Study Grant Proposal for Fall Semester, 2011

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Tectonics and Stratigraphy of the Rio Grande Rift

1. Rationale – Significance of the Rio Grande Rift

My study grant proposal aims to review the literature of the Rio Grande rift, a significant and spectacular geological formation that extends to Western Texas; it constitutes a fundamental part of the geology of our broader region.

During the last 30 years, the Rio Grande has become widely recognized as a major Cenozoic continental rift zone. Much has been learned about the structure and evolution of the rift, however, many gaps in our knowledge remain that prevent us from fully understanding its evolution and the processes that formed it.

When viewed from a broad perspective, the Rio Grande rift is a lithospheric-scale feature that follows the topographic crest of the Southern Rocky Mountains. Therefore, I am planning to include readings about the lithospheric and mantle structure beneath the rift as well. As a physiographic rift valley, it consists of a series of interconnected, asymmetrical grabens extending from Leadville, Colorado to Presidio, Texas and Chihuahua, Mexico, a distance of more than 1,000 km. The northern portion of the Rio Grande rift is a distinctive tectonic and physiographic feature that separates the Colorado Plateau from the Great Plains, which are part of the stable North American craton. The southern portion of the rift is physiographically similar to the adjacent Basin and Range province. This difference between the northern and southern segments of the Rift seems significant to me, thus I collect papers distinctly for the northern and southern rift zone.

Heat flow data clearly define a major geothermal anomaly associated with the Rio Grande rift. The magnitude of this anomaly requires convective transfer of heat into the crust. The crust beneath the axis of the Rio Grande rift is thinned compared to adjacent crust. The Moho depth beneath the rift axis (Albuquerque basin) is about 34 km compared to 45 km under the Colorado Plateau near the Arizona-New Mexico border and 50 km under the Great Plains. The thinned crust and high heat flow must have significant consequences on fluid flow and perhaps hydrocarbon maturation that I would like to explore in my readings.

A subduction occurred at the western margin of the North American plate that lasted about 40 Ma, called the Laramide orogeny. In association with the orogeny, a major period of magmatism occurred characterized by intermediate magmas spread widely throughout the southwestern U.S. and northern Mexico. During this event, the lithosphere was thermally weakened, allowing later extension. However, it is still puzzling how the major, continent-wide compression turned to large-scale extension. I am planning to collect key publications on this issue. The mechanism of extension also looks complicated and appears different between the northern rift (where a single
graben structure formed) and the southern rift (which is similar to the Basin and Range type extension that was controlled by low angle normal faults).

The Rio Grande rift region has experienced considerable uplift since the Cretaceous, but the time and amount of uplift that accompanied Cenozoic extension is poorly constrained. I will focus part of my investigation for getting a better understanding for the relationship between the uplift and rift extension.

2. **Topics and Questions to be Explored – Work Plan**

   (1) Tectonic and stratigraphic models of continental rifts – Weeks 1-2

*Rationale*

In the beginning of my study program, I am planning to review the main published models of continental rifts. It is essential to lay down a foundation on which I can build the specifics of the Rio Grande rift. Several scholars have worked on the mechanics of continental rifting in the last few decades. Brian Wernicke at Harvard is a key author who developed the “simple-shear” model, which was used to explain the Basin and Range extension in the Western United States, therefore his contributions are essential to understand the formation of the Rio Grande as well. Additionally, Buck and Ziegler’s papers are important in rift tectonics. M.R. Leeder at University of Leeds, UK, was a pioneer of developing a conceptual model for stratigraphy in continental rifts. He and his students and other co-authors made a major contribution to advancing this field. Renault and Ashley (2002) edited an excellent volume on sedimentation in continental rift basins.

*Reading list on rift mechanics:*


Reading list on rift stratigraphy:


(2) Geological overview of the Rio Grande Rift zone – Week 3

Rationale
Randy Keller has been one of the renowned scholars of the Rio Grande Rift who contributed several publications and co-edited volumes on the Rift. The best book to gain a regional knowledge about the rift zone is the 1994 GSA Special volume, which contains many in-depth papers.

Reading list


(3) Lithospheric structure, tectonic evolution – Weeks 4-7

Rationale
In this segment of my study, I will be focusing on structural deformations, the tectonic evolution of the rift zone. The tectonics of the Rio Grande is rather complicated as it formed in the interaction of a Basin and Range type extension, a gravitational collapse of elevated crust and thermal thinning of the lithosphere. The mode of extension along the rift changed from north to south—in the north, the extension was focused in a narrow region encompassing a single basin,
whereas in the south, the rift is wider and extension was distributed over multiple adjacent basins and the rift merges into the southern Basin and Range province of southern New Mexico and northern Mexico.

Reading list


(4) Sedimentary processes, stratigraphy of subbasins – Weeks 8-12

Rationale
I have a particular interest in the stratigraphy of continental rift basins. I am planning to devote a large portion of my study program to reading about the sedimentary processes and stratigraphic evolution of the Rio Grande rift basins. I am going to explore the relative roles of tectonics, magmatism, uplift-subsidence and climatic changes in the sediment transport and depositional processes. The Rio Grande is a natural laboratory for studying alluvial sedimentation in complex extensional settings, including half-grabens and full-grabens. I want to pay special attention how multi-storey channel sands were deposited in narrow belts near the footwall uplifts in response to tilt of the basin floor towards the border fault; and how smaller footwall catchments and their alluvial fans compare to those of the hanging-wall mountains. I also would like to explore how the ancestral Rio Grande river traversed the full grabens, depositing interbedded channel and floodplain sediments. I also would like to understand how paleosols formed and in what tectonic context and how glacial-climate cycles were related to aggradation and degradation of the river.
Reading list

Weeks 8-9: Northern Rift


Weeks 10-12: Southern Rift


Geology of the Big Bend – Weeks 13-15

Rationale
The Big Bend area is the south-easternmost branch of the Basin and Range Province and it has a
tectonic relationship with the Rio Grande Rift. The Ouachita-Marathon orogenic belt across
Texas and portions of Oklahoma, Arkansas and Mississippi formed in the late Paleozoic. After
about 100 million years, the Big Bend area was inundated by the advancing Cretaceous sea,
depositing thick, massive limestones. The Laramide orogeny at the end of the Mesozoic
produced the Cordilleran Orogenic Belt and the Rocky Mountains. Big Bend is located in the
intersection of the Cordilleran and Ouachita belts. From about 24 Ma, the Big Bend area
underwent Basin and Range type extension. In this segment of my study, I will get an insight
about the Cenozoic extension and sedimentary processes of the Big Bend area.

Reading list
stratigraphy: A possible example from the Cretaceous-Tertiary transition of the Tornillo Basin,

Pause, P. H., and Spears, R. G. (Eds), 1986. Geology of the Big Bend area and Solitario Dome,
Texas. West Texas Geological Society, Midland, TX.

Dickerson, P. W., Muehlberger, W. R. (Eds), 1985. Structure and tectonics of Trans-Pecos
Texas. West Texas Geological Society, Midland, TX.

Thurwachter, J. E., 1984. Sedimentology of Neogene basin-fill deposits, lower Tornillo Creek
area, Big Bend National Park, Texas. Master's thesis, University of Texas at Austin, Austin, TX.

3. Scholarly and Practical Benefits

The Rio Grande Rift is a significant geologic feature in the United States that can be regarded as
a natural laboratory for continental rifts. Major theoretical models in the areas of structural
geology and stratigraphy have been developed or nurtured from studies in the subbasins of the
rift zone. My Ph.D. and most of my subsequent research was focused on continental rifts,
including the Pannonian Basin and the Dead Sea rift, therefore I have a profound interest in
reviewing the literature of the Rio Grande.
The study program would help me in my research to acquire a broader and deeper understanding of the tectonics and stratigraphy of rifts in general and specific knowledge about the Rio Grande. Thus this study program would contribute to enriching the geological research at our college. Ways in which results might be brought to other audiences: (1) presentations at CASMNS (Center of Advanced Studies in Mathematics and Natural Sciences) forums, (3) presentations at scientific conferences, (4) presentations at other colleges and community groups.

The study program also would introduce me to the geology of the Big Bend National Park, which is an internationally recognized wonder of Texas. This knowledge would help me to enrich my teaching at Collin College in the following: (1) geology field trips to the park (possibly jointly with other faculty members); (2) new course development.


Thurwachter, J. E., 1984. Sedimentology of Neogene basin-fill deposits, lower Tornillo Creek area, Big Bend National Park, Texas. Master's thesis, University of Texas at Austin, Austin, TX.

