Chapter 3

Case Study

In the present research work, the pre-and post-stack seismic data have been used along with the well log data available as open access resources. The open-access data from the OpendTect seismic repository (dGB Earth Sciences), which was suitably structured, has been used for current research work. The 3D post-stack data from the F3 block, the Netherlands, has been used for all post-stack inversion and geostatistical based investigations. Further, the 3D pre-stack seismic data from the Penobscot field, Canada, has been used for pre-stack inversion analysis. Both the data are downloaded from www.opendtect.org (dGB Earth Sciences). The well log data for both the oil and gas fields was also available as open source. Therefore, it has been used for seismic-well log data tie-ups in the present research.

3.1 F-3 Block, the Netherlands

The present study makes use of offshore 3D seismic data from the F3 block, North Sea, the Netherlands, which is a gas bearing field. The survey was carried out in this field in 1987 in an area of 384 square km. The F3 block is mainly located on the top of the Dutch central Graben (shelf of the North Sea) as one of the key Kimmerian rift basins in the Dutch northern offshore and a part of the structural component of the Mesozoic Southern North Sea Rift System (De Jager and Geluk, 2007). It is basically

characterized by great horizontal and vertical variability. Three generational faults system is prominent in the F3 block. The first generations are known to be oblique-slip, reversing, sinistral faults with orientation SSW-NNE. The second generation is oblique-slip, normal, dextral faults with orientation W-E, and the third generation are faults disturbed by Permian halokinesis, which are genetically connected with first and second-generation faults. This survey was carried out to explore oil and gas in the layer of Upper-Jurassic to Lower Cretaceous generally found below a certain interval. The upper part up to 1200ms is made up of reflectors belonging to the Miocene, Pliocene, and Pleistocene (De Bruin and Bouanga, 2007; Wolak et al., 2013). The deltaic bundle comprises sand and shale, which has very high porosity. The study area map is shown in Fig. 3.1 and the stratigraphy of the North Sea region is shown in Fig. 3.2. The cross-section of seismic data is shown in Fig. 3.3.

Seismic data over the F3 block, the Netherlands were acquired in 1987 and consist of 649 Inline and 900 Crossline. The size of the survey area is 24 km and 16 km in inline and cross-line directions, respectively, with a $25m \times 25m$ bin size. The two-way travel time record of seismic data is 1,848ms, with a sampling rate of 4ms. The initial F3 dataset was noisy and therefore, to eliminate the noises, a dip-steered median filter with a limit of two traces was applied to the data. There are four vertical wells within the survey area and all the wells had sonic and gamma-ray logs. The depth of well log was about 1700ms (Aminzadeh and De Groot, 2006). The well location of F02-1 is 362 inline and 336 cross line, F03-2 is 722 inline and 848 cross line, F03-4 is 442 inline and 1007 cross line and F06-1 is 244 inline and 387 cross line. The seismic survey area ranges from Inline 100 to 749 and cross-line 300 to 1200. The essential data needed for the inversion procedure are P-wave sonic, density, S-wave sonic, and check shot logs. Sonic and gamma-ray (GR) logs were available for all the wells. Density data were available only for Well F02-1. The density and sonic logs of Well F02-1 were performed to train a neural network relationship between density and sonic logs. The trained neural network was then used to compute sonic logs for the Wells F06-1 and F03-4.

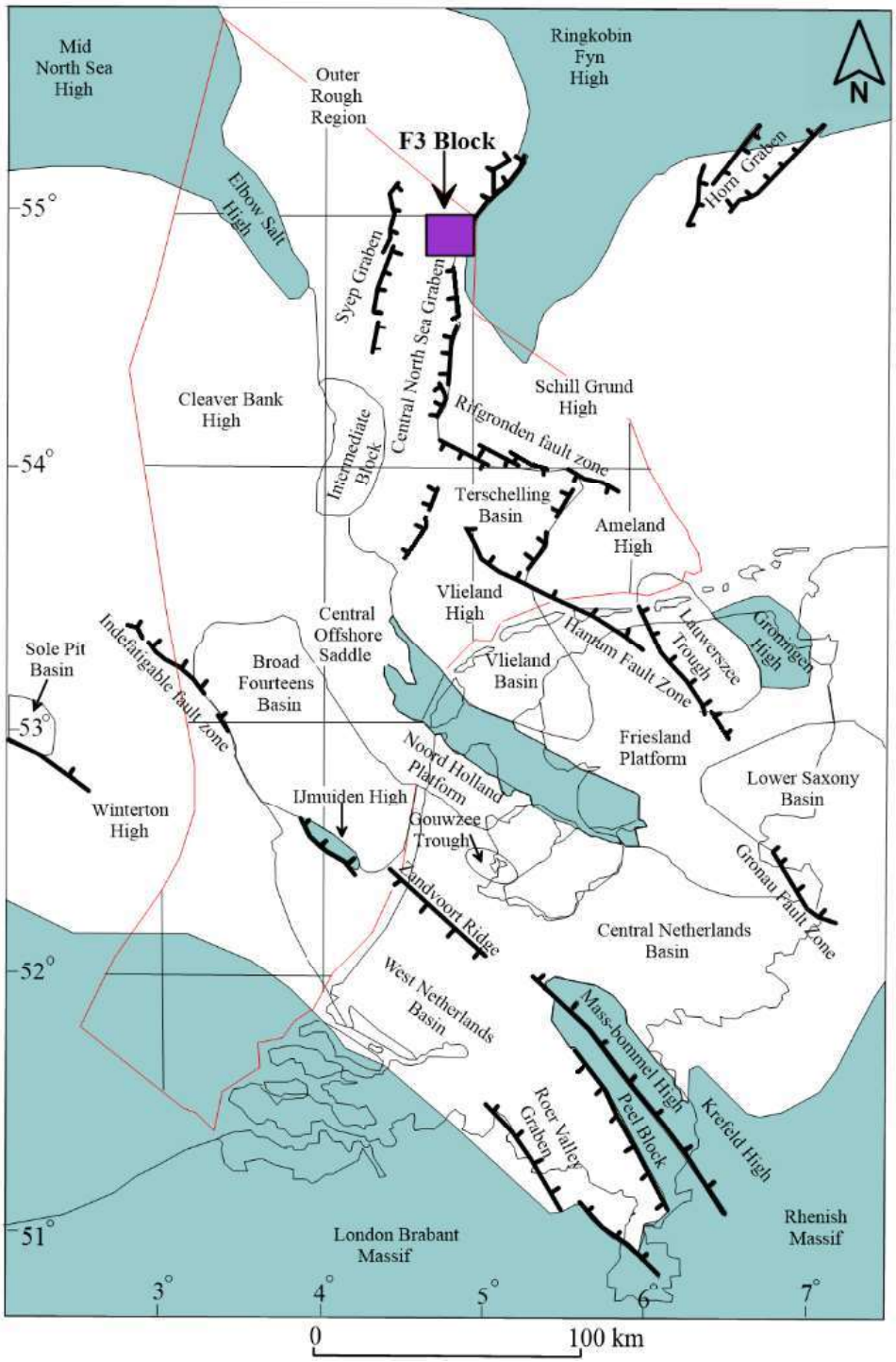

FIGURE 3.1: F3 block, the Netherlands study area

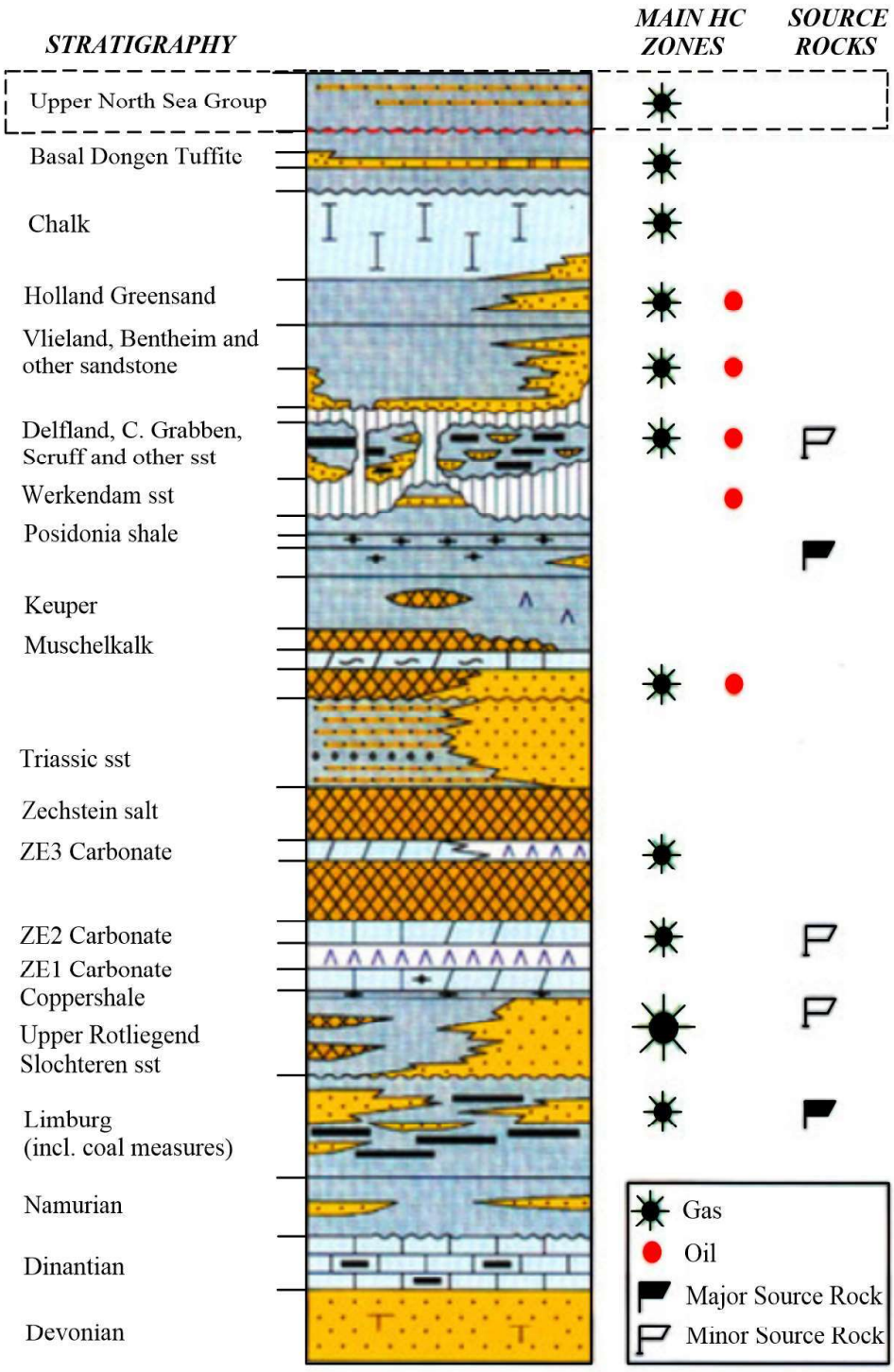

FIGURE 3.2: The North Sea Basin deals with the hydrocarbon and stratigraphy (After Rondeel et al., 1996)

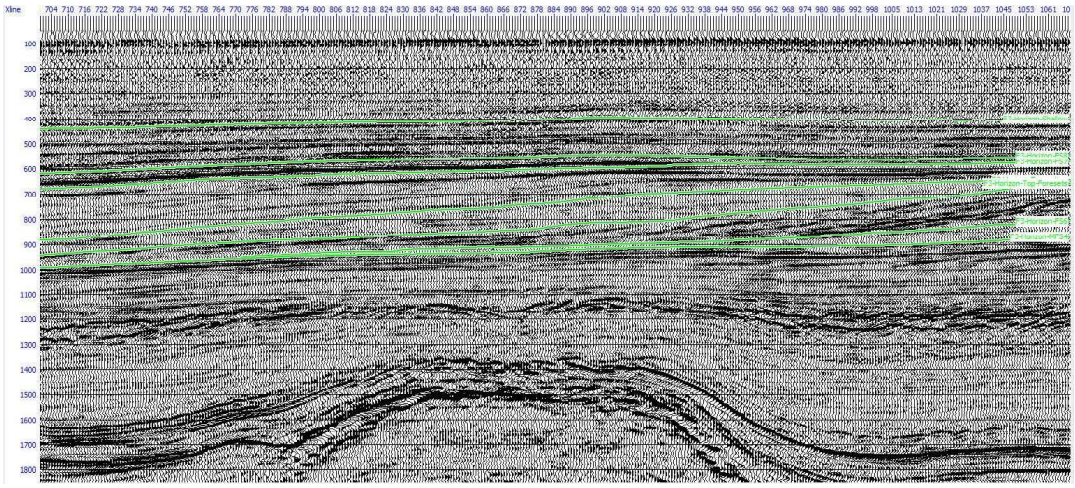

FIGURE 3.3: Cross section of post-stack seismic data from F3 block, the Netherlands

3.2 Penobscot region, Canada

The Penobscot study area is located in the Scotian Basin, offshore of Nova Scotia, Canada. The Scotian Basin, Canada, occupies an area of 300,000 km^2 with depths of sediments of up to 18 km. Its coordinates are $44^0$07'46" N/$60^0$06'00" W. The map of the study area is shown in Fig. 3.4. It is split into four sub-basins: Sable, Abenaki, Shelburne and Laurentian (Campbell et al., 2015). Scotian Basin geological history was initiated in the Middle Triassic period. After the break-up of Pangaea, it formed interconnected rift basins containing the Scotian Basin. The Abenaki Formation is deposited in the southwestern part of the Scotian Basin during the Late Jurassic Period (Kidston et al., 2005). Fig. 3.5 shows detailed lithology of the subsurface. The Abenaki Formation is the formation being studied in this study, which is recognized on the stratigraphic column in Fig. 3.5. The Abenaki Formation was deposited throughout seafloor spreading. The survey was conducted in 1992. The seismic data occupied an area of 66 km^2 and was collected in a $12.5m \times 25m$ bin size (Inline by Crossline) with 60-fold coverage and a 2ms sampling rate. The bandwidth of seismic data is 8-40 Hz. The seismic coverage survey ranges for each volume from Inline 1000 to 1600 and from crossline 1001 to 1481. The survey contains several structural and stratigraphic features. Throughout the survey area, two major faults that construct the en-echelon

pattern could be observed in the seismic section (Campbell et al., 2015). The interpreted surfaces are often displaced by these faults. Such features may be illustrated by the similarity of multi-trace, volumetric curvature, or volumetric amplitude maps (Cummings and Arnott, 2005). The measured seismic signal is bad below 3.0 seconds in length (about 5 km) (Fig. 3.6). Two wells, B-41 and L-30, were bored in the region, invading Misaine and Baccaro affiliates of the Jurassic Abenaki Formation (Kidston et al. 2005). The well Penobscot L-30 (Inline 1177, Crossline 1153) was bored to a depth of 4237m while well B-41 (Inline 1130, Crossline 1048) was drilled up to a depth of 3444m.

Many gas and oil fields are found at these intervals, from Late Jurassic to Cretaceous. The sands from Lower Logan Canyon in the L-30 well were considered oil-bearing (small accumulation) (Smith and Gidlow, 1987). The seismic and well data have been taken from the OpendTect seismic data portal. From the CNSOPB report, the time to depth model has been taken (Kidston et al., 2005). The survey includes a limited range of pre-stack data. The data cover many geological features, including channels, mega-scale dewatering faults, graben-bound faults, and reefs (Kidston et al., 2007).

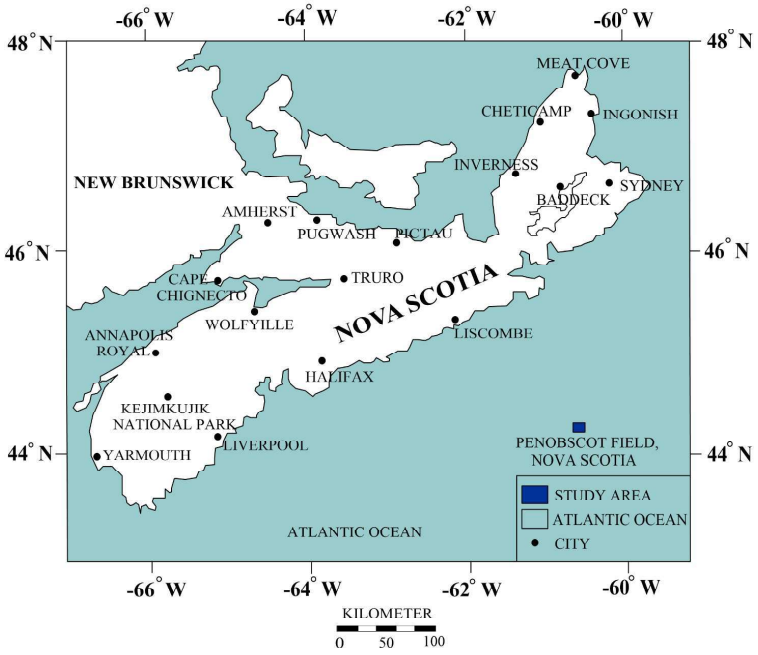

FIGURE 3.4: Penobscot study area, Canada

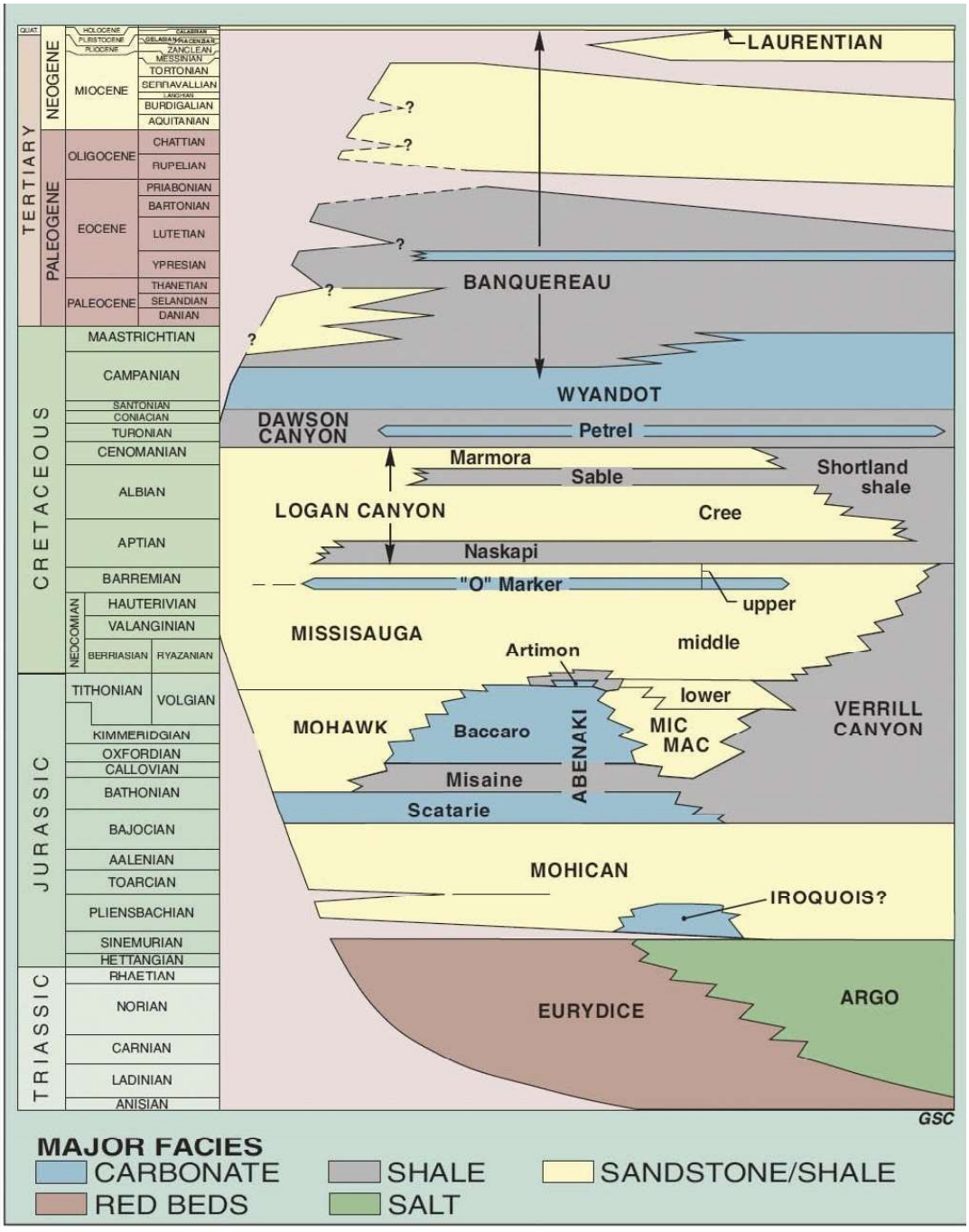

FIGURE 3.5: Detailed lithology of Penobscot study area, Canada

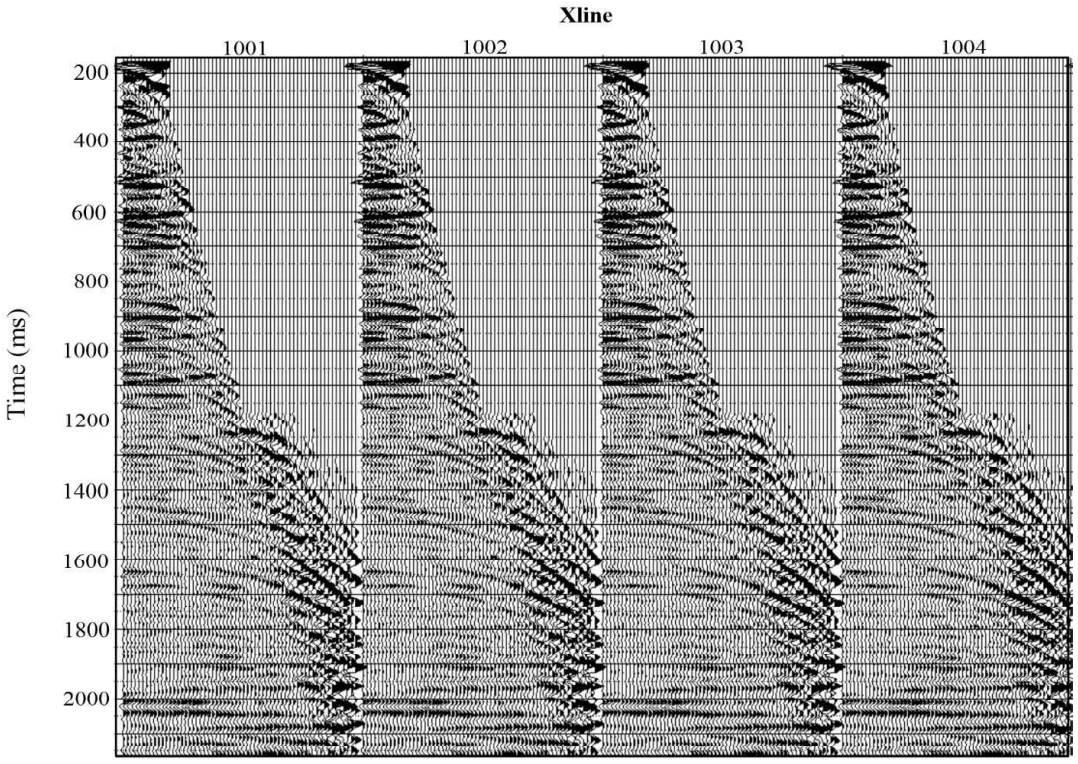

FIGURE 3.6: The cross section of pre-stack seismic data from Penobscot, Canada