BLOT'S ENERGY TRANSMIGRATION LAW AND THE SEPTEMBER 2015 M8.3 CHILE EARTHQUAKE

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Abstract: The powerful earthquake which rocked south of Coquimbo, Chile on 16 September 2015 with a tsunami was successfully predicted by a concerted effort by International Earthquake and Volcano Prediction Center (IEVPC) and local seismologists. The initial prediction more than one year prior by IEVPC was based on the energy transmigration concept which allows to predict the delay time of earthquake energy from deep to shallow Earth. A team of local seismologists, Chilesismos, who continued monitoring short-term signals found psychrometric anomalies about one month prior and publicly warned 21 days prior to the mainshock. The Coquimbo quake prediction exercise has proven that catastrophic earthquakes are predictable if we take a right approach armed with right earthquake model and tools supported by a synergetic international cooperation. The formation of a well-funded international research organization is in order to save human lives and help mitigate damages.

Keywords: *September 2015 Coquimbo Earthquake, earthquake prediction, Blot's ET law, seismic energy convergence*

Introduction

The International Earthquake and Volcanic Prediction Center (IEVPC) has been issuing long to medium-term earthquake alerts in the last few years as part of its test program. Their major tool is the Claude Blot's (1976) energy transmigration concept or the ET law (Grover, 1998). It links the deep and shallow earthquakes, and allows to predict the time of shallow appearance 3 to 5 years before the major earthquakes hit.

Since 1973 USGS recorded a total of 44 deep (300km+) very strong (7.0+) shocks worldwide. After a few years, almost all of them had appeared at shallow depths as catastrophic earthquakes with similar or stronger magnitude (IEVPC internal data); their genetic link between the deep and shallow shocks were verified by the ET law. Today we are seeing the shallow appearance of the 2011 deep energies worldwide. The latest Chile quake is one of those examples.

All of the deep quakes, 300 km or deeper, have occurred along major deep rooted fault zones, hence they appear in the Circum Pacific region; South and Western Pacific, and South America. By analysing geological structure, the loci of shallow appearance can be roughly predicted, because we know that the deep energy transmigrates along deep fractures and is trapped in culminated structures (Choi, 2011; Choi and Kubota, 2015), although many areas especially oceanic areas are geologically poorly controlled which makes it difficult to judge in which way the energy will flow. In the Pacific coast of South America, we have clarified southward seismic energy propagation in the upper mantle and lower crust. In the Central American coast, the direction of energy movement was found to be controlled by solar cycle (Choi, 2014). Many other studies mainly by our NCGT colleagues proved the energy transmigration phenomena under the mobile belts (Tsunoda et al., 2013, and others). Today energy flow in the mantle is a well-established fact.

In the above backdrop, IEVPC analysed a strong (M7.0) deep shock that occurred near Santiago del Estero, Argentina in January 2011 (**Fig. 1**), and issued a warning in early September 2014, which was lifted at the end of December. In 2015 our study was followed up by a team of local seismologists who is properly equipped with earthquake analysis tools and concepts. The present paper briefly introduces the scientific ground which led to the announcement of the Coquimbo warning in September 2014 on the IEVPC website as one of its test programs, #004-09-01-14, www.ievp.org.

The ET law applied to a deep precursory shock

Fig. 1 illustrates the ET analysis with deep faults and energy flow direction. This figure was circulated among the IEVPC and other colleagues on 10 September 2014. For calculation purpose, based on geological

data, a hypothetical shallow epicenter was placed at the 30-35 km depth in the coast between Coquimbo and Valparaiso where NE-SW block fault crosses. The main reason of this site selection was that a large structural culmination is present in the north or the Coquimbo area, therefore the seismic energy would move into this structure and be trapped, which is a prerequisite for major earthquakes to be generated. Based on geological analysis of numerous powerful earthquakes, we have learnt that the mainshocks tend to occur at a deep fault zone bounding major structural culminations (Choi, 2011 for example). Interestingly, the actual mainshock of the September 2015 quake occurred right near this point.

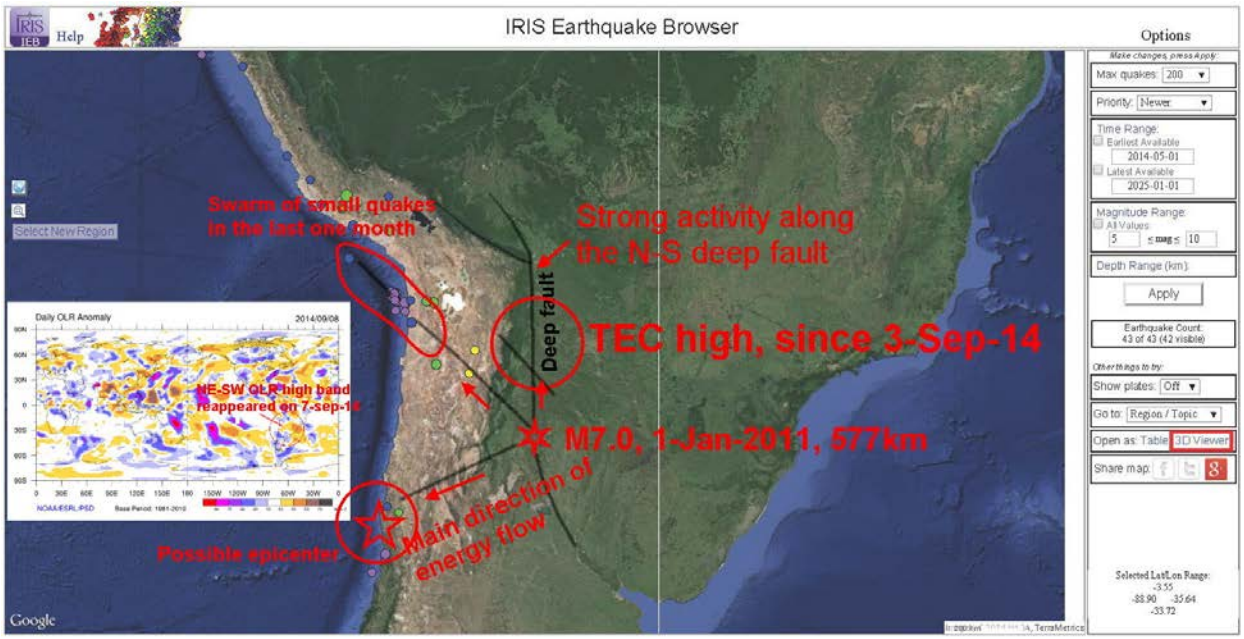

Figure 1. Deep fracture zones and energy flow of the study region. Prepared and circulated as an internal confidential document among the IEVPC colleagues and some selected researchers on 10 September 2014, almost one year prior to the actual occurrence. Base map from the IRIS site http://ds.iris.edu/seismon/.

The ET formula resulted in the following shallow appearance time:

Appearance at 20 km, 15 June, 2015
Appearance at 25 km, 27 February, 2015
Appearance at 30 km, 1 December, 2014
Appearance at 35 km, 17 September, 2014

Based on these results mainly at the depths from 30 to 35 km, IEVPC issued a first warning on 1 September, 2014 with the following parameters.

Epicenter; Coastal area between Coquimbo and Valparaiso
Magnitude: M7.0 to 8.3
Depth: 10 to 60 km
Time of occurrence: Before the end of December 2014

Southward energy flow

In analysing the Coquimbo quake, it is essential to take another energy flow into account – along the Pacific coast of the South America from north to south. This energy flow was identified by the latitude-time diagram of strong earthquakes (M7.0 or greater), **Fig. 2** (Choi, 2014).

Given the wide scatter of the M6.0 to 6.5 quakes plotted on the same diagram, this flow itself is considered capable of generating up to M6.5 quakes, but if this energy is converged with deep Earth-sourced strong energy in large culmination structures, catastrophic earthquakes can occur. The 1 April 2014 M8.0 Tarapaca quake is one of them (Choi, 2014a), and the present Coquimbo quake as well. However, the gigantic M8.8 2010 Maule quake, southern Chile was not accompanies by precursory deep shocks. Geologically the region has a major NW-SE trending Precambrian structure, Chile Rise, south of the epicenter, which forms an effective barrier. This would suggest that the southward flowing seismic energy had been trapped in the

structure for some time before the release in Feburary 2010.

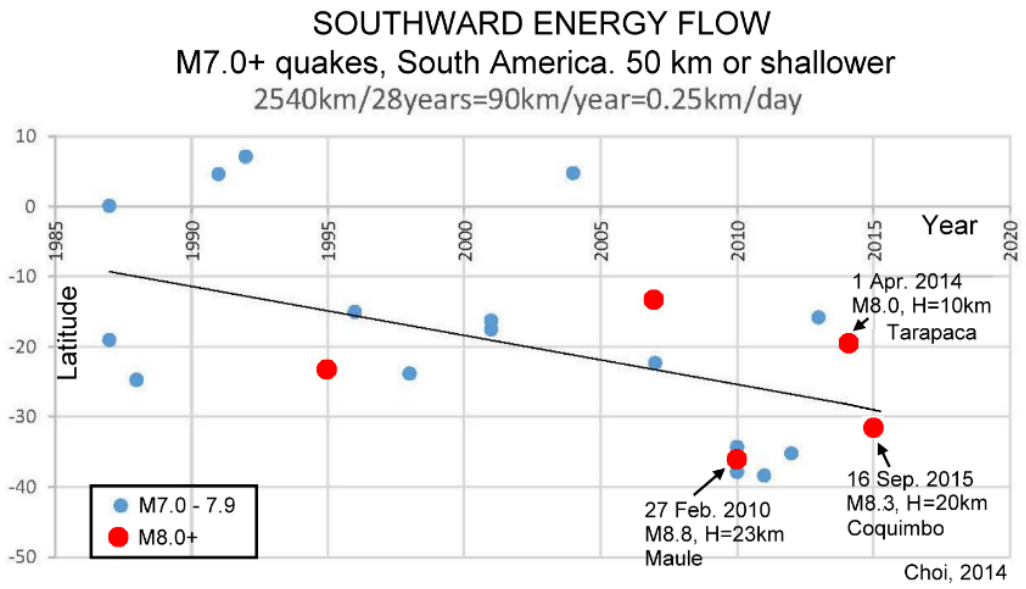

Fig. 2. Earthquake (M7.0+) latitude-year diagram along the coast of South America, suggesting the southward seismic energy flow. Original figure by Choi 2014. New data added.

Discussion

During the intensive monitoring period from September to December 2014, the study area showed a flurry of electro-magnetic activities. These data confirmed our prediction. However, the region became relatively quiet in late December, which probably was the time when most of the energy moved into the Coquimbo trap. Although the IEVPC warning was lifted in late December, the monitoring was continued by a group of local seismologists, Chilesismos, who specializes in psychrometric analysis (Césped, 2015). They found a significant anomaly in their data, and issued a warning on 26 August, 2015, which is 21 days before the main event.

The IEVPC's original prediction parameters were proven correct in terms of epicentre, magnitude and depth. However, it missed the time by nine months to one year. This delay in occurrence was partly caused by our assumption of deeper occurrence at 30 to 35 km than the actual one which was 25 km depth (USGS). An in-depth analysis of the 37 M7.0+ deep quakes from 1973 to 2011 shows the time delay from deep to shallow shocks ranges from 3 to 5 years. The current Chilean quake's time delay from deep to shallow Earth is about 4 years and nine months, which falls in the longer end of the delay. The time of shallow appearance is also affected by geological conditions of trap structures and partly galactic effects. Another possibility would include the arrival time of southward flowing energy surge, which may well be affected by solar cycles.

Conclusions

The latest Coquimbo quake has proved again that the Blot's ET concept is a powerful long to medium-term prediction tool. When it is combined with a short-term local monitoring operation guided by right earthquake models, catastrophic earthquakes can become predictable.

Together with other precursor detection tools, such as Hayakawa's (2012) VLF wave propagation analysis which has a strong proven record and been commercially adopted for some years, this Coquimbo exercise has destroyed the official myth, "No one can predict earthquakes".

This success is attributed to the multiparameter and synergetic approach adopted by IEVPC armed with a right earthquake model. In this process, a long to medium term precursory detection tool was combined with a short-term detection tool. This heralds a new birth of catastrophic earthquake prediction and international cooperation, and warrants a concerted funding base to begin saving lives around the world.

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