



Application network for monitoring of green house gas emission from lithosphere in Khibina territories

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The aim of project is to estimate the contribution of lithospheric flue gas emission of gases CH_4 , CO_2 , H_2 in the general composition of atmospheric pollution of Arctic zone.

The main task is organization of the ecological monitoring in the area of exploitation of large apatite and rare earth ore deposit from Khibine massive on the base of modern WSN (wireless sensor network) technologies. Application network consist from sensors of gas H_2 , CH_4 , CO_2 , complex autonomous equipment for measurement temperature, pressure, humidity and network of telecommunications (used ZigBee protocol).

Our project offer technical decisions for experimentally-methodical monitoring network on the base of WSN and the high-sensitive sensors of hydrogen and methane, software and electronic equipment with a transmitter network. This work is the first project in Russia.

The advantages of this technology is autonomous work (to several months and more), high-frequency programmable measurement of gas sensor, low cost (on one node of network), possibility to connect to one node of supervision a several types of sensors. And as a result is complex monitoring of environment.

It has long been known that the pollution in Arctic Khibine and Lovosero region contains unusually high levels of hydrocarbon gases (HCG) [Petersilie,1964]. The presence of these gases has a number of practical implications and it is therefore important to understand their source and distribution. Among alkaline intrusive complexes with high (for magmatic rocks) concentrations of hydrocarbon and hydrogen– hydrocarbon gases occluded as fluid inclusions in minerals. The Khibina and Lovozero massives are well known, as region of spontaneous emissions of these gases from lithosphere [Khitarov et al., 1979; Ikorskii et al., 1992; Beeskov 2007; Nivin 2005, 2009].

The presence of the HCG, however, raises a number of questions and possibilities. It is unclear how homogeneously the HCG are distributed through the complex? What is the total volume of gas stored within the complex? What contribution abiogenically produced hydrocarbon gases to the Earth's carbon cycle? Is it really that methane and hydrogen continually released to the atmosphere through the roofs of the Khibiny and Lovozero plutons? And if it is so how it influence on the negative anomaly in the ozone layer in central part of the Kola peninsula [Syvrotkin, 2002]?

In addition, naturally combustible, and potentially explosive hydro-carbon gases, are released during mines work the apatite deposits of Khibiny pluton. Changes in gas chemistry and gas-dynamic indices have been documented during the changes in the geo-mechanical state of a rock. And therefore we may use these events as predictive indicators for, catastrophic, rock bursts during the underground works. It therefore is important to develop a comprehensive picture of the distribution of the HCG. It remains debatable by what means these reduced gases evolved in association with oxidized silicate rocks although recent models, suggest that hydro-carbon gases evolution might be the result of abiogenic sub solidus reactions, possibly of a Fischer–Tropsch reaction . However, the potential productivity of the reaction remains uncertain.

Inflow of methane from soil is caused by methanotroph the microorganisms bioactivity, changing depending on a thermal model of microorganisms activity. However, inflow of lithosphere's gases, related to geological processes, remains practically uninvestigated.

Unique devices have been developed in our project for maintenance service of gas emissions monitoring. Tools were constructed in department of physics and nano system of National Research Nuclear University of Moscow Engineering Physics in laboratory "Mining and examination of sensor controls on the basis of MDP structure". Heart of gas analyzer is device D-1. Data device D-1 represent sensing devices for measuring of concentrations of hydrogen, deuterium, hydrogen sulphide, dioxide of nitrogen, chlorine and ammonia. A basic element is MDP (metal-dielectric-semiconductor) - structure of type Pd-Ta₂O₅-SiO₂-Si which electric capacitance changes at in-

teraction with gas. The sensing device can be used for definition of concentrations of any of the numbered gases in a ambient temperatures from -30 to +40.

At this moment, ZigBee protocol communication for WSN is set the standard. Since the 2004. this specification has been repeatedly updated and expanded. Platform MeshLogic Russian development software was chosen to create WSN (www.meshlogic.ru). MeshLogic platform designed to create wireless sensor networks for various applications. MeshLogic standard to be distinct from other products its own network protocol stack that provides the following key benefits:

- Fully homogenous network topology and algorithm of calculation position nodes in spatial;
- All nodes are equal and are routers;
- Self-organization, and automatic search routers;
- Resistance to conflicts between nodes with simultaneously inter transmit data;
- High scalability and reliability of data delivery;
- Ability all the nodes to work on independent power supply.
- Special software for service monitor radio equipment and sensors tools.

Wireless OEM-modules ML-Module-Z is a complete, integrated solution that enables third-party developers to create their own wireless network. In modules built a special version of the network stack MeshLogic, optimized for distributed data acquisition systems, in which a plurality of devices transmit data to one or more collection points (base stations, gateways, etc.). The main feature modules ML-Module-Z is that they all are identical and routers, that is able to retransmit packets, if necessary. At the same time, they can automatically go into "sleep" mode (ad-hock), significantly reducing the average power consumption and increasing battery life. To switch to standby routers do not need to configure access to a synchronized environment or set some other options as modules independently determine the optimal mode of operation depending on the network load.

Note that not all solutions on the market for WSN allow you to create full mesh-network in which all nodes can perform retransmission when running on battery-free.

Module ML-Module-Z consists of a microcontroller, transceiver standard IEEE 802.15.4, a 48-bit serial number, flash memory capacity of 4 MB and provides two options for connecting a 50-ohm antenna: via pads or U.FL-connector. Sensor Connection is realized via the RS232, RS485.

Field work were carried out in autumn 2014 in the Khibiny massive near Apatity town. Experienced network consisted from 5 nodes and 3 sensors. It is possible to organize the testing ground site is about 2 km². The maximum length, experimental profile for monitoring gas was about 3 km. Tests were conducted in different landscape conditions (plains, foothills, mountains) to assess the passing of radio signals in different conditions.

Carry out test measurements and experiments on energy consumption.

Measurement concentration gas with different climatic situation (temperatures and humidity). We made program independent evaluation of the network elements and consumption modes of transmitting and measuring equipment. Range communication between nodes reached 500-700m. In general, a data transmission system corresponded to the declared parameters.

In tests we examined, the algorithm data transfer in situation practiced signal loss and delayed transmission of information. Network device and restructuring roadmap network worked in the proposed mode, providing reliable data transfer within the segment, in this situation. Optimal frequency data positioning system nodes were determined. Number of design flaws in the sensors was found. In particular, great modified was done in construction of power management - power consumption was reduced to 7 mV (approximately 2-times lower from the initial).

In the first year, the results of our tests carried out the significant change in project, both the sensor construction and the host data structure. We solved a number of technical issues on WSN nodes placement schemes and time data collection system. As a result, the technical documentation for a series of new sensors was create. In 2015 we planned to release the prototype with the elimination of deficiencies, on the base of which a permanent network segment will be establish.

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