GRAVITY CONSTRAINTS ON THE GEOMETRY OF THE BIG BEND OF THE SAN ANDREAS FAULT

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Abstract

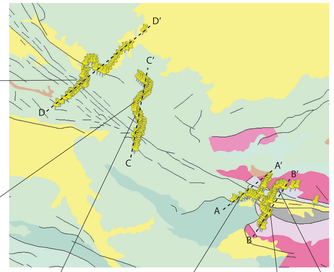
The overall goal of this research project is to use gravity observations coupled with subsequent modeling to better understand the curvature of the San Andreas Fault in the "Big Bend" and its role in producing hydrocarbon-bearing structures in the southern Central Valley of California. The SAF is the dominant plate boundary structure between the Pacific and North American plates and accommodates ≈ 35 mm/yr of slip. The SAF can be divided into three main segments: the northern, central and southern segments. The major structure between the southern and central segments is the "Big Bend", which is characterized by an ≈ 30 deg. eastward bend. This fault curvature led to the creation of a series of roughly east-west thrust faults and the transverse mountain ranges.

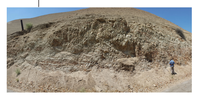
The Big Bend in the SAF also forms the southern boundary of the Central valley, and the goal of the project is better define the geometry of the bend near its inflection point. For this purpose, four high-resolution gravity transects were conducted across locations on either side of the bend. Two transects were on the northern side of the bend in the southern part of the Carrizo plains. The SAF has a strike of ≈ 315 deg. at this transect. There are productive oil fields just east of the SAF at this location, and the bend in the fault may be involved in the creation of hydrocarbon bearing structural traps. The northern transects are characterized by multiple fault strands which cut Quaternary alluvial valley deposits, as well as marine and terrestrial Miocene sedimentary rocks. These fault strands are characterized by short wavelength ≈ 6 mgal negative Bouguer gravity anomalies which may correspond to low density fault gouge. The southern transects cross part of the SAF with a strike of 285 deg. At this location the rocks on either side of the fault are Proterozoic - Cretaceous metamorphic or/and plutonic rocks. The gravity signature observed along the southern transects is a broad ≈ 20 mgal Bouguer gravity anomaly high. The potential field data, both newly collected and pre-existing, will be integrated with geologic observations to create a new quantitative structural model of this tectonically important region. The ultimate goal is to have a detailed 3-D geologic model of the region.

Method and Field Photos

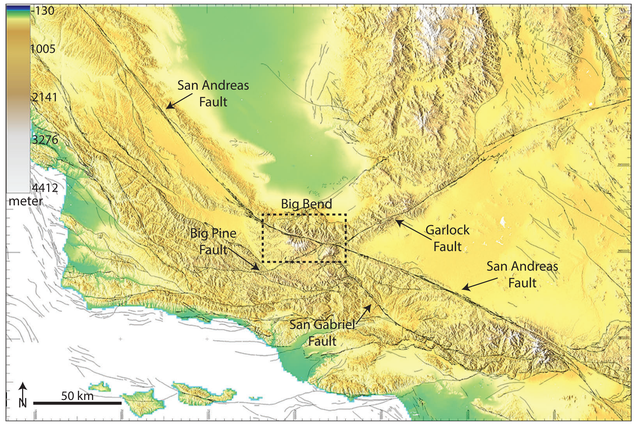
• Station locations and elevations were measured with a Trimble Pro XRT differential GPS receiver.
• Most of the stations have horizontal and vertical accuracy better than 10 cm.

• Gravity surveys were conducted with a Worden gravimeter.
• There were a total of 166 stations.
• Average spacing between most stations is 0.2 miles.



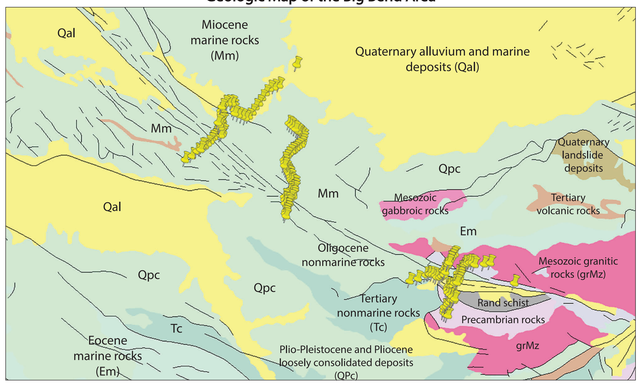


Topographic Map of the Area

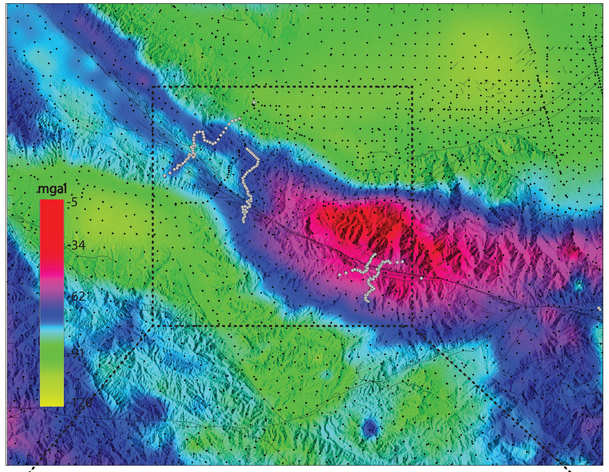


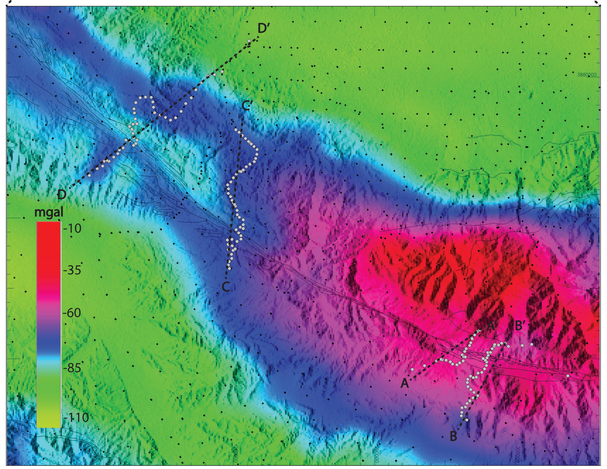
•Topographic map showing Big Bend area(study area), San Andreas Fault, Garlock Fault, Big Pine Fault and San Gabriel Fault.

Geologic Map of the Big Bend Area



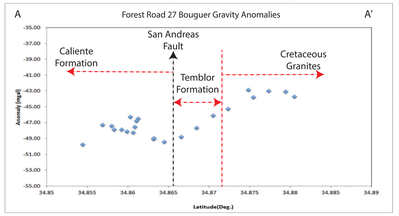
Bouguer Gravity Map of the Area





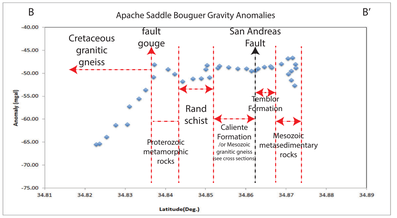
- Dashed area in larger scale map indicates study area.
- Gray circles are survey points in August 2014.
- Black diamonds show pre-existing gravity data in the area.
- Dashed lines in small scale map indicate gravity transects.

Gravity Anomalies Along the Transects

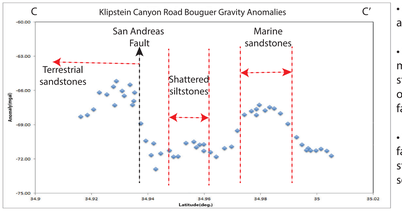


• Gravity anomalies along A-A' transect.

• Graphic showing Temblor Formation and Cretaceous granites on the north of the fault. Whereas Caliente Formation is on the south.



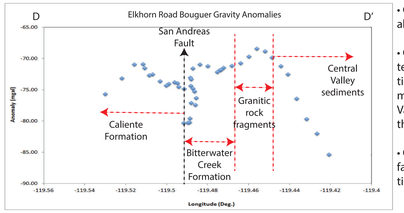
• Gravity anomalies along B-B' transect.
• Graphic showing Temblor Formation and Mesozoic metasedimentary rocks on the north of the fault.
• On the south of the fault, Caliente Formation, Rand schist, Proterozoic metamorphic rocks and Cretaceous granitic gneiss can be observed.



• Gravity anomalies along C-C' transect.

• Graphic showing marine origin sandstones and siltstones on the north of the fault.

• On the south of the fault, nonmarine sandstones can be observed.

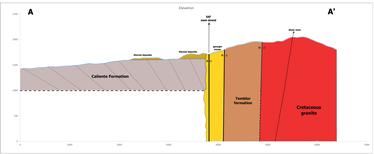


• Gravity anomalies along D-D' transect.

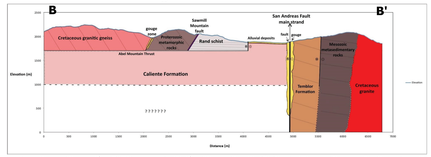
• Graphic showing Bitterwater Creek Formation, granitic rock fragments and Central Valley sediments on the north of the fault.

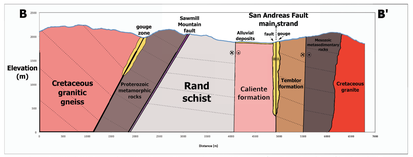
• On the south of the fault, Caliente Formation can be observed.

Geologic Cross Sections



• Geologic cross section for A-A' transect. On the south, alluvial deposits are overlain Caliente Formation at some locations.





• We have two hypotheses for B-B' transects. In first hypothesis, Caliente Formation rocks thrust under the basement rocks. In this hypothesis, there is no clear evidence for the depth of Caliente Formation.
• In second hypothesis, geological units on the south of the fault are much deeper and there is no thrust sheet(Abel Mountain Thrust).

Initial Conclusions

1. High resolution gravity surveys indicate the detailed crustal structure along the San Andreas Fault.
2. Gravity surveys indicate positive flower structures in northern transects (C-C' and D-D') which are composed of sedimentary rocks on both sides of the fault. Crustal slivers are visible in these transects.
3. Higher gravity anomalies in the southern transects (A-A' and B-B') correspond to the uplift and the exposure of the basement rocks. This uplift caused by strike-slip and thrust motions in the area.
4. Both geological observations and geophysical data are associated with the existence of the transpression zone in the Big Bend of the San Andreas Fault

Future Work

1. Creation of gravity models along each transect to test various geologic hypotheses
2. Further definition of the geometry of the SAF Big Bend near its inflection point
3. Determination of the role of the SAF Big Bend in producing hydrocarbon bearing structures in the southern Central Valley of California
4. Creation of a 3-D geologic model of the area

References

• Kellogg, K.S., and Miggins, D.P., 2002, Geologic Map of the Sawmill Mountain Quadrangle, Kern and Ventura Counties, California: U.S. Geological Survey Open File Report 02–406, scale 1:24,000
• Vedder, J. G., Geologic map of the Wells Ranch and Elkhorn Hills quadrangles San Luis Obispo and Kern Counties, California, U.S. Geological Survey Misc. Geol. Inv. Map 1-585, 1970.