Preliminary Analysis of the Geologic Structure of the Eastern San Agustin Plains, New Mexico

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ABSTRACT

We use borehole data, Bouguer gravity data, and geologic mapping of surrounding mountains to preliminarily characterize the geologic structure underneath the eastern San Agustin Plains. Home to the Very Large Array, the eastern San Agustin Plains occupies the 1400 km^2 basin east of a 20-100 m tall topographic high that extends north between the Luera Mountains and Datil, which we refer to as the McClure hills for sake of reference (after a local well). It is surrounded by the Datil Mountains to the northwest, the Gallinas Mountains to the northeast, Tres Montosa to the east, and the Mount Withington area of the northern San Mateo Mountains to the southeast. A 14 km-wide embayment on the southwest side of the basin, holding the C-N playa, extends 16 km between the Luera and northern San Mateo Mountains. Sandy basin-fill correlative to the Santa Fe Group underlies the eastern San Agustin Plains, whereas the surrounding mountains are composed of ignimbrites, volcaniclastic sediment, and lava flows of the Mogollon-Datil volcanic field

We interpret at least two, possibly three, structural grabens underneath the eastern San Agustin Plains. A subsurface bedrock high manifested in the gravity data, and consistent with a borehole drilled near the VLA headquarters, trends northeast from the middle of the McClure hills and separates the North graben to the north from the C-N graben to the south. Southeast of the eastern extension of this bedrock high, relatively low gravity values suggest a third possible fault-bounded graben, which we call the White Lake graben, between Tres Montosas and Mount Withington.

The North graben is an east-tilted half-graben, tilted towards a north-northeast striking, 3 km-wide fault located 8-9 km east of Datil. A deep exploratory borehole indicates at least 3500 ft of basin-fill immediately east of this master fault zone. Although west-down, northwest-trending faults are present on the east side of North graben, their respective throws are relatively minor and do not produce notable gravity gradients. On the north end of North graben, the North Lake playa has formed in a minor graben between two of these eastern faults.

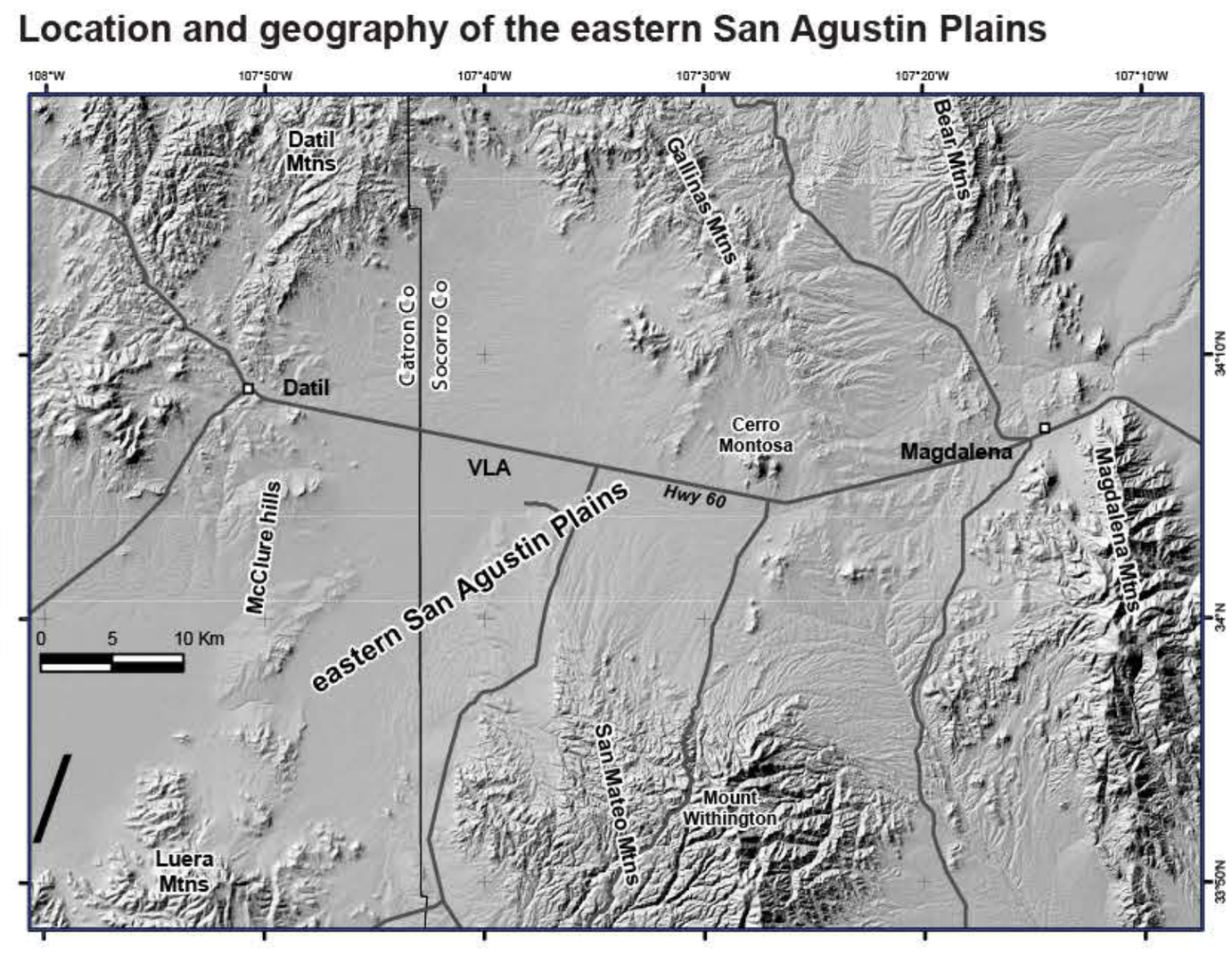
The C-N graben underlies the northern C-N embayment. Rather than a simple half-graben, we interpret a northeast-elongated, fully-fault bounded graben. Its northern bounding fault corresponds to an inferred northeast-striking, normal or normal-oblique fault that bounds the southern side of the aforementioned bedrock high that extends to the VLA headquarters. Its eastern bounding fault corresponds to the VLA fault, which has formed 40 m-tall scarps in middle Pleistocene alluvium. The gravity anomally associated with the C-N graben is similar to that of the western North graben, so we infer similar basin-fill thicknesses of 3500-4000 ft.

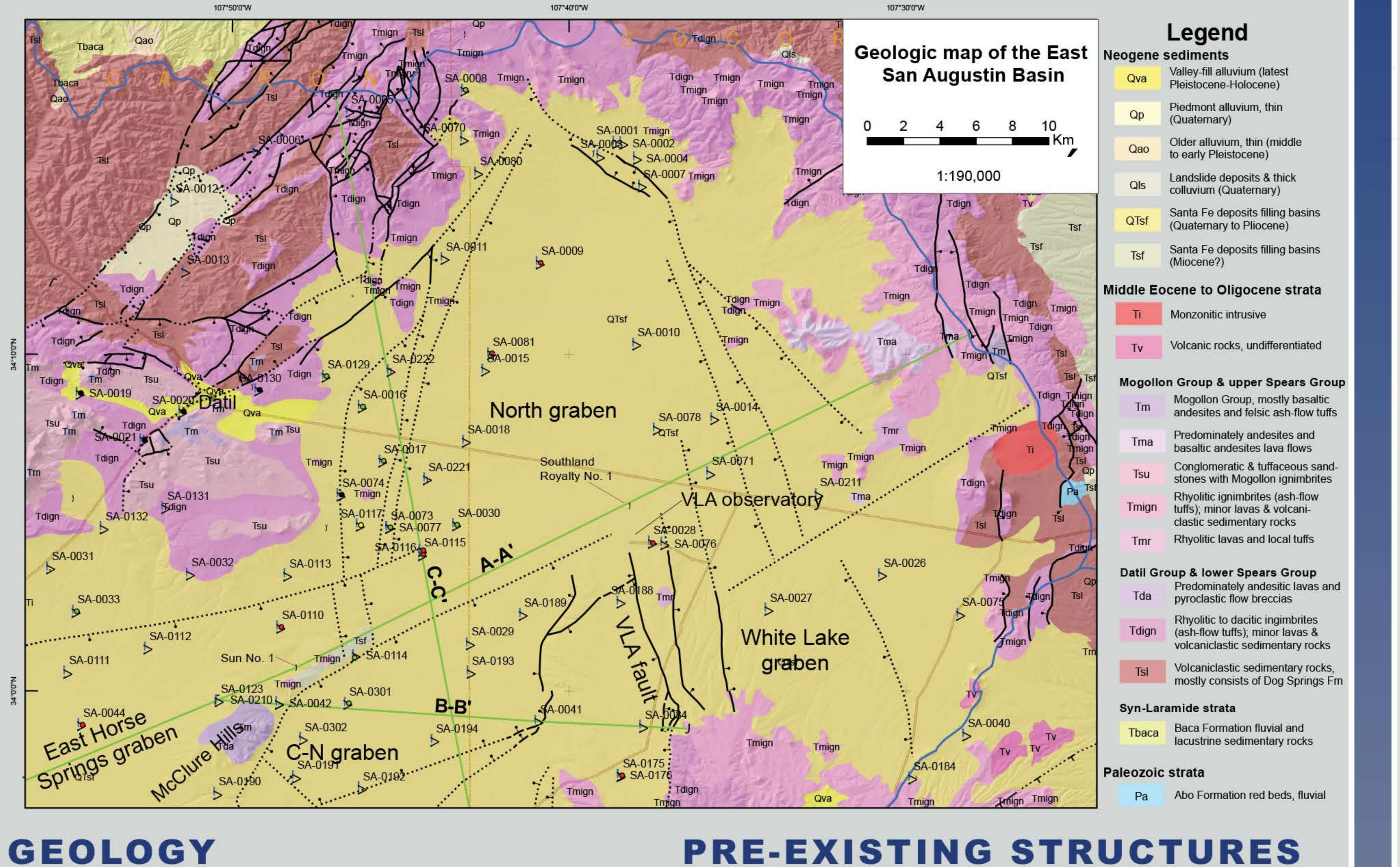
These grabens have formed over the past 30 Ma during west-east extension associated with Rio Grande rifting. Previous workers have suggested that the northwest-trending faults in the eastern North graben are reactivated Laramide structures. The rectangular shape of the C-N graben suggests a pull-apart structure created by oblique slip along its northeast-striking, north bounding fault

INTRODUCTION

- The eastern San Agustin Plains is a 1400 km2 basin that hosts the Very Large Array radio telescope.
- It presently is a closed basin, although in the past it was connected to the western San Agustin Plains, at least intermittently,via topographic low areas in the McClure hills.
- This on-going study strives to better understand the depths of Santa Fe Group basin fill under the eastern San Agustin Plains by synthesizing:
  1) Bouguer anomally gravity data.
  2) Borehole geophysical logs and lithologic descriptions from the Sun No. 1 well (12,284 ft deep), Southland Royalty No. 1 stratigraphic test well (1795 ft deep), and two new exploratory wells east of Datil (SA-221 and SA-222 -- drilled to 3511 ft and 1560 ft, respectively).
  3) Borehole lithologic descriptions.
  4) Previous geologic mapping in surrounding highlands: Chamberlin (1974); Coffin (1981); Ferguson and Osburn (1994, 2011, 2012); Lopez and Bornhorst (1979); Osburn and Ferguson (2010, 2011); Osburn et al. (1993); Wilkinson (1976).
  5) Previous electrical resistivity surveys (Myers et al., 1994).

Location and geography of the eastern San Agustin Plains



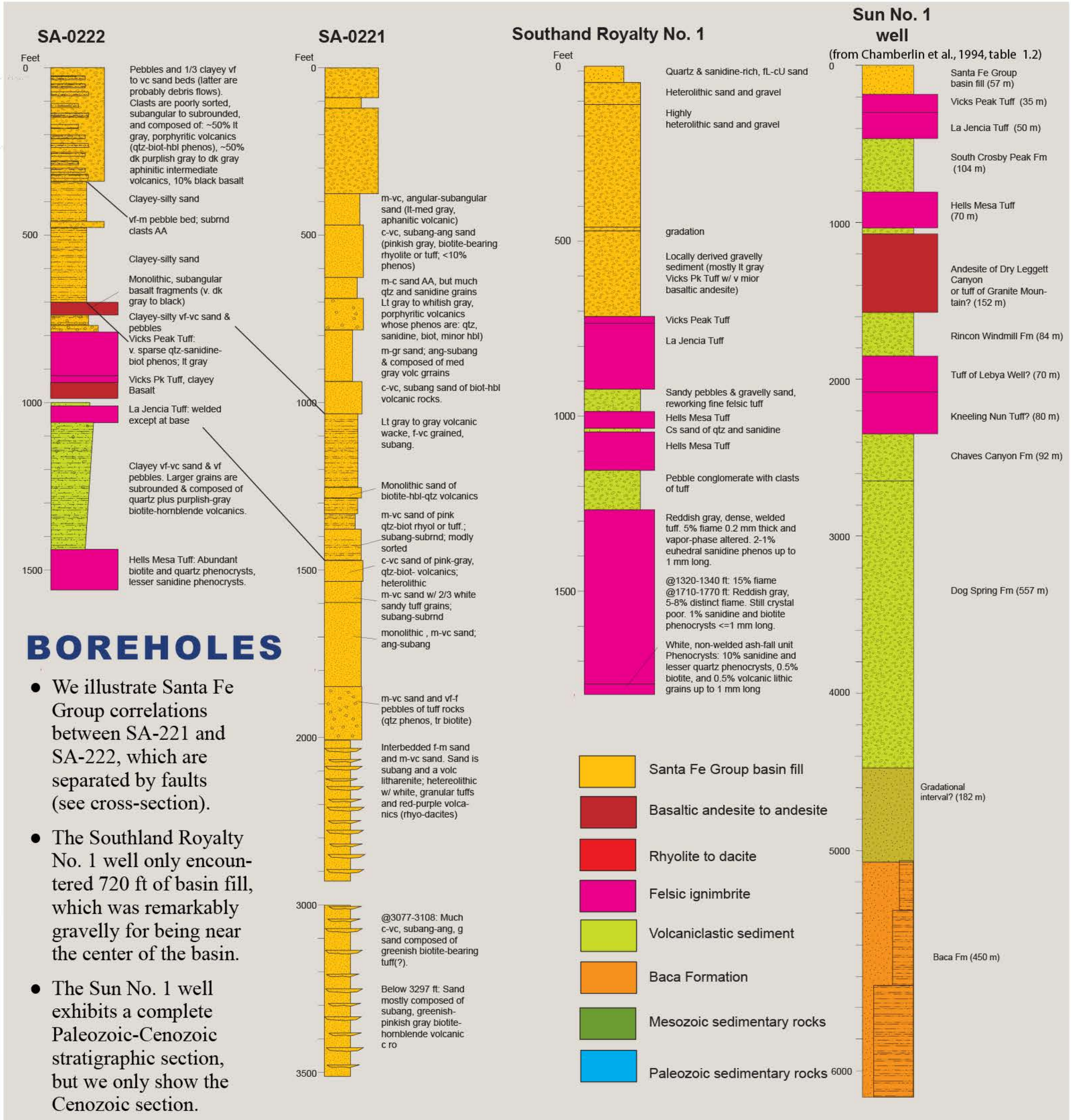


GEOLOGY

- The above figure was modified from the 1:500,000 scale New Mexico State geologic map to show more detail of previously mapped faults in the mountains.
- We show our interpreted faults in the basin.
- The surrounding mountains are underlain by volcanic and volcaniclastic strata of the Mogollon, Datil, and Spears Groups.
- The Santa Fe Group basin fill is comprised largely of sandy piedmont facies, with minor, relatively thin lacustrine facies in the uppermost part (from episodic middle-late Quaternary pluvial lakes).
- We interpret three fault-bounded grabens based on gravity and borehole data: North graben, White Lake graben, and C-N grabens.

PRE-EXISTING STRUCTURES

- North-striking faults appear to end at northeast-striking faults, such as the one inferred to extend across the VLA Observatory.
- Northeast-striking structures are likely older than north-trending faults and may reflect pre-existing crustal structural weaknesses.
- Although rift extension was largely east-west, these older structures probably experienced oblique motion.
- The oblique motion is speculated to have caused a pull-apart basin at the C-N graben.



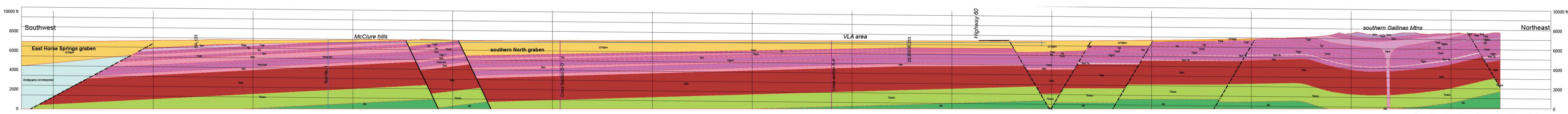
BOREHOLES

- We illustrate Santa Fe Group correlations between SA-221 and SA-222, which are separated by faults (see cross-section).
- The Southland Royalty No. 1 well only encountered 720 ft of basin fill, which was remarkably gravelly for being near the center of the basin.
- The Sun No. 1 well exhibits a complete Paleozoic-Cenozoic stratigraphic section, but we only show the Cenozoic section.

CROSS-SECTIONS

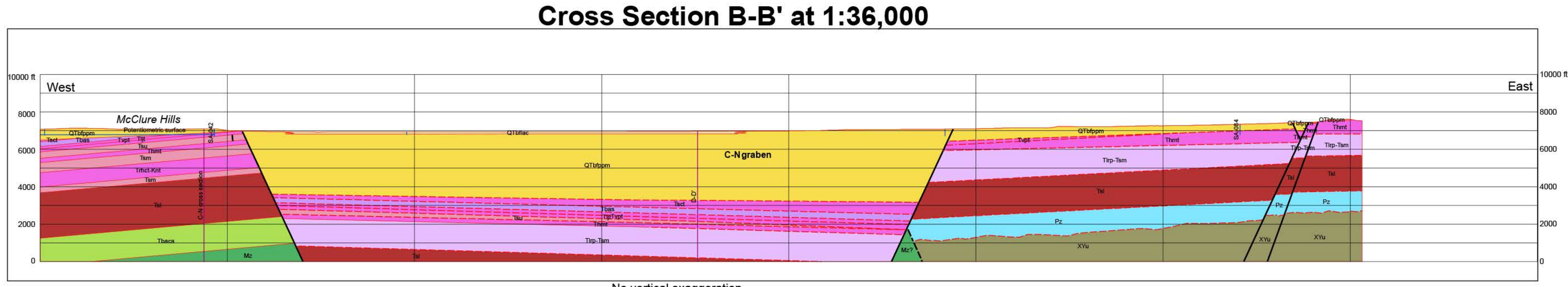
- The three cross secctions to the right illustrate our structural interpretations for the eastern San Agustin Plains
- Cross-section C-C' extends south of the area of the geologic map.
- Bedrock units generally have shallow dips.
- Maximum fault offsets are ~1 km.
- North graben is tilted to west.
- Subsurface stratigraphy constrained by the four aforementioned boreholes.

Northeast part of Cross-section A-A' at 1:36,000



No vertical exaggeration

Cross Section B-B' at 1:36,000



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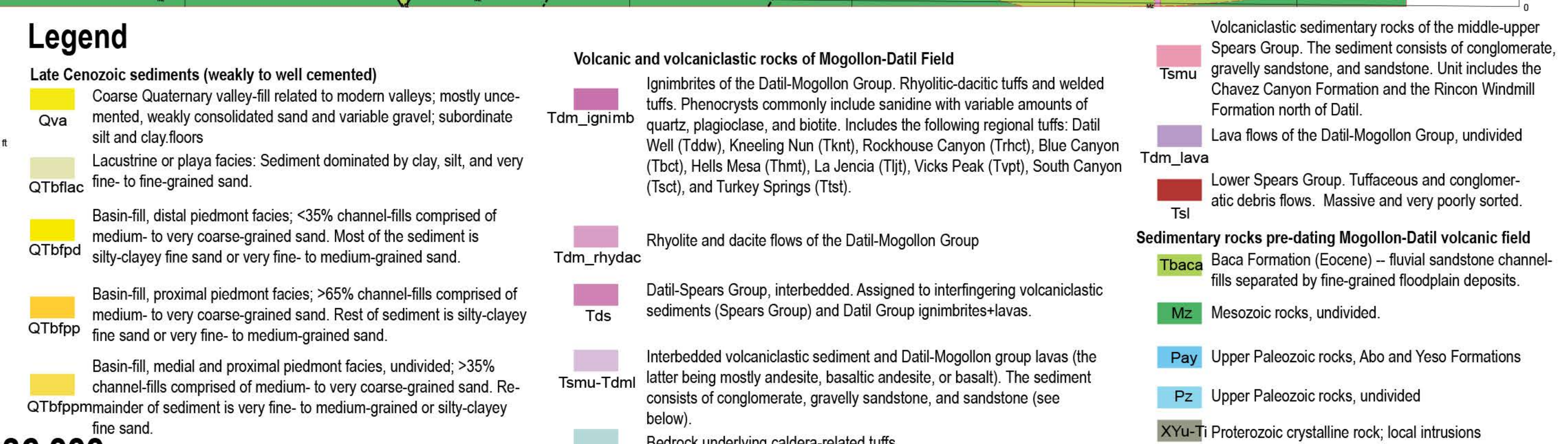
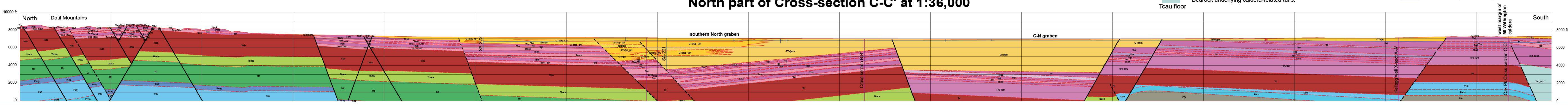


North part of Cross-section C-C' at 1:36,000



No vertical exaggeration

GRAVITY, ELECTRICAL RESISTIVITY, AND BASIN FILL THICKNESS

Left panel

- Gravity data acquired from U.S. Gravity Database (Hildenbrand et. al, 2002) hosted at UTEP.
- Grabens and thick basin-fill were interpreted for gravity lows.
- Concealed faults drawn along steep gravity gradients (e.g., north and west sides of the C-N graben).

Right panel

- Superimposed on the Bouguer gravity anomally map are elecrical resistivity data from Myers et al. (1994) together with their interpreted depth to bedrock.
- Resistivity data were used to draw the southeastern fault of the C-N graben and collectively support the bedrock high between North and C-N grabens.

Figure 3a

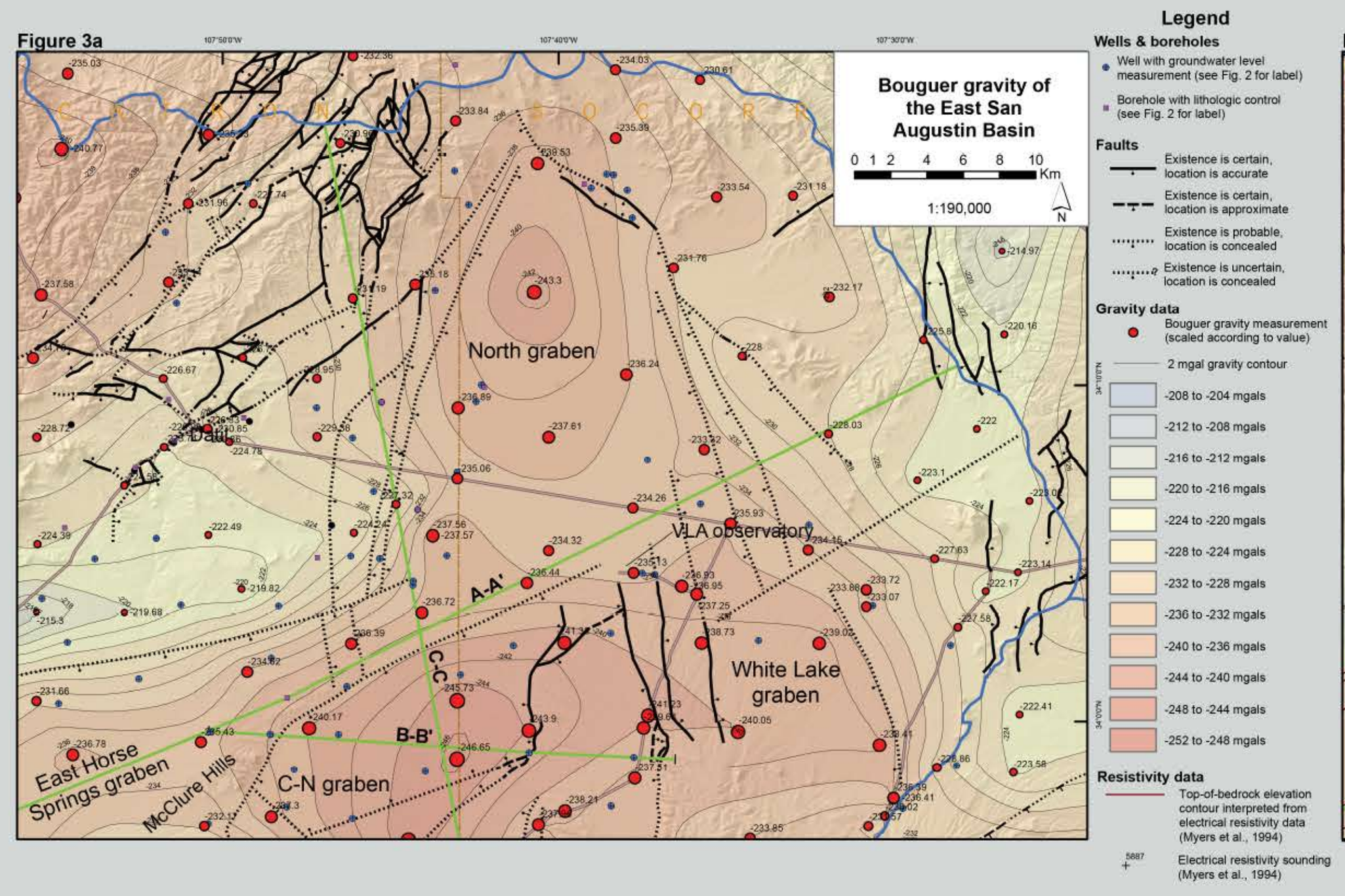
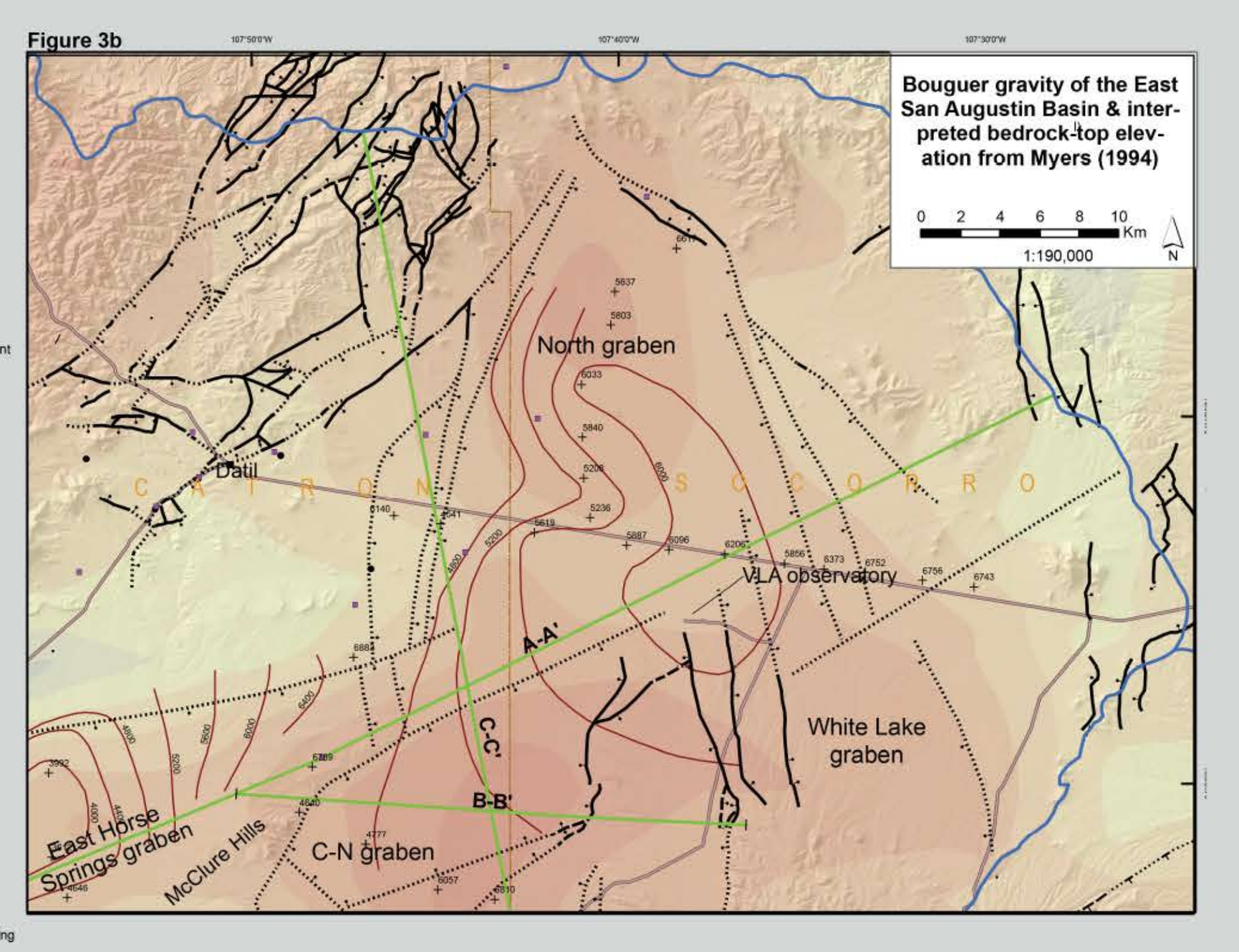


Figure 3b



DISCUSSION

Gravity and electrical resistivity data indicate two grabens in the eastern San Agustin Plains (the North and C-N grabens). These two grabens are separated by a northeast-trending bedrock high bounded on the south by a northeast-trending fault with a south-down component of throw. There is a westward sloping gravity gradient in North graben, indicating that it is a west-tilted half-graben whose master structure is the NNE fault system that bounds the foot of the eastern Datil Mountains. This fault, together with the VLA fault on the east side of the C-N graben, have produced scarps in middle Pleistocene alluvium. Mapped faults and gravity data suggest a third graben to the southeast (the White Lake graben).

Faults mostly trend north-northeast in the western study area, but 050-060° trending faults are inferred in the south and 340-350° striking faults are present in the east (paralleling the trend of the Gallinas Mtns). The north-northeast faults likely formed in response to west-east rift extension over the past 30 Ma. The other faults may represent older structures that experienced Laramide movement.

CONCLUSIONS

- At least two grabens underlie the easternSan Agustin Plains
- North graben is asymmetric, tilted to the west.
- C-N graben is rectangular and bounded on the north by a northeast-trending fault inferred by gravity and electric resistivity data.
- The SA-0221 borehole indicates that basin fill in the North graben is at least 3500 ft (we infer 3600-3800 total thickness).
- The northeast-trending fault passing through the VLA headquarters is probably a reactivated structure broadly corresponding to the San Agustin lineament of Chapin (1971)
- Assuming east-west rift extension, we infer oblique-normal movement along the northeast-trending structure, producing a pull-apart basin coinciding with the C-N graben.
- Possible graben on southeast side of the eastern San Agustin Plains, bounded on the west by mapped east-down faults and a gravity-inferred east-down fault on its east side.

ACKNOWLEDGMENTS

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REFERENCES

Chamberlin, R.M., 1974, Geology of the Council Rock District, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 40, 134 p. and 1 plate.

Chamberlin, R.M., Cather, S.M., McIntosh, W.C., Anderson, O.J., and Ratte, J.C., 1994, First-day road log from Socorro to Magdalena, Datil, western Crosby Mountains, Sawtooth Mountains, Pie Town, Quemado and Quemado Lake: New Mexico Geological Society Guidebook, 45th Field Conference, Mogollon Slope, p. 1-45.

Chapin, C.E., 1971,The Rio Grande rift, Part I: Modifications and additions: New Mexico Geological Society, Guidebook 22, p. 191-201.

Coffin, G.C., 1981, Geology of the northwestern Gallinas Mountains, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open File Report 159, 202 p. and 2 plates.

Ferguson, C.A., and Osburn, G.R., 1994, Geologic map of the Mt. Withington 7.5 minute quadrangle, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open File Report 403, 2 p., 1 map.

Ferguson, C.A., and Osburn, G.R., 2011, Geologic map of the C-N Lake 7.5-minute quadrangle, Catron County, New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-file Digital Geologic Map OF-GM 218, scale 1:24000.

Ferguson, C.A., and Osburn, G.R., 2012, Geologic map of the Luera Mountains East 7.5-minute quadrangle, Catron County, New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-file Digital Geologic Map OF-GM 222, scale 1:24000.

Lopez, D.A., and Bornhorst, T.J., 1979, Geologic map of the Datil area, Catron County, New Mexico: U.S. Geological Survey, Miscellaneous Investigations Series Map I-1098, scale 1:50,000.

Myers, R.G., Everheart, J.T., and Wilson, C.A., 1994, Geohydrology of the San Agustin Basin, Alamosa Creek Basin upstream from Monticello Box, and upper Gila Basin in parts of Catron, Socorro, and Sierra Counties, New Mexico: U.S. Geological Survey, Water-Resources Investigations Report 94-4125, 70 p.

Osburn, G.R., Laroche, T.M., and Weber, R.H., 1993, Geology of Lion Mountain and northern Arrowhead Well quadrangles, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 68, 1 sheet, scale 1:24,000.

Osburn, G.R., and Ferguson, C.A., 2010, Geologic map of the Oak Peak 7.5-minute quadrangle, Catron and Socorro Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-File Geologic Map 65, scale 1:24,000.

Osburn, G.R., and Ferguson, C.A., 2011, Geologic map of the Monica Saddle 7.5-minute quadrangle, Socorro County, New Mexico: Open-file Digital Geologic Map OF-GM 217, scale 1:24,000.

Wilkinson, 1976, Geology of the Tres Montosas-Cat Mountain area, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 39, 158 p. and 3 plates.

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