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SEISMOLOGY

VOLCANO-TECTONIC SEISMICITY IN CONTINENTAL COLLISION ZONE: EARTHQUAKE SWARMS IN GEGHAM VOLCANIC RIDGE (ARMENIA)

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Abstract

In recent years, the rapid development of temporary as well as permanent seismic and GPS geodynamic monitoring networks in Armenia has facilitated the study of deformational processes in volcano-tectonically active regions in the Arabia-Eurasia continental collision zone. In this study, we analyze five seismic swarms which occurred from 2014-2018 within a dense cluster of Upper Pleistocene-Holocene monogenetic volcanoes and active faults in the Gegham Ridge Area of Armenia. No mainshocks have been identified in these earthquake swarms, which are distinguished by frequent occurrences within relatively short time spans. Recorded data was used to improve the location accuracy and to understand the current state of the stress field in the area.

We investigate possible links between these earthquake swarms and active magmatic or geothermal processes. Such studies of earthquake swarms in the Gegham Volcanic Ridge area further our understanding of the relationship between tectonic and volcanic processes, in turn contributing to the assessment of volcanic hazards for this area. Beyond natural hazard assessment, the volcanically young Gegham Ridge also holds great potential as a geothermal energy source. Thus, our interdisciplinary research yields diverse outcomes, spanning scientific, environmental, and energy applications.

Keywords: Gegham Volcanic Ridge, volcanic earthquakes, earthquake swarms, monogenetic volcanoes

INTRODUCTION

At the present moment, limited data is available on seismic swarms that occur within young monogenetic volcanic clusters located in continental collision zones. Furthermore, compared to volcanism associated with arcs and some intraplate settings, tectonic and tectono-magmatic causes of monogenetic volcanism in collisional settings remain poorly understood. This paper aims to address these gaps in knowledge, through the case study of active volcano-tectonic processes within the Gegham Volcanic Ridge (GVR) – a dense cluster of Quaternary monogenetic vents in Central Armenia. A series of seismic events, comprised of five distinct earthquake swarms, recently occurred within the GVR between 2014 and 2018, near the western part of Lake Sevan (tab. 1). These events occurred with relatively high frequency, often separated by only one to three days, during swarms lasting about 15 days. The swarms are spatially associated with young volcano clusters and active fault zones.

Table 1

Seismic swarms occurred in Gegham volcanic ridge, during 2014-2018.

Date	**Number of events**	**Min. Magnitude (M_l)**	**Max.Magnitude (M_l)**
June 2014	30	0.1	1.0
April 2015	180	0.5	3.4
March 2016	85	0.2	1.7
June 2017	43	0.1	1.0
June 2018	37	0.6	1.9

The permanent seismic network of the Institute of Geological Sciences of Armenian National Academy of Sciences (IGS) is an initiative implemented in close collaboration with the Department of Geosciences of National Taiwan University since 2012. Further development of the seismic network of IGS, data from which used in this paper, is related to Caucasus TRANSECT International project funded by US Department of Energy (32 temporary stations in Armenia, 2018-2022). Swarms listed in Table 1 are the first sequences reported since the installation of permanent seismic stations in the area.

In this study, we perform a detailed analysis of recent earthquake sequences within the GVR. Through precise location of these sequences, earthquakes can be linked to known geologic, volcanological, and seismotectonic local settings, allowing for more accurate interpretation of the observed seismic clustering. This study will facilitate development of conceptual models of active volcano-tectonic processes within the GVR. Geologic evidence indicates the possibility of future volcanic activity within the GVR, and that spatially distributed monogenetic volcanism within the ridge poses a significant threat to the infrastructure and population in the area, including the Yerevan, Ararat and Sevan basins (Meliksetian et al., 2015). Current seismological study, based on detailed analyses of seismic swarms, is critical for estimating volcano-tectonic activity in the region.

GEOLOGICAL BACKGROUND

The Anatolian-Armenian-Iranian highlands represent a tectonically and volcanically active orogenic plateau, which formed through the continental collision of the Arabian and Eurasian tectonic plates during the Late Eocene to Early Miocene (~35–25Ma), and subsequent break-off of the north-dipping Southern Neo-Tethys oceanic slab beneath the Bitlis and Zagros sutures during the Mid to Late Miocene (~15–10Ma) (Keskin et al. 2003, Allen and Armstrong 2008, Zor 2008, van Hunen and Allen 2011, McQuarrie and van Hinsbergen 2013, Skolbeltsyn et al. 2014, Neill et al. 2015, Meliksetian et al. 2015). This activity resulted in orogenic uplift associated with long-term, widespread volcanism as seen today in Armenia which contains four Quaternary stratovolcanoes and 516 monogenetic vents and rhyolite domes within the country borders, ~30,000 km^2.

The tectonic setting of Armenia and the surrounding region is characterized by its SSW-NNE trending stress state linked to the ongoing N-NE movement of the Arabian Plate and interaction with the Eurasian plate (Allen and Armstrong, 2008, Philip et al., 1989). GPS data shows that the Arabian Plate moves northward at approximately 17mm/year (Reilinger et al. 2006, Vernant et al. 2004), (fig.1).

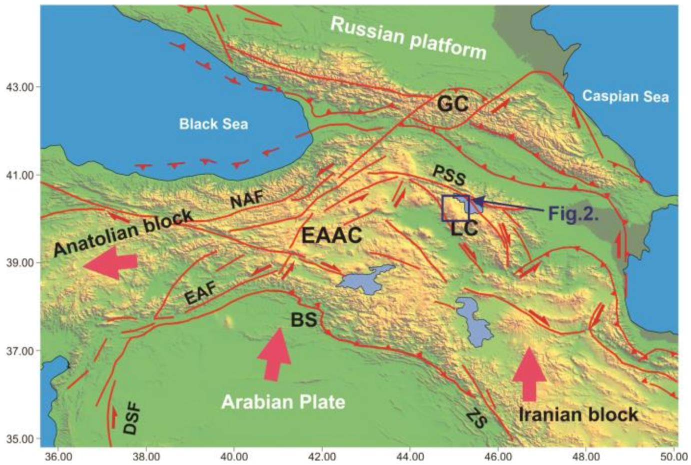

Fig.1. Tectonic units and faults in and around Armenia (after Karakhanyan et al., 2003, Philip et al., 1989, Avagyan et al., 2010). Key: North Anatolian fault (NAF), East Anatolian fault (EAF), Dead Sea fault (DSF), Bitlis suture (BS), Zagros suture (ZS), Pambak-Sevan-Syunik fault (PSS), Greater Caucasus (GC), East Anatolian accretionary complex (EAAC), Lesser Caucasus (LC). Blue square shows location of Gegham volcanic ridge and borders of the maps of fig. 2.

Internal deformation of the collisional plateau mostly occurs along strike-slip fault systems at rates of about ≤2mm/yr (Karakhanyan et al. 2013). The regional seismicity in the Lesser Caucasus Range is represented by strike-slip faulting with either reverse or normal slip components (Karakhanian et al., 2004). Recent active deformation in the region, characterized by strike-slip tectonics, is locally associated with transpression or transtension (Ritz et al., 2015, Karakhanyan et al, 2017). The study area, Gegham Volcanic Ridge, is located between two segments of major active faults in Armenia: the Pambak-Sevan-Syunik Fault (PSSF) and the Garni Fault (GF) (fig.2). The PSSF— the major active fault system within the territory of Armenia— is an approximately 400-km-long NW-SE trending right-lateral strike-slip fault with a horizontal slip rate between 0.5 and 3mm/yr, based on current geological estimates, and within 2±1mm/yr, based on GPS measurements (Avagyan 2001, Philip et al. 2001, and Karakhanyan et al. 2013). The NW-SE trending Garni Fault is located W-SW of the GVR.

ACTIVE TECTONICS AND VOLCANISM OF GEGHAM VOLCANIC RIDGE

The tectonic setting described above provides a unique opportunity to study volcano-tectonic interactions within a dense cluster of monogenetic vents in a collisional setting, on regional, sub-regional and local scales. The GVR in central Armenia is one of the densest clusters of individual monogenetic volcanoes in the world. It contains 127 Quaternary volcanic vents (mostly Mid to Late Pleistocene and Holocene) within a 65-km long and 35-km wide oval-shaped area of ~2100km^2 (fig.2).

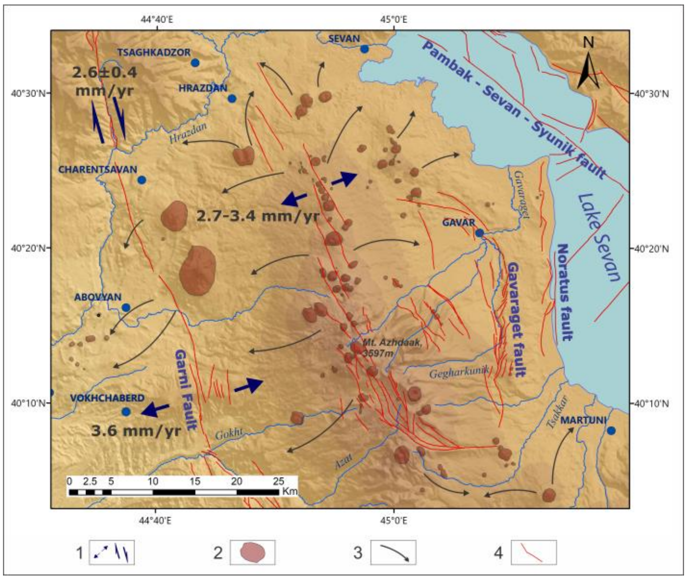

Fig.2. The volcano-tectonic setting of Gegham Volcanic Ridge (after Karakhanyan et al., 2004). 1. Strike-slip and GPS monitoring based extension rates; 2. Volcanoes; 3. Primary directions of basaltic-andesitic lava flows; 4. Active fault systems.

The orientation of volcano clusters within the GVR is largely NW-SE, perpendicular to the major regional SW to NE stress direction. Volcano-tectonic settings of the GVR are shown in fig.2, and suggest noteworthy links between observed seismic and volcanic activity. Karakhanyan et al. (2002) and Avagyan et al. (2005) relate Gegham Ridge volcanism to a pull-apart zone, formed between the PSSF and GF systems (fig.2).

Compositionally, Gegham Ridge volcanism varies from trachybasalts to rhyolites, while dacites are absent. Most monogenetic vents are trachybasaltic, basaltic-trachyandesitic and trachyandesitic in composition, and are characterized by strombolian to violent strombolian eruption types. Several rhyolitic domes exist within the ridge, namely Gutansar and Hatis in the west and Spitaksar and Geghasar in axial part. Volcanoes within axial part of the ridge exhibit clear alignment with the GVR crest, and range in elevation from 3200-3500m. The normal faults that dominate the Gegham ridge converge in a single zone south of the GVR, near the Armagan volcano (shown on fig 3, lava flow unit 2-9) and form a large "horsetail splay" structure (Karakhanyan et al. 2003).

The timing of volcanism within the GVR spans from the Late Miocene (Baghdasaryan and Ghukasyan, 1985) through the Holocene, with the most recent indication of volcanic activity dating back to 4500-4400 BP (Karakhanyan et al. 2003, Karakhanyan et al. 2002) or 3450 BP (Avagyan et al., 2020). It is noteworthy that in the late Miocene to Early Pliocene, a large caldera complex existed within the current GVR, as is demonstrated by the presence of the Vokhchaberd volcanoclastic suite, which is up to 500m thick in some locations. Later, during the Quaternary period, the GVR transformed into a dense cluster of spatially distributed monogenetic vents, and the area was covered by sequences of lava flows (fig.3). Such a transition from stratovolcano to monogenetic activity may indicate changes in local tectonic settings and the conditions of magma generation. Many generations of extended lava flows, Mid-Upper Pleistocene in age, originated from volcanoes in the GVR. They are distinct throughout the canyons of Hrazdan and Azat rivers, and in the western part of Lake Sevan.

ACTIVE FAULTS OF GEGHAM VOLCANIC RIDGE

On the western shore of Lake Sevan, the Gavaraghet fault system is oriented NNW-SSE and consists of three major normal faults branches, each with a length of 25-30 km (fig.2), as well as horst and graben structures (Karakhanyan et al. 2016).

The Gavaraghet Fault stretches from the town of Gavar in the north to Gegharkunik village in the south. South of Gavar, the fault splits into two branches – the western Saroukhan-Lanjakhpiur branch and the eastern Karmirgiugh branch. South of Gegharkunik village, these two branches merge. This fault zone geometry creates a meridian-elongated structure of ramp-graben type.

Motion along the fault kinematically corresponds to normal faulting with a small strike-slip component, where the fault changes its orientation with respect to the regional stress field (Karakhanyan, et al. 2016, Avagyan, 2017). Maximum vertical displacements of up to 200m have been recorded on the eastern branch. Data from GPS monitoring conducted in the area has provided preliminary results indicating extension at rates of 2.75-3.4mm/yr in the central cluster of the GVR, and 3.6mm/yr along the Garni Fault of the neighboring

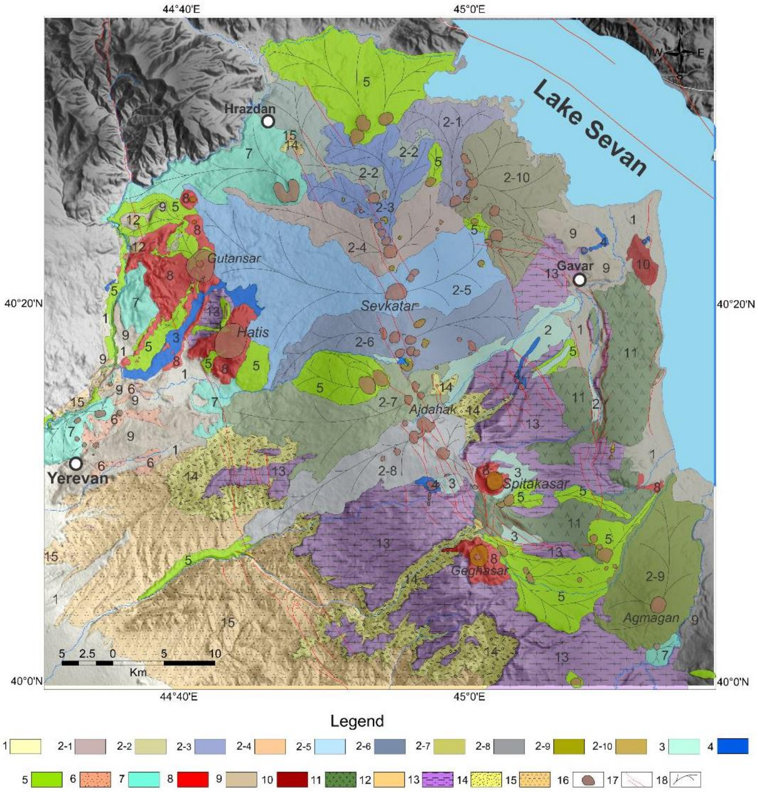

Fig.3. Volcanological map of Gegham Volcanic Ridge (by K. Karapetyan, S. Karapetyan, G. Navasardyan; active faults are from Karakhanyan et al., 2017). Legend: Upper Pleistocene-Holocene. 1. Alluvial and colluvial sediments. 2. Basaltic trachyandesites, trachyandesites. 2-1. Lava flow of Norashenik. 2-2. Lava flows of Tsluglukh and Srbisar volcanoes. 2-3. Lava flows of Kond, Vardanasar and etc. volcanoes. 2-4. Lava flows of Mazaz and Karmratumb volcanoes. 2-5. Lava flow of Sevkatar volcano. 2-6. Lava flows of Aknocasar and Lodochnikov volcanoes. 2-7. Lava flow of Aghusar volcano. 2-8. Lava flows of Azhdahak and Nazeli volcanoes. 2-9. Lava flow of Agmagan. 2-10. Lava flows of group Eratumber volcanoes. Upper Pleistocene. 3. Glacial and fluvioglacial deposits. 4. Trachybasalts, basaltic trachyandesites, trachyandesites. Middle Pleistocene. 5. Basaltic trachyandesites, trachyandesites. 6. Ignimbrite tuffs of Yerevan-Gyumri type. Lower Pleistocene. 7. Trachybasalts, basaltic trachyandesites, trachyandesites. 8. Trachydacites and rhyolites of Gutansar, Hatis, Spitakasar, Geghasar. Upper Pliocene. 9. Doleritic basalts, trachybasalts. 10. Volcanogenic formation. Suite of Noratus. 11. Basaltic trachyandesites, trachyandesites of Manichar lava flow. Lower Pliocene. 12. Rhyolites of Avazan, Gyumush and etc. volcanoes. 13. Basaltic trachyandesites, trachyandesites, trachytes (Gegham suite). Lower Pliocene-Upper Miocene. 14. Volcanic deposits (Vokhchaberd suite). Pre - Upper Miocene. 15. Volcano-sedimentary rocks: sandstones, tuff breccia, limestones, andesite lava flows. 16. Volcanic centers. 17. Active faults. 18. Directions of lava flows.

western cluster (fig.2). This suggests that the total rate of recent extension for the Gegham pull-apart basin should be within a range of 6.35 to 7mm/yr, which is the highest rate recorded for any structure in Armenia. Vertical slip rates along the Karmirgiugh branch of the Gavaraghet Fault range from 6-9mm/yr according to geological estimates (Karakhanyan et al., 2013; Doerflinger, et all 1999, Davtyan, 2007).

RECENT SEISMIC ACTIVITY

There are two historical earthquakes relevant to this area: the M6.2 Noratus earthquake of 1226/1227 AD and the M6.6 Vardenis earthquake of 1321/1322 AD. Both are likely associated with the Gavaraghet fault system (Karakhanyan et al., 2011). Among more recent seismic events are the Gavar earthquakes of 1905 and 1909, with magnitudes of M3.8 and M4.7 respectively. Their records have been preserved through local historical sources.

In this study, we consider seismic events from the catalogues of IGS and RSSP (Regional Survey for Seismic Protection of the Ministry of Emergency situations of Armenia) that fall within the GVR study area (fig.4) and compile a catalog of 566 events that occurred within the study area during the early instrumental period (1930-1962) and instrumental period (1962-present time). During the studied period, the GVR study area shows a generally diffuse distributions of weak earthquakes, and clear clusterings of weak earthquake epicenters within the vicinities of active faults and volcanoes (fig.4).

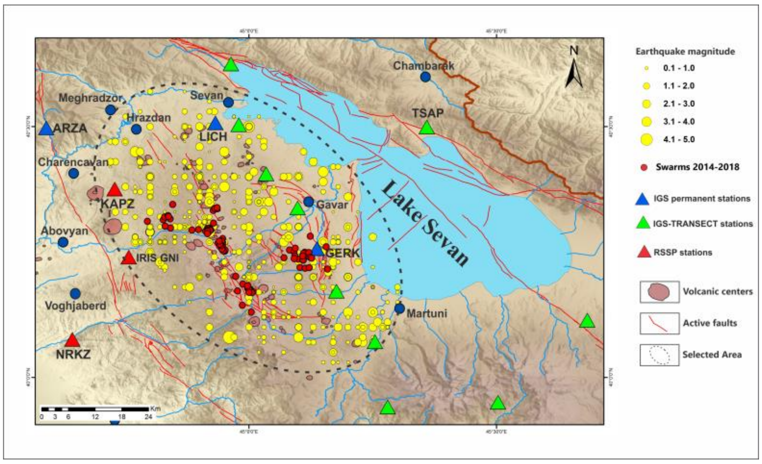

Fig.4. Distribution of seismicity from 1962 to 2018 in the Gegham Volcanic Ridge area. The dotted ellipse marks the study area.

A "swarm" of small (Ml <3.5) earthquakes that occurred in this region in January 2007 were classified as aftershocks of a prior Ml=3.7 event (Sargsyan, 2015). According to the MSK-64 scale, the mainshock was of intensity 5-6, was felt in Gavar, and generated minimal damage. It is considered to be the first reported evidence of seismic sequences within this region.

With the modernization and installation of new seismic stations by the RSSP (12 stations, since 2010) and IGS (13 stations, since 2012, 32 stations since 2018) in Armenia and particularly in the Lake Sevan area, the capability to record seismic activity has greatly increased as shown in fig.5 and 6, which represent magnitude cutoff values over time, based on instrumental capabilities.

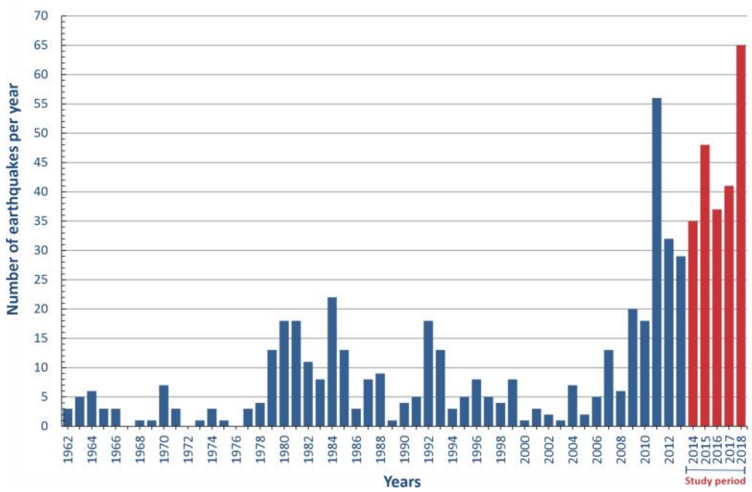

Fig.5. Time histogram of recorded earthquake frequency in the Gegham Volcanic Ridge study area from 1962 to 2018.

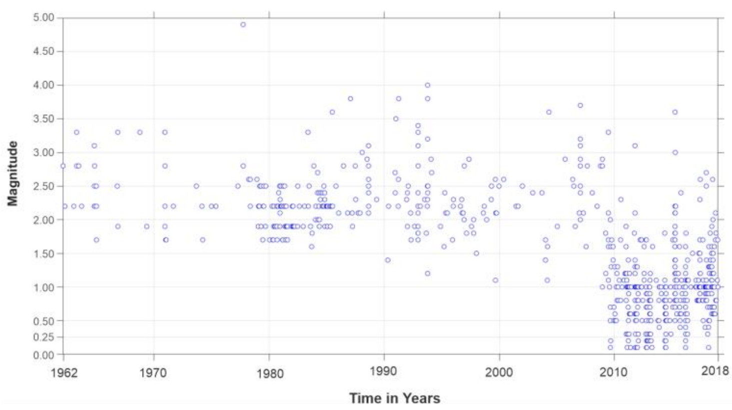

Fig.6. Time-magnitude distribution of earthquakes recorded in the Gegham Volcanic Ridge study area from 1962 to 2018.

In western Sevan, 15 earthquakes were reported from 1962 to 2012, while over 60 earthquakes have been reported from 2012 to 2018 (fig.5). The installation of the Gegharkunik (GERK) station in 2014 improved the location precision of the small earthquakes including the seismic swarms analyzed in the next section (fig.6 and 7).

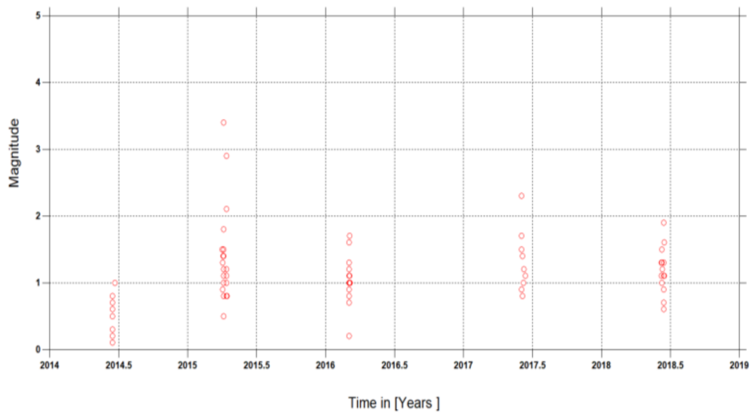

Fig.7. Time-magnitude distribution of swarms recorded in the Gegham Volcanic Ridge study area from 2014 to 2018.

SEISMIC DATA ANALYSIS

Several sequences of earthquakes occurred in the GVR area from 2014 to 2018 ($0.1<M_l \leq 3.6$). Most of the earthquakes were recorded only by the nearest station, GERK. Figure 9 shows a typical earthquake recorded in the GVR area during the 2015 swarm. Low signal-to-noise ratios of weak events and large azimuthal gaps between stations exceeding 150 degrees are not optimal for the qualitative location of most hypocenters. Manual picking of P- and S-wave arrival times was performed for all events recorded by one or more stations. As an example, fig.10 shows P and S phases for the same Ml 1.4 earthquake recorded in 2015 shown in fig.9. The local velocity model used in this study, is composed of four layers (tab.2). The first layer is 7km thick with V_p = 5.6km/s, and the V_p/V_s ratio is assumed to be 1.78 (for this region), but is noteworthy, that according to another tomography model for north/central Armenia V_p/V_s ratio for Gegham ridge is 1.9-2.1 (Lin et al. 2020)

Table 2

Local velocity model used for locating low-magnitude earthquake swarm events.

Thickness interval (H), km	Vp (km/s)
0.00	5.60
7.00	6.40
18.45	6.68
47.00	7.40

With the local velocity model, of the more than 400 weak earthquakes that occurred from 2014 to 2018, only 83 could be successfully located using Hypo71PC software (Lee, 1971, Lee and Valdes, 1985). The spatial distribution of located epicenters strongly corresponds with the areas of volcanism and active faulting observed within GVR (fig.4 and 11). The RMS travel time error values obtained after manual picking and location were less than 0.16s. The accurately located hypocenters, obtained by a minimum of three stations, largely occur with focal depths of up to 8 ±5 km. The remaining events could not be located due to the poor signal-to-noise ratios, or mainly because of having been recorded by less than 3 stations. The waveform features of the recorded earthquakes and the significant variation in the P and S-wave time delays (from 0.1-0.8 s) indicate that the GVR subsurface is laterally inhomogeneous. The GVR subsurface is also characterized by non-uniformly distributed Vp/Vs velocity ratio values (Lin et all, 2020). The seismic record shows similar waveforms for different events within the same cluster, suggesting that such earthquakes come from the same location and are generated by identical source mechanisms (fig.8). In fig.9 are shown the spectrogram of individual event recorded by Gekharkunik Station. Figure 11 shows maps and vertical cross-sections of the earthquake swarms that occurred within the GVR from 2014-2018:

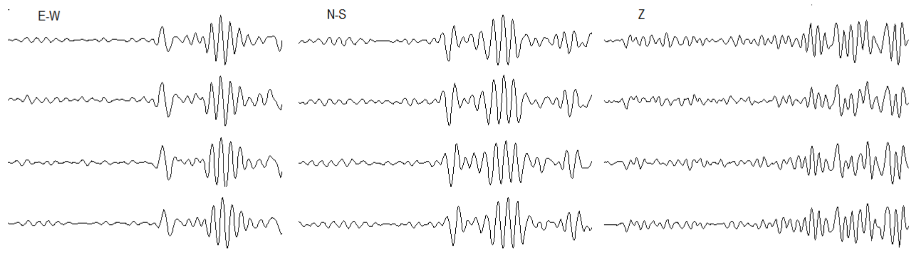

Fig.8. Similarities between waveforms for selected representative earthquakes of the seismic swarm recorded by GERK.

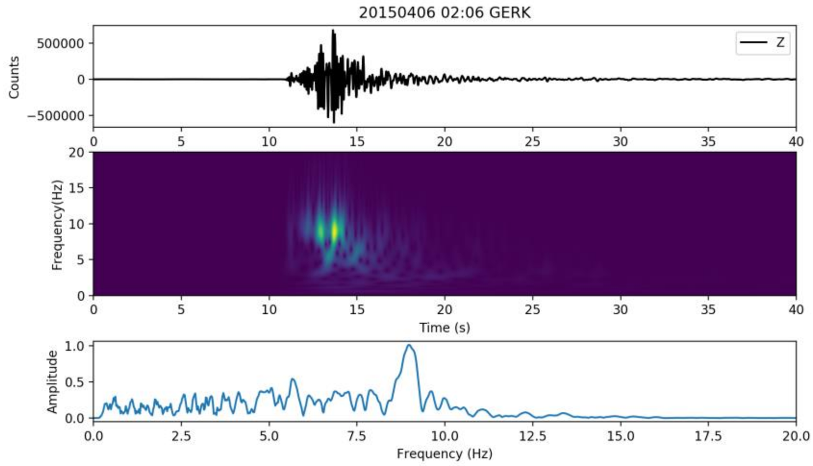

Fig.9. Waveform, spectrogram and spectrum for a selected representative earthquake of the 2015 seismic swarm recorded by GERK (Ml=1.4).

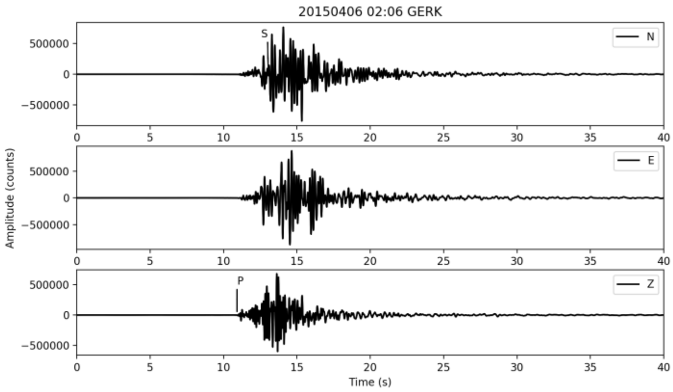

Fig.10. Phase picking of the selected representative earthquake recorded by GERK station. In this case, S-P is 1.6 sec.

- The June 2014 swarm with more than 30 evens (located 14 EQs, M_L 0.1-1.0), which occurred over the course of several days in the northern part of GVR near Ashtarakner volcano, marks the first seismic activity recorded since the installation of the GERK station in 2014. The depth range for this recorded activity is 4 to 14 km, with the majority of events occurring at depths greater than 10 km.
- In April 2015, a swarm occurred in the southern part of the GVR, 1.6-5km from Sahakasar and Mesropasar volcanoes and near the graben-like structure associated with Gavaraghet fault. This swarm featured over 180 events within a span of 15 days, as recorded by the nearest GERK station (located 38EQs, M_L 0.5-3.4). Most waveforms from this swarm have clear P- and S-wave onsets and relatively low frequencies. The sources were found to be very shallow, between 1 and 8 km deep.
- Another swarm occurred in March 2016 along the GVR axis, near the Lchayin, Lodochnikov and Sevkatar volcanic centers. This swarm included over 85 events of magnitude M_L0.2-1.7 (located 19EQs). In this case, the hypocentral depths ranged from 12 to 16 km.
- The June 2017 swarm included more than 43 events of magnitude M_L<1.0. (located 13EQs, M_L 0.1-1.0) occurred in the western axis of the GVR. Here, hypocenter depths ranged from 7 to 19 km.

The most recent swarm occurred in June 2018 with more than 37 events (located 17EQs, M_L0.6-1.9) along the GVR axis, near Azhdahak and Tar volcanic centers. Hypocenter depths ranged from 14 to 20km.

DISCUSSION AND CONCLUSIONS

A good understanding of the prevailing seismicity that occurs in the GVR area is critical for determining the stress field of the region. As mentioned in the introduction, this region's geological evolution is highly complex. Today, this is

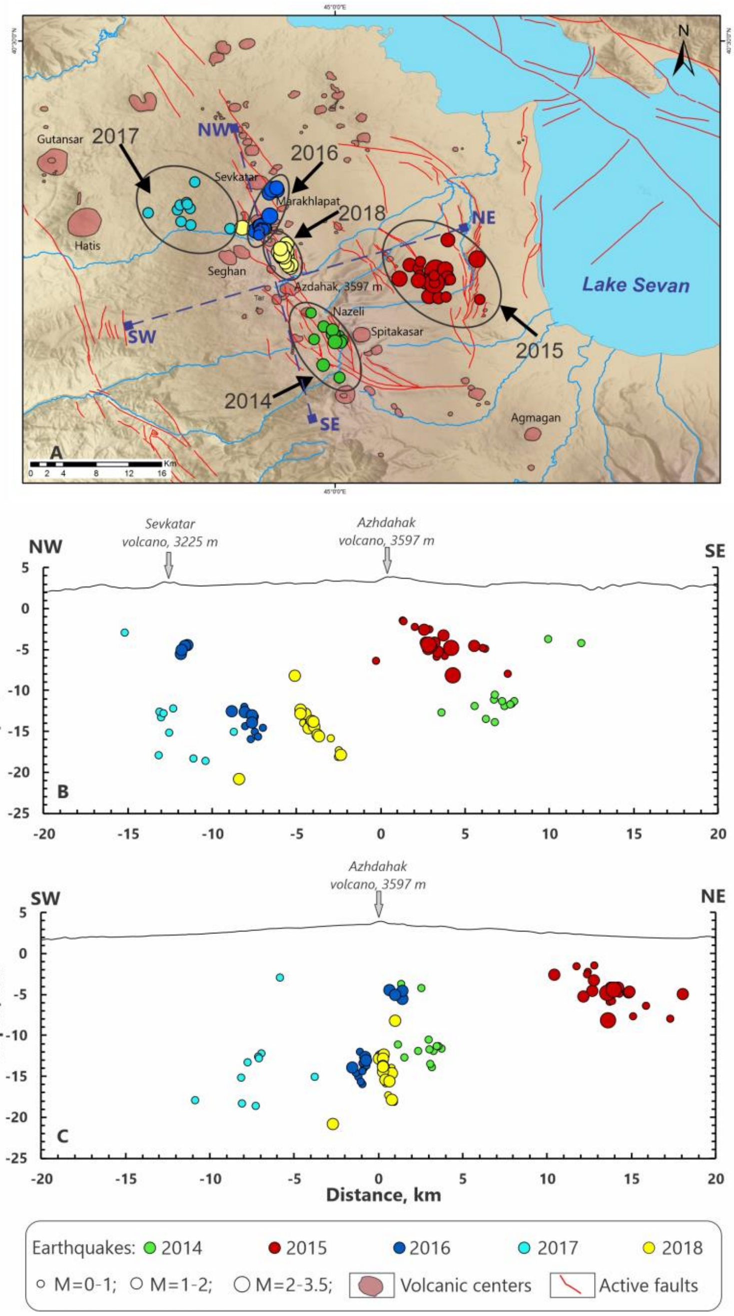

Fig.11. Map (A) and cross-sections (B, C) showing seismic swarms that occurred in 2014-2018 within Gegham Volcanic Ridge, which are located using seismic networks of IGS and RSSP and investigated in this study. A: Map of GVR with colored circles showing 2014-2018 swarm event locations, as well as volcanoes and active faults. Marker size corresponds to magnitude. Dark blue squares show endpoints of NW-SE and SW-NE cross-sections. B: Vertical cross-section along NW-SE profile, depicting projected hypocenters of seismic swarms. C: The same, for SW-NE profile.

indicated by the morpho-tectonic topographies and dense clustering of monogenetic volcanic centers seen at the surface. The accurately located hypocenters appear to have occurred near both clusters of monogenetic volcanic centers and the active Gavaraghet fault system. The relatively deeper (12-16km), smaller-magnitude events appear to preferentially occur near volcanoes (observed in the 2016 and 2018 swarms); the shallower (1-8km), higher-magnitude earthquakes (including the strongest event across all swarms, an Ml3.4 earthquake in 2015) seem to cluster within the Gavaraghet fault area.

Furthermore, very clear similarities are observed within 2015 swarm family of earthquakes, both in waveform patterns, and in spectrograms of distinct events within the swarm recorded by the same station.

Previous studies discussed above suggest that the current stress field in the study area is extensional. Observations of continuous GPS stations indicate that velocity directions, varying between 2.5 and 3.5mm/yr, follow the Garni Fault in a southeast orientation. This results in a compressive stress field that triggers the reactivation of normal faulting in the area near the volcanic ridge (where the pre-existing faults zones are associated with normal faulting).

Seismic observations and analysis of such tectonic settings, paired with local and regional geologic information, suggest that the recent seismic swarms identified within the axial part of the Gegham Volcanic Ridge could be attributed to volcano-tectonic seismicity as most of it occurred nearby recent volcanic centers. On active volcanoes VT seismicity is commonly recorded prior and during eruptions. Last volcanic activity at Gegham ridge occurred ~3.4Ka (Avagyan et al., 2020), or 4.5-4.4Ka, (Karakhanyan et al., 2002), and estimations of recurrence rates of monogenetic Upper Pleistocene-Holocene volcanism is ranging $3.1\text{-}5.7\times10^{-4}$ per year (Meliksetian, 2018), that corresponds to average of one eruption per every 1754-3225 years. Although monogenetic eruption episodes are obviously not uniformly distributed through time and are usually grouped in active periods with frequent eruptions divided by intervals of hiatus. The question here is whether this seismicity is linked to purely tectonic movements and if so, how to explain recurrent tectonic activity near dense monogenetic volcanic clusters.

A second hypothesis is the existence of hydrothermal processes involving an interaction between groundwater and active magmatic zones generating internal overpressures. In this case an important question is the origin of the magma, if it is resulting from past eruptions or represents new intrusions of magma at depths. In this hypothesis, observed seismic processes may include stresses associated with dyke propagation at depths up to 15 km beneath the ridge, or hydrothermal processes resulted from residual heat from existing magma chamber from the past episodes of volcanism. We cannot answer these questions at this stage of our study. A more in-depth study of the spatial and temporal migration of the seismicity as well as a detailed study of the rupture mechanisms appears to be necessary. As pointed by Roman and Cashman (2006), the analysis of VT fault–plane solutions and their comparison with regional stresses can reflect pressurization of the mid-level conduit system in case of presence of magmatic fluid. This kind of study would be useful to better understand the dynamics of the seismogenic and possibly magmatic systems which are producing the observed seismic swarms. A recent study of crustal Vp/Vs ratio beneath the Armenian Volcanic Highland of the Lesser Caucasus by P-wave receiver functions method revealed extremely high Vp/Vs ratios (1.90–2.15) localized beneath Aragats stratovolcano and Gegham volcanic ridge (Lin et al., 2020). The presence of magmatic fluids is therefore plausible and must be taken into account into the analysis of the seismicity observed in this region.

Based on preliminary results investigated in this study, we propose to monitor Gegham volcanic ridge with more seismic stations and increase density of seismic stations in the region and apply regional seismic tomography to image the structure beneath Gegham Volcanic Ridge.

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ՄԱՅՐՑԱՄԱՔԱՅԻՆ ԿՈԼԻԶԻԱՅԻ ԳՈՏՈՒՄ ՀՐԱԲԽԱՏԵԿՏՈՆԱԿԱՆ ՍԵՅՍՄԻԿՈՒԹՅՈՒՆ. ԵՐԿՐԱՇԱՐԺԵՐԻ ՊԱՐՍԵՐ ԳԵՂԱՄԻ ՀՐԱԲԽԱՅԻՆ ԼԵՌՆԱՇՂԹԱՅՈՒՄ (ՀԱՅԱՍՏԱՆ)

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Ամփոփում

Հայաստանում վերջին տարիներին ժամանակավոր, ինչպես նաև մշտական սեյսմիկ և GPS գեոդինամիկ մոնիթորինգային ցանցերի արագ զարգացումն ու լայն տարածումը մեծ դեր ունեցան Արաբական և Եվրասիական մայրցամաքային սալերի բախման գոտում հրաբխա-տեկտոնական ակտիվ պրոցեսների ուսումնասիրությունների համար:

Այս աշխատանքում իրականացվել են Գեղամի հրաբխային լեռնաշղթայի տարածքում տեղի ունեցած հինգ սեյսմիկ պարսերի վերլուծություններ, որոնք գրանցվել են 2014-2018թթ-երի ընթացքում Վերին Պլեյստոցեն-Հոլոցեն մոնոգեն հրաբուխների և ակտիվ խզվածքների խիտ կլաստերում: Գրանցված երկրաշարժերի պարսերի ժամանակ որևէ «հիմնական ցնցում» չի առանձնացվում, դրանք բնութագրվում են համեմտաբար կարճ ժամանակահատվածում հաճախակի գրանցվող թույլ ցնցումներով: Սեյեմիկ կայաններից ստացված տվյալներն օգտագործվել են երկրաժարժերի էպիկենտրոնների տեղադիրքերի ճշտությունը մեծացնելու և այդ գոտում առկա լարվածային դաշտի ներկա վիճակը գնահատելու համար: Խիստ կարևորվում է, վերջին տարիներին գրացված երկրաշարժերի պարսերի և ակտիվ հրաբխային կամ գեոթերմալ պրոցեսների միջև հնարավոր կապի բացահայտման և ուսումնասիրմանն ուղղված հետազոտությունները: Գեղամի հրա-

բխային լեռնաշղթայում գրանցվող սեյսմիկ պարսերի նման հետազոտությունները թույլ կտան հասկանալու և գնահատելու տեկտոնական և հրաբխային պրոցեսների միջև հարաբերակցությունը, ինչն էլ իր հերթին կնպաստի այս տարածքում հրաբխային վտանգի գնահատման աշխատանքներին: Գեղամի հրաբխային լեռնաշղթան մեծ պոտենցիալ ունի նաև որպես գեոթերմալ էներգիայի աղբյուր և հետևրաբար մեր հետազոտությունները թույլ կտան իրականացնել այնպիսի ուսումնասիրություններ, որոնց արդյունքները կիրառելի են ինչպես գիտական, այնպես էլ բնապահպանական տեսանկյունից:

ВУЛКАНО-ТЕКТОНИЧЕСКАЯ СЕЙСМИЧНОСТЬ В ЗОНАХ КОНТИНЕНТАЛЬНОЙ КОЛЛИЗИИ: РОИ ЗЕМЛЕТРЯСЕНИЙ ГЕГАМСКОГО ВУЛКАНИЧЕСКОГО ХРЕБТА (АРМЕНИЯ).

Саргсян, Л.С., Меликсетян, Х.Б., Метаксян Ж-Ф., Левонян А.Ф., Григорян Э.С., Тограмаджян Н., Навасардян Г.Х., Манучарян Д.А., Геворгян М.Р. и Арутюнян К.А.

Резюме

В последние годы быстрое развитие сейсмических и GPS геодинамических мониторинговых сетей в Армении способствовало изучению деформаций в активных вулкано-тектонических регионах в зоне континентальной коллизии Аравии и Евразии. Данное исследование посвящено анализу пяти роев землетрясений произошедших в течение 2014-2018гг. в пределах Гегамского вулканического хребта в Армении, в районе плотного кластера верхне-плейстоцен-голоценовых моногенных вулканов и активных разломов. В этих роях землетрясений, отличающихся частыми толчками, произошедшими в относительно короткие промежутки времени, не было выявлено «основных толчков». Записи землетрясений были использованы для повышения точности определения эпицентров и гипоцентров толчков и понимания текущего состояния поля тектонического напряжения в этом районе.

Цель исследований состоит в изучении возможной связи между этими роями землетрясений и активными магматическими или геотермальными процессами. Такие исследования роев землетрясений в районе Гегамского вулканического хребта способствуют пониманию взаимосвязи между тектоническими и вулканическими процессами, что, в свою очередь, содействует оценке вулканической опасности в регионе. Помимо оценки природных опасностей, молодой вулканизм Гегамского хребта также имеет большой потенциал в качестве источника геотермальной энергии. Таким образом, приведенные междисциплинарные исследования могут иметь различные приложения как научные, так в области охраны окружающей среды.