

February 26, 2024

News and notes

Before going on to discuss the geology and geopolitics of Chile, here are some news items I thought were interesting.

Geopolitics

- The modern polycrisis: [History's crisis detectives: How we're using maths and data to reveal why societies collapse – and clues about the future.](#)

Research

- Mineralogy and nuclear war: [Condensation of fallout glasses in the Hiroshima nuclear fireball resulting in oxygen mass-independent fractionation](#); Phys.org summary [here](#).
- Mineralogy, plate tectonics and earthquakes: [Effect of Low Viscosity Contrast between Quartz and Plagioclase on Creep Behavior of the Mid-Crustal Shear Zone.](#)
- Geochemistry of rock alteration in Cyprus: [Imaging of boron in altered mantle rocks illuminates progressive serpentinisation episodes.](#)
- Oceanography, related to today's post: [Scientists Confirm Underwater Mountains Harbor Abundant Life Off Chile's Coast.](#)

Plate Tectonics

- Geology Bites Podcast: [Damian Nance on What Drives the Supercontinent Cycle.](#)
- [Long-lived Northern Hemisphere convergence systems driven by upper-mantle thermal inhomogeneity.](#)
- [Revealing the Secrets of the Western Mediterranean: A Deep Earthquake and the Overturned Slab](#); Phys.org summary [here](#).
- [Tracking cycles of Phanerozoic opening and closing of ocean basins using detrital rutile and zircon geochronology and geochemistry.](#)
- Geophysics and plate tectonics: [Implications of Surface Heat Flux for Shear Stress and Temperature on the Plate Interface Beneath Northern Honshu](#); Phys.org summary [here](#).

Anthropocene

- Opinion: [Tinkering with Time: The Campaign to Conjure Up an "Anthropocene" Epoch.](#)
- Nature: [Buried microplastics complicate efforts to define the Anthropocene.](#)

Sedimentology

- [Late-Holocene counterpoint deposition in the Lower Rhine River.](#)

- [High-frequency palaeoenvironmental changes in the mixed siliciclastic–carbonate sedimentary system from a lower Permian restricted basin \(West Gondwana, southern Brazil\).](#)
- [Characteristics and geological significance of early carboniferous soft-sediment deformation structures in the Kushanhe section, southwest Tarim Basin, Northwest China.](#)

Paleontology

- [Morocco dinosaur discovery gives clues on why they went extinct.](#)
- [A large therian mammal from the Late Cretaceous of South America](#); IFL Science summary [here](#).
- [The Diet of *Metriorhynchus* \(Thalattosuchia, Metriorhynchidae\): Additional Discoveries and Paleoecological Implications.](#)

Mining and Energy

- Mineral deposit geology: [Influence of magmatic and magmatic-hydrothermal processes on the lithium endowment of micas in the Cornubian Batholith \(SW England\).](#)
- Copper sulphide deposit geology: [Mineral and S-Isotope Compositions of Cu-Sulfide Deposits in Southern Siberia \(Kodar–Udokan Region\), Russia.](#)
- Petroleum geology: [Employing Statistical Algorithms and Clustering Techniques to Assess Lithological Facies for Identifying Optimal Reservoir Rocks: A Case Study of the Mansouri Oilfields, SW Iran.](#)
- Shale oil extraction research: [Study on the rock physical mechanical properties evaluation of tight oil reservoir in Chang 7 member, Longdong area, Ordos Basin, China.](#)
- [Charting the Course of U.S. Oil Production.](#)
- Geology of shale gas extraction: [Research on the data-driven inter-well fracture channeling identification method for shale gas reservoirs.](#)
- [Thermogenic methane and hydrogen generation in subducted sediments of the Nankai Trough.](#)
- [Warm Winter Drags U.S. Natural Gas Prices to Three-Decade Low.](#)
- [‘There is enough natural hydrogen underground to meet all demand for hundreds of years’, says US government agency.](#)

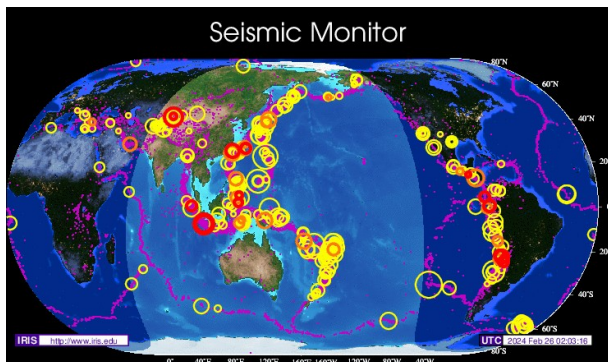
Environmental Geology and Hydrogeology

- [French recycling plant on fire housing 900 tonnes of lithium batteries.](#)
- [Arsenic in landfills is still leaching into groundwater – 20 years after colleagues and I learned how the ‘king of poisons’ could escape trash dumps.](#)
- Groundwater management: [An ancestral river runs through it.](#)
- FREE book from the Groundwater Project: [Geologic Frameworks for Groundwater Flow Models.](#)

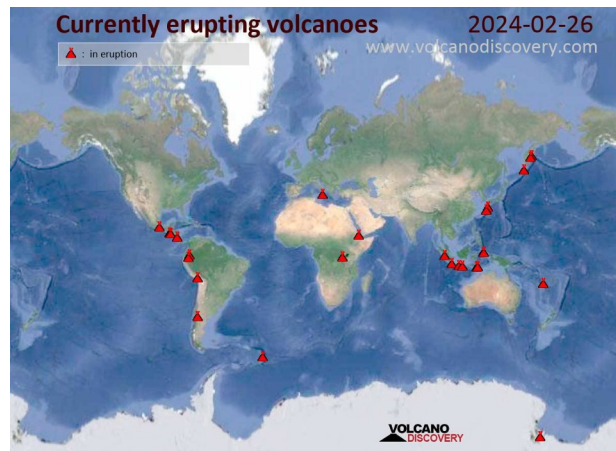
Glaciers and Climate Change

- Glacial geology: [Variability in geochemical weathering indices in loess over the last full glacial cycle at Karamaidan, central Asia \(Tajikistan\)](#).
- More glacial geology: [Investigating Subglacial Water-Filled Cavities by Spectral Analysis of Ambient Seismic Noise: Results on the Polythermal Tête-Rousse Glacier \(Mont Blanc, France\)](#).
- [Indigenous Colombians fret as sacred mountain glaciers melt](#).
- [A high-resolution calving front data product for marine-terminating glaciers in Svalbard](#); Phys.org summary [here](#).
- [Large-scale drivers of the exceptionally low winter Antarctic sea ice extent in 2023](#).
- Climate: [Observed humidity trends in dry regions contradict climate models](#).

Volcanoes, Earthquakes and Geohazards



[Seismic Monitor](#)



[Active Volcano Map](#)

- United States Geological Survey (USGS) Volcano Watch: [Appreciating the contributions of ‘Ōlelo Hawai‘i to volcanology](#).
- USGS Yellowstone Volcano Observatory: [What is “normal” earthquake activity in Yellowstone?](#)
- [Smithsonian / USGS Weekly Volcanic Activity Report](#).
- Video: [Feb 21, 2024: New Eruption at Popocatepetl Volcano](#); related: [Sunset video shows volcano spew ash in Mexico](#).
- Iceland: [Could be looking at another eruption as early as next week](#).
- [Euro-Mediterranean Seismological Centre](#).
- Earthquakes, video on You Tube: [New Madrid Seismic Zone: Why The Middle Of The U.S. Could Be Hit By A HUGE Earthquake](#).

February 26, 2024

Geology and the Fate of Societies – Chile



Figure 1 – Republic of Chile

Credit: CIA World Factbook – Chile, public domain

The Republic of [Chile](#) is located on the west side of the [Andes Mountains](#) in [South America](#). According to the [Central Intelligence Agency \(CIA\) World Factbook on Chile](#) the country has a total area of 756,102 square kilometres (km²) of which 743,812 km² is land and 12,290 km² is water. In addition to the territory on mainland South America, Chile rules several Pacific islands, including the [Juan Fernández Archipelago](#), [Isla Salas y Gómez](#), the [Desventuradas Islands](#), and [Easter Island](#). Chile also claims about 1,250,000 km² of [Antarctica](#) as the [Chilean Antarctic Territory](#). To the west of Chile is a long coastline on the [Pacific Ocean](#) and to the south, Chile's coastline extends to the [Drake Passage](#). East of Chile is [Argentina](#); northeast is [Bolivia](#); and to the north is Peru. (Last year we looked at [Argentina](#) and [Bolivia](#) in this blog).

Also according to the CIA World Factbook, the current population of Chile is about 18,549,457. 88.9% of the population is considered [white](#) and non-Indigenous. The remaining 10.1% are various indigenous peoples including [Mapuche](#) 9.1%, [Aymara](#) 0.7%, together with small numbers of [Rapa Nui](#) (Easter Islanders), [Likan Antai](#), [Quechua](#), [Colla](#), [Diaguaita](#), [Kawesqar](#), and [Yagan](#) peoples. The official language of Chile is [Spanish](#). Most people, 60% in Chile are [Roman Catholic](#). Of the remainder, 18% are [Evangelical Protestants](#), 4% call themselves [atheist](#) or [agnostic](#) and 17% have no professed religion.

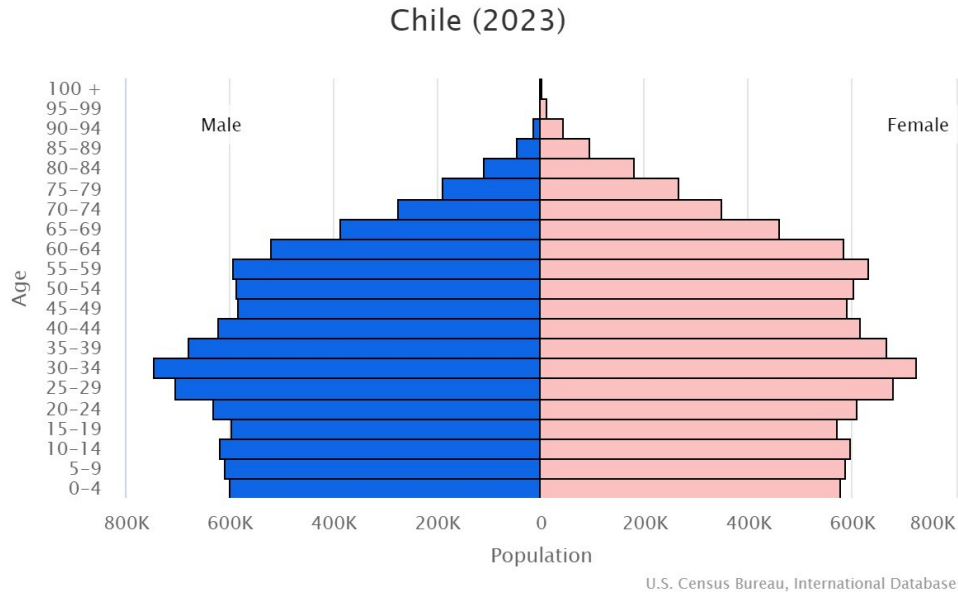


Figure 2 – Demographic Profile of Chile
Credit: [United States Census Bureau, International Database](#), public domain

The demographic profile for Chile shows an aging population with a declining population of people under 25. The total fertility rate is 1.75 births per woman, which is below replacement rate. The median age in Chile is 36.6 years and the average life expectancy is 80 years for both male and female.



Figure 3 – [Palacio de la Moneda](#) in Santiago de Chile
Credit: [Miguel hernandez](#), [Creative Commons Attribution-Share Alike 2.0 Generic](#) license

Under the [current constitution](#), adopted in 1980, the government of Chile is [presidential republic](#); the current President is [Gabriel Boric](#) (the [Palacio de la Moneda](#) is his residence). The government structure includes: a [Senate](#), with [Juan Antonio Coloma](#) as President of the Senate; a [Chamber of Deputies](#), with

[Ricardo Cifuentes](#) as President of the Chamber; and a [Supreme Court](#), with [Juan Fuentes Belmar](#) as President of the Supreme Court.

The Capital City and largest city in Chile is [Santiago de Chile](#) (pop. 6,269,384). The legislature is based in [Valparaíso](#) (pop. 284,630).

Geology

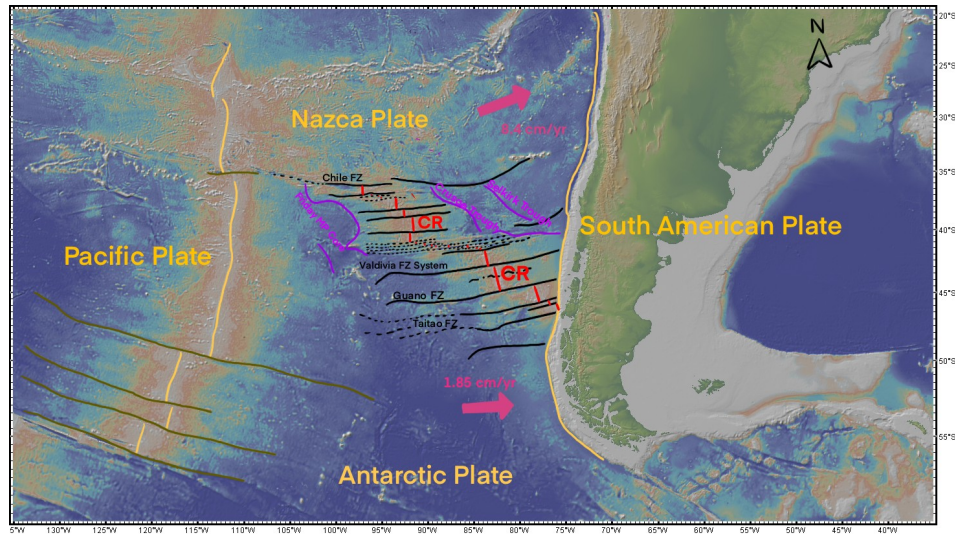


Figure 4 – Chilean Ridge and the Formation of the Andes

Credit: [Candyueung168](#), [Creative Commons Attribution-Share Alike 4.0 International](#) license

The [geology of Chile](#) is very much the [geology of the Andes Mountains](#). The [Andean Orogeny](#) that [formed the Andes](#) began during the [Jurassic](#) and [Early Cretaceous](#) and was characterized by the expansion of the [Nazca Plate](#) and its [subduction](#) under the [South American Plate](#). At the south end of the Nazca plate, the [Chilean Ridge](#) marks a [divergent plate boundary](#) between the Nazca Plate, the [Antarctic Plate](#) and the [Scotia Plate](#).

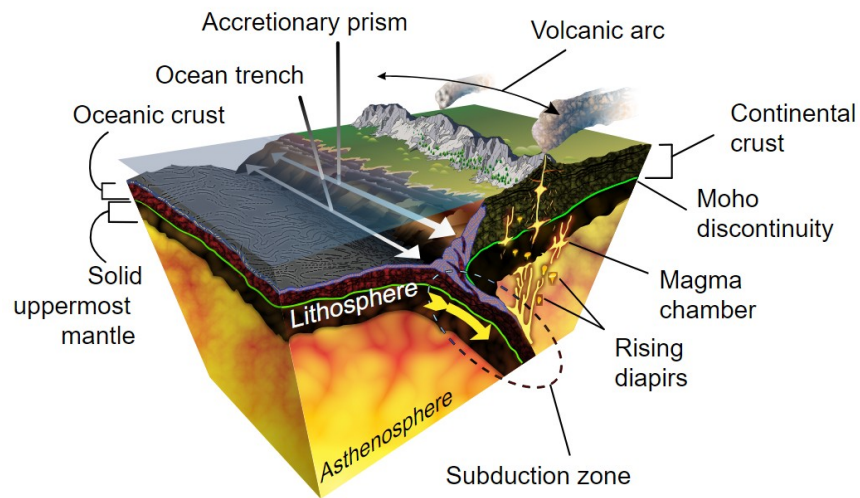


Figure 5 – Subduction Zone

Credit: [K. D. Schroeder KDS4444](#), [Creative Commons Attribution-Share Alike 4.0 International](#) license

A consequence of the subduction of the Nazca Plate is the melting of the buried [oceanic crust](#), the rising of [magmatic melt](#), and the consequent creation of a [volcanic arc](#), i.e. the Andes Mountains. Overall, the Andes Mountains in Chile are divided into three main units:

- On the west coast is the [Chilean Coast Range](#);
- East of the Coast Range is the Central Valley of the [Intermediate Depression](#); and
- Inland of the Central Valley are the Andes Mountains proper including the [Norte Grande](#) mountain with a series of plateaus such as [Puna de Atacama](#) and the [Altiplano](#).

The oldest rocks in Chile are Paleozoic aged [micaceous schist](#), [phyllite](#), [gneiss](#) and [quartzite](#) many of which are found in the Coast Range. The schist rocks of southern Chile originated in the sediment of the [proto-Pacific Ocean](#) metamorphosed in the [forearc](#) wedge of the [Peru–Chile Trench](#).

Many of the [volcanic rocks](#) of the [Andes](#) began to be deposited following the breakup of [Gondwana](#) and the beginning of the Andean Orogeny in the Jurassic. The Altiplano Plateau formed during the [Cenozoic](#). In the latest period of the Cenozoic, the [Quaternary](#), extensive glaciations began during the [Pleistocene](#) and many glaciers persist into the current [Holocene Epoch](#).

Resources

Agriculture



Figure 6 – Flock of sheep and farm, [Laguna Blanca](#), Magallanes, Chile
Credit: [LBM1948](#), [Creative Commons Attribution-Share Alike 4.0 International](#) license

According to the CIA World Factbook on Chile, agricultural land makes up 21.1% of the total land area. Of this 1.7% is [arable land](#), 0.6% is covered in [permanent crops](#), and 18.8% is [permanent pasture](#). Agriculture makes up 4.2% of the national economy. The wide range of climate and geography in Chile allows for a large range of agricultural production in the country. Major agricultural products of Chile include grapes, apples, onions, wheat, corn, oats, peaches, garlic, asparagus, beans, beef, poultry, wool,

and farmed fish such as salmon. [Chilean wine](#) has a high reputation as do many of their other [fruit products](#). We frequently see Chilean fruit products on our store shelves here in Canada. Statistics on agriculture in Chile are found [here](#).



Figure 7 – Chilean Salmon Farms

Credit: [Sam Beebe/ECOTRUST](#), [Creative Commons Attribution-Share Alike 3.0 Unported](#) license

In general, [hunger is rare in Chile](#). However, economic dislocations, such as the 2020 – 2022 [Covid-19 Pandemic](#), seriously disrupted food distribution systems and food insecurity [happened in Chile](#).

Forestry



Figure 8 – Southern Chile Forest

Credit: [Luis Enrique Pérez López](#), [Creative Commons Attribution-Share Alike 4.0 International](#) license

Forestry is a [major industry in Chile](#), making up 14% of the [country's exports](#). Major wood species harvested include [Pinus radiata](#), [Eucalyptus globulus](#) and [Eucalyptus nitens](#). About 112,200 people are employed in the industry.

In contrast to some countries where deforestation is a problem, [Chile's total forest area has been increasing since the turn of the 21st century](#). Production statistics are [here](#).

Mineral Resources



Figure 9 – Copper Mine in Chile

Credit: Sebastian Kawa & Tomasz Kawa, [Creative Commons Attribution-Share Alike 3.0 Unported](#) license

Chile is a [major mining producer](#). Metallic minerals produced include [copper](#) (from about 32 mines), [gold](#), [iron](#), [lead](#), [mercury](#), [molybdenum](#), [rhenium](#), [silver](#) and [zinc](#). Industrial minerals produced include: [boron](#), [iodine](#), [lithium](#), [phosphates](#) (including [guano](#)), [potash](#), [salt](#), and [sulphur](#). Mineral fuels produced include [coal](#), [natural gas](#) and [petroleum](#). At one time [Chilean nitrates](#) were considered a [major strategic mineral](#) for the production of fertilizer, ammonia, nitric acid and explosives; the development of the [Haber-Bosch Process](#) meant that they were less important.

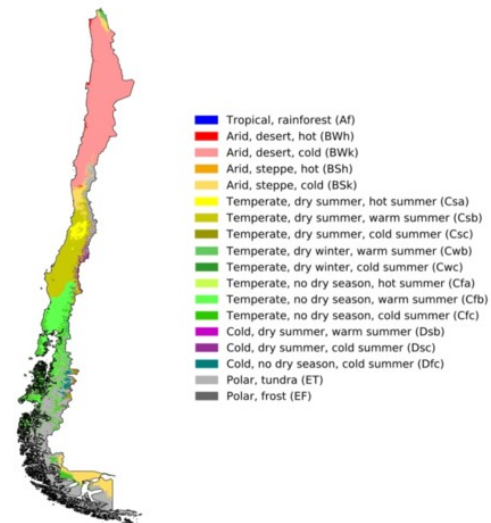
Mineral production statistics from the USGS Minerals Yearbook is [here](#); other statistics can be found here.

Climate

Given the north to south extent of Chile, it is not surprising that it has a wide range of climates. In the north are dry deserts, including the world's driest desert, the [Atacama](#). The central portion of the country

is more temperate and the extreme south there is polar tundra. If you want to visit Chile, check out these sites [here](#), and [here](#). Travel advisories for the worried are [here](#).

Köppen climate types of Chile



*Isotherm used to separate temperate (C) and continental (D) climates is -3°C
Data source: Climate types calculated from data from WorldClim.org

Figure 10 – Köppen Climate Types of Chile

Credit: Bdm121, [Creative Commons Attribution-Share Alike 4.0 International](#) license

You can find a key to description of the climate types shown in Figure 10, [here](#).

History and Geopolitics

History



Figure 11 – The Inca Army on the March

Credit: [Miguel Vera León](#), [Creative Commons Attribution 2.0 Generic](#) license

In the [history of Chile](#), the earliest evidence of human settlement was from the [Monte Verde site](#), dated at approximately 14,500 years ago. This finding really [threw a wrench](#) into the [archaeological community's](#) assessment of human settlement in the Americas, but the [hard science evidence](#) has withstood the scrutiny.

Various tribes of hunter/gathers inhabited Chile for the next 14,000 years. The earliest state-level culture to exist in Chile was the [Inca Empire](#), who occupied part of northern Chile after they fought against the [Mapuche](#) between 1460 and 1491. The three-day [Battle of the Maule](#) set the limit to the Inca territories in Chile at the [Maule river](#).

The [arrival of the Spaniards](#) in 1528 led to the Spanish conquest of the Inca territories and beyond into Chile. It was [not a peaceful take over](#). Following the extermination of indigenous tribes, mostly Spanish settlers moved into the most fertile lands in the centre of Chile. Wars with indigenous peoples in the Chile, the so called [Arauco War](#), lasted until 1656.

By 1810, the descendants of the Spanish settlers were ready for independence from their Spanish masters. The result was the [Chilean War of Independence](#) from 1810 to 1827. Independence was followed by a [civil war](#) that was in turn settled in the [Constitution of 1833](#). A relatively peaceful time followed from 1833 to 1861 in the so-called [Conservative Republic](#) followed by [Liberal Republic](#) of 1861 to 1891. These republics were followed by the [Parliamentary Era](#) (1891 to 1925) and the [Presidential Era](#) (1925 to 1973). Border disputes with Argentina led to a [naval arms race](#) and the eventual resolution of the border dispute in the [1902 General Treaty of Arbitration](#).

In 1970, the election of a doctrinaire socialist, [Salvador Allende](#), led to an openly [Marxist regime](#) that lasted from 1970 to 1973. With the [generous aid by the CIA](#) and other American organizations, the Chilean military, under General [Augusto Pinochet](#), overthrew the Allende government in a [coup d'état](#) in September 1973.

The [Pinochet regime](#) lasted from 1973 to 1990 and was marked by [harsh suppression of their political opponents](#) – approximately 30,000 people were killed and countless others illegally detained. Thousands others [fled the country](#), in fear of their lives. It should be pointed out that the Pinochet regime enjoyed [widespread support from middle-class Chileans](#). The people supporting the overthrow of the Allende regime feared a repeat in Chile of [measures enacted by other socialist regimes](#). As well, the Pinochet regime faced an [armed insurrection](#) by people opposed to the military government, so many of the people executed by Pinochet's regime were people at war with the government.

The Pinochet regime reformed the economy of Chile under the guidance of the [Chicago School](#) of economists who followed the direction of [Nobel Laureate Milton Friedman](#). Friedman's advice – reduce excessive regulation and free up economic activity – had [overall positive results](#).

The 1980 constitution allowed General Pinochet to remain in office until he retired in 1990. Since then, Chile has been ruled by a variety of governments, some socialist and some conservative. Overall, there seems to be [no wish to return to the bad old days](#) of the Pinochet regime. However, the general [economic and political upheaval](#) of our times has led to the [current troubles in Chile](#) as well. The current troubles in Chile seems to be exacerbating the rivalry between right-wing and left-wing political parties that is a [feature of Chilean history](#). Recently, in 2023, a right-wing party [came to power](#), to the distress of the left-

wingers. Some of this is just democratic churn and some of it [reflects deep divisions](#) within Chilean society. These strains in the body politic persist to this day, as shown in a [recent failed attempt](#) to reform the 1980 constitution. It is hard to see where this will lead, but it may not be good.

Geopolitics



Figure 12 – Quirihue, Biobío, Chile

Credit: [CARLOS SALGADO MELLA](#), [Creative Commons Attribution-Share Alike 3.0 Unported](#) license

Leaving aside the internal issues in Chile, let's take a look at the relationships that Chile has with its neighbours. For now these relations are peaceful, [it hasn't always been so](#). Looking at each of the three neighbouring states, here is how their relations with them seem to be in 2024:

[Argentina and Chile](#) share a long border and have similar cultures and histories. Relations between the two countries have varied from tense to cooperative. Right now, there doesn't seem to be any existential issues dividing the two countries, in fact there has been a fair amount of cooperation. I don't expect their disagreements to get out of hand anytime soon; although that all depends upon wise or foolish leadership.

[Bolivia and Chile](#): the Bolivians have not forgotten that Chile took the land connecting Bolivia to the Pacific Ocean in the [War of the Pacific](#), 1879 to 1884. Since then, attempts to secure access Bolivian to the sea with Chilean agreements have failed. This dispute will not likely go away anytime soon.

[Peru and Chile](#): in another case of long memories, Peru was also a loser in the 1879-1884 war. As well, there have been many other conflicts between the two countries, often in disputes over

resources. It is hard to see where this will lead; again it will depend on the leadership in the two countries.

In the wider world, the [United States](#) (USA) maintains a [strong interest in Chile](#), involving a wide range of bilateral agreements and relationships. We can expect that the USA will continue to take a keen interest in Chilean affairs, if only because Chile is a [major producer](#) of critical minerals vital to the American economy.

Another world actor, [China](#), is also taking an interest in [South American affairs](#). China's main interest in Chile seems to be [trade and investment](#), although we shouldn't discount its [great power rivalry](#) with the United States as a motive for playing in [America's backyard](#). It could become a theatre of operations in a conflict.

That kind of wraps it up for this very brief look at Chile. I am optimistic for the country. Provided their leaders remember the lessons of their harsh past (still in living memory) they should be able to accommodate the contrasting ambitions of the left and right wings in their body politic. All they need is good people.

Check out the links in this post if any of this interests you.

Standard Caveat

The purpose of my weblog postings is to spark people's curiosity in geology. Don't entirely believe me until you've done your own research and checked the evidence. If I have sparked your curiosity in the subject of this posting, follow up with some of the links provided here. If you want to, go out into the field and examine some rocks on your own with the help of a good field guide. Follow the evidence and make up your own mind.

In science, the only authority is the evidence.