Areas of concern related to operation of the trunk gas pipeline's linear routes in the natural and man-caused risk zones

M. Zaderigolova, Winner
of Gazprom PAO's Award, 2015.

Safe operation of the trunk gas pipeline's linear routes in the natural and man-caused risk zones (landslides, active tectonic faults, karst, underground mining) depends mostly from efficient techniques and systems of geotechnical monitoring.

This statement is completely proved by experience of our works at the facilities of such production associations as "Chaykovsky", "Stavropol", "Makhachkala", "Tomsk" and "Krasnodar", where hazardous geodynamic processes are developed.

Their sudden activation often leads to mass-scale emergencies.

Here are some examples.

Fig. 1

A landslide in Taiwan momentarily blocked the traffic on the highway and led to casualties (Fig. 1).

Fig. 2

Another landslide in the Urals knocked the national railroad out of operation for a long time (Fig. 2).

Threatening situations are observed at the linear routes of trunk gas pipelines as well. For instance, the major disturbance of gas pipelines' integrity took place at the Caucasian gas transportation system (Stavropol, Figs. 3&4), (Makhachkala, Fig. 5).

Fig. 3

Fig. 4

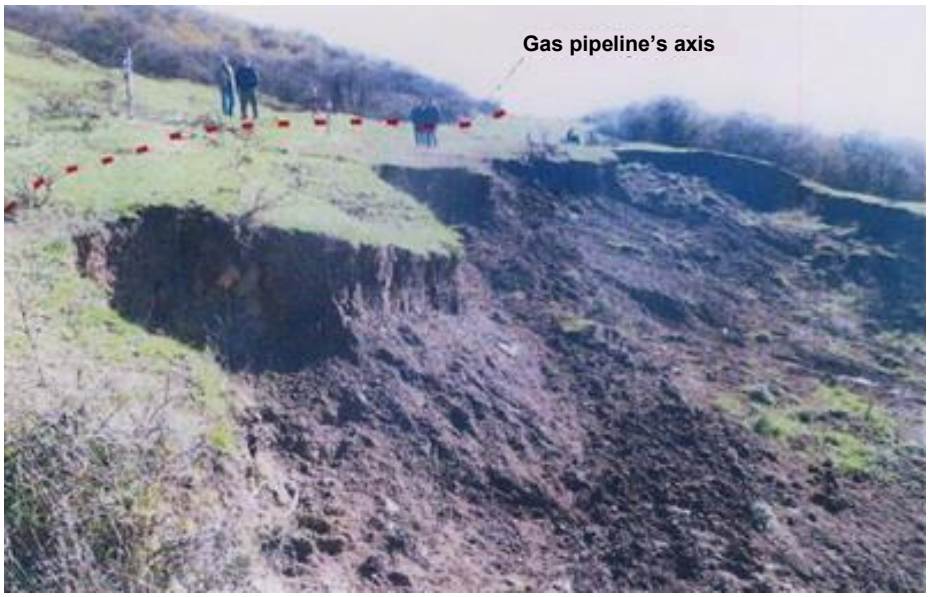


Fig. 5

Abandoned potash mines bring serious problems for uninterruptable gas supply to the Perm industrial hub, as they cause massive spontaneous holes in the earth surface (Figs. 6, 7).


Fig. 6


Fig. 7

It should be noted that spontaneous craters appear as closely as in 500-700 m from the linear route of the trunk gas pipeline (Figs. 8&9).


Fig. 8. 2014


Fig. 9. 2015

We can give you a lot more examples, but the main conclusion is quite sad. Traditional geomonitoring techniques (geodetic surveying, IV-2 flow nozzles, fiber optics, aerospace, etc.) **do not ensure forecasting** of the above-mentioned catastrophic phenomena. All these methods are useful only to register the events already occurred (ground movements, holes, subsidences, etc.). But any management decisions in these cases come too late!

Not a single method mentioned above is not able to control the initial, preparatory period of a landslide, for instance (Fig. 10).

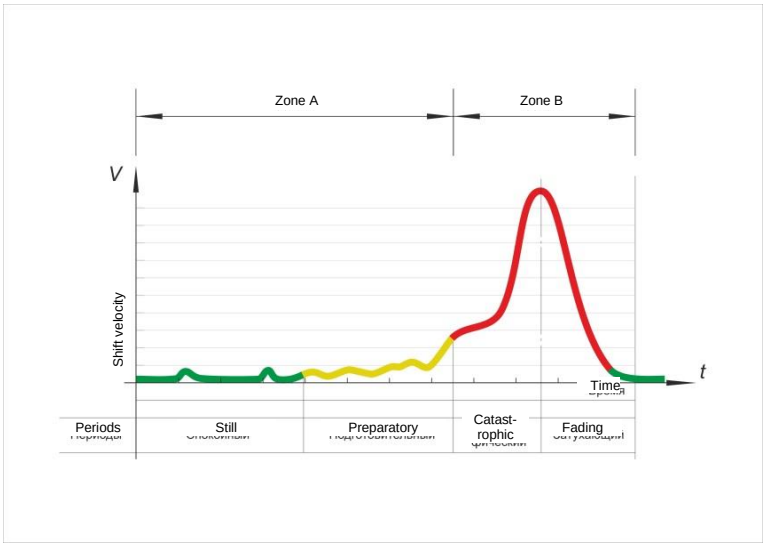


Fig. 10

This period (Fig. 10 a) may take up to 70–90 percent of the full phase of the landslide's ground deformation. These deformations **do not reveal any signs** on the earth surface. Stress deformation changes result in sharp changes of electric soil properties. These phenomena can be reliably registered, and the revealing anomalies can be time-monitored by special devices of type MTZ-01 (Fig. 11).

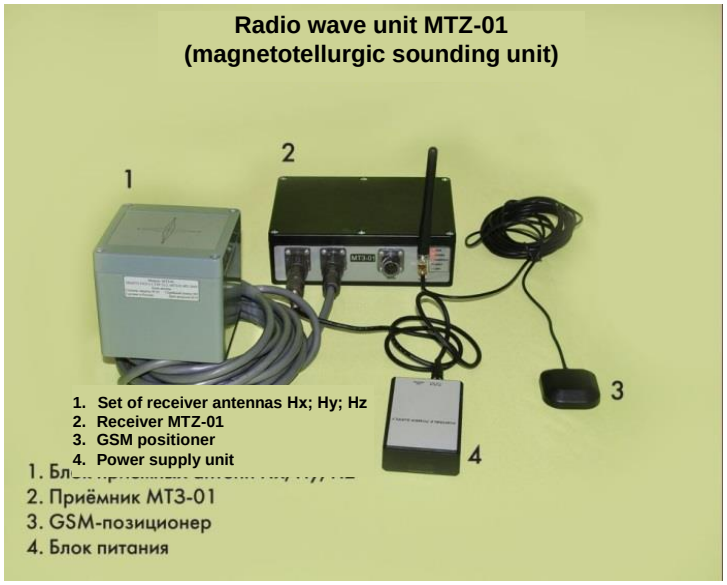


Fig. 11

On-foot diagnostics of the grounds surrounding a pipeline allows accurate **mapping** of all geodynamic zones, caverns and fractures, and repeated observations, i.e. **monitoring**, register their development (Fig. 12).

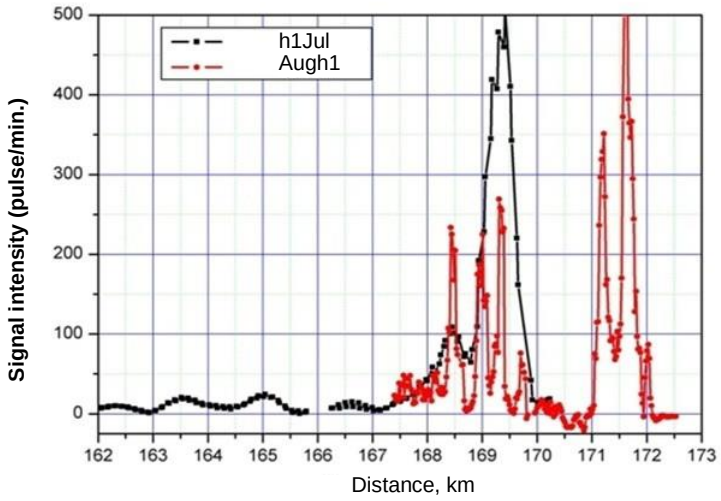


Fig. 12

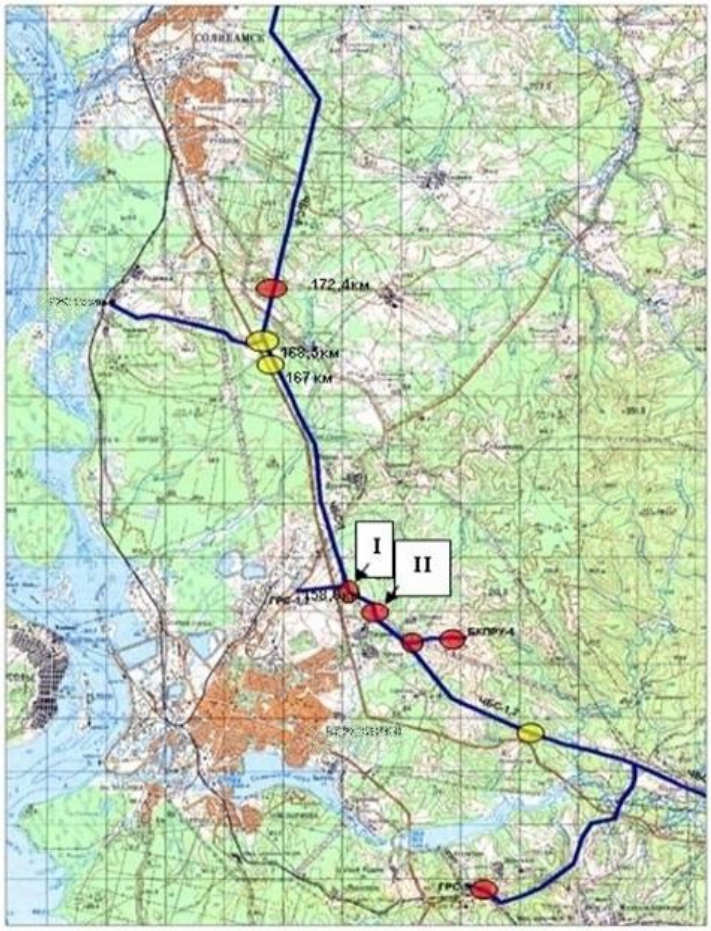


Fig. 13

These data are further represented on a map (sample on Fig. 13).

In case of operational needs and based on the survey of potentially hazardous segments of the trunk gas pipeline's linear route, there appears a real opportunity to arrange the stationary monitoring system, i.e. the system of early warning on activation of hazardous geodynamic processes (Fig. 14).

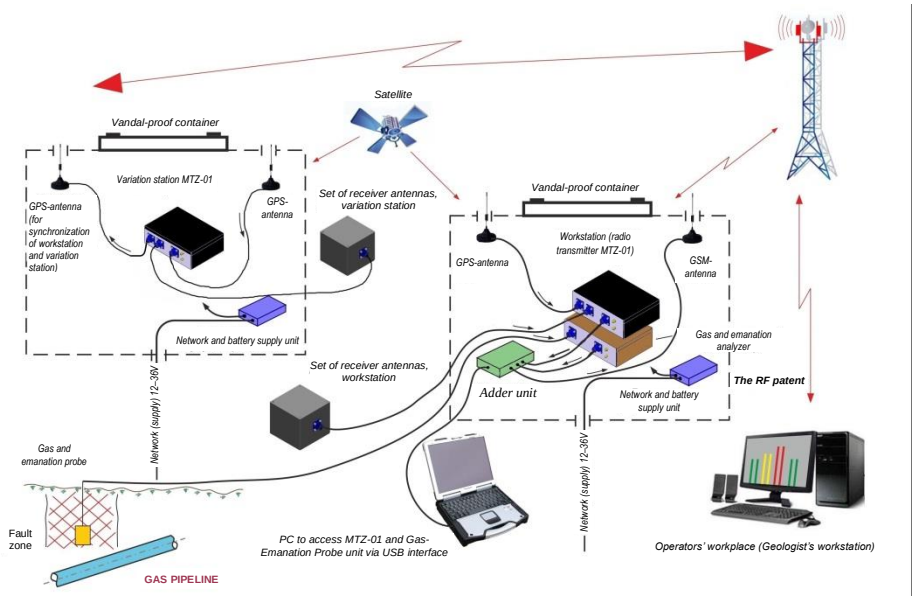


Fig. 14

Similar systems are already operating, for instance, at the underwater Kama River crossing of the Urengoy-Pomary-Uzhgorod trunk gas pipeline 1,852 km long (2006), where 6 (six) emergencies have been eliminated, and the trunk gas pipeline Dzuarikau-Tskhinval, trunk gas pipeline Mozdok-Kazymagomed (607 km), trunk gas pipeline Chusovoy-Berezniki-Solikamsk.

It should be specially noted that our automated radiowave system won the Gazprom PAO' Science and Technique Award-2015, and its author M. Zaderigolova was awarded the Winner's Diploma.

Dear colleagues, we can show you the on-line operation of the automated geomonitoring system controlling the landslide at the Kama River underwater crossing of the trunk gas pipeline.

Finally, I wish to mention that this year our company, in cooperation with the Gubkin Russian State University, launches the works on creation of a principally new type of geomonitoring of trunk gas pipeline's linear routes using radiowave devices on unmanned aerial vehicles.

Successful realization of this project will ensure undeniable advantages to this type of monitoring of the design position of the gas transportation system's integration, as well as of gas pipeline's safety.

It is widely assumed that all catastrophic geological phenomena (landslides, sinks, subsidence) occur unexpectedly.

However, scientists know that each of the above hazardous processes is preceded by a long-term "preparation period".

We have learned how to detect it and to provide its scenario monitoring based on technologies which allow for capture of the slightest changes in the radio-wave field of the Earth within the potentially hazardous areas. Implementation of this method has proven that it can be undoubtedly useful in protecting human life and activities in such unquiet regions, making it vitally critical for major facilities of Fuel and Energy Sector (FES). For this very reason our Automated Geomonitoring Systems have been successfully implemented in a number of vitally critical sites and facilities of Gazprom OJSC.

The author of the RADIO-WAVE TECHNOLOGY design solution is Mikhail Zaderigolova, Doctor of Science, Senior Specialist.

Our long-term successful experience of practical usage of the radio-wave method provides safety and integrity protection for construction facilities located in the areas of natural and industrial hazards.

In addition to the unique scientific solutions our team provides the highest level of competence and expertise necessary to carry out the entire scope of work: from engineering design, surveys, subsoil diagnostic and construction operations to implementation of the Automated Geomonitoring System followed by its operation and maintenance.

In other words, we combine the advanced technology and reliability, which means we mitigate risks in the most complicated conditions.

Mikhail Zaderigolova (Jr.)
General Director, GEOTEK Ltd.

For over 10 years GEOTEK Ltd. has been involved in design engineering and implementation of the radio-wave monitoring of weak soil conditions in potentially hazardous sections of utility facilities and lines operated and located in the areas of Hazardous Geological Processes (**HGP**).

PHYSICAL BASIS OF RADIO-WAVE METHOD

All hazardous processes seem to occur instantly, spontaneously and immediately. But visible signs are actually the very final stage of, for example, landslide process.

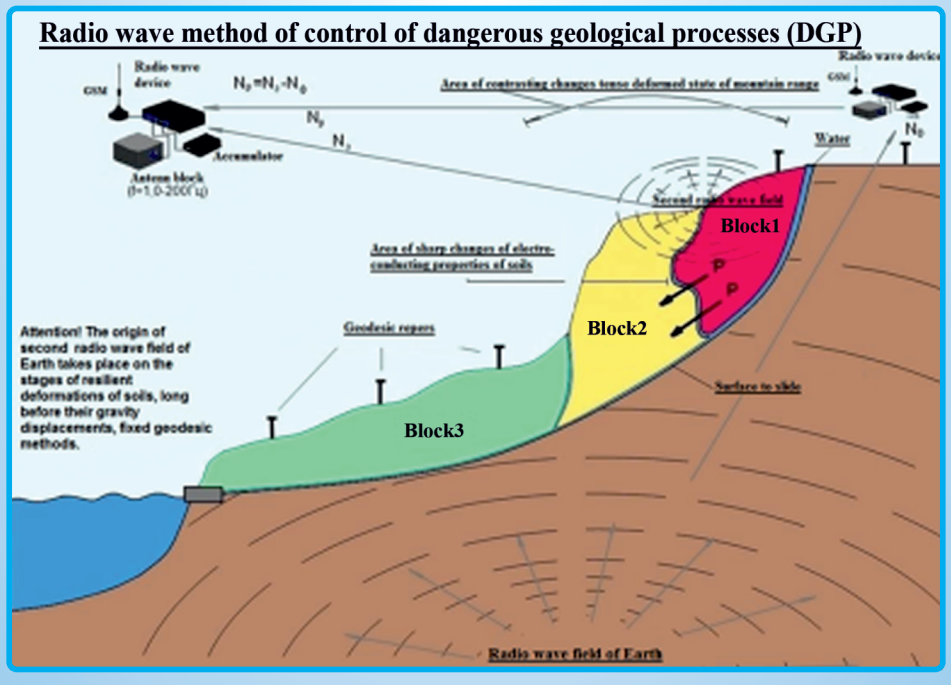
landslide

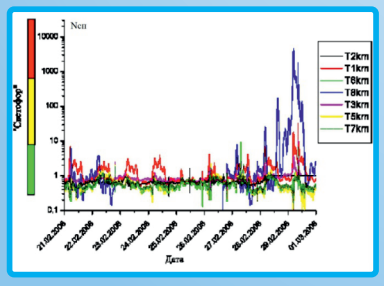
underworking excavation

Exactly these final stages of permanent deformations of the rock mass may be detected by conventional methods: geodesic, tensometric, fiber-optic technologies, inclinometers, etc. All the above methods positively monitor only the results which have already occurred; such methods are essentially incapable of forecasting the initial development phase of the catastrophic deformations. The inescapable fact is that such events never happen instantly, the phenomenon develops in a long-term concealed manner, and its preparation takes to 70-90% of the entire period of HGP occurrence.

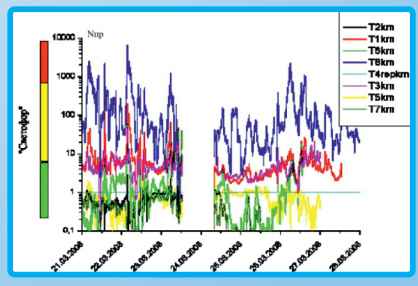
A very effective method (proven by practice) in such cases is to monitor the HGP instant activation processes based on **the radio field of the Earth**. The method allows for early detection of the geodynamic hazards, in particular landslide hazard, at its very initial phase by detecting occurrence of local anomalies in the natural impulse electromagnetic field of the Earth (NIEMFE) or the radio-wave field.

The model of observed Earth's radio-wave field anomaly occurrence is shown in Fig. 1



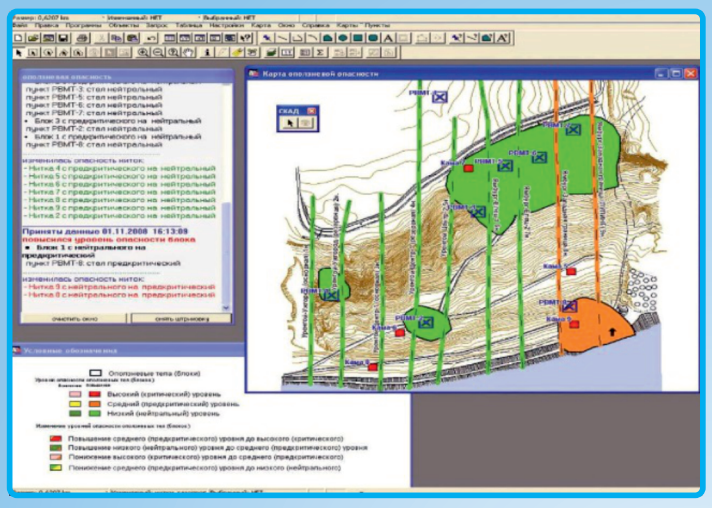


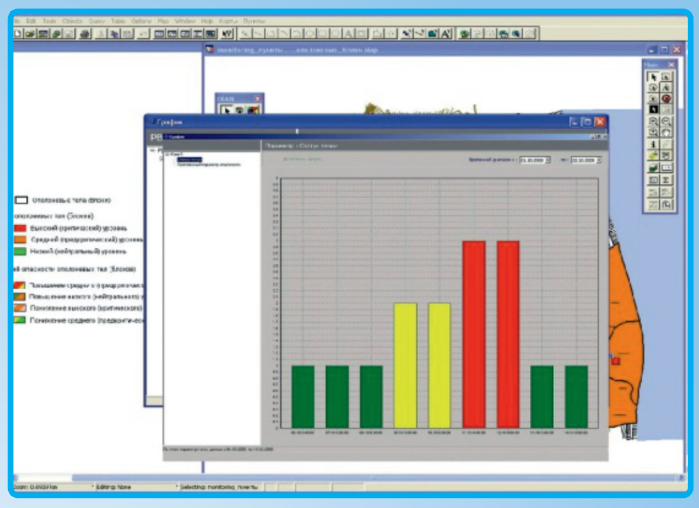
a) quiet and –



b) problem (HGP activation)

periods on the monitor of dispatcher the fragments of radio-wave evidences in





a) the overall situation, b) the mode of traffic lights windows of «geologist workstation» software on the monitor of dispatcher

The proposed method is based on observation of the Earth's radio-wave field anomalies (1-200 kHz) in the areas of elastic deformations in the soil mass, as these anomalies occur long before gravity movements or destruction.

These anomalies within the rock mass are caused by mechanoelectrical processes which occur during tectonic, landslide activity, initial development of earth surface subsidence within karst areas, in underground mining regions, etc. The intensity of the geodynamic activity increase or decrease is measured by the radio-wave working station. Allowance for corrections for the natural and industrial electromagnetic noise (disturbances) shall be provided by the variation station installed within the quiet area of the operation site.

In practice the Earth radio-wave field monitoring is performed by special MTZ-01 type instruments (magnetotelluric probe, model 1) in stationary (a) or field (b) options.

Certification and patents are available for all instrumentation and techniques.

In order to enhance representative features and validity of the acquired data, the basic method of radio-wave diagnostic is supplemented with engineering-geological and geochemical methods (RF Patent No. 123546 dd. December 27, 2012). These methods provide distinct geodynamic markers which together with the radio-wave method allow for more accurate and correct models of the hazardous scenarios of irreversible effects.

The first stage of the geomonitoring activities shall include:

- Subsoil diagnostic in order to detect and delineate the areas of potentially hazardous geological process activity (karst, landslide, tectonic fault, undermining, etc.);

- Modeling of the initial activity of the hazardous geological processes during the phase of concealed development, which allows for timely implementation of management measures, thus drastically reducing the natural and industrial risks;

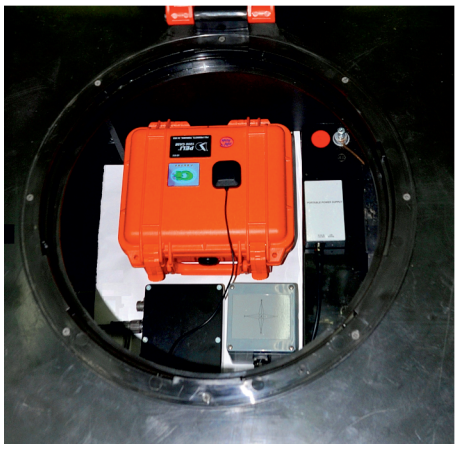
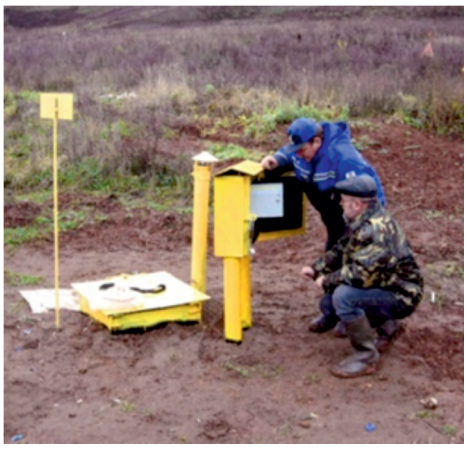
- Optimization of plans for overhauls, funding and terms of repair and recovery operations, primarily in the detected potentially hazardous areas;

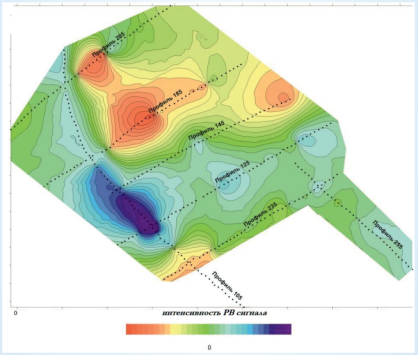
- Acquisition (within front-end engineering and design stage) of correct data on the locations and geodynamic conditions of the hazardous natural and industrial sections of the designed route (for gas or oil pipeline, railway or automobile roads, etc.).

When necessary, within **the second stage** our company designs of the **Automated Early Warning System for Active Hazardous Geological Processes (ASK-GP).**







ASK-GP
IS THE WORLD'S ONLY METHOD
FOR EARLY WARNING OF
HAZARDOUS GEOLOGICAL PROCESSES
AND FOR SAVING TREMENDOUS AMOUNTS
OF MONEY OTHERWISE SPENT ON THE EMERGENCY RESPONSE

ASK-GP is the *Automated Early Warning System for Active Hazardous Geological Processes* (landslide, karst, active tectonic faults, soil subsidence, mountain underground excavation, etc.). The system **is one-of-a-kind** in Russia and in the world due to a number of unique features:

1. Advanced *technology of the monitoring method is based on radio-wave technique*, an author-**design solution developed by a team of well-known Russian scientists**. The efficiency of this method has been proven by over 30 years of laboratory and field tests and many years of successful operation in GAZPROM companies.

2. ASK-GP – *is the world's only system* capable to guarantee early warning of the hazardous geological process scenarios **5-7 days before the emergency situation occurrence**, which is absolutely unachievable for systems built on other physical principles (which provide 0-1 day warning). The long-term forecast provides **an opportunity to take effective preliminary measures to mitigate the damage** and to save the immense costs otherwise incurred in its recovery.

3. The special design ASK-GP System is dedicated to provide reliable continuous operation in any challenging conditions, and to display the real-time data with color indicators of hazards (red-yellow-green) for the attention of operators and managers of the site.

4. The ASK-GP System designers have rich experience and all necessary licenses (permits) for oil and gas industrial operations.

ASK-GP SYSTEM APPLICATIONS

The System is designed to provide safety of the following facilities of critical importance:

- Automobile and rail roads;
- Facilities of oil and gas, energy and defense sectors,
- Major utility facilities, hydropower facilities (dams and dikes),
- Pipelines;
- City infrastructures.

ASK-GP SYSTEM FEATURES

1. Real-time display of initial changes in subsoil stress deformation conditions at early phases due to hazardous geological processes, which otherwise cannot be visually observed on the surface and are inaccessible for conventional control methods;

2. Effective forecasting of the hazardous geodynamic scenarios;

3. Real-time monitoring of the conditions and possibility for implementation of operative yet well-considered management decisions.

ASK-GP SYSTEM BENEFITS

The Automated Monitoring and Early Warning System allows for **acquisition of early and valid data on catastrophic hazards occurrence within the problem area and forecasting** its scenario! The key effect of the Early Warning System implementation shall be **the rapid reduction of the failure rate** due to the timely implemented measures for prevention of the emergency situations at sites located in areas of potential geodynamic hazards, as well as drastic decrease of damage caused by emergency situations.

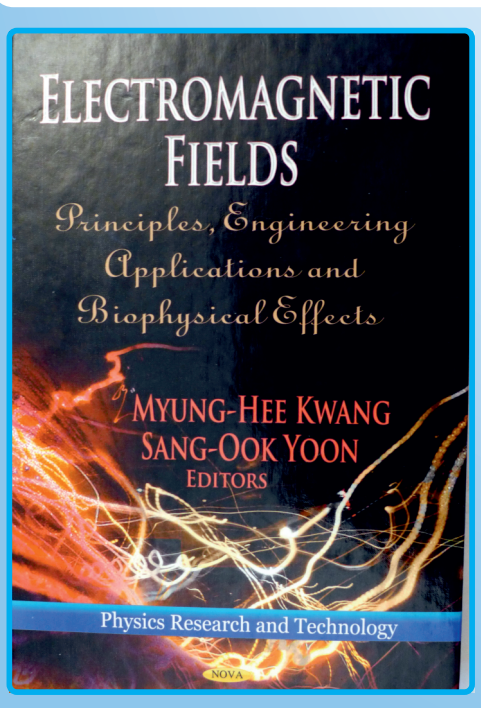
ASK-GP SYSTEM SCOPE OF SUPPLY

The system features an area-distributed hardware and software package which includes the following components:

- Central Monitoring Station: Geologist's Automatic Work Station (Geologist's AWS) including a data acquisition unit, telephone modem, GSM-modem, radio modem, control computer, software applications;
- Field stations (unlimited number), each including a depth radio-wave transmitter, data acquisition unit, modem (cable, GSM or radio), and control computer;
- Special software.

The ASK-GP systems have been installed and operated at a number of GAZPROM OJSC sites.

GEOTEK has a long-term successful experience in practical application of the radio-wave solutions in a wide range of industrial facilities of Russian FES (Perm Region, Udmurtia Republic, North Ossetia-Alania Republic, Dagestan, Orenburg Region and Kamchatka), as well as abroad (Australia, Hungary, Cuba, Panama, Brazil, etc.).



We will be glad to provide upon request detailed information on the scope of the hardware and technological package supply, methods and techniques of field operation, as well as procedures for processing of the data acquired.

We guarantee fast feedback in terms of cost-estimate preparation, formulation of the engineering and economic feasibility studies and commercial proposals for your specific conditions and operations.

Please contact us today and mitigate your tomorrow risks!