

# NEW MEXICO BUREAU OF GEOLOGY & MINERAL RESOURCES OPEN-FILE REPORT - 537

## *GENERALIZED GEOLOGIC MAP OF THE SOUTHERN SACRAMENTO MOUNTAINS, OTERO AND CHAVES COUNTIES, NEW MEXICO*

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### Introduction

This geologic compilation map was produced as part of a regional hydrogeologic study of the Southern Sacramento Mountains. New geologic mapping was limited to the area east of the crest of the Sacramento Mountains, where the San Andres and Yeso Formations are exposed. Work was begun in late 2005 and completed in early 2009. Compilation of map data sets, cartography and editing were completed in early 2012. The new mapping was compiled together with the mapping of Pray (1961) of the western escarpment of the range and some northern portions of the map of Black (1973), as shown on the data source index map.

### Methodology

In addition to standard geologic field mapping procedures, much geology, especially in the sparsely wooded eastern portion of the study area, was interpreted from aerial photographs. Subdivision of the members of the San Andres formation into its constituent members (as defined by Kelley, 1971) was performed in this way. These interpretations were locally field checked and compared to the regional map of Kelley (1971). In most places, the interpretations are similar.

Pray (1961) mapped the Yeso Formation to include the "Hondo Member" of the San Andres Formation, thus including with the Yeso Formation overlying basal limestone beds of the San Andres up to and including the distinctive tan quartz sandstones that are equivalent to the Glorieta Sandstone of northern New Mexico. This member ranges from 60 to 120 feet thick. Pray (1961) correctly observed that the tan sandstone beds form the only reliably mappable horizon above the Abo-Yeso contact. We chose to map the Yeso contact directly because of its hydrologic significance; we mapped the contact in the field by placing it 80 feet (two contour intervals) below the lowest appearance of the tan sandstone beds, and remapped Prays contact using this approach.

Cross-sections were drawn using subsurface data such as lithologic and geophysical logs from water and oil and gas wells. Numerous well cuttings in storage at the NMBGMR in Socorro were examined to aid in determining unit boundaries and to confirm unit boundaries picked on scout cards and geophysical logs.

### Yeso and San Andres Formations

Geology on the map west of a roughly north-south through High Rolls (approximately following the West Side Road), is largely from Pray (1961). Aside from basic unit descriptions provided here, the reader is referred to his excellent discussion for details on the complex stratigraphy and structures of this area. From the aforementioned line to the crest of the range and east the exposed rocks are the Permian Yeso and San Andres Formations, which dip shallowly (2-3°) to the east. The new mapping presented here is largely concerned with these two units, so additional discussion is warranted.

The Yeso Formation is exposed in valley bottoms and the lower portions of valley side slopes, whereas the overlying San Andres Formation comprises the upper portions of valley slopes and caps the ridges. This pattern extends to a few miles east of longitude 105°30'0" West (a few miles east of Mayhill) where the easterly dip of the sedimentary rock layers causes the Yeso Formation to plunge beneath the ground surface. From this point east, the exposed bedrock is entirely the San Andres Formation. Furthermore, in this same vicinity it becomes possible to subdivide the San Andres Formation into the lower Rio Bonito member, middle Bonney Canyon member, and upper Four Mile Draw member. As noted by Kelley (1971) and Black (1973), this subdivision is generally not possible further west because of tree cover and poor exposures. For example, it is likely that there is additional surface extent of the Bonney Canyon Member in the southwest portion of the study area, in the wooded high elevation areas east of Timberon.

The Yeso Formation is composed of, gray to tan, often silty, carbonate rocks (limestone and dolomite), yellow to tan siltstone and fine sandstone, red to pink muddy siltstone and fine sandstone, and the evaporite minerals gypsum, anhydrite, and halite. Good natural exposures of the Yeso Formation are rare, as it is less resistant than the overlying San Andres Formation and is usually covered with colluvium and valley bottom alluvium. A complete section is not exposed in the study area; Pray (1961) and Kelley (1971) measured one complete and two partial sections on the western escarpment, 11 miles north of the present study and at the extreme southwest corner of the present study. They estimated total thickness at 1300 – 1400 feet. The Apache Canyon water test well near Cloudcroft penetrated 1650 feet of the Yeso formation. Anhydrite and/or gypsum was first observed at 1240 feet below the top of the Yeso in this well, but at 260 feet depth in the southern surface section of Pray (1961). Anhydrite and minor halite were observed below 940 feet below the top of the Yeso in the Southern Production Co. #1 oil test well between Cloudcroft and the Rio Penasco. No evaporites have been observed in surface exposures in the newly mapped area. In general, Kelley (1971) and Pray (1961) noted that the gypsum content of the Yeso Formation increases to the north and the carbonate content increases to the south.

In the upper portions of the Yeso Formation the evaporate minerals have been dissolved, resulting in chaotic bedding dips. As a result, individual beds are not traceable laterally for more than a few tens of meters in outcrops and beds cannot be correlated between outcrops. Ziegler (2010) examined cuttings from four water wells less than 6 km apart in canyons tributary to James Canyon and showed that individual beds in the Yeso Formation could not be correlated at depth. She attributed this to initial stratigraphic variability and the effects of evaporate dissolution. However, reasonable correlations of

transgressive and regressive intervals in the stratigraphy can be made based on the vertical groupings of gross lithologic characteristics rather than individual beds (Ziegler 2010).

The San Andres Formation is composed of light to dark gray and bluish-gray carbonate rocks (limestone and dolomite). Freshly broken surfaces are darker gray than weathered surfaces and often fetid. Subdivision of the San Andres into the lower dominantly thick-bedded Rio Bonito Member and middle dominantly medium- to thin-bedded Bonney Canyon member (Kelley, 1971) was based largely on interpretation of aerial photographs. In most areas, the differences in the nature of the bedding are not reliably distinguishable on the ground. Kelley estimated thicknesses for the Rio Bonito Member at 250-350 feet and the Bonney Canyon Member at up to 300 feet. Based on our mapping, cross-sections, and well-log interpretations, the thicknesses are ~580 and 400 feet, respectively, in the vicinity of the regional cross section A. These differences are significant, but Kelley mapped at a much smaller scale (1:125000) using a mix of air photo and topographic bases, and presented no cross-sections or well control to constrain his thickness estimates. Thickness variations on the order of  $\pm 100$  feet are likely in both members across the mapped area.

A small area of the uppermost member of the San Andres Formation, the Four Mile Draw member, is present in the northeast corner of the mapped area. On aerial photographs it presents an even-textured, much less-prominently bedded, and slightly darker and more grayish-brown appearance than the underlying Bonney Canyon member. Although it contains abundant gypsum elsewhere (Kelley, 1971), in the mapped area it is composed of thin bedded, locally brecciated dolomite (Ziegler, personal communication, 2007). The total thickness is not exposed, but it is at least 100 feet.

For the purposes of this compilation, younger geologic units have been generalized into Quaternary undivided alluvium and Quaternary and Tertiary terraces and gravels. The undivided alluvium includes unconsolidated alluvium in modern drainages, areas of colluvium, aeolian sand sheets, travertine deposits around springs, and broad flat terraces and valley bottoms underlain by fine-grained sediment. The terrace and gravel unit includes coarse grained sediments and gravels that have been incised by modern drainages. Some of these gravels are well lithified and may be as old as Miocene.

## Structural Geology

The generally shallowly east-dipping Yeso and San Andres beds are complicated by faulting and folding. The Sacramento River drainage extends southeast of Sunspot, through Timberon, and out of the mapped area. This drainage is structurally controlled as it follows a zone of west-side down normal faults and associated folds that form east-tilted structural blocks, or half-grabens. These faults are probably of Tertiary age and related to the uplift of the Sacramento Mountains.

The northeast-trending segment of the Rio Peñasco drainage that passes by Mayhill follows the Mayhill Fault, which has minor west-side down displacement. This fault and valley segment is aligned with the Border Buckle, one of several linear right-lateral strike-slip fault zones that extend for tens of miles to the northeast across the Pecos Slope (Kelley, 1971). The Mayhill Fault may be an extension of this regional structure and have some component of right-lateral slip. This fault appears to die out in the vicinity of Denny Hill north of Weed. There are several small folds extending to the southwest and northeast along the trend of this fault that are probably due to the distribution of displacement across a broad zone at the fault tip.

The southern end of the Dunken-Tinnie anticlinorium, or Dunken uplift, forms a linear north-south trend of ridges and low hills in the eastern third of the map area. This regional structure extends north to the eastern end of the Capitan Mountains (Kelley 1971), and dies out within the mapped area just northeast of Piñon. The anticlinorium is a complex structure of subparallel anticlines and synclines and discontinuous east- and west-side-down faults, but overall is a structural as well as topographic high, as the Rio Bonito member is uplifted along the ridgeline.

The complex zone of faulting and folding in the southeast corner of the map area near the southern termination of the anticlinorium may be partly due to the interaction of this structure with the Six-Mile and Y-O buckles, two more of the zones of right lateral strike slip faulting on the Pecos Slope (Kelley 1971). The Six-Mile buckle enters the mapped area in the northeast corner, within the outcrop area of the Four-Mile Draw member. Synclinal folding is associated with this buckle here, thus the Four-Mile Draw member is preserved on the surface. The Y-O buckle impinges on the mapped area about 15 miles to the south, where faults change trend from northwest-southeast to roughly north-south. Kelley (1971) and Black (1973) both interpreted the Dunken-Tinnie anticlinorium and the buckles as Laramide-age features. However, the deformation in the southeast corner of the mapped area may also be related to Rio Grande rift extension, as extensional faults with Tertiary movement are present to the west in the Sacramento River valley and to the south along the west face of the Guadalupe Mountains. There are no faults scarps in the Quaternary units.

Structural contours derived from elevation points along the mapped San Andres – Yeso geologic contact are illustrated in on the tectonic map in brown. The elevation of the surface defining the contact between these two units decreases from more than 9000 feet near the range crest to less than 7200 feet on the east side of the Yeso outcrop belt. The structure contours indicate that the strata dip gently to the east from a broad anticline at the range crest. Troughs in the contoured surface along major drainages are broad folds that probably influenced the formation of the drainages and likely continue to influence ground water flow directions.

Structural contours derived from elevation points along the mapped contact between the Rio Bonito and Bonney Canyon members of the San Andres Formation are illustrated on the tectonic map in blue. The western extent of these contours occurs where the vegetation becomes dense enough to prevent reliable mapping of these two units on aerial photographs. Tight anticline-syncline pairs and discontinuous faults define the north-south Dunken-Tinnie anticlinorium through the eastern third of the mapped area. Southeast- and north-south-trending faults of the Sacramento River valley and the northern Guadalupe escarpment are associated with very complex, though broad folding.

Carbonate rocks throughout the mapped area are deformed by joints. Most fractures in the Sacramento Mountains are probably joints. We measured 170 joints at 70 sites west of the Dunken-Tinnie anticlinorium (Walsh 2008). There are two predominant joint sets, NE-SW and NW-SE, consistently oriented throughout the high mountain area. Outcrops containing joints occur at roadcuts, bedrock stream channels and stream valley walls that are not covered with alluvium and/or vegetation. No consistent age relationship could be established between the joint sets.

## References

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