Identification of accretionary wedge at Sumatra subduction zone using 2D seismic reflection

A N Risqi1, A Riyanto2 and N D Hananto3

1Department of Physics, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok 16424, Indonesia
2Geoscience Study Program, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok 16424, Indonesia
3Research Center for Oceanography, Indonesian Institutes of Sciences (LIPI), Jakarta 14430, Indonesia

Corresponding author’s email: agus.riyanto@sci.ui.ac.id

Abstract. This research is focusing on structure at Nias Islands subduction zone. Subduction zone Sumatra is the collision zone of Eurasia continental plate and Indo-Australia oceanic plate. Prior to the establishment of the subduction zone there is an event of the making of continental crust in which in this research area is marked by Wharton Fossil Ridge. An odd feature of the Sunda subduction zone is the non-volcanic forearc ridge that comes up raised sea level assemble a lot of islands betwixt the trench and the mainland. The forearc ridge is the cap of a chunky sequence of sediments and sections of sea floor, known as the accretionary wedge, that are folded, faulted and plastered into the upper plate. Accretionary wedge structure which has the melange rock characteristics because of the plates’ subduction. The accretionary wedge could be interpreted using seismic reflection data with characteristic reflector doesn’t formed or visible. The islands offshore southwestern Sumatra might have a akin origin. The most appropriate study of these is Nias, which its southwest coastline is 90 km form the subduction deformation front and 20 km above the dipping plate interface. Southwest of Nias, the oceanic seafloor is dipping at a homogeneous angle 6° to 7° against Nias for a horizontal distance of 25 km beneath the accretionary wedge, where it attains a depth of just over 10 km. In this research it has been done 2D seismic reflection data processing and the interpretation of the Wharton fossil ridge establishment, subduction zone, and accretionary wedge.

Keywords: Subduction zone, accretion wedge, 2D seismic, interpretation

1. Introduction
Indonesia is an active tectonic zones country caused by the meeting of three tectonic plates, that is Indo-Australia oceanic plate, Pasific oceanic plate and Eurasia continental plate. Sumatra is one of island the collision zone of Eurasia continental plate and Indo-Australia oceanic plate. Subduction zones are convergent inter-plate boundary zones. Many studies in the field of geological processes have already done in the Sumatra Island, where the whole island of Sumatra has been Sumatra Fault Zone (SFZ) that stretched to the Andaman Sea. The fault zone is formed as a result of tilting subduction zones along Sumatra Island. This Subduction zone will produce an accretion wedge structure. Accretion wedge complex has unique morphological characteristics which is formed from the results of
deformation and sedimentation that develop in the area. This research is focusing on structure at Nias Islands subduction zone. One of method for Identification Accretion Wedge Structure is seismic reflection data.

The research area is located in south of the island Nias is an active plate meeting Indo-Australia oceanic plate and Eurasia continental plate which results in the formation of subduction zones. Sumatra has inter-plate subduction which forms a complex and unique geological. Sumatra is located on the continental Sunda and exposes granite rocks aged 240 Ma. In general, from the Northeast to Southwestern of the Sumatra island there are different geological structures. At the southwestern part of Sumatra, the march of islands started from Enggano Island in the Southeast to the Simeuleu Island in the northwest, they forms the ridge. The forearc ridge is the cap of a chunky sequence of sediments of sea floor, this sequence called as the accretionary wedge, that are deformed onto the upper plate (figure 1) [2]. The most appropriate study of these is Nias, which its southwest coastline is 90 km form the subduction deformation front and 20 km above the dipping plate interface. Southwest of Nias, the oceanic seafloor is dipping at a homogeneous angle 6° to 7° against Nias for a horizontal distance of 25 km beneath the accretionary wedge, where it attains a depth of just over 10 km.

Accretionary wedge is formed on inside of ocean trench wall. The internal architecture and structure of these aspects have been gleaned from seismic reflection profiles and drilling at active subduction zones, and based the research of ancient subduction complexes now exposed on land. Accretionary wedge develops where trench-filled turbidites (flysch), and some pelagic sediments, are scraped off the descending oceanic plate by the leading edge of the overriding plate, to which they become accreted. Seismic reflection data and the ages of deformed sediments imply that the youngest faults in accretionary wedge appear at the deformation front and generally become older away from the trench [3].

2. Data and method

2.1. Data acquisition
The study began by processing seismic data with a path BGR06-126 in Segy format. Seismic data BGR06-126 is geographically located to the south of Nias Island with positions 0° LU–1.5° LU and 98° BT–96° BT. These data are the closest seismic data of the earthquake epicentral zone which was obtained from the results of a survey conducted on January 21 until February 25, 2006 carried out by the Indonesian partnership (BPPT, Bakosurtanal, and PPPGL) and Germany BGR (Bundesanstalt Fur Geowissenschaften und Rohstoffe) namely Sonne Cruise 186 -2 SeaCause-II in the western waters of Aceh to the Continental Shelf area beyond 200 miles. During these activities 2D seismic data collection has been carried out along approximately 1500 km of track with 43 seismic trajectories of multichannel reflections.

2.2. Methodology
Figure 2 shows methodology steps which first step is storing raw data of seismic 2D with SEGY format. The seismic data was continued to gave PSTM seismic data. Next conditioning data to reduce the noise and increase singal to noise ratio (S/N) on post stack time migration (PSTM) step. Seismic processing data using PROMAX software and Interpreting data is useful for constructing 2D condition of research data. It also give a result seismic cross section BGR06-126 to intrepreted and correlate with existing geological data.

3. Results and discussion
Line BGR06-126 in figure 3 correlate with figure 1. The discussion will refer to figure schematic cross-section of the Sumatran plate boundary which is in the red box in accordance with the seismic cross section of the trajectory data processing BGR06-126. Figure 3 can be interpreted as a Sumatran
subduction zone with seismic cross section where oceanic crust and continental crust are present. Subduction zones are inter-plate meetings due to the subduction process which in the study area contained Indo-Australian and Eurasian plates. This subduction process greatly results in the two plates colliding or pressing against one another and causing strain.

Figure 4 shows Line BGR06-126 is interpreted as Wharton Fossil Ridge which is part of the determination of past oceanic crust which is characterized by the dominant reverse fault due to the compression force originating from a collision between two plates.

![Figure 1](image1.png)

**Figure 1.** Schematic cross-section of the Sumatran plate boundary.

![Figure 2](image2.png)

**Figure 2.** Methodology step

![Figure 3](image3.png)

**Figure 3.** Cross-section results data seismic processing line BGR06-126.
Figure 5 shows the distance of 2.1 km to 2.6 km from the BGR06-126 trajectory is interpreted as accretionary wedge leading to the northeast (NE) seen in the rising seismic crossing which indicates that it has entered the Nias Islands. In the cross section the seismic reflector does not form a coating as is the characteristic of the mangle of the accretionary prism. In Nias Islands, according to Samuel in 1995, Nias stated that the complex part of accretion was raised. On Nias has bedrock similar to mixed rock (mélange) which is assumed to be flanked. Rocks such as serpentine and basalt.
4. Conclusion
With 2D seismic cross section result get an interpreted subduction zone structure. In Line BGR06-126 is reserve fault which indicated the area of Wharton Fossil Ridge. The reflection seismic cross section can interpret the structure of the accretion prism which in the cross section doesn’t form a layer which is a characteristic of the accretion wedge and the lithology melange rock is matches with characteristics of accretion wedge.

Acknowledgments
This work was financially supported by Universitas Indonesia under research grant PITTA with grant contract number 2221/UN2.R3.1/HKP.05.00/2018. We would like to thank Research Center of Oceanography for their support and providing data for this research.

References
[1] McCaffrey R 1992 J. Geophys. Res. 97 8905-15
[2] McCaffrey R 2009 Annu. Rev. Earth planet. Sci. 37 345-66
[3] Moore G F and Karig D E 1980 Am. J. Sci. 280 193-223
[4] Singh S C et al. 2008 Nature Geoscience 1 777-81
[5] Singh S C et al. 2011 Nature Geoscience 4 308-11