Action Group:

'Last Permafrost Maximum and Minimum (LPMM) in Eurasia'

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Objectives and scope of the Action Group:

Background:

The period of permafrost evolution between the Last Permafrost Maximum (LPM)(i.e. ca 20 ka BP) and the Last Permafrost Minimum (LPMin) (ca. 8.0 to 4.5 ka BP), termed here the LPMM, is important in reconstructing the longer-term trends of permafrost changes. Therefore, a relevant starting point for reconstructing such permafrost evolution is the state of permafrost both at the LPM and the LPMM (i.e., two snapshots).

A preliminary map of LGM permafrost for the Eurasian continent was presented during NICOP (Vandenberghe et al, 2008). Current knowledge of LGM permafrost in the Northern Hemisphere and its paleogeographic and paleoclimatic context is summarised in several recent papers (Vandenberghe et al, 2012; French and Millar, 2013; Zhao et al, 2014; Wetterich et al, 2011; Saito et al, 2013; Vasil'chuk and Vasil'chuk, 2014). Climate and permafrost modelling in conjunction with reconstructions from field data have also been undertaken (Levasseur et al, 2011; Kitover et al, 2012; Saito et al, 2013).

Most recently, a comprehensive work undertaken under the auspices of IPA in a previous Action Group entitled '***Permafrost extension during the Last Glacial Maximum in the northern hemisphere and derived mean annual temperatures***' has culminated in the production of a special issue of *Boreas* (Vol **43**, in press) edited by J. Vandenberghe and H. M. French *('Permafrost extension during the Last Permafrost Maximum (LPM) in the northern hemisphere'*). A special LPM map of the Northern Hemisphere at a scale of 1:20,000,000 is included in this volume. This acts to complement the 1997 IPA Circum-Arctic Map of Permafrost and Ground Ice (Brown et al, 1997).

Several striking conclusions are drawn from the LPM map and described in the summary paper that accompanies the map (Vandenberghe et al, 2014). For instance, the extensive area of LPM permafrost in Eurasia, especially when compared to that in North America, is striking. Moreover, recent research shows the increasingly added value of

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climate and permafrost modelling in conjunction with reconstructions from field data (Levavasseur et al, 2011; Kitover et al, 2012; Saito et al., 2013).

The previous research in the Action Group has demonstrated shortcomings in our knowledge of LPM permafrost. These are summarised as follows:

1) LGM permafrost differs from LPM permafrost spatio-temporally. It also has a temporally asymmetric build-up and decay process. This needs further investigation and/or elaboration. Although the LGM timeframe is relatively well known, the LPM timeframe remains largely unsolved. In fact, the LPM could have antedated the LGM rather than lagged behind.
2) Certain regions show a shortage of paleodata and there is an urgent need for additional inventory. For example, the complex and fragmentary nature of elevational (i.e., alpine/mountain and plateau) permafrost hampers its exact mapping. In addition, because permafrost occurrence is not only determined by mean annual temperature, its dependence on more specific temperature and moisture conditions relative to other variables (e.g. soil lithology, vegetation, and snow cover) has to be better clarified. In addition, evidence for past permafrost especially in China and Kazakhstan is often fragmentary.
3) Because the derivation of paleo-climatic permafrost parameters is mainly based on present-day analogs, there is a need for better records of present-day climatic parameters as they relate to the presence of continuous, discontinuous and sporadic permafrost. Moreover, the distinction between continuous, discontinuous and sporadic permafrost is typically based on spatial coverage. This works well in lowland areas but a more appropriate classification may be more useful in regions where elevation plays an important or decisive role in permafrost distribution.
4) In order to compare the Last Permafrost maximum (LPM) with the Last Permafrost Minimum (LPMin), for which a similar situation could occur in the 21st century (or under a climate warming of 2-4°C), it is necessary to understand the shifts in periglacial and/or permafrost environments. The varying extent of permafrost during the LPMM could be used, therefore, as a baseline for many other relevant studies. This change in environment may also have implications for the long-term adaptive strategies that must be adopted in cold regions in the foreseeable future.
5) In comparison with studies of the LGM and LPM, the extent of permafrost during the Last Permafrost Minimum (LPMin) is less understood and more complicated. For example, in regions such as Siberia and Tibet, permafrost has often degraded and become detached from younger permafrost. At certain locations, the relic (i.e., buried) permafrost table is between 10-120 m below the ground surface. Ocean transgressions due to the rising sea levels during the warming period have led to subsea or sub-lake permafrost in some places. In general, permafrost distribution probably became less continuous and smaller in areal extent. This further complicates the mapping of permafrost during the LPMin.

Objectives of the new Action group:

1. To define the different categories of permafrost that occurred on the Eurasian continent, during the LPMM. In particular, the occurrence of permafrost in mountainous areas was a function of elevation and specific climatic conditions; this needs a better understanding. A methodology has to be set-up for the compilation of data to be reproduced into a map.
2. To relate, as far as possible, individual kinds of permafrost to conditions of seasonal temperature and other environmental factors. Deriving climatic conditions will be carried out within certain limits because of the complexity of many controlling variables.
3. To derive, more exactly, the present-day climatic conditions that are linked to the presence of different kinds of permafrost.
4. To map, and document in detail, the proxies for permafrost in those regions that contain, until now, inadequate or limited amounts of data. It appears from the work of the previous Action Group that proxies for the reconstruction of former permafrost existence are well agreed on. However, in continental semi-arid areas the usual permafrost indicators are sparsely distributed and/or lively debated. A special effort should be undertaken to complete the inventory, and to clarify the argued evidence for relict permafrost or periglacial remains. Suggested experts: French (Ottawa) and Vandenberghe (Amsterdam).
5. To further support the development of models on permafrost reconstruction during LPMM and on permafrost evolution since the LPM. Especially, efforts should be supported that combine field-based reconstructions and (physically based) numerical modeling. Suggested experts: Saito (Fairbanks) and Renssen (Amsterdam).
6. To construct a database structure that will document all permafrost proxies and their environmental context. A preliminary structure has been initialized by Bertran (France) and co-workers for such a database of proxy-data recorded in France; to be presented in a key lecture at EUCOP IV). Suggested expert: Bertran (Bordeaux).

Because the LPMM in China, Kazakhstan and eastern/southern Siberia is poorly known, the proposed IPA-AG LPMM will largely focus on eastern Eurasia. Research would be regionally coordinated as follows: Russia (Vasil'chuk and Stanilovskaya), central Asia (Kazakhstan and neighbouring countries: Marchenko), eastern Asia (Jin/T. Zhang). A number of expert meetings (workshops, possibly field meetings) between experts will be needed. Vandenberghe will assist Bertran in updating western European databases and paleo-reconstructions and will also contribute to work of Jin and Zhang. French will provide linkage with current North American permafrost and paleo-permafrost investigations.

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Working Plan

1. Goals of first meeting:
- Agree on the common targets and the time frame.
- Agree on a way to converge permafrost data into climatic and environmental data as 'derived' results.
2. Afterwards, the work can start effectively, and much (most) can be done by electronic correspondence. Joint field meetings in areas of crucial importance may have to be organized.
3. Next meeting(s) is (are) planned to discuss all collected data and to finalize the project.
4. The last phase is to report on achieved results.

Outreach:

The results will contribute substantially to a better understanding of the dynamics of permafrost in response to climate changes and as a function of other environmental factors. The results will assist in modeling the evolution of permafrost under warmer climatic conditions.

Management structure:
Given the small scope of the project there is no need for a formal structure. Huijin Jin (Lanzhou) is prepared to operate as coordinator.

Timeline:

The timeframe proposed is that the LPM will be detailed during the first two years (June 2014-May 2016). The LPMin will be more carefully formulated during the following two years (July 2016-June 2018). The LPMM will then be incorporated into a global map that complements the recently-completed 2014 LPM Map of the Northern Hemisphere (Vandenberghe et al, 2014).

- A one-day jump-meeting of project participants in spring 2015. Proposal to meet in Lanzhou.
- Mapping operation during 2015 and 1st half of 2016 with possibly joint field expeditions.
- A one-day meeting of project participants in summer-autumn of 2016 to compile and finalize results of LPM map update; discussing set-up for LPMM map in 2016-2018.

End of 2018: all maps and papers ready for publication.

Other Action Group Members:

Project coordinator: H.J. Jin (China)
Group members: P. Bertran (France), S. Marchenko (Kazakhstan), Y. Vasil'chuk (Russia), T. Zhang (China), J. Stanilovskaya (Russia), K. Saito (USA), H. Renssen (Netherlands), H.M. French (Canada), J. Vandenberghe (Netherlands)

International dimension:

'Mental' support will be asked from the CRE (Cold Region Environments) Commission of IGU. In addition, Professor Em. H. M. French (Ottawa) and Professor Em. J. Vandenberghe (Amsterdam) will provide an international perspective in an advisory role.