J. Black Sea/Mediterranean Environment
Vol 10: 113-122

Investigation of Karstic Cavities by Using EM - VLF Method

EM - VLF Yöntemi Kullanarak Karstik Boşlukların Bulunması

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Abstract

Electromagnetic VLF method can be used for the investigation of karstic cavities, which may often be seen along Turkey's southern coasts, the determination of these cavities which are naturally or artificaly filled or halfly-filled by sea water, natural or artificial. This method is easier and more rapid than some other geophysical exploration methods. In this study, EM-VLF investigation method, which operates between 16 and 25 KHz as considered to be very low frequencies of electromagnetic spectrum, is used along with natural potential and direct current electric resistivity. During the studies, karstic cavities and fault systems related to these cavities and sea water were considered to be the most suitable model representing the region. In this model, structure is considered to be an excessively resistant medium and the fluid that fills the structure is considered to be a conductive medium.

Keywords: Karstic cavities, EM-VLF exploration, Sarıgerme

Introduction

In this study, in the Iber Motel which is built within archaic ruins in Sarıgerme, a settlement area in Muğla-Dalaman, electromagnetic VLF investigation method (Bernard and Valla, 1991), resistivity and self potential methods (SP) have been used together in order to find out what causes acoustic noises coming from underground. The study area was nearly 1000 m^2. In the area, 3 East-West oriented profiles were choosen and 2 m was taken as measurement interval. Resistivity and SP applications were also conducted on the very same profiles (Figure 1).

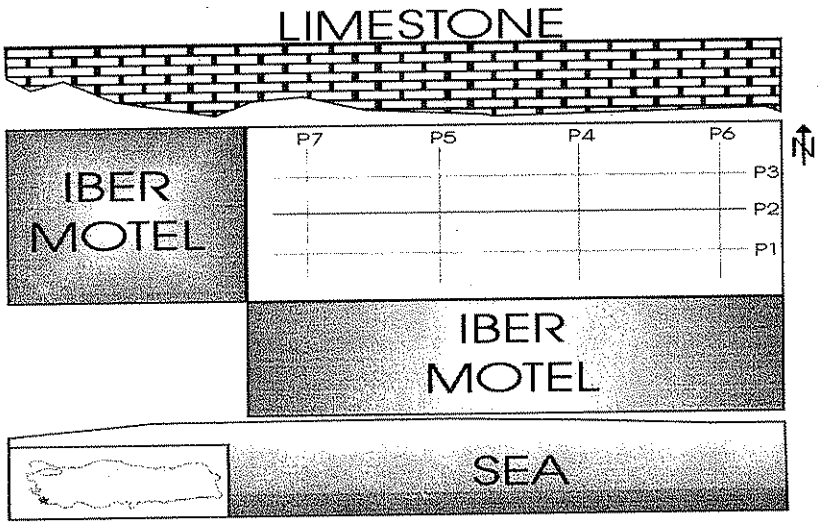

Figure 1. Location of measurement profiles.

As the study area was in the field of Sarıgerme Hotel, the rate environmental electricity noise was quite high. Since the rate of signal-to-noise (S/N) was very low, especially it was rather hard to obtain Self Potential measurings. In order to prevent the damages that can be caused by these noises, during the measuring period, the whole electric current was turned off at the transformer center. So, the most suitable working medium was tried to be created.

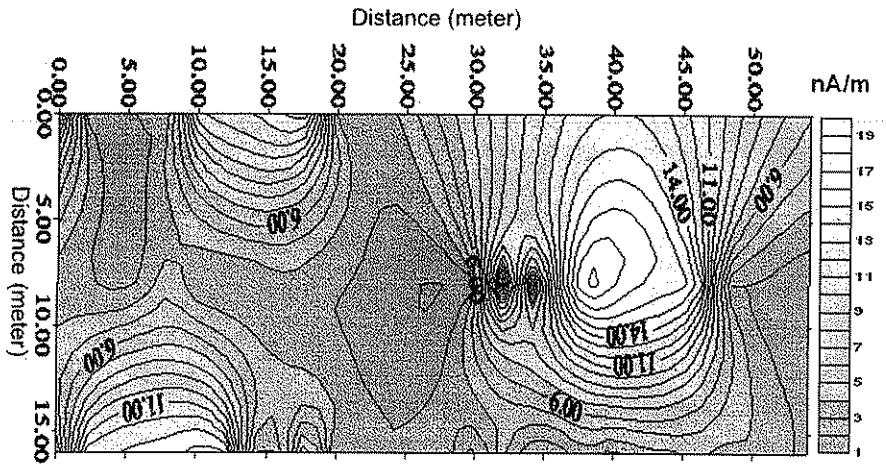

Figure 2. EM T-field distribution at Sarıgerme Iber Motel area.

Studies were realized by 2 teams in May 2000 at the same time. The first team measured T-field, tilt angle, in–phase (reel component) and out-of phase (imaginer) parameters along the profiles by using EM-VLF methods (Figures 2, 3 and 4). Later, the second team determined tension and Resistivity Direct Current methods (DES) on the same profiles. Resistivity measures were realised in order to control VLF measures.

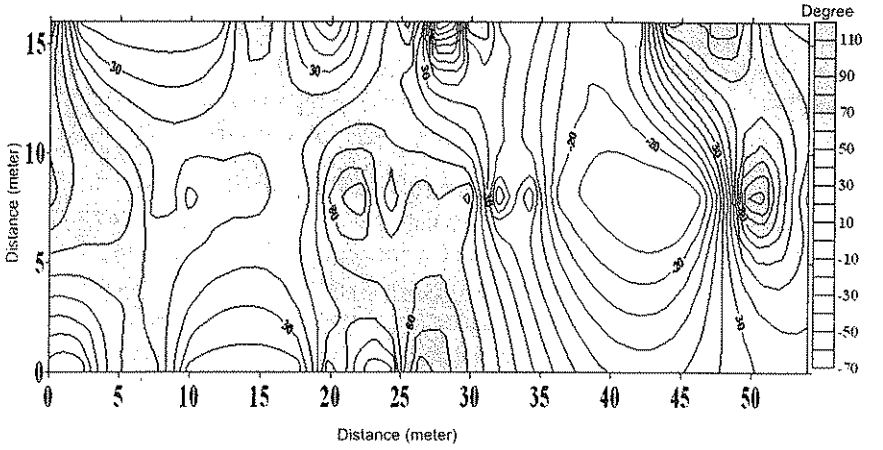

Figure 3. Tilt angle distribution in the study area

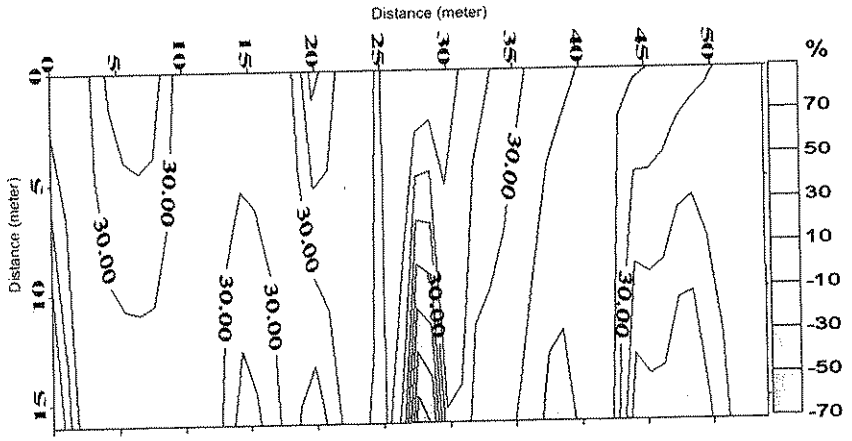

Figure 4. Real component (H_R) distribution in the study area.

Properties of the Study Area

The study area is surrounded by the Mediterranean Sea, to south, and by the Likya Naps (Mesozoic limestones) constituting the West Taurus Mountains, to north (Pamir, 1974; Brunn et al., 1975). Looking at the morphology to its northern section, the limestones form quite fractured structure and are in relation with the sea. The saline water within these cracked systems behaves as a conductive medium and it is considered that this will cause effect like coal-basalt gap surface (McCofffrey et al., 1995) and must be taken as a sign for the required structure.

It had been informed that, the mouths of the (karstic) caves (artificial or natural) of the Sarıgerme archaic city were filled during the construction of the motel, in order to gain more open space. By determining the events that could come out related to earth's dynamics in these closed cavities (such as water flow, constitution of wind tunnel, etc.), the source of acoustic noise and its source will also be determined. The standing walls of archaic city were still distributed around the motel. To east and north sides of the study area, beaches took place.

Meterial and Methods

The EM-VLF method is used to measure the areas that electromagnetic waves constitute by induction on conductors that they affect in the medium they spread out and various components belonging to these areas (the primary field + secondary fields + noisy fields) (Reynolds, 1997). Owing to this, it results in a good way on conductive areas (Benson, et.al., 1997). In this method, the sources of the electromagnetic waves were usually the military navigation stations, diffusing waves with the frequencies well known by the users. Thus, the diffusion direction of the electromagnetic wave coming out from the source can be determined (Wright, 1988). The EM-VLF method is a quite rapid exloration method; it ends up in a good way in accomplishment with the degree of differences between the conductivity coefficients of rocks lying between the depths of 0-25 m.

The electromagnetic VLF receiver used in this study was Scintrex ENVI-MAG system, with 3-channels. This material is able to give information about an underground conductor at a certain place, simultaneously by using 3 signals with different frequencies. The total electromagnetic field values measured in different frequencies can give an approximate opinion about the possible direction of structure; its depth can be also calculated, by considering the relation between frequency-depth penetration, which is known as skin depth.

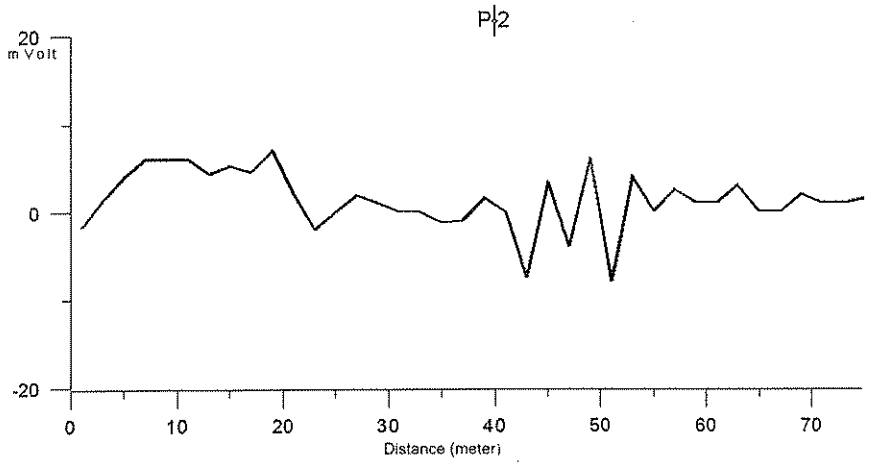

Figure 5. P-2 Profile SP (dipol) measurement values in the study area.

The penetration depth is a function of the frequency of electromagnetic wave that is diffused. Therefore, the furthest distance can be determined by the following simple equation (Reynold, 1977);

$\delta = (2/\omega\sigma\mu)^{1/2} = 503\,(f\sigma)^{1/2}$

$\varpi = 2\pi f$, where f stands for frequency in Hertz,

δ = the depth in meter,

μ = Magnetic permeability (≈ 1),

σ = Mho (Conductivity, S/m).

The data relating to the measured parameters which are conducted on the gridded profiles (Figure 1) are given in Figures 2-5.

Results and Discussion

In order to determine the subsurface source of the acoustic noise several geophysical methods were used. Firstly, amplitude variation of total electromagnetic field vector (Figure 2) was evaluated in electromagnetic measurement. This variation also showed the amplitude of the major axis of polarization ellipse. In addition, this variation of field intensity showed the effects of the underground constitution. The structural discrepancies occuring between the distances of 40-45 meters in the anomaly distribution map was also determined similarly in the measurements of SP (Self Potential) (Figure 6) and resistivity (Figure 7).

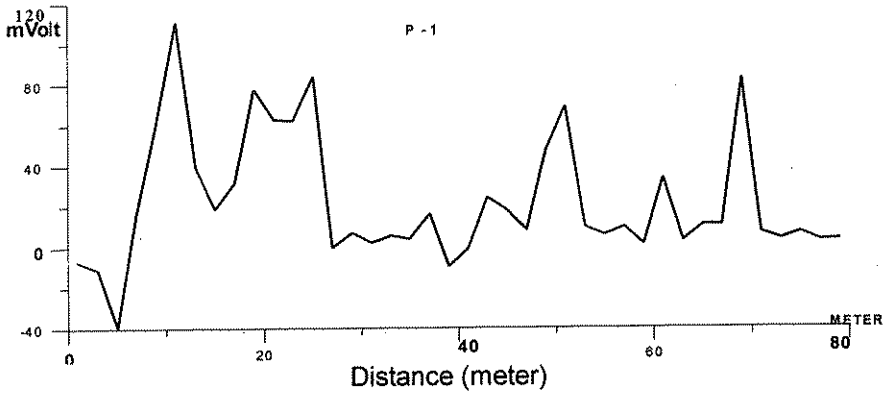

Figure 6. SP dipol measurement variations along the Profile P-1 at Sarıgerme Iber Motel (Gür, 2001).

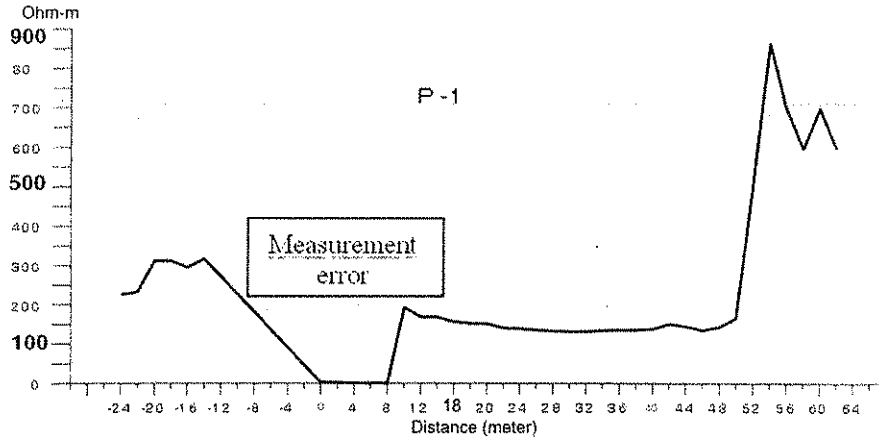

Figure 7. Resistivity variations along the Profile P-1 at Sarıgerme Iber Motel (Gür, 2001).

The increment of the field intensity as well as the increment in the reel (in-phase) component (Figure 8) shows that there is a conductive structure, in other words, some cavities filled by sea water. Similarly, Figure 4 shows that a more resistant medium starts by passing to a sudden increase after 45 meters at this same point. Our observations in the study area indicated that this resistant structure corresponded to a limestone complex. The structural defeat seen in the upper parts of the profiles corresponded to the construction channels of the buildings. In these areas the total field component part and in-phase values indicated a porous structure.

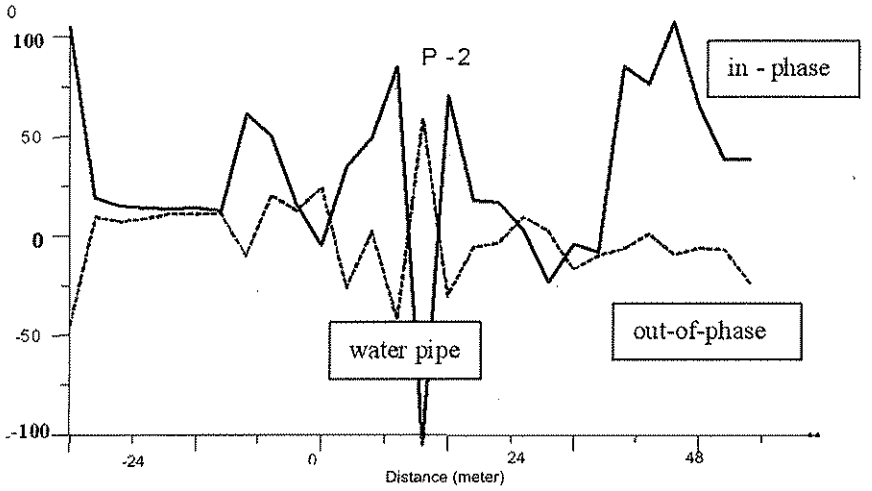

Figure 8. In-phase and out-of-phase measurement values at Sarıgerme Iber Motel (P-2).

The increase in the resistivity curve also supports this interpretation. At the SP (Figures 5 and 6), measurements, increment occur at the anomaly transition places.

Evaluation of all of the geophysical measurements considering all the evaluations above and the whole area, it is determined in penetration calculations that anomalies in the area are completely underground and close to the surface (about 10 meters). Signatures of this structure were observed along three profiles running NNW-SSE with the variation in the in-phase and out of phase components. This implies that this structure is a karstic channel or a cave. This interpretation agrees with the information given by the workers, who have built the Iber Motel.

As a result, the EM- VLF System is a very rapid and economical exploration method in geophysics. In addition, it is believed to be successful especially in determining the conductive areas surrounded by non-conductive areas. The water pipe laid for the irrigation of grass, can be easily monitored on the in-phase (reel) and out-of-phase (imaginary) components at the depth of 28 m (Figure 8).

Özet

Özellikle Akdeniz kıyılarımızda sıkça görülen, karstik boşlukların EM-VLF jeofizik yöntemi ile aranması, deniz suyu ile tam veya yarı dolmuş, doğal ya da yapay boşlukların belirlenmesi bazı jeofizik arama yöntemlerine göre hızlı ve daha kolay yapılabilmektedir. Bu makalede bu amaçla elektromanyetik spektrumun çok alçak frekansları olarak kabul edilen 16–25 KHz arasında çalışan elektromanyetik VLF arama yöntemi ile doğal potansiyel ve doğru akım elektrik özdirenç yöntemleri kullanılmıştır. Çalışmada bölgeye en uygun yapı modeli olarak, karstik boşluklar ve bunların tuzlu deniz ile ilişkilendiren bir kırık sistemi öngörülmüştür. Bu modelde yapı yüksek dirençli bir ortamdan oluşurken, bu yapının içi iletken bir akışkan ile doldurulmaktadır.

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Received: 27.04.2001
Accepted: 17.02.2003