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DEPARTMENT OF SUPPLY AND DEVELOPMENT

REPORT ON THE GEOPHYSICAL TEST SURVEYS
MOONTA-WALLAROO COPPER FIELD
SOUTH AUSTRALIA.

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DEPARTMENT OF SUPPLY AND DEVELOPMENT

REPORT ON THE GEOPHYSICAL TEST SURVEYS MOONTA-WALLAROO COPPER FIELD, SOUTH AUSTRALIA.

I. INTRODUCTION

The Moonta-Wallaroo copper field was discovered in 1860 and has been one of the most productive copper fields in Australia. At the time that large scale mining operations ceased in 1923, copper to the value of over £20,000,000 had been produced. At the present time no active mining is in progress and the old mines are closed and the mining plant completely dismantled.

There are two main copper producing areas in the field, namely Moonta and Kadina which are 10 miles apart. There are a number of smaller copper areas between and around the main ones.

A recent investigation by Mr S.B.Dickinson of the South Australian Mines Department indicates that while some of the old mines have small known ore reserves, the cost of re-establishing these mines would be too high to warrant such an enterprise.

It is evident that, if the field is to again become an important producer of copper, substantial new discoveries must be made.

A study of the history of the field shows that the surface evidence which led to the discovery of the lodes was, without exception, extremely limited. For example, it is recorded that the main Wallaroo lode -- the largest individual lode worked on the field -- was discovered through the presence of small stones of copper ore in a mound thrown up by a native rat. In other cases green staining in the travertine limestone which covers almost the entire area led to the discovery of rich lodes at depth.

The reason why the lodes show so little surface evidence of their presence can be found in the considerable thickness of soil, drift sand, travertine limestone and, in places, sub-horizontally disposed post-mineralization rocks, which cover the rocks containing the lodes.

Another factor which has been responsible for this lack of surface evidence is the leaching of copper from the uppermost parts of the lodes. In other cases the lodes have never reached the surface and were found by prospecting in the deep levels of the mines.

A number of the lodes worked in the Moonta area were found by costeaning and by means of an earth auger.

It will be readily appreciated, therefore, that the popular belief that more undiscovered copper ore exists in the ground on the field than was ever mined may in fact be true.

It is probable that all the surface showings of copper have been fully investigated but it is also probable that many lodes exist which show no surfade signs. How these lodes are to be discovered is a matter of immediate concern.

Recent investigations by Mr Dickinson aimed at expressing the geological structures of the lodes with a view to enumerating those structures which have governed the localization of the ore deposits.

On the basis of his investigation he has outlined a program for preliminary exploration. In this connection it is of interest to quote from his report as under:-

> "Unfortunately, the copper deposits have such a character that they are extremely local in occurrence, and although

(Mr Dickinson's report cont.)

the areas in which they are most likely to be present can be reasonably limited by geological factors, there still remains the big handicap, namely, the extremely large ratio of barren country to ore bearing country.

The geological investigation has resulted in the establishment of principles which may guide an exploration campaign. However, before a complete testing program is formulated, it would be desirable to arrange the practice of geophysical survey methods in the district in order to find out if there exists a suitable method which would give indications of the fissures. The successful application of geophysical survey methods in this district would fulfil a twofold purpose.

i. It would specifically locate the geological structures which are concealed by overburden, and which are believed to contain ore shoots at certain favourable localities.

ii. It would explore extensive tracts of geologically unknown country that may possibly contain ore shoots which may be localized through geological interpretation of the geophysical effects."

The geophysical tests which are reviewed in the present report were made as a result of Mr Dickinson's recommendations.

Geophysical methods have previously been used at Moonta by the Imperial Geophysical Experimental Survey. This work which was carried out at the end of 1929 is reviewed in a report+ dealing with the findings of the above Survey. The (electrical) equipotential line and high frequency electromagnetic methods were used.

In the conclusions of the report is is stated that the investigations carred out at Moonta have shown that a satisfactory application of these methods is almost, if not entirely, impracticable in this locality. By way of explantion it is stated that the presence of a highly conductive near surface layer, and the high salinity of the ground water produce screening effects which would make the response of deeper conductive zones so feeble that they could not be detected at the surface.

While it must be admitted that these conclusions are sound for the methods employed, it does not necessarily follow that the application of different and more sensitive methods would meet with equal failure.

A close study of the geological conditions existing on the field suggests that such methods as the self-potential, magnetic, potential gradient and low frequency electromagnetic methods might have a reasonable chance of mapping the structures. Equipment for these methods was not available at the time the Imperial Geophysical Experimental Survey was made at Moonta. Owing to the uncertainty introduced by the results of the earlier tests, however, it was decided that before any extensive geophysical survey should be undertaken on the area, testing with the potential gradient, electromagnatic, self-potential and magnetic methods should be carried out.

This report deals with the results of such tests which were conducted on the field between March 16th and 28th, 1942.

+ "Principles and Practice of Geophysical Prospecting" by Edge and Laby; Cambridge University Press, 1931.

On the Kadina area tests were carried out over the Wallaroo, Stirling, Kurilla and Duryea lodes, while at Moonta tests were made at three places over Elder's Main lode, over the Wild Dog lode and over the Allie and Hall lodes.

In addition to tests over known lodes, tests were made at Kadina over the Eastern and Western northeast-southwest striking shear zones which appear to have limited the lateral extent of the ore bodies in the Wallaroo lode.

Because the rocks in which the lodes occur are different at Kadina and Moonta (although the lode types are similar) it is proposed to treat the tests at these two places separately.

II. THE KADINA AREA

A. GEOLOGY.

For the purposes of this report it will be necessary to relate briefly the geological conditions on the area with particular reference to the lode structures. It will be assumed that the reader has access to Dickinson's report which deals at length with these factors.

The rocks of the Kadina area are principally quartzites, slates, limestones and their metamorphic derivatives and they are of Pre-Cambrian age. They are in places overlain by sub-horizontally disposed layers (of small thickness) of Tertiary and Cambrian sediments which however are absent in the areas tested.

Recent deposits of soil, drift sand, travertine limestone and clay cover the area so that neither the rocks nor lodes outcrop.

Where the Pre-Cambrian rocks are exposed in the mine workings they are upturned and generally highly contorted. Owing to an almost complete absence of outcrops, however, it is not possible to determine the rock structure or its influence, if any, on the formation of the lodes. In the following discussions of the lode fracture pattern it will be assumed that the fractures occur in a homogeneous rock.

Lode Structures. The principal lodes of the Kadina area occur in well pronounced fractures which strike between 90 degrees and 120 degrees. These fractures have been designated the east-west main lode shears.

In the case of the Wallaroo lode, the values in the lode and the character of the lode channel have been largely influenced by intersecting northeast-southwest shear zones.

There are two such zones recognised in the Wallaroo lode and values are confined to a length of 2,500 feet between them. They have been called the Eastern and Western shear zones, and apparently consist of relatively wide zones occupied by a large number of faults.

The Stirling and Matta lodes, to the east of the Wallaroo lode, are apparently continuations of the main Wallaroo lode channel eastward from its intersection with the Eastern shear zone. The lode filling in the Stirling and Matta lodes is substantially the same as in the Wallaroo lode, but in them copper values are lower and pyrite content considerably higher than in the Wallaroo lode.

To the south of the Wallaroo lode is a number of small lodes, namely Devon, Kurilla, Duryea and Doora Lodes. They also occupy east-west main lode shears. At their eastern ends the lode channels are considerably disturbed by a cross feature which in each case is believed to be a southern continuation of the Eastern shear zone.

It is suggested that the principle lodes of the Kadina area are confined to east-west main lode shears and lie between the Eastern and Western shear zones. Local enrichments may be controlled by favourable bends in the lode channels and may be influenced in an unknown fashion bythe rock type which the lode channel intersects.

B. NATURE OF THE GEOPHYSICAL PROBLEM

The problem from the geophysical point of view is one of discovering more copper lodes either directly through measuring physical properties which can be directly attributed to the mineral content of the lodes, or by locating such features as the east-west main lode shears and northeast-southwest shear zones, and by geological interpretation of such features determine places most favourable to the formation of ore bodies.

It is therefore desirable at this stage to examine closely the physical character of the lodes and associated features.

The lodes in the primary zone are metasomatic replacements of the country rock along planes of shattering. The lode filling is pegmatitic in character and comprises quartz, mica and a little felspar with minor amounts of other pegmatitic minerals. The metallic minerals present are chalcopyrite, pyrite, pyrrhotite and small amounts of galena, blende, scheelite, molybdenite and gold. Radio-active minerals are also reported as being present in even the minutest quantities in all the lodes, their presence suggests the possibility of using one of the extremely sensitive ray-counting devices, such as a Gieger-Muller counter, or a sensitive electro-scope, for determining their presence in the soil and hence locating the lodes from which the radio-active minerals have been derived. Apparatus for such measurement was not available at the time the present tests were made, but if further geophysical work should be done on the area the method would be worthy of a test.

Above ground water level, which varies from 30 to 50 feet on the area under discussion, the lodes have been completely oxidized and leaching has removed most of the metallic minerals. That copper which remains is mainly in the form of chlorides and carbonates while some of the iron remains in the form of limonite. Of the gangue minerals, quartz is most prominent while the felspars have been kaolinized.

The way in which the lodes differ electrically from the rocks containing them is not immediately obvious. The primary zone, by virtue of the metallic sulphides it contains may be much more conductive than the country rock but to what extent they will differ in this respect depends on the electrical continuity of the sulphide particles in their resistive matrix of quartz and associated minerals. The lode channels are probably considerably more porous and consequently contain a greater proportion of saline water than the country rocks, a factor which will increase their conductivity relative to the enclosing rocks.

In the oxidized zone leaching has probably resulted in a large increase in pore volume and this increase, together with the presence of kaolin resulting from the weathering of the felspars, has probably resulted in the formation of a relatively conductive channel. On the other hand the residual quartz would be extremely resistive, so that the nett effect of all the factors involved is not immediately apparent.

In the potential gradient method a ratio of conductivity of 3 to 1 should be detectable and it seemed reasonable to suppose that the ratio of resistivity of the lode channels to that of the country rocks would be at least 3 to 1.

As far as the northeast-southwest shear zones are concerned, it seems reasonable to suppose that the faulting and shearing within the zones would produce increases in conductivity sufficiently large to be detectable by the potential gradient method.

The presence of oxidizing sulphide minerals, such as chalcopyrite, pyrite and pyrrhotite, at shallow depths in the lodes might reasonably be expected to be the source of a measurable self-potential effect.

The occurrence of large quantities of pyrrhotite, which has a high magnetic susceptibility, in some of the lodes at Kadina might be expected to favour magnetic methods of detection.

It will be apparent from the foregoing discussion of the physical character of the lodes that further testing by geophysical methods was warranted in spite of the adverse findings of the Imperial Geophysical Experimental Survey at Moonta.

C. RESULTS OF THE TESTS

1. Wallaroo Main lode and Western Shear Zone.

The potential gradient method was the only one used in this test and the results are shown on plate 2 in the form of a potential gradient contour plan. Low contour values correspond to places where resistivities are lower than the average for the area and vice versa.

The site for the test was selected from an inspection of the plan of the stopes, (shown by Dr Jack in his Bulletin, No.6), pending the arrival of more detailed information. The choice was not a good one, for, although the stope plan suggests that near the Office shaft more of the original ore body remains in situ than elsewhere along the lode, the reason for this lies in the pinching of the lode, rather than in a decrease in grade of the ore.

The Western shear zone, which is shown crossing the traverses on the layout plan, further complicates the conditions. Furthermore, the section covered by the test is one in which the east-west main lode shear has split up into a number of sub-parallel shears carrying small copper lodes.

It will be appreciated, therefore, that geological conditions were exceedingly complex but the tests were none the less valuable because they indicate the nature of the geophysical reactions under these complex conditions.

Two layouts will be observed on the plan, namely layout A comprising traverses 70E,0,100W, and 200W, and layout E comprising traverses 0 and 50N. Layout A was used in tests over the main lode shears while the direction of the traverses on layout E was most favourable for obtaining reactions from northeast-southwest striking cross courses.

a. Layout A. It will be observed that the centre of Layout A is occupied by a zone of relatively conductive material some 200 feet in width. The relation, if any, between this wide conductive zone and the known main lode shears is not obvious. The known main lode shears in part occupy this zone, but the most southerly members lie outside it. Its similarity in strike to the main lode shears suggests that it may be in some way related to those structures. On the other hand where the strike of the country has been noted in the deep workings from Young's shaft, it has been found that, although it varies within fairly wide limits, the average trend seems to be approximately the same as that of the conductive zone. This similarity in trend suggests the possibility of the conductive zone, being due to the presence of a band of rock of lower resistivity than the surrounding rocks.

b. Layout E. The group of narrow conductive zones at the western end of traverses 0 and 50N layout E may be considered as representing a westerly continuation of the wide conductive zone on Layout A. The conductive effects have become more localized in occurrence and may possibly be related to westward continuations of the main lode shears.

The conductive zone between 300W and 400W traverses 0 and 50N coincides with the northeast-southwest shear which crosses the main lodes to the immediate west of the Office shaft. This shear is part of the Western shear zone.

The narrow conductive zone at the far eastern end of Layout E cannot be assigned to any known geological feature but in strike it closely resembles the northeast-southwest shears. The intersection of such features and the main lode shear has resulted in the impoverishment of the main lode and it may not be a coincidence that a zone of impoverishment occurs where this conductive zone would meet the main lode if continued to the north-east on its present strike.

2. STIRLING LODE AND EASTERN SHEAR ZONE

Two layouts were used in the tests on this area and they are shown on the accompanying plan, plate 3, as layouts C and D. Layout C comprises four traverses, namely, 50W, 0, 50E and 100E, the direction of the traverses being so chosen that they crossed the Stirling lode normal to its strike. Layout D comprises the four traverses, namely 50S, 0, 50N and 100N and its direction was so chosen that the traverses crossed the Eastern northeast-southwest shear zone at a favourable angle.

Potential gradient, electromagnetic and self-potential tests were made on layout C. For the potential ratio tests a 50 feet electrode separation was used although selected portions of three of the traverses were repeated with a 25 feet separation, the phase relation of the potential drops being determined at the same time. The results of these tests are shown in the form of a potential gradient contour plan and indications plan on plate 3. The potential gradient and phase angle profiles, electromagnetic profiles and self-potential profiles are also shown on plate 3. A geological section of traverse 0, layout C, is also shown on this plate.

Layout D was covered by a potential gradient survey using 25 feet electrode separation and the results in the form of a potential gradient contour plan and indication plan are shown on plate 3.

a. Layout C.

1. Potential Gradient Method. An examination of the potential gradient contour plan shows that layout C is crossed by four distinct zones of relatively good conductivity. These are shown on the indications plan as zones A, B, C, and D. In addition to showing the wide zones, the indications plan also shows the axes of the conductive indications which comprise the zones. These axes have been lettered A, B, C_1, and C_2, and D.

Zone B coincides roughly with the plotted position of the Stirling lode. The agreement in position is good on traverse 100E but the axis of the conductive zone diverges from the outcrop, as shown, towards the western edge of the layout. The zone, however, reflects the bending which the Stirling lode exhibits and this fact, together with the evidence of widespread mineralization as demonstrated by No. 4 diamond drill hole (see geological section of traverse 0, plate 3) and the coincidence between the potential gradient indications and self-potential indications, makes reasonably safe the assertion that the conductive zone B represents the locus of the mineralization associated with the Stirling lode.

Because of its low copper content much of the Stirling lode remains in situ. Further, the lode contains a large amount of pyrite and the pronounced electrical effect obtained over it, in contrast to the absence of such an effect over the Wallaroo lode in the Office shaft test, may be attributed to these factors.

The potential phase curves which are shown on plate 3 are of particular interest. Phase angles were determined over short sections of traverses 100E, 50E and 0 and it will be observed that the only place on the traverses where appreciable phase disturbances are present coincide with the potential gradient minima corresponding to Zone B. Although actual phase measurements were not made over parts of the traverses corresponding to other conductive zones, it was apparent from the ratiometer readings that phase disturbance was much less evident over them than over Zone B.

As a result of the limited phase test described, it is evident that such measurements might provide a satisfactory means of locating the conductive zone associated with the mineralization and if routine surveys are to be undertaken on the area more exhaustive phase tests should be an integral part of such a survey.

Zone A occupies the southern end of layout C and its axis (marked A-A) shows pronounced bending in sympathy with Zone B. Diamond drill hole No. 4 intersected a lode formation at approximately 100 feet vertically beneath 375.S/0 and it is suggested that the conductive zone A is associated with this lode formation. The formation, where intersected by No. 4 drill hole, contained only traces of copper so that further prospecting on Zone A is probably not warranted.

Zones C and D are on the northern half of the layout and they have east-west strikes. This strike also represents the strike of the axis D-D but the axes $C_1 - C_1$ and $C_2 - C_2$ of the indication which make up Zone C strike roughtly NE-SW.

As these zones extend onto layout D, they will be discussed in more detail when the results for that layout are discussed.

ii. <u>Electromagnetic Method</u>. The electromagnetic tests on layout C were confined to traverses 100E and 50W, the primary cable being 550S. Near-cable intensities of 16 microgauss per ampere were measured indicating abnormally high ground conductivity. This result was not unexpected because the presence of a conductive clay layer (300ohm-cm) immediately underlying the surface travertine had previously been noted.

The real horizontal component profiles are shown on plate 3 and it will be observed that they show minor departures from the smooth curve shape. By assuming a smooth curve for ground conductivity effect and plotting the differences between this and the observed curve, the curves A and B are obtained. It will be seen that the A and B curves show pronounced anomalies which, in each case, have a double maximum. The positions of the maxima are shown on the indications plan. The wide nature of the anomalies on the A and B curves suggest that they are of relatively deep-seated origin. The Stirling mineralized zone is dipping to the south and it is possible that the electromagnetic indications arise from the deeper parts of this mineralized zone. The electromagnetic indication and potential gradient zone B indications are probably responses from different levels in the same feature.

There is a suggestion of an extremely weak electromagnetic anomaly associated with potential gradient zone C but nothing could be detected in the vicinity of zone D.

The weakness of the electromagnetic indication at Zone C and absence of effect from Zone D are attributed to the screening effect of zone B and because of this, it is apparent that the potential gradient method gives a more reliable picture of the electrical conditions than does the electromagnetic method.

iii. Self-potential Method. The results of the self-potential test are shown in the form of potential profiles on plate 3, while the position of the individual negative centres is shown on the indications plan. The manner in which the negative centres should be connected between the traverses is not clear but the connections shown on the plan are regarded as being the most probable ones.

It will be observed that the self-potential indications are grouped in a zone about 100 feet wide which roughly coincides with potential gradient zone B and includes the Stirling lode. The nature of the results suggests the presence within this zone of a number of discontinuous bodies of oxidizing sulphide minerals.

The position of the outcrop of the Stirling lode as shown on the plan is based on a plan of the levels and not on direct observation nor on recorded description of the lode. The nature of the self-potential indications introduces a doubt in the writer's mind as to whether the direction of the levels can be taken as a true indication of the existence of a continuous lode followed by such levels or whether the levels connected a number of discontinuous lodes.

b. Layout D. The potential ratio method was the only one used in this layout and the results, in the form of a potential gradient contour plan and an indications plan, are shown on plate 3.

It will be observed that three zones of relatively conductive rocks cross the layout. The most southerly two are apparently westerly continuations of zones C and D, layout C. The zone at the northern end of the layout has the same strike as zones C and D and has been called zone E.

The axes of the individual indications are shown as broken lines marked I-I, II-II, etc.

An examination of the pattern of conductive zones and indication axes for the two layouts reveal certain trends which may be associated with the lode structures. As already pointed out in the discussion of the results of layout C, zones A and B and the axes A-A and B-B are apparently associated with mineralized zones of the east-west main lode shear type and it seems possible that zone D and the axes D-D and IV-IV may be associated with a similar feature. On the other hand, although the wide zones C and E have an east-west strike, the indications which comprise these zones namely, C_1-C_1,C_2,-C_2, I-I and II-II in zone C and VII-VII, VI-VI and possibly V-V in zone E have strikes which differ appreciably from the strike of the zones themselves. The strike of the indication lines approximates that of the northeast-southwest shear zones and it is believed that they are associated with such a feature.

The Eastern NE-SW shear zone is believed to occupy the area between the eastern end of the Wallaroo lode and the western end of the Stirling lode and its approximated boundaries, based on geological interpretation of mine plans, are shown on the indications plan. It is not possible to reconcile the geophysical results with the shear zone as shown.

A geological interpretation of the indications believed to be due to NE-SW shears is shown on the indications plan and it is believed that this interpretation, which does not differ greatly from the geological mapping, may be a true representation of the Eastern shear zone. In support of the geophysical interpretation, attention is drawn to that section of the Stirling lode to the northeast of the Stirling West Shaft. It will be observed that its strike is similar to that of the axes C_1 -C_1 and I-I and it is suggested that the lode may have followed one of the NE-SW faults of the Eastern shear zone. If such an explanation is correct, then its attitude can be regarded as supporting the strike of the Eastern shear zone as given by the geophysical interpretation.

The east-west strike of zones C, D and E in contrast to the strike of the majority of the indications contained in them, introduces an interesting possibility.

Although the argument which follows is of a highly speculative character, it suggests a line of investigation which might be profitably followed.

It is suggested that the zones C,D and E represent bands of country rock which are more conductive than adjourning rocks because they have been more susceptible to shattering than the adjoining rocks during the formation of the lode structures. Although little is known of the rock structure in the area under discussion, it is believed that the rocks may have an east-west strike.

Fig 1.

In explantion of the geological conditions which have produced the electrical pattern on layouts C and D, Fig 1 is presented.

It is assumed that the country rock consists of two types which are interbanded. Type 1 is harder than type 2 and the crossing fractures are clean breaks with little, if any, shattering of the rocks adjacent to the factures. In type 2, however, the crossing fractures have developed as relatively wide zones of shattering which has rendered rock type 2 conductive where intersected by the crossing structure.

Thus, the crossing shear zone has produced in rock type 2 conductive zones which have the strike of the country rocks but in which the individual conductive indications have the strike of the shear zone, while the shear zone has produced no appreciable change in the resistivity of the type 1 rocks.

The influence of rock type on the nature of the fracturing in the Wallaroo main lode has been recognised by Dr Jack and it is believed that the application of geophysical methods to an area embracing the whole of the Wallaroo lode and immediate vicinity might lead to a better understanding of the structures controlling ore deposition in the Kadina area. Whether or not such a survey would be justified at the present time is a debatable point because the present structural conceptions should provide a satisfactory basis for an immediate prospecting campaign.

3. KURILLA LODES

The Kurilla mine is approximately 3,000 feet southwest of the Wallaroo lode. Three lodes were worked on the property of which the most important were Hall's and Morphett's lodes, worked from shafts of those names.

The lodes are stated to have varied in width from 1 foot to 9 feet and to have dipped northward af an angle of approximately 70 degrees.

The lodes occupy shears of the east-west main lode type and their courses at the eastern end of the working have been considerably disturbed by the presence of a cross feature believed to be a southwesterly continuation of the Eastern shear zone.

Production appears to have been mainly from a shoot of ore on Morphett's lode to the immediate east of Morphett's shaft. A shoot of ore has also been mined from a section of Hall's lode. The western end of this latter shoot is due south from Morphett's shaft.

The section selected for the tests was therefore to the immediate west of the productive sections of the lodes. Nothing definite is known of the size or character of the lodes in the part tested, but the existence of lode channels has been proved by the workings.

In Dr Jack's description of the Wallaroo lode channel in the upper levels of the Wallaroo mine, he makes the statement that "the distinction between the lode channel and the actual ore shoots in these (Wallaroo) upper levels is very marked - - - - as between the actual ore shoots the lode is practically destitute of copper or of lode filling".

If this statement is true also of the Kurilla lodes, they are probably only weak features within the area tested.

The tests consisted of potential gradient surveys of the seven traverses, 120W,0,100E,200E,300E,380E and 550E, electromagnetic surveys on all these traverses with the exception of 380E, and self-potential and magnetic tests on traverse zero.

i. Potential Gradient Method. The results of this test are shown on plate 4 in the form of a potential gradient contour plan. The axes of the individual conductive indications are shown on the indications and electromagnetic contour plan on the same plate.

It will be observed that the contours and indications present a complex pattern which seems to have little, if any, relation to the lode pattern. The conductive indication which crosses traverses 100E and 200E at 325N coincides approximately with the outcrop of Morphett's lode and is probably due to that feature. A small conductive indication crossing traverse 0 at 55S may be due to the lode which was intersected by a diamond drill hole near Hall's shaft (see cross-section of traverse 0). Apart from the two indications described, the known lodes have produced no noticeable effect.

The general trend of the indication lines suggests that they might be divided roughly into two groups despending on their strike. Indications 9,12 and 14 have the east-west strike of the main lode shears. Indication 12 seems to be associated with Morphett's lode and it is possible that indications 9 and 14 are associated with similar features. The remainder of the indications (with the exception of No. 8, which is known from the results of only one traverse and hence its direction is indefinite) vary in strike from 320 degrees to 330 degrees. One of the components of the Wallaroo fracture pattern has this strike, (for instances, the Wandilta lode shear and the cross feature which faults the Doora ore body), and it is possible that the conductive indications under discussion may be due to comparable fractures.

ii. Electromagnetic Method. The results of the tests with this method are shown in the form of Real Horizontal Component profiles and Real Horizontal Component contour plan on plate 4.

As in the case of a similar test at the Stirling area, near cable intensities were very high (of the order of 15 microgauss) and these high intensities are attributed to abnormally high ground conductivity.

In order to reduce the curves to a form suitable for contouring, it has been necessary to assume a form for the ground conductivity effect. The differences between the observed curve and the assumed ground conductivity curve have been plotted along the datum line for each curve. This procedure is somewhat artificial and produces results which are open to doubt because the final curve shape depends entirely on the shape assumed for the normal ground effect about which information is scanty. The contour plan shows a broad maximum which follows the course of Morphett's lode.

The most intense parts of the electromagnetic indication are at 300N/515E, 230N/200E and 320N/200E. The first two places coincide roughly with Morphett's lode and are believed to be due to that feature. The last-mentioned is in an area of unknown geology but it may possibly be due to a parallel lode.

No measurable effect was obtained from Hall's lode or from the lode near 40S/0. The potential gradient survey showed that there is no pronounced conductive effect associated with Hall's lode where it crosses the layout so that the absence of an electromagnetic effect from it is understandable.

There are no electromagnetic indications corresponding to the potential gradient indications on the southern side of the layout. The reason for this lies in the screening effect produced by the conductive zone nearer the cable, i.e., the zone which coincides with Morphett's lode.

iii. Self-potential Method. Owing to the unsuitable nature of the surface✝ on most of the layout, tests by this method were confined to traverse 0. The potential profile is shown on plate 4. The potentials varied somewhat erratically but the smoothed curve seems to exhibit three weak negative centres. The positions of these are shown on the indications plan. The most southerly one coincides roughly with potential ratio indication 7 and the lode pierced by the drill hole south of Hall's lode near Hall's shaft, and it may be due to oxidizing sulphide minerals in this lode. The centre one coincides roughly with the western end of Morphett's lode, with the axis of the electromagnetic indication, and with the potential gradient indication 11. The smoothing of the curve at this place has been largely influenced by the low reading at 250N which may be due to surface causes and not to oxidizing sulphide minerals in Morphett's lode.

The negative centre at the northern end of the traverse is in an area of unknown geology, but, because surface conditions were particularly unfavourable at this end of the traverse, it may be due to surface causes.

iv. Magnetic. Vertical intensities were measured on traverse zero and the profile is shown on plate 4.

From 225S to the 550S and 175N to 300N the profile is very flat, the northern section, however, differing in intensity from the southern section by approximately 100gamma. Minor disturbances occur over the centre section of the traverse but they do not appear to bear any relationship to the known lodes.

It seems possible that the magnetic curve may be related to the rock types present, but as knowledge of these is confined to the very limited zone intersected by the workings no attempt can be made at correlation.

✝ The surface of the area was littered with piles of rock debris, tailings etc. and only a small part of it was natural soil. In addition, the area was extremely dry and S.P. Contacts had to be artificially prepared.

4. DURYEA LODES.

The Duryea mine lies approximately 1200 feet south of the Kurilla. The mine has not been worked for a great number of years and very little is know about the lodes. Their plan position is not known for certain but a plan by Dr Jack shows an east-west lode at about 120 feet north of the Main shaft.

Two lodes which were pyritic in character are stated to have been worked. The geophysical tests consisted of self-potential observations along two north-south traverses called 0 and 60E, and magnetic observations along traverse 60E. The centre of the traverse was opposite the Main shaft and the traverses extended for 600 feet north and south of the centre point.

The results of the test are shown on plate 5 in the form of self-potential and magnetic profiles.

i. Self-potential Method. It will be observed that the self-potential curves are much less disturbed than was the case in the Kurilla test. This is due to the ground conditions being much more favourable - the surface being covered mainly by soil of even texture.

Three weak negative centres are shown in the smoothed curves on each traverse. Of these, the centre one is a very broad feature which has apparently a deep-seated origin. It may be due to the lode shown by Dr Jack at 120 N and which dips to the south.

The negative centre near 275S is over unknown conditions but the fact that it occurs on the two traverses and that the axis has an east-west strike makes it seem likely that it may be due to oxidizing sulphide minerals in an east-west lode. Further work by this method and a potential gradient or electromagnetic survey for confirmation purposes is warranted and testing would be subject to the results of such additional work.

The negative centre between 200N and 250N is somewhat indefinite owing to disturbed readings, but it is an indication which might profitably be followed up by additional surveys.

ii. Magnetic Method. The general wavy nature of the profile is probably due to variations in the susceptibility of the country rocks. Nothing is known of the habit of the rocks in the area so that no correlation can be obtained. The test, however, shows that even if weak magnetic anomalies were present over the lodes, it would not be possible to distinguish between them and anomalies due to variations in the country rocks.

III. MOONTA AREA

Geophysical tests were made at the following places on the Moonta area.

1. Alice and Hall lodes -- Layout A
2. Elder's Main & East Lodes--Taylor shaft Section -- LayoutB
3. Elder's Main & West Lodes -- Warmington's shaft section - Layout C.
4. Wild Dog Lode -- Layout D.
5. Elder's Main lode (Smith's shaft Section) -- Layout E.

The relative positions of the test areas ~~is~~ are shown on the locality mpa, plate 1. These tests will be described separately.

The Moonta area of the field differs from the Kadina area, principally in the attitude of the lodes and in the nature of the country rock.

A. GEOLOGY OF THE MOONTA AREA

The rock in which the lodes of the Moonta area occur is a felspar porphyry which has a relatively uniform texture.

The porphyry has been weathered near the surface to a variable degree, its uppermost parts being weathered mostly to clay.

The outcrop of the porphyry, and the lodes it contains, are covered by this clay which in turn is overlain by travertine limestone soil, and in places, drift sand.

The lodes occupy fissures or shears within the porphyry and are pegmatitic in character. The lode filling has practically the same composition as the Kadina lodes, but evidently less sulphur was available during their formation because most of the iron in the lodes occurs as haematitite whereas at Kadina the iron occurs in the form of pyrrhotite and pyrite.

1. THE LODE STRUCTURES

The fissuring of the Moonta area belongs chiefly to the northeast-southwest type in contrast to the Kadina area where the fissuring was chiefly of the east-west type.

The following components of the fracture pattern are recognised:-

(a) Main-lode shears
(b) West-lode shears
(c) Strike faults
(d) Northwest-southeast cross courses
(e) East-west traverse faults.

Of these, (a) (b) and (c) belong to the general northeast-southwest fissure group.

The lodes occur in Main-lode shears and West-lode shears, but the ore-shoots appear to have been localized by the intersection of two or more components of the fracture system.

Of the areas tested, Alice and Hall lodes, Elder's West lode and the Wild Dog lode are classified as West-lode shears, while Elder's Main lode occupies a Main-lode shear.

In addition to the shears carrying the lodes,a fault of type (c), namely Taylor fault, crosses layouts B and C, while fractures of types (d) and (e) may be present on layouts B and E.

In order to fully appr ciate the nature of the geophysical results it is necessary to briefly outline the physical characteristics of the lode shears, Taylor fault, and other structural components.

(a) Main-lode shears — show little smashing of the wall rock but the wall rocks and the material contained therein have been altered by the action of the vein-forming soltutions. This alteration has resulted in the wall rocks becoming more friable than the unaltered porphyry — a change which might reasonably be associated with an increase in electrical conductivity.

The copper minerals occur in shoots along the Main-lode shears. Betw en the shoots the Main-lode shear is generally a weakly developed feature in which only minor amounts of lode or crushed material are present. Thus from a geophysical point of view one would expect strong reactions from the lode channels in the vicinity of the ore shoots and poor reactions elsewhere.

(b) West-lode shears — are typical faults which have been filled with crushed material . The wall rock alteration is usually more extensive than in the Main-lode shears. The West-lode shears have a composite character and consist of a number of parallel fractures. The lode filling has ~~ten~~ a selective route in the West-lode shears with the result that the ore bodies are arranged in a number of disjointed and not necessarily collinear sections along the shears.

(c) Strike faults -- are so called because they are more or less parallel to the Main-lode shears, but they dip at a flatter angle. They are not mineralized but their intersection with the Main-lode shears and West-lode shears appears to have had a marked influence on the disposition of the ore shoots in those shears.

Taylor fault which intersects Elder's Main and West lodes at depth is the only fault of this kind the existence of which has definitely been established, although the occurrence of other is suspected.

Taylor fault where intersected by the mine workings contains from 1 to 2 feet of crushed material.

(d) Northwest-southeast cross courses -- are fairly well developed in the Moonta Mines and have caused offsetting of the Main-lode shear in places. They consist of unmineralized fractures of limited lateral extent and appear to have a marked local influence on the character of the ore-bodies. A cross feature of this type crosses Elder's Main lode in the vicinity of Taylor's shaft.

(e) East-west traverse faults -- are in character similar to the northwest-southeast cross courses. No faults of this type are known on the areas tested by the geophysical methods.

B. NATURE OF GEOPHYSICAL PROBLEM

The problem at Moonta was similar to that at Kadina, namely, to determine what geophysical reactions, if any, could be obtained from the known lodes or lode-structures. The problem was somewhat simpler, than at Kadina because the rock in which these lodes and [at Moonta] lode-structures occur has a uniform character and no geophysical reactions due to variations within the bedrock were expected.

Owing to the remarkable decrease in resistivity which usually accompanies shearing of a rock, it was believed that the Main and West-lode shears, strike faults, and cross features would all be more conductive than the massive porphyry which contained them.

It was realized, however, that any effect arising from these cross features would be considerably reduced in intensity by the screening effect of the conductive near surface layers and that the factor which would ultimately decide whether or not a feature could be located electrically would be the degree of shearing present.

It was known that the Main and West-lode shears which contain the ore shoots were not uniformly sheared along their whole length -- lode filling which has replaced the shattered material in the shears reaches a width of 25 feet in places while in others it is only a few inches wide and may even be absent. Thus it was expected and subsequently borne out by the results of the tests, that the conductivity of the shears would vary from place to place along their strikes.

It might be appropriate at this stage to mention that the conductive effects associated with the shears were found to be extremely local in character. In the potential gradient tests an electrode separation of 25 feet was used. Many of the conductive effects were apparent in only one electrode interval and with a wider separation it is possible that some of the effects might have been overlooked. It was apparent that even 25 feet may have been too large a separation, and in any routine survey which might be carried out a maximum separation of 20 feet should be used.

C. RESULTS OF THE TESTS

1. Alice & Hall Lodes - Layout A

a. Introduction. The Alice & Hall lodes occur in the most westerly of the three main zones of fracturing at Moonta. The lodes contained small shoots of ore and show little promise for development of large tonnages of copper ore.

The shears in which the lodes occur are classified, beaause of their strikes as west lode shears. Shears of the Main-lode type have not been located but may be present in the country to the east of the lodes.

b. Potential Gradient Method. The results of the potential gradient test are shown in the form of a potential gradient contour plan on plate 6.

The potential gradient profiles and geological sections of traverses 0 and 200W are also shown. The potential gradient contour plan shows a zone of low gradient values which coincides roughly with the outcrop of Hall's lode. On traverses 0 and 50E, where the indication is strongest, the centre of the indication lies approximately 15 feet from the outcrop. This displacement can be accounted for by assuming that the conductive indication is coming from a depth of approximately 25 feet down the dip of the lode.

The series of conductive indications which cross the layout at a slight angle from 200N/50E to 130N/200W is probably due to the Alice lode which was cut in No. 1 and No. 5 bore holes (see geological section of traverse 200W). The onnductive indication crossing traverse 50W at 250N may be due to another lode lying to the hanging wall side of the Alice lode and which was cut by No. 1 bore hole.

With the exception of the conductive zone along the southern edge of the layout, the conductive indications on the southern side of the layout are weak and irregularly disposed, and it is unlikely that they are associated with any pronounced geological features.

The conductive indication on the southern edge of the layout may be due in part to the influence of conductive layers lying beneath the power electrodes. The usual practice of commencing the readings 300 feet from the power electrodes was followed in this case. This distance is usually sufficient to render the reading free from effects of horizontal discontinuities beneath the power electrodes, but it is believed that in this case, as in fact in the majority of the potential gradient tests in the Moonta-Kadina area, the distance was not sufficiently great. The conductive zone should therefore be confirmed by repeating the readings under more favourable electrode conditions before any interpretation in terms of geological features is attempted.

c. Self-potential Method. Three traverses, namely 0, 50W and 100W, were surveyed with this method and the self-potential profiles are shown on plate 6.

The most striking feature of the profiles is the steady fall in potential from the northern end of the traverses toward the south. Traverse zero was extended at a later date from 500S to 1500S but the potential curve was found to have a much flatter shape over this extension.

There seems to be little doubt that the effect measured was due to stray potentials from the town D.C. supply. The layout, on its northern side adjoins the town of Moonta and it is apparent that the earth beneath the town is charged to a positive potential.

Without a knowledge of the true form of the potential drop, due to this cause, it is not possible to determine with any degree of certainty what part, if any, of the measured effects might be coming from Alice or Hall lodes. By assuming a smooth shape for this stray potential effect, as has been done in the case of the curve for 50W, it is possible to arrive at a potential curve which may be due to the effects of the lodes. It will be observed that this treatment of the results gives a negative centre which coincides with Hall's lode; however, a similar treatment of the other curves gives results which are not as promising. In view of the uncertainty which exists in the interpretation of the results, the method cannot be regarded as a satisfactory one for those parts of the Moonta area which lie near the town of Moonta.

2. Elder's Main lode - Taylor Shaft Section - Layout B.

a. Introduction. The layout consists of four traverses, namely, 0,70W, 120W and 170W, which extend from 400S to 600N of the base line.

Elder's Main and East lodes, the latter being an offshoot of the former, cross the layout at approximately 100-150 feet south of the base line. The lodes dip at approximately 60 degrees to the northwest.

Taylor fault intersects the abovementioned lodes at approximately 500 feet from the surface and its projected outcrop crosses the layout at approximately 200S.

Elder's West lode also lies beneath the area tested. Its upper edge is approximately 600 feet from the surface but the West lode shear may possibly reach the surface. Its projected outcrop would cross the layout at approximately 300N.

Dickinson's plan of the lode structures at Moonta shows two cross features, one with the strike of the West-lode shear and the other with a northwest-southeast strike crossing Elder's Main and East lodes to the immediate S.W. of Taylor shaft. These cross features are not shown on the plan for layout B because their plan position is not known for certain.

b. Potential Gradient Method. The results of this test are shown in the form of a potential gradient contour plan on plate 7.

Two pronounced conductive zones cross the layout. The most southerly of these is a wide zone containing two minima. Elder's Main and East lodes pass through this conductive zone but there is no obvious correlation between the conductive minima and the lodes.

The two cross features mentioned above may cross the layout and it is believed that one or both of these features may have influenced the results.

The strong conductive indication which crosses the layout between 450N and 475N is too far to the northwest to permit a correlation between it and the West lode shear. It is a strong feature and its strike resembles that of the Main lode shear. It may possibly represent a northerly continuation of Bennett's lode which has this strike and, where known, lies approximately 650 feet to the west of Elder's Main lode.

The projected outcrop position of the West lode shear crosses the layout at approximately 300N. but it is not known for certain whether this feature actually reaches the surface. Thereis no indication near 300N which could be correlated with the West-lode shear.

No indication was obtained over the assumed outcrop of Taylor fault.

c. Self-potential Method. A survey with this method was made of traverses 70W and 120W and the results in the form of potential profiles are shown on plate 7. As was the case in other tests with this method the surface conditions were most unfavourable. The individual readings were somewhat erratic in their behaviour but the profiles as a whole show a certain regularity of potential distribution which the smoothed curve is intended to represent.

The most outstanding feature of the curves is the potential maximum which occurs at approximately 475N on traverse 120W and to a lesser extent on the adjoining traverse.

This maximum or positive centre coincides with the pronounced resistivity minimum on the northern side of the layout. The occurrence of a positive centre is a surprising result and there is nothing in the known geology which can account for it.+

In view of the fact that large positive earth potentials were found to be associated with the town D.C. supply on layout A, it seems a reasonable assumption that the positive centre herein described is in some way connected with such a supply. Layout B, however, is more than a mile from the township and the connection between the positive centre and town D.C. supply is not obvious. However, a pipe line connected with the town water reticulation system crosses the conductive zone with which the positive centre coincides at no great distance to the southwest of traverse 120W and this pipe line might be at a high positive potential which it in turn has landed on to the conductive zone it intersects. The fact that the positive potentials on traverse 70W are less than on traverse 120W could be consistent with this theory.

In view of the fact that the pipe line in question also intersects other conductive zones on the layout, it is not possible to determine which of the effect measured are due to causes such as outlined above and which, if any, might be due to oxidizing sulphide minerals at depth. The latter cause would produce negative centres in contrast to the positive effects of this stray source.

3. Elder's Main and West lodes near Warmington's Shaft - Layout C

a. Introduction. This layout is traversed by Elder's Main lode, Elder's West lode and Taylor fault.

It should be apparent from the preceding discussion of the physical character of the lode structures that the main lode shear is not developed with equal intensity at all places along its length and that where the ore-shoots occur shearing has probably been more intense than elsewhere on the shear.

From a geophysical point of view, one would expect strong reactions from the Main-lode shear over the ore shoots and poor reactions elsewhere on the shear. Applying this to the area under discussion one might, on the basis of the stope plan shown in Dr Jack's report, classify that section of Elder's Main lode between traverses 100E and 200W, layout C, as one over which poor reactions are to be expected, while that section between traverses 200W and 300W, layout C, might be classified as one over which relatively strong reactions might be expected.

+ Graphite and anthracite coal deposits are sometimes the source of positive centres.

As regards the West lode shear little is known of its character near the surface. The upper limit of the West lode ore body in the vicinity of layout C is 240 feet from the surface but Dr Jack states in his report that the 'track' of the lode persists towards the surface. It is difficult to determine from published descriptions of the lodes what physical character this lode 'track' has. In one or two places where it has been described it appears to consist of a few inches of crushed material containing a little quartz and copper sulphide. If this description applies generally to the West lode shear near the surface in the area tested, no appreciable geophysical reaction could be expected from it.

(b) Potential Gradient Method. The results of this survey are shown in the form of a potential gradient contour plan on plate 7.

A zone of low resistivity values crosses the layout between 0 and 100S. It embraces two lines of minima (shown by the closed contours) the most northerly of which coincides roughly with the outcrop of Elder's Main lode. The coincidence is best on the southwestern edge of the layout and there is little doubt that the line of minima is due to the main lode shear. It will be observed that the indication is most intense on traverses 200W, 250W and 300W. Geological evidence suggests that the shearing is more intense over this section of the layout than elsewhere on the layout so that a correlation is possible between degree of shearing and intensity of indication.

The second line of minima passes through, and is most intense on, 90S/ 200W, 95S/100W, and 70S/50E. In plan position it is midway between the assumed outcrop of Taylor fault and the outcrop of Elder's Main lode. It may be due to an offshoot of Elder's Main lode (c.f. Elder's East lode on layout B) or to a parallel shear of the Main lode type. On the other hand the position of Taylor fault at the surface is uncertain and the indication may possibly be due to this feature.

A weak conductive indication crossing traverse 0 at 150N and traverse 50E at 165N coincides roughly with the projected position of the West-lode shear. Elsewhere along the course of this shear, resistivity values are high and on traverse 200W the projected position coincides with a resistivity maximum. As stated earlier in the discussion of the physical characteristics of the shears, there is reason for believing that the West lode shear near the surface comprises a few inches of crushed material containing quartz and copper sulphides so that the absence of a definite electrical effect over the feature is not surprising.

Other conductive indications on the layout are in areas of unknown geology. With the exception of the wide zone along the southeastern edge of the layout, these conductive indications are discontinuous in strike and no attempt will be made to interpret them in terms of geological structures.

It is believed that the low resistivity values on the southeastern edge of the layout are due in part to the nearness of the power electrodes and that a repetition under more favourable electrode conditions might remove part, if not all, of the effect. It will be appreciated, therefore, that an interpretation of this effect in terms of geology is not justified.

(c) Magnetic Method. Many of the lodes at Moonta contain appreciable quantities of hematite. Although this mineral is only weakly magnetic there was a possibility that it would give rise to weak magnetic anomalies which would serve to trace the lodes.

Vertical magnetic intensities were determined on traverses 100W and 150W and the profiles are shown on plate 7.

It will be observed that variations of the order of 150 gamma occur on the profiles but these variations do not bear any relationship to the known geological structures.

The variations may be due to segregations of magnetic minerals in the porphyry.

4. Wild Dog Lodes - Layout D

a. Introduction. The shear in which the Wild Dog lode occurs is probably a continuation of Elder's West lode shear. A small but very rich shoot of ore was worked in a part of the shear a few hundred feet southwest of the area tested. A shaft near the centre of the layout discloses a band of weakly sheared porphyry without lode filling or appreciable amounts of crushed Material. No. 15 diamond drill hole, shown on the accompanying section of traverse 50W proved the downward continuation of the lode. This drill hole intersected two other lode formations, one 4 feet wide and the other 8 feet wide, lying to the northwest of the Wild Dog lode. These lodes evidently traverse the area tested.

(b) Potential Gradient Method. The layout consisted of two traverses, namely 50W and 0, and the results are shown in the form of a potential gradient plan on plate 8.

It will be observed that three conductive zones cross the traverses but none of them coincides with known geological features. The known lodes or shears gave no recognizable anomalies.

c. Self-Potential Method. The two traverses were surveyed by the self-potential method. Potentials measured were so erratic that effective smoothing was not possible. There is evidently no negative centre present which can be associated with the known mineralization.

d. Magnetic Method. Vertical magnetic intensities were measured along traverse zero. The profile, shown on plate 8, has minor irregularities along its length but the smoothed curve shows a pronounced fall in intensity from south to north, suggestive of a regional effect. Such a regional effect may be due to magnetic segregations within the porphyry.

5. Elder's Main lode - Smith's shaft Section - Layout E

a. Introduction. The layout comprised two traverses, namely 0 and 50S each 1200 feet in length.

The traverses crossed Elder's Main lode, Elder's East lode and the so-called Diamond Drill lode; the outcrops of the three lodes lying between 100E and 200E. The two last mentioned lodes are evidently branches of the Main lode.

The tests were confined to the self-potential and magnetic methods.

b. Self-potential Method. Traverses 0 and 50S were surveyed by this method. As was the case elsewhere in the district, surface conditions were unfavourable.

The results of the test are shown in the form of profiles and a contour plan on plate 9.

The profiles show minor irregularities along their length but it is apparent that a large positive indication is present on both traverses in the vicinity of 250E.

The axis of this positive centre lies approximately 125 feet to the east of, and has the same strike as, the Main lode. The Eastern and Diamond Drill lodes are nearer the axis but none of the lodes coincides with it.

The cause of the indication is unknown. No potential gradient survey was made so that it is not possible to tell whether this indication, like the positive S.P. indication on layout B, is associated with a conductive zone.

As far as is known, the area is a considerable distance from any pipe line connected to the town water supply, so that it is doubtful whether the positive potentials can be attributed to stray town D.C. supply.

This fact also introduces a doubt as to the cause of the similar indication on layout B. The explanation offered in that case may not be a true one.

In the event of a routine survey being made in the Moonta district, a more detailed investigation of the positive self-potential effects would be justified and in fact, would be essential to the understanding of the cause of the indications and their association, if any, with the lode structures.

d. Magnetic Method. Traverse 50S was the only one investigated with this method and the magnetic profile corresponding to it is shown on plate 9.

It will be observed that the curve has a smooth shape in which two maxima are apparent. The most easterly of these is a broad feature with high intensity values over that section of the traverse between 200E and 500E. The maximum value over this section appears to be at 300E. The other maximum has high intensity values between 125E and 50E, with a maximum value at 100E. This maximum coincides with Elder's Main lode if it is assumed that the effect is coming from about 50 feet from the surface. The broad maximum, however, is too far east to permit a correlation between it and the eastern and Diamond Drill lode. A more likely explanation of the magnetic curve is that the magnetic effect is due to a magnetitite segregation within the porphyry and that if the lode shears had not been present the curve would have had a shape as indicated by the dotted line, i.e., there would have been only one broad maximum instead of two narrower ones.

It is suggested that the shearing has resulted in the alteration of the magnetitite to hematite or other non-magnetic mineral with a result that in the vicinity of the lode shears the magnetitite content of the porphyry is less than on either side resulting in the reduction in magnetic intensity in this part.

This argument is highly speculative and additional evidence is required before the true character of the anomalies can be determined.

IV. CONCLUSIONS.

The object of the geophysical test surveys was to determine, if possible, whether the copper lodes, or the structural features associated with them could be detected beneath a covering of clay, travertine limestone, and soil by geophysical methods.

The ideal place for such tests would have been over a known but unworked copper lode of reasonable dimensions, i.e. over such a body as a routine survey would seek to discover. For the obvious reason that all the known lodes have been extensively mined in the past, such ideal conditions for testing were not presented. The nearest approach to these conditions was found in the case of the Stirling lode at Kadina where, because of its low copper content, a wide lode with lode filling comparable with that in the worked lodes remains more or less intact. A number of tests were made over this lode.

At other places tested only the upper and leached portions of the lodes remained, while in some instances tests were made over sections of the lode channel where the lode was absent or was only a very narrow feature.

It will be appreciated, therefore, that in assessing the value of the tests as a whole more weight has been given to the results of the Stirling test than to the results of others.

Tests with the potential gradient method gave reasonable correlations between conductive zones and the lode shears in the Stirling test at Kadina and in the tests on Alice and Hall lodes and Elder's Main lode at Moonta. Similar tests on the Wallaroo lode and Kurilla lodes at Kadina and on the Wild Dog lode at Moonta gave, at the best, a very poor correlation between known lodes and conductive zones.

To sum up, it might be said that the potential gradient method showed that some sections of the lode shears were electrically conductive and that such sections can be traced by the method. Furthermore, the results suggest in a general way that there is a relationship between the strength of the electrical indication and the intensity of shearing; the relationship being based on the assumption that the lode filling favoured the most sheared portions of the lode shears.

A limited potential phase test made over the Stirling lode gave promising results which warrant further tests by this method in the event of a routine survey being made.

Tests were made with the electro-magnetic method over the Stirling lode and the Kurilla lodes.

The principal effect measured was due to the presence of a layer of conductive clay near the surface but minor anomalies, which could be associated with the known lodes, were superimposed on the effect of the clay layer. The method might prove to be a useful one for rapid reconnaisance purposes.

The self-potential method was used ~~and~~ in tests over the Stirling, Kurilla and Duryea lodes at Kadina and over Alice and Hall lodes, Elders Main lode and the Wild Dog lode at Moonta.

Surface conditions were found to be extremely unfavourable and potentials generated at the artificially prepared surface contacts introduced a considerable uncertainty into the interpretation of the results.

A definite reaction which can be associated with oxidizing sulphide minerals in the Stirling lode was found in the test on that area. As it was the only lode tested in which any appreciable quantity of the original sulphide lode remained, the result augers well for the successful application of the method on undeveloped sulphide lodes, should such be present elsewhere on the area. It is suggested, however, that any routine survey by this method should be made at a time of year more suitable than that at which the tests were made. The area receives most of its rain during the winter months. The obvious time for a self-potential survey is therefore during the winter when the soil is moist.

The results of magnetic tests gave little promise for this method. Anomalies were present on most of the traverses but the reason for their occurrence is obscure. It is believed that the magnetic results reflect susceptibility changes in the bedrock. In the case of the Kadina area such changes may be related to the various rock types present but the only explanation which can be offered for the variations in susceptibility at Moonta where bedrock is a felspar porphyry is that segregations of magnetic minerals occur within the porphyry. Whatever their cause, it is apparent that the magnetic results bear little, if any, relation to the lodes or associated structures.

Tests made over the Eastern and Western shear zones which appear to confine the ore shoots in the Wallaroo and adjoining mines suggest that these structures are electrically conductive and might be traced by the potential gradient method.

In view of the excellent chances which appear to exist for the occurrence of hitherto undiscovered ore bodies and the difficulties associated with their discovery by other means, it is believed that the results of the geophysical tests are sufficiently encouraging to warrant a geophysical survey of the Moonta-Kadina copper area.

Because the lodes occur in a homogeneous rock (felspar porphyry) at Moonta whereas at Kadina the country rock has a variable habit, it is suggested that a survey be carried out in the first instance at Moonta and that the results of this be thoroughly tested before extensive surveys of the Kadina and surrounding areas be undertaken.

It should be clearly understood that the geophysical methods would be primarily directed towards the disclosure of the structures with which the ore-bodies are associated. Providing these structures can be located by the methods, the selection of places favourable to the occurrence of ore shoots would be governed largely by the geological interpretation of these structures. The term largely is used advisedly because, at least one of the methods, namely, the self-potential method, might give direct indications of the sulphide minerals which occur in the lodes, and hence locate the lodes directly.

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Canberra,
31st July, 1942.