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A REVIEW OF THE RESULTS OF INDUCED POLARIZATION SURVEYS ON THE LIPANGUE BRECCIA PROPERTY METROPOLITAN REGION CHILE

FOR

MEDINAH MINERALS, INC.

BY

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CANADA

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INTRODUCTION

At the request of Medinah Minerals, Inc. Peter E. Walcott and Associates Limited undertook a review of the induced polarization surveys carried out on the Lipangue Breccia property for Medinah Energy Chile S.A.

These surveys were carried out in 1998 and 1999 by Geodatos SAIC using the dipole-dipole method of surveying with equipment manufactured by Zonge Engineering operating in the frequency domain.

The 1998 survey was carried out employing a 100 metre dipole on nine north-south profiles 200 metres apart, Profiles A to I respectively, while the 1999 survey was designed to look deeper and was conducted with a 200 metre dipole on three north-south profiles, Profiles P-F, E-F, and F-G respectively, 200 metres apart and intermediate to Profiles D through C, and on two east-west profiles, Profiles 850 and 1000.

Measurements - first to sixth separation – of the fundamental phase shifts and amplitudes of the 0.125, 0.5 and 1.0 Hz responses as well as those of the 3rd, 5th, 7th and 9th harmonics were made in 1998 as well as those of apparent resistivity. In 1999 similar measurements were made employing frequencies of 0.125, 1.0 and 8.0 Hz respectively.

The raw data provided by Geodatos was reprocessed and is presented in pseudosection form on profiles relabelled Line 0 through 1600E, and 850S and 1000S respectively to conform to the grid system. In addition inversion was carried out using the Zonge Smooth Model Algorithm. The results are shown on the accompanying maps at 1:10,000.

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SURVEY SPECIFICATIONS

- **Equipment**

The survey was carried out using a GDP-16, 6-channel receiver and a GGT-10, 10 kw transmitter both manufactured by Zonge Engineering of Tucson, Arizona, USA, operating in the complex resistivity mode.

The surveys were conducted using the "dipole-dipole" electrode array. This electrode configuration and the method of presenting the results are illustrated on the pseudo-sections. Depth of penetration with this array is increased or decreased by increasing or decreasing "a" and/or "n".

In practice, the equipment is set up on a particular station of the line to be surveyed; three transmitting dipoles are laid out to the rear, measurements are made for all possible combinations of transmitting and receiving dipole, up to the sixth separation, i.e. n=6; the equipment is then moved 3 "a" metres along the line to the next set-up.

A 100 metre dipole was employed on the 1998 survey using frequencies of 0.125, 0.5 and 1.0 Hz while a 200 metre one was used on the 1999 survey with frequencies of 0.125, 1.0, and 8.0 Hz respectively.

In each case data recorded in the field consisted of measurements of the injected current (I) in ampere flowing through the current electrodes C1 & C2, the fundamental phase shifts referenced to the transmitted signal along with those of the 3^{rd}, 5^{th}, 7^{th} and 9^{th} harmonic between potential electrodes P1 through P7 in milliradians and the magnitude of the received signal in millivolts as well as those of the above harmonics between the same electrodes.

- **Decoupling**

The basis for this is that the induced polarization effect can be considered to have an approximate constant phase over limited frequency ranges up to 10 Hz while the induced phase response varies with different powers of frequency.

Two point linear and three point quadratic curves are used to approximate the coupling depending upon its magnitude and the layered resistivity geometry.

A typical quadratic coupling curve must pass through zero for dc and is concave upwards in a plot of phase shift versus frequency - negative phase shift increases with increasing frequency up to a maximum then levels out.

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SURVEY SPECIFICATIONS CONT'D

As the measured phase response consists of the constant induced polarization phase and the polynomial induced coupling curve, removal of the latter will leave only the induced polarization response.

The three-point formula as written below is the one most commonly applied to multi-frequency measurements and is the one used by the Zonge receiver.

$$\varphi_{dc} = 1.875\ \varphi\ (1) - 1.25\ \varphi(3) + 0.375\ \varphi(5)$$

where $\varphi(1)$ is the phase measured at the fundamental frequency and $\varphi(3)$ and $\varphi\ (5)$ are the phases measured at the third and fifth harmonic frequencies.

There is no theoretical basis for the use of the above for the removal of grounded coupling *i.e.* when the plots of the above phase shifts do not show the concave curve shape and are beset with noise. In cases it is used with arbitrary justification based on the ability to extract the same φ_{dc} from different fundamental frequencies.

Three point extrapolation will always increase the error in a measured value as the third harmonic has 1/3 the measured strength of the fundamental, the fifth harmonic 1/5 the measured strength and so on. Thus if there is little difference between the three point value and the fundamental, or between the harmonics, or the data is noisy the writer prefers to use the fundamental (raw) phase value particularly in areas of moderate to high resistivity to avoid the introduction of further unnecessary noise.

- **Data Quality**

On examining the raw data from the 1998 survey it was noted that only some 10-15% of the readings exhibited the previously described shape on plotting. Most plots showed irregular patterns of horseshoe and inverted horseshoe shapes, or somewhat linear decrease in phase shifts with frequency.

They do not appear to be discrete zones, and whether they are the result of instrumentation, methodology or real ground response is unknown.

Some values of apparent resistivity did not agree with the plotted values and the writer has removed them from his presentation. He also used the raw phase in milliradians in the pseudosection plots and the smooth inversion modelling.

The same could be said of the 1999 data except that it was considerably noisier than the 1998 data as expected due to the doubling of the dipole length. The writer removed several readings from the database before processing the data. Again he used

SURVEY SPECIFICATIONS CONT'D

the raw phase and not the three point decoupled values, a practise Geodatos also saw fit to do this time.

- **Data Presentation**

Two-dimensional smooth model inversions of the resistivity and raw phase data were carried out using the Zonge Smooth Model Algorithm. This algorithm uses a 2-D finite element method and incorporates topography in modelling resistivity and I.P. data. Nearly uniform starting models are generated by running broad moving-average filters over the respective lines of data. Model resistivity and chargeability properties are then adjusted iteratively until the calculated data values match the observed as closely as possible, given constraints which keep the model smooth.

The smooth chargeability and resistivity models along with the plots of the apparent and synthetic (calculated) phase and resistivity are plotted for each individual line at 1:10,000.

The 100 metre dipole 1998 data is plotted using the supplied topography, but that of the 200 metre dipole work is shown on an idealized surface as no additional topography was supplied.

DISCUSSION OF RESULTS

This section should be studied in conjunction with the reports on the exploration and drilling programmes on the property by Gordon D. House, P.Geo and reviewing reports on the above by Robert Cinits, P. Geo of Howe Chile Limitada.

As described in the above the property is underlain by a northerly striking easterly dipping volcanic-sedimentary package intruded to the east by Cretaceous granodiorite of the Central Batholith.

The Lipangue Breccia pipe is located on or near the contact between the above which runs roughly north-south through the central part of the property.

The surface expression of the pipe is an oval shaped area of hydrothermal breccia material, some 250 x 150 metres in the east-west and north south directions and centred around L800E - Line E.

Drilling to date has suggested the pipe to be an oval shaped body plunging steeply to the southeast.

The IP survey showed the background polarization of the rocks to be in the order of 3 to 8 milliradians above which several area of anomalous response are discernible on the plots of the respective profiles.

It should be noted that while the writer has not masked out the grid on the smooth inversion models to conform to the measured data they should be viewed with this limitation in mind.

The results are best discussed on an individual line basis. This will follow below starting with the L800E (PE) the traverse over the breccia pipe.

Line 800E (PE): The IP responses - *100 metre dipole* - obtained here shows the classic pant-leg pattern obtained over a narrow steeply dipping body. The IP inversion model suggests the causative source to be a shallow subcropping body lying between 600S and 725S and dipping steeply to the south. The body appears to lie at the contact between more resistive rocks to the north and those of lower resistivity to the south as evidenced from the pseudo-section plots of apparent resistivity and the resistivity inversion model. Plots of the seven drill holes on Section "E" on the IP inversion model show very good correlation between the latter and the sulphides outlined in the breccia pipe and alteration halos in the surrounding rocks.

Line 1000E (P-F): The IP response – *100 metre dipole* - shows a stronger pant-leg pattern at depth centred around 600S on a pseudo-section of mostly anomalous values. The IP inversion model suggests the traverse is underlain by anomalous rocks with a central body of higher responses located some 75 metres below the surface and

DISCUSSION OF RESULTS CONT'D

presumably related to the increase in sulphide content in the pipe and nearby hanging and footwall rocks. Again this body would appear to be at a resistivity contact, although not as well defined as on L800E. Drill hole 99-02 collared on the northern edge of this modelled body intersected disseminated pyrite and magnetite in altered granodiorite.

L1200E (P-G): The IP results – *100-metre dipole* – here show a generally broad area of intermediate response at depth from 700S southwards, a one dipole shallow response around 500S, and a stronger shallow response at the northern end of the line undefined to the north. Modelling suggests a body of stronger IP response at a depth of about 200 metres at a resistivity contact that could correspond to the breccia pipe, and a shallow body of similar response at the north end of the line associated with rocks of higher resistivity.

L 1400E (P-H): The IP response – *100-metre dipole* – here shows a very similar pattern to that of the previous line except that the response in the south is deeper, and the undefined response to the north is not as strong – it should be mentioned here that the intermediate response to the south on this and the previous lines has also not been properly delineated as the coverage is too limited. The IP modelling also gave similar results to the last line, but the resistivity modelling suggested that the southerly body was associated with higher resistivities as also seen on the resistivity pseudo-section.

L 1600E (P-I): The IP response – *100-metre dipole* – showed the line to be underlain by rocks of intermediate phase response above which a stronger response is observed on the smaller separations between 700S and 800S. This is shown on the IP modelled section which would be somewhat similar to that of the previous line if the top 100 metres was removed from the southern section of the latter. The resistivity results were dominated by a strong pant-leg low in the middle of the line, but higher resistivities were associated with the stronger phase response.

L 600E (P-D): The IP response here – *100-metre dipole* – showed this line to exhibit background phase response at the shallower spacings and intermediate response at the deeper levels. Inversion modelling suggested a polarizeable body at about 200-metre depth centred beneath 600S. This occurs at the same resistivity contact as the breccia pipe on L 800E.

L 400E (P-C): The IP response here – *100-metre dipole* – showed the line to be mostly underlain by rocks of background IP response with the exception of some weak response on the north end.

L 200E (P-B): The IP response here – *100-metre dipole* – showed the line to exhibit background response in its entirety on the shallower separation with a small increase in response on the larger separations. IP inversion modelling suggests the possibility of a

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DISCUSSION OF RESULTS CONT'D

body of anomalous response at some 250 metre depth. Lower resistivity values were more widespread than on the previous line.

L 0 (P-A): The results here - *100-metre dipole* – showed a strong shallow anomalous phase response to exist from 700S to the northern limit of the line, and increasing in intensity northwards. Modelling suggested the causative source of the above to be shallow northerly dipping body.

L 700E (P-DE): The results here - *200-metre dipole* – showed the line to exhibit anomalous response from 1000S to its northern limit, with the strongest response at depth. The southern part of the response could be due to sulphides related to breccia pipe and hydrothermal activity while the northern part occurs in higher resistivities as seen by the respective responses at the northern end of L 600E. Modelling suggests a steeply southerly dipping body for the causative source of the southern portion of the anomaly, the core of which occurs at some 300 metres depth between 800S and 900S in a modelled resistivity low on the previously noted resistivity contact circa 700S. Drill holes 00 – 09 and 10 drilled 50 metres to the east appear to be too far north and/or too shallow to intersect the modelled core as projected between Lines 700E and 800E.

L 900E (P-EF): The IP response – *200-metre dipole* – is very similar to those of 700E except that the northern anomaly is stronger at shallower separations. The southern anomaly, if separated from the northern one, could exhibit a pant-leg response similar to that of L800E. Modelling suggests the whole line to be underlain by material of anomalous IP response and appears to show the pipe as a steeply southerly dipping feature below 700S. Plots of drill holes 00-14 and 00-18 on Section "E-F" show good correlation between the sulphides in the breccia pipe and surrounding wall rocks and the core of the modelled response. Drill hole 00-17 appeared to have stopped short of the modelled core, while 99-04, drilled southwards, intersected pyritized granodiorite in the hanging wall. The resistivity again shows the resistivity contact between 600S and 700S as noted before.

L 1100E (P-FG): Again this line – *200-metre dipole* – exhibits anomalous phase response through out its entirety with the strongest response on its northern end. The pattern of a strong response at depth in the south, a shallow surface response in the centre, and a strong shallower response at the north end is the same as seen on L's 1200E and 1400E on the 100 metre dipole work. The latter is associated with a zone of higher resistivity presumably indicating related silicified granodiorite underlying the height of land.

L 850S (P-850): It should be noted here that 0 corresponds to 200 in the Geodatos report on these two east-west traverses. This line – *200-metre dipole* – exhibits

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DISCUSSION OF RESULTS CONT'D

background responses on its extremities, and anomalous responses in the centre with the strongest on the deeper separations. Resistivities are also lower across the line particularly on the shallower separations. Modelling suggests a body of anomalous response to underlie most of the line with a central core between 550E and 750E. This modelled core at a depth of some 300 metres below the overlying andesites was also confirmed by the modelling on L700E, and could represent an extension of the breccia to the west at depth, or adjacent porphyry sulphide mineralization. It is associated with a modelled resistivity high suggesting silicification.

L 1000S (P-1000): This line – *200-metre dipole* – exhibits background responses across the entire line on its smaller spacings with a strong response at depth at its western end. Lower resistivities were also observed across the whole traverse. Modelling suggests a zone of higher IP response at depth between 400E and 800E, weaker than that obtained on L850S, that could reflect similar sulphide mineralization. It is also associated with a modelled zone of higher resistivity. There is some conflict with the results from L1100E where strong phase responses were obtained on the observed and modelled data.

Overall there tends to be higher resistivities north of 600S on most of the lines particularly in the areas of underlying granodiorite. At present the writer can see no evidence of any structure and/or lithological change to explain this apparent east west trending contact. While this could be indicative of silicification in areas surrounding the breccia pipe, in the northeast corner of the grid it also could be related to silicification associated with mineralization at depth.

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CONCLUSION AND RECOMMENDATIONS

On reviewing this data it is readily apparent that the survey coverage was too limited to properly cover the large indicated mineral system. The indicated anomalous conditions on most lines were not fully delineated.

The 200-metre dipole was too large to refine drill targets in this environment with the undersampling resulting in the amalgamation of anomalous zones. In hindsight a step-up to a 150-metre dipole would have been better in the writer's opinion.

Nonetheless the surveys and subsequent inversion modelling appeared to successfully locate the breccia pipe and its alteration halo on L 800E and 900E respectively, although the surveys suggested the mineralization to be more widespread than reported in the drill holes.

The pipe and accompanying sulphide mineralization appear to extend to the west as indicated by the similarity of response on L's 700E and 850S, underneath the overlying andesites.

The writer does not believe magnetite in the andesites, as noted in outcroppings, to be the sole causative source of the above-mentioned anomalous response or for that matter that of L0. If such were the case he would expect to see a stronger response on the shallower separations. As mentioned previously the strong anomaly at the northern end of L1100E is probably related to sulphide mineralization in the underlying granodiorites, evidence of which is suggested by the quartz vein system – Veta Espanola.

As a result the writer recommends that during the next phase of drilling, in addition to further delineating the pipe as outlined by previous drilling, that the following also be investigated.

1. the possible extension of the pipe to be west at 850S on L700E.
2. the strong phase response on L0 at 300S.
3. the strong phase response on L1100E at 300S.

He also suggests that physical property measurements be made on samples of the core and on hand samples in an effort to gain more understanding of the phase and magnetic response of the rocks.

CONCLUSIONS AND RECOMMENDATIONS CONT'D

Should the above drill results prove encouraging and further induced polarization is contemplated then 150 metre dipole surveying be undertaken on lines at least 3 kilometres long in an effort to obtain sufficient coverage on the sixth separation.

Respectfully Submitted

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May 2001

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APPENDIX

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CERTIFICATION

I, Peter E. Walcott, of the city of Coquitlam, British Columbia, hereby certify that:

1. I am a graduate of the University of Toronto in 1962 with a B.A. Sc., in Engineering Physics, Geophysics Option

2. I have been practicing my profession for the past thirty-nine years.

3. I am a member of the Association of Professional Engineers of British Columbia and Ontario

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May 2001