AN IMPROVED TECHNIQUE FOR STATIC CORRECTION IN A HIGH RESOLUTION SHALLOW SEISMIC REFLECTION DATA USING DIFFERENCE IN REFLECTION TIMES.

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Abstract

Shallow Seismic reflection survey was carried out in Zaria, located in the basement complex of central northern Nigeria, with the aim of characterising the granitic batholith. However, the effect of near surface material, which could make reflection events appear disjointed or deeper than they really are, could be enormous if not corrected for. This work sets out to correct for this events by making use of difference in reflection times estimated from initially known models of the subsurface. During the data acquisition the receivers where placed at 1 m interval, with a constant offset of 1 m. the common midpoint (CMP) method with a 12 fold coverage was employed. Previous refraction tomography model carried out in the area was used as a guide during the 2D velocity model generation, making use of the observed travel times. The observe time was used to generate the initial model, which was later corrected using the previous known subsurface model, thereby noting the difference in travel time induced by the near surface materials. The results obtained showed that the reflection events were more coherent and in their actual reflecting point on the statically corrected seismic sections, than the section without static correction because of the excess time from the near surface material with variable p wave velocity. This experiment has proved that difference in reflection travel times obtained from previous known model or borehole information in conjunction with the observed travel times serve as a better tool in applying static correction to seismic reflection data, than any previous known conventional methods that relies on a single technique.

Key Words: Static correction, High resolution, Seismic reflection, Reflection times

Introduction

The object of weathering corrections, as has been noted, is to eliminate the effect on travel times of variations in the thickness of the low-speed zone (Dobrin, 1976). Many methods exist for correcting for near-surface effects. These schemes are usually based on (1) uphole times, (2) refraction from the base of the low velocity layer (LVL), or (3) the shooting of reflections (Telford et al, 1976). Reflection times on seismic traces have to be corrected for time differences by the near surface irregularity, which has the effect of shifting reflection events on adjacent trace out of their true time relationships. If the static corrections are not performed accurately, the traces in a CMP gather will not stack correctly. Furthermore, the near surface static effects may be interpreted as spurious structures on deeper reflectors. Accurate determination of static corrections is one of the most important problems which must be overcome in seismic processing (Kearey et al, 2002).

Static corrections are made to seismic reflection data to compensate for time shifts in the data caused by changes in topography and variations in near surface seismic wave velocity. Recent developments in ultra-shallow seismic imaging indicate that static

time shifts in seismic data caused by relatively small changes in the thickness of very low velocity surficial layers may be significant. The velocity-variation component of the correction involves what is commonly called the "weathered zone. In some places the weathered zone consists mostly of unconsolidated, near surface materials. It is not commonly realized that P-wave velocities in these shallow, unconsolidated materials can be substantially lower than the velocity of sound in air. The primary purpose is to show that when low-velocity surface layers are present, a thickness of even a few feet can have profound static effects (Don and Gregorys, 2008). Any meaningful seismic reflection work requires substantial static corrections, owing to the high variability of weathered layer seismic velocity and thickness. The determined depths to the base of the low velocity layer (LVL) is a vital information for the proper location of energy source for 'noise' reduction and a resultant improvement in the signal to noise ratio. In most cases, locating the source below the LVL bypasses the layer thereby maximizing energy transmission (Enikanselu, 2008). This method has a better advantage, because both known previous model and the observed travel time is used to determine the excess time resulting from the unconsolidated material that need to be subtracted.

The aim of this research work is to make use of difference in reflection times generated from a known previous model and observed travel time, to effectively remove the effect of the unconsolidated near surface material. The instrument used for this survey includes: Terraloc Mark6 24 channels digital seismograph, vertical geophones, reels of cables with takeout and sledge hammer strike on base plate.

Location and Geology of the study area

The study area is bounded by latitude 11° 08.870' N, 11° 08.876' N and longitude 007° 38.085' E, 007° 38.093' E with an average elevation of 659 m above sea level (Figure 2).

The older granite outcrops in the vicinity of Zaria are exposures of a syntectonics to late-tectonic granite batholiths which intruded a crystalline gneissic basement during the Pan-African Orogeny as depicted in the geological map of figure 1. These rocks have been variably metamorphosed and granitized through at least two tectono-metamorphic cycles and folded during the Pan African Orogeny where exposure is good, contact of the batholiths with country rocks is sharp and often exhibits a phenomenal interbanding of granite injections with sheets of pre-existing schists and gneisses McCurry (1970).
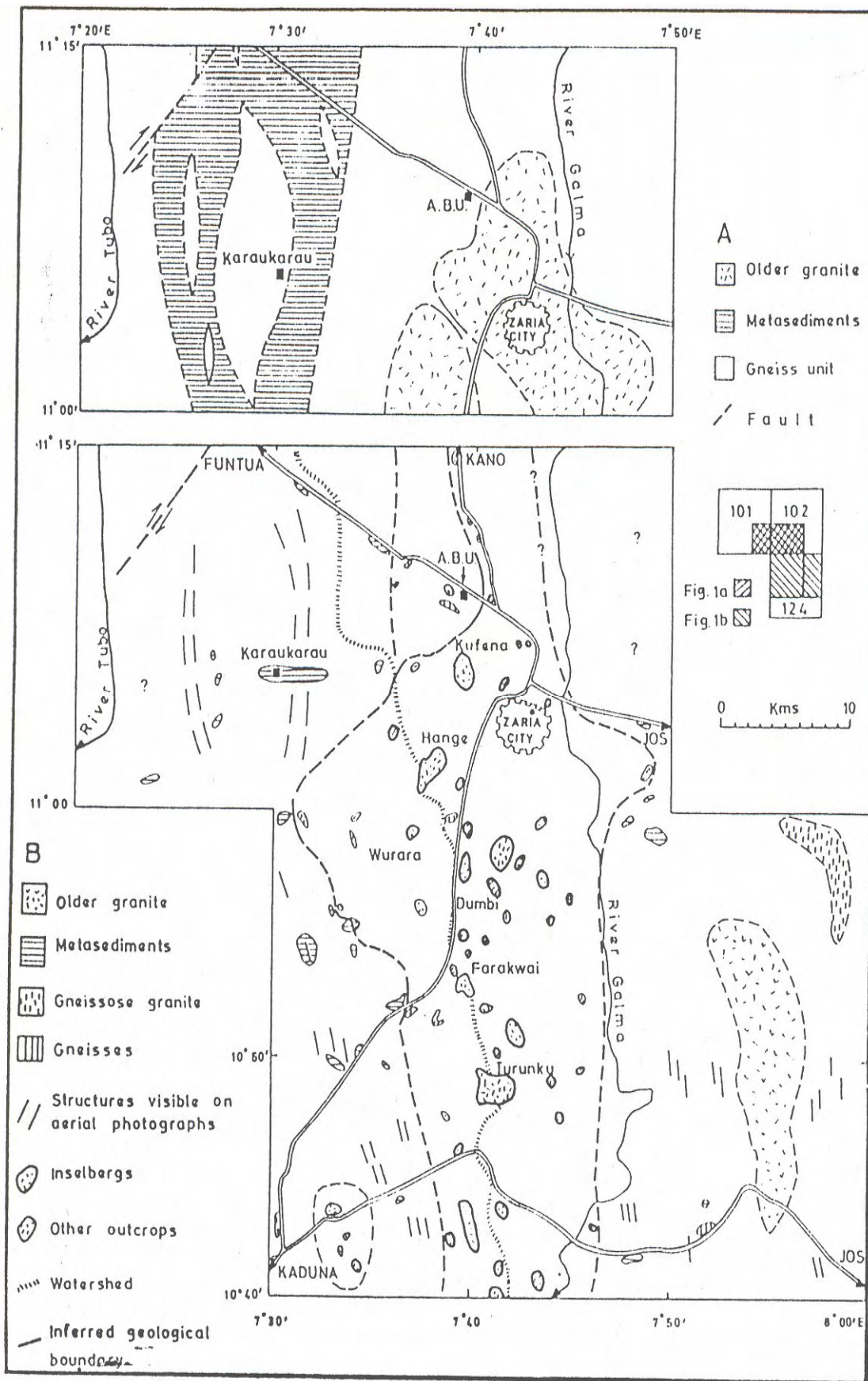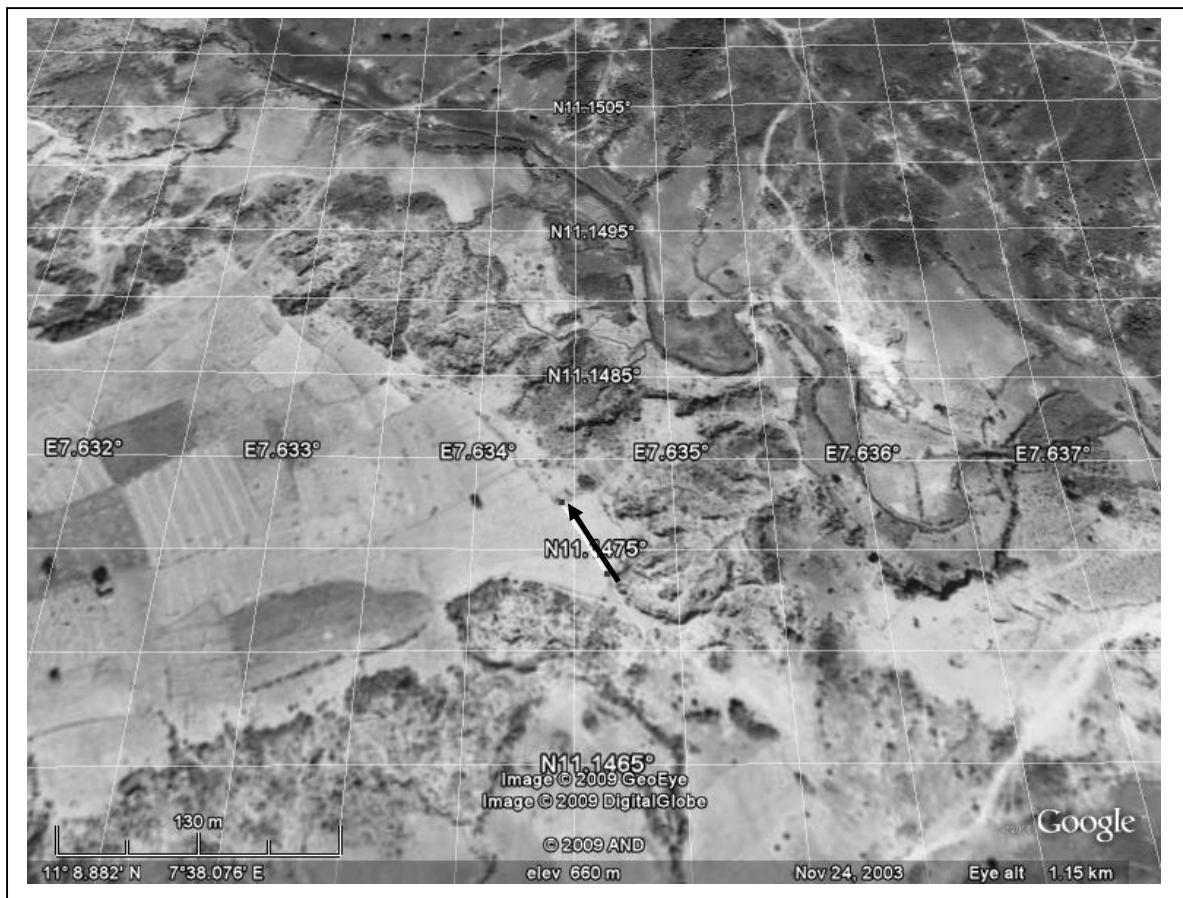
During the data acquisition the receivers (geophone) were placed at 1 m. A constant offset of 1m, which signifies the distance between the shots and the first receiver was used throughout the survey. After each shot the first receiver closest to the shot was moved ahead of the other receivers, and placed 1 m after the last receiver, the connection to each of the takeout was swapped in the direction of increasing profile. When all the connections were completed, the shot was repeated with a stack of 5 shots, and the generated seismogram was recorded for onward processing.

Data processing

The data processing started with the importation of the raw seismic data into the ReflexW software, generally used for reflection and refraction seismic data processing. The imported data was corrected for wrong geometry mistakenly entered in the field, so that the traces will be properly displayed in their correct position. The gain filter was applied to the raw seismic data to enhance the amplitude of weak traces due to attenuation and geometric spreading of the seismic energy. Frequency wavenumber (fk) filter was then applied to remove the effect of surface waves or ground roll. The filtered data was subjected to semblance analysis to generate a subsurface model and 2D velocity model making use of the observed travel time (Figure 3). Thus, the initial position of the observed travel time of the reflection events and the initial depth of the subsurface model generated with the observed travel time were noted. It was observed that the depth registered on the subsurface model was more than the initial known subsurface model, hence the generated subsurface model was adjusted, until there was

a match between the generated subsurface model and the initial known model. The difference in the reflection time was noted. The fk filtered data was then reloaded, and the excess time which was due to the unconsolidated near surface material was removed. The new processed data with static correction was subjected to semblance analysis to generate the 2D velocity model. The generated 2D velocity model was used for dynamic correction and stacking of the CMP data. The stacked data was migrated in time and depth, and the data without static correction was also migrated in time and depth, to produce time and depth seismic reflection section.

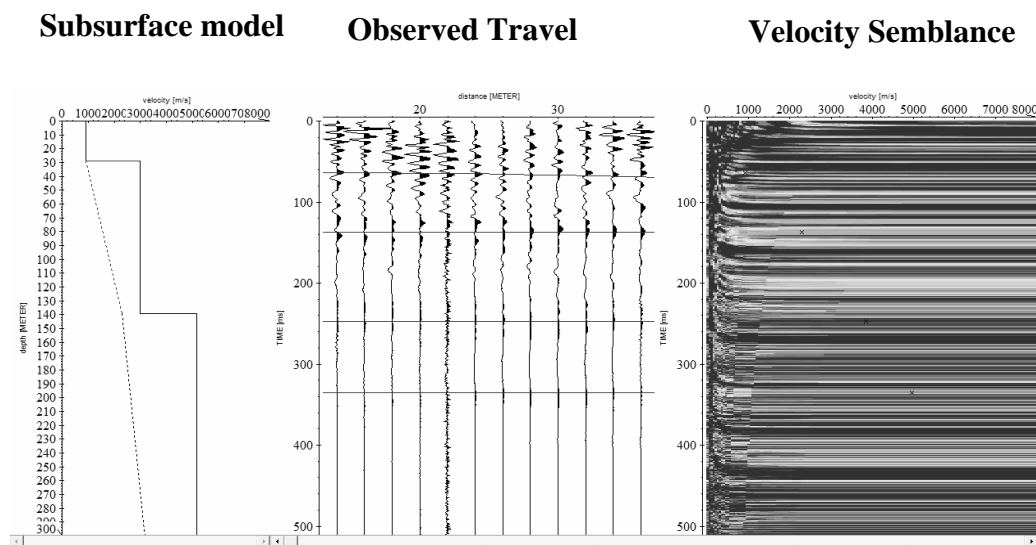**Subsurface model**   **Observed Travel**   **Velocity Semblance**

Figure 3: Generated subsurface model, observed travel time with the picked reflection
events and velocity semblance

Results and discussion

Figure 3 depicts the subsurface model, the observed reflection time and the semblance velocity. It also represents the first initial subsurface model that was generated. From the model it was observed that the interface between the overburden and the weathered basement was at a depth of 29 m, which correspond to an observed reflection time of 64.725 ms and a velocity of 913 m/s for the overburden and 2929 m/s for the weathered basement. However previous refraction tomography model (Figure 4) carried out on the same profile showed that the depth to the weathered basement was 22 m, with an overburden velocity of 931 m/s and a weathered basement velocity of 2845 m/s. This was compared with the initial generated subsurface model, and it was found that the only remarkable difference between the two models was in their depth. The depth of the initial subsurface model was adjusted (Figure 5), until it became equal to the depth of the previously known model in figure 4. The new position of the observed travel time after adjustment was noted to be 50.234 ms, and the difference in travel time was determined to be 14.491 ms. When the fk filtered data was reloaded, the excess 14.491 ms was subtracted from the total time to effect the static correction (Figure 6). The fk filtered data with static correction was subjected to semblance analysis again. The generated subsurface model (Figure 7) resulted in an interface between the overburden and the weathered basement at a depth of 22 m, which correspond to an observed reflection time of 49.886 ms and a velocity of 913 m/s for the overburden and 2897 m/s for the weathered basement., which was in complete agreement with the known model without adjustment, hence this was used to generate

the velocity model that was used for dynamic correction and stacking of the CMP traces. The stacked seismic sections of both static and non static corrected data, was migrated in time and depth to produce a time and depth migrated seismic section. The time and depth migrated seismic sections with static correction (Figure 8), showed more coherent reflection events displayed at their correct depth, when compared to the seismic section of Figure 9, with time and depth migrated seismic sections, which registered high level of disjointed reflection events especially at the near surface zone. Also the reflection events appeared deeper than they actually were, because of the excess time that was not corrected for.

Conclusion

This research work has actually shown that the difference in travel time obtained from a previously known model, generated subsurface model and observed travel time is a more effective tool for applying static correction to a high resolution shallow seismic reflection survey. It has advantage over the previous techniques in that, it makes use of previously existing model or borehole information in conjunction with the observed travel time obtained from the actual data under analysis to estimate the excess time resulting from the unconsolidated layer. Most other conventional techniques do not make use of the observed travel time, but only rely on borehole information or results of convection refraction shooting only.
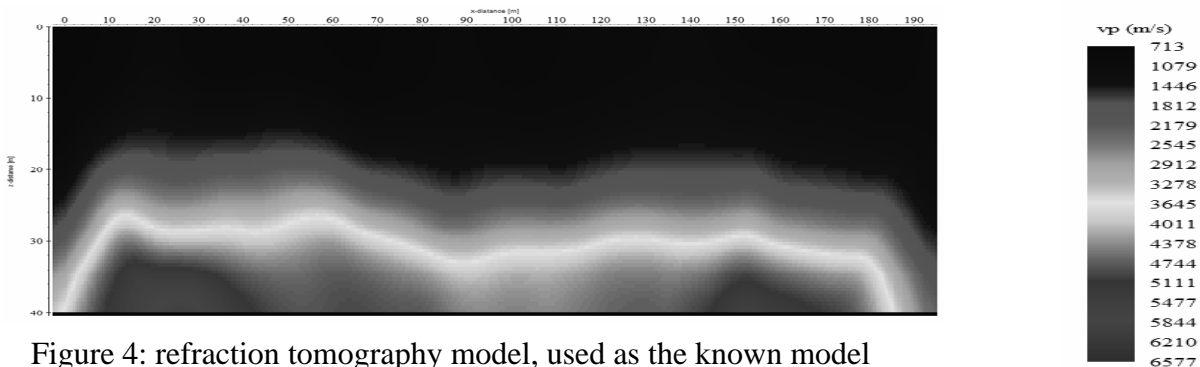

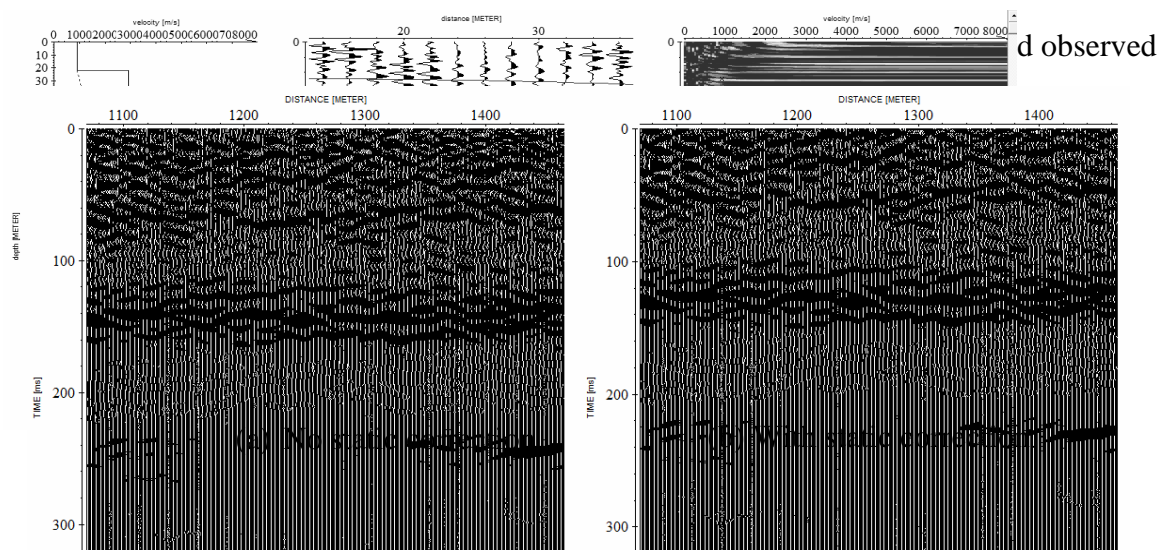Figure 4: refraction tomography model, used as the known model

Figure 6: (a) fk filtered data with no static correction (b) fk filtered data with static correction (excess time removed)
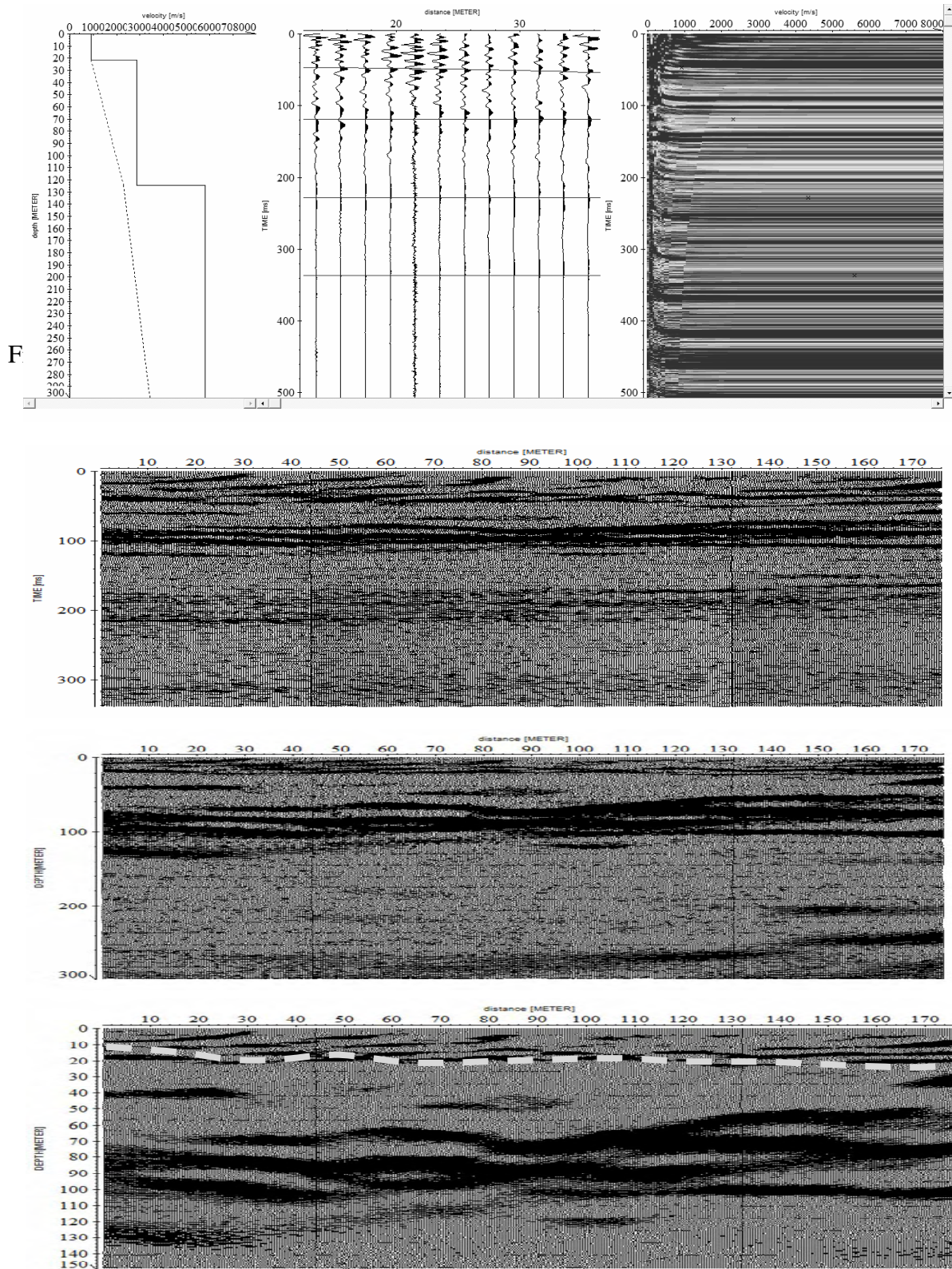
Figure 8: Static corrected sections, (a) Time migrated section (b) depth migrated section (c)

depth migrated seismic with vertical exaggeration to display the weathered basement
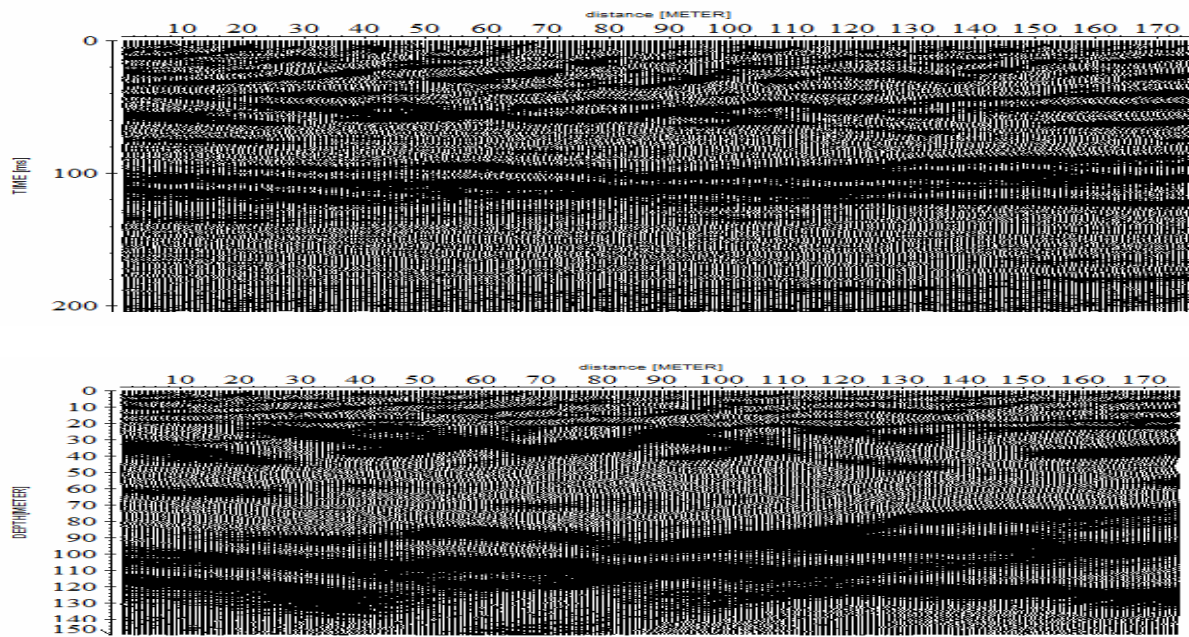
Figure 9: Non static corrected sections, (a) Time migrated section (b) depth migrated section

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