		5	9
Tanganyika Con.	1	2	0		15	6
Tharsis (£2), Spain	3	5	0	2	10	0

LEAD-ZINC:	Mar. 10, 1932.			April 11, 1932.		
	£	s.	d.	£	s.	d.
Amalgamated Zinc (8s.), N.S.W.		6	3		6	3
Broken Hill Proprietary, N.S.W.		11	9		11	9
Broken Hill, North, N.S.W.	2	12	6	2	6	3
Broken Hill South, N.S.W.	1	15	0	1	11	6
Burma Corporation (10 rupees)		9	0		7	6
Electrolytic Zinc Pref., Tasmania		17	6		16	3
Mount Isa, Queensland		10	6		8	0
Rhodesia Broken Hill (5s.)		1	0			9
San Francisco (10s.), Mexico		8	9		6	9
Sulphide Corporation (15s.), N.S.W.		8	6		7	3
ditto, Pref.		10	9		9	0
Zinc Corporation (10s.), N.S.W.	1	3	0		19	6
ditto, Pref.	2	15	0	2	12	6

TIN:

Aramayo Mines (25 fr.), Bolivia		15	0		10	0
Associated Tin (5s.), Nigeria		3	9		3	0
Ayer Hitam (5s.)		10	9		9	9
Bangrin, Siam		10	3		9	6
Bisichi (10s.), Nigeria		4	0		3	9
Chenderiang, Malay		1	6		1	6
Consolidated Tin Mines of Burma		3	0		2	6
East Pool (5s.), Cornwall			6			6
Ex-Lands Nigeria (2s.), Nigeria		1	3		1	3
Geevor (10s.), Cornwall		2	0		2	0
Gopeng, Malaya	1	12	6	1	11	6
Hongkong (5s.)		13	0		12	6
Idris (5s.), Malaya		6	6		6	0
Ipoh Dredging (16s.), Malay		14	9		12	6
Kaduna Prospectors (5s.), Nigeria		4	0		3	9
Kaduna Syndicate (5s.), Nigeria		8	9		8	9
Kamunting (5s.), Malay		4	9		4	0
Kepong, Malay		8	9		8	9
Kinta, Malay (5s.)		6	6		6	0
Kinta Kellas, Malay (5s.)		5	6		5	0
Kramat Pulai, Malay	1	1	0		18	9
Lahat, Malay		4	0		4	0
Malayan Tin Dredging (5s.)		16	6		14	6
Naraguta, Nigeria		7	6		7	6
Nigerian Base Metals (5s.)			6			6
Pahang Consolidated (5s.), Malay		4	9		4	0
Penawat ($1), Malay		1	0		1	0
Pengkalen (5s.), Malay		10	9		9	6
Petaling (2s. 4d.), Malay		7	6		7	3
Rambutan, Malay		5	0		5	6
Renong Dredging, Malay		13	9		12	6
Siamese Tin (5s.), Siam		7	3		5	6
South Crofty (5s.), Cornwall		2	6		2	0
Southern Malayan (5s.)		10	6		7	9
Southern Perak, Malay	1	2	6	1	1	3
Southern Tronoh (5s.), Malay		6	0		5	6
Sungei Besi (5s.), Malay		7	0		6	6
Sungei Kinta, Malay		8	9		8	6
Tanjong (5s.), Malay		6	9		6	9
Tavoy (4s.), Burma		5	0		3	6
Tekka, Malay		12	9		12	6
Tekka Taiping, Malay		4	6		11	3
Temengor, Malay		1	6		1	6
Toyo (10s.), Japan		1	6		1	6
Tronoh (5s.), Malay		13	9		13	0

DIAMONDS:

Consol. African Selection Trust (5s.)		6	3		5	6
Consolidated of S.W.A. (10s.)		2	0		1	6
De Beers Deferred (£2 10s.)	3	15	0	2	11	3
Jagersfontein	1	0	0		12	6
Premier Preferred (5s.)	1	3	9	1	5	0

FINANCE, ETC.:

Anglo-American Corporation (10s.)		7	6		5	6
Anglo-French Exploration		10	0		8	9
Anglo-Continental (10s.)		2	3		2	9
Anglo-Oriental (Ord., 5s.)		5	9		5	6
ditto, Pref.		9	0		7	6
British South Africa (15s.)	1	1	0		16	9
Central Mining (£8)	9	0	0	7	5	0
Consolidated Gold Fields	1	3	9		18	9
Consolidated Mines Selection (10s.)		6	0		5	0
Fanti Consols (8s.)		6	6		6	6
General Mining and Finance		18	0		14	6
Gold Fields Rhodesian (10s.)		3	3		3	0
Johannesburg Consolidated	1	3	6	1	0	0
London Tin Corporation (10s.)		11	0		8	0
Minerals Separation	2	10	0	2	2	6
National Mining (8s.)			3			3
Rand Mines (5s.)	3	5	0	2	17	0
Rand Selection (5s.)		7	6		6	9
Rhodesian Anglo-American (10s.)		6	3		5	9
Rhokana Corp.	3	10	0	2	10	0
Rhodesian Selection Trust (5s.)		6	6		5	0
South Rhodesia Base Metals		2	0		2	0
Tigon (5s.)		3	6		2	6
Union Corporation (12s. 6d.)	2	10	0	2	8	9
Venture Trust (10s.)		4	0		4	0

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section abstracts of important articles and papers appearing in technical journals and proceedings of societies are given, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

THE GEOLOGY OF THE COPPER BELT, NORTHERN RHODESIA

The following extracts are taken from "Mineralische Bodenschätze im südlichen Afrika," by Professor H. Schneiderhöhn, in which work [1] the results of the author's observations made during the XV International Geological Congress are set out. After dealing with the Union, South-West Africa, and Southern Rhodesia, the author passes on to the geology of Northern Rhodesia. Considering the principal geological features the author says that on a rapid superficial survey the geological formation in the northern part of Northern Rhodesia does not differ essentially from the southern part, or from Southern Rhodesia. Reduced to the most simple formula, it represents: Floating blocks and remains of highly metamorphosed basement strata intersected with old granite, both constituting primary formations; over which lie discordantly, in individual stages of synclinal-denudation, an important series of less-metamorphosed terrestrial sediments, called collectively the "Katanga formation," having much similarity stratigraphically, tectonically, and perhaps also petrographically, with the Lomagundi formation of Southern Rhodesia, and the coeval Transvaal-Nama formation of South Africa and South-West Africa. The limbs of this formation, which generally speaking are approximately concordant, are divided into various "series," chiefly from the petrographic point of view. According to the view of the Northern Rhodesian geologists, only a part of the granite is said to be older, that is, to belong to the primary formation. Another portion, which, it is true, cannot be superficially distinguished from the first, is in their view younger than the strata of the Katanga formation. An horizon fairly low down at the base of the lowest series of this Katanga formation is the ore carrier; it is exceedingly extensive, and the mineralization with copper sulphides is remarkably regular. These are the main general features.

These formations are then briefly considered individually.

(1) Primary Formation (Basement Strata and Old Granite).—The basement strata are here rootless blocks, with the petrographic versatility usual in the more southern areas: Quartzites, quartz-mica schist, and mica-schist constitute the main part and these were once sediments; in addition, there are areas with injected mixed gneiss and augen-gneiss, and, as equivalent of archaic eruptives, chlorite-schist and hornblende-schist are present. Strongly metamorphosed, purely granular katarocks (Kata gestein) also appear in granitic, kyanite, and andalusite-gneisses. There are also conglomerate-gneisses and banded ironstones. The metamorphosed facies is not always alike, as has already been pointed out. Thus, belonging to the basement group are also the rather less metamorphosed phyllites, schists, and dolomites of the Broken Hill series.

The basement strata appear to occupy, in the north of Northern Rhodesia, a larger area than further south, but everywhere their rootlessness is apparent—they all float upon the granite. Small copper-ore veins and intrusions of copper are numerous, particularly in the higher Broken Hill series. They are in parts payable to work, though only representing small deposits. Unpayable quartz veins with pyrites and a little copper pyrites are known in enormous numbers and intersect the strata everywhere. In addition there are numerous, but always poor, gold-quartz veinlets, reaching down into the granite. Taken by themselves, all these deposits in the primary formation of northern North Rhodesia are quite unimportant. The author has, however, something to say as to the exceedingly important part which they play, in his opinion, in the origin of the more recent copper ore deposits of the Katanga formation.

The old granite ("M'Kushi granite") is in this field partly granular, partly gneissic. This is probably due less to difference of age than to the fact that the granular parts correspond more with purer, inner magmatic parts, whilst in the gneissic portions there is an injection and complete impregnation and melting of the basement strata with granite magma. Also the former generally occur further within the granite masses, whilst the latter become more frequent towards the basement contacts.

(2) Bwana M'Kubwa or Roan Series.—The deepest strata of the Katanga formation, lying discordantly upon the basement rocks and old granite of the primary formation, are called by Bancroft the Bwana M'Kubwa series, by Gray, Sharpstone and others, the Roan series. The facies is the same, wherever this series is encountered in Northern Rhodesia. The sequence of stratification also agrees everywhere more or less, whilst the thickness and petrographic composition individually may differ considerably over short distances; phenomena which with this kind of facies are quite usual.

(*a*) The series begins with a sequence varying greatly in thickness of felspathic sandstones, felspathic quartzites, and arkose, with beds of rubble or conglomerate, and often also with true "fanglomerate." They are occasionally 20 m. thick, but usually between 60 and 120 m. A basal conglomerate over the granite or the basement strata is missing, except in a few places. The sedimentary strata appear usually to have been formed out of the underlying primary rock as eluvial unclassed detritus and at 1 to 2 m. both gradually work into each other. The author was able to study similar sections in complete boring cores, chiefly from the N'Changa trough. At the Roan Antelope good indications can also be seen at depth down to the gneiss. Higher up the rocks become more uniform,

[1] "Mineralische Bodenschätze im südlichen Afrika." By Professor H. Schneiderhöhn. Berlin: Nem-Verlag.

but still remain very coarse and comparatively little classed. Throughout the whole series there are always many fresh felspars in them. Cross stratification often occurs and there are frequently little fossil blebs of clastically-enriched iron ores in the bands. Here and there beds of rubble or more substantial conglomerate layers have been formed and well-rounded rubble of the underlying rocks also occurs. In general, however, stratification and bedding is not pronounced. Higher up, towards the ore bearing stratum, one finds almost everywhere a conglomerate band, which has been called the "foot-wall conglomerate."

(*b*) Various signs indicate that the next sequence, the copper horizon, is sharply separated from the foot-wall. Stratification often in thin plates or thin slate is strongly pronounced, and the rock is frequently much more uniform, the granulation considerably less, and the various parts well classified. Mineralogically the felspar content decreases greatly, whilst the mica content increases; carbonates, mostly dolomite, occur either enriched in the layer or injected. The whole horizon is 6–36 m. thick and usually impregnated over the whole thickness with copper sulphides and copper-iron sulphides. It is true that usually only a portion of the strata contain more than 2% copper and this is considered as payable. More detailed particulars regarding the ore horizon are given in the book under the various mining areas.

(*c*) The strata above at first still resemble the ore rocks greatly. These are felspar- and mica-bearing sandstones and quartzites with occasional layers of shale in between, often a green band of shale constitutes for a long time the guiding horizon and lies 45 to 60 m. above the ore strata, In the lower parts of some of the ore areas mineralized strata also occur. The thickness of this portion is at least 60 m., often considerably more, up to 250 m. Locally the uppermost layers have developed as coarse arkose sandstones and felspathic quartzites.

(*d*) Further up comes a sequence of strata of dolomitic shales, usually very thick, with intervening beds and lenses of pure dolomite. This sequence may go to 360 m. thickness, decreasing locally down to 60 m.

(*e*) In the upper part these beds are transformed into massive dolomites with a few interpolated bands of shale. They are 100 m. thick on an average, but may be as little as 60 m. or as much as 150 m.

(3) CHRISTMAS SERIES.—Concordantly upon the last-named dolomites lies a thick sequence of shales and quartzites. It starts in places with a conglomerate of rubble from the foot-wall Roan rocks and was, for that reason, considered separately as a series by itself. It belongs, however, considered stratigraphically and with regard to its facies, entirely to the older Roan series. The quartzites usually only form individual strata—shale predominates. In the quartzite strata fair quantities of interspersed pyrite are found here and there with sometimes a low copper content. The quartzites are called in the literature on the subject "oolitic," but this is not correct. They are only rounded clastic quartz grains surrounded concentrically with a quartz cement.

(4) KUNDELUNGU (TANGANYIKA OR MUTONDO) SERIES.—Above the Christmas series comes a series several kilometres thick, the concordance of which with the Christmas series is not certain. Gray affirms it. Bancroft denies it—no doubt on account of coarse conglomerates in the lowest part of the stratification. Here shale alternates with sandstone and conglomerates in 150 m. thickness. The conglomerates, particularly the lowest, show jagged rubble, sometimes scratched. The rock is wholly unclassed, quite big boulders and finely granulated sand lie side by side. In former times these rocks were considered by various explorers as fluvio-glacial deposits, and this view is still held by some today, but since E. Kaiser (Munich) has pointed out the phenomena of terrestrial detrital deposits arising under conditions corresponding with our present-day arid climate, it is no longer possible to consider such unclassed sediments and scratched rubble merely as survivals of former glacial periods. Detrital masses from mainland may show quite a similar appearance. Seeing that in all these areas the abraded underpart with its characteristic forms is missing—which alone could be considered satisfactory proof of glacial conditions—it appears much more reasonable to look upon these sediments as terrestrial detrital sediments or "fanglomerates," seeing that they fall quite easily into place with the facies of the whole Katanga formation. Following upon these deposits are finely granulated and thick clayey dolomites and dolomitic shale, reddish and brown shale, blue-gray and red sandstone, over 1,000 m. thick ("purple sandstone").

(5) METAMORPHIC CONDITION OF THE ROCKS OF THE KATANGA FORMATION.—While the basement strata are highly metamorphic, belonging to the katazones or at least the mesozones, the metamorphism of the rocks of the Katanga formation is considerably lower. Even with the naked eye one can almost always recognize the primary sedimentary characteristic of the rock. In the two lower series, however, a metamorphic transformation both mineralogically and also in respect of structure and texture can clearly be recognized. This is particularly noticable in the more strongly disturbed folds at the bends. In general the metamorphic condition answers to the epizone, sometimes, especially at the more strongly disturbed parts, it approaches the mesozone.

(6) YOUNGER IGNEOUS ROCKS IN THE KATANGA FORMATION.—Geologists of Northern Rhodesia assert that part of the granite in the territory is more recent than the Bwana M'Kubwa series. This already appeared doubtful to the author at the outset of the Congress excursion, and on the occasion of his second visit he paid special attention to the point. He thanks the authorities in charge for the opportunity of seeing nearly all the places which were supposed to "prove" recent granite. After exhaustive examination, however, the author concludes that not one of these proofs could be maintained. So-called contact zones turned out to be recent ground-water ferrifications on the boundary of the old granite and the overlying detrital arkose. Or again, large masses of granite porphyry which had penetrated the Bwana M'Kubwa strata were found to be augen-gneiss belonging to the basement strata, which rose, dome-like, from the floor at the time of the deposit of the Bwana M'Kubwa arkose. In fact similar alterations of the floor level are frequently observed and when the floor happened to be granite these places were considered to be indications of an intrusion of the younger granite into the Bwana M'Kubwa rocks. The author considers, however, that nowhere does one find true veins or apophyses, so that after all he had seen he concluded that one has to do here only with an

irregular relief of the floor and not with recent granite. Moreover, he could find no difference, mineralogically or microscopically, between the old granites and those which were presented to him as recent ones.

In conclusion, the last proof of the presence of a younger intrusion is supposed to be furnished by numerous cross-veinlets in the Bwana M'Kubwa strata, particularly in the ore strata, which were considered to be pegmatite and aplite veins. After studying the ground at depth thoroughly, and thousands of metres of boring cores, he arrived at the conclusion that these are not intrusive veins. The further examination of his numerous collections at home and under the microscope have brought to him the certainty that these little veins are lateral and secretionary fillings from fissures which occurred at the time of the deformation under metamorphic conditions of pressure and temperature. They may be compared with the Alpine mineralized clefts, and the character of the minerals found in them is frequently very similar to those in those clefts. For these reasons, he is not in a position to recognize any sign of a younger granite in Northern Rhodesia, at all events within the range of the copper deposits.

On the other hand there does occur in one of the synclinal areas a true younger intrusive mass among the Bwana M'Kubwa rocks, and apparently concordantly, as veins. This is a basic rock approximately of the composition of a gabbro or dolerite. It is quite fresh and undeformed, and is possibly equivalent to the Karroo diabases of South Africa.

(7) TECTONICS.—Within the range of the Northern Rhodesian copper area the Katanga rocks are only preserved in individual folded troughs which lie upon the rocks of the primary formation, the basement strata and the old granite. There are in the present main copper area, the N'Kana concession, four such trough areas. The depth of the fold is not very great. The folds are mostly non-symmetrical, and "dragfolds" often occur also, but generally the intensity of the dislocation is not great. The synclinal strike is not uniform. In general it is S.E.–N.W., but there are important deviations of direction. The curves are usually very sharp, whilst the flanks may stretch long distances in a uniform way. Particularly conspicuous is the important increase of metamorphosis in these curves. The rocks are more crystalline and considerably more folded and disturbed in themselves, transverse schist with numerous small slips is formed, and the secretion veinlets mentioned above become much more numerous. Overthrusts occur in these synclines, but so far as is known, they play no important part in Northern Rhodesia. The extent to which the strata are displaced is quite small and no disturbance of the work of mining exploitation has so far been caused.

(8) ORIGIN OF THE NORTHERN RHODESIAN COPPER DEPOSITS.—From the sequences of the strata in the various deposits and the position of the ore horizon, it can be seen at once that in the whole vast territory of 100,000 sq. km., the stratigraphic, facial, and petrographic conditions of the Bwana K'Mubwa formation, both generally and with regard to the ore horizon in particular, are as uniform as one can reasonably expect in beds of this character. The various facies of the Bwana M'Kubwa formation appear clearly enough from the preceding descriptions. It may be said with certainty that one has to do with rubble and eroded masses ("fanglomerates") and more or less classed mainland sediments, whether accompanied with chemical separations or not, of a kind such as may be found and be seen forming to-day in the interiors of large basins without outlet and on flat plains in arid climates. The basement (the old granite and basement strata) was first of all, during lengthy periods, eroded in thicknesses to be measured by kilometres. Then masses of rubble began to fill in the slowly sinking depression. The author was enabled in several boring cores, very plainly at N'Changa for instance, to follow the complete transition of the granite into the lowest Bwana M'Kubwa strata; first as unclassed granite rubble (true fanglomerate), then arkose, and only higher up as well-classed felspathic quartzites (prepared fanglomerate). Cross stratification, intercalations of beds of rubble or single boulders, horizons of blebs containing heavy iron-ores ("fossilized blebs") occur very frequently. A really-merging basic conglomerate is thus often, though not always, missing, but even when present it is mostly of the nature of fanglomerate. The lowest sequence of strata thus has everywhere the plain appearance of eluvial, incompletely transported, and, therefore, little altered, detritus. True coarser conglomerates only begin further up, sometimes quite thick and very coarse, the component parts changing and no longer so purely autochthonous as in the basic strata. At the same time there appear suddenly, alternating with the coarse conglomerates, very finely granulated quartzites, sandstones, and well-banded quartz-shale. All the rocks become suddenly well-classed, with very uniform medium-to-fine granules. Here and there an impregnation of dolomite is found. On this spot and in this facies lies the ore horizon. Sometimes the sequence repeats itself. Upon "ore-less" or "ore-poor," irregular, little-changed, coarsely-granulated strata follows a second, or even a third, ore-horizon, but always only in medium or finely granulated quartz-shales or micaceous quartzites with uniform granulation and good stratification, with or without dolomite impregnation. Higher up the rocks generally get more finely granulated and contain much more mica, the dolomite content increases, massive impure dolomite beds or lenses are to be found with here and there a felspathic quartzite, until at last in the uppermost portion there is an unchanging alternation between shale and micaceous sandstone with more or less dolomite.

Northern Rhodesian geologists believe that the metallic contents immigrated from hydrothermal solutions, which became free upon the congealment of a younger granite. The more the author studied conditions on the spot the less able he found himself able to subscribe to this view. The pros and cons were debated in long discussions with the Northern Rhodesian experts; every possibility was afforded him in a most liberal manner to visit places, even at great distance, which they considered proved their theory. A thorough study in the microscope of the extensive material collected has finally convinced him that his original view was correct. It has already been pointed out that one of the chief reasons alleged for an epigenetic-hydrothermal mineralization, namely, the young granite, is not tenable on the strength of developments hitherto. All Northern Rhodesian explorers also admit that the entire nature of the occurrence, the constancy of level, almost complete and in many cases literally so, and the uniform stratification over hundreds of kilometres, constitute a strong proof of a coeval sedimentary origin of the ore content.

They even lay stress upon the great difficulties which arise when they try to follow the reasons of the mineralization of just these strata in any section. Within a limited area plausible reasons may be adduced at a pinch. The comparison of various areas shows that, for instance, porosity, dolomite content, content of clayey earth and minerals, size, form, binding and arrangement of the granulation, etc., vary but little in the ore strata in general, but that the ore stratum to the hanging or foot-wall varies completely in the different areas in regard to every one of these factors. Thus, one ore stratum may be relatively the most porous, elsewhere the ore stratum will be the least porous ; sometimes it has the most, elsewhere the least dolomite or mica, sometimes the granules are smaller, at other times larger than those of the hanging- or foot-wall, etc. Thus, the comprehensive, all-embracing, views upon the origin of such uniform enormously extended deposits fail completely when one has to explain why more recent ore-solutions should have mineralized only the present ore horizons.

What also, in the author's opinion, speaks decisively against a hydrothermal origin is the metallic association, or rather the absence of any. The deposits are pure copper deposits ! Iron sulphides are almost entirely absent, pyrite is of the greatest rarity. A silver content is either entirely absent or insignificant, gold is altogether absent, also lead and zinc. Quite dispersed one finds occasionally a metal which in hydrothermal deposits is always found in quite another association, but never with copper alone, that is—cobalt. Nickel is missing. In extensive hydrothermal deposits such an association of metals does not occur.

A. M. Bateman, who visited the Northern Rhodesian deposits before the Congress, and who has published a comprehensive description of them, was the first to give a close description of the microscopic and mineralogical conditions of the ores. After examining his samples the author can thoroughly agree with the conclusions of Bateman. The most frequent ores are bornite and chalcocite, approximately in equal quantity. Somewhat behind comes copper pyrites. Chalcocite is usually plainly paramorphic, that is to say, it was formed over 91°. Chalcocite and bornite usually appear as intergrowths, which points to an origin under high temperatures. Dissociations are frequent and extensive. The author considers the fact, mentioned by Bateman but not stressed by him, that the sulphides mostly lie with their own crystal surfaces in the neighbourhood, a fact which is quite unusual with minerals so unready to crystallize as bornite and copper pyrites, exceedingly striking. Bateman concludes, quite rightly, from the microscopic paragenetic picture, that the present mineral content arose under high temperatures, but the author cannot follow him when he affirms that the picture of the ore strata as present to-day arose from the epigenetic impregnation of the rocks with hot, magmatic-hydrothermal, solutions, and that these precipitated the copper sulphides so that the non-metallic minerals of the country rock were considerably extruded by the sulphides. In order to understand the present picture of the ore stratification it is necessary to consider the rocks of the Bwana M'Kubwa series petrographically as a whole. They all have the character of weakly metamorphically-altered rocks, and they are all "epi-rocks" according to the definition of Grubenmann. To this metamorphically-altered mineral mass belong also the sulphides. They were there when the rock was transformed and were themselves strongly altered in character as to crystallization and mineralization, seeing that sulphides react much more readily than silicates. This alteration took place under high temperatures, and thence came the mineralization, intergrowth, and dissociation in the ores, including the very frequent crystal forms of the sulphides, all of which unanimously point to high temperatures. These are not extrusions in the usual sense, but new "idioblastic" growths formed during the metamorphosis. At the time of this metamorphosis, which no doubt occurred hand in hand with stronger pressure and consequently increased temperature, small fissures were torn. The solutions circulating under pressure in the rock, charged with minerals from the country rock, diffused quickly into the fissures and, as the pressure decreased, the matter in solution crystallized and thus arose those finger-long secretion-fissures filled with quartz, adularia, calcite, and sulphides, which have hitherto been taken by the explorers there for "pegmatite" veins. They appear entirely similar to the corresponding alpine secretionary clefts ; the water-clear beautiful rock-crystals, the flat crystal forms of the adularia are exactly the same, only in the Alps copper sulphides are almost entirely absent, not being contained in the country rock there, whereas here they do occur in the country rock. Characteristically, the secretionary clefts in the hanging- and foot-walls of the ore-horizon are always oreless and they only contain sulphides when they form in the ore-horizon itself. In other respects no great shifting of the metals has taken place at the metamorphosis, the sulphides still lying generally in their original place.

The country rocks themselves and the other rocks of the Bwana M'Kubwa series have a similar metamorphic character. Occasionally the metamorphosis is very much stronger, for instance, locally in N'Changa or Muliashi, but this can always be explained by a more intensive movement of the rocks, with considerably increased "small-folding" and deformation. Moreover the character of these rocks differs from that usual in the case of a contact metamorphosis, which Bateman considers it to do.

The presence of tourmaline, very sparse and well away from the ore horizon, has no connexion with the ore mineralization. It is clastic tourmaline of the sediments, metamorphically changed minerally, sometimes merely detached tourmaline granules.

The original nature of the ore mineral before the metamorphosis and the manner of its formation are then considered. The author considers it to be syngenetic-sedimentary. Even to-day very numerous small deposits outcrop in the native rock in Northern Rhodesia. These are mostly gold-bearing copper-iron-sulphide deposits of paragenetic nature peculiar to the lower roots of hydrothermal ore lodes already in the granite itself, the so-called "embatholitic" type. The higher portions of these lodes, now eroded, the "epi" and "acrobatholitic" types, are generally much richer, particularly in copper. The archaic granite of Southern and Northern Rhodesia must have produced an immensely rich copper ore. When, after the soil had been carried away, a new sedimentation of the eroded detritus and its concentrated products began, the eroded fragments of the ore lodes were in the detritus and the leached-out metallic solutions circulated in the ground water of the undrained depressions in which the Bwana M'Kubwa rocks deposited themselves. Thus, during the sedimentation of the whole of the strata, the metals would be precipitated as sulphides in a particular stratum where the conditions were favourable. This need not have been a syngenesis in the literal sense of the word, the precipitation may have taken place quite gradually within the sedimentary cycle of the Bwana M'Kubwa rocks. Either this took place coevally with the depositing of the country rock of the ore, or soon afterwards, or possibly very much later, seeing that hundreds of metres of sediment overlay it. Or, what is perhaps more probable, isolated sulphides within the present-day ore-horizon, which may in part have got in clastically, operated as embryos and during long periods through the reducing action of these constantly-growing sulphides from the ground water, the metals were precipitated and concentrated to a small thickness. In any case according to this explanation the immediate metallic content of the ore horizon originates from the ground waters of the coevally-formed sedimentary series; the ground waters got their metallic content from the ore deposits of the sub-stratum, which had been carried off from the surrounding rocks; the precipitation took place in the geological epoch of the Bwana M'Kubwa formation. That is the type of sedimentary concentration deposits in terrestrial arid detrital rocks.

The author does not pursue the question of the formative processes in further detail, as it is his intention to do this in a special treatise in which the petrographic-microscopic texture of the whole rock series, the structure, and particularly the ore content, will be exhaustively dealt with. He simply points out that the peculiar, one-sided metal content is at once explainable by these formative processes. Further, he shares the view of many other authors, Bateman, for instance, that the sulphidic parts of the copper deposits of Katanga belong to the same stratigraphic-facial position and have the same origin. In conclusion, the author points out that W. Lindgren more than 10 years ago, with the help of the meagre literature then known, considered the Katanga deposits from the same point of view as is explained above and numbered them among his genetic group "Deposits formed by concentration of substances contained in the surrounding rocks by means of circulating waters." In the latest edition of his manual, Lindgren believes that the Northern Rhodesian copper deposits adjoining in the south also have the same origin.

MAGNETIC SURVEYS OVER DYKES

The *Canadian Mining and Metallurgical Bulletin* for March contains an article by A. S. Eve and D. A. Keys in which results are given of some magnetic surveys over mineral, diabase, and artificial dykes. The authors point out that the detection of magnetic dykes by using magnetic variometers is the oldest application of geophysics to mining, and is also one of the more simple and certain methods of locating such deposits. As a result of recent improvements in the instruments, it is now possible to find the dyke, determine with magnetic variometers its strike and dip with fair accuracy, and to estimate the approximate depth of overburden when there is no outcrop. The application of electrical methods may be used to distinguish mineral from diabase dykes.

The authors have had an opportunity of making surveys with the modern Askania types of vertical and horizontal variometers over magnetic dykes in the Sudbury region of Ontario. The interpretation of the results has been confirmed by diamond drilling in some cases, and by experiments over models. The variometers used were the standard form of Askania instruments. The sensitivity of the horizontal type was 17·2 gammas per division, and that of the vertical variometer double this quantity.

To make a preliminary survey of the district, parallel lines were laid off 200 ft. apart running north and south and readings were taken with the vertical variometer every 100 ft. along these lines. This can be done very rapidly and when an indication of a magnetic deposit is found, the readings may be taken every hundred feet, or less if the size of the deposit warrants smaller intervals. If the deposit is a vein or dyke, the readings along the adjacent lines immediately indicate the strike of the body. Thus the presence and strike of a magnetic dyke, whether of mineral value, like the pyrrhotite and nickel deposits of the Sudbury district, or simply a worthless diabase dyke, is simply and rapidly found.

The next problem is to determine the approximate dip of the vein. This is done by making a careful survey with both the vertical and horizontal variometers along a line crossing the dyke perpendicularly to the strike. For this purpose readings are made first of the vertical and then of the horizontal variations in magnetic intensities at each point, using the one tripod, on which each instrument is placed in turn. From these readings, the normal values of the vertical and horizontal intensities in the region undisturbed by the presence of magnetic ore are respectively subtracted. Thus the resulting figures, when plotted, give the vertical and horizontal anomalies due to the presence of the magnetic dyke. For

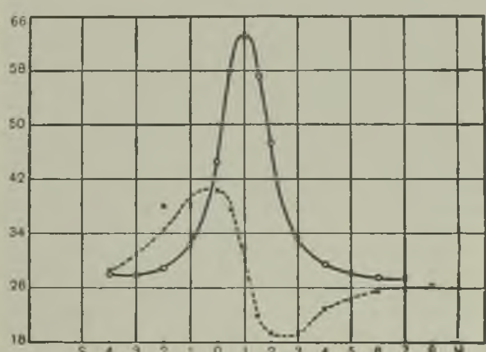


FIG. 1.—N.-S. MAGNETIC SURVEY ACROSS AN E.-W. PYRRHOTITE-NICKEL DYKE. FULL LINE SHOWING VERTICAL VARIATIONS.

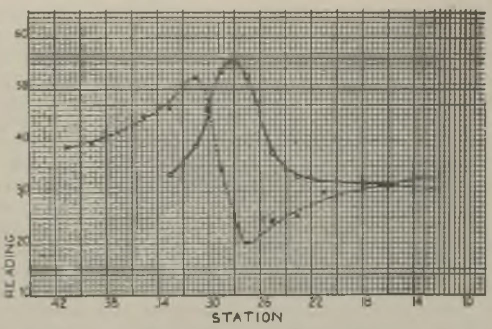


FIG. 2.—N.-S. MAGNETIC SURVEY ACROSS AN E.-W. DIABASE DYKE.

comparative purposes, it is preferable to reduce the readings of the horizontal anomalies to the same scale of sensitivity as that of the vertical variometer (by dividing by two in the case of our instruments). The results of such a survey over a magnetic mineral vein are given in Fig. 1, and the results of a similar survey over a magnetic diabase dyke in Fig. 2. From these curves the direction of dip of the vein may be deduced. In both cases dykes which run approximately magnetic east and west are dealt with, while the lines of survey are approximately magnetic north and south. The problem of dykes that run north and south still requires further investigation in the field and in the laboratory.

To illustrate how the dip of a dyke may be determined from the vertical and horizontal anomalies on a line perpendicular to the strike, some experiments over model magnets were performed. If a small bar-magnet be placed on a horizontal board on the ground, so that the axis of the magnet (representing a dyke) is vertical, the readings made with the vertical and horizontal variometers along the magnetic meridian passing through the magnet result in curves such as the typical example shown in Fig. 3. Curve *A* represents the result of plotting the vertical anomalies, and curve *B* the horizontal anomalies on the same scale, the station designated as zero being the point on the meridian directly above the centre of the vertical magnet. It will be seen that both curves are symmetrical about the origin, which is taken

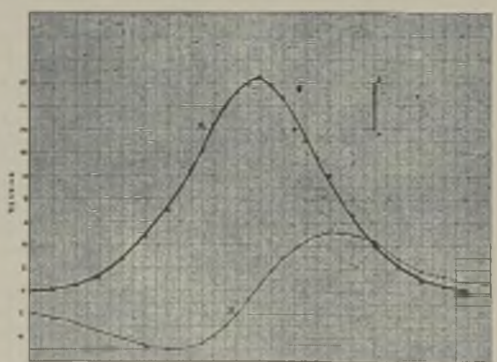


FIG. 3.—N.-S. MAGNETIC SURVEY OVER A VERTICAL BAR MAGNET. CURVE A REPRESENTS VERTICAL, CURVE B HORIZONTAL, VARIATIONS.

as the point where the vertical magnet is placed. When the magnet is tilted, so that it dips 37° to the north, and the readings along the same line repeated, the centre of the tilted magnet being at the station marked zero, we obtain the asymmetrical curves given in Fig. 4. Curve *A* represents the vertical anomalies, and curve *B* the horizontal. From an inspection of the curve representing the vertical anomalies, two characteristics are at once evident. First, the anomaly to the north goes below the normal value ; it does not do so to the south ; and second, the long flatter inclined side of the curve is also to the north. Both of these characteristics indicate a dip to the north. When the horizontal variations are inspected, it will be seen that the maximum variation from the normal value is to the north, reaching a value 9·5 divisions, while to the south the maximum anomaly is only 5·8 divisions. Hence the side on which the maximum variation occurs is the side towards which the vein dips.

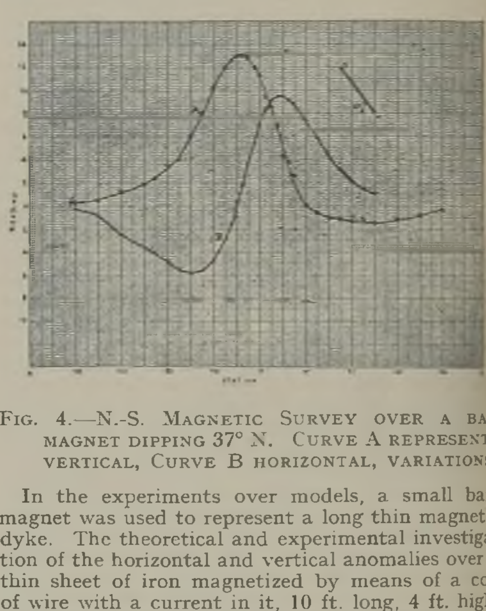


FIG. 4.—N.-S. MAGNETIC SURVEY OVER A BAR MAGNET DIPPING 37° N. CURVE A REPRESENTS VERTICAL, CURVE B HORIZONTAL, VARIATIONS.

In the experiments over models, a small bar-magnet was used to represent a long thin magnetic dyke. The theoretical and experimental investigation of the horizontal and vertical anomalies over a thin sheet of iron magnetized by means of a coil of wire with a current in it, 10 ft. long, 4 ft. high, and half an inch thick, gives results similar to those indicated above. It should be remembered, however, that the results of such ideal experiments will only agree in a qualitative way with field observations over veins that are usually irregular in width, depth, and magnetic intensity.

Applying the information obtained from the experiments over models to the field results shown in Figs. 1 and 2, the authors conclude that the mineral vein has a slight dip to the south, and that the diabase dyke has a small dip to the north. This conclusion is confirmed by diamond-drill records in the case of the pyrrhotite dyke, but no such information is available in regard to the diabase dyke.

Some idea of the depth of overburden may also be obtained from the results of the observations made with the two variometers. At each point on the line of survey we have the value of the horizontal and vertical anomalies due to the vein, from which we may construct, by the parallelogram law, the direction and magnitude of the resultant

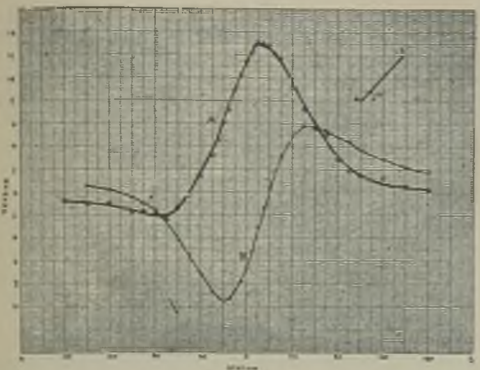


FIG. 5.—N.-S. MAGNETIC SURVEY OVER A BAR MAGNET DIPPING 37° S. CURVES A AND B AS IN FIG. 4.

anomaly at each station. When the resultant vectors are drawn for points on the line over and very near the centre of the dyke, they will tend to point towards the upper magnetic pole of the vein. Although the depth obtained from such readings will be approximate only, it will give at least an upper value to the overburden, the knowledge of which may in some cases be useful. In Fig. 6 are

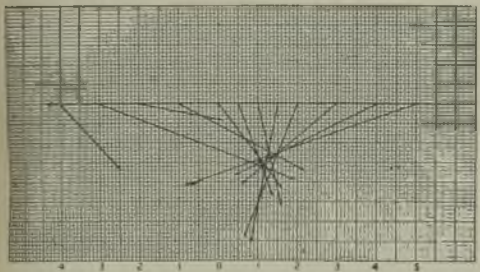


FIG. 6.—RESULTANT VECTORS OF MAGNETIC ANOMALIES OVER PYRRHOTITE-NICKEL LODE.

shown the results of such measurements made over the mineral vein, indicating a depth of, roughly, 140 ft. The actual amount of overburden was about 120 ft., a value estimated from the diamond-drill records and confirmed by electrical surveys. The results for the diabase dyke are shown in Fig. 7, from which an estimate of about 600 ft. would be made. The vectors drawn from the observations taken at any distance from the point vertically above the centre of the dyke would be of no value and must be disregarded. The actual amount of overburden in this case is not known, but some preliminary experiments made over both the above dykes, in an effort to determine the vertical extent of the dyke, gave indications that the overburden above the diabase dyke is greater than that over the pyrrhotite vein.

A magnetic diabase dyke may be readily differentiated from a well-mineralized vein by an electrical method of geophysical surveying. Both the radiore and the resistivity methods indicated a good conductor over the nickel-pyrrhotite vein, and a very poor conductor for the diabase dyke, while magnetically they both gave similar indications. The strength of the magnetic indications

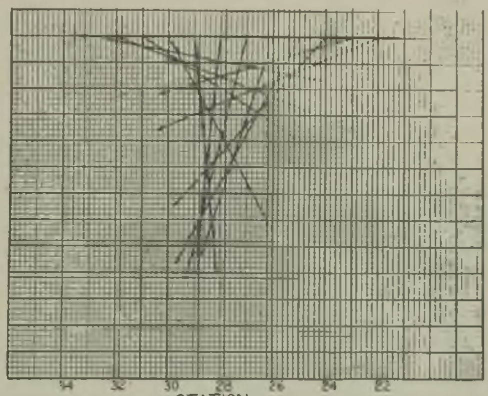


FIG. 7.—RESULTANT VECTORS OF MAGNETIC ANOMALIES ABOVE A DIABASE DYKE.

remained fairly constant along the diabase dyke, but varied considerably along the strike of the mineral vein. This difference was interpreted in the early stages of the investigation as indicating that the uncharted diabase dyke, which we located in the above experiments, was not a nickel pyrrhotite vein. Tracing the strike for more than two miles by such magnetic means, we finally came on an outcrop which confirmed the nature of the magnetic dyke.

The results presented in the paper indicate a few of the possibilities of magnetic surveys in geophysical prospecting. The ordinary dip-needle might be used in place of the variometers, but the sensitivity of the former is so much less than that of the latter, that, in many cases, the required accuracy of measurement could not be obtained.

EXPLOSIVE CRUSHING

Report of Investigations 3118 of the United States Bureau of Mines deals with the "explosive crushing" of minerals and covers investigations by R. S. Dean and J. Gross into the explosive shattering of minerals as a substitute for crushing preparatory to ore dressing. The authors say that the principle of explosive crushing depends upon the fact that an expandable substance contained within the pores of a solid body will disrupt such a body upon expansion. Such expansion may be obtained by the detonation of an explosive or by the sudden release of pressure of a superheated liquid. That this principle of disruption may be applied to minerals rests on the fact that cracks, cleavage planes, and pores exist in all minerals. Crushing by this method takes advantage of forces applied from within the mineral rather than from forces applied from without. A consideration of the possibilities of such a method for crushing led to some experimental work of a preliminary nature, the results of which are embodied in the report.

Explosives.—The detonation of an explosive confined within the open spaces of a mineral offers a fertile field. This may be accomplished by the impregnation of the mineral with an explosive or the explosive may be formed *in situ* by allowing the reaction for the formation of the explosive to take place within the mineral.

The bulk of the experiments carried out made use of the expansive power of water when suddenly released from pressure at a temperature sufficiently high to convert the water to steam. The experiments were made in a cylinder 2 in. in diameter by 4 in. long, fitted at one end with a cover held in place by a trigger which could be suddenly released when desired. Upon heating the cylinder a pressure was produced by the steam, such pressure being recorded on a gauge. Results of experiments made with 100 grams of 4 to 6 mesh quartz soaked in water one day were as follows :—

Heated to pressure	*Crushed to minus* 6 *mesh*
lb.	%
30	1
60	5¼
80	9¼
100	16
120	22½
150	33
180	37

These results indicate that the crushing falls off with higher pressures.

Results of experiments with 100 grams of 4 to 6 mesh galena soaked in water one day were as follows :—

Heated to pressure, lb.	*Crushed Product, %* + 6	6/14	14/48	48/200	− 200	*Percentage crushed to minus 6 mesh*
50	87·7	7·9	0·9	0·9	2·6	12·3
100	63·4	24·1	6·7	2·2	3·6	36·6
150	46·5	33·7	12·5	3·5	3·8	53·5
180	46·2	33·0	13·1	3·5	4·2	53·8
210	50·6	22·3	18·1	4·8	4·2	49·4

These results indicate, as did those with quartz, that the crushing falls off with higher pressures. It is also interesting to note that the production of minus 200 mesh increases very slowly with higher pressures, which may indicate a small percentage of useless grinding. By comparing the quartz data with that of the galena, it is seen that the greatest differential crushing takes place at about 150 lb. pressure.

One hundred grams of 4 to 6 mesh quartz was taken and, after soaking, the excess water was drained off and a measured amount added, all exploded at 150 lb. pressure.

Soaked in water. Days	*Water added after draining. c.c.*	*Crushed to minus* 6 *mesh.* %
4	0	1·0
4	5	1·5
4	10	6·5
5	15	14·8
1½	15	11·2
3	20	13·8
3	25	14·9
3	30	22·2
4	35	26·6
4	40	30·5
4	50	35·6
4	60	29·7

These results indicate that the maximum results are obtained with 50 c.c. of water. There is also some indication that time of soaking has an effect. Tests were made with 100 grams 4 to 6 mesh quartz to which 50 c.c. water had been added after draining off excess of soaking water. All exploded at 150 lb. pressure.

Soaked in water	*Percentage crushed to minus* 6 *mesh*
15 minutes	34·2
1 day	40·4
2 days	41·6
3 days	42·5
4 days	49·2
5 days	47·0
6 days	47·0

These results indicate that several days' soaking are required with quartz for maximum results. This series was made with a different sample and shows a considerably higher per cent crushed than the former quartz experiments. The reason for the difference in crushing in the two samples has not yet been investigated.

One experiment only on a larger charge of quartz was made ; 400 grams (the full capacity of the apparatus) of 4 to 6 mesh quartz, after soaking two days in water, was drained and 125 c.c. of water added to the quartz in the explosion chamber. This amount of water was just enough to cover the quartz. This charge was exploded at 150 lb. pressure and resulted in 34·8% crushed to minus 6 mesh. This result is smaller than the two-day soak experiment in the previous table.

Several samples of iron ore and one sample of Tri-State jig tailings were received from the Rolla station and subjected to explosive crushing. The sized products were analysed to determine whether selective crushing took place. A sample of iron ore from Woodward County, Ala., all of which had been crushed to pass a ½-in. sieve was soaked two days in water and exploded at 150 lb. pressure. The results, which follow, are an example of easily crushed material with little selective crushing.

Size of product, mesh	*Head sample,* %	*Crushed product.* %	*Fe,* %	*Insol.* %	*CaO,* %
Plus 4	63·0	18·2	28·4	30·4	17·2
4/14	20·5	30·8	26·0	42·4	8·8
14/48	11·9	36·7	32·1	36·0	8·2
48/200	2·9	8·8	37·3	28·0	9·6
Minus 200	1·7	5·5	32·4	34·0	6·9
Average	—	—	30·0	36·1	10·1

A sample of iron-ore jig tailings from the Patrick mine, Minn., which had been crushed to pass a ½-in. sieve was soaked in water for two days and exploded at 150 lb. pressure. The results, which follow, show that, while this ore is not so easily crushed as the previous one, it gives a more selective crushing.

Size of product, mesh	*Head sample,* %	*Crushed product.* %	*Fe,* %	*Insol.* %
Plus 4	65·2	50·4	31·5	26·2
4/14	14·4	19·9	48·0	24·8
14/48	6·1	8·8	50·8	20·6
48/100	6·9	8·7	42·1	32·8
Minus 200	7·4	12·2	34·1	44·0
Average	—	—	37·7	28·0

A sample of jig tailings from the Tri-State district did not crush easily, but resulted in good selective crushing both for lead and zinc. These tailings were soaked in water for two days and exploded at 150 lb. pressure. The results follow :—

Size of product, mesh	*Head sample,* %	*Crushed product.* %	*Pb,* %	*Zn,* %	*Metal in each size,* % *Pb*	*Zn*
Plus 4	41·9	34·9	0·85	1·70	20·9	28·9
4/14	49·4	44·8	0·35	1·15	11·1	25·5
14/48	7·6	13·2	3·50	2·40	32·2	15·7
48/200	0·6	4·1	8·60	6·90	24·5	13·7
Minus 200	0·5	3·0	5·20	10·90	11·2	16·2
Average	—	—	1·43	2·04	—	—

These results on ores, while not startling, may be looked upon as encouraging and worthy of further experiment. The work, so far, has been done with a rather crude apparatus and has been in the nature of a preliminary investigation in a new and promising field.

The temperature attained at 150 lb. pressure is 180° C. On an ore charge of 4 parts ore to 1 part water by weight and taking the specific heat of ore at 0·25, the heat capacity of the ore is the same as that of the water. On a basis of 1 ton of ore, 500 lb. of water would be used, and this would require : $130 \times 2 \times 500 = 130{,}000$ heat units for a 1-ton ore charge. Assuming coal at 8,000 heat units per lb., 16 lb. of coal would be required per ton of ore at 100% coal burning efficiency. On a basis of 30% coal burning efficiency, approximately 50 lb. of coal would be burned. At a cost of $2 per ton of coal, this would make a fuel cost of 5 cents per ton of ore. These figures are held to show that from a cost standpoint the method has great possibilities, even without any regeneration of heat.

TELLURIDE MINERALS AT KALGOORLIE

The occurrence of telluride minerals at Kalgoorlie is described by Dr. F. L. Stillwell in the *Proceedings* of the Australasian Institute of Mining and Metallurgy (N.S. 84). The author reminds us that the announcement of the occurrence of tellurides at Kalgoorlie by A. G. Holroyd in the *Kalgoorlie Miner* on May 29, 1896, followed by their discovery in comparative abundance, stimulated the further study of these minerals. In this locality there is a general absence of well-formed crystals, and the knowledge gained has been confined to the record and description of previously known, but exceedingly rare, species. No new species has been recorded, but the intimate association of various species resulted in the early description of two supposedly new species, kalgoorlite and coolgardite. These have been discredited since the investigation by L. J. Spencer in 1903, based on a collection of specimens presented to the British Museum. Spencer's list of species at Kalgoorlie comprises calaverite, sylvanite (or krennerite), petzite, coloradoite, and altaite, and does not include hessite, previously mentioned by Krusch. In 1912 melonite and a copper telluride were added by J. A. Thomson, and the presence of hessite confirmed. In 1912 there also appeared a full and detailed account by E. S. Simpson on behalf of the W.A. Geological Survey, which embraced his earlier notes on the tellurides, and which represents the state of our knowledge of the Kalgoorlie minerals, practically as far as can be attained without the use of the reflecting microscope.

The position had been stationary for about 18 years, and it was thought that the best use to which a new collection of Kalgoorlie tellurides could be devoted was an attempt by mineragraphic methods to study the mineral relationships, not only of the tellurides among themselves, but also to gold and other associated minerals. The precise mineral content and relationships become a factor of added importance with the development of flotation methods of treatment at Kalgoorlie. Moreover, the study would supplement the description of the ore deposits of the Boulder Belt that has recently been published.

The following is the summary of the author's results, which appears at the end of his paper. He says that tellurium-bearing minerals occur in veinlets and segregations in the Kalgoorlie lodes and find their best development in the richer shoots of ore. The course of the veinlets is commonly transverse to the lodes and the schistosity of the rocks. The veinlets are generally very small, often of microscopic dimensions and, even in good specimens, seldom attain a width of more than 2 or 3 mm. and a length of a few centimetres. Only in rare specimens does the width of a veinlet reach 5 mm. when the length is greatly increased. When the ore is broken the fractures tend to run along the veinlets so that the tellurides frequently seem to occur in patches on the surface of a specimen. The veinlets are composed essentially of tellurium-bearing minerals. A little idiomorphic quartz and carbonate may be embedded in the tellurides as well as earlier-formed pyrite, chalcopyrite and fahl ore.

The observed species of telluride are altaite, coloradoite, melonite, rickardite, hessite, petzite, sylvanite, krennerite, calaverite, and nagyagite, with the possible addition of stützite. Of these, coloradoite, calaverite, and krennerite are the most abundant, and, together with the rarer altaite, melonite, and nagyagite, only occur in the unaltered primary ore. Rickardite occurs only as a secondary telluride, while hessite, petzite, and sylvanite may occur in both primary and secondary associations.

The gold-bearing tellurides are decomposed in the oxidized zone with the liberation of free gold alloyed with a little silver. Rare instances of the occurrence of silver chloride are mentioned in records, but the bulk of the silver has been removed in solution. Evidence of the downward percolation of silver-bearing solutions is disclosed in isolated specimens by the dissociation of the richer gold tellurides into sylvanite, petzite, and hessite.

Altaite.—The occurrence of altaite is widespread in microscopical amounts. Its best known locality is the Hidden Secret mine, where it occurs in veins of hessite and petzite. It is characterized by abundant microscopical inclusions of the silver sulphoselenide aguilarite. It occurs as minute inclusions in massive fragments of the gold-silver tellurides, as well as in specimens characterized by the lead minerals nagyagite, jamesonite, and bournonite. At Mulgabbie it is associated with krennerite in micrographic intergrowths.

Coloradoite.—Coloradoite is one of the most abundant primary tellurides whose association with particles of free gold is most conspicuous. It is generally free from included minerals and occasionally shows lamellar twinning.

Melonite.—The amount of nickel in the Kalgoorlie ores is very small, and the occurrence of melonite is usually limited to microscopical inclusions in calaverite and krennerite.

Rickardite.—The copper telluride, rickardite, is restricted in its occurrence to the zone of secondary tellurides, and has been formed by the action of descending copper-bearing solutions on primary gold-silver tellurides. The most noted locality is the intersection of a fault and a lode in the Kalgurli mine, a short distance below the oxidized zone. It is associated intimately, partly in the form of minute micrographic intergrowths, with particles of free gold derived from the decomposition of the gold telluride. In the initial stages of replacement a thin development of copper telluride takes place along the cleavage planes of krennerite. With increasing replacement the veins increase in width, and finally coalesce, producing dark masses of copper telluride and gold, with small amounts of an undetermined mineral. The etching behaviour of the Kalgurli copper telluride is very similar to that of chalcocite. Its composition is that of a mineral which has been recorded as weissite, a preoccupied name, and, pending further discovery, it is regarded as a solid solution of the cuprous and cupric tellurides for which the name rickardite is extended.

Hessite.—Hessite is an anisotropic mineral, which is recognized in polarized light by its intermittent and confused lamellar twinning. It is relatively abundant in the Hidden Secret ore in association with petzite and altaite. It also occurs sparingly throughout the Boulder mines, both in shallow and deep levels. In some cases it forms peculiar and intimate micrographic intergrowths with sylvanite, which possess a homogeneous appearance in the hand specimen. It also occurs as microscopical inclusions in the larger masses of fahl ore. Secondary hessite is recognized in veins that intersect crystals of krennerite from the locality of the copper telluride. It is associated in these veins with secondary petzite, while the same specimens contain veins of another mineral, which is regarded as probably stützite. It is inferred that these secondary silver minerals arise from the silver content of the replaced krennerite.

Petzite.—Petzite is widespread, and, except in special cases in the Hidden Secret and Kalgurli mines, is less abundant than other gold-bearing tellurides. It occurs both as a primary and secondary telluride. Its secondary occurrence includes the hessite-petzite veins in krennerite occurring with the copper telluride in the Kalgurli mine. It also develops with subordinate sylvanite and free gold from the dissociation of calaverite in the shallow levels. This type of change denotes a silver enrichment, and the origin of the silver is likely to be the decomposed tellurides in the oxidized zone.

Sylvanite and Krennerite.—Sylvanite is similar in composition and etching behaviour to krennerite, but it can often be distinguished from krennerite by its bireflection, lamellar twinning, and stronger anisotropism. Primary sylvanite occurs occasionally in association with calaverite, but more often with petzite and hessite. It has been recognized as a secondary mineral when developed as a paramorphic alteration of krennerite accompanying the development of copper telluride and when accompanying the dissociation of calaverite into petzite and free gold. Krennerite, which cannot always be distinguished from sylvanite, is probably the more abundant gold-silver telluride, which has only been recognized as a primary mineral.

Calaverite.—Calaverite is similar in etching and appearance to krennerite, but is distinguished from it by the absence of good cleavage and by a low silver content. Both minerals develop with HNO_3 a series of very fine etch lines, which seem to be due to a fine multiple twinning. Both on account of its abundance and its high gold value, calaverite is the most important economic telluride in Kalgoorlie.

Nagyagite.—Nagyagite is a very rare species of telluride at Kalgoorlie, and, apart from an isolated record in the Oroya Brownhill mine, has only been observed in two specimens, and a probable third. In one case it occurs with free gold, krennerite, and coloradoite, and is characterized by abundant inclusions of corroded particles of fahl ore, seligmannite, and coloradoite. In the second specimen the telluride species is mostly petzite with small amounts of altaite and sylvanite. A crystal of nagyagite is totally free from inclusions and surrounded by a micrographic intergrowth of petzite and seligmannite, except where in contact with fahl ore. In the third instance it appears to form a narrow film with free gold along part of the wall of a vein of krennerite and coloradoite. The observations suggest that nagyagite arises by an interaction between the earlier sulphides and the later tellurides, and that it tends to be unstable under the natural conditions which produced considerable quantities of calaverite, krennerite, and coloradoite.

Associated Metallic Minerals.—The metallic minerals associated with the primary ore of Kalgoorlie are: Native gold, pyrite, pyrrhotite, arsenopyrite, fahl ore, seligmannite, bournonite, enargite, jamesonite, stibnite, galena, sphalerite, chalcopyrite, hæmatite, and magnetite.

Native gold occurs not infrequently in narrow veinlets and rough particles which are visible to the naked eye, but the larger portion of the native gold occurs in particles of microscopical dimensions. The fine particles occur disseminated through the ore, and are, for the most part, absent from the telluride veinlets.

Pyrite is the most abundant sulphide, and is usually detached from the gold and telluride particles, which were deposited later than pyrite. Pyrrhotite has not been observed in polished sections of Kalgoorlie ores, but it takes the place of pyrite in telluride ore from Mulgabbie. Arsenopyrite is an unusual constituent and only occurs sporadically. Fahl ore includes the antimonial tetrahedrite and the arsenical tennantite, and is the most important sulphide found within the telluride veinlets. It also occurs in the quartz veins and segregations that are associated with the lodes. Many of the small crystals of fahl ore are free from inclusions, but larger masses may enclose particles of sphalerite and chalcopyrite and other minerals, of which the most noteworthy are native gold and hessite. It has been found to be intersected by veins of secondary covellite just below the oxidized zone.

Seligmannite is a rare sulphide that has been recognized in specimens containing nagyagite. In once case it occurs as inclusions in nagyagite, and in the other it forms a fringing micrographic intergrowth with petzite. Bournonite is also rare, and occurs in association with sphalerite and jamesonite. Enargite occurs as inclusions in jamesonite, and in rare cases is in contact with tellurides. In the Mulgabbie ore it is noteworthy as a fringing sheath separating chalcopyrite from the tellurides. The antimonial lead mineral, called jamesonite, is a rarity from the Ivanhoe mine, as are also the occasional segregations of stibnite. Galena is uncommon, and has been found as inclusions in fahl ore. Sphalerite is not so infrequent, and usually contains numerous inclusions of chalcopyrite. Chalcopyrite is fairly common, and, with fahl ore, absorbs the copper in the primary mineral solutions. Like fahl ore, chalcopyrite is often a constituent of the telluride veinlets, and, in the vicinity of the oxidised zone, it may be replaced by chalcocite and covellite. The iron oxides, hæmatite and magnetite, are common in the vein-altered greenstones, in the ore-bodies, and in the quartz-veins and segregations. Magnetite is sometimes visible as well-defined octahedra. Hæmatite sometimes appears as specular iron with brilliant lustre. More often the two oxides are intergrown in shapeless masses with dull lustre.

Occurrence of Selenium.—Selenium is present in small quantities in the Kalgoorlie tellurides. It is accounted for in altaite by the presence of inclusions of aguilarite. In the gold-silver tellurides it is considered to be possibly due to inclusions of a selenide-mineral which has not been distinguished from altaite, but which may be a mineral similar in type to the lead seleno-sulphide, naumannite. Evidence is insufficient to exclude the possible presence of a combination of selenium with mercury.

Shinyanga Diamond Fields.—In Short Paper No. 9 of the Geological Survey Department of Tanganyika Territory, Dr. E. O. Teale reviews the geology and probable past geographical history of the region, making, as he says, an attempt not only to show what is known of the region, but also to point out those unsolved problems that materially affect the question of the source of the detrital diamonds. The author emphasizes how obscure are some of these points, how little is really definitely established, and the need for further detailed observation of minerals and rocks of the region. Regarding the Kizumbi detrital diamonds, the author states that the bulk of the evidence appears to be in favour of a source which should not be very distant. It may be that it is buried beneath superficial deposits of clay or "cement." Both from the point of view of immediate further return of detrital diamonds and as a possible source of the payable pipe, it is believed that the area in the vicinity of Boshoff's claims, still covered with "cement," deserves systematic attention. Until the floor of the old valley of the region under the "cement" is definitely traced and proved, the area cannot be condemned, and it may have important treasures awaiting recovery. All detrital deposits including "cement," gravels, high level or present river material, deserve close attention.

Milling Methods at Minas de Matahambre, South America.—Milling methods and costs at Minas de Matahambre, South America, in the province of Pinar del Rio, Cuba, are described in Information Circular 6,544 of the United States Bureau of Mines, by A. R. Kirchner, J. V. Galloway, and W. P. Schoder. The ore treated is a copper ore containing 4·55% copper and consisting of chalcopyrite associated with pyrite in a gangue of shale and quartzite. The authors give a brief history of the milling operations and the changes in practice together with comparisons of capacities and costs of operation for the years, 1922 to 1930, inclusive. Flow sheets are included for the different sections of the plant ; crushing, primary grinding, secondary grinding and classification, flotation, dewatering, thickening, water supply and power distribution. The unit costs of the principal operations are shown on the flow sheets for the year, 1930, and are summarized in a table at the end of the paper. The various operations are discussed in the text, and tables are presented showing the screen sizes of heads, concentrates and tails together with the assays of each size. The use of various reagents in the flotation circuit, the effect of different reagents and the consumption and cost of each per ton of ore are discussed in some detail.

SHORT NOTICES

Square-Set Mining. — In *Engineering and Mining Journal* for March, M. J. Elsing deals with the cost of square-set mining.

Shaft Sinking.—The first of a series of articles on shaft-sinking equipment, by Lucien Eaton, appears in *Engineering and Mining Journal* for March.

Shovelling and Sweeping. — Notes of shovelling and sweeping on the New State Areas, Ltd., with special reference to the conservation of fines created by the blast, by J. D. Mackenzie and R. S. Tompson, appear in the *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa for January.

Sampling with Hammer Drills.—In Information Circular 6594 of the U.S. Bureau of Mines, J. B. Knaebel discusses sampling and exploration by means of hammer drills.

Koepe Hoisting. — A. Schurig deals with improvements in koepe hoisting in *Engineering and Mining Journal* for March.

Dust Prevention.—P. H. Hay discusses dust prevention in mines in the *Chemical Engineering and Mining Review* of Melbourne for January 5.

Mine Cages.—The coupling of mine cages is discussed by M. L. Lahoussay in *Revue de l'Industrie Minérale* for February 15.

Cement-Gun Control of Loose Ground.—In *Engineering and Mining Journal* for March, T. E. Smith describes cement-gun control of loose or of moving ground.

Mine Statistics.—Operating statistics as applied to the engineering department of a mine are given by G. Hildick-Smith in the *Journal* of the South African Institute of Engineers for February.

Cyanide Practice.—A review of de-aeration of cyanide solutions by F. Wartenweiler appears in the *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa for January.

Pyrite Flotation.—W. G. Hubler describes the flotation of pyrite at the Aldermac mine, Quebec, in the *Canadian Mining and Metallurgical Bulletin* for March.

Gold Assay.—W. Branch Pollard describes a method for the volumetric assay of gold in the *Bulletin* of the Institution of Mining and Metallurgy for March.

Sherritt Gordon Mill.—R. C. Mott gives a description of the mill at the Sherritt Gordon mine, Manitoba, in the *Canadian Mining Journal* for March.

Electrolytic Zinc.—The production of zinc by electrolysis is discussed by Harry Hey in the *Chemical Engineering and Mining Review* of Melbourne for February 5.

Magnetic Surveying.—F. W. Lee gives the results of some magnetic measurements on dykes, with experiments upon geophysical differentiation of nickel-ore deposits in the Sudbury district of Ontario, in Technical Paper 510 of the United States Bureau of Mines.

Magmatic Chromite.—In *Economic Geology* for March–April, E. Sampson describes magmatic chromite deposits in Southern Africa.

Native Silver.—The results of a metallographic investigation of native silver by Sir H. C. H. Carpenter and M. S. Fisher appear in the *Bulletin* of the Institution of Mining and Metallurgy for March.

Great Bear Lake, Canada.—D. F. Kidd describes a pitchblende-silver deposit at Great Bear Lake, Canada, in *Economic Geology* for March–April.

Norwegian Magnetite.—The magnetite mines of Fosdalen, Norway, are described by E. Mossberg in *Metall und Erz* for March 1.

Lake Superior Iron.—Details of operating practice and equipment in the mines of the Lake Superior region of Michigan, U.S.A., are given by A. H. Hubbell in *Engineering and Mining Journal* for March.

Gold Production.—L. C. Graton deals with future gold production from the geological outlook in the *Transactions* of the American Institute of Mining and Metallurgical Engineers, 1931.

RECENT PATENTS PUBLISHED

☛ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C.2, with a note of the number and year of the patent.*

21,343 of 1930 (365,606). R. Peale, W. S. Davies and W. B. Oakes, New York. Coal and other intermixed divided materials are separated by a process which involves first a subjection to loosening and lifting by air currents and then, after passing over a screen, the re-subjection of the coarse product to the primary separation process.

31,783 of 1930 (366,015). E. J. Kohlmeyer, Berlin-Charlottenburg, Germany. A process for the treatment of silica-bearing materials based on the recognition that by heating an intimate mixture of the silicic-acid-containing material with the necessary quantities of zinc sulphide and carbon at low temperatures, the entire silicon content can be vaporized.

32,133 of 1930 (366,114). H. Salmang, Aachen, Germany. Tridymite bricks are manufactured by a process in which, for the conversion of the quartz, two oxides are present in addition to lime in chalk, one of these additional oxides being an alkali.

32,139 of 1930 (366,020). British Thomson-Houston Company and H. de B. Knight, Rugby. An electrical method which permits of the quantitative measurement of firedamp in mine atmospheres.

32,571 of 1930 (366,123). W. E. V. Abraham, Burmah Oil Company, Upper Burma. An improved clinometer for use in bore-holes.

33,982 of 1930 (367,013). A. G. McGregor, London. Electrolytic refining of copper and other metals which involves the use of thick anodes, the electrolysis being carried out in stages by periodically removing the anodes and stripping the deposited cathode plates.

34,093 of 1930 (366,168). Dr. M. Lissauer, H. Lissauer, and B. Griesmann, Cologne. Non-ferrous metals are separated from molten metalliferous materials by a process in which the nature of the combustion gases at the surface of the melt and the amount of reducing gases passed through the melt per unit period are adjusted so that neutrality obtains at the surface of the melt, the metal being thereby produced in a reguline form.

34,963 of 1930 (366,628). Dr. M. Lissauer, H. Lissauer, and B. Griesmann, Cologne. Small amounts of volatile metals are separated from molten metallic copper by a process in which reducing gases are introduced into the fluid metal bath.

36,606 of 1930 (365,725). T. W. Keet, Klerksdorp, South Africa. An improved crushing device for ores or sands.

6,603 of 1931 (367,194) and **6,749 of 1931 (367,196).** E. C. Saint-Jacques, Paris. An elutriation apparatus for the separation of materials by pneumatic means.

11,822 of 1931 (365,903). J. R. Williams, Johannesburg. Precious metals are recovered from ores or other materials by the method in which a pulp of metalliferous material containing bisulphate of soda as an activator is passed over a surface coated with an amalgam of a metal high in the electropositive series, such as zinc.

12,864 of 1931 (365,915). American Cyanamid Company, New York. A method of recovering minerals from ores by flotation in the presence of a water-soluble salt of secondary butyl xanthate as a promoter.

17,376 of 1931 (365,964). P. Gamichon, Paris. A combined chlorinating and sulphating roast process for the conversion of the metals in lead-bearing ores into soluble salts.

NEW BOOKS, PAMPHLETS, Etc.

☛ Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London, E.C. 2.

Aus der Geschichte des österreichischen Eisenwesens. Die österreichisch - Alpine Montangesellschaft, 1881-1931. Cloth, quarto, 537 pages, illustrated, with maps. Price RM 21. Vienna : Julius Springer.

Leitfaden der Tiefbohrtechnik. By P. Stein. Paper covers, 52 pages, illustrated. Price RM 4·20. Berlin : Julius Springer.

A Textbook of Organic Chemistry. By Dr. J. Schmidt. Cloth, octavo, 843 pages, illustrated. Price 25s. London : Gurney and Jackson.

British Red Cross Society Tropical Hygiene Manual No. 10. By Major D. T. Richardson. Limp cloth, 218 pages, illustrated. Price 2s. London : Cassell.

Studies of Geophysical Methods, 1928 and 1929. Canadian Geological Survey Memoir 165. Paper covers, 225 pages, illustrated, with maps. Price 45 cents. Ottawa : Department of Mines.

Quebec Mineral Production, 1931 : Preliminary Statement. Paper covers, 9 pages. Quebec : Bureau of Mines.

Quebec Bureau of Mines, 1930 ; Annual Report, Part D. Paper covers, 233 pages, illustrated, with maps. Quebec : Bureau of Mines.

Hydrogenation : Status of Hydrogenation of Petroleum, Bitumen, Coal Tar and Coal. By T. E. WARREN, Canadian Department of Mines Memorandum Series No. 52. Typescript, 12 pages. Ottawa : Department of Mines.

Oil-Shale : A world survey of recent oil-shale developments. By A. A. SWINNERTON. Canadian Department of Mines Memorandum Series No. 53. Typescript, 9 pages. Ottawa : Department of Mines.

Piet Retief : The Geology of the Country South of Piet Retief ; An explanation of Sheet No. 68, S.A. Geological Survey. By Dr. W. A. HUMPHREY and Dr. L. J. KRIGE. Paper covers, 72 pages, including map. Price 5s. Pretoria : Department of Mines and Industries.

Tanganyika Territory : Geological Survey Annual Report, 1930. Paper covers. 34 pages, illustrated. Price 2s. 50c. Dodoma : Geological Survey Department.

South Australia.—Mining Review for half-year to June, 1931. No. 54. Paper covers, 134 pages, illustrated. Adelaide : Department of Mines.

South Australia.—Annual Report of the Director of Mines and Government Geologist, 1930. Paper folio, 8 pages, with map. Adelaide : Department of Mines.

U.S. Bureau of Mines : List of Publications, 1910-1931. Paper covers, 241 pages. Washington : Superintendent of Documents.

Mineral Resources of the United States, 1930. Part I, pp. 267-296, Cobalt, Molybdenum, Titanium, and various rare metals, by P. M. TYLER and A. V. PETAR ; pp. 297-332, Manganese and Manganiferous Ores, by R. H. RIDGWAY ; pp. 355-383, Tin, by C. W. MERRILL. Part II, pp. 247-261, Lime, by A. T. COONS ; pp. 263-275, Asbestos, by O. BOWLES and B. H. STODDARD ; pp. 291-301, Barytes and Barium Products, by R. M. SANTMYERS and B. H. STODDARD ; pp. 333-373, Stone, by A. T. COONS. Washington : Superintendent of Documents.

Forty Years in Africa. By MAJOR TUDOR G. TREVOR. Cloth, octavo, 278 pages, illustrated. Price 12s. 6d. London : Hurst and Blackett.

COMPANY REPORTS

Crown Mines.—This company was originally formed in 1892, the present name being adopted in 1909. It works a gold mining property on the Central Rand. The report for 1931 shows 3,612,914 tons of ore was mined and sent to the mill, where, after sorting out 475,014 tons as waste, 3,136,000 tons was crushed, 986,328 oz. of gold being recovered, worth £4,185,660. Silver and osmiridium brought the total revenue up to £4,193,349, equal to 26s. 9d. per ton milled. Working costs amounted to £3,099,300, and the working profit to £1,094,049, of which £660,144 was absorbed as dividends, equal to 70%. The ore reserves at the end of the year were estimated to be 10,578,940 tons, averaging 6·53 dwt. over a stoping width of 47·8 in. These figures show an increase in the total reserve of 712,180 tons, the Main Reef Leader reserve being increased by 909,370 tons, while reserves on the South Reef fell by 197,190 tons. There is a decline in value by 0·17 dwt. in the value of the Main Reef Leader reserve, which is associated with an increase of 1·7 in. in stoping width.

Robinson Deep.—This company was formed in 1915 and in 1930 it acquired the Village Deep, the joint property being situated on the Central Rand. The report for 1931 shows that 1,348,827 tons of ore was mined and, after sorting out 190,827 tons as waste, 1,158,000 tons was sent to the mill, where 334,456 oz. of gold was recovered, worth £1,420,292. The working profit amounted to £291,530, or 5s. 0·422d. per ton milled, and £155,052 was absorbed as dividends, equal to 3s. on each " A " share and 10½d. on each " B " share. The fully developed ore reserves at the end of the year were estimated to be 2,592,000 tons, averaging 5·9 dwt. over a stoping width of 60 in., as compared with 2,397,000 tons, of the same value over 58 in.

Simmer and Jack Mines.—This company has worked a gold mining property on the East-Central Rand since 1887. The report for the year 1931 shows that of 1,172,413 tons of ore mined, 245,613 tons was sorted as waste, while 926,800 tons went to the mill where 262,548 oz. of gold was recovered, worth £1,115,512. The working profit for the year amounted to £135,798, equal to 2s. 11·166d. per ton milled. A dividend paid during the year absorbed £41,667, equal to 6⅔%. The fully-developed ore reserves at the end of the year were estimated to be 1,558,700 tons, averaging 6·0 dwt. over a stoping width of 50 in., a decrease of 66,300 tons in amount and of one inch in stoping width when compared with the previous year.

Government Gold Mining Areas.—This company was formed in 1910 and works a gold mining property on the Far East Rand. The report for 1931 shows that 2,937,218 tons of ore was mined and, after allowing for the sorting of waste and addition of ore from stock, 2,435,000 tons was crushed, 1,129,873 oz. of gold being recovered, in addition to 1,275 oz. of osmiridium concentrates. The revenue amounted to £4,799,396, or 39s. 5d. per ton, while working costs were £2,087,626, or 17s. 1·7d. per ton. The working profit was £2,711,770 and £1,260,000 was absorbed as dividends, equal to 90%, the Government's share of the profits being £1,458,998. The ore reserves at the end of the year were estimated to be 10,510,000 tons, averaging 8·9 dwt. over a stoping width of 60 in.

New State Areas.—This company was formed in 1918 to work a gold mining property on the Far East Rand. The report for 1931 shows that 1,425,851 tons of rock was mined, 1,252,100 tons being sent to the crusher station where, after sorting out waste, 958,000 tons was milled. The gold yield amounted to 479,205 oz., in addition to which 325 oz. of osmiridium concentrates was recovered. The revenue amounted to £2,035,533, equal to 42s. 5·9d. per ton milled, working costs being £1,084,052, or 22s. 7·6d. per ton. The working profit was £951,481, of which £302,807 was distributed as dividends, equal to 20%, the Government share of the profits being £552,732. The ore reserves at the end of the year, excluding ore of less value than 4·5 dwt., were estimated to be 2,737,000 tons, averaging 8·9 dwt. over a stoping width of 50 in.

Randfontein Estates.—Originally formed in 1889, this company works an amalgamation of gold mining properties on the Far West Rand. The report for 1931 shows that 3,450,509 tons of ore was mined, of which 2,855,587 tons was sent to the crusher station, 2,751,000 tons being milled, 178,000 tons more than in the previous year. The gold recovered amounted to 745,313 oz., 500 oz. of osmiridium concentrates being recovered in addition. The revenue from gold and osmiridium amounted to £3,172,726, the working profit being £595,628, which was £183,108 more than the profit for 1930. A dividend paid during the year absorbed £101,589, equal to 2½%, while £146,400 was used for the redemption of debentures. The ore reserves at the end of the year were estimated to be 6,324,000 tons, with an average value of 6·2 dwt. over a stoping width of 42 in. The development of this mine is now in an interesting stage, the year's development work confirming the anticipations of a progressive flattening of the reefs, which are expected to assume a reverse dip farther east, towards the Witpoortje fault.

Van Ryn Deep.—This company was formed in 1902 and works a gold mining property on the East Rand. The report for 1931 shows that 925,797 tons of ore was mined, while 138,762 tons was obtained from reclamation work, the tonnage finally milled, after sorting out waste, being 753,000. The gold recovered amounted to 268,938 oz., while, in addition, 114 oz. of osmiridium concentrates was recovered. The revenue amounted to £1,142,380, equal to 30s. 4·1d. per ton, against 32s. 9·5d. in 1930, while the working costs totalled £807,110, or 21s. 5·2d., against 20s. 10·3d. The working profit, at £335,270, was £124,000 less than in 1930 and dividends absorbed £299,223, equal to 25%. The ore reserves at the end of the year were estimated to be 2,669,000 tons, averaging 6·7 dwt. over a stoping width of 48 in.

Langlaagte Estate.—Formed in 1888, this company works a gold mining property on the Central Rand. The report for 1931 shows that 978,054 tons of ore was mined—533,039 tons from the Main Reef Leader and 445,015 tons from the South Reef—the tonnage milled, after sorting out waste, being 943,000. The gold yield totalled 317,660 oz., while 76 oz. of osmiridium concentrates was also recovered, the revenue from gold and osmiridium amounting to £1,351,425. The working profit was £370,376—a decrease of £15,269 on the previous year's results, £303,967 being absorbed as dividends, equal to 20%. The ore reserves at the end of the year were estimated to be 1,190,000 tons, averaging 7·2 dwt. over a stoping width of 44 in.

Witwatersrand Gold.—This company, formed in 1887, operates a gold mining property on the East Rand. The report for 1931 shows that 817,251 tons of ore was taken from the mine, 717,500 tons being crushed after waste had been sorted. The gold yield totalled 145,818 oz., the revenue being £620,562. The working profit dropped from £37,955 in 1930 to £8,241 in 1931 on account of a fall in revenue of 1·43s. per ton. Dividends paid during the year absorbed £23,481, equal to 5%, revenue from other sources having brought in £26,040. The ore reserves at the end of the year were estimated to contain 265,000 tons, averaging 5·5 dwt. over a stoping width of 52 in.

Durban Roodepoort Deep.—This company, formed in 1895, works a gold mining property on the West Rand. The report for 1931 shows that 645,700 tons of ore was sent to the mill, where, after sorting out waste, 565,200 tons was crushed, yielding 183,019 oz. of gold, worth £776,718, silver and osmiridium bringing the total revenue up to £777,928, or 27s. 6d. per ton milled. Working costs amounted to £690,409 and the working profit to £87,519, of which £56,250 was absorbed as dividends, equal to 15%. The available ore reserves at the end of the year were estimated to be 2,150,200 tons, averaging 6·72 dwt. over a stoping width of 49·8 in.

East Rand Proprietary.—Formed in 1893, this company now works an amalgamation of gold mining properties on the East Rand. The report for the year 1931 shows that the crusher station received 2,096,300 tons from the mine and that, after sorting out waste, 1,866,200 tons was sent to the mill. The gold yield totalled 501,085 oz., worth £2,125,988, the value of the osmiridium and silver recovered bringing the total revenue up to £2,129,986. Working costs totalled £1,976,805, and the working profit £153,182, of which £75,000 was absorbed as a dividend, equal to 5%. The available ore reserves at the end of the year were estimated to be 3,519,480 tons, averaging 6·3 dwt. over a width of 59 in., an increase of 264,220 tons in the total reserve being registered.

Geduld Proprietary. — This company was formed in 1899 and works a gold mining property on the Far East Rand. The report for 1931 shows that 1,012,100 tons of ore was mined and sent to the mill, where 323,611 oz. of gold was recovered, worth £1,371,731. Working costs amounted to £823,686, and the working profit to £548,047, or 10s. 9·97d. per ton milled. Dividends paid during the year absorbed £493,039, equal to 33⅓%. The ore reserves at the end of the year were estimated to be 5,900,000 tons, averaging 6·6 dwt. in value over a stoping width of 59 in., a decrease of 100,000 tons, when compared with the end of the previous year.

Modderfontein Deep.—Formed in 1899, this company works a gold mining property on the Far East Rand. The report for the year 1931 shows that 669,000 tons of ore was mined, the tonnage milled, after sorting out waste, being 533,800. The gold yield totalled 268,790 oz. and the revenue from gold, silver, and osmiridium amounted to £1,142,334, or 42s. 9·6d. per ton milled. Working costs amounted to £416,217 and the working profit to £726,117, or 27s. 2·47d. per ton milled, while £600,000 was distributed as dividends, equal to 120%. The ore reserves at the end of the year were estimated to be 1,600,000 tons, averaging 8·3 dwt. over a stoping width of 78 in., which represents a decrease of 450,000 tons in amount, of 0·3 dwt. in value, and of 1 in. in width when compared with the figures at the end of 1930.

City Deep.—This company was formed in 1899 and works a deep level property on the Central Rand. The report for the year 1931 shows that 1,134,180 tons of ore was mined, the tonnage milled, after sorting out waste, being 1,021,000. The amount of gold recovered was 264,018 oz., which realized £1,120,328, silver and osmiridium bringing the total revenue up to £1,121,968, or 21s. 11·7d. per ton milled. Working costs totalled £1,123,594, the working loss being £1,626. The reorganization of the mine in order to work on a reduced scale was completed by August of the year under review and the mine is now working at a profit. The available ore reserves at the end of the year were estimated to be 1,323,800 tons, averaging 6·08 dwt. in value, over a stoping width of 42·9 in., an increase of 55,600 tons in amount and of 0·1 dwt. in value, as compared with the figures at the end of 1930.

Witwatersrand Deep.—Formed in 1895, this company works a gold mining property on the East Rand. The report for the year 1931 shows that 439,939 tons of ore was mined and, together with 2,961 tons taken from the surface dumps, sent to the mill, where 442,900 tons was milled, 103,779 oz. of gold being recovered, worth £439,211. The working costs were £449,097, the working loss being £9,886. This loss has largely resulted from the pressure burst, which occurred in the West Incline Shaft in April of the year under review, and which affected the tonnage milled to the extent of 55,100 tons. This shaft was completely repaired by the end of the year. The payable ore reserves at the end of the year were estimated to be 583,800 tons, averaging 6·4 dwt. over a stoping width of 48 in., an increase of 1,200 tons as compared with the previous year.

Tweefontein Colliery.—Formed in 1907 this company has interests in Tweefontein United Collieries, Ltd. The report for 1931 shows the output of the Tweefontein Collieries to have been 725,977 tons, as compared with 791,383 tons for the previous year. Electric coal cutters have now been installed at the mines, but the outlook for the current year is considered uncertain. The gross revenue of Tweefontein Colliery, Ltd., was £22,558 and, after allowing for the sum of £37,309 brought in and other allowances, there was an available total of £41,640, of which £10,500 has been absorbed as dividends, equal to 12½% on the ordinary and 4% on the preference shares, leaving £31,140 to be carried forward.

Rezende Mines.—Originally formed in 1908, this company now works mining properties at Rezende, Umtali, Southern Rhodesia. The report for the year 1931 shows that 76,400 tons of ore was milled, exactly as in 1930, the revenue per ton milled rising from 36s. 2d. to 37s. 8d., the working profit being £72,567, equal to 19s. per ton. Dividends declared during the year absorbed £39,375, while £19,700 was written off against the Reliance and Monarch options, which have been abandoned. The ore reserves at the end of the year were estimated to be 159,000 tons, averaging 8·7 dwt., as compared with 180,000 tons, of the same value, at the end of the previous year. Small interests have been taken in an alluvial gold mining venture in Portuguese East Africa and an option over the Taba Mali gold mine, near Que Que.

Lower Bisichi (Nigeria) Tin.—This company was formed in 1912 and works an alluvial tin mining property in Northern Nigeria. The report for the year to September 30 last shows the output of tin concentrates to have been 71 tons, as against 89 tons in the previous year, the amount received per ton being £79 18s. 6d,, against £98 14s. 2d. The profit for the year was £292, increasing the balance carried forward to £2,628.

Mysore Gold.—This company, formed in 1880, works a gold mining property in the Kolar district of Mysore, Southern India. The report for 1931 shows that 93,871 oz. of gold (including 5,289 oz. from rich pillars) was produced from 182,731 tons of ore milled, while 2,171 oz. was recovered in clean-up of plant. The net revenue from the sale of gold, after allowing for royalty and refining charges, was £425,554, sundry other revenue bringing the total up to £432,629. Working costs amounted to £310,220 and the profit to £122,409. A dividend equal to 1s. per share has been paid for the year, leaving a balance of £7,231 to be carried forward. The reserves of ore at the end of the year were estimated to be 445,260 tons, 26,158 tons less than at the end of the previous year. Prospects in depth are considered encouraging and negotiations have been opened with the Mysore Government with regard to the terms of the leasehold mining rights beyond March, 1940.

Nundydroog Mines.—Formed in 1920, this company works a gold mining property in the Kolar district of Mysore, Southern India. The report for 1931 shows that 122,717 tons of ore was treated, producing 68,676 oz. of fine gold, while 7,109 oz. was recovered from 105,485 tons of accumulated tailings. In addition, 4,051 oz. was obtained from dismantling the old mill, making a total of 79,836 oz. for the year, against 78,746 oz. in 1930. After allowing for royalties and other charges, the total revenue was £359,909, while expenditure amounted to £243,889, leaving a profit of £116,021, against £100,409 the year before. The dividend for the year was equal to 27½% as compared with 25% for each of the previous two years. The ore reserves at the end of the year were estimated to be 319,656 tons, an increase of 16,829 tons, when compared with the previous year. The severe fire of May last and the consequent flooding of the lower levels seriously interfered with operations and, in addition, the Oriental shaft and Main winze were damaged beyond economic repair, so that adequate ventilation facilities will have to be provided. As with the Mysore, negotiations with the Government are in hand with respect to the extension of mining rights beyond March, 1940.

Ooregum Gold.—This company was formed in 1880 and works a gold mining property in the Kolar district of Mysore, Southern India. The report for 1931 shows that 49,235 oz. of gold was produced from 135,095 tons of ore milled, 12,507 oz. from 260,905 tons of tailings re-treated, and 1,341 oz. from dismantled tube-mills and other sources, making a total of 63,083 oz. gold. Receipts from the sale of bullion, after making allowances for royalty and other charges, amounted to £293,992, while working costs totalled £254,072, leaving a working profit of £39,920. Dividends to be paid for the year will absorb 1s. 3d. each on the preference shares and 3d. per share on the ordinary capital, leaving £13,525 to be carried forward. The reserves of ore in the mine at the end of the year were estimated to be 174,047 tons, or 41,453 tons less than at the end of the previous year. As with the other mines, negotiations for the extension of mining leases are in hand.

Champion Reef Gold.—This company, formed in 1921, works a gold mining property in the Kolar district of Mysore, Southern India. The report for 1931 shows that 56,758 oz. of gold was produced from 98,930 tons of ore milled, 8,260 oz. recovered from 228,226 tons of tailings re-treated, and 702 oz. from old copper mill-plates, making a total return of 65,720 oz. for the year. After making all allowances the total income was £297,703, while costs amounted to £229,079 and the profit was £68,624, an increase of £26,046 when compared with the previous year's results. A dividend of 1s. 6d. per share, equal to 15%, absorbs £39,780. The ore reserves at the end of the year were estimated to be 239,055 tons, an increase of 9,928 tons on the previous year's total. Work on No. 70 level is said to indicate the probability of a new ore shoot and work is being actively carried on to prove the ground below. Similar negotiations with regard to mining leases are also being conducted for this mine.

Balaghât Gold.—This company was formed in 1919 and works a gold mining property in the Kolar district of Mysore, Southern India. The report for the year 1931 shows that 41,850 tons of ore was treated, producing 25,835 oz. of gold, an increase of 3,399 oz. when compared with the previous year's total. The value of the bullion was £123,067 and, after making various allowances, the total revenue was £117,744. Expenditure amounted to £103,367 and the profit to £14,377, against a loss of £6,797 in the previous year. The reserves of ore in the mine at the end of the year were estimated to be 19,754 tons, showing a decrease of 21,769 tons. Exploratory work continued to disappoint and certain details with regard to the future of the property will be found elsewhere in this issue.

Central Provinces Manganese.—This company was formed in 1908 and works manganese properties in various districts of the Central Provinces, India. The report for 1931 shows a net profit of £161,366, of which £90,000 has been distributed as dividends, equal to 9%, and £25,000 placed to reserve, the balance of £46,366 being carried forward.

Toyo Tin.—Formed in 1927, this company, through a Japanese company, operates the Mitate tin mine in the island of Kyushiu. The report for the year ended November 30 last shows that operations at the mine were continued, but that, in consequence of the low price of tin, the mine earned no profit. Ore broken during the period amounted to 86,129 tons, 81,670 tons, averaging 1·2% tin oxide, being crushed for a recovery of 842·2 tons of concentrate. The average operating cost per ton milled, over the whole period was equal to 17s. 1½d., a figure which was reduced to 14s. 11d. for the last six months. Operations are now self-supporting, although development has been seriously affected.

Tharsis Sulphur and Copper.—This company was formed in 1866 and operates the Tharsis, Calañas and Lagunazo mines in the Huelva district of Spain. The report for 1931 shows that work was carried on at the mines without interruption, although shipments of ores show a decrease of about 30% as compared with 1930. At the metal works, operations were restricted owing to the limited supply of pyrite residues available and the falling off in the demand for purple iron ore. The net profit for the year was £62,577, which, added to the sum brought in, gave an available total of £93,470, of which £62,500 will be distributed as a dividend, equal to 5%, leaving a balance of £30,970 to be carried forward.

East Pool.—This company was formed in 1913 and works mines situated at Illogan, Cornwall. The report for the year 1931 shows 33,458 tons of ore was crushed, of which 24,850 tons was drawn from the Rogers lode and 8,608 tons from the Moreing lode. The production of black tin amounted to 555·16 tons, against 900·48 tons in the previous year, while the output of refined arsenic was 65 tons. The price realized for black tin fell from £90·09 to £72·56, while the net price realized for the 82·12 tons of arsenic sold and delivered averaged £13·19, as compared with 417 tons at £9·96 in the preceding period. The total expenditure amounted to £48,900, as against £95,975, the reduction being due to the reduced scale of operations, the loss for the year being £7,245, which increases the debit brought in to £17,421.

DIVIDENDS DECLARED

Ayer Hitam.—1½d., less tax, payable March 31.

Balaghat.—Pref. 2s., Ord. 1s., less tax, payable May 3.

Central Provinces Manganese.—1s., less tax, payable April 7.

Chicago-Gaika.—6d., less tax, payable March 24.

Gopeng Consolidated.—3d., less tax, payable April 7.

Kramat Tin.—6d., less tax, payable April 30.

Minerals Separation.—2s., less tax, payable March 23.

Ooregum.—Pref. 1s. 3d., Ord. 3d., less tax, payable April 23.

Surprise Mining.—3d., less tax, payable March 24.

Taiping Tin.—2⅛%, less tax, payable April 6.

Tharsis Sulphur and Copper.—2s., less tax, payable May 9.

Transvaal Gold Mining Estates.—6d., less tax, payable May 10.

Tweefontein Colliery.—Pref. 4%, Ord. 12½%, less tax, payable March 31.

NEW COMPANIES REGISTERED

Lomah (Rhodesia) Gold Mines.—Registered as a public company. Capital: £150,000 in 5s. shares. Objects: To acquire the mines, mining claims and rights in Rhodesia and elsewhere owned by Lomah (Rhodesia) Mining Co., Ltd. (incorporated in 1924), together with the property and assets used in connexion therewith, and to carry on the business of prospectors, explorers, miners, etc. Office: 87, Bishopsgate, E.C. 2.

Thracian Galena Products.—Registered as a private company. Capital: £100,000 in £1 shares. Objects: To acquire certain processes, inventions and patents relating to the manufacture or treatment of lead ore or lead concentrate, and for the manufacture of lead pigments, lead products, and by-products in the Near East, or elsewhere; to carry on the business of manufacturers of lead pigments and paints, oil and colour men, chemical manufacturers or merchants, etc. Directors: Sir Arthur H. Crosfield, A. H. Jackson, P. A. Ivanoff, S. S. Webb-Bowen, T. H. Evans. Office: 219, Grand Buildings, Trafalgar Square, W.C. 2.

Thracian Union Trust.—Registered as a private company. Capital: £100,000 in 2s. 6d. shares. Objects: To acquire all or any of the assets and liabilities of the Thracian Mining Syndicate, Ltd., and to acquire and hold stocks, shares, etc.

Tin Holdings.—Registered at Somerset House. Capital: £150,000 in 1s. shares. Objects: To acquire from British American Tin Corporation, Ltd., its stocks of metallic tin. Directors: O. Lyttelton, J. H. C. E. Howeson, J. S. Wetzlar.

Western Gold Syndicate.—Registered as a private company. Capital: £5,000 in 5s. shares. Objects: To acquire mines, mining oil, water, timber, and other rights, etc. Directors: R. K. Stevens, T. W. Meldrum.