TEMPORAL VARIATION OF V_P / V_S AS A PREQURSORY IN AUGUST 11 , 2012 AHAR – VARZAQHAN EARTHQUAKE

Zari BORDBAR
Expert, Institute of Geophysics, University of Tehran, Tehran, Iran
zbordbar@ut.ac.ir

Mohammad Reza HATAMI
Assistant Professor, Institute of Geophysics, University of Tehran, Tehran, Iran
mrhatami@ut.ac.ir

Amin ABBASI
Researcher, Institute of Geophysics, University of Tehran, Tehran, Iran
amabbasi@ut.ac.ir

Keywords: Ahar-Varzaghan Earthquake, Ratio of Shear and Compressional Wave Velocities, Earthquake Prediction

ABSTRACT

On August 11, 2012, two earthquakes of Mw = 6.5 and Mw = 6.3 took place in part of the Western Alborz seismotectonic province, Ahar-Varzaqhan region.We processed the phase data recorded in 8 seismic stations during 2006-2012 using Wadati method. Temporal variations of Vp/Vs were studied as a tool in earthquake precursory researches in these earthquakes. We impose a number of restrictions on the computation. The number of stations involved in this process is more than 3 and recorded earthquakes with M ≥ Mc. Under these restrictions, the study shows that Vp/Vs in and around Ahar-Varzaqhan study area normal-low-normal process a few months before main shock occurrence.

INTRODUCTION

Changes in vp/vs ratio of a region, can be used as precursor of earthquake occurrence (Whitcomb at al., 1973). A great deal of research has been done on the subject of the speed of seismic waves because the speed of waves is sensitive to stress changes and the characteristics of earth cracks. several case studies with using the arrival time data had been done in the 1970s (Semenov, 1969, Aggarwal at al., 1973, Whitcomb at al., 1973, Robinson at al., 1974). Vp/Vs as an important physical parameter reflects the characteristics of the upper crust in the study area (Lee, 1981). Zhou and Han, 2004 showed that the incidence of fractures caused changes in Vp/Vs. The changes for earthquake prediction accuracy is highly dependent on the reading phase error.

These changes can be the result of the parameters revealing from the change in existing tension in the region before the earthquake (Rainer et al., 2006). Wang et al., 2008 studied changes before and after the earthquake of July 4, 2006 Van An, China at 4 stations. Changes have been reported approximately one year before the earthquake, normal, and then drop back to normal in 4 stations.

WAVE VELOCITY CALCULATION METHOD

Japanese seismologist, invented Wadati method in 1928 for the direct calculation of Vp/Vs from earthquake source to earthquake seismic recording stations on the surface.They are using a linear relationship between the arrival time direct wave P and the arrival time difference S-P wave. Wadati method is useful for areas with dense seismic network.
For ideal homogeneous elastic media: P-wave velocity, Vp, and S-wave velocity, Vs, are related to Poisson's ratio of media , σ, Young's modulus, E, elastic constant of media, μ and medium density, ρ, as follows (LI, 1981).

$$V_P = \sqrt{\frac{E}{\rho}\left[1 + \frac{2\sigma^2}{1-\sigma-2\sigma^2}\right]} \quad (1)$$

$$V_S = \sqrt{\frac{E}{\rho}\frac{1}{2(1+\sigma)}]} \quad (2)$$

$$\frac{V_P}{V_S} = \sqrt{\frac{2(1-\sigma)}{1-2\sigma}} \quad (3)$$

Equation (3) shows that Vp/Vs is a function of Poisson's ratio σ, and it mainly reflects the variation in Poisson's ratio of the upper crust.

DATA AND ANALYSIS

The temporal variations of this parameter, as a tool in earthquake precursory researches in part of west Alborz seismotectonic zone, before two earthquake on Aug 11, 2012, Mw=6.5 and Mw=6.3 were studied. Earthquakes occurs in the study area (45.73 - 47.26°E and 37.57-39.42°N) from 01/01/2006 to 09/22/2014 with Mn ≥ 3, recorded by Iranian Seismological Center, Institute of Geophysics, University of Tehran (figure 1).

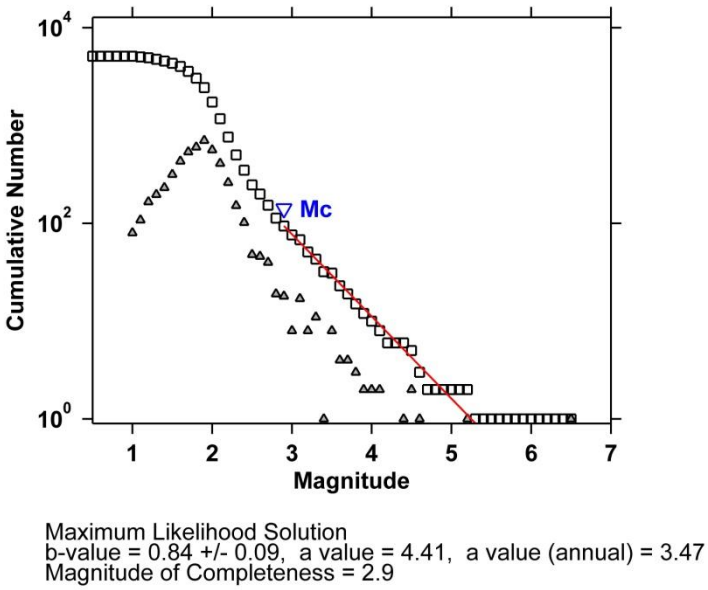

Figure 1. A Cumulative number of earthquakes, excluding clusters, as a function of magnitude for the study area during 01/01/2006 to 09/22/2014 (Mn ≥ 1.5). The minimum magnitude of completeness is 2.9.

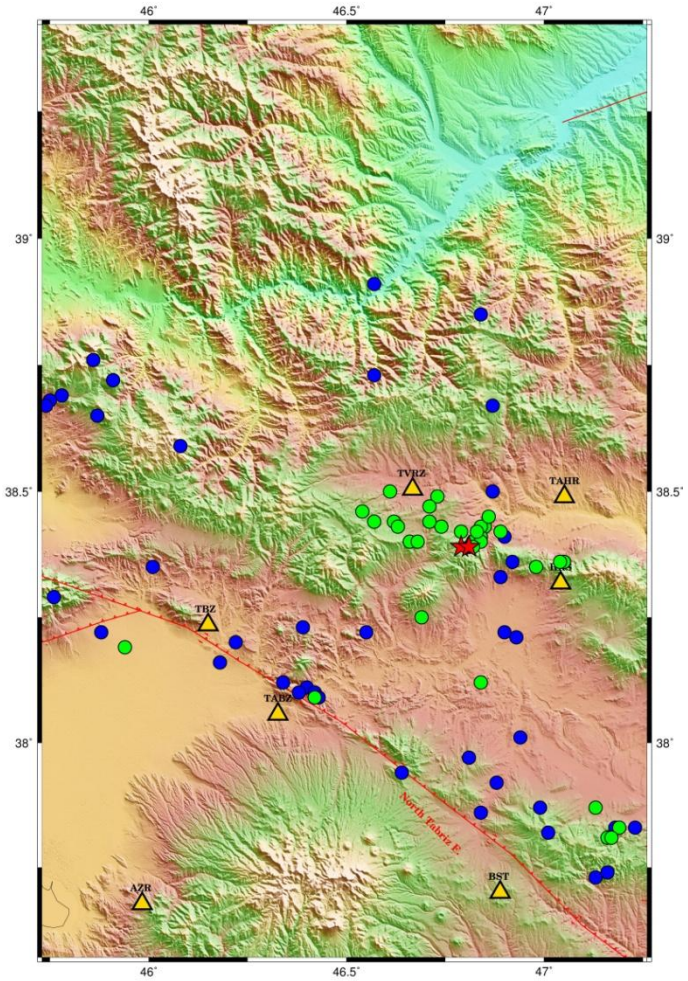

Figure 2. All events with Mn ≥ 3 occurred from 01/01/2006 to 09/22/2014. Earthquakes before main shock are shown by blue sign and Earthquakes after main shock are shown by green sign.

The diagram of the Vp/Vs time variation plotted in two time period 2006 to 2012 and 2010 to 2012.

Figure 3 shows the time fluctuations of velocity ratio using Mn ≥ 3 , 2006-2012. This figure shows normal-drop-normal variation before earthquake occurrence. Vp/Vs comes to 1.57 a few months before the main shock. The value is less than normal value i.e. 1.73. After earthquake occurrence this ratio will increase to 1.75. Figure 4 shows the time fluctuations in shorter interval between 2010 to 2012. This value goes to 1.57 or less than 1.73 (normal value) beginning from a few months before incidence of the earthquake to the moment of it. This value gradually increases and returns to 1.75 after the incidence.

CONCLUSIONS

According to seismicity of this region continues monitoring of this wave velocity ratio by dense local stations and appropriate azimuthally cover in recording earthquake events, changing in this ratio before and after earthquake occurrence can act as a precursor in region and may be help for earthquake prediction. By accurate data possessing in this manner (well spatially and temporally located events M ≥ 2 by well distributed and sufficient stations) more certainty short time windows before and after earthquake happenings may be achieved, The fact that is hardly possible in our case studies.

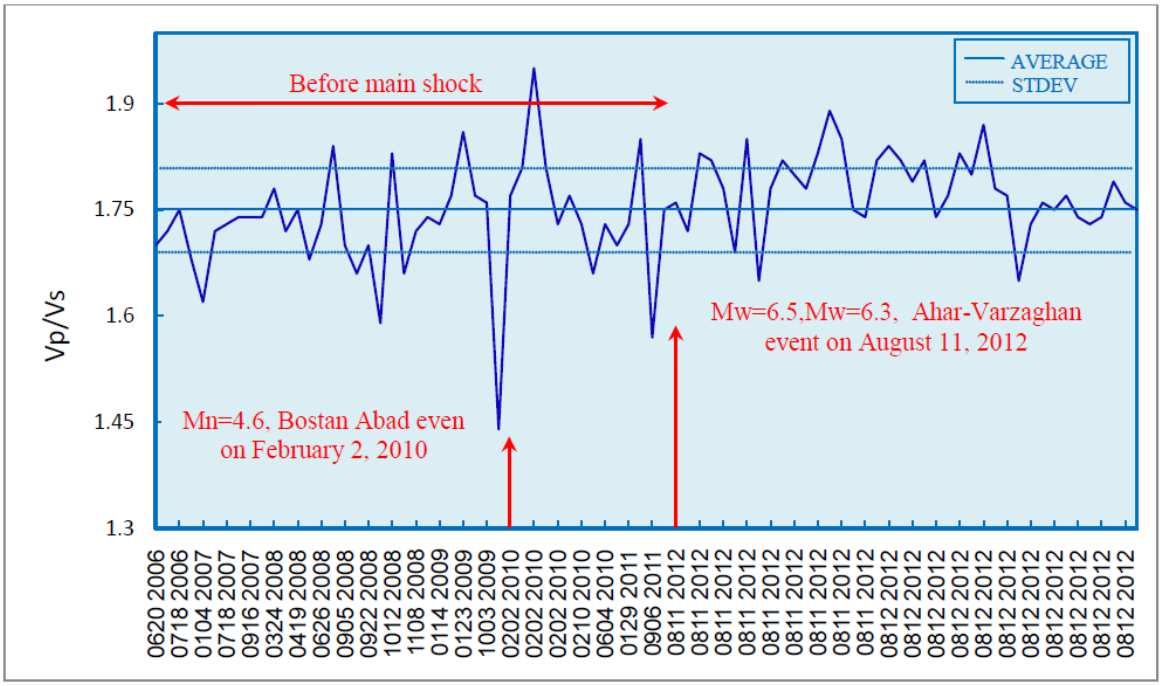

Figure 3.Temporal variations of Vp/Vs ratio, Mn ≥ 3, 2006-2012. Reduces of this ratio has shown before Mn=4.6 Bostan Abad and Mw=6.5, Mw=6.3Ahar-Varzaqhan earthquakes.

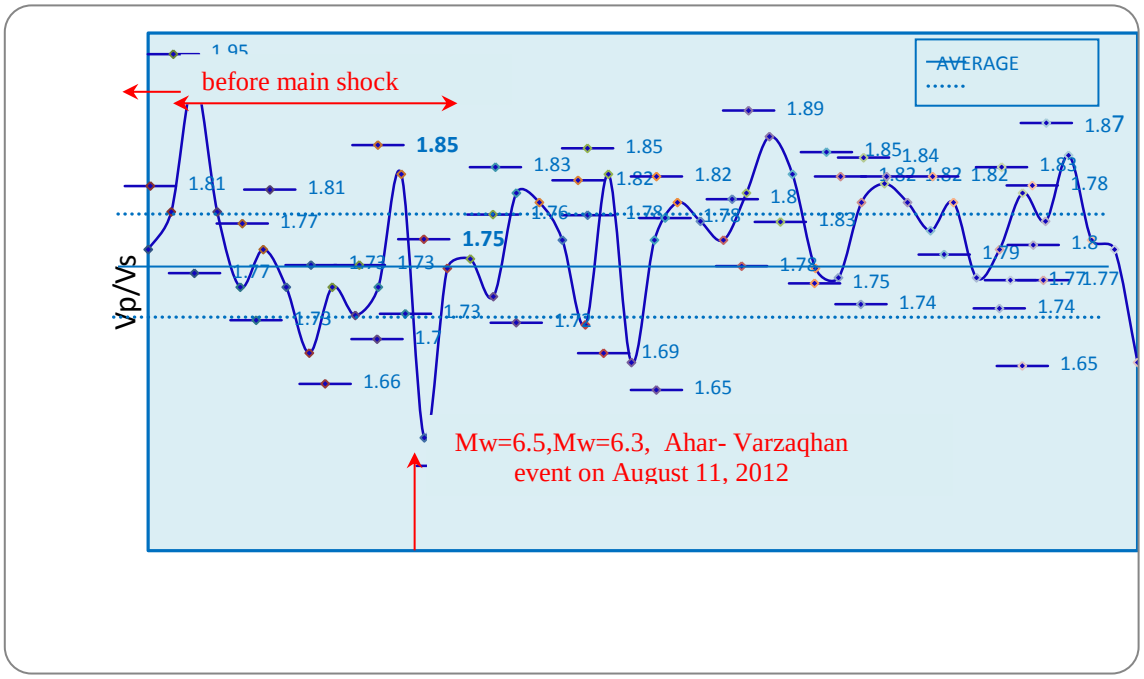

Figure 4. temporal variation of Vp/Vs ratio 2010-2012. Mn ≥ 3.
Reduces of this ratio has shown before Mw=6.5, Mw=6.3Ahar-Varzaqhan earthquakes.

REFERENCES

Aggarwal YP, Sykes LR, Simpson DW And Richards PG (1975) Spatial and Temporal Variations in and in P Wave Residuals at Blue Mountain Lake, New York' Application to Earthquake Prediction, *JOURNAL OF GEOPHYSICAL RESEARCH*, VOL. 80, NO. 5

Aggarwal YP, Sykes LR, Armbruster J and Sbar ML (1973) Premonitory changes in seismic velocities and prediction of earthquakes, Nature 241, 101-104

LI Shan-bang, (1981) Earthquakes in China [M]. Beijing: Seismological Press: 522-528, 566-575

Reyners M et al. (2006) Imaging subduction from the trench to 300 km depth beneth the central North Island, New Zeland, with Vp and Vp/Vs, *Geophysical Journal International*, 165 (2), 565-583

Robinson RR, Wesson RL and Ellsworth WL (1974) Variation of P-wave velocity before the Bear Valley, California earthquake of February 24, 1972, Science 184, 1281-1283

Semenov A (1969) Variatuons in the travel time of transverse and longitudinal waves before violent earthquakes. Bull. Acad. Sci. USSR, Phy. *Solid Earth*, 3: p. 245-24

Wadati K (1928a) Shallow and deep earthquakes, Geophys. Mag, 1, 162202

WANG Lin-ying1, GUO Yong-xia, LIU Fang and JIANG Chang-sheng1 (2008) Temporal Vp/Vs variation characteristics in different zones of China's Capital Circle area before and after Wen'an earthquake, ACTA SEISMOLOGICA SINICA, 21 (3), 243-257

Whitcomb JH, Garmany JD and Anderson DL (1973) Earthquake prediction: variation of seismic velocity before the San Francisco earthquake, Science, 180, 632-635