Ambient noise study over a gas field in Qeshm Island

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SUMMARY:
Recently, some anomalous signals have been reported over the hydrocarbon reservoirs during the microtremor studies around the world. After a relatively destructive earthquake happened in Qeshm Island, a seismological survey including 17 stations have been carried out in this island and ambient noise recorded for a period of 3 month. In this survey, one of the stations was located over a gas reservoir which has 4 main peaks of amplitude. In this paper, we tried to compare these 4 peaks of the station over reservoir with other stations and find out if there are any differences between them which probably related to reservoir. Study showed, observed peaks of amplitudes are not related to gas reservoir.

Keywords: Microtremor, Qeshm Island, Hydrocarbon.

1. INSTRUCTION

There exist numerous continuous seismic signals which are usually rather weak and which were often considered as useless background noise only. This seismo-acoustic background (ambient) -noise is present as a certain broadband at every location around the world. However, this noise can carry useful information which is contained in its characteristics, such as the frequency spectrum, statistical properties or non-linear behavior. Moreover, it may contain a spectral signature characteristic of the media or environment which it has passed through (Dangel et al., 2003).

The frequencies of ambient noise below 1 Hz are largely generated by oceanic and large-scale meteorological events (microseism) (Longuet-Higgins 1950; Peterson 1993; Webb 2007) and the frequencies above 1 Hz is dominated by cultural sources in urban settings, and by wind generated noise in remote sites (high frequency noise) (Peterson 1993; Withers *et al.* 1996; Young *et al.* 1996; Wilson *et al.* 2002; McNamara and Buland 2004; Marzorati and Bindi 2006; Bonnefoy-Claudet et al., 2006). Usually, there is a rather seismically quieter window which dominates the background wave field at frequencies between 0.5 to 10 HZ (Peterson 1993).

The background noise (microtremor) recordings have been used as an inexpensive and convenient tool for estimating resonant frequency and shear-wave velocities of relatively shallow sediments (Nakamura, 1989; Field and Jacob, 1995; Field et al., 1995; Fäh et al., 1997, 2001; Bard , 1999; Bindi et al., 2000; Liu et al., 2000; Louie, 2001; Parolai et al., 2001; Ohori et al., 2002; Hartzell *et al.* 2003; Scherbaum et al., 2003; Talhaoui et al., 2004; Tuladhar et al., 2004; Chavez-Garcia and Luzon 2005; Kind et al., 2005; Bard et al., 2005; Bonnefoy-Claudet et al., 2006; Tada and Shinozaki 2006; Nunziata, 2007, Chavez-Garcia and Rodriguez 2007; Dutta *et al.* 2007; Haghshenas et al., 2008; Guillier et al., 2008; Wathelet *et al.* 2008; Stephenson *et al.* 2009; Gerivani et al., 2011; Shabani et al., 2011).

Using the information carried by ambient noise has been developing very fast and new possessing techniques and new field of usage have been presenting. For example recently, applications of interferometric (cross-correlation) techniques have allowed seismic sections to be created from microtremor recordings (Wapenaar et al., 2006; Curtis et al., 2006; Shapiro and Campillo, 2004; Sabra et al., 2005; Shapiro et al., 2005; Larose et al., 2006; Yao et al., 2006; Lin et al., 2007; Halliday et al., 2008; Gouédard et al., 2008).

More recently using microtremor measurements to detect and study the hydrocarbon reservoirs has been suggested. High spectral amplitude anomalies of microtremor signals in the 1–6 Hz frequency range, with a peak around 3 Hz, named “hydrocarbon microtremors (HM)”, have been reported over a number of hydrocarbon reservoirs. (Singer et al. 2002; Dangel et al. 2003; Holzner et al. 2005a,b, 2006a,b,c, 2007a,b; Frehner et al. 2006, 2007; Rached 2006, 2009; Lambert et al. 2007, 2009a,b; Steiner et al., 2007, 2008a; Graf et al., 2007; Kaya et al., 2007; Saenger et al. 2007b; van Mastrigt and Al-Dulaijan 2008; Nguyen et al. 2008, 2009; Goertz et al. 2009; Saenger et al 2009a,b,c).
On the other hand, there are some case studies that have cast doubt upon the applicability of the microtremor technique for hydrocarbon detection (Berteussen et al., 2008a,b; Ali *et al.*, 2007, 2009a,b,c,d, 2010; Hanssen and Bussat, 2008).

After a relatively destructive earthquake happened in Qeshm Island (Persian Gulf-Iran), a seismological survey including 17 stations for 3 month have been carried out in this island. One of these stations was situated over a gas reservoir. In this study, ambient noise recorded in the station located over gas reservoir (Gas Station) compared with records in other and tried to find the source of recorded signals in different frequencies and their probably relation to gas reservoir.

2. SURVEY AREA

The study area is located in Qeshm Island in Persian Gulf. After the earthquake with Mw=6.0 happened in 11/27/2005 and caused 10 victims, more than 100 injured and some damages to villages, a temporary seismic network, including 17 stations, simultaneously, for a period of 75 dyes between 14 December 2005 and 26 February 2006 were carried out, using 3 component broadband Guralp CMG-6TD velocimeters. Location of stations showed in figure 1 over geological map of study area.
Form a geological point of view, study area, Qeshm Island, consists of 4 anticlines and one syncline which located in the center of island. Anticlines are including Salakh anticline in the west of island, Suza anticline in the south, Holor anticline in the east and Gavarzin anticline in the north. In spite of the other folds which axes directed from north- east to south- west, Gavarzin anticline axis directed from north- west to south- east(figure 1). Gavarzin gas reservoir is situated in this anticline.
Surface geology of island consists of quaternary soft deposits and soft to hard older rocks. Quaternary soft deposits are including sand dunes, beach sands, salt flat, mud flat, and sandy and silty alluvium and rocks usually are including sandstone, siltstone, marl and limestone. Airport, Gavarzin, Soheili, Baghbala, Golenakhl, Rigou, Jijian, Shotormorgh and masen stations are located on soft quaternary deposits, Gas station is located on marl and other stations are situated on relatively hard rocks like sandstone.

3. DATA PROCESSING

Fourier amplitude spectra and horizontal/vertical ratio were analyzed for every one hour record by using Geopsy software, with the smoothing procedure of Konno and Ohmachi (1998), using a b-value of 40. Figure 2 and 3, respectively; show Fourier amplitude spectra of Z component and H/V ratio for tow stations including Gas station which located over gas reservoir and Airport station.

Assessing the amplitude spectrums show 4 main peaks under frequencies less than 7 Hz in Gas station which can be seen in all other stations (figure 4), including peaks between: 0.1 to 0.3 Hz, 0.5 to 1.5

Hz, 3 to 4 Hz and 6 to 7 Hz. In the next parts, these peaks were analyzed to find out the source of them and probably relation between ambient noises recorded in Gas station and gas reservoir.

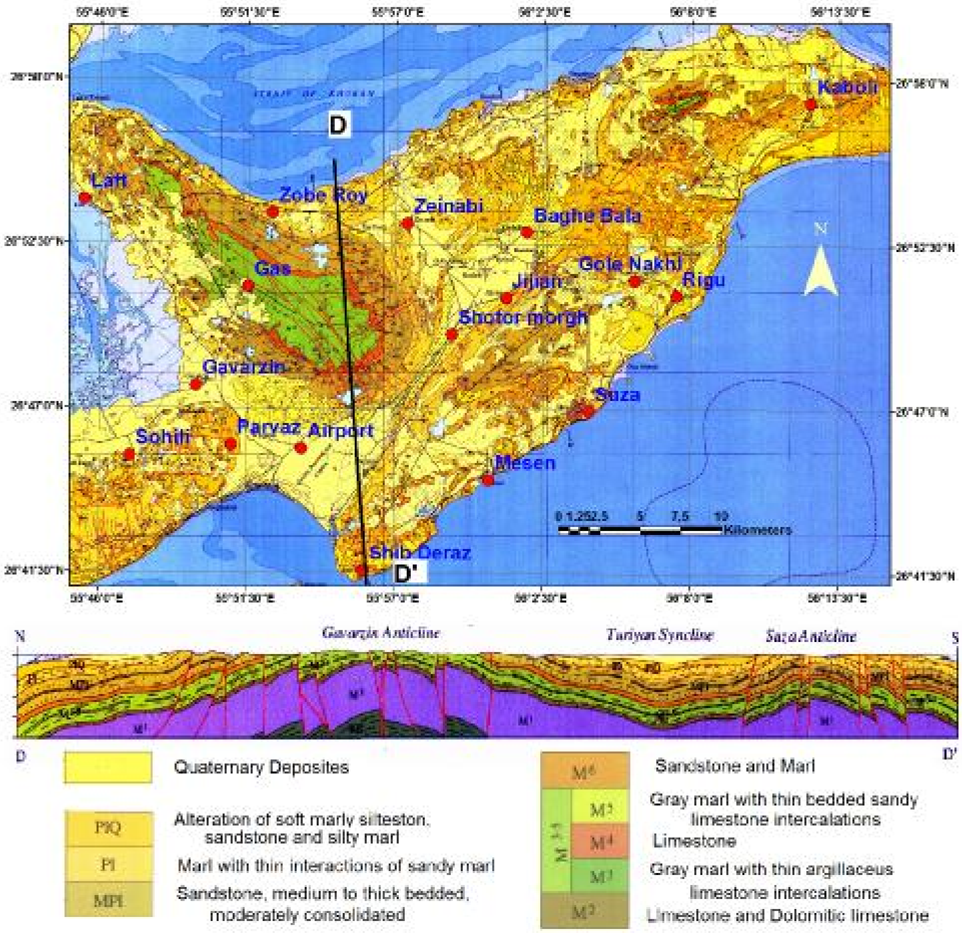

Figure 1. Geological map of Qeshm Island, geological section of Gavarzin anticline and location of stations (geological map prepared by Haghipoor et al, 2005).

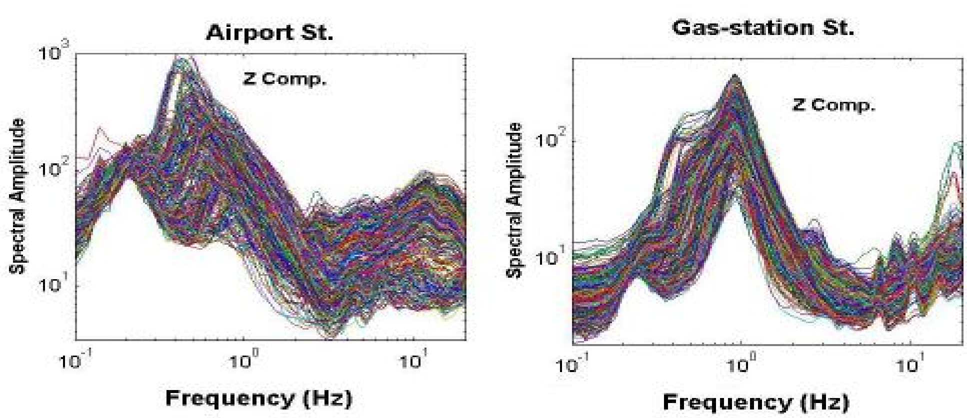

Figure 2. spectral amplitude of Z component for tow stations: Air port and Gas stations (located over gas reservoir). Analyses were done for 407 hour and every hour separately

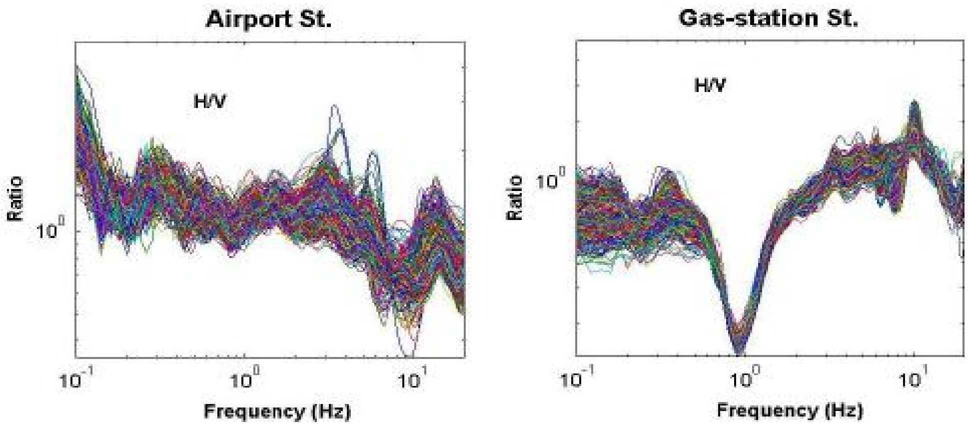

Figure 3. Horizontal/vertical ratio for tow stations: Air port and Gas stations (located over gas reservoir). Analyses were done for 407 hour and every hour separately

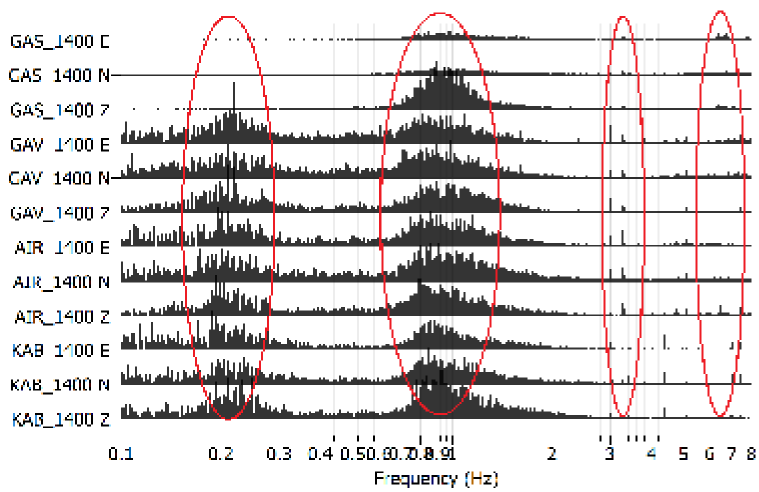

Figure 4. Frequency- amplitude of 4 stations and 4 main peaks of amplitude. For Gas station, peak in 0.2 Hz can not been seen but filtering the frequencies higher than 0.5 Hz shows a clear peak.

4. FREQUENCIES BAND BETWEEN 0.1 TO 0.3 HZ

As shown in figure 2, in the frequency range 0.1–0.3 Hz, the noise spectrum is dominated by a strong and easily recognizable peak at 0.2 Hz. This peak is called the double-frequency peak (Longuet-Higgins 1950). It is believed that this double-frequency microseism occurs as a result of the non-linear interaction between two ocean swells with the same frequency, propagating in opposite directions (Longuet- Higgins 1950; Kedar and Webb 2005; Tanimoto 2007; Webb 2007).

We extracted the amplitude of this peak for every one hour record for all stations and drew amplitude variation in time to compassion Gas station with others (figure 5). As shown in the figure, amplitude of peaks for Gas station changes by time like other stations and this suggests one source for all peaks observed in frequencies around 0.2 Hz. Gas station records have lower amplitudes rather than other stations because the velocimeter used in this station has lower response for frequencies less than 1 Hz.

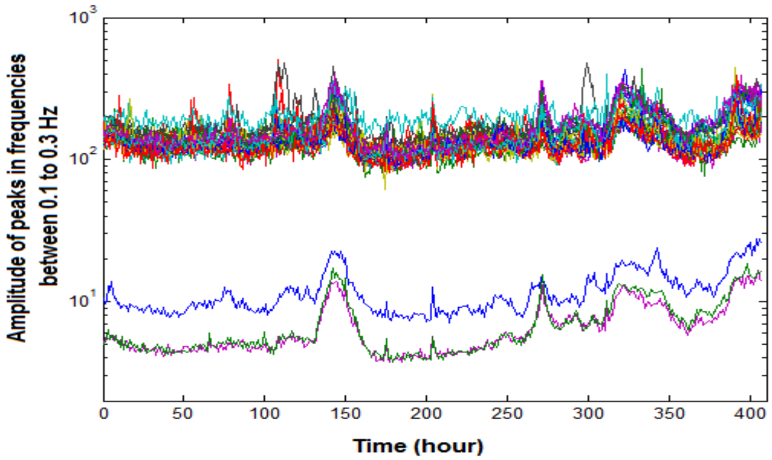

Figure 5. Amplitude variation of peaks over time for frequencies between 0.1 to 0.3 Hz for all stations. The three curves with low amplitude recorded in Gas station over gas reservoir.

5. FREQUENCIES BAND BETWEEN 0.5 TO 1.5 HZ

In the frequency range 0.5 – 1.5 Hz, the spectrum is dominated by a very high energy waves which has a clear peak around 1 Hz for all stations. As can be seen in figure 3, H/V ratio in 1 Hz for gas station shows a sharp and clear downfall. Testing the seismometer located over reservoir in other places shows that the Z component has a stable instrumental noise in 1 Hz. In this frequency band, amplitude of peaks also changes by time in the same pattern for all stations and it suggests a single source for all of them (figure 6). In the figure 6, green curve shows wind speed variation. As can be seen, variation of wind speed and microtremor amplitude usually has a similar pattern.

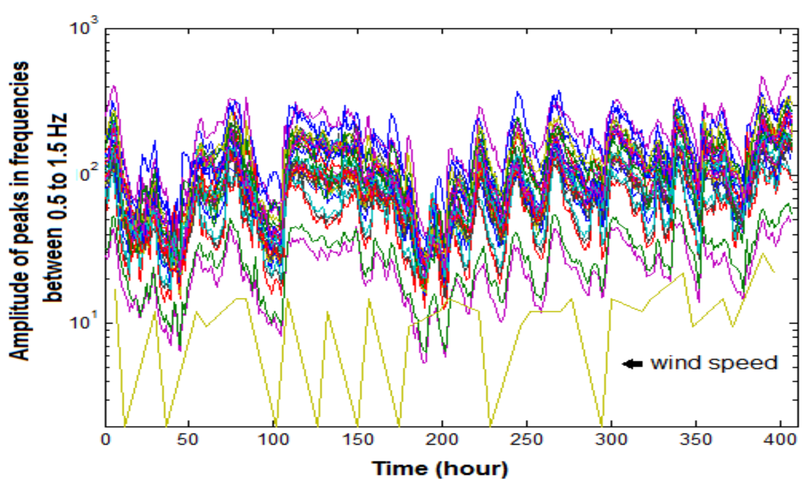

Figure 6. Amplitude variation of peaks over time for frequencies between 0.5 to 1.5 Hz for all stations and wind speed variation. Wind speeds are in (m/s).

Here, average amplitude of peaks for 14 day records of every station except Gas station which had not acceptable response in frequencies less than 1 Hz calculated and isomap of them prepared (figure 7). As can be seen, amplitudes decreased from south-east to north-west. Then, probably, observed peaks around 1 Hz must be generated by sea waves which are raised with wind and strikes to the southern coast of Qeshm island.

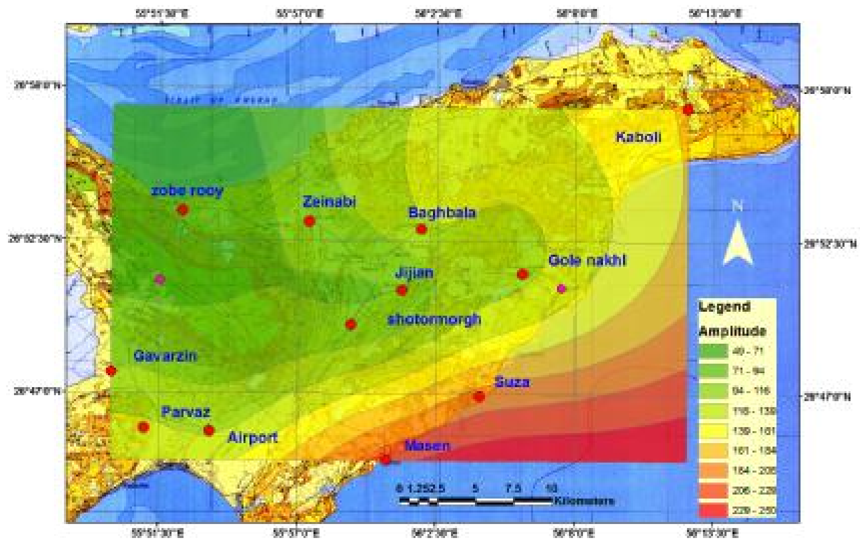

Figure 7. Isomap of average amplitude of Z component for 14 days record in 12 stations.

5. FREQUENCIES BAND BETWEEN 3 TO 4 HZ AND 6 TO 7 HZ

In these frequencies, two peaks can be seen in the all stations. Here, time- amplitude curves of peaks for 14 days prepared which are presented in figure 8. As shown, during the daytime strong microtremor signals consistently appears, whereas during the night only weak microtremor signals were detected. The strong diurnal variation in the microtremor signal suggests that the source responsible is possibly related to the noise caused by the coupling of anthropogenic noise which is minimum at night due to the cyclical nature of cultural noise. Such daily variations in spectral amplitudes of microtremor signals have been reported in many other studies (Yamanaka *et al.* 1993; Bonnefoy-Claudet *et al.* 2006, Ali et al, 2009).

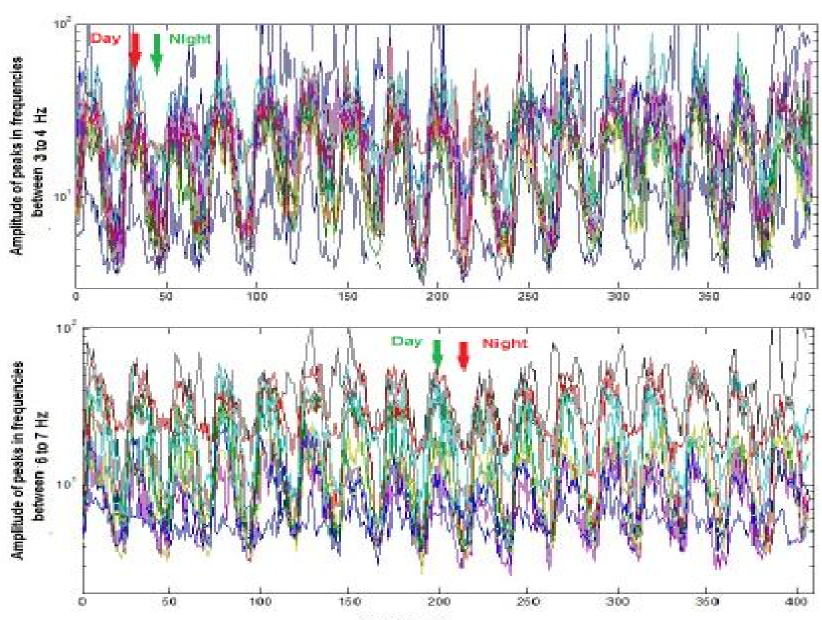

Figure 8. Amplitude variation of peaks over time for frequencies between 2.5 to 3.5 Hz (up) and 6 to 7 Hz (down) for all stations.

7. CONCLUSION

In the station over gas reservoir, 4 main peaks of amplitudes were observed which existed always notwithstanding amplitude of peaks with different frequencies changed in time. Comparing the amplitudes variation of main peaks in the station over gas reservoir with other stations, showed they change in a similar pattern in all band of frequencies. Study shows signals in frequency between 0.5 to 1.5 Hz generated by sea wave which themselves were raised by wind and signals in frequency band 3 to 4 and 6 to 7 generated by cultural noise because amplitude of them have a diurnal variation pattern. Base on these observations, it seems that there are not relation between ambient noise and hydrocarbon reservoir in our study area.

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