Bolivia

Module 1 • i2P • La Ruta de Sal

The Salar de Uyuni (Lucag)

"Chlorine is a deadly poison gas employed on European battlefields in World War I. Sodium is a corrosive metal which burns upon contact with water. Together they make a placid and unpoisonous material, table salt. Why each of these substances has the properties it does is a subject called chemistry."

- Carl Sagan

BOLIVIA

In May 2011 impossible2possible will be visiting the mountain nation of Bolivia, to run across the world's largest salt flats and celebrate the International Year of Chemistry.

Bolivia is a landlocked country that sits ten degrees below the Equator in the center of continental South America. The south-western part of the country is situated on a high plateau that straddles the Andes mountains, while to the north-east the country spills down into a lush tropical basin that feeds the headwaters of the Amazon. The climate of Bolivia varies significantly with changes in elevation. The mountainous regions are cool year round, while the tropical lowlands are hot and humid.

Bolivia is a nation of contrasts; it is one of the poorest countries in Latin America, but also boasts a rich diversity of cultures, languages, flora and fauna. The administrative capital of Bolivia is La Paz, the highest capital city in the world at 12,000 feet. It's located on a high mountain plateau and sees cool temperatures year round.

The population of Bolivia is ethnically diverse, with 36 native cultures and 20 official languages. The majority of Bolivians are aboriginal, with the first indigenous peoples migrating into the region over 2,000 years ago. The area was part of the Inca Empire until the arrival of European conquistadors in the sixteenth century. Bolivia was also a Spanish colony for approximately 300 years until it gained its independence in 1825. The period following independence was marked by persistent political unrest and military rule, with almost 200 military coups occurring over a span of 160 years (see: Bolivia). In 1982 Bolivia became a democratic republic, with an elected president. The current

Figure 1: Bolivia is in the middle of South America

president Evo Morales is in his second term in office.

ALTIPLANO

Running the length of the South American continent is the Andes mountain range, the world's longest mountain chain stretching 7,000 kilometers from Venezuela in the north to Argentina in the south. In Bolivia the Andes reach their greatest width, splitting into two ranges that enwrap a high plateau called the Altiplano. With an average height of 12,000 feet, the Altiplano (see: Altiplano) is a great plain that was formed by the collision of two tectonic plates, the mainland of South America with the floor of the Pacific Ocean. This collision, which occurred between 138 million and 65 million years ago, caused the Earth's crust to heave, creating the Andes as well as the high plateau of the Altiplano.

The Altiplano resembles a giant flat-bottomed bowl, with the surrounding mountain ramparts forming a continuous rock wall through which lakes cannot drain. Historically the Altiplano was filled with water that formed a massive lake called the Humbolt Sea

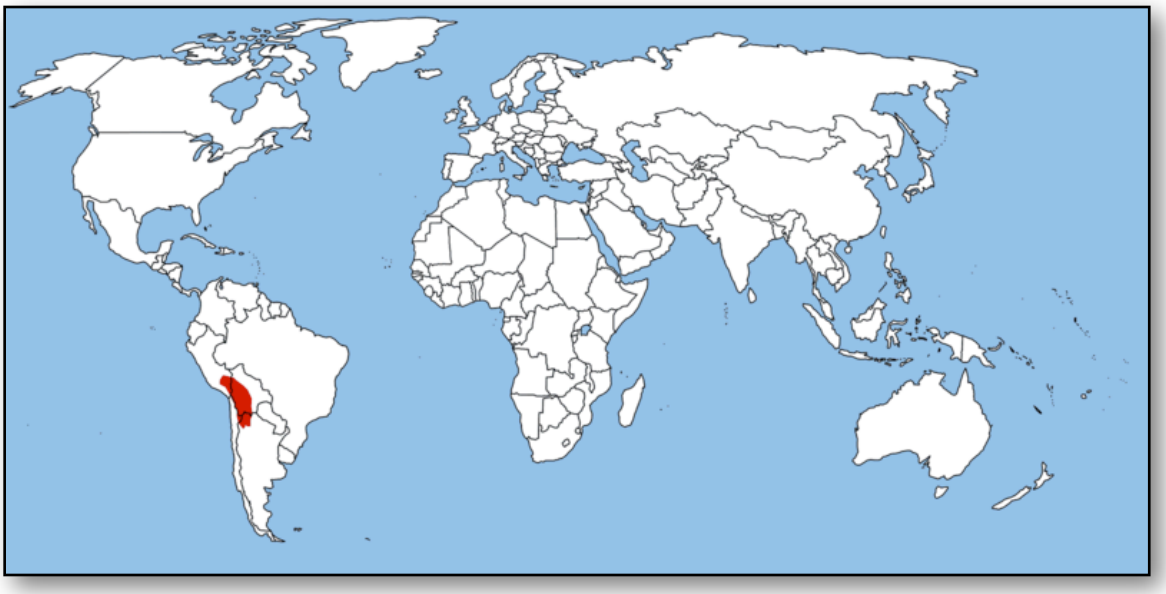


Figure 2: The location of the Altiplano on the World Map (source: TBjornstad)

(see: titicaca). As the climate changed the Humbolt Sea gradually receded, leaving behind residual lakes, notably Titicaca, Poopo and Coipasa.

The water that feeds the Altiplano comes from two sources, rainfall and glacial melt. Water flows into the plateau by tumbling down mountain streams and rivers and by percolating through the ground. This process liberates mineral salts from the ground which dissolve in the water. Principal among these mineral salts are sodium, chloride, sulfate and magnesium. All freshwater in the world contains small amounts of these

mineral salts, which are delivered to the ocean, where the vast majority of all freshwater in the world flows. This accounts for the high salt content of sea water. The exception to this rule are lakes that do not drain into the sea, called *terminal lakes*. Terminal lakes do not shed their mineral salts, but collect them.

The Altiplano plateau, cut off by the encircling mountains is home to terminal lakes in which mineral salts have been collecting for thousands of years. With a desert-like climate these lakes are drying up, and as they do mineral salts are becoming concentrated. Some lakes have vanished completely, leaving behind vast mineral fields, or salt flats. It is this process that has led to the creation, high on the Altiplano, of the world's greatest salt flat, the Salar de Uyuni (see: Altiplano).

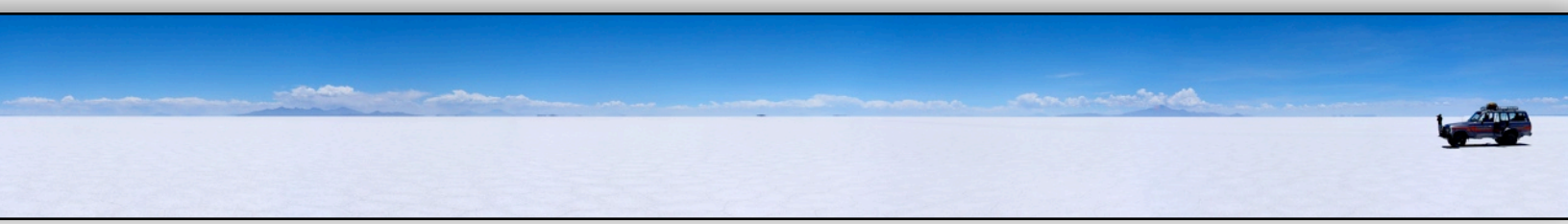


Figure 3: The world's biggest salt flats the Salar de Uyuni (source: Martin St-Amant)

The International Year of Chemistry

The United Nations has declared that 2011 is the International Year of Chemistry, a worldwide celebration of the achievements of chemistry and its contributions to the well-being of humankind (IYC 2011). Under the unifying theme "Chemistry—our life, our future," IYC 2011 has sponsored a range of interactive, entertaining, and educational chemistry activities for all ages. Among the sponsored activities is the next in i2P's series of expeditions dedicated to experiential learning: i2P's Expedition Bolivia, La Ruta de Sal (see: i2Pchemistry). i2P has chosen the Salar de Uyuni as the destination for their expedition. The unique environment of the Salar will enable i2P to take the principles of chemistry out of the classroom and into the 'real world,' making it an ideal location to pay tribute to the International Year of Chemistry..

New this year i2P welcomes the partnership and support of Simon Fraser University (SFU) (http://www.sfu.ca/). Dr George Agnes, chemistry professor and SFU Associate Dean of Graduate Studies will be joining the i2P expedition team travelling to Bolivia. Under Dr. Agnes' supervision the i2P team will conduct chemistry experiments in the field and transmit them back to participating schools over the

The Goals of the International Year of Chemistry 2011:

"To increase the public appreciation of chemistry in meeting world needs, to encourage interest in chemistry among young people, and to generate enthusiasm for the creative future of chemistry."

International Year of CHEMISTRY 2011

internet.

La Ruta de Sal

The Salar de Uyuni is an ideal location to explore the world of chemistry. The largest salt flats on Earth, the Salar is a remnant lake which is covered with a thick crust of salt, strong enough to support heavy vehicles. Below the crust lies a brine of water, salt, magnesium and over half the world's lithium reserves. The locale is a veritable storehouse of elements; complementing the sodium, chloride, lithium and magnesium found in the Salar, are adjacent lakes rich in boron, manganese, sulfur, copper, arsenic and lead. Ten and a half thousand kilometers in area, the Salar is the flattest area in the world, and is used by NASA to calibrate satellite altimeters. Ringing the Salar are

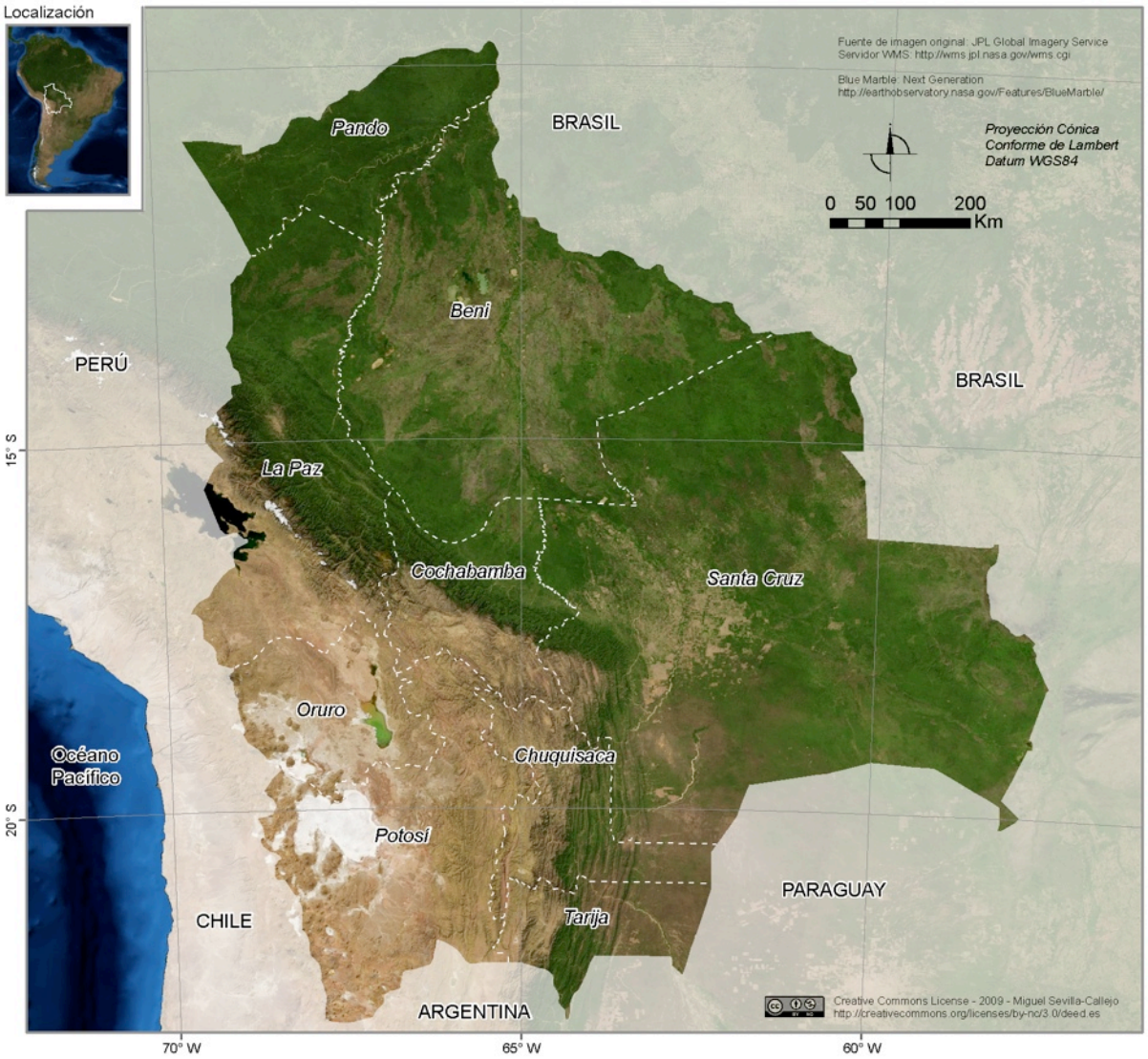


Figure 4: The Salar de Uyuni is clearly seen as the white area in southern Bolivia in this satelite image (source: Miguel Sevilla-Callejo)

volcanoes. Mount Irruputuncu, which lies a mere 35 kilometers to the south-west of the salt flats, last erupted in 1995 (see: volcano).

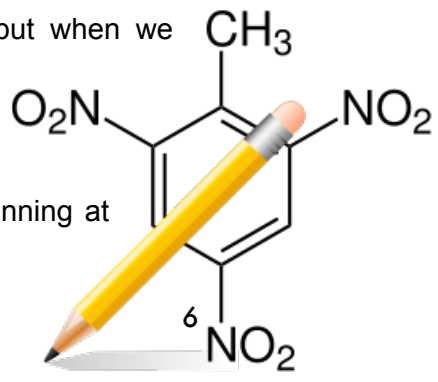
At an elevation of 12,000 feet the Salar de Uyuni has a significantly decreased atmospheric pressure compared to sea level. The decreased atmospheric pressure impacts how matter and chemical reactions behave in this environment. One chemical process that the i2P team members will need to pay closes attention to is their ability to extract oxygen from the atmosphere, which at 12,000 feet is decreased by 35% from sea level (see O2 calculator: altitude). A one third reduction in available oxygen will have an impact on the chemistry of the human body, particularly for those engaged in strenuous activity such as running.

Figure 5: Fun on the Salar de Uyuni (Source: (Lucag)

A LIVING LABORATORY

There are ten billion tons of salt in the Salar de Uyuni. Each grain of salt is comprised of thousands of small salt crystals. In turn each crystal is composed of a lattice of atoms. Principle among them are sodium and chloride atoms, respectively, the components of table salt. Table salt provides human being with important minerals essential for human function. They help drive the chemical process that will power the i2P team members across the vast field of salt; the rhythmic contracting of leg muscles that enables running.

In its most basic form, chemistry can seem a complicated science, but when we experience that science in the context of this expedition, the principles of chemistry will come alive. You will see how through a series of chemical reactions the plant-life of the Altiplano can capture the suns energy and make fuel for humans and machines. You will see how running at



altitude will put incredible pressure on the bodies of even some of the world's most accomplished runners. Chemistry, from its humble origin thousands of years ago, has matured into a fascinating way to understand how matter, the essence of everything, works. We're excited to have you along for the ride.

Chemistry is the study of all matter and how it changes in different environments. In the incredible backdrop of the salt fields of the Bolivian Altiplano, i2P will bring the world of matter alive, from the study of basic elements like sodium and lithium, to complex compounds that make up everything from human tissue to the mountains, lakes and plains of the Altiplano. A study of the everyday life of the expedition will allow us to understand how the principles of chemistry define both the physical world, and our behavior as human beings. Chemistry, from its origin thousands of years ago has matured into a fascinating portal on the behavior of all matter.

Figure 6 : Images of the Bolivian Altiplano (sources clockwise from above: Stevage, MartinT11, Ville Miettinen,)