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FROM HEROIC EXPEDITIONS TO MODERN FIELD PROGRAMS IN PERIGLACIAL ENVIRONMENTS

Abstract

Some of the earliest observations upon periglacial processes and phenomena were made by the European explorers of the vast subarctic regions of North America and Eurasia. Later, expeditions in search of the North and South Poles provided the opportunities for further observation. The records of these early traders and explorers contain casual, opportunistic and largely non-scientific information. The real growth in periglacial field programs in high latitudes commenced after the Second World War. Today, modern programs usually operate within the context of sophisticated, usually government-backed, logistical organizations. In recent years, and in response to world economic conditions, oil and gas companies and other resource extraction industries provide medium-term opportunistic logistics.

HEROIC BEGINNINGS

In the English-language literature the earliest observations upon periglacial processes and phenomena were casual, opportunistic, and largely non-scientific. They were made by the European explorers of the vast subarctic regions of North America. For example, the employees of the Hudson's Bay Company, and those who traded with them, frequently made observations related to the terrain over which they traveled. Thus, a Capt. CHRISTOPHER MIDDLETON, F. R. S., Commander of His Majesty's Ship Furnace, reported in 1741–42 (MIDDLETON, 1743) upon ...'The Effects of Cold; together with Observations of the Longitude, Latitude and Declination of the Magnetic Needle, at Prince of Wales' Fort, upon Churchill River in Hudson's Bay, North America'. In Alaska, frozen ground was first mentioned by OTTO VON KOTZEBUE as he moved through the Bering Strait (KOTZEBUE, 1821). Following GEORGE BACK's Journey through what is now northeast Keewatin in 1833–34, Dr JOHN RICHARDSON, the physician who accompanied FRANKLIN's Journeys of 1819–22 and 1825–27 to northwest Canada, summarized his sporadic

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observations upon frozen ground in northern Canada. These were presented, first, to The Royal Geographical Society in London (RICHARDSON, 1939), and then to the fashionable Wernerian Society, in Edinburgh, in 1840 (RICHARDSON, 1841).

As regards Eurasia, a Professor BAER of St Petersburg reported (BAER, 1838) upon the sinking of a well in perennially frozen ground at Yakutsk, Siberia, to a depth of 382 feet and subsequently, the German scientist A. VON MIDDENDORF reported (MIDDENDORF, 1862) upon the permafrost temperatures measured within the well in 1848.

The numerous 'Franklin searches' in the Canadian Arctic in the two decades after 1850 maintained a public interest, at least in Great Britain, in the existence of frozen ground. Then, following upon United States expeditions to northern Alaska and Ellesmere Island between 1880–1883, data on the depth of frost penetration at various latitudes on the North American continent were summarized in the reports of a special committee of The Royal Geographical Society set up to '.... inquire into the Depth of Permanently Frozen Soil in the Polar Regions'. These reports were presented by General Sir J. H. LEFROY (1885, 1887, 1889).

Typical of the non-English literature of the time are the reports by P. A. KROPOTKINE (1871) to the Imperial Russian Geographical Society upon his expedition to the northern seas of Russia in which terrain, coastal morphology and sea ice conditions were commented upon, and that of JACZEWSKI (1889) on the perennial frozen soil of Siberia.

THE TURN OF THE CENTURY

The beginnings of the twentieth century witnessed a sharp increase in our knowledge of periglacial environments. In North America, this was the period of the Klondike Gold Rush of 1898, to be followed by the migration of many of these same miners to Alaska in 1901–3. Observations upon frozen ground, the gravels, and the bitter, cold-climate conditions which they experienced, were numerous and first-hand. Subsequently, officers of the Geological Survey of Canada and of the United States Geological Survey were sent to the northwestern Arctic of North America to undertake geological mapping and surveys. These rugged field scientists typically spent several years in the north, providing detailed and systematic accounts of geomorphological features (e.g. terraces by R. G. MCCONNELI, 1905; regional planation by D. D. CAIRNS, 1912), periglacial landforms (e.g. altiplanation by H. M. EAKIN, 1916, rock glaciers by J. B. TYRELL, 1910, and S. R. CAPPS, 1910), and permafrost conditions (e.g. thermal contraction cracking by E. K. LEFFINGWELL, 1915, 1919; ground ice by J. B. TYRELL, 1904, 1917). In European Russia, there was an expedition made to document the taiga – boreal forest transition by G. I. TANFILJEF (1911).

At about the same time, on the other side of the world, in a much quoted paper, ANDERSSON (1906) described the mass wasting and 'stone runs' on the damp and windy Falkland Islands in the South Atlantic. Based upon his earlier observations on Bear island in the subarctic North Atlantic ANDERSSON introduced the term 'solifluction' to the periglacial literature.

On the Antarctic continent itself, this was the decade of intense polar exploration and nationalism on the part of certain European nations, especially Great Britain. Observations by J. PRIESTLEY and other members of Scott's Northern Party (PRIESTLEY, 1914), who spent 2 winters of incredible hardship in the Northern Foothills in 1911–12, were probably some of the earliest to describe the importance of wind action in periglacial environments and to record the audible sound of thermal contraction cracking. GRIFFITH TAYLOR, another member of the 1910–1913 British Expedition, was the first to describe the large polygons of the McMurdo Sound region (TAYLOR, 1915, 1924).

It is against this setting of exploration and hardship, and in comparative comfort, that a number of European academics attending the XI International Geological Congress at Stockholm made an excursion to Spitzbergen, at latitude 80°N, in 1910–1911. There, the periglacial concept, first developed by WALERY ŁOZIŃSKI (1909, 1912), was applied to present-day high latitudes. A number of influential benchmark papers were produced in the following years (e.g. upon patterned ground by W. MEINARDUS (1912), and upon frost shattering by B. HÖGBOM (1914).

THE 1919–1939 PERIOD

The chaos arising out the First Great War (1914–1918) in Europe, and the 1917–18 Bolshevik Revolution in Russia, probably accounts for the scientific hiatus of the 1920's, and an apparent isolation between the European, Russian and North American geologists working in the polar and sub-polar regions. It almost certainly accounts for the relatively slow development of periglacial research in the inter-war period.

Following upon these significant world events, Soviet field programs in permafrost terrain were the first to systematically develop. In the 1920's, as Siberia was increasingly used as a penal colony for political prisoners and other unfortunates, a state-sponsored Permafrost Institute of the Siberian Branch of the Soviet Academy of Sciences was established at Yakutsk. By the late 1930's, the first textbooks on permafrost and ground ice were being produced in the USSR (e.g. SUMGIN, 1927, 1937). In 1940, the first edition of Obshcheye merzlotovedeniye ('General Permafrost studies') was published by M. I. SUMGIN and colleagues (SUMGIN *et al*, 1940) of the Soviet Academy of Sciences. However, the European 'periglacial' concept was not widely embraced in Russia, mainly because it was realized that the distinctive terrain features of large areas of Siberia were unrelated to the proximity of glaciers, either today or in the Pleistocene. Likewise, in North America, there was little interest in periglacial studies as attention focused mostly upon economic geology and mineral exploration (e.g. WERNECKE, 1932; JOHNSON, 1930), and on land clearance for settlement in Alaska (e.g. see ROCKIE, 1942).

In Europe, the 1919–1939 period saw the slow growth of periglacial field programs, mostly to Svalbard and Greenland. A few publications, mostly in German (e.g. GRIGORIEV, 1925; POSER, 1932, 1936; SHOSTAKOVITCH, 1927; SORENSEN, 1934), indicate certain of these field programs but there were others, such as the Polish expeditions in 1937 and 1938 of A. JAHN to Greenland and M. KLIMASZEWSKI to Spitzbergen. However, the relative lack of interest in periglacial research in the polar regions at this time is difficult to understand. Likewise, in Arctic North America, geomorphological and botanical expeditions to the Canadian Arctic in the 1930's, such as the University of Cambridge Wordie Arctic Expedition to the east coast of Baffin Island in the summer of 1934 (PATTERSON, 1940), and those by A. L. WASHBURN in 1938, 1939 and 1940–41 to the western Canadian Arctic were typical of the small, academically-oriented expeditions of this period.

THE SECOND WORLD WAR (1939–45) AND ITS AFTERMATH

The real growth of periglacial field studies followed the 1939–45 war. In North America, the construction of the Alaskan Highway in 1942–43 focused attention upon the peculiarities of permafrost terrain (e.g. MULLER, 1943; TABER, 1943). It was further stimulated by the 'Cold War' and the post–1950 strategic importance of northern Canada and Alaska. In Alaska, the United States Navy set up the Naval Arctic Research Laboratory (NARL) at Point Barrow in 1951. The Cold War saw the construction of the DEWLINE stations across the entire North American continent, the closing of vast areas of Siberia to international travel, and the expansion of the Permafrost Institute in Yakutsk.

In this political climate, the military and strategic significance of both polar regions quickly became explicit. In the United States, the US Army CRREL and the Alaska Division of the USGS became active in cold regions research of various kinds. In Canada, the National Research Council of Canada embarked upon a program of nation-wide permafrost mapping, and numerous site investigations for new settlements, roads, hydro-dams, and railways in northern Canada. To overcome the extreme logistical difficulties, and partly with the political aim of demonstrating sovereignty over the Arctic islands, the Canadian government created the Polar Continental Shelf Project (PCSP) in 1958. This was an aircraft-supported logistics organization designed to assist government mapping, monitoring, and scientific programs in the Canadian Arctic. One of the first periglacial geomorphological programs to use these logistics in the High Arctic was that of D. A. ST-ONGE, on Ellef Ringes Island, in the summers of 1958, 1959 and 1960. Subsequently, the 1960's saw government and university–based scientists develop long-term field programs in the western and High Arctic regions of Canada (e.g. J. ROSS MACKAY, O. L. HUGHES, H. M. FRENCH and others). Elsewhere, A. L. WASHBURN was able to undertake long term studies on slope processes and patterned ground, first near the settlement of Mesters Vig, northeast Greenland and then, in the 1980's, at Resolute Bay, Canada. In central Alaska the late 1940's and early 1950's saw T. L. PÉWÉ, D. HOPKINS, R. F. BLACK, H. J. WALKER and others begin long term permafrost and Quaternary geological investigations, usually with the support of the USGS and concentrated in central Alaska, on the Seward Peninsula of western Alaska, and on the Arctic North Slope. Oil and gas exploration activity was the stimulus for investigations on the North Slope while elsewhere, in central Alaska, the impact of permafrost upon all forms of human activity was the underlying focus.

In Antarctica, the 1958 International Geophysical Year witnessed the beginnings of the formal presence in Antarctica of a US-sponsored research program. Periglacial and permafrost research programs were undertaken by T. L. PÉWÉ, R. F. BLACK and others. The 1960's saw the expansion of certain national programs (e.g. British Antarctic Survey) and the birth of others.

In the European countries, especially Poland, France and Germany, the post–1945 period saw the emergence of Pleistocene and Quaternary periglacial studies aimed at paleogeographic reconstruction. This trend was associated with the research of A. CAILLEUX, J. TRICART, J. DYLIK, A. JAHN, H. POSER, J. BÜDEL, G. C. MAARLEVELD and others. These important developments, however, are not the primary concern of this paper. Instead, mention must be made of the renewed European interest in the high latitudes in the late 1950's and 1960's. These regions were viewed as possible cold-climate analogues for the Pleistocene periglacial environments of mid-latitudes. Thus, there were small expeditions to Svalbard by J. BÜDEL, A. JAHN, J. DYLIK and A. RAPP, the latter as a complement to his long-term field observations on cold-climate slope processes at Karkevagge in northern Sweden, and others to Greenland (J. MALAURIE), Iceland (E. SCHUNKE) and Prince Patrick Island in the Western Canadian Arctic (A. PISSART).

Modern and relatively sophisticated field programs in Svalbard began to develop in the mid 1970's. By this time, on-going Russian, Polish, and Norwegian research programs had all been established on western

Spitsbergen. Hornsund, the location of the Polish station, had been in existence since 1958–59, while the Soviet coal-mining settlements of Barentsburg and Pyramiden, served as the logistical and administrative centres for Russian – sponsored investigations. The airstrip at Longyearbyen was substantially enlarged to accommodate Soviet long-range aircraft. In Norway, the Norsk Polarinstitutt, located in Oslo, began to provide resources for extensive research and mapping programs in both Svalbard and northern Norway. This was carried out by O. LEISTOL, J. SOLLID and others, and research facilities at Longyearbyen and Ny Alesund were subsequently established. In the late 1970's, T. L. PÉWÉ undertook field investigations on the Bloomsletta Peninsula and in the vicinity of Sveagrua.

The emergence of periglacial field programs in China in the 1970's was associated, as in North America and Russia, with political and strategic objectives. The importance of rail links to Northeast China and the Sino-Russian border in the early 1970's, led to permafrost research being an important component of the Northwest Railway Institute located in Harbin. Likewise, on the Quinghai-Xizang (Tibet) Plateau, the necessity to construct an all-year highway to Lhasa initiated permafrost and periglacial studies, first by the Desert Research Institute of the Chinese Academy of Sciences and by the Northwest Railway Institute, and then, in the late 1970's, by the newly-created Lanzhou Institute of Glaciology and Geocryology (LIGG). Since then, the Lanzhou Institute continues to conduct periglacial field programs on the Plateau, mostly concentrated along the Tibet Highway corridor, in possible anticipation of a rail link to Lhasa.

PROGRAMS IN THE NEW MILLENIUM

It is against this background that modern field programs are conceived. Today, almost without exception, periglacial field programs operate within the context of sophisticated, and usually government-backed, logistical organizations. In certain instances, the oil and gas industry, or mining and resource extraction companies, provide medium-term opportunistic logistics (e.g. the BHP Ekati diamond mine at Lac des Gras, NWT, Canada). Explicit military or political support for research programs in the northern polar regions is now rare, but in Antarctica and Tibet this support is axiomatic. In the Northern polar region the International Arctic Science Committee (IASC) and the Arctic Council exists to coordinate research activities at the national level. In Antarctica, the Antarctic Treaty performs a similar role.

The use of automatic data recording systems and computer technology means that extended periods in the field for research personnel are no longer so essential, and helicopter, aircraft or road links are usually available. Individual self-sponsored field programs are increasingly rare. Instead, permanent research and logistical bases are now the norm for many periglacial regions. For example, in Canada, PCSP maintains a facility at Resolute Bay, NWT, the town of Inuvik provides logistics for the Mackenzie Delta and Western Arctic coast, and the Dempster Highway provides access to interior Yukon. Likewise, in Alaska, the Point Barrow settlement, the vast Prudhoe Bay oilfield facilities, and the 'haul-road' from Fairbanks provide an excellent logistical framework. In western Siberia, the town of Tyumen and the Arctik Gas Company town of Nadym have become the administrative and logistical bases for oil and gas development in the Yamal and Gydan regions. In Sweden, permanent research stations exist at both Tarfala and Abisko, while on Svalbard, UNIS at Longyearbyen and the Ny Alesund station provide logistical field support. In Antarctica, the Unites States maintains the large McMurdo Sound complex and the South Pole station, the British Antarctic Survey maintains a number of permanent research stations on the Antarctic Peninsula (e.g. Palmer station), and there are a number of other year-round or seasonal bases operated by Australia, New Zealand, Italy, Japan and Russia, to name but a few. Many of the logistics for the field programs of the United States, Italy and New Zealand are now coordinated through the Antarctica Center at Christchurch, New Zealand. Today, satellite communications, e-mail linkages, laptop computers and international airlines permit global science to take place.

CONCLUSIONS

The growth of field programs in periglacial environments has seen a progressive transformation over 3 centuries from isolated observations made under conditions of incredible hardship to systematic scientific investigations conducted over many years and made possible by increasingly sophisticated logistical support systems. Today, only governments and research agencies can provide such facilities. The era of the individual field scientist working in relative isolation (and tranquility) in the periglacial high latitudes of the world has largely passed.

References

(Only references earlier than 1945 have been cited in the text)

ANDERSSON, J. G., 1906 - Solifluction; a component of subaerial denudation. *Journal of Geology*, 14; p. 91-112.

Professor BAER (no initials), 1838 – The Ground Ice or Frozen Soil of Siberia. *Journal of the Royal Geographical Society,* London, Vol. VIII, London, John Murray, Albemarle Street; p. 210–213.

CAIRNS, D. D., 1912 – Differential erosion and equiplanation in portions of Yukon and Alaska. *Bulletin, Geological Society of America,* 23; p. 333–348.

CAPPS, S. R., 1910 – Rock glaciers in Alaska. *Journal of Geology,* 18; p. 359–375.

EAKIN, W. M., 1916 – The Yukon – Koyukuk region, Alaska. *United States Geological Survey Bulletin* 631; p. 67–88.

GRIGORIEV, A., 1925 – Die typen des tundra-mikroreliefs von Polar-Eurasien, ihre geographische Verbreitung und genesis. *Geographische Zeitschrift,* 31; p. 3435–359.

HÖGBOM, B., 1914 – Über die geologische Bedeutung des Frostes. *Uppsala Universiteit, Geological Institute Bulletin,* 12; p. 257–389.

JACZEWSKI, J., 1889 – On the perennial frozen grounds in Siberia. *Journal of the Imperial Russian Geographical Society,* 25; p. 341–355 (In Russian).

JOHNSON, W., 1930 – Frozen ground in the glaciated parts of Northern Canada. *Transactions, Royal Society of Canada,* Section IV; p. 31–40.

OTTO VON KOTZEBUE, 1821 – A voyage of discovery into the South Sea and Bering's Strait for the purpose of exploring a northwest passage. London. (English translation, 3 volumes)

KROPOTKINE, P. A., 1871 – Expedition for the exploring of the northern seas of Russia. *Imperial Russian Geographical Society,* St Petersburg, Russia; 91 pp. (In Russian).

LEFFINGWELL, E. K., 1915 – Ground ice wedges, the dominant form of ground-ice on the north coast of Alaska. *Journal of Geology,* 23; p. 635–654.

LEFFINGWELL, E. K., 1919 – The Canning River Region, Northern Alaska. *United States Geological Survey Professional Paper,* 109; 251 pp.

LEFROY, J. H., 1887 – Second Report of a Committee for enquiring into the Depth of Permanently Frozen Soil in the Polar Region. *Proceedings, Royal Geographical Society,* vol IX, New Series, London; p. 769–774.

LEFROY, J. H., 1889a – Report upon the depth of Permanently Frozen Soil in the Polar Regions, its geographical limits and relations to the present poles greatest cold. *Proceedings of the Geographical Section of the British Association,* London, 1889; p. 740–746.

LEFROY, J. H., 1889b – On the Depth of the Permanently Frozen Soil in British North America. *Proceedings of the Geographical Section of the British Association,* London, 1889; p. 761–763.

ŁOZIŃSKI, W., 1909 – Über die mechanische Verwitterung der Sandsteine im gemassibten Klima. *Acad. Sci. Cracovie Bull. Intern., cl. Sci. Math. et naturelles,* 1, 1–25. English translation in: D. J. A. EVANS *(ed.),* Cold climate landforms, J. WILEY, U. K., 1994; p. 119–134.

ŁOZIŃSKI, W., 1912 – Die periglaziale fazies der mechanischen Verwitterung. *Compte rendu, 11th International geological Congress, Stockholm,* 1910; p. 1039–1053.

MCCONNELL, R. G., 1905 – Report on the Klondike Goldfields. *Geological Survey of Canada Annual Report,* volume 14, B; p. 1–7.

MEINARDUS, W., 1912 – Beobachtungen über Detritussortierung und Strukturboden auf Spitzbergen. *Gesell. Erdkunde Berlin Zeitschr.,* 1912; p. 250–59.

MIDDENDORF, A. VON, 1862 – Sibirien Reise. Part 1. Uebersicht der Natur Nord–und Ost–Siberiens St Petersburg, Kaiserlichen Akademie der Wissenschaften; 783 pp.

CHRISTOPHER MIDDLETON, 1743 – The effects of cold; together with observations of the longitude, latitude and declination of the magnetic needle, at Prince of Wales Fort, upon Churchill–River in Hudson's Bay, North America. *Philosophical Transactions, Royal Society of London,* 42; p. 157–171.

MÜLLER, S, 1943 – Permafrost or permanently frozen ground and related engineering problems. *Special report No 62, United States Geological Survey, Intelligence Branch Office, Chief of Engineers, U.S. Army*; 136 pp.

PATERSON, T. T., 1940 – The effects of frost action and solifluxion around Baffin Bay and in the Cambridge District. *Quarterly Journal of the Geological Society*, London, 96; p. 99–130.

POSER, P., 1932 – Einige untersuchungen zur morphologie Ostgrönlands. *Meddellelser om Grönland,* 94; 55 pp.

POSER, H., 1936 – Talstudien aus Westspitzbergen und Ostgrönlands. *Zeitschrift Gletch.*, 24; p. 43–98.

PRIESTLEY, J., 1914 – Antarctic Adventure. Scotts's Northern Party. T. Fisher Uwin, London, with a new foreward by Sir Vivien Fuchs, McClelland and Stewart Limited, 1974; 382 pp.

RICHARDSON, J., 1839 – Notice of a few Observations which it is desirable to make on the Frozen Soil of British North America; drawn up for distribution among the Officers of the Hudson's Bay Company. *Journal, Royal Geographical Society*, London, 9; p. 117–120.

RICHARDSON, J., 1841 – On the frozen soil of North America. *Edinburgh New Philosophical Journal,* 30; p. 110–123.

ROCKIE, W. A., 1942 – Pitting on Alaska farms: a new erosion problem. *Geographical review,* 32; p. 128–134.

SHOSTAKOVITCH, B., 1927 – Der ewig gefrorene boden Siberiens. *Zeitschrift Gesellschaft Erdkunde,* Berlin; p. 394–427.

SORENSEN, T., 1934 – Bodenformen und pflanzendecke in Nordostgrönland. *Meddelelser om Grönland,* 93; pp. 69 (English translation *in*: D. J. A. EVANS (*ed.*), Cold Climate Landforms, JOHN WILEY and Sons, U. K., 1994; p. 135– 175).

SUMGIN, M. I., 1927, 1937 – Soil permafrost within the USSR. 1st edition, Vladivostok; 2nd edition, USSR Academy of Sciences, Moscow – Leningrad (In Russian).

SUMGIN, M. I., KACHURIN, S. P., TOLSTIKHIN, N. I., ANDTUMEL, V. F., 1940 – Obshcheye merzloto-vede-niye. Idz-vo Akad. Nauk SSSR, Moscow–Leningrad.

TABER, S., 1943 – Perennially frozen ground in Alaska; its origin and history. *Bulletin, Geological Society of America,* 54; p. 1433–1548.

TANFILJEF, G. I., 1911 – Location and delimitation of the boreal forest/tundra transition in the Timar–Ssamojeden region, northern polar region of Russia. Fedosenko Publishing House, Odessa, Russia, 285 pp + 34 photos (In Russian with German summary).

TYRELL, J. B., 1904 – Cryostophenes or buried sheets of ice in the tundra of Northern America. *Journal of Geology,* 12; p. 232–236.

TYRELL, J. B., 1910 – Rock glaciers or chrystocrenes. *Journal of Geology*, 18; p. 549–553.

TYRELL, J. B., 1917 – Frozen muck in the Klondike District. *Transactions, Royal Society of Canada,* Section 4; p. 39–46.

L. WERNECKE, L., 1932 – Glaciation, depth of frost and ice veins at Keno Hill and vicinity. *Engineering and Mining Journal*, 133; p. 33–43.