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# STRUCTURAL INTERPRETATION USING REFRACTION VELOCITIES FROM SEISMIC SURVEYS.

**EDWARD O. OSAGIE**

*Benson Idahosa University, Faculty of Science, Department of Physics Benin City – Edo State*

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***ABSTRACT***

*A compressional wave velocity model is presented for the upper few kilometers of Thomson in McDuffie county, Georgia. The velocities were determined from refractions, that is first arrivals, on individual seismic reflection records. The refractions are clear, and it is possible to define the gross structure in addition to the predominant velocity layers of 2.8, 3.7, 4.5 and 6.1 km/s. The observed velocity model implies pronounced variations in thickness of the tertiary, Mesozoic and Paleozoic strata and extreme structural relief of the crystalline basement. The most conspicuous feature shown by the velocity data is a horst, an intrarift uplift of the Precambrian basement.*

## INTRODUCTION

Seismology has continued its role as the key technique for determination of the structure of the continental and oceanic crust. Seismic reflection exploration, the study of the earth using sound waves reflected from beneath the surface is the dominant method in exploration geophysics. A seismic reflection profiling of Thomson, Georgia totaling 150 km was run across and parallel to the structure (Fig 1). The Vibroseis source of 24-fold common depth point (CDP) shooting with 48 seismometer groups was used with 100m (Lines 1 and 2) and 133 m (Lines 3 and 4) group interval. A Vibroseis is a seismic method in which a vibrator is used as an energy source to generate a controlled wave train. It is one of a number of seismic sources used in reflection seismology.

*Corresponding author: EDWARD O. OSAGIE

*E-mail address:* eosagiee@yahoo.com

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The seismic sections revealed thick alluvium, extensive normal faulting and a buried intragraben horst. A strong reflector at about 20-km depth was interpreted as a magma body. The existence of magma at this depth was proposed to account for phases observed on local micro earthquake seismograms. Supporting evidence includes high heat flow, diffuse micro sesismicity, recent uplift and low upper mantle P-wave velocities [1].

## REFRACTION STUDY

Refracted waves give information about the velocity and dip of layers. Although these first arrivals or refractions are usually muted or eliminated before common depth point (CDP) stacking is done [2]. They do however, contain useful information about near surface velocities. The velocity of a layer is given by the of the refracted arrivals on slope a time –distance plot [3]. A reversed refraction profile (one shot in the opposite direction is necessary to derive the true velocity from the observed apparent velocity. Such reversed data were not collected in the field for this study.

The refraction arrivals on 100 individual reflection records for VP1 (Vibrator point) for lines VP1 and VP2 were used to define a section through the region. The layer velocities are from the slopes of straight lines fit through the arrivals and depths (in time) to these layers are given by the intercept times of the straight lines at zero offset. By determining the depth to the refracting layer at adjacent vibrator-point locations, the structure can be defined. A similar approach was used to determine velocities on the northwest Atlantic continental shelf [4]. Example of refractions on first 1.6s of an individual seismic reflection record is shown in Fig (3).

## INTERPRETATION

The velocity model for lines 1 and 2 is shown in Fig 4.  The model is superimposed on a constant-offset section for the near trace of each record. This common offset is shifted in time to account for the offset between the source and the first seismometer group. The velocity model is presented as a time section rather than a depth section because the intercept (zero-offset) times are measured directly from the refraction profiles. A conversion from time to depth would be indeterminate because the thickness and velocity of the near-surface are unknown and also because the refraction technique cannot detect low-velocity layers that may be present in the section [5]. The refracted waves for line 1 are good quality and have string similarity from one vibrator point location to the next. For line, it was possible to define the structure by determining the time depths to the refracting layers.

The predominant velocities of the layers were 3.7, 4.5 and 6.1 km/s with uncertainties of about ± 0.15 km/s. The time intercept for the 3.7 km/s layer was non-zero. This indicated that these waves were not direct arrivals and implied the presence of an overlying lower velocity layer. Because of the 600m offset between the source and the first seismometer group, any surface layer less than 200m thick will not return first arriving direct waves. There is a hint of a 2.8 km/s layer near the surface between VP70 and VP90 where direct arrivals on a number of seismic records are observed. At VP92 on line1 there is no offset between the source and first seismometer group, there is a very thin layer of 1.5 km/s alluvium, perhaps 60 to 70 km thick, over a 2.7 km/s layer A thicker amount of low-velocity material is present in the western part of line1. There is a transition from 3.7 to 3.8 km/s at about VP60 and then a change to 2.1 km/s at about VP100. The middle and lower parts of Fig 4 are only meant to give an indication of the velocity regimes. This tentative identification of velocity units is confirmed by examination of the refraction for line 2, which crosses an outcrop of Mesozoic and Paleozoic rocks. The location of the surface of the 6.1 km/s layer correlates fairly well with the bottom of the sequence of basin reflector as noted by [4].

## DISCUSSION

A velocity model for Thomson, McDuffie county Georgia is derived from refracted waves on individual seismic reflection records. The data for line1 are good quality and indicate relatively uniform thickness velocity layers of 2.8, 3.7, 4.5 and 6.1 km/s. The data for line2 are poorer quality and although some layers with similar velocities as those for line1 are identical, none can be traced continuously. The refraction velocities appear to correlate with the stratigraphic section. Tertiary, 2.0 and 2.8 km/s; Mesozoic 3.7 km/s; Paleozoic 4.5 km/s and Precambrian 6.1 km/s crystalline basement. This velocity study is an attempt to correlate seismic data with the stratigraphy of Thomson. Although the correlations of the refraction derived velocity units with stratigraphy are not completely certain, it is possible to make some inferences about the history of the area.

There is evidence of structural relief probably of Tertiary age, of the Paleozoic and Mesozoic strata beneath the alluvium blanket and a high velocity horst, an uplift of the Precambrian basement, with thin or missing Paleozoic cover. This study of seismic lines at a single location is, of course, insufficient to resolve the complete history of the area. This study does not give additional information about the nature of the boundary faults, whether listric or normal. More data with better velocity control will provide a more complete picture of the fault geometry with depth, as well as lateral variation in thickness of the stratigraphic column. Then the timing and nature of the deformation in the area could be more fully deduced.

## CONCLUSION

Seismic refraction techniques, long used in exploration for minerals and petroleum, was effectively used in modelling the upper few kilometers of Thomson Piedmont area of Georgia.

First arrival refractions of compressional wave were used to map bedrock topography, detect lateral and vertical heterogeneity in the soil overburden and image a host in the basement. There appears to be a strong correlation between experimental setup (source), receiver positions, source wavelets, background velocity and the lithological composition of the various rock types in the area.

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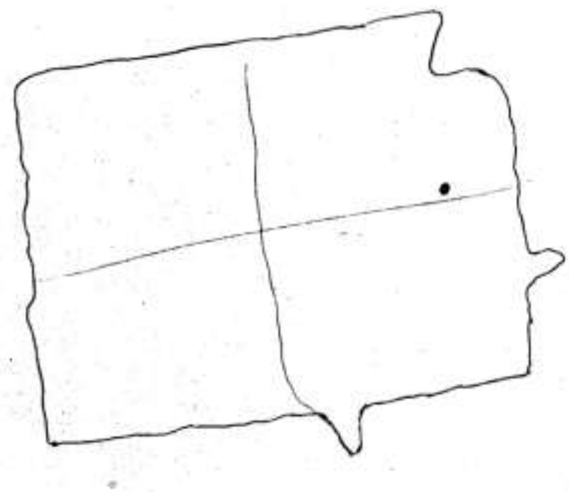

Figure 1. Map shows the location of Thomson, GA within the Piedmont physiographic province.

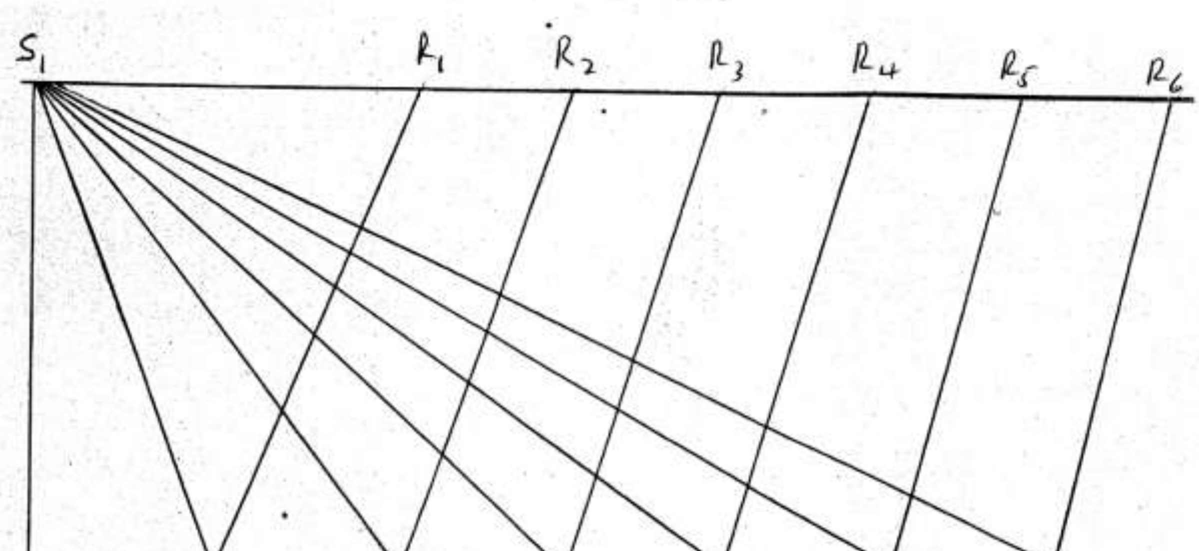


Figure 2. Seismic recording geometry.

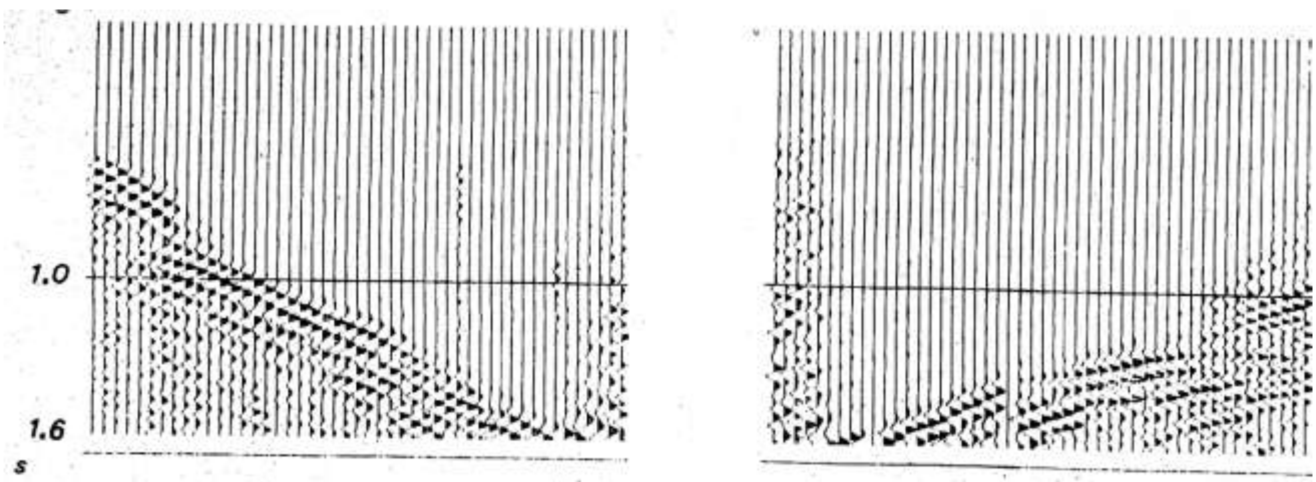


Figure 3. Example of refractions on first 1.6s on individual seismic reflection record.

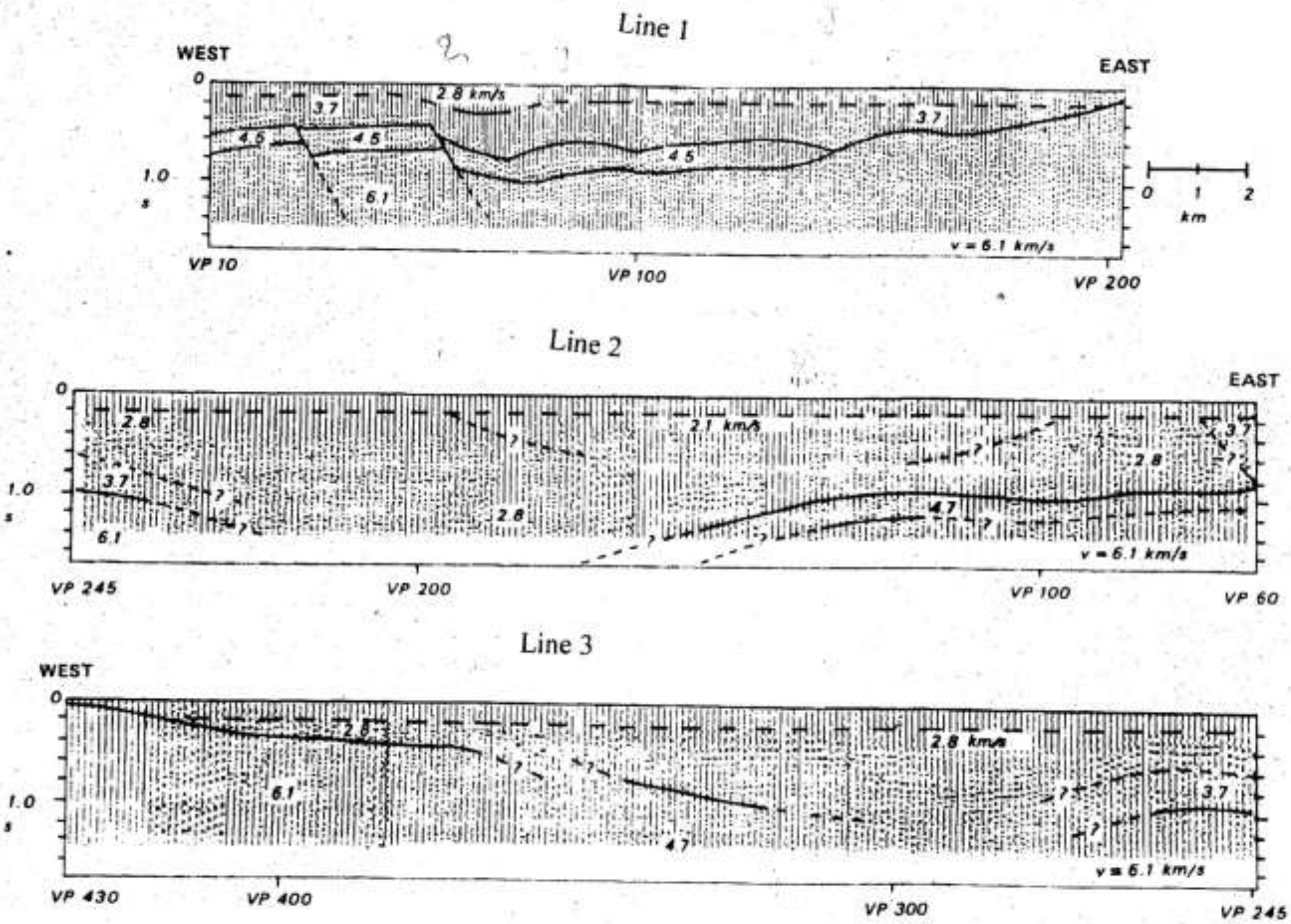


Figure 4. Velocity structure for the first 1.6s for line 1.