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PERMIAN ROCKS OF THE SAN JUAN BASIN

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INTRODUCTION

The colorful redbeds of Permian age are exposed only on the major uplifts surrounding the San Juan Basin, but are present throughout the basin in deep wells. It seems that each area of exposure is unique and much controversy prevails regarding the stratigraphic relationships. Baars (1962) summarized the problems, and using subsurface data available at that time proposed regional correlations throughout the Colorado Plateau province. Numerous deep wells have been drilled in the meantime, confirming regional correlations and at the same time extending some formations beyond their previously known geographic limits. This study is an update of the 1962 publication and utilizes all well control penetrating Permian strata in the San Juan Basin as of early 1977.

STRATIGRAPHY

The Permian System varies considerably from north to south in the San Juan Basin. In the northeast it is composed entirely of reddish brown arkosic clastics derived from the Uncompahgre element of the ancestral Rocky Mountains. This major paleotectonic uplift, which lies just off the map area to the north and east, was an active source area from Early Pennsylvanian through Permian times. The thick arkosic wedge derived from the Uncompahgre is shown on the maps as Cutler Formation undifferentiated. The clastic sediments thin and become somewhat finer in grain size toward the south and west, and are overlain by an orange colored eolian sandstone, the De Chelly Sandstone, throughout the southwestern portion of the basin. In the southern San Juan Basin marine formations cap the sequence and thicken southward. These are the Yeso (restricted), Glorieta and San Andres formations in ascending order (see fig. 1, Stevenson and Baars, elsewhere in this volume). South of the San Juan Basin the entire sequence becomes marine (Baars, 1962).

Lower Cutler-Abo Formations

Arkosic redbeds overlie the Pennsylvanian Hermosa Group in the Four Corners area; the equivalent Madera Formation in the Albuquerque region; and the Precambrian basement rocks of the Defiance, Zuni and San Pedro uplifts. These redbeds are referred to as the lower Cutler to the north and the Abo Formation to the south. The entire unit, regardless of the name applied, was derived from the Uncompahgre uplift to the north and east and was transported by streams to typical fluvial and evaporative lacustrine environments. A marine limestone sequence, the Bursum Formation, interfingers with the basal redbeds in the eastern Zuni Mountains and Albuquerque region, but it is difficult to determine from subsurface information how far north these thin limestones were deposited. Consequently, they may be here included as thin carbonate beds in the basal Abo Formation.

The Abo Formation, perhaps with Bursum equivalents, appears to be the stratigraphic correlative of the entire pre De Chelly-Cutler section in the Four Corners. In other words, the Abo appears to represent all of Halgaito-Cedar Mesa-Organ Rock time, and is here mapped accordingly (fig. 1). The unit generally thins southwestward away from its source region, and thins markedly on the Zuni, Defiance and Nacimiento uplifts, suggesting that the structural highs bounding the San Juan Basin were positive in Early Permian (Wolfcampian) time. Figure 1 differs from maps of Baars (1962) in that the Organ Rock Shale was mapped separately in the Four Corners region in the earlier work and the two thick regions north of Gallup and west of the Nacimiento Mountains were unknown at that time. This stratigraphic unit would also be the Supai Formation of Peirce (1967).

De Chelly Sandstone

The lower Cutler-Abo redbeds are overlain by an orange-red, fine-grained sandstone throughout much of the San Juan Basin (fig. 2). This highly cross stratified unit is known as the De Chelly Sandstone in the Four Corners area and is the Meseta Blanca Sandstone Member of the Yeso Formation in the Albuquerque region. Baars (1962) advocated that the two names had been applied to one and the same sandstone body, and that since the term De Chelly Sandstone has priority over the Meseta Blanca it should be called the De Chelly Sandstone. Some disagreement ensued from New Mexicans and it is doubted that the proposed term has yet to be used in New Mexico. However, recent drilling in the San Juan Basin leaves little doubt as to the correlation (fig. 2). The formation is petrologically identical throughout its extent, except that it changes from an eolian facies of the north into a water-laid facies in southern exposures, both in New Mexico and Arizona.

Peirce (1967) tried to refute the correlation on the basis of Defiance uplift stratigraphic relationships, naming five new members and calling for facies changes. His disagreement with Baars (1962) was the result of correlation of thin carbonate beds in the Abo-Cedar Mesa equivalent section with the Yeso Formation (restricted) or San Ysidro Member of previous writers. This restudy of updated subsurface information in the San Juan Basin and research on the Permian stratigraphy of the Mogollon Rim of Arizona was well underway at the University of Northern Arizona to confirm the original correlations, and this put to rest the terminology of Peirce (1967). As such, only the lower orange-red sandstone at Peirce's key section at Hunters Point, Arizona, is equivalent to the type De

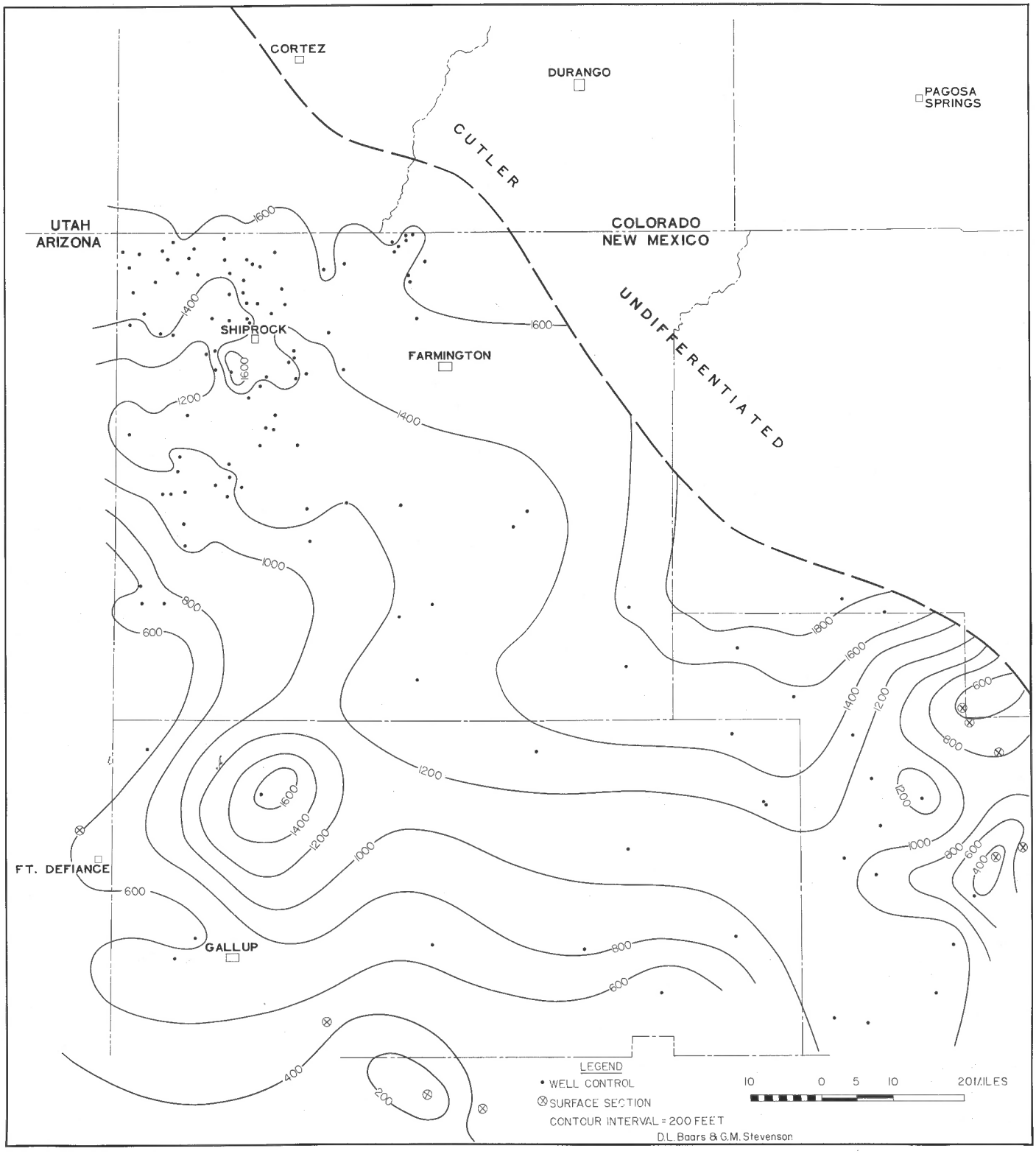


Figure 1. Isopachous map of the Abo Formation and its stratigraphic equivalents in the Cutler Group. These include the eastern red-bed facies of the Halgaito, Cedar Mesa and Organ Rock formations in the Four Corners region.

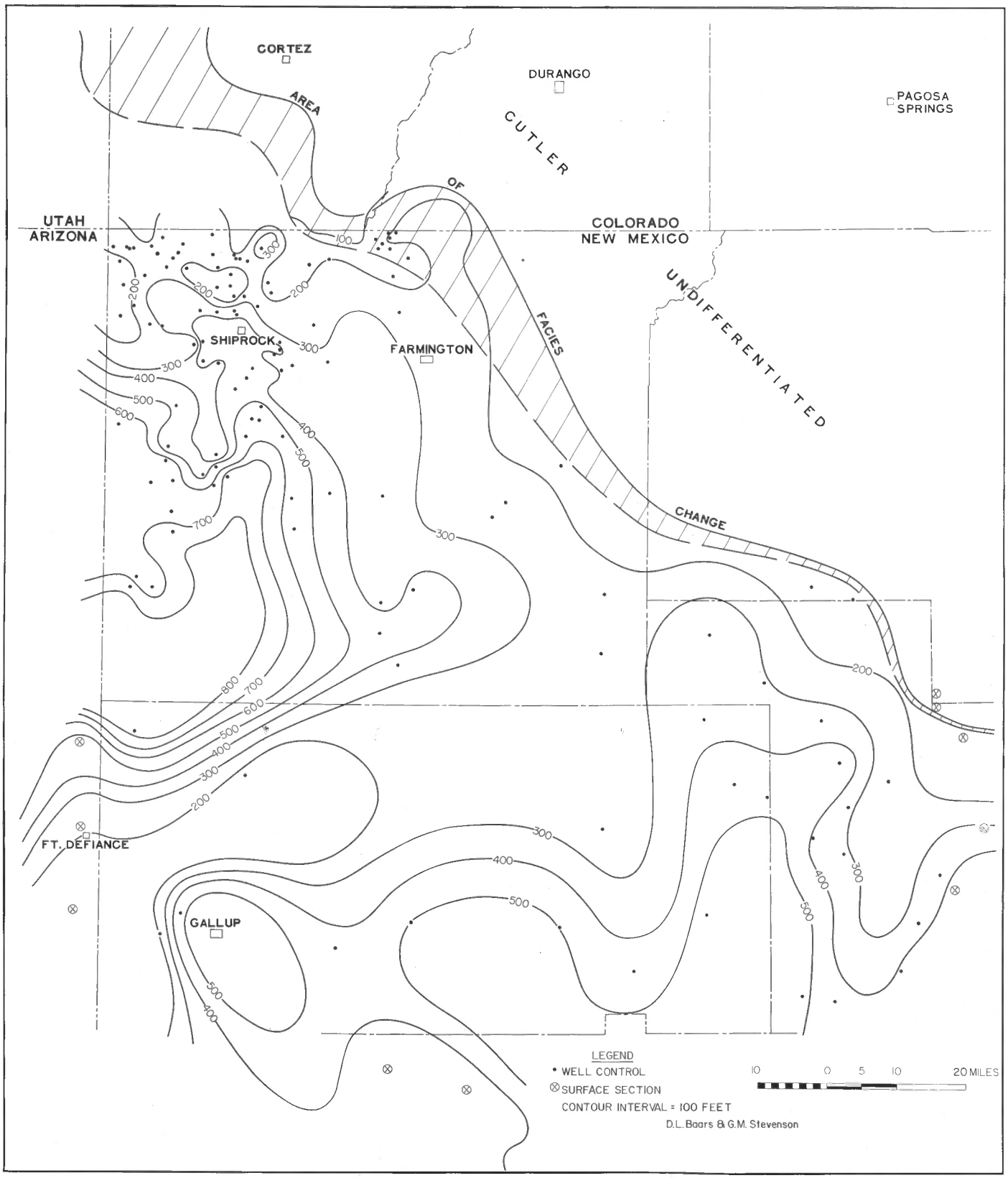


Figure 2. Isopachous map of the De Chelly Sandstone (Meseta Blanca Sandstone Member of the Yeso Formation in New Mexico).

Chelly Sandstone (the Meseta Blanca Sandstone Member of the Yeso Formation), and overlying stratigraphic units at that locality represent younger formations of central New Mexico.

The regional isopachous configuration of the De Chelly Sandstone indicates that the largely eolian sand body was blown into and filled the major paleotectonic basins, barely covering the highs. It thickens to over 1000 feet in the Black Mesa basin west of the Defiance uplift and to over 800 feet in the San Juan Basin. Notice that the thin (200 ft) and thick (800 ft) trends in the Ft. Defiance region do not correspond to the present-day northerly trend of the uplift. Instead the paleo-trends were northeasterly on the Defiance uplift and northwesterly in the Zuni-Gallup area (fig. 2). Cross stratification studies indicate that the source of the sand was from the fluvial Cutler sediments to the north (Baars, 1962).

Yeso Formation (Restricted)

As originally defined, the Yeso Formation included the De Chelly Sandstone (Meseta Blanca Sandstone Member) and the upper San Ysidro Member. As restricted by Baars (1962) to properly indicate the natural distribution of the De Chelly, only the upper redbeds and gypsums are mapped as the Yeso Formation. Recent subsurface control shows that the red-bed facies extends somewhat farther north in the San Juan Basin than was originally suspected. The restricted marine gypsiferous facies thickens southward from a line running approximately from Gallup to Albuquerque, but is missing in exposures on the Zuni uplift. North of that line the evaporites and associated thin dolomites are generally missing and crop out in the southern Defiance uplift as the "Oak Springs member" of Peirce (1967). Consequently, the Yeso of the San Juan Basin is almost entirely composed of redbeds between the prominent De Chelly and Glorieta sandstones, and may grade into the upper De Chelly Sandstone toward the northwest (fig. 3).

Glorieta Sandstone

The Glorieta Sandstone is a prominent cliff forming unit in exposures in the Zuni and southern Nacimiento mountains, and is a good marker bed in the subsurface. It is typically a white, fine- to medium-grained sandstone with relatively small scale, low angle cross stratification indicating its water laid origin. The formation is now seen to extend considerably farther north into the central San Juan Basin than was previously mapped, and a previously unrecognized isolated remnant appears to be present in the Beautiful Mountain area (fig. 4).

The upper white, obviously water-laid sandstone in the eastern Defiance uplift is, without question, the Glorieta Sandstone. Peirce (1967) proposed the "Black Creek member" for this unit. This and several other members suggested for the De Chelly Sandstone may confuse the stratigraphic issue. The Glorieta is clearly younger than the De Chelly and is of a completely different origin. Consequently, the authors proposed that it should not be considered a member of the De Chelly Sandstone.

San Andres Formation

The San Andres Formation in the Zuni Mountains is an interesting shallow shelf carbonate sequence. It consists of a lower unit of thin dolomites and fine-grained clastics and an upper massive limestone and dolomite cliff-forming member. The upper carbonate unit is quite variable in sediment type, ranging from micrite to particulate sand textures, and fossils, especially brachiopods, are common. Numerous small bioherms occur in the western exposures.

The formation grades abruptly into redbeds immediately north of the Zuni Mountains and locally, as in the southern Nacimiento Mountains, contains a thin bed or two of dolomite. A thin remnant of similar redbeds underlies the Permo-Triassic unconformity near Ft. Defiance, Arizona, and may be an outlier of this northern facies. The zero line for the formation occurs just north of the Zuni Mountains, barely onto the base map, and since new well control alters the isopachous lines only slightly, no San Andres map is included. The interested reader is referred to Baars (1962) for thickness distribution of the San Andres.

The San Andres abruptly changes to a red-bed facies north of the Zuni Mountains and a gypsiferous facies to the south and east (Baars, 1962). On the uplift it is a shallow shelf carbonate deposit, strongly suggesting that the Zuni was somewhat positive at the time of deposition of the San Andres providing shoaling conditions and encouraging shallow shelf carbonate deposits, much like those in the shallow seas of the south Florida shelf.

CONCLUSIONS

The San Juan Basin was a structural basin during the Wolfcampian and Leonardian epochs of the Permian Period. The sediments are largely red clastics derived from the Uncompahgre uplift which lies to the north and east of the basin. The bounding uplifts were positive in Lower Permian time, causing Permian redbeds to be deposited on Precambrian basement rocks on the Defiance, Zuni and San Pedro uplifts. The uplifts were not present in their modern configuration, however, with the exception of the Zuni positive. The isopachous map of the lower Cutler-Abo section shows the Defiance uplift to be a northeasterly trending structure and the Nacimiento-San Pedro mountains to be composed of two separate thin areas with uncertain trends (fig. 1). Also, the configuration of the basin was quite different in Abo time, as the thickest sedimentation was north of Gallup and in the Shiprock area. The obvious thick and thin areas of the De Chelly Sandstone near Ft. Defiance (fig. 2) also display a prominent northeasterly trend, extending from the uplift into the present-day basin. Furthermore, the Yeso (restricted) (fig. 3) and the Glorieta Sandstone (fig. 4) show northeasterly trending zero lines in the vicinity of Ft. Defiance that parallel the thin ridge in the De Chelly Sandstone.

It seems apparent that the northwesterly and northeasterly trends of the basement structure suggested by Stevenson and Baars (elsewhere in this volume) were rejuvenated in Permian time, causing northeasterly trending paleo-structure in the Defiance uplift and northwesterly trending positive conditions on the Zuni uplift as shown by thinning of some formations and the shallow shelf environment in San Andres time. The strong west-northwest structural trends in the Nacimiento-San Pedro region in pre-Permian strata seem to become obliterated, perhaps buried, by Permian sediments. They are ill-defined in Abo time, and become increasingly more difficult to detect in the younger Permian formations.

New well control that prompted this restudy confirmed the regional correlations of the Permian System by Baars (1962) and extended the geographic limits of some of the formations farther north into the San Juan Basin.

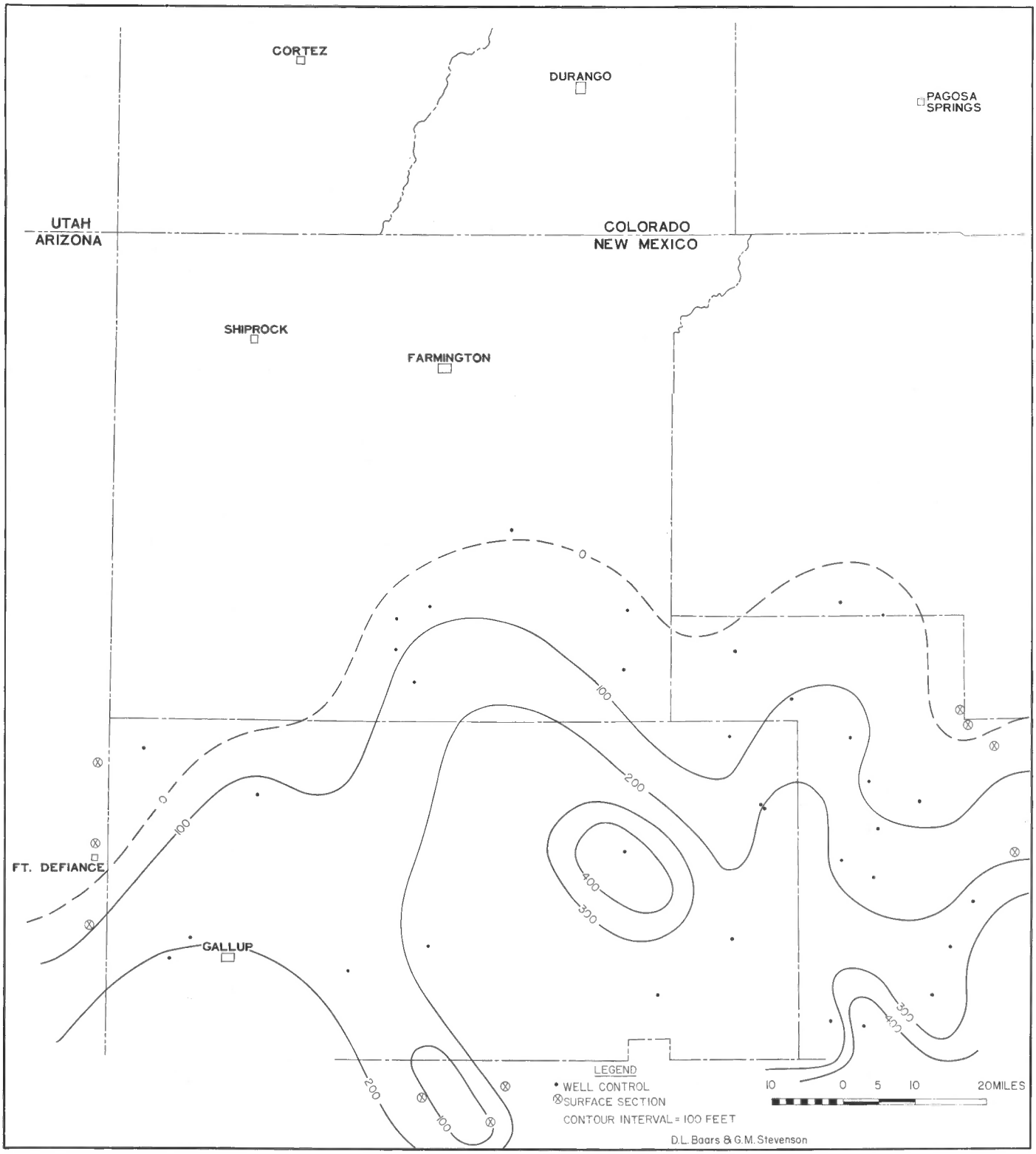


Figure 3. Isopachous map of the Yeso Formation (restricted). This is the San Ysidro Member of the Yeso Formation of previous usage, and does not include the former Meseta Blanca Sandstone Member.

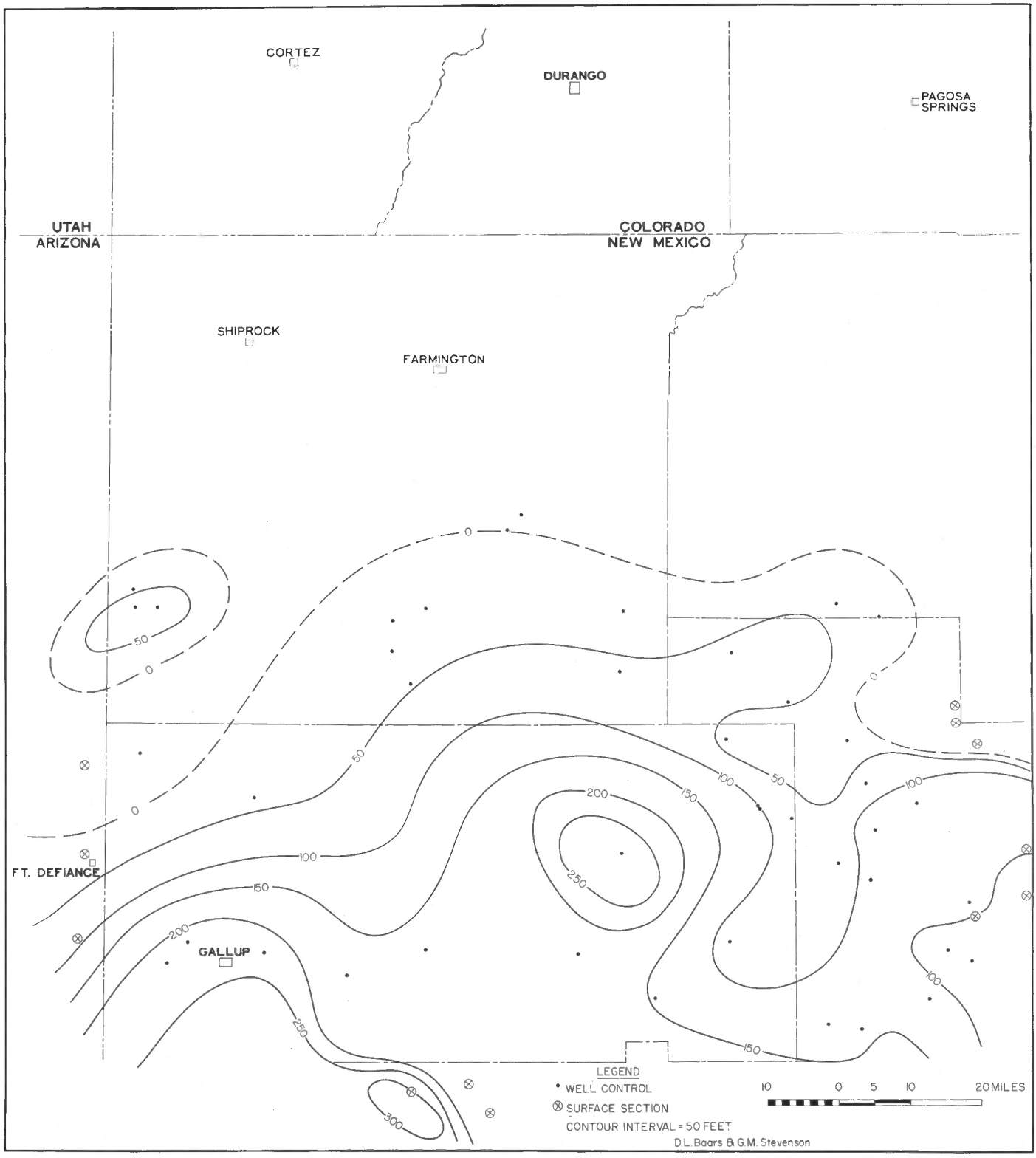


Figure 4. Isopachous map of the Glorieta Sandstone.

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