

## TECTONIC AND GEOTHERMAL HISTORY OF THE SUBANDEAN RANGES AND THE EASTERN CORDILLERA OF SOUTHERN BOLIVIA.

M.Reinhardt & J.Kley

Institut für Geologie der Freien Universität Berlin, Altensteinstr. 34A, 1000 Berlin 33, Germany

### Resumen

Investigaciones sobre la tectónica y la geotermometría muestran que las temperaturas más altas alcanzadas en la Cordillera Oriental tuvieron lugar durante el Paleozoico superior. En las Sierras Subandinas las paleotemperaturas nunca superaron los 70°C que se alcanzaron en el Terciario.

Key Words: Bolivia, Andes, Eastern Cordillera, Subandean Ranges, Tectonic History, Geothermal History

### Introduction

The studied area extends along 21°30'lat.S between Villamontes and S.Vicente in Bolivia. In the east the section comprises Devonian to Tertiary sediments of the Subandean Ranges and a Transition Zone to the Eastern Cordillera. The Eastern Cordillera is built up mainly of Ordovician sediments overlain by Cretaceous and Tertiary strata and is bordered in the west by the Altiplano. Although the main geological features of the region have been recognized, many aspects of the tectonic evolution remain poorly understood, and little data is available about the geothermal history of the area.

## Results

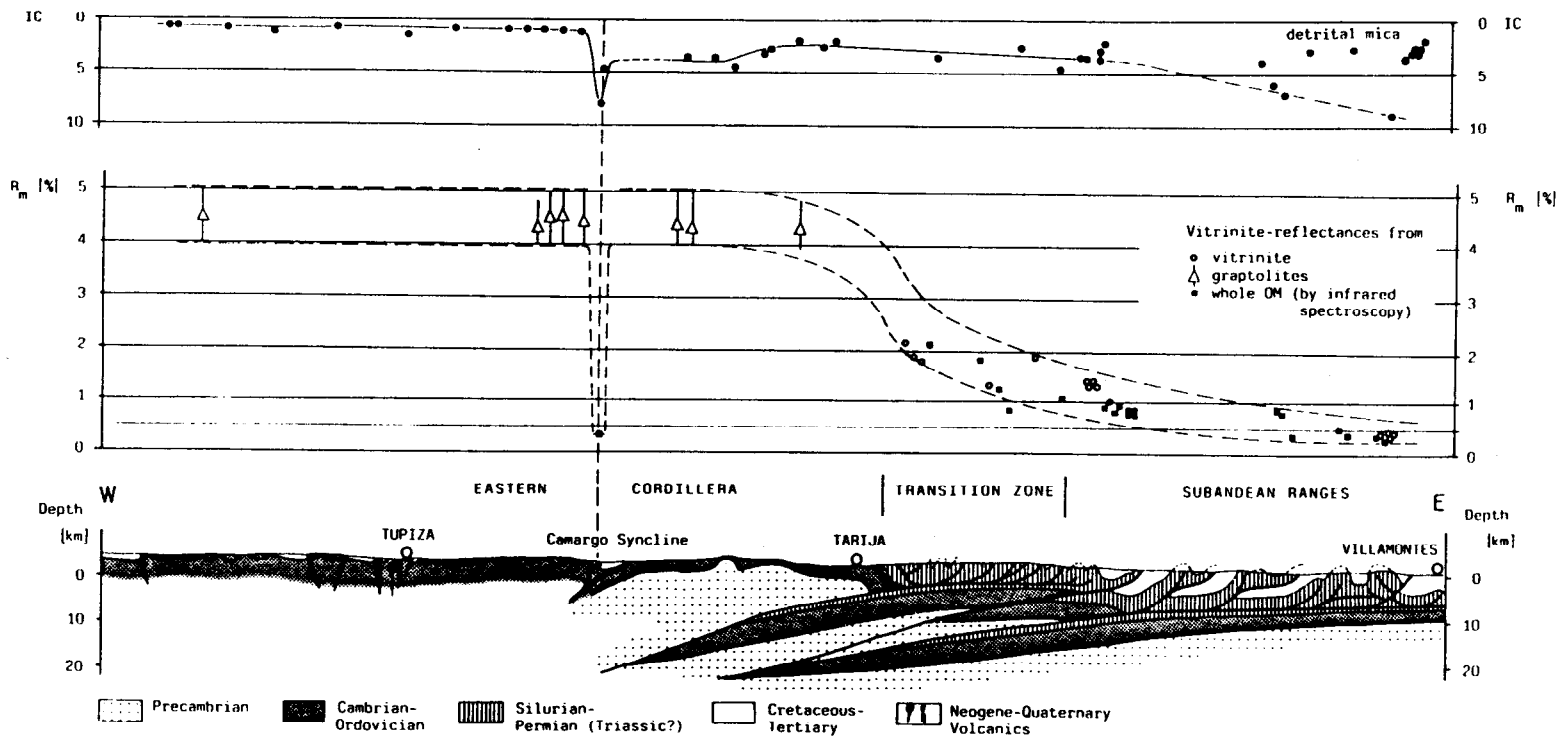
The tectonic evolution of Southern Bolivia from early Paleozoic up to the Andean Phase, is characterized mainly by weak epirogenetic movements. During Paleozoic and early Mesozoic times the area was situated at the western border of the Brazilian Shield and, since Jurassic times, to the east of the volcanic arcs. Epirogenetic movements led to the formation of several unconformities, which can be correlated with orogenic phases:

- The lack of sediments of Llandellian to Llandoveryan age may be caused by an Upper Ordovician Oclöyic Phase; however, a corresponding thermal event in the studied area cannot, as yet, be proved.
- Generally, paleozoic orogenic movements did not produce strong folding but caused a slaty cleavage in deep-seated rocks of Ordovician and lower Silurian age. In the Eastern Cordillera greatest depth and maximum temperatures were reached during the Upper Devonian (e.g. about 280°C for Tremadocian rocks) followed by uplift. An Upper Devonian Eohercynian Phase is indicated by three lines of evidence: 1. in the Eastern Cordillera (e.g. the synclinal structure of Camargo) weakly diagenetic Cretaceous rocks overlie, with a very low angle unconformity, very-low-grade metamorphic Ordovician strata with slaty cleavage and quartz-veins; 2. while the Silurian and Devonian strata do not show significant lateral facies variations, carboniferous sediments thin out towards the Eastern Cordillera and indicate that the western border of the basin, near Tarija, has experienced uplift since Upper Devonian/Early Carboniferous times; 3. in some places, Carboniferous strata unconformably overlie Devonian rocks (the extent of the stratigraphic gap is not known).
- In the Subandean Ranges subsidence persisted with some interruptions (Triassic? - Lower Cretaceous) until the start of the Andean Orogeny in the Tertiary. Crustal shortening led to significant uplift of the Eastern Cordillera while intense lateral compressions with folding and thrusting characterized the whole area.

Maturation studies on organic matter (reflectance-measurements on vitrinite and graptolites, infrared-spectroscopy) and clay minerals (mainly illite-crystallinity) were used for the interpretation of the geothermal history. The maturity of sediments varies between undermature and very-low-grade metamorphic. The stratigraphic gaps of the Oclöyic Phase and (locally) the Eohercynian Phase are not marked by sudden increases in rank, which would indicate a heating event, so that an Upper Devonian (Eohercynian) 'heating event' in the Eastern Cordillera can only be proved indirectly, as discussed above. In the Transition Zone between the Eastern Cordillera and the Subandean Ranges the rank decreases continuously from older to younger strata. Burial curves show that in this region the maximum depth and temperatures were not reached before the beginning of the Neogene Quechuan Phase. The paleotemperatures of Devonian rocks at the easternmost part of the Subandean Ranges near Villamontes did never exceed about 70°C. Thus, in this region the paleogeothermal gradient reached about 15°C/km at the time of maximum heating (Late Tertiary) and ranged significantly below 30°C/km - at least since Permian times. In the Eastern Cordillera, however, the paleogeothermal gradient attained values of 30°C/km or even more before the Upper Cretaceous.

# SEDIMENT MATURITY IN THE EASTERN CORDILLERA AND SUBANDEAN RANGES OF SOUTHERN BOLIVIA

Top: Illite-Crystallinities (half-height peak width in [nm] )  
 Middle: Vitrinite-Reflectances  
 Bottom: Schematic cross-section



### Conclusions

The tectonic and geothermal histories of the Eastern Cordillera and Subandean Ranges have differed considerably since the Upper Devonian, although both are largely dominated by epirogenetic movements. From Ordovician to Devonian times subsidence took place over the whole area. In the Eastern Cordillera maximum burial depths and temperatures were reached in the Upper Devonian/Lower Carboniferous with a paleogeothermal gradient around 30°C/km. In this area the Carboniferous to Upper Cretaceous is generally characterized by uplift. Further to the east, however, subsidence or stable conditions lasted until the Late Tertiary. The Subandean Ranges were relatively 'cool' during this time span with geothermal gradients significantly below 30°C/km in the Mesozoic and values of about 15°C/km in the Late Tertiary.