GEOPHYSICAL PROSPECTING FOR MINED AREAS IDENTIFICATION. "SAN JOSE" MINE CASE HISTORY (CACERES - SPAIN)

GRANDA, A.
Compañía Gral. de Sondeos
Madrid.

CASAS, J.

SASTRE, J.L.
TOLSA - Madrid.

ABSTRACT

Geophysical methods, especially those of resistivity, offer interesting possibilities for use in the study of some problems which are related with subsurface water and mine diggings. Particularly attractive due to its versatility, ease of use and good results, the "mise-à-la-masse" method is perhaps the one which has the greatest potential use in this field.

The present work is concerned with a trial carried out in the surroundings of the "San José" Mine (Caceres - Spain). This is a mine which has been abandoned for years and we have sought to check the effectiveness of the method to define the position of the old drifts and the approximate magnitude of the exploitation.

The results obtained have been completely satisfactory and on the basis of these results a more complete study has been planned that will be carried out during next summer.

1. INTRODUCTION AND GEOLOGICAL PLAN

The San José mine is situated about 3 km. S.E. of the city of Caceres. Operations in this mine were abandoned over 30 years ago, leaving behind abundant building remains, tips, etc. that makes one think that the exploitation could have been important.

The deposit is made up of a vein system with mineralization of cassiterite and amblygonite that can be defined as a typical "stockwork". These mineralizations are found in close relationship with the fracturing of the metasedimentary materials -slate and greywacke. The veins are normally subvertical with frequent inflections, variable thickness between 0.1 and 1 m. and a bearing of N65E. There is another family bearing of N30E with a dip of 45° S.

Considering the old mine diggings, it can be estimated that they became important as there were at least five shafts, as well as several superficial diggings. Only two of the shafts are still open, without knowing how far the drafts go down, what connection they have with drifts, etc. Hence the interest firstly to find out the magnitude of the mined area before making any plans to survey the mine.

2. SURVEY APPROACH

The application of the "mise-à-la-masse" method approaches its ideal conditions of application the more conductive the character of the body to be prospected is, and the greater the resistivity contrast between it and the rock wall. Obviously, the primitive applications of the method in metallic sulphides is quite close to the theoretical conditions - hence its great popularity in this field.

In the hydrogeological field the method has been used fairly frequently in the study of problems associated with kastificated media : identification of the feed areas of springs, connection between drillings, direction and speed of the subterranean flow etc. In general, these applications, despite their efficiency, present in principle the drawback that the difference in resistivity between the conductive element - water - and the resistive medium made up of rocky surroundings, is clearly inferior to that which exists in the case of the massive metallic sulphides.

However, subsurface water associated with a kastificated media or with a mine exploitation that in this case would be the same, present other features that greatly increase the spectrum of the applications modalities of the method. These features can be summed up in the capacity of temporary alteration of its physical properties and especially its electrical conductivity. In each particular case this can result in variations of the geophysical response in space and in time. Variations which contain in themselves great informative wealth, ease of translating them into terms which have immediate physical sense.

Bearing in mind these basic ideas and applying ourselves to the actual problem of the "San José" Mine, we can consider in a simple way as an attempt to locate a conductor body similar to horizontal cylindrical elements - with or without connection between themselves, constituted by the old drifts which are full of water. This "conductor" is placed in a medium, in principle, homogeneous and far more resistive. Moreover, one can reach this from the surface through the two shafts remaining from the old exploitations. There are, therefore, the basic conditions for applying the geophysical method of "mise-à-la-masse".

3. WORK CARRIED OUT

This brief study does not claim to be an exhaustive study of the entity of the old exploitation, but to carry out a trial which is valid enough to make a rough estimate of the magnitude of the exploitations. In the event that the results obtained make it advisable, a second more detailed phase would be set up and with the participation of other specialists. So, seven work profiles

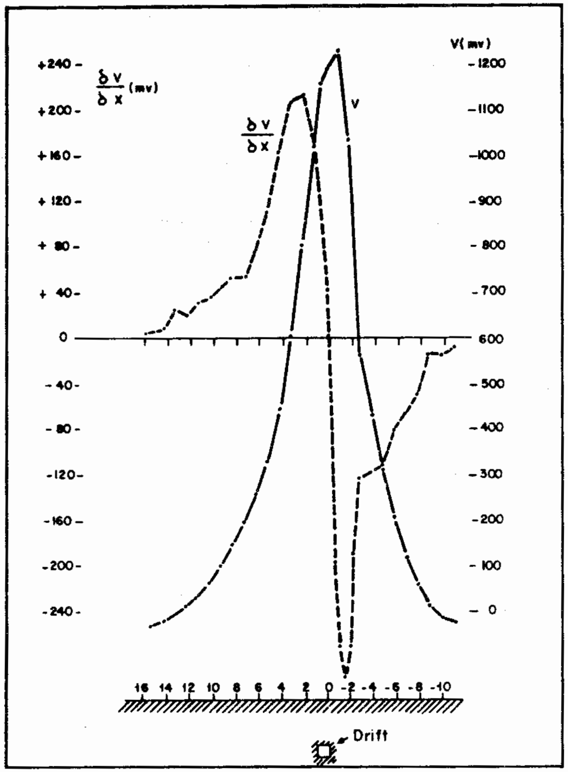

Fig.-1 Potential and potential gradient in profile 2 (Transmitter in shaft nº 1)

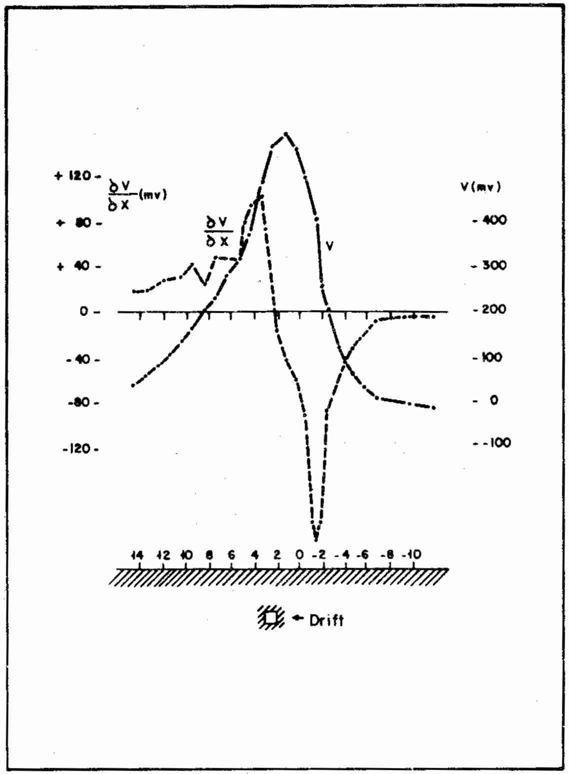

Fig.-2 Potential and potential gradient in profile 3 (Transmitter in shaft nº 1)

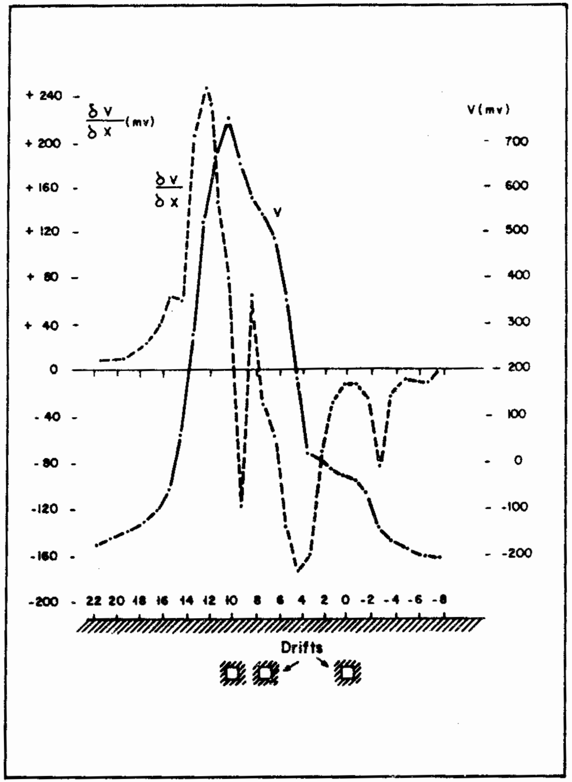

Fig.- 3 Potential and potential gradient in profile 4 (Transmitter in shaft nº 2)

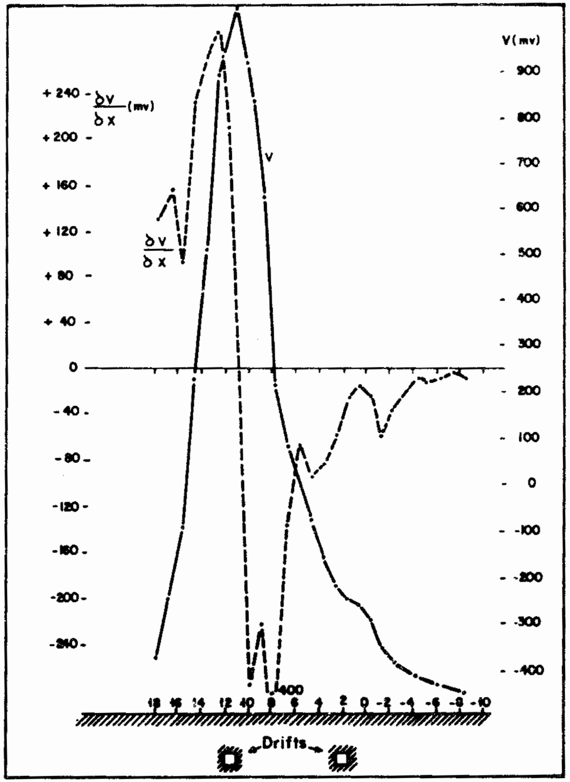

Fig.- 4 Potential and potential gradient in profile 5 (Transmitter in shaft nº 2) separated at intervals of 25 m. were established, except P-1 and P-2 which are at 40 m. The average length of these profiles is about 270 m. and their direction mainly perpendicular to that of the dikes in which the exploited mineralization is situated.

Before starting to collect data, a salinization of the "conductor" was provoked by pouring 100 litres of ClNa saturated water in each of the shafts. There are no facts concerning the hydraulic gradient in the area, although due to its limited extension, it is foreseeable that, apart from other considerations, it is ionic diffusion and not the movement of water in the drifts which is the determining factor in that the salinization spreads as far as possible from the shafts. So, salinization was provoked at least 24 hours before starting data collection Although it would have been desirable to prolong this period, the results obtained showed that, on the whole, it was sufficient.

Placing a transmitter electrode by sinking it in Shaft 1, the profiles of P.1, P.2, P.3 and P.4 were measured, while with the transmitter through shaft 2 the profiles in P.4, P.5, P.6 and P.7 were measured. In both cases the transmitter circuit was closed by an electrode placed in the direction of the profiles and removed far from the study area. (800 m.).

Once suitable signals from the transmitter and receiver were established, measurements of potential of the profiles mentioned were carried out using the gradient method and at intervals of 10 metres.

Finally the profiles of each shaft were connected by means of a transverse profile to enable equipotential maps to be drawn up.

The system was powered by batteries supplying a difference in potential of 200 V. between transmitter electrodes. The measured intensity was kept practically constant in each circuit during the collection of data and it was 680 mA in Shaft 1 and 720 mA in Shaft 2.

The readings of difference in potential, carried out with a digital millivoltmeter developed by Compañía General de Sondeos, were characterized by its great repeatability and its high order of size, consequently the readings are accurate and ensure reliable interpretation.

4. INTERPRETATION OF THE RESULTS

The analysis of the profiles of potential and potential gradient allow us to identify the position of the flooded drifts to a high degree of accuracy. In fact, the horizontal projection of the axis of the conductor corresponds to points in which the gradie potential is zero or of maximum potential. Due to the uneveness of the shafts with limited dimensions with respect to the distance between measurement electrodes (MN = 10 m.), the gradient curves of potential pass from their maximum to minimum value very brusquely. The size of the given maximum and minimum are in di rect relationship with the restivity contrast between "conductor" and the rock wall. According to this idea, it is obvious that the salinization was very effective in our application,as can be observed in the profiles we offer. Translated into geophysical terms, the drop in potential in the limits of flooded drifts is spectacular and its absolute value on them is very high.

Apart from the main maximum of potential observed in each profile, and which we interpret as drifts directly connected with the corresponding shaft, in some cases there are other maximum of smaller amplitude , which present themselves as easily identifiable dishing. In this connection, see profiles 4 and 5. In the first, the main maximum (the drift directly connected to Shaft 2), is between pegs 10 and 11. There are also another two maxima regarding the potential, around pegs 7 and 0 respectively. We interpret these other maxima as flooded drifts not directly connected to the shaft. On profile 5, the assumed drift not connected to the shaft is situated around peg (-1) in clear correspondence with the anomaly of peg. 0, identified in profile 3.

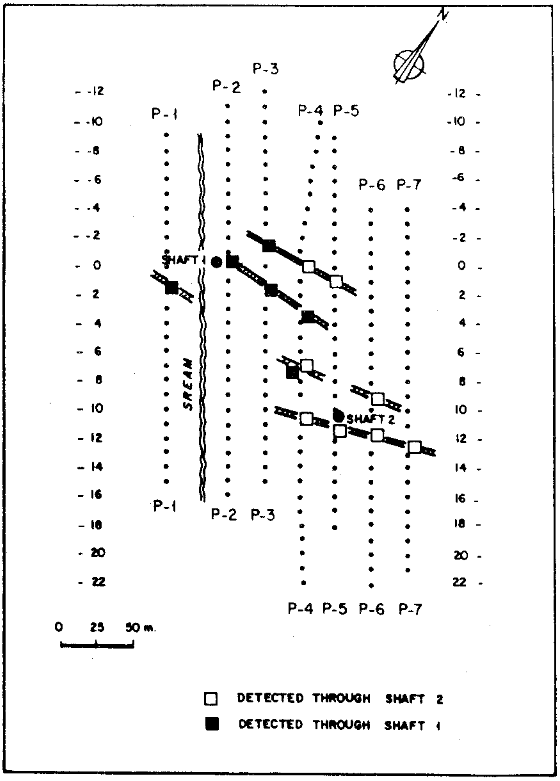

Fig.- 5 Approximate drifts location from geophysical interpretation

Based on this set of observations, we have drawn up figure 5 as a synthesizing document, correlating the results of the different profiles. The direction which the drifts appear to follow is coherent with the morphology and position of the mineralized bodies. On the other hand, these results confirm that the mine diggings were quite important, which is a significant point with regard to the possibilities of working the mine.

Other consequences of a qualitative nature can also be drawn, such as the possible presence of flooded areas within the drifts. This fact is shown basically by a considerable drop in potential between nearby profiles. Thus, for example, in the area of Shaft 1, it is very likely that the drift between profiles 2 and 3 - pegs 0 and 2 respectively - is obstructed. Notice the great difference in size of the maxima of potential between both curves (Figures 1 and 2). On the other hand, the same analysis in profiles 4 and 5 shows less relative difference in the maxima of potential, which could be explained by the absence of sunken areas in the stretch under consideration.

Apart from the profiles commented on, equipotential maps have been drawn up which furnish complementary information, although in less detail than can be deduced from the profiles of potential and gradient of potential.

As an example, we include figure 6 which corresponds to the distribution of potential in the surroundings of Shaft 2. In it we can see how the distorsion of the equipotential lines occurs mainly in the direction of the principal drift connected to the shaft. It would not be very realistic to try to deduce the presence of other drifts from this document.

As a final detail, deduced by applying the method of Jakuvoskii and Liajkov, the depth has been calculated at which the drifts detected lie. The application of this method calls for a series of conditions in the morphology of the gradient profiles of potential, which in our case only occur in profiles no. 2 and 5. After calculation, they work out to be depths of about 27 m. and 20 m. respectively with respect to the theoretical axis of the drifts.

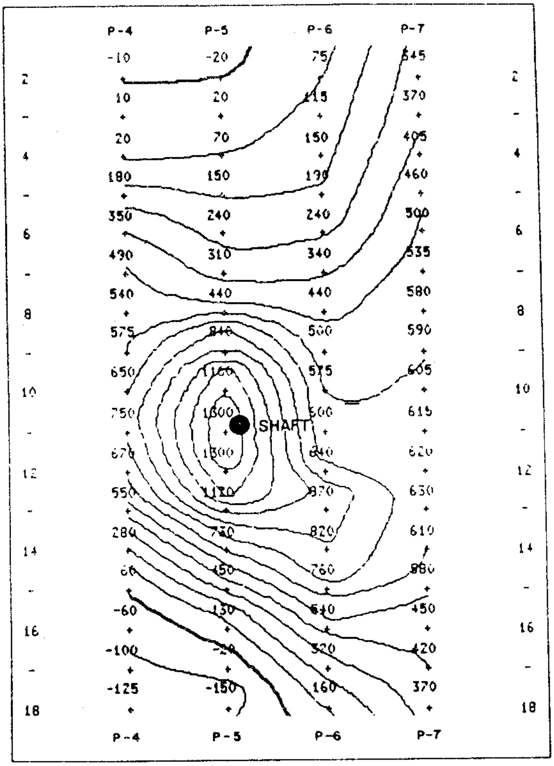

Fig.-6 Equipotential distribution in shaft nº 2

5. CONCLUSIONS AND ACTION PROPOSED

Bearing in mind the quick test nature of this paper, it is obvious that its results are very attractive from the point of view of providing objective information which can be interpreted perfectly. The distribution and position of the assumed areas mined is coherent with the geological model and with previous information available.

However, with a view to solving better the connection between drifts and to extending the area under study, to define how far mining really took place, different forms of action are possible, which we are now considering and which will be carried out in the coming months.

To enlarge the survey area, the use of a generator motor is foreseen, capable of supplying a maximum power of 3 KVA. and longer waiting time between salinization and data collection.

It is also planned to carry out combined measures, similar to those performed, but at different time intervals after pumping in one of the shafts, etc. From all this, we can expect excellent results, as shown by similar experiments in other areas, and the test which constitutes the object of this publication.

---oOo---

REFERENCES

1. Grant F.S. 1965. Interpretation theory in applied geophysics. McGraw-Hill. Toronto.

2. Jakuvoskii and Liajkov. 1979. Prospección eléctrica. Ed. Reverté. Barcelona.

3. Milizo R. et al. 1979. Theoretical and experimental investigations for cavity research with geoelectrical resistivity methods. Geophysical Prospecting. Vol. 27. p. 640-652.

4. Mwenifumbo C.J., 1980. Interpretation of mise-à-la-masse data for vein type bodies. Dr. Thesis. University of Western Ontario.

5. Parasnis, D.S., 1967. Three-dimensional mise-à-la-masse survey of an irregular lead-zinc-copper deposit in Central Sweden. Geophysics. Vol. 41. pages 407-437.

6. Zvonimir, K., 1977. Geophysics in karst-hydrogeology. 7th International Speleogical Congress, Sheffield, England.
