# Seismic signatures of fluid migration and accumulation at offshore N-W Sumatra

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**Keywords**

Seismic, Fluid Migration, Amplitude blanking, Reverse Polarity, Sumatra.

**Summary**

Here, we present results after processing of a 5.5 km long 2D seismic data set acquired in 2006 across the N-W offshore Sumatra subduction system where the Indo-Australian plate has been subducting below the Eurosian plate. This study suggests that the dewatering and dehydration of the subducting plate, and the landward compression associated with the subduction processes may have expelled out pore-fluid from the trench sediments, migrating updip along the frontal slope. The processed seismic section shows the possible path of the fluid migration and its accumulation at the anticline below the frontal slope. The reverse polarity with respect to sea floor and amplitude blanking observed in the migrated section and sudden decrease in 1D velocity profiles, further suggest that the accumulated fluid might be linked with a potential hydrocarbon reserve.

## Introduction

At the convergent plate margin where the subduction of oceanic crust causes an extensive deformation of sediments, forming an accretionary wedge (Ghosal et al. 2014), often encompasses the expulsion of the fluid from the trench sediments. The migration of the fluid and then accumulation give a distinct type of reflections on a seismic section (Calvert and Clowes, 1991). These migrated fluids, which are hydrocarbon in most cases, are assets as in the realm of the world's energy consumption, the dynamic change of the scenario with the need and supply demand has become a herculean challenge. In this regard the exploration and a worth production of the unconventional resources has become as important as conventional resources. Therefore for proper quantification and assessment of the resources by studying the migration behavior of these fluid resources is essential.

In this regard subduction of the Indo-Australian plate under the Sunda plate with a sediment rich Sunda trench is a place with type of migration and accumulation condition. The trench fill deposits at NW offshore Sumatra (Fig.1) is of 2-5 km thick, which has been accumulated forming a perceptible accretionary wedge (Chauhan, 2010; Singh et al. 2012; Ghosal et al. 2014,). The study area is surrounded by the Nicobar Island in the north, Whaton spreading centre in the south (Liu et al. 1983), Aceh forearc basin in northeast and prolonged ninety-east ridge in the west (Fig. 1).

The seismic data acquisition was carried out during July-August 2006, using the French R/V Marion Dufresne and the Western Geco M/V Geco Searcher Vessels, carrying 8,260 and 10,170 cubic inch air gun array sources, respectively, keeping a shot interval of 50 m (Singh *et al.* 2012). The orientation of the WG2 profile was 20° anticlockwise from the normal to the trench. In order to collect high resolution reflection data of the near surface features, a 5.5 km long Q-marine streamer with a group interval of 12.5m was deployed at 7.5 m water depth, (Martin et al. 2000). Another 12 km long streamer at 15 m water depth was also used to record deep seismic reflection energy. A coincident refraction survey using 56 ocean bottom seismometers with 8.1 km spacing (Chauhan, 2010) was also carried out to obtain the deeper velocity information. However, in this study we have used the 5.5 km long streamer data to describe the evidence of fluid migration and its accumulation.

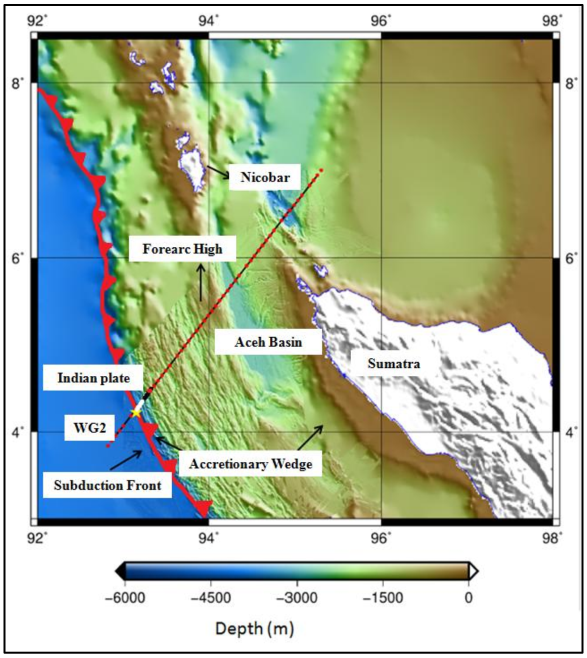


Figure 1: Studied profile is whitened. Bathymetry data from French survey (Singh et. al., 2008) with GEBCO data set in background. Black line is WesternGeco seismic reflection profile WG2. Shot point (11405) marked by yellow star on the WG2 line has been shown in figure 2. Red dots indicate OBS locations.

## Methodology

For processing the datasets, we have used PARADIGM FOCUS Version 15.5 software. The processing steps are explained by flow chart described below (Fig 3).

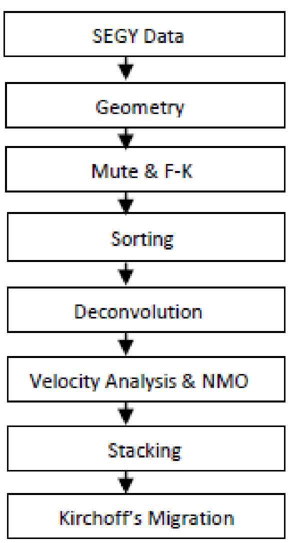


Figure 2: Processing Steps

First the direct waves and refracted phases are muted from the geometry applied raw gathers (Fig. 3a) and the effect of hydrostatic pressure fluctuations and swell noises are eliminated using F-K filter (Fig. 3b).

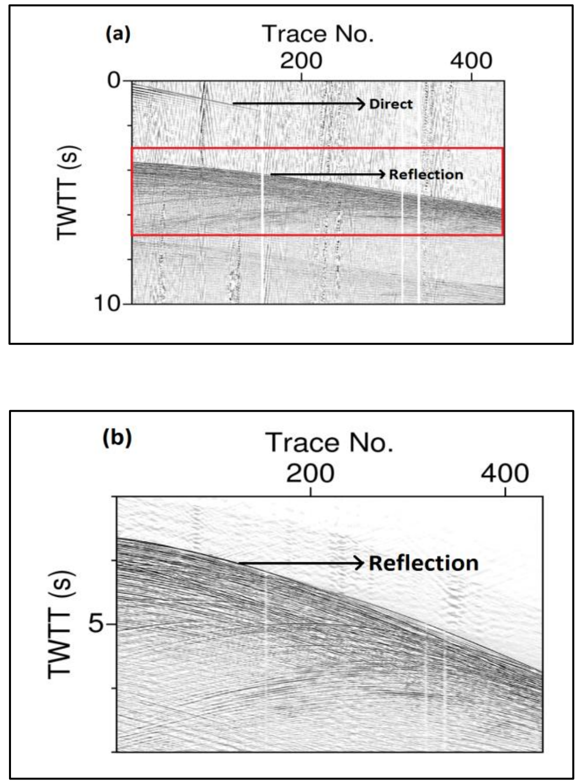


Figure 3 (a) raw data. Red box indicating the zoomed portion of the shot gather in the (b) part. (b) Muted and filtered data of shot no 11405.

To reduce the ringing effect of the airgun bubble pulse, we have applied predictive deconvolution. As the water depth is very high in the study area the multiples mostly appear at deeper part of the shot gather, which is beyond our interest. After the preprocessing, the datasets are sorted into common depth-point (CDP) gather and are used for velocity analysis. In order to delineate minute reflection pattern from the complicated accretionary wedge deposits, a super gather of 8 CDPs is formmulated with a group interval of ~300m (Fig. 4). Finally velocity-time function shown in (fig. 4(c)), for the CDP numbered 6604, indicates P wave velocity in water ~1500 m/s at ~3.625 s (TWT) giving the depth of sea floor 2773 m and increases gradually with depth but a reversal in observed at time 4.68 s. The NMO based velocity analysis derived root mean square (RMS) velocity is used for stacking and migration (Fig. 5).

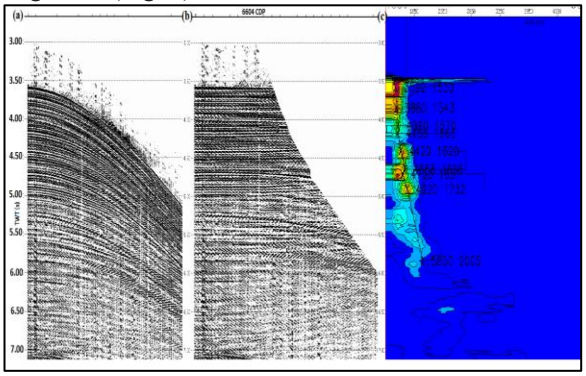

Figure 4: (a) Processed CDP (6604) (b) NMO corrected muted CDP (c) semblance panel. Interval velocity marked by the black line drops at 4.68 s.

## Results

The sea-floor, from the migrated section, shows a drastic change in the water depth from 4500 m on the trench to 2400m on the frontal slope at CDP 6850 (Fig. 5). Examining the migrated section carefully (Fig. 6), we observe two reflectors with opposite polarity to the seafloor between CDPs 6430 and 7160 shown in green box. Also there is amplitude blanking between these reflectors (Fig. 6b).

The 1D velocity-time profile (Fig.7), further, indicates a drop in velocity at 4.6s. Crosschecking the velocity at this particular CDP at a two time, we found a drop from 2340 m/s to 2200 m/s at 4.6 s to 4.8 s (TWT), respectively, indicating a low velocity zone (LVZ).

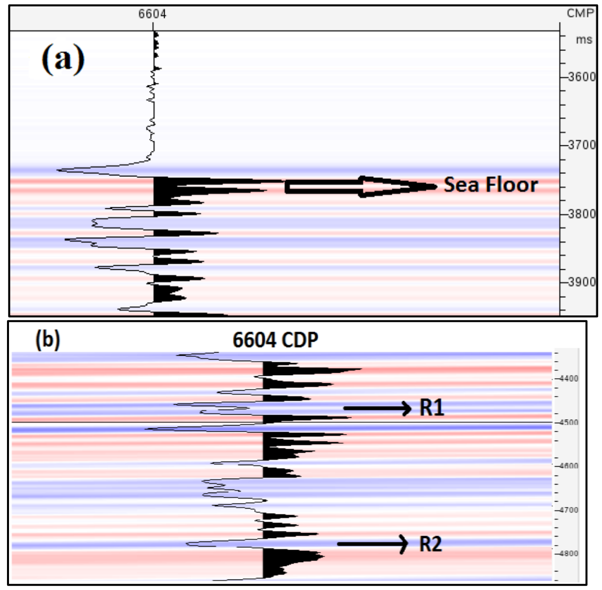


Figure 6 (a) Sea floor wiggle plot b) R1 and R2 are the reflectors with opposite polarity as of sea-floor at CDP 6604

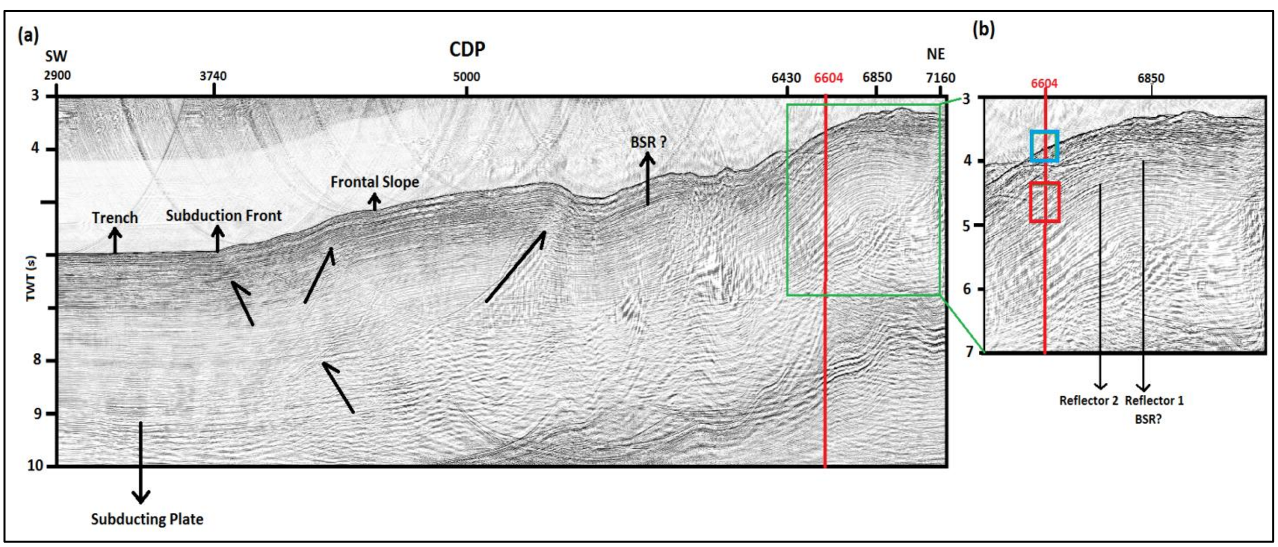


Figure 5: Migrated section showing the trench, subduction front, frontal slope and subducting plate. Arrows indicate the location of the thrusts associated with the subduction processes. In (a) Green box indicating the CDP 6430 -7160 and red line indicating the CDP 6604 while in (b) the zoomed section of the CDP 6430 – 7160, blue box indicating the sea floor as shown in figure 6 (a) and red box indicating the reflectors as shown in figure 6 (b).The 1D velocity-time profile at the CDP 6604 is shown in figure 7

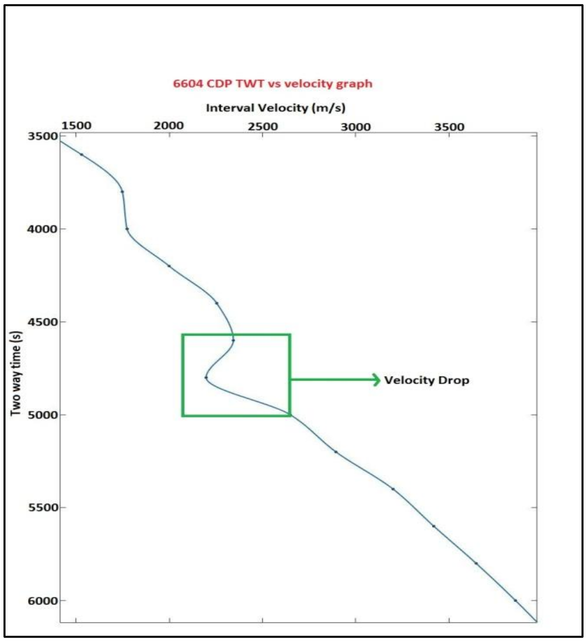


Figure 7:1D interval velocity-time profile at CDP 6604. Red box shows the low velocity zone (LVZ).

## Conclusions

In this study we have processed a 5.5 km high resolution multi channel seismic datasets acquired over N-W offshore Sumatra and found two reflectors below the frontal slope with reverse polarity. The polarity reversal associated with these reflectors might be due to migration of the over pressured pore-fluid (i.e. water or hydrocarbon) from the trench sediments and dehydrated subducting plate along the frontal slope. By observing the reflection in migrated section at 6604 CDP (Fig.6) we inferred that there might be possibility of sudden dewatering at the bottom of the accreted wedge, with the deformation and disruption in the sediments (Calvert and Clowes, 1991). There is also a possibility of the creation of overpressure zone because of the blockage of the fluids due to accumulation of the sediments along the frontal slope, or may be because of minerals which are precipitated from the rising fluids (Calvert and Clowes, 1991).However, fluid released from dehydrated subducting plate may be migrated obliquely because of change in the horizontal and vertical permeability. Observing the velocity–TWT time trend (Fig.7), we infer that there is continuous increase in the interval velocity till 4.5s (TWT), after which there is drop in the velocity indicating either the presence of hydrocarbon (such as gas) or sudden mineralogical phase change. Since phase change may be absurd at such shallow depth, we therefore speculate that this velocity drop along with the polarity reversal of the reflector might be either associated with the presence of conventional hydrocarbon (oil or gas) or gas hydrates reserves in which R1 might be the Bottom Simulating Reflector (BSR).

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