TREND OF NEAR-SURFACE VELOCITIES, FROM COASTLINE TO SWAMP ZONE OF THE SOUTHEASTERN NIGER DELTA, NIGERIA

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INTRODUCTION

Near-surface velocities are made up of the velocities of the weathered layer, and that of the underlying refractor or consolidated layer. The trend of this group of velocities from the coastline axis to the swamp environment in the transition zone of the Niger delta shows a decreasing behavior with magnitudes ranging from 934m/sec to 1140m/sec. The near-surface sediments of the Niger Delta, are characterized by unique irregularities in the rock-type, heterogeneous in pore-spaces and compaction, irregular geomorphology or topography as well as sediment densities and velocities. The propagation velocity in this medium is influenced by the looseness of the sediments within the weathered layer, also called the "Low-Velocity-Layer". The weathering velocity is the velocity through the weathered layer of the near surface sediments. It is within the zone of unconsolidated sediments at the near-surface region which in the southeastern part of Niger Delta ranges from 440m/sec to 650m/sec. The Niger Delta is made up of sediments of marine and mixed continental depositional environment originating from Upper Cretaceous to Tertiary, and earlier Quaternary sediments. The sedimentary formations comprise the Benin Formation, the Agbada Formation, which is the reservoir rock formation, and the Akata Shale, the source rock, of Eocene to Miocene age (Eze, etal 2003; Kogbe, 1976). The Benin formation is made up of coarse grained, to gravelly sandstones with minor intercalations of shale. The Benin formation originated from continental deposits of Miocene to younger age with thickness up to 1800m or 2000m. Outcrops of Benin formation have been commonly identified at Benin, and Onitsha areas. The Agbada Formation is made up of alternating sequences of sandstone and shale of fluviomarine origin (Nwajide, 2012). It started in the Eocene at the northern part of the Niger Delta and latter in the Pliocene developed in the south of the delta. The sedimentary accumulation was up to the thickness of 4600m. The Niger Delta in its overall sedimentary pile built up to about 8000 meters. The detrital pile of the Niger Delta has grown outward over the margin of the continental basement and southward into the Gulf of Guinea, the abyssal plain area. The three independent sources of the Niger delta sediments comprise the Niger-Benue drainage basin, the drainage basins of the rivers east of the delta, and the drainage basins of the rivers west of the delta (Reyment, 1965).

The reason for the top-layer high-velocity which is greater than the normal average weathering velocity range of 450m/s to 550m/s: The Niger delta catchment is eroded into the basement at some areas. The stratigraphic sequences are revealed on the succession of transgression and regression of marine conditions which influence deposition of different lithologic assemblages. The sustaining sediments that are not washed off by erosion exist wholly or partially, tracing from the shoreline to the continental plains or the swamps. Where active erosion activities wash off the lop layers of sedimentary deposition before deposition of recent sediments, hiatus or non-conformities emerge. Given that velocity (V) is a function of depth (z).

The near surface velocity trend does not show a gradual rise with depth, but reflects first-layer velocity "highs" greater than the normal trend of 450m/s to 550m/s or 600m/s characteristic of simple weathering layer velocities. It is the occurrence of possible non-conformities that permits older sediments on top of sequence, with the recent sediments missing.

METHODOLOGY

The investigation of the weathering velocities Vw and thicknesses Wd with associated consolidated layer velocities Vc were conducted from coastline into the transition zone which is majorly the swampy portion of the Southeastern Niger delta. The instrument in use was Mc-Seis 160 OYO equipment. The downhole sensors were made up of hydrophone elements at various depths tied to the harness at different the depths to ground surface location of the instrument. The energy source comprised fingerlets of 0.2kg sticks of dynamite explosive with lead wire detonators.

RESULTS AND ANALYSIS OF DATA

The near-surface velocities consisting of weathering layer velocity, and underlying refractor or consolidated layer velocity. The trend of this group of velocities, weathering and underlying consolidated layer velocities from the coastline axis to the swamp environment in the transition zone shows a decreasing behavior 934m/sec to 1140m/sec. The near-surface sediments of the Niger Delta, are characterized by unique irregularities in the rock-type, heterogeneous in pore-spaces and compaction, irregular geomorphology or topography as well as sediment densities and velocities. The propagation velocity in this medium is influenced by the looseness. The principle of Superposition was revealed in the velocity layering of sediments. The propagation velocity in the top layer medium is influenced by the looseness of sediments hence the "Low-Velocity-Layer". Figure 4 and figure 5, show typical cases of missing weathered layers due to active erosion activities of the top loose sediments of the vadose zone.

TABLE-1: UPHOLE (UH) Lithologic Sequences Revealing Stratigraphic Succession of Sediments, and Velocity (Weathering Velocities Vw, and refractor/consolidated layer Velocities Vc,) Characterization at Near-surface in Southeast part of Niger Delta Nigeria.

UH Litho LEVELS	UH-1	Vel (m/s)	UH-2	Vel (m/s)	UH-3	Vel (m/s)	UP-4	Vel (m/s)	UH-5	Vel (m/s)
1	Soft clay	444	Clay	667	Soft clay	688	Soft clay		Clay	1107
2	Sand	799	Sand		Sharp sand		Sharp sand	934	Clay sand	
3	Fine sand	1488	Gravel		Clay sand	1135	Clay sand	1165	Gravel	
4	Clay		Sand	1736	Sand	1815	Sand		Sand	1799
5			Sandy silt		Clay		Clay sand		Stone	
6			Clay						Clay sand	

The Colour codes show some degree of correlation of Weathering velocities and Consolidated layer velocities at different UH locations.

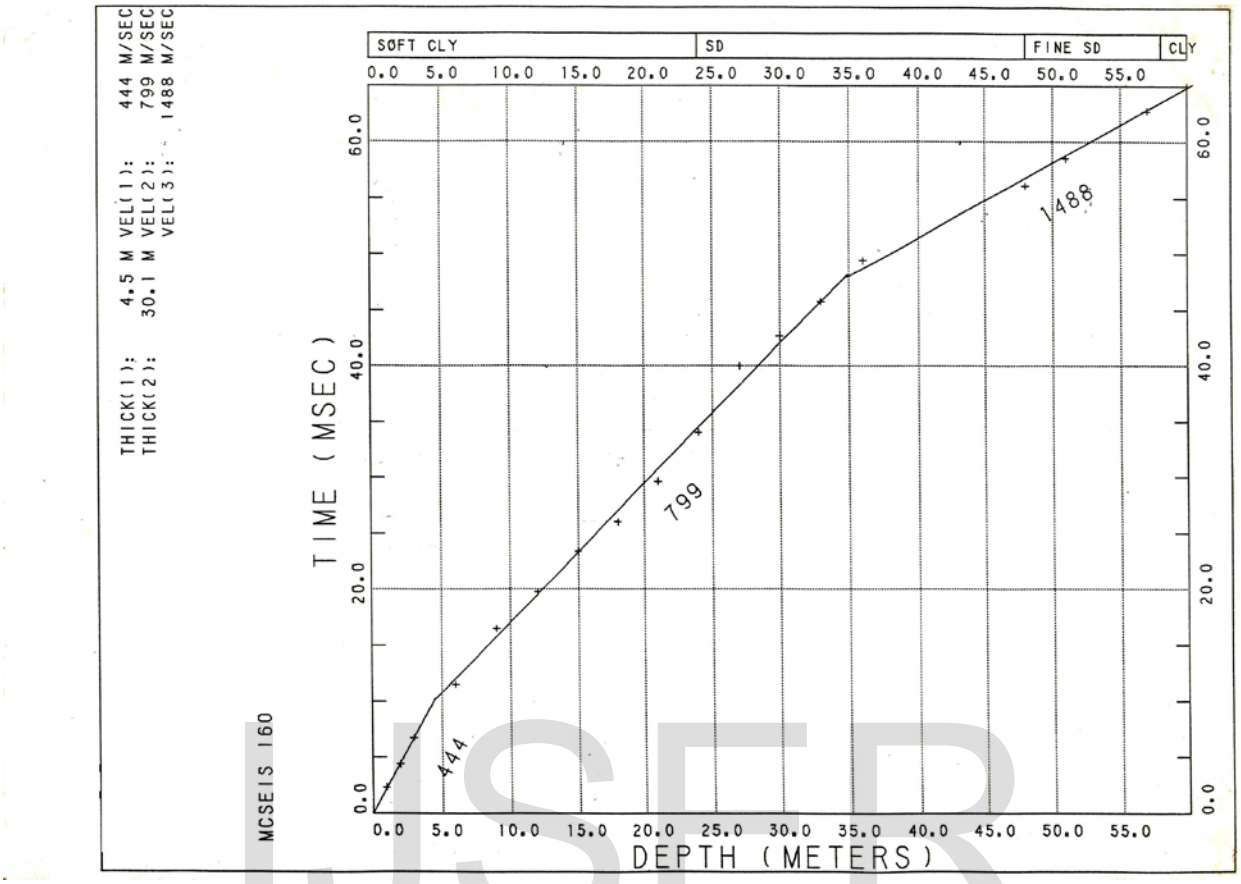

Figure 1 Shows 3-layer sediment deposition of the SE Niger Delta area.

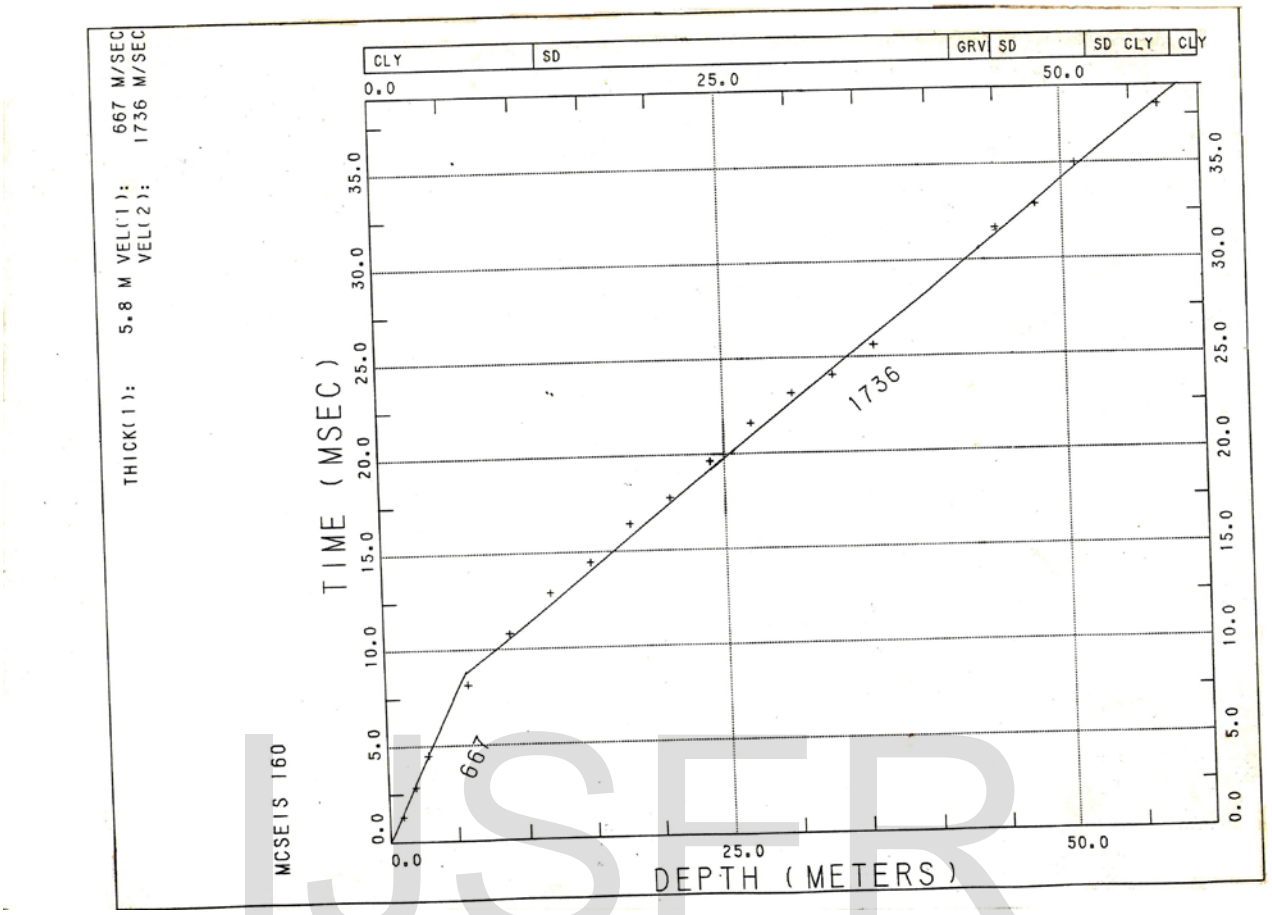

Figure 2: 2-Layers of sediments in a swamp environment of Niger Delta sediment,

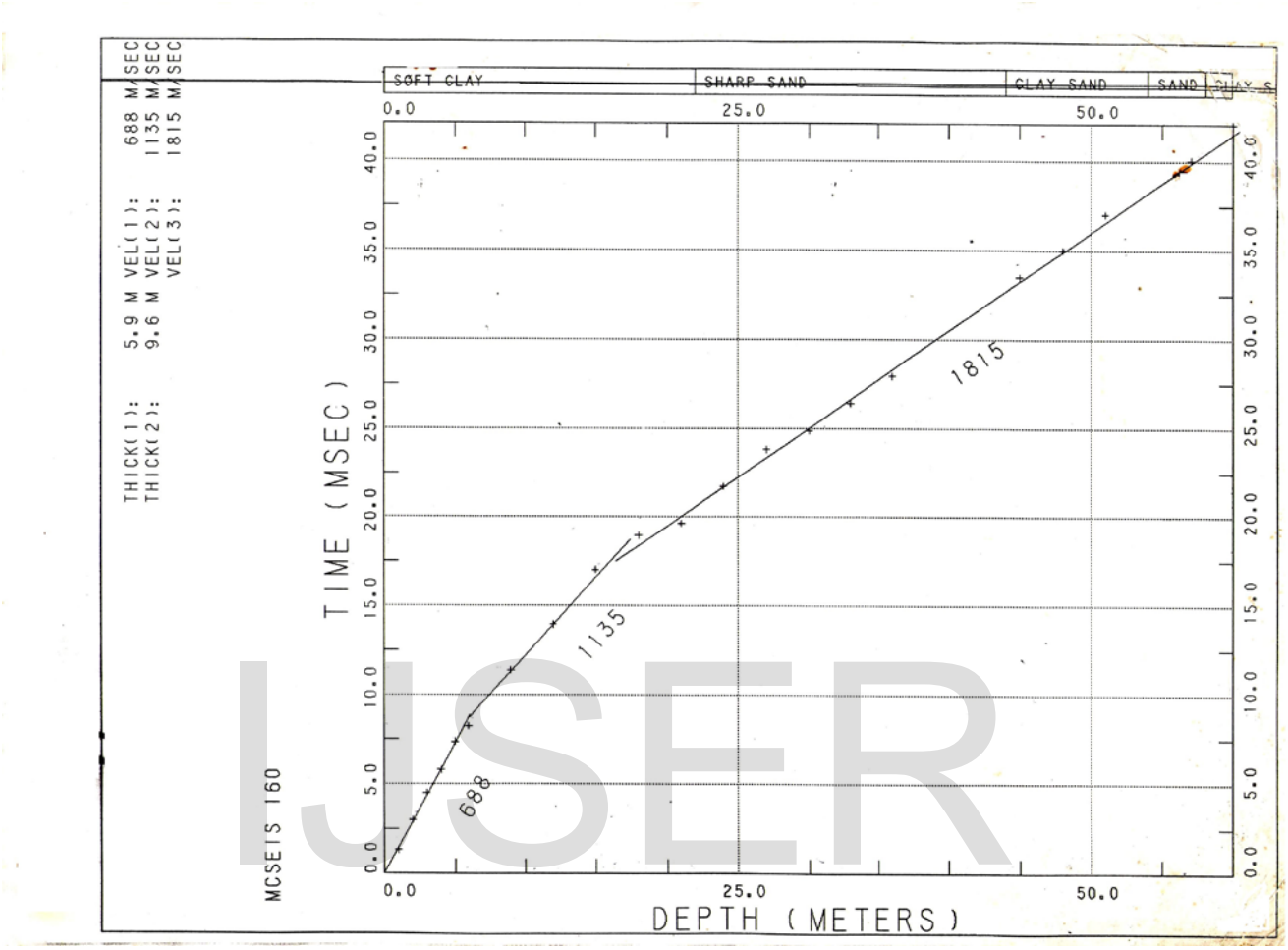

Figure 3: Shows 3-layers of sedimentary deposition of the SE Niger Delta area.

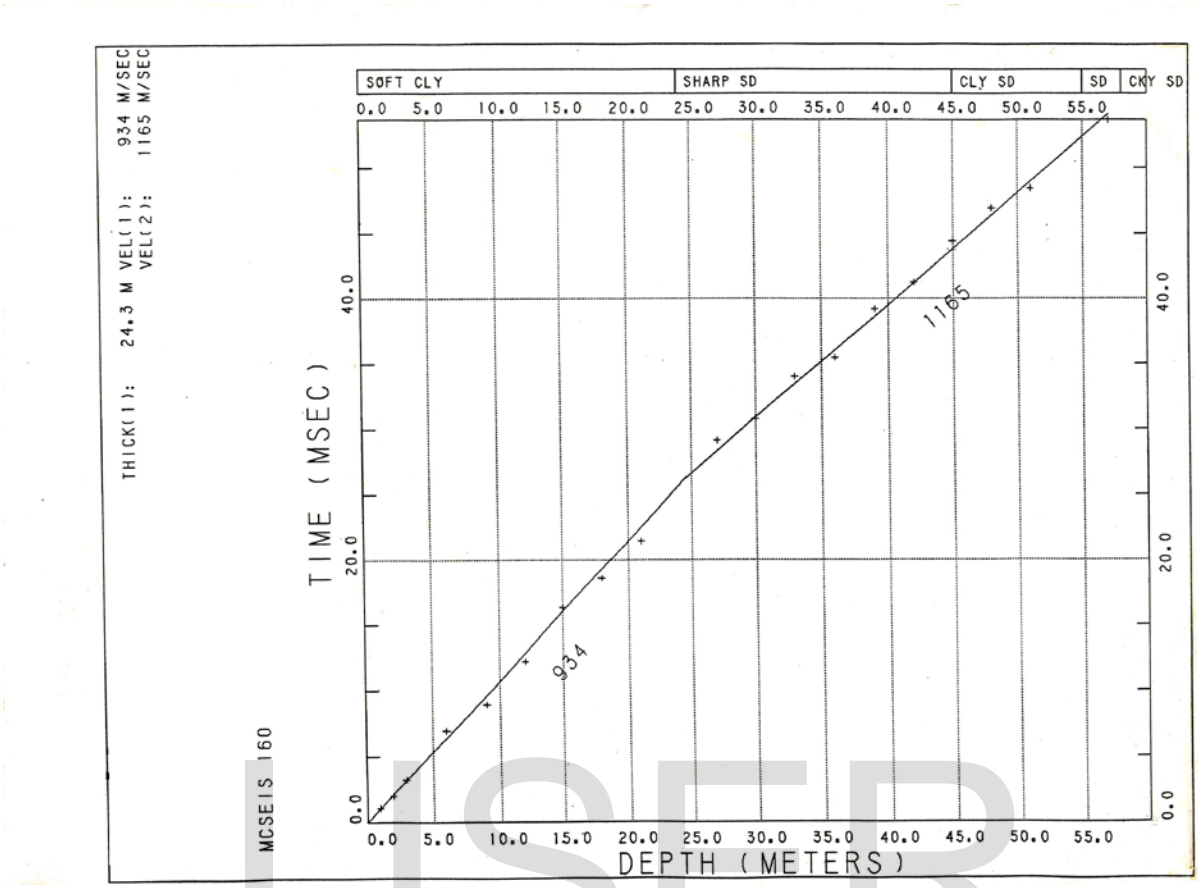

Figure 4: High velocity 2-Layer medium, suggestive of eroded weathering surface

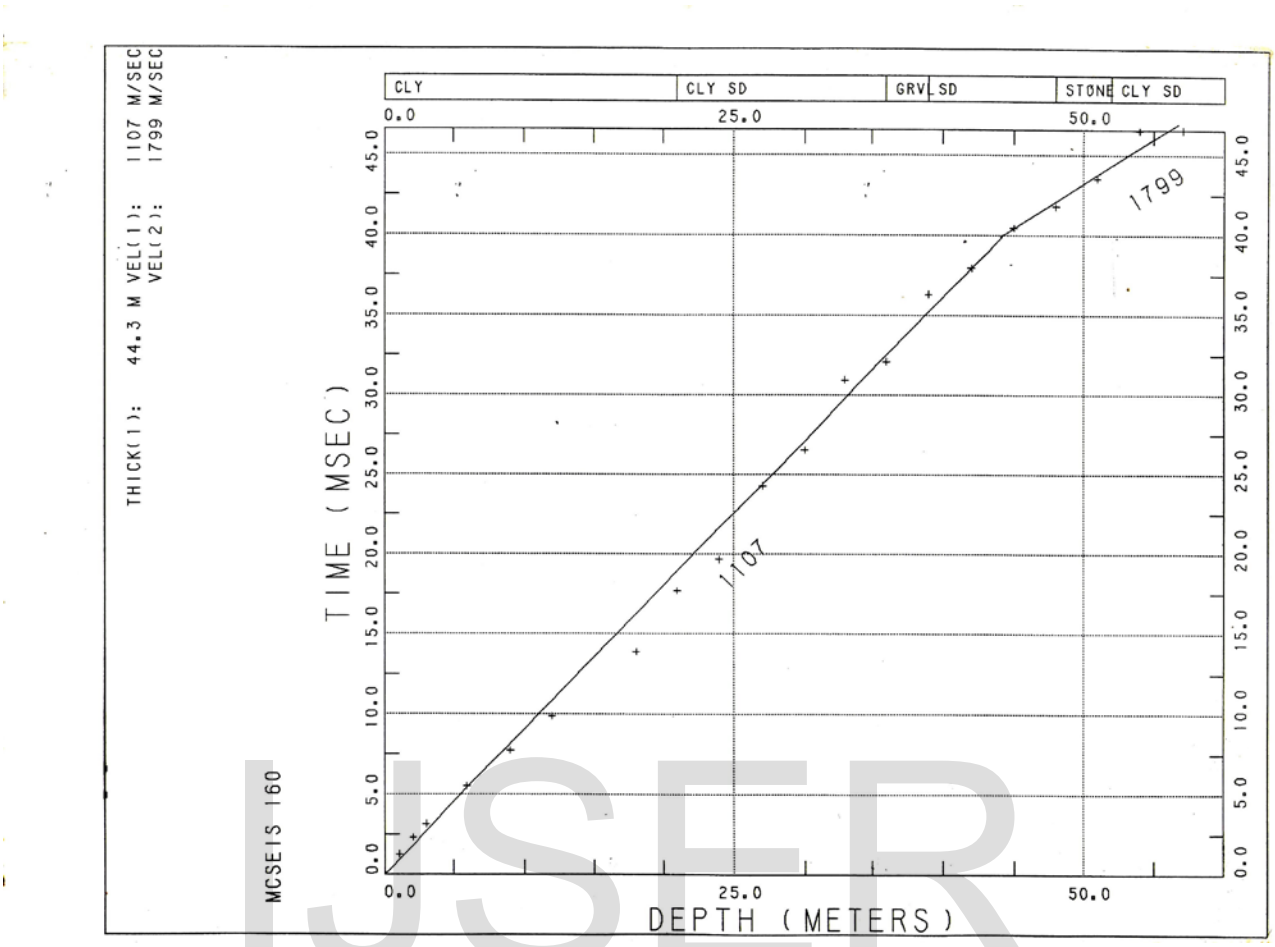

Figure 5: Showing High-Velocity top layer of a 2-Layer sedimentary terrain, with weathering layer apparently eroded or washed–off.

INTERPRETATION

The first three upholes revealed a normal trend of bottom sediments as clay, followed by clay sand and sandy clay, stone or gravel transiting to the top layer or near-surface sediments comprising fine sands, silt and soft clays with associated simple weathering layer velocities ranging from 440 to 650m/sec. The sediments at the bottom of the boreholes consist of clays and sandy clays characterized by velocities ranging from 1736m/sec to 1815m/sec, representing the consolidated layer velocities. However, the last series of uphole records revealed a unique case suggestive of possibility of non-deposition or erosion of deposited sediments at top or near-surface layer, thus, exposing the underlying consolidated layers. Records from UH4 and UH5 reveal first layer high velocities and congruous sub-layer sediments suggesting the occurrence of erosion activities which washed-off the top layer sediments. Similarly, their velocities reflected apparent top layer sediments of substrata velocities, ranging from 998m/sec to 1137m/sec. This could suggest that the upper bed velocities of range of 440m/sec to 650m/sec have been washed off by intense erosion activities.

Swampy areas have associated erosion activities which washed off loose and unconsolidated near-surface sediments over geologic time.

CONCLUSION

There is a thinning out of weathering velocities at the coastline axis in the range of near-surface velocities weathered layer and underlying refractor or consolidated layer. The trend of this group of velocities, weathering and underlying consolidated layer velocities from the coastline axis to the swamp environment revealed a decreasing behavior 934m/sec to 1140m/sec. The near-surface sediments of the Niger Delta are characterized by unique irregularities in lithology, heterogeneous in pore-spaces and compaction, irregular geomorphology or topography as well as sediment densities and velocities. The propagation velocity in this medium is influenced by the looseness 450m/s to 550m/s or 600m/s, and corresponding increase in the consolidated layer or refractor velocities ranging from 1736m/sec to 1815m/sec. At the coastline there is a reduction of weathering thickness, and increasing consolidated layer velocity. From the coastline through the transition, to swamps, the weathering thickness increases, with corresponding descent of weathering velocities. The first bifurcation of the Niger River to the flood plain, and to the tidal swamps, there is increasing thickness of sediments. But from the mangrove swamps to the coastline, the first layer velocities are significantly high, as representing of lower bed velocities ranging from 998m/sec to 1137m/sec, contrary to normal weathering velocities of 440m/sec to 650m/sec range.

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