**Subsurface Seven Rivers (Guadalupian) Anhydrite-Dolomite Transition, Eddy Co., New Mexico, USA: Modification of a Depositional Facies Change by Permian Meteoric Dissolution**

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**Abstract**

The anhydrite - dolomite facies change in the Seven Rivers Formation (SRF) exposed on outcrop can be interpreted as depositional or dissolution. To reduce ambiguity resulting from Cenozoic outcrop dissolution, the facies change was examined in the subsurface of eastern Eddy County, New Mexico.

North of the facies boundary, over 80% of the SRF section is anhydrite with thin dolomites and siltstones. Over a narrow zone approximately two kilometers wide, anhydrite abundance drops to about 20% anhydrite as dolomite thickens. By four kilometers south of the start of anhydrite thinning, all of the SRF is tight (1 - 4% porosity) dolomite with thin siltstone beds. The dolomites in the transition zone have high, irregular gamma ray (GR) related to high uranium. The high-GR dolomite grades southwards into low-GR dolomite with higher porosity.

The SRF thins by about 30.5 meters in the transition zone, with the most abrupt thinning near the northern end of the facies transition. The abrupt SRF thinning is equal to the thinning of net SRF anhydrite. Farther south within the transition zone, SRF thinning is irregular, and thinner anhydrite is compensated by thicker dolomite. Net SRF thinning is compensated mainly by thickening in the Yates Formation.

The SRF depositional anhydrite-dolomite facies change is interpreted as an originally gradational facies change that maintained a relatively constant position on the shelf interior. SRF sulfate thickness was modified during Yates deposition. Permian subaerial exposure, especially along the Yates B surface, could have caused meteoric, shallow-subsurface sulfate dissolution selectively within the carbonate facies, making the overall facies transition more abrupt.

Although the shelf margin during SRF deposition shows significant seaward progradation, the anhydrite-dolomite transition shows no evidence for seaward progradation. SRF shelf-interior processes are apparently decoupled from shelf margin processes. The same lack of seaward
progradation is evident in the Yates anhydrite-dolomite facies transition. Major sea-level events (such as SRF-Yates boundary) reset the position of shelf-interior facies boundaries, and these boundaries remain rather static between major sea-level events.

The outcrop Seven Rivers facies change thus represents a gradational facies change modified first by Permian meteoric dissolution throughout SE New Mexico and then by Cenozoic dissolution near the outcrop belt.
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Modification of a Depositional Facies Change by Permian Meteoric Dissolution

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Abstract

The depositional facies change from Seven Rivers gypsum to dolomite in Eddy County, New Mexico, is well exposed in the Rocky Arroyo outcrop, and is analytically interpreted on a regional scale. The transition zone is modified by Permian meteoric dissolution.

Introduction and Background

The transition from Seven Rivers gypsum to dolomite in Eddy Co., New Mexico, is well exposed in the Rocky Arroyo outcrop, and is analytically interpreted on a regional scale. The transition zone is modified by Permian meteoric dissolution.

Stratigraphic Framework

The Seven Rivers Formation is an early Guadalupian shelfmargin deposit with strata developed from Late Guadalupian (Castile) to Lopingian (Shattuck) times. The Seven Rivers Formation is an early Guadalupian shelfmargin deposit with strata developed from Late Guadalupian (Castile) to Lopingian (Shattuck) times.

Rocky Arroyo Outcrop

The transition from Seven Rivers gypsum to dolomite is modified by Permian meteoric dissolution. The gypsum-dolomite transition is modified by Permian meteoric dissolution. The gypsum-dolomite transition is modified by Permian meteoric dissolution. The gypsum-dolomite transition is modified by Permian meteoric dissolution. The gypsum-dolomite transition is modified by Permian meteoric dissolution.
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Stratigraphic Comments

Stratigraphic determinations are generally accepted for the area, with the following additional clarifications:

- Base salt is picked rather than top Tansill evaporite or Fletcher Anhydrite. In the discussion, the unit below base salt is referred to as Tansill Permian, but this is for convenience only.

- Core and thin section data indicate that the base of modern anhydrite beds in the Three Rivers Formation is at or near the water table, where diffusion of meteoric water has occurred.

- Base Tansill in Seven Rivers is at the base of the dolomitized strata as indicated by RQD values and local detailed correlation.

- Section is kept to the base of the Seven Rivers Formation Member of the Seven Rivers Formation. The top Bowers appears to locally amalgamate with another high-clastic unit, causing uncertainty in the base of the Bowers Sandstone at the north end of the cross section.

- The base of Seven Rivers dolomite is taken as the base of the Seven Rivers Formation at the east end of the cross section in part of the Seven Rivers Formation.

- Base Seven Rivers is picked at the base of the Shattuck Sandstone. The Shattuck Sandstone was correlated from area of Shattuck production and is restricted to the upper Shattuck in the Shattuck Province. There is no subcrop with anhydrite in the lower Seven Rivers, but may be increased in the lower Seven Rivers. There is a large area of the Shattuck that may be observed and the base of the Shattuck is taken as the base of the Seven Rivers Formation.

- The top of the Queen is picked at the top of the Shattuck Sandstone. The Seven Rivers dolomite below the Bowers Sandstone is to be anomalously thick towards the middle of the cross section.

- Anhydrite above top Seven Rivers is the base of the dominantly siliciclastic section as indicated by FDC-CNL cross plots and lithology and GR response across the area. Underlying strata are clearly Yates based on high lithodensity and FDC-CNL responses.

Methods

Three north-south cross sections were picked and selected where anhydrite is preserved and well control is adequate. Sections extend from the base of the Shattuck Sandstone to the base Salina salt. Tops were picked from a combination of all available logs (including by bottom, density, and GR logs. Only section 3 is displayed and discussed in detail. Similar features are seen on the other two north-south sections, but these sections do not extend as far south as section 3 or lack close well control.

Lithodensity or FDC-CNL logs were used so that anhydrite can be identified and differentiated from dolomite and argillaceous siltstones/sandstones. A cutoff of 2.88 g/cc was used to identify anhydritic beds from the density or density-porosity curves in Cross Section 3. This cutoff probably includes some non-anhydritic argillaceous dolomite, but modern anhydrite beds are usually denser than the 2.88 g/cc cutoff. Modern anhydrite can have a density of 2.95 g/cc or higher, but this lower cutoff is still effective in picking the base salt. The Yraguelo horizon at 1,222 ft was picked as the base of the salt in Cross Section 3. The Yraguelo horizon is picked at 1,180 ft in Cross Section 1 and 1,162 ft in Cross Section 2. The choice of a low density cutoff rather than a value close to the true grain density for anhydrite, while convenient and quick and does indicate anhydrite in the rock. Also, older FDC tools had no ability to log true density. The log log is not compared to the 2.95 g/cc cutoff, but a value of 2.88 g/cc was used for standards to compare to the density logs in Cross Section 3. The base of the salt and the top of the gas column is picked at a cutoff of 2.88 g/cc. The FDC tool is calibrated to read density, and not true density, so the 2.88 g/cc cutoff is used for both logs in Cross Section 3. The FDC tool in Cross Section 3 has a 2.88 g/cc cutoff for densities, and the top of the gas column is picked at a 2.88 g/cc cutoff for densities. The top of the gas column is not picked at 2.88 g/cc in Cross Section 1 or 2 where the tool is not calibrated to the cutoff.

Thicknesses of anhydrite and dolomite sections are calculated and used to analyze controls on the facies change. Core and thin section data were not examined.

Figure 10. Cross section 3. Interpreted anhydrite distribution in the Seven Rivers Formation is shown in red. Anhydrite distribution is interpreted to be a depositional facies change. Small scale map is right side of map. All scale bars are in feet. Locations are shown on figure 12. The red figure is a stratigraphic section hung on base salt (Figure 12).

Figure 12. Stratigraphic cross section hung on base salt horizon. See cross section at left for well names and locations. Rectangles on wells 3, 6, and 10 are zones with lithology discussion on next sheet.
Subsurface Seven Rivers (Guadalupian) Anhydrite-Dolomite Transition, Eddy Co., New Mexico, USA: Modification of a Depositional Facies Change by Permian Meteoric Erosion

### General

- **Facies change is naturally abrupt.** Most anhydrite is in a zone 1.5 km wide, with the remaining anhydrite systematically lost on an additional 1.5 km wide.
- **High-angle fractures** are lost to shale overlying anhydrite. Abundant network of thin anhydrite laminae forms a vuggy, throat-like network.
- **Abundant replacement of anhydrite by dolomite**.
- **Tree-like karst development on thin anhydrite layers**.

### Subsurface Interpretations

#### Nature of Evaporite-Carbonate Facies Transition

- **Carbonate facies are present adjacent to evaporite facies.** Carbonate facies are present adjacent to evaporite facies, indicating a peritidal or restricted marine environment.
- **Interbedded carbonate and evaporite facies** characterize the Seven Rivers Formation.

#### Lithofacies Characteristics

- **Dolomitic Facies**
  - Adults: 10-30 cm thick, vertically isolated, with a linear trend of evaprite-dolomite transition.
  - Laminated: 1-3 cm thick, horizontally isolated, with a random trend of evaporite-dolomite transition.
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#### Width of Evaporite-Carbonate Transition

- **The evaporite-gypsum facies transition is interpreted from Bates and Rattalakana (1942) cross sections (Figure 8).** This transition is an additional 1.5 km wide, with an additional 1.5 km wide of thin anhydrite laminae.

#### Implications for Outcrop

- **The evaporite-gypsum facies transition occurs over a relatively narrow interval.** This interval is approximately 0.3 km wide, with an additional 0.3 km wide of thin anhydrite laminae.

### One Minute Summary

The evaporite-gypsum facies transition is interpreted from Bates and Rattalakana (1942) cross sections (Figure 8). This transition is an additional 1.5 km wide, with an additional 1.5 km wide of thin anhydrite laminae.

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#### Contrasts an Outcrop Evaporite-Carbonate Transition

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#### Stratigraphic Implications

- **When offsets of Permian and Cretaceous strata are combined, the pattern of offset is correlated with a gradual change.** This pattern occurs over an additional 1.5 km wide, with an additional 1.5 km wide of thin anhydrite laminae.
- **New markers are identified, allowing for a more complete understanding of the stratigraphic relationships.** These markers are identified, allowing for a more complete understanding of the stratigraphic relationships.

### References