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Geophysical Studies Data of The Kangan Region Iran Using Principal Component Analysis

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ABSTRACT

This paper describes a methodology for the integrated interpretation of airborne magnetic and airborne gray spectrometer data. The Kangan porphyry copper deposit is situated in the Kangan magmatic assemblage of Iran. Phyllic and propylitic alterations are pervasive in the area but potassic and argillic alterations are not readily recognized on the surface. The spatial distributions of geophysical data resemble the lithological and alteration patterns in the area. The Kangan porphyry copper deposit is considered as a control site for determination of the degrees that the geophysical data is correlated with the mineralization zone. Airborne magnetic radio metric, and geochemical reiteration data sets have been integrated and analyzed using principal component analysis. This technique is found to be useful for the delineation of hydro thermally altered areas and data compression.

KEYWORDS: Mineral exploration; Statistical analysis; Airborne geophysics; Geochemistry; Iran

1. INTRODUCTION

Many of the known porphyry Cu deposits are situated in the Iranian Volcanic Belt Fig1. This belt has a great potential as far as tertiary porphyry copper is concerned. Given the poor soil development but abundant outcrops, the arid semiarid part of the belt is suitable for airborne geophysical survey and remote sensing study A helicopter magnetic reflector magnetic radiometric survey HMER was flown by Geonex Aerobat over an area of 7000 km in 1992 in the Kangan Province. The aim of the project was mainly for exploration of porphyry and vein type mineralization in the kangan region. The survey was conducted over the area in 200m of line spacing and constant height at average elevation of 60m for spectrometer, 45m for magnetometer and 30m for electromagnetic coils. The data then, were processed by various filtering's and enhancing techniques for noise removal and data correction Pitcher et al., 1994. The data, both in digital and analogue formats, are currently maintained by the geological survey of Iran. The integration of multiple data sets is a necessary step in mineral potential mapping. A major focus in modern exploration programs aims at the search for blind ore bodies. Because of the advent of advanced computer technologies, various multivariate techniques have been introduced to interpret and synthesize multiple geodata sets for target selection Agterberg., 1989. Principal component analysis is a multivariate analysis that can be used for the data that are spatially distributed and have common geographical locations. Statistical analysis of geophysical data has been reported by many authors in the recent years e.g., Duval., 1977; Pan., 1993. The previous studies have shown that the elevated potassium in the Seri cite zone is often observed around the mineralization areas and also acid sulfate conditions resulting from weathering of near surface sulfides can result in eTh mobilization from host rocks and can precipitate with iron in gossan Dickson et al., 1996. The porphyry copper deposits in the Kangan region are associated with a distinct magnetic low, relative to the host rocks, a potassium high and resistivity low Pitcher et al., 1994.

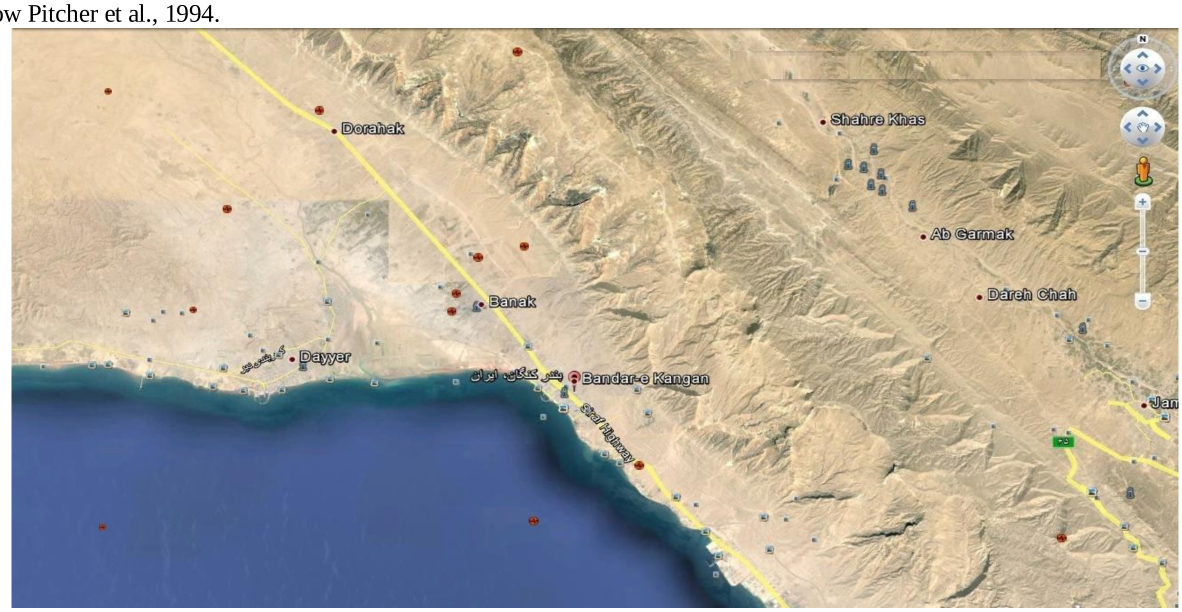

Fig.1 Study Site

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2. Geological setting

Pariz area is situated within the southern part of the Iranian Volcanic Sedimentary complex, southeast of Kangan City. Its geological evolution can be simplified as a formation and folding of Early Tertiary Volcanic Sedimentary rocks, b emplacement of Late Tertiary granodiorite, diorite, quartz diorite, monzonite, and tonalite in the Volcanic Sedimentary complex. Their subsequent faulting, fracturing, alteration and mineralization, both within the porphyry rocks and the associated volcanic rocks are followed by c formation of supergene environment and oxidation zone in some of the deposits Shahab pour., 1982. Hydrothermal alteration involving chlorite, sericite, epidote, carbonate, silica, tourmaline and clay minerals are common. However, phyllic, argillic and propylitic alteration are more common in the area Dimitrijevic., 1973. Kangan area is located southeast of the Sar Cheshmeh porphyry Cu deposit. The topography around the deposit is mountainous. Data from detailed geophysical, geochemical and geological survey carried out in 1969 are given by GSI 1973. The deposit was later studied by Grujicic and Volickovic., 1991, Maanijou., 1993, Ranjbar., 1996 and Hassanzadeh and Torabi., 1998. The Kangan porphyry is situated in a diorite quartz diorite pluton of Oligocene Miocene age that intrudes an Eocene Volcanic Sedimentary complex comprised mainly of volcaniclastics, andesite and sedimentary rocks. The porphyry locally grades into granodiorite Figs2 and 3.

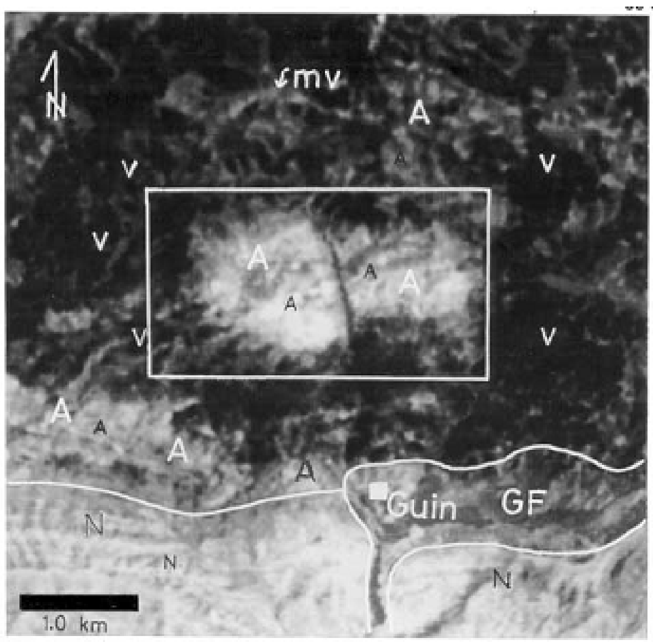

Fig.2 SPOT image in XS mode of the Kangan area. Altered rocks phyllicrargillic alteration , V volcanic rocks, Neogene sediments, GF gravel fans and MV mineralized vein. The control area is outlined by the rectangle

The hydrothermally altered rocks are highly fractured, and supergene alteration has produced extensive limonite and leaching of sulfide, giving a characteristic reddish or yellowish color to the altered rocks. A weathered zone is developed from a few meters to 80m below the surface GSI., 1973. Propylitic and phyllic alterations are pervasive in the surface rocks with sporadic small areas of argillic alteration Maanijou,. 1993. Phyllic alteration persists below the oxidation zone, as is evident from a limited number of samples collected from creeks. Potassic alteration is not seen on surface, possibly as a result of an intense phyllic overprint or surface related weathering. A sampling grid with a cell size of 150*150m was set up over the control area Fig2, see also Section 3. A total of 262 rock samples were collected over the area and analyzed for major and trace elements by standard atomic absorption spectrometry methods. The phyllic zone is characterized by enrichments in Si, Al and K, and depletions in Na, Ca, Mg and Mn. Propylitic alteration is well developed in the area and extends a few hundred meters around the central phyllic zone. The mineralized area is roughly outlined by high Cu contents. Mo correlates positively with Cu rs0.43. Rb and K concentrations are higher in the phyllic zone, whereas Sr and Ca are more abundant in the propylitic zone Ranjbar., 1997. Soil geochemical survey of the area has been carried out by GSI 1973. The soil samples were analyzed for Cu, Mo, Zn and Pb Table 1, but because Cu and Mo mineralization was expected in the study area, soil samples for these two elements were considered in this study

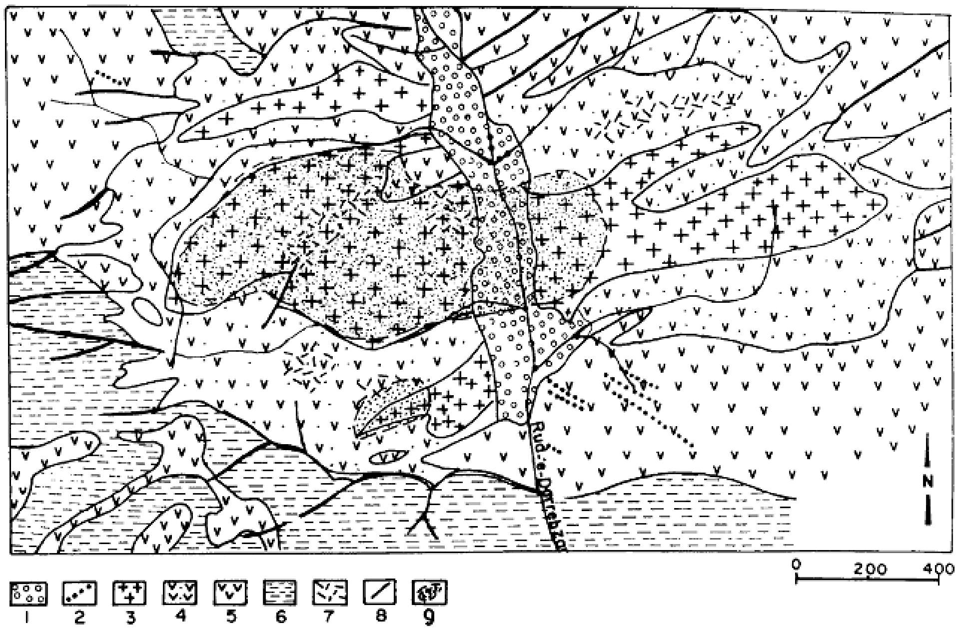

Fig.3 Simplified geological map of the Kangan Cu deposit after GSI, 1973. 1 River terrace, 2 microdiorite dikes, 3 altered diorite porphyry, 4 altered rocks, 5 andesite and trachyandesite, 6 pyroclastic and sedimentary rocks, 7 silicification, 8 fault, and 9 Cu deposit. This area covers the rectangle in Fig 2

3. Data analysis and discussion

The search of ore deposits generally requires prediction of rare spatial phenomenon through chemical and physical measurements. Target variables provide direct and firm evidence for mineral deposit e.g., detail geochemical data, drilling data and alteration. data. Explanatory variables, observable through the entire region with relatively low costs, are expressive of indirect evidence for mineralization e.g., airborne geophysical data Pan and Harris, 1992. Rock and soil geochemical anomalies in the study area are consistent with the occurrence of copper mineralization. They in turn, have a good correlation with phyllic alteration zone Table 1. Therefore, copper, molybdenum concentrations, phyllic zone and Cu in drill cores were selected as target variables. gray and total magnetic field intensity were selected as explanatory variables. The area containing the copper mineralization was identified as the control area Fig2. for estimation of eigenvector loadings for transformation of explanatory variables. Principal component analysis determines the eigenvectors of a variance covariance or a correlation matrix. The analysis consists of a linear transformation of marginal variables tom new variables, where each new variable is a linear combination of the old. The process is performed in a fashion that requires that each new variable accounts for successively as much of the total variance as possible. The use of principal components in exploration has been to separate variable associations into a number of groups of variables that to gether accounts for the greater part of the observed variability in the original data Davis, 1986. This type of analysis is useful when there is a number of data layers which can be overlain one over another. With the arrival of geographic information system, integrated analysis of spatially distributed data can be done easier. Principal component scores are calculated by the projection of original observation onto the principal axes. The elements of the eigenvector that are used to compute the scores of observations are called principal component loadings which are simply coefficients of the linear equation that the eigenvector defines. The original principal components may be rotated until the loadings for the elements are maximized in contrast. The process involves moving each principal component axis to a position so that projection from each variable onto the principal component axes is either near the extremities or near the origin. Therefore, high loadings tend to 1.0 and low ones to 0.0. It will facilitate interpretation in terms of the original variables, as each principal component has few significantly high loadings and many insignificant loadings Davis, 1986. The data are digitized manually using the procedure given by Eklundh and Martensson 1995. A grid cell with a cell size of 150*150 m, the cell. size of litho geochemical survey grid is overlain on the contoured geophysical, geochemical and alteration maps and the value of each cell is assigned by averaging contour values in each cell. Alteration maps are digitized by assigning 0s to the areas beyond the alteration zone and 20s to the altered zone. To reduce scale differences, all variables were standardized into new ones with zero means and unit standard deviations. The data are then placed on a grid and contoured using kriging method in Surfer software Figs. 4 and 5 .

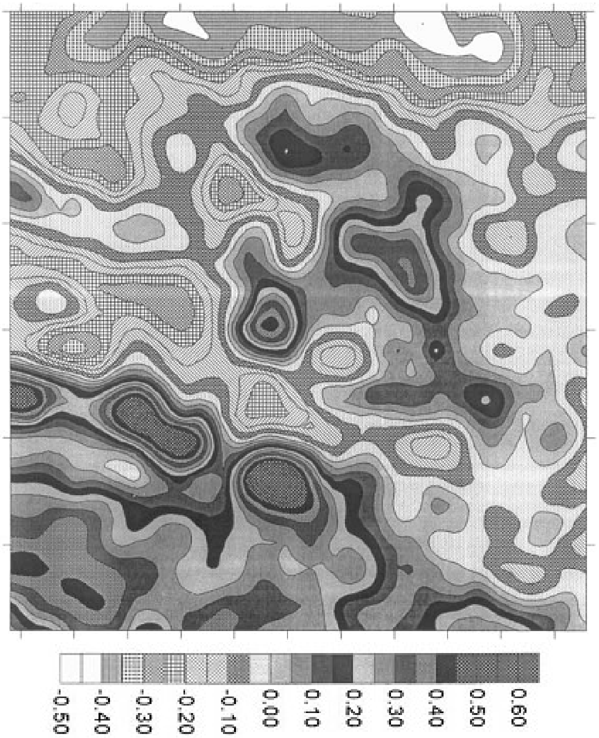

Fig.4 Thorium counts radiometric data standardized values from the Kangan area. The data covers the area of Fig. 2

Statistical analysis of the data was done by SPSS software Table 1 The data analysis is performed in two steps 1. integration and analysis of target and explanatory variables in the control area Kangan copper deposit and 2 transformation of explanatory variables by using the eigenvector loadings of first step. Integration and analysis of 26 variables around the Kangan deposit are carried out using principal component analysis. shows association of all these variables, is shown in Fig. 6. PC2 shows the association of ground resistivity, total magnetic and K, Th, U counts. This component shows that more resistive rocks are located in the outer portion of the deposit that have a higher concentration of magnetite. PC3 shows the association of K O, Rb and K counts that encircle the 2 central phyllic zone. PC4 shows association of Cu and Mo in rock samples, Mo in soil samples, Cu in diamond drill cores and K counts. This factor indicates that collection of lithological samples is more useful for delineation of mineralization than soil samples in the detail survey sericite minerals The thin sections from the propylitic zone revealed that the observed higher total magnetic intensity over this zone is mainly due to the presence of abundant magnetite. Similar result has been obtained over the Sar Cheshmeh area located just north of the Kangan area Ranjbar,. 1996 . These limited data can suggest that the areas with higher potassium and thorium counts may not be associated with any type of mineralization in this area. As was experienced in the field, some of these anomalies were found to be associated with salt encrustation or brackish water, which is a common phenomenon in the semiarid areas. Association of total magnetic halo surrounding the higher potassium, thorium and uranium counts zones increases the chance of finding Cu mineralization with limited field checks. Interpretation of geophysical data in such area can be carried out using satellite data as an auxiliary data. These images provide data on geomorphology, lithology, fault patterns, human made structures, areas with salt encrustation, alteration, etc., if suitable image enhancement techniques are applied on these images. A simple false color image is generated by combination of the three spectral bands of SPOT in red, green and blue Fig. 2 . As the altered phyllicrargillic zones appear lighter, they have a higher reflectance in the SPOT images. Comparison of satellite image with the geophysical data gray. data shows that there is a good correlation between areas with higher reflectance and higher gray values. The sedimentary rocks in the southern part of the area also show lower magnetic and resistivity values, higher K, Th, and U counts values. These rocks also have a higher reflectance, mainly due to presence of altered rock fragments and intrusive rock fragments in these sediments. There is no salt encrustation seen in the image

4. Summary and conclusions

Airborne magnetic and radiometric data sets have been integrated and analyzed using principal component analysis. Kangan porphyry copper deposit is chosen as a control area for determining the correla tion between airborne geophysical data and geochemical reiteration data. The data analysis is performed in two steps: 1 integration and analysis of target and explanatory variables around the mineralization zone and 2 transformation of explanatory variables by using the eigenvector loadings of gray and total magnetic field resulted from the first step. This technique is found useful for delineation of hydrothermally altered zones, which in turn, provides information about the mineralization type. PC1 reflects the phyllic and argillic zones. The areas with higher magnetic intensity are also shown in the PC score map the areas with lower score values surrounding the Kangan area . We now based on these limited data which can suggest that the areas with higher potassium and thorium counts may not be associated with any type of mineralization. The association of magnetic intensity halo surrounding the areas with higher potassium and thorium counts surely increases the chance of finding a porphyry Cu mineralization with limited field checks.

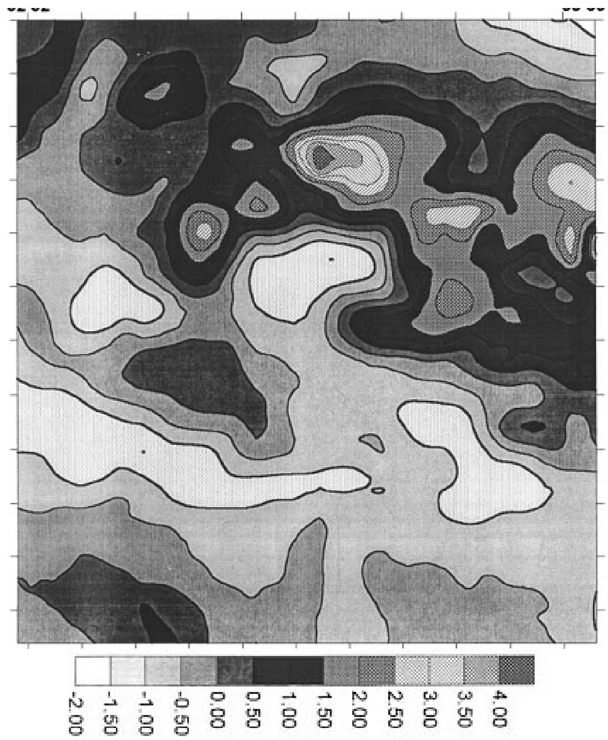

Fig.5 Total magnetic intensity data from the Kangan area standardized values. The map covers the area of Fig. 2.

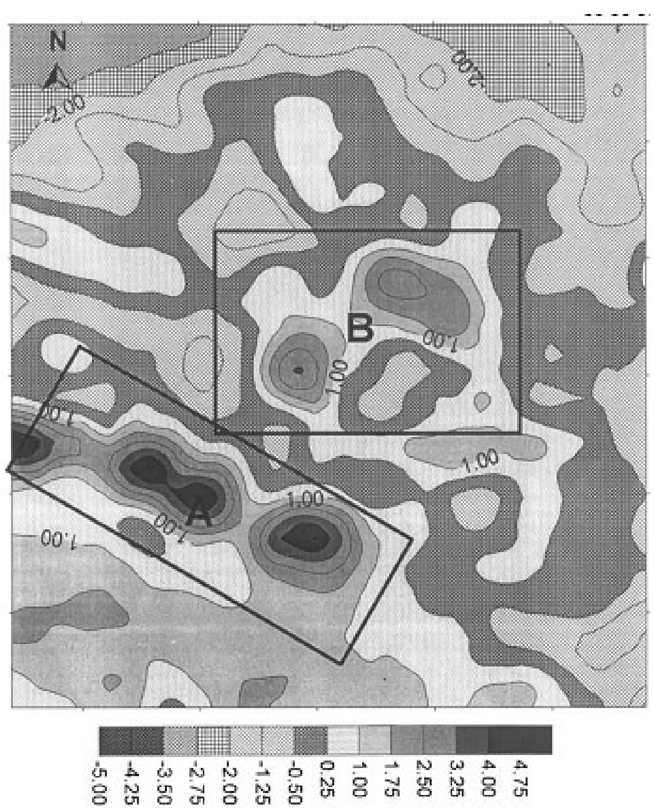

Fig.6 Distribution map of principal component scores generated by using the eigenvector loadings of the spectrometry data in the first principal component

5. Refraction Method

Seismic refraction surveying is the first major geophysical method to be applied in the search for oil-bearing structures. Recent progress in geophysical exploration from computer-assisted processing and enhancement of the data can assist in resolving complicated problems in structural geology and engineering. Refraction is a usual method in engineering geophysical exploration. Low cost, simple in survey and Varity in interpretation of this method caused it uses more and more in study of site in different engineer size. The refraction method consists of measuring the first travel times of compression or shear waves generated by an impulsive energy source. The energy source is usually a small explosive charge or strike hammer. The arrivals of different kinds of seismic waves are detected by geophones array and recorded by seismograph. By extracting time-distance curves from seismograms we can calculate seismic parameters of section such as wave velocities and thicknesses of layers. All measurements are made at surface of the ground, and the subsurface structure is inferred from interpretation methods based on the law of energy propagation. The propagation of seismic energy through subsurface layers is described by essentially the same rules that govern the propagation of light rays through transparent media. The refraction or angular deviation that a light ray or seismic pulse undergoes when passing from one material to another depends upon the ratio of the transmission velocities of the two materials. The fundamental law that describes the refraction of light ray is Snell's law and this together with the phenomenon of "critical incidence" is the physical foundation of seismic refraction surveys. Suppose a medium with a velocity V_1 underlined a medium with a higher velocity V_2 ($V_2 > V_1$), Until the critical angle of incidence is reached, almost all of the compression energy is transmitted(refracted) into the higher velocity medium when the critical angle is exceeded, the energy is almost totally reflected and no energy is refract into the high-speed layer in the refraction equations assume that the subsurface layers possess certain characteristics: each layer within a stratigraphic sequence is isotropic with regard to its proportion velocity, ray paths water supply are made up of straight-line segment and each layer has a higher velocity than overlying one. These are entirely reasonable assumptions and relatively few actual cases will depart from these assumptions. In this method produce the seismic wave by synthetic energetically source(explosion, sparker or hammer) at a point and received by array of receivers in a straight line.

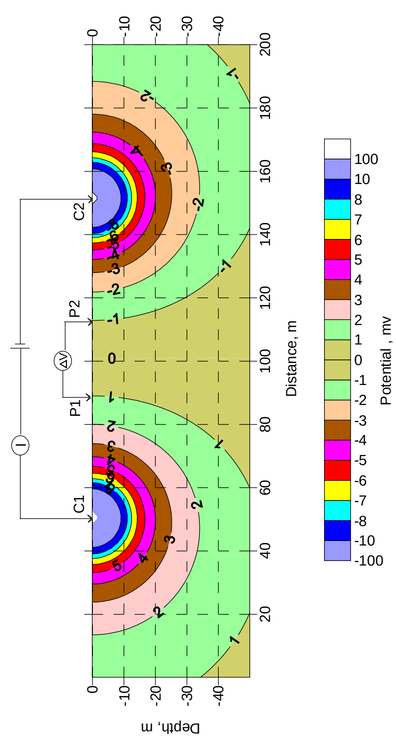

Fig.7 Schematic of geoelectric resistivity method

6. Conclusions

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