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PRE-PENNSYLVANIAN STRATIGRAPHY OF SOUTHERN NEW MEXICO

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"Things are seldom what they seem;
Skimmed milk masquerades as cream." -Gilbert

Twenty years ago the earlier Paleozoic of New Mexico was simple. The Cambrian was represented by the Bliss sandstone. The Ordovician was represented by the lower El Paso limestone and the upper Montoya dolomite. The Silurian was the Fusselman dolomite; the Devonian was the Percha shale. The Mississipian was largely, if not completely, the Lake Valley formation. Subsequently all this was changed by an annoying group of geologists who approached the problem more or less on the premise that, in view of the complexity of Paleozoic deposition throughout the world, it was doubtful whether this simplicity was real. So the formational names have increased, and the sediments have come to be further divided. Out of this seeming increase in complexity and the attendant confusion there is coming, however, a realization of the Paleozoic history of New Mexico in terms of discrete intervals of deposition and an evaluation of apparent changes in terms of interfingering facies, in some cases, and in others, of overlapping distinct depositional units.

There are two realities in geology. The first, the apparent one, is what we see at the present, and this must inevitably serve as the original basis of classification of sedimentary rocks. There is, however, another and more important reality, the sequence of events which governed the deposition of the strata. It is this record that is greatly obscured by erosion, solution, and alteration of sediments by dolomitization, silicification, mineralization, and sometimes by metamorphism. These are only a few of the agencies which may produce such alteration as to obscure original differences in lithology and to create new ones--and to obscure or destroy faunas to such an extent that the safest rule is sometimes to suspect the obvious. Out of the welter of increasing formations, members, zones, facies, and most horrible of all, faunal lists, we may derive some comfort that these increasing trivia with which we are asked to burden our minds are a means toward a closer understanding of the geological history of the earth.

CAMBRO-ORDOVICIAN

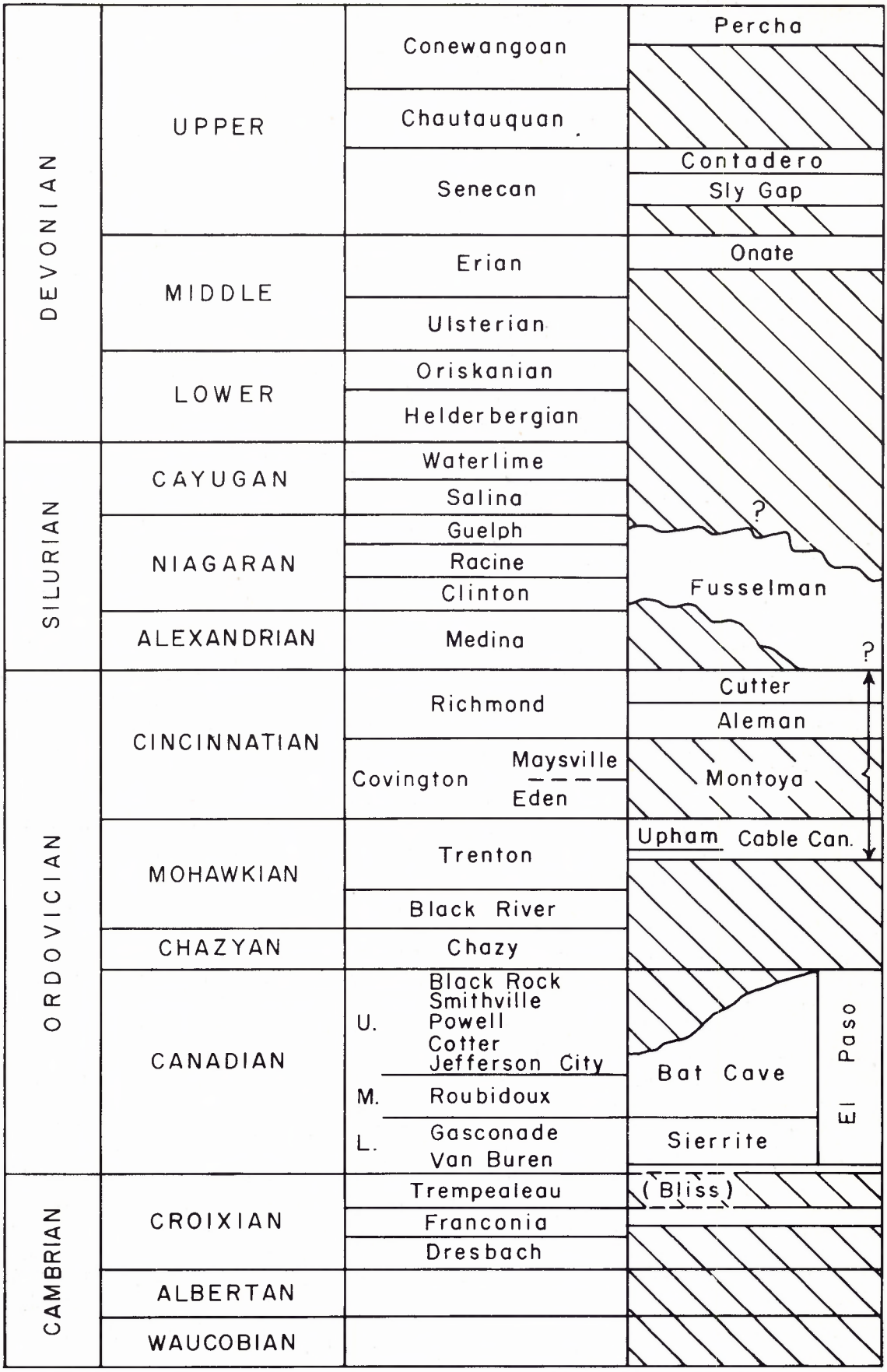
Bliss Sandstone

The Bliss sandstone is a conspicuous black-weathering group of clastic sediments. It contrasts strongly with the red-weathering Precambrian below, and the gray-brown El Paso above. Because of the color difference, it is easily the most conspicuous unit in the earlier Paleozoic, one readily recognizable at a distance. In south-central New Mexico the Bliss sandstone ranges from 120-160 feet thick, but thickens to 225 feet at the type section at the southern end of the Franklin Mountains. It is dominantly clastic, but contains a great variety of lithologies, ranging from sedimentary quartzites through relatively pure to strongly calcareous sandstones, with red-weathering beds with varying amounts of hematite, and green beds of glauconite. In close view the beds are varicolored, weathering in all shades from reds to purples, browns, blacks, and greens. There are even very thin beds of relatively pure limestone. If it is not as good as the best sandstones, it is not as bad as the worst, though whether it be called the Bliss sandstone or the Bliss formation is an academic and profitless matter of discussion.

The age of the Bliss, a recent matter of controversy, is a problem which has yielded to paleontological evidence. The lower beds in south-central New Mexico have yielded faunas of the *Ptychaspis-Prosaukia* zone, (Flower, 1953c) and are of late Franconian age (middle Upper Cambrian). The upper portion has yielded faunas equivalent to those of the lowermost Ordovician of Utah (Hintze, 1952, zone B) with *Symphysurina, Bellefontia and Apheorthis melita.* Equivalence to the Tremadoc is indicated by *Dictyonema flabelliforme* var. *anglicum.*

Continuous but very slow deposition was at first believed to continue from Franconian into Tremadoc (early Gasconade, possibly Van Buren) time. Later studies indicate that there is instead a sedimentary break. No Trempealeauan (latest Upper Cambrian) is present in New Mexico or adjacent parts of western Texas or southeastern Arizona. Ordovician deposition is found to begin with a characteristic and easily recognizable cross-bedded coarse-grained sandstone. Beds above are thinly laminated and as Kelley and Silver noted (1952) essentially the same type of deposition as is expressed in the lower El Paso (Sierrite limestone) beds. As a matter of fact, the Bliss-

LOWER PALEOZOIC OF SOUTHERN NEW MEXICO



El Paso contact in central New Mexico is gradational, marked by decrease and finally disappearance of sand and glauconite as conspicuous contributors to the sediments. The contact is clearly gradational in many sections, and there is probably some slight local variation in the exact horizon at which the transition occurs.

Anomalously, the 225 feet of the type section of the Bliss sandstone (Franklin Mountains) appears to be completely Ordovician from the present evidence, and is separated from the overlying dolomites of the El Paso by a zone with large sparsely scattered foreign pebbles (Cloud and Barnes, 1946).

EL PASO GROUP

The El Paso group consists dominantly of calcareous sediments which, in the type section, range, with the underlying Ordovician Bliss sandstone, throughout the entire Canadian epoch. Cloud and Barnes (1946, p. 361-369) have presented an excellent analysis of the section. (Flower, 1953c) has presented this in a more generalized form for purposes of an earlier field trip. Only minor additions are required to the remarks of Cloud and Barnes. It is now evident that the lower 80 feet are of Gasconade age, and are separated by beds with foreign pebbles from the underlying Bliss and again from the overlying Middle Canadian beds. In New Mexico sections in general, the Gasconade portion is proportionally thicker, and there is no evidence of such interruptions in sedimentation. Beds 24-18 of Cloud and Barnes are Middle Canadian. Upper Canadian deposition begins with a sandy zone, succeeded again by limestone. *Mcqueenoceras* near the base marks the beginning of Jefferson City deposition. Subunits B1 and B2a are largely limestones, not readily differentiated, extending from Jefferson City probably through Cotter and Powell time. Sand marks the inception of late Upper Canadian deposition, subunit B2b, the Smithville-Fort Cassin equivalent to the Odenville and Black Rock beds.

The New Mexico sections are very different, notably in that dolomite and sand are rare or absent at the prominent breaks. The Lower Canadian part is more complete, and the whole section has suffered more extensively from erosion, so that the upper beds are largely missing, and some sections may not penetrate very far into the Jefferson City equivalents.

The zonation possible in the New Mexico sections has already been indicated briefly (Flower, 1953b) and is reviewed as follows:

1. Ordovician Bliss-Tremadoc, lower Gasconade (or Van Buren) equivalent (70-85 feet).

2. Thin-bedded calcilutites, typical Sierrite limestone (Kelley and Silver, 1952) Gasconade equivalent (100-120 feet).

3. A thin interval, usually 35-40 feet, equivalent to the *Kainella-Leiostegium* zone of Utah (Hintze, 1952). These beds are a Cordilleran unit, represented by a period of nondeposition and erosion in the east.

The above units comprise the Ordovician Bliss and the Sierrite limestone. The following divisions in the Middle and Upper Canadian embrace what is properly the Bat Cave formation, though the Sierrite-Bat Cave division is complicated by the fact that the stromatolites by which the unit is primarily characterized are sometimes scarce or locally absent. In such a section, one would tend to group the lower beds with the Sierrite.

1. First endoceroid zone. Limited stromatolites, coarse lime sands, and a characteristic fauna with the first endoceroids, trilobites, and abundant and characteristic gastropods. *Raphistoma trochiscus* Meek is the name (wrongly) applied, generally, to the commonest form. This equals unit 24 of Cloud and Barnes and probably G1 of Hintze's (1952) Utah section (130 plus feet).

2. First piloceroid zone. Stromatolite reefs are conspicuous, and contain abundant piloceroids and sponges, usually silicified and conspicuous. Equivalent are units 22-20 of Cloud and Barnes (1946), and the upper Gorman of central Texas (100 plus feet).

3. Oolite zone. Conspicuous dark-weathering beds with an abundance of oolite; interspersed with pebble beds and beds of algal pellets. A unique and large fauna--without apparent correlatives. This zone is present in units 19-18 of Cloud and Barnes but has not been traced farther (40 plus feet).

4. Massive reefs with sponges of Orospira. The *Mcqueenoceras* zone is locally present at the base, as is some sand, and this represents the inception of the Upper Canadian (Jefferson City, Honeycut, etc.) deposition (30 plus or minus feet).

5. Thin-bedded limestones with little besides hoards of tiny gastropods which usually defy extraction (120 plus or minus feet).

6. Massive beds, rarely stromatolitic, with the second piloceriod zone. The fauna is that of subunit B1 of Cloud and Barnes (1946). Differences in the whole Upper Canadian succession between central New Mexico and El Paso are clearly faciological (40 feet).

7. Thin-bedded limestones with a more varied fauna (160 feet).

8. A third piloceriod zone (60 feet).

Sections in New Mexico have suffered from pre-Montoya erosion. No beds equivalent to subunit B2b or unit C of Cloud and Barnes have yet been recognized. Erosion has removed beds so that the El Paso at Cable Canyon terminates shortly above the second piloceroid zone, and at Mud Springs Mountains the top beds reach only the base of the second piloceriod zone.

The El Paso limestone as developed in southern New Mexico and western Texas is clearly continuous with the Ellenberger, but also was originally with the Manitou limestone of Colorado and the Garden City beds of Utah. Present discontinuity is a function in part of pre-Montoya erosion, but more largely of later pre-Pennsylvanian erosion.

Montoya Group

The Montoya is a group, dominantly of dolomites in New Mexico, divisible into four easily recognized units, the Cable Canyon sandstone at the base, the massive, noncherty Upham dolomite, the dark dominantly cherty Aleman dolomite, and light fine-grained beds, the Cutter formation (Kelley and Silver, 1952).

The Cable Canyon consists properly of white sandstone, barren, and therefore of uncertain age, ranging up to three feet in thickness, rarely more. The basal beds of the Upham may contain coarse sand and weather dark brown, but the amount of sand in the base is variable. It may recur in higher beds, and it may even be absent at the extreme base and abundant 10-20 feet above the base. These beds are certainly only a basal sandy phase of the Upham. Whether the white sandstone below is a basal phase of this deposition or whether it is materially older than the remainder of the Montoya, possibly having the same relation to it as the Harding sandstone has to the Fremont limestone of Colorado, is not as yet evident.

The Upham is a massive dolomite (60-90 feet) in most New Mexico sections, with the original bedding and most of the fossils obscured. It is this part of the section which yields a fauna of Red River aspect, with massive corals, particularly *Halysites* (now *Catenipora*), *Receptaculites, Maclurites, Stromatocerium* and endoceroids. The upper beds may contain some chert, usually in large spheroidal masses, and a quite different fauna, with *Sowerbylla* and *Rhynchotrema* n. sp.

Still a third zone is recognized in some sections. It is not evident whether its local absence is due to destruction of the fossils, or to local nondeposition or erosion.

The Aleman dolomites (approximately 120 feet) are dark coarse-grained beds with abundant cherts, among which many silicified brachiopods and other fossils are found. These beds are divisible into at least three major zones. The Aleman fauna is of Richmondian aspect, and is responsible for the former widespread correlation of the whole of the Montoya with the Richmond.

The Cutter formation (115-200 feet) consists of finer-grained lighter-weathering dolomites, within which at least two faunal zones are developed. Chert is minor, and when present developed as spheroidal or botryoidal masses quite unlike the abundant irregular nodules of the Aleman below. Some sections show some interfingering of Aleman and Cutter lithologies at the contact of the formations.

The correlation of the Montoya involves the same problems encountered in the correlation of the Fremont limestone of Colorado, the Bighorn formation of Wyoming, the Red River group of Manitoba, and later Ordovician beds from there to northwestern Greenland. From Chazyan time onward, Ordovician faunas show an interplay of boreal and austral elements, boreal elements invading the east in Black River, late Trenton, and again in Richmond time. One may expect that as the source of these faunas is approached, regions may be encountered where the intervening austral faunas, are absent, not through nondeposition, but because they never penetrated into those regions. Consequently, these beds in the boreal realm have been compared with Black River, Cobourg (late Trenton) and Richmond, but never with the beds between them. It is evident (1) that such beds may be present there but may be unrecognized because of the absence of austral faunal elements and (2) that in the boreal region differentiation of beds containing essentially a continuously evolving fauna may be extremely difficult. From the present evidence it appears that the "Red River" type of fauna extends through a considerable part of the section in Manitoba, but becomes progressively confined to the lower members in the Bighorn, Fremont, and Montoya as it is traced southward. The Montoya sequence shows a succession of Richmondian types in the upper beds, beneath which the boreal type of fauna is found. Present indications are that the Cutter is late Richmondian (Liberty to Elkhorn), the Aleman contains early Richmond (Arnheim through Waynesville) and the earlier beds must therefore be pre-Richmond. Adequate evidence does not exist as yet to show whether these beds are (1) Covington (Eden and Maysville), early Upper Ordovician, (2) Cobourg, the late Trenton in which

many boreal elements, previously considered diagnostic of the Richmond, invaded the eastern Ordovician, or (3) partly Covington and partly Cobourg.

SILURIAN

The Silurian is represented by the Fusselman dolomite, of restricted occurrence in southern New Mexico. It has recently been restricted still further by the removal of the lower beds, formerly included in it, which are now the Cutter formation placed properly with the Montoya group (Kelley and Silver, 1952).

Recently Pray (1953) reported a fauna from the restricted Fusselman of the Sacramento Mountains regarded as Alexandrian (Lower Silurian). If this is correct, the Fusselman may actually contain several divisions of the Silurian, for the large *Pentamerus oblongus* suggests Clinton or Racine age, and a smaller *Conchidium* suggests a similar age range. The problem of correlation is a difficult one. The Fusselman is everywhere strongly dolomitized. There is indication of fossils only as faint shadows if at all, except where they have been silicified, and silicification varies from one locality to another. If, as seems possible, several Silurian horizons are represented in this formation, it will take much time and effort to differentiate them, and even then many exposures may remain in which differentiation of these beds will probably be impossible.

DEVONIAN

In New Mexico the Devonian is divided into the Onate formation, the Sly Gap formation, the Contadero formation, and the Percha formation. In the Percha there is further differentiation of a Ready Pay and a Box member. Except for the Onate, which may be dolomitic and resistant the Devonian is dominantly shaly in New Mexico.

Onate Formation

Typically this consists of about 25 feet of orange-yellow-weathering dolomitic silts with some shales and sands. Vexingly, where it lies on the Ordovician without intervening Fusselman, the contact may be hard to place on lithologic grounds alone. The known fauna is a meagre one, largely of brachiopods and bryozoa, among which the characteristic bryozoan *Sulcoretepora* is one of the most characteristic and easily recognized fossils. Aside from the obvious fact that it is older than the early Upper Devonian Sly Gap beds which it underlies, its age is not definitely established. The suggestion that it may be as old as the Onondaga rests upon the appearance of *Spirifer acuminatus* in cherty beds at Mockingbird Gap. It is not evident that this fossil came from true Onate beds. The idea that the species is necessarily Onondagan, early Middle Devonian, is a myth. The Onate may therefore be late Middle or early Upper Devonian.

Sly Gap Formation

The typical Sly Gap is developed in the San Andres and Sacramento Mountains, but elements of its faunas are found in the Devonian in the Caballo and Mud Springs Mountains. The fauna is a large one, primarily of brachiopods, and indicates close affinities with the fauna of the Independence shale of Iowa. It is clearly early Upper Devonian in age.

Contadero Formation

Beds above the Sly Gap in the San Andres Mountains were separated as the Contadero formation by Stevenson (1945). Its fauna is inadequately reported, and said to differ from that of the Sly Gap beds below mainly by the addition of an undescribed species of *Ambocoelia*. Its age is probably not materially younger than that of the Sly Gap beds which it overlies. It was originally set apart from the Sly Gap mainly because of lithologic differences. It consists dominantly of thin even-bedded sediments and contains a limestone which yields fossils. It contrasts with the Sly Gap primarily in lithology and preservation of the fossils.

Percha Formation

The typical Percha shale is divided into a lower Ready Pay member, 132 feet thick in the type section, of barren fissile black shales, and an upper member (46 feet) of greenish and yellowish shales with calcareous nodules, which alone has yielded the 'Percha' fauna. Stainbrook (1947) in describing the Percha fauna included some species from the upper part of the Devonian section not far south of Rhodes Canyon. The typical Percha fauna contains some elements of Mississippian aspect, but restudy has shown that, in some cases at least, resemblance to Mississippian species, and even genera, is only superficial. The fauna is largely one of brachiopods. The Percha has yielded one of the three clymeniid ammonoids known from North America. These forms, exclusively Devonian, have been used as significant zone markers in Germany and North Africa.

MISSISSIPPIAN

Laudon and Bowsher (1949) have summarized the Mississippian of southern New Mexico, to which there are few emendations or additions yet available. Strata embrace the Kinderhook, Osage, Meramec, and Chester, all four of the main divisions of the Mississippian.

KINDERHOOK

The Caballero formation consists of 60 feet more or less of nodular shales and shaly limestones in the Sacramento and San Andres Mountains. The fauna indicates equivalence with the Kinderhook of the Mississippi Valley. At Lake Valley the Caballero is thinner, and represented by even-bedded silty limestones, with only minor nodular limestones.

OSAGE

The beds of Osage age are included in the Lake Valley formation which has been divided into the following members:

Andrecito: A maximum of 75 feet of calcarenites, with, locally, thin-bedded silty layers with *Taonurus*.

Alamogordo: Typically a massive hard fine-grained limestone with abundant chert nodules, 12 feet at Percha Creek. The crinoidal bioherms of the Sacramento Mountains begin in this unit.

Nunn: A maximum of 100 feet of soft shales and marls from which a prolific fauna weathers. These beds are the source of most of the known fauna, and are noted for their crinoids.

Tierra Blanca: Thin beds of calcarenite, highly crinoidal and rich in bryozoa, succeeding the Nunn, averaging 40 feet thick.

The remaining members, the Arcente and Dona Ana, are recognized only in the Sacramento Mountains.

MERAMEC

The Meramec beds are developed in the southern part of the Sacramento and San Andres Mountains, consisting of the Las Cruces and Rancheria formations, 120 feet and 250 feet thick respectively.

CHESTER

The Helms formation, 150 feet thick, consists of green- and yellowish-weathering calcareous beds, shaly weathering in large part, developed in the Franklin and Hueco Mountains. In the Big Hatchet Mountains similar beds are more calcareous, and resemble the upper part at least of the Paradise formation of Arizona which may contain some Meramec beds in its lower part.

The Mississippian when traced southward shows a disappearance of lower beds, and an appearance of upper beds between the Devonian and Pennsylvanian. Some anomalies and problems still exist. Armstrong discovered Mississippian fossils in the lower gray limestone of the Sandia formation in northern New Mexico, beds which are restricted in extent, and are preserved apparently only in depressions on the Precambrian surface below the Pennsylvanian. Laudon and Bowsher identify as Kelly limestone crinoidal limestones above the rest of the Lake Valley in the Silver City area. As the post-Lake Valley, and implied Meramec, age of the type Kelly is extremely doubtful, this correlation may prove invalid.

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