AUTOMATED MINERAL DETECTION USING SONAR WAVE

Mr.Kaushik Banerjee, Mr.Subhas De, Mr. Rahul Sourav Singh,Mr.Souren Jana

Abstract-SONAR is a sound wave used for navigation and various purposes. Every material have property to absorb sound due to different density. Absorption of sound is used here to detect different mineral. Mineral detection using SONAR will be cheaper compared to other method presently used for exploration of sea surface in search of minerals. Also it will not cause pollution and unnecessary of disruption of aquatic life.

Index Terms— Hydrophone, ping, reflection, sound, sonar, shipping levels.

1. INTRODUCTION

Sonar is an acronym used for **So:** Sound **Na:** Navigation and **Ra:** Ranging. It is a technique that uses sound propagation to navigate, communicate with or detect objects on or under the surface of the water. Two types of technology share the name "sonar": passive sonar is essentially listening for the sound made by vessels or undersea living things; active sonar is emitting pulses of sounds and listening for echoes.

Active SONAR[Figure 1] uses a transmitter and receiver. Active sonar creates a pulse of sound, often called a "ping", and then listens for reflections (echo) of the pulse. This pulse of sound is generally created electronically using a sonar projector consisting of a signal generator, power amplifier and electro-acoustic transducer/array. A beam former is usually employed to concentrate the acoustic power into a beam, which may be swept to cover the required search angles.

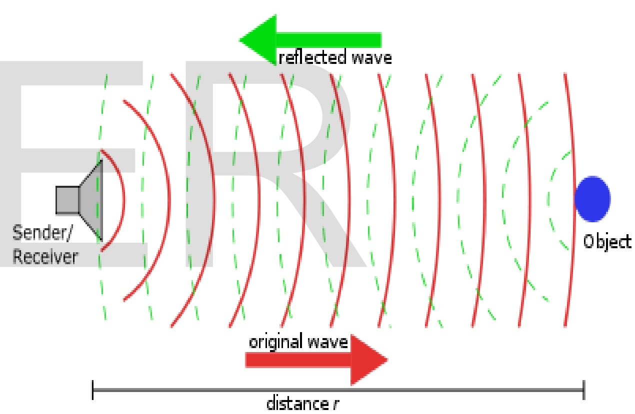

FIGURE 1: ACTIVE SONAR WORKING

- *Kaushik Banerjee is currently Professor in Institute of Engineering and Management, India, PH-09830203495.E-mail: kaushik.saltlake@gmail.com*
- *Subhas De is currently pursuing masters degree program in Institute of Engineering and Management, India, PH-9903967916. E-mail: desubhas@gmail.com*
- *Rahul Sourav Singh is currently pursuing masters degree program in Institute of Engineering and Management, India, PH-09681090300. E-mail: rahul.sourav.singh.85@gmail.com*
- *Souren Jana is currently pursuing masters degree program in Institute of Engineering and Management, India, PH-09547355088. E-mail: souren.jana@gmail.com*

2.PERFORMANCE PARAMETER OF SONAR WAVES

Performance of SONAR is based on many factors. Discussing the factors and effects on SONAR.

2.1 Propagation Speed

For a non-dispersive medium, which water is to some extent, we would also expect the same type of relationship between wavelength and frequency as with electromagnetic waves. The only difference is that the speed of propagation is slower, on the order of **1500 m/s in water**, and it is no longer a constant. The speed of propagation depends on the ambient temperature, pressure and salinity of the water. Therefore we can write

Fl = c(T,p,S); where c(T,p,S) is the speed of propagation as a function of temperature (T), pressure (p) and salinity (S).

The speed of propagation is a fairly complicated function, and the effects of these three independent parameters are best stated as thumb rules:

1 degree C increase in temperature
3 m/s increase in speed.

100 meters of depth increase
1.7 m/s increase in speed.

1 ppt (part per thousand) increase in salinity
1.3 m/s increase in speed.

By far the greatest variation occurs in the ambient temperature. Changes by as much as 30 degree Centigrade are possible in the water in which a submarine operates. The equivalent change in depth which would change the propagation speed by the same amount is more than 5000 ft. Variations in salinity are limited to regions where fresh and salt water mix.

2.1 Sound Pressure Level (SPL)

The fundamental parameters of an acoustic wave are the amplitude, which is a pressure, and the wavelength (or frequency). Pressure has units of force/area or in SI (system international) units, N/m2. The SI unit of pressure is the Pascal (Pa), where 1 Pa = 1 N/m2.

The sound pressure level, or SPL is defined as:

SPL = 20 Log [p/(1 mPa)] ,
Where 1 mPa is the reference value, similar to the way 1 mW is used in the definition of dBm

2.2 Ambient Noise

The introduction of noise from other sources is a significant factor in sonar performance. There are a wide variety of noise sources present in the underwater environment, but the main, consistent contribution comes from only a few types. **Ambient noise, unlike other sources, does not come from a particular direction or source. The noise level is the same everywhere in the local area. Therefore the SPL will be the same everywhere and it is not necessary to specify the range at which it was measured at**. So the ambient noise is specified as a particular SPL.

The most obvious contribution to the ambient noise is the action occurring on the surface of the ocean. The greater the size of the waves, the greater the ambient noise contribution. The waves are driven by the winds, so there is a direct correspondence between the steady wind speed and the sea state. The condition of the ocean surface is quantified by the sea state, which is a number ranging from 0-9. The Beaufort Wind Scale which ranges from 0-12 is the standard measure of the consistent wind speed(the table is shown in the last page).

The greater the wind speed or sea state, obviously the greater the ambient noise contribution. The frequency of the noise from sea state tends to be greater than 300 Hz. See Table 1.

Beaufort	Wind speed (knots)	Wave height (meters)	Sea State
0	<1	0	0
1	1-3		
2	4-6	0-0.1	1
3	7-10	0.1-0.5	2
4	11-16	0.5-1.25	3
5	17-21	1.25-2.5	4
6	22-27	2.5-4	5
7	28-33	4-6	6
8	34-40		
9	41-47		
10	48-55	6-9	7
11	56-63	9-14	8
12	>64	>14	9

TABLE 1: BEAUFORT WIND SCALE AND SEA STATES

The second main contribution to ambient noise comes from shipping in general. In regions where there are many transiting ships, the ambient noise will be increased substantially. This noise, in contrast to the noise from sea

Shipping Levels.

Hence, the two contributions to ambient noise, sea state and shipping can be predicted using the two tables we have defined above. The noise can be represented as a function of frequency, it is calculated on a graph from a series of measurements called the Wenz curves.

To find the combined ambient noise level (AN), you must combine the sound pressure levels from the two curves using:

AN = Shipping (SPL) Sea State (SPL).

Trying to show by example for the better understanding of our project -

TABLE 2: CATEGORY TABLE

state, will be at low frequency (< 300 Hz). The amount of shipping traffic can be estimated by broad geographical considerations. For the purposes of estimating the ambient noise, we will arbitrarily describe locations as falling into one of six categories:

Category	Description
Very remote	No other ships present for many miles.
Remote	Infrequent distant ships.
Quiet	Occasional ship nearby.
Shipping Lanes	Many ships nearby.
Heavy traffic (deep water)	Constant passing of ships nearby, offshore.
Heavy traffic (shallow water)	Constant passing of ships nearby, inshore.

For e.g. if we have to predict the ambient noise at 300 Hz from shipping lanes and seastate 2.

The shipping noise is 65 dB
The sea state noise is 62 dB

65 dB 62 dB = 65 + 2 = 67 dB (tabular method) (Since they are in Log they are not added like simple addition)

AN = 67 dB

The third possible ambient noise sources are sea-life. These are as widely varied as they are unpredictable. Source for this are whales and dolphins. It is impossible to estimate the contribution from biologics to the ambient noise beforehand. It has very mild effect almost negligible for the calculation. However we can on site calculate the noise produced by sea creature by monitoring the presence of the particular kind of sea animal present. But if we are picturing a large undersea are (sea bottom surface) then its an negligible effect, it matters when we are using narrow beam or single wave of SONAR. However we will be using multiband SONAR.

2.3 Total Noise Level

The ambient and self-noise must be combined, using the special method for combining sound pressure levels. Thus

NL=AN+SN

2.4 Detection of Acoustic Energy

Transducers designed to receive equally well in all directions, they are called Omni-directional. The transducer can be constructed with some directionality in which case it will have some range of angles from which it can receive energy which will be its beam width, q. The beam width can only be made as small as the diffraction limit, meaning

q=2l/D

Where l is the wavelength and D is the diameter of the aperture or face of the transducer. Transducers are usually small devices, on the order of 10 cm. Now the size of the array, or aperture, L, will determine the beam width.

q=2l/L.

Array/Shape	Beamwidth, θ	DI
Circular plate, diameter D	$(2.4)\lambda/D$	$20 \text{ Log } (\pi D/\lambda)$
Linear array, length L	$2\lambda/L$	$10 \text{ Log } (2L/\lambda)$

TABLE 3: Array directivities.

When receiving, the narrow beam width will allow the array to reject more interfering noise, since the ambient noise comes from all directions. This is completely analogous to radar antenna gain, and we have a similar expression in sonar. It is a logarithmic term called the directivity index, DI. It is roughly the equivalent of antenna gain in decibels (i.e. 10 Log (G)). However, in sonar this term is applied only to the reception of energy, since the definition of SL accounts for the gain achieved in transmission. [see Table 3]

3. Detection Criterion

The criterion for detection requires the amount of power which is collected by the receiver to exceed the noise level by some threshold. The ratio of signal-to-noise in logarithmic form is the SNR. The minimum SNR for detection is called the **detection threshold, DT**. Therefore detection generally occurs, meaning more than 50% of the time, whenever

SNR > DT.

Thus SNR for an active system =>

SNR = SL - 2TL + TS - NL + DI

SL = source level
TL = transmission loss
NL = noise level (AN SN)
DI = directivity index
TS = target strength.

The target strength acts as a source level after reflection, and therefore includes any directional effects of reflection. The target strength is a function of the target size, surface material and shape in the same way that radar cross section varies.

3.1 Mineral Extraction and Exploration

Extraction here is synonym used to the extraction of mineral from sea bed. Before mentioning our innovative idea behind the new technique we proposed we would like to mention the present the minerals we will extract and the present scenario of mineral extraction.

3.2 Minerals that are Mined

The deep sea contains many different resources available for extraction, including silver, gold, copper, manganese, cobalt, and zinc. These raw materials are found in various forms on the sea floor, usually in higher concentrations than terrestrial mines.

Various minerals are found at different depth. We try to show various category of minerals found at the given depth in a tabular form. [See Table 4]

Type of mineral deposit	Average Depth	Resources found
Polymetallic nodules	4,000 - 6,000 m	Nickel, copper, cobalt, and manganese
Manganese Crusts	800 - 2,400 m	Mainly cobalt, some vanadium, molybdenum and platinum
Sulfide deposits	1,400 - 3,700 m	Copper, lead and zinc some gold and silver

TABLE 4: Depth of mineral deposit from sea bed

3.3 Extraction Techniques used presently

Recently for mining, the minerals are traced from satellite takes a picture of a large zone of sea. On finding anomalies like change in color of water, elevation in sea surface points the presence of mineral. After noticing such changes **remotely operated vehicles** (ROVs) are used to collect samples from different site where possible changes had been noticed. Also many places the sites are dug at a few spots and samples are collected.

However this process has adverse environmental impacts. The removal of parts of the seafloor result in disturbances to the benthic layer, increases toxicity of the water column and sediment plumes from digging. Since this method is a hit and trial method, it is not efficient. Also several sites are tested by gathering sample (digging) the cost of this process is also high.

3.4 Exploration using SONAR WAVES

Everyone must have noticed during the cricket matches, when our home team travels to different country, what happens. The conditions are different, condition like weather, outfield, players, wind and pitch. Some pitches are bouncy, some dull, in some balls spin and in other it does not. Well our idea for mineral exploration comes into existence from this behavior of pitches. We are more concerned about the bounces of different pitches rather than other attributes. .

Why there is difference in bounce? And here lies our idea of our method. Different pitches have different bounce because the curator (the man in charge of laying the pitch) uses different material in the pitch, the upper surface is always covered with mud, however the sub layer (layer just lying beneath the top layer of soil) actually have different constituent. Somewhere they use clay, somewhere limestone and so on. This shows that the presence of different material in the sub layer affects the bounce of the pitch.

Also when we bounce a rubber ball on solid surface, hollow surface, table and soil the bounce is again different under same condition at different places.

Similarly SONAR wave is bounced on the sea floor and the reflected (echoed) wave is traced to find the presence of mineral. If for an instance we take the SONAR as a ball from our cricket match and the seabed as the pitch. Like the pitch the presence of mineral in sub layer will have different effect on the reflecting wave then that in normal condition. Also, its density of the mineral present in the sub layer that affects the variation in the echoed wave. Hence different minerals with different density will have different ratio of echoed wave in changed condition (presence of mineral) to ratio of echoed wave in normal condition (hard seabed).

This ratio will also fall under a particular range depending on the depth of mineral presence. We have discussed in a table in 4.1 presence of various mineral in a particular depth range. Hence the TS (mentioned in 3.3) will be affected by the presence of a mineral of different density at different depth.

Active SONAR procedure can be used to get the reading of echoed wave. Also we have to maintain a table of ratio of echoed wave under different condition to normal condition. Once we get the reading of echoed wave we can tally the present ratio to pre saved ratio of echoes. If the ratio falls under a particular range then we can be 100% sure of presence of a particular kind of mineral (by density).

Sound waves striking an arbitrary surface are either reflected, transmitted or absorbed; the amount of energy going into reflection, transmission or absorption depends on acoustic properties of the surface. The reflected sound may be almost completely redirected by large flat surfaces or scattered by a diffused surface. When a considerable amount of the reflected sound is spatially and temporally scattered, this status is called a diffuse reflection, and the surface involved is often termed a diffuser. The absorbed sound may either be transmitted or dissipated. [See Figure 2]

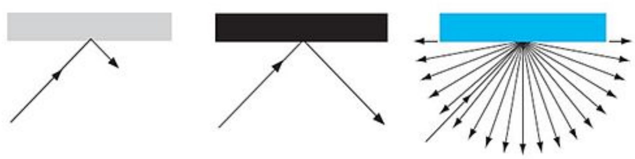

FIGURE 2: Surface-sound interaction- absorption (left), Reflection (middle) and diffusing (right)

Sound energy is dissipated by simultaneous actions of viscous and thermal mechanisms. The absorption coefficient α is a common quantity used for measuring the sound absorption of a material and is known to be the function of the frequency of the incident wave. It is defined as the ratio of energy absorbed by a material to the energy incident upon its surface.

The Sound absorbing coefficient can be mathematically presented as follows:

$$\alpha = 1 - \frac{Ir}{Ii}$$

Now in our proposed method a multi beam SONAR (Acoustic Wave) Wave is send in the direction of the sea floor.

[See Figure 3]

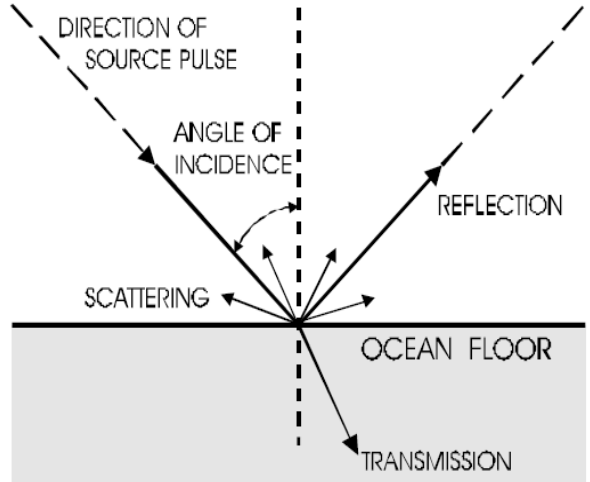

FIGURE 3:Component of an echo event on the sea floor

As the image suggest some waves are reflected and some are absorbed based on the principle of acoustic absorption. The reflected wave is received by our proposed system. The reflected sound wave velocity and incident sound waves velocity our compared and α is calculated from the above the formula. A pre calculated chart of Acoustic Absorption Coefficient for different material is store in the computer database that is used to operate the whole system. The new α calculated for the instant is compared to the values in the table. If it matches to any pre stored value then it informs the presence of a particular kind of mineral. The chart can be created by gathering the Acoustic Absorption Coefficient from any society that is concerned for the study of material and acoustics.

For a given material α is fixed**.** Also by the above formula we can calculate the α using the intensity of reflected rays and Intensity of incident rays. By comparing the α calculated recently and pre calculated α we can suggest the type of minerals present.

4. FEASIBILITY

Since for extraction by this method we do not need to dig the sea bed to gather sample, hence we can control the adverse environmental effects as mentioned earlier.

In this process we start the extraction method only when we are 100% sure that there is a presence of mineral. Hence it is more efficient than the methods used recently. We can guarantee the results as they are based on calculation and unlike the present methods used, it is not a hit and trial method.

SONAR waves are used over electromagnetic waves for the process as it suffers very less attenuation compared to later. The effects caused by different form of noise can be calculated at receiver end. Hence they can be removed by simple calculations based on the table as mentioned. The tables and calculation of noise are not hypothetical data but they are mathematically proved.

Also compared to satellite and ROVs a SONAR system is very cheap. It is mobile and we do not need extra setup for it. SONAR are already used in fishing boats, such SONAR can also be programmed in the above manner and can be used to carry out the process. So a simple fishing boat using SONAR can be programmed using a microprocessor in our proposed manner to do the job. Apart from exploration of minerals it can also be used for the general purposes that they are already being used, hence its multipurpose.

5. CONCLUSION

We are using simple ways to find minerals. Our goal is to reduce the petroleum price.

6. ACKNOWLEDGMENT

We are thankful to Geological Survey of India, Webel Executive Director, West Bengal Govt, India.

References

1 www.FAS.org - Research Paper on Naval Weapons Engineering at FAS (Federation of American Scientist).
www.soest.hawaii.edu - Research article submitted by Mary MacKay and Stan Zisk on RADAR and SONAR: A Primer for the Geophysically-Challenged at Hawaii Centre for Vocanology.

2 Alexander N. Gavrilov and Iain M. Parnum - IEEE journal on Oceanic Engineering - Fluctuations of Seafloor Backscatter Data from Multi-beam Sonar Systems.

3 www.en.wikipedia.org

4 Sea Beam Multi Beam Theory of Operation –L3 communication.

5 Tsuyoshi Yamashita, Kazuhiro Suzuki, Souichiro Nishino and Yo Tomota - Relationship between Sound Absorption Property and Microscopic Structure Determined by X-ray Computed Tomography in Urethane Foam Used as Sound Absorption Material for Automobiles.

6 Francesco Asdrubali- Survey on the acoustical properties of New Sustainable Materials for Noise Control.

7 Hoda S. Sedeqq – Factors Influencing Acoustic Performance of Sound Absorptive Materials.

8 R.A. Neville and K. Staenz, T. Szeredi and J. Lefebvre, MacDonald Dettwiler and P. Hauff – Automatic Endmember Extraction From Hyperspectral data for mineral exploration.

9 Ronald Sauro, Michael Vargas and Gary Mange – Absorption Coefficient, the edge effect.

10 Prof Colin H Hansen – Fundamentals of Acoustics.

11 Eric M Gullikson – X-Ray – Mass Absorption Coeeficients.

12 Philippie H Cluzel, Michael G. Quivy and Bernard Tocquet – United States PATENT – Underwater Acoustic Reflectors.