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Detection of Concealed Military Targets Location by Using Airborne Electromagnetic Method

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ABSTRACT

Investigating the possibility of detection of the concealed military structures is one of the complicated problems. This structures is created a significant conductivity in opposite of the earth which can be detected using electromagnetic method. Airborne electromagnetic method is considered as an important geophysical method that is used in the airborne survey. This method is characterized by high speed, extensive coverage, cost-effective and performance capabilities for implementation in sever topographical relief. In this paper, we used electromagnetic data to solve the problem. In order to analyze this problem, both forward and inverse problems are treated in this contribution. In the forward problem, with the assumption of the known size and position of the structure, secondary magnetic field signal is modeled. Then, using the modeled signals, some points about the detectability of the structures are discussed. Finally, both of the forward and inverse problems are implemented based on simulated data and some suggestions are made to decrease the probability of detectability of the underground military targets.

1. Introduction

Electromagnetic (EM) methods are advantageous to investigate the electrical resistivity distribution for anomaly mapping in variety of field such as mineral exploration and the near subsurface conductive targets. An airborne electromagnetic system can be used for a quick search for resistivity anomalies. It is helpful for data presentation (mapping) and interpretation to convert the data-in-phase and quadrature measurements of a given magnetic field component of a transmitter coil using a single frequency-into apparent resistivity values, i.e., into the resistivity of a homogeneous half-space (Mundry, 1984).Various methods are used in electromagnetic (EM) modeling, e.g., integral-volume method, finite-difference method, and finite-element method (Li et al. 2016). Deeply buried facilities have significant implications for national security, principally in terms of giving a state an effective sanctuary for protecting its weapons or command and control functions from attacks with modern precision guided weapons. At the same time, these facilities pose a difficult challenge for our military forces, which will want to locate and destroy them in the event of a military confrontation (Sepp, 2000).The experience of pervious wars suggest the aggressive country concentrates over destruction critical infrastructure, especially military facilities. Therefore, in order to reduce the damages of these crucial structures against the modern weapons of the enemy, they are usually constructed in a safe depth beneath the surface and proper geological settings. The safe depth and proper geological settings for crucial structures implies a position that the enemy is not able to detect and locate them using modern geophysical equipment such as airborne EM systems. In this paper, after introducing the airborne EM method, we will investigate the possibility of the detecting different types of subsurface models. The main purpose of this paper is to show how we protectour strategic targets can and conceal military facilities against airborne geophysical sensors of enemy.

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2. Methodology

Advanced frequency-domain helicopter borne electromagnetic (HEM) have different type of transmitter and receiver coils. Transmitter signal or primary magnetic field created by a sinusoidal electrical current within the transmitter coil in different frequencies. The mechanism of the mentioned system is so called a magnetic dipolar system. An HEM system transmits an electromagnetic signal inducing electrical currents in the earth, which are subsequently sensed by receiver coils in the system. The kind of received signal by the coils is depended on the type of subsurface material and electrical resistivity of the earth. The acquired data then can be analyzed to predict the lithology of the subsurface material and the concealed bodies. Figure 1 show that how transmits the EM field and it received by the receiver coil after convolution the signal in the conductor.

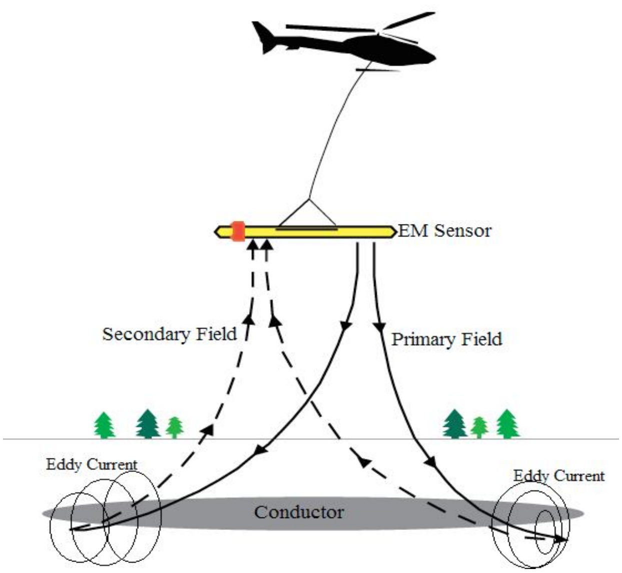

Figure. 1. A helicopter- borne electromagnetic system

As the secondary field is very small with respect to the primary field, it is generally bucked out and the relative secondary field is measured in parts per million (ppm) (Siemon, 2006). Due to the induction process within the earth, there is a small phase shift between the primary and secondary field, i.e., the relative secondary magnetic field is a complex quantity (Siemon, 2009). Because of close distance between transmitter and receiver coil in an airborne EM system compare to flight elevation, the transmitter and receiver can be considered as an oscillator magnetic dipole (Fraser, 1972). Then the components of the field can be described as continuous spectral of wavelengths. Usually Z is representative of normalized secondary magnetic field. Suppose:

$$h \geq 3.3r \tag{1}$$

where, r is distance of between transmitter and receiver coils and h is flight elevation. Now well-known integral of Mundary is given as follows (Mundary, 1984):

$$Z \cong G_j (\frac{r}{h})^3 \int_0^\infty k^2 R_1 e^{-2k} dk \tag{2}$$

where, k=λh, the factor G_j is a number implies installation array of transmitter and receiver coils in the EM system. This factor is j=1, G_1=1 for horizontal coplanar coils array, j=2, G_1=1/2 for vertical coplanar coils array and j=3, G_1=-1/4 for vertical coaxial coils array. R_1 is the reflection factor related the earth layers parameters and it is complex quantity that consists of two part of real and imaginary.

3. Results and discussion

3.1. Forward modeling

One of the main problems in the process of modeling of airborne EM data is solution of integral of Mundary. Because of the mentioned integral cannot be resolved by the common method, therefore it is needed to use of numerical solution methods such as Henkel coefficients method (Johansen and Sorensen, 1979; Rajabi, 2008; Arab-Amiri et al., 2010a). This method is given as follows:

$$f(r) = \int_0^\infty k(\lambda) J_n(\lambda r) dk \tag{3}$$

where λ is variable of the integral. r is spatial position. k(λ)is Kernel function and $J_n(\lambda r)$ is Bessel function. This integral can be rewritten in form of some function or constant weighting coefficients, as following (Guptasarma and Singh, 1997).

$$f(r) = \frac{1}{r} \sum_{i=1}^{n} k(\lambda_i) W_i \tag{4}$$

where k (λ_i) signify certain functions which the values is changed based on different λ. Also W_i is weighting coefficients which the values is changed based on different i. The coefficients are calculated using digital filtering methods. To explain the function of k(λ_i), we use λ which is defined as follow:

$$\lambda_i = \frac{1}{r} \times 10^{[d+(i+1)s]} \tag{5}$$

where d and s are constant and certain and they are defined according the number of used coefficients for solution of the integral. Now is needed to determine the weighting coefficients and Kernel function. Here we compare the similarity between Henkel transfer function and the function of airborne induction EM field in frequency domain. So, according to the Mundary integral, we have:

$$f(r) = \frac{4}{M} \int_0^\infty \lambda^2 e^{-2\lambda} R_1 J_n(\lambda r) dk \tag{6}$$

where $M = \frac{4}{G_i} (\frac{h}{r})^3$. Now it is needed to adjust the equation 6 to form of usable in equation of Gupta-Singh (equation 4). Therefore, according introduced equation of Sengpiel, we have (Sengpiel and Siemon, 2000):

$$f(a) = \frac{4}{M} \int_0^\infty \lambda^2 e^{-2\lambda} R_1 J_n(\lambda a) dk$$

$$R_1 = \frac{\sqrt{\lambda^2 + 2i\delta^2} - \lambda}{\sqrt{\lambda^2 + 2i\delta^2} + \lambda}$$

$$f(a) = \frac{4}{M} \int_0^\infty \lambda^2 e^{-2\lambda} \frac{\sqrt{\lambda^2 + 2i\delta^2} - \lambda}{\sqrt{\lambda^2 + 2i\delta^2} + \lambda} J_n(\lambda a) dk \tag{7}$$

With considering $a = \frac{r}{h}$, we have:

$$f(\frac{r}{h}) = G_i(\frac{r}{h})^3 \int_0^\infty \lambda^2 e^{-2\lambda} \frac{\sqrt{\lambda^2 + 2i\delta^2} - \lambda}{\sqrt{\lambda^2 + 2i\delta^2} + \lambda} J_n(\lambda \frac{r}{h}) dk \qquad (8)$$

and

$$\lambda_i = \frac{h}{r} \times 10^{[d+(i+1)s]} \qquad (9)$$

$$K(\lambda_i) = G_i(\frac{r}{h})^3 \lambda^2 e^{-2\lambda \frac{\sqrt{\lambda^2+2i\delta^2}-\lambda}{\sqrt{\lambda^2+2i\delta^2}+\lambda}} \qquad (10)$$

where the value of $G_i(\frac{r}{h})^3$ is constant, so Kernel function is simplified as follow:

$$K(\lambda_i) = \lambda^2 e^{-2\lambda \frac{\sqrt{\lambda^2+2i\delta^2}-\lambda}{\sqrt{\lambda^2+2i\delta^2}+\lambda}} \qquad (11)$$

and finally with considering Gupta-Singh equation, we have:

$$f(\frac{r}{h}) = \frac{h}{r} \sum_{i=1}^{n} k(\lambda_i) W_i \qquad (12)$$

Equation 12 is used for solving Mundary equation with different level of flight altitude, skin depth, Kernel function and weighting coefficients.

One important problem for solving EM induction equations is considering the resistivity of the air. Seimon (2008) introduced a procedure to resolving this problem. In this procedure, the coefficient of a_0h in Mundary integral is replaced with quantity of K, so the parameter of a_0 defined as follow:

$$\alpha_0 = \sqrt{\lambda^2 - \omega^2 \varepsilon_0 \mu_0 + \frac{i\omega\mu_0}{\rho_0}} \qquad (13)$$

where ε_0 is vacuum permeability coefficient, so it is constant and equal 8.8542×10^{-12}. Also $\rho_0 \geq 10^{10}$ and it is the resistivity of the air. In frequencies of more than 100 kHz, the real part of the secondary field equation is very less than the imaginary part. Therefore, in this condition we can consider α_0 is the equal λ.

In the current study we were programming in MATLAB environment using the above mentioned algorithm (i.e. solving Mundry integral with Henkel coefficients using Gupta-Singh method).

3.2. Inverse modeling

In an airborne EM survey, at least four following parameters is measured (Hauser et al., 2016):

- Information about the applied frequencies during measurements; consists of the number and the amount of the frequencies, distance between coils and type of coils,
- Information about the data stations; consists of the station coordinates, the number of the stations and station spacing,
- Information related to the flight elevation and bird elevation,
- Information related to the transmitter and the receiver coils; consists of values of the primary and secondary magnetic fields.

In this study, synthetic data is produced using forward modeling that mentioned the algorithm in the previous section. This data is representative EM response of a concealed military structure. After applying the necessary corrections on the received data, we are able to reconstruction the depth and resistivity of the earth structures under the study area, using inverse modeling. Figure 2 show schematic representation of HEM data collection and interpretation.

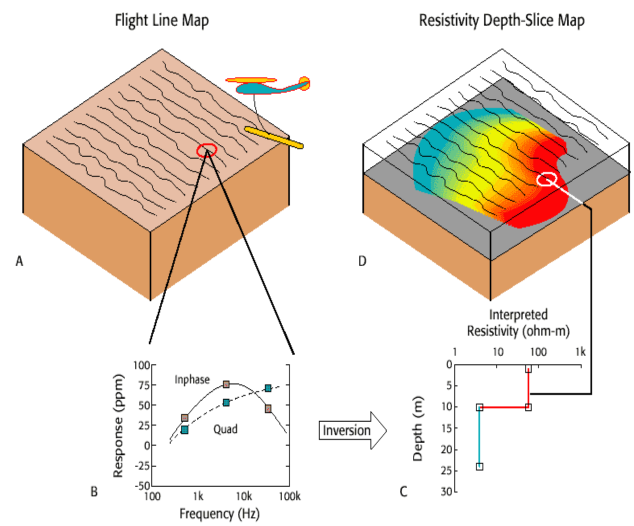

Figure. 2. Schematic representation of EM data collection and interpretation: (A) Flight lines are flown along parallel lines, (B) The bird measures the in-phase and quadrature electromagnetic response at several frequencie, (C) The measured response is used to determine the resistivity-depth function by a process called inversion, (D) The resistivity-depth functions are combined to produce an interpreted resistivity depth-slice map

One important stage of the EM data interpretation is the calculation of the resistivity and its corresponding depth. As the dependency of secondary field to the half space resistivity is non-linear (Eq. 2), the resistivity calculation is possible using iterative inverse modeling, curve fitting and look up table. In the case of a layered half-space, the true resistivity distribution can be approximated by a resistivity-depth, $\rho_a(z)$, sounding curve which is derived by presenting the apparent resistivity (ρ_a) for each frequency at the corresponding depth values (Siemon, 2001). In multi-frequency EM surveys the sensor height (h) and the two components of the secondary magnetic field (i.e. R and Q) are measured at each frequency. Therefore, the corresponding apparent resistivity, ρ_a, can be obtained using twoof these three measured parameters (Mundary, 1984). As the real response (R) is very small for great penetration depths and the quadrature response (Q) peaks at an intermediate depth, thus it is not recommended to use the real or quadrature response alone for obtaining the apparent resistivity together with the available sensor height. Furthermore, the sensor height maybe affected by trees or buildings, hence both real and quadrature components of the normalized secondary magnetic field are normally required to calculate the apparent resistivity at each frequency precisely. In the latter routine the apparent resistivity, ρ_a, and the calculated sensor height or apparent distance, will be the results of modeling. The apparent distance is the distance between sensor and the top of the conducting half space. The foundation of this routine relates to the spatial filtering technique that was introduced by Zonge (1993) for static shift correction of MT apparent resistivity sounding curve. In this method, a static-corrected resistivity data, ρ_c, is derived by integrating of the static-free phase data for each sounding station as bellow:

$$\rho_c = \rho_N \exp\left[-\frac{4}{\pi} \int_{f_H}^{f_L} (\varphi - \frac{\pi}{4}) d \ln f \right] \quad (14)$$

where ρ_N is the constant of integration (the static offset or normalizing value), f_H and f_L are the highest and lowest survey frequency respectively, and φ is the phase difference of E/H (Zonge, 1993). In this study attempts to modify Eq.14 for the first time so that it could be used to obtain resistivity data from the measured EM data using a reference or initial resistivity model. The required initial resistivity model, ρ_N, of each station could be obtained by any of the aforementioned HEM inversion schemes, such as the combined (R and Q) method as described by Siemon (2001). Thus we have $\rho_N = \rho_S$. So Eq. 14 reduced to:

$$\rho_Z = \rho_s \exp\left[-\frac{4}{\pi} \int_{f_H}^{f_L} (\varphi - \frac{\pi}{4}) d \ln f \right] \quad (15)$$

where ρ_Z is Zonge apparent resistivity, and ρ_s is Siemon apparent resistivity. As phase, φ, of each station varies with varying survey frequency, we have $\tan\varphi$=Q/R and the value of phase for each specific point and frequency, for example at the first point and the first frequency, is given as $\tan^{-1}(\frac{Q_1}{R_1})$. Therefore Eq. 15 changes to form of Eq. 16:

$$\rho_{new} = \rho_s \exp\left[-\frac{4}{\pi} \left\{ \tan^{-1}(\frac{Q}{R}) - \frac{\pi}{4} \right\} \int_{f_H}^{f_L} d \ln f \right] \quad (16)$$

Also we can write:

$$\int_{f_H}^{f_L} d \ln f = \ln f \quad (17)$$

As the range of HEM frequency is very large, for each survey frequency, f, the lower, f_1, and the upper, f_2, limits of the above integral is described as the upper and lower neighboring values of measuring frequency. Now in such limiting conditions by substituting the value of ($\int_{f_H}^{f_L} d \ln f$) from Eq. 17 in Eq. 16, the following formula is defined to produce a new apparent resistivity, ρ_{New}, at each frequency:

$$\rho_{new} = \rho_s \exp\left[-\frac{4}{\pi} \left\{ \tan^{-1}(\frac{Q}{R}) - \frac{\pi}{4} \right\} (\ln f_1 - \ln f_2) \right] \quad (18)$$

For the modeling of HEM data, however, two parameters of apparent resistivity and their corresponding depth value are required at each frequency to contribute to a resistivity-depth curve. To determine the apparent depth related to the measured resistivity, the response of variety of different synthetic layered models was inverted by several depth relations. It has been found that the following formula is the best for depth calculation:

$$Z_{new} = +\frac{P_a}{\sqrt{2}} \quad (19)$$

This proposed inversion method incorporates the improved Guptasarma-Singh forward core developed by this and other authors in some research works (Arab-Amiri et al., 2010a; 2010b). Its corresponding complete inversion computer codes were prepared in MATLAB software and were used to invert HEM data.

3.3 Electrical conductivity

In this research, the possibility of detecting and locating concealed military structures or targets is investigated using the introduced forward and inverse procedures. In case of forward, we were calculated EM response of a concealed structure with specific depth, dimension and resistivity. Then in case of inversion, we were inverted the synthetic EM signal produced in the forward step, using mentioned modeling algorithm to evaluate the possibility of detecting and locating the concealed targets.

One of the most impartment parameters that playing a critical role in concealed target investigation is electrical conductivity contrast between the target and its host rocks. Table 1 shows the resistivity range of some main geological minerals. As it can be seen, the electrical resistivity of the minerals has a broad range. There are some factors affecting electrical resistivity values, such as moisture, joints, temperature, pressure, and materials and minerals of rock. As it illustrated, sandstone has a wide spectrum of resistivity, ranging from 100 to 1000 (ohm-meter). Metals, such as iron, have extremely low resistivity values. Electrical resistivity will be low as long as the rocks joints are filled with water. Shallow depths of the earth crust is generally comprised of sedimentary rocks, magmatic rocks, and metamorphic such as limestone, granitic sandstone, andesite and schist. Shale, sandstone, and limestone are most general rock units in orogenic belts of Iran such as Zagros, and Alborz mountains. Schist is most general rocks that exist in Sanandaj-Sirjan zone (a large extended area lies off north-western parts to south-eastern of Iran). In the eastern parts of Iran, there are different magmatic, limestone, and sandstones units.

Overall, it must be considered a broad range of the resistivity of the materials to achieve a valid modeling of the geological structures. Therefore, in this study, a range of 200 to 1000 ohm-m is considered for modeling of the host rocks and targets. Regarding table 1, this range of resistivity is a good coverage for the geological targets and rocks. Electrical resistivity contrast is an important parameter that plays a critical role in the target exploration using modeling of the EM data. It is noticeable; the materials used in the military structures are usually made of conductive minerals such as Aluminum, Magnetite, and clay. But the materials used in the ordnances and the other objects which is kept in the military structures are made of different minerals such as Calcite, Sulfur and many types of minerals mentioned in table 1. In the other word, the materials used in the military structure and inside them, are made of the material with various conductivity. Therefore for modeling EM data, we are considering an average conductivity of 5 to 20 ohm-m for whole of structure and its inside objects.

4. EM modeling of underground structures

In the forward modeling, we used regular shape of synthetic underground military structures such as horizontal cylinder with certain specifications. In this study we used a cylinder structure which is representative of a concealed arsenal. According table 2, the depth and conductivity of this structure is changed to research the ability of detecting EM method in the different kinds of concealed military structures. As can be seen, the considered dimensions of synthetic models are close to real military structures. In this modeling, we attempt to cover whole range of conductivity and depth of the possible military structures. The amplitude of secondary magnetic response field is equivalent to the reversely cube root of the distance. So the distance between location of the structure and the measuring station is a crucial parameter in EM exploration. Therefore, in this study is investigated the influence of the distance between the target and the observation point. This distance is consisting of flight elevation and structure depth. In this modeling, we are considering a fixed flight elevation of 40 meters and changing the structure depth to 20, 40 and 100 meters. The previously-introduced computer code was used to produce EM responses of two dimensional synthetic models shown in Table 2. The improved code is included two parts: forward and inverse modeling of airborne EM data

As it mentioned, in this program the desired parameters of the structure such as conductivity and depth defined by user, then the program is able to produce the forward modeling data in the first phase and inverse them in the second phase. The final output is a table with five columns, as following:

- Transmitter frequencies of the EM system (18 frequencies in the range of 100 to 500000 Hz),
- Real part (R) of the model EM response,
- Imaginary part (Q) of the model EM response,
- Estimated depth in each frequencies,
- Estimated conductivity in each frequencies.

Table 1 Specification of filled military structure in EM forward modeling

No.	Structure geometry	Dimensions (m)	Depth (m)	Conductivity contrast between structure/host media (ohm-m)
1	Horizontal Cylinder	Radius = 10 Length = 150	20	195
2				490
3				980
4			40	195
5				490
6				980
7			100	195
8				490
9				980

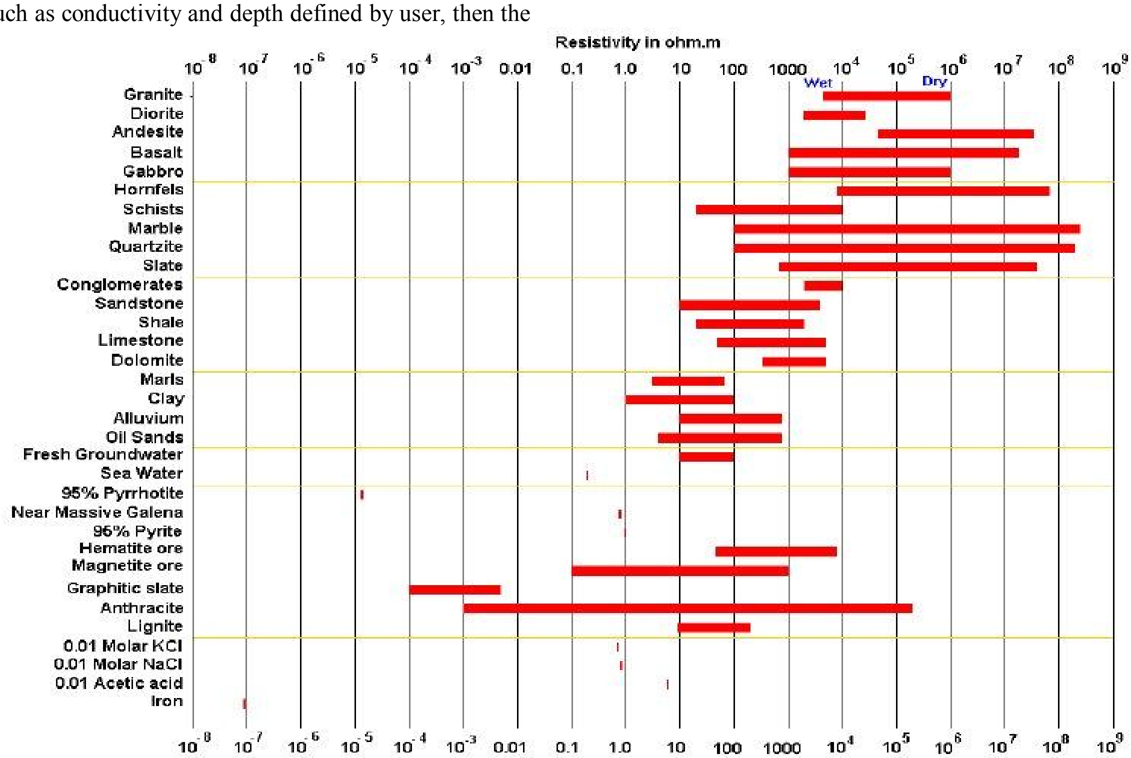

Figure. 3. The resistivity of rocks and minerals

After estimation of the depth and the conductivity of the conductive structure, the pseudo-section of electrical resistivity versus depth of EM response can be created. We used IX1D and Surfer software for gridding data in minimum curvature method. The final produced section was introduced as the electrical resistivity model of the earth. This model would present some useful information about electrical resistivity of the earth under the study.

Figures 4 to 12 show the inverted models of synthetic data of table 2. In this modeling the conductivity of the earth has been recovered to 150 m below the surface. These figures show the importance of EM method in the subsurface structures exploration.

Figure 4 shows the inverted model from a horizontal cylinder (diameter=10 m; length =100 m; electrical resistivity contrast= 195 ohm-meter), located at a depth of 30 meters. It can be easily seen that yellow strip highlighted in the model represents position of the conductor (target), located at a depth of about 15-25 m. Therefore it can mention that the target has been recovered using airborne EM method with an acceptable error. Also figures 5 and 6 illustrate inversion results of the structures whose electrical conductivity contrast values are 490 and 980 ohm-meter. As it shown, the targets are recovered with an error of 5-10 m. So the results sound good. Figure 7 to 9 show inverted models being extracted from a horizontal cylinder (diameter=10 meters and length=100 meters), located at depth of 40 to 50 meters. The resistivity contrasts of these models are 195, 490 and 980 ohm-meters respectively. The inverted section show rather good results. But the recovered structures have been estimated with at least 10 meters error.

Figure 10 to 12show inverted models being extracted from a horizontal cylinder (diameter=10 meters and length=100 meters), located at depth of 100 to 110 meters. The resistivity contrast of these models is 195, 490 and 980 ohm-meters respectively. The inverted section shows no good correlation between synthetic and recovered models. Due to the shape and the location of the recovered body is different from original one. The depth has been estimated with a considerable error, about 30 to 50 meters. The other mistaken inverted model which can be seen in the sections of figures 10 to 12 is a shallow conductive zone that can be interpreted as a pseudo-target. It seems increasing the depth of the target increasing uncertainty of the recovered models. Regarding above modeling, the depth of the target is a crucial parameter to be safe against electromagnetic sensors. This study reveals a concealed target in the depths of more than 70 or 80 meters below the surface, is not be detected using EM method despite high conductivity contrast. So increasing depth of the structure is a best way to be safe against electromagnetic sensors.

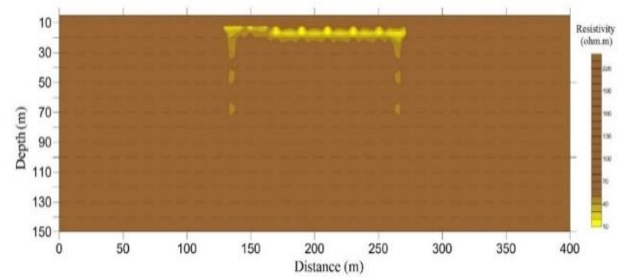

Figure. 4. Inversion results of a buried horizontal cylinder located in depth of 20 m, diameter 10 m and conductivity contrast 195 ohm-m

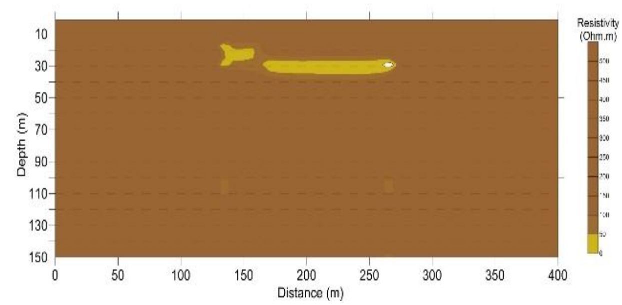

Figure. 5. Inversion results of a buried horizontal cylinder located in depth of 20 m, diameter 10 m and conductivity contrast 490 ohm-m

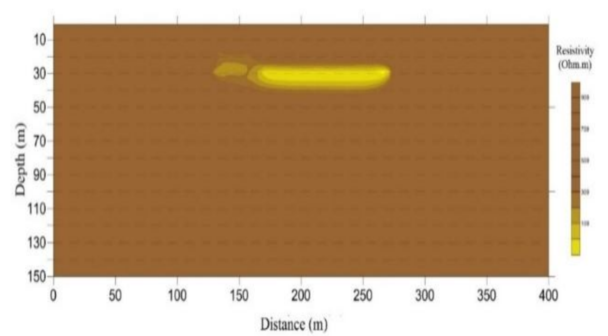

Figure. 6. Inversion results of a buried horizontal cylinder located in depth of 20 m, diameter 10 m and conductivity contrast 980 ohm-m

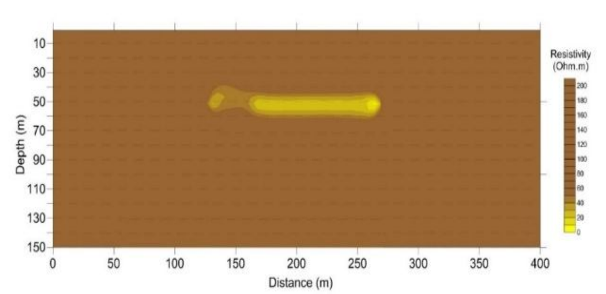

Figure. 7. Inversion results of a buried horizontal cylinder located in depth of 40 m, diameter 10 m and conductivity contrast 195 ohm-m

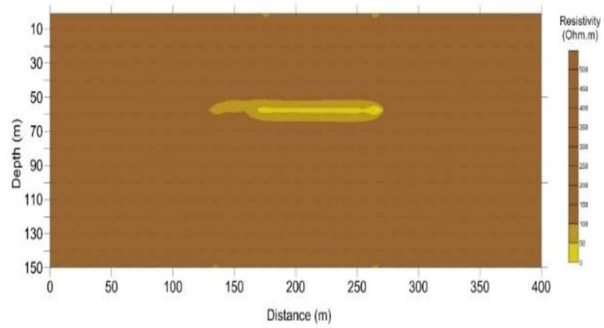

Figure. 8. Inversion results of a buried horizontal cylinder located in depth of 40 m, diameter 10 m and conductivity contrast 490 ohm-m

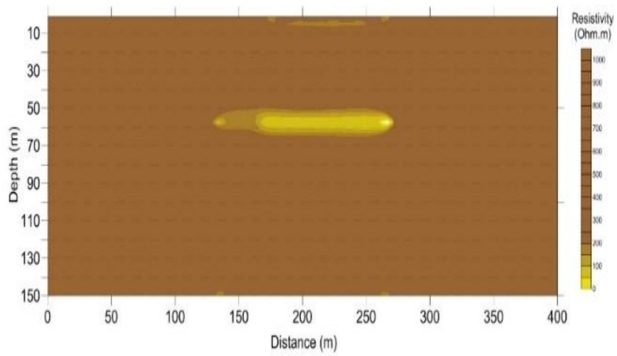

Figure. 9. Inversion results of a buried horizontal cylinder located in depth of 40 m, diameter 10 m and conductivity contrast 980 ohm-m

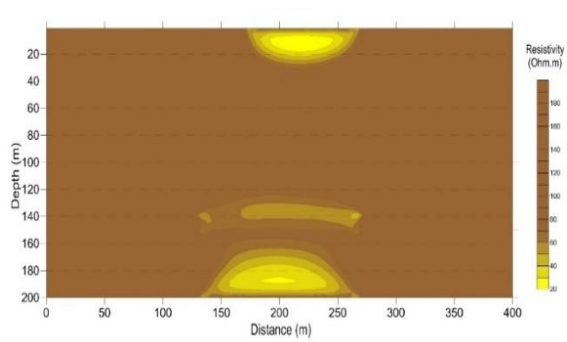

Figure. 10. Inversion results of a buried horizontal cylinder located in depth of 100 m, diameter 10 m and conductivity contrast 195 ohm-m

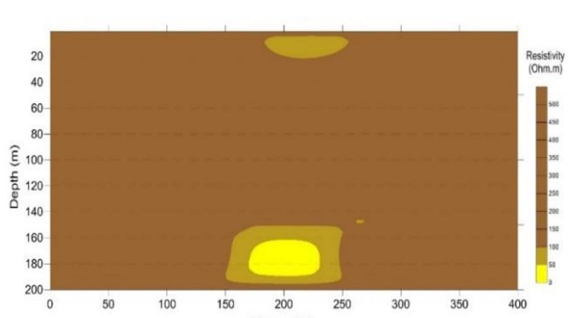

Figure. 11. Inversion results of a buried horizontal cylinder located in depth of 100 m, diameter 10 m and conductivity contrast 490 ohm-m

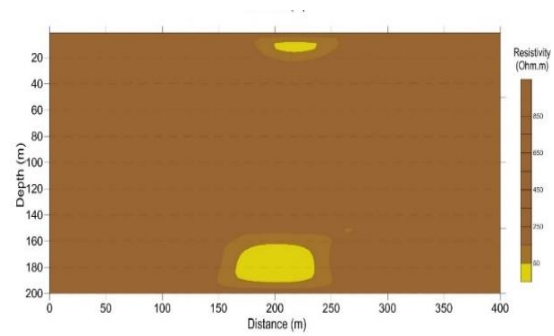

Figure. 12. Inversion results of a buried horizontal cylinder located in depth of 100 m, diameter 10 m and conductivity contrast 980 ohm-m

5. Conclusion

In this study investigated application of the airborne EM survey in detection of conceals military targets. In order cover all aspect of the subject, both forward and inverse problems was treated in the contribution. In the forward step, some synthetic concealed targets with certain characteristics (conductivity contrast, physical dimensions, and depth) were considered and calculated the EM response. In the inverse step, the calculated data was inverted using introduced algorithm to analyze the possibility of the detection. Results of various modeling show the algorithm is an effective program for exploration of conductive structure using airborne EM method. In this study, we found that applied martial in the synthetic underground structure would be easily detected using airborne EM methods. Based on maximum depth of exportation in airborne frequency EM method, we investigated the detection of the synthetic military targets in a depth range of near surface to 100 m. The results show the airborne EM method is an effective method for detection of concealed targets in depth of less than 70 meter. Despite of high conductivity contrast, the deeper targets will not be properly recovered in the inverted sections. Therefore in EM exploration, the depth of the structure is more important as conductivity contrast.

Also in the current research suggested some important suggestions in passive defense for elimination chance of discovery of the concealed military targets. The first of them is increasing depth of the targets. It seems, the targets constructed in depth of more than 100 meters will be safe against airborne EM systems of the enemies. The second suggestions which can be founded of the inversion results are considering geological setting of the area for construction the military structures. The conductivity of the geological layers and natural changes of the conductivity of the earth can be affected the chance of the discovery. The results show the targets with conductivity contrast of more than 200 ohm-meters will be properly detected using airborne EM method in a region with homogenous geological settings such as a sedimentary basin. If the structure is filled with high conductive materials such that the general conductivity exceed of 500 ohm-meters, the exploration possibility of the targets will be increased to depth of 80 meters from the surface. Therefore the other suggestion for elimination of the possibility of target detection is construction of them in the regions with natural heterogeneous conductivity. In Iran there are many regions with mentioned specifications. The Urumieh-Dokhtar magmatic arc (UDMA)is a region with mentioned geology which can be one of the good area for construction the military targets. UDMA is elongated about 1500 km parallel Zagros mountain chain in west of Iran. The region is composed of sedimentary and igneous rocks so that the conductivity of the ground is completely heterogeneous. There is some other region with geology setting like this. For finding of them can be referred to geological references of Iran.

Considering and estimating electrical conductivity of the military targets, forward and inverse modeling of the known targets using introduced algorithm and considering general geological of the area are important solutions for protection of this military targets against airborne EM systems.

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