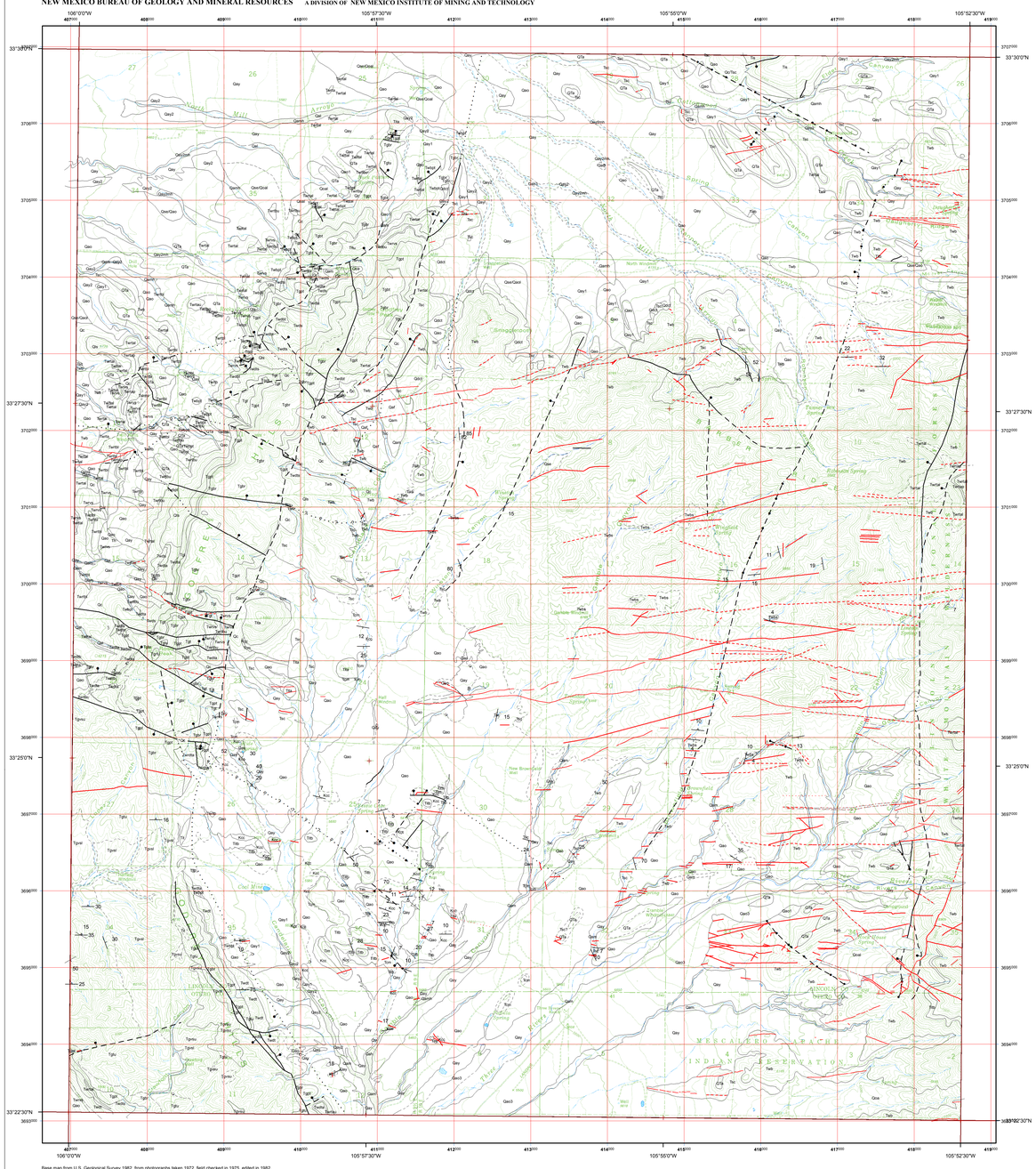
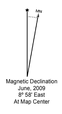
NEW MEXICO BUREAU OF GEOLOGY AND MINERAL RESOURCES A DIVISION OF NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY



Base map from U.S. Geological Survey 1982, from photographs taken 1972, field checked in 1975, edited in 1982.
New Mexico coordinate system, central zone, 1927 North American datum, Reprojected to UTM projection – zone 13N
1000-meter Universal Transverse Mercator grid, zone 13, shown in red

QUADRANGLE LOCATION



Magnetic Declination
June, 2009
8° 58' East
At Map Center

1:24,000

1 0.5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0.5 0 1 Kilometers

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

This draft geologic map is preliminary and will undergo revision. It was produced from either scans of hand-drafted originals or from digitally drafted original maps and figures using a wide variety of software, and is currently in cartographic production. It is being distributed in this draft form as part of the bureau's Open-file map series (OFGM), due to high demand for current geologic map data in these areas where STATEMAP quadrangles are located, and it is the bureau's policy to disseminate geologic data to the public as soon as possible.

After this map has undergone scientific peer review, editing, and final cartographic production adhering to bureau map standards, it will be released in our Geologic Map (GM) series. This final version will receive a new GM number and will supercede this preliminary open-file geologic map.

DRAFT

New Mexico Bureau of Geology and Mineral Resources
New Mexico Tech
Earth Science for the 21st Century

NEW MEXICO STATEMAP

Geologic map of the Godfrey Peak quadrangle, Lincoln & Otero Counties, New Mexico

June 2011
by
Shari Kelley [1], Kirt Kempter [2], Daniel Koning [1], Fraser Goff [3] and Colin Cikoski [1]

[1] New Mexico Bureau of Geology and Mineral Resources, Socorro, NM, 87801
[2] 2623 Via Caballero del Norte, Santa Fe, NM, 87505
[3] Earth and Planetary Sciences Dept., University of New Mexico, Albuquerque, NM 87131

New Mexico Bureau of Geology and Mineral Resources
Open-file Map Series
OFGM 136

Mapping of this quadrangle was funded by a matching-funds grant from the STATEMAP program of the National Cooperative Geologic Mapping Act, administered by the U. S. Geological Survey, and by the New Mexico Bureau of Geology and Mineral Resources, (Dr. Peter A. Scholle, *Director and State Geologist*; Dr. J. Michael Timmons, *Geologic Mapping Program Manager*).

New Mexico Bureau of Geology and Mineral Resources
New Mexico Tech
801 Leroy Place
Socorro, New Mexico
87801-4796

[505] 835-5490
http://geoinfo.nmt.edu

COMMENTS TO MAP USERS

A geologic map displays information on the distribution, nature, orientation, and age relationships of rock and deposits and the occurrence of structural features. Geologic and fault contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic quadrangle map may be based on any of the following: reconnaissance field geologic mapping, compilation of published and unpublished work, and photogeologic interpretation. Locations of contacts are not surveyed, but are plotted by interpretation of the position of a given contact onto a topographic base map; therefore, the accuracy of contact locations depends on the scale of mapping and the interpretation of the geologist(s). Any enlargement of this map could cause misunderstanding in the detail of mapping and may result in erroneous interpretations. Site-specific conditions should be verified by detailed surface mapping or subsurface exploration. Topographic and cultural changes associated with recent development may not be shown.

Cross sections are constructed based upon the interpretations of the author made from geologic mapping, and available geophysical, and subsurface (drillhole) data. Cross-sections should be used as an aid to understanding the general geologic framework of the map area, and not be the sole source of information for use in locating or designing wells, buildings, roads, or other man-made structures.

The map has not been reviewed according to New Mexico Bureau of Geology and Mineral Resources standards. The contents of the report and map should not be considered final and complete until reviewed and published by the New Mexico Bureau of Geology and Mineral Resources. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the State of New Mexico, or the U.S. Government.

Unit descriptions

Quaternary Deposits

Qam Modern alluvium (Holocene): Modern sand and gravel in active stream bottoms that are generally incised at least a meter below adjoining **Qay** or **Qao** surfaces. 1-3(?) meters thick.

Qamh Modern and historical alluvium (Holocene): sand and gravel that includes modern sediment and historical sediment that are generally incised at least 0.5 meters below adjoining **Qay** or **Qao** surfaces. 1-3(?) meters thick.

Qc Undivided colluvium (Holocene): Hillslope colluvial deposits composed of pebble to boulder size clasts from a variety of rock types. Common on north-facing slopes. Varies in thickness from ~ 5 – 50 m.

Qls Landslide deposit (Holocene): locally derived blocks of trachyte bedrock associated with a head scarp in cliffs along the western escarpment of the Godfrey Hills.

Qse Eolian deposits modified by slope wash (Holocene): fine-grained tan very fine windblown sand intermixed with granules and pebbles of local rocks. 1-3 m.

Qtr Travertine and carbonate cemented gravel (Holocene): large deposit of carbonate cemented gravel and banded travertine forms a prominent knickpoint in a small tributary off of Gamble Canyon in the southwestern corner of the area. <5 m thick

Qay2mh Alluvium inset in recent valleys (Late Holocene to modern): Unit includes three inset units found within a larger valley eroded in the middle to late Holocene. These units include modern, historical, and late Holocene alluvium (as described in units **Qam**, **Qamh,** and **Qay2).**

Qay Younger alluvium, undifferentiated (Holocene): Units Qay2 and Qay1 undifferentiated, see individual descriptions for more information. Used where the two units cannot be separated due to the scale used or due to the lack of a surficial expression of their individual distributions. 0.5 to 4 m thick.

Qay2 Pre-historical alluvium in relatively narrow valleys (middle(?) to late Holocene): Pebbly sand with minor sandy pebble beds, locally clayey. Internally massive to well-bedded; sand and pebble beds are commonly laminated to thin and tabular. Soil is marked by a stage I carbonate morphology. Moderately consolidated. Greater than 2 meters thick.

Qay1 Alluvium capping older alluvial deposits (early(?) to middle Holocene) – Poorly bedded to internally massive pebbly sand and clayey sand. Sand is brownish and very fine- to very coarse-grained. Very fine- to fine-grained sand fraction may have abundant gypsum grains; medium- to very coarse-grained sand is composed of volcanic grains. Topsoil is marked by stage II to I+ carbonate horizon, where there are minor (<10%) soft, calcium carbonate nodules equal or less than 1 cm. Moderately consolidated and 1-3 m-thick.

Qdct Debris flows, colluvium, and talus deposits (middle Pleistocene to Holocene) – Very poorly sorted pebbles and cobbles, with lesser boulders, in a sand to clayey sand matrix. Sand is poorly sorted. No bedding. Unit deposited primarily by debris flows, with colluvium and talus found at the base of steep slopes. Weakly to moderately consolidated. Commonly several meters thick.

Qao Older alluvium (middle to late Pleistocene) – Pebbly sand, sandy gravel, sand, and clayey-silty sand. Sediment is in very thin to medium-bedded, tabular beds. Topsoil generally contains a calcic horizon with stage III carbonate morphology. Generally assigned to either **Qao1, Qao2, or Qao3** based on the relative height of the surface capping each deposit, but these divisions are entirely allostratigraphic and not based on sediment characteristics.

Qao3 Older alluvium, youngest subunit (upper? Pleistocene). Gravel and sand characterized by strongly developed carbonate horizons and buried soils capped by a surface inset upon that of **Qao2**. See descriptions below. 1- 3 m thick.

Qao2 Older alluvium, younger subunit (upper? Pleistocene). Gravel and sand characterized by strongly developed carbonate horizons and buried soils capped by a surface inset upon that of **Qao1**. See description of **Qao** for a description of this unit's sediments. As no sedimentary difference could be established between deposits of **Qao1** and **Qao2**, these deposits could be the same with the lower surface being entirely erosional. This problem also precludes confidently determining the deposit's thickness, but it is probably 1 to 3 m thick.

Qao1 Older alluvium, older subunit (middle? to upper Pleistocene). Gravel and sand characterized by strongly developed carbonate horizons and buried soils capped by a surface inset upon by **Qao2**. See description of **Qao** for a description of this unit's sediments. As no sedimentary difference could be established between deposits of **Qao1** and **Qao2**, these deposits could be the same with the lower surface being entirely erosional. Thickness is difficult to determine as the basal contact is often poorly exposed, but **Qao1** is 1 to at least 10 m thick.

QTa High-level sand and gravel deposits (late Pliocene-early Pleistocene?) – Deposit consists of rounded gravels that are donated by syenite at the base of Sierra Blanca and by trachytic lavas at the base of the Godfrey Hills. The unit is poorly exposed. In general, base of deposit lies above modern surfaces developed on units Qay and Qao. 2-4 m thick.

Neogene Volcanic Rocks

Godfrey Hills Formation

Tgvsu Upper volcaniclastic sediments (Oligocene): heterolithic landslide deposit with a white ashy matrix that contains large (1-5 m) angular boulders of porphyritic trachyandesite, Palisades tuff, and trachyandesite breccia. In places the stratigraphy of the debris is in the appropriate order but the units are thoroughly brecciated. 5-15 m thick.

Tgvsl Lower volcaniclastic sediments (Oligocene): sandy, matrix-supported, carbonate- cemented conglomerate that contains upper trachyte lava as the dominate clast. The clasts are angular and <0.5 m in diameter The pronounced imbrication in the deposit indicates flow toward 20° to 90°. 30 m thick.

Tgtu Upper trachyte to trachyandesite (Oligocene): light to dark gray fine-grained lava with a trachytic texture and contorted platy flow foliation. Microphenocrysts are aligned plagioclase, pyroxene, and magnetite. The unit is composed of a series of thin flows 1-10 m thick with basal scoriaceous breccia and vesicular flow tops with elongated vesicles. Red to yellow alteration of the flow breaks is common. Base fills paleocanyons, top is eroded by modern processes or is cut by Oligocene paleocanyons. 50 m thick.

Tgbr Trachyandesite breccia (Oligocene): light gray trachyandesite lava flows with phenocrysts (<5-7%) of sanidine and pyroxene interbedded with monolithologic breccia with subround to angular clasts in a light gray matrix. $^{40}Ar/^{39}Ar$ ages of 28.59±0.05 Ma and 28.53±0.03 Ma obtained from sanidine in the unit (Peters, personal communication, 2010). 60-70 m thick.

Tgbt Biotite trachyte breccia (Oligocene): trachyte lava flows that are similar to **Tgbr** flows, but this lava contains biotite in addition to sanidine and pyroxene. Furthermore, the flows are lighter gray in color and are more sugary in texture compared to typical Tgbr flows. This lava is separated from the overlying **Tgbr** flows by a distinct, mappable flow break. The trachyte breccia is present only on Godfrey Peak and on hills northwest of Godfrey Peak. 60-70 m thick.

Tgpt Palisades tuff (Oligocene): Cliff-forming welded tuff with pronounced eutaxitic foliation and taphony weathering texture. Contains < 2% lithic fragments composed of trachyandesite and trachyte lavas. Phenocrysts include plagioclase, sanidine, pyroxene, magnetite, and sparse biotite and hornblende. $^{40}Ar/^{39}Ar$ ages of 28.67±0.07 Ma and 28.66±0.08 Ma were obtained from sanidine in the tuff (Peters, personal communication, 2010). Geochemically, this tuff is a trachyte (see appendix). 25-90 m thick.

Tgt Trachyte flows (Oligocene): Cliff-forming succession of light gray flow-banded lava flows and flow breccias of trachyte with ~10% phenocrysts of plagioclase, biotite, and pyroxene. Other phenocrysts include twinned feldspar, magnetite, and apatite. 60-70 m thick.

Walker Group

Published K-Ar and $^{40}Ar/^{39}Ar$ ages for the Walker Group lavas and breccias are 29.3-37.3 Ma (Moore et al., 1991).

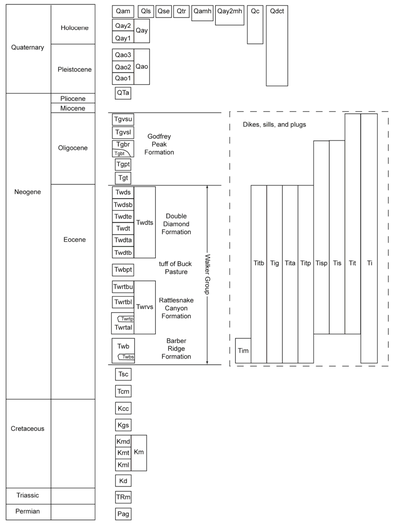
Double Diamond Formation

Twdts Intercalated alkaline lava flows and volcaniclastic sediments (Oligocene to Eocene): interval of thin to thick (1-10 m) discontinuous trachyte, porphyritic trachyandesite, biotite trachyte, and trachybasalt flows complexly intercalated with volcaniclastic sediments (**Twds**). The volcaniclastic sediments are sandy conglomerate with subangular to subrounded pebbled, cobbles and boulders of trachytic lava. The deposits are poorly sorted and bedding is not distinct. 90 to 100 m.

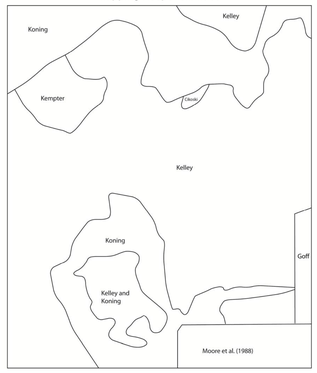
tuff of Buck Pasture

Twbpt tuff of Buck Pasture (Oligocene to Eocene): Welded to unwelded lithic-rich tuff. The lithic fragments are angular pieces of trachytic lavas. The phenocrysts are sanidine, plagioclase, biotite, and pyroxene. The tuff contains mafic clots that are flattened near the base and that are rounded to embayed, but more equant, upsection. The mafic clots are reddish brown with crystals of plagioclase and pyroxene (5-7%) set in a fine-medium grained pinkish tan matrix. Thickness highly variable 1 – 100 m; fills paleovalleys.

Correlation Chart for Godfrey Peak 7.5-Minute Quadrangle



Mapping Responsibilities



Neogene Intrusive Rocks

Attempts to date dikes and sills on the Golondrina Draw quadrangle to the south of the Godfrey Peak quadrangle have met with limited success because of the lack of datable minerals and alteration. The ages of dikes and sills associated with Sierra Blanca are likely 37 to 42 Ma, based on $^{40}Ar/^{39}Ar$ age determinations for dikes and sills in the Three Rivers area to the west and in the Sacramento Mountains to the southeast (McManus and McMillan, 2002). New dates of poor quality on sills to the south are 36 to 38 Ma.

Mineralization is generally absent along the dikes and sills. The dikes frequently occur in subparallel pairs separated by 5 to 10 m. Dikes generally fill fractures, are 1 to 2 m wide, and commonly strike E-W. Some dikes are up to 7 m wide. Dikes do, on occasion, fill faults, but the dikes generally are not deformed by reactivation of the filled faults. An exception to this observation is the porphyritic trachyte dike SSE of Halfway Windmill, which is brecciated in a N-striking fault zone. E-W dikes clearly cut N-S dikes at UTM coordinates 13 S 417534 3694662 (NAD 27). Near Hall Windmill, the syenite dike with the more E-W strike cuts the syenite dike with the slightly more northeasterly strike.

Ti undifferentiated dikes and sills mapped from air photos.

Tit Porphyritic trachyte (Miocene?-Eocene): dikes and sills of light-gray porphyry with 5 to 15% phenocrysts of plagioclase feldspar, biotite ± hornblende, and dark green pyroxene that are 1-10 mm across. $^{40}Ar/^{39}Ar$ dating of sanidine from a dike of this composition cutting the Palisades tuff on the east side of Rose Peak yielded a range of ages between 29 (~ age of the Palisades tuff) and 18 Ma. The older ages are likely xenocrysts incorporated into the dike and the youngest ages of 18 Ma provide a maximum age of the dike.

Tis/Tisp Syenite (Eocene): pink, medium-grained equigranular sill composed of potassium feldspar, plagioclase feldspar, pyroxene, and hornblende. Tisp has a similar composition, but contains 5-20 mm phenocrysts of feldspar.

Titp Porphyritic dikes with aligned plagioclase (Eocene): Dikes of light gray to dark-gray porphyry with 15 to 25% plagioclase laths 10 to 20 mm long set in an equigranular to fine-grained matrix of dark green pyroxene and feldspar. The plagioclase laths are often distinctly aligned parallel to the margins of the dike. Dikes 1 to 4 m wide.

Tita Porphyritic trachyandesite (Eocene): dikes and sills of light-gray porphyry with 5 to 15% phenocrysts of plagioclase feldspar, dark green pyroxene, and potassium feldspar that are 1-10 mm across. These intrusive bodies may grade into more equigranular textures (Tig). Syenitic and sedimentary xenoliths are locally present. This unit includes intrusive bodies to the east of Rose Peak and north of Buck Pasture Spring.

Titb Fine-grained trachybasalt (Eocene): Black to dark green, most are aphanitic, but some are fine-grained dikes with barely discernable needles of plagioclase and pyroxene. Dikes 1 to 2 m wide.

Tig Alkali gabbro-syenogabbro (Eocene): equigranular, fine- to medium-grained, salt-and-pepper textured dikes and sills with plagioclase feldspar and pyroxene phenocrysts. These intrusive bodies may grade into more porphyritic textures (Tita). Alkali gabbro may contain amphibole and biotite (Moore et al., 1988).

Tim Megacrystic trachyte porphyry (Eocene): greenish gray porphyritic sills and dikes with megacrysts of embayed tschermakitic hornblende or green pyroxene that are up to 2 to 4 cm across. Often contains hornblende ± biotite. These intrusives can contain xenoliths of pink coarse-grained syenite with phenocrysts of orthoclase feldspar and hornblende.

Neogene Sedimentary Rocks

Tsc Sanders Canyon Formation (Eocene): Purplish maroon to red siltstone with gray to tan tabular sandstone beds. Sand grains include biotite. Conglomeratic intervals contain mud rip up clasts and volcanic pebbles, including crystal rich-porphyritic hornblende and biotote dacite. Pedogenic carbonate nodules are common. Thin (< 1 m) black micritic limestone beds are exposed in two places near the top of the unit. 260-380 m thick.

Tcm Cub Mountain Formation (Eocene): Yellow cross-bedded sandstone and maroon mudstone. Mud clasts conglomerates occur higher in the section . Sandstone is medium to coarse grained and is poorly- to well-sorted, with angular sand grains of quartz, feldspar (often altered to clay), and black lithic fragments. Bedding is tabular to cross-bedded to ripple-laminated. The base and the top are not exposed. 350-390 m thick.

Mesozoic Sedimentary Rocks

Kcc Crevasse Canyon Formation (Upper Cretaceous): A yellow-tan trough cross-bedded sandstone is present near the upper contact of the Crevasse Canyon Formation. This sandstone generally contains well-rounded pebbles and cobbles of quartz and chert. The troughs indicate flow toward 30 to 60°. 550 m thick.

On cross section only

Kgs Gallup Sandstone (Upper Cretaceous): Distinctive white to tan, poorly cemented sandstone with high to low-angle cross stratification. 150 m thick.

Km Mancos Shale (Upper Cretaceous):
Kmd: D-Cross Shale Member 90 m thick
Kmt: Tres Hermanos Member 30 m thick
Kml: lower shale member 105 m thick

Kd Dakota Sandstone (Upper Cretaceous): Medium to thick-bedded to thinly laminated, medium- to coarse-grained, cross bedded white sandstone with lenses of dark gray shale. 90 m thick.

TRm Moenkopi Formation (Upper Triassic): Red-brown, fine-grained, thin bedded, trough cross-bedded to ripple laminated sandstone. 100 m thick.

Pag Grayburg Formation, Artesia Group (Permian): red siltstone with green reduction spots, red mudstone, and massive gypsum. Siltstone is massive to occasionally cross-laminated.