

# Investigation of hydro-geochemical precursors of several earthquakes occurred in the territory of Armenia

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## Abstract

- The regime seismo-geochemical observations in the territory of Armenia are performed permanently on the seven observation stations: Ararat, Surenavan, Kajaran, Karchakhbuir, Akhurik, Tsovagyugh, Saratovka. The gases (He, CO<sub>2</sub>, O<sub>2</sub>, R), macro-components (HCO<sub>3</sub>, Cl, SO<sub>4</sub>, Ca, Mg, Na), micro-components (K, NH<sub>4</sub>, NO<sub>3</sub>, NO<sub>2</sub>, Li) and some parameters such as debit, temperature, gas-factor, pH, Eh are daily investigated. All the regime geo-chemical observations are accompanied with metrological works on all the stages: sample selection, sample storage, analysis.

## Introduction

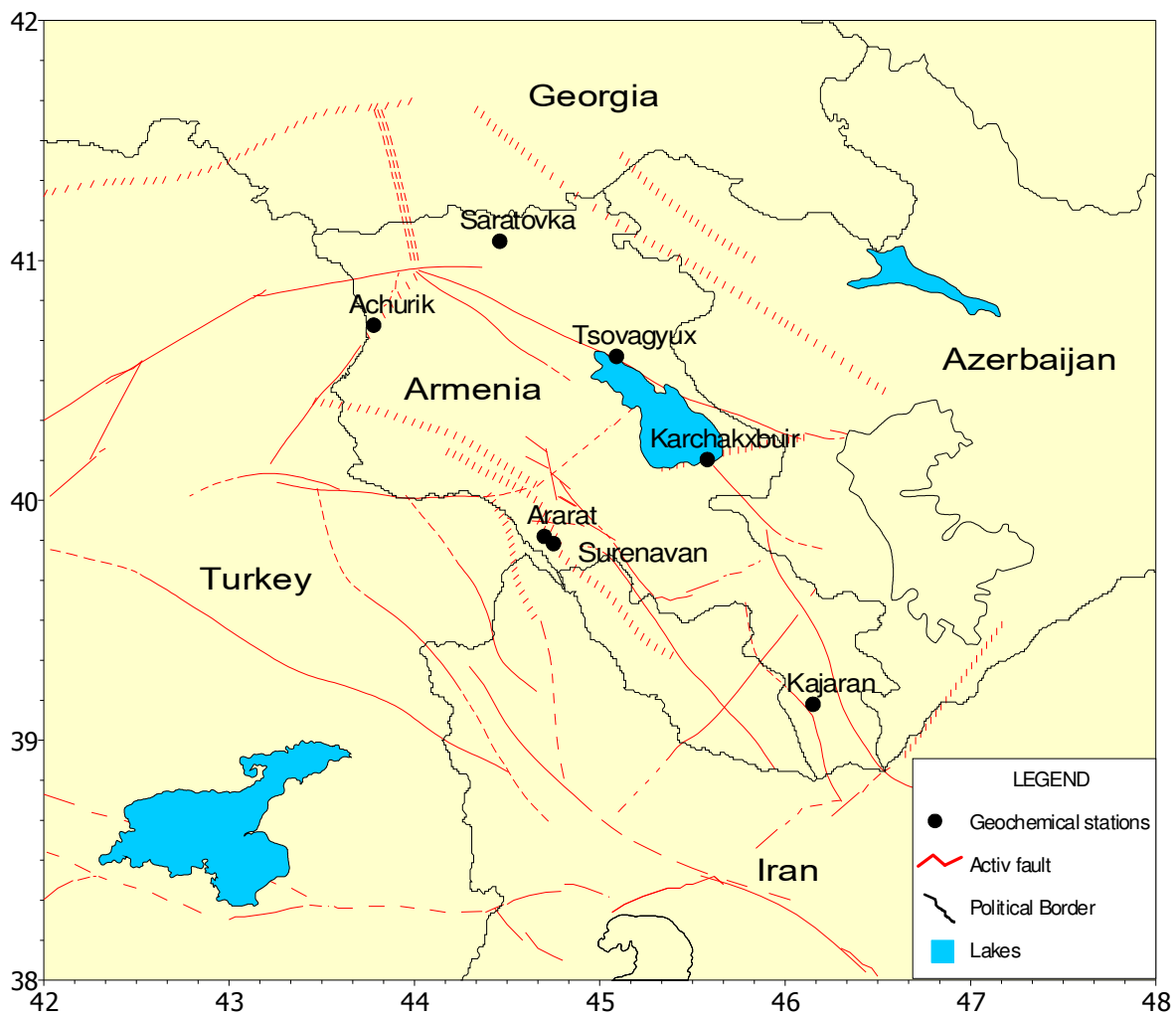
- There are daily sample selection and analysis on all the sites, and on the automated Readiness stations from 1 our to several seconds.
- All observation drills are located in the zones of active faults (Pic. 1). Selected location of observation drills allows to observe the geochemical reaction on the earthquakes not only in the territory of Armenia but also in the territory of Turkey, Georgia, Azerbaijan and Iran.
- Since 1994 in Kajaran and Akhurik, and since 2000 in Karchakhbyur and Saratovka fully automated geochemical stations of READINESS network, installed thanks to GeoForschungZentrum organization, are operating. Those four stations are equipped with satellite data transfer system to the data acquisition and processing centers which allows to carry out complex geophysical, hydro-geological and geochemical monitoring in the real time scale and to use daily data for current seismic hazard assessment.
- The relation between the change of micro- and macro-components in underground waters and the process of strong seismic events preparing is well studied. A large amount of pre-,co-, and post-seismic anomalies of physical and chemical parameters of underground waters are defined [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11].
- With the aim to current seismic hazard assessment in the territory of Armenia and adjacent regions the research of hydro-geochemical data was carried out and earthquake precursors have been distinguished.
- In this paper the techniques of data processing and results of analysis of hydro-geochemical earthquake precursors by the example of He diluted in mineralized water, are presented.
- The work was carried out in 2002, some earthquakes occurred on the territory of Armenia was investigated, but in this paper presented only Martuni (10.12.1992, M=5.0) and Tsovagyugh (19.02.1993, M=3.8) earthquakes.
- On data analysis the modern techniques and Seishelp, Dynamic Fields, Expert software developed at the NSSP, have been used [1,2,4].
- In the result of He concentration time series analysis marked out anomalous that could be precursors of a number of earthquakes occurred in the territory of Armenia are distinguished, amplitude and frequency characteristics of anomalies-precursors are defined (Seishelp, DF) and the zones of the highest current seismic hazard by the hydro-geochemical precursors by the example of helium (He) are distinguished (Expert).

## Result

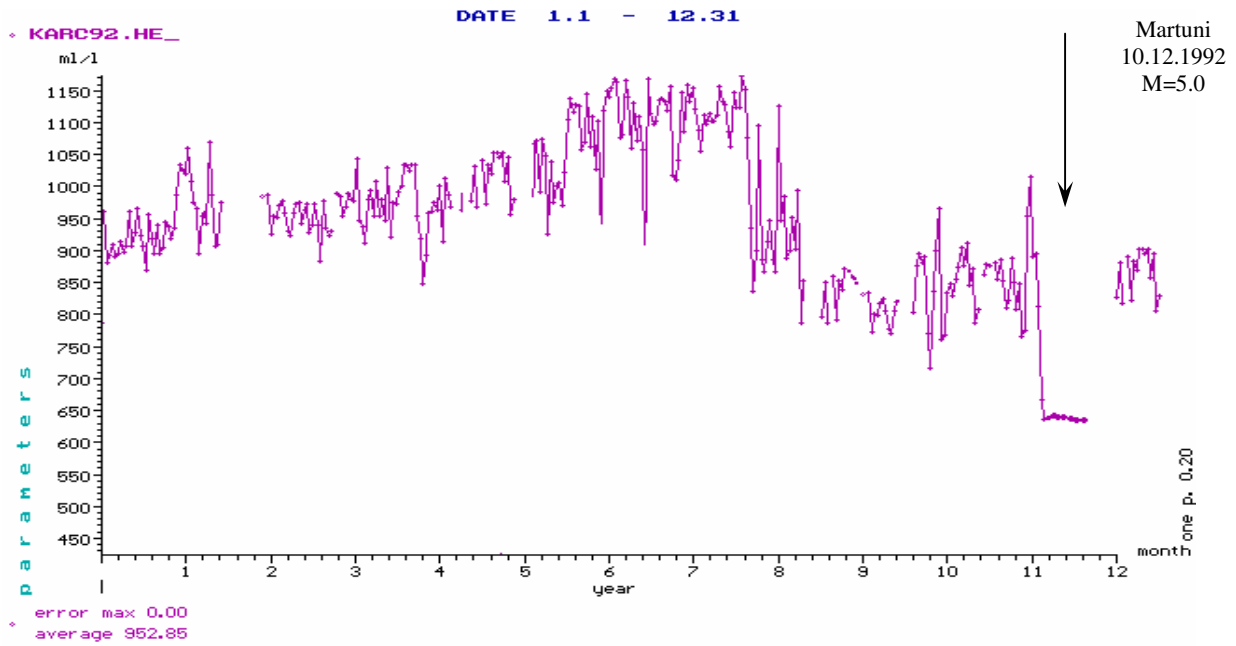
- Earthquakes prediction by geochemical methods is based on anomalous changes of the chemical composition of mineralized water before an earthquake preparation period. Formation of the geochemical anomalous is conditioned by physical processes of earthquake preparation.
- For investigation of peculiarity connection between geophysics, geochemical data and earthquakes the following program packets are used:
  - 1. Seishelp – for initial data visualization
  - 2. Dynamic Field (DF) – for isolation of amplitude-frequency characteristics of dynamical fields
  - 3. Expert – for critical and current seismic hazard assessment.
- On this paper the changes of He the connected with earthquake preparation are studied, since He is the most susceptible to earthquake preparation process. As a rule, before strong or weak, close or distant earthquakes He values in mineralized water structure are decreased. As premonitory symptoms of earthquake the changes of He structure before Martuni earthquake with  $M=5.0$  dated by 10.12.1992 and Tsovaguyugh earthquake with  $M=3.8$  dated by 19.02.1993 were studied.
- Time series of He the seven regional geochemical station (Ararat, Surenavan, Kajaran, Karchakhbuir, Akhurik, Tsovaguyugh, Saratovka) before Martuni and Tsovaguyugh earthquakes are investigated.
- On the curve the change of He values connected with Martuni and Tsovaguyugh earthquakes is clearly expressed (Pic. 2,3).
- The amplitude-frequency changes of dynamic fields characteristics are isolated by Dynamic Fields (DF) program (Pic. 4,5)
- But there are time series where anomalous changes are not exposed by visual observations. For their exposure it is used another methods and programmes, in particular Expert programme developed by National Survey for Seismic Protection (NSSP) (Pic. 6,7).
- Below it is given an anomalous part of He content curve, with 12 hour period of filtering, and from above – a curve got by automatic method by Expert programme (an anomalous amplitude given in conventional unit).
- After marked anomalous Expert programme defines value of critical seismic hazard ( $Z_{crit}$ ) and current seismic hazard ( $Z_{cur}$ ) before Martuni and Tsovaguyugh earthquakes. Evidently, in the case of Martuni earthquake  $Z_{crit}$  (10,95) is bigger than  $Z_{cur}$  (8,86), and in the case of Tsovaguyugh earthquake also  $Z_{crit}$  (2,34) is bigger than  $Z_{cur}$  (1,88). In reality in these zones earthquakes occurred accordingly on 10.12.1992 and 19.02.1993 (Pic. 8, 9).
- You can see from the pictures 8 and 9 that Expert programme allows to define a acceptable probability of next earthquake occurrence.

## Conclusion

- An accumulation of energy had an effect for the preceding changes in geochemical composition of underground waters before Martuni and Tsovaguyugh earthquakes.
- By the character of changes the time intervals of an accumulation of large amount of energy in the sites of geochemical monitoring in the territory of Armenia (Ararat, Surenavan, Kajaran, Karchakhbuir, Akhurik, Tsovaguyugh, Saratovka stations) are observed.
- In result of our calculations we have the short term He precursor before Martuni's earthquake 4 months and before Tsovaguyugh's earthquake 1 months.



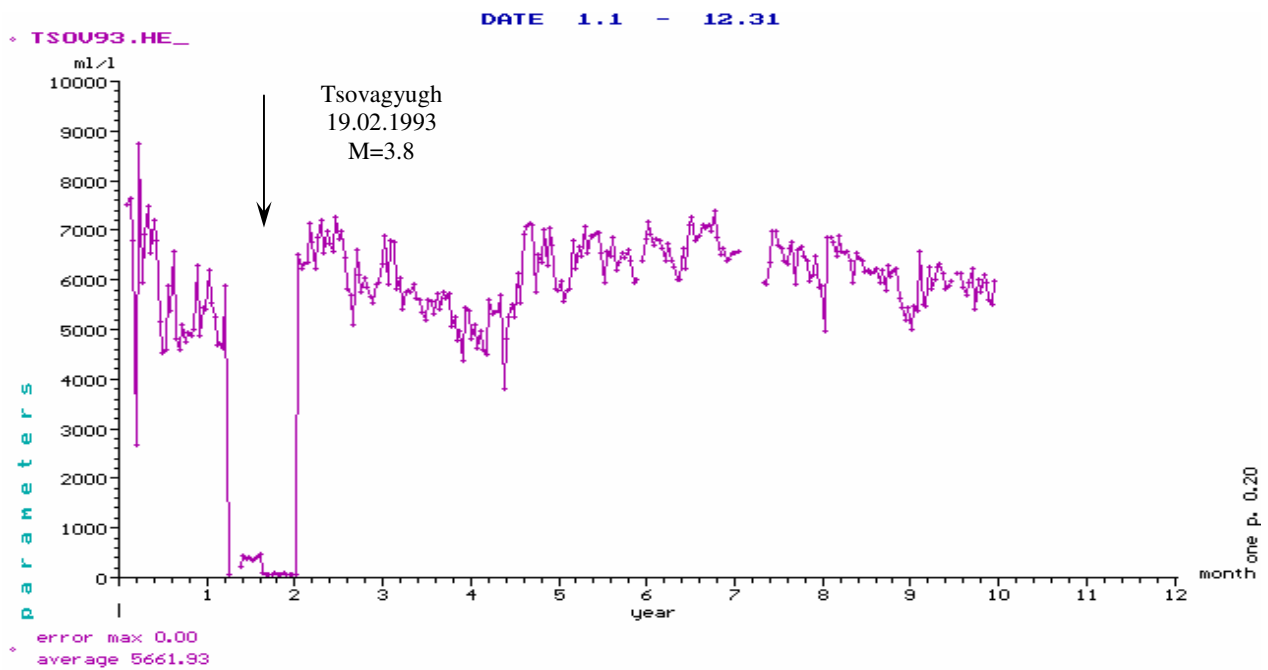
**Pic. 1** Activ fault and geochemical network in Armenia



SEISHHELP

National Survey of Seismic Protection

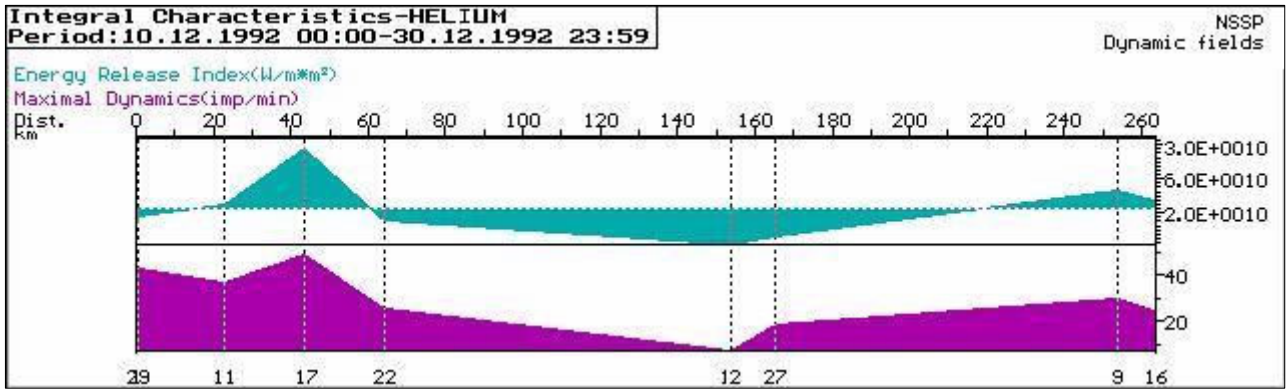
Pic. 2. Time series of He before and after Martuni earthquake, M=5.0



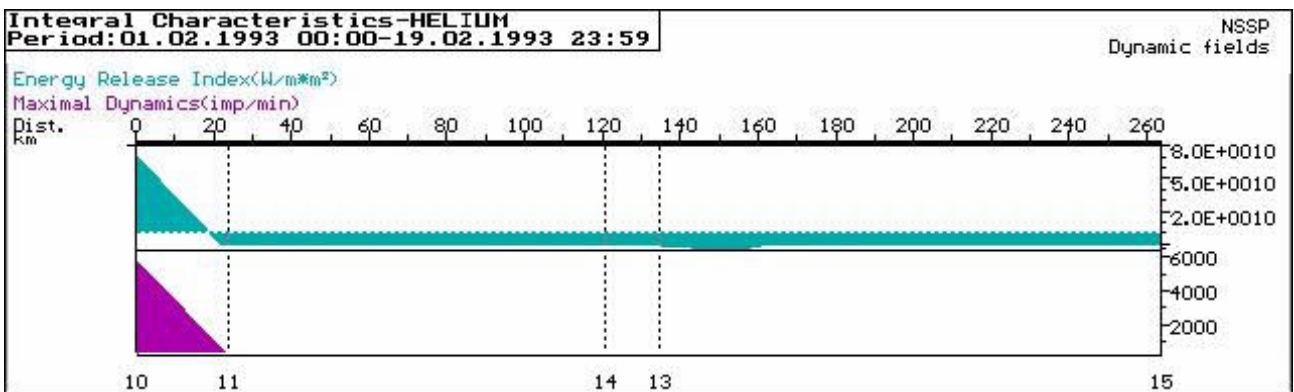
SEISHHELP

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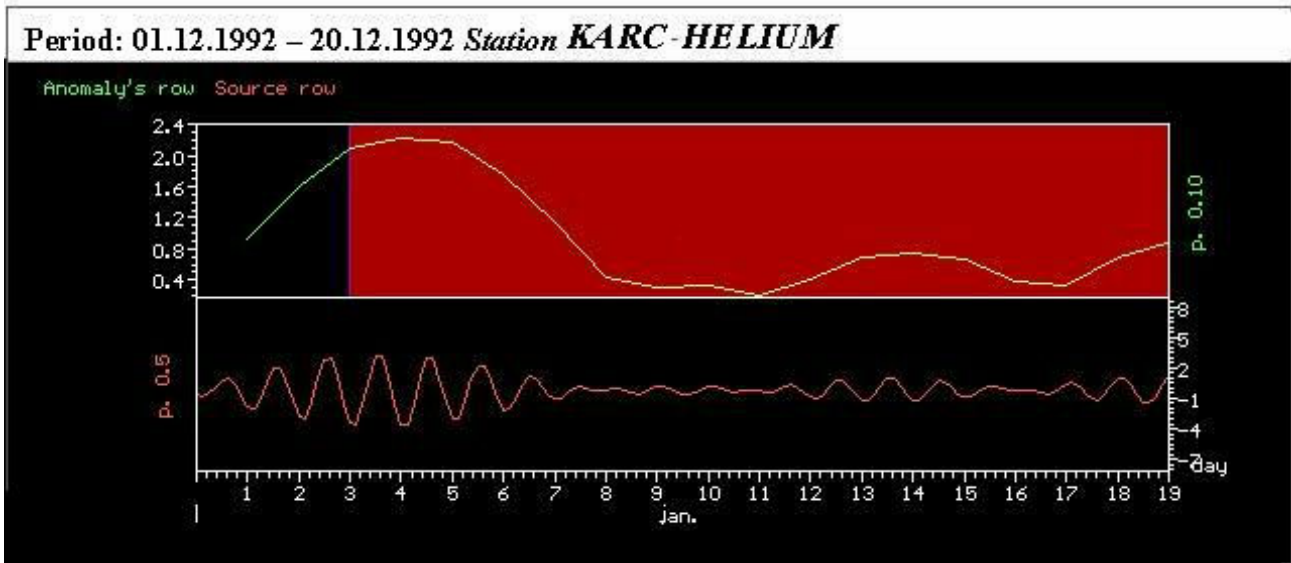
Pic. 3. Time series of He before and after Tsovagyugh earthquake, M=3.8



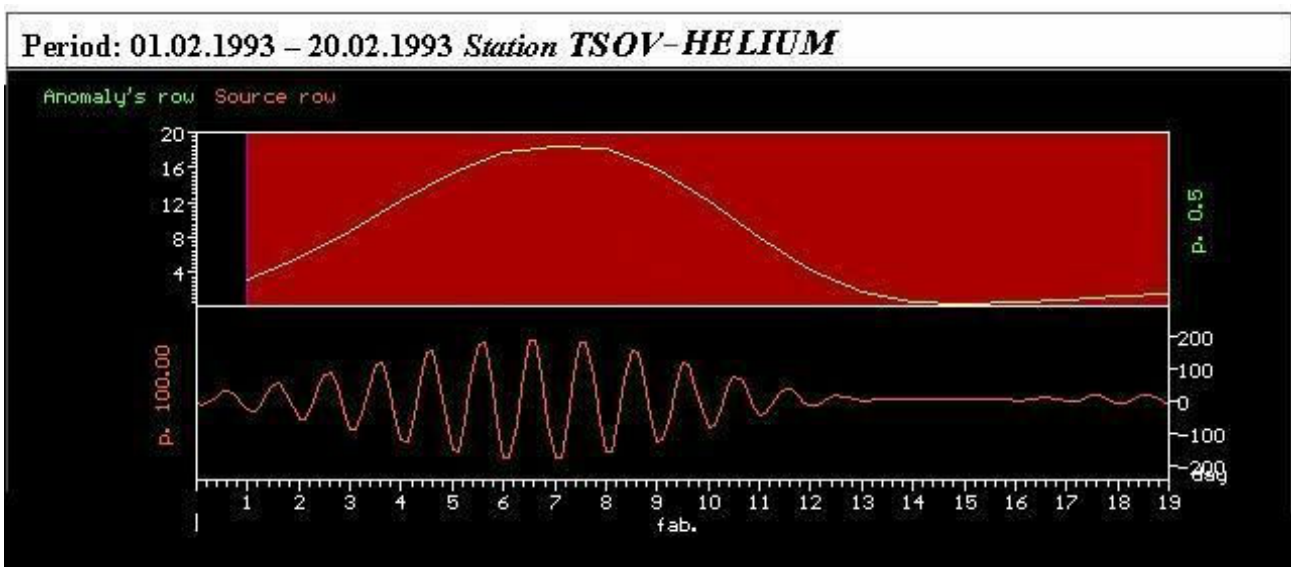
**Pic. 4. Amplitude-frequency changes of He characteristics on Karchakhbuir geochemical station, isolated by the Dynamic Fields (DF) programme before and after Martuni earthquake, M=5.0.**



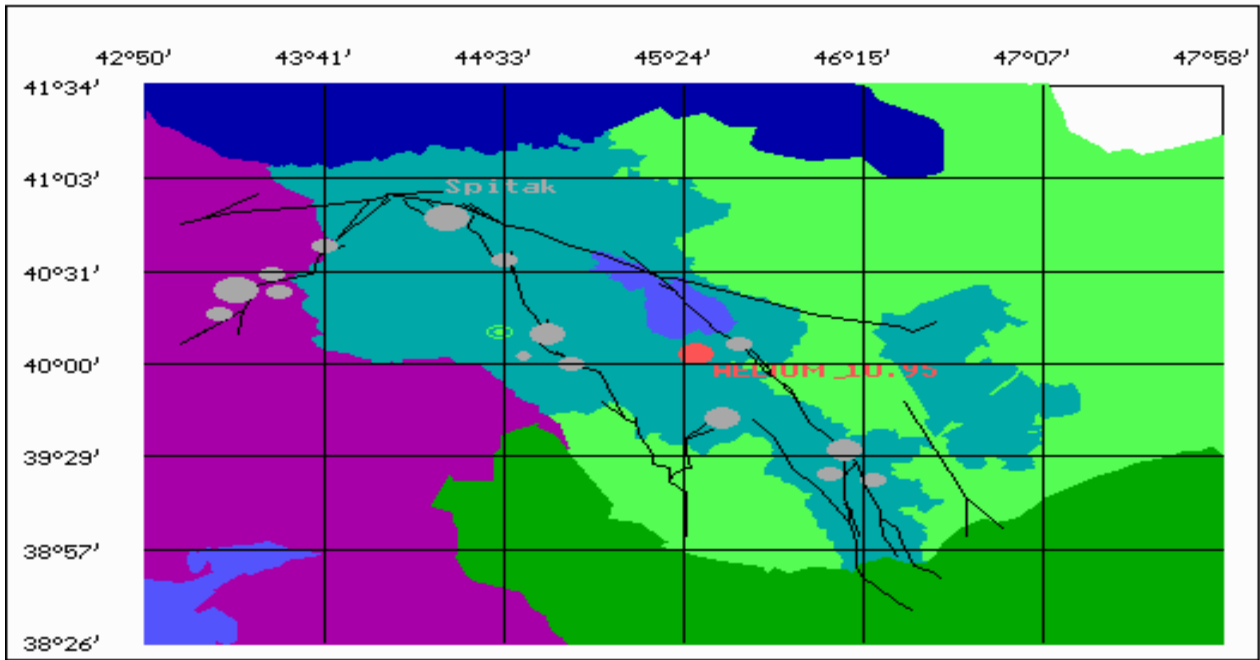
**Pic. 5. Amplitude-frequency changes of He characteristics on Tsovagyugh geochemical station, isolated by the Dynamic Fields (DF) programme before and after Tsovagyugh earthquake, M=3.8.**



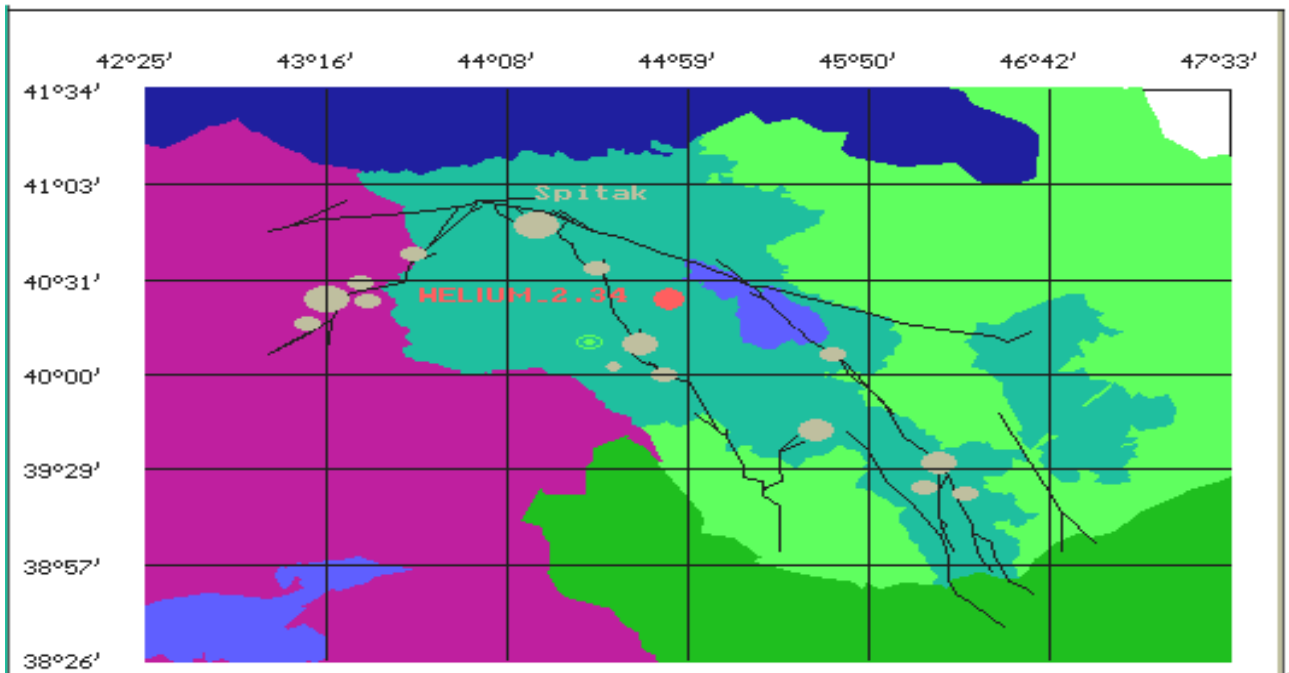
**Pic. 6.** Precursor-anomaly He of geochemical Karchakhbuir station marked out before Martuni earthquake, M=5.0 by Expert programme.



**Pic. 7.** Precursor-anomaly He of geochemical Tsovagyugh station marked out before Tsovagyugh earthquake, M=3.8 by Expert programme.



**Pic. 8. Zone of current hazard assessment, value of critical and current hazard, defined by Expert programme before Martuni earthquake, M=5.0, epicentre of it is marked out by red point**



**Pic. 9. Zone of current hazard assessment, value of critical and current hazard, defined by Expert programme before Tsovaghyugh earthquake, M=3.8, epicentre of it is marked out by red point**

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