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Precursor Study by a Physical Model of the Ahar-Varzaghan Doublet Earthquakes (6.5, 6.3) 2012 at the Northwest of Iran

Introduction:

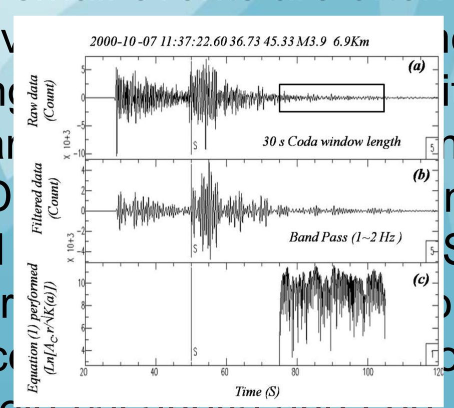
Local earthquake coda wave decay parameter, called Q coda, studying is a worldwide motivation. It is independent of local site geology and source-receiver distance and azimuth, and may be an indicator of regional tectonic activity. Geometrical spreading, scattering attenuation due to heterogeneities and intrinsic absorption due to inelastic properties of the media are some reasons to decay of wave amplitude or energy during its propagation. As summarized by Jin and Aki (1989), the coda Q^{-1} measured for many regions of the Earth (e.g., Singh and Herrmann, 1983; Jin and Aki, 1988) show a positive spatial correlation with the current seismicity of large earthquakes.

Since then, numerous papers have been published reporting changes in coda Q^{-1} associated with the occurrence of major earthquakes. In many cases, coda Q^{-1} showed a peak during a period of 1-3 yr before a major earthquake, but somewhat different patterns in other cases. In general, the value of coda Q^{-1} is relatively low during an aftershock period, and an anomalously high coda Q^{-1} is observed during the periods of seismic quiescence (e.g., Su and Aki, 1990).

Seismic coda waves of short-period *S* waves (Q_C) was estimated from local earthquakes for 4~8 Hz frequencies of the coda before doublet Ahar-Varzaghan (Mw 6.5, Mw 6.3 2012) of NW of Iran. We evaluated the attenuation of coda waves by applying the single isotropic scattering theory. We used the dataset of 36 selected events which occurred in the region and recorded by the nearest station which was deployed in the area. All events analyzed were located within the exploitation area with source-to-receiver less than 60 km.

Method:

Source and receiver collocation is the assumption of the single back-scattering model of Aki and Chouet (1975). However, in case of measurements of coda waves close to the S-wave arrival or in seismically noisy environments, the amplitudes of coda waves from small events are often below the background noise level after twice the S-wav… …ediately measurement of the coda waves after following… …ital task. This is a viable approximation for signals that ar… …nary wave (i.e., after twice the S-wave lapse-time). D… …ngs produced by local earthquakes that were selected… …Sato's (1977) model to determine coda Q_C form the ear… …ords. Sato's method, where the correction for distanc… …of geometrical spreading, was applied at both once (Novelo-casanova and Lee, 1991; Gunduz *et al.,* 1998; Wong *et al.,* 2001; Biescas *et al.,* 2007; Abdel-Fattah *et al.,* 2008) and twice the S-wave travel time (Jin and Aki, 1988; Mamada *et al.,* 1997; Baskoutas *et al.,* 2004).



Sato (1977) released the following formula under the assumptions of single isotropic scattering with source-receiver offset by the amplitude of the coda envelope A_C *(f, t)* at frequency *f* and lapse-time *t.*
where $A_0(f)$ is the source factor, *f* is frequency, *t* is lapse-time measured from the earthquake origin time, $a = t / t_S$, t_S is the S-wave lapse-time, and for $a > 1$ is the geometrical spreading factor for the single isotropic scattering model. *K(a)* contains the effect of increasing the coda-wave amplitudes at lapse-times near that of the S wave. So, we can apply an amplitude correction between t_S and $2t_S$, where t_S is the travel time of the S wave, by the term *K(a)*. By

Conclusion:

In order to monitor seismic activity, the Tabriz seismic network, comprised of eight three-component seismic stations, was installed in the NW Iran in the middle of 1996. Each station has been equipped with three short-period SS-1 seismometers with 1 Hz natural period and a 16-bit digitizer. These stations continuously recorded data at 50 samples per second. For this study, micro-earthquakes in near Ahar fault regions by HRS seismic station were selected.

Physical Model for Temporal Variation Coda Q^{-1}:

Coda Q^{-1} varies in time and space showing a correlation with seismicity. However, the spatial correlation is simple which may be considered to measure the density of fracture in the lithosphere, the temporal correlation is complex. In order to develop a physical model to account for the above observations, we shall look at the phenomena from dilatancy-diffusion model viewpoints.

This hypothesis was developed from the observation of changes in geophysical properties associated with dilatant strain in laboratory tests (Nur 1972). It was one of the first to be put forward as a physical basis for purported earthquake precursors, also assuming (implicitly) linear scaling of the physics involved from lab to field (Scholz et al. 1973). A key element of the dilatancy-diffusion model (Nur, 1972; Scholz et al., 1973) is, of course, dilatancy or opening of cracks that will reduce the pore pressure and increases the frictional strength of a fault. A greater scattering and attenuation for seismic waves, and coda Q^{-1} would increase due to the opening of cracks. Increase in frictional strength would cause quiescence like the Misasa earthquake (Tsukuda, 1988).

Conclusion:

Coda variation has been studied against time. The inherent large error of every single measurement can only be reduced by averaging over many events. Many investigators (e.g., Jin and Aki, 1988; Peng, 1989; Su and Aki, 1990) have found that the average value of coda Q becomes stable when the number of single measurements reach 10-20. In our case, we could find fewer earthquakes available for some earthquake-deficient times. So, coda measured both 7 and 11 consecutive earthquakes respectively each set sharing three and five common earthquakes with their neighbours. Also, we have studied six month average seismic activity by 1.5 months shared data from previous point. I have assigned every average to a fixed central date point, an acceptable correlation can be seen a good between coda variation and seismic activity (Fig2).
We have assigned every coda average to a fixed central date point. Then an acceptable correlation can be seen between coda variation and seismic activity (Fig2).

Due to our results, coda variation before Ahar-Varzaghan is compatible with dilatancy-diffusion model viewpoint; however, we believe additional data can improve the model for whole the region.

Acknowledgement

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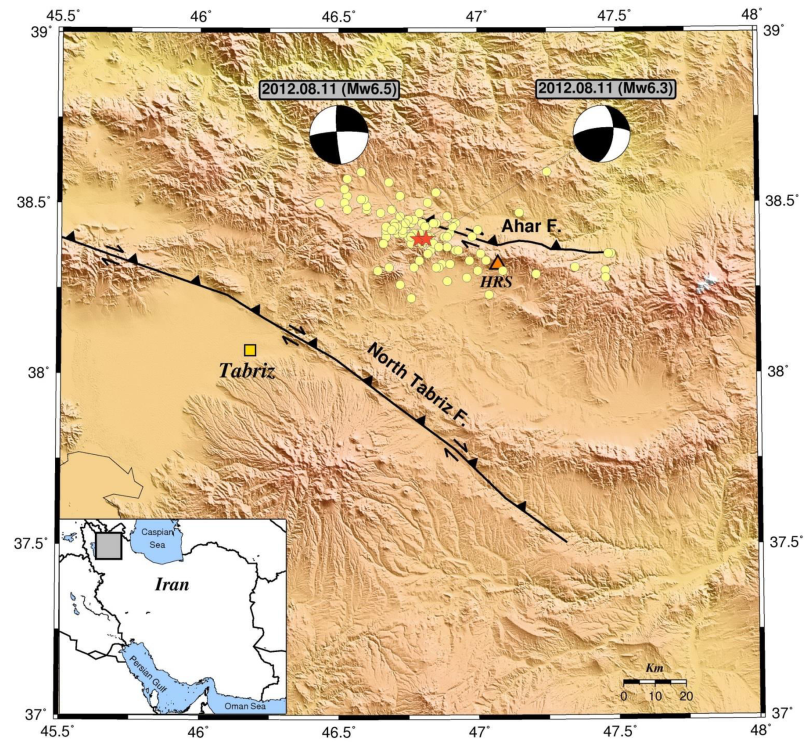

$$E(t,f) = S(f)t^{-\alpha}e^{-2\pi f t/Q_C}$$

$$\ln\left[\frac{A_C(r,f,t)r}{\sqrt{K(a)}}\right] = \ln[A_0(f)] - \frac{\pi f}{Q_C}$$