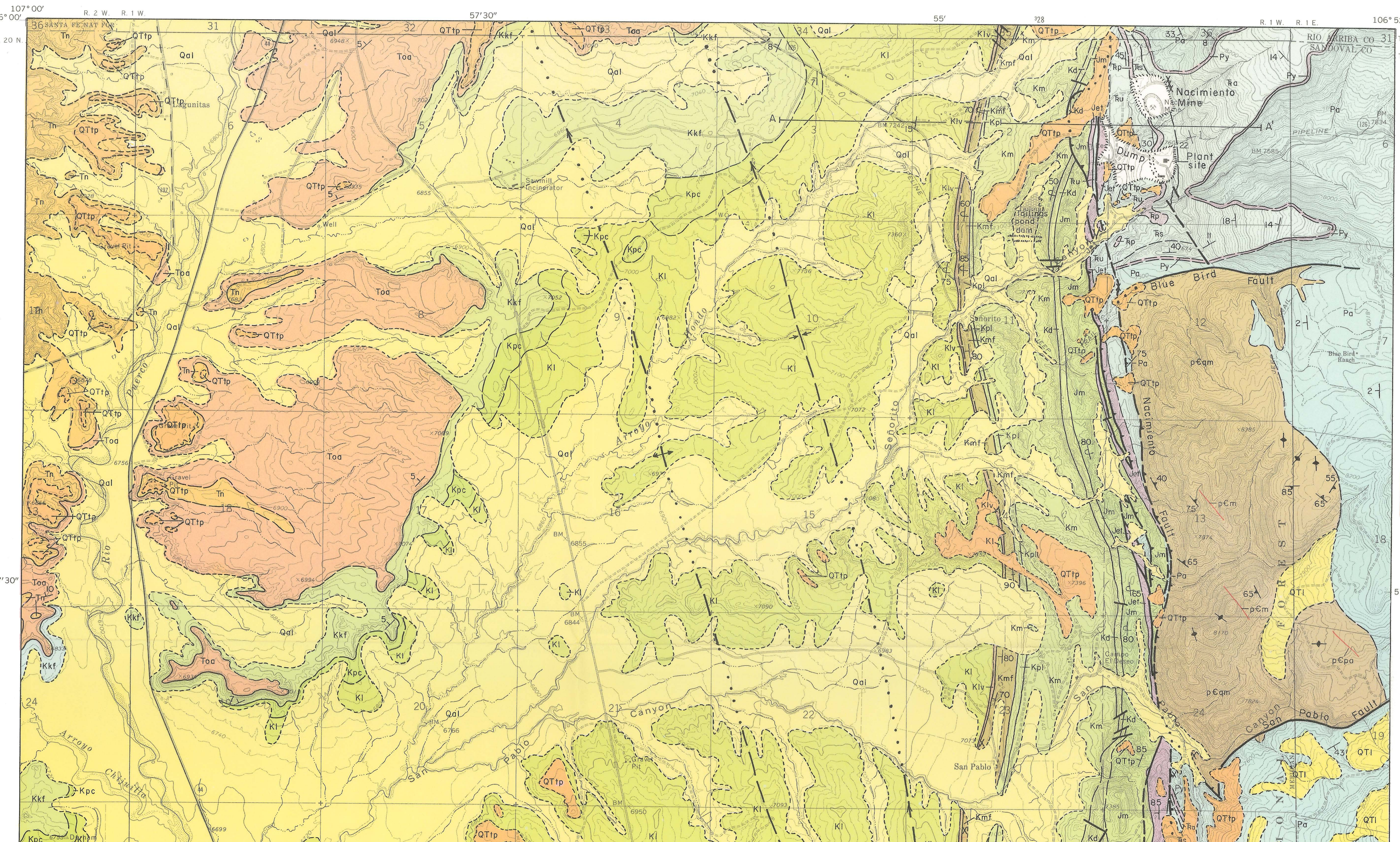


Base from U.S. Geological Survey

Geology by Lee A. Woodward, John B. Anderson, William H. Kaufman, and Richard K. Reed, 1970

EXPLANATION

QUATERNARY

Qal — **Alluvium**
Clay, silt, sand, and gravel, mostly along valleys, includes some colluvium, 0 to 25(?) feet thick

QTl — **Lag deposits**
Mostly large blocks of Agua Zarca Sandstone that have been let down by erosion of underlying units

QTtp — **Terrace and pediment deposits**
Mostly boulder gravel with clasts of Precambrian age, or, locally, Paleozoic and Mesozoic age. Includes minor sand and lag gravel, 0 to 30(?) feet thick

TERTIARY

Tn — **Nacimiento Formation**
Gray and olive-gray shale and siltstone with subordinate white, yellow, and buff sandstone and argillaceous sandstone, about 800 feet thick

Toa — **Ojo Alamo Sandstone**
Tan to buff, thick-bedded sandstone with local lenses of conglomerate and gray and olive shale, 70 to 90 feet thick

CRETACEOUS

Kkf — **Kirtland Shale and Fruitland Formation undivided**
Olive-gray to dark-gray shale and light-gray to buff sandstone, locally carbonaceous, 240 feet thick

Kpc — **Pictured Cliffs Sandstone**
Gray to buff, thin-bedded sandstone and gray shale, 45 to 65 feet thick

Kl — **Lewis Shale**
Gray to black shale with minor light-gray to buff sandstone and yellowish nodular limy concretions, 1500 to 2000 feet thick. Lower part is laterally equivalent to upper part of La Ventana Tongue of Mesaverde Group

Kmv — *Mesaverde Group*

Klv — **La Ventana Tongue of Cliff House Sandstone**
Light-gray to brown, medium-grained, salt-and-pepper-textured sandstone with gray shale interbeds; 15 to 900 feet thick; thickens southward, upper part laterally equivalent to lower part of Lewis Shale

Kmf — **Menefee Formation**
Light- to dark-gray carbonaceous shale, light-gray sandstone, and coal, 265 to 700 feet thick; thickens southward

Kpl — **Point Lookout Sandstone**
Light-gray, medium-grained, salt-and-pepper-textured sandstone, minor gray shale interbeds, 40 to 275 feet thick; thickens southward

Km — **Mancos Shale**
Black shale with minor thin-bedded, light-gray sandstone and yellowish limy concretions; 2200 feet thick

Kd — **Dakota Formation**
White, fine- to medium-grained sandstone; gray to black carbonaceous shale, yellowish to buff sandstone; locally, coal near the middle; 115 to 190 feet thick

JURASSIC

Jm — **Morrison Formation**
Four members in ascending order: brownish-maroon siltstone and very fine-grained sandstone with minor light-gray sandstone and maroon shale; brick red and pale green mudstone and very fine-grained sandstone with gray to yellow-buff sandstone and minor pellet limestone; yellow, white, buff, and pink sandstone with minor shale and conglomeratic sandstone; green shale; 900 feet thick

Jet — **Entrada and Todilto Formations undivided**
Todilto: basal black to brown, laminated limestone, 5 to 20 feet thick, overlain by white gypsum 60 to 140 feet thick; Entrada: white, yellow, buff, and tan-brown, massive sandstone, 100 to 200 feet thick

TRIASSIC

Ꞧc — *Chinle Formation*

Ꞧu — **Upper Shale Member**
Red shale and minor green and maroon shale and red siltstone and sandstone, 460 to 600 feet thick

Ꞧp — **Poleo Sandstone Member**
Greenish, very fine- to coarse-grained, micaceous sandstone with subordinate green and reddish-maroon shale and minor pellet limestone and maroon micaceous sandstone; 2 to 135 feet thick; cannot be mapped as a separate unit south of San Miguel Canyon because of thinning

Ꞧs — **Salitral Shale Member**
Maroon shale with subordinate green shale and, locally, minor, very coarse-grained, green, limy sandstone; 300 to 336 feet thick

Ꞧspu — *Mapped as one unit south of San Miguel Canyon*

Ꞧa — **Agua Zarca Member**
White to light-buff, very thick-bedded, coarse-grained, quartzose sandstone, conglomerate, and conglomeratic sandstone; 80 to 120 feet thick

PERMIAN

Py — **Yeso Formation**
Tan-brown and orange-buff, even-bedded, fine- to very fine-grained sandstone; 60 to 300 feet thick

Pa — **Abo Formation**
Reddish-brown mudstone and lenticular sandstone and arkose; locally light-gray sandstone, arkose, and minor limestone; 150 to 750 feet thick

PRECAMBRIAN

p€m — **Mafic dikes**
Longitudinally discontinuous, up to 2 feet wide, consist of fine-grained hornblende, feldspar, and biotite

p€pa — **Pegmatite and aplite dikes**
Longitudinally discontinuous, up to 2 feet wide, fine to very coarse grained

p€qm — **Quartz monzonite**
Porphyritic biotite quartz monzonite, coarse-grained pink microcline phenocrysts in medium- to coarse-grained matrix, locally foliated along shear zones producing flaser gneiss and schist

p€g — **Gneiss**
Fine- to medium-grained, lenticular quartzo-feldspathic gneiss with minor biotite; locally includes fine-grained biotite-quartz-feldspar schist and fine-grained hornblende schist

Contacts of surficial deposits

Bedrock contacts
Dashed where approximate

Upthrust fault
Teeth on upthrown block, dashed where approximate, dotted where concealed

High-angle fault
Dashed where approximate, dotted where concealed

Strike and dip of bedding

Strike and dip of overturned bedding

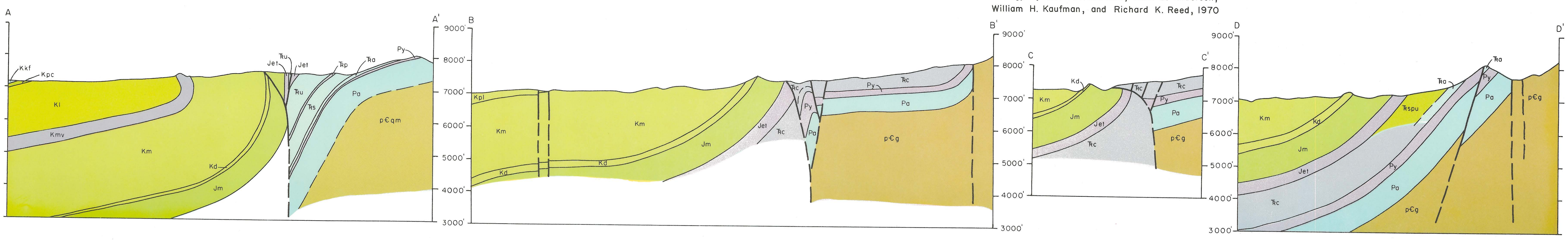
Strike and dip of schistosity or foliation

Anticline
Showing plunge, dashed where approximate, dotted where concealed

Syncline
Showing plunge, dashed where approximate, dotted where concealed

Arbitrary cutoff
Separating laterally equivalent facies of different map units

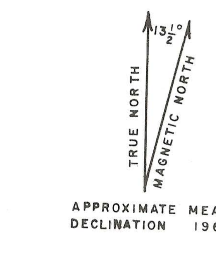
X
Prospect or mine



GEOLOGIC MAP AND SECTIONS OF SAN PABLO QUADRANGLE, NEW MEXICO

by Lee A. Woodward et al.

0 — 1 — 2 Miles



PREVIOUS WORK

The La Ventana NW quadrangle was included in reconnaissance maps by Renick (1931) and Dane (1936). Wood and Northrop (1946) also covered this quadrangle in a reconnaissance map of the Sierra Nacimiento and San Pedro mountains. Parry (1957) mapped the Mesaverde Group in the southern part of the quadrangle. The northwestern part of the La Ventana NW quadrangle was also covered in an inch-to-the-mile geologic map delineating the Mesaverde Group (Cretaceous) and younger strata of the east-central San Juan basin (Baltz, 1967).

PRESENT WORK

Responsibility for mapping this quadrangle is shown on inset map. Reed mapped the Precambrian rocks in the southeastern corner on a scale 1:12,000; his data were generalized and transferred to this map. Everything else was mapped at 1:24,000; Kaufman mapped the northeastern part; Woodward, Kaufman, and Anderson mapped the steeply dipping and faulted beds at the foot of Sierra Nacimiento. Woodward mapped the western two-thirds of the quadrangle.

STRATIGRAPHY

In this quadrangle the crystalline rocks are overlain by the Abo Formation (Permian). In adjacent areas of the Sierra Nacimiento the crystalline rocks are overlain by strata as old as Mississippian (Fitzsimmons and others, 1956). These crystalline rocks are probably Precambrian because the only major igneous and metamorphic events known for this region prior to Mississippian are dated as Precambrian (Muehlberger and others, 1967).

The suggested relative ages of these rocks are shown in the LEGEND; however, the evidence is not conclusive in all cases. Though not in contact with the gneiss, the quartz monzonite is probably younger because it has not undergone the regional synkinematic metamorphism that produced the gneiss. The pegmatite and aplite dikes transecting both the gneiss and the quartz monzonite are younger. The age relation of the mafic dikes and the pegmatite-aplite dikes is not known.

The Poleo Sandstone Member of the Chinle Formation (Triassic) thins southward and cannot be mapped south of Miguel Canyon. Here the Poleo is about two feet thick and consists of a bed of sandstone and a bed of pellet limestone. Where exposures of the Salitral, Poleo, and Upper Shale members are poor, these units cannot be distinguished; therefore, the Chinle is divided into two map units in the south, the Agua Zarca and the Salitral-Poleo-Upper Shale undifferentiated.

Where the upper part of the La Ventana Tongue of the Mesaverde Group intertongues northward with the lower part of the Lewis Shale, an arbitrary contact was drawn to these units.

Several areas covered with very large blocks (up to 20 feet across) of Agua Zarca Sandstone Member that have been let down during erosion of the underlying beds are interpreted and mapped as lag deposits (TQl). These blocks do not appear to have stratigraphic continuity with the underlying units, nor do they appear to be in tectonic contact.

STRUCTURE

Precambrian Deformation

Regional synkinematic metamorphism of the gneiss represents the oldest episode of deformation in the quadrangle. The quartz monzonite appears to have been emplaced after regional metamorphism; contacts with the metamorphic rocks are not exposed and evidence concerning the mechanism of emplacement is lacking. Shear zones in the Precambrian rocks began to develop during Precambrian time. Dikes were emplaced by dilation after crystallization of the quartz monzonite.

Paleozoic Deformation

Isopach maps by Wood and Northrop (1946) show that the Nacimiento area was a positive structural element during Pennsylvanian time and continued to show positive tendencies during Permian time, as evidenced by thinner strata here than in adjacent areas.

Laramide Deformation

Both major structural features, the Nacimiento uplift in the eastern part of the quadrangle and the San Juan basin to the west, are Laramide. These features are separated by a belt of steeply dipping and complexly faulted beds at the western foot of the Sierra Nacimiento. Structural relief is at least 9,000 feet and may be as much as 10,700 feet.

The belt of strongly deformed beds separating the uplift and the basin is up to one mile in width, and, in the northern three-fourths of the quadrangle, includes vertical to overturned strata. The synclinal bend formed by this belt (structure sections AA', BB', CC', and DD') marks the eastern edge of the San Juan basin.

Though dipping steeply at deep structural and stratigraphic levels, the Nacimiento fault flattens upward. Where preserved at high structural and stratigraphic levels, it dips gently (structure section CC'). Apparently it terminates near San Miguel Canyon. Also, in the northern part of the quadrangle are several subsidiary thrusts having the same attitude.

The principal stress causing the Nacimiento uplift and its associated synclinal bend and fault was vertical. The configuration of the upthrust is due partly to the initial fracture being a curved surface. The easterly-trending Blue Bird, San Pablo, and Trail Creek faults separate the uplift into several segments that have been uplifted different amounts. Several north-trending synthetic and antithetic high-angle faults along the range margin also appear to be related to development of the uplift; some have undergone the same relative sort of movement as the Nacimiento fault, and others may be the result of tension related to stretching of the uplifted block as it yielded horizontally over the basin (structure sections BB' and CC').

Near the southern boundary of the quadrangle is a high-angle west-dipping reverse fault formed mainly by tilting of basement blocks (structure section DD').

Evidence of right shift between the uplift and basin during their early development is seen in several northwest-plunging en echelon folds along the synclinal bend marking the eastern margin of the San Juan Basin (Kelley, 1955; Baltz, 1967). These folds are also of Laramide age. Thus, right shift between the uplift and basin was followed by the principal movement which was vertical.

ECONOMIC GEOLOGY

Earth Resources Company is currently developing the Nacimiento Copper Mine in the Agua Zarca Sandstone (Triassic) in the northern part of the quadrangle. The ore consists mainly of malachite, azurite, chrysocolla, and some chalcocite. Ore deposition occurred in channels containing carbonaceous fossil wood; chalcocite replaced fossil plants, and the copper carbonates and silicate occur in the interstices of the sandstone and conglomerate. Past production has been summarized by Elston (1967); reserves and grade of ore have not been disclosed. Lindgren and others (1910) reported that ore mined during early development ran one to three ounces of silver per ton. Other occurrences of copper mineralization in the Agua Zarca are shown on the map, but do not appear to be commercial. The prospect in the Nacimiento fault about one quarter mile south of Highway 126 consists of a tectonic slice of mineralized Agua Zarca.

Gypsum is found in the Todilto Formation (Jurassic), but steep dip and thick overburden preclude large-scale open pit mining of the gypsum.

Coal occurs in thin, lenticular beds in the Menefee Formation, the middle unit of the Mesaverde Group (Cretaceous). Some of these seams have been mined, currently a few on a small scale. Steep dip, thin seams, and excessive overburden preclude large-scale open pit mining.

Immediately south of this quadrangle coal and carbonaceous shale in the Mesaverde Group contain an average of 0.10 percent uranium (Bachman and others, 1959). Likely uranium is present in the Mesaverde Group in this quadrangle also, but geologic conditions already noted prevent large-scale mining of low-grade ore. A uranium prospect in the Dakota Formation (Cretaceous) is shown in the southern part of the quadrangle.

Tertiary-Quaternary terrace and pediment deposits are excellent sources of aggregate. The clasts consist mostly of Precambrian crystalline rocks up to two feet in diameter. These deposits are commonly rather thin, 2-10 feet, but locally up to 30 feet thick. Some are used for road surfacing and pit-run sub-base.

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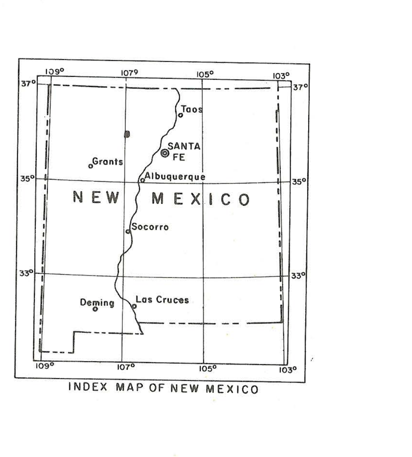
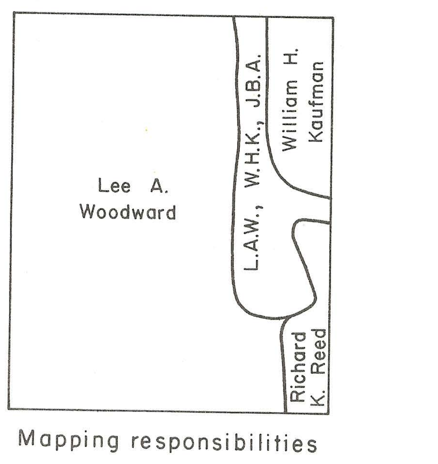


INDEX MAP OF NEW MEXICO



Mapping responsibilities