Overview of trunk pipeline practice in Russian permafrost

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The main regions of fossil fuel reserves in Russia are located in the permafrost zone – north of European Russia, the Yamal peninsula, Western and Eastern Siberia, Southern Yakutia. A boom in trunk pipeline construction occurred after sharp price rises of oil and gas since 2000. 12 000 km of oil and 23 000 km of gas new trunk pipelines were commissioned [Lisin and Soschenko, 2013] between 2000 and 2013, including several notable new projects in permafrost: the "Eastern Siberia – Pacific Ocean" – 1, 2 (ESPO), the "Vankor – Purpe", the "Bovavenkovo – Ukhta", the "Power of Siberia", the "Zapolyarye – Purpe", and the "Kuyumba - Taishet".

Russian experience in the Cold Regions shows that interaction between permafrost and pipeline is complex and depends on various parameters of frozen strata themselves (ground temperature, active layer depth, ice content, cryogenic processes, soil type and geological origin, landscapes and soil-vegetation cover) and the anthropogenic impact of the pipeline on the environment. Inadequate appreciation of these characteristics during surveys, construction or operation stage leads to disturbance of normal operation, increased repairs and greater risk of accidents.

Analysis of Russian pipeline practice based on the new mega pipeline projects exemplifies the main new tendencies in pipeline practice, which have been combined in the following topics:

1. The development of a regulation-standard basis for engineering-geological survey, design and operation of pipeline. The Russian Building Code SP36.13330.2012 [2012] "Trunk pipelines" addresses design, construction and operation

2. Intensive application and developing of pipeline experience in the new pipeline projects - the evolution of Russian pipeline practice in permafrost. Thus, the "Zapolyarye – Purpe" pipeline is based on the design and construction of the "Vankor – Purpe" pipeline; the "Kuyumba – Taishet" and the Power of Siberia trunk pipelines are continuation of the practice on the ESPO-1, 2

3. The active application of thermo-hydromechanical modeling in pipeline practice at pre-investment, survey and operation stage. The goals of this modeling vary from estimation of artificial ground cooling and oil and gas temperature in the pipe to evaluation of economical efficiency of technical developments application [SP25.13330.2012, 2012]

4. The increasing importance of pipeline strain monitoring at the operation stage as a basis for efficient repair works.

The intensive development of Russian pipeline practice is based on new technical developments in pipeline construction. Russian practice of recent years demonstrates the feasibility of pipeline construction in severe natural conditions: from northern tundra to the southern permafrost boundary. The construction of a new pipeline in permafrost zone occurs in a relatively short time, for example, 6 years for ESPO-1 (from first discussion to pipeline commissioning). A few main design and technology developments are presented:

1. The main pipeline laying out way in permafrost is buried: the ESPO – 1, 2 and the Power of Siberia, the "Ukhta-Bovanenkovo" and the "Taishet – Kuymba" trunk pipelines were buried. The pipe-bridge way with thermal heat pipes has been implemented only for the "Vankor – Purpe" and the "Zapolyarye – Purpe" trunk pipelines on areas with continuous distribution of ice-rich permafrost. The widespread application of buried pipelines has lead to the development of compensators for pipe couplings

2. For buried gas pipelines various ballasting and anchorage methods have been developed in order to provide pipeline stability and ensure uplift prevention

3. Development of pipe insulation technology, including heat insulation and corrosion protection is an alternative to thermal heat pipes and thermosyphons. A totally new design is thermal insulation screen, installed under buried pipelines on bottom of trench in ice-rich permafrost area. The three main aims of pipe insulation evolution are: protection from mechanical impacts, protection from corrosion and chemical-biological weathering and protection from heat exchange between pipeline and permafrost. Development of pipe insulation, especially thermal insulation, is gradually decreasing the role of artificial ground cooling by thermosyphons

4. Development of construction technology of water transition of pipeline in permafrost. Today the main way for water transition is microtunelling; pipelining in the trench on the basin bottom is not implemented in new pipeline project. The sea crossing of the "Bovavenkovo – Ukhta" pipeline through Baydara Bay is a unique project of sea gas pipeline in the Arctic Ocean on shallow permafrost. The main method of pipeline laying out is an aboveground pipelining with concrete solidification of pipes. The blasting of pipes by concrete solidification allows protecting of pipeline from mechanical damages by storms, landslides, iceberg gouging and uplifting.

Despite the rapid development of pipeline technology, Russian pipelining practice is facing some issues. These difficulties are caused by different factors: from absence of law-regulation base to violations at construction and operation stages. The main cause of the problems at each stage (survey, design, construction and operation) is underestimation of initial permafrost properties and triggering of cryogenic processes development due to disturbance of natural conditions after construction.

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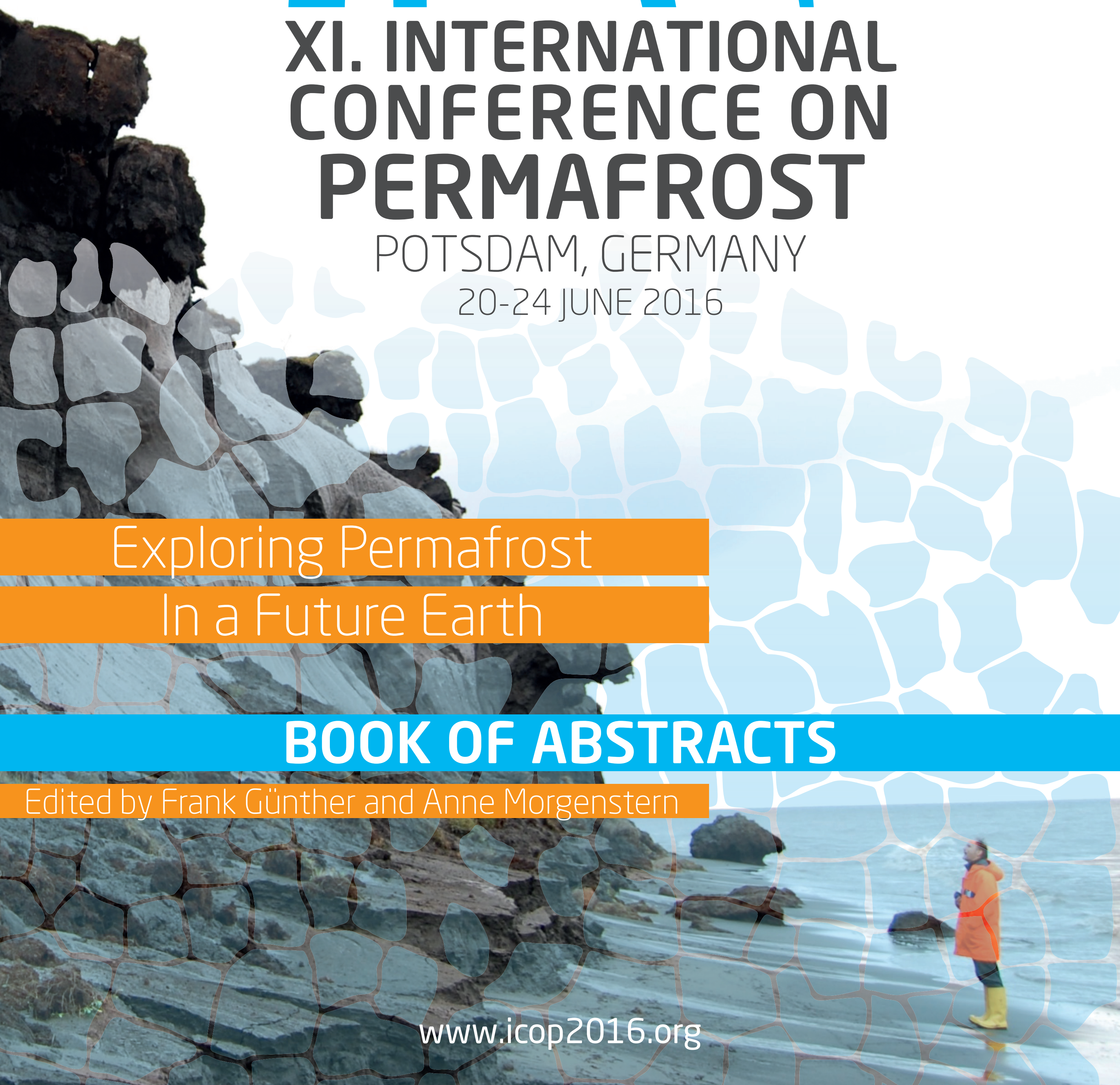

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