SOUTHEAST NEW MEXICO CORRELATED FORMATION TOPS DESCRIPTION

1. RSLR Rustler Anhydrite  
   This pick was made on the sharp gamma-ray break at the base of the overlying Dewey Lake clastics. The Rustler is present over most of the Southeast New Mexico area. The top is extremely variable due to dissolution of salt from the underlying Salado formation.

2. TNSL Tansil Formation  
   Underlies the Salado formation on the Northwest Shelf and Central Basin Platform. Due to rapid lateral facies changes, the Tansil was able to be picked in local areas only.

3. CSTL Castile Formation  
   Composed of anhydrite, dolomite and salt. It is very difficult to pick on most gamma-ray logs and consequently was picked only where log resolution permitted.

4. YTES Yates Formation  
   Underlying the Tansil on the Shelf, the Yates is present throughout the Northwest Shelf and Tatum Basin. Because of sudden facies changes, the Yates top is a difficult pick.

5. LMAR Lamar (Delaware Limestone)  
   The uppermost member of the Bell Canyon formation. Picked on radioactive shale-limestone immediately below the clean anhydrite of the Castile formation.

6. SVNR Seven Rivers Formation  
   A back-reef equivalent of the Captain Reef. Contains many facies changes. Several overlying shale units have extensive areal presence and were used to separate the Seven Rivers from the Yates.

7. QUEN Queen Formation  
   The Queen was picked on an upper sandstone member with a distinct gamma-ray character. Locally, where facies changes have obscured the unique character, the pick was not made.

8. SNDR San Andres Formation  
   This is present extensively on the Central Basin Platform and throughout the Northwest Shelf. It progrades from a back-reef dolomite into the Delaware Basin as the Victoria Peak Reef. The upper surface is an unconformity that is variable and difficult to pick consistently.

9. PIMK Pi Marker  
   This mid-San Andres marker has been used by the oil industry historically as a valuable mapping point. An excellent gamma-ray marker, it is present throughout the Northwest Shelf.

10. TPTY Top of Porosity  
    This was picked locally where discernible by log character. This is a very subjective pick and, due to the variability of logs, is a very difficult pick.
11. CPTN Captain Reef  
Massive bio-limestone reef which rings the Delaware Basin and separates the Delaware sands from the back-reef Tansil, Yates and Seven Rivers. It has been penetrated by a very few wells because of its limited width. The pick can be made with any or all of the back reef formations.

12. BLCN Bell Canyon Formation  
The Delaware Basin equivalent of the Tansil-Yates-Seven Rivers on the Shelf, this unit is composed entirely of clastics. The pick was made on the base of the Lamar Limestone.

13. CYCN Cherry Canyon Formation  
The Delaware Basin time equivalent of the San Andres. Good pick over the Delaware Basin area of Southeast New Mexico.

14. BYCN Brushy Canyon Formation  
Delaware Basin equivalent of the Middle San Andres formation. This unit overlies the Bone Springs formation. Locally, may not pro-grade shelfward as far as the overlying Cherry Canyon.

15. GLRT Glorieta Sandstone  
Northwest Shelf and Central Basin Platform unit equivalent to the First Bone Springs sandstone in the Delaware Basin. This was a difficult pick due to facies changes normal to the basin edge.

16. BSGL Bone Springs Limestone  
Composed of black siliceous limestone directly beneath the Brushy Canyon clastics. Very consistent over the Delaware Basin. This unit is the time equivalent of the Lower San Andres on the Shelf.

17. FBSG First Bone Springs Sandstone  
Occurring 1,000-5,000 feet below the Bone Springs limestone, the first sand is equivalent to the Glorieta on the Shelf and Central Basin Platform. The three Bone Springs Sands are subject to great interpretive differences. We have tried to maintain as much consistency as possible while staying as close to published interpretations as possible.

18. SBSG Second Bone Springs Sandstone  
Picked as the basal clastic unit above the Wolfcamp. It is the Delaware Basin equivalent of the Tubb Sandstone of the Northwest Shelf and Central Basin Platform.

19. TUBB Tubb Sandstone  
The sandstone facies of the Clearfork formation, the Tubb is present on the Northwest Shelf and the Central Basin Platform. Equivalent to the Third Bone Springs Sandstone of the Delaware Basin.

20. TBSG Third Bone Springs Sandstone  
Picked as the basal clastic unit above the Wolfcamp. It is the Delaware Basin equivalent of the Tubb Sandstone of the Northwest Shelf and Central Basin Platform.
21. **AABO** Abo Formation
   Present throughout the Northwest Shelf and the Central Basin Platform as dolomite and shelf facies. Equivalent to Wichita/Albany in Texas. Although we do not make our Abo pick in the Delaware Basin, some lower clastics of the Third Bone Springs sandstone are probably Abo equivalent. This pick also includes the Abo reef at the Shelf edge.

22. **WFMP** Wolfcamp Formation
   Very widespread Lower Permian limestone and shale unit. Present over entire Southeast New Mexico area except where missing at the top of high structures. The Wolfcamp is thickest along the Shelf edge.

23. **XXMK** XX Marker
   Very consistent gamma-ray marker 100-150 feet below the top of the Wolfcamp. Not picked on Central Basin Platform or in the Delaware Basin.

24. **BTBR** Base Three Brothers
   This pick is based totally on the gamma-ray and is composed of cyclic limestone and shale. The basal unit of the Wolfcamp, the Three Brothers is present only on the Northwest Shelf.

25. **PSLV** Pennsylvanian
   This pick was made in areas where the Cisco and Canyon pick was indefinite. Used throughout southeast New Mexico except where eroded.

26. **CSCO** Cisco
   Present on the Northwest Shelf and Central Basin Platform as a carbonate bank ringing the Delaware Basin. In the Delaware Basin, it is present as a thin, black shale which we did not pick. Not present on high structures of the Central Basin Platform. Available paleo information was used with discretion.

27. **BGHC** Bough C
   Pennsylvanian age pay zone in northernmost part of area. A possible Cisco age limestone, it was picked on gamma-ray and resistivity character.

28. **CNYN** Canyon
   Present on Northwest Shelf and Central Basin Platform as a carbonate bank. Was not picked in the Delaware Basin. Available paleo information was used with discretion.

29. **STRN** Strawn
   Present on Northwest Shelf and Central Basin Platform as a carbonate bank. Was not picked in the Delaware Basin. Available paleo information was used with discretion.

30. **ATOK** Atokan
   Present throughout Southeast New Mexico area. Most commonly shale with occasional limestone beds. It was picked at the base of the Strawn limestone. The Atokan overlaps all but the higher structures on the Northwest Shelf and Central Basin Platform.
31. ATBK  **Atoka Bank Limestone**
   A lower carbonate pay within the Atokan. Opinions vary widely as to the exact correlations of the "Bank Limestone". We have tried to be as consistent as possible in making our Bank Limestone pick.

32. MRRW **Morrowan**
   Lower Pennsylvanian limestones, shales and sandstones. Present in the Delaware Basin, Tatum Basin and areas of the Northwest Shelf. Picked at base of Atokan.

33. LMRW **Lower Morrow**
   Picked on base of last sandstone. Present only in the deep Delaware Basin.

34. MSSP **Mississippian (Upper)**
   Picked on base of last sandstone. Present only in the deep Delaware Basin.

35. BRNT **Barnett Shale**
   Used when only shale is present in the Upper Mississippian. When carbonates intermix with the shale, the top of the shale is picked as Mississippian.

36. MSPL **Lower Mississippian**
   Massive limestone facies present throughout southeast New Mexico except on local highs.

37. WDFD **Woodford Shale**
   Typical black radioactive shale common to Woodford (Chattanooga) localities throughout the mid-continent.

38. SLRN **Silurian**
   Picked as the first carbonate below the Woodford. It is very massive, thinning to the northwest and missing locally on uplifts. Although a small area of Devonian is present in extreme Southeast Lea County, we have not picked it in this phase of the project, but have included it with Silurian.

39. FSLM **Fusselman Formation**
   Picked only southern Lea County. The pick was made on the base of a thin radioactive shale on top of the clean Fusselman carbonate.

40. MTYA **Montoya Formation**
   Picked only in southern Lea and Eddy Counties. Called with a shale gamma-ray kick at the base of the Fusselman.

41. SMPS **Simpson Group**
   Up to 1,000 feet thick in southern Lea County, the Simpson is a mix of limestone, shales and minor sandstones. The pick was made on top of the massive "bromide" limestone.

42. EBGR **Ellenburger Formation**
   Massive dolomite, present throughout the area except on local high structures where eroded and in the extreme northwest portion of the area.
43. **PCMB Precambrian**

The first occurrence of igneous or metamorphic rocks below the Ellenburger. We have made every effort to separate granite wash and basal sands by using available samples and logs.
INTERPRETED FORMATION TOPS

MIDLAND BASIN CORRELATED FORMATION TOPS DESCRIPTION

1. **BCRC Base Cretaceous:**
   This shallow pick was made in the southern-most parts of the Midland Basin, Central Basin Platform and Ozona Arch to give northern definition to maps and cross-sections created by geologists interested in the Val Verde Basin, Del Rio (Diablo) Uplift and the Marathon Overthrust areas to the south. Here, the base of Cretaceous is also the top of the Chinle formation of the Dockum Group of Upper Triassic Age.

2. **RSLR Rustler:**
   The Rustler formation is the first Permian age pick included in this file. This unit belongs to the Ochoan Series of Upper Permian age. The anhydrite of the Rustler is in sharp contrast to the overlying shales and siltstones of the Santa Rosa and Dewey Lake formations and should be particularly useful to production geologists and geophysicists needing this sharp interface for shallow control. This top is sometimes very erratic due to salt dissolution.

3. **TNSL Tansil:**
   This upper-most formation of the Whitehorse Group of the Guadalupian Series underlies, conformably, the salt and anhydrite of the Upper Permian Salado. The Tansil is an anhydritic dolomite that represents the back-reef facies of the Capitan Reef to the west and, thus, covers all of the Central Basin Platform and the Midland Basin.

4. **YTES Yates:**
   The Yates sands, as the overlying Tansil, cover all of the subject area and are limited on the west by the Capitan Reef and to the east by pre-Cretaceous surface erosion. The pick was made at the base of the anhydritic dolomite of the Tansil on the first occurrence of clean sand.

5. **SVNR Seven Rivers:**
   The Seven Rivers formation is conformably overlain by the Yates and underlain by the Queen. Its areal extent is restricted by the same limiting factors as the Yates. A distinct shale break at the base of the Yates that persists throughout the subject area was used for the correlation pick.

6. **QUEN Queen:**
   The top of the Queen formation has a distinct gamma-ray character that persists throughout the subject area, and in places of local facies modification, close control of selected well logs is used to make the correlation.
7. **GYBG Grayburg:**
   The Grayburg formation underlies the Queen sands and is the basal unit of the back-reef Whitehorse Group and unconformably overlies the San Andres. The Grayburg pick is made on top of the clean dolomite that immediately underlies the Queen sands. At the south end of the Central Basin Platform the Grayburg is represented by part of the lower Delaware Mountain Group that tongues into the Sheffield Channel. The Grayburg is picked up again south of the channel on the Southern Shelf in southern Pecos County.

8. **SNDR San Andres:**
   The San Andres was deposited as a cyclic, strandline sabkha with interbedded dolomite, anhydrite, siltstone and salt, that prograded southward through Upper Leonard and lower or early Guadalupe time. Our model has the Lower San Andres equivalent to that portion above the First Sand of the Upper Bone Springs formation of the Delaware Basin. The pick was obtained from published reports on prominent producing fields and carried regionally with help from the overlying and more lithologically persistent Grayburg formation. This method was used in all of the area except the deepest part of the Midland Basin where the similarities of the Grayburg and San Andres precluded differentiation and subsequent identification.

9. **PIMK Pi Marker:**
   This valuable Gamma-Ray marker of the mid-San Andres is an important mapping pick on the Northwestern Shelf of New Mexico and has been carried east into the Northern Shelf of the Midland Basin.

10. **GLRT Glorieta:**
    The Glorieta sands occur at the base of the San Andres on the Central Basin Platform, the Northern Shelf and the Eastern Shelf of Texas. In the recent past the Glorieta has been considered lowermost Guadalupian in age. In the GDS file we have followed the recent work of several stratigraphers and correlate the unit to be equivalent to the First Bone Spring Sand of the Delaware Basin and the Upper Spraberry Sand of the Midland Basin. This model then would lower the age of the Glorieta to the Leonard.

11. **SAGL San Angelo:**
    The San Angelo sands, after examining several published reports, have been placed in several stratigraphic positions. The GDS file will carry the unit as the Eastern Shelf equivalent of the Glorieta sands of the Central Basin Platform and the Northern Shelf which immediately underlie the San Andres.

12. **CLFK Clearfork:**
    In West Texas the Clearfork formation is divided into a lower and upper unit that is separated by the Tubb sands on the Central Basin Platform and Northern Shelf. GDS recognizes that some workers divide the Clearfork into three units with a middle unit equivalent to the lower Spraberry in the Midland Basin. We pick the first clean carbonate below the Glorieta sands as the top of the Clearfork on the shelves and platform and equate that to the Spraberry limestone that underlies the Upper Spraberry sands in the Midland Basin.
13. **TUBB Tubb:**
   This middle Clearfork sand is an excellent and reliable pick on the Central Basin Platform and the Northern Shelf. In our model for correlation we have equated the Tubb on the platform and shelf with the basal or Third Bone Spring Sand in the Delaware Basin and the Dean Sand in the Midland Basin.

14. **AABO Abo:**
   In Texas this platform-shelf pick represents the reef facies of the Wichita/Albany of lower Leonard age. In New Mexico we followed industry practice and used the Abo designation to include both the reef facies and the back-reef of the Texas Wichita/Albany.

15. **WCAB Wichita/Albany:**
   This predominately back-reef dolomite underlies the Lower Clearfork carbonates and is equivalent to the New Mexico Abo as explained above. The Wichita/Albany basin equivalents are best represented by the lower clastics of the Third Bone Spring Sand in the Delaware Basin and the Dean Sands in the Midland Basin. Recent work by Mazzullo and Reid has suggested with strong evidence that the Leonard-Wolfcamp contact in the two adjacent basins lies some two to four hundred feet below the base of the Third Bone Spring Sand and the base of the Dean Sand. If so, this would give the Lower Leonard or Wichita/Albany a more realistic representation in the two basins.

16. **USBY Upper Spraberry:**
   This pick is an excellent marker on well logs in nearly all of the Midland Basin. As remarked above, this formation is believed to be Upper Leonard in age and is the basinal equivalent of the Glorieta sands on the surrounding shelves and platform and is equivalent to the First Bone Spring Sand of the Delaware Basin.

17. **LSBY Lower Spraberry:**
   The Lower Spraberry sands are present throughout the Midland Basin. This massive sand unit is Middle Leonard in age and is correlative to the Second Bone Spring Sand of the Delaware Basin. As with the Upper Spraberry sands, this is a reliable pick that was made at the interface of the Spraberry limestone and the underlying sandstone.

18. **DEAN Dean:**
   The Dean sandstone, like the Spraberry sands above, is a broad tongue of clastics of interbedded sands, silts, shales, and impure limestones which extend the length of the Midland Basin between the Central Basin Platform and the western edge of the Eastern Shelf. The Dean represents the base of the Leonard in the Midland Basin, and is equivalent to the Tubb on the shelf and platform and the Third Bone Spring Sand of the Delaware Basin.
19. **WFMP Wolfcamp:**
   The Wolfcamp is lowermost Permian and covers all of the subject area with the exception of some extreme structural features on the Central Basin Platform such as the Fort Stockton High. Sedimentation was controlled by the waning orogenic forces and resultant structures created during Pennsylvanian and early Wolfcamp time. The waters of the Midland Basin had been connected to the open seas, via the Delaware Basin, through recognized channels of the San Simon in west-central Gaines County and the Sheffield in central and east Pecos County. Predominately clean limestones were deposited on the Central Basin Platform and the Northern Shelf with the thickest section occurring along the basinal edges. The basinal Wolfcamp sediments are predominately black shales and dark argillaceous limestones with the upper two to four hundred feet possibly being the basinal Wichita/Albany equivalent as discussed above. The earliest basinal Wolfcamp sediments extended north into the Texas Panhandle and to the east toward the Bend Arch. Basinward prograding phylloid-algae Wolfcamp "reefs" shortened the basin on the north and sand and clay clastics with cyclic westward prograding "reefs" restricted the open seas to the east. Thus, by end of Wolfcamp time the essential Midland Basin as we know it was delineated. The GDS file uses the base of the Wichita/Albany dolomitic carbonates and the top of the recognized clean Wolfcamp limestone as the pick on the platform and shelves and the base of the Dean sands in the Midland Basin as the top of the Wolfcamp.

20. **BPDT Base Permian Detrital:**
   In the GDS file this pick is limited to the Central Basin Platform, the Ozona Platform and the Northern Shelves. The early Permian transgressing seas created an angular unconformity on the platform and shelves covering first the youngest Pennsylvanian Cisco sediments, proceeding over the lower eroded Paleozoics and then finally over the Precambrian core. The detrital deposits on the higher structures were not covered until deposition of the back-reef facies of the Wichita/Albany.

21. **PPRF Permo/Penn Reef:**
   This pick is used exclusively in the Horseshoe Reef area on the Garza Platform in the north part of the Midland Basin. Continuous carbonate deposition on the atoll throughout the Pennsylvanian makes differentiation of the individual correlation units, or identification of the uppermost unit, impractical.

22. **PSLV Pennsylvanian:**
   This pick is used only in problem areas where a unit of rock is known to be Pennsylvanian but cannot be reliably correlated to any nearby wells with adequate control for unit differentiation.

23. **CSCO Cisco:** (Virgil)
   This youngest Pennsylvanian unit occurs as a limestone bank that encircles the Central Basin Platform and occurs on the Northern Shelf, an eastern extension of the Northwest Shelf of New Mexico. On the east side of the Midland Basin, the Cisco is represented by a dark gray, unfossiliferous shale that lies between Permian and Canyon sediments. This shale or mudstone is correlated to the Crystal Falls limestone to the east in the Bend Arch area of the Eastern Shelf.
24. **CNYN Canyon**: (Missouri)
The Central Basin Platform and the Midland Basin were part of a broad general area that was affected in Canyon time by a westward subsidence due to uplift and compression from the Bend Arch to the east and by continuing orogenic forces during the closing of the Ouachita Geosyncline. Carbonate bank growth kept pace with subsidence on the shelves and platform, but not in the downwarping Midland Basin. The "starved basin" concept of John Emory Adams is well illustrated in the Midland Basin with the lack of identifiable Canyon sediments. The Central Basin Platform with its carbonate "reef" banks denotes sea level fluctuations with green and red shales and sands originating from an inland source and interfingering into the limestone edge. Studies have shown that northward flowing warm marine waters provided the necessary nutrients for the organisms that built the Canyon banks, reefs and, most certainly, the Horseshoe Atoll. The GDS pick for the Canyon was predicated on lithology, using well-bore and sample logs, with Paleo reports, where available. The base of the "black shale marker" was picked as the top of the Canyon in the southern and eastern Midland Basin.

25. **STRN Strawn**: (Des Moines)
The Strawn age sediments are conformably overlain by the Canyon described above, but locally on the west side of the Midland Basin and on the Ozona Arch, Wolfcamp rocks overlie the Strawn, due perhaps to sweeping by submarine currents of accumulated Cisco-Canyon detrital. Between 500 and 1000 feet of reef and bank deposits occur on the Horseshoe reef and the margins of the Central Basin Platform. In early Strawn all of our area of concern was part of a much larger region that is considered to be a large detrital apron that bordered the Ouachita belt to the south and east. Except for the highs, a blanket limestone was laid down and is composed of lime mud and calcareous fossils with terrigenous mud and sands along the margins. At the end of this early Strawn deposition, compressional orogenic forces changed the physical nature of the area. A subsiding Midland Basin became starved for sediments and the later Strawn reef banks described above flourished. Paleo was very useful in the delineation of the top of the Strawn lime from the overlying Canyon.

26. **ATOK Atoka**:
The GDS pick for the Atoka is a definite shale break on Gamma-Ray logs at the base of the blanket Strawn limestone discussed above. Thickness of the Atoka is greatest on the southwestern edge of the Central Basin Platform and thins rapidly eastward into the Midland Basin where it is absent over most of the eastern part. Fine grained clastic detritus formed apron deposits on the flanks of the Central Basin Platform and coarse arkosic material moved south from the Matador Arch into the north end of the Midland Basin. This suggests that these two positive areas were tectonically active during Atoka time with erosion occurring on the larger structures. From the coarser clastics to the north, the Midland Basin Atokan increases in limestone percentage to the south end of the basin.
27. **MRRW Morrow:**
Following the precedent set by the Stratigraphic Committee of the WTGS in their 1984 east-west cross-section, GDS has opted to place the Morrow in the Midland Basin. The pick selected is the top of a series of radioactive shales that has been used by many geologists in the past as the top of the Barnett Shale and the base of the Atoka. The rationale for this decision is predicated on reports that the upper Barnett is younger in the Midland Basin (USGS PP #853) than the Barnett in the Llano area where the upper Barnett has been dated early Pennsylvanian by paleo. In addition, within the deeper portions of the Midland Basin, near continuous deposition seems to have occurred from the lower and known Mississippian Barnett into the Pennsylvanian Atoka. This would include the Morrow. Marine waters had possible access around the north end of the Central Basin Platform from the Delaware Basin and/or through channels in the Matador Archipelago from the Palo Duro Basin. The top and base of the Morrow, as used by GDS, is very distinct and the unit is easy to pick. Non-deposition or post depositional erosion has removed the Morrow from all the Central Basin Platform but not from the structurally deeper portions of the east flank of the basin.

28. **PVDT Pennsylvanian Detrital:**
On the Central Basin Platform, the Northern Platform and the north side of the Pecos Arch, this pick was made on top of the detrital material accumulated from the eroded Paleozoics that were covered by Atoka or younger Pennsylvanian sediments.

29. **MSSP Mississippian:**
Rocks of Mississippian age cover all of the subject area with the exception of eroded structural highs on the Central Basin Platform, the north side of the Pecos Arch and that portion of the Matador Arch in northwestern Cochran County. This pick is used to denote the top of the sequence in the northern portion of the Midland Basin and the Northern Shelf where the Barnett shale interfingers laterally with the upper Mississippian lime.

30. **BRNT Barnett:**
The Barnett shale extended originally from the Llano Uplift to the Franklin Mountains north of El Paso with its greatest thickness developing to over 1600' just west of the Central Basin Platform. Post Mississippian deformation and erosion has removed this shale entirely from the Eastern Shelf east of the center of Sterling and Howard Counties and from the high structures on the Central Basin Platform and the Pecos Arch. The GDS pick for this formation is distinct at the base of the Morrow and its eroded surface is readily found by its unique gamma-ray trace on electric logs. Difficulties in correlation arise in the northern part of the area where the upper Barnett shale laterally changes to interbedded limestones and shale of Chester age.

31. **MSPL Lower Mississippian:**
This pick is made on top of the lower Mississippian lime which as a unit directly overlies the Woodford shale. In the southern part of the Midland Basin the Mississippian in its entirety is represented by the Barnett shale from upper Kinderhook through upper Chester age. This lower Mississippian lime then develops laterally northward representing the upper Kinderhook, Osage and Meramec lime facies of the Barnett. On the Central Basin Platform this limestone extends upward into the lower Chester.
32. **WDFD Woodford:**
This highly radioactive shale is recognized on logs by all correlation geologists who have worked the Permian Basin. The formation has its maximum thickness (600'+) in Winkler County on the western side of the Central Basin Platform, and from there thins in all directions. The age of this shale has been determined to be late Devonian to early Mississippian, but an unconformity lies at both its base and part of the top with the possibility that either age could be missing in any one locale with the formation still being recognizable. In the subject area the pre-Woodford truncation has the unit deposited on Ordovician Ellenburger through Devonian age rocks. The Woodford shale extends north and becomes sandy in central Cochran County with the erosional limit bending to the southeast. From there the eastern limit continues into west-central Mitchell County where it turns due south into northwest Irion. From Irion County west the limiting factors are denudation of pre-Permian structures south of the Big Lake fault on the Pecos Arch and the major elements within the Central Basin Platform.

33. **DVNN Devonian:** (Thirty-One Formation)
The Devonian, or now more properly, the Thirty-One formation, attains its greatest thickness (1000'+) in central Crane County with its axis located just east of the Central Basin Platform and parallel to that structure. From that location the formation thins rapidly in all directions due to depositional restrictions and pre-Woodford erosion. The Devonian is barely present in the southeast corner of New Mexico with its zero isopachous line extending from there into north-central Andrews County, then ESE into north-central Glasscock County. From Glasscock County this line is directed southward into eastern Crockett County. The top of the Devonian is an easy pick with its chert-limestone makeup in sharp contrast to the overlying and highly radioactive Woodford. It is to the north that problems arise when the underlying Silurian shale changes into a carbonate facies or shelf bank and seemingly merges into the Devonian. GDS was aware of this situation and it was resolved with the aid of publications by E. H. McGlasson.

34. **SLRN Silurian:** (Wristen Formation)
The upper Silurian of west Texas consists of a predominately gray-green basinal shale that abruptly changes to fossiliferous shelf carbonates. The shale is thickest (300') on the Central Basin Platform in Winkler, Ward and Crane Counties. From there to the south and east the shale feathers down to as little as twenty feet but is still conformable with the overlying Devonian and underlying Fusselman. To the north in southern Andrews County this shale changes into shelf carbonates that thicken rapidly (+1500'), merge with the Devonian, and are overlain by the Woodford shale. The Silurian carbonate extends as far north as central Cochran County and as far east as eastern Glasscock and western Irion counties.
35. FSLM  
**Fusselman:**
The lower Silurian Fusselman formation rests unconformably on the upper-most Ordovician Sylvan shale and Montoya formation and underlies the upper Silurian with apparent conformity. The Fusselman reaches its maximum thickness (+400') in Winkler County, the San Simon Channel area in western Gaines County and the Northern Shelf in Yoakum County. The formation thins rapidly to the north from Yoakum County and is gone in northern Cochran County. From northeastern Cochran County the pinch-out line extends southeast to southwestern Mitchell County where it bends sharply to the south through central Sterling and Irion counties and into eastern Crockett. The Fusselman is divided into fossiliferous limestone and dolomite facies with the dolomite north of a line through central Andrews, Martin and Howard Counties with a small but economically important southward loop into Glasscock County. South of this line the limestone extends out into and, perhaps, past the Val Verde Basin. The Fusselman is believed by many workers to have extended over a much larger area than its erosional boundary now suggests.

36. SLVN  
**Sylvan:**
The Sylvan shale has been described as a green-gray to olive-gray micaceous shale that is easily identified in samples and on logs and is extremely useful in separating the carbonates of the Fusselman from the underlying Montoya. The Sylvan covered the Montoya throughout the entire Midland Basin and Central Basin Platform but in some places its thin veneer was stripped by pre-Fusselman erosion. The Sylvan is found mainly in the eastern Midland Basin as an elongate band running north-south from northern Lubbock County to central Crockett County with a width of fifty miles. To the west remnants of this shale are found on the Central Basin Platform in parts of Andrews and Ector Counties. The Sylvan reaches a maximum of 110 feet in the Midland Basin.

37. MTYA  
**Montoya:**
A paleo-lithofacies map of the Montoya gives one of the best illustrations of John E. Galley's Tabosa Basin. Shallow water limestone was deposited in the core of the Tabosa Basin with restricted shelf dolomites crowding the existing Texas Peninsula on the east in the eastern Midland Basin and the Northern Shelf. The greatest thickness of the Montoya lies to the west of the Central Basin Platform and thins gradually to the east to a line that runs from Lubbock County to Edwards County. On the east side of the Midland Basin, the overlying Sylvan and Fusselman formations have been removed and the Montoya is overlain by Woodford shale.

38. SMPS  
**Simpson:**
The Simpson Group is composed of five recognizable formations that are composed of alternating beds of dolomitic limestone, dolomite and sands. GDS' file follows the industry practice of not attempting to correlate these individual units regionally. The Simpson picks for both the top and base of the group are readily apparent once regional correlation has established the base of the Montoya and the top of the Ellenburger to the overlying Joins. The Simpson is unique in west Texas in that its thick axial sediments thin rapidly from its depo-center in central Pecos county. Here, just west of the Fort Stockton High, the Simpson Group exceeds 200' and thins unit by unit to zero in south-central Reagan County. The Simpson limit to the north extends into southern Cochran County and then runs south-southeast to the southwestern corner of Edwards County.
39. **EBGR Ellenburger:**
This predominately dolomitic unit covers all of the Central Basin Platform and Midland Basin areas except those places on high structures that were eroded during Pennsylvanian and Wolfcamp time. The top of this unit is difficult to pick on the eastern and southern edge of the Midland Basin where the Simpson is eroded and the Ellenburger is overlain by younger and laterally more extensive beds. The base of the Ellenburger is also difficult to pick but to a lesser degree because of the presence of Cambrian sediments on the southernmost end of the Central Basin Platform and the eastern and southeastern end of the Midland Basin.

40. **CMBR Cambrian:**
Once identified by samples, this unit was easy to detect and correlate. The Cambrian is present only on the south end of the Central Basin Platform and the eastern portion of the Midland Basin. Guidance for dealing with the Cambrian was obtained from the Bureau of Economic Geology, ROI #88, *The Moore Hollow Group of Central Texas*, by V.E. Barnes & W.C. Bell.

41. **GRWS Granite Wash:**
This pick was only used when the bit penetrated the full section of the Ellenburger present and the Cambrian if applicable. The presence of weathered igneous and/or metamorphic rock in the samples below the in-place lower Paleozoics was the key to correlation in any one specific area.

42. **PCMB Precambrian:**
The Precambrian was encountered in only a few wells in the subject area and the pick was determined again with samples that showed a preponderance of igneous and/or metamorphic rocks in the samples. Drilling times were also used when the Mud-loggers charts were available.
INTERPRETED FORMATION TOPS

DELAWARE BASIN CORRELATED FORMATION TOPS DESCRIPTION

1. BCRC  Base Cretaceous
   This shallow pick was made in the southern-most parts of the Delaware Basin, Central Basin Platform and Ozona Arch to give northern definition to maps and cross-sections created by geologists interested in the Val Verde Basin, Del Rio (Diablo) Uplift and the Marathon Overthrust areas to the south. Here, the base of Cretaceous is also the top of the Chinle formation of the Dockum Group of Upper Triassic Age.

2. RSLR  Rustler
   The Rustler formation is the first Permian age pick included in this file. This unit belongs to the Ochoan Series of Upper Permian age. The anhydrite of the Rustler is in sharp contrast to the overlying shales and siltstones of the Santa Rosa and Dewey Lake formations and should be particularly useful to production geologists and geophysicists needing this sharp interface for shallow control. This top is locally very erratic due to salt dissolution.

3. TNSL  Tansil
   This upper-most formation of the Whitehorse Group of the Guadalupian Series underlies, conformably, the salt and anhydrite of the Upper Permian Salado. The Tansil is an anhydritic dolomite that represents the back-reef facies of the Capitan Reef.

4. YTES  Yates
   The Yates sands cover much of the subject area and are limited on the west by the Capitan Reef. The pick was made at the base of the anhydritic dolomite of the Tansil on the first occurrence of clean sand.

5. LMAR  Lamar (Delaware Limestone)
   The uppermost member of the Bell Canyon formation. Picked on radioactive shale-limestone immediately below the clean anhydrite of the Castile formation.

6. SVNR  Seven Rivers
   A back-reef equivalent member of the Capitan Reef which contains many facies changes. Several thin shale units were used to separate the Seven Rivers from the overlying Yates.

7. QUEN  Queen
   The top of the Queen formation has a distinct gamma-ray character that persists throughout much of the subject area, and in places of local facies modification, close control of selected well logs is used to make the correlation.
8. **GYBG** Grayburg
The Grayburg formation underlies the Queen sands and is the basal unit of the back-reef Whitehorse Group and unconformably overlies the San Andres. The Grayburg pick is made on top of the clean dolomite that immediately underlies the Queen sands. At the south end of the Central Basin Platform the Grayburg is represented by part of the lower Delaware Mountain Group that tongues into the Sheffield Channel. The Grayburg is picked up again south of the channel on the Southern Shelf in southern Pecos County.

9. **SNDR** San Andres
The San Andres progrades from a back-reef dolomite into the Delaware Basin as the Victoria Peak Reef, the surface of which is an unconformity. The pick was obtained from published reports on prominent producing fields and carried regionally with help from the overlying and more lithologically persistent Grayburg formation.

10. **CPTN** Capitan Reef
Massive bio-limestone reef, which rings the Delaware Basin and separates the Delaware sands from the back-reef Tansil, Yates and Seven Rivers. It has been penetrated by a very few wells because of its limited width. The pick can be made with any or all of the back reef formations.

11. **BLCN** Bell Canyon
The Delaware Basin equivalent of the Tansil-Yates-Seven Rivers on the Shelf. This unit is composed entirely of clastics. The pick was made on the base of the Lamar limestone.

12. **CYCN** Cherry Canyon
The Delaware Basin time equivalent of the Lower Queen Sands. Good pick over the Delaware Basin.

13. **BYCN** Brushy Canyon
The Delaware Basin equivalent of the San Andres. Locally may not prograde shelfward as far as the overlying Cherry Canyon.

14. **GLRT** Glorieta Sandstone
This upper-most Leonard unit is equivalent to the First Bone Springs sandstone in the Delaware Basin and Upper Spraberry in the Midland Basin. This was a difficult pick due to facies changes normal to the basin edge.

15. **BSGL** Bone Springs Limestone
Composed of black siliceous limestone directly beneath the Brushy Canyon clastics. Very consistent over the Delaware Basin. This unit is the time equivalent of the Middle San Andres on the Shelf.

16. **FBSG** First Bone Springs Sandstone
Occurring 1,000-1,500 feet below the Bone Springs limestone, the first sand is equivalent to the Glorieta on the Shelf and Central Basin Platform. The three Bone Springs Sands are subject to great interpretive differences. We have tried to maintain good consistency while staying as close to published interpretations as possible.
17. CLFK Clearfork  
We pick the first clean carbonate below the Glorieta sands as the top of the Clearfork on the shelves and platform.

18. SBSG Second Bone Springs Sandstone  
It is the Delaware Basin equivalent of the Blinebry Sandstone of the Northwest Shelf and Central Basin Platform.

19. TUBB Tubb  
In our model we have equated the Tubb on the platform and shelf with the basal or Third Bone Spring Sand in the Delaware Basin and the Dean Sand in the Midland Basin.

20. TBSG Third Bone Springs Sandstone  
Picked as the basal clastic unit above the Wolfcamp. It is the Delaware Basin equivalent of the Tubb Sandstone of the Central Basin Platform.

21. WCAB Wichita/Albany  
This predominately back-reef dolomite underlies the Lower Clearfork carbonates and is equivalent to the New Mexico Abo as explained above. The Wichita/Albany basin equivalents are probably represented by the lower clastics of the Third Bone Spring Sand in the Delaware Basin and the Dean Sands in the Midland Basin. Recent work by Mazzullo and Reid has suggested with strong evidence that the Leonard-Wolfcamp contact in the two adjacent basins lies some two to four hundred feet below the base of the Third Bone Spring Sand and the base of the Dean Sand. If so, this would give the Lower Leonard or Wichita/Albany a more realistic representation in the two basins.

22. WFMP Wolfcamp  
Very widespread Lower Permian limestone and shale unit. Present over entire Delaware Basin area except where missing at the top of high structures. The Wolfcamp is thickest along the shelf edge.

23. BPDT Base Permian Detrital  
In the GDS file this pick is limited to the Central Basin Platform, the Ozona and the Northern Shelves.

24. CSCO Cisco  
Present on the Northwest Shelf and Central Basin Platform as a carbonate bank ringing the Delaware Basin. In the Delaware Basin, it is present as thin, black shale, which we did not pick. Not present on high structures of the Central Basin Platform. Available paleo information was used with discretion.

25. CNYN Canyon  
Present on Northwest Shelf and Central Basin Platform as a carbonate bank. Was not picked in the Delaware Basin. Available paleo information was used with discretion.
26. STRN  Strawn
   In early Strawn time, the area of concern was part of a much larger region that is
   considered to be a large detrital apron that bordered the Ouachita belt to the south and
   east. Except for the structural highs, a blanket limestone was laid down and is composed
   of lime mud and calcareous fossils with terrigenous mud and sands along the margins. At
   the end of this early Strawn deposition, compressional orogenic forces changed the
   physical nature of the area. The subsiding basin became starved for sediments and the
   later Strawn reef banks described above flourished. Paleo was very useful in the
   delineation of the top of the Strawn lime.

27. ATOK  Atokan
   Present throughout the Delaware Basin area. Most commonly shale with occasional
   limestone beds. It was picked at the base of the Strawn limestones. The Atokan overlaps
   all but the higher structures on the Central Basin Platform.

28. ATBK  Atoka Bank Limestone
   A lower carbonate pay within the Atokan. Opinions vary widely as to the exact
   correlations of the “Bank Limestone.” We have tried to be as consistent as possible in
   making our Bank Limestone pick.

29. MRRW  Morrowan
   Lower Pennsylvanian limestones, shales and sandstones. Present in the Delaware Basin,
   Tatum Basin and areas of the Northwest Shelf. Picked at base of Atokan.

30. LMRW  Lower Morrow
   Picked on base of last sandstone. Present only in the deep Delaware Basin.

31. PVDT  Pennsylvanian Detrital
   On the Central Basin Platform, the Northern Platform and the north side of the Pecos
   Arch, this pick was made on top of the detrital material accumulated from the eroded
   Paleozoics that were covered by Atoka or younger Pennsylvanian sediments.

32. BRNT  Barnett Shale
   Used when only shale is present in the Upper Mississippian. Difficulties in correlation
   arise in the northern part of the area where the upper Barnett shale laterally changes to
   interbedded limestones and shale of Chester age.

33. MSPL  Lower Mississippian
   This pick is made on top of the lower Mississippian lime which as a unit directly overlies
   the Woodford shale. On the Central Basin Platform this limestone extends upward into
   the lower Chester. May be thin or even absent on some local highs.
34. **WDFD Woodford**  
This highly radioactive shale is recognized on logs by all correlation geologists who have worked the Permian Basin. The formation has its maximum thickness (600’+) in Winkler County on the western side of the Central Basin Platform, and from there thins in all directions. The age of this shale has been determined to be late Devonian to early Mississippian, but an unconformity lies at both its base and part of the top with the possibility that either age could be missing in any one locale with the formation still being recognizable.

35. **DVNN Devonian**  
The Devonian attains its greatest thickness (1000’+) in central Crane County with its axis located just east of the Central Basin Platform and parallel to that structure. From that location the formation thins rapidly in all directions due to depositional restrictions and pre-Woodford erosion. The Devonian is barely present in the southeast corner of New Mexico with its zero isopachous line extending from there into north-central Andrews County, then ESE into north central Glasscock County. The top of the Devonian is an easy pick with its chert-limestone make-up in sharp contrast to the overlying and highly radioactive Woodford. It is to the north that problems arise when the underlying Silurian shale changes into a carbonate facies or shelf bank and seemingly merges into the Devonian. GDS was aware of this situation and it was resolved with the aid of publications by E.H. McGlasson.

36. **SLRN Silurian**  
The upper Silurian of west Texas consists of predominately gray-green basinal shale that abruptly changes to fossiliferous shelf carbonates. The shale is thickest (300’) on the Central Basin Platform in Winkler, Ward and Crane Counties. From there to the south and east the shale feathers down to as little as twenty feet but is still conformable with the overlying Devonian and underlying Fusselman. To the north in southern Andrews County this shale changes into shelf carbonates that thicken rapidly (±1500”), merge with the Devonian, and are overlain by the Woodford shale.

37. **FSLM Fusselman**  
The pick was made on the base of thin radioactive shale on top of the clean Fusselman carbonate. The lower Silurian Fusselman formation rests unconformably on the uppermost Ordovician Sylvan shale and Montoya formation and underlies the upper Silurian with apparent conformity. The Fusselman reaches its maximum thickness (±400’) in Winkler County, the San Simon Channel area in western Gaines County and the Northern Shelf in Yoakum County.

38. **MTYA Montoya**  
A paleo-lithofacies map of the Montoya gives one of the best illustrations of John E. Galley’s Tabosa Basin. Shallow water limestone was deposited in the core of the Tabosa Basin with restricted shelf dolomites crowding the existing Texas Peninsula in the Midland Basin and Northern Shelf. The greatest thickness of the Montoya lies to the west of the Central Basin Platform and thins gradually to the east on a line that runs from Lubbock to Edwards County. Called on a shale gamma-ray kick at the base of the Fusselman.
<table>
<thead>
<tr>
<th>No.</th>
<th>Formation</th>
<th>Description</th>
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<tbody>
<tr>
<td>39</td>
<td>SMPS Simpson</td>
<td>The Simpson Group is composed of five recognizable formations that are composed of alternating beds of dolomitic limestone, dolomite and sand. GDS’ file follows the industry practice of not attempting to correlate these individual units regionally. The Simpson picks for both the top and base of the group are readily apparent once regional correlation has established the base of the Montoya and the top of the Ellenburger. The Simpson is unique in west Texas in that its thick axial sediments thin rapidly from its depo-center in central Pecos County. Here, just west of the Fork Stockton High, the Simpson Group exceeds 2000’ and thins unit by unit to zero in south central Reagan County. The pick was made on top of the massive “Bromide” limestone.</td>
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<tr>
<td>40</td>
<td>EBGR Ellenburger</td>
<td>This predominately dolomitic unit covers all of the Central Basin Platform and Delaware Basin areas except on high structures that were eroded during Pennsylvanian and Wolfcamp time.</td>
</tr>
<tr>
<td>41</td>
<td>CMBR Cambrian</td>
<td>Once identified by samples, this unit was easy to detect and correlate. This Cambrian is present only on the south end of the Central Basin Platform. Guidance for dealing with the Cambrian was obtained from the Bureau of Economic Geology, ROI #88, <em>The Moore Hollow Group of Central Texas</em>, by V.E. Barnes &amp; W.C. Bell.</td>
</tr>
<tr>
<td>42</td>
<td>GRWS Granite Wash</td>
<td>This pick was only used when the bit penetrated the full section of the Ellenburger. The presence of weathered igneous and/or metamorphic rock in the samples below the in-place lower Paleozoics was the key to correlation.</td>
</tr>
<tr>
<td>43</td>
<td>PCMB Precambrian</td>
<td>The Precambrian was encountered in less than 100 wells in the subject area and the pick was determined again with samples that showed a preponderance of igneous and/or metamorphic rocks in the samples. Drilling times were also used when the Mud-loggers charts were available.</td>
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EASTERN SHELF CORRELATED FORMATION TOPS DESCRIPTION

1. BCRC  **Base Cretaceous:**
   The Base Cretaceous pick was made in the southern-most part of the Midland Basin, Central Basin Platform and Ozona Arch and extends into the southwestern part of the Eastern Shelf. This top was picked to give a shallow top for maps and cross-sections created by geologists interested in the Val Verde Basin, Del Rio (Diablo) Uplift and the Marathon Overthrust area.

2. RSLR  **Rustler:**
   The Rustler Formation is the first Permian age pick included in this file. This unit belongs to the Ochoan Series of Upper Permian age. The anhydrite of the Rustler is in sharp contrast to the overlying shales and siltstones of the Santa Rosa and Dewey Lake formations. It is particularly useful to production geologists and geophysicists needing this sharp interface for shallow control. This top is sometimes very erratic due to salt dissolution. The Rustler Anhydrite thins to the east until it pinches out in the western part of the Eastern Shelf.

3. TNSL  **Tansil:**
   The Tansil is the upper-most formation of the Whitehorse Group of the Guadalupian Series and conformably underlies the salt and anhydrite of the Upper Permian Salado. The Tansil is an anhydritic dolomite that represents the back-reef facies of the Capitan Reef to the west and, thus, covers all of the Central Basin Platform and the Midland Basin and extends into the western part of the Eastern Shelf.

4. YTES  **Yates:**
   The Yates Formation, as the overlying Tansil, covers all of the Permian Basin but is limited on the west by the Capitan Reef and to the east on the Eastern Shelf by pre-Cretaceous surface erosion. The pick was made at the base of the anhydritic dolomite of the Tansil on the first occurrence of clean sand. The Permian beds from the Yates through the Clearfork crop out from the west to the east in this area.

5. SVNR  **Seven Rivers:**
   The Seven Rivers Formation is conformably overlain by the Yates and underlain by the Queen. Its areal extent is restricted by the same limiting factors as the Yates. A distinct shale break at the base of the Yates that persists throughout the Eastern Shelf was used for the correlation pick.

6. QUEN  **Queen:**
   The top of the Queen Formation has a distinct gamma-ray character that persists throughout the Eastern Shelf. However, in areas of local facies modification, careful examination of more closely spaced key logs was used to make the correlation.
7. **GYBG Grayburg:**
The Grayburg Formation underlies the Queen sands and is the basal unit of the back-reef Whitehorse Group which unconformably overlies the San Andres. The Grayburg pick is made on top of the clean dolomite that immediately underlies the Queen sands. This Permian Basin formation extends eastward into the Western part of the Eastern Shelf. At the south end of the Central Basin Platform the Grayburg is represented by part of the lower Delaware Mountain Group that extends into the Sheffield Channel. The Grayburg is picked up again south of the channel on the Southern Shelf in southern Pecos County.

8. **SNDR San Andres:**
The San Andres was deposited as a cyclic, strandline sabkha with interbedded dolomite, anhydrite, siltstone and salt, that prograded southward through late Leonard and early Guadalupe time. In our model the Lower San Andres of the Delaware Basin is equivalent to that portion of the Upper Bone Springs Formation above the first sand. The pick was obtained from published reports on prominent producing fields and carried regionally with help from the overlying and more lithologically persistent Grayburg formation. This method was used in all of the area except the deepest part of the Midland Basin where the similarities of the Grayburg and San Andres precluded differentiation of the two formations.

9. **SAGL San Angelo:**
The San Angelo sands, after examining several published reports, have been placed in several stratigraphic positions. The GDS file will carry the unit as the Eastern Shelf equivalent of the Glorieta sands of the Central Basin Platform and the Northern Shelf which immediately underlie the San Andres.

10. **CLFK Clearfork:**
In West Texas the Clearfork Formation is divided into a lower and upper unit that is separated by the Tubb sands on the Central Basin Platform and Northern Shelf. GDS recognizes that some workers divide the Clearfork into three units with a middle unit equivalent to the lower Spraberry in the Midland Basin. We pick the first clean carbonate below the Glorieta sands as the top of the Clearfork on the shelves and platform and equate that to the Spraberry limestone that underlies the Upper Spraberry sands in the Midland Basin.

11. **USBY Upper Spraberry:**
The Upper Spraberry pick is an excellent marker on well logs in nearly all of the Midland Basin. As stated above, this formation is believed to be Upper Leonard in age and is the basinal equivalent of the Glorieta sands on the surrounding shelves and platform and is equivalent to the First Bone Spring Sand of the Delaware Basin.

12. **LSBY Lower Spraberry:**
The Lower Spraberry sands are present throughout the Midland Basin. This massive sand unit is Middle Leonard in age and is correlative to the Second Bone Spring Sand of the Delaware Basin. As with the Upper Spraberry sands, this is a reliable pick that was made at the interface of the Spraberry limestone and the underlying sandstone.
13. DEAN Dean:
The Dean Sandstone, like the Spraberry sands above, is a broad tongue of clastics of
interbedded sands, silts, shales, and impure limestones which extend the length of the
Midland Basin between the Central Basin Platform and the western edge of the Eastern
Shelf. The Dean represents the base of the Leonard in the Midland Basin, and is equivalent
to the Tubb on the shelf and platform. The Dean is equivalent to the Third Bone Spring
Sand of the Delaware Basin.

14. WFMP Wolfcamp:
The lowermost Permian Wolfcamp is present in all of the Permian Basin including the
Eastern Shelf except for some extreme structural features on the Central Basin Platform
such as the Fort Stockton High. Sedimentation was controlled by the waning orogenic
forces and resultant structures created during Pennsylvanian and early Wolfcamp time. The
Midland Basin sea was connected to the open ocean, via the Delaware Basin, through
recognized channels, the San Simon channel in west-central Gaines County and the
Sheffield channel in central and eastern Pecos County. Predominately clean limestones
were deposited on the Central Basin Platform and the Northern Shelf with the thickest
section occurring along the basinal edges. The basinal Wolfcamp sediments are
predominately black shales and dark argillaceous limestones with the upper two to four
hundred feet possibly being the basinal Wichita/Albany equivalent as discussed above. The
earliest basinal Wolfcamp sediments extend north into the Texas Panhandle and to the east
toward the Bend Arch. Basinward prograding phylloid-algae Wolfcamp "reefs" shortened
the basin on the north and sand and clay clastics with cyclic westward prograding "reefs"
restricted the open seas to the east. Thus, by the end of Wolfcamp time the Midland Basin
as we know it was delineated.

The GDS data file uses the base of the Wichita/Albany dolomitic carbonates and the top of
the recognized clean Wolfcamp limestone as the pick on the platform and shelves. For ease
of correlating the base of the Dean sands is used as the top of the Wolfcamp in the Midland
Basin and the western central part of the Eastern Shelf data file area. On the Eastern Shelf
most of the "Canyon Sand" production west of Nolan and Fisher counties is actually
Wolfcamp in age.

15. BCMJ Base of Coleman Junction: (Wolfcamp)
The Base of the Coleman Junction is picked on a distinctive SP shift to the right. The
Coleman Junction in central and northern Texas is described as a massive brittle yellowish
brown slightly cherty limestone. Prior to 1933 the Coleman Junction was thought to be
Cisco in age.

16. BDTN Base of Dothan: (Wolfcamp)
The Base of the Dothan is picked on the top of a generally massive shale unit 70 feet thick.
The Dothan Limestone is a 20 - 40 feet thick clean limestone showing some SP porosity.
The Dothan Limestone was also thought to be Cisco prior to 1933.

17. NDCK Noodle Creek: (Wolfcamp)
The Noodle Creek is a 50 feet thick unit underlying the massive shale unit mentioned
above. It appears to be interbedded limestone and shales about 10 feet thick. Occasionally
the limestone exhibits good SP porosity.
18. **BSDK** Base of Saddle Creek: (Wolfcamp)
   The Base of the Saddle Creek is picked on the top of a shale that is usually about 10 - 15 feet thick. The Saddle Creek is a 10 to 30 feet thick limestone described in central and north central Texas as a massive light gray limestone. To the north and east between the limestone and the top of the shales used for the Base of the Saddle Creek pick a thin coal bed develops. We include the Saddle Creek in the Wolfcamp, but it may be Cisco in age.

19. **CSCO** Cisco: (Virgil)
   This youngest Pennsylvanian unit occurs as a limestone bank that encircles the Central Basin Platform and occurs on the Northern Shelf, an eastern extension of the Northwest Shelf of New Mexico. On the western Eastern Shelf of the Midland Basin, the Cisco is represented by a dark gray, unfossiliferous shale that lies between Permian and Canyon sediments. This shale or mudstone is correlative with the Crystal Falls limestone to the east in the Bend Arch area of the Eastern Shelf.

20. **BCKG** Breckenridge: (Virgil)
   In north central Texas the Breckenridge Limestone is described as a gray massive limestone.

   The Breckenridge top is picked in Coke, Runnels, Tom Green and Schleicher Counties. It is a 20 - 40 feet thick limestone in the upper Cisco shale section. It thickens to the west before it rapidly thins and plunges into the Midland Basin.

21. **GNSG** Gunsight: (Virgil)
   In central and north central Texas the Gunsight Limestone is described as two limestones. The upper is up to 20 feet thick and the lower is up to 12 feet thick and they are separated by a shale up to 60 feet thick. In the Eastern Shelf the Gunsight top is picked in the same areas as the Breckenridge top. It is picked on the top of two thin limestones separated by a shale about 10 feet thick. The limestone may thicken to the west before it rapidly plunges into the Midland Basin and can no longer be picked.

22. **CNYN** Canyon: (Missouri)
   The Central Basin Platform and the Midland Basin were part of a broad general area that was affected in Canyon time by a westward subsidence due to uplift and compression that formed the Bend Arch to the east and by continuing orogenic forces during the closing of the Ouachita Geosyncline. Carbonate bank growth kept pace with subsidence on the shelves and platform, but not in the downwarping Midland Basin. The "starved basin" concept of John Emory Adams is well illustrated in the Midland Basin with the lack of identifiable Canyon sediments. The Central Basin Platform with its carbonate "reef" banks denotes sea level fluctuations with green and red shales and sands originating from an inland source and interfingering into the limestone shelf edge. Studies have shown that northward flowing warm marine waters provided the necessary nutrients for the organisms that built the Canyon banks, reefs and, most certainly, the Horseshoe Atoll. The GDS pick for the Canyon was predicated on lithology, using well-bore and sample logs, with paleo reports, where available. The base of the "black shale marker" was picked as the top of the Canyon in the southern and eastern Midland Basin. On the Eastern Shelf the Home Creek Limestone is picked as the top of the Canyon.
23. **BPLP** Base of Palo Pinto: (Missouri)
The Palo Pinto is the lower canyon limestone that overlies the Strawn sandstone and limestones. The Base of the Palo Pinto top is picked in the southeastern part of the Eastern Shelf area except in Edwards County.

24. **STRN** Strawn: (Des Moines)
The Strawn age sediments are conformably overlain by the Canyon described above, but locally on the west side of the Midland Basin and on the Ozona Arch, Wolfcamp rocks overlie the Strawn, perhaps due to sweeping by submarine currents of accumulated Cisco-Canyon detrital. Between 500 and 1000 feet of reef and bank deposits occur on the Horseshoe reef and the margins of the Central Basin Platform. In early Strawn the Eastern Shelf was part of a much larger region that is considered to be a large detrital apron that bordered the Ouachita belt to the south and east. Except for the highs, a blanket limestone was laid down and is composed of lime mud and calcareous fossils with terrigenous mud and sands along the margins. At the end of this early Strawn deposition, compressional orogenic forces changed the physical nature of the area. A subsiding Midland Basin became starved for sediments and the later Strawn reef banks described above flourished. Paleo was very useful in the delineation of the top of the Strawn lime from the overlying Canyon. In the eastern area of the Eastern Shelf the Capps Limestone is picked as the top of the Strawn.

25. **CPSL** Lower Capps: (Des Moines)
The Lower Capps Limestone is an upper Strawn limestone, about 20 - 50 feet thick present in the east central part of the Eastern Shelf. It overlies the Goen and where they can be differentiated they are separated by a 20 - 60 feet thick shale.

26. **GOEN** Goen: (Des Moines)
In the Eastern Shelf area the Goen is a limestone in the middle of the Strawn Section overlying the Odom Limestone. To the west towards the Midland Basin the Strawn section loses sandstone and the shales thin, and the Goen and Odom Limestones cannot be differentiated.

27. **ODOM** Odom: (Des Moines)
The Odom Limestone is the lower Strawn limestone in the Eastern Shelf area. It appears to be equivalent to the Midland Basin's lower Strawn which is present over most of the area except where it was not deposited over very high features like the Central Basin Platform.

28. **CDDO** Caddo: (Des Moines)
The Caddo Conglomerate is a basal Strawn conglomerate and produces intermittently on the Eastern Shelf. The Caddo is present in all but the western most part of the Eastern Shelf and in Edwards County.
29. **ATOK Atoka:**
The Atoka is picked as a definite shale break on Gamma-Ray logs at the base of the blanket Strawn limestone discussed above. Thickness of the Atoka is greatest on the southwestern edge of the Central Basin Platform and thins rapidly eastward into the Midland Basin where it is absent over most of the eastern part. Fine grained clastic detritus formed apron deposits on the flanks of the Central Basin Platform and coarse arkosic material moved south from the Matador Arch into the north end of the Midland Basin. This suggests that these two positive areas were tectonically active during Atoka time with erosion occurring on the larger structures. From the coarser clastics to the north, the Midland Basin Atokan increases in limestone percentage to the south end of the basin.

30. **PVDT Pennsylvanian Detrital:**
On the Central Basin Platform, the Northern Platform and the north side of the Pecos Arch, this pick was made on top of the detrital material accumulated from the eroded Paleozoics that were covered by Atoka or younger Pennsylvanian sediments. In much of the Eastern Shelf the Pennsylvania Detrital unconformably overlies the Ellenburger.

31. **BRNT Barnett:**
The Barnett Shale extended originally from the Llano Uplift to the Franklin Mountains north of El Paso with its greatest thickness developing to over 1600' just west of the Central Basin Platform. Post Mississippian deformation and erosion has removed this shale entirely from the Eastern Shelf east of the center of Sterling and Howard Counties and from the high structures on the Central Basin Platform and the Pecos Arch. The GDS pick for this formation is distinct at the base of the Morrow and its eroded surface is readily found by its unique gamma-ray trace on electric logs. Difficulties in correlation arise in the northern part of the area where the upper Barnett shale laterally changes to interbedded limestones and shale of Chester age.

32. **MPLM Mississippi Lime:**
This pick is made on top of the lower Mississippian lime which as a unit directly overlies the Woodford Shale. In the southern part of the Midland Basin the Mississippian in its entirety is represented by the Barnett Shale from upper Kinderhook through upper Chester age. This lower Mississippian lime then develops laterally northward representing the upper Kinderhook, Osage and Meramec lime facies of the Barnett. On the Central Basin Platform this limestone extends upward into the lower Chester. On much of the Eastern Shelf lower Mississippian limestone may unconformably overlie the Ellenburger except where eroded over local structural highs.
33. **WDFD Woodford:**
   This highly radioactive shale is recognized on logs by all correlation geologists who have worked the Permian Basin. The formation has its maximum thickness (600'+) in Winkler County on the western side of the Central Basin Platform, and from there thins in all directions. The age of this shale has been determined to be late Devonian to early Mississippian. An unconformity lies at both its base and part of the top with the possibility that either age could be missing in any one locale. In the subject area the pre-Woodford truncation has the unit deposited on Ordovician Ellenburger through Devonian age rocks. The Woodford shale extends north and becomes sandy in central Cochran County with the erosional limit bending to the southeast. From there the eastern limit continues into west-central Mitchell County where it turns due south into northwest Irion. From Irion County west the limiting factors are denudation of pre-Permian structures south of the Big Lake fault on the Pecos Arch and the major elements within the Central Basin Platform.

34. **FSLM Fusselman:**
   The lower Silurian Fusselman Formation rests unconformably on the upper-most Ordovician Sylvan Shale and Montoya Formation and underlies the upper Silurian with apparent conformity. The Fusselman reaches its maximum thickness (+400') in Winkler County, the San Simon Channel area in western Gaines County and the Northern Shelf in Yoakum County. The formation thins rapidly to the north from Yoakum County and is gone in northern Cochran County. From northeastern Cochran County the pinch-out line extends southeast to southwestern Mitchell County where it bends sharply to the south through central Sterling and Irion counties and into eastern Crockett. The Fusselman is divided into fossiliferous limestone and dolomite facies with the dolomite north of a line through central Andrews, Martin and Howard Counties with a small but economically important southward loop into Glasscock County. South of this line the limestone extends out into and, perhaps, past the Val Verde Basin. The Fusselman is believed by many workers to have extended over a much larger area than its erosional boundary now suggests.

35. **MTYA Montoya:**
   A paleo-lithofacies map of the Montoya gives one of the best illustrations of John E. Galley's Tabosa Basin. Shallow water limestone was deposited in the core of the Tabosa Basin with restricted shelf dolomites crowding the existing Texas Peninsula on the east in the eastern Midland Basin and the Northern Shelf. The greatest thickness of the Montoya lies to the west of the Central Basin Platform and thins gradually to the east to a line that runs from Lubbock County to Edwards County. On the east side of the Midland Basin, the overlying Sylvan and Fusselman formations have been removed and the Montoya is overlain by Woodford Shale.
36. **SMPS Simpson:**
The Simpson Group is composed of five recognizable formations that are composed of alternating beds of dolomitic limestone, dolomite and sands. We follow the industry practice of not attempting to correlate these individual units regionally. The Simpson picks for both the top and base of the group are readily apparent once regional correlation has established the base of the Montoya and the top of the Ellenburger to the overlying Joins. The Simpson is unique in west Texas in that its thick axial sediments thin rapidly from its depo-center in central Pecos county. Here, just west of the Fort Stockton High, the Simpson Group exceeds 2000 feet and thins unit by unit to zero in south-central Reagan County. The Simpson limit to the north extends into southern Cochran County and then runs south-southeast to the southwestern corner of Edwards County.

37. **EBGR Ellenburger:**
This predominately dolomitic unit covers all of the Central Basin Platform and Midland Basin areas except those places on high structures that were eroded during Pennsylvanian and Wolfcamp time. The top of this unit is difficult to pick on the eastern and southern edge of the Midland Basin where the Simpson is eroded and the Ellenberger is overlain by younger and laterally more extensive beds. The base of the Ellenburger is also difficult to pick but to a lesser degree because of the presence of Cambrian sediments on the southern end of the Central Basin Platform and the eastern and southeastern end of the Midland Basin.

38. **CMBR Cambrian:**
Once identified by samples, this unit was easy to detect and correlate. The Cambrian is present only on the south end of the Central Basin Platform and the eastern portion of the Midland Basin. Guidance for dealing with the Cambrian was obtained from the Bureau of Economic Geology, ROI #88, *The Moore Hollow Group of Central Texas*, by V.E. Barnes & W.C. Bell.

39. **RILY Riley:** (Cambrian)
The Riley is an Upper Cambrian Sandstone described as being light red, brown, yellow and white with a thickness of 300 to 400 feet. The top of the sandstone below the top of the Cambrian carbonates is picked as the top of the Riley in the Eastern Shelf data file. Only a few wells penetrated the Riley, but it seems to be present mostly in the southern part of the Eastern Shelf.

40. **PCMB Precambrian:**
The Precambrian was encountered in only a few wells in the subject area and the pick was determined again with samples that showed a preponderance of igneous and/or metamorphic rocks in the samples. Drilling times were also used when the mud-loggers charts were available.
INTERPRETED FORMATION TOPS

OKLAHOMA CORRELATED FORMATION TOPS DESCRIPTION
(excluding Arkoma Basin)

1. BPRM  Base of the Permian
   Locally picked where obvious, sometimes base of the Pontotoc Group.

2. MGGL  Megargel Limestone
   Good regional limestone marker in the Hollis Basin.

3. BHBR  Base of the Heebner Shale
   The shallowest horizon picked and one of the best markers in the Anadarko Basin, we have picked the base of the black shale above the Douglas. Regionally, the Heebner Shale disappears near the Nemaha Ridge and with the Granite Wash influx near the Wichita Mountain front. Locally, there is more than one black shale; we have always picked the base of the lowest one.

4. HXBR  Top of the Hoxbar Group
   Locally picked in the south central area where consistent.

5. TNKW  Tonkawa
   This pick was made at the top of the Tonkawa Zone sometimes known as the Haskell Limestone or the Tonkawa Limestone where present. This zone does not include the Lovell Sandstone, or "Upper Tonkawa".

6. LNSG  Lansing Group
   Present only in the very northernmost townships in Beaver, Harper, Woods, Alfalfa and Grant Counties.

7. CNYN  Canyon Limestone
   Good regional marker in the Hollis Basin.

8. CGGV  Cottage Grove Zone
   Picked on persistent coal/black shale where present or on "Avant Limestone" where present. As zone markers die out on shelf, pick is made on top of Cottage Grove Sandstone.

9. HGTR  Hogshooter Limestone
   Picked on top of black shale above Hogshooter where present or on top of the limestone itself.

10. CCKB  Checkerboard Limestone
    Picked where possible on black shale above Checkerboard or with older logs on top of the limestone itself.

11. CLVD  Cleveland Sandstone
    Sandstone developed between Checkerboard Limestone and Marmaton Group. Pick made on first sand development. Most consistent in western Oklahoma and Texas Panhandle. Not commonly well developed on upper shelf.
<table>
<thead>
<tr>
<th></th>
<th>Formation</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>12.</td>
<td>STRN Top of Strawn Group</td>
<td>Locally picked in the southwest area where consistent.</td>
</tr>
<tr>
<td>13.</td>
<td>DEES Top of Deese Group</td>
<td>Locally picked in south central area where consistent.</td>
</tr>
<tr>
<td>14.</td>
<td>OSWG Oswego Limestone</td>
<td>Pick made on top of Oswego Limestone. The Big Lime was not picked because it is too erratic. Pick was carried beyond &quot;Putnam Reef&quot; front into the basin to maintain a regional picture.</td>
</tr>
<tr>
<td>15.</td>
<td>CHRK Cherokee Group</td>
<td>Generally picked at base of Oswego on a persistent black shale. Locally along the &quot;Putnam Reef&quot; front there is a considerable carbonate buildup at the top of the Cherokee sometimes to the point of merging with the Oswego above. The black shale pick is very consistent into the deep basin area.</td>
</tr>
<tr>
<td>16.</td>
<td>VRDG Verdigris Limestone</td>
<td>Picked at top of limestone between Prue and Skinner Sandstones. Becomes very shaley and undefined locally.</td>
</tr>
<tr>
<td>17.</td>
<td>PINK Pink Limestone</td>
<td>Not commonly picked except in northeast area.</td>
</tr>
<tr>
<td>18.</td>
<td>RDFK Red Fork Zone</td>
<td>Generally picked on the base of the Pink Limestone (or on first sand if Pink is not present) except on eastern shelf where Pink splits with a sand in between, locally called Red Fork (or Lower Skinner). To maintain consistency, our pick (on the west side of the Nemaha) remains at the bottom of the second limestone. Locally, if the Pink is not present, pick was made on the top of the first sandstone.</td>
</tr>
<tr>
<td>19.</td>
<td>BART Bartlesville Sandstone Zone</td>
<td>The first sand below the Inola in the southeast and northeast areas. Very erratic thickness due to extensive channeling.</td>
</tr>
<tr>
<td>20.</td>
<td>BRWN Brown Limestone</td>
<td>First limey zone below the Bartlesville. Very shaley interval, nonproductive.</td>
</tr>
<tr>
<td>21.</td>
<td>BOCH Booch Sandstone Zone</td>
<td>Consistent marker within the Middle Des Moines. Contains occasional very thick sandstones.</td>
</tr>
<tr>
<td>22.</td>
<td>HRSR Hartshorne Sandstone</td>
<td>Basal Des Moines regional marker throughout the Arkoma Basin and some of the northeastern shelf area.</td>
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<tr>
<td>23.</td>
<td>UDHL Top Upper Dornick Hills</td>
<td>Picked locally in the Ardmore Basin - usually very thick shale section.</td>
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<tr>
<td>No.</td>
<td>Acronym</td>
<td>Formation</td>
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<tr>
<td>24.</td>
<td>ATOK</td>
<td>Atokan Group</td>
</tr>
<tr>
<td>25.</td>
<td>GLCR</td>
<td>Gilcrease Sandstone</td>
</tr>
<tr>
<td>26.</td>
<td>DTCR</td>
<td>Dutcher Sandstone</td>
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<tr>
<td>27.</td>
<td>WPCK</td>
<td>Wapanucka Limestone</td>
</tr>
<tr>
<td>29.</td>
<td>LDHL</td>
<td>Lower Dornick Hills</td>
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<tr>
<td>30.</td>
<td>CMWL</td>
<td>Cromwell Sandstone</td>
</tr>
<tr>
<td>32.</td>
<td>CSTR</td>
<td>Chester Group</td>
</tr>
<tr>
<td>33.</td>
<td>LCSR</td>
<td>Lower Chester Marker</td>
</tr>
<tr>
<td>34.</td>
<td>BRNT</td>
<td>Barnett Shale</td>
</tr>
<tr>
<td>35.</td>
<td>CNEY</td>
<td>Caney Formation</td>
</tr>
</tbody>
</table>
36. **MRMC Meramec Limestone**
   Equivalent to Mississippian Lime; used in deeper basin areas. Changed name to Mississippian Lime on shelf for use with Mississippian Chat. This pick was used in the western Anadarko.

37. **MSCH Mississippian Chat Zone**
   Picked top of the Chat Zone where present. Determined by porosity at top of the Mississippian Lime section.

38. **MPLM Mississippian Limestone**
   The first occurrence of dense massive carbonate below the Chester. If Chat is present, the base of the Chat was picked as the top of the Mississippian Lime. This pick and the Meramec pick are transitional due to the shaling out basinward of the upper dense limestones. This pick was used in the northeast Anadarko and central and eastern Oklahoma.

39. **MYES Mayes Limestone**
   Massive limestones equivalent to Lower Meramec. Picked only in southeast and northeast areas. Excellent marker.

40. **SCMR Sycamore Formation**
   Lower Mississippian unit comprised of very consistent carbonates. Equivalent to Mayes.

41. **CHPL Chappel Limestone**
   Hollis Basin only. Insignificant pick due to limited extent.

42. **WDFD Woodford Shale**
   Picked at top of black shale when GR curve goes off scale or when no GR-log is available, picked at an equivalent point on resistivity curve.

43. **MSNR Misener Sandstone**
   Any sandy development at the base of the Woodford Shale sitting on Hunton, Sylvan Shale or Viola Limestone.

44. **HNTN Hunton Group**
   Massive dolomite/limestone below Woodford, which thins gradually to the north, due to erosion. Absent on extreme northern shelf of Anadarko.

45. **SLVN Sylvan Shale**
   Conformable shale at the base of the Hunton. Very consistent thickness. Becomes very limey in northern Texas Panhandle (Maquoketa).

46. **VIOL Viola Limestone**
   Ordovician Limestone which lies conformably under the Sylvan.

47. **SMPS Simpson Group**
   Generally the top of the first sandy zone or sandy dolomite below the Viola Limestone.
48. **ABCK**  Arbuckle Group
    Massive carbonate group underlying the Simpson. The top is difficult to pick due to its transitional nature.

49. **REGN**  Reagan Sandstone
    Lower Cambrian sandstone, locally present on Precambrian erosional surface.

50. **PCMB**  Precambrian
    Any basement rock penetrated below the Arbuckle or Reagan.
TEXAS PANHANDLE CORRELATED FORMATION TOPS DESCRIPTION
(excluding Arkoma Basin)

1. **BLIN** Blaine Anhydrite
   Picked only in Carson, Moore, and Potter Counties in TXPH. Very erratic top complicated by post-depositional dissolution.

2. **CFKU** Upper Clear Fork Zone
   The first consistent carbonate below the Blaine. (Carson, Moore & Potter only)

3. **CMRN** Cimarron Zone
   Very erratic top picked at base of upper Clear Fork Shale on first sandy zone. Not present over much of area. Anhydrite marks the base of the section. (Carson, Moore & Potter only)

4. **TUBB** Tubb Zone
   Top of clastic section immediately below the Cimarron Anhydrite. Mostly shale in the Panhandle field area.

5. **CFKL** Lower Clear Fork Zone
   First distinctive section below TUBB. Completely loses distinctive character in NW Moore County where TUBB sits on RDCV. (Carson, Moore & Potter only)

6. **RDCV** Red Cave
   Clastic Section below lower Clear Fork Major Gas producer from thin erratic sands. (Carson, Moore and Potter only)

7. **WLNG** Panhandle Limestone / Wellington
   Thin bedded limestone directly below RDCV. Top is very erratic as thin beds develop and shale out.

8. **CHSE** Brown Dolomite / Chase Group
   More massive carbonate zone below Panhandle line. Major gas producer in Panhandle/Red Cave gas area.

9. **BCHS** Base Brown Dolomite / Chase Group
   Base of carbonates where arkosic deposits become predominant. Very erratic and inconsistent.

10. **CCGV** Top Council Grove
    First regional pick below the Brown Dolomite. In many areas it is difficult to separate from Brown Dolomite. Absent near the Wichita Mountain uplift due to influx of granite wash.
INTERPRETED FORMATION TOPS

11. **BHBR Base of the Heebner Shale**
   One of the best markers in the Anadarko Basin, picked on the base of the black shale above the Douglas. Regionally, the Heebner Shale disappears near the Nemaha Ridge and with the Granite Wash influx near the Wichita Mountain front. Locally, there is more than one black shale; we have always picked the base of the lowest one.

12. **TNKW Tonkawa**
   This pick was made at the top of the Tonkawa Zone sometimes known as the Haskell Limestone or the Tonkawa Limestone where present. This zone does not include the Lovell Sandstone, or "Upper Tonkawa".

13. **CGGV Cottage Grove Zone**
   Picked on persistent coal/black shale where present or on "Avant Limestone" where present. As zone markers die out on shelf, pick is made on top of Cottage Grove Sandstone.

14. **HGTR Hogshooter Limestone**
   Picked on top of black shale above Hogshooter where present or on top of the limestone itself.

15. **CCKB Checkerboard Limestone**
   Picked where possible on black shale above Checkerboard or with older logs on top of the limestone itself.

16. **CLVD Cleveland Sandstone**
   Sandstone developed between Checkerboard Limestone and Marmaton Group. Pick made on first sand development. Most consistent in western Oklahoma and Texas Panhandle. Not commonly well developed on upper shelf.

17. **OSWG Oswego Limestone**
   Pick made on top of Oswego Limestone. The Big Lime was not picked because it is too erratic. Pick was carried beyond "Putnam Reef" front into the basin to maintain a regional picture.

18. **CHRK Cherokee Group**
   Generally picked at base of Oswego on persistent black shale. Locally along the "Putnam Reef" front there is a considerable carbonate buildup at the top of the Cherokee sometimes to the point of merging with the Oswego above. The black shale pick is very consistent into the deep basin area.

19. **VRDG Verdigris Limestone**
   Picked at top of limestone between Prue and Skinner Sandstones. Becomes very shaley and undefined locally.
20. RDFK **Red Fork Zone**
   Generally picked on the base of the Pink Limestone (or on first sand if Pink is not present) except on eastern shelf where Pink splits with a sand in between, locally called Red Fork (or Lower Skinner). To maintain consistency, our pick (on the west side of the Nemaha) remains at the bottom of the second limestone. Locally, if the Pink is not present, pick was made on the top of the first sandstone.

21. ATOK **Atokan Group**
   This pick changes from the top of the Thirteen Fingers Limestone to the base of the Inola Limestone locally. Not present on the upper shelf and east and west flanks of Nemaha Ridge.

22. MRRW **Morrow Formation**
   Picked where possible on the base of the Thirteen Fingers Limestone. Pick becomes very difficult near Morrow limit. More difficult in south central area with development of thick Springer. Picked at top of Wapanucka Limestone in southeast area.

23. CSTR **Chester Group**
   One of the most difficult picks in the Anadarko basin. Commonly picked on the first carbonate below the Morrow Sands where the Morrow is present. In some areas it was not picked due to the difficulty of the pick.

24. LCSR **Lower Chester Marker**
   The first good continuous marker below the Morrow in the Watonga Trend. Carried regionally up the shelf until truncation. The Lower Chester was called only where the marker was present. The entire Chester erosional surface was picked as Chester.

25. MRMC **Meramec Limestone**
   Equivalent to Mississippian Lime; used in deeper basin areas. Changed name to Mississippian Lime on shelf for use with Mississippian Chat. This pick was used in the western Anadarko.

26. KDHK **Kinderhook Formation**
   Lower Mississippian Limestone, only able to correlate in Central Texas Panhandle.

27. WDFD **Woodford Shale**
   Picked at top of black shale when GR curve goes off scale or when no GR-log is available, picked at an equivalent point on resistivity curve.

28. HNTN **Hunton Group**
   Massive dolomite/limestone below Woodford, which thins gradually to the north, due to erosion. Absent on extreme northern shelf of Anadarko, and near and on the Wichita Mountain uplift.

29. SLVN **Sylvan Shale**
   Conformable shale at the base of the Hunton. Very consistent thickness. Becomes very limey in northern Texas Panhandle (Maquoketa).
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<th>No.</th>
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<th>Description</th>
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| 30. | VIOL | **Viola Limestone**  
Ordovician Limestone which lies conformably under the Sylvan. |
| 31. | SMPS | **Simpson Group**  
Generally the top of the first sandy zone or sandy dolomite below the Viola Limestone. |
| 32. | ABCK | **Arbuckle Group**  
Massive carbonate group underlying the Simpson. The top is difficult to pick due to its transitional nature. |
| 33. | REGN | **Reagan Sandstone**  
Lower Cambrian sandstone, locally present on Precambrian erosional surface. Much cleaner than typical granite wash. |
| 34. | GRWS | **Top Granite Wash**  
Generally the first occurrence of arkosic or granite wash material. In many cases it is very difficult to distinguish from in place weathered and fractured Precambrian. |
| 35. | ARKD | **Top Arkosic Dolomite**  
Random massive units comprised of Arkosic Carbonates. Probably redeposited wedges of eroded Arbuckle or Viola. |
| 36. | BAKD | **Base Arkosic Dolomite** |
| 37. | PCMB | **Precambrian**  
Any basement rock penetrated below regular section. Contains erratic intrusive zones of very dense and very quartz rich rock. In many areas it has appearance of granite wash as it has been weathered in place. |
The following is a list of the 41 total formation tops picked by IHS in the Arkoma Basin. To maintain consistency over the entire Arkoma Basin, IHS has used Oklahoma nomenclature where there were conflicts of names. Conflicts are shown in parentheses ( ).

1. **VRDG Verdigris Limestone**  
   Picked at top of Limestone between Prue and Skinner Sandstones. Becomes very shaley and undefined locally.

2. **RDFK Red Fork Zone**  
   Generally picked on the base of the Pink Limestone. Locally if the Pink is not present, pick was made on the top of the first sandstone.

3. **BART Bartlesville Sandstone Zone**  
   The first sand below the Inola Limestone. Very erratic thickness due to extensive channeling.

4. **BRWN Brown Limestone**  
   First limey zone below the Bartlesville. Very shaley interval, nonproductive.

5. **BOCH Booch Sandstone Zone**  
   Consistent marker within the Middle Des Moines. Contains occasional very thick channel sandstones.

6. **HRSR Hartshorne Sandstone**  
   Picked at the top of sand development and/or increase in resistivity at base of persistent shale at base of Booch zone. Des Moines regional marker throughout the Arkoma Basin.

7. **CRPA Carpenter "A"**  
   Picked at top of sand development and/or resistivity marker. Gradual increase in thickness from north to south. Mainly in Arkansas but present in extreme eastern Oklahoma.

8. **MATK Middle Atokan Marker**  
   Gamma ray marker just above the top of the Alma.

9. **ALMA Alma Sandstone**  
   Picked at the top of sand development and/or resistivity increase at the base of persistent shale at base of Carpenter "A". Gradual increase in the thickness from north to south with increase in rate of thickness across hingeline. Very consistent sandstone.

10. **ALML Lower Alma Sandstone**  
    Picked at the top of sand development and/or resistivity increase at the base of persistent shale at base of Alma. Gradual increase in thickness from north to south with increase in rate of thickening across hingeline. Also exhibits slight decrease in thickness on east and west sides of study area.
11. **BSHM Basham Sandstone**
   One of two consistent sandstones recognized in the Middle Atokan in the deep Arkoma Basin. The top of the Basham interval is a marker which corresponds to a sudden conductivity increase and is well developed in the Hanna #1 Marshall (Sec 1, T5N-R30W) at a depth of 3,145 feet. This marker is recognizable over a large area of the deep basin except east of R29W. The Basham pick is made on the top of the first sand below this marker when possible. Some picks were made by maintaining a constant interval below the conductivity marker. Picks may vary to a minor degree due to the extreme lenticularity of the sands.

12. **RDKO Red Oak Sandstone Marker**
   Excellent producing sandstone found only in the west end of the deep Arkoma Basin. Sandstone is very erratic so picks were made on the good shale marker at the base of the upper Red Oak Sandstone in Red Oak Field.

13. **CRPB Carpenter "B" Sandstone**
   Picked on top of sand development and/or resistivity marker. Gradual increase in thickness from north to south with increase in rate of thickening across hingeline.

14. **BRUM Borum Sandstone**
   The second of two consistent sandstones recognizable in the Middle Atokan in the deep Arkoma Basin. The top of the Borum interval is a marker which occurs at a depth of 5,570 feet in the Hanna #1 Marshall (Sec 1, T5N-R30W). The Borum pick is made on the first sandstone below this marker. Picks may vary due to the extreme lenticularity of the sands.

15. **MRRS Morris Sandstone**
   Picked on top of the sand development and/or resistivity increase at the base of persistent shale at base of Carpenter "B". Gradual increase in thickness from north to south and from west to east with increase in rate of thickening across hingeline.

16. **BRZL Brazil Sandstone Zone**
   Consistent interval of erratic, thin-bedded sandstone development. West end of Arkoma Basin.

17. **TCKT Tackett Sandstone**
   Picked on top of sand development and/or resistivity increase at base of Morris shale zone. Gradual increase in thickness from north to south and from west to east. Increase in rate of thickening across hingeline. Occurs mainly in Arkansas.

18. **ARCI Areci Sandstone**
   Picked at top of sand development and/or resistivity increase at base of persistent shale at base of Tackett. Increase in thickness from north to south and from west to east. Exhibits substantial thinning from north to south across hingeline area. Mainly present in Arkansas.

19. **BYNM Bynum Sandstone**
   Picked at top of sand development and/or increase in resistivity at base of shale beds in overlying zone. Gradual increase in thickness from north to south. Mainly present in Arkansas.
20. **HRST**  **Hurst Sandstone**  
Picked at top of sand development and/or increase in resistivity at base of shale beds in overlying zones. Gradual increase in thickness from north to south. Present only in Arkansas.

21. **FRBG**  **Freiburg Sandstone**  
Picked at top of sand development and/or increase in resistivity at base of shale beds in overlying zones. Gradual increase in thickness from north to south. Present only in Arkansas.

22. **CSEY**  **Casey Sandstone**  
Picked at top of sand development and/or increase in resistivity at base of shale beds in overlying zones. Gradual increase in thickness from north to south. Present mainly in Arkansas.

23. **CCIL**  **Cecil Sandstone**  
Picked at top of sand development and/or increase in resistivity at base of persistent shale in Casey. Gradual increase in thickness from north to south and from west to east. Substantial decrease in thickness and sand content south of hingeline.

24. **PTSN**  **Patterson Sandstone**  
Picked at top of sand development and/or increase in resistivity at base of persistent shale of Cecil. Gradual decrease in thickness from north to south. Occurs only in Arkansas.

25. **SPRO**  **Spiro Sandstone**  
Most productive and most widespread sandstone in the Arkoma Basin. Basal Atokan. Picked at top of sand development and/or increase in resistivity at base of persistent shale of Patterson. Gradual increase in thickness from north to south and from west to east. Possible erosion into underlying Wapanucka in eastern part of area particularly east of R21W. Northwest to southeast trending channels (Foster Sandstone) increase thickness locally in Oklahoma.

26. **WPCK**  **Wapanucka (Kessler)**  
Upper Morrow marker in Arkoma Basin - most consistent marker in basin. Picked at top of resistive limestone or at base of Spiro sand. Gradual increase in thickness from north to south. Gradual decrease in thickness from west to east due in part to apparent erosion at top of zone.

27. **MRRW**  **Morrow Formation**  
Only picked when Wapanucka is not present. Shale zone above Wapanucka.

28. **BRND**  **Brentwood Formation**  
Picked on top of resistive limestone at base of persistent shale in Wapanucka. Gradual increase in thickness from north to south and from west to east. Zone is characterized by lenticularity and an absence of good markers.
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<td>CMWL</td>
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<tr>
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<td>PTKN</td>
<td>Pitkin Limestone</td>
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<td>32.</td>
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<td>Fayetteville Shale</td>
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<tr>
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<td>WDFD</td>
<td>Woodford (Chattanooga) Shale</td>
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<td>HNTN</td>
<td>Hunton Formation</td>
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<td>SLVN</td>
<td>Sylvan (Cason) Shale</td>
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<td>VIOL</td>
<td>Viola Limestone</td>
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<td>39.</td>
<td>SMPS</td>
<td>Simpson Formation</td>
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40. ABCK  Arbuckle Formation
Correlation is based on published correlation from "Information Circular #20-D" published by the Arkansas Geologic Commission, slightly adjusted to coincide with good log marker. Correlations were extended from this well to remaining Arbuckle penetrations based on log character and an attempt to maintain a fairly consistent Simpson thickness.

41. PCMB  Precambrian
Any basement rock penetrated below the Arbuckle.
WESTERN KANSAS CORRELATED FORMATION TOPS DESCRIPTION

1. NBRR Niobrara Chalk
   Upper Cretaceous chalk unit picked on consistent GR response at the top of the formation.

2. FRHS Fort Hayes Limestone
   Basal member of the Niobrara Chalk picked on consistent GR response at the top of this chalky limestone.

3. CDLL Codell Sandstone
   Uppermost member of the Carlile Shale picked at the base of the Fort Hayes Limestone where GR shows sandy or silty zone at the top of the Carlile Shale. Locally absent or unrecognizable.

4. CRLL Carlile Shale
   Upper Cretaceous shale unit with top picked at either the base of the Codell Sandstone or, where Codell is not picked, at the base of the Fort Hayes Limestone. A map of the true top of the Carlile Shale can be made by selecting CDLL and CRLL in that priority order.

5. GRHN Greenhorn Limestone
   Upper Cretaceous chalky limestone picked on consistent and characteristic GR and resistivity log response. Excellent regional marker.

6. GRRS Graneros (X Marker)
   Pervasive bentonite marker bed within the Upper Cretaceous Graneros Shale.

7. DKOT Dakota Sandstone
   Lowermost sandstone unit of the Lower Cretaceous Dakota Group. Also known as Cheyenne Sandstone. Top varies regionally due to nature of sand deposition.

8. MRSN Morrison Formation
   Upper Jurassic shale with lenses of sandstone, limestone, chert, and anhydrite. Major unconformities lie both at the top and base of the Morrison Formation. The Morrison top, where present, is picked at the base of the Dakota Sandstone.

9. SCRL Stone Corral Formation
   Pervasive and easily recognizable anhydrite within the Permian redbed section. Picked on top of consistent high resistivity response. Excellent shallow marker over most of Western Kansas.

10. WLNG Wellington Salt
    Salt member of the Permian Wellington Formation also known as the Hutchinson Salt Member. Picked at the top of salt easily recognized on logs by resistivity response. Absent in westernmost and northwestern Kansas along the Colorado and Nebraska borders.
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<tr>
<th>Number</th>
<th>Acronym</th>
<th>Description</th>
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| 11.    | CHSE     | Chase Group  
Lower Permian group of carbonates with thin alternating shales. Picked at top of the Herrington Limestone at or near the base of the Wellington Salt. Contains the major producing zones of the Hugoton Gas Field. |
| 12.    | KRDR     | Krider Limestone  
Upper dolomitic limestone member of the Chase Group. Picked on SP and/or resistivity response in the Hugoton area and beyond where recognized. |
| 13.    | CCGV     | Council Grove Group  
Lower Permian group of carbonates picked by consistent resistivity log response at the base of the Wreford Limestone of the Chase Group. |
| 14.    | NEVA     | Neva Limestone  
Limestone member of the Council Grove Group picked in the western part of the Western Kansas area. |
| 15.    | TOPK     | Topeka Limestone  
Limestone formation of the Virgilian Shawnee Group. Picked in western portion of the Western Kansas area. |
| 16.    | BHBR     | Base of Heebner Shale  
Pervasive and consistent Upper Pennsylvanian marker bed. Picked at base of lowermost black (hot) shale recognized by characteristic GR response. The most consistent and widespread regional marker in Western Kansas. |
| 17.    | LNSG     | Lansing Group  
Uppermost group of the Pennsylvanian Missourian Stage containing mostly carbonates and thin alternating shales. Picked at the top of limestone buildup interpreted to be a carbonate bank. To the southeast in Harper and Barber Counties the bank shales out and the Lansing thins considerably. |
| 18.    | MRTN     | Marmaton Group  
Uppermost group of the Pennsylvanian Desmoinesian Stage containing alternating limestones and shales. Picked on top of the first limestone below the base of the Kansas City Group. |
| 19.    | CHRK     | Cherokee Group  
Lowermost group of the Pennsylvanian Desmoinesian Stage containing alternating sandstones, shales, limestones, and coal beds. Picked at the top of the upper of two persistent black (hot) shale or coal markers which are easily recognizable on GR logs. Excellent regional marker. |
| 20.    | VRDG     | Verdigris Limestone  
Good marker limestone within the Cherokee Group. Picked in southern portion of the Western Kansas area to tie with Oklahoma. |
21. **ATOK Atokan**
   Middle Pennsylvanian unit containing alternating limestones and shales with black shales common. Picked in southwestern part of Western Kansas area where recognized.

22. **MRRW Morrow Formation**
   Lower Pennsylvanian shale with minor limestone beds and sandstone lenses. Top picked at the base of the Atokan on the base of lowest resistivity marker. Present only in western half of the Western Kansas area.

23. **CSTR Chester**
   Upper Mississippian unit containing limestones, shales, and sandstones. Very difficult to pick consistently because of major unconformity between Chester and Morrow and similarity of rocks with the Lower Morrow. Eroded everywhere in Kansas except southernmost counties of the Western Kansas area where it is subjectively picked at the base of the Morrow. Also picked at the base of the Morrowan age Keyes Sandstone where present.

24. **MRMC Meramec**
   Upper Mississippian group containing in ascending order the Warsaw, Salem, St. Louis, and St. Genevieve Limestones. Picked on the top of thick highly resistive limestone characteristic of this unit. This is the top of the Mississippian where Chester is absent. No attempt was made to subdivide the Meramec.

25. **MPLM Mississippian Lime**
   Used to denote any Mississippian rocks in areas where Meramec is absent or questionably present, particularly around the Central Kansas Uplift. Here the Mississippian is typically represented, at least at the top, by thick beds of reworked chert. A top of the Mississippian map can be constructed by selecting CSTR, MRMC, and MPLM, in that priority order.

26. **CTNG Chattanooga Shale**
   Upper Devonian and/or Lower Mississippian carbonaceous shale technically containing both the Kinderhook Shale and the equivalent of the Woodford Shale of Oklahoma. Picked at the top of the shale recognized by strong positive GR response. Present only in southeastern most portion of the Western Kansas area. Not picked unless the Woodford equivalent shale is present along with the Kinderhook Shale.

27. **MSNR Misener Sandstone**
   Locally recognizable sand unit present at the base of the Chattanooga Shale above the Viola Limestone.

28. **VIOL Viola Limestone**
   Middle Ordovician unit containing limestones and dolomite with cherty beds. Picked at top of first carbonate below Kinderhook Shale or Chattanooga Shale where present.

29. **SMPS Simpson Group**
   Middle Ordovician shales, sandstones, and minor carbonates. Picked at the base of the Viola Limestone which is usually the top of a persistent sandstone.
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| 30. | ABCK  | Arbuckle Group  
|   |   | Upper Cambrian and Lower Ordovician unit consisting mainly of dolomite. Picked at easily recognizable base of Simpson shale or sandstone on top of first dolomite. |
| 31. | REGN  | Reagan Sandstone  
|   |   | Upper Cambrian sandstone unit locally present on the Precambrian erosional surface. |
| 32. | PCMB  | Precambrian Basement  
|   |   | Igneous or metamorphic basement rocks usually recognized by high GR and resistivity log responses. |
DJ BASIN - CORRELATED FORMATION TOPS

Tertiary/Cretaceous Unconformity
Fox Hills
Pierre
Larimer-Rocky Ridge
Sussex
Shannon
Niobrara
Fort Hayes
Codell
Carlile
Greenhorn
Graneros (X Mkr)
'D' Sand
Huntsman
'J' Silt
'J' Sand
Skull Creek
Dakota
Morrison
Ralston Creek
Entrada
Chugwater
Lykins
Forelle
Minnekahta
Opechee
Blaine
Lyons
Stone Corral
Lower Satanka
Fountain
Wolfcamp
Council Grove
Admire
Virgil
Missourian
Des Moines
Cherokee
Atokan
Morrow
Mississippian
Kinderhook
Arbuckle
Reagan
Precambrian

TRCE
FXHL
PIRR
LRRR
SSSX
SNNN
NBRR
FRHS
CDLL
CRLL
GRHN
GRRS
DKTD
HNSM
DKTS
DKTJ
SKCK
DKOT
MRSN
RLCK
ENRD
CGTR
LKNS
FRLL
MNKT
OPCH
BLIN
LYNS
SCRL
STKL
FNTN
WFMP
CCGV
ADMR
VRGL
MSSR
DSMS
CHRK
ATOK
MRRW
MISS
ABCK
REGN
PCMB
**INTERPRETED FORMATION TOPS**

**GREATER GREEN RIVER BASIN CORRELATED FORMATION TOPS DESCRIPTION**

1. **TRTR** *Tertiary Undifferentiated*
   
   Not a correlated top. TRTR was used in formation at TD field mainly for shallow wells.

2. **WSTC** *Wasatch Formation*
   
   Lower Eocene unit with the top picked at the base of a highly resistive sand section at the base of the Green River formation. Good shallow marker which occurs and is picked in southern GRB, MA, and Central Washakie Basin.

3. **FRUN** *Fort Union Formation*
   
   Paleocene package of alternating sand, shale, and coal, which is present over much of GGRB. However, the top of the Fort Union is usually unrecognizable and therefore was not picked in Wyoming. In SWB, however, the top was picked because of the large number of wells that produce from Fort Union sands in the northern part of the basin. Here, FRUN is a good pick locally, but correlations are difficult township to township. FRUN is used in the formation at TD field in all areas of GGRB, where needed.

4. **LNCE** *Lance Formation*
   
   Upper Cretaceous sequence of alternating non-marine sandstones and shales with interspersed coal seams. This top corresponds to the Tertiary/Cretaceous unconformity. LNCE is picked at the base of the Fort Union Formation at the change from massive blocky sands to mainly shale (i.e., change from high resistivity to low resistivity) of the upper Lance. Sandstone and coal beds become more predominant in the lower Lance section. Because of the Tertiary/Cretaceous unconformity, the Lance section thins markedly to the west and is completely eroded west of R104W.

   **Coal**
   
   Total thickness of coal and the number of seams within the Lance section are estimated.

   **Note**
   
   The Tertiary/Cretaceous unconformity can be accurately mapped over all of GGRB by pulling Z values in the following priority order: LNCE, FXHL, LWIS, ALMD, MVRD.
5. **FXHL Fox Hills Sandstone**
   Upper Cretaceous littoral sandstone section marked by high SP and relatively low resistivity log character. The Fox Hills was deposited during regression of the "Lewis" sea and is transitional between the underlying marine shale of the Lewis Formation and overlying non-marine Lance. In general, the pick was made on the top of the first clean blocky sand below the alternating sand, shale, and coal section of the Lance. As a rule of thumb, coal seams indicate Lance Formation. The Fox Hills was not deposited west of RSU and is indistinguishable in WRDB north of T23N.

   **Sand**
   A gross sand thickness estimate was picked from logs by subtracting the footage of obvious shale from the total thickness of the FXHL to LWIS interval.

6. **LWIS Lewis Shale**
   Upper Cretaceous marine shale unit with the top picked at the base of the Fox Hills Sandstone. As with FXHL, consistent correlations are difficult because of the interfringing/transitional contact, but regionally LWIS is an excellent pick. Offshore marine and deltaic sand development in the Upper Lewis also make correlations difficult in certain areas. The Lewis was not deposited west of RSU at the terminus of the "Lewis" sea marine transgression. The Lewis section forms a wedge which thickens eastward.

7. **LWSM Middle Lewis Marker**
   Consistent bentonite marker bed picked over almost all of WRDB and northern SWB. LWSM is equivalent to the "b" time marker of Asquith (1966, p. 1202 - 1205) and "x marker" of Winn et. al. (1987). Consistent correlations were made on easily recognizable character of the resistivity curve. LWSM is an excellent marker which appears to be at or near the limit of maximum transgression of the "Lewis" sea.

8. **LWSL Lower Lewis Marker**
   Consistent bentonite marker bed picked over all but the westernmost portion of WRDB and SWB. Equivalent to "z marker" of Winn et. al. (1987). Consistent correlations were made with the resistivity curve at the base of a high resistivity, high gamma ray section (i.e., hot shale).

9. **MVRD Mesaverde Formation**
   This pick is recognized and used only in the La Barge Platform area (LBP). Here high resistivity Tertiary sandstones and shales of the Fort Union or Hogback formations rest unconformably on lower resistivity sandstones and minor shales of the Mesaverde. MVRD, time-wise, is not equivalent to the top of the Mesaverde Group, but rather is roughly equivalent to the upper part of the Baxter Shale (see Figure 2).
INTERPRETED FORMATION TOPS

10. ALMD Upper Almond Formation
Youngest formation of the Upper Cretaceous Mesaverde Group. The Upper Almond is a marine sequence of littoral sandstones and shales deposited during transgression of the "Lewis" sea. In WRDB and SWB, ALMD is easily correlated at the base of the Lewis Shale, but north, south and west of RSU correlations are more difficult where ALMD is an unconformable surface underlying the Lance or Fort Union Formations. In the eastern half of SWB, ALMD is used for the top of the equivalent Williams Fork Formation.

Sand
A gross sand thickness estimate is made for the Upper Almond where the Almond can be subdivided into an upper and lower unit (i.e., both ALMD and ALDL are picked). The thickness estimate is made by subtracting the footage of obvious shale from the total thickness of the ALMD to ALDL interval.

11. ALDL Lower Almond Formation
Non-marine sequence of sandstone, shale, and coal. ALDL is recognized by increased resistivity below the marine sandstones of the Upper Almond, and also by the presence of coal seams which are rarely present in the Upper Almond section. ALDL is only used in association with ALMD, thus, where Upper Almond (marine) section is not deposited and Lewis Shale rests directly on non-marine Lower Almond. ALMD is picked and ALDL is 99996 (i.e., no correlation).

Coal
Total thickness of coal and the number of seams are estimated for the ALDL section in WRDB.

12. ERCS Ericson Formation
Massive non-marine sandstone unit of the Upper Cretaceous Mesaverde Group. ERCS is picked on massive sand character of the SP and resistivity curves at the base of the Almond Formation. West of RSU and possibly for a distance eastward, the base of the Ericson marks a significant unconformity. To the west and northwest, the Ericson becomes thinner and more conglomeratic.

* Note
The Pre-Ericson Unconformity can be mapped in GRB and MA by pulling Z values in the following priority order: RKSP, BXTR. On LBP and north and west, the pre-Ericson unconformity is terminated (eroded) by the Tertiary/Cretaceous Unconformity (see Figure 2).

13. ILES Iles Formation
Basal formation of the Mesaverde Group in eastern SWB picked east of R95W at the top of the Trout Creek Sandstone, easily identified by high SP and low resistivity log character. Roughly time-equivalent to the lower Ericson and upper Rock Springs formations.

Coal
Total thickness of coal and the number of seams are estimated for the Iles section.
14. **RKSP** Rock Springs Formation
   Non-marine sequence of sandstones, shales, and abundant coal seams of the Upper Cretaceous Mesaverde Group. Picked west of R95W at the unconformable base of the Ericson Formation. RKSP is completely eroded by the pre-Ericson unconformity at the southern and northern ends of MA. East of R96W in WRDB and SWB, RKSP intertongues with the Steele and Mancos Shales and the Illes Formation. RKSP is present in northwestern SWB, but was not picked.

**Coal**
Total thickness of coal and the number of seams are estimated for the Rock Springs interval in the area between T12N and T27N and R105W and R96W.

15. **BLIR** Blair Formation
   Not a correlated top. The Blair is the lowermost formation of the Mesaverde Group on and around RSU. BLIR is used only in formation at TD field.

16. **STEL** Steele Shale
   Upper Cretaceous marine shale which conformably underlies the Mesaverde Group and is equivalent to the Mancos Shale of SWB. The Steele is present only in eastern WRDB and is not picked west of R95W, where it intertongues with the Rock Springs and Blair Formations.

17. **HLRD** Hilliard Shale
   Upper Cretaceous marine shale present in northwesternmost GRB and LBP, which is equivalent to the lower part of the Baxter, Steele, and Mancos Shales to the east. HLRD is recognized on logs as the relatively solid shale sequence underlying and interfingering with the sandstones of the Mesaverde Formation. HLRD occurs and is only used in association with MVRD.

18. **BXTR** Baxter Shale
   Thick Upper Cretaceous marine shale conformably underlying the Mesaverde Group which is picked in GRB, RSU, western WRDB and northwestern SWB (i.e., the areas where the equivalent HLRD, STEL, or MNCS are not picked). BXTR is recognized on logs as a consistent break into lower resistivity shale at the base of the more sandy Mesaverde sequence.

19. **MNCS** Mancos Shale
   Upper Cretaceous marine shale picked in all but northwesternmost SWB which is equivalent to the Steele and Baxter Shales to the north in Wyoming.

20. **APBC** Airport Bench Sandstone
   Correlatable sandstone unit and marker within the upper Baxter shale, found at 400' to 800' below the BXTR pick. The Airport Bench Sandstone gradually shales out east and west of RSU. However, the top of the unit can be recognized by log character as far east as the Table Rock Field in R98W and as far west as the west flank of MA, south of T23N.
21. **BXTM Middle Baxter Marker**
Consistent (bentonite?) marker bed recognized on the resistivity curve at approximately 1500' to 2500' below the top of the Baxter. BXTM is correlated over the western two thirds of GGRB as far east as R97W. BXTM is an excellent time-stratigraphic marker for mapping.

22. **MNCM Middle Mancos Marker (Middle Steele Marker) (STLM)**
Consistent marker bed recognized on the resistivity curve which is correlated in the eastern half of SWB as far west as R94W. The Middle Steele Marker pick (STLM), different from MNCM in name only, occupies the BXTM slot in WRDB of Wyoming. That is, BXTM picks east of R96W are STLM picks and do not correlate with BXTM of western GGRB.

23. **BXTL Lower Baxter Marker**
Consistent (bentonite?) marker bed recognized on the resistivity curve at approximately 500' to 1000' below BXTM. BXTL is correlated over roughly the same area as BXTM and likewise is an excellent time-stratigraphic marker for mapping.

24. **MNCL Lower Mancos Marker (Lower Steele Marker) (STLL)**
Consistent marker picked in a very limited area (12 townships) in the easternmost portion of WRDB and SWB along the Wyoming and Colorado border. The Lower Steele Marker (STLL) occupies the BXTL slot in Wyoming.

25. **NBRR Niobrara Formation**
Upper Cretaceous shaley chalk sequence conformably underlying the Steele/Mancos Shale in eastern WRDB and eastern and southern SWB. NBRR is picked on increased resistivity at the base of the Steele/Mancos low resistivity shale. The Niobrara sequence thins and completely shales out to the west and is not picked beyond R92W in Wyoming and R97W in southern SWB of Colorado.

26. **NBRM Middle Niobrara**

27. **NBRL Lower Niobrara**
Subdivision of the Niobrara Formation in SWB recognized on the resistivity and conductivity curves.

28. **FRNR Frontier Formation**
FRNR is only picked along the eastern and northern margin of WRDB and in SWB at the base of the Niobrara on the break from higher resistivity chalk to low resistivity shale. This shale is equivalent to the Carlile Shale which extends to the east.

* **Note**
A true top for the Frontier Formation is not recognizable regionally over all of GGRB. However, two excellent mappable horizons, FRN1 and FRSD, at or near the accepted top of the Frontier are picked. FRN1 is a time-stratigraphic marker and FRSD is a lithostratigraphic marker.
29. **FRSD Frontier Sand**

The Frontier Formation is a marine and transitional shale and sandstone sequence at the base of the Upper Cretaceous. The conformable contact with the overlying Baxter (Hilliard/Steele/Mancos) shale is difficult to recognize other than the top of the first significant sandstone unit, which is where FRSD is picked. FRSD is a litho-stratigraphic correlation which is very consistent except for regional stratigraphic jumps (see Figure 2), which are necessary because younger and younger sand facies develop from south to north and northwest. FRSD's position relative to FRN1 and FRN2, therefore, changes across GGRB. In the southern half of GGRB, FRSD is picked below FRN2. At a line which runs east-west at approximately T20N, FRSD jumps to a stratigraphic position between FRN1 and FRN2. In the far northwest area of GRB north of T27N and on LBP, FRSD jumps above FRN1 and becomes the first Frontier pick.

30. **FRN1 Frontier 1**

31. **FRN2 Frontier 2**

32. **FRN3 Frontier 3**

Rough time-stratigraphic subdivisions of the Frontier Formation which initially were loosely based on operator picks in southern MA and GRB areas and then successfully correlated over all of GGRB.

**Sand**

Gross sand thicknesses within each of these subdivision were made by estimating the total sand present in the intervals between FRN1 - FRN2, FRN2 - FRN3, and FRN3 - MWRY respectively. Exception was made in the northwest part of GRB and in LBP where FRSD is above FRN1. Here this sand thickness above FRN1 was included with that below FRN1.

* **Note**

A mapping project incorporating the subdivisions of the Frontier, their corresponding gross sand thicknesses and the top of the Frontier (i.e., FRSD) can provide a detailed analysis of the Frontier sequence.

33. **MWRY Mowry Shale**

The Mowry Shale, also known as the Aspen Shale in far western GRB, is continuous over all of GGRB and represents the top of the Lower Cretaceous. MWRY is one of the most reliable picks because it is easily recognized as a higher resistivity shale below the sandy Frontier sequence. Wherever possible cross-sections were hung on the top of the Mowry Shale.
34. **MDDY Muddy Sandstone**
   Lower Cretaceous sandstone unit which is recognized and picked on a consistent response on the resistivity curve. Deposited only in the northern and eastern parts of GGRB as the Muddy shales out into the Mowry to the south and west. Correlated MDDY picks seem to occupy the same time-stratigraphic position throughout the area.

   **Sand**
   Gross sand thicknesses are estimated within the Muddy section.

35. **TMPL Thermopolis Shale**
   Thin shale unit, 50' to 100' thick, separating the Muddy and Dakota units. TMPL is picked only in the northeastern margin area of WRDB in the Rawlins Uplift (RU) and Bison Basin (BB) areas.

36. **DKOT Dakota Formation**
   Lower Cretaceous sequence of transitional and marine sandstone and shale. DKOT is picked on increased resistivity at the base of the Mowry (or Thermopolis) Shale. The top may be a clean sand, but is often just a silty zone. The Dakota Formation is continuous over all of GGRB, but is a thicker sequence to the west in LBP, MA, GRB, and RSU areas. Here the sequence has been divided into lithologic packages, DKT2, DKT3, DKT4, and DKT5.

37. **DKT2 Dakota 2**
38. **DKT3 Dakota 3**
39. **DKT4 Dakota 4**
40. **DKT5 Dakota 5**
   Subdivisions of the Dakota Formation sequence based mainly on lithologic breaks (i.e., sand packages). The subdivisions were arbitrarily established in the southern MA and GRB and then correlated northward and eastward to RSU, except for DKT5, which cannot be picked in the RSU area (see Figure 2). DKT2 through DKT4 could not be correlated east of the Table Rock Field in R97W and in SWB, because of the lack of control across WRDB and because of the thinning of the Dakota sequence. DKT2 picks that occur east of R96W in WRDB, and all those in SWB, BB and RU areas, are exactly the same as DKOT picks. They are entered to accommodate sand thickness values in the area where the Dakota is not subdivided. (In an oversight, a field for sand thickness values opposite DKOT was omitted when the original data base format was built.) The DKT2 through DKT5 picks are quite consistent considering their lithologic nature. The Dakota sequence can not be divided on time-markers like the Frontier because of the lack of marine shales within the sequence.

   **Sand**
   Gross sand thicknesses within each of the Dakota subdivisions were made by estimating the total sand present in the intervals between DKT2 - DKT3, DKT3 - DKT4, DKT4 - DKT5, DKT5 - MRSN, respectively. In the area east of R96W in WRDB, and in the SWB, BB and RU areas, DKT2 contains the total sand estimate for the Dakota (DKOT).

   - 54 -
41. **MRSN** *Morrison Formation*
   Upper Jurassic sequence of continental sands and shales unconformably underlying the Dakota Formation. Locally, MRSN is not easily recognized, but is most often picked at the base of the last Dakota sand unit. Therefore, in cases where Morrison sands are developed at or near the base of the Dakota, the MRSN pick may not represent the true top of the Morrison. Regionally, however, MRSN is a good correlation. The Morrison is also known as the Gannet Formation in parts of Wyoming.

42. **SNDC** *Sundance Formation*
   Sandy unit which appears to be equivalent to the lower Morrison. SNDC is picked only in eastern WRDB, and in BB and RU areas. SNDC is roughly equivalent to SLWS of SWB.

43. **SLWS** *Salt Wash Member*
   Lower member of the Morrison Formation in SWB. SLWS is picked at the top of the sandy sequence above the Curtis.

44. **CRTS** *Curtis Formation*
   Upper Jurassic unit picked at the top of a high resistivity carbonate zone, approximately 50’ to 100’ thick. CRTS was initially picked in southern GRB and correlated to the north and east over the rest of GGRB. The CRTS pick is equivalent to the Stump Sandstone in LBP.

45. **ENRD** *Entrada Sandstone*
   Upper Jurassic sandstone zone typically with low resistivity and low to medium SP response. The Entrada is approximately 150’ to 200’ thick in western GGRB, but was not deposited in eastern WRDB, BB and RU areas. ENRD is equivalent to the Preuss Sandstone in LBP.

46. **CRML** *Carmel Formation*
   Middle to Upper Jurassic carbonate and shale unit picked at the base of the Entrada on high resistivity, low SP log character. The Carmel is not present in eastern WRDB, BB and RU areas. CRML is equivalent to the Twin Creek Limestone in LBP.

47. **NGGT** *Nugget Sandstone*
   Upper Triassic eolian sandstone sequence, easily recognized by low resistivity, low GR, and high SP log response. The top of the Nugget is an unconformable surface and the section thins from west to east and south because of erosion. The Nugget is usually 500’ to 800’ thick in MA and LBP and thins to 100’ or less in southeastern WRDB. The Nugget is completely eroded in all but northernmost SWB.

48. **CGTR** *Chugwater Formation*
   Triassic shale and minor carbonate interval picked at the conformable base of the Nugget Sandstone, except in south and eastern SWB where it unconformably underlies the Entrada. CGTR is continuous over all of GGRB and is easily recognized with resistivity and/or GR curves.
49. SRMP  Shinarump Formation
    Triassic sandstone unit within the Chugwater Group recognized and picked in SWB.

50. MNKP  Moenkopi Formation
    Lowermost Triassic unit in SWB. Picked on unconformity with overlying Shinarump.

51. TYNS  Thaynes Limestone (Alcova Limestone) (ALCV)
    Triassic shaley carbonate and shale section picked west of RSU. TYNS is not a very
    distinctive top, but is consistently correlated. In eastern WRDB, and BB and RU areas, the
    TYNS tops field has been used for the top of the Alcova Limestone (ALCV). The Alcova
    is a distinctive limestone, which is easily recognizable as a 20’ to 50’ bed with a very high
    resistivity response. TYNS (ALCV) is an excellent marker bed within the Chugwater.

52. WDSD  Woodside Formation
    Triassic sandstone and shale sequence picked at the base of the Thaynes shaley carbonate
    section (i.e., change from high resistivity to low resistivity). WDSD is picked only west of
    RSU.

53. DNDY  Dinwoody Formation
    Limey shale unit deposited during earliest Triassic. DNDY is picked on characteristic
    response of resistivity curve usually occurring 100’ to 200’ above the Phosphoria. DNDY is
    picked everywhere except southern and eastern SWB.

54. PSPR  Phosphoria Formation
    Permian phosphatic limestone and shale sequence lying unconformably below the
    Dinwoody Formation and unconformably above the Weber Formation. PSPR is an
    excellent pick characterized by high resistivity, high SP and low GR response, which is
    continuous over all of GGRB. The Phosphoria is also known as the Park City Formation.

55. WEBR  Weber Sandstone
    Upper Pennsylvanian sandstone sequence lying unconformably below the Phosphoria
    Formation. The GR log was used wherever possible to pick the top of the sand, because the
    pick is very difficult without it. WEBR is continuous over all of GGRB, and is also
    commonly known as the Tensleep Sandstone in much of Wyoming.

56. MRON  Maroon Formation
    Pennsylvanian clastic red bed sequence which occurs only in southern SWB. The Maroon
    intertongues with the Weber Formation from the east.

57. MNRN  Minturn Formation
    Lower Pennsylvanian sequence picked in southern SWB that is roughly equivalent to the
    Morgan Formation occurring to the north and west.

58. MRGN  Morgan Formation
    Lower Pennsylvanian limestone and minor shale sequence picked at the base of the Weber
    Sandstone, usually at the change from high SP to low SP. The MRGN correlations are
    difficult. The Morgan is also known as the Amsden Formation.
59. MDSN Madison Limestone
Mississippian massive carbonate sequence lying unconformably below the Morgan, or Minturn in southern SWB. MDSN is easily recognized with a GR log and with more difficulty with the resistivity curve.

60. LDVL Leadville Limestone
Madison equivalent in Colorado.

61. DRBY Darby Formation
Devonian shale and limestone sequence lying unconformably below the Madison in the area west of RSU. DRBY is picked at the shale break at the base of the Madison.

62. DVNN Devonian Undifferentiated
Darby equivalent in southern SWB picked at the base of the Leadville.

63. BGHR Bighorn Dolomite
Ordovician carbonate sequence which occurs west of RSU. BGHR is picked on the GR and/or resistivity curve at the top of a massive carbonate. The top and base of the Bighorn are unconformable.

64. CMBR Cambrian Undifferentiated
The top of the Cambrian is usually picked at the top of a shale and carbonate zone which lies unconformably below the base of the massive carbonate section of either the BGHR, MDSN, or DVNN, depending on the area.

65. FLTD Flathead Sandstone
Basal Cambrian sandstone which rests unconformably on the Precambrian basement. FLTD is picked at the top of a massive sand.

66. PCMB Precambrian Basement
Difficult top which is rarely penetrated in GGRB. The PCMB pick is usually based at least partially on sample data.
SAN JUAN BASIN FORMATION TOPS DESCRIPTION
(Conoco Proprietary Area)

1. OJAM  Ojo Alamo
50-200 feet. The Ojo Alamo is a fining upward sand section which thickens and thins rapidly with conglomerate deposited at its base. The top is picked on the base of a good sealing shale about 15 feet thick. Sand thickness is generally 10-50 feet less than the interval thickness, depending on the development of shale. It appears that the Ojo Alamo interval pinches out to the north and that another sand-conglomerate interval slightly higher in the section develops, complicating the stratigraphy and the tops picked in townships 31 and 32 north.

2. KRLD  Kirtland Shale
* 160-500 feet. The Kirtland Shale is a low conductivity shale that thins to the northwest. Sands present in the Kirtland Shale are numerous and vary in thickness, thus overall sand thickness is highly variable.

3. FRLD  Fruitland
450-600 feet. The Fruitland is a non-marine sand and shale section with a higher conductivity than the Kirtland above. Coal beds are found higher in the section to the north and the unit generally thins (180-450 feet) to the northwest. An upper Pictured Cliffs tongue called the Fruitland Sand builds to the northwest (0-340 feet). The combined interval of Fruitland coal and Fruitland sand is fairly constant. For consistency, an abrupt shift in the conductivity curve was used as a marker for the top Fruitland.

4. PCCF  Pictured Cliffs
* 70-230 feet. The Pictured Cliffs sand is extremely variable, generally coarsens upward and has 1-3 cycles of sand development. The unit becomes more shaley to the northeast. Pictured Cliffs sand thickness is generally 10-50 feet less than interval thickness depending on the development of shales.

5. BPFC  Base of Pictured Cliffs
130-500 feet. The Base of the Pictured Cliffs is picked at the base of the producing interval where it becomes shaley, marked by low resistivity and conductivity. The interval below the Base of Pictured Cliffs generally shows slight coarsening upward and grades into the Pictured Cliffs sand producing interval.

6. LMFS  Lewis Maximum Flooding Surface

7. HRFB  Huerfanito Bentonite

8. LWIS  Lewis Shale
80-250 feet. The Lewis Shale is a very shaley interval that thins northward. The interval contains the Huerfanito Bentonite Marker bed which is well defined in the south but fades rapidly to the north.
9. **MLWS Middle Lewis Shale**  
   400-450 feet. The Middle Lewis Shale is a very constant silty interval with a few thin sands near the base. The unit thickens abruptly in the northeast part of the area.

10. **CHCR Chacra A Sand**  
   40-90 feet. The Chacra A Sand is usually a well-developed sand, but is very well developed in the western part of the area. Conductivity reverses south of the area and just south of the main Chacra producing trend.

11. **CHCB Chacra B Sand**  
   70-100 feet. The Chacra B Sand is a fairly uniform shale unit which develops a good upper sand halfway across the basin. The unit generally coarsens upward.

12. **EMKR E Marker**  
   20-70 feet. The E Marker marks the top of a moderately developed sand unit which has a fairly constant thickness over the area.

13. **LLWS Basal Lewis Shale**  
   230-500 feet. The Basal Lewis Shale is a very uniform shale interval which thickens northward.

14. **CLFH Cliff House Sand (top Mesaverde)**  
   10-250 feet. The Cliff House Sand consists of 1-3 cycles of sand which build northward. The sand is best developed south of the main Mesaverde pool. Cliff House sand thickness is highly variable depending on the development of interfingering sands.

15. **MENF Menefee**  
   120-900 feet. The Menefee is an extremely variable continental sand and shale unit which thins to the north and contains coal beds.

16. **PNLK Point Lookout Sand**  
   * 30-190 feet. The Point Lookout Sand is generally a more massive sand than the others but is sometimes shaley. It usually coarsens upward, and may have radioactive thorium sands interbedded. Sand thickness is generally 10-50 feet less than overall thickness depending on shale development.

17. **BMVR Basal Mesaverde**  
   50-450 feet. The Basal Mesaverde is a coarsening upward shale that grades into the Point Lookout Sand. It generally thickens northward.

18. **MNCS Mancos Shale**  
   700-850 feet. The Mancos Shale is a fairly constant shale interval with at least 4 cycles. The lowest two cycles become more sandy to the north. These lower units probably become the productive El Vado Sand to the east.
19. **UGLP Upper Gallup Sand**
   50-80 feet. The Upper Gallup Sand is a distinctive coarsening upward sand unit that shales out to the north, and in the southwest corner of the area. The SP frequently reverses, probably indicating a water sand.

20. **CALM Calcareous Member**
   0-400 feet. The Calcareous Member of the Mancos consists of calcareous shales and sandstones that increase in carbonate content to the east to become the Niobrara Limestone. (Kilgore and Budd 1957)

21. **MGLP Middle Gallup Marker**

22. **GLLP Gallup Sand**
   0-80 feet in the area. The Gallup Sand thickens to the south becoming a well-developed coarsening upward sand cycle with a constant thickness of 350-450 feet. The interval thins to the north due to erosional truncation and deposition of the Calcareous Member. It is present only in the extreme southwest corner of area. (RMAG 1972)

23. **BNUC Basal Niobrara Unconformity**

24. **SNST Sanostee Marker**
   240-360 feet. The top of the Sanostee is picked on a thin coarsening upwards limy sand deflection. Very high conductivity develops in the middle of the unit, and sand can develop at the base, just above the Greenhorn top.

25. **GRHN Greenhorn "Lime"**
   40-70 feet. The Greenhorn "Lime" is a lime cemented sandstone that is frequently shaley but with a very constant interval thickness.

26. **GRRS Graneros**
   70-100 feet. The Graneros is a shaley interval with a distinctive gamma, SP, and resistivity kick at its base (Orange Point Marker).

27. **DKOT Dakota Sand**
   * 250-310 feet. The Dakota Sand is very erratic, with marine and continental sand development and erosional unconformities. Because many wells TD in the Dakota and very few logged a complete section, overall sand thickness picked contains variability dependent upon amount of Dakota drilled and logged.

28. **MRSN Morrison**
   Very few wells reach the Morrison. It is picked on the top of a thick non-sand bearing shale at the base of the Dakota.

   * Denotes formations with sand thickness in the data base.

29. **WNKH Wanakah**
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INTERPRETED FORMATION TOPS

Note that there are explanation codes (need to be null values for map gridding) for missing tops:

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