

MEMBERS' EVENING 2009

The third Members' Evening was held on 14th March 2009, when the theme was volcanoes. The instructions to the presenters were simple: *show us your interests and infect us with your enthusiasm*. It is hoped that other members, especially those who are amateur, will offer short presentations to continue the success of the Members' Evenings into future years.

Volcanoes of Chile

Alan Filmer

Chile's past and present are inextricably tied to the subduction zone in the Pacific Ocean that runs down the length of the South American coast. Subduction of the Nazca Plate in the north and the Antarctic Plate in the extreme south, both sliding beneath the South American Continent, has been continuing since before the break up of Gondwanaland during the Jurassic. There is therefore a wide age range of rocks uplifted by the orogenesis to form the Coastal Range, which rises to over 4000 m in the north of the country but is lower further south. In the north the coastal mountains are mineralised and produce Chile's most valuable exports, copper and silver. These mountains also prevent many of the northern rivers from the Andes from reaching the sea, the water evaporating in the Central Depression between the Andes and the Coastal Range - where evaporites are exploited for lithium and boron salts. Further south the Central Depression forms the Central Valley around the capital, Santiago de Chile. There the climate is lovely, and Chile's fruit and vineyards thrive. Still further south, the Depression forms the Chilean Lake District, which, in spite of its annual rainfall of over 4 m, is a popular tourist destination.

Inland from the Central Depression, the Andes rise to 6800 m to form a volcanic mountain chain for the length of the country, that is 5000 km long on the borders with Bolivia and Argentina. The most striking volcanoes are of Pleistocene or Holocene age and many have near perfect cones. Of these, 250 are active. Those in the far north rise from the Altiplano, a high plain at 4500 m



Parinacota and its debris avalanche on the Altiplano.

above sea level or the Atacama Desert at 3000 m. Here rain is rare or unknown, and the volcanoes are easily seen. Further south in the Lake District the volcanoes are lower and rise from temperate rain forests at around 1000 m, and they are usually hidden by cloud.

In the north of Chile the extreme aridity of the continent results in almost no supply of sediment to the subduction trench. So rather than the usual accretionary process, subduction causes erosion of the continental margin - which has retreated east by about 250 km within the last 25 Ma. The descending slab of oceanic crust rasps the underside of the continent, occasionally breaking pieces off, to generate deep-seated earthquakes. Shallow earthquakes result from movements along the numerous north-south trending faults within the continental plate.

Arica is the most northern Chilean coastal city and although only 17° south of the equator may be quite cold. It has not rained in Arica for over 100 years though it is often foggy. A good road leads inland, over the Coastal Range to the small town of Putre. At 3500 m altitude, this is a good place to acclimatise before continuing up to the Altiplano at 4500 m, most of which is in Bolivia. The small Chilean section is designated the Lauca National Park, with its abundance of wildlife, thermal springs and impressive volcanoes. These include Parinacota and its spectacular 8000 year old debris avalanche (Waltham, 2004).



The town of Putre, built on a pyroclastic flow 2000 years old from Taapaca.

The crust here is said to be the thickest on Earth at about 70 km. Above the Benioff Zone, the subducted Nazca plate is boiling off the sea water that is taken down in the subducted plate, and this aids the melting of the rocks at the base of the continent to form magma. There is a small contribution from the mantle and from oceanic sediment taken down on the plate. The magma incorporates more continental rock as it rises, so eruptions are highly explosive and produce mainly andesitic ash and lavas.

The small tourist town of San Pedro de Atacama is 600 km to the south and gives access to the great salt flats, also to both the Andes and the inland sides of the Coastal Range (Filmer, 2008). Nearby are the volcanoes of Lincabur and Lascar; the latter is Chile's most active, with 26 eruptions since 1900. Access for visitors is not easy, but the very scenic twin lakes and volcanoes of Miscanti and Miniques are easily reached.

The Lake District, 2500 km further south is a very different, verdant and very watery world. Most of its volcanoes rise to about 3000 m, with the intervening lakes at about 1000 m. Many are in National Parks or have developed ski facilities, so have easy access, but others such as Llaima and Chaiten (both of which were erupting in 2008) are more remote.

Charles Darwin in Chile

In 1834-5 Darwin was travelling on HMS Beagle when it was engaged in surveying the coasts of Argentina and Chile. He took every opportunity to go ashore, and spent over a year in total making several expeditions across the Coastal ranges and into the Andes. He examined the volcanic and metamorphic rocks and studied Cretaceous ammonites. He was particularly struck by finding marine shells on mountain tops. While in the Lake District he witnessed Osorno erupting, and ashore at Valdivia he felt an earthquake. Twelve days later HMS Beagle reached Talcahuano, the port serving the city of Concepcion. Darwin was horror-struck at the total devastation of the coastal settlements and port by the tsunami that had followed the earthquake, and



The beautiful cone of Osorno in the Lake District.

found there was not a stone building left standing in the city. He also noticed that the coastline had been raised by several feet. Surprisingly the death toll was less than 100 and Darwin recorded many eye-witness accounts of events. The inhabitants had been pre-warned by seeing great flocks of birds flying inland, by tides occurring at the wrong times, by smoke seen rising from the sea and by the sight of a great whirlpool. When the town's dogs all set off for the hills, the people knew it was time to follow. Darwin also learned that several volcanoes along a 1000 km length of the Andes had erupted two days after the earthquake. The local people knew that all these events were connected, but Darwin was the first to write a scientific account that clearly connected all the events to movements in the Earth's crust, thus giving support to Charles Lyell's revolutionary, uniformitarian ideas about crustal evolution, uplift and erosion.

References

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- Mereno, T. & Gibbons, E., 2007. *Geology of Chile*. Geological Society: London.
- Waltham, T., 2004. Parinacota, Chile. *Mercian Geologist*, **16**, 53.



The lake and volcano of Miscanti, near the oasis town of San Pedro de Atacama.