



25th world gas conference  
"Gas: Sustaining Future Global Growth"

# ANALYSIS AND ASSESSMENT OF NATURAL RISKS FOR UNIFIED GAS SUPPLY SYSTEM FACILITIES OF RUSSIA USING PROMISING GEOINFORMATION TECHNOLOGIES

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(Gazprom VNIIGAZ)

Date: 7 JUNE 2012

Venue: CS3.2: WOC3

Integrity Of Gas Transmission Systems



Patron



Host



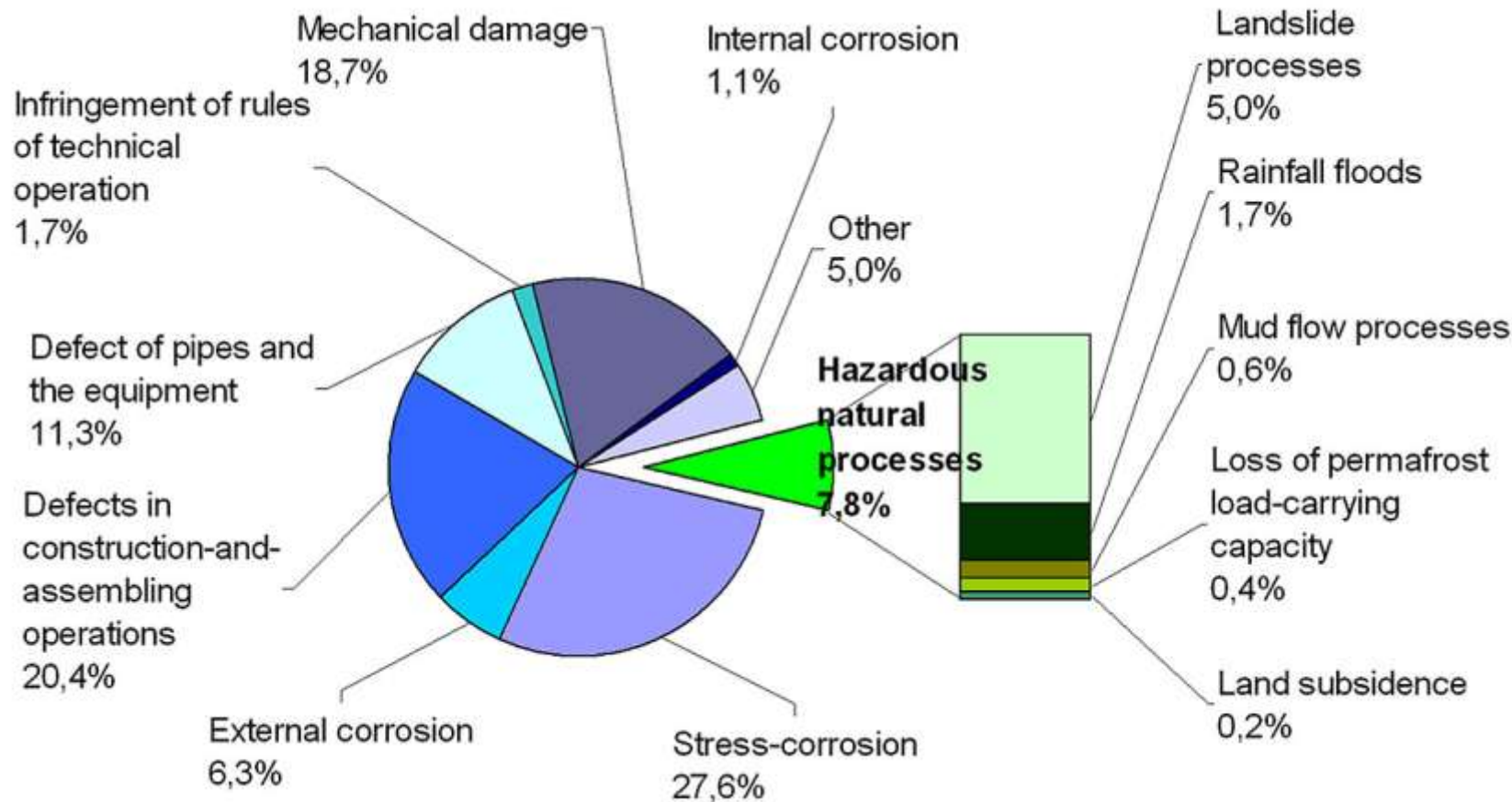
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The analysis of corporate statistics of accidents has shown, that a role of natural hazards in gas pipeline accident rate consists:

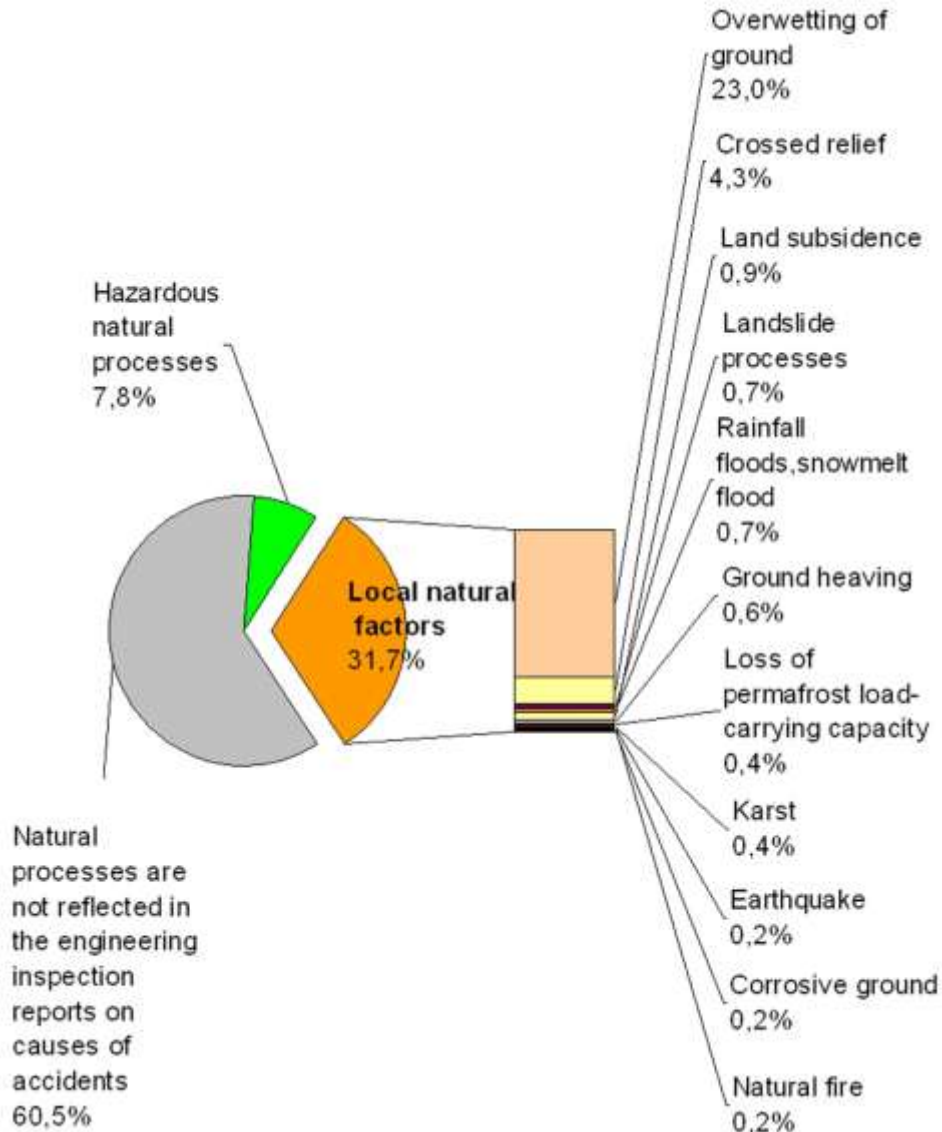
- in the creation of short-term and specific loads that cause “instantaneous” destruction of facilities (activation of hazardous natural processes including earthquake, landslides, rainfall floods, mud flows, etc.);
- in the formation of continuous and long-term loads (long-term impact of adverse factors including erosion processes, flooding, change in soil chemical composition, etc.) stimulating the development of hidden defects in pipelines.

## The reasons of accidents at the linear pipeline portion



According to multiyear data, hazardous natural processes and phenomena are the main reason of 7.8% of accidents on linear pipeline portions and 7% of accidents at the **Unified Gas Supply System (UGSS)** facilities (mainly at gas distribution stations (GDS)).

# Structure of local adverse natural factors, on which background there were accidents at the linear pipeline portion



The largest per cent of local natural hazards falls at accident rate due to the reasons as follows:

- stress-corrosion,
- external corrosion,
- defects in construction-and-assembling operations;
- pipe defects

Correct quantitative estimations of natural hazards and risk meet a number of the restrictions connected with absence of homogeneous systematized data. Therefore the base cartographical model (on the basis of GIS-technologies) is developed by **Scientific-Research Institute of Natural Gases and Gas Technologies – Gazprom VNIIGAZ** under the order **Gazprom**.

The cartographical model is the information environment for research of that questions.

At various stages of creation of model as coauthors scientists and collectives from leading institutes of Russia were involved:

- A.P. Karpinsky Russian Geological Research Institute – VSEGEI (Moscow Branch of VSEGEI );
- Geological Institute RAS (GIN RAS);
- Institute of Earth Cryosphere SB RAS (IEC SB RAS).



## Groups of thematic layers

### ■ Cartographical level of scrutiny of territory

Geological, hydro-geological, engineering-geological, geocryological and geocological maps M 1:1 000 000, 1:200 000, 1:500 000

### ■ Accident rate and technical characteristics of gas supply facilities

### ■ Factors of natural hazards and risks:

#### ■ Geological conditions ■ Tectonic structure of territory

Geological maps      Tectonic structure  
Active faults      Lineaments

#### ■ Engineering-geological and hydro-geological conditions

Engineering-geolog. regions      Morpholithodynamic complexes  
Seismic zoning      Landslides zoning and hazard  
Karst zoning and hazard      Mud flow zoning and hazard  
Land subsidence zoning and hazard  
Stream-channel and coastal processes  
Cryogenic processes      Hydro-geological conditions

#### ■ Contemporary climate changes and estimations of permafrost zone state

Trends of the contemporary annual air temperature change  
Air temperature increase during the warm season  
Air temperature increase during the cold season  
Climate warming and criolithozone's degradation  
Potential geocryological hazard events under the climate change

#### ■ Hazardous hydrometeorological phenomena

Floodings hazard during a spring high water.  
Periodicity of extreme meteorological processes and phenomena capable to lead to infringement of electrosupply at compressor stations (CS)(a strong snow, glazed frost, a wind and etc.)

### ■ Supplementary data

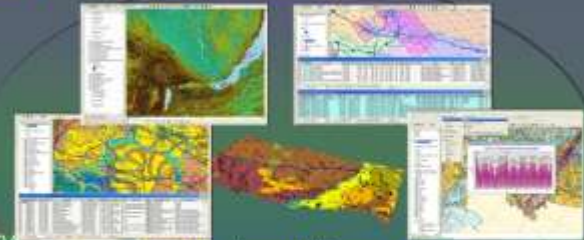
Raster maps SGM-200 (geological, hydro-geological, geocological maps); text descriptions and etc.

### ■ Topographic maps



## Functions

### ■ Visualization



Natural conditions maps of operation of gas supply facilities

### ■ Geoprocessing, analysis, modelling



Models

### ■ Estimations of influence of natural factors on UGSS facilities



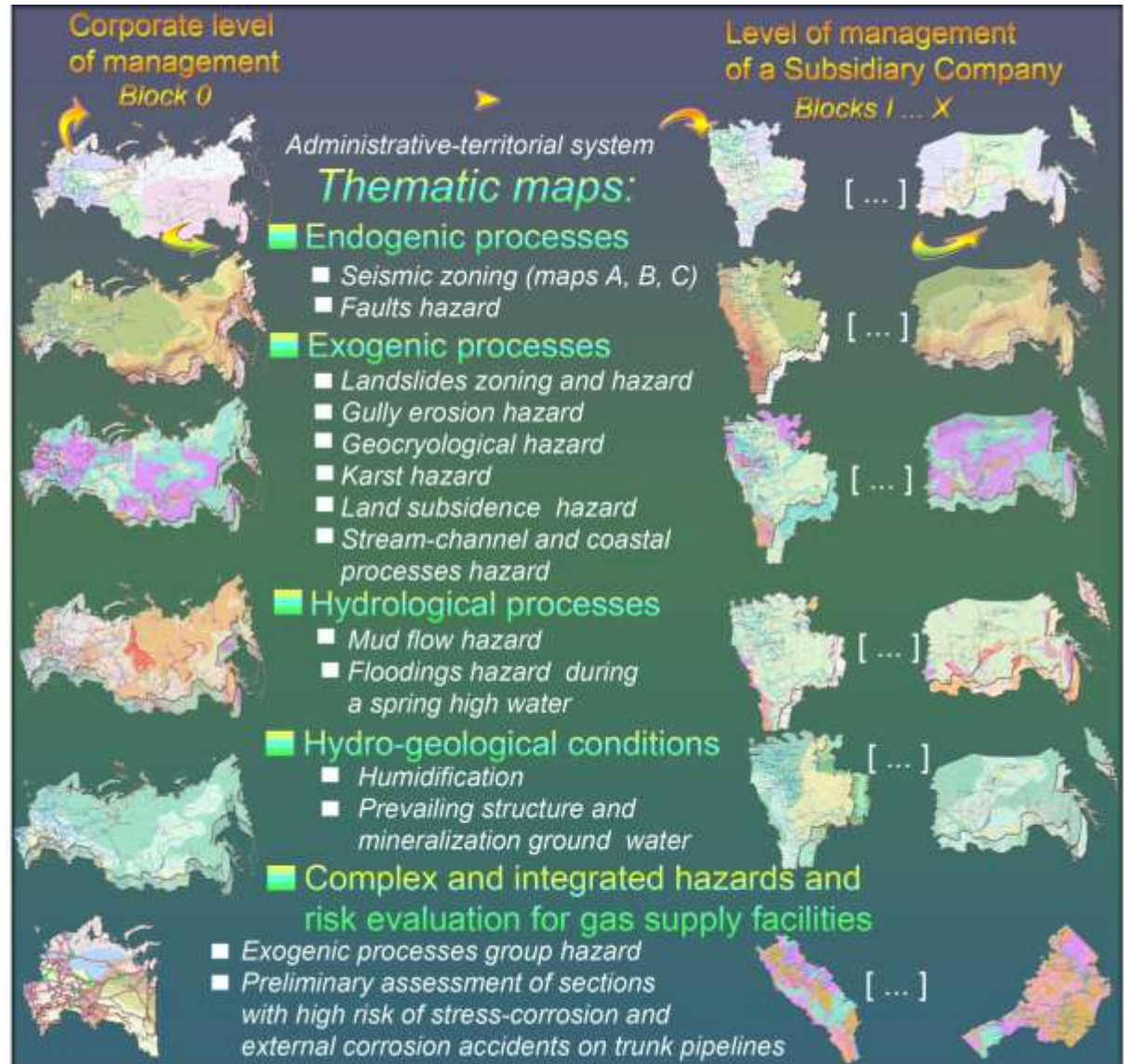
Estimated, predictive maps, maps of hazards and risks

GIS-Atlas contains not only the thematic maps describing natural factors which can be direct sources of accidents –

- earthquake,
- landslides,
- karst,
- mud flow,
- flooding,

but also factors which promote accumulation of damages and reduce reliability of objects –

- faults,
- linear erosion,
- geocryological processes,
- land subsidence,
- stream-channel and coastal processes,
- structure and a mineralization of ground waters.





The **hard version** of the atlas includes more than 150 maps describing potential sources of natural risk. Explanatory notes to maps reflect the distribution of hazardous natural processes, principles of their classification and mapping, influence of the natural processes on actual accident rate of gas supply facilities, the mechanism of their damage effect; location of gas supply facilities in hazardous zones. Explanatory notes are illustrated by insert maps, tables, diagrams obtained during the analysis of corporate statistics.

The **soft version** of the GIS-Atlas (interactive application) provides availability of the electronic vector information to the users without special GIS skills and is installed on workplaces of users without the additional special software.

The vector materials included in an electronic version of the GIS-Atlas, irrespective of scale of a hard version of thematic maps, are presented mainly in volumes of maps 1:2 500 000, and on a number of problem regions - in volumes of maps 1:1 000 000 and 1:500 000. Therefore, in spite of the fact that both versions of the atlas have unified substantial structure, the electronic version of the atlas gives to the user an opportunity to receive the expanded information on object.

Hard version

Soft version

*Functions of the soft version:*



reduction  
of map  
scale  
(increase)



the information  
on object



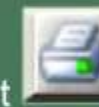
choice of  
an any  
fragment  
for increase



activation  
of a legend  
of a map



displacement  
of a map



print of a  
map  
(fragment)  
with  
the set  
parameters



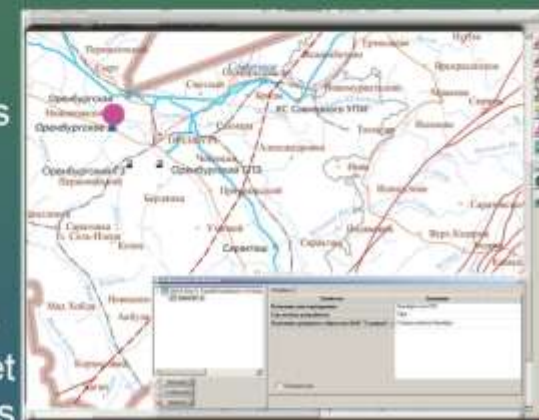
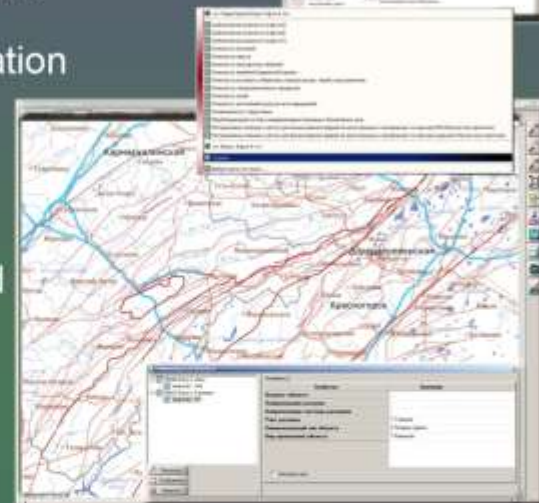
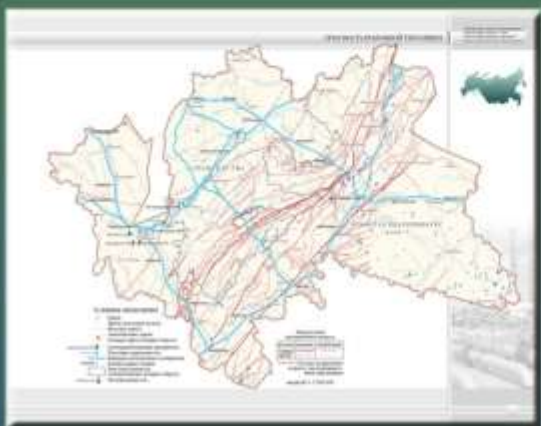
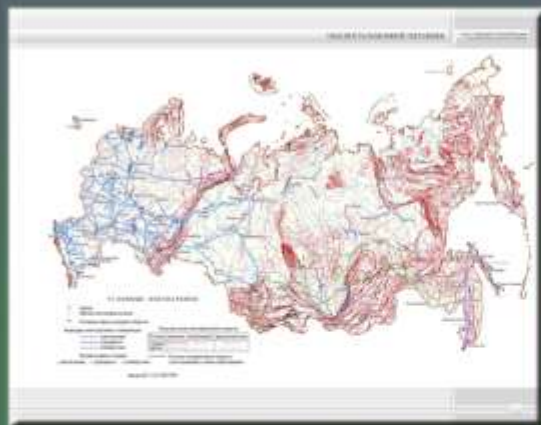
display of  
a map  
completely  
(panorama)



saving of  
a TIF-file  
a map  
(fragment)  
with the set  
parameters



search  
of object  
on a map



•for designing programs of gas transmission system development in prospective regions.



# Examples of maps of the GIS-Atlas: Seismic hazard



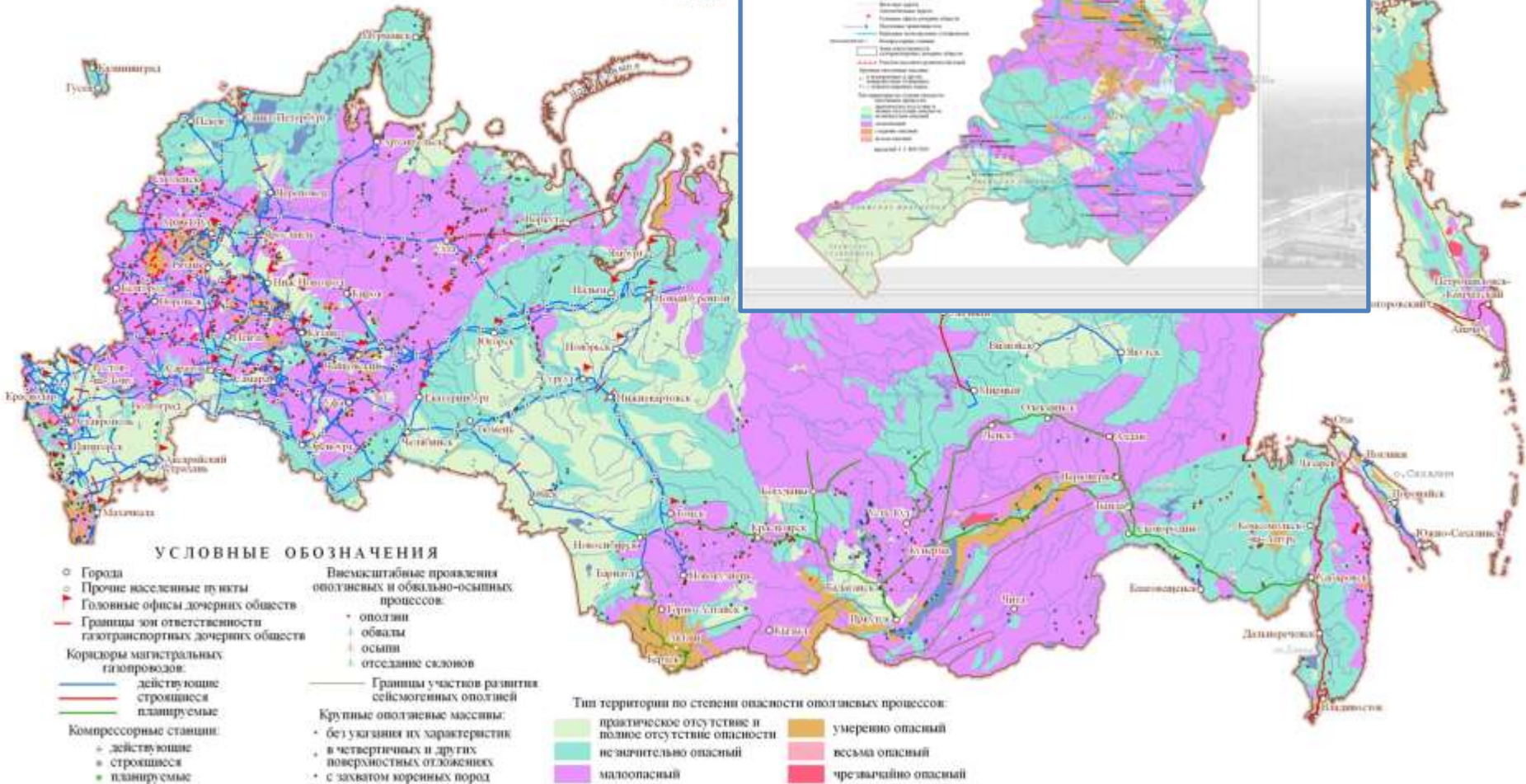
Territory of Russia

Territory of the block  
(zone of the responsibility  
one or several subsidiary  
companies)



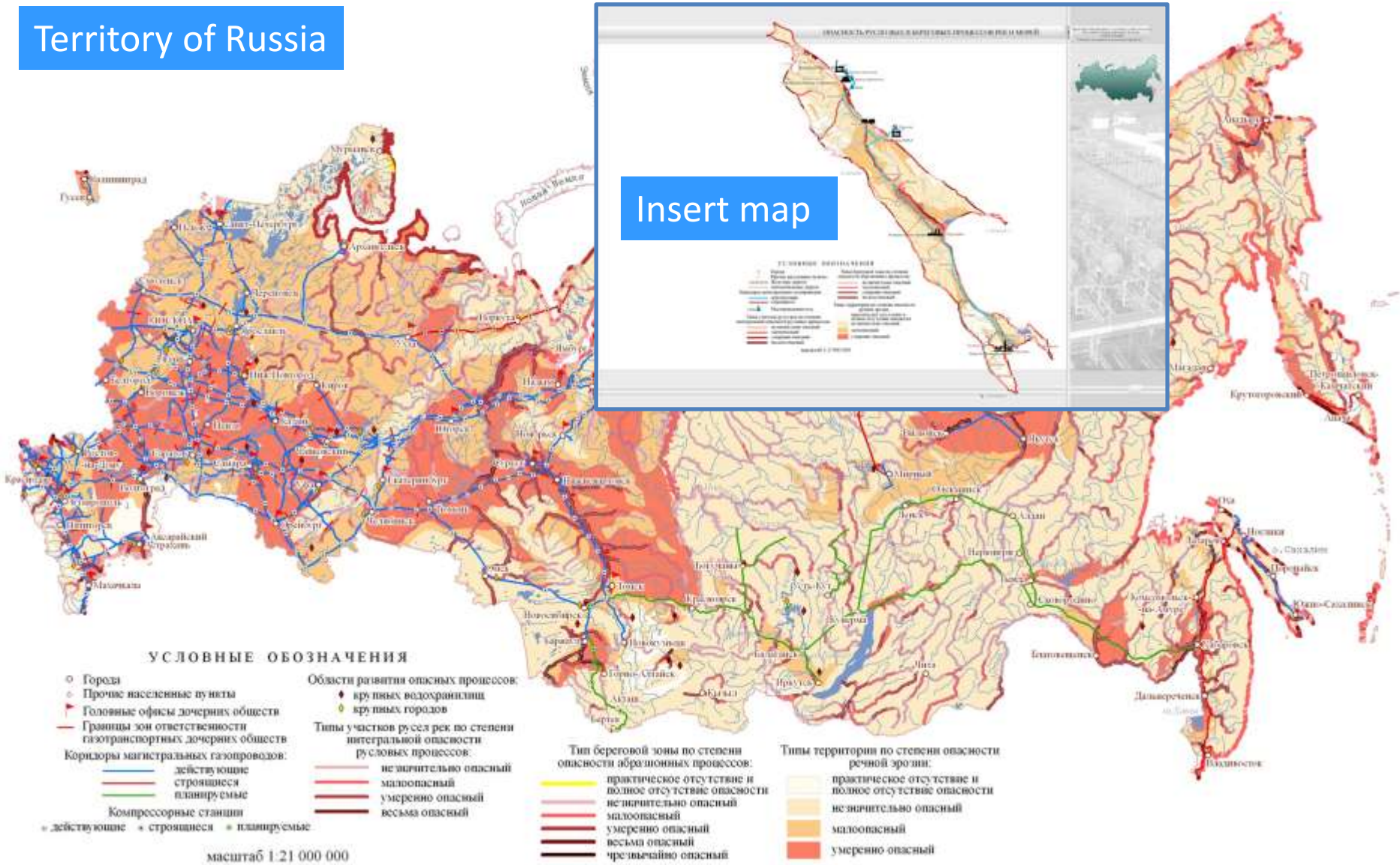
Territory of Russia

Insert map



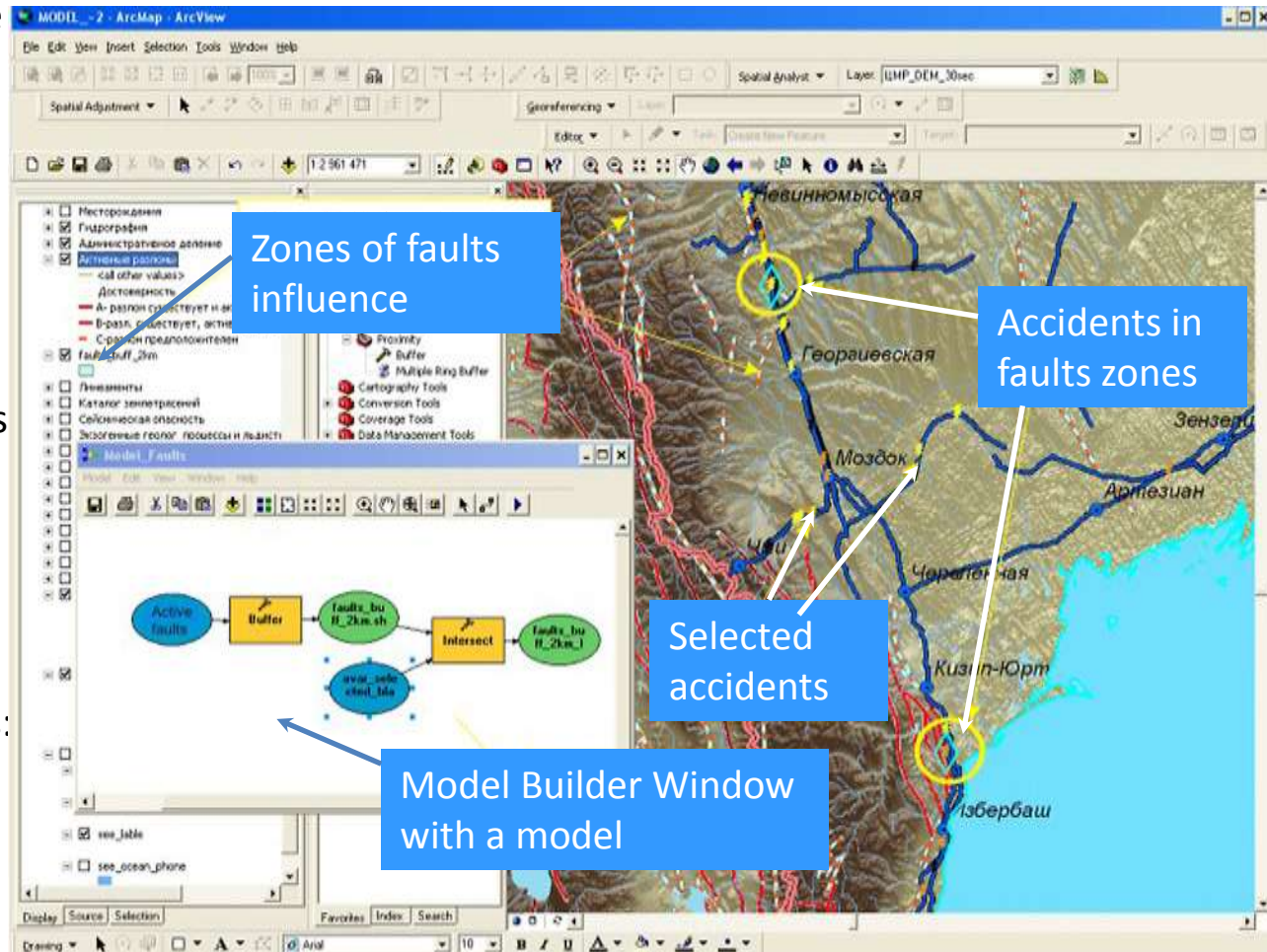
масштаб 1:21 000 000

## Territory of Russia



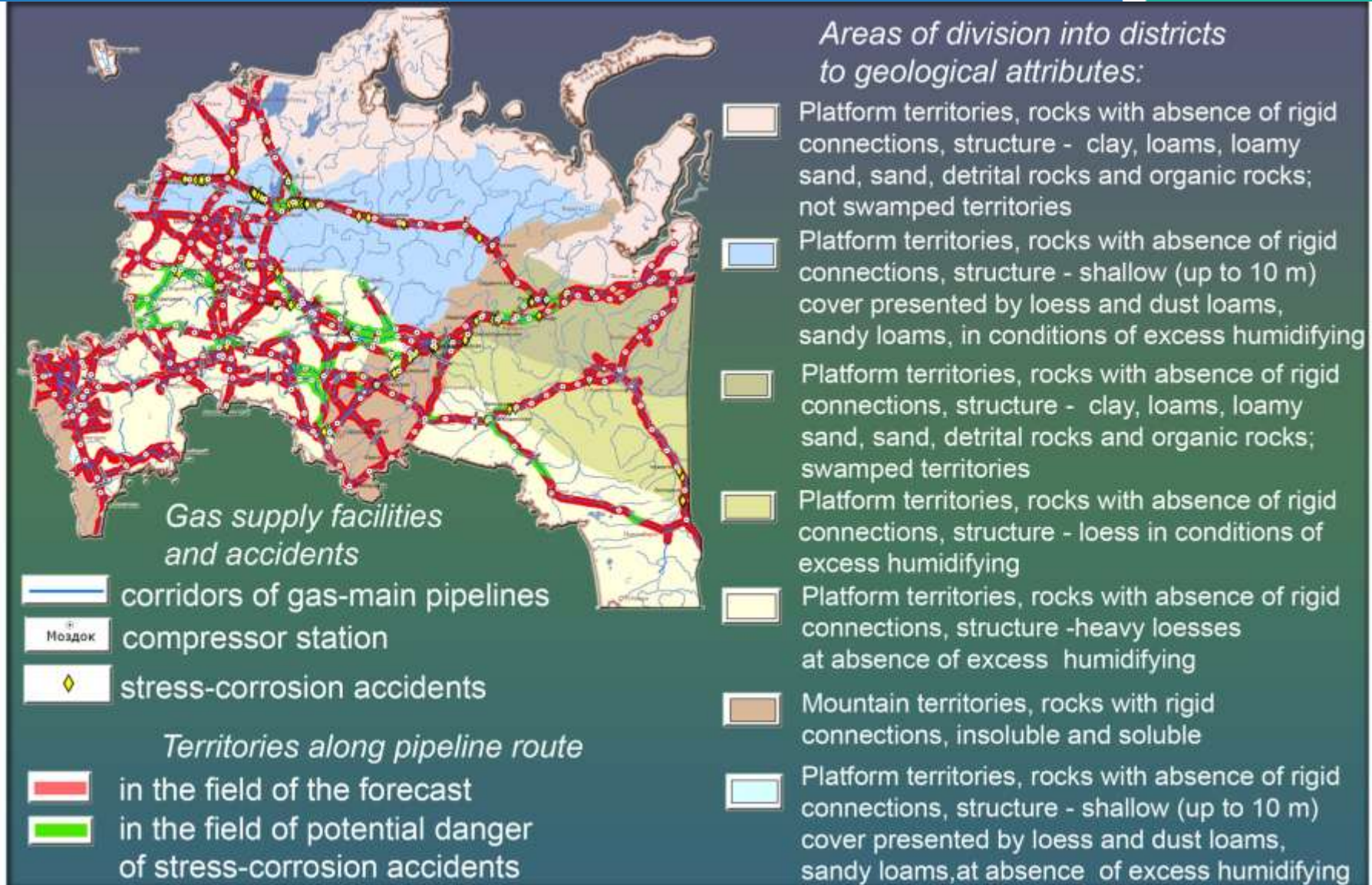
Insert map

- Accidents are chosen (selected) from database of model for the reasons: defect of pipes, the external corrosion, stress-corrosion, defects in construction-and-assembling operations.
- 7,5 % selected accidents (4,8 % from total of accidents) are in zones of geodynamic structures influence.
- Accidents are more often dated for zones of active faults (mountainous areas), than to lineaments (platform areas). Average frequency of accidents: in zones of crossing with an active faults of 0,12 accidents (on one crossing), in zones of crossing with lineaments - 0,09 accidents (on one crossing).



- Conditions for occurrence of some accidents are formed at a combination of set of natural factors which are indirect attributes, so long as relationship between these factors and emergency condition is unobvious and ambiguous.
- The natural factors influencing occurrence of accidents, are presented in the form of cartographical objects and reflected in layers of base cartographical model. Therefore thematic layers of model (natural factors, constructive-technological and operational parameters) are offered for using as indirect images at forecasting potentially dangerous sites for occurrence of accidents on the trunk gas pipelines.
- The choice for prognostic evaluations of danger of occurrence of accidents for the reasons external corrosion and stress-corrosion is connected not only with a significant share of these reasons in accident rate: for these groups of accidents the highest contribution of local adverse natural factors (from 33 up to 55 %) is noted.

# Preliminary assessment of sites with high risk of stress corrosion (SCC) accidents at trunk gas pipelines







*Gas supply facilities and accidents*


 corridors of gas-main pipelines

 Моздок compressor station






 external corrosion accidents

*Territories along pipeline route*

 in the field of the forecast

 in the field of potential danger of external corrosion accidents

*Areas of division into districts to geological attributes:*

-  Platform territories, rocks with absence of rigid connections, structure - clay, loams, loamy sand, sand, detrital rocks and organic rocks; not swamped territories
-  Platform territories, rocks with absence of rigid connections, structure - shallow (up to 10 m) cover presented by loess and dust loams, sandy loams, in conditions of excess humidifying
-  Platform territories, rocks with absence of rigid connections, structure - clay, loams, loamy sand, sand, detrital rocks and organic rocks; swamped territories
-  Platform territories, rocks with absence of rigid connections, structure - loess in conditions of excess humidifying
-  Platform territories, rocks with absence of rigid connections, structure - heavy loesses at absence of excess humidifying
-  Mountain territories, rocks with rigid connections, insoluble and soluble
-  Platform territories, rocks with absence of rigid connections, structure - shallow (up to 10 m) cover presented by loess and dust loams, sandy loams, at absence of excess humidifying

## The cartographic model and GIS-Atlas will be used:

- as scientific-information, methodical and factual support of projects aimed at integrity and sustainability of gas transmission system;
- for analysis of risks and technical condition of gas supply facilities (generation of hypotheses, identification of new patterns of mutual impact of pipeline system and environment, substantiation and assessment of risk factors, integral assessments);
- for documents on industrial safety;
- at pre-investment stages of design and at initial stages of investments substantiation;
- for designing programs of gas transmission system development in prospective regions.

*The holder of the right for presented intellectual property - basic cartographic model, GIS-Atlas and geodata base for accident-dangerous pipeline sections is JSC Gazprom*