International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 3, ISSN No. 2455-2143, Pages 251-256
Published Online July 2021 in IJEAST (http://www.ijeast.com)

AQUIFER MAPPING USING AEM SKYTEM

Balendhu Shaji
Department of Civil Engineering
Ilahia College of Engineering and Technology, Ernakulam, Kerala, India

Abstract— **The new tool is called SkyTEM. It's an aerial geophysical survey system towed by helicopter that measures aquifers electronically. SkyTEM uses electromagnetics, a global positioning system, lasers, loggers, and a computer strapped to a giant hexagon-shaped frame. Constructed from nonconductive fiberglass and wood, the frame will not interfere with SkyTEM's electronics as they probe the ground for electrically conductive layers. Ringing the bottom of the frame is a cable of wound copper wires that acts as a transmitter.**

Keywords— **SkyTEM, aquifer, electromagnetic, global positioning system**

I. INTRODUCTION

Airborne electromagnetic (AEM) methods complement spaceborne remote sensing techniques. AEM surveys carried out from low flying aircraft are capable of detecting geological structures not visible on the surface. The flight height of AEM systems above the ground ranges from 30 to 120 m. Most systems generate primary EM fields by using a loop transmitter; conducting coils are used as antenna to measure the secondary magnetic field caused by conductive in homogeneities in the ground. The frequency used in AEM surveys (100 Hz to 50 kHz) allows ground penetration in excess of 100 m. At present, two types of AEM systems are widely used: helicopter, frequency-domain, and fixed-wing, towed-bird, time-domain. The most common survey products are apparent conductivity maps. AEM methods are extensively used in prospecting for base and precious metal deposits, kimberlites, uranium, and also in geological mapping, groundwater exploration and environmental investigations.

II. AQUIFER

An **aquifer** is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt). Groundwater can be extracted using a water well. The study of water flow in **aquifers** and the characterization of **aquifers** is called hydrogeology.

.

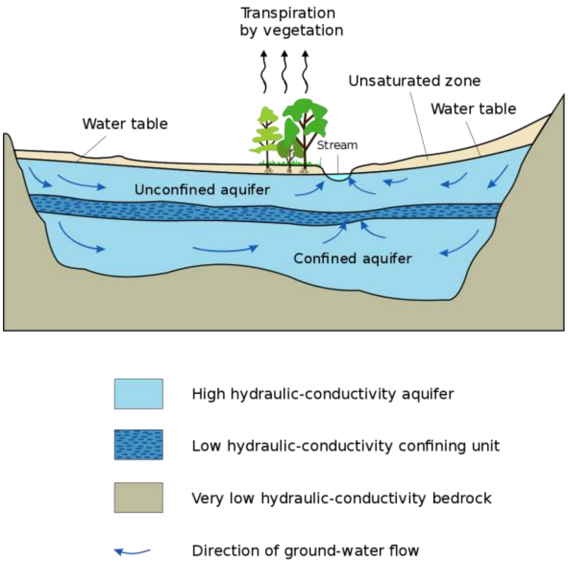

Fig. 1. Aquifer

III. AQUIFER MAPPING

Aquifer mapping is a multi-disciplinary holistic scientific approach for aquifer characterization. It leads to aquifer-based groundwater management. Mapping of aquifers helps determine the quantity and the quality of groundwater in a particular area including:

- Vertical and lateral extent of aquifer
- Productivity of the aquifer
- Concentration of various chemical constituents in groundwater in different aquifer
- Identification of groundwater discharge areas of the aquifer
- Delineation of vulnerable areas with regard to exploitation and contamination

All such information is required to develop a strategy of sustainable groundwater management. The benefits of aquifer mapping include the following:

- Identifying zones for drilling productive well
- Understanding of aquifer vulnerability

- Identification of streams at risk for reduced base flows as a result of heavy groundwater use
- Formulation of effective aquifer management plans
- Identification of areas for groundwater development, rain water harvesting and groundwater recharge
- Information sharing with stakeholders

IV. SKYTEM

Fill up a glass of water to quench your thirst. Wonder where it comes from? Chances are it's from underground water sources called aquifers, which provide fresh water for most people on Earth. Unlike highly visible rivers and streams or lakes and ponds, aquifers are beneath the surface, so finding them is tricky. The new tool is called SkyTEM. It's an aerial geophysical survey system — towed by helicopter — that measures aquifers electronically. SkyTEM uses electromagnetics, a global positioning system, lasers, loggers, and a computer strapped to a giant hexagon-shaped frame. Constructed from nonconductive fiberglass and wood, the frame will not interfere with SkyTEM's electronics as they probe the ground for electrically conductive layers. Ringing the bottom of the frame is a cable of wound copper wires that acts as a transmitter. maps aquifers from 100 feet in the air
The SkyTEM rig electronically maps aquifers from 100 feet in the air As the helicopter flies 50 miles per hour, it pulls the SkyTEM rig 100 feet above the ground, traveling back and forth in parallel lines along a predetermined mapped grid. The target for this survey is a 150-square-mile area in southeast Nebraska's Lower Platte South Natural Resources District.

SkyTEM creates precise records by shooting rapid-fire electromagnetic waves, similar to radio signals, into the ground every 9 feet — to a depth of 900 feet — all the way to bedrock. The rocks feel that radio signal and then get a little energy and send energy back out, It says, 'I'm a sandstone' or 'I'm a sand and gravel body' or 'I'm clay and silt.' And that's what we're mapping."

SkyTEM sends electromagnetic waves into the ground to map sands and gravels that make up aquifers.
SkyTEM measures electrical conductivity and electrical resistivity. The sand and gravel aquifer materials resist. So, that's what we want to see if you want to know where the aquifer is. But clays and silts are electrically conductive, like putty.Not much water gets through putty, so that tells us where the aquifer isn't. Between those two we map that difference and we make a map of where everything is.

Figure 2

Figure 3 Technicians prepare the SkyTEM rig for aerial mapping.

Figure 4

International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 3, ISSN No. 2455-2143, Pages 251-256
Published Online July 2021 in IJEAST (http://www.ijeast.com)

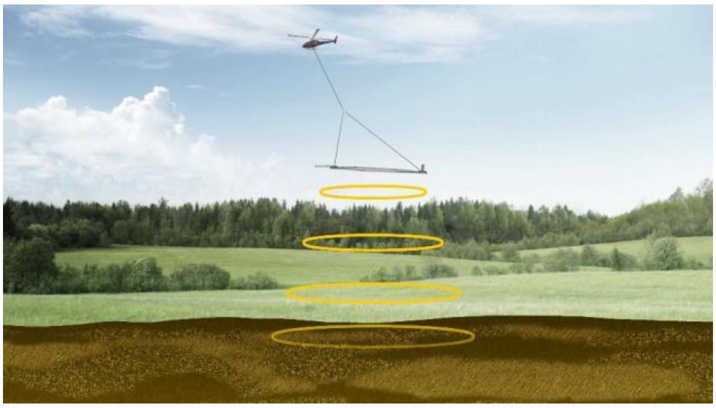

Figure 5
SkyTEM sends electromagnetic waves into the ground to map sands and gravels that make up aquifers.

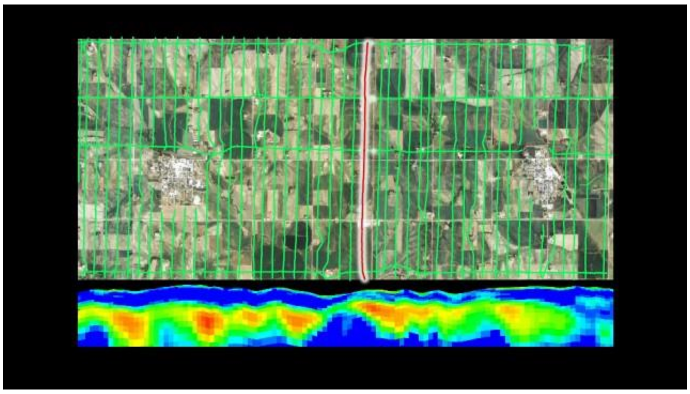

Figure 6
SkyTEM mapping produces colorful displays of aquifers

V. DESIGN AND WORKING OF SKYTEM

A. History of Airborne Electromagnetic Systems

Airborne electromagnetic (AEM) systems have been in use forϖ over 50 years. The first attempts in the 1950s were quite successful in base-metal exploration in Canada, and in that decade over 10 systems were in the air. With the decline in exploration for base metals, the use of AEM methodsϖ turned from anomaly detection to conductivity mapping and frequency domain helicopter EM (HEM) systems began appearing. Of the more than 30 systems that have made their appearance since the inception of the AEM method, only a few are currently in routine use. Only recently has the concept of a transient helicopter system come of age, and new systems are emerging making broadband measurements with a small footprint possible. The SkyTEM system is designed forϖ mapping of geological structures in the near surface for groundwater and environmental investigations, and was developed as a rapid alternative to groundbased TEM surveying.

B. SkyTEM: A new high-resolution helicopter transient electromagnetic system

SkyTEM is a time-domain, helicopter electromagnetic system designed for hydrogeophysical and environmental investigation. • Developed as a rapid alternative to ground-based, transient electromagnetic measurements, the resolution capabilities are comparable to that of a conventional 40 40 m2 system. • Independent of the helicopter, the entire system is carried as an external sling load. • In the present system, the transmitter, mounted on a lightweight wooden lattice frame, is a four-turn 12.5 12.5 m2 square loop, divided into segments for transmitting a low moment in one turn and a high moment in all four turns. • The low moment uses about 30 A with a turn-off time of about 4 µs; the high moment draws approximately 50 A, and has a turn-off time of about 80 µs. • Standard field operations include establishment of a repeat base station in the survey area where data are acquired approximately every 1.5 hours, when the helicopter is refuelled, to monitor system stability. • Data acquired in a production survey were successful in detecting and delineating a buried-valley structure important in hydrogeophysical investigations.

Fig. 7. (a) The SkyTEM system in operation during the spring of 2003 overSabro, a 40 km2 survey area west of Aarhus, Denmark. The box between the helicopter and the transmitter lattice contains computers and power supply.

International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 6, Issue 3, ISSN No. 2455-2143, Pages 251-256
Published Online July 2021 in IJEAST (http://www.ijeast.com)

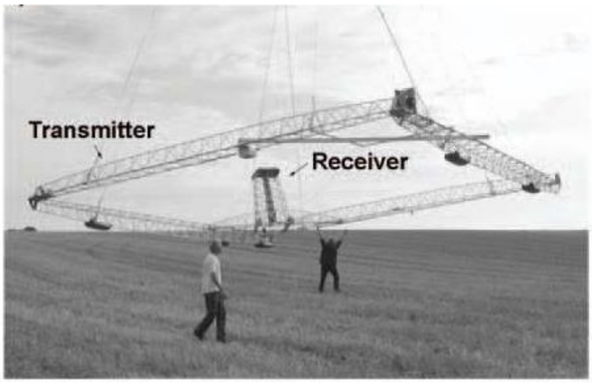

Fig (8)(b) A detailed photograph of the wooden lattice transmitter frame. The receiver coil is located at the top of the tail. The cables attached to the frame are transmitter and communication cables. Laser altimeters and angle measurement devices are mounted on the frame (not visible in the photograph).

• Inclinometers are mounted in both the x and y directions.

• The measured data are averaged, reduced to data subsets (soundings), and stored together with GPS coordinates, altitude and inclination of the transmitter/receiver coils, and transmitter waveform.

• Transmitter waveform information (current, turn-on and turn-off ramp times) and other controlling parameters of the measuring process are recorded for each data subset, thereby ensuring high data-quality control.

• Not having an operator in the helicopter reduces the total weight by 75 to100 kg.

• A small display is temporarily mounted inside the helicopter, to allow the pilot to monitor the altitude and the inclination of the transmitter and receiver coils, and the status of the receiver/transmitter system.

• The transmitter loop, horizontal and 12.5 m square, is mounted on the wooden lattice frame.

• The total weight of the system including the electronics, power supply, GPS, and other related instruments is about 280 kg.

• The SkyTEM system operates continuously while the helicopter is airborne with sufficient transmitter power for about 2 hours of operation, more than the fuel endurance of the helicopter.

VI. ARRAYCONFIDURATION & TRANSMITTER SYSTEMS

a. Transmitter Coil

• The transmitter is a four-turn 12.5 12.5 m2 square loop divided into segments to allow transmitting with a low moment using one turn, and a high moment using all four turns.

• The transmitter current for the low moment is about 35 A resulting in aturnoff time of about 4 μs. The high moment has a turn-off time of about 80 μs transmitting with approximately 50 A.

• The transmitter loop is attached to a wooden lattice frame constructed without any metal.

B. Receiver Coil

• The receiver coil (dimensions 0.5 0.5 m) is located 1.5 m above the corner of the transmitter loop. This configuration is practically a central-loop with a vertical offset.

• The lattice framework ensures an extremely stiff structure resulting in rigid control of the relative position of receiver coil with respect to the transmitter.

C. Receiver System

• The receiver coil is a shielded, overdamped, multi-turn loop, with a first order cut-off frequency of 450 kHz.

• The effective receiver area is 31.4 m2.

• The SkyTEM receiver system uses two embedded computers that are electrically separated. One computer controls and stores the measurements from the receiver coil while the other controls the transmitter and logs the transmitted waveform, GPS coordinates, laser altitude, and angle data.

VII. FLIGHT SPEED AND ALTITUDE

A. Flight Speed

• The flight speed and altitude of operation are crucial parameters for resolution of the subsurface resistivity distribution

.

• The operational flight speed of the SkyTEM system is 15 to 20 km per hour (4.1 to 5.5 m/s or 8–11 knots).

• This results in a high-moment stack size of approximately 1000 transients. This is sufficient to obtain data out to 2 to 4 ms.

• Increasing the transmitter moment leads to a larger turn-off time, but allows greater flight speed and production rate, or an increased depth of penetration

B. Flight Altitude

• The spatial resolution of near-surface resistivity structures decreases with increasing flight altitude because the fields are upward-continued from the ground surface.

• Reasonable compromise between resolution and safety concerns for the helicopter and SkyTEM system is to operate so that the transmitter loop is at an altitude of 15 to 20 m, and the helicopter is at about 50 m.

VIII. MODELLING OF SKYTEM DATA

• About 1000 SkyTEM transients are averaged into a sounding yielding data starting from 20 µs and ending at between 2 to 4 ms.

• The system transfer function is not deconvolved from the field data because, deconvolution is an inherently unstable process.

• The transmitter waveform is applied using a piecewise-linear approximation to the ramp.

• Filters before the front gate are modelled in the frequency domain while filters after the front gate are modelled by a convolution in the time domain.

• A sounding consists of low- and high-moment segments.

• The two segments are spatially separated (the system has moved between the soundings) hence the datasets are inverted with different altitudes.

IX. AIRBORNE ELECTROMAGNETIC SURVEY

Airborne geophysical surveying is a process of measuring the variation in several key physical or
geochemical parameters of the earth. The most important parameters measured are the conductivity (which is the inverse of resistivity), magnetic susceptibility, density, and radioactive element concentration. Any change in earth's near surface that causes a measurable change in these parameters presents a potential application for airborne geophysics.
Electromagnetic surveys map the three dimensional variation in conductivity, caused by changes inmineralogy, intensity of alteration, water content or salinity. Airborne magnetic surveys map the variation of the magnetic susceptibility, generally due to changes in the magnetite content of the rock. Gamma-rayspectrometric surveys measure the radiation of one or more of the natural radio-elements: potassium, uranium, or thorium, or a specific man-made radioelement. Airborne gravity surveys map density variations within the earth.
Airborne electromagnetic surveys are used to conduct a rapid survey at a relatively low cost of a broad area to search for metallic conductors. Graphite, pyrite and or pyrrhotite are present in the bedrock and are most commonly what provides the electromagnetic response. The conductivities which is determined through the electromagnetic method varies over seven orders of magnitude between various geologicmaterials. The strongest responses come from massive sulphides. Fresh water on the other hand is highlyresistive and will provide responses very different from salt water.

A. Basic Principles

Electromagnetic-induction prospecting methods, both airborne and (most) ground techniques, make use of man-made primary electromagnetic fields in, roughly, the following way: An alternating magnetic field is established by passing a current through a coil, (or along a long wire). The field is measured with a receiver consisting of a sensitive electronic amplifier and meter or potentiometer bridge. The frequency of the alternating current is chosen such that an insignificant eddy-current field is induced in the ground if it has an average electrical conductivity. If the source and receiver are brought near a more conductive zone, stronger eddy currents may be caused to circulate within it and an appreciable secondary magnetic field will thereby be created. Close to the conductor, this secondary or anomalous field may be compared in magnitude to the primary or normal field (which prevails in the absence of conductors), in which case it can be detected by the receiver.

B. Systems

1) The transmitter coil may be fixed to aircraft and the receiver mounted in a bird which is trailed some distance behind

.2) Both transmitter and receiver may be mounted in the aircraft.

3) Both are mounted in the bird.

X. APPLICATIONS

Some of the major applications of Air borne Electromagnetic survey are:

A. Structural Mapping

Airborne magnetic surveying has been used extensively in oil exploration for mapping bedrock structure and depth to basement. Gravity and gravity gradiometry are also commonly used for a variety of oil and gasexploration and development applications.

B. Mineral Exploration

Airborne electromagnetic surveying originally grew out of the field of mineral exploration, in particular the search for conductive metallic sulphides and oxides in resistive geology. These applications are still common, but have been extended to almost every kind of economic mineral deposit.

c. Environmental

Environmental monitoring is a relatively new application of airborne geophysics, requiring precisemeasurement of the geophysical parameters (conductivity, etc.) and high resolution of anomaly size and depth. While EM is used most often for mapping groundwater location and salinity, magnetic surveys have been used to detect buried metallic objects and pipelines, and gamma-ray spectrometry can be used to detectman-made radioactivity.

d. Oil and Gas Exploration

Airborne geophysics has been used for petroleum exploration for many years. Recent years have
seen the application of airborne electromagnetic data to hydrocarbon exploration and development in the areas of oil sands exploration and engineering, groundwater management, shallow drilling hazards and Quaternary gas exploration

XI. ADVANTAGES OF AEM

The advantages of airborne surveying include the rapid acquisition of multiple datasets, access over difficult terrain and non-invasive ground investigations which allow the localization of potential target areas for ground surveying, and are therefore highly cost effective.

XII. CONCLUSIONS

Air borne electromagnetics is a very useful method for surveying large areas in order to support hydrogeological investigations. Due to the dependency of Geophysical parameter electrical conductivity from both the mineralization of ground water and the clay content, information about water quality and aquifer characteristics, respectively, can be derived from AEM data. The results however are sometimes ambiguous- as a consequence, additional information e.g: from drillings, are requires for a solid hydorgeological interpretation of the AEM data. The ability to reveal the availability and movement of groundwater can be a huge asset for countries and regions with the need to responsibly and sustainably manage their aquifers.

XIII. REFERENCE

[1] Mapping Aquifer Systems with Airborne Electromagnetics in the CentralValley of California https://www.researchgate.net/publication/323665473Ryan SmithMissouri University of Science and Technology, Ted AschAqua Geo Frameworks, LLC, Andrea Viezzoli Aarhus Geophysics, Graham E FoggUniversity of California, Davis

[2] Airborne Surveys Worldwide Skytem Surveys Aps Tel: +45 8620 2050www.Skytem.Comdyssen 2 Vat: 27704379 Info@Skytem.Com Hus N, Denmark 20160901

[3] A review of helicopter-borne electromagnetic method for groundwater explorationhttps://www.researchgate.net/publication/282500385 Bernhard SiemonBundesanstaltfürGeowissenschaften und Rohstoffe, Anders Vest Christiansen Aarhus University, EsbenAuken Aarhus University

[4] .Bill Brown *bb@skytem.com*

[5] .WIKIPEDIA

[6]. GOOGLE