# EMERGENCY PREVENTION AND SITUATION MONITORING IN CARPATHIAN REGION

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*Abstract: Carpathian region is well known as tectonically active zone. So, in addition to common problems of such region, as common water floods, possible mudflows and landslides a local seismic activity must be taken in account. In this paper a main points of situation monitoring in Carpathian region and ways how they help in emergency prevention are described. A short overview of existing solutions and future approach is being made.*

*Keywords: emergency prevention, situation monitoring, early warning systems*

*ACM Classification Keywords: H.3.4 Systems and Software*

## Introduction and current situation overview

Carpathian region extending over the Folded Carpathians, foremountain and intermountain troughs and the adjacent parts of the platform, i.e. the parts of Transcarpathian, Chernivtsi, Ivano-Frankivsk and Lviv regions of Ukraine, is known as tectonically active zone. Its modern activity is attributed to processes forming the Carpathians, Transcarpathian and Forecarpathian Troughs and manifests itself through local seismicity.

Maximum intensity of earthquakes in the Carpathian region reaches $7^0$-$8^0$ in the MSK scale (Tyachiv, 1781, 1870, MSK $I_0 = 6^0$-$7^0$; Rokoshyno, 1797, MSK $I_0 = 6^0$-$7^0$; Dovhe, 1872, MSK $I_0 = 7^0$; Svalyava, 1908, MSK $I_0=7^0$; Teresva, 1926, MSK $I_0 = 6^0$-$7^0$; Drahovo, 1937, MSK $I_0 = 7^0$; Berehove, 1965, MSK $I_0 = 7^0$; Zalishchyky, 1832, MSK $I_0 = 7^0$; 1835, MSK $I_0 = 7^0$-$8^0$; Velyki Mosty, 1875, MSK $I_0 = 6^0$-$7^0$). That constitutes a serious danger to population, civil and industrial installations located here.

According to the present map of seismic hazard there are two zones in the Transcarpathian region – Mukachiv and Tyachiv – where the risk is considerably high.

Earthquakes with intensity of up to $8^0$ in the MSK scale and energy class K=14 (K=lgE) recur almost every 160 years in the Mukachiv zone. The most recent MSK intensity $7^0$ earthquake occurred to the South of Svalyava on January the 5th, 1908, and intensity $6^0$ earthquake – on October 24th, 1965 (near Berehove). There have been no significant tremors in the Mukachiv zone since a few decades what may indicate the increasing probability of strong earthquake in the zone in the nearest future.

The Tyachiv zone is remarkable for more frequent but of considerably lower intensity earthquakes.

In 1965 Lviv geophysicists organized the Carpathian Integrated Geodynamic Test Site in the Transcarpathian region to study connections between geophysical fields, structure and dynamics of lithosphere and local seismicity. In the site the network of 6 permanent geophysical stations (PGS) (“Mukachiv”, “Berehove”, “Trosnyk”, “Nyzhnye Selyshche”, “Bushtyno”, and “Brid”) was set up. Geophysical station “Ivano-Frankove” was located in the Lviv region. Continuous registration of the local earthquakes, microseisms, crustal deformations, borehole temperature and temporal changes of a broad set of geophysical fields is held at PGS. Integrated analysis of data series observed within the period of 1991-1995 shows a possibility of predicting the total seismic energy release in the region within the nearest 2-3 months.

There are a number of existing stations, specified on map as 1 including:

*MUK – Mukachiv. Observations: seismological, meteorological, electromagnetic emission (em pulses from rock massifs);*

*BRD – Brid. Observations: seismological, geomagnetic (geomagnetic field modulus);*

*NSL – Nyzhnye Selyshche. Observations: seismological, geomagnetic, multicomponent magnetovariational, meteorological;*

*BST – Bushtyno. Observations: seismological;*

*TRS – Trosnyk. Observations: seismological, geomagnetic, meteorological, borehole acoustoemissive and geotemperature;*

*KOR – Koroleve, TRS division. Observations: seismological, extensometric, meteorological;*

*BRG – Berehove. Observations: seismological, geomagnetic, extensometric, tiltmetric, meteorological.*

Seismic Stations:

*UZH – Uzhgorod;*

*MEZ –Mizhgirya.*

Also three new stations, mostly in mountains are planned:

*DOB – Dobron;*

*UKL – Uklin;*

*VBR – Velykyi Bereznyi.*

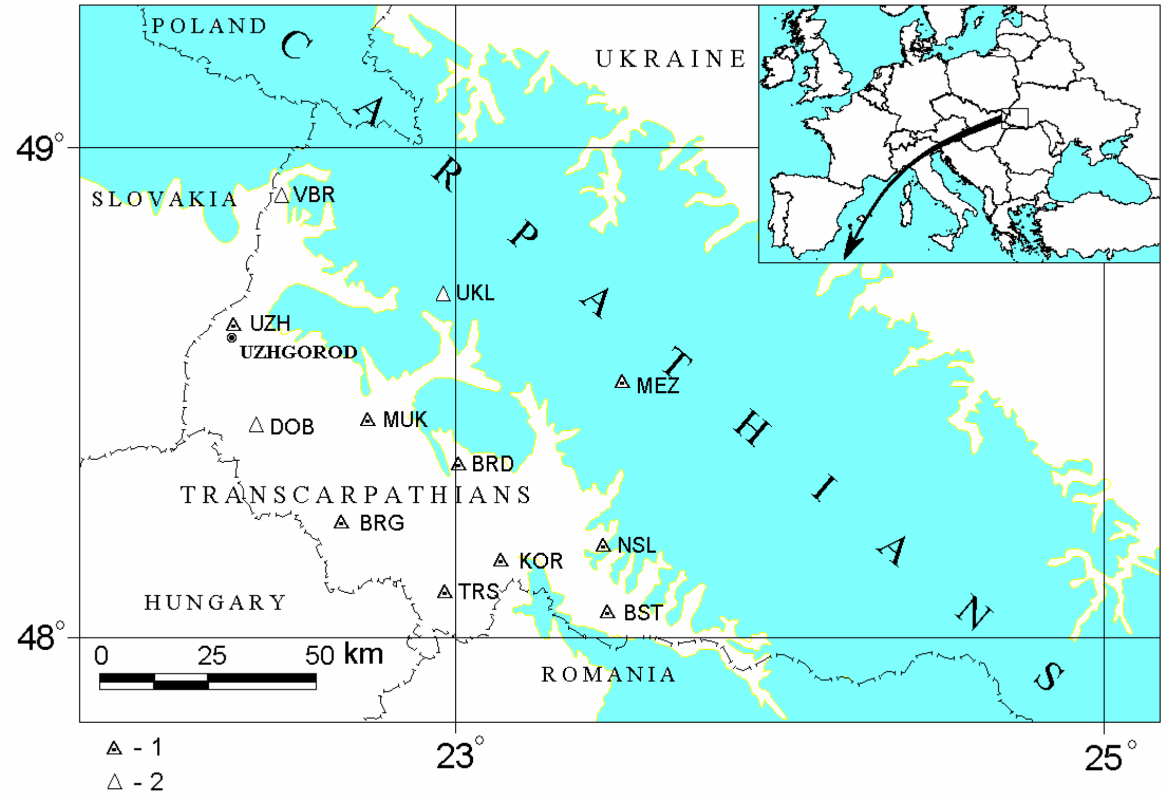


Fig. 1. Carpathian Integrated Geodynamic Test Site

## Main task of the system

Gas blowing, coal mining, mudflows and landslides, tectonic activity and other emergencies greatly influence on rock arrays and result in rearranging tensions and deformations in them. Depending on scale of this process it can result in physical characteristics change of rock arrays and in generation of acoustic and seismic impulses.

Having a possibility to control such changes in time and space (especially parameters of seismic waves and acoustic emission) allows implementing a totally new ability of emergency prognosis and prevention (so called “early warning system”). By monitoring parameters of such waves we can precisely estimate physical parameters of rock arrays and their current state using non-intrusive, and so, way more cheap, methods

The primary task of the project – is development of theoretical and practical approaches for seismic and geophysical monitoring of earth’s crust high layers, which are heavily affected by technogenic factors and estimation of possible emergency on that base.

The primary steps for this task are:

1. Analyze and develop mathematical model of seismic waves sources, which are created in zones with high tension concentrations (including earthquakes and acoustic emission);
2. Perform a model selection for such source, which maximally close describes the process of seismic waves creation (an analysis of other geophysical and geological fields may be required;
3. Develop the algorithm of seismic signals calculation based on selected model;
4. Estimate the influence of tension change in rock arrays on seismic signals from that array;
5. Analyze possible wave effects which may appear during seismic wave passing rock arrays with micro fissures.
6. Develop a set of recommendations for seismic and geophysical emergency monitoring development
7. Implement the following recommendation on practice
8. Estimate effectiveness of developed system and implement learning processes in it.

## Proposed method

The main idea of proposed method is to establish a constant network of monitoring devices, based on existing and newly created stations, which will provide a current state of environment to knowledge base, which will contain previous estimations, the emergencies happened and what actions were taken order to prevent or overcome them. In other words each time a sensor request is being made our situation can be described as the following set:

$$S = s_1 \bigcup s_2 \bigcup ... \bigcup s_n$$
$$s_k =< (x, y, z), P >, \ k = \overline{1..n}$$

where S is a general situation composed from situations $s_1 \ldots s_n$ measured on stations. Each that “small” situation can be described as a subset of coordinates where measurement was made, and current parameters P of sensors on that station. Proposed technology of the prognostication of emergency danger is the information complex, which consists of three basic blocks:

1. knowledge base- is intended for collection, storage and initial processing of the data of seismic and weather services, provided sensors information from stations, which contain information about tensions modifying in surface and rock arrays;
2. Mathematical and algorithmic guarantee - is the collection of mathematical methods and approaches, on base of which is produced the simulation and the prognostication of emergencies danger. The

prognostication of emergency situation is characterized by four basic parameters: by place, by type, by time and with its degree of power. Each of the characteristics has available their mathematical, algorithmic and program apparatuses.

3. block of results assignment for different levels of users - the obtained forecasts are analyzed by experts, after which they are transferred for modification to the system of decision making support for the purpose of use with the correction of anti-emergency measures and to the elimination of the consequences of gathering emergency.

The structure of proposed solution is showed on figure 2.

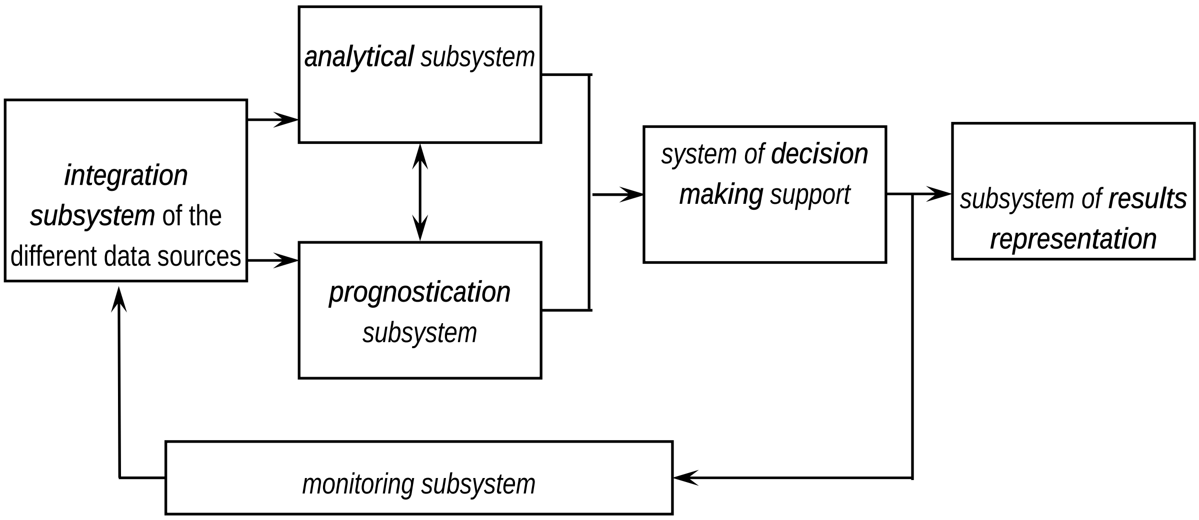


Fig. 2. Proposed system structure.

The system is easily extensible and allows a quickly reaction on all kinds of emergencies including technogenical situations. The main point of making system working is implementation of knowledge base, which will store all sets of different situations, occurred during last 10 years. This task is required to be solved on government level in order to create integral structure for easy storage, access, and managing such data.

## Conclusions

Proposed system demonstrates a possibility of effective emergency situation management in Carpathian region. This involves all steps of early warning system development including technical means (set of monitoring stations), program solutions (knowledge base implementation) and mathematical and algorithmic approaches for such system modeling.

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