form similar to that on Earth.

Recently attention has been drawn to gas (methane) hydrates in permafrost that spread through the pores and appear to be of a biogenic origin distinct from that of currently-extracted major gas deposits lying at greater depths (Yakushev and Chuvilin, 2000). Understanding the microbiology of permafrost also has more immediate practical implications, in developing bioremediation procedures where bacterial activity is used to overcome contamination in freezing ground.

Importance of sampling techniques

Techniques for sampling in permafrost for microbiological studies (Vishnivetskaya et al. 2000) are not well-established. The requirement is for biological cleanliness and absolute avoidance of contamination while the sample is brought to the surface and subsequently. Proper procedures are expensive and time-consuming. S.S. Abysov (Abysov et al. 1979., Abysov et al., 1982), of Russia's Institute of Microbiology, and specialists at the St. Petersburg Mining Institute developed the technique for drilling ice cores without contaminating the samples, used at the Vostok Station in the Antarctic since 1974. It involves taking liquid samples from the melting interior of the drill cores.

Because frozen soils are not always able to flow on thawing, our (AB's) suggestion was to penetrate a drilled sample (1, in fig. 1) with another sterilized pipe (2, fig.1). This procedure was used recently (1999-2000) for investigating permafrost on the Kara Sea coast. The pipe (2, fig.1) is sealed with hot plastic prepared in aseptic conditions, and the frozen soil transported to the laboratory. Samples from 3 to 4 metres depth in permafrost, at a temperature of about -4°C, were taken to the Institute of Microbiology for examination. Fig 2 shows micrographs of bacteria found in the samples. The viability of these bacteria has not yet been established and in any case, only a few of the individuals present are likely to be viable (Fredrickson and Onstott, 1996). Their state of preservation is noteworthy (and typical) in that the sediments are believed to have been frozen for at least 10,000 years.

Relationship with the unfrozen water: no way in and no way out?

An important characteristic of permafrost is that some water, held tightly onto the surfaces of mineral particles by electrochemical forces, or under the influence of capillary forces, occurs in even hard-frozen permafrost (Williams and Smith 1991). The thin liquid layers provide a route for water flow, which is normally from the warmer to the colder parts (Derjaguin and Churaev, 1986). The water may carry solutes and small particles and thus perhaps, bacteria, but its movement is extremely

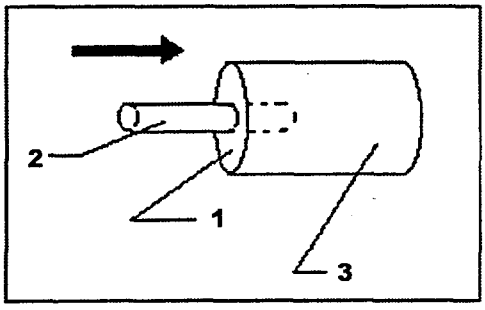

Fig. 1. Diagram of device for taking sample from interior of frozen core.

slow (Burt and Williams, 1976). The equation for the water transfer is well-known:

$$\frac{\partial W_{uf}}{\partial t} = a\frac{\partial^2 W_{uf}}{\partial x^2} \qquad (1)$$

Where W_{uf} – unfrozen water content, t – time, sec, x – coordinate, cm; and a – diffusion coefficient, which has a value of about 10^{-7} $cm^2 s^{-1}$ (Foundations of Geocryology, 1995; Brouchkov, 1998). At a few degrees below °C it may thus take thousands of years to move a metre. A bacterium of greater size than the thickness of the water layer is likely to move much more slowly than the water. The microorganisms are about 0.3 to 1.4 microns in size, while the thickness of the water films is usually less. It depends on particle size, mineral composition and decreases sharply with temperature, to less than 1 micron by about - 0.5 °C.

One concludes that microorganisms in permafrost have been isolated, certainly from the ground surface, trapped among the mineral particles and ice, for many orders of magnitude longer than a normal lifespan and maybe millions of years. The longest, *continuously* frozen permafrost is variously estimated as between one and three million years old.

Microorganisms in permafrost: are they really living?

Abyzov's investigations at the Vostok station (Abyzov et al. 1979; Abyzov et al. 1982) revealed bacteria, fungi, diatoms and other microorganisms which were probably carried to Antarctica by winds. The ages of these individuals could be more than half a million years. Bacteria have been found 3, 600