The Permanently Frozen Soils of Russia.

FOR more than two hundred years it has been known that in the extreme north of Siberia there are soils the lower strata of which are in a perpetually frozen condition. Since then a considerable literature on the problem has accumulated, but it is widely scattered, partly in almost inaccessible local publications, and a general critical survey of the literature, together with the results of original observations, recently published by the Far Eastern Geophysical Observatory in Vladivostok,[1] is therefore of great interest.

The author defines these perpetually frozen soils as those the temperature of which is always below the freezing point, regardless of the presence, or absence, of water in the soil. This definition is more exact than most of the earlier ones, which have been usually based on the soil being cemented by frozen waters. It happens with some sufficiently loose and very dry soils that their particles remain free and the soil loose even after freezing; such soils nevertheless should be classified as permanently frozen.

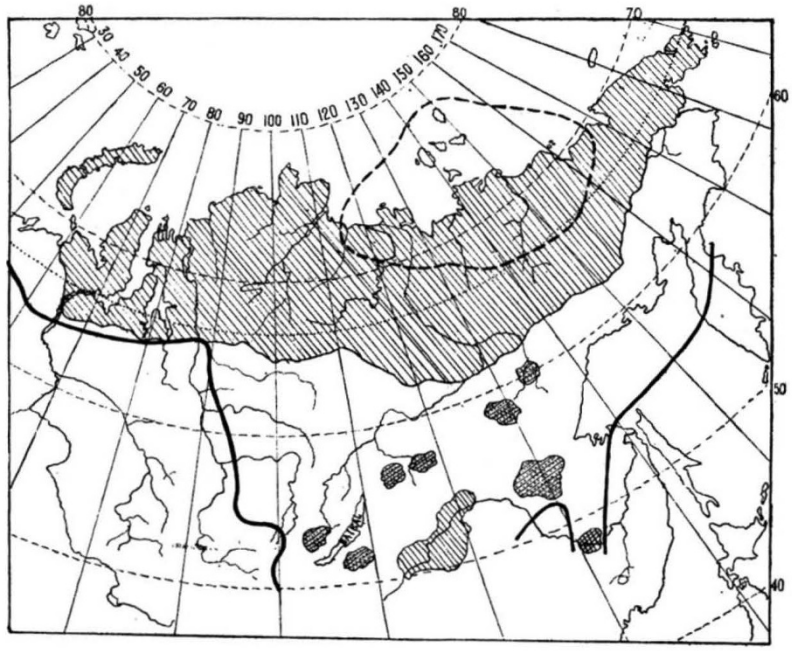

FIG. 1.—Diagrammatic map of permanently frozen soils of Russia (re-drawn after Soumgin). Oblique lines—continuous areas of permanently frozen soils; oblique lines and dots—areas of permanently frozen soils with 'islands' of normal soils; crossed lines—areas of normal soils with 'islands' of permanently frozen soils; heavy continuous black line—southern limit of permanently frozen soils; heavy interrupted black line—the boundary of the area where considerable strata of solid ice are present in the soil.

The geographical distribution of such soils in Russia is at present fairly well known, though the information is still very fragmentary. As a matter of fact, there are 336 places where observations on permanently frozen soils have been made; of course these observations vary widely in their scope and in their value. However, they are sufficient for a map to be prepared from them (Fig. 1). The whole area of permanently frozen soils in Russia occupies about 7,000,000 sq. km., that is, very nearly one-third of the whole territory of Russia, and a little less than the area of Europe, and about the same as the area of the United States or of the whole continent of Australia. The southern boundary of permanently frozen soils is, as will be seen from the map, very irregular; in European Russia it begins at the White Sea shores and runs eastwards, almost parallel to the Arctic Circle and a little south of it, up to Turukhansk in Siberia, where it turns sharply south-eastwards until it reaches latitude 50° N.; its course beyond the latter is not known, being outside Russian territory in Mongolia; near Blagovestshensk and Khabarovsk the southern boundary of the permanently frozen soils again enters Russia, running in a north-easterly direction to the northern part of Kamtchatka about latitude 60° N.

Inside this enormous region of permanently frozen soils several areas may be distinguished. Thus, a very large continuous area of permanently frozen soils occupies the whole extreme north of Siberia along the shores of the Polar Sea; another compact area is situated in Transbaikalia; in the rest of the region 'islands' of permanently frozen soils are scattered.

The depths to which soils may be in the permanently frozen condition were determined in a number of cases, and fluctuate from 36·3 m. in Pustozersk to 74·68 m. in Taldan, Amur province, and even to 116·4 m. in Yakutsk; in the latter case the actual depth has not been determined, since non-frozen stratum has not been reached. Detailed observations on the temperature conditions of these soils are still very inadequate. Middendorf, in 1848, made some determinations of temperatures in a shaft at Yakutsk and found that the temperature decreased with the depth, reaching −3° C. at 382 ft. below the surface; a constant annual temperature was found at 100 ft. deep. From these figures Middendorf determined the lower limit of the permanently frozen soil in Yakutsk at about 600 ft. below the surface, but all his observations are somewhat doubtful as to exactitude. Much more thorough studies in this respect were made recently at Bomnak, Amur province, but they were restricted to relatively small depths, not exceeding 5 m. The upper limit of permanently frozen soil at Bomnak was found to be at 2·8 m. from the surface.

During the ten years of observations at Bomnak, a correlation has been observed between the thickness of snow and the seasonal fluctuations of the temperature of the soil. In years when snow fell late and was not very thick, the temperature was found to increase with the depth, while in winters with abundant snow it protects the soil from cold and the temperature of the soil decreases with the depth, monthly maxima and minima of temperatures in the soil, at 1·5 metres deep, lagging two months behind the air temperatures. When the upper layers of the soil freeze or thaw, the water contained in them gives up, or absorbs, respectively, the heat energy, thus

[1] "Everfrozen of Soil in the Boundaries of U.S.S.R.", by M. Soumgin. Pp. 372. The Far Eastern Geophysical Observatory, Vladivostok, 1927.

interfering with the distribution of temperatures in the soil. In this way a 'zero curtain' in the soil is formed which is of the greatest importance for the temperature regime of the soil; this 'zero curtain' does not lie at a constant depth, but moves up or down, according to the air temperature. The amplitudes of the monthly mean temperatures at depths exceeding one metre are very small and rapidly decrease with the depth. Observations in other places lead to the conclusion that three different types of the distribution of temperatures in permanently frozen soils may be distinguished, namely: (1) temperature increases with the depth; (2) temperature decreases with the depth; (3) temperature decreases down to a certain depth, then increases. The distribution of temperatures at greater depths has not been studied since Middendorf's work, but it may be safely assumed that it is very complicated.

As regards the origin of permanently frozen soils, many authors consider them to be the result of the present climate, but Soumgin believes that they have remained frozen since the glacial period.

A special chapter of the book is devoted to the study of hydrological conditions in the region of permanently frozen soils, while other chapters deal at some length with the influence of the frozen soils on the surface features, especially the distribution of forest types, and with the practical difficulties in building and other engineering work on frozen soils.

An elaborate programme of studies on permanently frozen soils is put forward by the author, who concludes his interesting monograph with a somewhat startling project for establishing somewhere in the area of permanently frozen soils a refrigerator-museum, where bodies of various animals and men should be deposited in order to be examined and compared with later types after several thousands of years.

Fisheries of Madras.

VALUABLE work by the Madras Fisheries Department is described in the administration report for the year 1926–27 by the Director, Dr. B. Sundara Raj (Madras Fisheries Bulletin, vol. 22, pp. 1-99. Madras. 1 rupee. 1928). The report deals mainly with the commercial development of the department as applied to fish, pearl, and chank fisheries.

The Chaliyam Fish Cannery, which was expected to recommence its manufacture during this period, did not operate, as Sir F. A. Nicholson was prevented from undertaking the management of the experimental and manufacturing operations, due to ill-health. Yet it is hoped that the cannery will be continued, as it has not been given a chance to prove the commercial possibilities of canning as a remunerative industry, especially as two private canneries started on the model of the one at Chaliyam had not prospered. At Tanur, researches were continued on the methods of preserving fish in a fresh condition for sale in the interior markets, of curing, pickling, and tinning bonito, cat-fish, and others for disposal in Japan and other places abroad, and of preparing fish-oil from the liver of sardines. The initial experiments carried out with sodium hypochlorite as a preservative of fish in a fresh condition have shown "that about 200 c.c. of solution (with 1 per cent available chlorine) is sufficient to keep 1 lb. of smaller varieties of fish for over 30 hours". Fish-meal, with a low fat content, was made from chamban (*Caranx crumenopthalmus*), and shrimp by the use of a press more powerful than a hand-press.

Investigations for improving the resources of edible fish in inland waters were continued. Despite adverse seasonal conditions, the experiments at Vellore and Chingleput Fort Moat Farms demonstrated the utility of stocking catla. The catla fry from the Godavari channel grew to a length of 1½ to 2 feet in eight months in these farms. For want of material the Hilsa hatching experiments have not been satisfactorily concluded; the gourami (*Osphromenus sp.*), the tench, and the carp have flourished in inland waters. Experiments are being conducted on the trawling grounds close to the Madras coast to ascertain the possibilities of deep-sea fishing.

In the whole history of Ceylon and Indian pearl fisheries, no more than a single fishery was considered possible in any year. For the first time, a fishery was commenced in the autumn of 1926 on Nov. 6 and lasted until Dec. 4. This small fishery brought a net profit of Rs. 26,801. Another fishery, which excelled all previous fisheries in its excellent organisation of the camp and in the operations at sea, was opened on Feb. 11 and closed on April 30. The time-honoured method of fishing and disposing of the oysters was in vogue, except for the fact that the lots of 500 each were counted at sea on board the depot schooners, to avoid extra wages to the labourers and to minimise the pilfering of pearls by divers on their way back to the shore from the banks. Although the usual difficulties which marred the administration of the pearl fisheries in the past, such as wrong locations of banks, epidemics, etc., were circumvented, other adverse factors, such as bad weather, depreciation of the market value of pearls, etc., contributed towards a lower yield of revenue than was anticipated. Yet this fishery ranks first among those held within the last hundred years, and the Government realised a net profit of Rs. 172,316. Owing to the pearl fisheries, the chank fisheries suffered a set-back, and only a fourth of the normal catch in a good year was fished. It is interesting to note that steps are being taken to develop the ancient chank bangle industry, and that the initial difficulty in the development of this industry has been overcome.

The marine aquarium continued to be popular. The researches on the development of the edible oyster (*Ostrea madrasensis*), carried out in the laboratory of the aquarium, revealed the fact that the Indian oysters fatten and breed only in low salinities, whereas the English oysters flourish when there is a rise in salinity. The tiles put out at Ennur to collect oyster-spat were attacked in such large numbers by a molluscan pest (*Modiola sp.*) that it is proposed to abandon oyster culture in this locality. It is proposed that, if the Marine Biological Station at Krusadai Island is established, its immediate lines of inquiry should be: (1) Biological investigations with special reference to pearl and chank fisheries; (2) hydrographic and meteorological investigations; and (3) technical and industrial researches with special reference to fishing methods. Further, it is suggested that the following laboratories, aquaria, etc., are required to start the proposed lines of research: (1) The establishment of three new research laboratories, in addition to the one at Calicut, with adequate facilities; (2) the construction of aquaria at Rameswaram and at Vizagapatam; and (3) the establishment of a bio-chemical laboratory equipped with requisite apparatus and staff to deal with the technology of fishery industries. It is very gratifying to note that the Fisheries Department has continued with success the introduction of elementary education to children of the fishing population, the organisation of the co-operative movement on a wide scale, and the promotion of temperance and other social benefits to the community.