= Lake Untersee =

Lake Untersee (German : Untersee , " Lower Lake ") is the largest surface freshwater lake in the interior of the Gruber Mountains of central Queen Maud Land in East Antarctica . It is situated 90 kilometres (56 mi) to the southwest of the Schirmacher Oasis . The lake is approximately 6 @.@ 5 kilometres (4 @.@ 0 mi) long and 2 @.@ 5 kilometres (1 @.@ 6 mi) wide , with a surface area of 11 @.@ 4 square kilometres (4 @.@ 4 sq mi) , and a maximum depth of 169 metres (554 ft) . The lake is permanently covered with ice and is partly bounded by glacier ice .

Lake Untersee is an unusual lake , with pH between 9 @.@ 8 and 12 @.@ 1 , dissolved oxygen at 150 percent supersaturation , and very low primary production in the water column . Despite the high oxygen supersaturation in most of the lake , there is a small sub @-@ basin at the southern end that is anoxic and its sediments may have a higher methane concentration than those of any other known lake on Earth . Much of the primary production is in microbial communities that grow on the floor of the lake as stromatolites . The water temperature varies between 0 @.@ 5 ° C (32 @.@ 9 ° F) and 5 ° C (41 ° F) and the ice cover on the lake is 2 ? 6 metres (6 @.@ 6 ? 19 @.@ 7 ft) thick . The ice cover may have persisted for over 100 @,@ 000 years , and some scientists studying climate change fear significant environmental changes associated with global warming in the coming decades . In the past , the water chemistry of the lake has been compared to Clorox . However , the chemical activity of bleach is due to Cl ? in addition to a pH that is higher than that measures in Lake Untersee , and Lake Untersee does not have high chlorine or chlorite concentrations .

= = Geography = =

Lake Untersee lies in the interior of the Gruber Mountains of central Queen Maud Land in East Antarctica , which is roughly on the same longitude as Huab , in the Skeleton Coast National Park on the northern coast of Namibia . It is situated 90 kilometres (56 mi) to the southwest of the Schirmacher Oasis .

The lake is approximately 6 @.@ 5 kilometres (4 @.@ 0 mi) long and 2 @.@ 5 kilometres (1 @.@ 6 mi) wide and has a surface area of 11 @.@ 4 square kilometres (4 @.@ 4 sq mi) (10 square kilometres (3 @.@ 9 sq mi) is also reported) . Its maximum depth is 169 metres (554 ft) . It is permanently covered with ice , which has an average thickness of 3 metres (9 @.@ 8 ft) in summer . The lake is dammed by the Anuchin Glacier , and meltwater from the Anuchin Glacier is the main source of water . The lake has no outlet . Water is lost through sublimation and ablation of the ice cover . The lake is categorized as an ultra @-@ oligotrophic lake .

= = History = =

Isotope studies have established that the lake has long had a permanent ice cover . Further , studies carried out during the austral summer confirm the lake 's homogeneous characteristics , with thermal convection as the reason given for its hydro @-@ geochemical and isotropical nature . It is replenished perennially by a process of underwater melting of the adjacent glacier ice . It is also stated that the lake existed during the Holocene period when it emerged from a melt @-@ water pond .

Studies of Lake Untersee have revealed that there are a number of large boulders which dam the lake . Geodetic studies carried out during two summer seasons indicated that the boulders move at an annual rate of 1 @.@ 1 ? 3 @.@ 9 metres (3 @.@ 6 ? 12 @.@ 8 ft) . Residence time of the boulders has been estimated as 500 years . The floating boulders , which are several metres in diameter , have evolved as result of debris deposits from pro @-@ glacial interaction , mass wasting from hills surrounding the lake and the displacement of glacial ice by lake ice .

The lake was first discovered by the German Antarctic Expedition of 1938 ? 39 . After that , several expeditions have studied the lake 's characteristics . The first reconnaissance study of the lake was carried out by N. G. Kosenko and D. D. Kolobov in early 1969 , followed by more studies by Russian and German scientists , namely by W. D. Hermichen et al . (1985) , E. Kaup et al . (1988) and A.

Loopmann et al . (1988) .

= = = Research = = =

In studies carried out prior to 1991 ? 92 on physical and chemical parameters of the lake water , Lake Untersee was stated to be well @-@ mixed and unstratified . However , studies performed in the summer of 1991 ? 92 found significant stratification in a 500 @-@ metre (1 @,@ 600 ft) wide trough in the southeastern part of the lake , where it is up to 105 metres (344 ft) deep . There were sharp vertical gradients of temperature , pH , dissolved oxygen and electrical conductivity . While a thermocline was recorded at a depth between 40 metres (130 ft) and 50 metres (160 ft) , an oxycline followed at 70 ? 80 metres (230 ? 260 ft) , with a chemocline extending from 80 metres (260 ft) to bottom of the lake . Below 80 metres (260 ft) , the water column was anoxic and smelled of hydrogen sulfide . The presence of hydrogen sulfide was associated with decreased sulfate concentrations , indicating that it probably arose from bacterial reduction of sulfate .

The salt content of the upper levels of the lake is about 50 times that of glacial melt water . Salinity increased below 80 metres (260 ft) , with sodium ion concentration and electrolytic conductivity more than doubling . The lake is highly alkaline (pH 10 @.@ 4) down to a depth of 70 metres (230 ft) ; below this depth , pH drops , reaching the slightly acidic value of 6 @.@ 1 at maximum depth . The proportion of methane in the sediment at the lake bottom is the highest recorded for any lake in the world , according to NASA scientists .

In 2008 , as part of the Tawani Foundation 2008 Antarctic International Expedition (see below) , Dale Andersen and Ian Hawes discovered conical stromatolites growing in Lake Untersee , the largest living ones known to date . Small microbial pinnacles are also present , and it appears that the large conical stromatolites and the small pinnacles are made by different microbial communities . These communities provide an important analog to some of the oldest fossil stromatolites found to date .

= = = Expeditions = = =

In November and December 2008 , the " Tawani Foundation 2008 Antarctic International Expedition " headed by Richard Hoover of NASA 's Marshall Space Flight Center used the lake as a test bed in its hunt for extreme life . Conditions in the lake are similar in some respects to those thought to exist on other moons and planets that contain water ice and methane ; thus , this lake might provide an analog to environments that exist elsewhere in space . The expedition did find several new strains of extremophile microorganisms in the lake 's waters , including a chemolithotroph that metabolises hydrogen .

This expedition involved an interdisciplinary international team of ten scientists and two teachers who explored not only Lake Untersee but also the Schirmacher Oasis . The geomicrobiological aspects of this expedition had three objectives : " to test laser induced fluorescence emission (L.I.F.E.) to be used for the exploration of the Mars regolith and poles ; monitor global climate change ; and to evaluate methods for detecting hydrocarbon contamination and subsequent bio @-@ remediation in a fragile , endangered ecosystem . " The results indicate that Lake Untersee , as a permanently ice @-@ covered region , has very little usable soil and could be likened to the polar regions of Mars .

Experiments conducted have examined the metagenomes of eukaryotes ; identified Prokaryotes and viruses inhabiting the lake ; provided evidence of virus @-@ mediated horizontal gene transfer and adaptive metabolic or cold protective phenotype alterations , identified microbial nanowire connections between multiple species at the ice @-@ water interface , in the water column , and in the sediment ; and established biomass estimates of life in the lake ice during the early spring growing season using laser @-@ induced fluorescence emission (L.I.F.E.) imaging techniques .

Two scientific divers were also part of this team . Dale Andersen , with the SETI Institute 's Carl Sagan Center for the Study of Life in the Universe , and Ian Hawes of Aquatic Research Solutions dove in Lake Untersee to study its unique microbial communities .