

# Postcolonial Mining and Development: The Chilean Example

# Chile (the narrowest nation in the world)

- 756,000 sq. km
  - Texas is 692,000 sq. km
- 15.5 million people
- One of the wealthiest nations in Latin America
- Per capita GDP
  - \$10,000

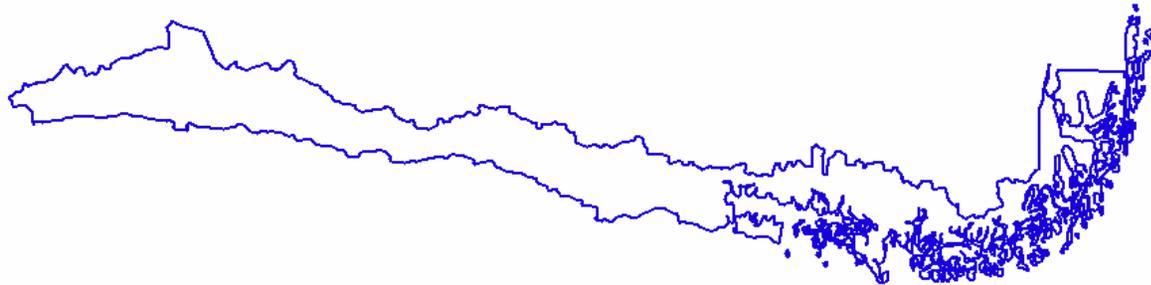


# Size Comparisons of Chile, Texas, and Mexico

Chile: 756,000 sq. km

Texas: 692,000 sq. km

Mexico: 1,972,000 sq km



Atacama  
Desert,  
northern  
Chile

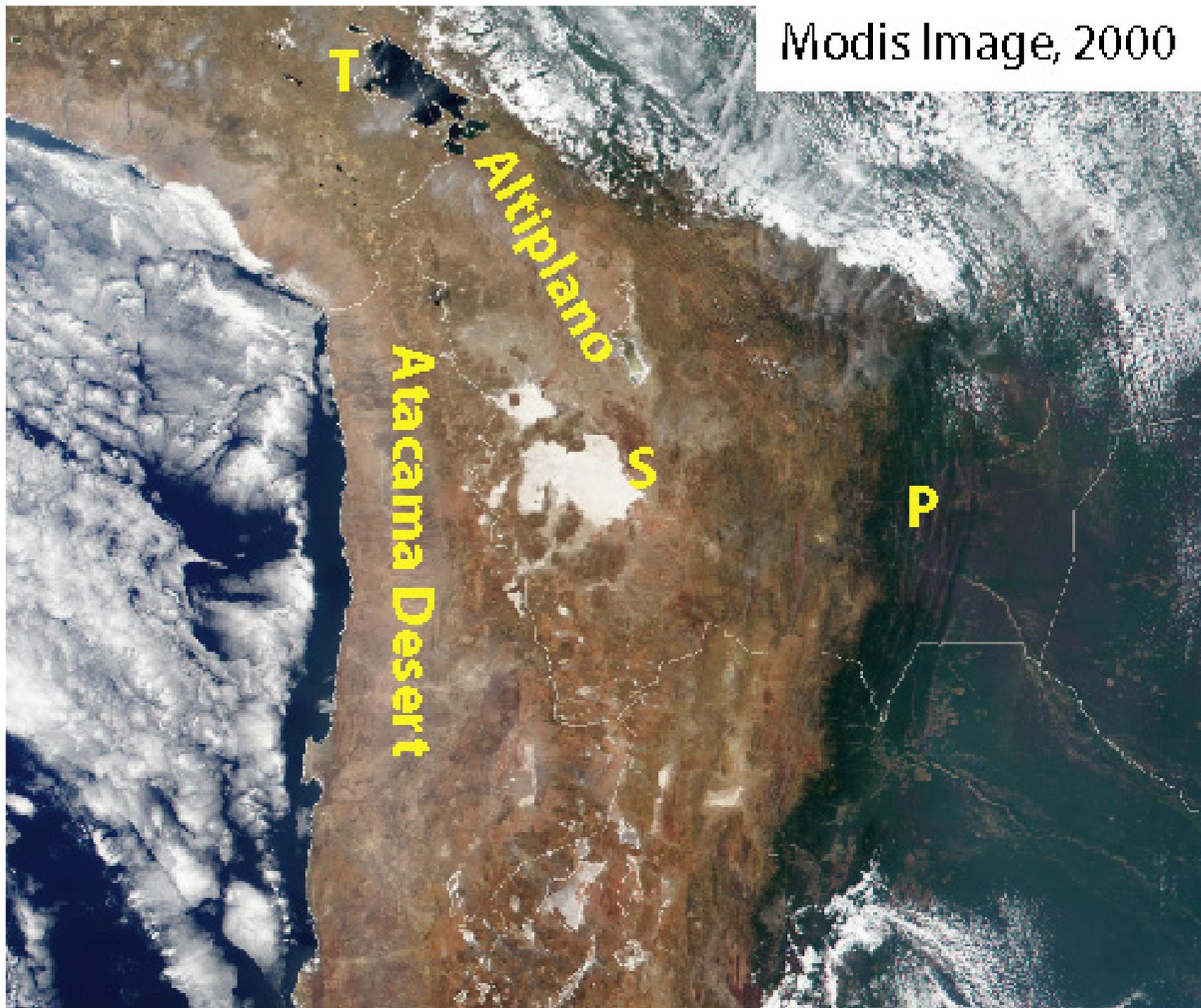


# Atacama Desert

- The Atacama Desert of Chile is a sparsely populated virtually rainless plateau, running from the Pacific Ocean to the Andes Mountains. The average width is less than 100 miles but it extends 600 miles south from the Peruvian border.
- The Atacama Desert is Earth's second driest regions (after Antarctica).
- The Atacama is made up of salt basins (salars) sand and barren rock outcroppings.
- The first European to cross the forbidding waste was Diego de Almagro, the Spanish conquistador, in 1537. From then until the middle of the 19th century it was largely ignored



Modis Image, 2000



- T = Lake Titicaca; P= Potosí; S = Salar de Uyuni

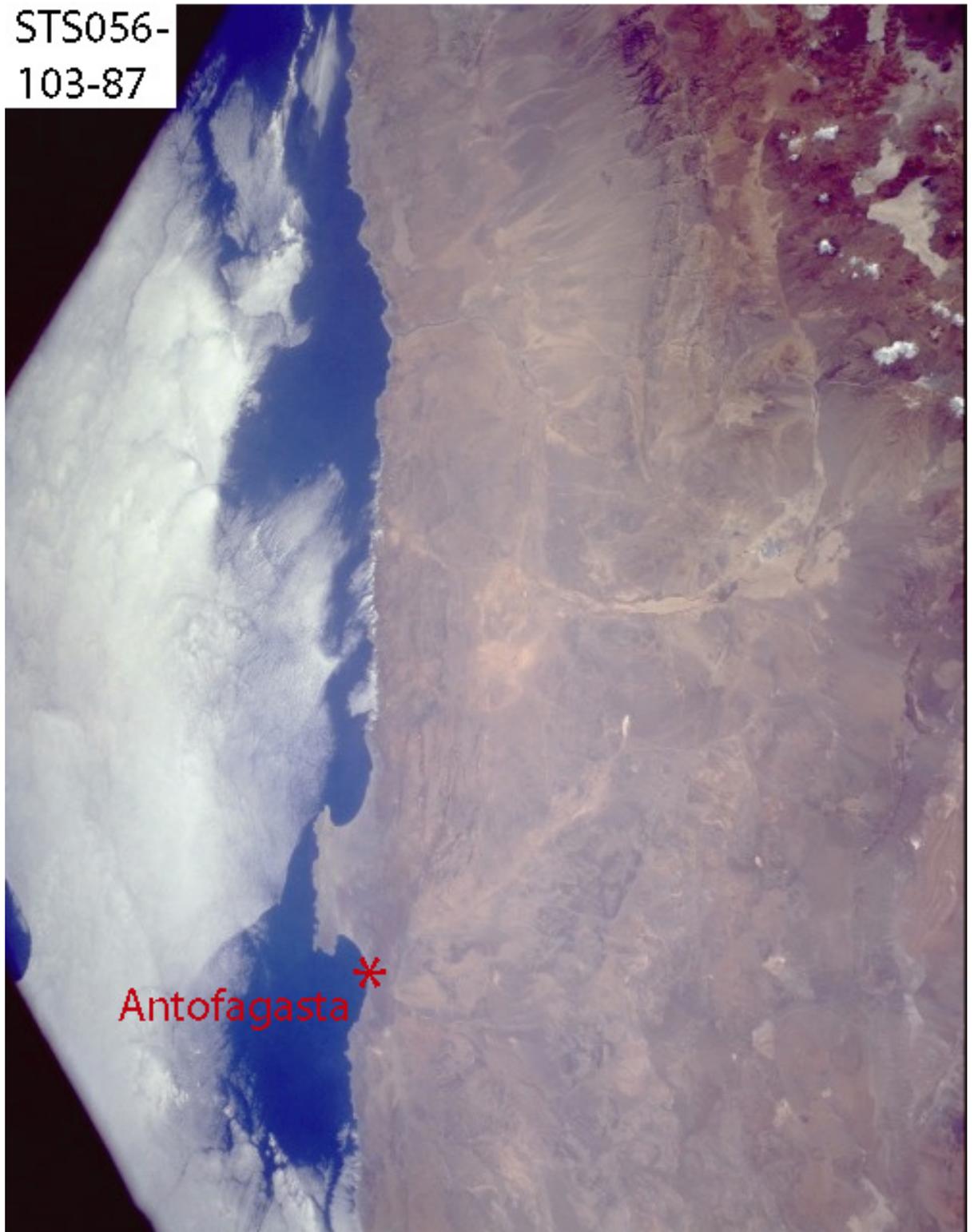
# Atacama Desert Mineral Resources

- *The desert has the world's largest natural supply of sodium nitrate, which was mined on a large scale until the early 1940s, and rich deposits of copper and other minerals. The port city of Antofagasta on the peninsula's southwest coast is a major shipping port for sodium nitrate, copper, and other minerals.*



STS056-  
103-87

# Astronaut photo of Atacama Desert

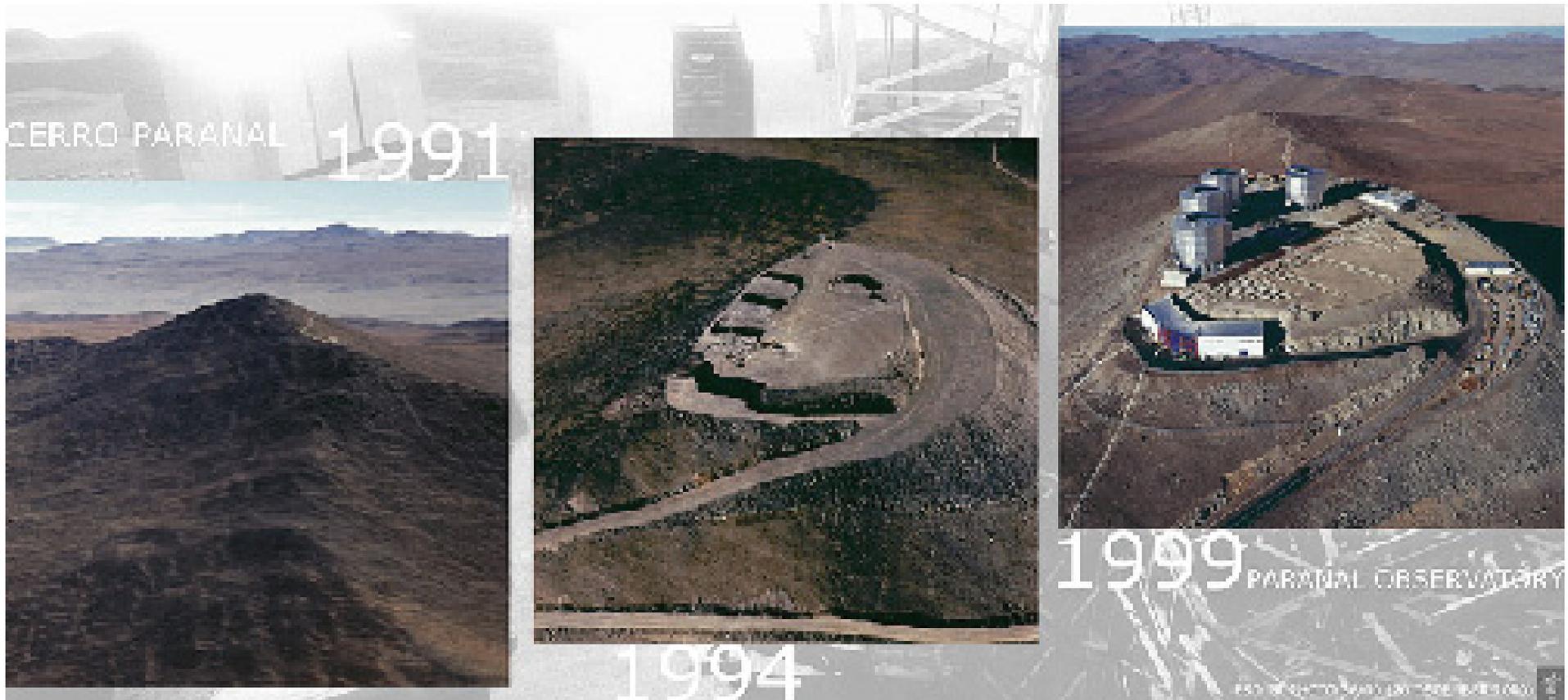


Antofagasta \*

# Atacama Desert

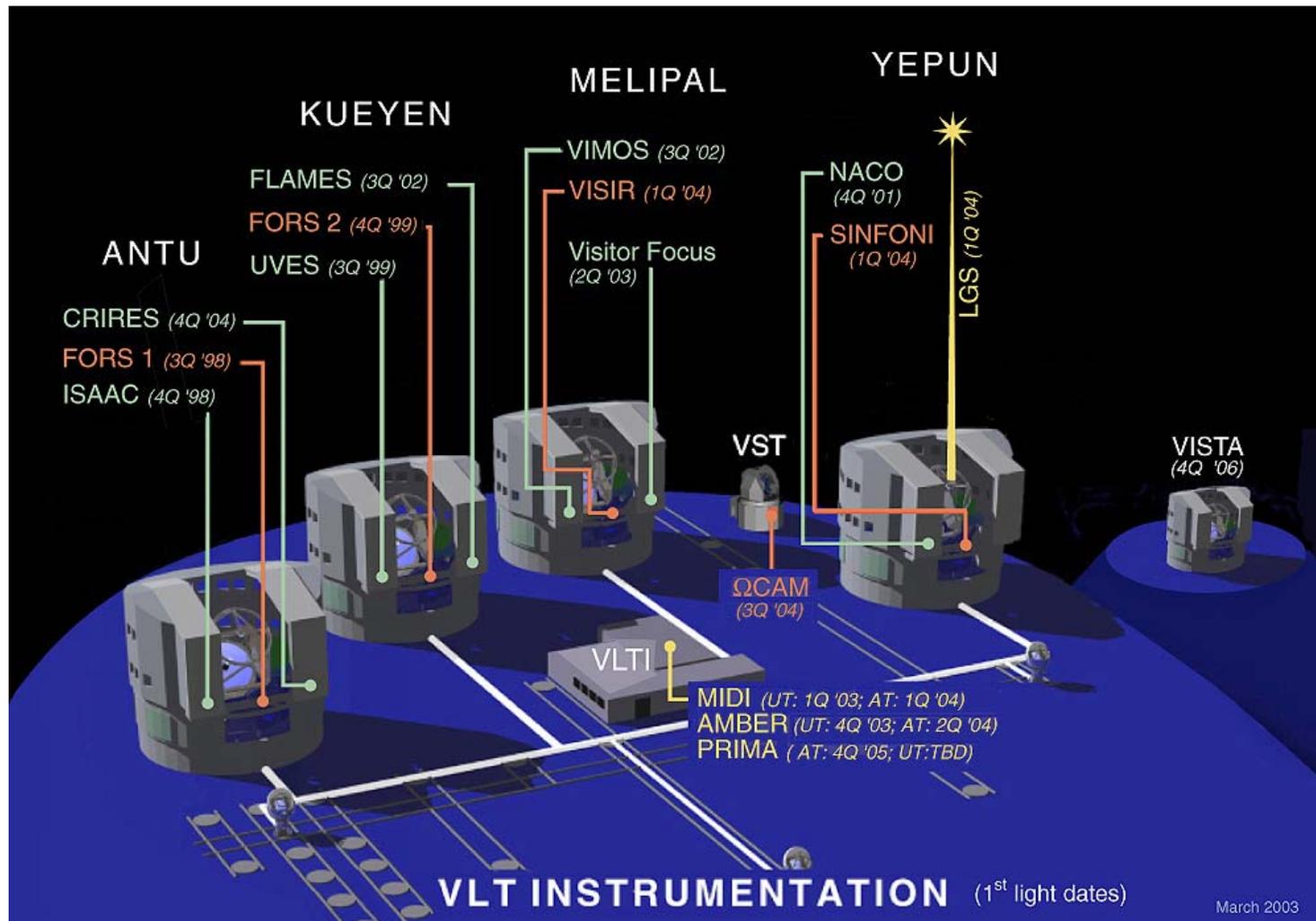
- The desert is completely barren and while most areas only receive moisture from an occasional fog or a shower every few decades, the rain gauge at Calama has never recorded any measurable precipitation. The Atacama is a high and cold desert, average temperatures range from 0° to 25° Celsius (32° to 75° F).
- Chile's leading export of the nineteenth century was nitrate which came from mines in the Atacama. Since the beginning of the twentieth century, when synthetic nitrates began to be produced, the Atacama Desert became responsible for Chile's current leading export, copper. Copper is mined in the eastern portion of the country, lying near the Argentina border.

# Atacama & Astronomy



- The Atacama has the clearest skies of the world, where only 20 days out of the year is there a cloud in the sky.
- La Silla Observatory began in 1969 by a consortium of European nations
- The world's largest telescope (Very Large Telescope) is on Cerro Paranal (8645') 200 km south of Antofagasta.

# Atacama & Astronomy (cont'd)



- 4 telescopes that are digitally combined to yield single image
  - Seven of ultimately ten first generation instruments are in operation at the VLT.
- Largest has mirror 7' thick and 27' across
- Run by European Southern Observatory

# Chile looking south



*Andes Volcanoes*

*Salar de Atacama*

Antofagasta



Photos by M. Leybourne

# The War of the Pacific (1879-1883)

- Under an 1866 treaty, Chile and Bolivia divided the disputed area encompassing the Atacama Desert at 24° south latitude (located just south of the port of Antofagasta) in the understanding that the nationals of both nations could freely exploit mineral deposits in the region. Both nations, however, would share equally all the revenue generated by mining activities in the region. But Bolivia soon repudiated the treaty, and its subsequent levying of taxes on a Chilean company operating in the area led to an arms race between Chile and its northern neighbors of Bolivia and Peru.
- In February 1879 Chile ordered its military forces into the Bolivian port of Antofagasta.
- Two months later Peru, an ally of Bolivia, declared war on Chile, precipitating the War of the Pacific.
- Chile acquired considerable territory, including the province of Antofagasta from Bolivia and the province of Tarapacá from Peru. Peru also yielded Arica to Chile.

# Antofagasta from the old Nitrate pier



Photo by M. Leybourne

- Atacama Desert was the center for mining of sodium nitrate, which was used in fertilizers and explosives.
- Mining of sodium nitrate was a bonanza that lasted four decades, until synthetic nitrates were produced by German chemists during WWI.
- Export taxes on nitrates often furnished over 50 percent of all state revenues, relieving the upper class of tax burdens. The income of the Chilean treasury nearly quadrupled in the decade after the War of the Pacific.
- The mining bonanza generated demand for agricultural goods from the center and south and even for locally manufactured items, spawning a new wealthy class in Chile.
- As result of losing the war Bolivia become a landlocked nation.



# Chilean Nitrates Today

- The world's primary producer of nitrates is Chile. It produces about 69% of the world's supply of these minerals.
- Mining of nitrates is second to copper as source of income for Chile.
- The huge nitrate industry provides jobs for almost 100,000 people and has a total net profit of \$50 million from a total of \$300 million in sales.
- Nitrates are used for a wide range of purposes. They are used for the production of gun powder and explosives. Nitrates are a vital part of the construction industry, used in mixing and fortifying concrete.

<http://gurukul.ucc.american.edu/ted/nitrate.htm>

# Copper (Cu)

- Element 29
- Latin cuprum: named after the island of Cyprus
- Copper is man's oldest metal, dating back more than 10,000 years. A copper pendant discovered in what is now northern Iraq goes back to about 8700 B.C.
- Copper is extremely ductile metal and has a pleasing color and luster, it takes a high polish, and it forms alloys readily with almost all metals
- Copper conducts heat and electricity better than any other metal except silver.
- The major modern sources of the metal have been the two Americas and Central and Southern Africa.

# Modern uses of Copper

- Most of the copper produced in the world is used in electrical products; Another third is used in metal products such as pipe, tubing, plumbing fixtures, hardware, and machine tool products.
- An average single-family home contains about 450 lbs of copper:
  - 195 pounds - electrical wire
  - 151 pounds - plumbing tube, fillings, valves
  - 24 pounds - plumbers' brass goods
  - 47 pounds - built-in appliances
  - 12 pounds - builders hardware
  - 10 pounds - other wires and tubes
- Most copper is combined with other metals to form more than 1,000 different alloys. Important alloys in which copper is the chief constituent are brasses (copper and zinc), bronzes (copper and tin), and nickel silvers (copper, zinc, and nickel).
- Copper was the second most utilized metal (after iron) until the 1960s when cheaper and more plentiful aluminum surpassed it in world production.

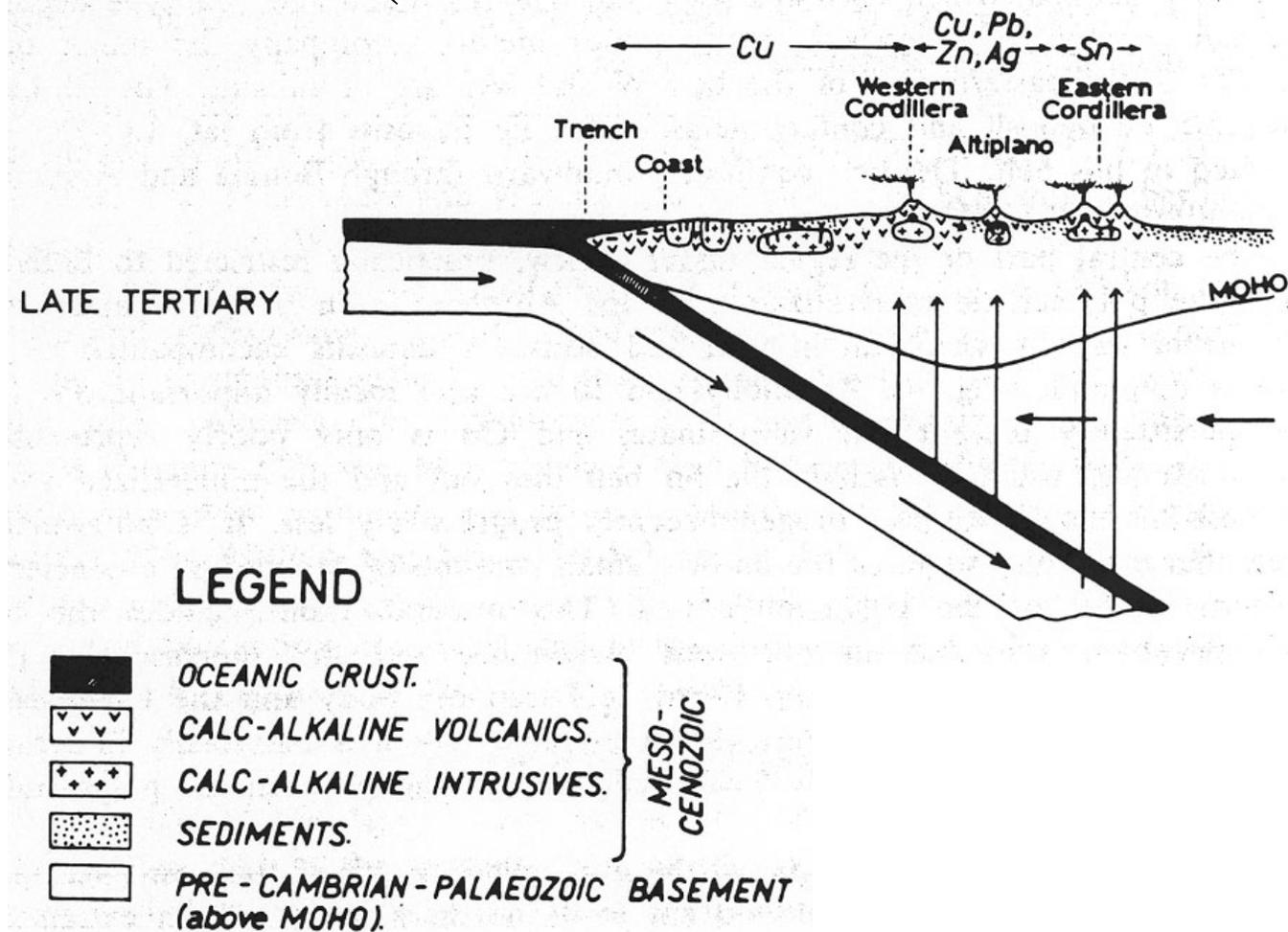
# Chile & Copper

- Copper has played a large role in the Chilean economy since at least 1825, when British and Americans were already competing with other foreign investors to control Chile's copper.
- By 1835, Chile was exporting 12,700 tons of copper a year, much of it to the United States. Copper accounted for 55% of the country's economy by 1860.
- Chile became highly dependent upon its copper exports. After the War of the Pacific (1879-83), the quantity of copper that Chile mined continued to skyrocket.
- Although the demand for copper put Chile at an economic advantage over other nations in the region, its increasing dependence on copper put it at the mercy of the world market. When copper prices dropped or industrial slumps hit Europe, Chile's economy went into a tailspin.

<http://gurukul.ucc.american.edu/ted/copper.htm>

# How the Copper deposits form.

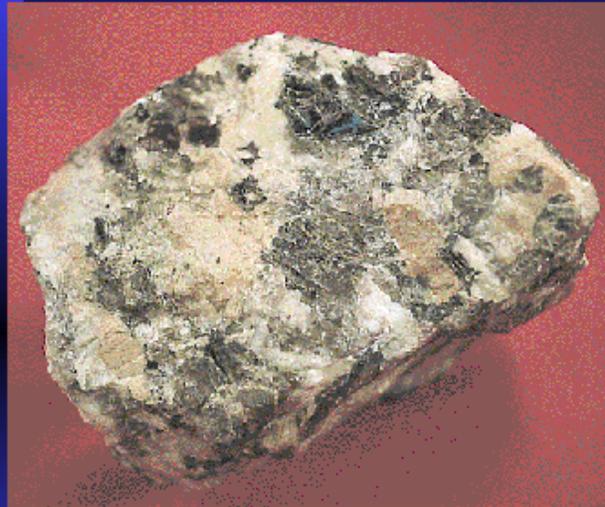
Andean mineral belts reflect different depths to subduction zone (note Cu-belt)



Sillitoe 1976

# Porphyry Copper Deposits: What is a Porphyry?

## Coarse-Grained vs. Porphyritic



Igneous Rocks only!

Porphyritic texture: Big crystals in a fine-grained matrix:  
Typical texture of shallow intrusions

# Importance of Porphyry Copper Deposits

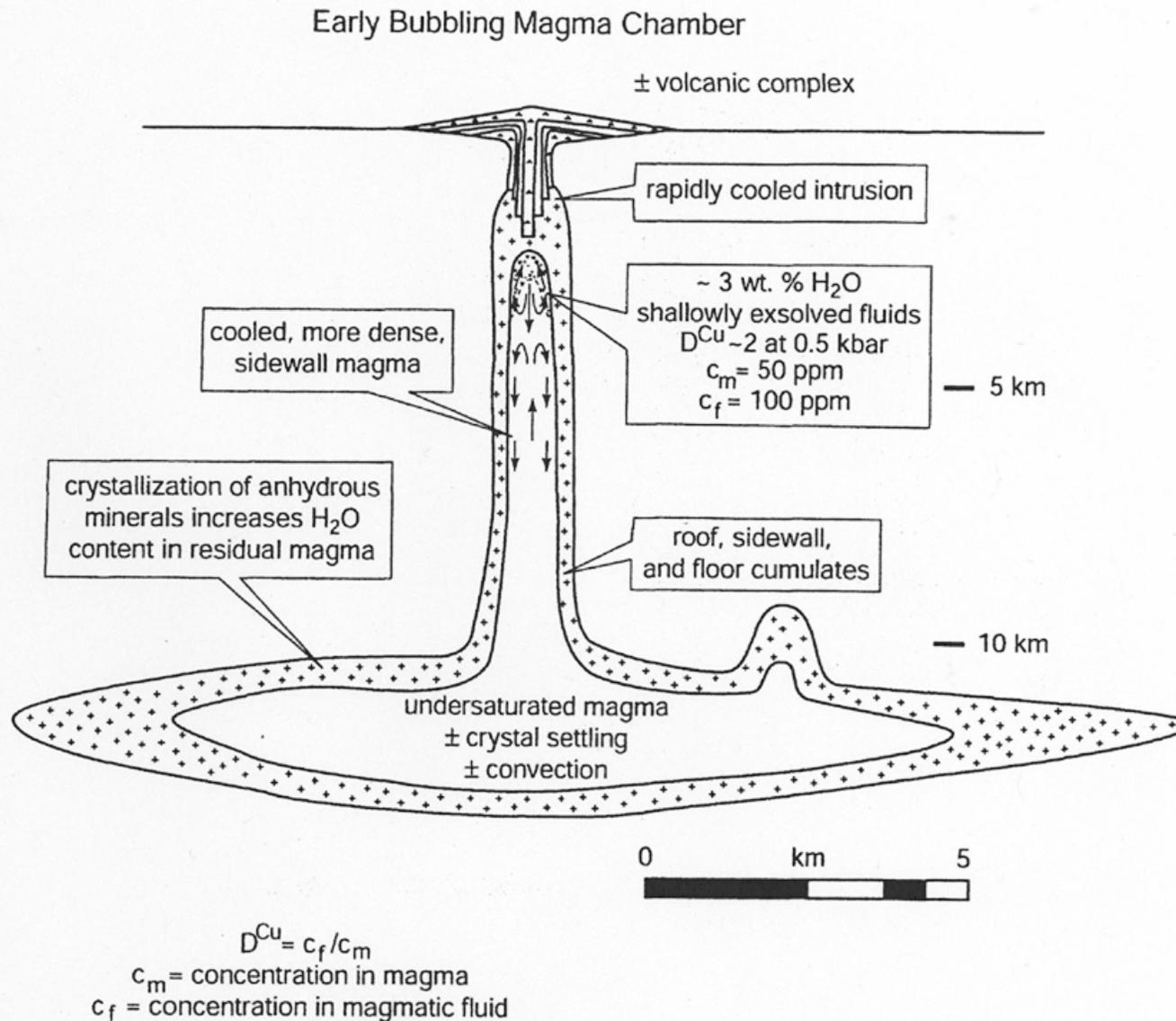
Mineralization of porphyritic intrusive rocks is the world's most important source of copper (and molybdenum) and a significant source of gold.

Porphyry ore deposits form within and adjacent to porphyritic intrusions that are shallow parts of larger intrusions.

Porphyry copper deposits form as a result of magmatic water bubbling out of magma within the upper several kilometers of the crust (think of shaken-up soda)

The intrusions form huge hydrothermal systems of exsolved magmatic fluids with a carapace of convectively circulating meteoric water. This fluid mobilizes metals from several cubic kilometers of magma and concentrates them. Ore minerals precipitate from the fluid upon cooling and interaction with solidified rock.

# Porphyry Copper Deposits form in Shallow Magma bodies



# Copper Mining

- Copper ores fall into two main classes: oxidized ores and sulfide ores. The oxidized ores can be reduced directly to metallic copper by heating with carbon in a furnace. The sulfide ores require a more complex treatment in which low-grade ores must be enriched before smelting begins.
- Sulfide ores are more important commercially. Half of the world's copper deposits are in the form of **chalcopyrite** ore ( $\text{CuFeS}_2$ ).
- Ores are removed either by open-pit or by underground mining. Ores containing as little as 0.15% copper can be mined profitably in open-pit mining, but underground mining is profitable only if an ore contains 6% to 7% copper.

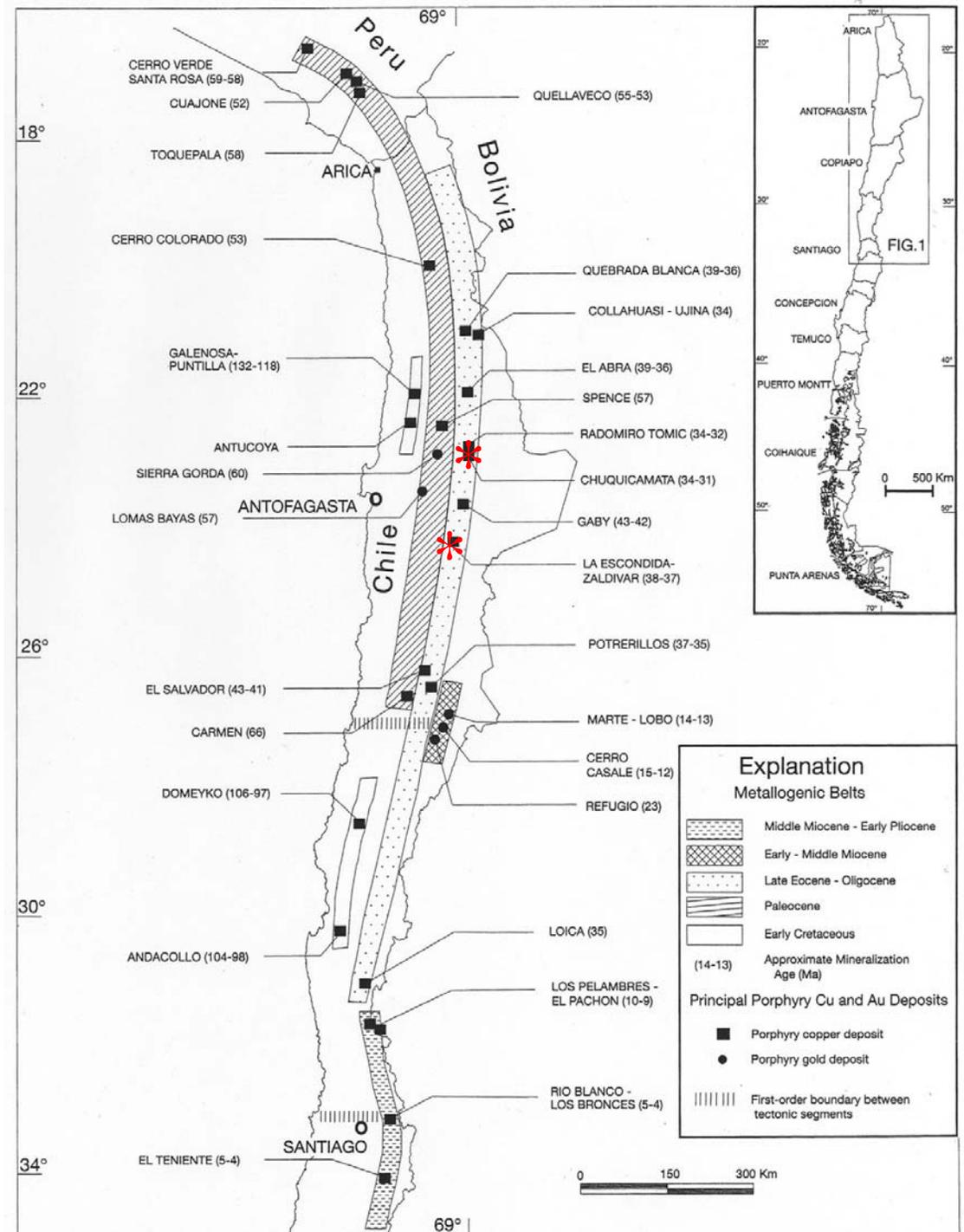
# Global Copper Production

- The U.S. Geological Survey reported that world production of copper in 1998 was 11.9 million metric tonnes, up 4 percent from 1997.
- The world's largest producer of copper is Chile with 1998 production estimated at 3.66 million tonnes (31% of world production).
- The U.S. is the second largest copper producer in the world.

# Metallogenic Belts and Porphyry Copper (and Gold) Deposits

Today there are 20 open pit Cu mines operating in Chile

Camus & Dilles 2001 Econ.Geol.



Note red stars indicating mines to be discussed

# ASTER satellite image of La Escondida Mine

- La Escondida copper, gold, and silver open-pit mine is at an elevation of 3050 m
- Began operation in 1990.
- Current capacity is 127,000 tons/day of ore
- 1999 production totaled 827,000 tons of copper, 150,000 ounces of gold and 3.53 million ounces of silver.
- Primary concentration of the ore is done on-site; the concentrate is then sent to the coast for further processing through a 170 km long, 9" diameter pipe.



# La Escondida Mine



Photo by M. Leybourne

ASTER 3-2-1 satellite image



# Zaldivar Mine



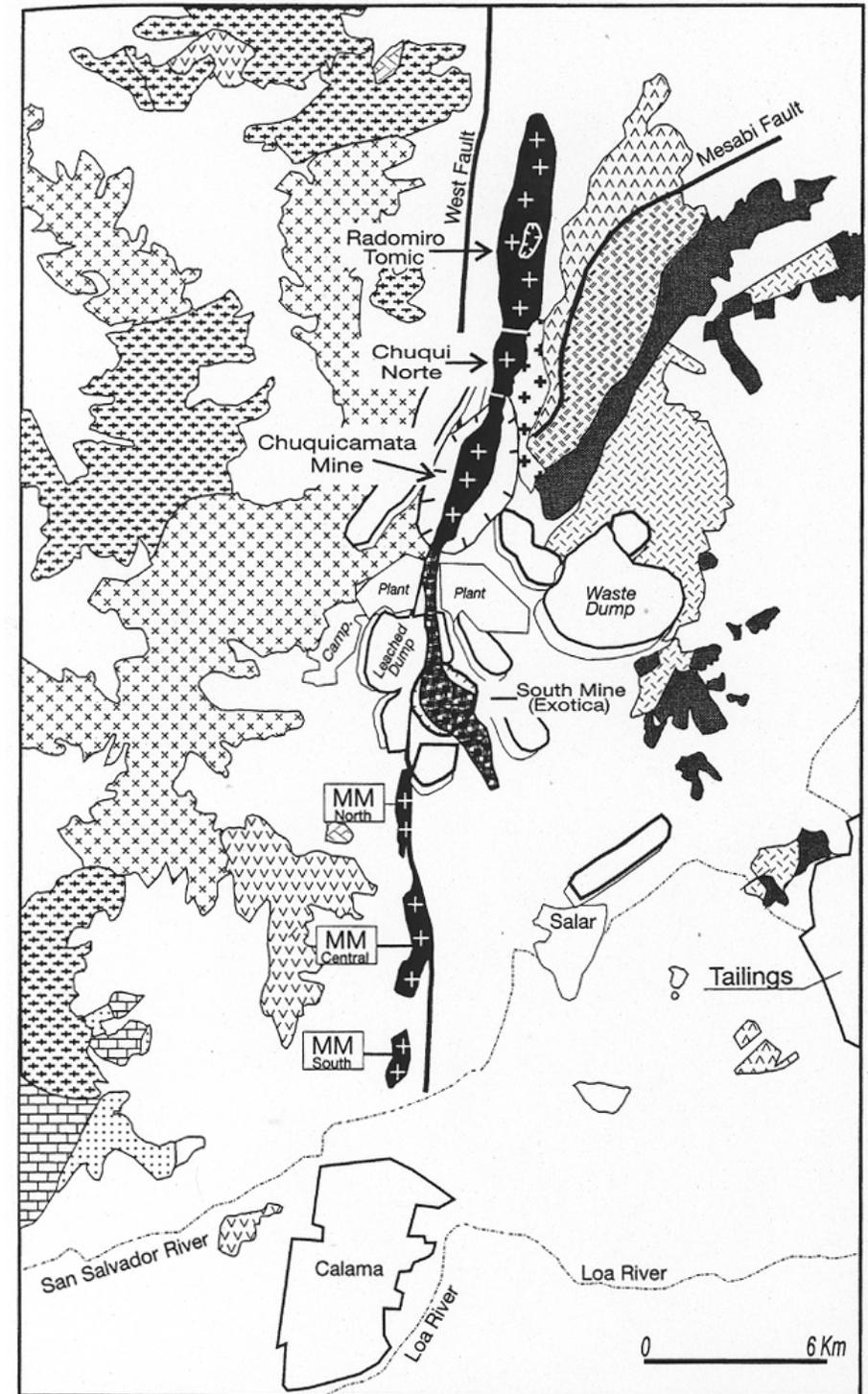
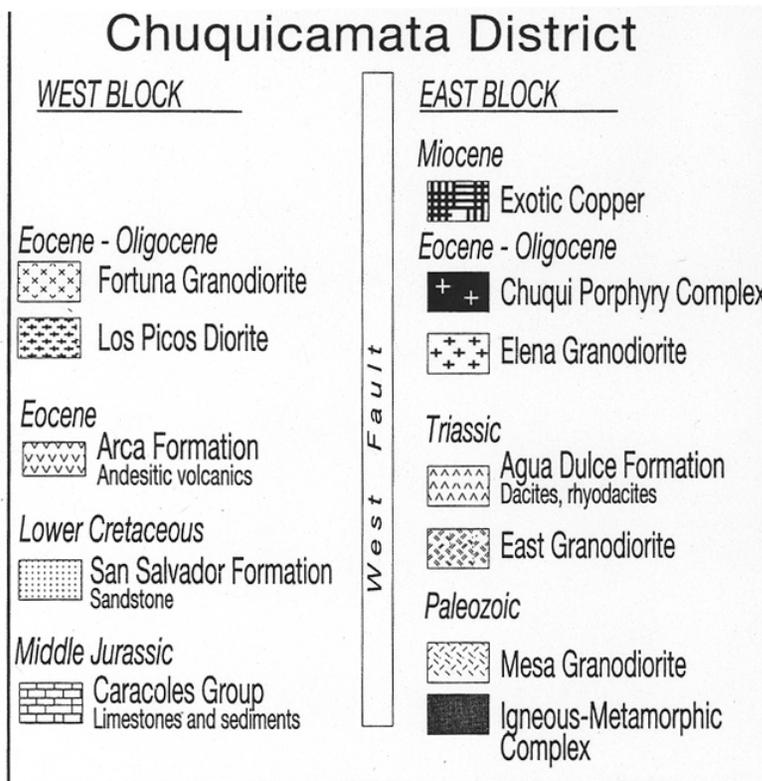
E. Campos, U. Concepcion

Benches are 6m tall

# Chuquicamata

- Chuquicamata is the world's largest and richest open-pit copper mine
- Shortly before nationalization in the early 1970's, an American mine engineering journal called Chuqui “a mine that staggers the imagination... the granddaddy of them all, by itself earning one-third of Chile's desperately needed foreign exchange income each year.”

# Geology of Chuquicamata District



Intrusion emplaced about 35 Ma

Ossandón et al. 2001 Econ. Geol.

# Chuquicamata (cont'd.)

- Mining at Chuquicamata at first depended on burros and Bolivian highland Indians who lived in caves that they dug in the surrounding hillsides.
- It was not until the Guggenheim interests brought in steamshovels from the Panama Canal to dig the huge, stadium-like pit that Chuquicamata was launched into its spectacular career as a contributor to United States corporate balance sheets.
- Today the prodigious task of removing ore and rock from the mine is done with huge machines—200-ton trucks and shovels with a bite of 13 cubic yards.



E. Campos, U. Concepcion

Norman Gall:

[http://www.normangall.com/chile\\_art2.htm](http://www.normangall.com/chile_art2.htm)

# Chuquicamata (cont'd.)

■ 3 km long, 1.5 km wide, 650 m deep

- The pit forms a gray-green elliptical amphitheater, two miles long and one mile wide, graded down toward its ever-deepening bottom by terraced benches 100 feet wide, blasted into existence over the past half-century by dynamite explosions and excavations that have removed 1.2 billion tons

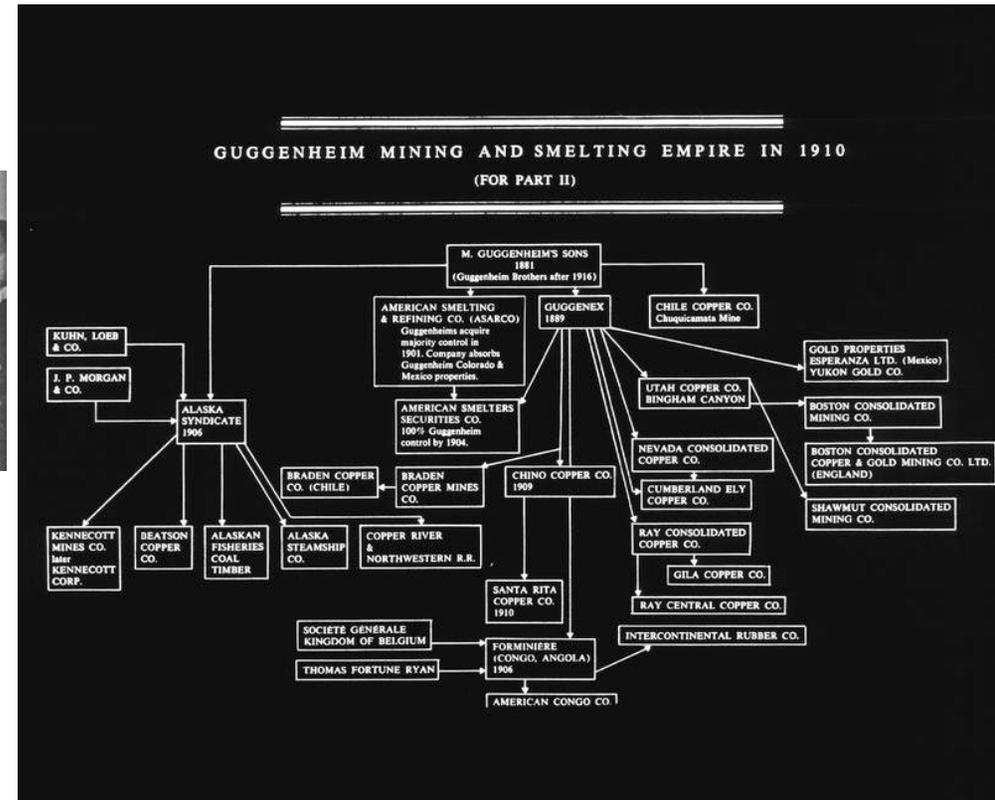
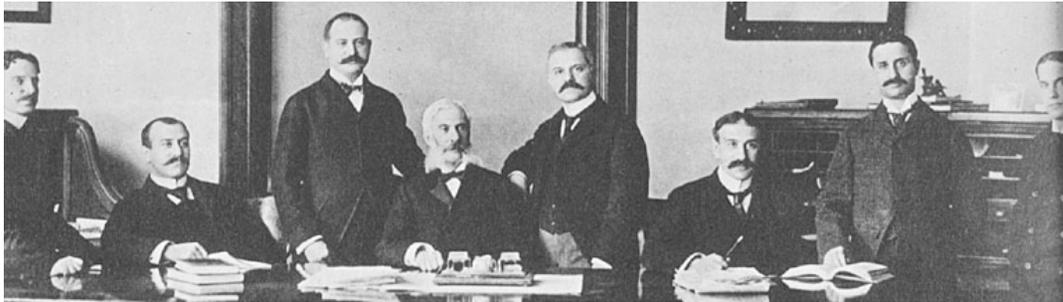


E. Campos, U. Concepcion

# Chuquicamata (cont'd.)

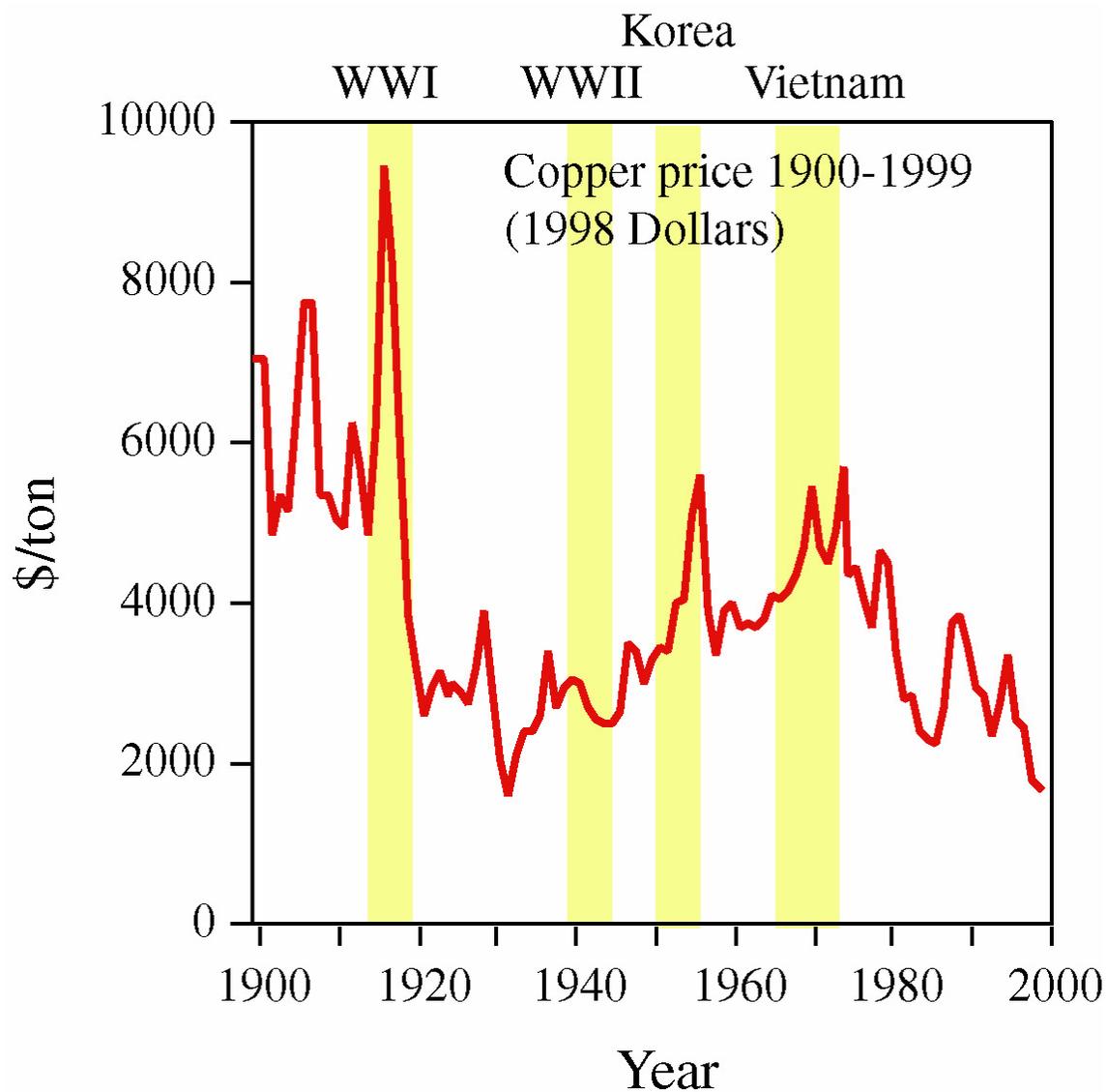
- The Guggenheims sold 51 per cent of Chuquicamata in 1923 for \$77 million to Anaconda, the biggest cash deal in Wall Street history up to that time.

Norman Gall:[http://www.normangall.com/chile\\_art2.htm](http://www.normangall.com/chile_art2.htm)



<http://history.sandiego.edu/gen/soc/guggenheims.htm>

Copper prices  
rose from the  
1940 into the  
mid 1970's



<http://minerals.usgs.gov/minerals/pubs/commodity/copper/>

# Anaconda & Chuquicamata

- Chuquicamata was a “cash cow” for Anaconda.
  - Anaconda made a net investment of only \$93 million between 1930 and 1965 in its two Chile operations—Chuqui and the smaller El Salvador - Potrerillos mine— Chuquicamata alone generated \$810 million in profits in the quarter-century from 1945 to 1969, with 60 per cent of these earnings coming in the 1959-1969 period.
  - In 1967, as the Vietnam War pushed world demand and prices for copper to unprecedented heights, Anaconda’s Chilean operations accounted for \$4.05 of the company’s total earnings per share of \$4.31.

# Nationalization of Chilean Copper Mines

- Nationalization of Big Copper in Chile was the product of a movement gathering strength throughout the 1950's and 1960's and embracing conservative business leaders as well as Marxist and moderate Christian Democratic politicians.
- Outright nationalization followed hard upon the “Chilenization” program of Christian Democratic President Eduardo Frei (1964-1970)
- Chilenization called for Chile government to own 51% of copper mines

# Nationalization of Chilean Copper Mines (cont'd.)

- Chilenization increased Chilean State financial participation in the copper industry and induced the foreign companies to make major new investments.
- Chilenization deals of the mid-1960s and the high copper prices and corporate profits of the Vietnam War period merely fueled the pressures for complete nationalization.
- By 1970 the Chilean treasury was receiving 84 per cent of Big Copper's profits in the form of taxes and stock dividends.
- By 1969 President Frei had announced a “pacted nationalization” of Anaconda's properties providing for 51 per cent government ownership immediately and the right to purchase the remaining stock after 1972.

# Elections of 1970



- The 1970 elections for president were a three-way contest
  - conservative National Party (former president Jorge Alessandri)
  - the left, which formed a coalition called Popular Unity (Unidad Popular, or UP; Salvador Allende of the Socialist Party)
  - The moderate Christian Democrats (Radomiro Tomic)
- Results were:

– Allende (UP)	1,075,616	36.6%
– Alessandri (PN)	1,036,278	35.3%
– Tomic (PDC)	824,849	28.1%
- Allende became the first democratically-elected socialist ruler in world history.

<http://www.hartford-hwp.com/archives/42a/130.html>

# US response to Allende's election

- Nationalization caused an escalation of ongoing U.S. plans to destabilize the Chilean economy.
  - Henry Kissinger, who in a famous quote said: "I don't see why we need to stand by and watch a country go communist due to the irresponsibility of its own people."
- U.S. cut off loans to Chile and blocked World Bank and other sources of money.
  - the U.S. ambassador to Chile remarked: "Not a nut or a bolt will reach Chile.... We will do all in our power to condemn Chileans to utmost poverty").

# Nationalization of Chilean Copper Mines (cont'd.)

- The nationalization of Big Copper was completed in the months following Allende's inauguration.
- By 1971, all parties in the Chilean Congress supported a constitutional amendment retroactively deducting all excess profits above 10 per cent of book value since 1955 from the compensation to be paid Anaconda and Kennecott.
- Acting on a Controller-General's financial assessment, Allende two months later decreed \$774 million in penalties against the two copper companies for excess profits and alleged defects in the planning and execution of their respective mine expansion programs.
- Because these penalties were greater than the book value of the mines, the government claimed that it owed the companies no indemnification.
- There was a national consensus on the nationalization of Chilean copper industry was a good thing.

# Chilean reaction to worsening economy

- As a result of the drop in aid and economic sanctions, Chilean industry ran into problems getting spare parts, technology, and new machinery.
- Inflation returned while shortages of goods occurred.
- Agriculture declined as the land reform disrupted production, and landowners took land out of production.
- Allende did not have a majority in Congress, did not control the judiciary, did not have the loyalty of the entire civil service nor of much of the army high command.

# Chilean reaction to worsening economy (cont'd.)

- Despite inflation and increasing polarization of Chilean society, the UP increased its share of the vote in the March 1973 congressional elections from thirty-six percent to forty-four percent.
- In May the copper miners went on strike
- On June 19 there was an attempted military coup
- On July 29 the truck drivers went on strike
- By 1973 Chile had split into 2 hostile camps

# The Other Sept. 11

- September 11, 1973 a military coup lead by General Pinochet overthrew the government.
- Allende died in the presidential palace.
- His final words, broadcast to the nation, were:
  - “Probably Radio Magallanes will be silenced and the calm metal of my voice will not reach you. It does not matter.... I have faith in Chile and in her destiny. Others will surmount this gray, bitter moment in which treason seeks to impose itself. You must go on, knowing that sooner rather than later the grand avenues will open along which free people will pass to build a better society.”

# Pinochet years (1973-1989)

- A military government, led by General Augusto Pinochet, took over control of the country. The first years of the regime were marked by serious human rights violations.
- A new constitution was approved by a plebiscite on September 11, 1980, and General Pinochet became President of the Republic for an 8-year term.
  - In its later years, the regime gradually permitted greater freedom of assembly, speech, and association, to include trade union activity.
  - The military government pursued decidedly laissez-faire economic policies.
  - Never reversed the nationalization of the copper mines but allowed foreign companies to come back in
- In a plebiscite on October 5, 1988, General Pinochet was denied a second 8-year term as president. Chileans voted for elections to choose a new president and the majority of members of a two-chamber congress.

# Epilogue

- In an interview in Feb. 2003, Secretary of State Colin L. Powell said that encouraging the coup that brought Gen. Augusto Pinochet to power for 17 years was “not a part of American history we are proud of.” reported by Larry Rohter (NY Times 2/25/03)
- Today Chile has a functioning democracy.