Chapter 3 Seismic Calibration

3.1 Introduction

Calibration of seismic data with drill holes and/or well logs is essential for interpreting internal stratigraphy and gross geometry of structures accurately. The primary goal of calibration is to convert seismic profiles from two-way travel time (TWT) into depth, likewise converting well logs from depth into TWT. Once calibrated, correlation between stratigraphic boundaries identified drill hole data and seismic reflections can be achieved.

The velocity at which elastic waves propagate through the earth is a characteristic property of a rock unit. However, it is not possible to define a single unambiguous velocity for all the sediments, since velocity is a function of density, which in turn is dependent on porosity. The velocity and density of sediments increases with depth, as porosity decreases.

The drill hole used for seismic calibration was oil-prospecting hole OP1 (see Appendix 1). OP1 is situated 250m southeast of Shot point (Sp) 450 on seismic line TB01-PM. The position of OP1 has been projected onto line TB01-PM for calibration and interpretation purposes. OP1 bottoms out in dolerite basement providing an excellent constraint on the thickness of Tertiary sediments.

Seismic calibration was a 2-step process. The first stage involved testing the accuracy of velocities used in processing the data and secondly, to calculate a Root Mean Square (RMS) velocity in the case of the any inaccuracies.

3.2 Testing Processing Velocities

The velocities that were used in processing the Longford seismic data are shown in Table 3.1. These values were consistently applied for Tertiary sediments over the entire basin.

Two way travel time (msec)	ν-RMS	ν-INT
2	1600	1600
440	1706	1706
585	1906	2413
698	2005	2454
783	2405	4502
1450	3110	3773

Table 3.1: Processing velocities for Shot point 435 on line TB01-PM. Where ν-INT stands for Interval velocity.

From these values, time was converted to depth using the formula:

$$S = \frac{\nu \times t}{2}$$

Where S = Distance (m)

ν = Velocity RMS ($msec^{-1}$) and

t = Two-way time/(sec).

The results are shown in Table 3.2:

Two-way travel time (msec)	Velocity-RMS ($msec^{-1}$)	Depth (m)
2	1600	1.6
440	1706	375.3
585	1906	557.5
698	2005	699.7
783	2405	941.6

Table 3.2: Calculated depths using RMS processing velocities at a given TWT.

Based on these results, Well OP1 was converted from depth to TWT and placed over the seismic section, shown in figure 3.1.

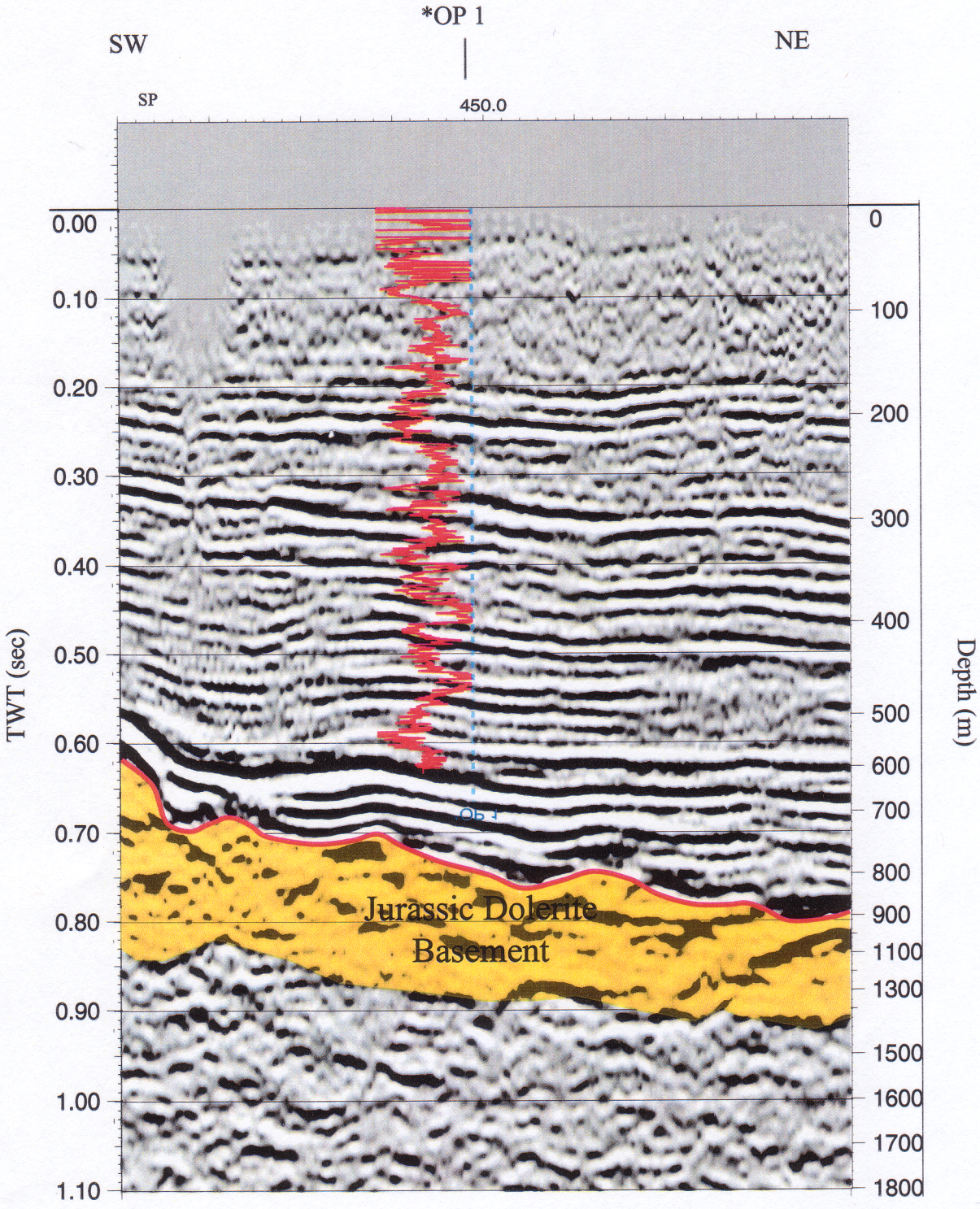

Figure 3.1: **Well OP1 tied to seismic line TBO1-PM at shot point 450. OP1 was converted to TWT using the processing RMS velocities from Table 2. The depth scale refers to the log position (blue dashed line). The gamma-ray log is utilized later for stratigraphic interpretations but not in the calibration process. The gamma log does not extend the full depth of OP1.**

Based on seismic interpretation the dolerite basement occurs at 0.73 sec (TWT), at shot point 450. Figure 3.1 clearly shows that by using the processing velocity well OP1 fails to intersect dolerite. The miss tie is approximately 0.06 sec. A time-depth curve (figure 3.2) has been generated for figure 3.1. From this, the depth to the dolerite basement pick (0.73sec) is 800m, calculated from a RMS velocity of 2190 $msec^{-1}$. Basement occurs at 685m in OP1 therefore 2190 $msec^{-1}$ used in processing is too high. The 0.06 sec or 115 m difference is considerable, warranting recalibration of the velocities to gain an accurate synthesis of stratigraphy.

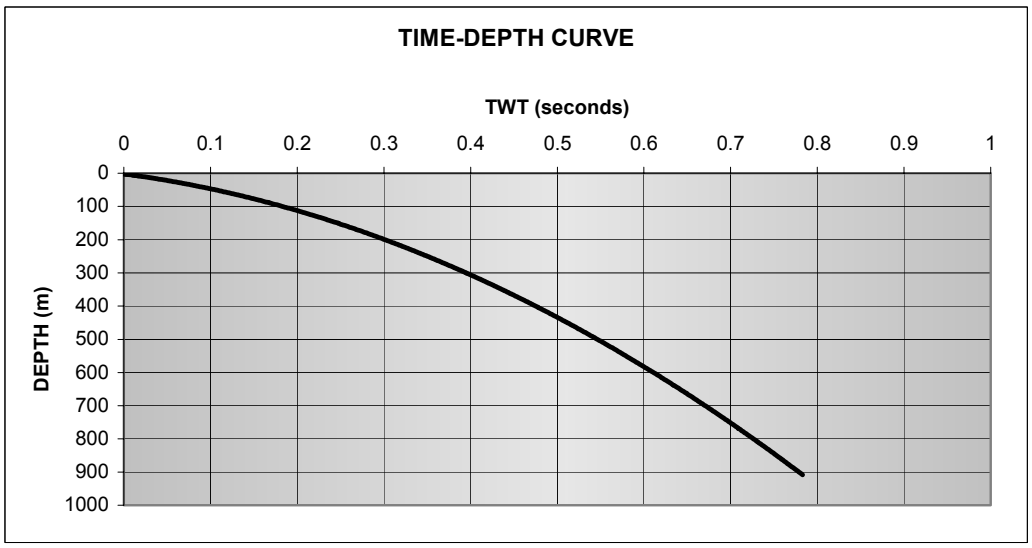

Figure 3.2: Time-Depth Curve constructed using processing RMS velocities.

Calibrating the seismic at shallow depth is limited by known lithological reflectors and is therefore assumed to be correct.

3.3 Correction of Velocities

Apart from the coal seams at the base of the Tertiary there are no major lithological changes or highly deformed (steeply dipping) rocks within the Longford Sub-basin. This means the seismic cannot be easily calibrated from internal reflections with known lithological breaks. Without downhole sonic logs, calibration is possible only by identifying basement. If the velocities between times 700 msec and 900 msec (see Table 3.1) were in the realm of 6000 $msec^{-1}$, the dolerite character would become more obvious. Nevertheless the basement is confidently picked at 0.73 sec TWT and since OP1 strikes dolerite at 685m the RMS velocity can be calculated:

$$v = 1877\ msec^{-1}$$

To make the base of OP1 tie with the interpreted basement pick (figure 3.3), the RMS velocity required at 0.73sec is approximately 1880 $msec^{-1}$. Applying the newly calculated RMS velocity to the entire Tertiary section formed figure 3.3. However velocity increases with depth, this would have minimal effects at depth but cause inaccuracy at shallow depths.

The final calibrated seismic section is shown in figure 3.4. The section differs from figure 3.3 in that it is calibrated using processing RMS velocities at shallow depths (1706 $msec^{-1}$ at 0.44 sec TWT) and the corrected RMS velocity at depth (1880 $msec^{-1}$ at 0.73 sec TWT). The results are displayed as a time-depth curve (figure 3.5) and should be referred to for TWT depth conversions for Tertiary sediments only.

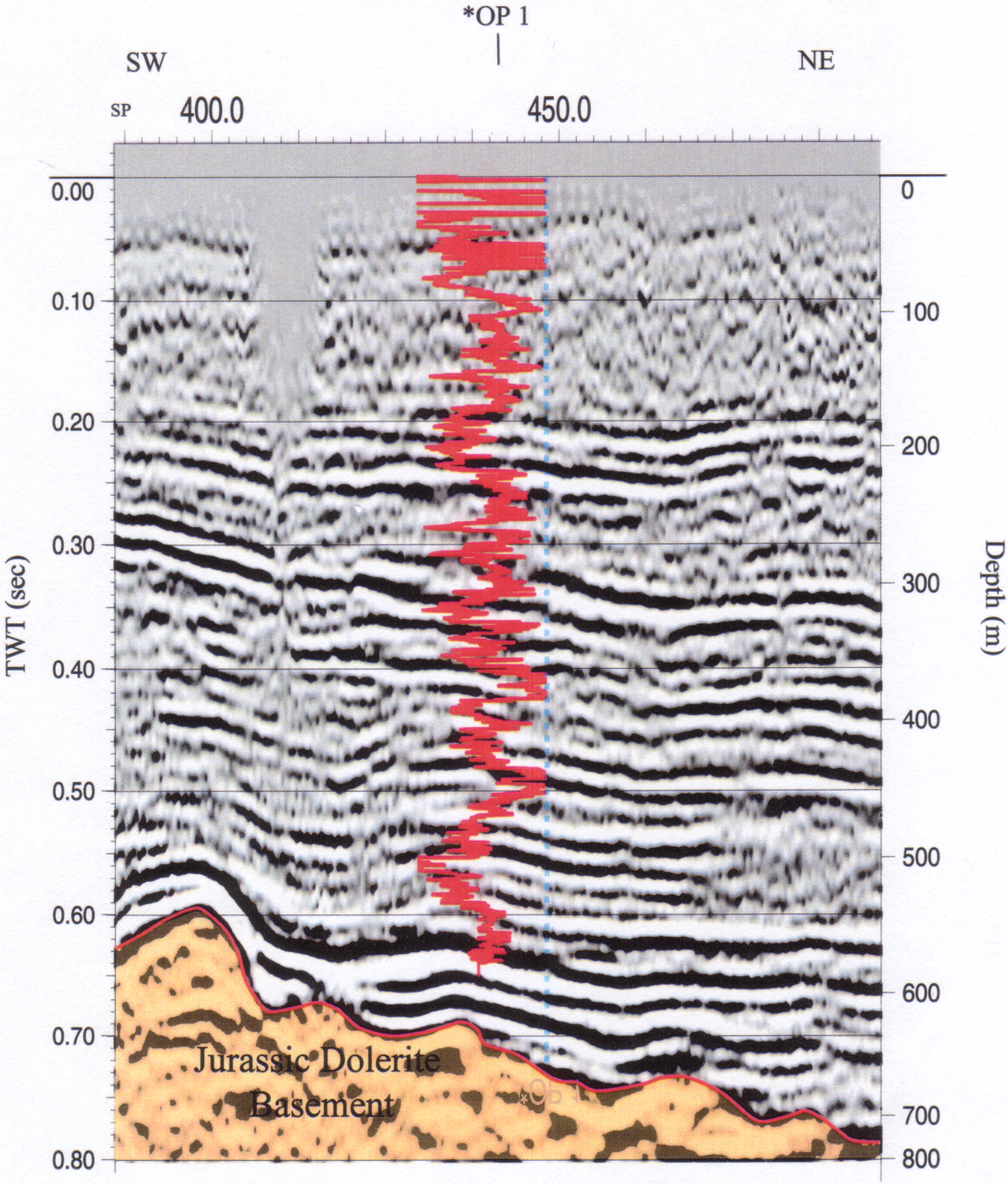

Figure 3.3: **Well OP1 tied to seismic line TBO1-PM. Logged and seismic interpreted basement and are fixed at the same TWT. The RMS velocity is calculated at this site.**

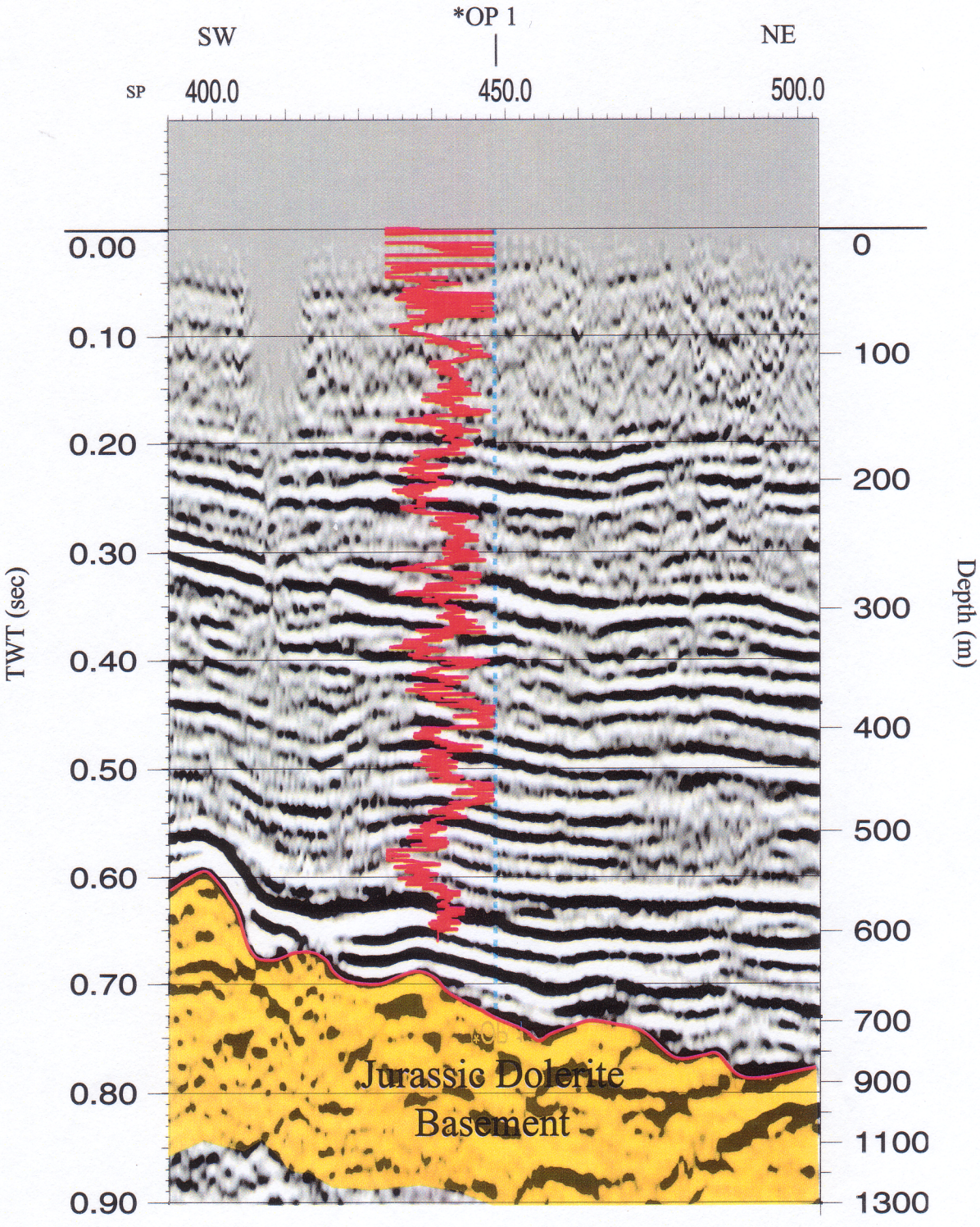

Figure 3.4: **Final calibration of seismic section TBO1-PM with OP1. At 0.44 sec and 0.73 sec TWT the RMS velocity is 1706 msec^{-1} and 1880msec^{-1} respectively.**

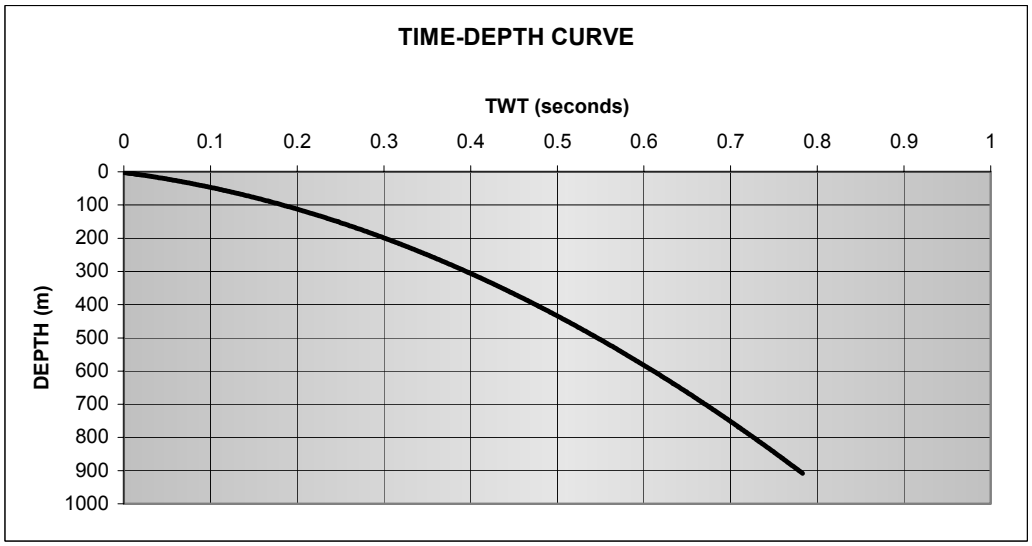

Figure 3.5: Time-Depth curve for final calibration.

3.4 Summary

Calibrating the seismic data is a critical process that must be carried out accurately in order to gain meaningful interpretations. Preferably seismic data should be calibrated against as many wells as possible. In the Longford Sub-basin there are few deep wells that intersect basement, fortunately OP1 lies close to line TBO1-PM, enabling TWT- depth conversion.

There is a lack of obvious of well-controlled lithological contacts at shallow depth. Hence the shallow velocities are poorly constrained. The good continuity of deep reflectors suggests the velocities used to process the data where sufficient. A further work suggestion would be reprocessing the seismic with different velocities to test reflector continuity.