The saga of the Dockum Group and the case of the Texas/New Mexico boundary fault

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Abstract—The Upper Triassic Dockum Group consists of continental red beds exposed around the southern High Plains of western Texas and eastern New Mexico. Although these strata are contiguous between the two states, different stratigraphic nomenclature is used in Texas and New Mexico. New mapping of the type area in Texas and physical tracing into New Mexico allow recognition of five units in the Dockum Group. A distinctive quartzose conglomeratic sandstone, the Santa Rosa Sandstone, is recognized as the base of the Dockum Group in New Mexico. The informal name Camp Spring Conglomerate should not be used for this same unit in Texas. The Santa Rosa Sandstone is overlain by multicolored shale of the Tecovas Formation in Texas. The name Garita Creek Formation should not be used for these same strata in New Mexico. The Tecovas Formation is overlain by cliff-forming lithic sandstone of the Trujillo Sandstone. The same unit was later named the Cuervo Sandstone in New Mexico. Overlying the Tujillo Sandstone is a thick sequence of red shale called the Cooper Canyon Formation in Texas. These same strata were given the name Bull Canyon Formation in New Mexico. The Redonda Formation comprises the uppermost unit in the Dockum Group, and it is only present in New Mexico. Use of the name Chinle Formation or Chinle Group for part or all of these strata in eastern New Mexico is not appropriate and ignores the fact that formal names had previously been given to these strata in Texas.

"Stratigraphy can be defined as the complete triumph of terminology over facts and common sense" (attributed to P. D. Krynine by J. Ferm *in* Burton et al., 1987)

Introduction

Over the past several years, a number of major stratigraphic revisions have been proposed for the Upper Triassic Dockum Group of west Texas and eastern New Mexico. Red beds of the Dockum Group crop out almost continuously around the Caprock Escarpment of the southern High Plains in Texas, through the Canadian River valley in Texas and New Mexico, and along the Pecos River valley in New Mexico southward into Texas (Fig. 1). Furthermore, these strata are present throughout the subsurface of the southern High Plains between the two states. The Dockum Group, like the overlying Tertiary Ogallala Group, is a complex of largely fluvial strata that bind Texas and New Mexico together along that artificial boundary running near the 103° west line of longitude.

Much of the stratigraphic nomenclature of the Dockum Group extends back more than a century, originating in the early days of the Geological Survey of Texas and the U.S. Geological Survey. Many of the early works on the Dockum Group were published by now venerated stratigraphers such as W. F. Cummins, N. H. Darton and C. N. Gould, and renowned paleontologists such as E. D. Cope, E. C. Case, and J. T. Gregory.

The purpose of this paper is to argue that most of the recently proposed revisions in the stratigraphic nomenclature of the Dockum Group: 1) are unnecessary and confusing, 2) violate the letter and spirit of the code of stratigraphic nomenclature by ignoring priority of established names, 3) are not supported by mapping, and 4) should be rejected by stratigraphers involved with mapping of Triassic strata in Texas and New Mexico.

This paper portrays a case study in the problem of a perceived state boundary "fault" between Texas and New Mexico. This case study illustrates what happens when stratigraphers across state boundaries do not communicate or lack regard for one another, and when paleontologists apply formal names to strata without actually mapping them. This report gives the preliminary results from work in progress and justifies the stratigraphic nomenclature used in our mapping program in west Texas. I advocate the use of this simple nomenclature in New Mexico as well. Geologic maps of several key regions, including the type area of the Dockum Group, are given here for the first time (Figs. 1, 3, 4). No new stratigraphic names are proposed.

A wealth of history

Study of the Dockum Group has a rich history entwined with the early geologic exploration of the southern High Plains region. A full investigation of this history is a wonderful exercise, and readers are encouraged to pursue the complete accounts of the works cited herein. A brief summary of this history is provided here to impress upon the reader the weight of tradition behind the original nomenclature of the Dockum Group.

The Dockum beds were named by W. F. Cummins, working for the Geological Survey of Texas in 1890, in his study of strata exposed along the northern part of the Caprock Escarpment in Texas (Fig. 2). The type area and sections were located along Dockum Creek in Dickens and Crosby Counties (Fig. 3). In their reports of 1891 and 1892, Cummins and his assistant N. H. Drake recognized that the Dockum beds extended completely around the High Plains into New Mexico and were the same strata identified as the "Keuper" or "American Trias" by Marcou in his accounts of the Canadian River valley of New Mexico in the 1850s. Drake (a member of the field party headed by Cummins) suggested that the Dockum could be subdivided into lower, central and upper beds.

In his 1906 and 1907 studies of the geology and water resources of the Canadian River valley, C. N. Gould of the U.S. Geological Survey elevated the Dockum to group status and formally subdivided it

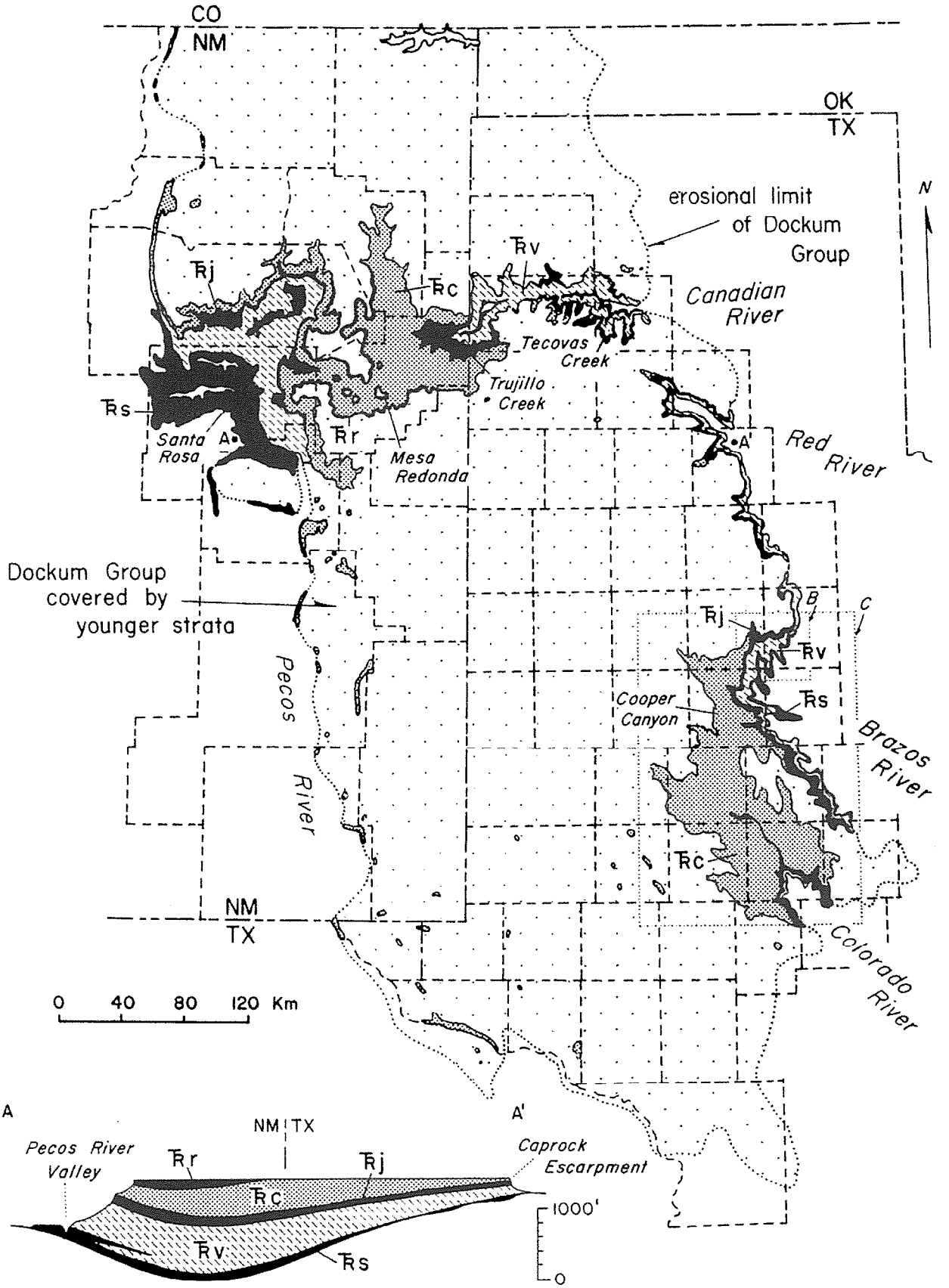


FIGURE 1—Generalized geologic map of the southern High Plains region of west Texas and eastern New Mexico, showing distribution of the Upper Triassic Dockum Group. Outcrops of major sandstone units (TRs = Santa Rosa Sandstone, TRj = Trujillo Sandstone, TRr = Redonda Formation) are shown in black; outcrops of shale units (TRv = Tecovas Formation, TRc = Cooper Canyon Formation) are stippled or cross-hatched. Type areas for the formations are indicated. Region where the Dockum Group is overlain by younger strata is shown in coarse stipple. Inset cross section (A–A') shows general subsurface geometry of the Dockum Group beneath the High Plains. Locations of detailed geologic maps in Figure 3 (B) and Figure 4 (C) are indicated. Outcrop distribution in upper Pecos River valley is adapted from Kelley (1972), and in Canadian River valley in part from *Geologic Atlas of Texas* Amarillo and Tucumcari sheets (1969).

into the Tecovas and Trujillo Formations (Fig. 2). The Tecovas Formation corresponded generally with Drake's lower beds, the Trujillo with Drake's central and upper beds. Gould (1907), and later Patton (1923), gave detailed descriptions and showed the map distribution of these formations over much of the Canadian River valley in Texas up to the New Mexico border. By 1928 many workers (e.g. Case, Darton, Hoots) realized that outcrops of the Dockum Group extended completely around the High Plains of Texas and New Mexico. Darton (1922, 1928) found that the base of the Dockum Group in the Pecos River valley of New Mexico is marked by a thick distinctive sandstone unit which he named the Santa Rosa Sandstone (Fig. 2). He clearly recognized that this unit comprised the base of the Dockum Group. Gould, Patton, and others found similar quartzose conglomeratic sandstone beds that occupied the same stratigraphic position in the base of the Tecovas Formation throughout the Canadian River valley in Texas and, at least locally, along the eastern Caprock Escarpment. In 1946, Dobrovolny and Summerson recognized a distinctive, rhythmically bedded sandstone unit at the top of the Triassic section exposed along the Canadian Breaks in New Mexico, which they named the Redonda Member (later elevated to formation by Griggs and Read, 1959).

Hence, at least 50 years ago the basic components of the Dockum Group (Santa Rosa, Tecovas, Trujillo, and Redonda Formations) were recognized. Unfortunately, trouble began shortly thereafter.

Reconciling the stratigraphy of the Colorado Plateau with the High Plains

The state of New Mexico straddles the boundary between two spectacular geologic provinces. The axis of the Rocky Mountains and Rio Grande valley separates the Colorado Plateau and highlands of the western part of the state from the High Plains and Permian Basin to the east. Each of these regions has its own history of geological exploration and tradition. Problems arise when considering strata, such as those of the Triassic System, that cross over between these two regions. Traditionally, separate nomenclature has been adopted for many units on either side of the state because these were separate centers of investigation. Moreover, strata are, for the most part, no longer physically contiguous between these areas (owing to uplift of the Rocky Mountains), although they certainly are genetically related in many cases.

As early as the 1920s, stratigraphers began using the Colorado Plateau term Chinle Formation for that part of the Dockum Group which overlies the Santa Rosa Sandstone in eastern New Mexico (Darton, 1928; Adams, 1929; Gorman and Robeck, 1946). Despite objections to this practice (e.g. McKee *in* Reeside et al., 1957, p. 1476), on the New Mexico state geologic map of 1965 Dane and Bachman "officially" extended use of the name Chinle Formation from the Colorado Plateau country eastward into the Pecos and Canadian River valleys of New Mexico. They applied the name Chinle Formation to all Triassic strata above the Santa Rosa Sandstone (Fig. 2). Most of what had previously been considered part of the Dockum Group was now Chinle Formation. Kelley (1972b) continued this practice and subdivided the Chinle Formation in eastern New Mexico into several informal members (lower shale, Cuervo sandstone, upper shale). The Redonda was variously mapped as a separate formation, or included as the uppermost member of the Chinle Formation. Hence, by the 1970s the Dockum Group and its constituent formations (Tecovas and Trujillo) named in Texas were completely ignored in connection with the same Triassic strata in eastern New Mexico (Fig. 2).

In retrospect, we can now see that extension of the name Chinle into eastern New Mexico was a mistake, and that it constitutes a violation of the code of stratigraphic nomenclature. These identical strata had previously been given names just across the border in Texas—the Tecovas and Trujillo Formations. No real attempt had been made to trace the strata identified as Chinle in eastern New Mexico into Texas to determine whether or not they were physically contiguous with the Tecovas or Trujillo. Moreover, the Dockum, named in 1890, has priority over the Chinle, named in 1915. In the 1972 New Mexico Geological Society Guidebook, Z. Spiegel (1972, p. 81) summed up this dilemma stating, "due to unfortunate provincialism, Gould's terminology of Tecovas and Trujillo for the complete Triassic section in Texas was not followed in New Mexico."

Maps produced in the 1970s and early 1980s as part of the *Geologic Atlas of Texas* series, which commendably overlap the Texas/New Mexico border, indicate the Tecovas and Trujillo as extending into New Mexico and equate only the uppermost shale of the Trujillo Formation (the upper beds of Drake) with the Chinle Formation of eastern New Mexico. This solution had also been advocated by Spiegel (1972). In several unpublished open-file reports, Finch et al. (1976) and Finch and Wright (1983) reached similar conclusions and showed how the Tecovas and Trujillo of Texas correlated with the Santa Rosa and Chinle in New Mexico. The Santa Rosa Sandstone is the basal sandstone of the Tecovas Formation in Texas, and the Trujillo Sandstone of Texas is the Cuervo Sandstone Member of the Chinle Formation in eastern New Mexico. Reviewing the Chinle/Dockum problem, Chatterjee (1986) concluded that use of the name Chinle in eastern New Mexico and Texas should be suppressed, and proposed the name Cooper Member for what had formerly been the upper shale interval of the Trujillo Formation (the upper beds of Drake, shown as Chinle Formation on the *Geologic Atlas of Texas* sheets).

So, in spite of the obvious physical continuity of these strata, by the beginning of the 1980s separate stratigraphies evolved in Texas and New Mexico without regard for the priority of established names on either side of the state line, and without any serious attempt to trace named strata from one state to -the other. This practice would be analogous in paleontology to naming a new species without comparing it to similar or identical taxa, without documenting how it differs from them, and without determining if it had already been named.

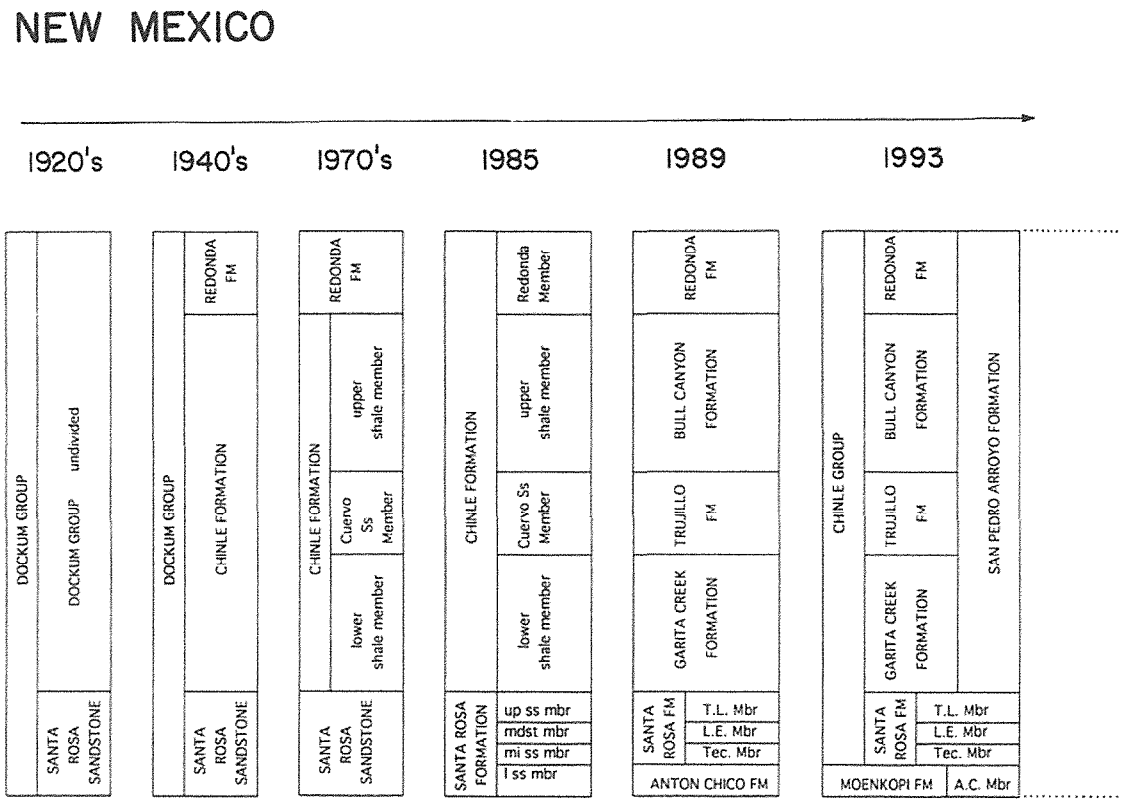


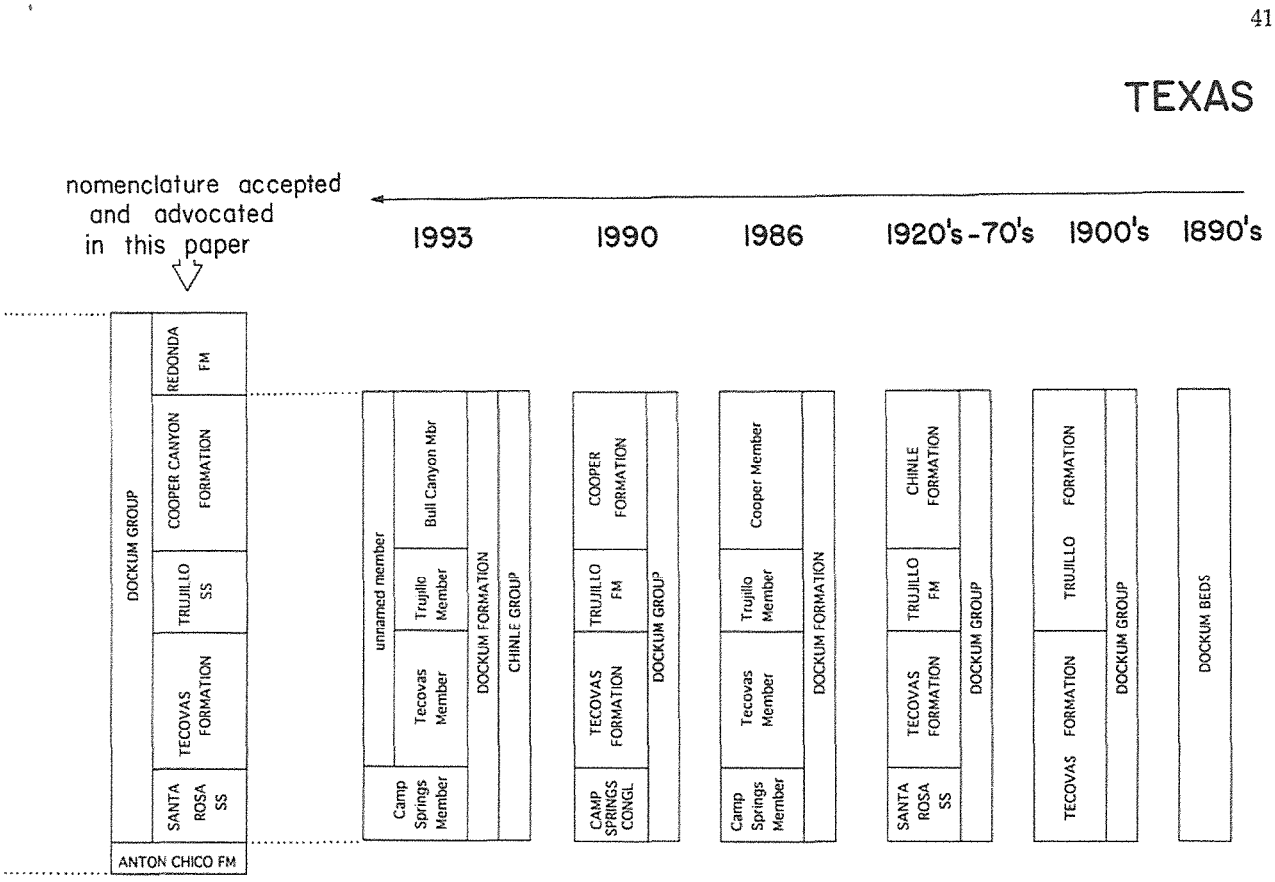
FIGURE 2—History of stratigraphic nomenclature for the Dockum Group in Texas and New Mexico showing nomenclature advocated in this paper. Sources for the stratigraphic subdivisions in New Mexico are: 1920s (Darton, 1928); 1940s (Dobrovolny and Summerson, 1946); 1970s (Kelley, 1972); 1985 (Lucas et al., 1985); 1989 (Lucas and Hunt, 1989); 1993 (Lucas and Anderson, 1992). Sources for the

The revisions of Lucas and colleagues

Beginning in the 1980s and continuing to the present, S. G. Lucas of the New Mexico Museum of Natural History & Science and various colleagues, most notably A. Hunt and 0. Anderson, have provided new names and various changing subdivisions for parts of the Dockum Group in both New Mexico and Texas. In less than 10 years, these revisions have been presented in more than 20 published papers and a like number of abstracts with various authorship arrangements (e.g. Lucas, 1991a; Lucas, 1991b; Lucas and Anderson, 1992; Lucas and Anderson, 1993; Lucas and Hayden, 1989; Lucas and Hayden, 1991; Lucas and Hunt, 1987; Lucas and Hunt, 1989; Lucas and Hunt, 1990; Lucas, Hunt, and Huber, 1990; Lucas, Hunt, and Morales, 1985; Hunt and Lucas, 1990; Hunt and Lucas, 1991a; Hunt and Lucas, 1991b; Kietzke and Lucas, 1991). Citations for these papers are given in the reference list, however in the following discussion I refer to these collectively as the works of Lucas and colleagues.

From 1985 to 1988 Lucas and colleagues generally accepted the standing division of Triassic strata in eastern New Mexico into the Santa Rosa and Chinle Formations, and the subdivisions of these strata proposed by earlier workers. Although earlier workers had avoided the issue, Lucas and colleagues explicitly rejected inclusion of these strata within the Dockum Group stating that "the term Dockum lacks specificity and refers to rocks that represent variable amounts of Triassic time" and that "the Triassic sequence in east-central New Mexico includes strata both older and younger than the Dockum Group of western Texas" (Lucas et al., 1985, p. 176). As continued justification for use of the name Chinle in eastern New Mexico, they also argued that Triassic deposits may have formerly been continuous between the Colorado Plateau and eastern New Mexico, and are thus genetically related. Neither of these reasons constitutes adequate justification for abandonment of the Dockum Group nomenclature. In fact, the North American Strati-graphic Code (1983) clearly states that "inferred time-spans, however measured, play no part in differentiating or determining the boundaries of any lithostratigraphic unit" (Article 22e). Similarly, "inferred geologic history, depositional environment, and biological sequence have no place in the definition of a lithostratigraphic unit" (Article 22d). The lithic characteristics and physical continuity of these beds outweigh all other considerations and reveal, without question, that the strata on either side of 103° W longitude are identical.

In 1989 (pp. 151-152) Lucas and Hunt reversed their earlier view and recognized that extension of the name Chinle Formation into eastern New Mexico had been a mistake all along, stating that "strata equivalent to the Chinle of the Colorado Plateau in east-central New Mexico include not just those strata previously referred to as Chinle, but the Santa Rosa Formation as well," and that "much of the Upper Triassic section in east-central New Mexico was deposited in a separate basin (or basins) than Chinle deposition to the



stratigraphic subdivisions in Texas are: 1890s (Cummins, 1890); 1900s (Gould, 1906); 1920s–1970s (Adams, 1929; *Geologic Atlas of Texas*, 1969); 1986 (Chatterjee, 1986); 1990 (Hunt and Lucas, 1990); 1993 (Lucas and Anderson, 1993). Abbreviations for local subdivisions of the Santa Rosa Sandstone in New Mexico are: Tec. = Tecolotito Member, L.E. = Los Esteros Member, T.L. = Tres Lagunas Member.

west." They now (as Chatterjee did in 1986) explicitly reject use of the term Chinle in eastern New Mexico. In spite of this, Lucas and Hunt (1989, p. 152) again refused to recognize these strata as part of the Dockum Group, stating that "Dockum is not a particularly precise or useful stratigraphic term." They were, however, compelled to accept one of the Dockum's constituent formations, the Trujillo Formation (as mapped by the *Geologic Atlas of Texas* and advocated by Chatterjee), as valid and equivalent to Kelley's Cuervo Sandstone Member of the Chinle in eastern New Mexico. Inexplicably, however, they did not recognize the equivalence of the overlying and underlying shale sections. This set the stage for the provision of new names of their own design for each of the units. In 1989, again without mapping or tracing the strata into Texas, or seriously investigating the Dockum type area, Lucas and Hunt named strata equivalent to the Tecovas Formation the Garita Creek Formation in New Mexico (Fig. 2). Further, they named strata equivalent to Chatterjee's Cooper Formation in Texas the Bull Canyon Formation in New Mexico.

Lucas and Hunt (1987) also assigned formal names to all of the informal local subdivisions of the Santa Rosa Sandstone that had been recognized earlier by Gorman and Robeck (1946) and Kelley (1972a). They separated out the lowermost sandstone unit of the Santa Rosa Sandstone as the Anton Chico Formation and redefined the remainder as the Santa Rosa Formation with several formal members (Tecolotito, Los Esteros, and Tres Lagunas Members: Fig. 2). Map distribution beyond a square mile of the type section was not included. However, Lucas and Hunt (1989) demoted the Anton Chico to member status within the Moenkopi Formation, extending use of this name from the Colorado Plateau into eastern New Mexico, a practice they strictly rejected in case of the Chinle in the same paper.

Coming full circle in 1992, Lucas and Anderson again return all Triassic strata in eastern New Mexico above the Anton Chico (member of the Moenkopi Formation) to the Chinle, now elevated to group rank (Fig. 2). The Santa Rosa, Garita Creek, Trujillo, Bull Canyon, and Redonda Formations are now contained within the Chinle Group. Hence, the net effect of their revisions has been to elevate most units in rank and give formal names to those previously recognized informally. Lucas (1991a) and Lucas and Anderson (1992) also propose another name, the San Pedro Arroyo Formation, to include the entire Chinle Group in eastern New Mexico above the Santa Rosa Sandstone where these strata cannot otherwise be locally subdivided (Fig. 2).

Turning to Texas in 1987, Lucas and Hunt accepted the stratigraphic revision of the Dockum offered by Chatterjee, but reinstated the Dockum as a unit of group rank with all units (Tecovas, Trujillo, and Cooper) identified as formations. They also used the name Camp Springs Conglomerate (or member) for the basal quartzose conglomerate of the Tecovas Formation, recognized as the Santa Rosa Sandstone by others. In 1992, however, Lucas and Anderson again demoted

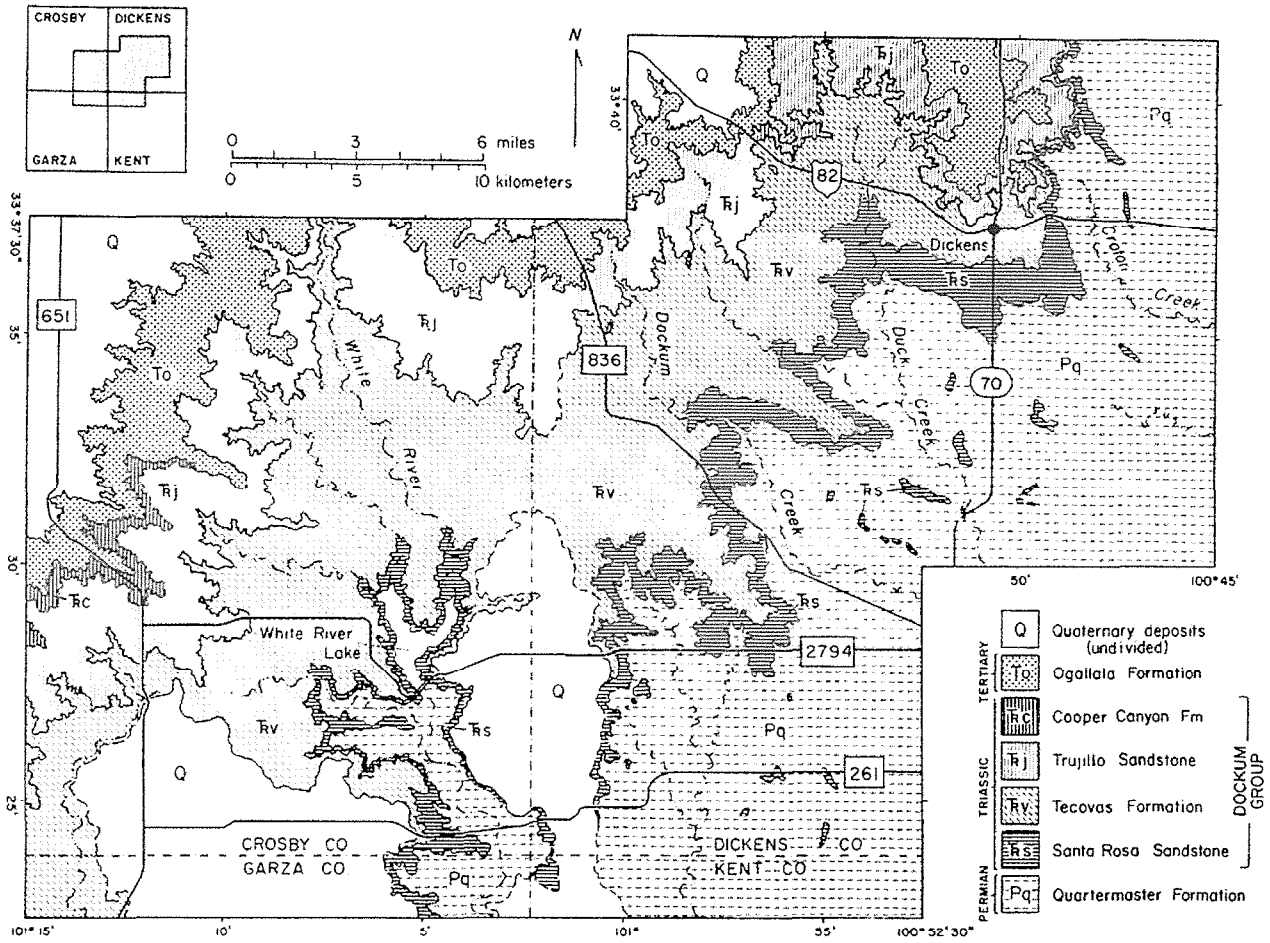


FIGURE 3—Geologic map of the Dockum Group type area in Crosby and Dickens Counties, Texas. Thin surficial covering by Quaternary alluvium, colluvium, and eolian sediment is not shown in some areas. See Figures 1 and 4 for location of this map area within the Dockum Group outcrop belt. Figure is based on mapping of 7.5 minute topographic quadrangles by T. Lehman and J. Schnable.

the Dockum to formation rank, now within the Chinle Group, extended into Texas without regard to the former rank and priority of the Dockum over Chinle. All formations have now become members again. In 1993, Lucas and Anderson abandoned the name Cooper Formation (now member again) and replaced it with Bull Canyon Formation from New Mexico (Fig. 2). The Bull Canyon now becomes a member of the Dockum Formation in Texas, but remains a formation in the Chinle Group across the border in New Mexico. Similarly, the Trujillo Sandstone of Texas remains a formation in the Chinle Group in New Mexico, but is demoted to a member of the Dockum Formation in its home state of Texas. Lucas and Anderson (1993) also contend that an as yet unnamed member of the Dockum exists: if past experience is a guide, this unit will not remain unnamed for long (Fig. 2).

It is this state of confusion that has brought about the present paper. The nomenclatural collage advocated by Lucas and collegues would be amusing were it not for the serious consideration it must be given by the geological community. Remember, in all of this the actual physical stratigraphy of the Dockum Group is not terribly confusing at all, and was for the most part worked out around the turn of the century. What has brought about this unfortunate and confusing sit uation? Several factors have contributed: 1) a lack of interaction or cooperation among stratigraphers working in adjoining states, 2) a lack of regard of respect for earlier generations of geologists and for the traditional courtesy accorded to other workers, 3J a lack of adherence to the code of stratigraphic nomenclature—both its letter and spirit, 4) the "naming syndrome" and achievement of stratigraphic immortality through assigning formal names to strata, and 5) the practice of assigning formal names to units recognized informally by other workers without physically tracing the strata or showing their distribution on maps (any serious attempt to show the distribution of these strata by mapping would have revealed, by physical continuity, that names had already been given to them).

I review below several specific cases which illustrate some of these problems.

The case of the Cooper Canyon Formation

When Chatterjee applied the name Cooper Member in 1986 to what had formerly been the upper shale section of the Trujillo Formation (the upper beds of Drake, or upper shale member of the Chinle Formation as it was then mapped in eastern New Mex-

ico), this was a clear attempt to address the problem of the relationship between the Chinle and Dockum. Chatterjee explicitly stated that the Cooper Member was to include the section of predominantly red shale above the Trujillo Sandstone (in the restricted sense, as mapped in the *Geologic Atlas of Texas),* and he indicated that these strata thickened into eastern New Mexico. It was therefore inappropriate when in 1989 Lucas and Hunt applied the name Bull Canyon Formation to the same red shales above the Trujillo Formation in New Mexico. It was evident in 1989 that Lucas and Hunt were providing a name for a stratigraphic unit that already had one. They made no attempt to relate their unit to the previously named Cooper Member, which they continued to use and accept as valid in several publications and even elevated it to formation rank (e.g. Hunt and Lucas, 1990; Fig. 2). The stratigraphic code (1983, Art. 7b) states that responsibility for avoiding use of different names for the same unit rests with the proposer. Physical tracing of the strata in outcrop prior to naming would have revealed the synonymy. The name Bull Canyon Formation is a unneeded synonym of the Cooper (now Cooper Canyon) Formation.

Nevertheless, continuing investigation of the Cooper Formation revealed additional problems. The name Cooper Formation is quite similar to a number of stratigraphic names already in use in North America. For example, a survey of the recent lexicon of U.S. stratigraphic names (Swanson et al., 1981) reveals the following: Cooper Limestone, Cooper Marl, Cooper Creek Limestone, Cooper Peak Dolomite, Coopers Lake Member, and Cooper Arroyo Sandstone Member. Was the name Cooper Formation preoccupied? Strictly speaking, no; the lithologic modifier was different. The lexicon reveals many stratigraphic names that differ only in minor ways, such as the geographic or lithologic modifier (see below). However, to reduce similarity to other names, an additional geographic modifier was provided, hence the revision to Cooper Canyon Formation (Lehman et al., 1992). Does this revision constitute a violation of the code? No. Article 7(c) of the stratigraphic code allows for modification of a name as long as the need is explained. Moreover, it was discovered that the Cooper Canyon Formation was much thicker in its type area than originally recognized by Chatterjee. As it was clearly Chatterjee's intent (1986, p. 142), and the published view of Lucas and colleagues (e.g. Hunt and Lucas, 1990), that the entire section of red shale above the Trujillo be included in the Cooper, the type section was lengthened to include this entire section. Does this revision violate the code? No. The stratigraphic code indicates that redescription of a unit and revision of its boundaries are preferable to abandonment (Articles 7c, 19a).

Lucas and colleagues have nevertheless seized upon this revision to suggest that the name Cooper (now Cooper Canyon) Formation, a name with priority which they had previously accepted as valid, should now be rejected in favor of the name Bull Canyon Formation, clearly a junior synonym. They state (Lucas and Anderson, 1993, p. 60) that the Cooper Formation was "ill-defined and improperly named." This is analogous to the situation in paleontology where, because of a minor perceived violation of the code of zoological nomenclature, an established name with priority is abandoned in favor of a new name, one conveniently supplied by the revisionist (e.g. the case of *"Rioarribasaurus"—a.k.a. Coelophysis;* see Hunt and Lucas, 1991a; Dodson, 1993).

Superseding these legalistic arguments, however, it should be remembered that there is a spirit as well in the code of stratigraphic nomenclature. We should respect that spirit. Chatterjee's *intent* was clear. Regardless of minor problems with his original proposal of the Cooper Formation, the spirit of the code is respected by fixing those problems, not by throwing priority away and substituting a new name.

The case of the Camp Springs conglomerate

Viewed in light of the debate over the Cooper Canyon Formation, the case of the Camp Springs conglomerate seems even more inexplicable. Various workers had used the name Camp Springs conglomerate informally for the basal sandstone of the Tecovas Formation in Texas—the same unit that Darton had named the Santa Rosa Sandstone in New Mexico. The name Camp Springs conglomerate had been informally proposed by Beede and Christner (1926, p. 16) for "the basal member of the Triassic" in west Texas. Lucas and colleagues adopted use of this term and continued this practice in Texas, despite the fact that no thickness had ever been given for this unit, no section (let alone type section) had ever been measured of this unit, its distribution had never been shown on a map, and (in their interpretation) it was clearly equivalent to the Santa Rosa Sandstone. The case for synonymy of the Camp Springs conglomerate (in the restricted sense advocated by Lucas and colleagues) with the Santa Rosa Sandstone is clear. Physical tracing through the Canadian River valley from New Mexico into Texas and southward along the Caprock Escarpment dearly reveals that they are the same unit.

The Texas Water Development Board, as well as many subsurface geologists and hydrologists, had long ago extended use of the term Santa Rosa Sandstone into Texas, where it is thoroughly ingrained in the literature and has long been in use for the so-called "lower Dockum aquifer" or "Santa Rosa aquifer" (e.g. Shamburger, 1967). In 1987 (p. 29), Lucas and Hunt frowned upon this practice, stating that "most uses of the term Santa Rosa in southeastern New Mexico and western Texas" are incorrect, and that workers have applied this term to what is actually the Trujillo Sandstone. More recently, however, Lucas and Anderson (1992) reversed this view and extended use of the term Santa Rosa at least into southeastern New Mexico.

Nevertheless, miscorrelation of the Santa Rosa and Trujillo does occur. Confusion arises from the fact that, in many areas, erosion prior to deposition of the Trujillo Sandstone removed much or all of the intervening Tecovas Formation, and the Trujillo Sandstone rests on the Santa Rosa Sandstone or directly on underlying Permian strata. This is particularly true in the southern part of the High Plains region and, unfortunately, in the probable "type" area for the Camp

Springs conglomerate (Fig. 4). In this area the Trujillo Sandstone rests alternately either directly on Permian strata, on a markedly thinned section of the Tecovas Formation which itself overlies lenticular "remnants" of the Santa Rosa Sandstone, or directly upon remaining lenses of the Santa Rosa Sandstone (Fig. 4).

The sandstone exposed at the community of Camp Springs, and to the west and south, is (as stated by Lehman, 1992, and shown by mapping here in Fig. 4) equivalent to the Trujillo Sandstone; sandstone beds exposed to the north and east of Camp Springs are outlying remnants of the Santa Rosa Sandstone (Fig.

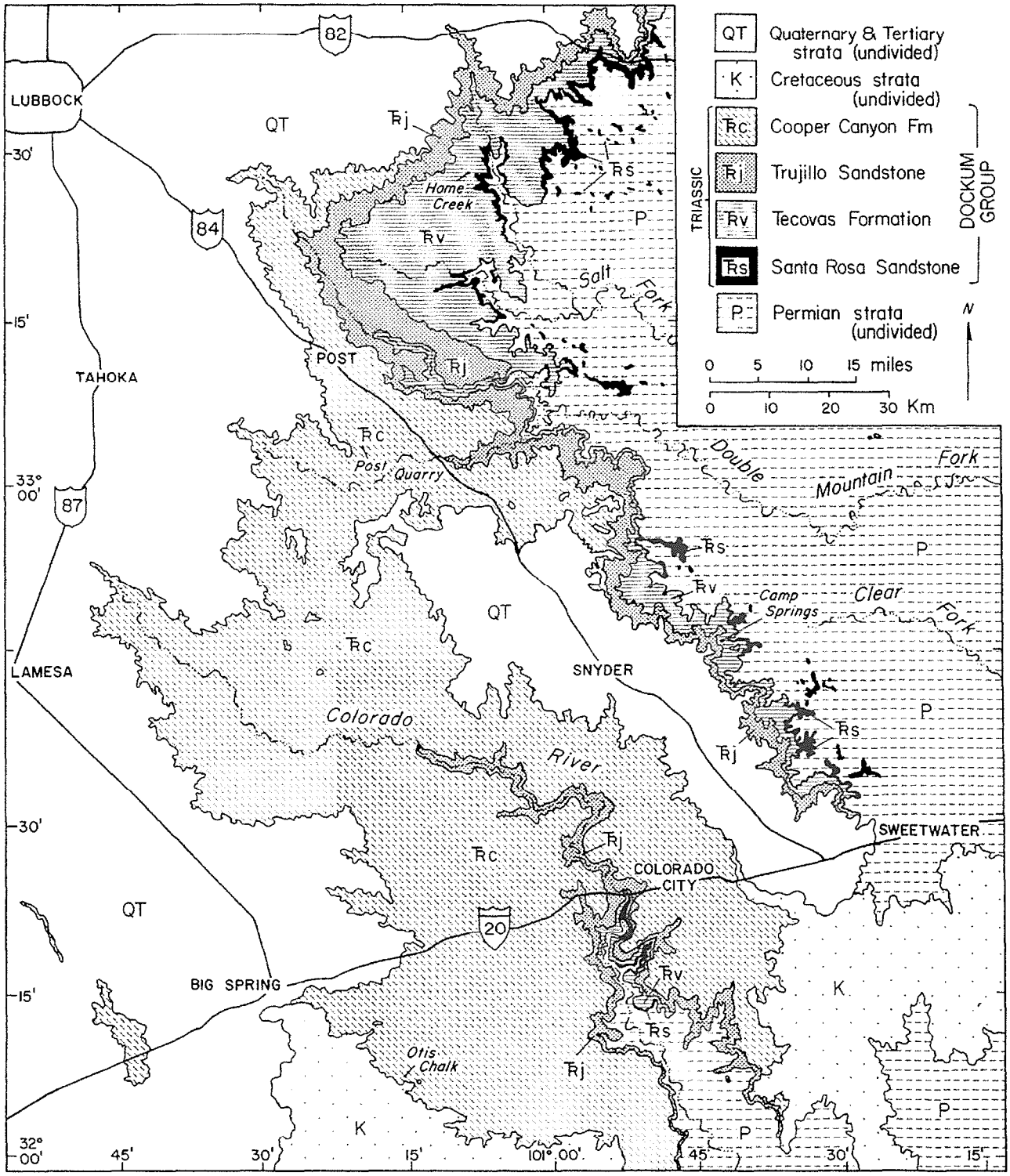


FIGURE 4—Generalized geologic map showing exposures of the Dockum Group in the upper Brazos and Colorado River valleys, Texas. See Figure 1 for location of this map area within the Dockum Group outcrop belt. The type area of the Dockum Group is at the northern edge of this map (detail shown in Figure 3). The locations of several important exposures discussed in the text are shown (e.g. Camp Springs, Otis Chalk). Areas of thin surficial covering by Quaternary alluvium, colluvium, and eolian sediment, and some exposures of Cretaceous strata are not shown. Figure is based in part on mapping of undivided Dockum Group exposures shown on *Geologic Atlas of Texas* Lubbock and Big Spring sheets (scale: 1:250,000), and on topographic base maps by T. Lehman, C. Bunting, and D. Mabbitt.

should not strata on both sides of the fence have the same names?

The solution is clear. The name Dockum Group should be retained as valid for much of the Triassic strata east of the Rocky Mountains, and the Chinle Formation (or group) should be retained for the equivalent strata west of the front range. This arrangement preserves tradition in both regions without forcing the issue of priority. What of the outlying exposures between these two regions? That problem must be addressed arbitrarily by those involved with actually mapping the intervening areas, as it is in many similar cases. The solution is not to assign new names in these areas (e.g. the San Pedro Arroyo Formation advocated by Lucas and colleagues), but to choose one of the existing stratigraphic nomenclatures that best fits the area.

Are Triassic strata of the Colorado Plateau and High Plains genetically related? Perhaps yes, perhaps no. It does not matter. Were strata ever completely contiguous between the two areas? It does not matter. They are not now, and we may never know. Moreover, the code of stratigraphic nomenclature (Article 22d) explicitly states that lithostratigraphic units must be based on lithic characteristics and are independent of inferred geologic history.

The letter and spirit of the code

As its purpose, formal stratigraphic nomenclature seeks to clarify the relationships among strata to facilitate mapping and ease of communication. While excusable in the past, it is critically important today to fully explore and map the extent of a stratigraphic unit prior to proposing a formal name for it. It may already have a name. Formal nomenclature should not be used to provide a name for every bed, to emphasize subtle regional facies variations, or conjectured age relationships based on biostratigraphy. Moreover, in a revision of stratigraphic nomenclature it is preferable to respect the spirit and intent of previous workers, and to preserve tradition and continuity with the older literature. Hence, there is a spirit as well as a letter to the stratigraphic code. The code is not a law book, it is a set of guidelines proposed to avoid problems like those examined above. These are not merely problems of semantics, but of ethical behavior and respect. The stratigraphic code allows for endless legalistic harangue, but hopes to enforce respect where it does not already exist. Where egos collide, the code provides a means of independent review to evaluate specific contentions. Such an evaluation may have little effect, however, if stratigraphers map their own states, without crossing the fence to see what is on the other side.

Several examples illustrate how the spirit of the code should be respected in addition to its letter. The lexicon of North American stratigraphic names is replete with formal names that differ by only a few letters, a geographic modifier, or a lithologic modifier. This does not necessarily invalidate any of them. For example, there is a Tecolote Member of the Santa Rosa Island Formation (Quaternary) in California. Could this be confused with Lucas and colleague's Tecolotito Member of the Santa Rosa Formation (Triassic) in New Mexico? Similarly, there is a Gartra Formation in the Chinle Group of Arizona. Can this be confused with Lucas and Hunt's (1989) Garita Creek Formation in the Chinle Group of New Mexico? The lexicon also reveals the following names, all very similar to the Bull Canyon Formation: Bull Formation, Bullion Canyon Formation, Bull Creek Limestone, Bull Fork Formation, Bull Hill Member, Bull Lake Till, Bull Ridge Member, Bull Run Shale, Bully Creek Formation, and Bullion Creek Formation. Similarity of the names Bull Canyon Formation and Bullion Canyon Formation, or Cooper Formation and Cooper Marl is not important. Obviously, the purpose of requiring different names is to avoid confusion, not to split hairs.

Does an inaccurate measurement of the thickness of a unit in its type area invalidate the name? No. For example, Lucas and Hunt (1987) reported the thickness of their Los Esteros Member of the Santa Rosa Sandstone in its type area as 9.4 m. The section was measured on the upstream side of the dam at Santa Rosa Lake. However, their section does not include strata below the normal level of the lake. The actual thickness of the type section should be 15.5 m (e.g. Fritz, 1991). Similarly, the thickness of the type section of the Anton Chico Formation, given by Lucas and colleagues as 22 m, should be 42 m. Does this justify abandonment of these names, as Lucas and colleagues have suggested in case of the Cooper Canyon Formation? No. Later workers may simply correct inaccuracies.

The names Bull Canyon Formation and Garita Creek Formation were formally proposed in a largely unrefereed in-house publication of the New Mexico Museum of Natural History distributed as a guidebook to participants of a field trip. Does this constitute valid publication according to the code (Article 4a, b)? Perhaps not. Similarly, Lucas and colleagues' designation of a lectostratotype section for the Camp Springs conglomerate was published in transactions distributed to the participants at a section meeting. Does this constitute valid publication according to the code? Perhaps not.

Strictly speaking, the present restriction of the names Trujillo Sandstone and Santa Rosa Sandstone to some part of their former definition is a violation of the code (Article 19g). Most would agree, however, that these are "good" violations, reflecting more natural stratigraphic breaks as well as recent practice. Should we follow the letter of the code and reinstate the Santa Rosa and Trujillo Formations with their former boundaries? No, such a revision would generate even more confusion than already exists.

Similarly, recognition of the Dockum Group as a valid unit with priority over the Chinle would suggest (in contrast to Lucas and colleagues' notion that virtually all Late Triassic strata in North America be subordinated within the Chinle Group) that the Chinle be subordinated as a formation within the Dockum Group. Should this be done? No. Such a revision, though perhaps adhering to the letter of the code, certainly would violate the tradition and respect due to several generations of venerated geologists. The outcry of Colorado Plateau stratigraphers would most certainly be heard in Texas.

4). There is little stratigraphic break between these sandstone beds. The name Camp Springs conglomerate (or member) should most assuredly be abandoned for the following reasons: 1) Beede and Christner never specifically indicated what part of this section was to be identified as the Camp Springs, 2) they did not indicate how this unit was related to previously named formations in the Dockum Group, 3) they did not give a thickness, 4) they did not measure a section or show the unit on a map, and 5) the name was not used for several decades. Clearly the Camp Springs conglomerate does not meet the requirements for a formal stratigraphic unit. The condensed stratigraphic section in the "type" area spans virtually all of the Dockum Group. Even if Lucas and colleagues have correctly isolated Beede and Christner's intent to refer only to the lowermost unit exposed in the "type" area, the name Santa Rosa Sandstone has clear priority for this unit. There remains no justification for retaining the name Camp Springs conglomerate. In the restricted sense advocated by Lucas and colleagues it is lithologically and genetically part of the Santa Rosa Sandstone and can be physically traced in outcrop and subsurface into the Santa Rosa type area.

Hence, in the case of the Camp Springs conglomerate (or member), Lucas and colleagues have attempted to preserve a name that was never defined, never measured, and never shown on a map, in favor of a name with overwhelming tradition and priority (the Santa Rosa Sandstone). This contrasts with the Cooper Canyon Formation, a unit with clear priority that was defined, measured (if inaccurately), and shown on a map, which is being abandoned in favor of its junior synonym, the Bull Canyon Formation.

The case of the Otis Chalk problem

Over much of the southern part of the High Plains region, the lower part of the Dockum Group (Santa Rosa and Tecovas) was markedly thinned and in many areas removed by erosion prior to deposition of the Trujillo Sandstone (Fig. 4). Hence, in these areas the Trujillo Sandstone rests on or close to underlying Permian strata, and the entire overlying section belongs to the Cooper Canyon Formation. Failure to recognize this has led to many problems of correlation, such as the mistaken identification of the Trujillo Sandstone with the Santa Rosa, as noted above. Such problems persist to this day.

In the southern part of the High Plains region, Lucas and Anderson (1992) mistakenly identified the entire basal-sandstone interval of the Dockum as the Santa Rosa Sandstone (on the New Mexico side) or its synonym, the Camp Springs conglomerate (on the Texas side). Based on this misidentification and the observation that there is no major persistent sandstone interval stratigraphically higher in the overlying section of dominantly red shale (where the Trujillo Sandstone "should" be), Lucas and Anderson (1992, 1993) concluded that two new names are necessary for these strata—the San Pedro Arroyo Formation (on the New Mexico side) and the "unnamed member" of the Dockum (on the Texas side, Fig. 2).

Lucas and colleagues' correlation is based in part or entirely on biostratigraphic grounds and reflects their belief that the red-shale section overlying the basal-sandstone series must be equivalent to the Tecovas Formation (Hunt and Lucas, 1990; Lucas and Anderson, 1993). Several well known vertebrate fossil localities occur high in this section of predominantly red shale near the community of Otis Chalk (Fig. 4). Although there is disagreement regarding the age of the fauna from these localities (e.g. Murray, 1989), Lucas and colleagues believe that the fauna is temporally equivalent to that of the Santa Rosa and Tecovas. They have based their lithostratigraphic nomenclature on this assumption. However, the basal-sandstone interval of the Dockum in this region is a condensed section with the Trujillo Sandstone resting directly on, or just above, the Santa Rosa Sandstone (Fig. 4). In some areas the Trujillo Sandstone is the basal sandstone and no Santa Rosa is present. The red-shale section is the Cooper Canyon Formation. This can readily be shown by physical tracing in outcrop southward from the type area of the Cooper Canyon Formation (Fig. 4), and it is supported by the marked contrast in lithology and paleocurrent orientation between the Santa Rosa and Trujillo (Lehman, 1992). Regardless of their fossil vertebrate fauna, the Otis Chalk localities are within the Cooper Canyon Formation and at least 60 m above the top of the Trujillo Sandstone. There is no justification for use of the names San Pedro Arroyo Formation in southeastern New Mexico or for the "unnamed member" in Texas. These strata already have a name—the Cooper Canyon Formation. The Otis Chalk "problem" illustrates a case of confusing biostratigraphy with lithostratigraphy.

The fate of the Dockum Group

Early in their revisionist work, Lucas and colleagues rejected the validity of the Dockum Group, going so far as to say that only the Trujillo Sandstone was present in the type area of the Dockum Group on Dockum Creek. This is not true. Recent mapping reveals that the section in the type area of the Dockum Group is quite complete, with all units except the Redonda Formation present (Fig. 3). Lucas and colleagues also originally rejected use of the term Chinle Formation in eastern New Mexico, whereas in more recent versions they have accepted the validity of both the Dockum and Chinle, but with the Dockum subordinated as a formation within the Chinle Group. This in spite of the fact that the name Dockum Group is valid and has clear priority over Chinle "Group."

The fortuitous location of the type area of the Trujillo Sandstone on Trujillo Creek, straddling the Texas/New Mexico state line, forces the issue (Fig. 1). We can thank Gould for his foresight in choosing such a location. If, as generally agreed, the Trujillo Sandstone can readily be correlated around exposures in both Texas and New Mexico, cannot the shale section above (the Cooper Canyon Formation) and the shale section below (the Tecovas Formation) likewise be traced? The answer is, of course they can. Similarly, if the Santa Rosa Sandstone can be easily correlated from the Pecos River valley into the Canadian River valley in New Mexico, why not a few more miles into Texas? The answer is, it can. Given this recognition,

These examples illustrate that in many cases upholding the spirit of the code is as important as upholding its letter. Often the more important question is not what is "legal," but what is the *right* thing to do. More valuable than strict adherence to the letter of the law is the question of what is ethical. What accords respect to the intentions, if not the words, of earlier workers? What preserves uniformity and tradition in a region?

A revision of stratigraphic terminology should do its best to repair and refine existing nomenclature, even if in its original form it falls short of one's perception of perfection. A revision should not search for legalistic loopholes needed to discard older established names in order to substitute names of one's own design.

Recommendations

I recommend that most of the revisions in the stratigraphic nomenclature of the Dockum Group offered by Lucas and colleagues be rejected because they violate both the spirit and letter of the stratigraphic code, as well as the intentions of previous workers. None of their revisions have been accompanied by mapping areas of more than a square mile or so around the type sections, and thus do not satisfy Article 12 of the code. In this paper the following stratigraphic conclusions are supported: 1) the Dockum Group has a clear priority over the Chinle Group (Article 7c), 2) the Tecovas Formation has a clear priority over the Garita Creek Formation, 3) revision of the Cooper Canyon Formation is allowed by the code and this name has priority over the Bull Canyon Formation, 4) the Santa Rosa Sandstone has priority over the Camp Springs conglomerate, and 5) the Anton Chico Formation should be recognized as separate from the Santa Rosa Sandstone, and should not be considered a member of the Moenkopi Formation for the same reason why the Dockum should not be considered part of the Chinle.

The simple stratigraphic nomenclature advocated here respects the priority of established names and tradition. It also returns to a more accurate picture of Texas/New Mexico Triassic stratigraphy true to the intent of stratigraphers at the turn of the century, perhaps before state boundaries became so marked. This simple nomenclature emphasizes the fact that these strata are common to both states. The type areas for two of the formations are in Texas (Tecovas and Cooper Canyon), two are in New Mexico (Santa Rosa and Redonda), and one (Trujillo) straddles the state boundary (Fig. 1).

The practice of naming strata should be every bit as exacting and rigorous as that of naming new species. Paleontologists should enlist the help of practicing stratigraphers to delineate and map the units for which they wish to provide formal names. Revisions of stratigraphic nomenclature should not be taken lightly and should be fully justified with supporting maps. A stratigraphic unit must be demonstrably different from previously named strata with which it is physically contiguous if it is to receive a new formal name.

Acknowledgments

This paper constitutes a rallying cry to save the Dockum Group from its untimely end. Having grown up, been educated, and spent much of my adult life in New Mexico and now teaching across the border in Texas, I am in a unique position to evaluate the condition of the Texas/New Mexico boundary "fault." The observations presented in this paper were developed during supervision of graduate-student research on the Dockum Group at Texas Tech University. Several of these students are now employed as professional geologists and educators in New Mexico. I thank Andrew Frelier, Brent and Susan May, Teri Fritz, John Schnable, Craig Bunting, and Derald Mabbitt.

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Postscript-What's in a name?

In their reponse to my critique of their work, Lucas et al. (this volume) acknowledge that the physical continuity and lithologic similarity of Triassic strata on either side of the Texas/New Mexico state line are not disputed. What remains debatable is the nomenclature that should be applied to these strata, and whether or not separate names are needed in Texas and New Mexico. The purpose of my critique has been to review this nomenclatural problem and to justify my choice of available formal names for use in the ongoing mapping program in west Texas. I have not proposed any new formal names, nor have I demonstrated any new or unusual stratigraphic correlations. I have simply argued that what we call these strata is important, and that the priority of previously established names should be respected.

Simply put, Lucas et al. (this volume) argue that 14 formal names are needed to describe these strata. In a period of five years they have proposed 10 new formal names for stratigraphic units previously recognized informally by earlier workers and have changed the name or rank of the remaining units. In contrast, I contend that the stratigraphic relationships of these units were largely deciphered by earlier workers, and that only six previously proposed formal names are necessary to describe them. Although Lucas et al. (this volume) suggest that I have applied a "double standard" in deciding which names should be accepted, in reality I have applied a single, simple stan-

dard—in each case only the name with priority is accepted for each unit. I also suggest, in accordance with the Code of Stratigraphic Nomenclature, that these formal names should be based on lithologic criteria and not on inferred biostratigraphic correlation or on subtle, unspecified depositional facies changes. Lucas et al. (this volume) suggest that I do not understand the procedure involved in applying formal names to strata, that mapping is not required when applying formal names to strata, and that I offer no new data. Arguments regarding interpretation of the Code of Stratigraphic Nomenclature are marginal to the real issues of this debate and illustrate the legalistic harangue that ensues when the letter of the code is used in defense of the proliferation of formal stratigraphic names. Moreover, the weight of superficial data amassed in more than 20 of their publications does not make the nomenclature they propose correct. Lucas et al. (this volume) have failed to respond adequately to the following questions.

1) Is the Dockum Group a valid stratigraphic unit with priority over the Chinle Group? Although Lucas et al. (this volume) quote extensively from Cummins' original 1890 paper on the Dockum beds, they ignore the much more thorough account published by Cummins' assistant Drake in 1892. Drake clearly traced the Dockum Group entirely around the High Plains of Texas and New Mexico. In the course of circumambulating the High Plains, Drake studied all of the major exposures of Triassic strata recognized today and measured sections in the Colorado River valley, along the Caprock Escarpment, through the Canadian River valley to Tucumcari Mountain, and southward along the Pecos River valley in New Mexico from Fort Sumner to Eddy, and from there to Pecos, Texas. It is significant that Lucas et al. (this volume) have chosen to largely ignore this important paper. I implore interested stratigraphers to read Drake's landmark paper of 1892, and the later detailed accounts of the Dockum Group in the Canadian River valley by Gould (1907) and Patton (1923). These papers, as well as mapping provided in the *Geologic Atlas of Texas* published in the 1970s and early 1980s, clearly document the extent and continuity of the Dockum Group in both Texas and New Mexico, and leave no question that the Dockum Group as originally conceived and subsequently mapped encompasses all of these Triassic strata. The *Geologic Atlas of Texas* Tucumcari Sheet (1983) is particularly instructive in this regard, and accurately depicts the extension of both the Tecovas and Trujillo Formations as part of the Dockum Group into New Mexico (contra Lucas and others). Lucas et al. (this volume) have ignored this important map. The most recent geologic map of Texas (Barnes, 1992) also retains the Dockum Group as a valid unit (contra Lucas and others). Lucas et al. (this volume) remark that my suggested subdivisions of the Dockum Group were not adopted in this recent map of Texas. This is not surprising, since I have only now reviewed this nomenclatural problem. Moreover, the nomenclature advocated by Lucas et al. (this volume) has not been adopted, and, given the scale of recent mapping, the Dockum Group is largely shown undivided. In summary, the name Dockum Group is clearly valid, used in all recent mapping, well established in the literature through use over more than a century, and must be given priority over the Chinle Group of Lucas and others. Lucas et al. (this volume) have not satisfactorily demonstrated otherwise.

2) Is the Camp Springs conglomerate lithologically different from the Santa Rosa Sandstone? The units are physically contiguous with one another and occupy the same stratigraphic position in the base of the Dockum Group. Both units are composed of a lower quartzose fluvial sandstone with chert-pebble conglomerate, and locally an upper, lenticular quartzose deltaic sandstone that intertongues with the overlying Tecovas Formation. The Camp Springs conglomerate is thinner, more lenticular, and in places more conglomeratic than the Santa Rosa Sandstone in its type area. Do the thickness difference and "facies change" justify the use of different names for this unit on either side of the state line? No. Continental sandstone units such as the Santa Rosa Sandstone commonly exhibit such subtle thickness and fades changes. Lucas et al. (this volume) have not demonstrated why two names are necessary for this unit.

3) Is the Garita Creek Formation lithologically different from the Tecovas Formation? The units occupy the same stratigraphic position and are physically contiguous with one another. Both units are composed predominantly of shale. Both units have a lower variegated lacustrine shale interval that intertongues with the underlying Santa Rosa Sandstone, and an upper red fluvial shale interval unconformably overlain by the Trujillo Sandstone (as first documented by Gould, 1907). In Texas much of the upper red shale interval was removed by erosion prior to deposition of the Trujillo Sandstone, and thus the Tecovas Formation is thinner there. In northeastern New Mexico the upper red shale interval escaped pre-Trujillo erosion in most areas, and is therefore thicker. Do the the thickness change and "facies change" justify the use of different names on either side of the state line? No. In fact, this is not a facies change at all, but a result of partial erosional truncation. Lucas et al. (this volume) have not demonstrated why two names are necessary for this unit. Lucas and others have applied the names San Pedro Arroyo Formation and Iatan Member to sections composed predominantly of red shale, which they believe to be broadly equivalent to some part of the Tecovas Formation. They have not demonstrated the stratigraphic position of these units relative to the Tecovas and Trujillo Formations, nor have they shown how these strata differ *lithologically* from the Tecovas or Cooper Canyon Formations. I contend that neither of these names is necessary.

There is no debate regarding the physical continuity and lithologic characteristics of the Trujillo Sandstone, Cooper Canyon Formation, and Redonda Formation in New Mexico and Texas. Rather the debate concerns only what these units should be called.

The Otis Chalk problem revisited

The only significant (non-nomenclatural) issue raised in my critique involves the equivalence of Dockum

Group strata exposed in the Colorado River valley of Howard and Mitchell Counties, Texas. I contend that these strata are lithologically identical to, and physically contiguous with, the Santa Rosa, Tecovas, Trujillo, and Cooper Canyon Formations exposed a few miles to the north and east across the drainage divide in the Brazos River valley. I have illustrated the distribution of these strata by mapping (Fig. 4). In contrast, Lucas et al. (this volume) contend (without mapping or demonstrating the relationships between these units and those exposed to the northeast) that yet another name, the latan Member, is required for these strata, and, furthermore, that only the lowermost part of the Dockum Group (Santa Rosa through Tecovas) is exposed in the Howard/Mitchell County area. The resolution of this issue is very important, and it is critical to the biostratigraphic zonation of Triassic strata advocated by Lucas et al. (this volume).

Simply put, the correlation of strata in the Howard/Mitchell County area suggested by Lucas et al. (this volume) is geometrically impossible. Construction of a simple cross section illustrates this (Fig. 5). As mapped by myself (Fig. 4) and Lucas et al. (this volume, fig. 4), the Santa Rosa, Tecovas, and Trujillo Formations all are readily recognized in exposures along the east side of the drainage divide between the Brazos and Colorado Rivers, for example, near the community of Camp Springs (Fig. 5). The stratigraphic relationships in this area are not disputed. In the Camp Springs area, the top of the Santa Rosa Sandstone lies at an elevation of approximately 2200 ft, and the top of the Trujillo Sandstone lies at an elevation of approximately 2300 ft. These strata dip less tha 1° to the .southwest, beneath the drainage divide and into the subsurface of the Midland Basin. All three units are exposed again in the canyon of the Colorado River about 20 mi to the southwest, at a slightly lower el

evation in accordance with the regional dip of these strata, and maintaining the same stratigraphic relationships observed farther to the northeast (Figs. 4, 5). The lowermost sandstone, resting directly on underlying Permian strata and exposed at an elevation of approximately 2050 ft in the canyon of the Colorado River, is a quartzarenite with chert-pebble conglomcerate—the Santa Rosa Sandstone. Overlying this sandstone is a thin interval of variegated gray, purple, and red shale—the Tecovas Formation. Resting on this shale is the spectacular cliff-forming sandstone of the Colorado River canyon. This sandstone is a highly micaceous litharenite with conglomerate composed of reworked sedimentary-rock fragments. This sandstone is lithologically identical to, and physically contiguous with, the Trujillo Sandstone as mapped in areas to the north and east. Readily accessible exposures of the Trujillo Sandstone may be observed along the canyon of the Colorado River and its tributaries, for example on Bull Creek downstream from Lake J. B. Thomas, along the bluffs south of the town of Colorado City, and on Morgan Creek at Lake Colorado City. Lucas et al. (this volume) have failed to demonstrate why this unit is not the Trujillo Sandstone. The extensive exposures of red, slope-forming shale to the west and east of the Colorado River are demonstrably *above* the Trujillo Sandstone and physically contiguous with the type section of the Cooper Canyon Formation farther north (Fig. 4). Throughout this region and elsewhere the Cooper Canyon Formation contains isolated discontinuous sandstone beds that are lithologically similar to those of the underlying Trujillo Sandstone.

The correlation of the Howard/Mitchell County area suggested by Lucas et al. (this volume), but not substantiated by mapping, would require that the Trujillo Sandstone *rises* more than 200 ft in elevation to the

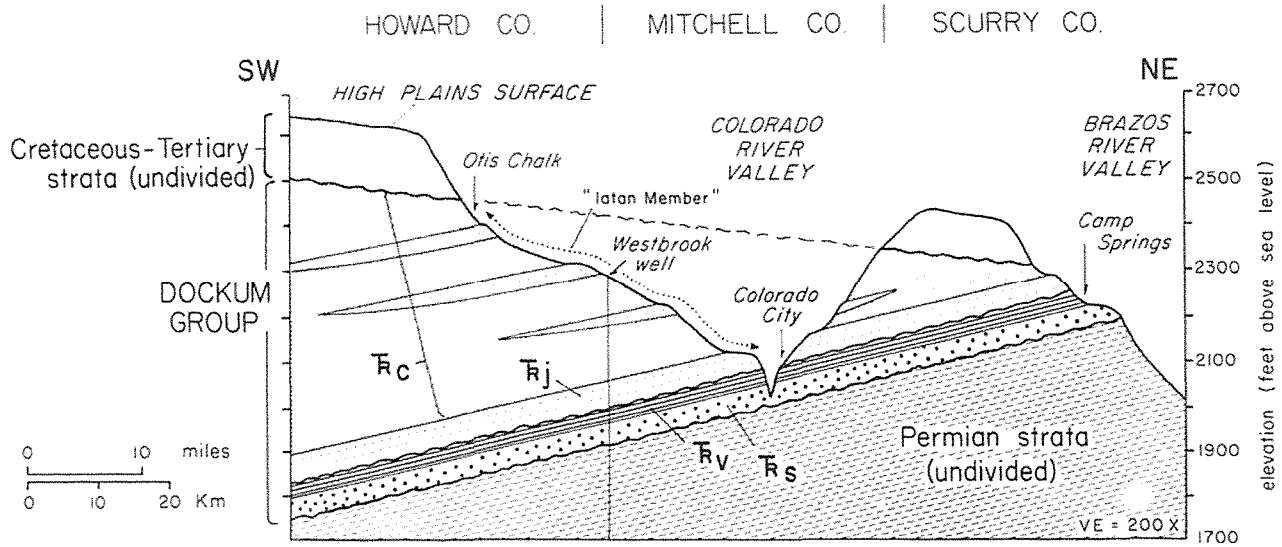

FIGURE 5—Geologic cross section showing the subsurface distribution of Triassic strata in Howard, Mitchell, and Scurry Counties, Texas. This section contrasts the interpretation of Dockum Group stratigraphy advocated in this paper with that of Lucas et al. (this volume). The line of section runs from the vicinity of Camp Springs in Scurry County to Colorado City in Mitchell County, and from there to the vicinity of Otis Chalk in Howard County (see Figure 4 for location of section). The position of the Westbrook well site in western Mitchell County (Lucas et al., their figure 5) is shown, as is the surface section described as the latan Member by Lucas et al. (this volume). Subdivisions of the Dockum Group are the Santa Rosa Sandstone (TRs), Tecovas Formation (TRv), Trujillo Sandstone (TRj), and Cooper Canyon Formation (TRc).

southwest, in opposition to the regional dip of Triassic strata, in order for it to rest *above* the Iatan/Otis Chalk section. Given the position of undisputed exposures of the Trujillo Sandstone east of the Colorado/ Brazos drainage divide, the correlation proposed by Lucas et al. (this volume) would also require a dramatic dip reversal in overlying Triassic strata, erosional truncation of almost 200 m of Triassic strata, and exposures of the Trujillo Sandstone to occur at high elevations along the headwaters of the Colorado River—none of which are observed. Even if the Triassic strata were perfectly horizontal (a physical impossibility given the westward decline in elevation of the Permian/Triassic contact), the Iatan/Otis Chalk area would remain above the level of the Trujillo Sandstone, as documented in undisputed exposures to the northeast.

Furthermore, the geophysical log from a well drilled near the town of Westbrook in Mitchell County, illustrated by Lucas et al. (this volume, fig. 5), also depicts stratigraphic relationships that are completely incompatible with their interpretation. Lucas et al. (this volume) state that this well log "allows clear recognition" of the entire Santa Rosa through Trujillo interval. The well site is situated *on the outcrop* of their Iatan Member, yet strata that they identify as the Trujillo Sandstone are encountered 300 ft below the surface, at an elevation of 1900 to 2000 ft in this boring (Fig. 5). This requires that all strata above 2000 ft are younger than the Trujillo Sandstone. Their type section of the Iatan Member runs from a surface elevation of about 2000 ft up to 2500 ft, and thus includes only beds that are demonstrably *above* the level of the Trujillo Sandstone encountered in the boring. Strata in the boring that Lucas et al. (this volume, fig. 5) identify as the Iatan Member are encountered at an elevation of 1500 to 1700 ft. Given the undisturbed, gentle southwest dip of these strata, beds encountered at 1500 to 1700 ft in the boring (which they "clearly recognize" as the Iatan Member) should not crop out anywhere west of the Colorado River! Nowhere in Mitchell County does the surface elevation drop below 1900 ft. The well log is, however, quite compatible with my mapping of this region and with the cross section shown here (Figs. 4, 5).

Lucas et al. (this volume) regard my mapping of the type area of the Dockum Group farther north as correct, and a "useful contribution." However, my map of the Howard/Mitchell County area is regarded as "erroneous" and "clearly wrong." This is unusual in view of the fact that all units were physically traced in exposure southward from the type area and the same criteria were utilized consistently in identification of each stratigraphic unit. Simply to state that this mapping is incorrect does not suffice. It is incumbent upon Lucas and others to demonstrate by mapping *how* this map is inaccurate and to show the southern extent of the Trujillo and Cooper Canyon Formations in this area, as well as their relationships to the Iatan Member. Furthermore, if my mapping of this region is upheld, it demonstrates that the Triassic tetrapod biostratigraphy proposed by Lucas et al. (this volume) is untenable. Localities such as those near Otis Chalk, which bear a vertebrate fauna considered to be primitive ("Otischalkian") by Lucas et al. (this volume), actually occur stratigraphically *above* localities that yield a fauna they consider to be much younger ("Revueltian"), such as the Post Quarry. This suggests that the ranges of many of these tetrapod taxa actually overlap and thus do not have the biochronological significance accorded them by Lucas et al. (this volume).

Finally, although Lucas et al. (this volume) are apparently unconcerned about the priority of established names, I am compelled to point out that the name "Iatan Member" is preoccupied by the Iatan Limestone, a unit variously included as a member of the Stranger Formation or as a formation in the Douglas Group of Iowa, Kansas, and Missouri, and in use since 1899 (Swanson et al., 1981).