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THE COMPUTATION OF LVL CORRECTION PARAMETERS IN PARTS OF WESTERN NIGER DELTA (OML 62)

IDARA O. AKPABIO, and HENRY N. ONWUSIRI
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ABSTRACT

Data from sixty one different locations in OML-62 in the Western Niger Delta were used for this study. This study determined the low velocity layer (LVL) correction parameter namely, weathering velocity, sub-weathering velocity, and the thickness of the weathering layer. Also, an isopach map and a NW-SE profile were used to depict variation trend in the thickness of the weathering layer. The results show that the weathering velocity ranges from 210 to 994 m/s, with an average value of 552m/s. The subweathering layer velocity varies from 1358 to 2464m/s, with an average of 1734m/s. The thickness of the weathering layer varies from 2.8 to 52.8m with and average of 19.3m. The parameters so computed are important to the exploration seismologist especially in determining the time delays needed for static corrections during seismic reflection data processing. Also, depth to which energy sources can be buried is known and the bearing capacity of the foundation rock for civil engineering works can also be assessed.

KEYWORDS: Low velocity layer, weathering velocity, sub-weathering velocity, thickness of velocity layer and correction parameters.

* To whom all correspondence should be addressed.

1.0 INTRODUCTION:

The corrections applied to seismic traces so that the data can be properly stacked are of two types. These are static and dynamic corrections. Static corrections involve a constant time shift to the data traces, whereas, dynamic corrections involve time variable shift. While the normal move-out correction, which depends on record time, is a typical dynamic correction, elevation static, datum static & weathering statics are examples of static corrections. In this study, weathering static also called low velocity layer static was dwelt on. The objectives are:-

i. Determination of the average weathering velocity, V_w.
ii. Determination of the average weathering thickness, D_w.
iii. Computation of the average subweathering layer velocity V_{sw} of the study area.
iv. Determination of the weathering layer variation trend using Isopach map.

In weathering statics, the problems of velocity and thickness variations in the low-velocity layers or, more particularly with their measurements and compensation of the data for their presence are considered. Generally, corrections when properly applied improve the quality and integrity of the acquired seismic data for more realistic and dependable interpretations. However, these corrections when not accurately determined and applied would rather impose problems to the interpreter, hence adequate measures have to be taken when deriving the correction parameters.

The low velocity layer which is a loose, aerated and geologically recent unconsolidated sediments on a substratum of harder consolidated rocks do not pose problems on its own. The problem comes in as a result of the variability in the velocity, and thickness of the low velocity layer. A previous work carried out by Uko et al (1992) in the Central Eastern Niger Delta clearly revealed these variations both in thickness and velocity of the low velocity layer.

2.0 THEORY AND CONCEPTS

The factors affecting the velocity of a seismic wave in rock helps one to foresee the anticipated velocity variations in an area and, of course, the velocity distortion likely to be expected in seismic data. The equation of compressional wave is given by:

$$V_p = \left(\frac{\lambda + 2\mu}{\rho}\right)^{1/2}$$

IDARA O. AKPABIO, Department of Physics, University of Uyo , Uyo , Nigeria
HENRY N. ONWUSIRI, Shell Petroleum Development Company, Port Harcourt, Nigeria.

The velocity of p-waves, V_p, in a homogenous solid is a function of the drastic constants λ, μ and the density, ρ. The dependence of velocity on the elastic constants and density appear simple but the situation is complicated because the elastic constants and density are interrelated both depending on lithology, porosity, interstitial fluids, pressure, depth, cementation, degree of compaction, etc. (Sheriff and Geldart, 1987). Some of the basic factors controlling the velocity of seismic waves are the depth of burial and lithology.

i. **Lithology**

This is an important factor affecting the velocity of seismic waves in a given rock. This is so because different rock units have different velocity associated with it, this is due to the affective pressure on the granular matrix resulting from the difference between the over-burden pressure and the fluid pressure. For instance, slates and shale at 1000 ft have a Vp in the range of 2400 – 5000m/s while basalt at the same depth has a Vp within the range 5500 – 6300 m/s (Sharma 1978).

The tremendous overlap of velocity values for different lithology suggests that velocity is not a good criterion for determining lithology. High velocity for sedimentary rocks indicates carbonate while low velocity indicates sands or shales, intermediates velocity can indicate other (Sheriff and Geldart, 1987).

ii. **Density**

If the elastic moduli were constant throughout in the rock, seismic wave velocity would vary as the square root of the inverse of the density. That is

Seismic velocity, $$\alpha = \frac{1}{(\rho)^{1/2}}$$

In other words, we can expect that since density generally increases with depth due to compaction, seismic wave velocity decrease with depth. Unfortunately, these expectations do not practically hold. Rather seismic velocity also increase with depth meaning that the elastic moduli increase with increasing density but at a rather faster rate than the density itself increase.

The density of a rock depends directly upon the densities of the constituent minerals making up the rock. The variations in the densities of these minerals making up a rock also play a significant role in velocity variation. However, it is generally accepted that high densities correspond to high velocities.

$$\rho = a\,V^{1/4}$$

Where ρ is in g/cm^3, V in m/s when a = 0.31 and in ft/s (Sheriff and Geldart, 1987).

iii. **Porosity**

Porosity, ϕ is the fractional portion of rock volume, which is occupied by pore space or voids. Despite the fact that porosity affects the velocity of seismic waves through the bulk density, it also has a direct effect on the velocity since a part of the wave path is in low density fluids (Sheriff and Geldart, 1987).

iv. **Depth of burial**

Porosity decreases as the depth of burial increases. As the depth increases, the over-burden pressure increases thereby, increasing the velocity. This increase in velocity due to increase in depth is as a result of the structure of sedimentary rocks, which are not homogeneous.

The rate of increase of velocity with depth is higher for sandy formations that for shaly formations. It is difficult to deduce the lithologic character of a given bed solely on the basis of velocity since the velocity versus depth curves for a typical sandstone and shale may intercept at almost any depth (Ebeniro and Ofoegbu, 1992).

v. **Pressure**

Velocity function is the increase of velocity with which can otherwise be attributed to pressure differential. Ostrander (1984) defined the differential pressure to be the difference between the overburden pressure and fluid pressure and it is a function of depth. As differential pressure increases, the bulk and shear moduli of a rock also increase, thereby, resulting in greater p-and s-wave velocities.

When a porous rock is subjected to pressure, both reversible and irreversible changes occur in porosity. In such a situation, when the pressure is removed, part of the original porosity is regained while some part is permanently lost, may be, as a result of the crushing of the grains, alternation of

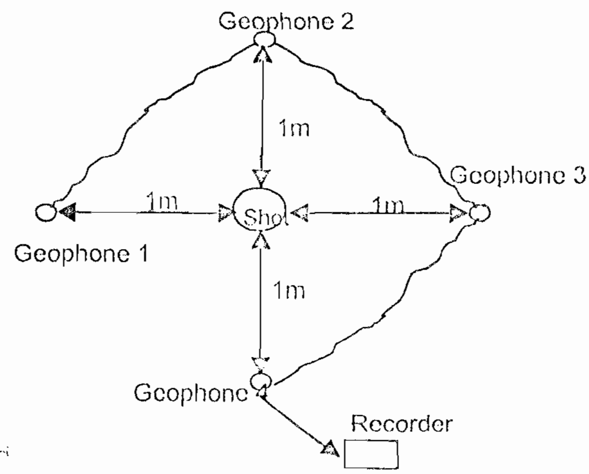


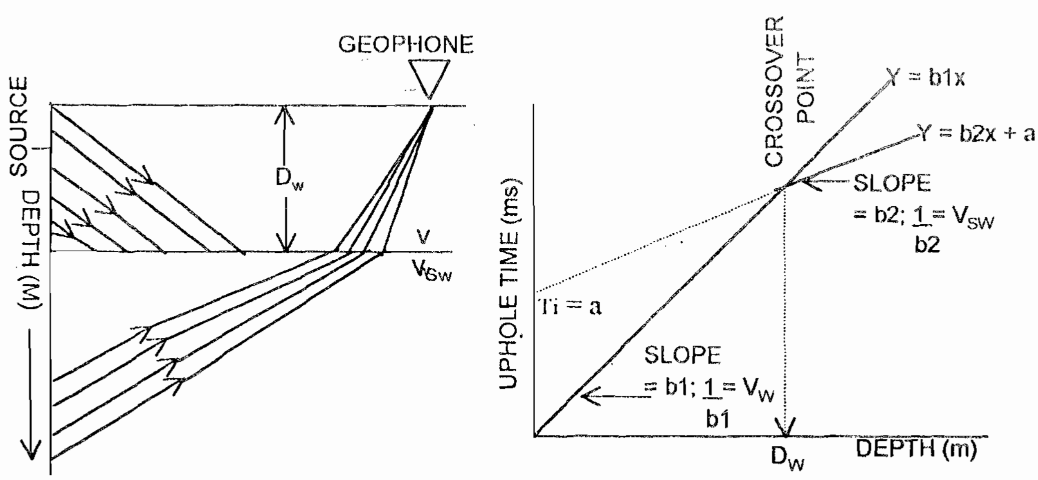
Fig. 2: Uphole shot and spread configuration

5. Data Analysis:

The basic procedure for the analysis are:-

- The arrival time at each depth of shot was recorded and picked
- The picked times were plotted against their corresponding depth of shots
- The weathering velocity, the sub-weathering velocity were computed from the inverse of the slopes of the corresponding graph segments. Fig. (3).
- The weathering thickness was obtained directly from the graph. The required thickness corresponds to the point where there is a crossover between the graph segments. The crossover point is produced to meet the depth axis. The point where the crossover point meets the depth axis is the required weathering layer thickness.

The Isopach map (Fig. 4) reveals that the weathered layer thickness decreases Southward and increases Northward.



(a): Vertical section showing uphole raypaths (b): Model of uphole time-depth plot axis

Fig. 3: Uphole Time Depth plot axis
Note: The letters are described in the theory

the packing and other permanent structure changes. However, a contradiction to the idea that compaction and consequent loss of porosity are responsible for the increase of velocity with depth is shown by non-porous igneous rocks. These non-porous rocks show an increase in velocity with depth but at a rather slower rate. Gardner et al. (1974) attributed the ability of such non-porous rocks to increase n velocity with depth to what he called microcracks existing in such rocks. These microcracks actually delay seismic waves and close with increased pressure.

3.0 METHODOLOGY

There are difference methods of investigating the low velocity layer. The choice of any of these often depends on factors such as cost, nature of crew available, previous geological information, efficiency and accuracy of the method. For this study, the uphole survey method was used.

Uphole Surveys are the most direct measures of near surface properties (Knox, 1967, Rogers, 1981). The uphole method has the advantage of further resolving thin beds (hidden layers) Marsden (1993), thus making interpretation less problematic. A deep hole was drilled and shots fired at varying depths, arrival times to detectors spread on the surface near the shot hole were recorded. In measuring these arrivals times, the first breaks were picked as consistently as possible.

The arrival times were plotted against their corresponding depths, thus giving the time-depth plot. The time-depth plot allows interpretation and evaluation of the weathering velocity, thickness, and the sub-weathering velocity respectively.

4.0 DATA ACQUISITION

The study area OML 62 is located in the Western Niger Delta. Fig. 1 on longitude 5^0.00-6^0.00'E and latitude 5^0.00-5.30'N. The vegetation is fresh water, raffia swamp and thick rain forest. The terrain is plain and has an elevation between 1.0 and 4.0m in land portion. The area is subject to seasonal flooding associated with high water level during the wet season and very dry with poor drainage during the dry season. The area forms significant seat of oil exploration in the Niger Delta. The geology of the Niger Delta are cited in standard articles (Reijers et .al., 1997, Short and Stable, 1967).

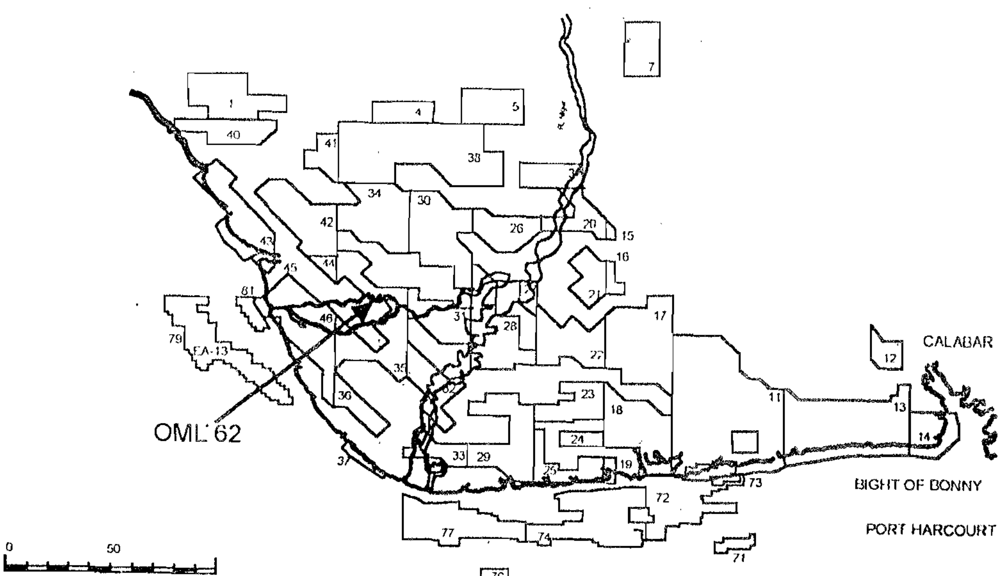


Fig. 1: Location Map of OML 62

Data from sixty one shot points were used in this study. They were obtained at a control depth of 60m at an interval of 5m for each charge detonation. The charges were detonated starting from the bottom and the travel times recorded using geophones planted on top of the earth surface near the shot-hold (Fig. 2).

As shown in Figure 2, the surface spread comprised four receivers connected in series planted firmly to the ground for good coupling. The receivers were usually 1m away from the top of the shothole. After a shot is taken, at a given depth, the traces from the four geophones are stacked together. This procedure was repeated for 12 shots, to yield twelve traces. From these traces, the arrival times were picked.

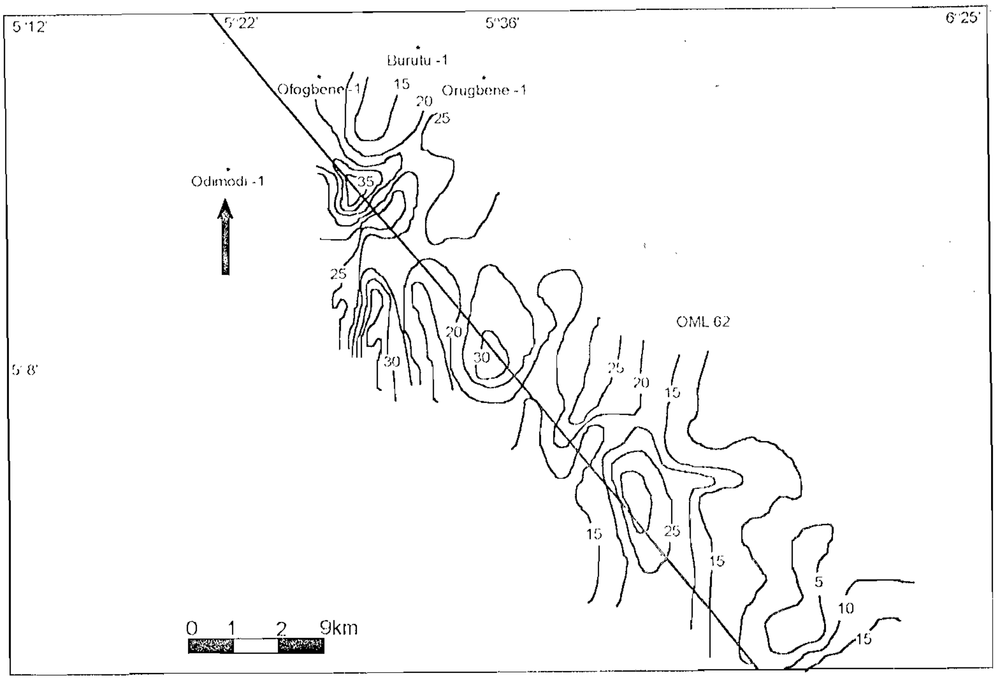


Fig. 4: Isopach map of the weathered layer with 5m contour intervals

6.0 DISCUSSION & CONCLUSIONS

The study revealed the erratic variation in LVL correction parameter. i.e. weathering velocity, sub-weathering velocity & weathering thickness. Vertical and lateral variations were prevalent.

- 210 to 994 m/s was the range of the weathering velocity obtained with an average value of 552 m/s.
- the sub-weathering velocity varies from 1368 to 2474 m/s, with an average of 1734
- the thickness of the weathering layer ranged from 2.8 to 52.8m, with an average of 19.3m.

Though the thickness of the weathering layer varied erratically both laterally and vertically, a general increase in thickness trend was observed northward with a maximum thickness of 52.8m. On the other hand, a decrease in thickness trend was observed southward towards the coast, 2.8m minimum.

The information obtained from this study showed little or no deviation from previous work carried out by Uko et. al. 1992 in the East Central Niger Delta. He obtained the sub-weathering layer velocity to be 1932m/s, and average weathering velocity to be 500m/s and average weathering layer thickness to be 20.0m.

It is here emphasized that the application of these average values regionally in static correction could be drastically misleading since these parameters vary erratically. Thus, an adoption of average values of these parameters regionally in the Western Niger Delta should be discouraged rather, the values that could be applied must be localized to the area in question.

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