ANALYSIS OF EARTHQUAKE FOCAL MECHANISMS FOR GREATER AND LESSER CAUCASUS APPLYING THE METHOD OF WORLD STRESS MAP

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For investigating the present-day stress pattern, the results of focal mechanism were re-analyzed. An update stress map of the Greater and Lesser Caucasus is introduced, plotted by applying a modern method of determining orientation of main stresses. With WSM technique, 226 focal mechanisms within the period of 1953-2000 years were grouped and tectonic regime for each event was determined by applying the WSM quality ranking. The visualised results confirmed the type of the stress state-the compression stresses, acting in horizontal plane across to the extension of the structures of General Caucasus direction. It was also evidenced that in the North, the stresses are approximately normally-oriented to the mountain chain of the Greater and Lesser Caucasus.

Introduction

The earthquake-prone Caucasus region is one of the zone of the Alpine -Himalayan orogenic belt. The territory of Azerbaijan is located within the central part of the Mediterranean mobile belt and characterized by the high activity of geological processes provoked by dynamics of the Arabian and Euroasian plates. Seismicity is the severest stress-induced geohazard in the Caucasian and Caspian areas. Figure 1 illustrates event distribution map for the territories of Azerbaijan, Caucasus, Turkey, Iran, Caspian Sea and western part of Turkmenistan for the period 2000-2005.

The stress state of Earth's crust represents one of the main factors defining character of geodynamic processes. In Azerbaijan, the stress state was studied on the basis of earthquake focal mechanism researches since 1957 (Agalarova, 1969; Agayeva, 2006). The principal aim of this study is to re-analyse previous research results, to introduce new modern method of creating a focal mechanism map of Greater and Lesser Caucasus (method CASMO – Create A Stress Map Online) of WSM project initiative (Reinecker et al., 2005; Müller et al., 2005) with an aim of investigating a present-day stress pattern of the Caucasus region, and define regional stress orientations. Knowing the contemporary tectonic stress pattern in the crust, it provides insights into the plate geodynamics (Kadirov et al., 2008).

The methodical approach

The previous method is acceptable in such case when there are data about polarity of first arrivals of longitudinal waves (P-waves) for a large number of seismic stations for earthquakes with magnitude M>4. Since information about orientation of the main stress axes of some strong events operating in earthquake source is insufficient, there was a necessity for research of focal mechanism of weak earthquakes with magnitude M<4. With that aim, the methods of total definition of the source mechanism of weak earthquakes was applied. Advantage of the method is that focal mechanism solution can be done with the use of earthquakes registered by around 5-7 seismic stations. For the Greater Caucasus, mechanisms of more than 150 earthquakes with M≥4 were researched (Agayeva, 2006). Figure 2 demonstrates stress concentration of earthquake focal mechanism datasets on the territory of Azerbaijan with the use of previous approach.

Since World Stress Map is the global database of contemporary tectonic stress of the Earth's crust and its uniformity and quality is guaranteed through quality ranking of the data according to international standards and standardized regime assignment, existing datasets required the application of the modern World Stress Map quality ranking system to make the data globally comparable. Due to that, it became obvious to revise focal mechanism solutions within the World Stress Map

database, investigate further focal mechanism solutions to be included in the WSM and apply WSM quality ranking data and assignment of data qualities.

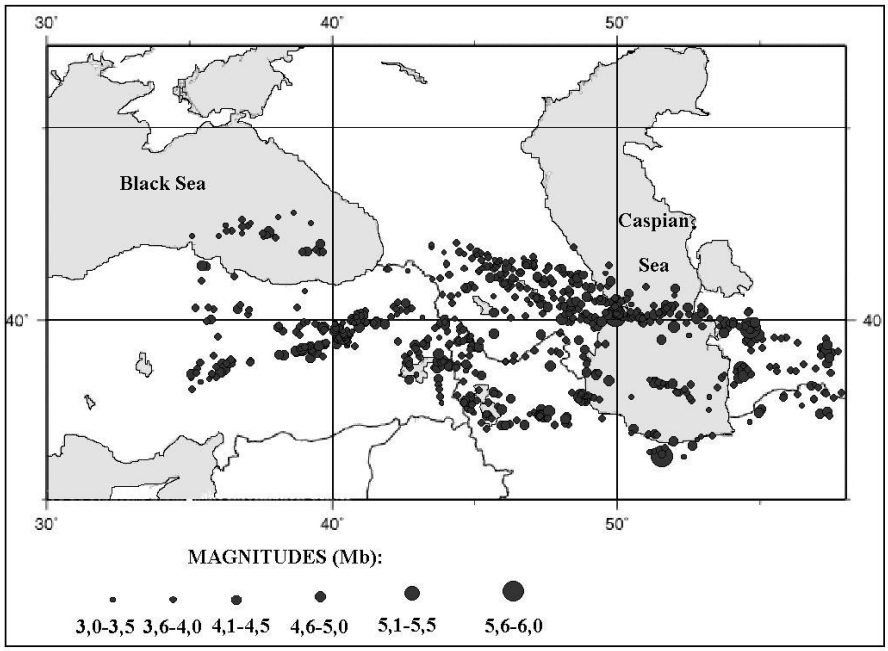

Fig. 1. Event distribution map for the whole Azerbaijan, Caucasus, Turkey, Iran, Caspian Sea and western part of Turkmenistan plotted with the data from Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) network for the period of 2000-2005.

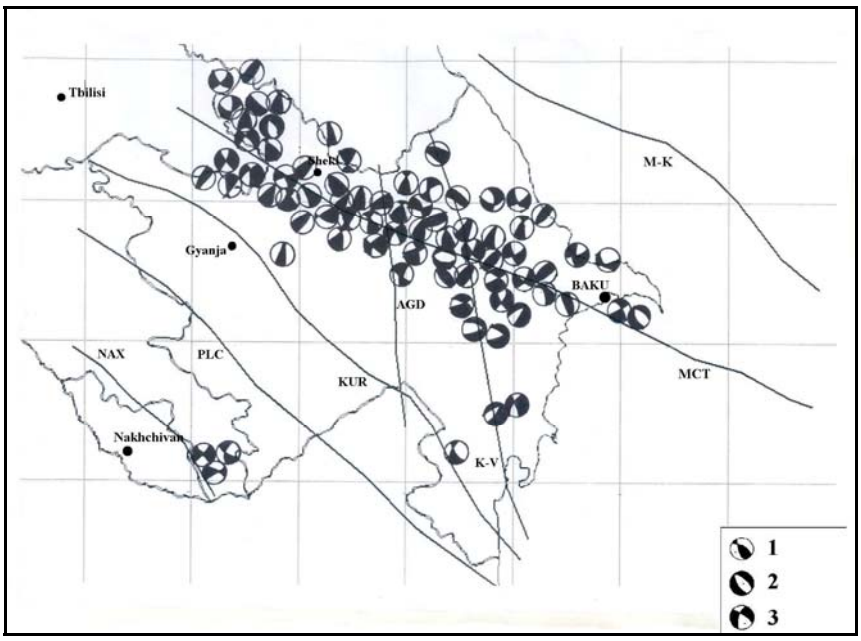

Fig. 2. Map of event focal mechanism of Greater and Lesser Caucasus (compiled by Agayeva S.T.)
M-K – Makhachkala-Krasnovodsk fault, MCT – Main Caucasus Thrust fault, K-V-Kizilagaj- Vandam fault, AGD – Agdash fault, KUR – Kura fault, PLC – Pre-Lesser Caucasus fault, NAX – Naxchivan fault.
1 – reverse fault; 2 – normal fault; 3 – strike-slip fault.
Note: tectonic basemap was compiled by Gadjiyev R.M.

The compilation of World Stress Map database with the additional 76 events was performed with the main concentration on composite, so-called grouping events, Focal Mechanism Composite (hereafter, FMC) and single events, Focal Mechanism Single (hereafter, FMS) (Heidbach et al., 2004). FMC required a careful attention, since the selection focus was mainly directed to the magnitude effect, the energy class of event and the number of stations registered an event. Among FMC events, the largest sub-event in the group was selected. In case with FMS, the selection was easier, mainly concentrating on the mainshock as WSM database disregards aftershocks. As a result, additional earthquake focal mechanisms were analysed (Sikharulidze et al., 1983) and added to the database, which contains 226 focal mechanism data altogether. For all of these data, the tectonic regime had been determined and the WSM quality ranking technique was applied (Table).

Figure 3 shows the updated focal mechanism map for 76 additional events of the Greater and Lesser Caucasus. The majority of stress data in the South Caucasus is of thrust faulting tectonics with NNE (North-North-East) trending horizontal compression in the western part of the South Caucasus and ENE (East-North-East) trending stress orientations in the easternmost Caucasus.

Properties of Focal Mechanism Solution (FMS) of Lesser & Greater Caucasus between 1953-2000 years.

Type of FMS	Definition	Number
NF	Normal Faulting	67
TF	Thrust Faulting	103
SS	Strike Slip	46
NS	Normal fault with Strike-slip component	4
TS	Thrust fault with Strike-slip component	6

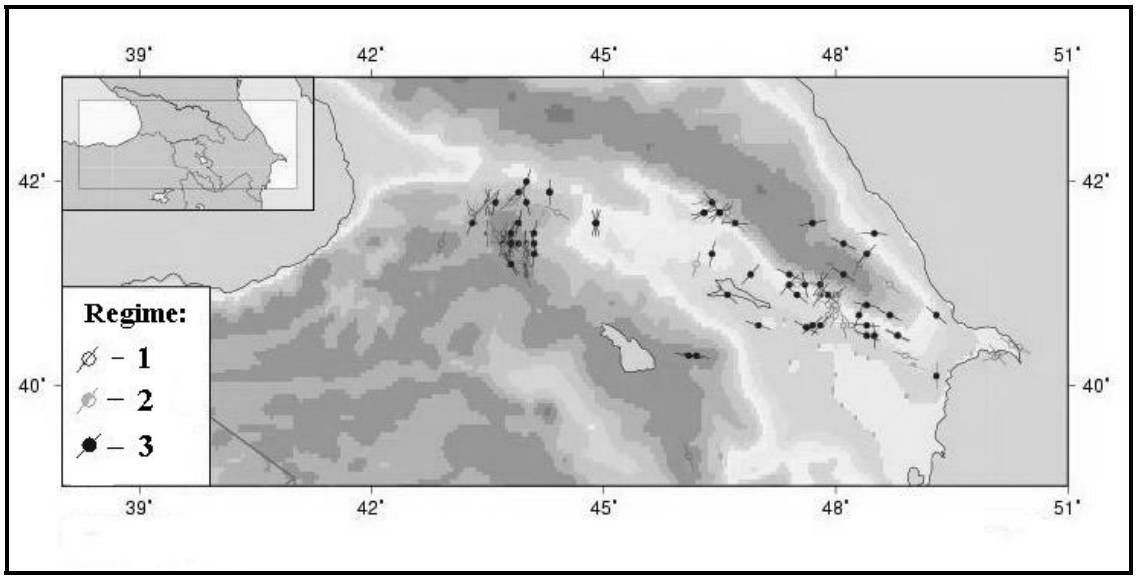

Fig. 3. Stress Map of the Greater and Lesser Caucasus (compiled by Babayev G.R.).
1 – Normal Faulting; 2 – Strike-Slip Faulting; 3 – Thrust Faulting.

Discussion

On the basis of focal mechanism research, it is determined that Greater and Lesser Caucasus is characterized by horizontal compression stress across to the regional structures of general Caucasus direction. New data entries of CASMO (WSM) are characterised by thrust fault type of focal mechanism with NNE (North-North-East) trending of horizontal compression in the western part of the South Caucasus and ENE (East-North-East) trending of stress orientations in the easternmost Caucasus. In western part of Azerbaijan, compression across the Greater Caucasus is distributed between the main Caucasus thrust fault and southward dipping into thrust fault along the northern edge of the mountain chain.

Conclusions

The main conclusion of this study indicates that earthquake focal mechanisms closely correlate with visualised active faults of Greater and Lesser Caucasus. Schematic maps show consistency of present-day rates of strain accumulation on the main faults. Furthermore, the results show that under the Greater Caucasus in the North, the main stress axes are approximately normally oriented to the mountain chain. By applying a new approach of CASMO (WSM) method, it confirms the reliability of the selection methods for focal mechanism solution and proves the correct orientation of the main stress axes over the studied region. The results clearly illustrate active convergence between Lesser and Greater Caucasus with strain concentrated along the Main Caucasus Thrust Fault (Kadirov et. al., 2008). Additionally, it can be obviously traced the transformation of left-lateral strike slip motion into predominant right-lateral strike slip motion towards South from mountain ridges of Greater Caucasus.

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Reviewer, associate member of ANAS, F.A.Kadyrov