International Atomic Energy Agency

IUREP N.F.S. No. 57
August 1977
Distr. LIMITED
Original: ENGLISH

INTERNATIONAL URANIUM RESOURCES EVALUATION PROJECT

I U R E P

NATIONAL FAVOURABILITY STUDIES

PERU

77-7578

INTERNATIONAL URANIUM RESOURCE EVALUATION PROJECT

IUREP

NATIONAL FAVORABILITY STUDY

PERU

CONTENTS

1. INTRODUCTION

(a) Geography

Peru has an area of almost 1,285,215 square kilometers, including about forty small islands near the central coast. The capitol is Lima. The country is divided geographically into several regions. The Costa region is broadest in the north and much narrower southward. It consists of dry, flat coastal plains and the western Andean foothills below the 1,995 meter elevation. The Sierra region consists of three Andean mountain ranges superimposed on a high plateau and connected by numerous ridges that rise from 914 to 1,829 meters above the plateau. The Andes mountains are 96 km. wide at the Ecuador border and widen to nearly 322 km. around Lake Titicaca. They consist of the Cordillera Occidental to the west, the Cordillera Central with its discontinuous ranges in the middle, and the Cordillera Oriental to the east with its low discontinuous ranges and deep river canyons that fringe the Amazon and extend into Bolivia. The lightly populated Selva (or Montaña) comprises about three-fifths of the area of Peru. It lies along the eastern Andes and is characterized by tropical rain forests. Lake Titicaca marks the Peru-Bolivia border. It is over 32 km. high and covers an area of 8,288 sq. km. Peru has frequent devasting earthquakes, floods, tidal waves and landslides.

(b) Climate

The cold Peru current modifies the climate of Costa despite its tropical location, and the mountains are temperate to cold. Most of the rainfall occurs in Peru in the September-March summer period. Areas west of the central cordillera and below 1,524 meters generally receive little rain while areas east of this range have heavy rainfall. The Selva region is hot and humid, with heavy rainfall and cool nights.

(c) Access

Peru has over 48,270 km. of generally unpaved and poorly maintained roads. Half of the country is without roads. Those in the Selva and Sierra regions are frequently impassable because of landslides or washouts from heavy rains. The principal highways are the Pan American which extends for 2,750 km. along the coast, the Central from Lima to Pucallpa, the Longitudinal Sierra, and the Transandean Marginal Highway along the eastern Andes. There are 1,930 km of railroad track. The Central Railroad extends for 492 km. between Callao, Lima, and Huancayo, with links at La Oroya to the 290 km. long Cerro de Pasco railroad, and at Huancayo to the 1,107 km. Huanavelica railway. The Southern Railroad connects ports and cities in the southern highlands. There are 317 airfields and air strips, with international service from Lima. Air transportation is important in Peru due to the deficiencies in road and rail networks and the lack of other modes of transportation in much of the Sierra and Selva. There are 8,688 km. of navigable rivers in the Amazon Basin of Peru but these are little used because of inadequate facilities. Lake Titicaca also serves for water transportation.

2. GEOLOGY IN RELATION TO POTENTIALLY FAVORABLE URANIUM-BEARING AREAS

The existence of Precambrian rocks in Peru is still the subject of considerable debate because of the scarcity of reliable age determinations. Consequently, most of the areas labeled Precambrian on the geological maps of Peru have been assigned this age mainly on the basis of their high degree of deformation and metamorphism. The rocks in question consist mainly of genisses, schists, amphibolites and metavolcanics. On the geological map of Peru at 1:4,000,000 (Bellido, 1969), considerable areas of Precambrian rocks are shown along a belt which generally coincides with the Cordillera Oriental and the eastern slopes of the Andes (the "Marañón - Mantaro - Apurimac - Urubamba geanticline," between 6°S and 13.5°S). Within this belt, the presumed Precambrian rocks commonly interfinger with, or are surrounded by lower and middle Paleozoic schists and shales. Precambrian rocks also are common along the "Coastal Cordillera" from about 15°S to 17°S, from the coast to almost 100 km inland. These rocks, known as the Atico complex, are cut by pegmatite dikes and stocks of red granite which have been dated as Ordovician by the K/A method. The occurrence of low grade iron formations in these rocks further supports their Precambrian age.

The lower and middle Paleozoic sedimentary rocks consist mostly of moderately metamorphosed but intensely deformed black shales with interbedded sandstones and quartzites of Ordovician and Devonian age. They crop out extensively along the aforementioned Marañón-Mantaro-Apurimac-Urubamba geanticline, where they are known as the Excelsior Group in the north (7°S to 12°S) and the Cabanillas Group in the south (12°S to the Bolivian border). Further east (10°S, 74.5°W) they crop out near the Ucayali river as the Contaya Formation. Lower and middle Paleozoic sedimentary rocks also crop out in isolated areas, in cores of domes along the axis of the Andes (5°-6°S, 79°-80°W; Cerro de Pasco; Yauli Dome; Julcani anticline), and in the Coastal Cordillera.

The upper Paleozoic sedimentary rocks cover the lower/middle Paleozoic units with a pronounced unconfirmity and comprise the following groups:

Mitu	Upper Permian	continental sandstones, shales and conglomerates ("red beds") interbedded with purple, brown and green pyroclastic rocks and lava flows

- - - - - - - - - - - - - strong unconformity - - - - - - - - - - - - - - - - -

Copacabana	Lower Permian	grey and black limestones with interbedded shales
Tarma	Pennsylvanian	black or grey shales and limestones
Ambo	Mississippian	continental grey and black carbonaceous shales with interbedded sandstones, quartzites, volcanic rocks and coal seams

Large areas underlain by upper Paleozoic sedimentary rocks occur along the Marañón-Mantaro-Apurimac-Urubamba geanticline from Chachapoyas to the Bolivian border, at 4°S, 80.5°W; 6°S, 81°W; 9.5°-11.5°S, 74°-75°W; and at isolated points along the Coastal Cordillera (15°-17°S).

Although small areas of Paleozoic intrusive rocks occur in the Coastal Cordillera (16°S, 74°W to 17°S, 72°W), the bulk of the Paleozoic (perhaps also Precambrian) intrusives are scattered along the Marañón-Mantaro-Apurimac-Urubamba geanticline (6.5°S, 78°W; 8°S, 77°W; 10°S, 76°W to 12°S, 74°W).

Mesozoic sedimentary rocks crop out extensively along three longitudinal belts: (1) along the coast; (2) along the axis of the Andes (5°S, 79°W - Cajamarca-Cerro de Pasco-Huancayo-Huancavelica-Cuzco-Lake Titicaca); and (3) in a sub-Andean belt (4°S, 78°W - Moyobamba - 13.5°S, 69°W). Along the coast, the Mesozoic sediments have a strong volcanogenic component. In the first two belts, the sediments are predominantly marine (commonly limestone), except for the lower Cretaceous, when sandstones and quartzites were deposited with some intercalated "red beds" and coal seams (Chimú and Carhuaz Formations, Goyllarisquizga Group, Marcavilca Formation, Yura Group, Murco and Huancané Formations). Along the sub-Andean belt, the sediments are mostly of Jurassic and Cretaceous age and of continental character. This gradual change in depositional environment from west to east across the Mesozoic Andean geosyncline is well represented on the generalized stratigraphic columns of Bellido (1969).

Sedimentation in the Andean geosyncline came to an end during the upper Cretaceous, and erosion of the emerging lands produced a prominent series of red beds (locally known as Pocobamba, Casapalca or Chota Formations and the Puno Group) extending from the continental divide toward the east. The age of these red beds is generally considered to be early Tertiary. Although sporadic igneous intrusion had occurred during the Mesozoic, the bulk of the igneous activity started in the upper

Cretaceous and continued into the early Tertiary with the intrusion of numerous stocks which coalesced to form the Andean or Coastal batholith (Cobbing and Pitcher, 1972). This batholith is exposed continuously from Trujillo (8°S, 70°W) to about 100 km southeast of Ica (15°S, 75°W), but it is evident that it extends at shallow depth and is exposed at places northward to the border with Ecuador (3°S, 80°W) and southward to Chile (18°S, 70°W).

During the Tertiary, marine sedimentation continued within isolated basins along the coast while igneous intrusion and volcanism prevailed along the Andes, and a thick red-bed series accumulated to the east in the sub-Andean region. The largest basin of Tertiary marine sedimentation stretches from Tumbes to the Chira river and has been the most important source of oil production for Peru. Shallower marine basins occur in the Sechura desert (south of Piura), southwest of Ica (14°S, 76°W) and in Camaná (16.5°S, 73°W). Along the southern coast, south of 16°S, the rising Andes also provided material for extensive continental Tertiary sediments (Moquegua Formation). The volcanism along the Andes produced mostly lava flows, breccias, agglomerates and tuffs (including ash-flow tuffs). The composition of these volcanic rocks is predominantly andesitic, although rhyolitic, dacitic and trachiandesitic rocks may be locally common. They crop out almost continuously from the border with Ecuador (4°S, 80°W) to the borders of Bolivia and Chile (17°S, 69°W to 18°S, 70°W). At the same time, several thousand meters of red beds accumulated to the east, in the sub-Andean region (Huayabamba and Chiriaco Formations, Contamana Group), interrupted only in the northern part during the Oligocene by a marine or brackish water invasion (Pozo Formation).

3. PAST EXPLORATION

In 1953 a joint program of exploration by the U.S. Atomic Energy Commission (USAEC) and the Junta de Control de Energía Atómica del Peru (JCEA) was organized to examine, as a first phase, museum specimens and mill concentrates. During four years this project revealed 43 radioactive samples and pointed to 17 mines as potential sources of uranium. Three of these mines, Sayapullo, Colquijirca and Jesus María, appeared sufficiently promising to warrant further investigation.

In 1957 the emphasis was placed on mine examinations. Of 236 mines and prospects examined, 20 revealed abnormal radioactivity. As a consequence, Vilcabamba, Sayapullo, Colquijirca, Eliana and Parag were examined in greater detail but eventually were rejected as uneconomic sources of uranium.

During 1956 and 1957 continuous radiometric profiles were made along the main roads of Peru with a scintillation counter adapted to a jeep, but no strong anomalies were detected. Following this, it was decided to examine areas which are not associated with metallic hydrothermal deposits:

1. Poorly sorted continental sediments with organic matter, particularly red beds. No strong anomalies were found.

2. Favorable structures. None of these investigations found anomalous radioactivity.

3. Petroleum fields. Two oil fields, La Brea y Pariñas in northwest Peru and Pirín near Lake Titicaca, gave negative results. However, in 1959 anomalous radioactivity was detected in thermal springs and altered red beds over the Aguas Calientes dome.

4. Asphaltic and bituminous shales along the continental divide in the departments of Lima and Junin. Only traces of uranium were found.

5. Igneous intrusions. The coastal batholith was found not to be abnormally radioactive. Its contact zone was studied, also with negative results, in several areas. Similarly, various intrusive stocks in the Olmos region and in the provinces of Ayabaca, Huancabamba and Piura (all in northern Peru) gave negative results. On the other hand, along the central and eastern portions of the Andes various stocks of pink granite were found to contain radioactivity measuring four times background.

6. Regionally metamorphosed rocks were examined in 1957 in the Chala-Atico region, but only small concentrations of radioactive minerals were found in a lens of granitic gneiss and in a granitic pegmatite.

7. Upper Tertiary lake beds of the Ayacucho basin were examined in 1957, also without finding anomalous uranium concentrations.

8. Two rhyolitic tuffs were found to contain up to four times background radioactivity: one near Cañete (department of Lima) and one near Tambo Quemado (department of Ayacucho).

During 1971 and 1972 limited scale radiometric airborne surveys were conducted under the technical guidance of the IAEA.

4. URANIUM OCCURRENCES AND RESOURCES

The AEC-JCEA joint program involved 6 1/2 years of work by competent experts. Although uranium was detected in a number of deposits, no commercial discoveries were made. Most of the uranium found was associated with silver, copper, lead and zinc. Companies operating these deposits have consistently refused to recover the small amount of uranium present, partly because of the fear of expropriation.

One of the more interesting discoveries was the recognition of uraninite associated with cobalt-nickel-copper mineralisation at Vilcabamba, La Convención Province. Following the discoveries, the province was withdrawn from denouncements for uranium and claims were staked by JCAE. Subsequently exploration was then carried out by the JCAE but with apparently unpromising results.

In 1974 the JCEA announced reserves of 700 tons of 0.3% U_3O_8 ore at the Colquijirca mine (Cerro de Pasco province). The radioactivity at this locality had initially been detected in 1953 by the AEC/JCEA joint program.

At almost the same time, in 1974, the JCEA announced "probable Peruvian uranium reserves of about 180,000 metric tons" (La Prensa newspaper, January 30, 1974). All indications suggest that this is a much inflated figure.

5. PRESENT STATUS OF EXPLORATION

Limited available information suggests that current exploration activities are at a low level. This may reflect, in part, the restrained interest by private companies which appear to have an almost paranoic obsession against finding radioactive minerals on their properties for fear they might be "nationalized in the public interest."

Mines and other natural resources generally are vested in the state. The Atomic Energy Control Board regulates all matters relating to radioactive materials. Foreign citizens and corporations may obtain exploration concessions for 2 years and exploitation concessions of indefinite duration. Radioactive substances may be extracted during exploration only if needed to prove a deposit.

6. AREAS FAVORABLE FOR URANIUM AND POTENTIAL FOR NEW DISCOVERIES

Inasmuch as exploration since 1952 has been largely unsuccessful it might be concluded that the chances for finding commercial uranium ore in Peru are small.

Although copper and vanadium deposits have been found in Peru, both in the Permian Mitu and in the Tertiary red beds, no uranium mineralization has been located to date in this environment, even though uranium deposits have been discovered in similar sediments in Bolivia. It may be concluded therefore that the general geochemical conditions in red beds of the Peruvian Cordillera lead to copper and vanadium enrichment, but are not conducive to uranium accumulation.

Nevertheless, there is still justification for prospecting further for uranium in Peru within arkosic or quartzitic sandstones containing organic matter of plant origin or other reductants and formed under fluvial, eolian, lacustrine or marginal marine conditions. Such rocks are widely represented throughout Peru and their distribution can be appreciated on the 1:4,000,000 geological map (Bellido, 1969) because they constitute the bulk of the areas labeled "c" as continental sedimentary rocks. Specifically, the following targets can be identified in this category:

1. Mitu Group (Permian)
2. Cercapuquio Formation (middle Jurassic)
3. Sarayaquillo Formation (upper Jurassic)
4. Carhuaz Formation (lower Cretaceous)
5. Farrat Formation (lower Cretaceous)
6. Goyllarisquizga Formation (lower Cretaceous)
7. Murco Formation (lower Cretaceous)
8. Muni Formation (lower Cretaceous)
9. Huancané Formation (lower Cretaceous)
10. Huanca Formation (middle-upper Cretaceous)
11. Moho Group (middle-upper Cretaceous)
12. Yuncaypata Formation (middle-upper Cretaceous)
13. Cotacucho Formation (upper Cretaceous)
14. Muñani Formation (upper Cretaceous)
15. Areniscas de Azucar Formation (upper Cretaceous)

16. Tertiary red beds (Chota, Pocobamba, Casapalca Formations - upper Cretaceous to lower Tertiary)

17. Huayabamba Formation (Tertiary)

18. Chiriaco Formation (Tertiary)

19. Contamana Group (Tertiary)

20. Puno Group (Tertiary)

21. Moquegua Formation (Tertiary)

These objectives can be ranked further by considering the following factors:

1. Association with known oil fields, particularly in the sub-Andean region.

2. Presence of reducing organic matter;

3. Interfingering of oxidized and reduced facies;

4. Optimum sandstone:shale ratios (between 4:1 and 1:1);

5. Regional dip;

6. Presence of acid volcanic tuffs;

7. Association with granitic intrusions or rhyolitic tuffs containing abnormal concentrations of uranium.

The best strategy would be to select first the areas containing the continental and marginal marine sandstones and arkoses listed earlier, and subsequently to launch a program to determine the uranium content of the intrusives and acid volcanic rocks in their vicinity. Exploration can then focus on areas with a favorable combination of uranium-rich source rocks, oxidizing or "neutral" sediments to serve as conduits for uranium transport, and reducing environments for precipitation of uranium. Probably the best way to select these favorable regions for more detailed examination is to study the 1:100,000 scale geological maps being published by the Servicio de Geología y Mineria.

In view of the conspicuous lack of exploration success to date, and notwithstanding the JCEA estimate of 180,000 tonnes of uranium in reserves, the potential resources of Peru are estimated to be in the range of 1,000 to 10,000 tonnes uranium metal.

7. BIBLIOGRAPHY

Bellido B., Eleodoro, 1969, Sinopsis de la geología del Peru. Serv. de Geol. y Min., Vol. 22, 54 pp., 1 map, Lima, Peru.

Cobbing, Edwin John and Pitcher, Wallace Spencer, 1972, The coastal batholith of central Peru. J. Geol. Soc. London, vol. 128, pp. 421-460.

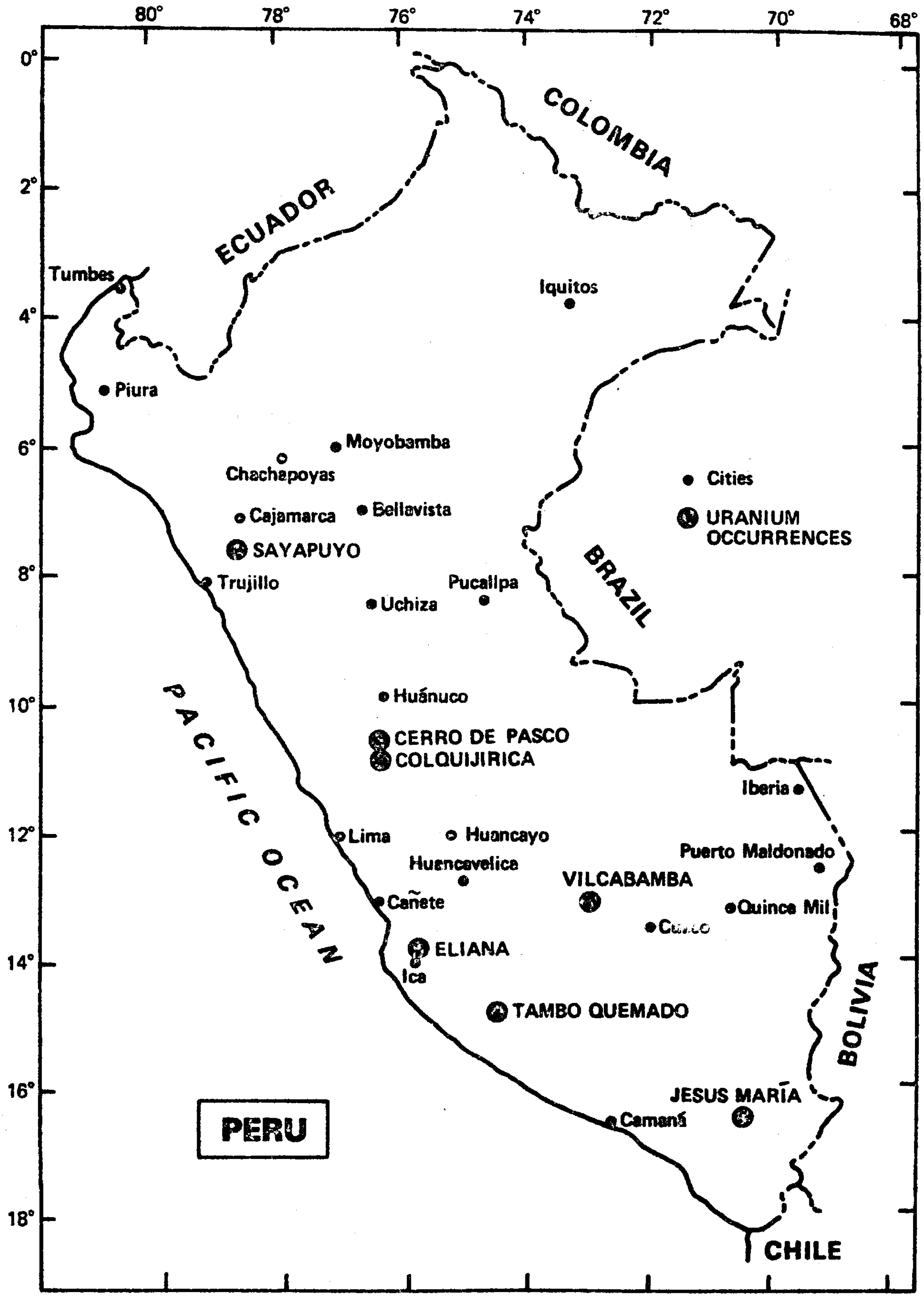
Gabelman, John W. and Beard, Raymond R., 1962, Uranium in Peru, U.S. Atomic Energy Comm. RME-4581, 162 pp.

Compiled by USERDA

August 1977

I would agree with this estimate though I would appreciate the potential being closer to the upper limit.

A geological map would have been useful mainly to determine possible source rock areas.


80°
78°
76°
74°
72°
70°
68°
0°
2°
4°
6°
8°
10°
12°
14°
16°
18°
COLOMBIA
ECUADOR
Tumbes
Iquitos
Piura
Moyobamba
Chachapoyas
Cities
Cajamarca
Bellavista
URANIUM OCCURRENCES
SAYAPUYO
BRAZIL
Trujillo
Pucallpa
Uchiza
Huánuco
PACIFIC OCEAN
CERRO DE PASCO
COLQUIJIRICA
Iberia
Lima
Huancayo
Puerto Maldonado
Huancavelica
VILCABAMBA
Cañete
Quince Mil
ELIANA
Ica
BOLIVIA
TAMBO QUEMADO
JESUS MARIA
PERU
Camaná
CHILE