

*Field Guide*  
**Geology of the Cordillera Principal**

*Guía de Campo*  
**Geología de la Cordillera Principal**

Victor A. Ramos



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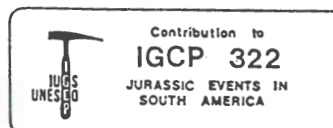
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*This guide was prepared for the 4th International Congress on Jurassic Stratigraphy and Geology (Neuquén-Mendoza, October 15-27, 1994).*



## Prefacio

La Dirección Nacional del Servicio Geológico y la Asociación Geológica Argentina han considerado de utilidad la publicación de Guías de Campo de alcance regional, dedicadas a mostrar en el terreno el conocimiento geológico y temático de una región determinada.

La actividad geológica se basa, fundamentalmente, en el registro e interpretación de las observaciones que se realizan de la corteza terrestre. Tal actividad se expresa mediante mapas, gráficos y textos, cuyo grado de detalle suele guardar relación con la superficie abarcada. Debido a ello, la geología de áreas extensas usualmente se presenta en publicaciones de tipo general, donde la información detallada es escasa o se halla ausente.

Una excepción la constituyen las llamadas Guías de Campo, que ofrecen síntesis de carácter regional sobre un tema geológico determinado, ejemplificadas con descripciones e ilustraciones precisas de aquello que se observa en el terreno, en localidades representativas y accesibles.

De esta manera, las Guías de Campo posibilitan el estudio directo de una región (y temática) específica. Tal facilidad resulta de suma utilidad, no sólo para estudiantes avanzados o graduados recientes en geología, sino también para profesionales de experiencia y especialistas, pues son éstos quienes contrastan las interpretaciones a las que los ejemplos elegidos se suponen fundamento.

Particularmente útiles resultan las guías referidas a regiones donde existe un buen conocimiento geológico, tal como sucede con el Jurásico del centro - oeste de la Argentina.

En tal sentido, ha resultado oportuno que, en ocasión del 4th International Congress on Jurassic Stratigraphy and Geology (Neuquén - Mendoza, 15-27 de octubre de 1994), se hayan preparado tres guías de campo en las que se muestra, ejemplificado con perfiles seleccionados, el grado de avance del estudio del Jurásico de la Cuenca Neuquina. Una de estas guías es la presentada aquí por la Dirección Nacional del Servicio Geológico y la Asociación Geológica Argentina.

## Foreword

The Mining Secretary of the Argentinian Government and the Geological Society of Argentina both value the publication of regional field guides in order to illustrate the state of geological knowledge of selected areas.

A principal component of geological activities is based on field records and observations and their interpretational summary in the form of maps, accompanying text and diagrams. The degree of detail of the information is directly related to the size of the area concerned; large areas are usually dealt with as regional synthesis. Field guides, however, are an exception where this regional geological synthesis is augmented by detailed and precise description and illustration of field observations.

Field guides, therefore, facilitate the study of both specific geographical regions and specialised subjects, and as such they are invaluable to senior undergraduates, postgraduates, experienced professionals and specialists alike. Field guides dealing with renowned geological areas, such as the Jurassic of west-central Argentina are particularly valuable.

It is timely, therefore, that three field guides prepared for the 4th International Congress on Jurassic Stratigraphy and Geology (Neuquén-Mendoza, October 15-27 1994) demonstrate on the basis of selected sections, the present state of our knowledge of the Jurassic of the Neuquén Basin. One of the guides is now published jointly by the Mining Secretary and the Geological Society of Argentina.

*Roberto F.N. Page*  
Director Nacional

Dirección Nacional del Servicio Geológico

*Alberto C. Riccardi*  
Presidente

Asociación Geológica Argentina

# CONTENTS

<b>INTRODUCTION</b> .....	7
<b>BRIEF REVIEW OF THE HISTORY OF GEOLOGIC EXPLORATION</b> .....	9
<b>MAJOR GEOLOGICAL PROVINCES</b> .....	11
<b>Frontal Cordillera</b> .....	11
<b>Principal Cordillera</b> .....	11
<b>Coastal Cordillera</b> .....	13
<b>MODERN PLATE TECTONIC SETTING</b> .....	15
<b>ANDEAN TECTONICS</b> .....	17
<b>ITINERARY</b> .....	19
<b>Stop 1- The Andes thrust-front</b> .....	19
<b>Stop 2- Potrerillos</b> .....	19
<b>Stop 3- Río Picheuta</b> .....	20
<b>Stop 4- Cerro Penitentes</b> .....	21
<b>Stop 5- Puente del Inca</b> .....	21
<b>Stop 6- Quebrada de los Horcones</b> .....	25
<b>Stop 7- Paramillo de Las Cuevas</b> .....	25
<b>Stop 8- Las Cuevas</b> .....	27
<b>Stop 9- Agua de La Zorra</b> .....	27
<b>REFERENCES</b> .....	29

# INTRODUCTION

The present field trip provides the opportunity to visit the Central Andes, in one of the classic sections. The objective of the trip is to study one of the most complete traverses of the Andes, and to observe the geological characteristics of the Mesozoic, mainly the Middle to Late Jurassic deposits.

The Andes is a non-collisional orogenic belt that reaches elevations over 7 km (the highest mountains of the Western Hemisphere). These mountains are in an area of no present volcanic activity, and therefore the Mesozoic deposits are observed directly without an important Late Cenozoic cover.

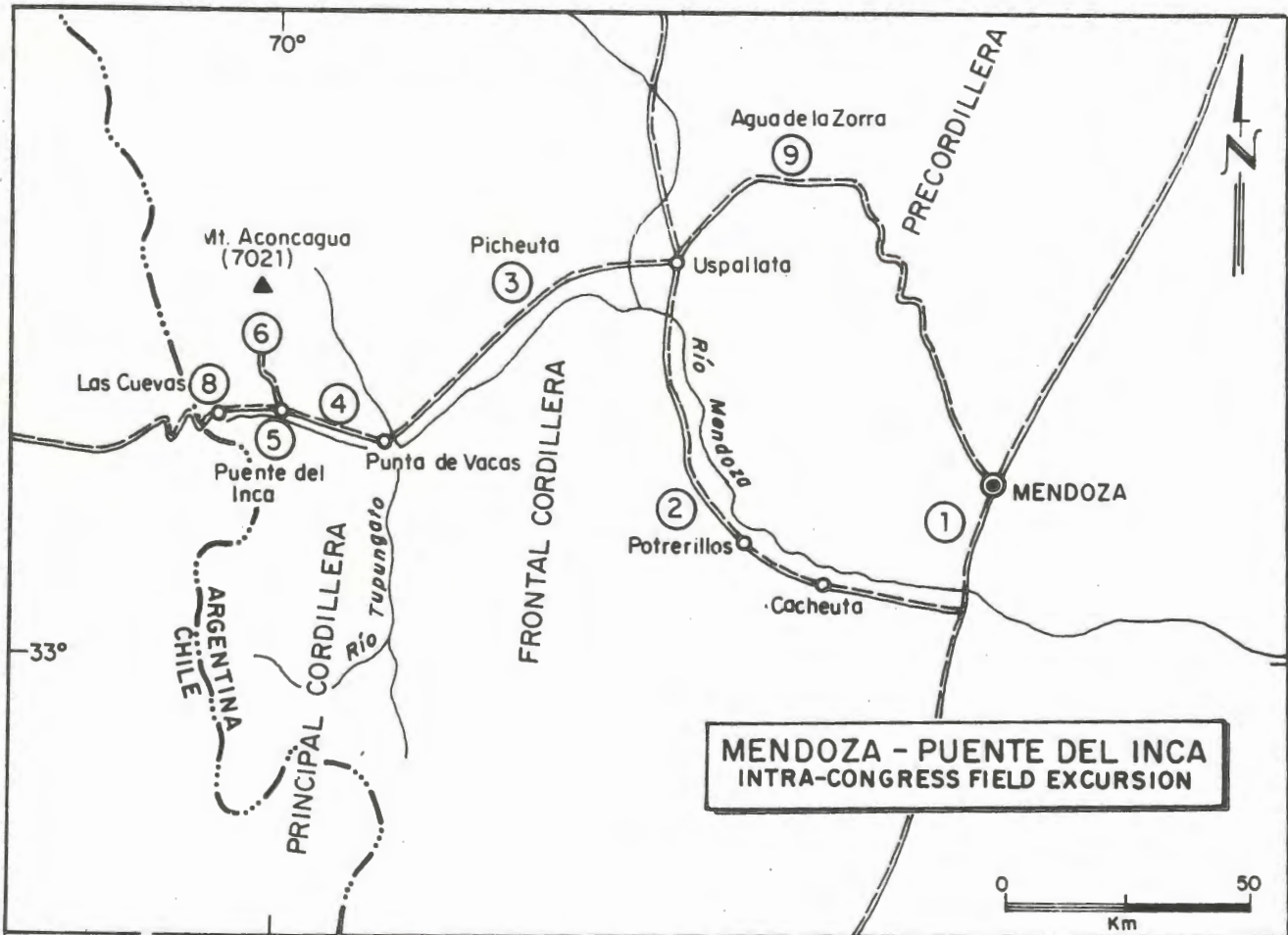


Figure 1: Road map from Mendoza to Las Cuevas.

V. A. Ramos

The route as chosen, will show the different geological components of the Argentine Frontal and

Principal Cordilleras as well as the Cuyo Precordillera. The field trip road is in figure 1.

## BRIEF REVIEW OF THE HISTORY OF GEOLOGICAL EXPLORATION

The geological understanding of the Central Andes started with the pioneering explorations of Charles Darwin in 1835, who was the first to describe the marine Mesozoic deposits deformed by faulting (figure 2 a) along the present road that crosses the High Andes. We are going to have the opportunity to examine the profile described by Darwin, and the mountain shelters where Darwin stayed during his mountain crossing.

Several German naturalists were sent by the Argentine National Academy of Sciences and the Museo de La Plata, to explore geologically the High Andes of San Juan and Mendoza. The early

observations of German Burmeister in 1857-1858, the structure outlined by Stelzner (1873) and the descriptions of Wherli and Burckhardt in 1897, presented the concept that the Andes were a relatively simple mountain chain without the thrusts and overthrusts, known in other mountain chains at that time.

Later in 1906 and 1907, Walter Schiller, a young geologist and mountain climber working for the Argentine Geological Survey conducted the first reconnaissance of the region. As a result of his work, many structural complexities and important thrusting were recognized (Schiller 1912) (figure 2 b).

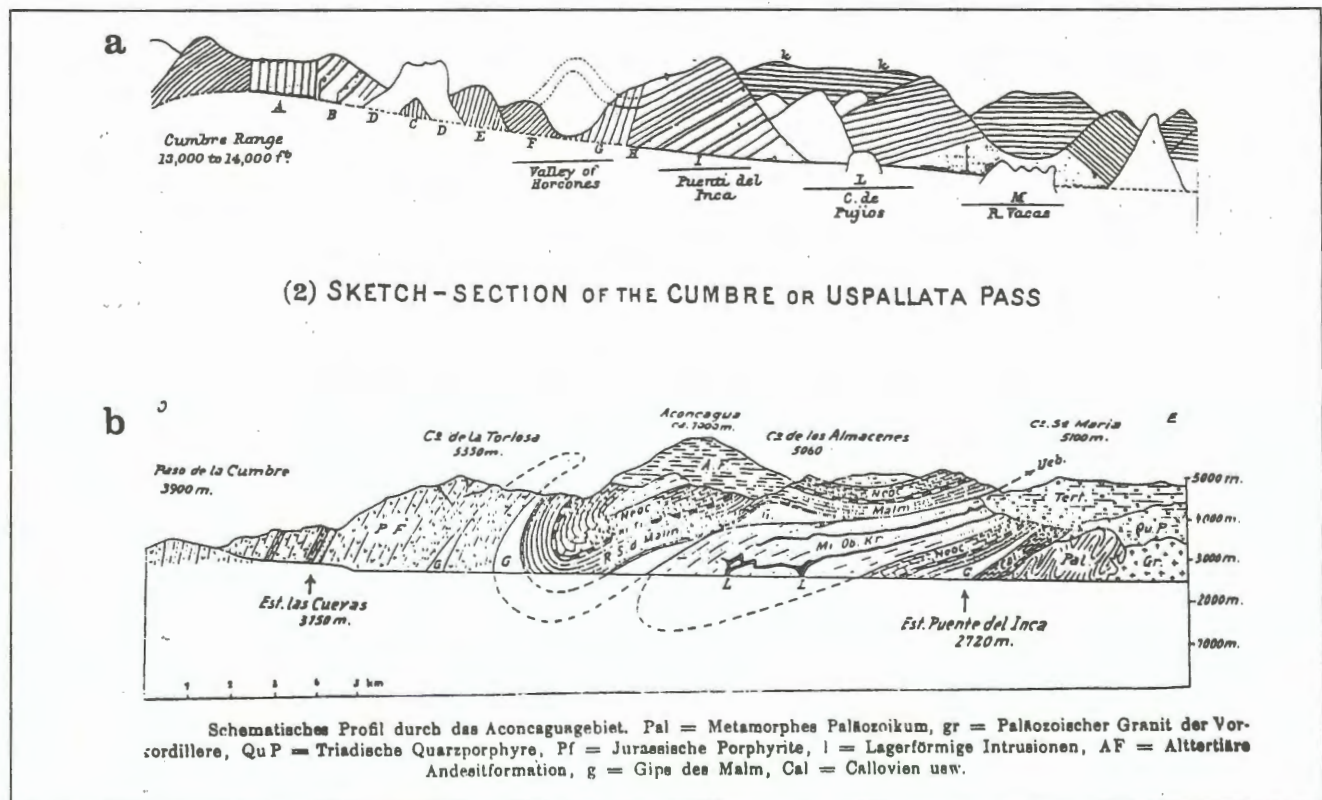


Figure 2: a) Sketch section of Puente del Inca after Darwin (1846), view to the south. b) Section of Puente del Inca by Schiller in Gerth (1926), view to the north.



## MAJOR GEOLOGICAL PROVINCES

This segment of the Central Andes has been divided into a series of morphostructural units or geological provinces based on structural styles, geological evolution, and morphological expression. These units are depicted in figure 3, and a short outline of the geology of the Frontal, Principal, and Coastal Cordilleras is provided here.

### FRONTAL CORDILLERA

The Frontal Cordillera is composed of units that formed during the Gondwanides orogeny in the Late Palaeozoic to early Mesozoic. These units result from Andean-type subduction, followed by generalized extension. Most of the rocks of this province are Late Palaeozoic-Triassic andesitic to silicic magmatic rocks of the Choiyoi Group (Caminos 1979). During the Andean deformation the Frontal Cordillera behaved as a rigid block, as shown by the presence of thick-skinned thrusts (Polanski 1959). Table I summarizes the stratigraphy of the Frontal Cordillera.

Scattered exposures of the pre Late Paleozoic basement of this province occur in Argentina and Chile. They consist of low to medium-grade metamorphic rocks of Latest Proterozoic to Early Cambrian age. The Early Palaeozoic is represented by isolated outcrops of Siluro-Devonian marine limestones which are covered by widespread Carboniferous-Early Permian turbidites. This Late Palaeozoic facies contrasts with the littoral facies of the Precordillera to the east (Caminos 1979).

Volcanic activity started in the Early to Middle Carboniferous with subduction related andesites, dacites and rhyolites. A subsequent period of generalized extension from Middle Permian to Early

Triassic times resulted in the thick pile of Choiyoi rhyolites, and associated granites (Kay et al. 1989; Llambías and Sato 1990). These volcanic rocks which reach thickness of up to 2-4 kilometers in Cordillera del Tigre unconformably overlie the older rocks. Deformation of the Carboniferous-Early Permian rocks occurred in the middle Permian San Rafael orogenic phase (Ramos 1988).

The boundary between the Frontal Cordillera and the Precordillera was the locus of Triassic rifting which is associated with up to 2 kilometers of synrift deposits, and scattered alkaline basalts (Ramos and Kay 1991).

### PRINCIPAL CORDILLERA

The Principal Cordillera, or Main Andes, was the locus of the Andean orogeny during latest Mesozoic and Cainozoic times. Jurassic and Cretaceous marine deposits were deformed in different styles depending on the extent of participation of the basement in the deformation. In the northern sector, a thick-skinned tectonic style is described by Moscoso and Mpodozis (1988), while to the south thin-skinned structures such as in the Aconcagua fold and thrust belt developed (Yrigoyen 1976, 1979; Ramos and Yrigoyen 1987; Ramos 1988). Table II summarizes the stratigraphy of the Principal Cordillera.

A thick sequence of marine Mesozoic deposits unconformably overlies the Carboniferous flysch and the Choiyoi volcanics of the Frontal Cordillera. Several sedimentary cycles are recognized from the Early Jurassic to the Early Cretaceous (Groeber 1946; Legarreta and Gulisano 1989). These cycles begin with black shales, sandstones and limestones and

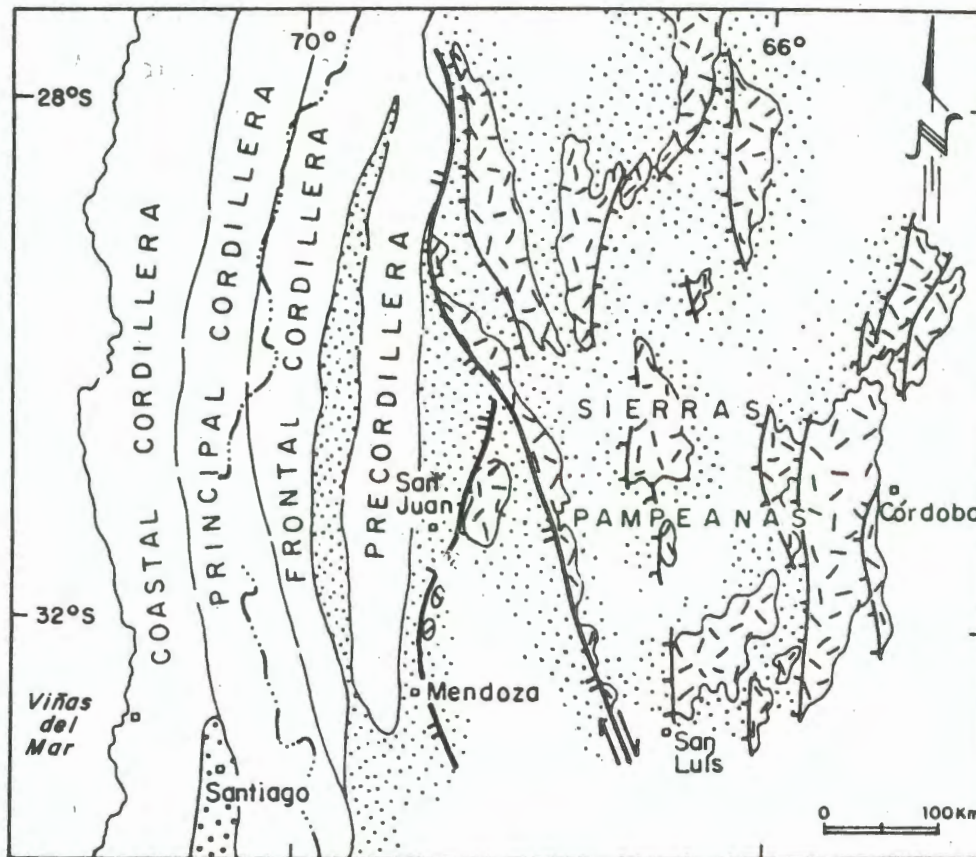


Figure 3: Major morphostructural units of the Central Andes (31°-34° SL).

terminate with thick gypsum levels and continental red beds. Fossils permit a biostratigraphical zonation of these deposits (Riccardi 1984). Along the continental divide these sedimentary sequences interfinger with volcanic and pyroclastic rocks of Late Jurassic-Early Cretaceous age. The volcanic pile which can be up to 6 km thick in the Chilean side, has a burial metamorphism typical of that developed in a high thermal gradient during active subsidence (Levi and Aguirre 1981). These volcanic sequences occur along a western inner arc developed between the Coastal and Principal Cordilleras, and an eastern outer arc along the present international border. An intra-arc basin between the two arcs is filled with shallow marine and continental deposits (Charrier 1973; Rivano et al. 1986; Ramos 1985b). Most of the early-

middle Mesozoic was dominated by an extensional regime closely linked with the early stages of the opening of the South Atlantic (Uliana et al. 1990). Later, the beginning of the drift phase in the Atlantic changed during the middle Cretaceous the tectonic regime to the present Andean compressional stage.

A series of volcanic arcs shifted from the Coastal Cordillera in the Jurassic to the Principal Cordillera in the Late Tertiary (Ramos 1988). The series of volcanic and volcanoclastic rocks interbedded with alluvial-fan facies.

Glacial deposits from four different glaciations are widespread in the main valleys, representing an alpine type glaciation during Pliocene and Quaternary times.

Geology of the Cordillera Principal

**TABLE I: STRATIGRAPHY OF THE FRONTAL CORDILLERA**

LATE TERTIARY	Several synorogenic deposits (Late Miocene to present)	Miocene subvolcanics
EARLY TRIASSIC LATE PERMIAN	Choiyoi Group (rhyolites and leucocratic granites)	( <i>extensional regime</i> )
----- San Rafael orogenic phase -----		
EARLY PERMIAN CARBONIFEROUS	Alto Tupungato F. (shales and sandstones)	Granitoids and volcanic rocks ( <i>subduction related</i> )
EARLY CAMBRIAN PROTEROZOIC	Middle - high grade Metamorphic rocks of Cordón del Plata	

**TABLE II: GENERALIZED STRATIGRAPHY OF THE PRINCIPAL CORDILLERA**

TERTIARY	FARELLONES F. (andesites)	Santa María Conglomerates (continental deposits)
EARLY CRETACEOUS	JUNCAL F. (volcaniclastic deposits and andesites)	
	CRISTO REDENTOR F. (continental deposits)	
	MENDOZA GROUP (limestones, shales and sandstones)	
LATE MIDDLE JURASSIC	TORDILLO F. (red sandstones and conglomerates)	
	AUQUILCO F. (gypsum)	
	LA MANGA F. (limestones)	
TRIASSIC	CHOIYOI GROUP (volcanics)	
EARLY PERMIAN LATE CARBONIFEROUS	Granitoids (Subduction related) ALTO TUPUNGATO F. (flysch facies)	

**COASTAL CORDILLERA**

Along the present continental margin, a series of Late Paleozoic metamorphic rocks are preserved which represent pieces of an accretionary prism that developed in the Late Paleozoic (Hervé 1988). Emplaced in this metamorphic basement, are a series of magmatic belts of Jurassic and Cretaceous age.

Most of this region is suspected to have significant latitudinal motions (Forsythe et al. 1986; Mpodozis and Ramos 1990). Table III summarizes the generalized stratigraphy of the Coastal Cordillera.

On the eastern flank of the Coastal Cordillera, the Mesozoic marine sequences which developed west of the Mesozoic volcanic rocks are preserved. These

Albian Aptian	Lo Valle F.	Andesites and pyroclastic rocks
Barremian	Veta Negra F.	Volcanic and volcanoclastic rocks with marine beds
Hauterivian Valanginian Berriasian	Lo Prado F.	Marine limestones interfingered with volcanic and continental deposits
MALM	Horqueta F.	Volcanic rocks and continental deposits
DOGGER	Cerro Calera F.	Marine sediments
LIAS	Aijal F.	Volcanic rocks and marine deposits
PALEOZOIC	Basement	Metamorphic rocks and granitoids

marine deposits are commonly interfingered with volcanic rocks and associated with Cu manto-type deposits.

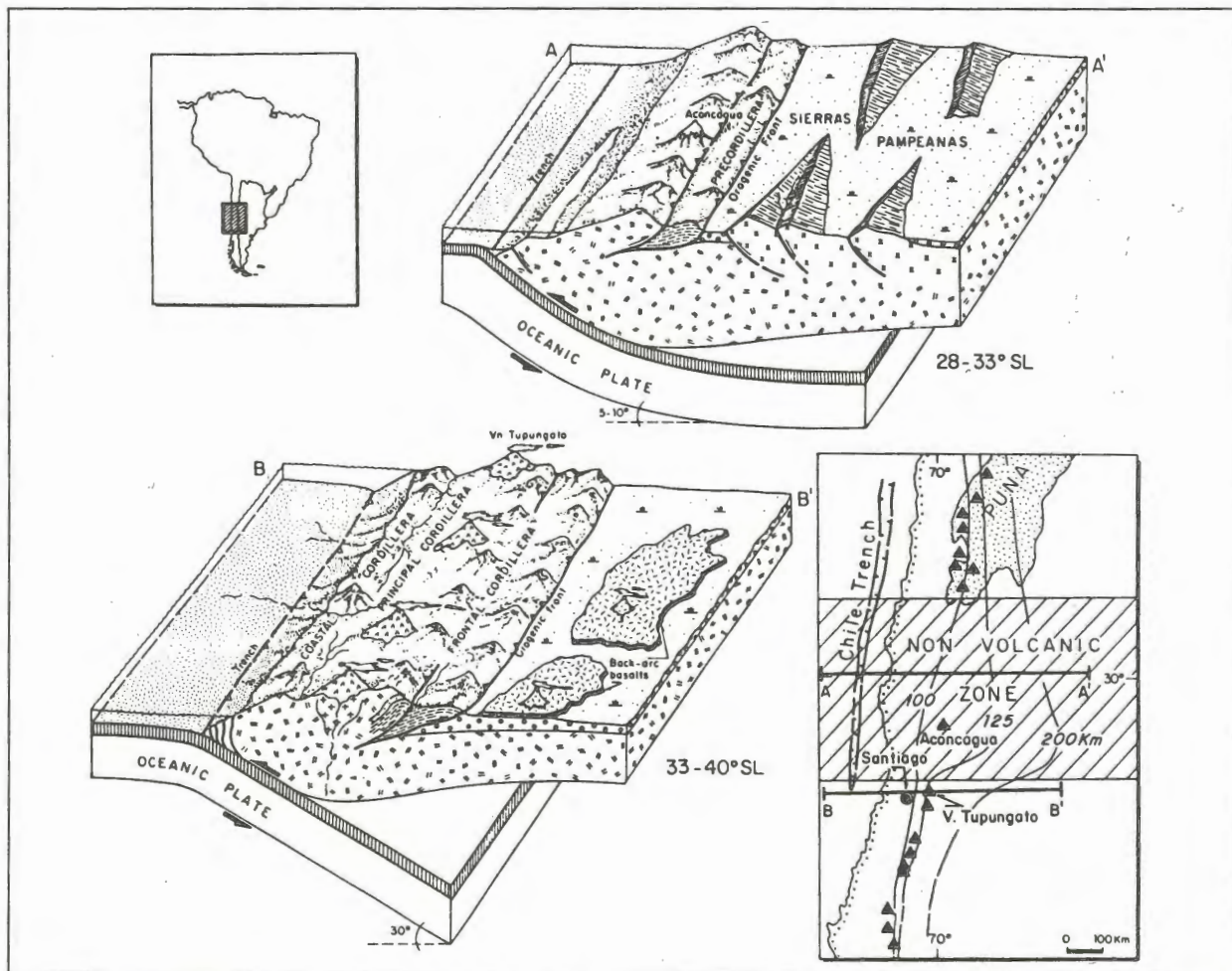
Isolated patches of accretionary prism deposits which are principally Palaeozoic to early Mesozoic in age crop out along the Pacific coast.

## MODERN PLATE TECTONIC SETTING

This segment of the Central Andes between 28-33° S has a distinctive plate tectonic setting. The present convergence rate between the subducted Nazca plate and the Southamerican plate averages about 9-10 cm per year. Earthquake locations delineate a Benioff zone that is gently dipping to the east defining a shallow subduction zone.

This flat subduction segment is characterized by an easterly dip of about 5° at about 100 kilometers depth, and it is flanked to the north and south by steeper segments that dip about 30° eastward (Figure 4).

A corresponding tectonic segmentation exists in the plate above the Benioff zone. The most obvious and consistent correlation is between Quaternary



**Figure 4:** Schematic block diagrams showing subducted plate segments, north and south of Aconcagua (after Ramos and Nullo 1993).

volcanism and the dip of the subducted slab. Quaternary volcanism is absent in the subhorizontal segment.

The origin of this flat subduction segment has been attributed to the approach and collision of

aseismic ridges to the Pacific continental margin, to changes in the age of the subducted oceanic crust, and more recently, to the differential shortening of a previously weakened hot continental crust (Isacks 1988).

## ANDEAN TECTONICS

The Cenozoic sedimentary history records the eastward migration of the orogenic front. Thick sequences of continental deposits (Santa María Conglomerates of Schiller 1912) unconformably overlie Mesozoic rocks in the Principal Cordillera (figure 5).

The angular unconformity is clearly seen east of Cerro Aconcagua and west of Cerro Penitentes. These conglomeratic deposits are interpreted as alluvial-fan sediments that are interfingered with the volcanics of the Farellones Formations (25 to 10 Ma, Munizaga and Vicente 1982). A minimum age of 8.6 Ma for the

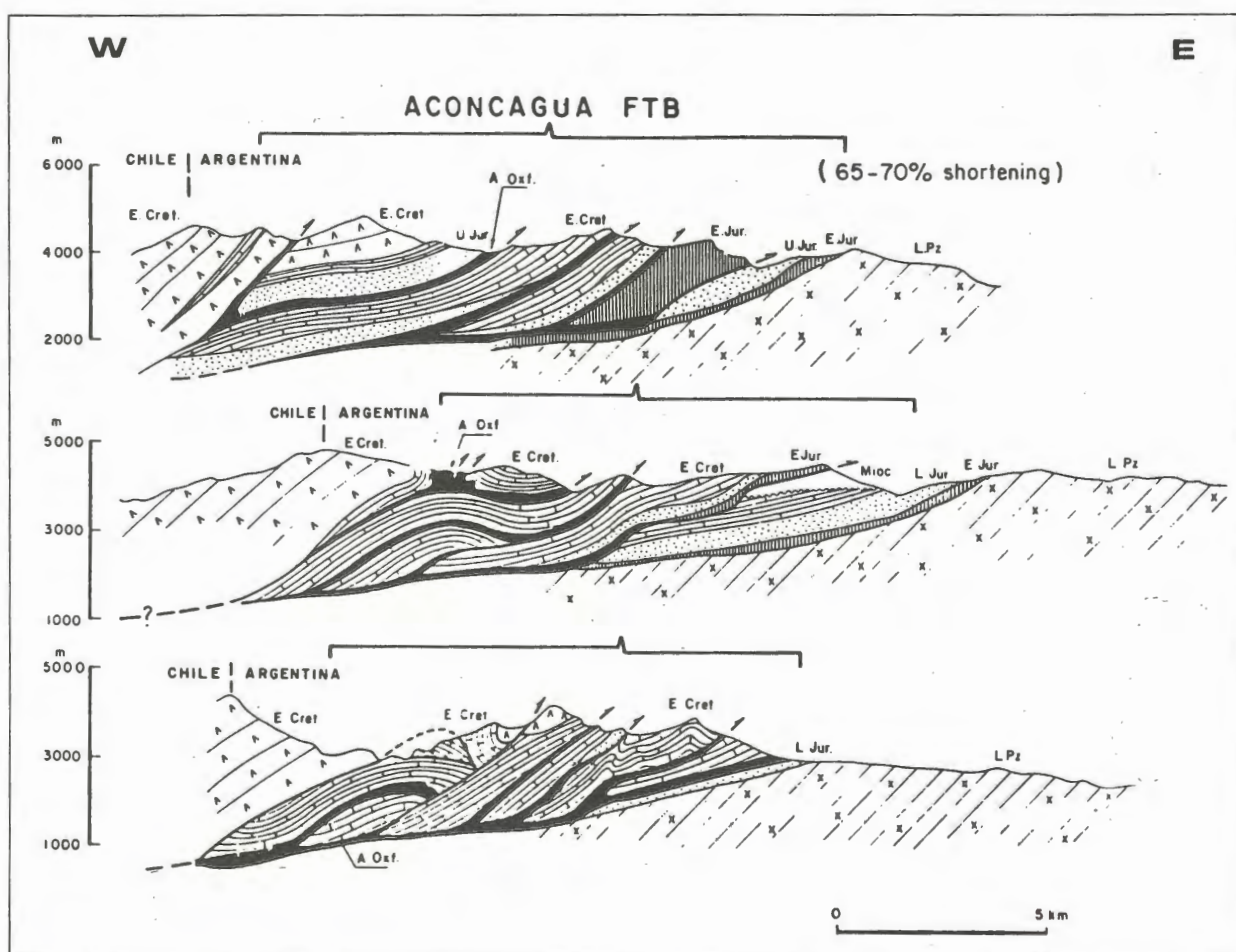


Figure 5: Aconcagua fold-thrust belt south of Puente del Inca, Mendoza (after Ramos 1985b).

continental deposits is based on K/Ar dating of pyroclastic rocks interbedded in the uppermost section of the Santa María Conglomerates (Ramos et al. 1990).

Further east, the Tertiary deposits of the High Cordillera are represented by distal fluvial facies which are partially synchronous with the Santa María Conglomerate and the Farellones Formation. The Tertiary extra-Andean sequences at these latitudes (30-33° S) contain several tuff layers which attest to the volcanic activity in the cordillera at that time.

An unconformity separates the La Pilona beds exposed in the Uspallata valley and the Cacheuta area (Pascual and Odreman Rivas 1973) from older Tertiary beds. This unconformity was produced during the Late Miocene (about 10-8 Ma) Quechua phase in which the Santa María Conglomerates and the Farellones volcanics were folded and thrust (ChARRIER and VICENTE 1972; MUNIZAGA and VICENTE 1982). Deformation and uplift also occurred in the Frontal Cordillera during the Late Miocene Quechua phase (POLANSKI 1964).

The eastern border of the Frontal Cordillera was uplifted during the Diaguitic phase which in the latest Pliocene gave rise to the present configuration of Frontal Cordillera (POLANSKI 1964, YRIGOYEN 1979). The Late Miocene and Pliocene deposits of the Uspallata and Cacheuta regions were folded and

thrust at that time. These deposits were subsequently covered by the alluvial-fan deposits of the Mogotes Formation in the Plio-Pleistocene (YRIGOYEN 1993).

Therefore, the Tertiary sedimentary facies show a migration of coarse alluvial-fan facies from a) Cerro Penitentes in the High Andes between 20-10 Ma to b) the Uspallata valley and Cacheuta between 10-5 Ma to c) the outer foot-hills near the city of Mendoza between 2 Ma and the present day. Plio-Pleistocene fanglomerates of the Mogotes Formation west of the city of Mendoza (Cerro La Gloria) and other younger alluvial fans have been deformed by neotectonic activity, like that described by POLANSKI (1962) in the extra-Andean area of the southern Mendoza region.

The Andean structure of the Central Andes cordillera results from a combination of tectonic mechanisms. There is a striking coincidence between the increased rate of plate motion, the cessation of magmatism, and the compressive deformation at the orogenic front. Most of the Oligocene was quiescent with low convergence rates, coincident with the lack of volcanic activity in the Cordillera. This quiescence ended at 25 Ma when the volcanic activity of the Farellones Formation started (MUNIZAGA and VICENTE 1982). The subsequent history of magmatism and deformation in this region document the subsequent shallowing of the Benioff zone.



## ITINERARY

### STOP 1. THE ANDES THRUST-FRONT

The eastern foothills of the Precordillera are characterized by an important tectonic activity. This activity is evidenced by numerous terraces which are segmented and uplifted by the Quaternary neotectonics. The Early Paleozoic Villavicencio Group rocks are thrust over the Tertiary continental deposits as seen in the foreground at Aguada Pizarro (figure 6). Towards the east, a series of north-south trending anticlines forms the low hills of Lunlunta and

Barrancas. These anticlines are half-graben systems formed during Triassic rifting, and inverted during the Andean deformation. The 1985 Mendoza city earthquake was located along these inverted faults as indicated by focal mechanisms.

### STOP 2. POTRERILLOS

A strong angular unconformity separates the conglomerates of the Triassic Río Mendoza Formation, from Early Palaeozoic rocks of

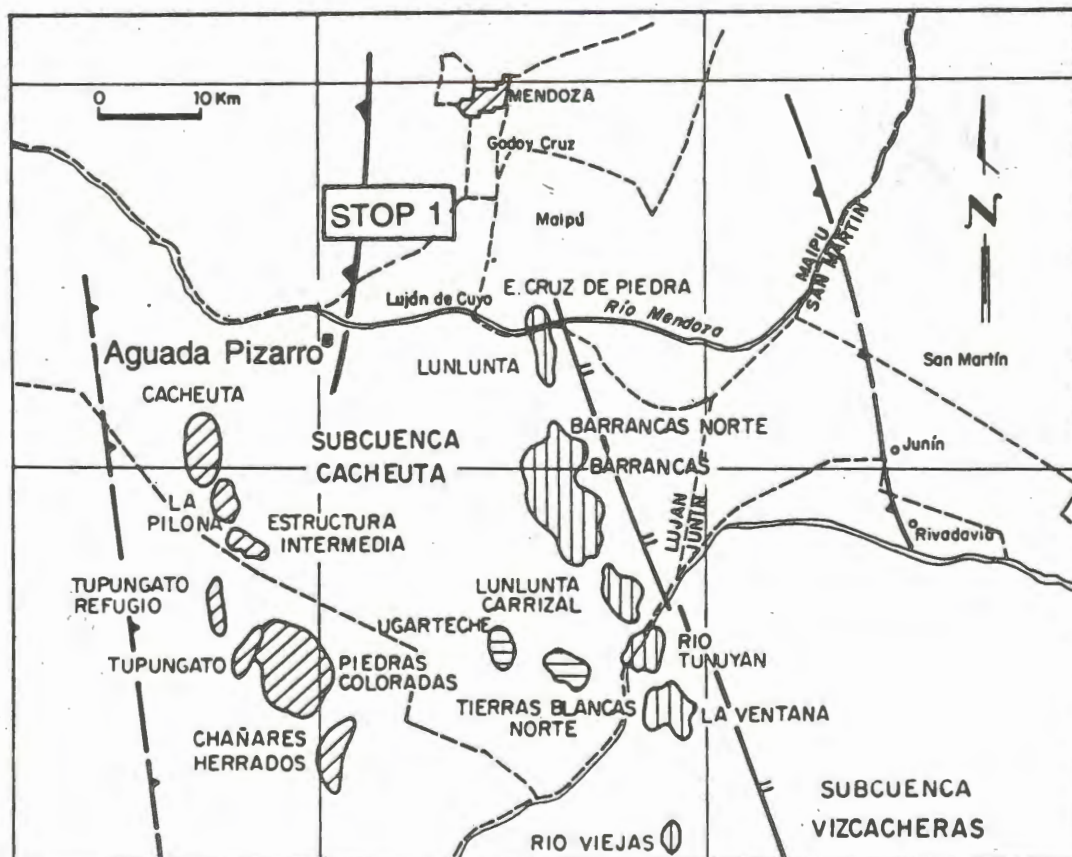


Figure 6: Aguada Pizarro thrust and the Triassic half-grabens.

Villavicencio Formation, and the volcanics of the Choiyoi Group (figure 7). The conglomerates represents alluvial fan deposits of the basal synrift sequence of the Cuyo rift.

At Cerro Cocodrilo, it is possible to observe a complete sequence of the Triassic rift deposits, represented by the Uspallata Group (figure 7). Above the previously seen conglomerates of the Río Mendoza Formation, are exposed red sandstones and shales interbedded with fine conglomerates of the Potrerillos Formation characteristic of fluvial facies. The first cycle of the rift sequence ends with lacustrine deposits of Cacheuta Formation which indicate the beginning of the sag phase. The Cacheuta shales contain abundant Conchostraca, fish scales, palynomorphs and plant remains of Late Triassic age. These black shales thickens to the east, and represent the most important source rock of the different oil fields of the Cacheuta basin, southeast of Mendoza city.

A second rift sequence represented by the Jurassic conglomerates of the Río Blanco Formation forms the uppermost part of Cerro Cocodrilo.

Alkaline basalts of Jurassic age are associated with this second rifting stage and they are mainly known in the subsurface.

### STOP 3. RÍO PICHEUTA

At this stop (figure 8), we are in the middle of the Choiyoi province at these latitudes. Thick piles up to 2-4 kilometers of pyroclastic and volcanic rocks of rhyolitic composition represent a widespread extensional period. Several rhyolitic domes north of río Picheuta, are emplaced in the pyroclastic sequences. The domes are recognized by their homogeneous texture and their columnar jointing. In this section, most of the ignimbritic and pyroclastic flows are of Triassic age.

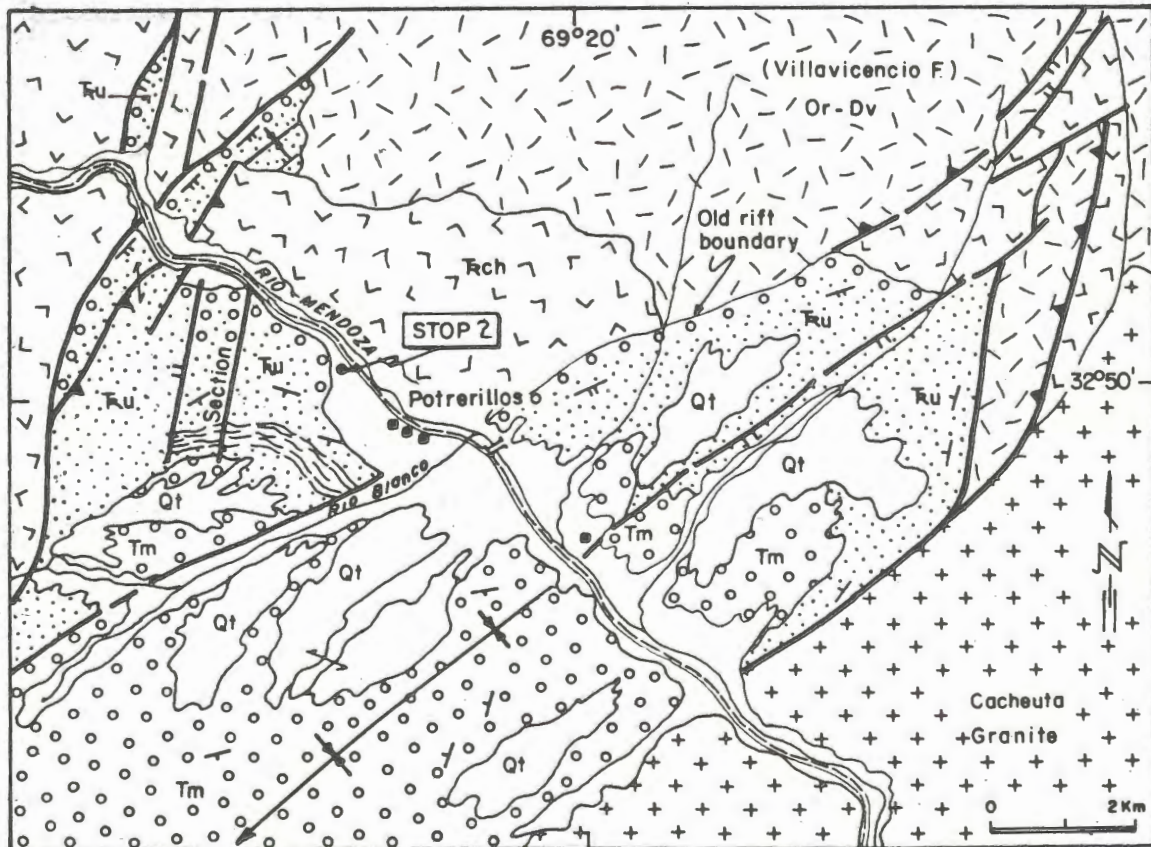


Figure 7: Geologic map of Potrerillos with the Triassic rift deposits of the Cacheuta basin (based on Lapido 1990).

## STOP 4. CERRO PENITENTES

This is the thrust front of the Aconcagua fold and thrust belt (figure 9). Middle to Late Jurassic limestones override the thick Santa María conglomerates of Middle Miocene age. These conglomerates unconformably overly marine and continental Jurassic strata. The Penitentes overthrust dips from 5° to 22° to the west, and erosion is almost forming a klippe on the top of Cerro Visera.

## STOP 5. PUENTE DEL INCA

This is the most classic section of the High Andes. Compare the evolution of the knowledge since Darwin and Stelzner (see figure 2 a and b) with the present interpretation of figure 10.

The section shows the autochthon represented by Carboniferous hornfels, thin pyroclastic deposits of the Choiyoi Group and Jurassic limestones and conglomerates of proximal facies and small outcrops of marine Early Cretaceous; the first thrust plate composed of Middle to Late Jurassic marine and

continental deposits and Early Cretaceous continental to transitional marine deposits; and the second thrust plate represented by Late Jurassic gypsum at the base and Titho-Neocomian continental and marine strata. All these sequences are intruded by thick Miocene dykes of trachyte (15 Ma). In the first thrust plate basaltic and andesitic lenses are interbedded in the sequence. They are more abundant in the westernmost thrust sheets (Ramos 1965a, b).

One of the representative sections for the Jurassic at these latitudes is seen in the southern margin of the Río Cuevas, at Puente del Inca. The section illustrated in figure 11 was described by Lo Forte (1992), and consists from base to top:

### La Manga Formation (Callovian-Oxfordian).

18 metres. Gray whitish to yellow oolitic packstones with isolated black chert nodules and cidaroid spines. Grading upwards to coralline boundstones.

3 metres. Yellow to gray, tabular laminated mudstones with cidaroid spines.

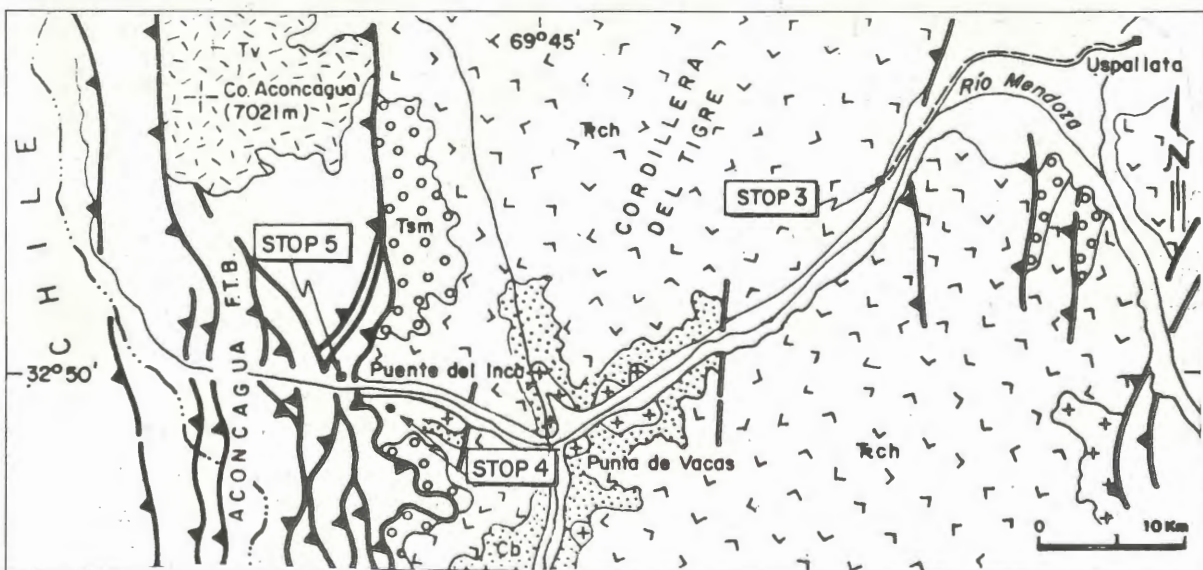


Figure 8: Generalized geological map of the High Andes. Stippled pattern: Carboniferous strata; crosses: Early Permian granites; Trch: Choiyoi Group; Tv: Farellones Formation; Tsm: Santa María Conglomerates.

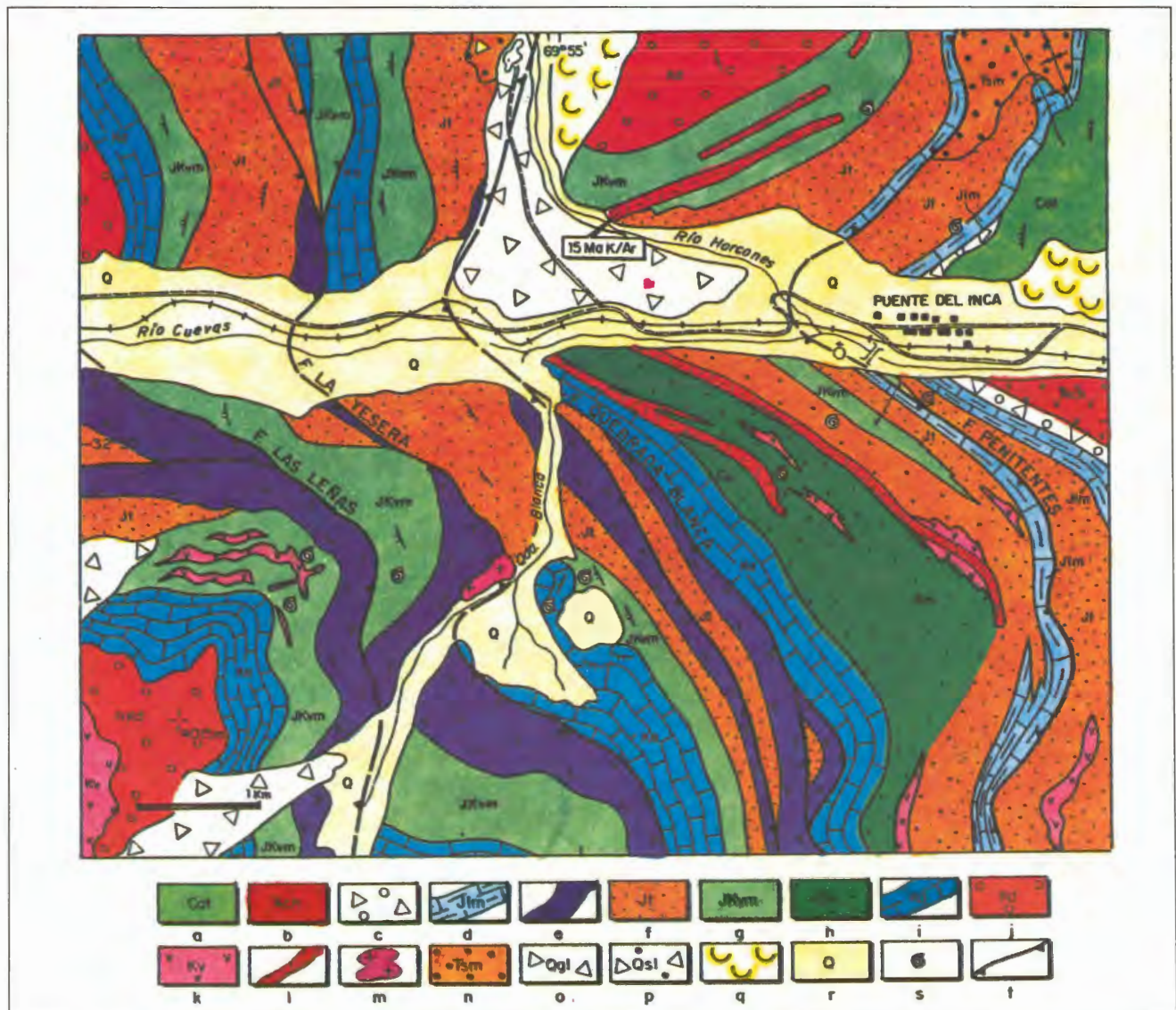
**Tordillo Formation (Kimmeridgian)**

10 metres. Red medium sandstones with carbonate cement. Tabular beds with erosive bases.

10 metres. Reddish to white conglomerates in tabular banks 2-3 meter thick. Rounded volcanic, calcareous, and quartzose clasts. 2-3 cm in diameter with coarse sandy matrix. Carbonate cement.

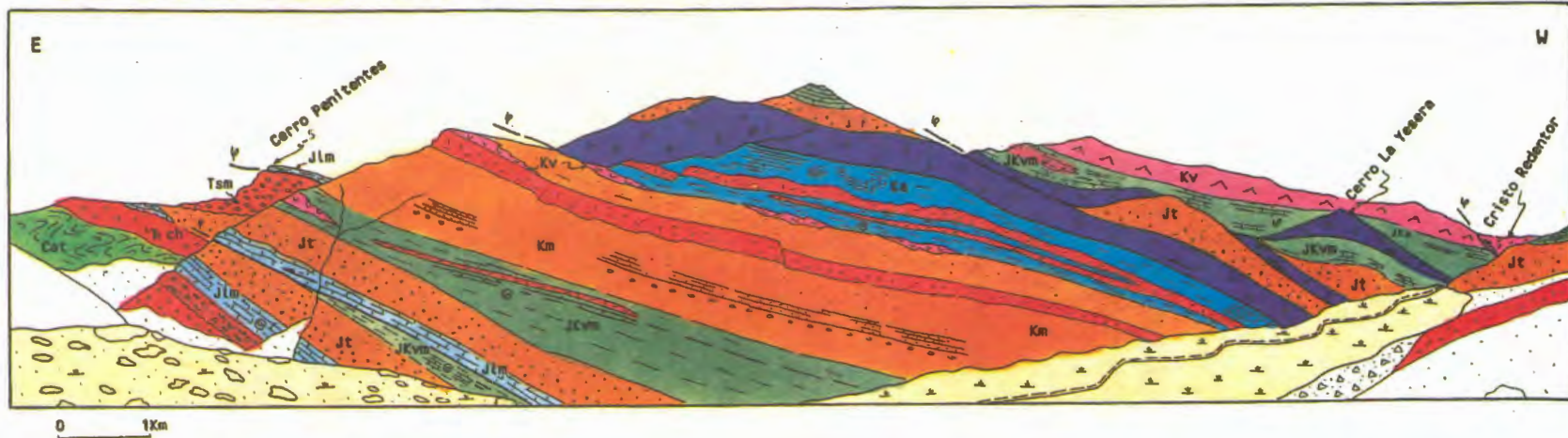
**Vaca Muerta Formation (Tithonian)**

7 metres. Fine reddish calcareous sandstones in lens 4-8 metres long, erosive base, interbedded with fine, laminated calcareous sandstones with abundant ammonites: *Choicensisphinctes* sp. nov. Massive red fine to medium conglomerates with subangular to subrounded volcanics clasts.



**Figure 9:** Detailed geological map of the Aconcagua fold and thrust belt at Puente del Inca. a) Carboniferous deposits, b) Choiyoi Group, c) Early Jurassic breccias, d) La Manga Fm., e) Auquilco Fm., f) Tordillo Fm., g) Vaca Muerta Fm., h) Mulichinco Fm., i) Agrio Fm., j) Diamante Fm., k) Cretaceous volcanics, l) Puente del Inca Trachyte, m) Miocene stocks, n) Santa María conglomerates, o) Glacial deposits, q) Slumps, r) Alluvium, s) Fossil locality, t) Thrust.

## CLASSIC SECTION OF PUENTE DEL INCA VIEW FROM THE NORTH



**Figure 10:** Panoramic view of Puente del Inca section with the present structural interpretation. Cat: Alto Tupungato Formation (Carboniferous), Trch: Choiyoi Group (Triassic), Jlm: La Manga Formation (Middle Jurassic), y: Auquilco Formation (Late Jurassic), Jt: Tordillo Formation (Late Jurassic), JKvm: Vaca Muerta Formation (Valanginian), Ka: Agrido Formation (Hauterivian), Kv: Cretaceous volcanics, JKs: Jurassic-Early Cretaceous volcaniclastics, Tsm: Santa María Conglomerates (Miocene), sills with pattern: Tertiary volcanics.

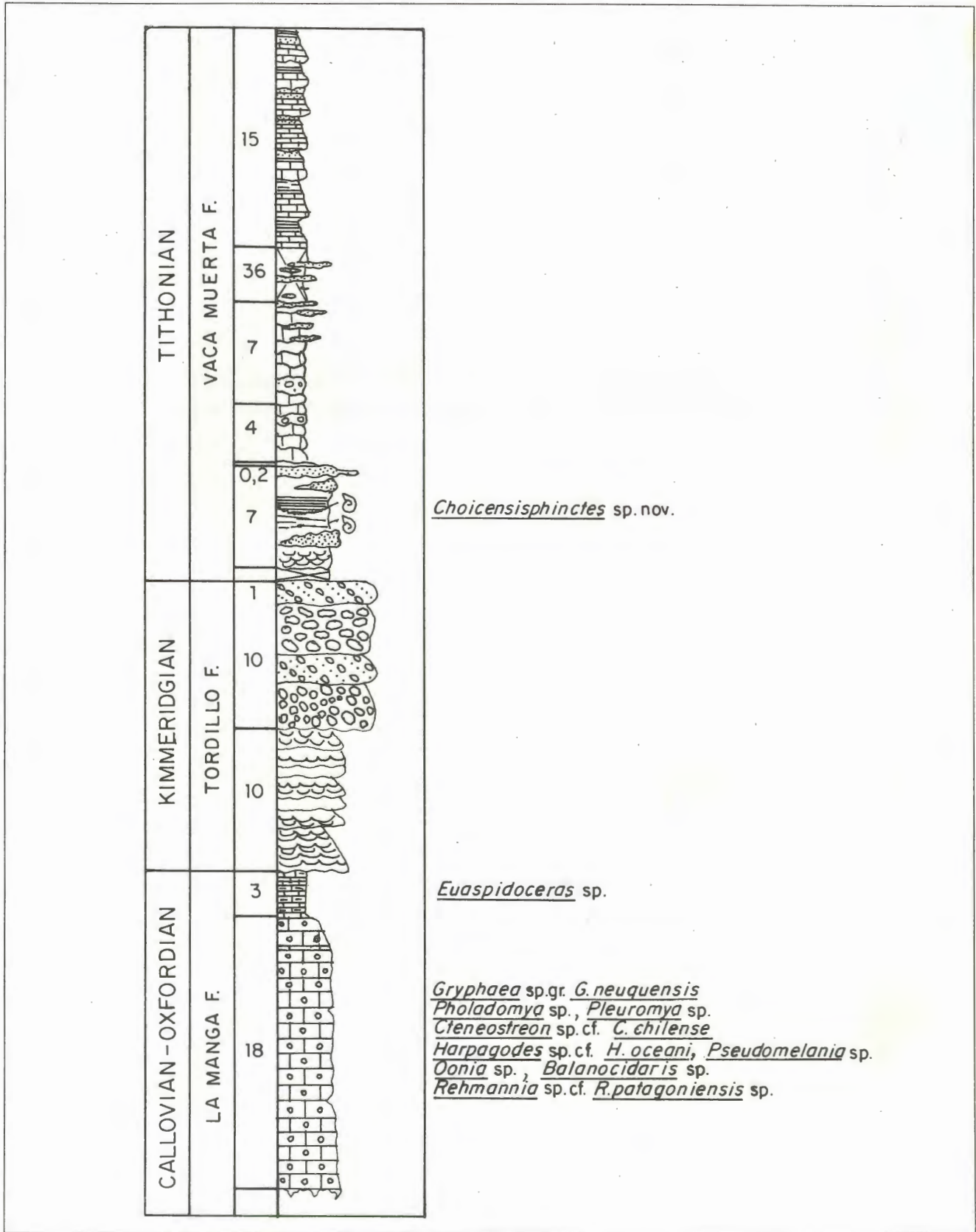


Figure 11: Jurassic section of Puente del Inca (based on Lo Forte, 1992).

4 metres. Coralline boundstones, red to yellowish colors, patches with corals in life position, beds 1 meter in thickness.

7 metres. Nodular, gray to yellowish limestones in beds one meter thick, with isolated fragmentary corals, cidaroid spines, and bivalves.

36 metres. Partially covered shales with saccharoidal gypsum levels.

15 metres. Dark gray massive mudstones grading upwards to thin-laminated mudstones, marls and green and reddish shales.

The fossil content of La Manga Formation is *Gryphaea* sp. gr. *G. neuquensis*, *Pholadomya* sp., *Pleuromya* sp., *Cteneostreon* sp. cf. *C. chilense*, *Harpagodes* sp. cf. *H. oceani*, *Pseudomelania* sp., *Oonia* sp., and ammonites such as *Rehmannia* sp. cf. *R. patagoniensis*, in the basal levels (Lo Forte 1992) and *Euaspidoceras* sp. in the top (Stipanovic 1966). There are also regular echinoids such as *Balanocidaris?* sp. The lower assemblage is Middle Callovian (Riccardi et al. 1991) while the top one represents the Late Oxfordian.

The Vaca Muerta Formation has yielded ammonites from the *Virgatosphinctes mendozanus* zone of Early Tithonian age (Riccardi 1984).

## STOP 6. QUEBRADA DE LOS HORCONES

At this stop (figure 12), there is a magnificent view of the Pared Sur (south wall) of the Aconcagua (7,021 m a.s.l.). The wall is formed by volcanic and breccia flows of andesitic composition of the Farellones Formation (15 to 19 Ma, Ramos and Yrigoyen 1987). On the western side of the valley, there is an imbrication of Jurassic continental red beds and Early Cretaceous limestones. On the eastern side the diapiric effects of the Late Jurassic gypsum of the Auquilco Formation produced the complex structure

of Cerro Panta. To the south, there are visible the imbricates of the second to fourth thrust sheets repeating the different Titho-Neocomian units.

## STOP 7. PARAMILLO DE LAS CUEVAS

This is one of the four shelters on the Argentine side preserved since the late XVIII century. In this shelter Charles Darwin stayed overnight during his crossing of Paso de la Cumbre in 1835 (see figure 2 a, and also Darwin 1846 for a picturesque description of the place).

At this altitude, it can be seen that the Quebrada de Navarro (figure 12) thrust dips more than 80° to the west. This is the result of the different underlying imbricates that have rotated this thrust.

## STOP 8. LAS CUEVAS

The Titho-Neocomian limestones overrides Late Jurassic-Early Cretaceous beds (figure 12). The thickness of these continental and volcanoclastic deposits exceeds several times the normal thickness of these units, indicating their proximity to the volcanic arc. The carbonates bear *Olcostephanus* sp. of Late Valanginian age. A rock avalanche was produced from one of the volcanoclastic members of the Mesozoic deposits.

Further west, at Cristo Redentor a complex out-of-sequence thrust folded and thrust the red beds and volcanoclastic rocks of the Early Cretaceous Cristo Redentor and Juncal Formations over the Titho-Neocomian limestones. The thick pile of Early Cretaceous rocks is deformed in a anticline structure.

To the north, along the Cordillera del Límite, interbedded limestones and volcanics represent the Titho-Neocomian deposits in the westernmost thrust sheet.

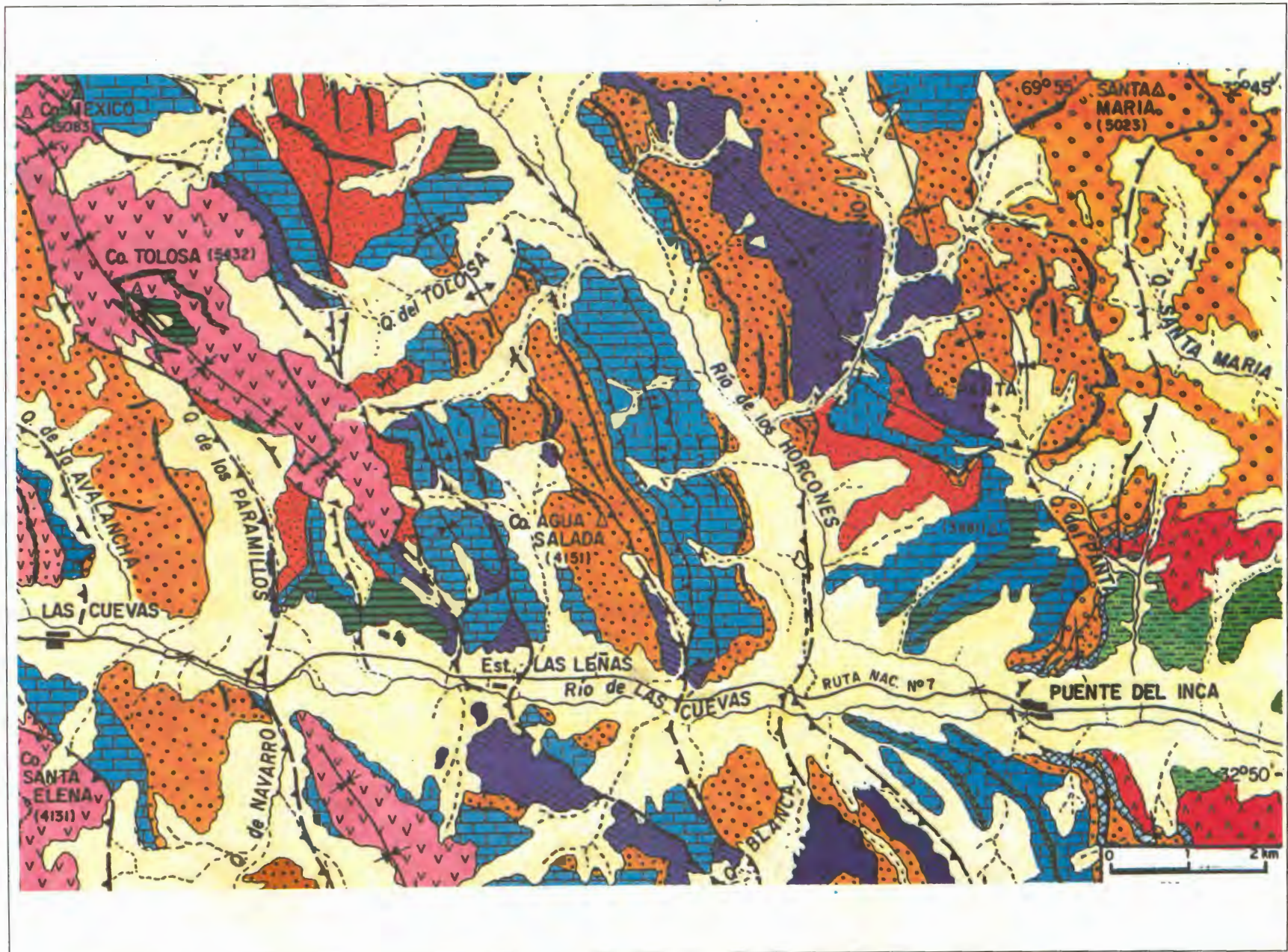


Figure 12: Geological map between Puento del Inca and Las Cuevas (based on Cegarra et al. (1993)). - (See references in page 26).



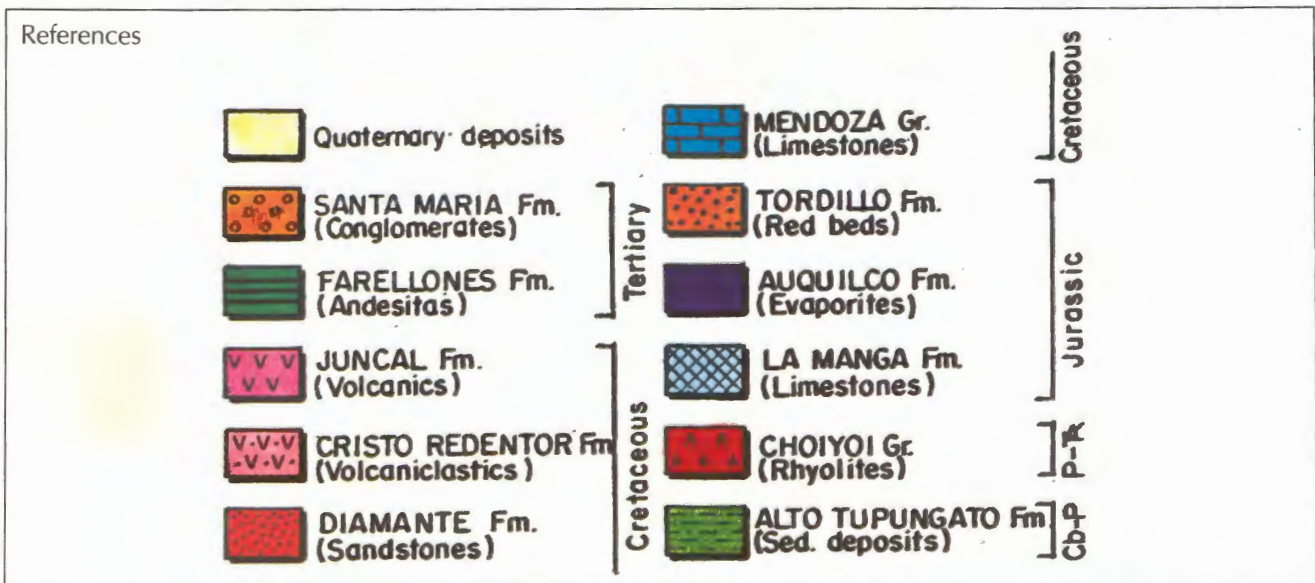


Figure 12

- distribución y sus relaciones con los acontecimientos diastróficos. V° Congreso Geológico Argentino, Actas 3: 293-338.
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