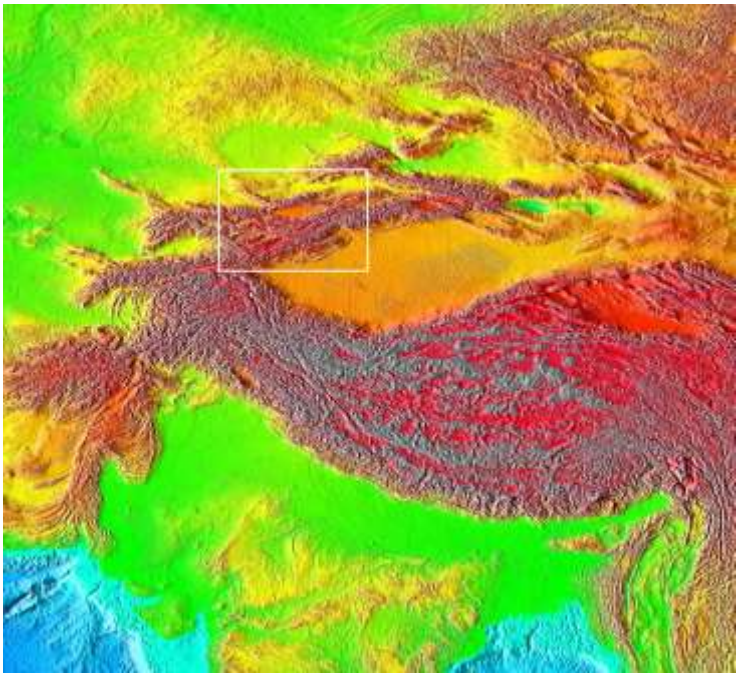
# Central Asian Institute of Applied Geosciences
# CAIAG
# Research & Development Programme for the years 2010-2012



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Introduction

The second CAIAG research and development programme (the first was realized in 2007-2009) for the years 2010-2012 (RP&DP 10/12) aimed at realization of the following interconnected priority directions that are fundamental for Central Asian region:

**I. Geogynamics and ecocatastrophes**
**II. Climate and water resources**
**III. Information and monitoring systems**

The projects within the frameworks of the foregoing priorities are provided to be realized in frames of budget and raised resources from third sources during two years. Expected results are directed at important problems solution having a positive impact on ecological and socio-economical progress of the neighbouring states.

- the region of Talas – Fergana and tectonic fault system that affect on the Toktogul reservoir, an important water supplier for irrigation Fergana valley system and Aral Sea basin.

- the region of the Sary-Dshaz river basin and the Inylchek glacier located there, constitutes one of the largest fresh water and important hydropower resources in the eastern part of Kyrgyzstan, Kazakhstan, China.

- resort Issyk-Kul region on the East of the country and the city of Bishkek (the capital of Kyrgyzstan) with adjacent territories are sensitive areas for earthquake hazard mitigation efforts.

The investigation of natural, natural technogeneous catastrophes, and priorities presented above are of big importance for water supply in Kyrgyzstan and neighbouring regions in Uzbekistan, Kazakhstan and Xinjiang Uigur autonomous region of China; for the planning of large-scale geotechnical projects in the region, such as hydropower station system, high-tension transmission line, reservoirs, and intrastate railway and road systems. The realization of these projects will have a positive impact on socio-economical development of central Asian States, as well as on living conditions and material well-being of the population.

It is considered to cooperate with specialized institutes under the mainstreams of CAIAG activity in the process of implementation of all projects described in the following section: Tomsk University, Institute of Geology and Mineralogy of Siberian RAS (Russia), National Nuclear Center (Kazakhstan), Institutes of National Academy of Sciences of Kyrgyzstan and of Central Asian States, Head Institute of Engineering Studies, State Construction Agency in Kyrgyz Republic and Central Asian States, specialized departments of Institutions of higher education, Ministries of Emergency Situations and geological Institutes of Kyrgyzstan and Central Asian States and other interested institutions in Europe and worldwide.

Bishkek, December 2009

Dr. Bolot Moldobekov

Prof. Dr. Helmut Echtler



# 1 Theme 1: Geodynamics and Geohazards

***Theme Supervision Usupaev Sh.***

## 1.1 Project: Neotectonic, engineering-geological, geocryological and seismic research of the Sarydjaz river basin as the region for future construction of a hydropower station system (continuation of research with preliminary geo risks assessment).

***Executive leaders: Sh. Usupaev., A. Meleshko, U. Abdybachaev.***

### *1. Project short title*

Neotectonic, engineering-geological, geological and seismic research of the Srydjaz river basin.

### *2. Project outline*

The Sarydjaz river basin located in the Eastern part of the Kyrgyz Tien-Shan has a large resource of ecologically pure fresh water concentrated in glacier system and is a region of high hydroelectric potential. Investigated region is recognized as a very promising one for investigating and mining operations, as well as for hydroelectric power station designing and construction in Kyrgyz as well as in China region (Xingjiang – Uygur AR).

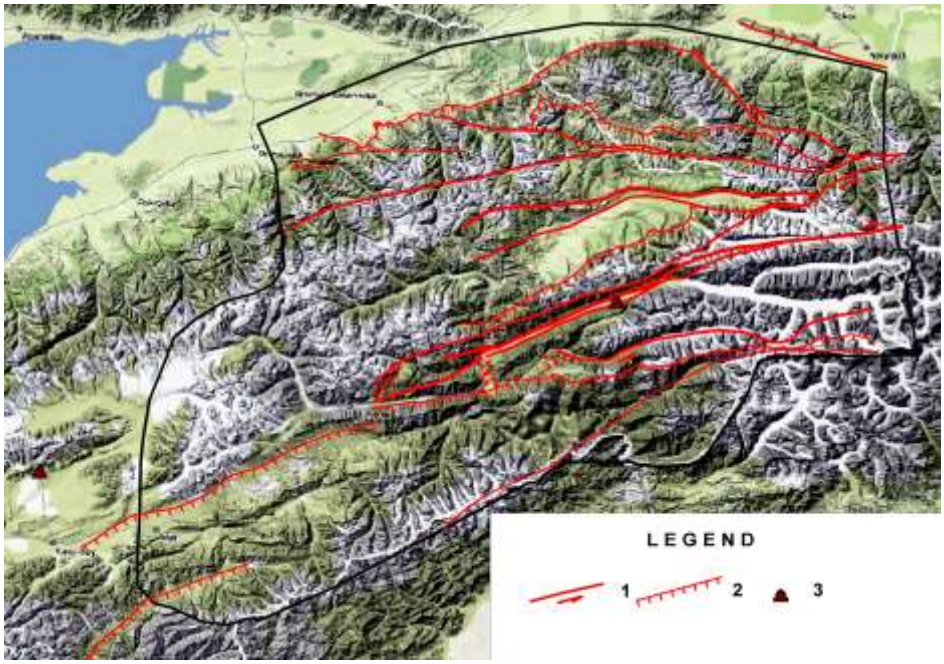
A number of tectonic, engineering geological, geocryological, and seismic research is to be done under the territory exploration that is mentioned above. This research includes the study and mapping of exogenous and endogenous processes and phenomena that threaten the future geotechnical constructions. Designing of hydrotectonical construction is impossible to start without study of engineering geological conditions, engineering geodynamical and geocryological survey, seismo-tectonical zonation, GEOPHYSICAL ELECTROMAGNETIC SENSING OF DEEP STRUCTURES and micro-seismic zonation of the regions of dams and reservoirs, as well as of canal and tunnel tracks ( 15)..

The area of complex geological investigations covers all tectonic units that the Sarydjaz river basin (tectonical zones of the Northern, Middle and Southern Tien-Shan) has. Meridian ridge is the Eastern boundary of investigated area. The northern boundary of investigated area is adjacent to the edge fault that delimits Terskey ridge and Issyk-Kul and Tekesskey depressions.

The Southern boundary is adjacent to the Kipchakskey fault that delimits Kokshaal and Tarimskey depression, actually passes along the China state border.

The western boundary is drawn conventionally along the watershed between the Sarydjaz and Naryn river basins. The total area of investigated region constitutes some 15 000 km$^2$ (see pict. 1). Considering that seismic data conventionally designated within coordinate grids, seismic information on the researched area confined within coordinates in latitude 41º -43º and longitude 78º - 81º.






Pic. 1. Location of investigated area on the relief scheme

1. Displacement 2. Overthrust 3. Seismic stations installed under the project

Data analysis on the Central Tien-Shan, carried out at the stage of preliminary study (2007-2008), as well as acquired on-site field work data made it possible to create a map of new faults for the eastern part of the investigated territory (Pic. 1)

In the course of field research carried out by Mikolaichuk 2008 in the interfluve of the Sarydjaz and Inylchek rivers, the main attention was focused on active fault study.

The eastern segment of the Atbashy-Inylchek fault is of greatest interest. It is determined through observations of the Inylchek river terraces that the fault was rather active in the Middle Pleistocene, and its reactivation could be assumed in the Late Holocene due to appearance of the thermal springs.

The movements in this fault are mainly left shifting, that resulted in confluence of the Sarydjaz and Inylchek rivers and formation of the local graben (or pull-apart structure).

In hard-to-reach areas of the right-bank Inylchek River samples are taken for the fission-track analysis, which allows reproducing the impulses of activization and attenuation on the Atbashy-Inylchek fault.

The Sarydjaz river basin according to (Sylvester, 1988), is referred to a depression class that is a component part of the tectonic plates that form the palm tree structures in conditions of transpression.

Mesozoic and Cainozoic Sarydjaz river basin complexes and adjacent territories within the range of the Central Tien-Shan, age interval deposits are presented as exceptionally continental sediments.

Thin alluvial and deltaic deposits of Early Jura being not widespread, lie in the Paleozoic platform.

Alluvial and lacustrine sediments of the late Cretaceous Paleocene lie in the Early Jurassic deposits or else in the Mesozoic residual soil that rarely reaches 50-80 m.. The stratum in the region with thickness of the first kilometers that marks the orogenic processes and makes a series of intramountain and intermountain depressions has been forming since the Oligocene.

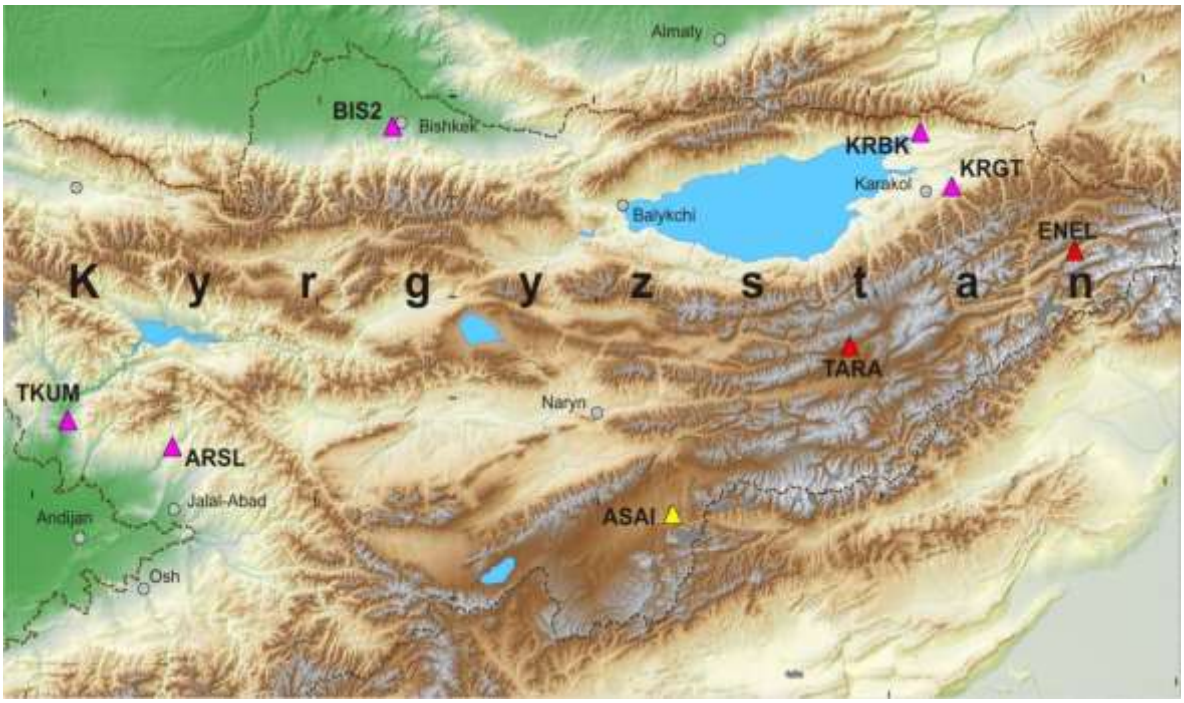
The Ms=8 Kakshaal earthquake epicenter in 1915 is caused by high concentration of small earthquakes in the regions of the Sarydjaz and Inylchek active sites. Data on focal mechanisms of small earthquakes denote that the boundary of blocks passes at the point of the Sarydjaz river outlet to the territory of China. Within the limits of different blocks there are different types of movements in earthquake sources – thrust movements to the East, normal movements to the West.

The analysis of earthquake catalogues 2005 carried out by Kalmetyeva Z.A. (2008), as well as of catalogues of focal mechanisms using data on China territory allows making the preliminary conclusion that there is a joint of the earth's crust blocks of different tectonic movement regimes that occurs at the point of the Sarydjaz river outlet to the territory of China

On three operational GPS stations Kerege-Tash, Taragai, and Inylchek nowadays the first baseline distance curves are built according to the components between observation points for each day of measurements.

Mean-square deviations of the horizontal components make less than 2 mm.

The broadband digital seismic stations installed by CAIAG in the area of Taragai and Inylchek function nowadays (pic. 2); incoming seismic information is in the process of development now.




Pic. 2 A map of CAIAG monitoring network layout chart.

The results of background research allowed of realizing reconnoitering field works; there were digitized active faults, installed two seismic stations, realized data collection on the

study of explored territory. In the years of 2010-2012 it's provided for the continuation of research works on neotectonics, engineering geology, geocryology, and seismic monitoring of exploring territory with the purpose of scientific exploration of the region for prospective dam hydro power construction in the Sarydjaz river basin.

According to the results of background research of the Sarydjaz river basin aimed at the monitoring improvement of seismic activity and surface deformation, three fixed broadband seismic stations, 5 GNSS were installed. The favourable conditions for enhancement efficiency of the monitoring network use are in process of developing resulted from partners' mutually beneficial arrangement about a date exchange with IS NAS KR, Kazakh Nuclear Center and Xingjiang-Uygur Seismology Office in China.

***Long-term objectives:***

The geographical location of the research area between Kazakhstan and China makes the installation of effective seismic, GNSS and meteorological observation station network highly attractive for an integrated observation network over the whole Central Asia. The experimental data obtained will be used for research work on the region's geodynamics, modern tectonics, present movements, engineering geology, geogryology, and seismicity. Complexification of geology and engineering geology data make it possible to assess the regional seismic and engineering geological risks of the region of planned hydropower station construction.

***Short-term objectives:***

The short-term goal of the project is the preliminary neotectionic, engineering geological, geocryological, and seismological characterization of the Sarydjaz river basin. For achieving the purpose it is necessary to collect literary and archival data, to create an interdisciplinary monitoring observation system, to carry out additional field geological research. Seismic stations are equipped with broadband sensors. This will allow investigating earthquakes of the whole region in the future. Sites of seismic observations are equipped with GNSS receivers of high resolution, which will allow very important studies on the linkage of the regional internal dynamics to potential hazards at the surface.

***Methods:***

- Geological methods (neotecnonics, paleoseisology, fission-track analysis);
- Engineering geological and geocryological methods (site mapping of hazard processes and phenomena, ground strength evaluation)
- Seismological methods (seismostatistics, spatiotemporal distribution, focal mechanisms, seismotectonic deformations);
- Satellite geodesy (GNSS station positioning) and geophysics (MGR sensing by natural electromagnetic Earth's pulses).
- Satellite remote sensing methods (radar, mulispectral).

***3, Current status and special requirements***

Neotectonics of the region studied within the frames of Shultz S.S. work, 1948 [9], and



background geological geophysical research, carried out under the seismic zonation of the territory of Kyrgyzstan East in the years of 1981-1985 [5].

Due to insufficient research of the area, special stress is expected to be done on remote methods, i.e. decoding of aero- and space photos by radar sensing method. In connection with highly disjointed relief the field work will be conducted as routs only on the sparse network.

In China, to the south of this area, seismic stations of the Xingjiang-Uygur Seismological Bureau are in operation. GPS measurements in the Tien-Shan region started in 1992 [6-8]. The very first measurement results displayed big velocity gradients on the East Issyk-kul side. In 997-2001, the number of sites was significantly increased there [6]. It's also planned to install 5 fixed observation sites by GNNS stations, three of them will be joined/connected with broadband seismic stations mentioned above.

The territory was not researched by the remote sensing methods previously. Since 2008 the existing data of multi-specter sensor processing (i.e. LAND SAT) and of radar data processing TERRA SAR are available over the region. Both of data types are proposed to be actively used under the project implementation.

### *3. External and Internal cooperation*

The project will be carried out by employees of the first department involving the experts of the second and forth departments of CAIAG. A close collaboration with relevant institutes in Kyrgyzstan (Institute of Seismology National Academy of Sciences in Kyrgyz Republic), Kazakhstan (national Nuclear Center, Kaselzaschita), Tomsk University of the Russian Federation (geophysical monitoring), China (Xingjiang-Uygur Seismological Office), Germany (the University of Potsdam/ the Institute of Geosciences, the University of Jena/ Geological Institute).

### *Coordination with CA GCO*

The current project has close links to the objectives of theme 3 of the CA GCO project (Earth's Surface Dynamics). First of all a close coordination for installation of new observation sites (Tomsk University in Russia), organization of data acquisition, transfer, and processing of these observations are proposed.

The first reconnaissance field trip for observation site selection (seismic and GNSS stations) was already carried out with the participants of the first department GFZ. For regional structure interpretation, well as for three-dimension area model are planned joint remote sensing data analysis, as well as exchange of data and analysis results obtained from seismic and GNSS stations.



### *i. Working plan and necessary resources*

**Duration of the project – 2008-2009**

**2010:**

- Geological, engineering geological, geocryological field works;
- Organization and development of the basis of modern network for geophysical remote sensing of deep interior structure and monitoring of natural electromagnetic pulses.
- Support of geo-database development of georisks, dangerous environmental changes by defining data formats and service programme.
- Collection and introduction of existing geological, engineering geological, geocryological, and historic earthquake data into the geo-database.

**2011:**

- Extended field geological, neotectonical, engineering geological, geocryological research.
- Processing of seismic observation data and analysis of results.
- Studying of GNSS station position time series for change determination of horizontal and vertical components, analysis of natural electromagnetic Earth's pulses.
- Analysis of surface deformations in the region according to D-InSAR data and permanent reflection methods by Envisat TeraaSAR-X data;
- Generalization of materials on neotectonics, engineering geology, geocryology, geophysics (electromagnetic sensing) (as obtained by field survey and remote sensing techniques);
- Characterizing of geodynamical, engineering geological, geocryological conditions of the Sarydjaz area on the basis of joint geological and geophysical data.

***Required manpower:***

- Department 1 - 210 man-months;
- Department 2 - 40 man-months;
- Department 4 - 60 man-months.

***Required observations/data and tools:***

- Seismic monitoring: high resolution digital broadband stations, software for seismometric data processing, archive data on seismicity of the Kyrgyz territory;
- Measurements of surface displacements,
- Equipping of installed stations by multichannel registrar MGR-01 C and organization of monitoring sensing of natural electromagnetic earth's pulses:



- Time series of GPS/CLONASS receiver 3D position;
- Optical and radar satellite images of region and interpretation software.

- Geological, engineering geological, geocryological field research, material from geological archives, field geological outfit.

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*Геология и геофизика*, 2009, т. 50, № 2, с. 152—172 http://www.izdatgeo.ru



***Theme supervisor: Usupaev Sh.***

**Project 2: Integrated study and georisk assessment on the example of landslides, mudflows, underfloodings in the territory of Kyrgyzstan and transboundary regions of Central Asian States (geobase data collection, analysis, generalization).**

***Project leaders: Meleshko A., Abdybachaev U.***

***1. Short title of the project*** .....

Integrated study and georisk assessment on the example of landslides, mudflows and underfloodings.

## 2. Project outline

According to the project title it is planned to carry out works on geobase data collection, analysis, generalization of the most spread hazard processes and phenomena, landslides, mudflows, and underfloodings (1-11).

A relief topographic map 1 (pic. 1) shows the territory of the Kyrgyz Republic with glacial regions(it is in blue; high-mountain outburst lakes that stimulate mudflow-flood processes are concentrated at the end of the glaciers), plain (it is in green; underflooding zones developed in these relief areas) and mountain regions (different tones of brown colour; the territory is under the exposure to exogenous hazards such as landslides, mudflows).

There are some 5000 – 7000 areas of landslides, including those of rocky genesis, that occurred In the territory of Kyrgyzstan.

About 3900 river basins 10-20 kilometers length refer to mudflow and flood hazardous areas. More than 2000 montain lakes are located in the mountain region, some 330 of them are outburst to a different degree. More than 330 settlements of Kyrgyzstan located are exposed to underfloodings, including Bishkek, Talas, Tokmok, Kant, Balykchy cities (pic. 2-4).

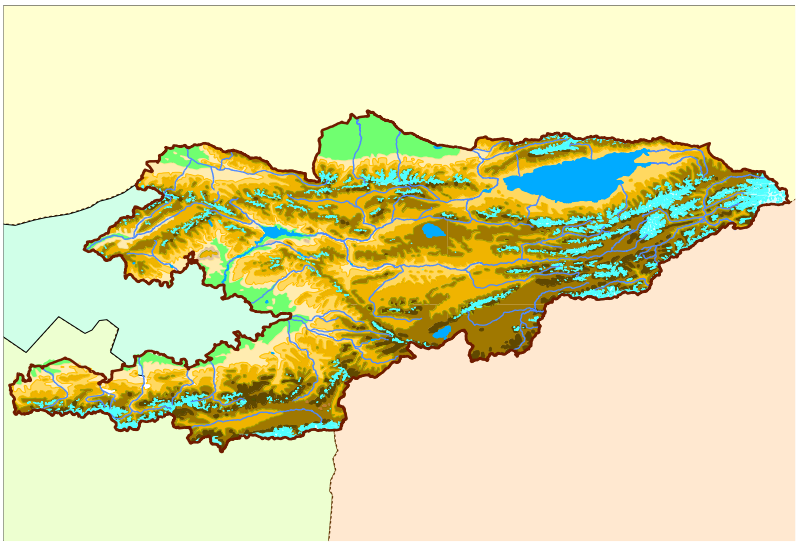

**Рис.1**. A map of psycho-geographical conditions of the Kyrgyz Republic territory

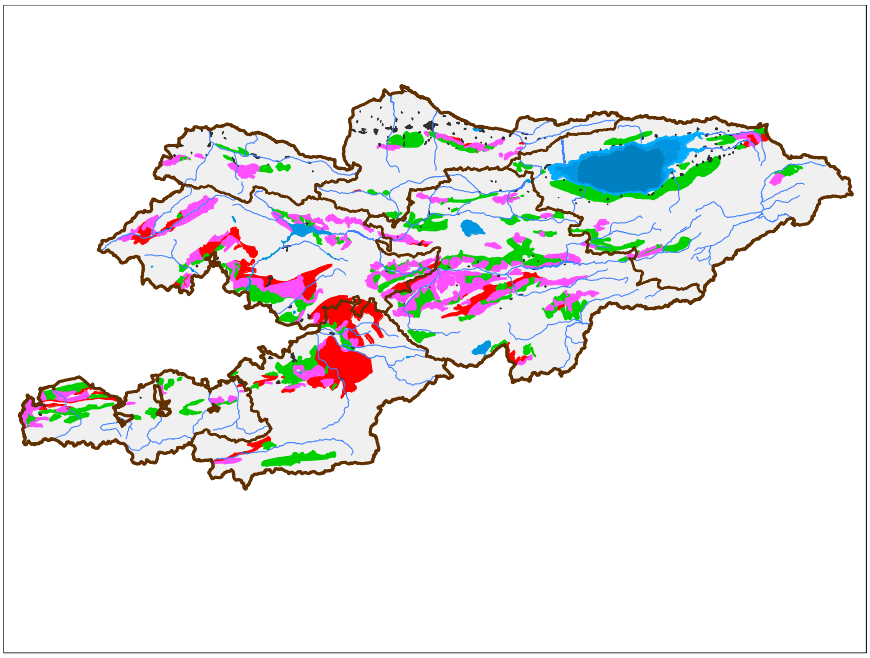

**Рис.2 .** Landslide hazard map of the territory of Kyrgyzstan

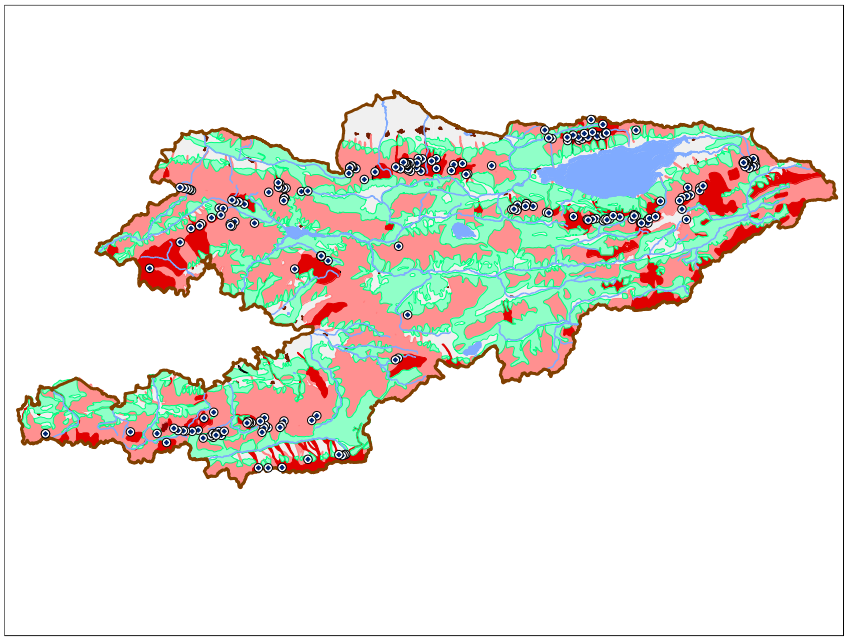

**Рис.3.** A map of mudflow hazard and high-mountain outburst lakes in the territory of Kyrgyzstan

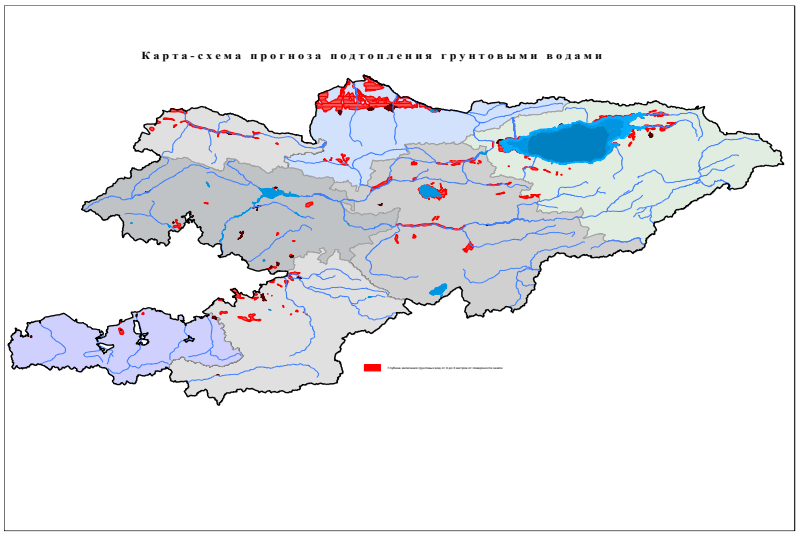


**Рис.4**. A map of underflooding in the territory of Kyrgizstan (high groundwater levels)

## 3. Project objectives and methods

The goal of the project is a complex solution of the following tasks:

The main goal of the project is an integrated study of landslide, mudflow processes, underflooding of settlements accompanied with collection, analysis and filling of geodata base of CAIAG that has being created by the 4 department.

Re problem solution of geobase data collection, analysis, generalization, and filling:

1. The collection of available data on landslides, mudflows, undeflooding in the territory of Kyrgyzstan and transboundary regions of Central Asian States.
2. Analysis of acquired information on landslides, mudflows, underflooding and parameter specification of identifying data taking into account requirements of normative and legal documents.
3. Generalization of information on selected conditioned data on landslides, mudflows and underflooding.
4. Preparation and filling of developed geo-database in CAIAG with necessary and sufficient information on landslides, mudflows and underflooding.

***Short-term objectives:***

**In the field of study of** landslide processes and phenomena:

1. Study of potential landsliding hazards that put Kurpsai hydropower under the threat, as well as of georisks of landslide processes in the region of Mailu-Suu town, Min-Kush and Gulcha settlements.

2. Study of landslide occurrence as a response to seismic activity.

3. ГЦО project “Fergana” support.

***Methods:***

- Decoding of aero and space images,
- Field observations, reconnaissance survey, photo documentation,
- Monitoring benchmark setting landslide, mudflow, underflooding risk areas and GPS affixment for the regime observation.
- Identification of principle landslide, mudflow, and underflooding areas through georisk mapping methods.
- Use of remote sensing and ground tool techniques and methods of observations on environmental changes.

***4. Current status and special requirements .....***

In the period of the years 1992-2009 a collection of facts on landslides, mudflows, underfloodings that occur in the territory of Kyrgyzstan and transboundary regions adjoined to Central Asian countries was carried out. A complex of research was carried out annually on the basis of data\activity of MES Kyrgyzstan under the participation of such relevant institutes as Sate Geological Agency, Osh SIER (State Institute of Engineering Research), Institute of Geology NAS KR, Institute of Water and Hydroelectric Problems, Scientific Research Center “Geopribor”. The acquisition of necessary data for prevention and mitigation of the risk of studied hazard processes and phenomena is possible under the research carried out.
Digitizing of large scale maps is carried out by the use of GIS with draw of accurate information about landslides, mudflows, underflooding regions.

There are few catalogues that analyze and generalize the information on landsides, mudflows and underflooding. They are expected to be reviewed and selected in order to be included in geo-database.

**5**. ***Internal and external cooperation……..***

The project will be carried-out by the 1 department with participation of the 2 and 4 departments of CAIAG. Close cooperation is planned with GFZ, the Institute of Geology, the Institute of Rock Physics and Mechanics, State Geological Agency, and Osh SIER. Furthermore, it is planned collaboration with scientists and specialists from the relevant organizations of Central Asian States (Kazakhstan, Uzbekistan and Tajikistan).

***6. Work plan and required resourses……..***

***2010:***
Data collection, analysis, generalization on landslide, mudflow, underflooding territories
Reconnaissance field works
Decoding of aero and space images

***2011:***
Preparation of collected data; processing of information for geo-database.
Thorough field works in three regions on the basis of decoding of remote sensing data.
Monitoring data acquisition on landslide, mudflow, undeflooding of the regions by the



use of installed automatic stations (seismic, meteorological, and geodesic).
Filling of geo-database with information on landslide, mudflow, underflooding monitoring.
Use of geo-database for the purpose of georisk assessment and hazardous environmental change prevention.
*Required manpower:*
Department 1-270 man-months
*Required observation/data and tools:*

- Aero and space images of high resolution;
- Affixment of landslides, mudflow focuses and underflooding areas to aero and space images, as well as to topographic bases of large scale.
- Parameter specification and classification according to normative and legal documents of landslides, mudflows, and underflooding.
- Use of operating network of interdisciplinary monitoring and observation network of environmental changes for the reduction and mitigation of landslide, mudflow, and underflooding risks.

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**Theme supervisor Sh. Usupaev**

**Project 3: seismic microzonation of the territory of populous cities and objects of strategic relevance in Kyrgyzstan and Central Asian states (continuation on research)**

***Project leaders:***

***J. Tokmulin, S. Orunbaev***

***1. Project short title*……**

Seismic microzonation of the territory of populous cities and objects of strategic relevance

***2. Project outline***

One of the major tasks of microzonation is to identify zones on exploring territories with different intensity of quakes that are distinguished according to engineering geological, tectonic, hydrogeological, geomorphologic and seismological conditions (1-14).

The initial intensity is defined on the basis of general seismic microzonation map, as well as of precise seismic zonation (ESZ). The initial intensity is a “model” regarding to ground that is used as ground I and ground II categories (and document “standard norms -II-7-81”). For seismic resistance of constructions required parameters of ground oscillation acceleration were acquired by means of extrapolation of averaged spectral characteristics obtained from small earthquake recordings and large earthquake accelerograms on bedrock base.

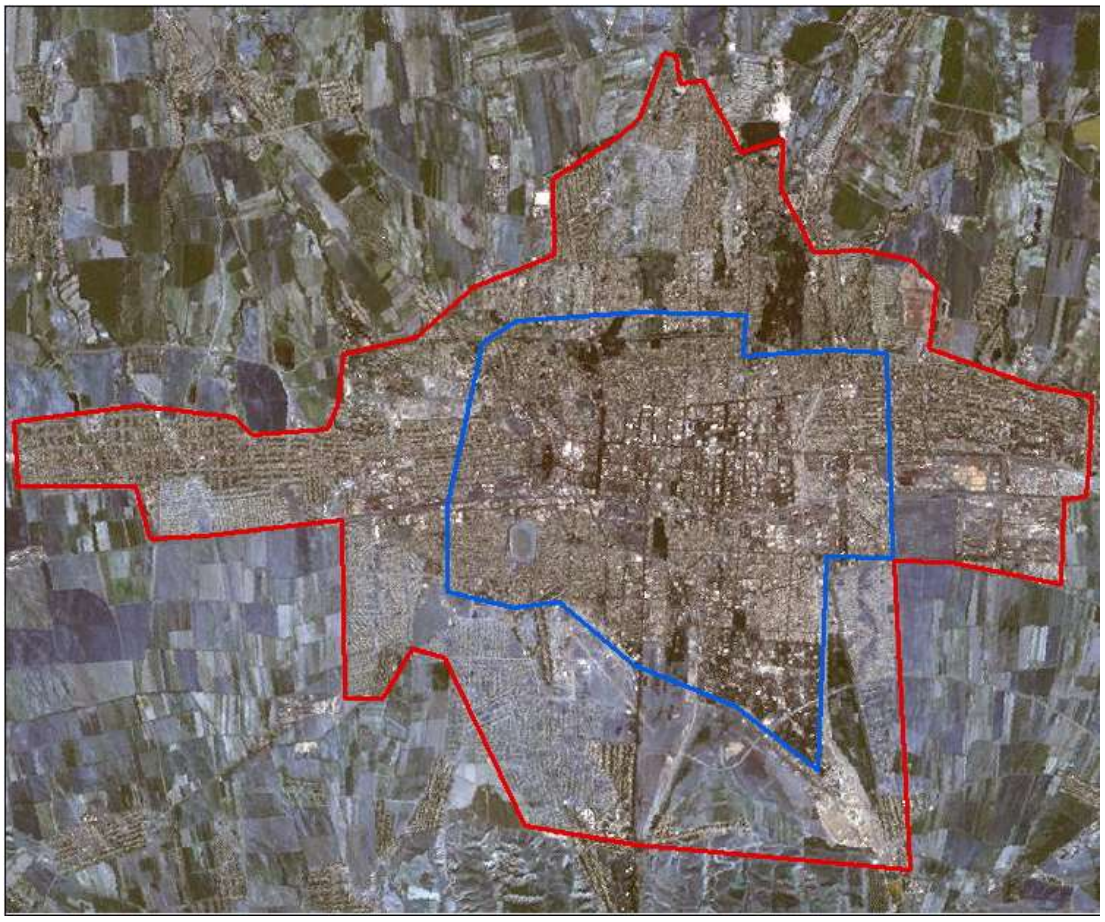
Methodological principles and first results of the processing of seismic data acquired from Bishkek city territory taking into account its area extension till 2025 (pic. 1,4), are given below as a work experience in the field of seismic microzonation.

The picture 4 shows the results of noise processing. Quantitative data of ground oscillation frequency were processed and received for each of 200 measuring points.



***Creation of earthquake early warning system (continuation on a theme seismic microzonation of Bishkek city for the years of 2008-2009)***

The project, field, and office work is expected to be carried out involving methodological participation in collaboration with colleagues from GFZ Potsdam, Germany and INGV, Italy; Dr. St. Parolai, A. Strollo from GFZ (Germany), Dr. D. Bindi, E. D'Alema, P. Auglie from INGV (Italy). The installation of accelerometers in different kind of buildings (for construction type), with different number of floors and different use (cultural centers or building of strategic relevance) is expected to be continued for the mapping of seismic and wear resistance of constructions and buildings on the territory of Bishkek city and its agglomerations.



Pic.1 Satellite image of Bishkek city territory with former (blue color) and new (red color) city borders.

## 1. Project objectives and methods

***Long-term objectives:***

Modern type seismic microzonation and risk assessment complex mapping for those cities, settlements, and objects of strategic relevance of Kyrgyzstan and Central Asian countries involved where a great need for DISASTER RISK ASSESSMENT AND REDUCTION exists – for example: regional centre of Kyrgyzstan; hydropower station

Kambarata 1and 2, Sarydjaz river basin, Central Asia region, Tashkent city, Almaty city, Dushanbe city, Ashgabat city.

At the same time in Central Asia countries interested in creation of early warning system in settlements and objects of strategic relevance it is planned to finish equipping seismic stations with geophysical registrars МГР 01 С that make it possible to carry out the monitoring sensing of early seismic risk precursors according to the measurements of natural electromagnetic Earth's pulses.

***Short-term objectives:***

The development of additional monitoring network of geophysical registrars of natural electromagnetic Earth's pulses, in the presence of seismic station network, on the territory of settlements and objects of strategic relevance that are mentioned above.

Collection, processing, and analysis of the neotectonic, engineering geological, hydrogeological, geomorphologic, seismic, geodesic (recent movements), and geophysical (electromagnetic) data will be performed. The study of soil frequency characteristics using the methods of strong movement recordings and permanent station measurements of noise. Determination of parameters of possible strong earthquakes in the proximity of investigated areas. Complex mapping of seismic microzonation and georisk assessment taking into account hydrogeological and soil conditions.

***Methods:***

Engineering geological and hydrogeological methodologies of the urbanized settlement survey (data collection, analysis, and generalization).

- Engineering geophysical methods of recording of natural electromagnetic Earth's pulses;
- Engineering seismological method of estimation of quantitative parameters of soil motions caused by strong earthquakes;
- Nakamura method for estimating the fundamental resonance frequency of sites and, if possible – where constraints on the sedimentary cover thickness exists – the S-wave velocity profiling.
- Research techniques consists in the following:

Three types of measurements are carried out:

1. Array measurements;
2. Earthquake recording;
3. Single measurements;

For the purpose of seismic microzonation the following current technologies and equipment are expected to be used:

Mark L4C-3D sensors, Guralp BB, Lennartz LE3D-5s, EarthData Recoreder PR6-24 digitizer, Reftek 130 Recordeer, GPS antennas.

*The measurements on the example of Bishkek city territory were carried out according to current techniques and work experience in the following sequence*:

First of all the array measurements (noise measurements in the area) were carried out. Two main areas were selected for earthquake recording that meet requirements: 200x200 meter array; and located at a safe distance from vibratory effect of the motor transport.

The following is selected by aspects that meet the requirements: 1) Area in the region of GAIAG location, 2) Area in the northern wing of the active Issyk-Ata fault to the east to Orto-Sai settlement. Each area was measured during the day by 20 seismic stations at the same time. H/V ratio is defined according to the results of noise measurements. Spectral ratio between horizontal and vertical components is widely used for the area parameter characterization (Lachet et al., 1996; Bonilla et al., 1997; Parolai et al., 2000). Lately the H/V method ratio is used for the noise processing (Nogoshi and Igarashi, 1970, 1971; Nakamura, 1989) and is being extensively researched now (Field and Jacob, 1993; Lachet and Bard, 1994; Lermo and Chavez-Garcia, 1994; Bard, 1998; Mucciarelli, 1998; Bindi et al., 2000).

The main result of the method is a reliable estimation of soil frequency resonance (e.g. loose rock) (pic.2)..

A standard spectral ratio is defined subsequently (SSR).

The spectral ratio between the components of 2 short distance stations.

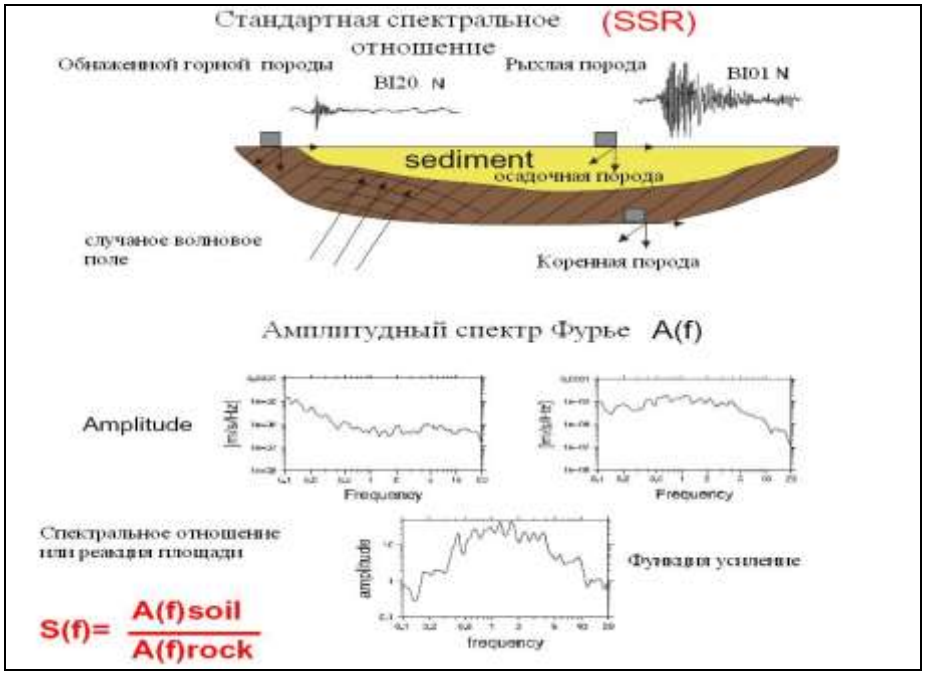
For SSR the distance between 2 stations is 5 times less with respect to the hypocentral distance. On the assumption of nonfulfilment of the requirements a non-reference point method is used.

***Non-reference point method***

There is provided a site response in a reference point method. The site response is estimated by the non-reference point method (H/V) (pic. 2 and 3).

Digital seismic microzonation maps are developed on the basis of acquired data processing.






Pic.2.. A chart of spectral ratio between two close stations

### 1.1.1. *Internal and external cooperation*

The project will be implemented and carried out as a bilateral collaborative activity of CAIAG (departments 1& 4) and the GFZ Potsdam (department 2), for the latter as an activity within the Global Change Observatory- Central Asia program (CA GCO, as well as the use of capacity of involved profiling initiatives and agencies). The collection of archival material will require intensive cooperation with the following organizations in Kyrgyzstan: KyrgyzGIIZ, Gosstroy, Institute of Seismology NAS KR and others. It is also planned to cooperate with other foreign organizations, specialized in such kind of research, such as the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Italy.

***Coordination with the GCO- CA and other profiling initiatives***

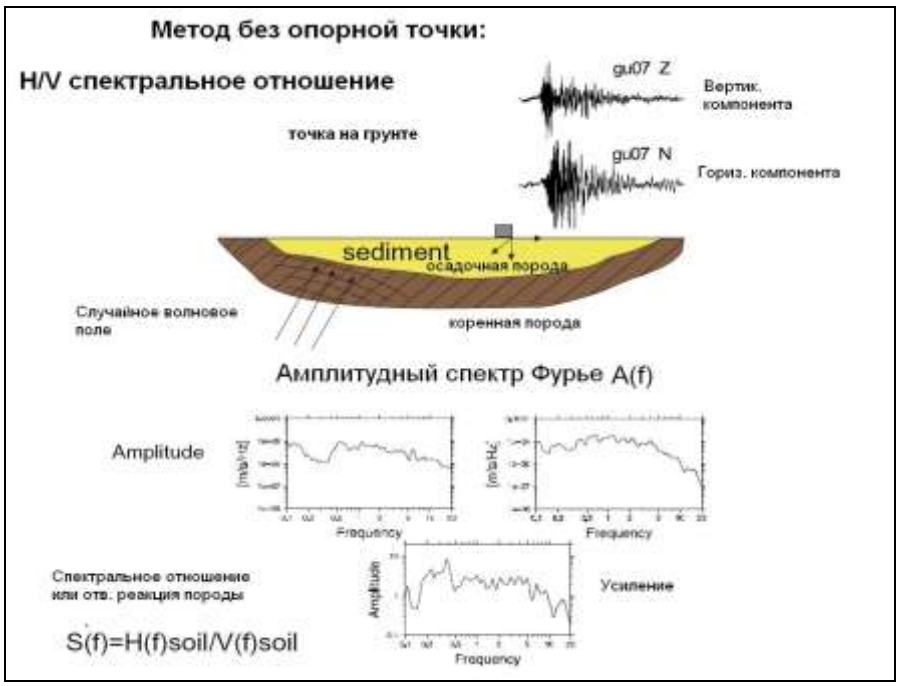



Рис 3 . Non-reference spectral ratio chart

Implementation of the project requires accelerograph and seismometer network installation. Seismic measurements in Tashkent city territory are carried out by joint affords of CAIAG, Bishkek and GFZ Potsdam within CA GCO program sub-task 2.2.2, with the title “Surface processes as a complex geodynamics response” within the project InWent (Tashkent city). It is planned to continue a close cooperation in the line of “Seismic microzonation of urban areas”.

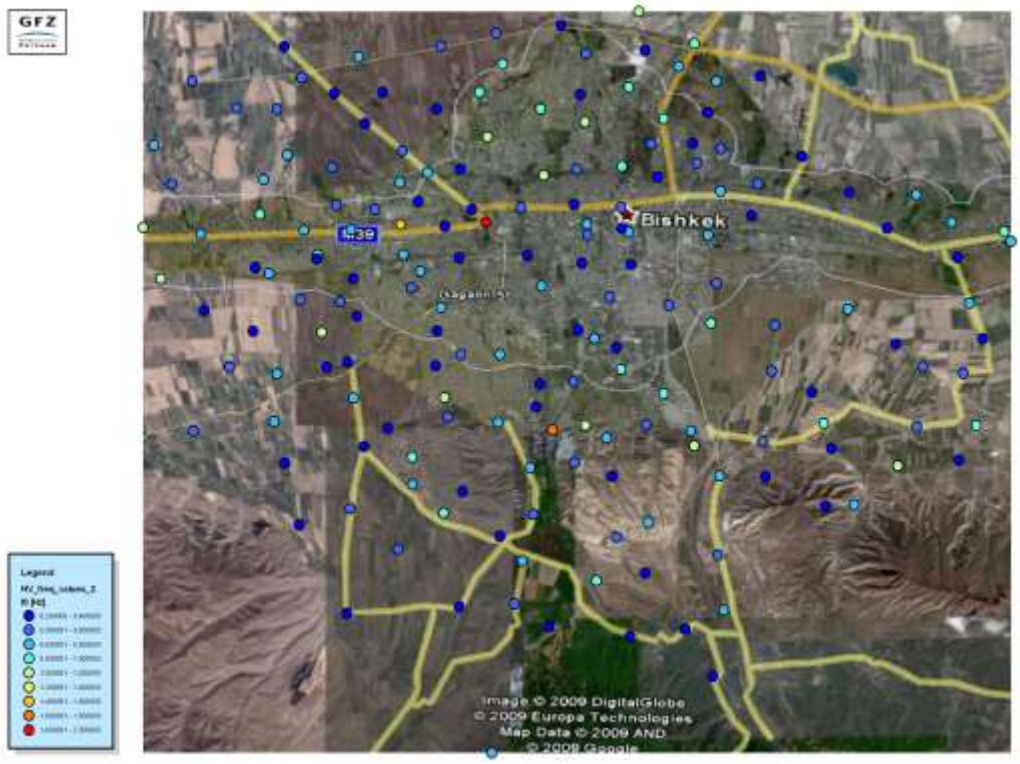



Рис.4 Soil oscillation frequency map according to noise measurements on the territory of Bishkek city and its agglomerations.

Planning of network layout, field observations, noise data analyses and the use of earthquake recordings for site response estimation will be implemented in close cooperation with the Institute of Seismology NAS KR, Seismic services of Central Asian States; aw well as with key scientists from GFZ: prof. Zschau J., dr. Parolai and with other involved partners from different countries.

**1.1.1. The project duration – 2010-2012.**

**2010:**

- Installation of a temporary network of modern digital seismic stations, on urbanized territory and activity coordination together with bodies of city board, and / or on a site of special major_object.;

- Conducting of reconnoitring and organizational-spadeworks on training, information gathering, transportation and equipment installation;

- Field researches (several weeks) by means of conditioning quantities of seismic stations based on seismic noise measurement, data processing;

- Allocation of a stationary network for earthquake recordings (several months), data processing and analysis.

**2011:**

- Further earthquake recording, its consequent processing and analysis;
- Quantitative estimation of seismic impacts and mapping of seismic microdivision for the citiy districts, big settlement, special major object
- Development of the final report, including digitized maps of seismic microzoning and estimation of georisks, preparation and publication of results

***Labor-hours:***

- 1 division –230 man./month.

***Required observations/data and equipment:***

- Digital seismic stations EDL equipped with sensor Mark 1HZ (15-20 units) for gaining S-wave profiles in typical sites;
- Portable systems for seismic noise recording Guralp (1 шт.);
- Sensors for strong motion registration;
- Broadband digital seismic stations for earthquake registration STS-2 (3 шт.);
- Software for spectral analysis of earthquake recordings;
- Multichannel recorders of electromagnetic field of the earth MGR 01 C, for building the bases for population early warning on seismic risk hazards and diminish their impact on population.
- Engineering-geological, hydro-geological, geo-morphological, seismic-tectonic and geo-technical materials.

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## *Project 4: Creation of an infrastructure of seismic monitoring of the territory of Kyrgyzstan by CAIAG*

***(Project leader: Z.Kalmetieva)***

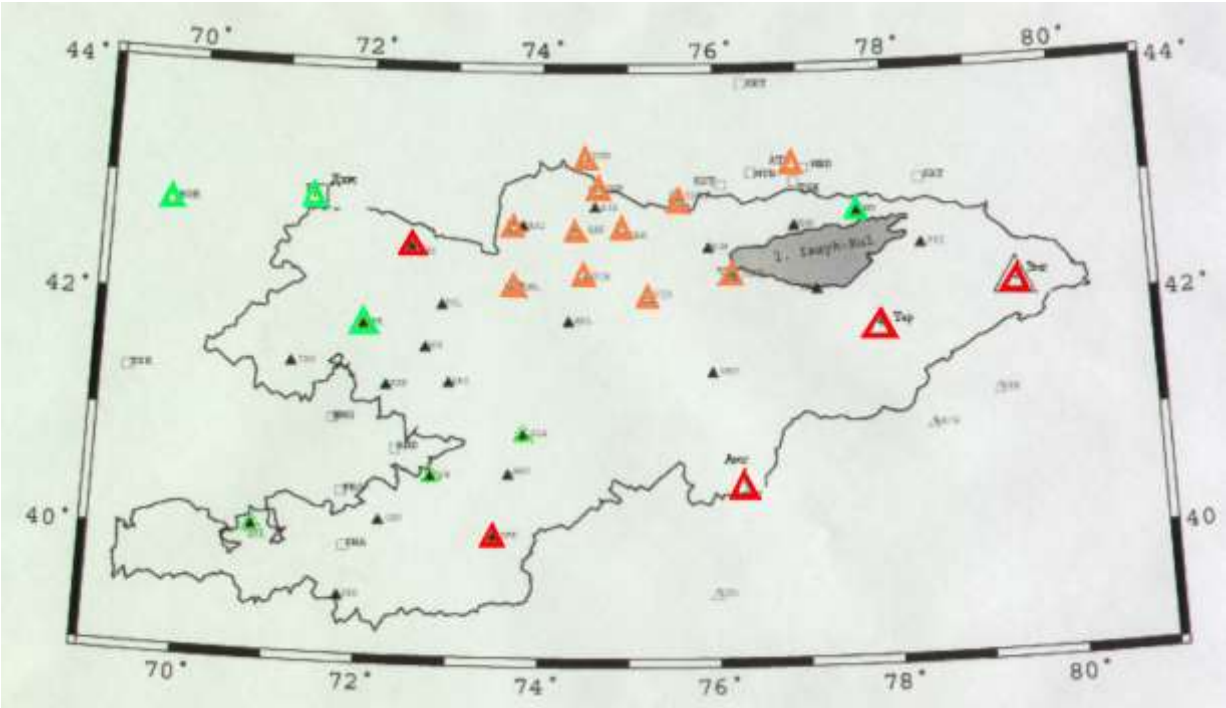
### *4.1. Project short title*

Organization of a seismic monitoring of the territory of Kyrgyzstan

### *4.2. Project outline*

In 2007 the 1st department of CAIAG offered the conception of developing of a permanent on-site network of CAIAG seismic stations for forming the research directions of CAIAG. Thus, an organization just of a permanent network was justified by necessity of an experimental base creation for holding regional research in the future. Existing network of seismic stations of the Institute of Seismology at that time in the territory of Kyrgyzstan, at first, the earthquake recording was realized with the help of analogue equipment and, secondly, it was gradually failed because of financial difficulties.

An incremental development of a wide network was supposed, i.e. a gradual growth of number of stations through the installation of a trace of permanent stations within the bounds of separate exploratory projects. So, three stations - Inylchek, Toragay and Aksay, equipped with modern digital and broadband hardware with data transfer through a satellite link in real time, were established within the bounds of the project «Preliminary geological-geophysical research of the Sarydjaz river basin as the future construction region of coordinated hydroelectric power stations».



*The layout of digital seismic stations:* red and orange triangles - data transfer in real time, green triangles- data incoming with regularity - once a month. (Black triangles - analogue stations of the Institute of Seismology of National Academy of Sciences (NAS) KR)

In 2009 a creation of Central-Asian network of the CAREMON seismic stations is started within the bounds of the project «Transboundary interaction … …», initiated by InWent. Two stations of this network are established in the territory of Kyrgyzstan - Sufi-Korgon and Talas. There is an arrangement in principle with the Nuclear Center of Kazakhstan and Scientific Station (SS) of the Russian Academy of Sciences on data acquisition of their stations as well as in real time (orange triangles in the picture) and with the Institutes of Seismology of Kazakhstan and Kyrgyzstan on data acquisition of digital stations with regularity - once a month (green triangles in the picture).

Within the bounds of the proposed project an Observed Data Acquisition and Processing Center is supposed to organize in CAIAG by digital seismic stations for creation and growth of the list of earthquakes of Kyrgyzstan and adjoining territories. In addition, an operative definition of parameters of descending earthquakes on the basis of SeisComp program enables to quick warning of MES KR about descending severe earthquakes. A creation of a program which allow defining possible types of damages in epicenter surrounding settlements in addition to the information about earthquake locus and magnitude.

### *4.3. Project objectives:*

- Organization of data acquisition of digital stations in real time.
- Installation and start of the SeisComp program for processing of incoming data in real time and creation of a computerized list.
- Installation and start of the Seisan and/or Seismic Handler programs for creation of a conclusive list on the basis of aggregate data processing, incoming in real time with data addition, incoming with a certain delay
- Development of the algorithm and program creation for quick warning of MES KR about descended severe earthquakes with indication of epicenter of event, its magnitude and intensity of occurrence in epicenter surrounding settlements, and also with definition of nature of possible building damages.

### *4.4 Current status and special requirements*

Any organization, which operates in research devoted to study of earthquakes or related phenomena, should have a list of earthquakes in its database. Now CAIAG has no such information and consequently uses a list, drawn and enlarged in the Institute of Seismology NAS KR, in its activity. However, the list quality has been continuously deteriorating last years. It caused by many reasons: a cease-time signal transmission in the territory of Kyrgyzstan, a financing shortage for photographic paper purchase and for equipment repair and station upkeep. Moreover, a method of analogue recording limits the facilities of modern seismological research greatly. It indicates that there is an urgency of organization of a seismic monitoring in Kyrgyzstan, based on observations by digital stations with an information transfer to the Data Processing Center in real time.

Execution of this problem requires follow-up:



- Staff - 2 people,
- Internet link,
- Two computers

### *4.5. External and internal cooperation*

The project will be carried out by Departments 1 and 4 of CAIAG. Close cooperation is provided with corresponding relevant organizations of Kyrgyzstan (Institute of Seismology NAS KR), Kazakhstan (National Nuclear Center (NNC), Institute of Seismology), China (Xingjiang-Uygur Seismological Bureau), and Russia (Scientific station in Bishkek).

### *4.6. The working plans:*

**Duration of the project - 2010-2011**

**2010:**

**-** Inclusion of new stations of other organizations (Institute of Seismology NAS KR, NNC Kazakhstan, HC of the Russian Academy of Sciences) to the Data Acquisition and Transfer System of digital seismic station network in CAIAG through a satellite link in real time.

**-** Organization of a data incoming of digital stations of other organizations (Institute of Seismology NAS KR, Institute of Seismology of Kazakhstan), working in an off-line mode.

**-** Start of the programs (Seisan and/or Seismic Handler)

**-** Development of the program «Urgent warning about descended severe earthquakes in the territory of Kyrgyzstan and adjoining states»

**2011:**

**-** Creation and growth of the list of earthquakes of Kyrgyzstan and adjoining territories.

**-** Setting of an operative list of earthquakes on the site of CAIAG

**-** Testing and implementation of the program «Urgent warning about descended severe earthquakes in the territory of Kyrgyzstan and adjoining states»

***Required labor costs:***

· Department 1 - 60 person-months

· Department 4 - 24 person-months

**Labor expenditures will include the following:**

*Department 4* – data acquisition and transfer of digital stations into the Department 1 in real time (Sharshebaev A.)

*Department 1* - creation of the operative list (Jusupova K. and engineer-vacancy) according to the data, incoming in real time and creation of earthquake registers

- Register data addition of digital stations, incoming with delay and formation of the list (Jusupova K. and engineer-vacancy)

- Analysis and drawing of the conclusive list, archiving, definition (Orunbaev S.)

- Development and start of the program «Urgent warning about descended severe earthquakes in the territory of Kyrgyzstan and adjoining states», incoming organization of an operative list of earthquakes on the site of CAIAG (programmer-vacancy)

- Development of the algorithm for programming «Urgent warning about descended severe earthquakes in the territory of Kyrgyzstan and adjoining states», a general management (Kalmetieva Z.)

***Project 5: Landslide research through the methods of ground observations and remote sensing (in the pilot area of a mountain ridge of the Fergana basin region and inner Tyan-Shan)***

***Project leaders: A.Mandychev, A.Detushev***

***5.1. Project short title***

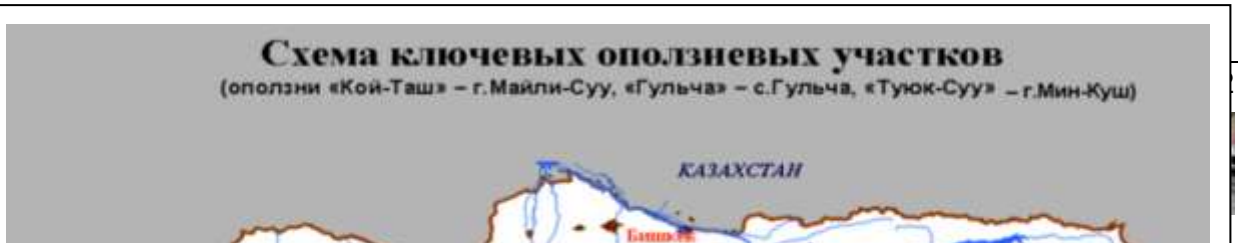
Landslide research of the Fergana basin region and inner Tyan-Shan

***5.2. Project outline***

Sliding processes are widespread in the territory of Kyrgyzstan and adjoining Central-Asian countries because of predominance of mountain landform. Sliding phenomena correspond to a considerable part of registered natural catastrophes in the territory of the Kyrgyz Republic.

Landslides are formed under effect of the group of factors and they are of highly complex nature, such as geomorphologic, geologic (including tectonic and lithologic), seismic, climatic, hydrological, hydro-geological, engineering-geologic characteristics. There are both natural and anthropogenic components in the system of factors.

Sliding processes cause a significant and severe economic damage and result in life losses. Therefore, their study and elaboration on the basis of results of the sliding hazard forecast research, measures on sliding hazard risk reduction is of great importance.



The given project, which is planned to be executed in the period from 2010 to 2012, is a logical continuation of the project 2, executed within 2008-2009 in the territory of the cities Minkush (inner Tyan-Shan), Gulcha and Maylisu (Fergana cavity). For these years the facts have been collected and their analysis concerning climatic, hydrological, hydro-geological, geologic and seismic conditions of research areas, including an analysis of the previous research results of landslides «Tuuksu» around Minkush, «Koytash» around Maylisu and «Gulcha» around the similar city is carried out. In 2008-2009 detailed field explorations on these landslides were done through measuring morphometric characteristics, mapping using GPS Topcon GB-1000, as well as high-precision definitions of landslide micro-motions estimators. In addition, soil and ground waters samples were taken for granulometric and chemical analysis. Selection and preliminary analysis of detailed space images of Quick Bird etc., covering researched landslides is executed. Digital maps of sliding areas in GIS MapInfo, and characteristics of main factors, defining an origin and development of sliding processes are made according to research results.

Necessity of research continuation in former areas is caused by rather short 2 summer periods of their study, low supply of special measuring equipments that allowed drawing only preliminary conclusions about landslide structure and the mechanism and factors of their development, requiring more detailed explanation.

Thus, a continuation of detailed research of three landslides is supposed within this project.

Both remote sensing archive data, i.e. satellite images of Landsat, Aster, Spot, Quickbird and other will be used for retrospective and actual analysis of sliding activity on regional scale. In addition, a differentiated radar interferometer (TerraSAR-X) is planned to be



used for observing crack and joint early formation and assessing landslide body deformations.

Information comparison, acquired through remote sensing observations, with a real situation in area will be implemented in the course of fieldworks. Various methods of ground explorations (geologic, geophysical, geodesic (GPS Topcon GB-1000, electronic tachometer), seismic) are supposed to be used on local scale.

The fieldwork comprises the following procedures: a soils sampling for defining a humidity, sizing and mineral composition and other physical-mechanical characteristics, sensing by electromagnetic penetrating radar or by broadband seismic station and acoustic noise measuring by a geophone under the field explorations.

The main task of landslide modeling will be executed on the basis of defining and refinement the poly-factor mechanisms of sliding process formation with development of qualitative, and then quantitative functioning models. The refinement of key factor characteristics, defining a developmental character of sliding processes and causes of their correlation and spatial-temporal evolution will be the significant research area under the field explorations. The innovative original mathematical model of sliding process will be assumed as a basis of landslide modeling on «particle-in-cell» method-based. The developed mathematical landslide model will allow forecasting their function and evolution adjusted for natural and anthropogenic components and influencing factors.

The elaboration of forecast algorithm of landslide process development will be conducted at the final stage of research on the basis of synthesis of all acquired results. As a project outcome the guidelines on risk assessment of sliding processes and on measures of sliding hazard reduction will be prepared, in particular, on the basis of creation of early warning system and scientifically substantiation of measures on engineering-geologic earth stabilization (melioration) of sliding slopes.

### *5.3. Project objectives and methods*

***Long-term objectives:***

The main objective of this project is a continuation of detailed research of the typical landslides, on the basis of which a modeling and forecast of landslide development, as well as a complex risk assessment of sliding processes will be accomplished.

Development of a regional conception of sliding process is supposed in its connection with a tectonic structure, geomorphologic and lithologic formations, and also with a seismic activity, change of climatic, hydrological, hydro-geological and engineering-geological conditions in the landslide areas, prone to high activity along the east ridge of the Fergana basin and inner Tyan-Shan.

This conception will be based on developing of a system of a detailed factorial assessment of sliding hazard and risk in spatial-time scale and monitoring of sliding phenomena and trigger factors, causing a slope destruction initiation (atmospheric precipitations, seismicity, structure and lithology).



Development of a special mathematical model of landslides and algorithm of sliding processes forecast will be in progress and on its basis the definition of sliding process development forecast in concrete areas and the guidelines on sliding hazard reduction will be executed. Development of guidelines on creation of an early warning system of sliding phenomena in Central-Asian region is supposed in prospect.

***Short-term objectives:***

In the frame of present project the systematic research activities of three typical landslides, selected in the course of analysis of existing geologic, engineering-geologic, hydro geological, hydrological, climatic, remote data and field explorations will be continued in the territory of Minkush, Maylisu, Gulcha.

The database formation, comprising the landslide characteristics and data analysis results, acquired through automatic station network and landslide field measurements will be continued. On the basis of these data the preliminary expected models of landslides functioning will be developed in connection with climatic changes, seismic activity, geological conditions and anthropogenic activity. The prospectus of early warning about landslide disastrous motions and forecasting of sliding process development will be worked out in concrete areas with guidelines on sliding hazard reduction.

***Methods:***

- Decoding of elaborated alternative data of remote sensing (multi-sensor, hyper-sensor, radar);
- Ground geophysical measurements (acoustic audition by geophone, sensing by penetrating radar or seismic station), geodesic measurements (GPS positioning, leveling, mapping by electronic tachometer), measurements by automatic hydro-meteorological stations;
- Geomorphologic, geologic, hydrological, hydro-geological and engineering-geologic field explorations. Study of relief nature, tectonic structure, lithologic formation, conditions of flooding and water-filled sliding slope and landslide body, mineralogical composition, filtration characteristics, granulometrical composition and other physical-mechanical features of landslide soils;
- Space - temporary modeling of sliding process and risk assessment.

### *5.4. The current status and special requirements*

Within 2008-2009 the fact collection on three observable landslides and regions of their development (geologic and a tectonic formation, hydrological and hydro-geological conditions, climatic characteristics) were accomplished. An analysis of these data allowed planning and carrying out field explorations more purposefully.

In 2008-2009 the detailed field explorations with measurement of morphometrical parameters and mapping, using GPS Topcon GB 1000, including high-precision



definitions of micro motions of landslide units were executed on landslides «Tuuksu» around Minkush, «Koytash» around Maylisu and «Gulcha» around the similar city. In addition, samples of soil and groundwater were selected for granulometrical and chemical analysis. A selection and preliminary analysis of detailed space images of Quickbird and etc., covering the observed landslides is executed. Digital maps of sliding areas in GIS MapInfo are made depending on parameters of main factors defining an origin and evolution of sliding processes. These data are comprised into the database and will be used further for analysis of sliding process mechanism.

Indispensable additional data comprise the alternative optical and radar space images of high resolution for project realization.

A necessity of electromagnetic penetrating radar and a portable seismic station for studying landslide structure, their lithologic discontinuity, defining a landslide body power, correlation of its dry and aqueous parts, and geophone for defining an landslide acoustic noise should be noted from an instrumental equipment.

In order to a high-precision operative landslide mapping it is necessary to use electronic tachometer, but for observing of microclimatic conditions around landslides - a mobile automatic weather station of VAISALA type. It is essential to allocate financial means for lab analysis on defining the soil physical-mechanical parameters and their mineralogical composition, as well as for studying a chemical composition of surface and ground water, related with landslides.

### *5.5. Internal and external cooperation*

The project will be executed in joint work by the Department 1, 2 and 4 of CAIAG. Close cooperation with GFZ, the Institute of Geology, the Institute of Physics and Rock Mechanics, EMSE NAS KR, MES KR, the State Geology Agency and Osh State Institute of Engineering Research is in the progress. Furthermore, there is the other collaboration planned with the University of Liege, Belgium and with scientists of adjoining Central-Asian countries: Kazakhstan, Uzbekistan and Tajikistan.

### *Coordination with the GCO-CA Initiative*

The proposed project is connected with the Central-Asian Global Change Observatory (GCO-CA) project subtask 2.1.2 «Hydrological cycle and aridization: Problem of water and soil management, vegetation, land-use, poverty reduction strategy» and, in particular, with its subsection «Surface instability» where the exogenic process research is supposed to be conducted in landslides, collapses, soil erosions, floods, torrents. Joint activities on landslide monitoring are being planned in cooperation with researchers from CAIAG, GFZ and DLR including the exploratory groups from other Central-Asian countries. Preparatory and programmed works will be grounded on most recent acquired data through remote sensing and directly subjects of inquiry and archive data of various sources.

Responsible scientists of GFZ: Dr. U.Votzel (RS techniques)
Dr. S.Resner (sliding processes)



### *5.6. The working plan and required resources*

**Duration of the project - 2010 - 2012**

**2010:**

- Acquisition and analysis of the archive actual data, remote sensing data, formation of geo-database division on landslides.
- Detailed field explorations in three sliding areas, an execution of field measurements of main parameters on key landslides and their analysis.
- Decoding of remote sensing data on areas of landslide evolution.

**2011:**

- Continuation of an acquisition and analysis of the archive actual data, remote sensing data.
- Detailed field explorations in three areas, and on the basis of a decoding of remote sensing data.
- Creation of sliding process monitoring network through an installation of automatic stations which will measure the seismic, meteorological and geodesic characteristics (GPS).

**2012:**

- Continuation of a monitoring network formation and execution of field explorations of landslides.
- Continuation of formation of geo-database division on landslides.
- Information analysis on remote sensing, seismological, climatic, geologic, hydro-geological data and physical-mechanical parameters of landslides.
- Generalization of the main multifactor regularities of studied landslide formation mechanism.
- Development of sliding process mathematical model.
- Validation of forecast algorithm of landslide development, measures on risk reduction and early warning system schemes.

***Required human resources:***

Department 2 - 120 person-months

*Required observations / data and equipment:*

- Decoding of optical and radar images of high resolution and image availability with resolution of 0,6 m/l with different survey time (Quick Bird, Terra SAR-X).
- GPS affixment of measurement points, leveling, high-precision mapping through an electronic tachometer;



- Field explorations of a morphometry, structure, landslide lithologic formation, hydrological and hydro-geological conditions in landslide areas. Landslide soil sampling.
- Exploration of physical-mechanical parameters of landslide soil samples in specialized labs
- Exploration of hydro-chemical and geochemical characteristics of surface and ground water related to landslides, their soil samples in specialized labs
- Sensing through a penetrating geo-radar, seismic sensing, measurement of acoustic noises by a geophone.
- Ground meteorology: observations on temperature, humidity and precipitations through an automatic weather station.

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***Project 6: Studying and monitoring of the Inylchek glacier with the goal of defining the glacier balance, its morphological and dynamic characteristics and its climatologic and hydrological conditions***

***Project leader: R. Usubaliev***

### *6.1. Project short title*

Study of the Inylchek glacier

### *6.2. Project outline*

The cause of the Tyan-Shan glaciation in the last decades is in climatic changes. It leads to a reduction of common water resources, activation of mud flows, freshets and outbursts of glacial lakes. The largest glacial Mertzbaher Lake differs in one of the strongest and regular and annually iterative outbreak glacial freshets. A study of hydrological, climatic, glaciological changes, related to atmospheric circulation changes in regional and global scale is possible around this lake, in the central part of the Inylchek glacier, in the place of its two branch fusion: North and South Inylchek.

The present project will be executed within 2010-2012 and is the continuation of the project 4 executed in 2008-2009. Such factors as climatic, hydrological and glaciological parameters of the Inylchek glacier will be studied in this project.

The study of the Inylchek glacier is supposed to be executed in the Mertzbaher station base, which was created jointly with CAIAG and GFZ in August, 2009. Now the several containers for equipments and residence and storage for the seismic station are set around the Mertzbaher Lake, in the southern part of the South Inylchek. A permanent GPS Topcon GB-1000, automatic weather station Vaisala are established to the north from the Mertzbaher Lake, in the northern part of the North Inylchek glacier and their data are transferred through the VSAT and IRIDIUM space communication systems to CAIAG and GFZ. Subsequently, a set of measuring equipments exploring the Inylchek glacier is supposed to be added in this station.

In the process of glaciological explorations it is planned to study glacier mass balance changes on the basis of morphometric parameter observations in representational areas and a motion rate of the glacier upper part on the basis of remote radar sensing methods, GPS and direct field measurements of the surface runoff, solar radiation level and ablation size.

A decoding of optical multi-spectral and radar space glacier images will be the relevant component of the research that will allow defining morphological features and parameters, character of interglacial hole, crack and canal distribution discontinuity of both surface and interglacial runoff. Automatic weather stations will provide information on temperature, precipitations, humidity, atmosphere pressure, wind and total solar radiation. It will help to reveal an effect of climatic parameter changes to glacier balance changes, the Inylchek river runoff and outburst runoff regime of the lake Mertzbaher.

The more exact definition of a summer glacier runoff separately on the North and South Inylchek glaciers is supposed using automatic hydro-posts, tracers in paint or salt and water course speedometer - Acoustic Digital Current Meter (Ott ADC). A sampling of glacier melt water, seasonal snow cover, ash pit-run fines and dust-organic substances from glacier surface will be executed for chemical, mineralogical, granulometric analysis.

Fluctuations of the Merzbacher Lake water level and its glacial surface shall be registered through GFZ developed water pressure receiver, Open-GPS - receiver using laser scanning and viewing technology and high-resolution web-camera for a monitoring of permanent water surface changes. In the long-term outlook an automatic system based on Open GPS technology will be applied for a monitoring of dangerous outbursts at high mountain lakes.

As well as an exploration of the Mertzbaher Lake and its floor sediments is planned through Raymarine A50D echo sounding device. Also a mechanism of glacial dam outburst will be investigated. A glacier structure, its power, physical and mechanical characteristics will be defined by a shallow-focus broadband seismic sensing or electromagnetic penetration geo-radar.

A measurement of glacier acoustic noises is also planned.

In addition, a project on the Inylchek glacier deep ice-coring study, planned in collaboration with Japanese, US and German scientists and supported by CAIAG and which will further refine an understanding of present and past (about 1000 years) global and regional climatic regime and relevant natural processes influencing on variability of water-glacial resources and environment in the region.



All acquired data will be comprised into the GIS "Inylchek", and being a part of Geo-database over Central Asia will be available for modeling the Merzbaher Lake regime, the Inylchek River, and the Inylchek glacier.

The acquired data will be an important contribution for planning and realization of a safe economic development of the Sarydjaz river basin, particularly, for designing, building and maintenance of hydroelectric power system in this region. Moreover, these data will serve as a base for climatic and ecological change assessment and forecast in Central-Asian region.

### *6.3. Project objectives and methods*

*Long-term objectives:*

The main objective of this project is an acquisition of key climatic, hydrological and glaciological parameters on the South and North Inylchek glaciers, the Inylchek River and the Mertzbaher Lake. In order to realization of this objective a monitoring of long term and short term dynamics of the Inylchek glacier system is provided setting and using a combined sensor system of remote sensing in the Mertzbaher complex station base. Parameters of time series of these systems and results acquired on the basis of their analysis will become an integral part of the Geo-database on Central Asia.

In a longer-term perspective the project aims at studying and understanding of the Inylchek glacier regression and changes in their dynamics in connection with the global climatic changes and their influence on water balance in Central Asia. A special emphasis will be focused on factor and process identification, which cause the Mertzbaher Lake glacial dam breach and integrated remote sensing system development for natural hazard monitoring in glacial dam breach in general.

*Short-term objectives:*

The most important short term objective is parameter line collection needed for the glacial, water, atmospheric subsystem definition, modeling and forecast, particularly in the aspect of possible geo-hazard risk occurrence and water resource change. This process comprises a systematic collection of already existed and newly acquired data, e.g. data on ice ablation, ice traverse speed, hydrological, hydro-chemical and meteorological parameters, as acquired both from remote sensing observations and repeated field measurements and continual working, recording and transferring ground sensor stations in the region.

Thus, in the short term perspective a set of automatic, meteorological, hydrologic and geodetic sensor stations and special sensors with space communication system will have a priority in the Inylchek glacier.

Secondly, the data processing and transfer to external users will be an important task of the project. And thirdly, a water-ice balance assessment of the Inylchek glacier will be an objective point on the basis of acquired data analysis and development of multifactor models of the main natural factor correlation, which define a functioning and evolution of the Inylchek glacier system.

***Methods:***



- Decoding of a remote sensing data (optical, multi-spectral, hyper-spectral and radar)
- Geodesic measurements and monitoring (Global positioning system (GNSS), GPS – reflectrometry, GPS – high-precision spot measurements, high-precision topographic measurements by electronic tachometer)
- Field measurements of meteorological, hydrological, glaciological parameters (hydro-meteorological stations and hydro-posts, measurement of water discharges, ablation and thermistor setting);
- Observations on lake level changes using pressure sensors and continual radar measuring tools. The Mertzbaher Lake floor sensing by an echo-meter;
- Observation on river displacement using a topographic laser station (Total Station) or electronic tachometer;
- Definition of a glacier structure, its power, ice physical-mechanical parameters using portable digital shallow-focus broadband seismic station or electromagnetic penetrating geo-radar. Measurement of glacier acoustic noises.
- Chemical, mineralogical, granulometric analysis of samples of glacier melt water, seasonal snow cover, ash pit-run fines and dust-organic substances from glacier surface;
- GIS technology for modeling processes on spatial-temporal scales.

### *6.4. The current status and special requirements*

The minor glaciological, climatic and hydrological information exists over the Inylchek glacier region and the Inylchek and Sarydjaz River basin. In 2005 a situation was improved by an expedition carried out in a close cooperation with GFZ (Mihailev V., Votzel U. and others) when new information on the Inylchek glacier balance, glacial flow, ice traverse speed, character of the Mertzbaher Lake level fluctuation were acquired. The creation of a complex station currently including a permanent GPS, automatic weather station, and satellite communication system was a continuation of these activities (as it was mentioned above) in August, 2009. The proposed project will be carried out in this station base and will comprise a complex of activities relevant to the specified objectives. The project successful implementation will depend on scientific instrument provision.

The necessary supplementary data for project implementation include the optical and radar space images of a high resolution of the Mertzbaher Lake region and the Inylchek glacier, in whole.

The electromagnetic penetrating radar and portable seismic station are necessary for studying the glacier structure and discontinuity, as well as for ice power and density identification, geophone for glacier acoustic noise identification.

An electronic tachometer is necessary for glacier high-precision operative mapping, but a mobile automatic weather station of VAISALA type – for observation on glacier microclimatic conditions. A mobile hydro-post is essential for surface liquid and sediment runoff discharge study.

It is essential to allocate financial means for analysis on defining a chemical water composition related to glaciers, and mineralogical-granulometric dust and sediment runoff composition. It takes 10 hours (minimum) of flight time by a helicopter to reach the glacier.



### *6.5. Internal and external cooperation*

The project will be realized by Departments 2 and 4 of CAIAG in close cooperation with scientists of the Department “Geodesy and remote sensing” of the GFZ. Researchers of the Main Department on Hydrometeorology within the MES KR, the Kyrgyz-Slavic University, the Institute of Water Problems, and the Institute of Geology NAS KR and from other Central-Asian countries will be involved into the project.

Additional foreign partners of the project will be:

- German Aerospace Centre, DFD, Oberpfaffenhofen;
- Technical University, Computer Vision and Remote Sensing, Berlin;
- Commission on Glaciology of the Bavarian Academy of Sciences, Munich;
- Alfred Wegener Institute for Polar and Marine Research, Bremerhaven
- Versuchsanstalt fon Wasserbau, Hydrologie und Glaziologie, Swiss Federal Institute of Technology, Zürich;
- Idaho University, College of Mines and Earth Resources, Moscow, USA;
- Universities of Nagoya and Kyoto, Japan.

### *Coordination with the GCO-CA Initiative*

The proposed project has a direct connection with the Central-Asian Global Change Observatory (GCO-CA) project sub-task 2.1.2 “Hydrological cycle and aridization: Problem of a water and soil management, vegetation, land use, poverty reduction strategy” and, in particular, with its subsection “Water Cycle”, where observations and modeling of the water cycle different aspects (including glaciers) and corresponding hazards (including glacial lake outbursts - GLOFs), which are in process of implementing, are being described. In the short term perspective a close coordination of the CAIAG activities together with the GCO-CA is planned for setting an operational monitoring system (glaciology, climatology, and hydrology) close by the Inylchek glacier system. In addition to these infrastructure development activities, a joint work for building regional hydrological and climatic models has already been started by both parties. These databases will be filled with new remote sensing data, various in-situ data and archive data.

Responsible scientists of GFZ Potsdam: Dr. A. Helm (Monitoring system)
Dr. U. Wotzel (RS techniques)
Dr. W. Mihailov (Glaciology)
Dr. A. Günter (Hydrology)



### *6.6. The working plan and required resources*

**Duration of the project - 2010-2012**

**2010:**

- Acquisition and analysis of remote sensing data, facts on climatic, hydrological conditions and parameters of the North and South Inylchek glaciers, the Mertzbaher Lake, the Inylchek and Sarydjaz Rivers.
- Field works in the Mertzbaher complex station base. Continuous equipping of the GPS/GLONASS station by automatic weather stations, hydro-posts, VSAT communication network development. Hydrological, ablative and topographic measurement execution, water and dust sampling, glacier geophysical sensing.
- Creation of a Geo-database glacial component in Central Asia with glaciological, hydrological data and metadata definition.

**2011:**

- Continuation of acquisition and analysis of remote sensing, meteorological, hydrological, glaciological data, GPS parameters, acquired on automatic station network and during previous field campaigns.
- Field glaciological, hydrological, geophysical explorations

**2012:**

- Acquired data analysis and development of multifactor model of the climatic, hydrological and glaciological element correlation of the Inylchek glacier system.
- Geo-database addition over Central Asia with climatic, hydrological and glaciological data, results of data processing and modeling over Central-Asian region.
- Development of the GIS models of the Mertzbaher Lake regime and the Inylchek glacier dynamics, its water balance component definition.
- Development of scheme validation of an early warning system about the Mertzbaher Lake outburst.

***Required human resources:***

Department 2 - 120 person - months

*Required observations/data and equipment:*

- Optical and radar remote sensing data (space images of various types and activities with different survey time).
- Geodesic and topographic measurements on the basis of networked GPS/GLONASS receivers, GPS - reflectometry, electronic tachometer and geodesic GPS Topcon GB-1000 (is available). Electronic tachometer.
- Glaciological (ablation), hydrological measurements through current meter - Acoustic Digital Current Meter (Ott ADC) (is available), sediment runoff value. Sensing of the Mertzbaher Lake floor by echo-sounder Raymarine A50D (is available).



- Glacier geophysical sensing for its thickness, structure and density observation using a geo-radar system or seismic station. Geophone for acoustic measurements. Geo-radar, portable mobile seismic station.
- Sampling for defining a chemical composition of river and glacial water, mineralogical and granulometric compositions of dust and sediment runoff. Financial means for lab analyses.
- Ground meteorology: automatic weather station network for temperature, precipitations and humidity observation. Automatic weather station.

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***Project 7: Study the surface runoff regularities in connection with a climate change, for assessing an erosion process intensity and precipitation transfer in the Toktogul water storage basin.***

***Project leader: A.Shabunin***

### *7.1. Project short title*

Study surface runoff in the Toktogul water storage basin.

### *7.2. Project outline*




The present project is planned to be implemented within 2010-2012 and is a continuation of the project 5, implemented in 2008-2009. Acquisition and analysis of before acquired facts on observations of atmospheric precipitation value, temperature, river runoff and erosion processes were carried out, also new field measurements of hydrological, topographic parameters were conducted, as well as erosion parameter intensity; reservoir sedimentation degree were previously assessed within the bounds of this project.

The further data acquisition and analysis of the last year observations on meteorological stations and hydro-posts of explored territory is planned within the bounds of this project. In addition, due to a quantity of existing stations and posts in the water storage basin is not enough for a qualitative analysis of meteorological element, water discharge, sediment trends and their correlation identification – a set of a new additional automatic weather station is planned in this territory and a wide usage of remote sensing and Land Sat, Aster, etc space image data. Realization of field explorations will be a relevant source of fact acquisition. In this aspect the observations of sediment runoff, reservoir floor and bank topographic measurements, as well as erosion form elements identified by space images is planned to be carried out through geodesic GPS Topcon GB-1000, electronic tachometer and echo sounder Raymarine A50D.

In particular, a decoding of natural environment elements on space images is planned defining physical-geological process direction and intensity in the reservoir adjoining territory - erosions, landslides, bank transformation. Complex of landscape elements, where a special place will belong to soil and vegetable cover, this direction will be closely associated with the WASA hydrological model structure for the Naryn basin within the bounds of joint with GFZ «Water in Central Asia» CAW project, started in 2008.

Both traditional mathematical methods of periodicity definition, and new ones, grounded on methods on atmosphere and a hydrosphere as determinate-stochastic oscillatory systems will be used for time series analysis of climatic and hydrological parameters.

The acquired (in the course of project implementation) facts will be used for climatic, hydrological and erosion process and their correlation modeling. Worked out methods of



above-listed process assessment and modeling can be used for other runoff basins of the territory.

In the practical aspect the acquired scientific results will allow to assess the Toktogul actual reservoir capacity reduction rate and possible ecological changes in its basin in connection with the climatic changes and anthropogenic activity.

Further continuation of the research area will allow defining preliminary results acquired within 2008-2009 more considerably and will increase an objective character of scientific conclusions and practical guidelines on optimization of the water-ecological situation in the region.

### *7.3. Project objectives and methods*

*Long-term objectives:*

The main long term objective of this project is a study the regularities of climate change, surface runoff, erosion process intensity and sediment runoff scale correlation in the Toktogul basin. This study will be based on acquisition and analysis of existing facts and on new field parameter explorations of aforesaid processes.

Consequently, it is planned to create the unified hydrological and erosion models for the Toktogul water storage basin. The successful execution of the project will allow working out recommendations on soil erosion control and reservoir sedimentation measures. Methodical experience will be used at similar problem solving in corresponding objects of Kyrgyzstan and neighboring countries of Central-Asian region.

*Short-term objectives:*

In short term perspective the climatic and hydrological data updating is planned in the Toktogul water storage basin on the basis of a network of the Kyrgyzhydromet stations and posts and CAIAG automatic weather station. The field topographic measurements is planned to be carried out for defining a relief change of reservoir drained floor and banks, erosion form parameters overland, echo sounding measurements in the reservoir area. Analysis of existing remote sensing and direct measurement data is planned in the field conditions.

Addition and development of the databases are provided comprising the climatic parameters, hydrological parameters of rivers, temporary watercourses and reservoir, parameters of erosion-sedimentation processes. As well as, the sketch maps of space image decoding and thematic maps of sediment power, erosion intensity and types, sedimentation.

And development on the basis of acquired data of pilot hydrological and erosion-sedimentation models. The first one will be presented largely by hydrological model WASA.

*Methods:*

- Remote sensing data analysis on multi-spectral and radar space images.
- Time series analysis of precipitations, temperature and river runoff.



- Field topographic, echo sounding, hydrological, meteorological measurements.
- Water and sediment balance modeling.

### *7.4. The current status and special requirements*

In 2008-2009 the acquisition and study of facts were conducted in the Toktogul water storage basin and neighboring territory. The data comprise the climatic, hydrological, geological and erosion parameters, and also remote sensing data on space images Land Sat, Aster, Quick Bird and others. On the basis of the analysis of archive data and on-site field observation results executed in 2008-2009, a number of thematic maps: of relief in different survey periods, spreading of erosion various types is created in GIS MapInfo, as well as the analysis of time series of climatic, hydrological parameters, hydrological regime of the Toktogul reservoir inflow and runoff is carried out, and also reservoir sedimentation volumes are previously calculated.

The special requirements in this project include the space images of various types and details and with different survey time, required for analysis of erosion and sedimentation process intensity, automatic weather station, and instruments for defining the sediment runoff value, electronic tachometer, GPS stations for carrying out the operative mapping of erosion and sedimentation landforms.

### *7.5. Internal and external cooperation*

The project is planned to be implemented by the Departments 2 and 4 of CAIAG and in cooperation with the Institute of Water Problems and Hydropower of NAS KR, the Institute of Geology of NAS KR, the Institute of Irrigation, and the Head Department on Hydrometeorology under MES KR and with scientists from Central-Asian republics.

### *7.6. The working plan and required resources*

*Project duration 2010-2012*

**2010:**

- Acquisition and analysis of remote sensing data, facts on climatic, hydrological, erosion parameters in the Toktogul water storage basin and in adjoining territory;

- Automatic weather station installation, field instrumental measurement of erosion-sedimentation process parameters;

- Involvement in creating a geo-database section on meteorological, hydrological, erosion parameters;

- Acquired material analysis using various data processing methods, calculation of climatic, hydrological, erosion and sedimentation process correlation.

**2011:**

- Continuation of fact acquisition on Toktogul basin;



- Repetitive field works, measurement of new hydrological, erosion, sedimentation, topographic parameters.
- Acquisition of new facts through space image decoding, and decoding result comparison of different temporary periods, GIS digital mapping.
- Development of hydrological and erosion-sedimentation models.

**2012:**

- Continuation of fact acquisition on Toktogul basin;
- Development of complex models of climatic, hydrological and erosion process interaction.
- Development of guidelines on optimization of the Toktogul basin water-ecological conditions.

*Required human resources:*

Department 2 - 120 person – months

Required observations/data and equipment:

- Optical and radar remote sensing data (space images of various types and details with different survey time).
- Meteorological parameters: temperature and precipitations on weather station network. Mobile automatic weather station is required.
- Hydrological observations: river discharges on hydro-post network and by current meter-Acoustic Digital Current Meter (Ott ADC) (is available), sediment runoff value measurement;
- Observations of reservoir level, bottom sediments by echo sounder Raymarine A50D in the water area (is available).
- Erosion and sedimentation processes: land use, topography, hydrographic network, erosion forms and their propagation;
- Geodesic surface mapping: geodesic observations by GPS Topcon GB-1000 (is available) and electronic tachometer (should be acquired).

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## CONCLUSION

1. Aforesaid worked out research programs are prepared in the form of the specified project proposals and correspond bases continuation realized within 2007-2009 budgetary activities of CAIAG, which, in described above second research stage on expected results, will be essentially adoption of modern monitoring systems, up-to-date GIS technologies, achievements of remote techniques for data acquisition with principles of disaster risk early warning system to the relevant organizations and agencies.

2. Along with foresaid, new more unified, adapted and advanced methodologies on identification the more complex and exact characteristics of natural environment dangerous changes are planned to be acquired at this stage of planned activities for their successful application not only in Kyrgyzstan, but also in transboundary countries of Central Asia.

3. Development of modernized and improved methodologies and scale of various thematic geo-risk assessment is planned with changes and additions by research results and for their adapting in Central Asian region.

4. Holding the international workshops, conferences, meetings and organization the teaching courses are planned for various groups of population according to conducted activity lines of CAIAG.