Benha University | Time: two hours.
Faculty of Science | First Semester 201٦-201٧
Dept. Of Geology | Date: ١٥/0١/201٧

Geophysical engineering & environment (451G) for Fourth Level Students (Geophysics)

جامعة بنها – كلية العلوم – قسم الجيولوجيا

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أستاذ مساعد بقسم الجيولوجيا بكلية العلوم

الاسئله ونموذج الاجابه

ورقه كامله

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Answer the following questions:

Question1. (12Marks)

- **How can you accomplish one of the following using geophysical methods**

a- Locating Shallow Sand and Gravel Deposits

b- Mapping Groundwater Surface and Flow

Question2. (36 Marks)

Write on four only of the following:

1- Detecting subsurface utilities

2- Spectral analysis of surface waves method

3- Ground penetrating radar method

4- Seismic refraction method

5- Nuclear magnetic resonance method

6- Determination of the rippability of rocks

BEST WISHES

Answer of Question1. (12 Marks)

- **How can you accomplish one of the following using geophysical methods**
  a- Locating Shallow Sand and Gravel Deposits

Clastic rocks, including sand and gravel, are classified by geologists according to size, sorting, and distribution of particles, as well as chemical content of silica, feldspar, and calcite. It is often convenient for engineers to define clastic rocks such as sand and gravel by particle size. The electrical properties and physical behavior of sand and gravel deposits will depend significantly on moisture content of the materials. Dry sand and gravel deposits will have a high electrical resistivity and a low seismic velocity. Saturated sand and gravel deposits will have a much lower resistivity and can be further influenced by the presence of salinity. Seismic velocity will probably be somewhat higher than that for water,

Methods

1-Resistivity; Soundings, and Traverses

Basic Concept: The resistivity of the ground is usually measured using one of several four-electrode arrays. Resistivity is measured by passing electrical current into the ground using two electrodes and measuring the resulting voltage using two other electrodes.

Data Acquisition: Resistivity measurements can be made along traverses using one electrode spacing, thus providing the lateral variation of resistivity.

Data Processing: The most important thing is to remove bad data points.

Data Interpretation: Resistivity soundings curves can be interpreted to give the resistivities and thickness of the layers imaged under the sounding site.

2-Automated Resistivity Systems

Basic Concept: Resistivity measurements can be taken using recently developed instruments that use addressable electrodes, called Automated Resistivity systems

3-Conductivity Measurements

Basic Concept: Electrical conductivity measurements can be made over an area and a map produced showing the conductivity down to a particular depth.

5-Time Domain Electromagnetic Soundings

<u>Basic Concept:</u> Time Domain Electromagnetic (TDEM) soundings are another method for obtaining the vertical distribution of the resistivity of the ground

b-Mapping Groundwater Surface and Flow

The groundwater surface lies at depths ranging from the ground surface to many hundreds of feet. The exact configuration of this surface depends on the geology of the area, topography, and precipitation. The groundwater surface is usually related to the topographic surface, although with smaller elevation changes. Geophysical methods are most applicable to mapping the surface of the water table aquifer, although saturated fracture zones can also be detected

Methods

I-Groundwater Surface

1-Resistivity Soundings <u>Basic Concept:</u> Mapping the groundwater surface will usually require sounding methods. Resistivity, or conductivity, soundings may be appropriate since there may be a significant resistivity contrast between the unsaturated soil and the saturated alluvium. Generally, the contrast will be greater for coarse-grained alluvium than for fine-grained alluvium.

2-Automated Resistivity Systems <u>Basic Concept:</u> Resistivity systems are available that make taking resistivity measurements much more efficient, automatically taking many measurements at different electrode spacings along a traverse.

3-Time Domain Electromagnetic Soundings <u>Basic Concept:</u> Time Domain Electromagnetic (TDEM) soundings are used to obtain the vertical distribution of resistivity.

4-Seismic Refraction <u>Basic Concept:</u> The seismic refraction method can be used to map the water table surface under certain conditions.

5-Ground Penetrating Radar <u>Basic Concept:</u> Ground Penetrating Radar (GPR) can be used provided the conditions are appropriate for the method.

6-Nuclear Magnetic Resonance <u>Basic Concept:</u> The Nuclear Magnetic Resonance (NMR) method is also known as the Proton Magnetic Resonance (PMR) method.

ii-Groundwater Flow

1-Self Potential Basic Concept: The only geophysical method used to detect groundwater flow is the Self Potential (SP) method.

2-Electroseismic Basic Concept: The Electroseismic method (also called the Seismoelectrical method) is based on the generation of electromagnetic fields in soils and rocks by seismic waves.

3-Borehole HydroPhysicalT Logging HydroPhysicalT logging is a technology used for evaluating the vertical distribution of permeability and water quality in wells. Using this procedure, interval-specific contaminant concentrations, hydraulic conductivity, and flow rates are assessed with great accuracy and sensitivity.

Basic Concept: Borehole fluids are replaced or diluted with deionized (DI) water. During this process, profiles of the changes in fluid electrical conductivity (FEC) of the fluid column are repeatedly recorded using a highly sensitive FEC/temperature logging probe. These changes occur when electrically contrasting formation water is drawn back into the borehole by pumping or by native formation pressures

Question2. (36 Marks)

***Write on four only of the following:**

1- Detecting subsurface utilities

Utilities are usually pipes and cables and include electric, natural gas, telephone, fuel, water, and sewer lines. The ability of geophysical methods to detect utilities depends on the material from which the utility is made, its size, depth, and proximity to other sources of "noise" that may mask the signal from the detection equipment. The main methods used to locate utilities are magnetic, electromagnetic, and Ground Penetrating Radar (GPR)

1-Magnetic Basic Concept: To be able to use magnetic methods, the utility must be constructed from, or have included in its construction, some ferromagnetic material. Ferromagnetic materials become magnetized by the earth's magnetic field, which then produce a secondary magnetic field. The resulting field at the ground surface is a combination of the earth's magnetic field and the secondary field from the utility. This creates an anomaly in the resultant magnetic field that can be detected by the instrument. Two kinds of magnetic detection instruments are used. One detects the strength of the magnetic field using one sensor, and the other detects the gradient of the magnetic field using two sensors. This instrument is called a Gradiometer.

2-Electromagnetic Basic Concept: Electromagnetic instruments for detecting utilities produce and sense electromagnetic fields. These instruments will only work if the utility is made from an electrically conductive material. The instruments produce the electromagnetic fields using a coil through which oscillating current is made to flow, thus producing an oscillating electromagnetic field.

3-Geophysical Electromagnetic Utility Instruments Basic Concept: Two instruments are commonly used by geophysical companies for utility locating. In order for electromagnetic methods to work, the utility must be electrically conductive.

4-Ground Penetrating Radar Basic Concept: Ground Penetrating Radar (GPR) is a technique that uses high frequency radar waves to image the subsurface. The GPR instrument consists of a recorder and a transmitting and receiving antenna.

2- **Spectral analysis of surface waves method**

Basic Concept: The velocity of shear waves can be obtained from the Spectral Analysis of Surface Waves (SASW) method. This method is based on the propagation of mechanically induced Rayleigh waves. By striking the ground surface with a light hammer, a transient stress wave is created, including surface or Rayleigh waves, which are registered by two transducers placed in line with the impact point on the ground surface at fixed separations.

Data Acquisition: The surface wave dispersion curve can be measured using an active source and a linear array of receivers. The dispersion curve is then inverted to determine the corresponding shear wave velocity profile.

Data Processing: In the SASW method, a Fast Fourier Transform (FFT) analyzer or PC-based equivalent is used to calculate the phase data from the input time-voltage signals. Typically, only the cross power spectrum and coherence are recorded.

Data Interpretation: Interpretation consists of modelling the surface wave dispersion to determine a layered V_S profile that is compatible.

Advantages: The major advantages of the SASW method are that it is non-invasive and non-destructive, and that a larger volume of the subsurface can be sampled than in borehole methods.

Limitations: The depth of penetration and resolution of surface wave methods have not been thoroughly studied. This is due, in part, to the widespread use of forward modelling rather than formal inversion. The depth of penetration and resolution are also heavily site and profile dependent.

3- Ground penetrating radar method

Basic Concept: Ground Penetrating Radar (GPR) is used to measure the moisture content of soils. The GPR signals respond to variations in the dielectric constant, water content is one of the most important factors. This, along with the velocity of the GPR signals in the soil, can be used to estimate soil moisture content.

Data Acquisition: GPR surveys are conducted by pulling the antenna across the ground surface at a normal walking pace. The recorder stores the data, as well as presenting a picture of the recorded data on a screen.

Data Processing: It is possible to process the data, much like the processing done on single-channel reflection seismic data. Processing might include distance normalization, horizontal scaling (stacking), vertical and horizontal filtering, velocity corrections- and migration.

Data Interpretation: Changes in the electrical properties of the soil are usually related to changes in the soil moisture content. Soil moisture content can be derived from the velocity of electromagnetic waves in the soil using a conversion from velocity to dielectric constant. Advantages: The GPR method is easy to use in the field and the data is presented

on a screen as is being recorded. This allows changes in the data recording parameters to be made during the survey. Thus, if the depth of penetration is insufficient then a lower frequency antenna can be tested.

Limitations: In determining the moisture content of soils, probably the most limiting factor is the amount of clay that the soil contains, since this will attenuate the GPR signal and limit penetration. In addition, determining soil moisture content requires fairly uniform soils. If the soil is not homogeneous, other factors may influence velocity changes and give false moisture content values.

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4- **Seismic refraction method**

Basic Concept: Seismic refraction can be used to find rock velocities, especially for depths less than 30 m. The method requires a seismic energy source, producing either compressional or shear waves. The seismic waves penetrate the overburden and refract along the bedrock surface. While they are travelling along this surface, they continually refract seismic waves back to the ground surface.

Data Acquisition: The design of a seismic refraction survey requires a good understanding of the expected refractor layers and overburden. With this knowledge, velocities can be assigned to these features and a model developed that will show the parameters of the seismic spread best suited for a successful survey. These parameters include the length of the geophone spread, the spacing between the geophones, the expected first break arrival times at assigned to these features and a model developed that will show the parameters of the seismic spread best suited for a successful survey. These parameters include the length of the geophone spread, the spacing between the geophones, and the expected first break arrival times at each of the geophones, and the best locations for the off-end shots.

Data Processing: The first step in processing/interpreting refraction seismic data is to pick the arrival times of the signal, called first break picking. A plot is then made showing the arrival times against distance between the shot and geophone. This is called a time-distance graph.

Data Interpretation: There are several methods of refraction interpretation. One of the most common methods is called the Generalized Reciprocal Method (GRM) The velocity of the refracting layer is found by calculating the function T= (T (AD) - T (GD) + T (AB))/2 and plotting this function against distance. The inverse slope of this line is the velocity of the refractor. Once the compressional and shear wave velocities are obtained from a common layer, the elastic moduli can be calculated by substituting these velocities in the relevant equations given above. Thus, Poisson's Ratio, Young's Modulus, Bulk Modulus, Rock Density, and Shear Modulus can all be found.

Advantages: The seismic refraction method provides a reliable technique for determining the shear and compressional wave velocity in the bedrock.

Limitations: Probably the most restrictive limitation is that each successively deeper refractor must have a higher velocity than the shallower refractor. If the water table is in the overburden and close to the bedrock, this may obscure the bedrock arrivals since saturated soils have a higher velocity than unsaturated soils. Local noise, for example traffic, may obscure the refractions from the bedrock.

1- Nuclear magnetic resonance method (10 degrees)

Basic Concept: The Nuclear Magnetic Resonance (NMR) method is also known as the Proton Magnetic Resonance (PMR) method. The NMR method is based on the excitation of protons in the subsurface water in the presence of the Earth's magnetic field. The instrument consists of a transmitter and receiver. The transmitter drives alternating current at the proton resonance frequency through a loop of wire laid on the ground.

Data Acquisition: NMR surveys are conducted by laying a loop of wire on the ground. The size of the loop depends on the Pulse Moment (current multiplied by time while current is transmitted) during the measurement, which determines the depth of investigation. Six basic steps define the general procedure for carrying out NMR soundings:

1. Measure the strength of the Earth's magnetic field. From this, the frequency of the signal to transmit can be found.
2. Transmit a pulse of current using the wire loop at the frequency found in step1.
3. Measure the amplitude of the water NMR signal.
4. Measure the time constant of the signal.
5. Change the pulse intensity to modify the depth of investigation.
6. Interpret the data using an inversion program to get porosity versus depth.

Data Interpretation: Since the method detects water, in order to obtain porosity, it is assumed that the layers are saturated. The method is also reported to be able to provide mean pore size along with permeability estimates. There are four important facts concerning the interpretation of the results.

- The method detects water. No signal is observed if no water is present.
- The amplitude of the NMR signal is related to the variation in water content with depth.
- The decay time constant of the NMR signal is related to the variation in mean pore size against depth.
- The phase shift between the NMR signal and the current is related to the layer resistivity variation with depth.

Advantages: The main advantage of the NMR method is that it responds only to the protons within water.

Limitations: The method requires large currents to be used when transmitting, necessitating large-diameter wire. Therefore, the wire is heavy and can be difficult to lay out in any area

with bush or significant topography. Probably the biggest limitation is the influence of electrical noise, such as power line noise.

5-Determination of the rippability of rocks

Determination of the rippability of rocks Rippability is the ease with which soil or rock can be mechanically excavated. Ripping is typically performed by tractor-mounted equipment. The size of the tractor (dozer) is determined by the ripping assessment of the rock. The hardness and competency of each individual material will determine the ease of rippability. Rock that is too hard to be ripped is fragmented with explosives.

Sedimentary rocks are generally the most rippable.

Few or no problems are found with hardpan, clays, shales, or sandstones. Likewise, any highly stratified or laminated rocks, and rocks with extensive fracturing are usually rippable.

The physical characteristics that are favorable for ripping are given below:

1. Frequent planes of weakness such as fractures, faults, and laminations.
2. Weathered rocks.
3. Rocks with moisture permeating the formations.
4. Highly stratified rocks.
5. Brittle rocks.
6. Rocks with low "shear strength."
7. Rocks with low seismic velocities.

Conditions that make ripping difficult are as follows:

1. Massive rocks.
2. Rocks with no planes of weakness.
3. Crystalline rocks.
4. Non-brittle energy absorbing rock fabrics.
5. Rocks with high "shear strengths."
6. Rocks with a high seismic velocity.