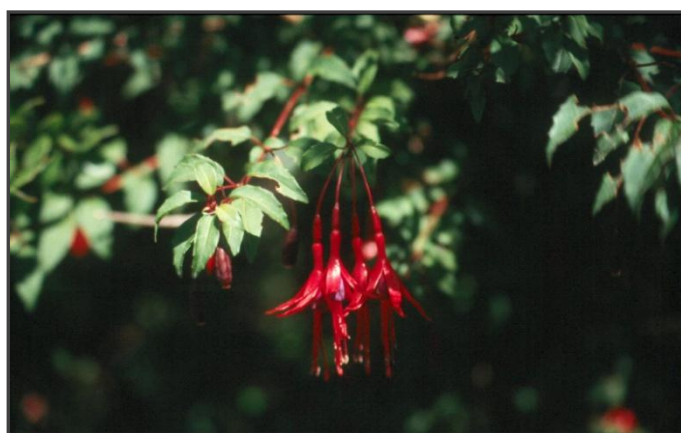


Lava, volcanic ash, fuchsias & hawks: In the environs of the Villarrica Volcano (Chile)

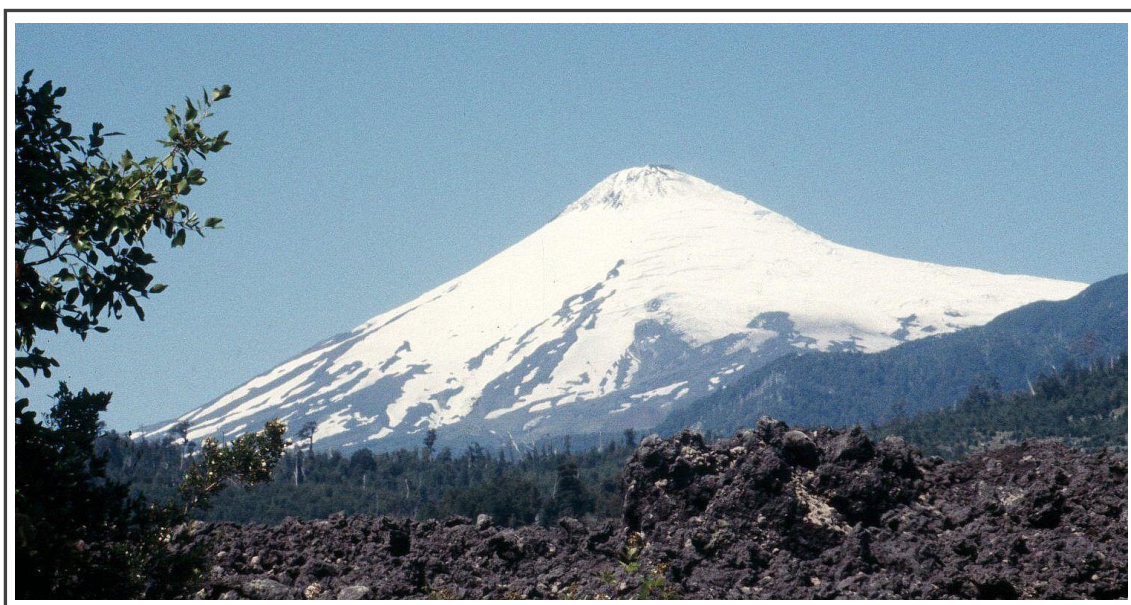
P. Cubas & R. Oyarzun

Aula2puntonet - 2021



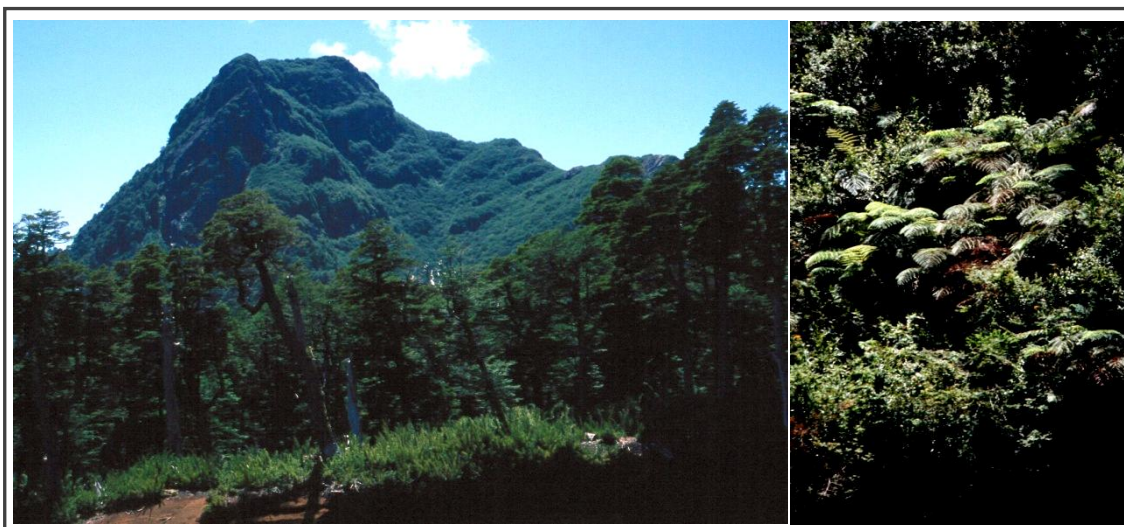
Hardy fuchsia (Fuchsia magellanica), a native plant of the southern region of Chile. Image: P. Cubas.

The Villarrica volcano is located in southern Chile (39.42°S/71.93°W), rises to 2847 meters above sea level, and has a significant volcanic activity, with about 64 eruptions since 1558 (*Volcano Discovery* 2021). The Villarrica volcano is also known as *Rucapillán*, an Araucanian native word that means “House of the Pillán”; in the Araucanian mythology (= *Mapuche*) the Pillán is a powerful spirit (*Wikipedia* 2021a). During the last thousands of years there have been Plinian eruptions and pyroclastic flows that have extended up to 20 km from the volcano. Lava flows up to 18 km long have erupted from the summit and flanks.



The Villarrica Volcano and its snowy crater (even in summer). In the foreground, basaltic AA lavas from the 1971 eruption. Image: P. Cubas.

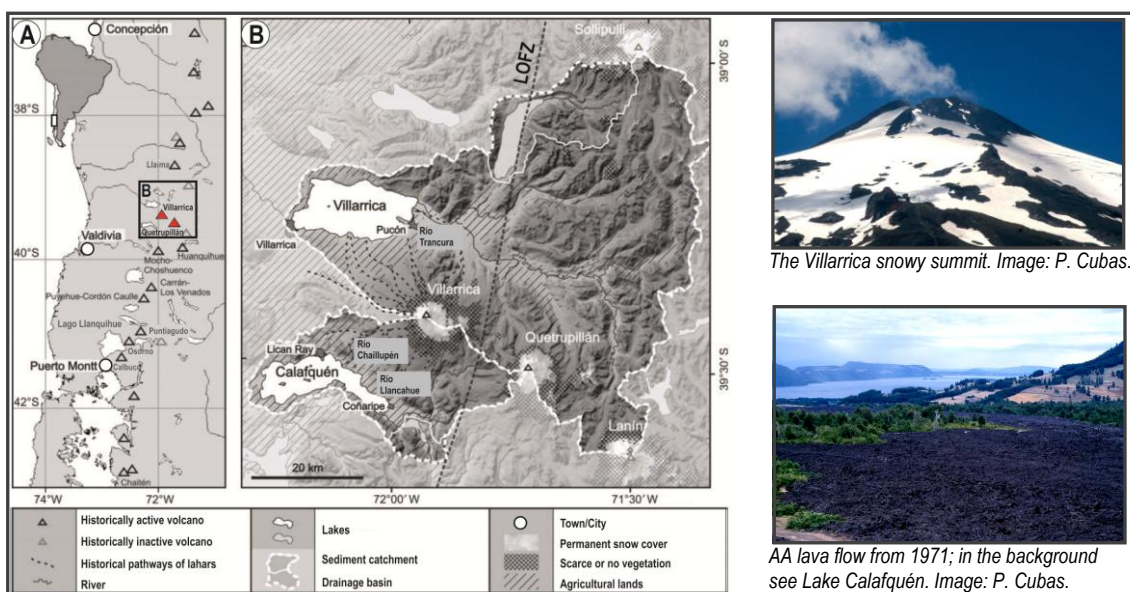
Precipitation in the Villarrica area is significant, with important rains even during the “driest” month. The average annual temperature is 11.3 °C in Villarrica and the average rainfall is 2659 mm ($L\ m^{-2}$) per year (Climate-Data.org 2021), with *all-year-round* snow in the upper sectors of the volcanic peak. These conditions allow the existence of the so-called “Selva Valdiviana” (Valdivian Jungle) that is characterized in southern Chile by dense multi-strata forests, in a temperate-rainy or oceanic climate (*near the coast*) (Wikipedia 2021b). The Villarrica National Park encompasses the volcano and its environs.



The vegetation covers everything, climbing up the mountains and settles even on the vertical walls where the ferns reign. Images: P. Cubas.

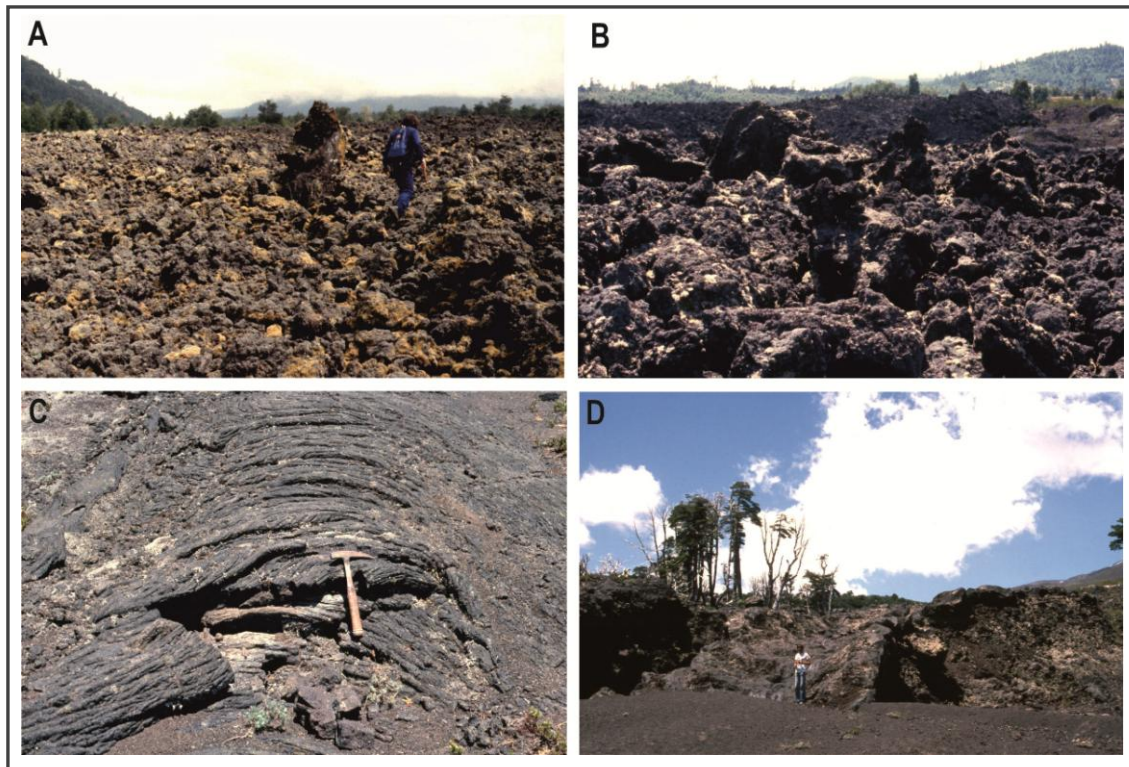
On the geology of the Villarrica Volcano

The Villarrica is an active volcano, with a long eruptive history dating back to the Pleistocene. The volcanic edifice and associated volcanic units (e.g. lava flows, pyroclastic deposits, debris flows) cover an area of about 700 km² (Clavero & Moreno 2004).



A) The chain of volcanoes in south-central and southern Chile. B) Surroundings of the Villarrica Volcano and lakes, indicating the historical passage of lahars in the area. LOFZ: Liquiñe-Ofqui Fault Zone. Adapted from Van Daele et al. (2014). The 1971 lava flow reached dimensions of about 14 km long, with an average width of 200 m.

The area is full of wonderful geological features that allow observation of the long history of the volcano. Trekking up from the town of Coñaripe towards the summit the visitor can see and study lava flows of the AA and pahoehoe types, lava tubes, fall deposits, pyroclastic flows and base surge deposits, from different episodes encompassing more than 100,000 years of volcanic activity.



A and B: AA basaltic lavas from the 1971 eruption, a difficult site to walk on as the chunks of rock break easily. The photos were taken 13 years after the eruption. C: Pahoehoe lava. D: Lava tube from the same eruption as in C. Fotos: P. Cubas.

Three chronostratigraphic units are recognized that summarize the volcanic history of Villarrica (Clavero & Moreno 2004):

- Unit 1: Middle to Upper Pleistocene, with basalts – basaltic andesites, volcanic breccias, dacitic domes and dykes.
- Unit 2: from the Upper Pleistocene to the Holocene, with ignimbrites, fall deposits (ash, lapilli), base surge, and basaltic to andesitic basaltic lavas.
- Unit 3: Holocene, with basalts - basaltic andesites, agglomerates, and fall deposits.

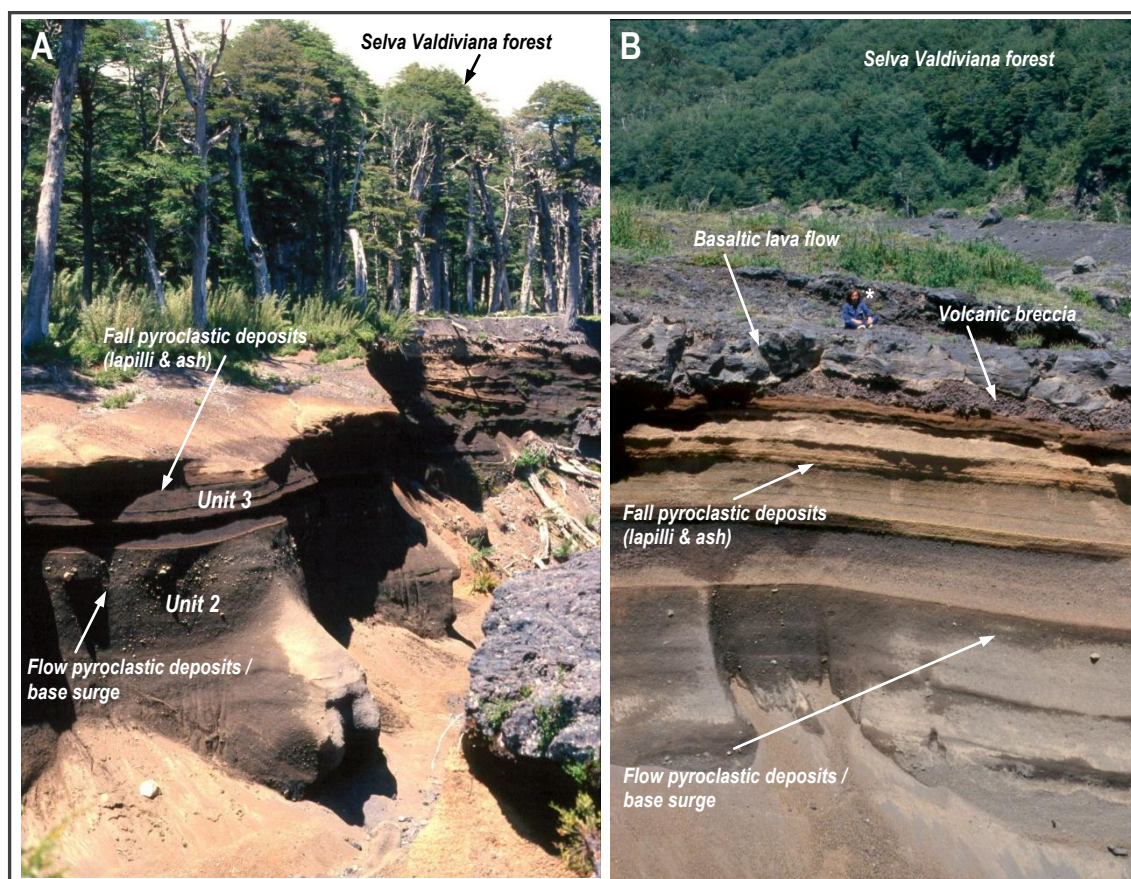
A few brief explanations:

Whether the basaltic lavas are **AA** type or **pahoehoe** is a matter more of the speed at which lava advances than anything else. If the speed is slow, the lava is rapidly solidifying and breaking (AA), on the contrary if this moves rapidly, then fluid structures will form as seen in pahoehoe lavas. A **lava tube** is formed when the top of flowing lava solidifies, but the lava continues to flow inside. When the lava flow is exhausted, an empty "tube" remains.

Fall deposits are formed from materials violently expelled from the volcano (**pumice**, **lapilli** or **ash**). They lack lamination within the layers but stratification can be recognized. **Pyroclastic flow deposits** (= **ignimbrites**), which originate from the lateral and downward movement of **pyroclasts** that form a "cloud" of hot gas and suspended particles. These rocks are formed of pumice and ash. The fragments can be very varied in size, with pumice fragments usually "floating" in an ash matrix. The **base surge** can be associated or not with ignimbrites. It is a flow deposit in which the proportion of gas is much higher than in the case of an ignimbrite. Furthermore, the character of the eruption is more explosive. And then we have the **debris flow**, which can be a **debris avalanche** (which originate from an avalanche of dry chaotic volcanic materials) or a **lahar**, that is, a sudden large stream of mud, rocks, and water originating on the flanks of a volcano, running along valleys and gulches.

Many times the danger does not have so much to do with lava flows as with lahars. It is worth remembering in this regard the tragedy of Armero (Colombia) on November 13, 1985. The pyroclastic flows emitted by the Nevado del Ruiz melted part of the high-altitude glacier, generating lahars that descended along the mountain valleys, eventually reaching the town of Armero, where more than 20,000 of its 29,000 inhabitants died when the lahar struck the town (Wikipedia 2021c).

Coñaripe is a small and bucolic tourist town of about 1400 inhabitants that is located on the eastern shore of Lake Calafquén, about 17 km to the SSW of the Villarrica Volcano summit. This relative “remoteness” (for those who are not geologists) of the volcano did not save it from being razed by a lahar during the 1964 eruption. That was the “old” Coñaripe, although the current one is located very close to the site of the tragedy.



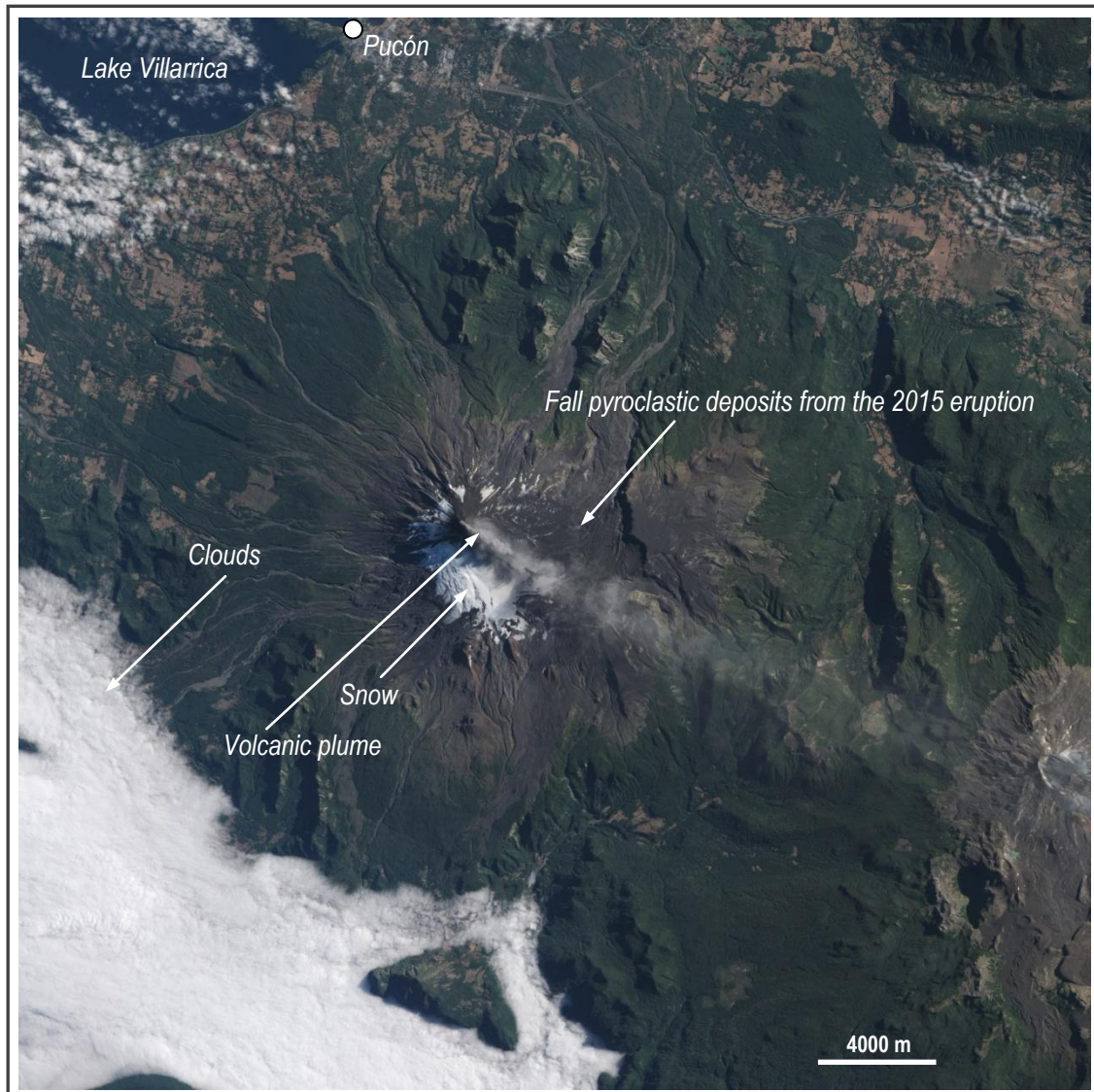
A: The “bull’s head” with different types of pyroclastic deposits from Villarrica Units 2 and 3. B: Equivalent to the previous one but the pyroclastic sequence from Unit 3 is sealed by a basal volcanic breccia and basalts. Interpretation based on figure 3 of Clavero & Moreno (2004). Images: P. Cubas. *: “Meditating” geologist that serves as scale.

The Villarrica is one of the few permanently active volcanoes in the world, with frequent strombolian activity and sometimes with a small lava lake present in its summit crater (Volcano Discovery 2021).

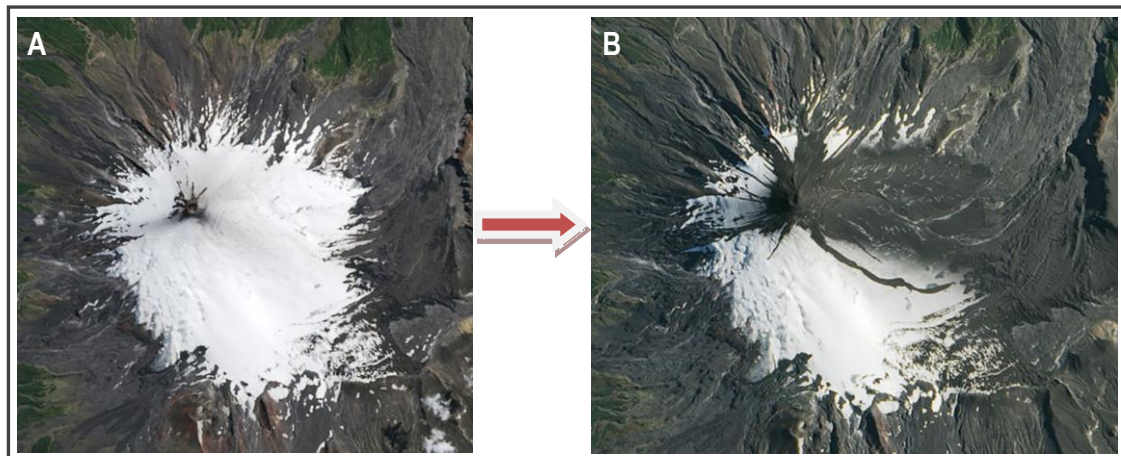
Villarrica eruptions: 2015, 2010-2012, 2008, 2005, 1985-2001 (lava lake), 1984-85, 1983, 1980, 1977, 1971-72, 1964, 1963(?), 1960-61, 1958-59, 1950(?), 1948-49, 1938, 1935, 1933, 1929, 1921, 1920-29, 1919(?), 1915-18(?), 1910?, 1909, 1908, 1907, 1906, 1904, 1897-98(?), 1893-94(?), 1883, 1879, 1877, 1875-76, 1874, 1869(?), 1867-68, 1864, 1859-60, 1853, 1852(?), 1837, 1832, 1822, 1815-18, 1806, 1801, 1799, 1796, 1792, 1790, 1787, 1780, 1777, 1759, 1751, 1745, 1742, 1737, 1716, 1688, 1657?, 1647?, 1640, 1594, 1562, 1558

Historical eruptions of the Villarrica Volcano. Updated from Volcano Discovery (2021) with the 2015 eruption.

The volcano erupted once more on March 3, 2015, covering its eastern flank with a large volume of volcanic materials, and after a brief rest period the volcano again spewed ash on March 18, 2015 (Earth Observatory 2021).



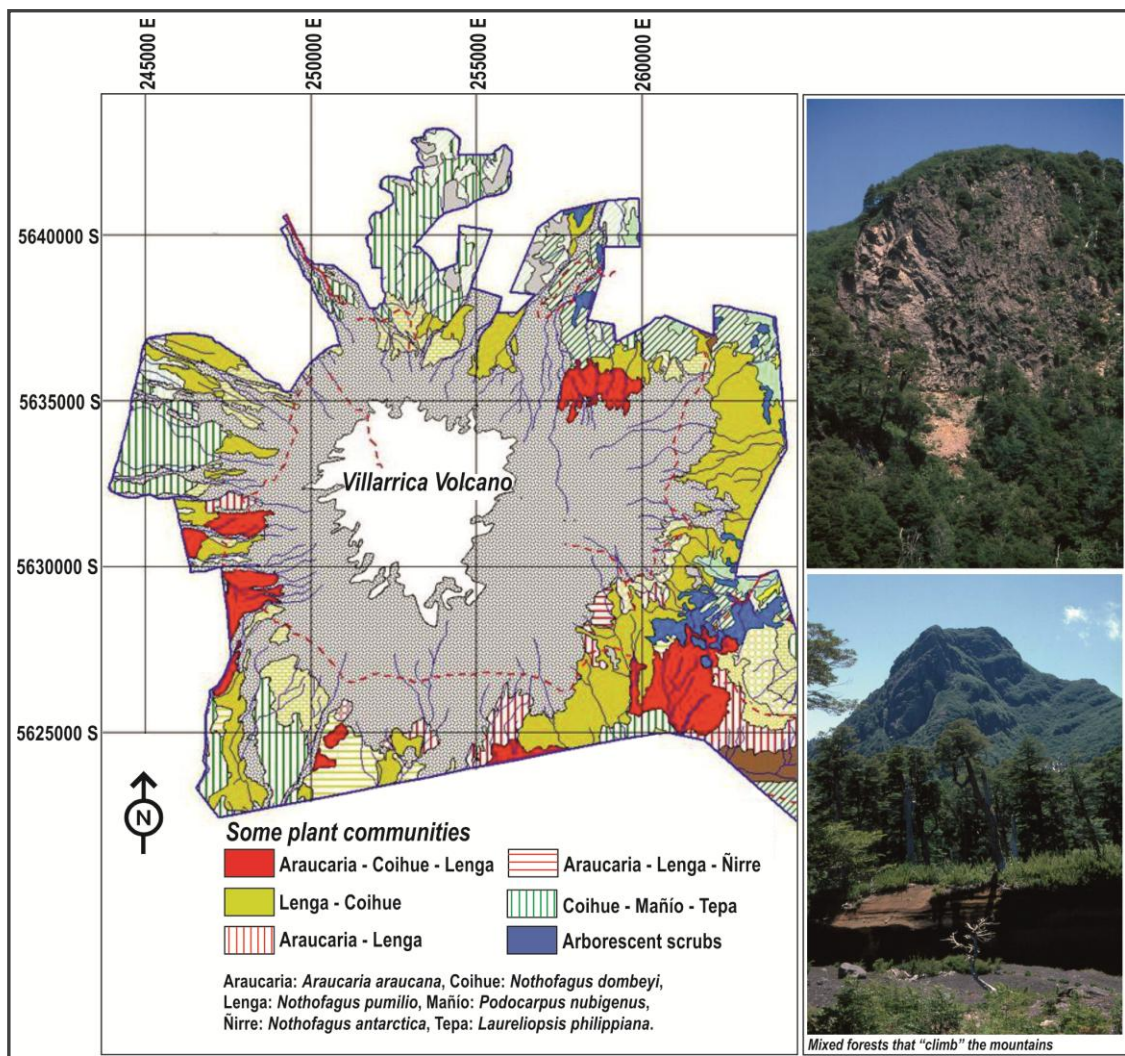
NASA image of March 18, 2015 during the last eruption of Villarrica (Earth Observatory 2021).



In the hours before dawn on March 3, 2015, Villarrica came to life. Thousands of people had to be evacuated within a 10 kilometer radius. The images (NASA) correspond to February 22, 2015 (A) and March 5, 2015 (B). Note how the falling pyroclasts (ash and lapilli) melted the snow and ice on the eastern flank (Earth Observatory 2021).

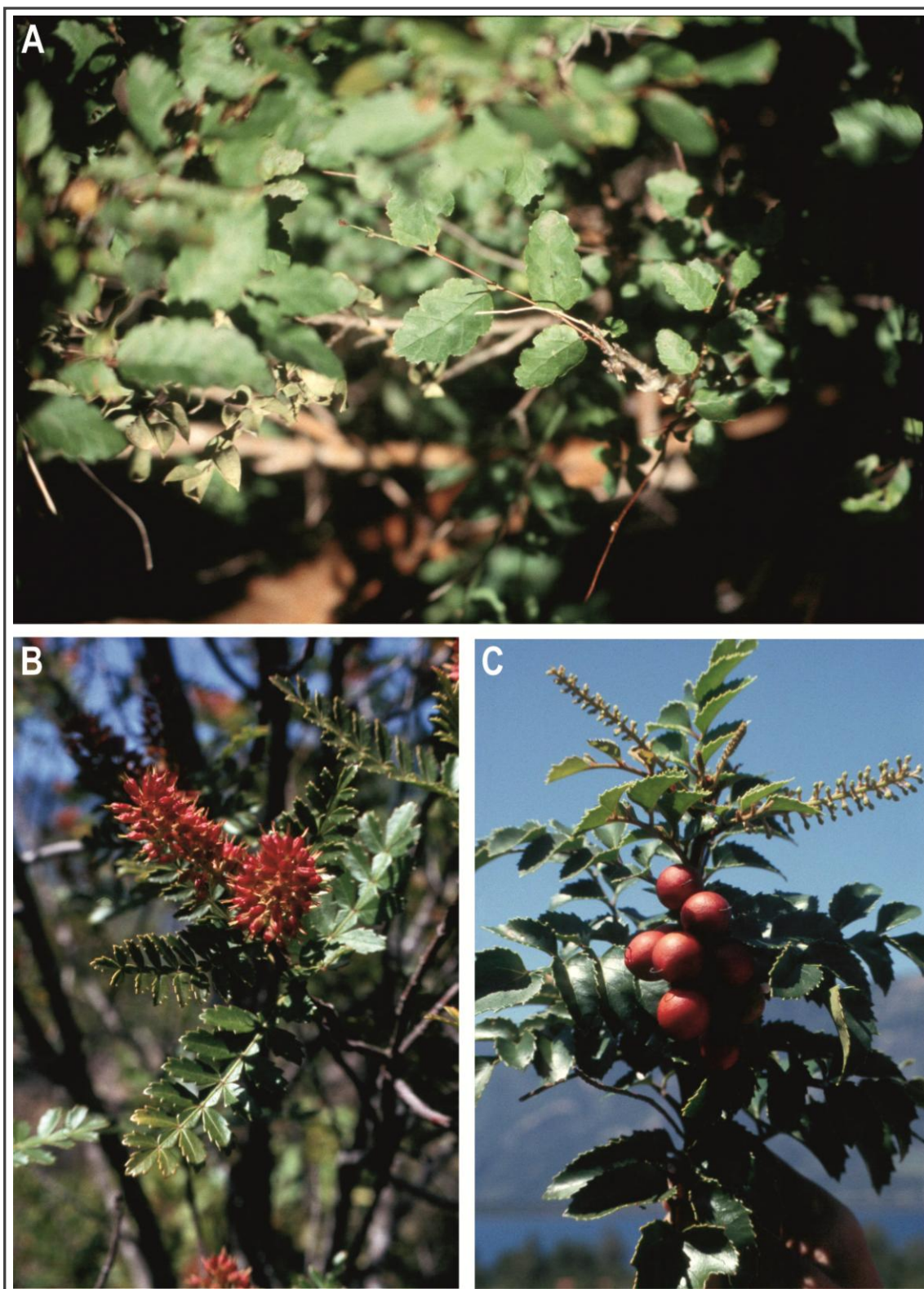
Vegetation

The Villarrica National Park is inserted in the Andean foothills of the Araucanía Region, and is considered an area of great ecological importance given the diversity of ecosystems that it presents as the result of the volcanic activity (*fertile soils*). There the visitor can find forest ecosystems, wetlands including rivers, lakes, scoria fields and high peaks.



Distribution map of plant communities in the surroundings of the Villarrica Volcano (Villarrica National Park) (adapted from Villarrica National Park 2009, CONAF 2013). On the right, the dense mixed forests of the area. Images: P. Cubas.

The existing vegetation in the Villarrica National Park corresponds to the Ecological Region of the "Andean – Patagonian Forests" and to the Ecological Region "Deciduous Forest" (Gajardo 1993, CONAF 2013). 66% of the surface of the Villarrica National Park is covered by vegetation, and specifically 50% is covered by forests. In the surroundings of the Villarrica volcano, the forests that occupy the greatest extension are the mixed ones where the araucaria (*Araucaria araucana*), the coihue (*Nothofagus dombeyi*), the lenga (*N. pumilio*) and the ñirre (*N. antarctica*) are combined as dominant trees; in more restricted areas there are coihue (*N. dombeyi*), mañío (*Podocarpus nubigenus*) and tapa (*Laureliopsis philippiana*) forests. Of the dominant trees, the various species of the genus *Nothofagus* (literally false beech) stand out. This genus in the past was included in the Fagaceae family, together with the beech (genus *Fagus*) from the northern hemisphere. However, they are now known to be quite genetically distant so *Nothofagus* is now included in its own family, Nothofagaceae.



Flora of the Villarrica National Park. A: Ñirre (*Nothofagus antarctica*); B: Tineo (*Weinmannia trichosperma*); C: Chilean hazelnut (*Gevuina avellana*). Images: P. Cubas.

In addition to the dominant arboreal canopy, there is an important lower arboreal and shrub layer where among many other plants, the tepa (*Laureliopsis philippiana*), the tineo (*Weinmannia trichosperma*), the trevo (*D. diacanthoides*), the lingue (*Persea lingue*), Chilean hazelnut (*Gevuina avellana*), radial (*Lomatia hirsuta*) and the chilco o hardy fuchsia (*Fuchsia magellanica*) thrive.



Flora of the Villarrica National Park. A: Radal (*Lomatia hirsuta*); B: Hardy fuchsia (*Fuchsia magellanica*), a shrub native to Chile and Argentina. Image: P. Cubas.

The fuchsia is a shrub of the Onagraceae family native to Chile and Argentina that preferably lives near water courses and in places with plenty of shade. It is cultivated as an ornamental plant due to the color and shape of its flowers and the numerous existing varieties that have been obtained by hybridization with other species of the genus from warmer climates (Wikipedia 2021c).

On a forgotten hawk

In these skies flies the “tiuque” o chimango caracara (*Milvago chimango* = *Phalcoboenus chimango*), which as Figueroa (2015) indicates, has become the forgotten raptor of Chile, at least with regard to studies on its natural history and ecology.



The tiuque (Milvago chimango = Phalcoboenus chimango) in the Villarrica National Park. Images: P.Cubas.

The tiuque is a species of falconiform bird of the Falconidae family. As Brittanica (2021) indicates, this is a group of swift, graceful birds known for their predatory skill as raptors, that includes eagles, condors, buzzards, kites, caracaras, ospreys, harriers, accipiters, vultures, secretary birds, falcons, hawks, and bateleurs.

The adult tiuques weigh about 300 g and are 37 to 43 cm long, they nest solitary and in colonies, breeding from September to December, showing a preference for building the nest on some vegetation that offers protection from the sun and rain. Incubation takes twenty-six to thirty-two days and at five weeks the young leave the nest (Wikipedia 2021e).

References

J. Clavero & H. Moreno (2004) *Evolution of Villarrica Volcano*. Servicio Nacional de Geología y Minería Boletín 61: 17-27.

Brittanica (2021) *Falconiform*. <https://www.britannica.com/animal/falconiform>

CONAF (2009) *Flora del Parque Nacional Villarrica*. <http://parquenacionalvillarrica.blogspot.com/2009/06/flora-del-parque-nacional-villarrica.html>

CONAF (2013) *Plan de manejo del Parque Nacional Villarrica*. <http://bibliotecadigital.ciren.cl/handle/123456789/29414>

Climate-Data.org (2021) *Villarrica clima (Chile)*. <https://es.climate-data.org/americadel-sur/chile/ix-region-de-la-araucania/villarrica-149144/>

Earth Observatory (2015) *Villarrica Volcano awakens*. NASA, <https://earthobservatory.nasa.gov/images/85550/villarrica-volcano-awakens>

R.A. Figueroa (2015) *El rapaz olvidado - ¿por qué hay tan pocos estudios sobre la historia natural y ecología básica del tiuque (milvago chimango) en Chile?* Boletín Chileno de Ornitología 21:103-118.

R. Gajardo (1993) *La Vegetación Natural de Chile. Clasificación y Distribución Geográfica*. Editorial Universitaria, Santiago de Chile, 165 p.

Parque Nacional Villarrica (2009) *Flora del Parque Nacional Villarrica*. <http://parquenacionalvillarrica.blogspot.com/2009/06/flora-del-parque-nacional-villarrica.html>

M. Van Daele et al. (2014) *The 600 yr eruptive history of Villarrica Volcano (Chile) revealed by annually laminated lake sediments*. Geological Society of America 126: 481-498.

Volcano Discovery (2021) *Villarrica volcano*. <https://www.volcanodiscovery.com/es/villarica.html>

Wikipedia (2021a) *Pillán*. <https://es.wikipedia.org/wiki/Pill%C3%A1n>

Wikipedia (2021b) *Ecorregión bosque valdiviano*. https://es.wikipedia.org/wiki/Ecorregi%C3%B3n_bosque_valdiviano

Wikipedia (2021c) *Tragedia de Armero*. https://es.wikipedia.org/wiki/Tragedia_de_Armero

Wikipedia (2021d) *Fuchsia magellanica*. https://es.wikipedia.org/wiki/Fuchsia_magellanica.

Wikipedia (2021e) *Phalcoboenus chimango*. https://es.wikipedia.org/wiki/Phalcoboenus_chimango