SALAR DE UYUNI

Salar de Uyuni is part of the Altiplano of Bolivia in South America. The Altiplano is a high plateau, which was formed during uplift of the Andes Mountains. The plateau includes fresh and saltwater lakes as well as salt flats and is surrounded by mountains with no drainage outlets.

The geological history of the Salar is associated with a sequential transformation between several vast lakes. Some 30,000–42,000 years ago, the area was part of a giant prehistoric lake, Lake Minchin. Its age was estimated from radiocarbon dating of shells from outcropping sediments carbonate reefs and varies between reported studies. Lake Minchin (named after the Juan B. Minchin of Oruro) later transformed into paleolake Tauca having a maximal depth of 140 meters, and an estimated age of 13,000 - 18,000 or 14,900 - 26,100 years depending on the source. The youngest prehistoric lake was Coipasa, which was radiocarbon dated to 11,500 - 13,400 years. When it dried, it left behind two modern lakes, Poopó Lake and Uru Uru Lake, and two major salt deserts, Salar de Coipasa and the larger Salar de Uyuni. Salar de Uyuni spreads over 10,582 km^2, which is roughly 25 times the size of the Bonneville Salt Flats in the United States. Lake Poopo is a neighbor of the much larger Lake Titicaca. During the wet season, Titicaca overflows and discharges into Poopo, which, in turn, floods Salar De Coipasa and Salar de Uyuni.

Underneath the surface of the Salar is a lake of brine 2 to 20 meters deep. The brine is a saturated solution of table salt, lithium chloride and magnesium chloride in water. It is covered with a solid salt crust with a thickness varying between tens of centimeters to a few meters. The center of the Salar contains a few "islands", which are the remains of the tops of ancient volcanoes, which were submerged during the era of Lake Minchin. They include unusual and fragile coral-like structures and deposits that often consist of fossils and algae.

The area has a relatively stable average temperature with a peak at 21° C in November-January and a low of 13° C in June. The nights are however cold all through the year with temperatures between -9 and 5° C. The relative humidity is rather low and constant throughout the year at 30 - 45 %. The rainfall is also low at 1-3 millimeters per month between April and November, but it may increase up to 70 millimeters in January. However, except for January, even in the rainy season the number of rainy days is below five per month.

The Salar contains large amounts of sodium, potassium, lithium and magnesium (all in the chloride forms of $NaCl$, KCl, $LiCl$ and $MgCl_2$, respectively), as well as borax. Salar de Uyuni is estimated to contain 10 billion tones (9.8 billion LT; 11 billion ST) tones of salt.

Tourism. Salar de Uyuni attracts tourists from around the world. As it is located far from the cities, a number of hotels have been built in the area. Due to lack of conventional construction materials, many of them are almost entirely (walls, roof, furniture) built with salt blocks cut from the Salar. The first such hotel was erected in 1993-1995 in the middle of the salt flat, and soon became a popular tourist destination. However, its location in the center of a desert produced sanitary problems, as most waste had to be collected manually. Mismanagement caused serious environmental pollution and the hotel had to be dismantled in 2002. New salt hotels were built near the periphery of the Salar, closer to roads, in full compliance with environmental rules.

Train cemetery. One major tourist attraction is an antique train cemetery. It is 3 kilometers outside Uyuni and is connected to it by the old train tracks. The town served in the past as a distribution hub for the trains carrying minerals enrooted to Pacific Ocean ports. The rail lines were built by British engineers arriving near the end of the 19th century and formed a sizeable community in Uyuni. The engineers were invited by British - Sponsored Antofagasta and Bolivia Railway Companies, which is now Ferrocarril de Antofagasta a Bolivia. The rail construction started in 1888 and ended in 1892. It was encouraged by Bolivian President Aniceto Arce, who believed Bolivia would flourish with a good transport system, but it was also constantly sabotaged by the local Aymara indigenous Indians who saw it as an intrusion into their lives. The trains were mostly used by the mining companies. In the 1940 s, the mining industry collapsed, partly because of mineral depletion. Many trains were abandoned, producing the train cemetery. There are proposals to build a museum from the cemetery.

Satellite calibration. **Some Earth observing satellites need to be precisely calibrated in terms the distance measurement while in orbit. For example, the primary objective of the NASA's Geoscience Laser Altimeter System (GLAS), which is installed on the Ice, Cloud and land Elevation Satellite (ICESat), is to detect changes in ice sheet elevations of as little as 1.5 centimeters per year, over 10,000 km^2. A common approach for calibrating the satellite elevation measurements is to compare them to an accurately surveyed terrestrial reference target. Salt flats are ideal for this purpose because they are large, stable surfaces having strong reflection, similar to that of ice sheets. Salar de Uyuni is especially suitable because it is the largest salt flat on Earth. In the low-rain period of from April to November, its skies are very clear, and the air is dry (relative humidity is about 30%; rainfall is roughly 1 millimeter per month). Absence of large industries and the high elevation also contribute to the clarity of the air. The Salar also has a stable surface, which is smoothed by seasonal flooding (water dissolves the salt surface and thus keeps it leveled). As a result, the variation in the surface elevation over the 10,582 km^2 area of Salar de Uyuni is less than 1 meter, and there are square kilometers there, which are flat within a few centimeters. The surface reflectivity (albedo) for ultraviolet light is relatively high at 0.69 and shows variations of only few percent during the daytime. Combination of all these features makes Salar de Uyuni about five times better for satellite calibration than the surface of an ocean. Using Salar de Uyuni as the target, ICESat has already achieved the short-term elevation measurement accuracy of below 2 centimeters.**

With the use of modern GPS technology, it can now be proved that the Salar de Uyuni is not perfectly flat. New measurements revealed previously missed features resembling ridges, hills, and valleys measuring only millimeters in height. They originate from the variation in material density, and thus the gravitational force, beneath the Salar's sediments. Just as the ocean surface rises over denser seamounts, the salt flat surface also rises and falls to reflect the subsurface density variations.

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