The Geology and Mining History of Mining Districts in Grant County, New Mexico

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ACKNOWLEDGEMENTS

- New Mexico Energy, Minerals and Natural Resource Department
- Company annual reports
- Personal visits to mines
- Historical production statistics from U.S. Bureau of Mines, U.S. Geological Survey, N.M. Energy, Minerals and Natural Resource Department (NM MMD), company annual reports
- Students at NM Tech
- New Mexico Mining Association

Outline

- Importance of minerals
- Copper in Grant County
- Gold in Grant County
- Summary

Historic photos are from the NMBGMR photo archive

Recent photos by myself

Silver City

- Silver City is the only New Mexico community still operating under its original territorial charter
- Historic document signed February 17, 1878
- Silver City was founded about 1870, shortly after silver was discovered at Chloride Flat by Captain John M. Bullard
- This area has a rich mining, ranching history as well as prehistoric cultures
- Ultimately became the center of commerce for the area

IMPORTANCE OF MINERALS

- NM has some of the oldest mining areas in the United States
- Native Americans mined turquoise from Cerrillos Hills, Tyrone and Santa Rita districts more than 500 yrs before the Spanish settled in the 1600s
- One of the earliest gold rushes in the West was in the Ortiz Mountains (Old Placers district) in 1828, 21 yrs before the California Gold Rush in 1849

One of the turquoise mines in the Cerrillos Hills district

Importance of minerals

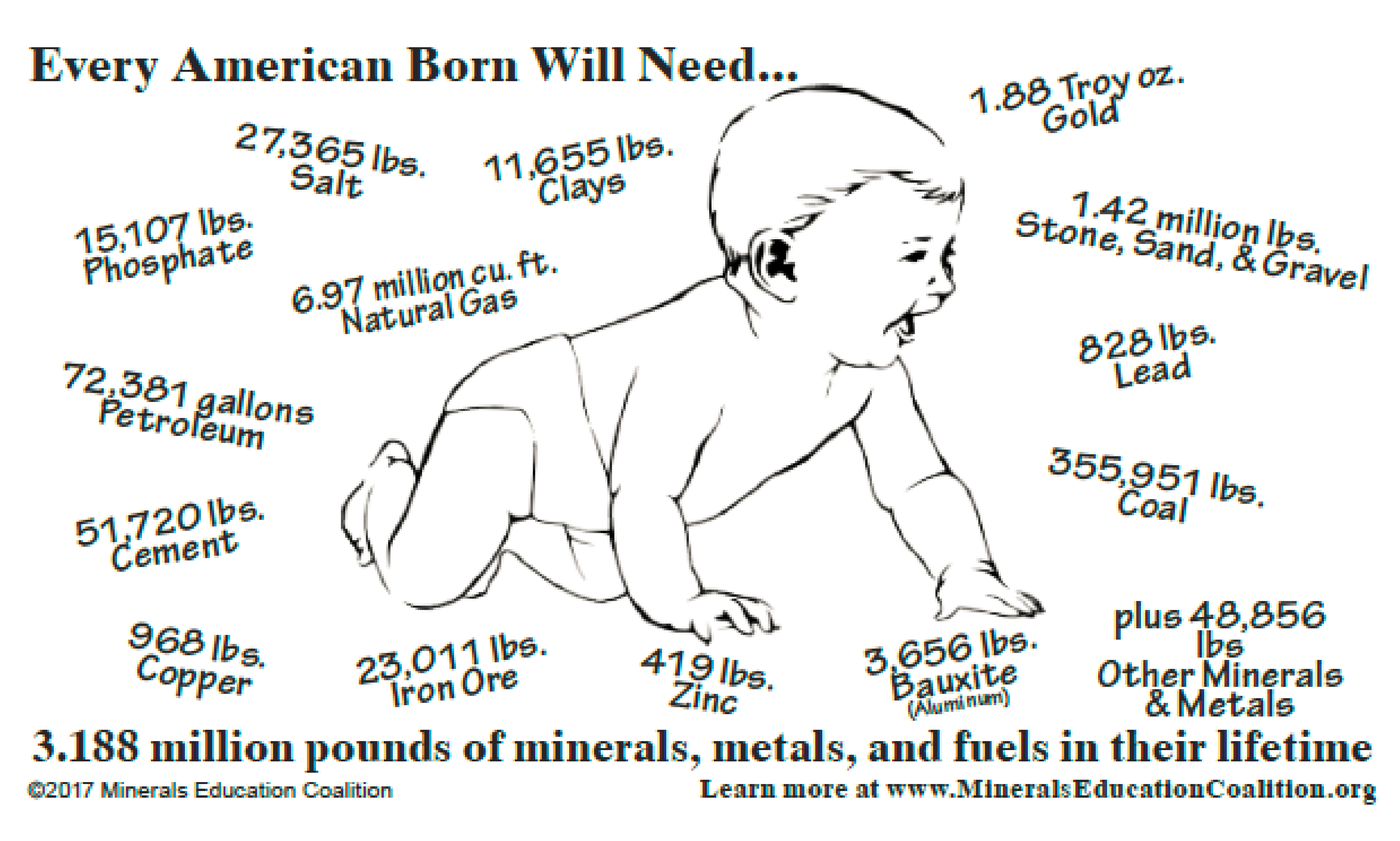
- Mining of minerals began with prehistoric man who wanted to improve their way of life
- Ancient cultures often settled time after time around areas that provided raw materials
- 300,000-100,000 years ago mining of flint in N France and S England
- Throughout history, wars were fought over natural resources

Important Cultural Eras

- Stone Age (prior to 4000 B.C.)
- Bronze Age (4000 to 5000 B.C.)
- Iron Age (1500 B.C. to 1780 C.E.)
- Steel Age (1780 to 1945)
- Nuclear Age (1945 to the present)

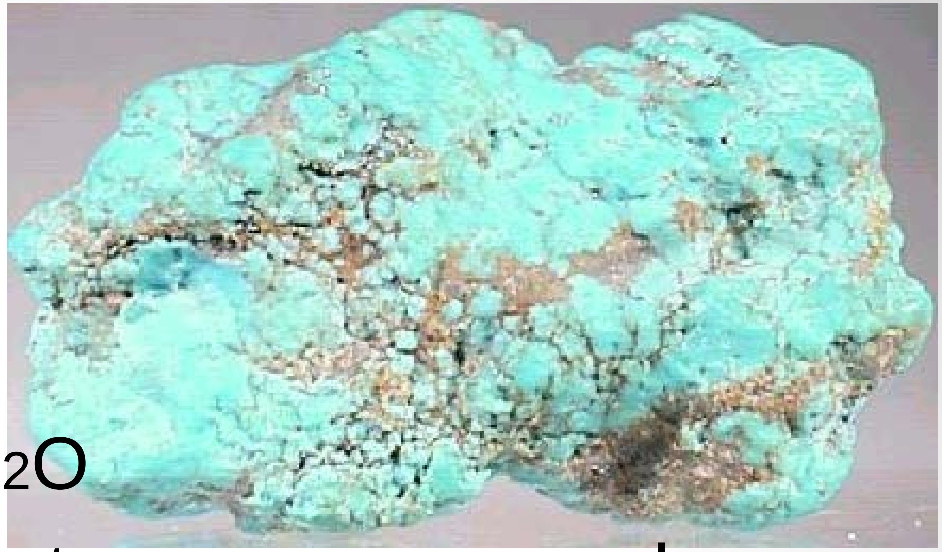
Native Americans depended upon minerals for their survival

- Obsidian and chert used for projectile points and cutting tools
- Clay for pottery
- Adobe and stone for construction of their homes
- Turquoise, native copper, gold, and other metals/gems for decoration and trade
- Hematite, malachite, other natural pigments used for decoration, paint, glazes
- Raw materials for pottery glazes
- Salt for preservatives, processing of silver, taste



https://mineralseducationcoalition.org/wp-content/uploads/2017-Mineral-Baby-Image.pdf

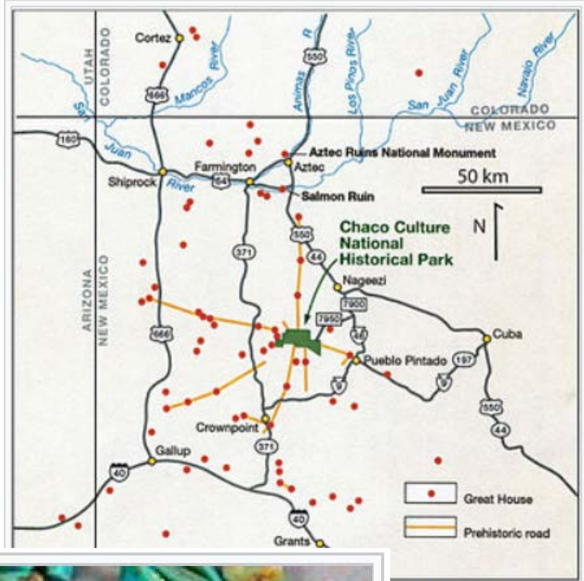
TURQUOISE



- $Cu\,Al_6\,(PO_4)_4\,(OH)_8 \cdot 4H_2O$
- believed to bring good fortune, success, and health, protect from danger
- thought by some to cure disease
- most turquoise is found near copper deposits in arid or semi-arid environments, typically near the surface
- name means Turkish stone, trade routes went through Turkey

Chaco Canyon, northern New Mexico

- turquoise was in use by about 750 A.D.
- excavations of features dating from 900 to 1150, have uncovered more than 100,000 pieces of turquoise
- at Pueblo Bonito more than 65,000 artifacts, fragments, and unworked pieces of turquoise were found
- no known prehistoric mines are in this area; all that turquoise was imported



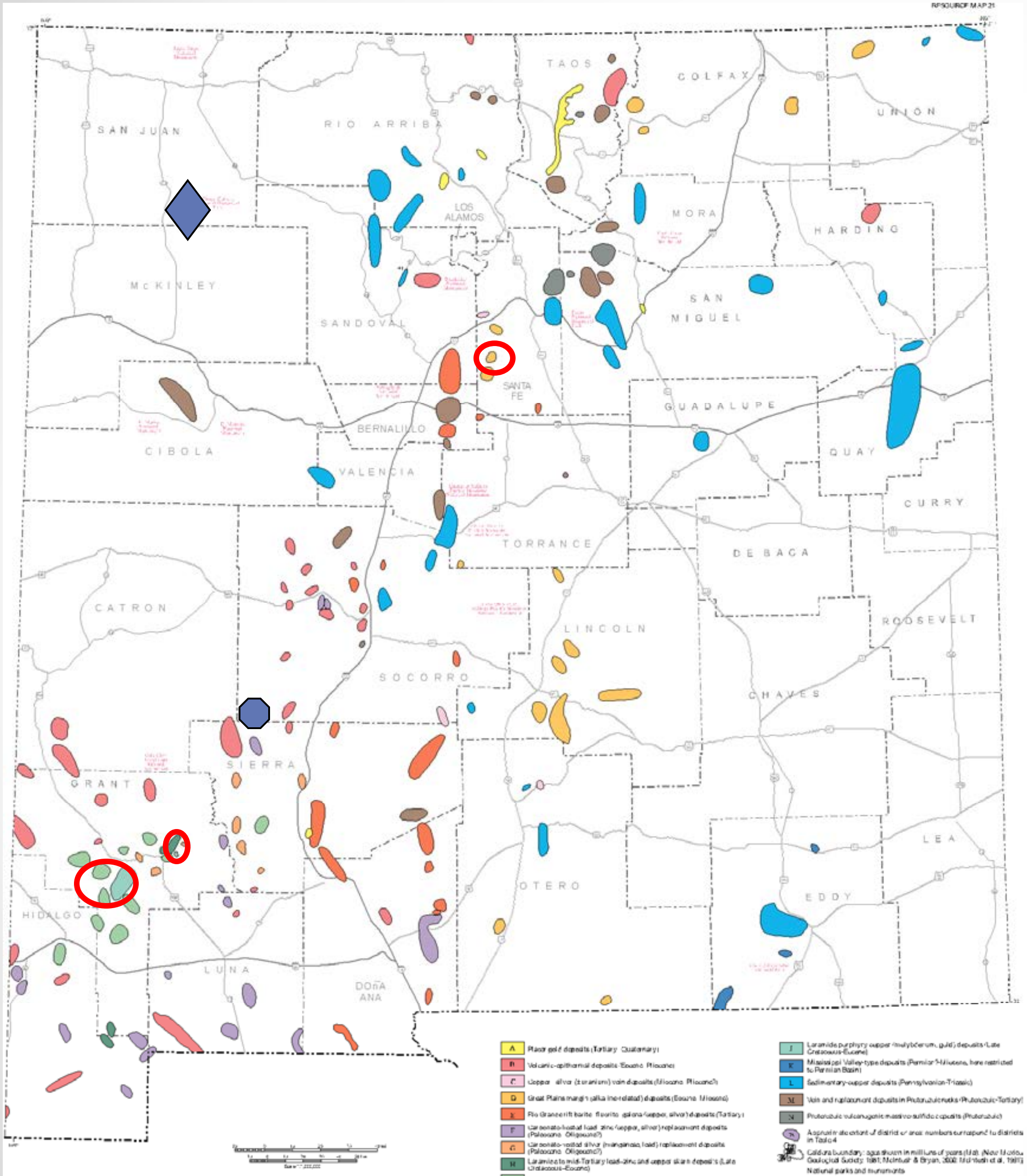
San Juan Basin,
roads and

Around 200,000 pieces of turquoise have been excavated from the ruins at Chaco Canyon. These turquoise and argillite (red) beads were found at Pueblo Alto.[66]

https://en.wikipedia.org/wiki/Chaco_Culture_National_Historical_Park

LOCALITIES

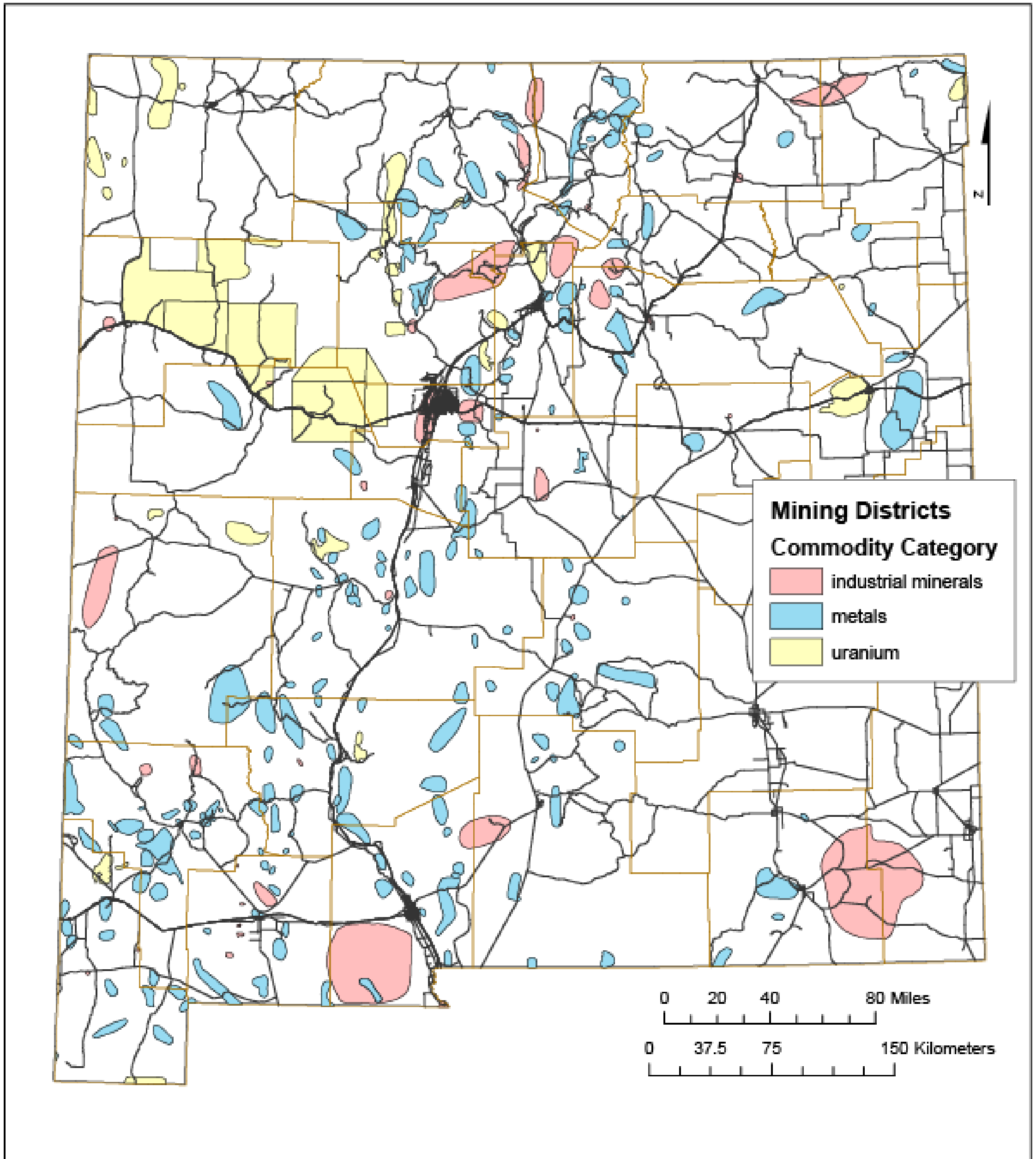
- Burro Mountains, New Mexico
- Santa Rita, New Mexico
- Cerrillos mining district, New Mexico
- Kingman, Arizona
- Morenci, Arizona
- Conejos, Colorado

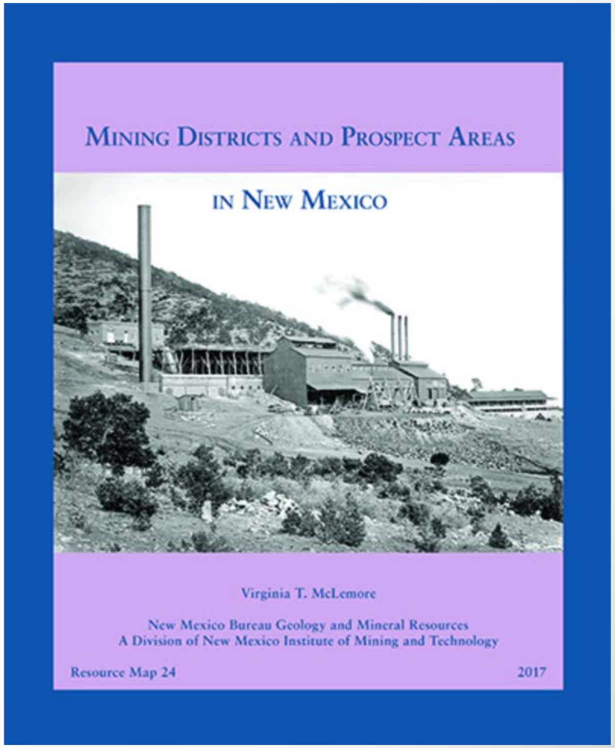

SAN JUAN
RIO ARRIBA
TAOS
COLFAX
UNION
McKINLEY
SANDOVAL
LOS ALAMOS
MORA
HARDING
SAN MIGUEL
SANTA FE
GUADALUPE
QUAY
CIBOLA
BERNALILLO
VALENCIA
TORRANCE
CURRY
DE BACA
ROOSEVELT
CATRON
LINCOLN
SOCORRO
CHAVES
SIERRA
GRANT
LEA
OTERO
EDDY
HIDALGO
LUNA
DOÑA ANA

TURQUOISE

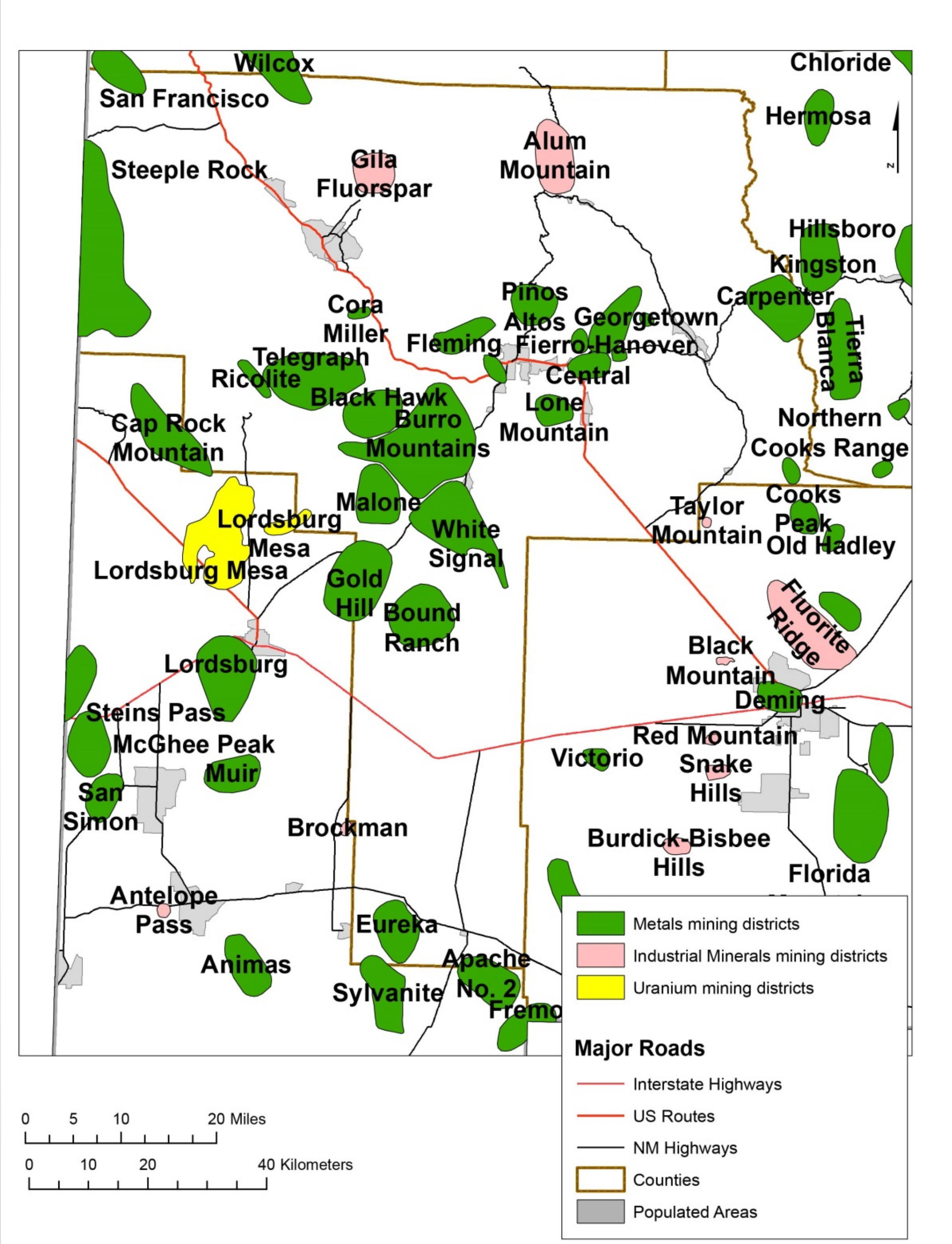
Geology and Mining History in Grant County

Mining districts in New Mexico

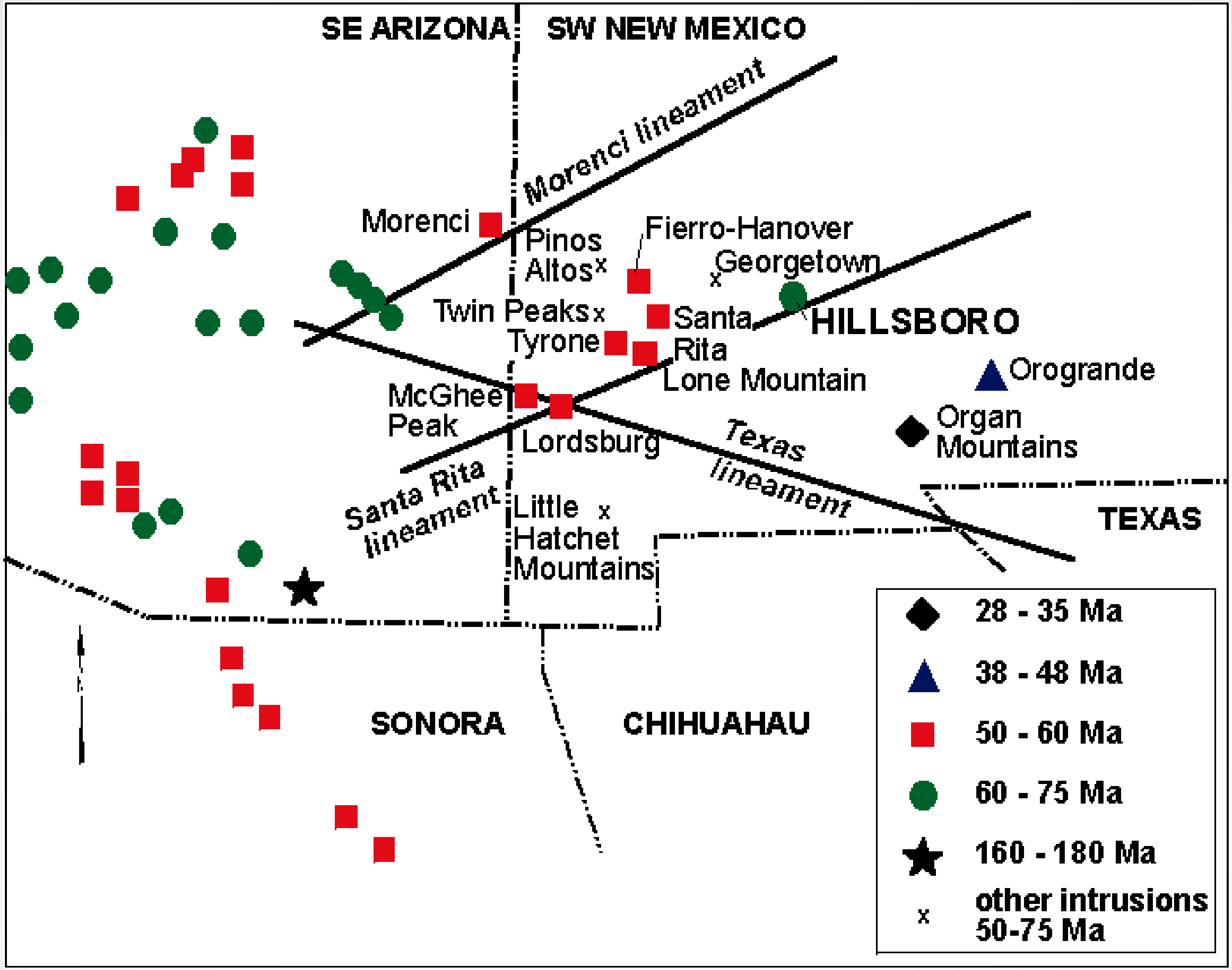




Mining districts in Grant County



Copper in Grant County, New Mexico



New Mexico is at the edge of one of the world’s greatest metal-bearing provinces

TABLE 2—Major copper districts in New Mexico (compiled by V. T. McLemore from U.S. Geological Survey, 1902–1927; U.S. Bureau of Mines, 1927–1994; and various published and unpublished sources, including company annual reports). District number refers to Fig. 1.

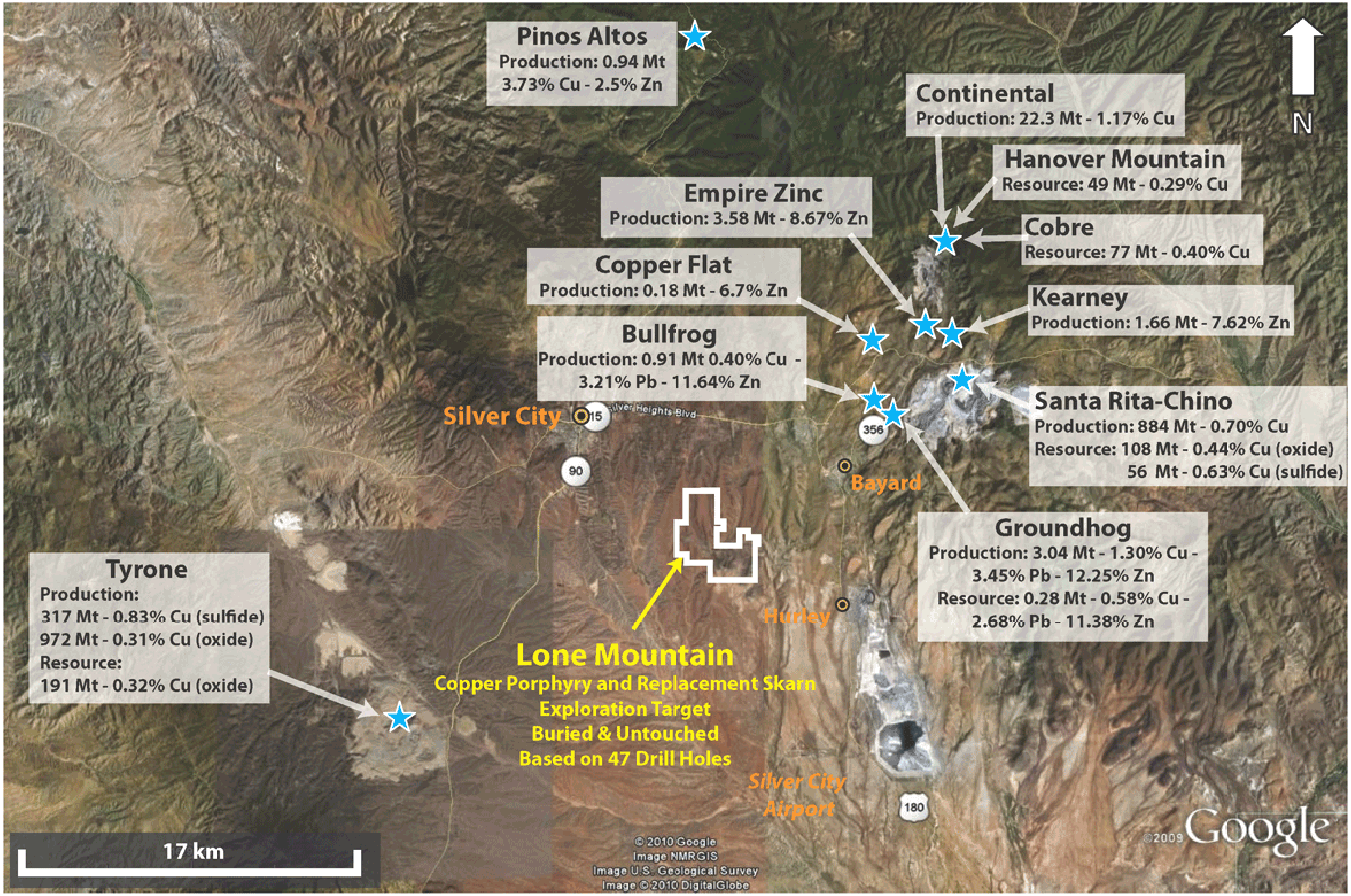
District	County	Estimated copper production (lbs)	Type(s) of deposit	Major commodities
1. Santa Rita (Chino)	Grant	9,080,000,000	Porphyry copper	Cu (Ag, Au, Mo)
2. Burro Mountains (Tyrone)	Grant	5,240,000,000	Porphyry copper, Laramide vein	Cu (Ag, Au)
3. Fierro–Hanover	Grant	1,250,000,000	Laramide skarn, prophyry copper	Cu, Zn, Pb
4. Lordsburg	Hidalgo	229,577,000	Laramide vein	Cu, Au, Ag, Pb, Zn
5. Bayard	Grant	110,000,000	Laramide vein	Zn, Cu, Ag, Pb
6. Pinos Altos	Grant	59,500,000	Laramide skarn, Laramide vein	Cu, Zn, Pb, Ag (Au)
7. Willow Creek	San Miguel	18,687,426	Volcanogenic massive sulfide	Zn, Pb, Cu, Ag
8. Hillsboro	Sierra	17,000,000	Laramide vein, porphyry copper	Cu, Au (Ag, Pb)
9. New Placers	Santa Fe	17,000,000	Great Plains margin	Cu, Au, Ag (Pb, Zn)
10. Pastura	Guadalupe	13,578,214	Sedimentary copper	Cu (Ag, Pb)
11. Magdalena	Socorro	12,000,000	Carbonate-hosted Pb-Zn replacement	Zn, Pb, Cu (Ag)
12. Gallinas	Lincoln	8,000,000	Great Plains margin, sedimentary copper	Cu, Pb (Ag, Zn)
13. Nacimiento	Sandoval	7,561,567	Sedimentary copper	Cu (Ag)
14. Orogrande	Otero	5,700,000	Great Plains margin skarn	Au, Cu (Ag, Pb, Zn)
15. Organ Mountains	Doña Ana	4,636,000	Carbonate-hosted Pb-Zn replacement	Pb, Zn, Cu, Ag (Au)
16. Jicarilla	Lincoln	4,201,474	Great Plains margin	Au, Ag, Cu
17. Chloride	Sierra	3,060,000	Volcanic epithermal	Ag, Pb (Au, Cu)
18. Mogollon	Catron	1,500,000	Volcanic epithermal	Ag, Au, Pb, Cu
19. Apache No. 2	Hidalgo	1,300,000	Carbonate-hosted Pb-Zn replacement	Ag (Pb, Zn, Cu)
20. Steeple Rock	Grant	1,200,000	Volcanic epithermal	Ag, Au, Pb, Zn, Cu
Estimated total New Mexico	all	16,720,000,000	all	—

Copper in New Mexico

http://geoinfo.nmt.edu/publications/periodicals/nmg/18/n2/nmg_v18_n2_p25.pdf

Copper reserves—2016

- Chino
  - milling reserves are 135 million tons of 0.59% copper, 0.04 g/t gold and 0.01% molybdenum
  - leaching reserves are 91 million tons of 0.28% Cu
- Tyrone
  - leaching reserves are estimated as 6 million tons of ore grading 0.51% Cu
  - Expected to close 2019
- Cobre
  - leaching reserves are 13 million tons of 0.57% Cu
- Niagara deposit
  - contains 500 million tons of ore grading 0.29% Cu (leaching)



Production & Resource Figures from Major Copper Mines in New Mexico

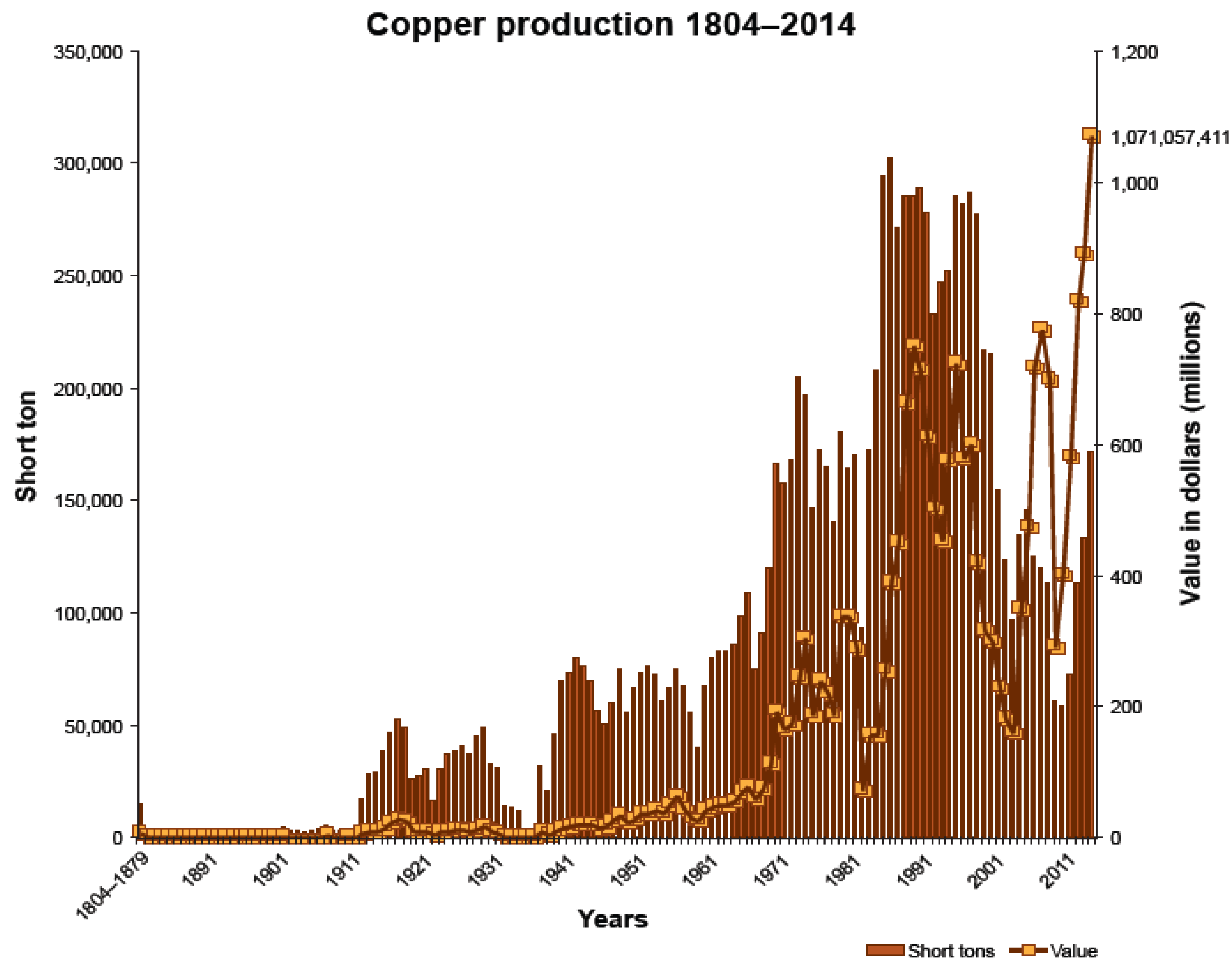


FIGURE 3. Copper production in New Mexico from 1882 to 2014.

- >11.5 million tons, $20.6 billion, 1804-2014

HISTORY

- Native Americans
- 1798 Col. Manuel Carrasco began mining
  - Est 6 mill lbs Cu per yr 1804-1809
- 1881 stamp mill and minor production
- 1904 John M. Sully arrived and began exploration and development
- 1910 production from the open pit began
- 2003 In 2003, Phelps Dodge became the sole owner
- 2007 Chino Mines joined Freeport-McMoRan

Apache Indian discloses the location of the Santa Rita del Cobre to Col. Carrasco, a Spanish Military officer in ca 1804

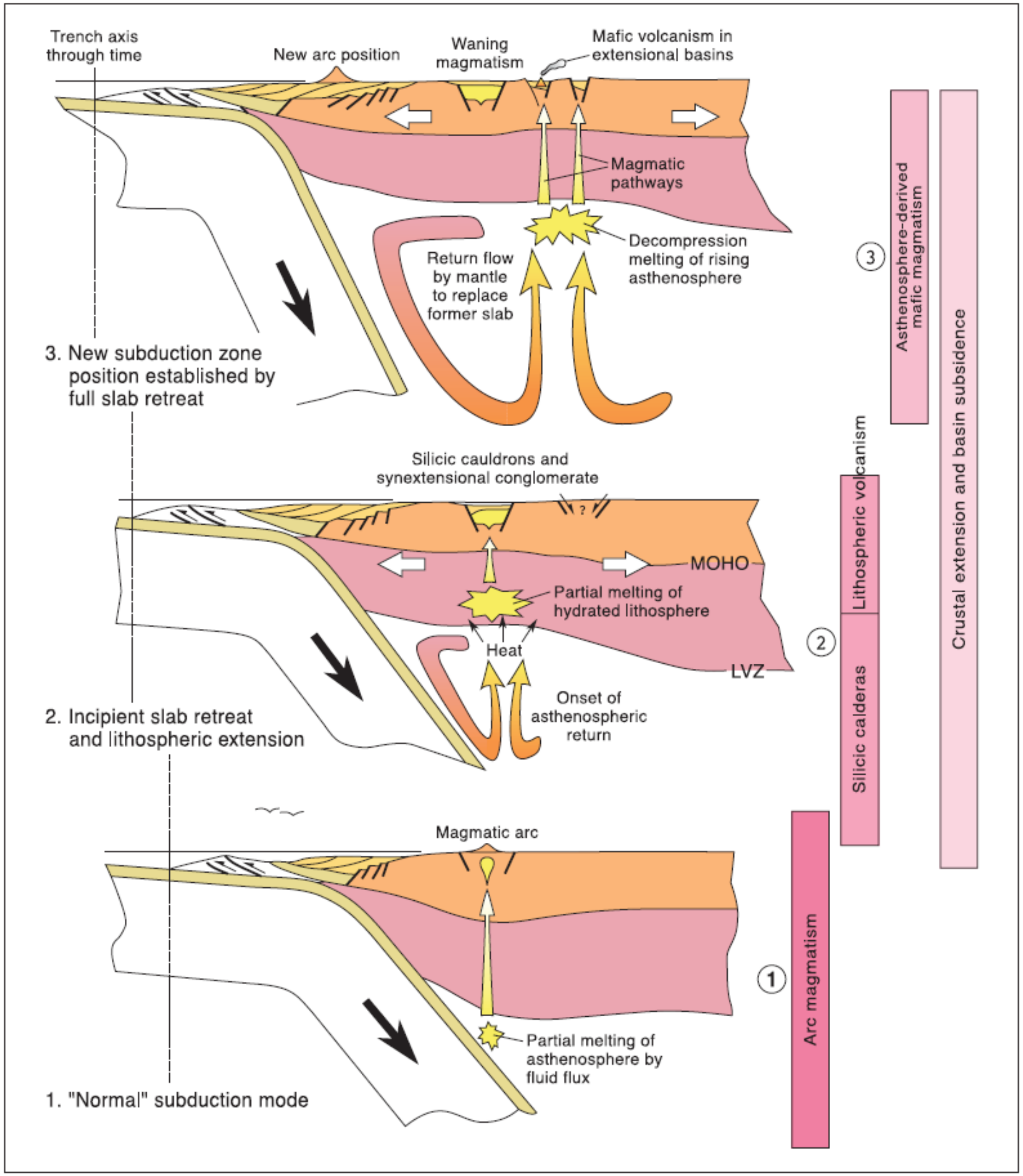
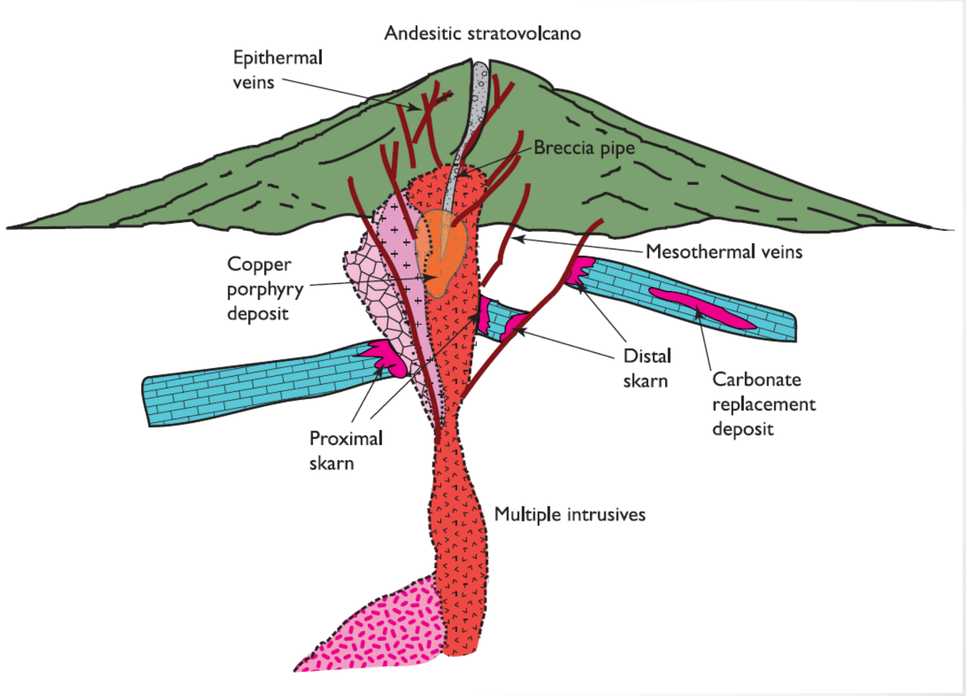


FIGURE 6—Tectonic model for creation of passive continental rift above foundering subducted slab. Redrawn from Lawton and McMillan (1999) with permission of the Geological Society of America.

Magmatic processes

- The Chino and Tyrone deposits are copper porphyry (molybdenum, gold) deposits, which are large, low-grade (<0.8% Cu) deposits that contain disseminated and stockwork veinlets of copper and molybdenum sulfides associated with porphyritic intrusions
- 59-60 Ma ago



The sources for the variety of mineral phases and chemical elements found in porphyry copper deposits

- Primary phases formed in the magma chamber and preserved in the rock (feldspar, quartz, pyroxene, amphibole, magnetite, apatite, etc.)
- Primary ore minerals formed during the main mineralization phase (chalcopyrite, pyrite, etc.)

Hydrothermal alteration

- *Hypogene alteration* occurred during the formation of the ore body by upwelling, hydrothermal fluids.
- *Supergene alteration* is the natural weathering, before mining, of the ore body, at low temperatures near the Earth's surface.

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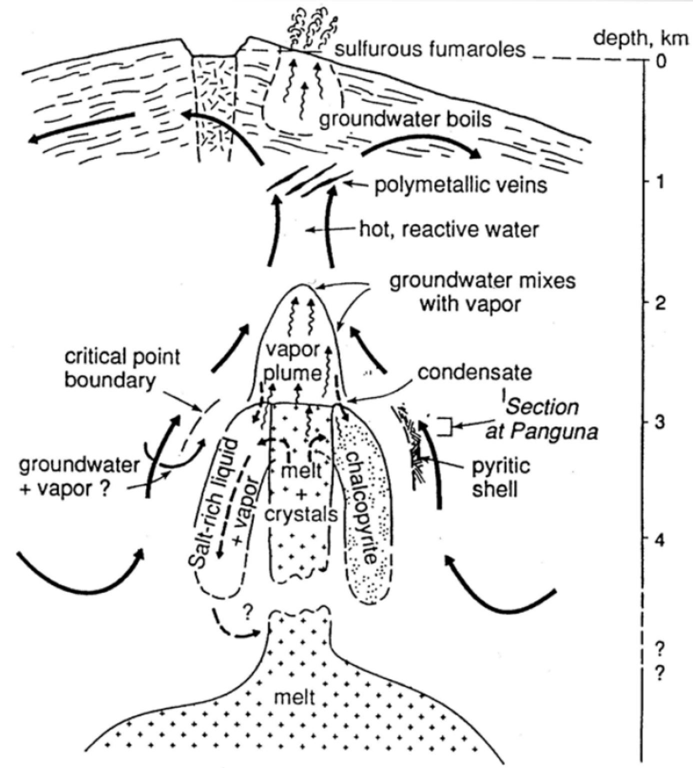

Fig. 1.6. Model of porphyry copper genesis developed by Eastoe based on his studies of the Panguna deposits in Papua New Guinea. On *right* side of the diagram at the level indicated for Panguna the mineralization is shown. On the *left* side of the diagram the fluids responsible for that mineralization (as indicated by fluid inclusion studies) are shown. Note presence of surrounding meteoric waters that will collapse inwards as soon as the flux of magmatic waters ceases (After Eastoe 1982)

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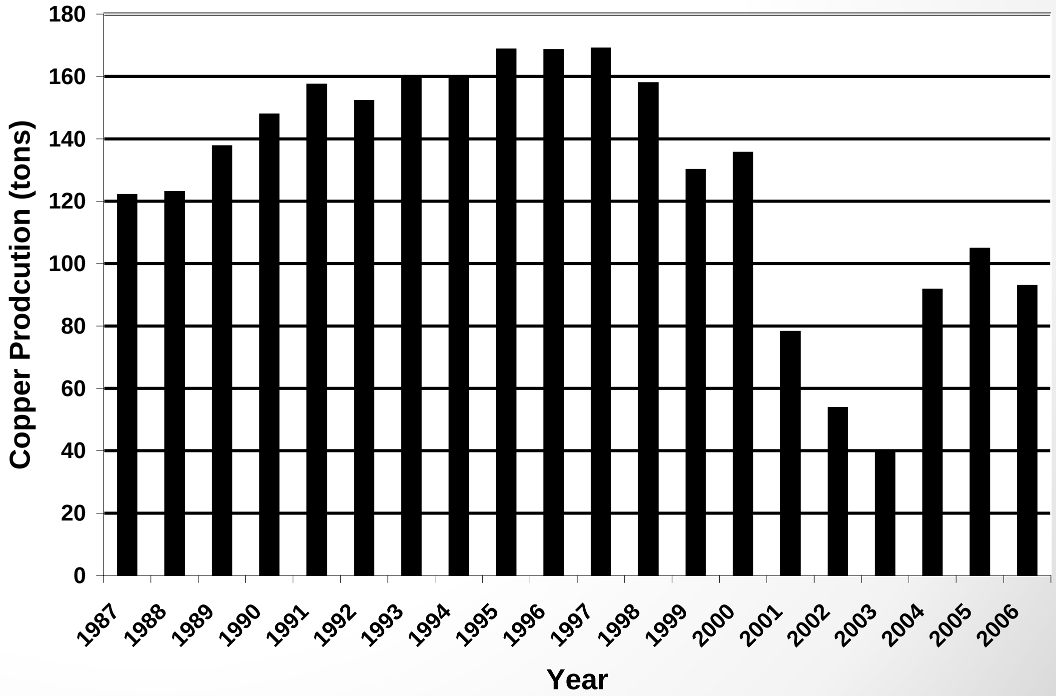
- Primary ore minerals formed during the main mineralization phase (chalcopyrite, pyrite)
- **Minerals formed when the ore deposit was hydrothermally altered (chalcocite, feldspar, pyrite, clay minerals, quartz, epidote, apatite, rutile, Fe- and Mn-oxides, etc.)**
  - **Addition of new elements by the hydrothermal fluids at different times**
  - **Redistribution of primary phases**

Summary

- Formation of a copper porphyry deposit is very complex and not as well understood as geologists would like
  - Magmatic processes
  - Hydrothermal processes
  - Supergene or weathering processes
- Stratigraphy and structure in this area is complex
  - Pre-porphyry rocks
  - Porphyry
  - Younger rocks
    - Kneeling Nun Rhyolite Tuff overlies the deposit

Production from Chino mine

More than 5.9 million tons Cu, 500,000 oz Au, and 5.36 million oz Ag plus some molybdenum and iron ore since 1911 worth >$2 billion



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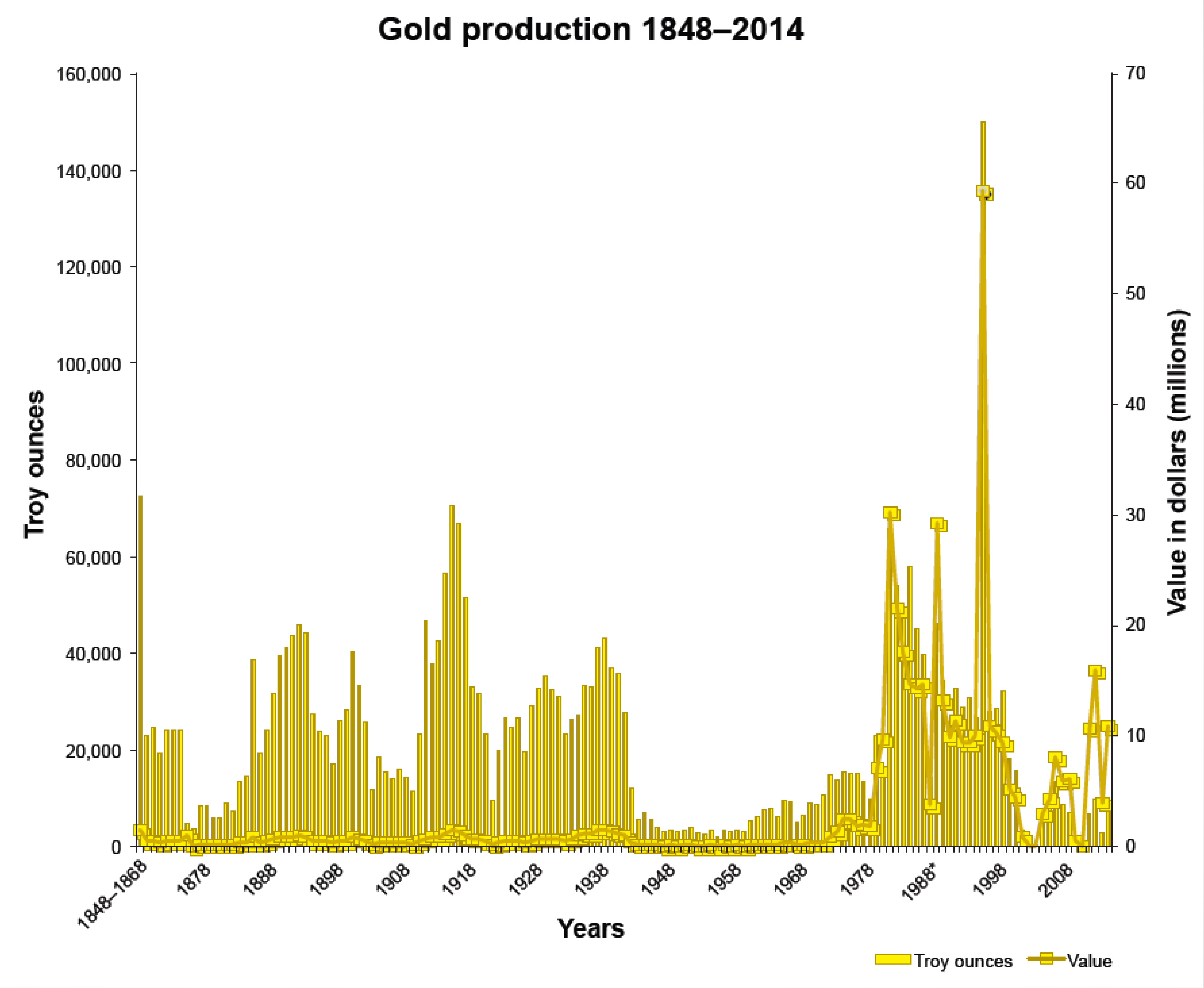
Decreasing copper grade with time

- In 1912, the grade was over 2% copper
- in 1925, it was averaging 1.5%
- in 1948, the grade was less than 1%
- in 1980, the copper grade was 0.81%
- In 2006, the grade is 0.67%
- In 2016, the grade is 0.59%

Gold, Silver in Grant County, New Mexico



1804-2015 >3.3 million troy ounces Au worth >$487 million

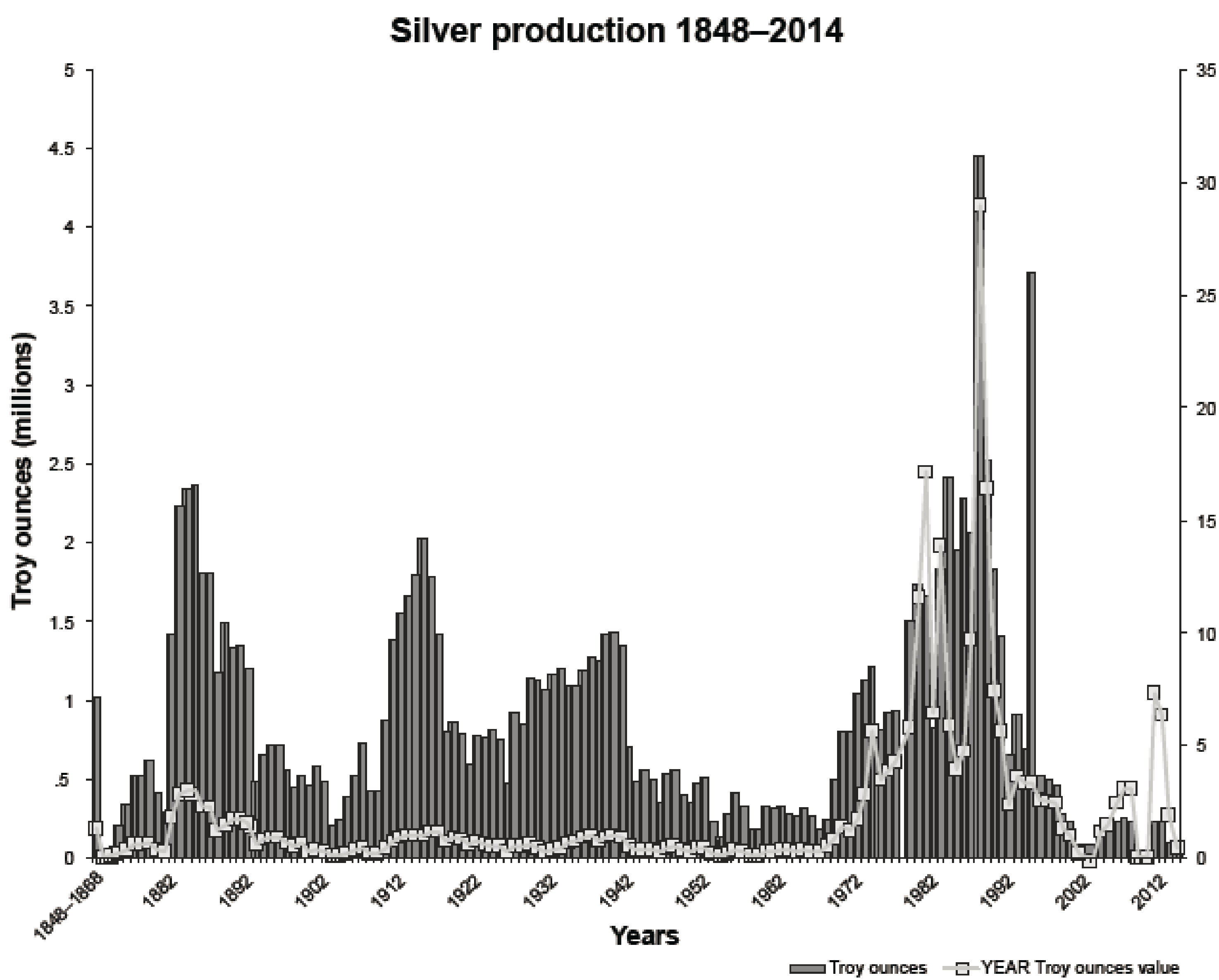


FIGURE 2. Silver production in New Mexico from 1828 to 2014.

1804-2015 >118.7 million troy ounces Ag worth >$279 million

TABLE 3—Major gold-producing districts in New Mexico (updated from North and McLemore, 1986, 1988). *Major placer production (>50,000 oz), +no known placer deposits.

District	County	Estimated gold production (oz)	Type of deposits
+Santa Rita	Grant	>475,000	porphyry copper
*Elizabethtown-Baldy	Colfax	471,400	Great Plains Margin, placer
*Old Placers	Santa Fe	450,000	Great Plains Margin, placer
+Mogollon	Catron	365,000	volcanic-epithermal
*Hillsboro	Sierra	270,000	Laramide vein, placer
Lordsburg	Hidalgo	266,600	Laramide vein, minor placer
Willow Creek	San Miguel	179,000	Proterozoic massive sulfide, minor placer
White Oaks	Lincoln	163,500	Great Plains Margin, placer
+Steeple Rock	Grant	151,000	volcanic-epithermal
*Pinos Altos	Grant	150,000	Laramide vein, carbonate-hosted, placer

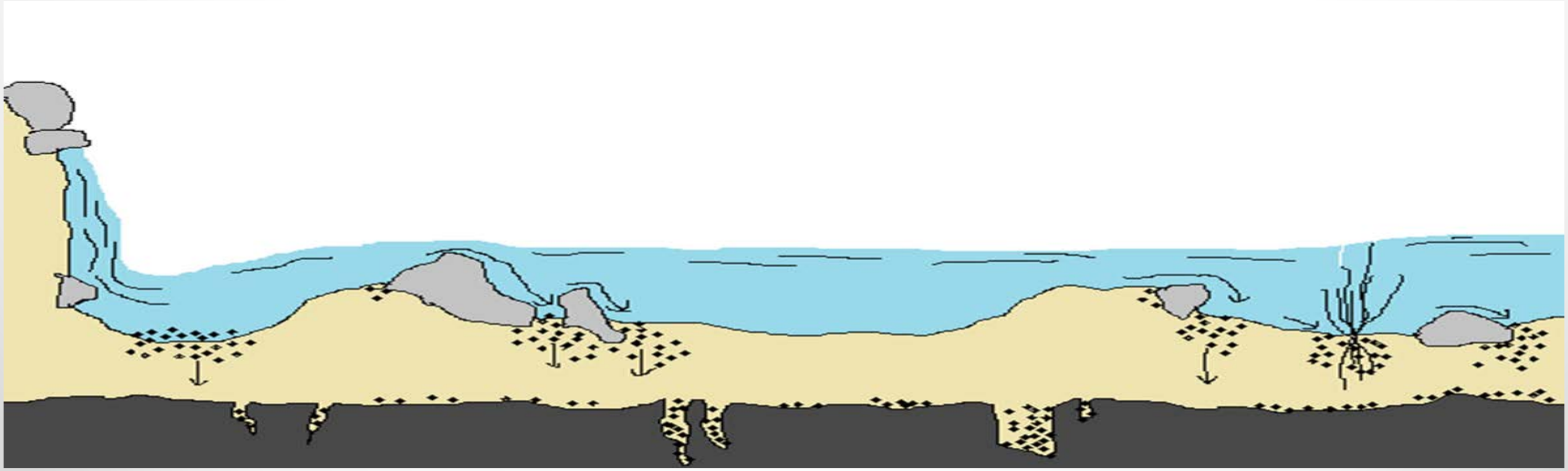
Piños Altos district

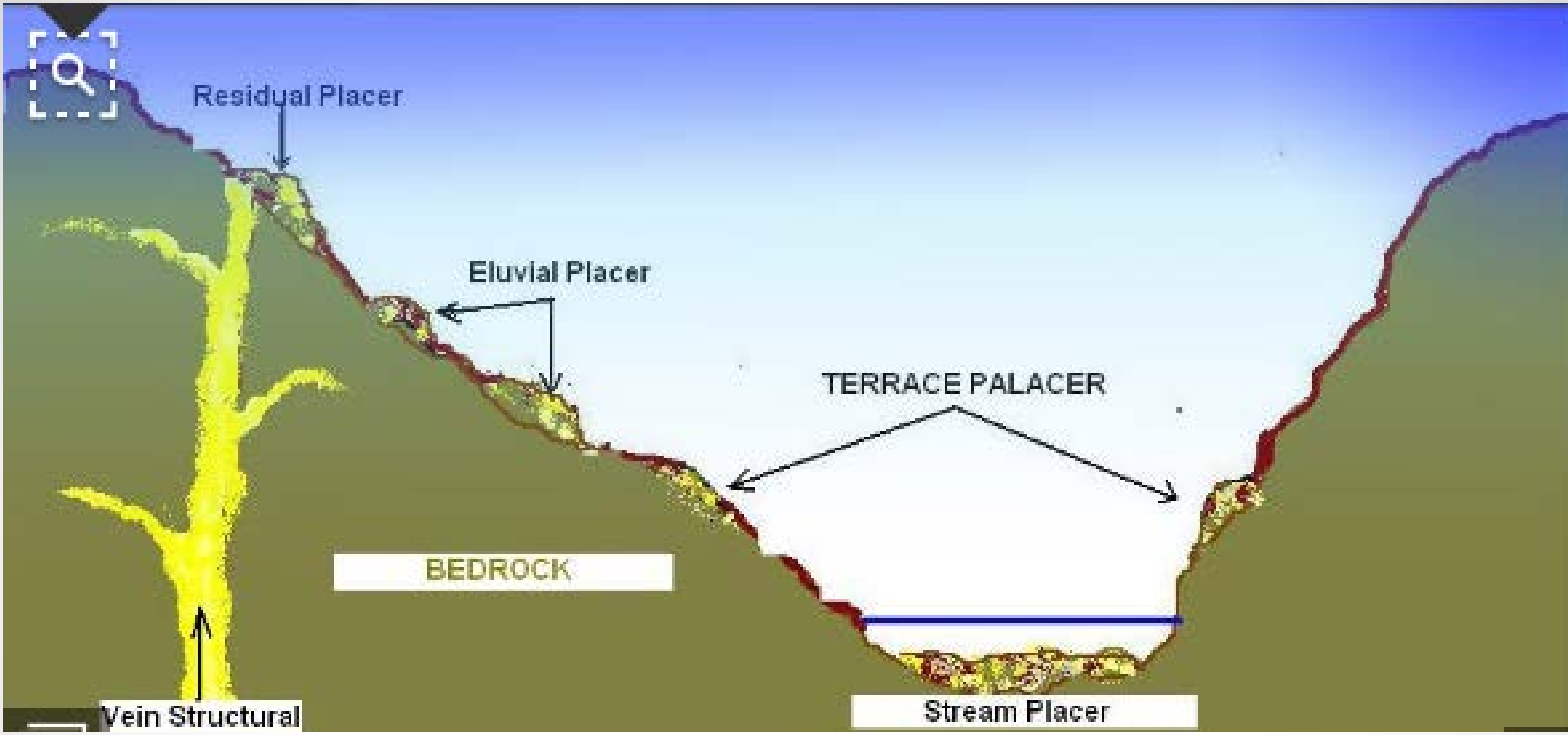
- Placer gold—1.5 mi^2 in Bear Creek, Rich, Whisky, and Santo Domingo Gulches
  - General Pedro Almendaris about 1837
  - re-discovered in 1860 in Bear Creek by three prospectors; Birch, Snively, and Hicks
- By September 1860, several hundred men were working the area
- World War I, Piños Altos yielded a considerable tonnage of zinc ore

Arrastre in action with John and Jake Long at Piños Altos New Mexico, 1892

Placer Gold

- Gold that has been weathered from the host rock where it was formed and been re-deposited either on a hillside, stream bed, or alluvial fan – typically by the action of gravity and water





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Placer deposits

- Placer is from Spanish meaning alluvial sand
- Any natural accumulation or concentration of a material in unconsolidated sediments of a stream, beach, or residual deposit
- Four conditions must occur
  - Source terrain must crop out
  - Source must be weathered
  - Gold is eroded, transported and concentrated
  - Deposit must be preserved from erosion

Piños Altos district

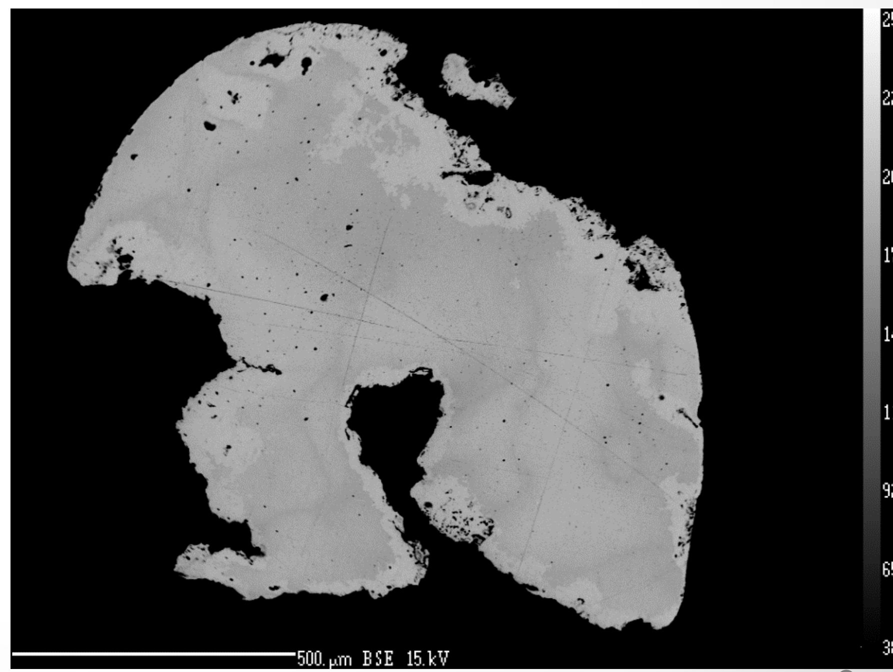
- Production from the entire district is estimated as
  - 59.5 million lbs Cu
  - 169,000 oz Au
  - 2.6 million oz Ag
  - 6 million lbs Pb
  - 64 million lbs Zn
  - worth more than $10.3 million
- Some iron ore was also produced.

Arrastre in action with John and Jake Long at Piños Altos New Mexico, 1892

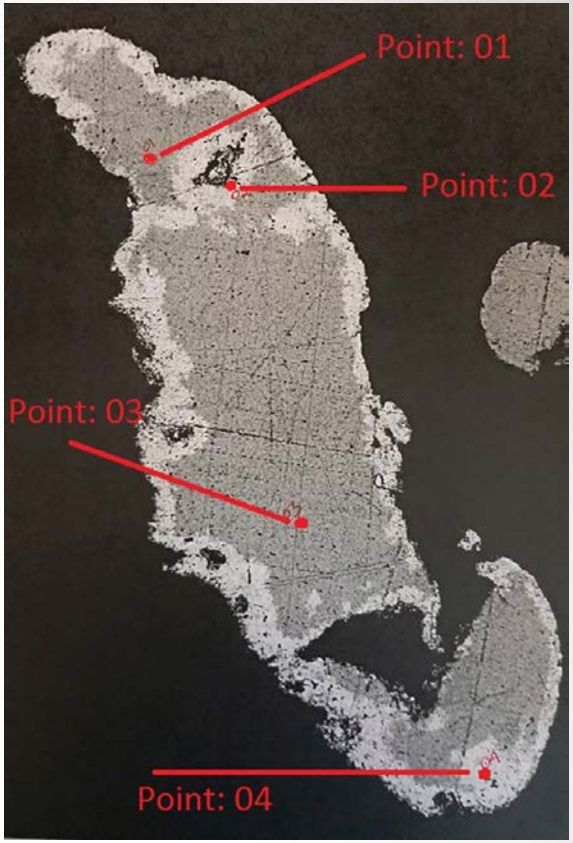
Using Trace Element Analysis of Placer Gold to Determine Source and type of original deposit

Backscattered Electron Imaging

- Analysis began with backscattered electron (BSE) imaging using an electron microprobe to determine if chemical or weathering zonation was present in gold particles



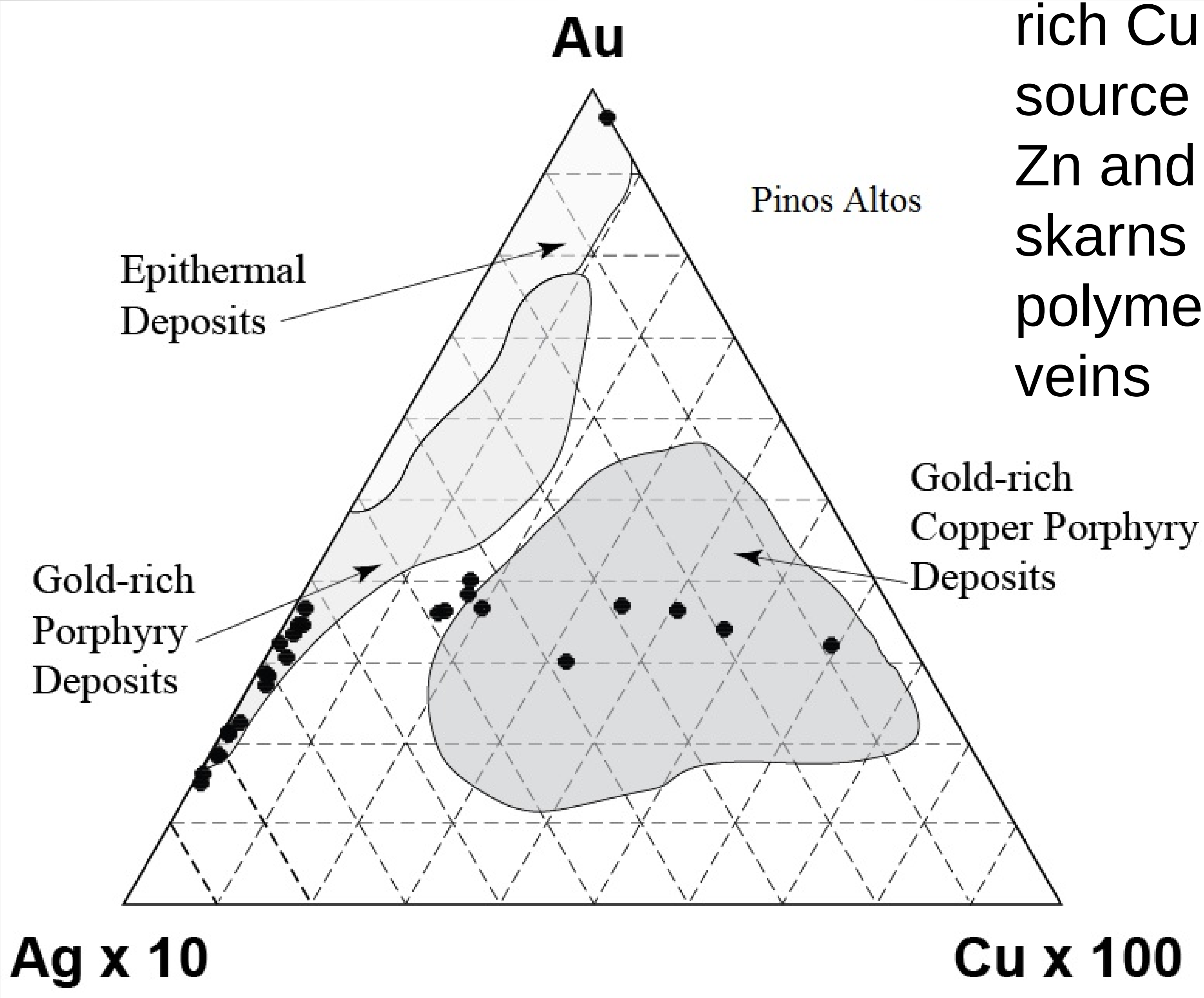
Quantitative Analysis



- Determine composition of different areas of a selected grain.
- Element selection
  - Ag, Au, Cu, As, Pb, Fe, S
- Analyses on:
  - Rims
  - Cores
  - Inclusions

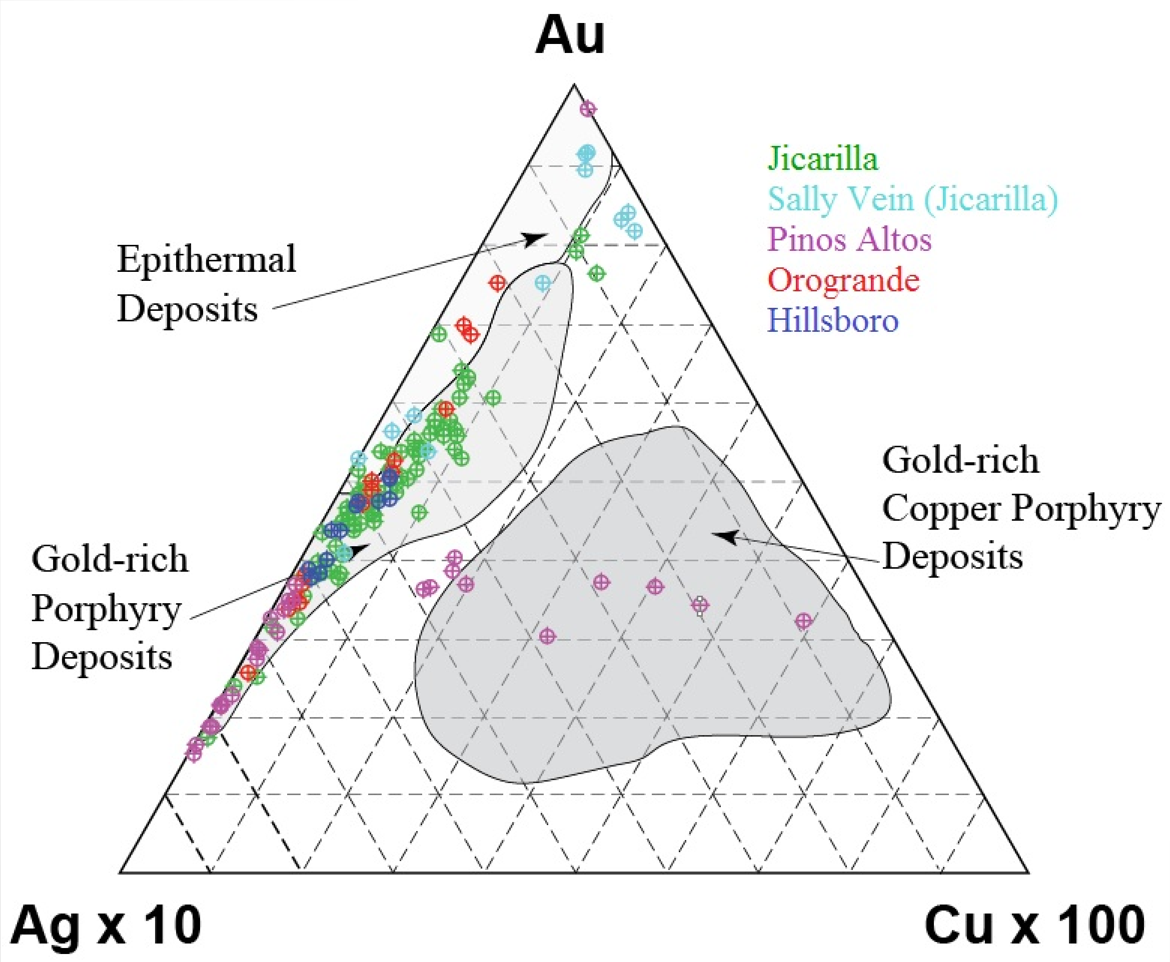
			Ag	Au	Cu	As	Pb	Fe	S	Total
38	37 / 1 .	DeadwoodGulch-01	24.55	72.77	0.02	0	0	0.01	0.02	97.38
39	38 / 1 .	DeadwoodGulch-02	0.87	96.34	0.06	0	0	0.01	0.03	97.31
40	39 / 1 .	DeadwoodGulch-03	24.62	72.95	0.02	0	0	0	0.02	97.6
41	40 / 1 .	DeadwoodGulch-04	1.32	95.48	0.05	0.01	0	0	0.03	96.88

Piños Altos, NM



Suspected Au-rich Cu porphyry source with Pb-Zn and Cu skarns and polymetallic veins

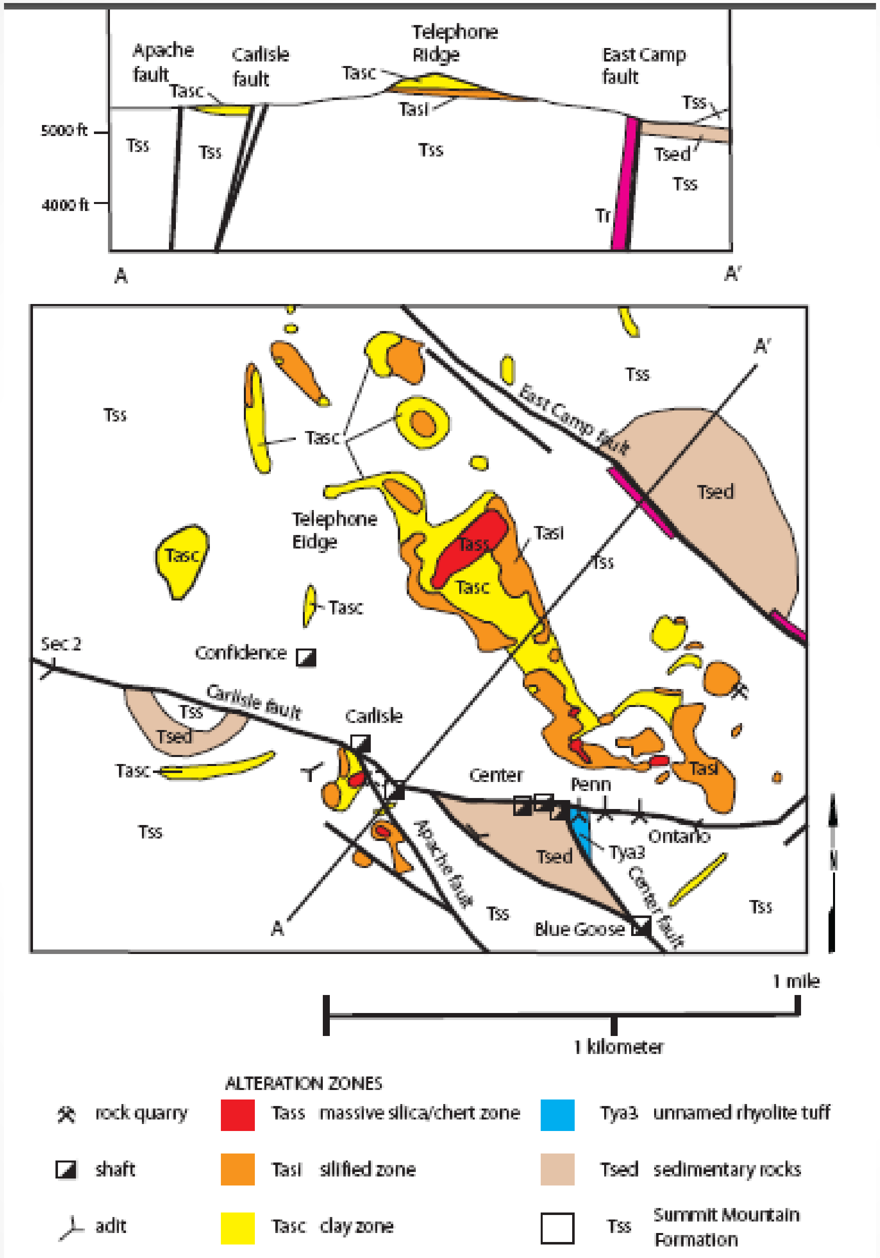
New Mexico placer gold districts



- New Mexico's placer gold didn't travel far from source
- Chemical compositions of placer gold samples can be correlated with specific

Steeple Rock district (volcanic epithermal veins)


Summit gold mine
In 2009, Santa Fe Gold opened the Summit mine in the Steeple Rock district
The ore was milled at Lordsburg and sold as silica flux



Apache fault
Carlisle fault
Telephone Ridge
East Camp fault
Tasc
Tasl
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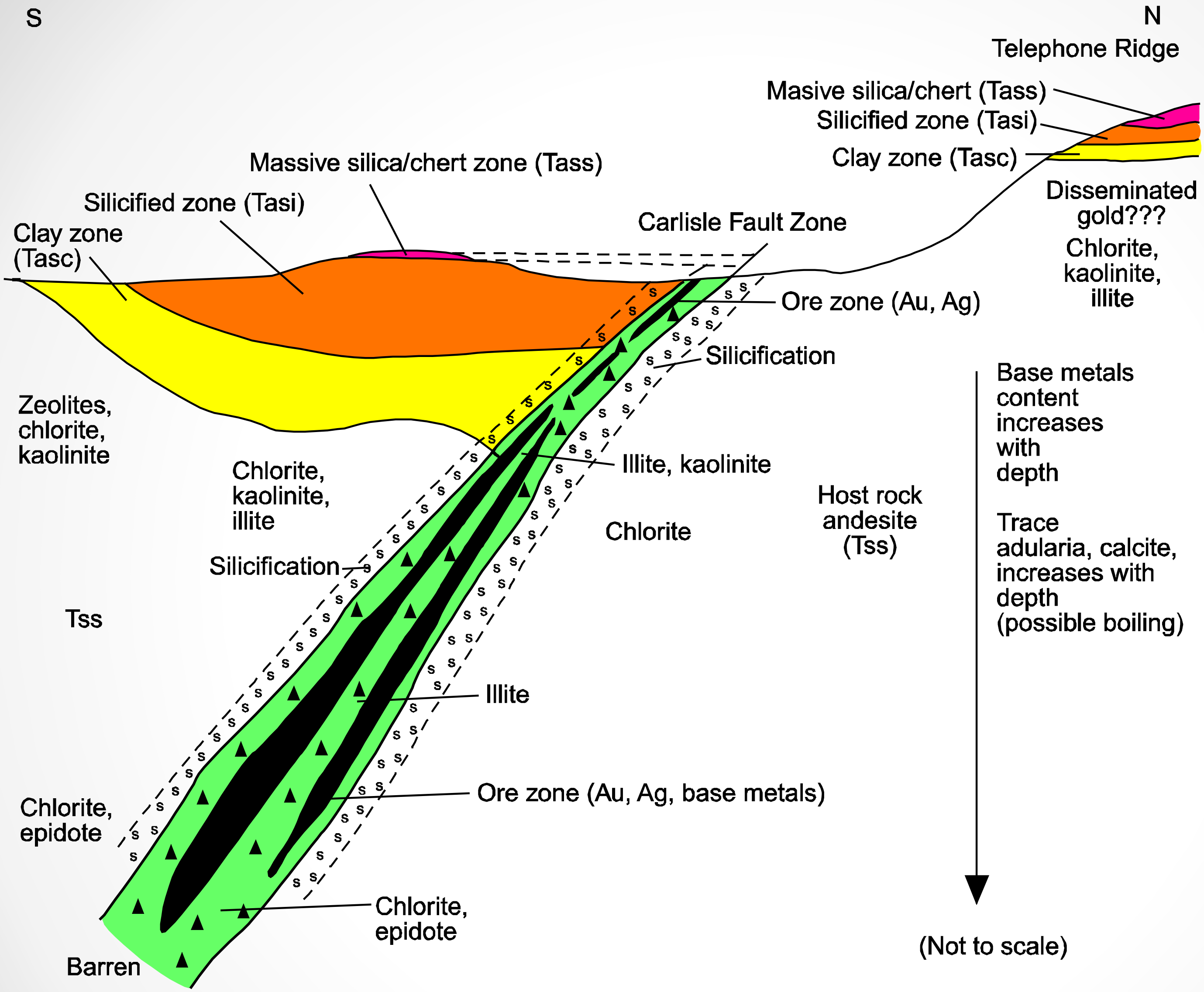
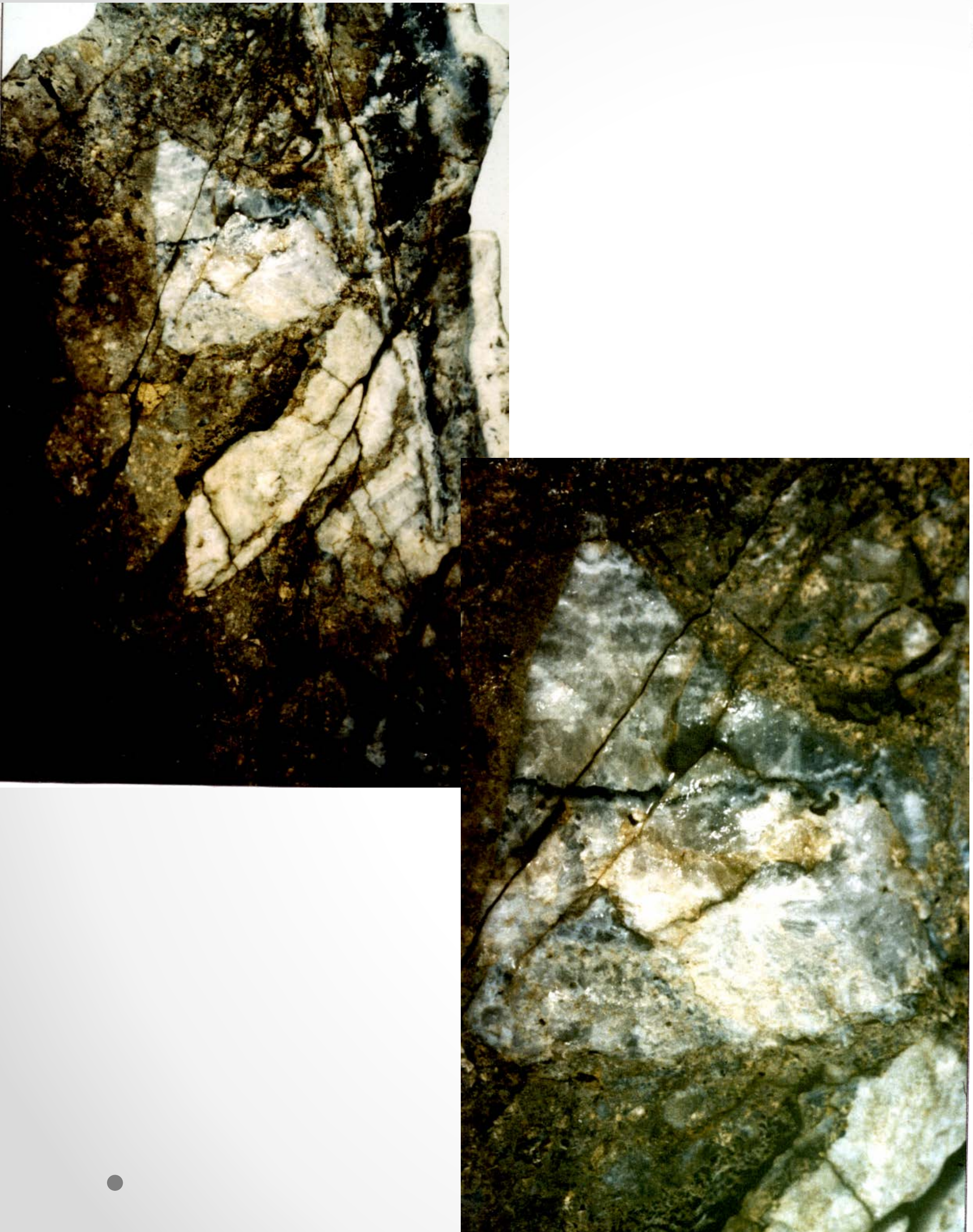
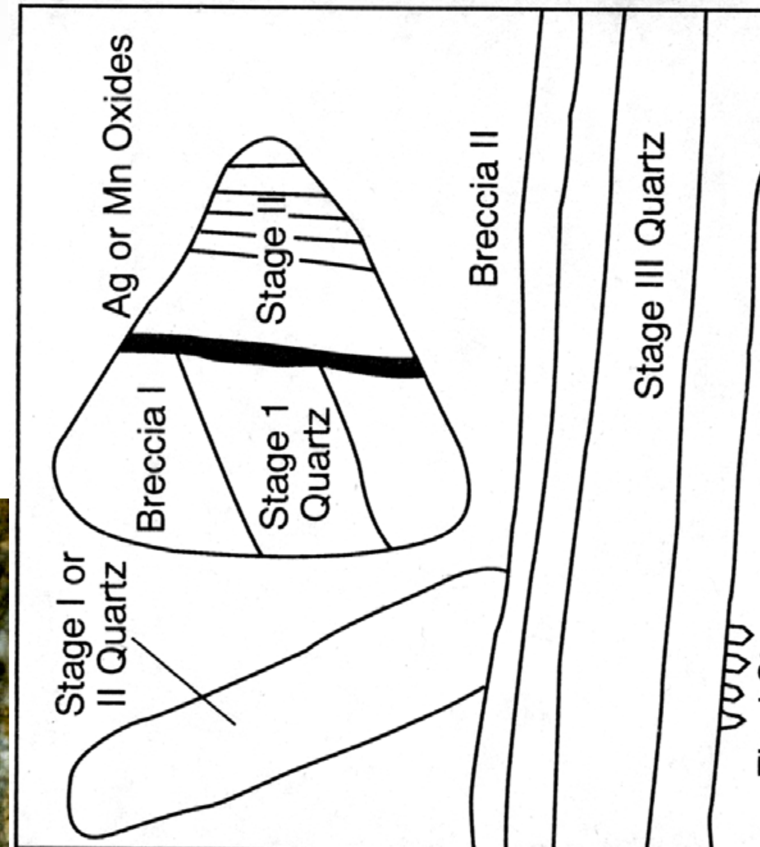
5000 ft
4000 ft
A
A'
Telephone Ridge
Tass
Confidence
Sec 2
Carlisle fault
Carlisle
Center
Penn
Ontario
Tya3
Apache fault
Center fault
Blue Goose
East Camp fault
1 mile
1 kilometer
ALTERATION ZONES
rock quarry
shaft
adit
Tass massive silica/chert zone
Tasl silified zone
Tasc clay zone
Tya3 unnamed rhyolite tuff
Tsed sedimentary rocks
Tss Summit Mountain Formation

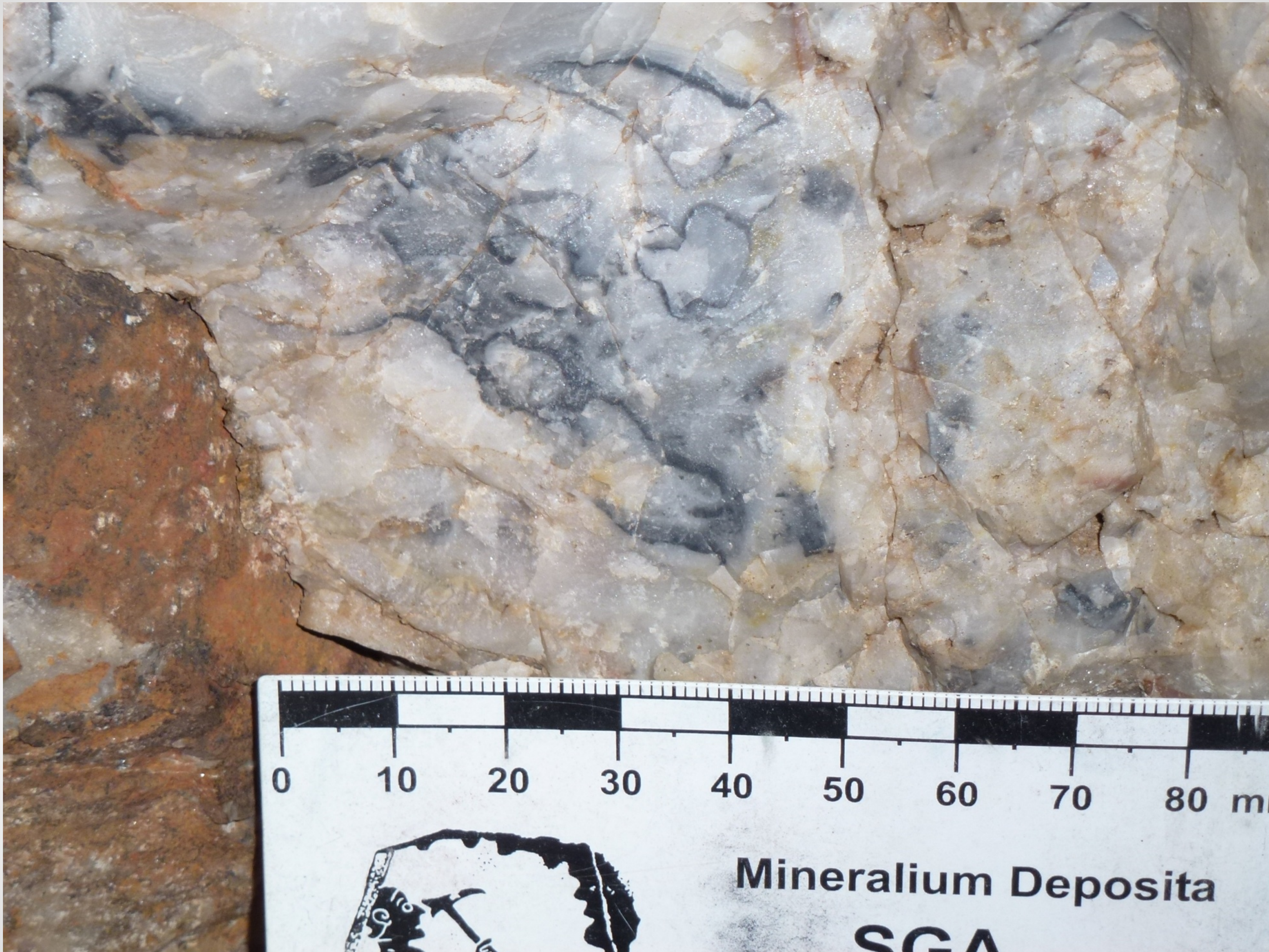


Relationship between alteration and vein deposits along the Carlisle fault (modified in part from Weaco drill data, McLemore, 1993, 2000).





Photograph and sketch of a handspeciman that shows the four stages of mineralization in epithermal veins. Breccia fragment is approximately 10 cm across.


0
10
20
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Mineralium Deposita
SGA
Society for Geology
Applied to Mineral Deposits
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1
2
Inch

Breccia ore

Clay

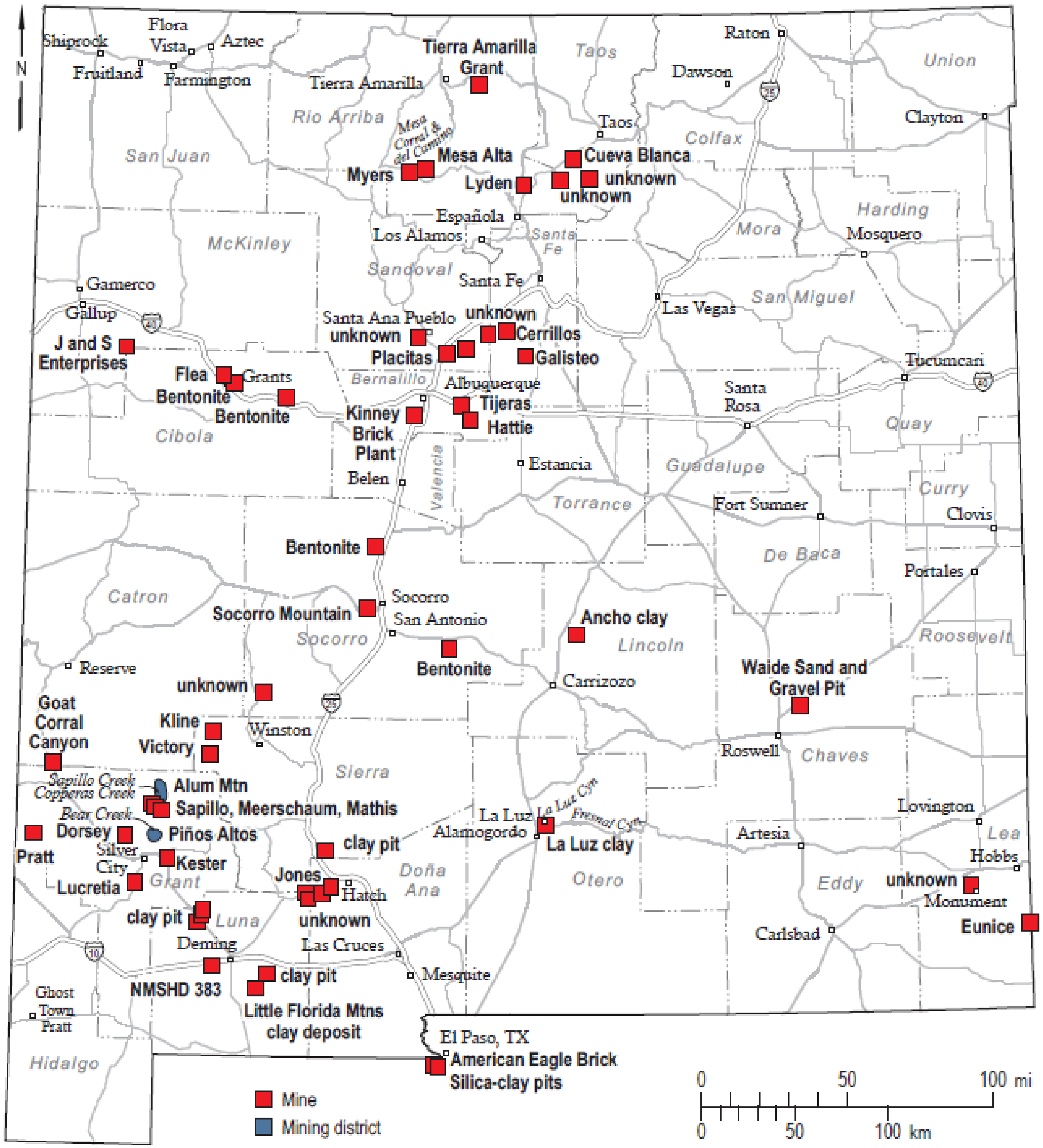


Figure 12. Major clay deposits in New Mexico.

Clay

- Pottery
- Adobe bricks
- Tiles
- Fired bricks
- Smelting
- Other uses
  - treat minor ailments such as food poisoning, aches and pains, infections, and mineral deficiencies
  - cosmetics

Common clay that could be used for pottery in the Cañada Alamosa area, Socorro County. This consists of illite and smectite.

One of the pots made with the clay

Clay

- Pottery
- Adobe bricks
- Tiles
- Fired bricks
- Smelting
- Other uses
  - o treat minor ailments such as food poisoning, aches and pains, infections, and mineral deficiencies
  - o cosmetics

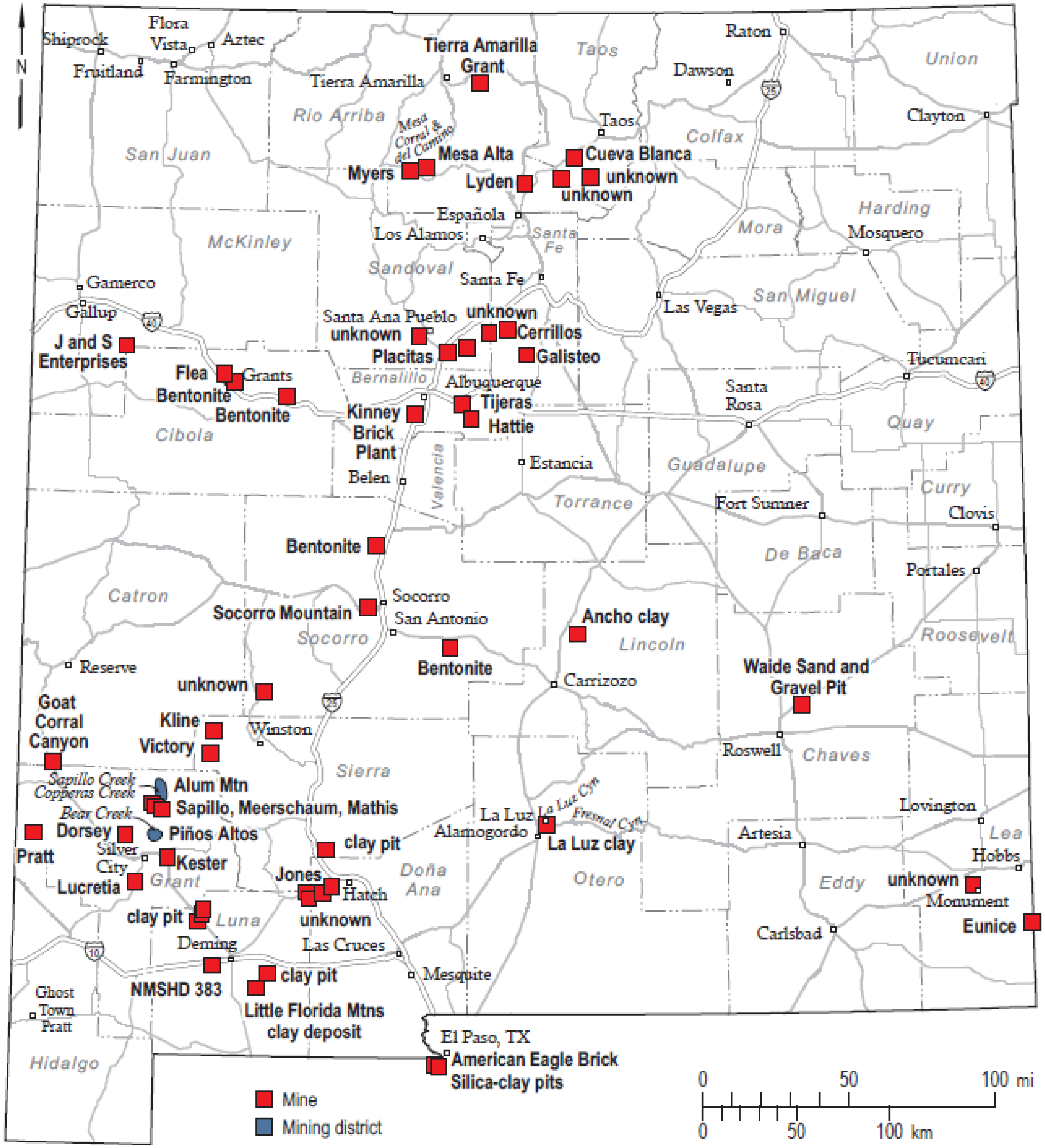
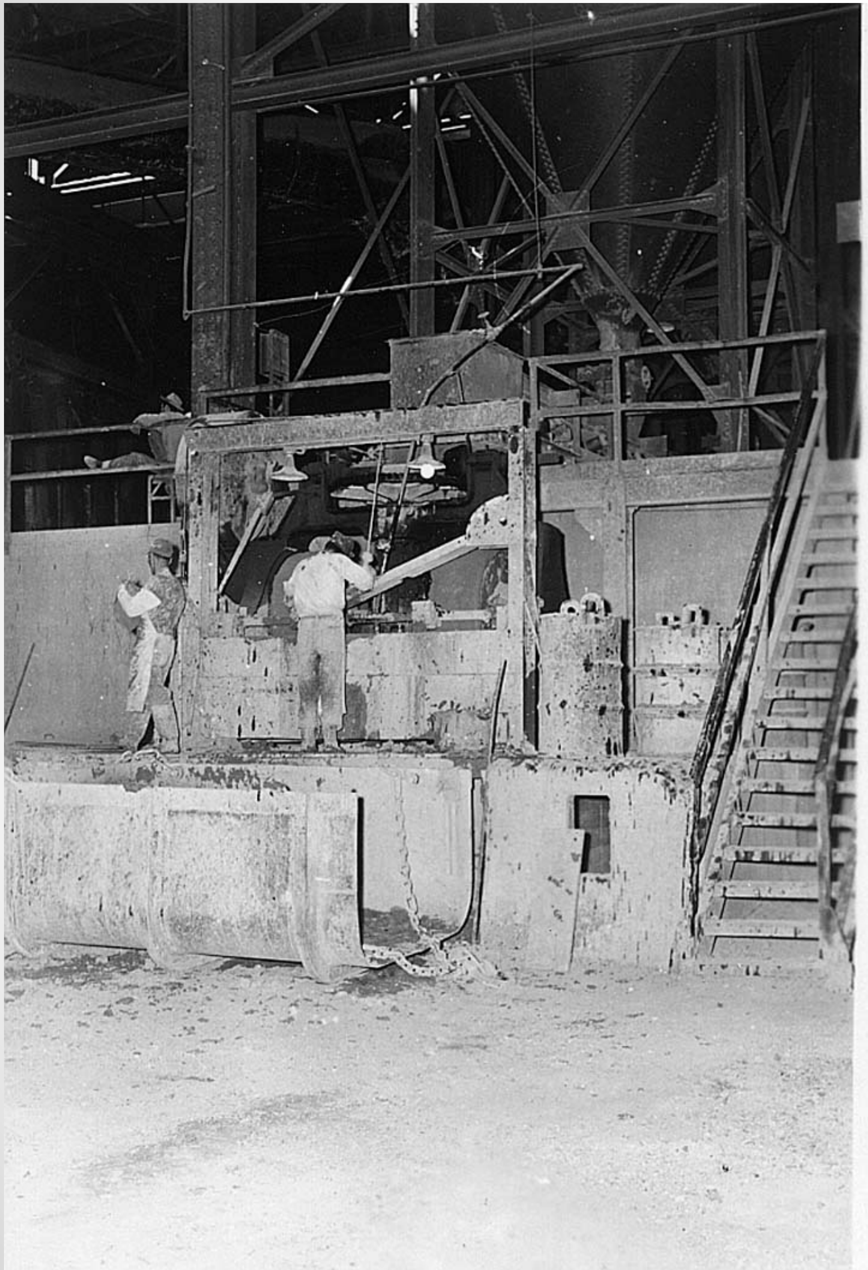


Figure 12. Major clay deposits in New Mexico.

Clay pit at Pratt New Mexico, ca 1940's



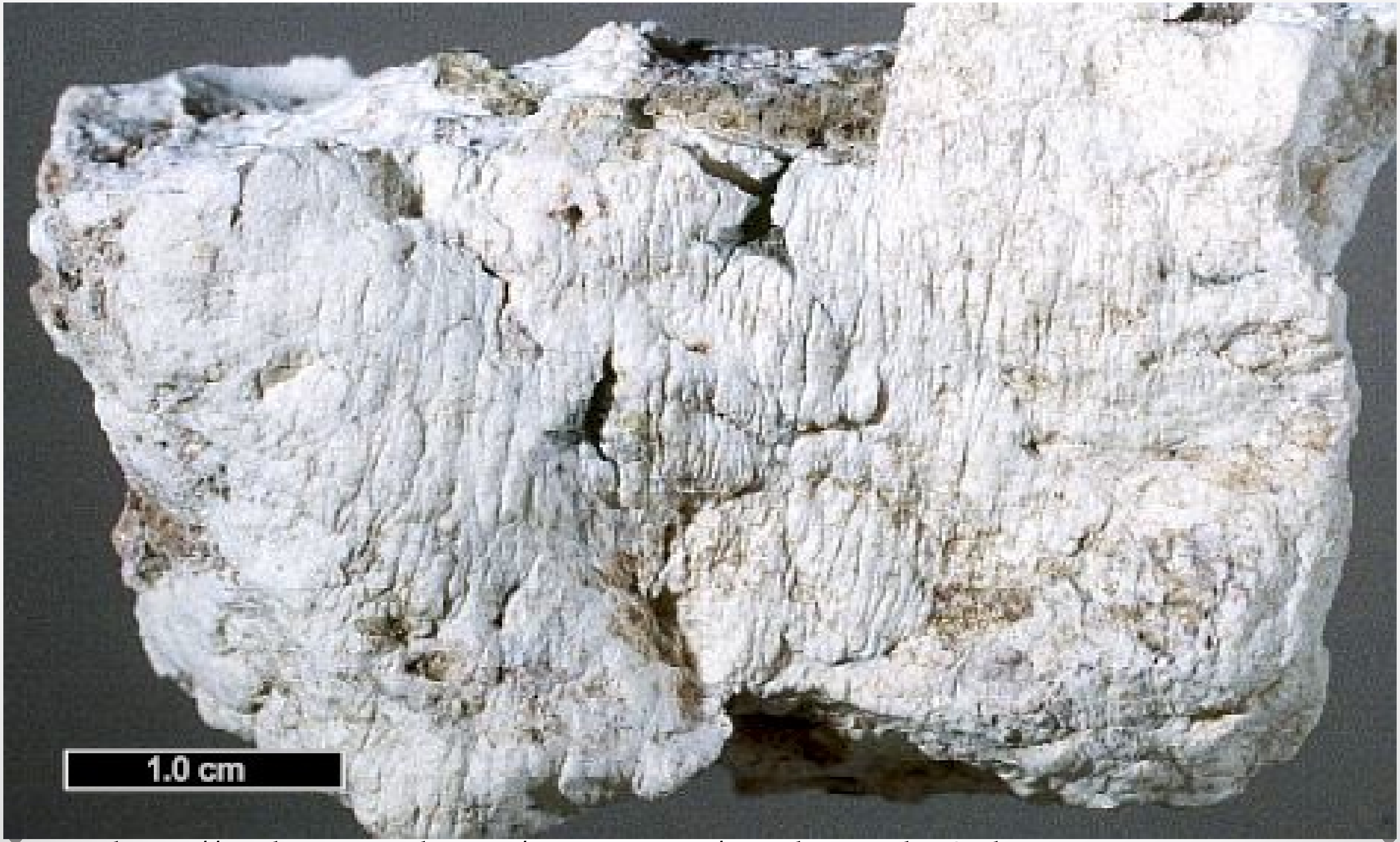
Preparing fireclay in wet pan at Kennecott Copper Corporation's Hurley smelter in Hurley, New Mexico, August 22, 1949

Meerschaum

http://www.meerschaumstore.com/proddetail.asp?prod=CL337

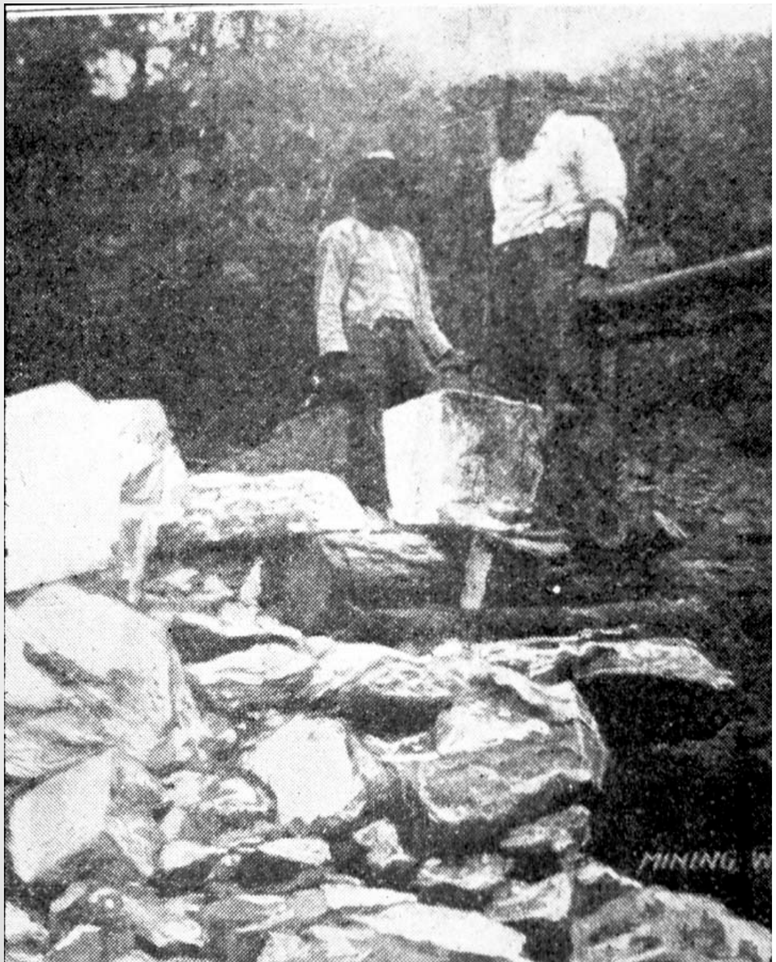
- Meerschaum or sepiolite
  - $Mg_8(Si_{12}O_{30})(OH)_4(OH_2)_4 \cdot N\ H_2O$
  - is a tough clay material
  - so lightweight that dry meerschaum (German word for sea foam) will float on water
- Used in pipes
- Sapillo Creek in the Alum Mountain district in 1875
- estimated 2 million pounds of meerschaum was shipped from the Meerschaum mine (NMGR0223) and from the Dorsey mine (NMGR0665) along Bear Creek in the Piños Altos district (DIS062)
- ceased shortly before World War I, but resumed in 1943 when approximately 1000 lbs was shipped for experimental purposes in an attempt to find improved materials for insulators in radios

Sepiolite

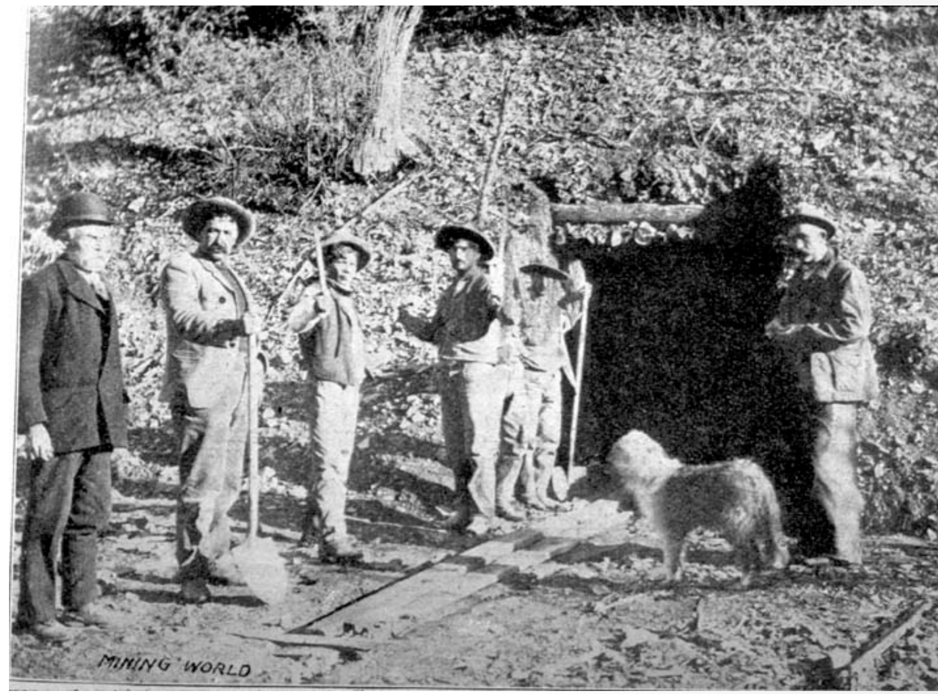


http://webmineral.com/specimens/picshow.php?id=2368

Meerschaum at Diablo Mountain (Alum Mountain district), New Mexico, June 1, 1907

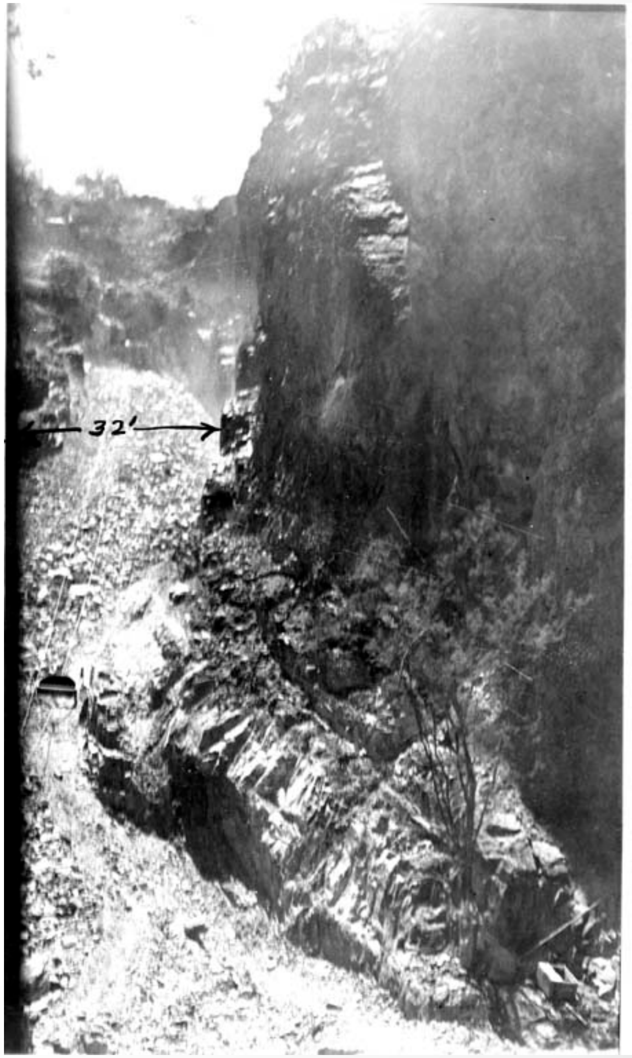


Raw Meerschaum on the Dump.



Ricolite (a form of banded serpentine) has been produced from the Ricolite district in Grant County for carving, decorative, and dimension stone

Ricolite quarry in Grant County, New Mexico, 1946



Summary

- Minerals are needed to improve our way of life
- The formation of mineral deposits require specific geologic processes
- New Mexico, especially Grant County has significant mineral resources that have been exploited in the past, present, and future

In Grant County

- Some of the earliest mining in New Mexico with production of turquoise and native copper
- Many districts were discovered by Mexican explorers and rediscovered by Anglos after the area became part of the U.S.
- Mining in 1800s was by small companies or individuals with primitive processing techniques
- After the Civil War (1860s), mining increased with the settling of the west by Americans from the east coast and European immigrants and the Hispanic residents played an important role
- Mining continues today and into the near future

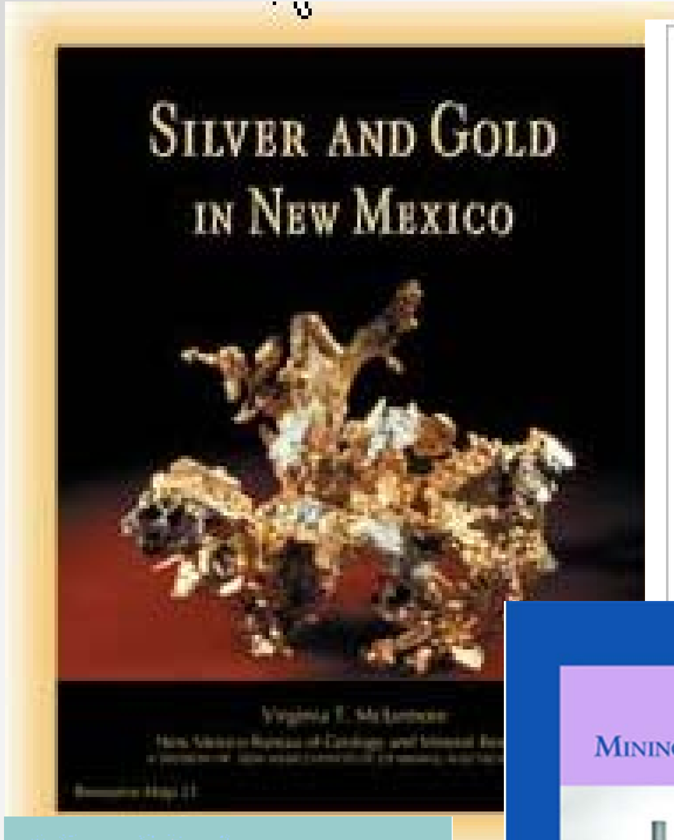
More Information

- NM Mines and Minerals Division

  http://www.emnrd.state.nm.us/MMD/index.htm
- Virginia McLemore web page

  http://geoinfo.nmt.edu/staff/mclemore/home.html
- New Mexico Bureau of Geology and Mineral Resources

  http://geoinfo.nmt.edu/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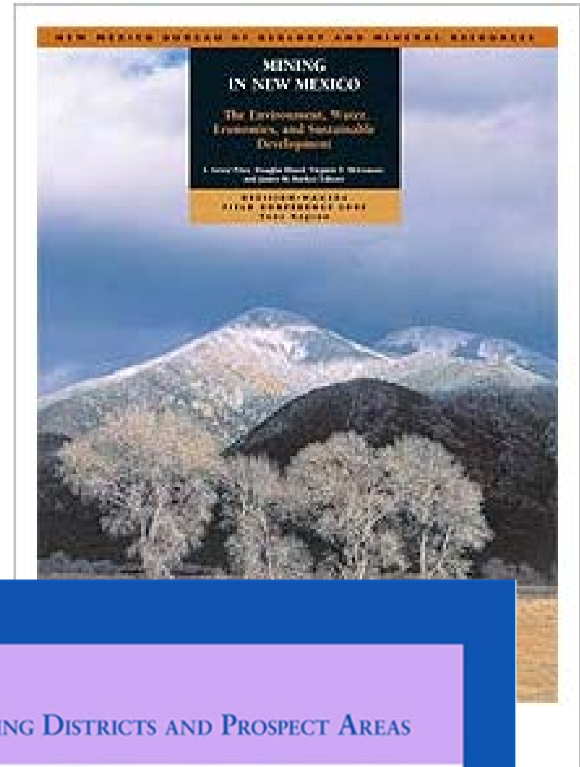
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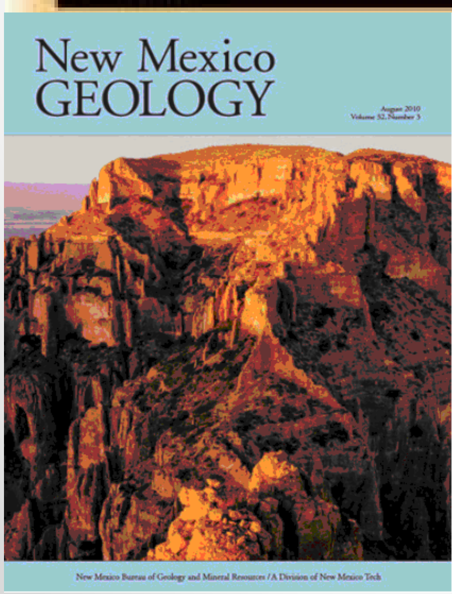
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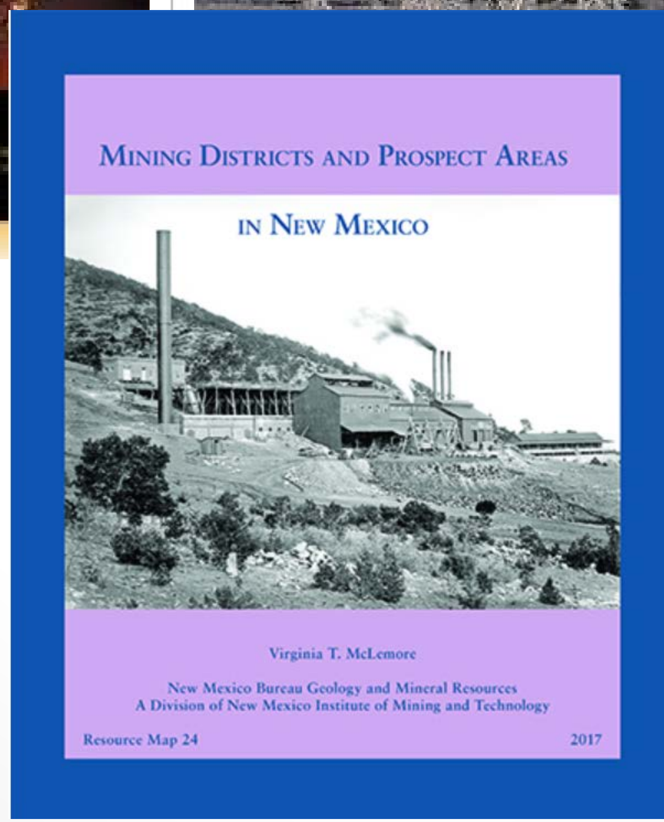
Mining Districts and Prospect Areas
in New Mexico
Virginia T. McLemore
New Mexico Bureau Geology and Mineral Resources
A Division of New Mexico Institute of Mining and Technology
Resource Map 24
2017


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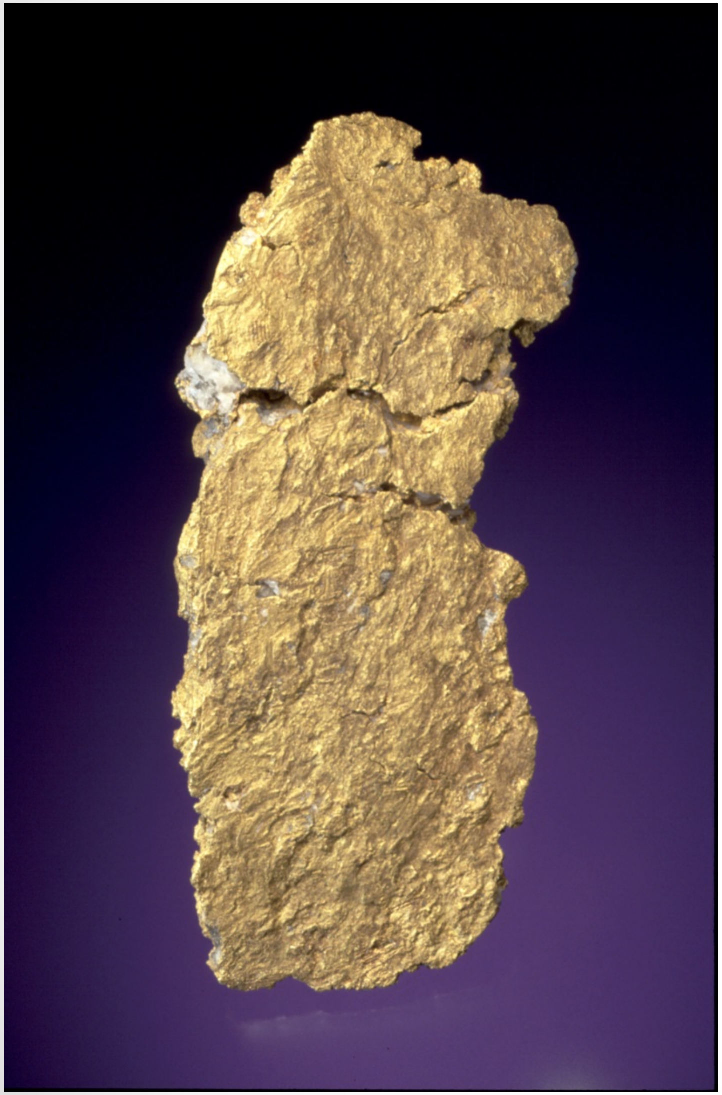

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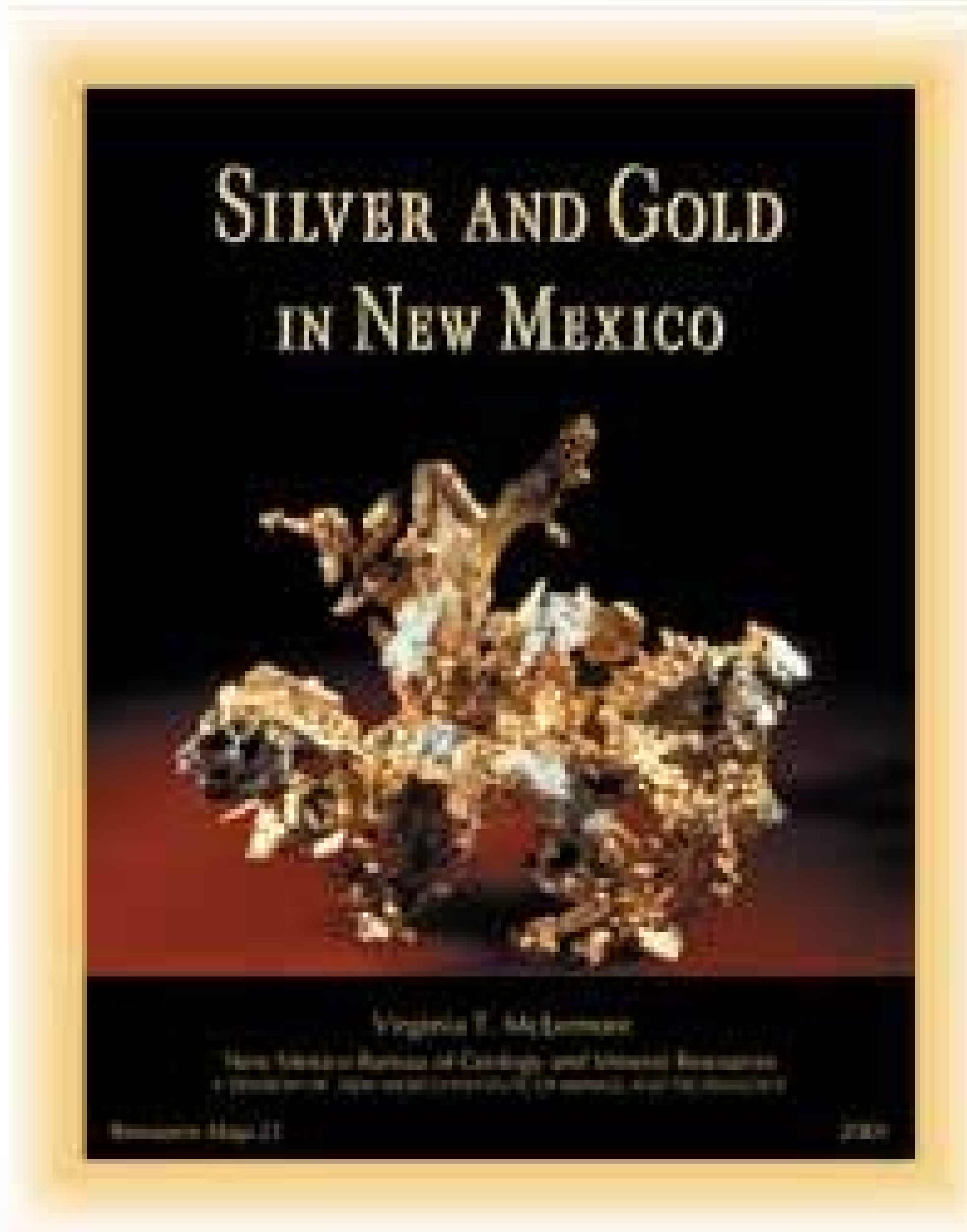

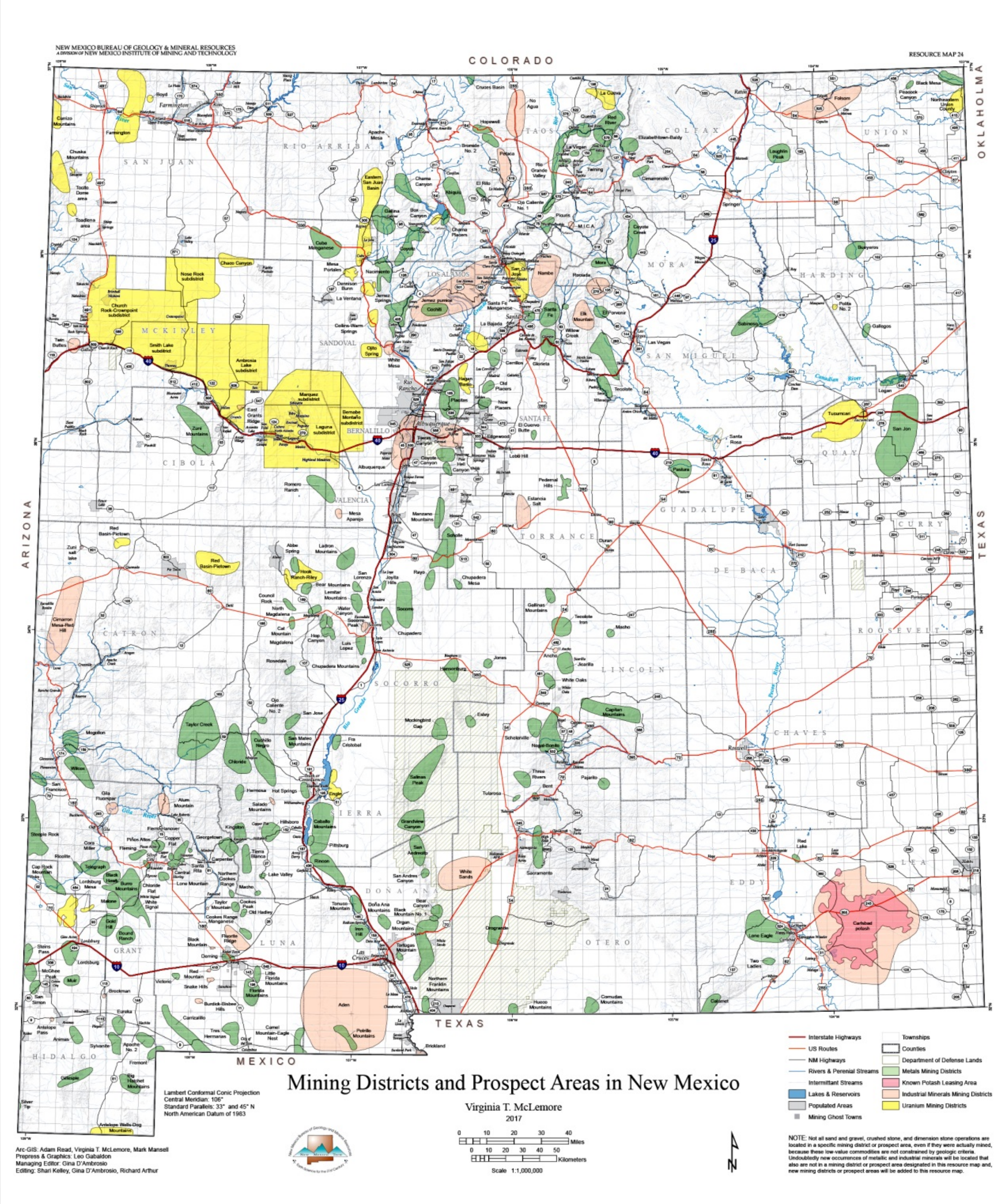

Resource Map 24- Mining Districts and Prospect Areas in New Mexico

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Placer gold deposits in New Mexico

by *Virginia T. McLemore*, New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico 87801

Abstract

Thirty-six mining districts in New Mexico contain placer gold deposits. Production from these deposits began as early as 1828, resulting in the first gold rush in the western United States; however, minor production by Pueblo Indians and Spaniards probably occurred 200 or more years earlier. Most placer deposits were discovered by 1900, and almost all placer production occurred before 1902. It is estimated that 662,000 oz of gold were produced from New Mexico placer deposits between 1828 and 1991. The deposits typically are found in late Tertiary to Recent alluvial or eluvial deposits; alluvial fan deposits, bench or terrace deposits, river bars, stream concentrations, and residual placers that formed directly on top of lode deposits are known. New Mexico placer gold deposits are derived from Oligocene–Miocene Great Plains Margin deposits, Laramide vein deposits, and Proterozoic vein and replacement deposits in highly weathered and eroded terrains. The future potential will depend on discovery of large-volume, low-grade deposits. Also, new technologies minimizing water may stimulate activity because lack

posits (Boyle, 1979, 1987): eluvial, alluvial, and aeolian. Eluvial deposits occur in weathered detritus at or near the outcrop of gold-bearing lode deposits. Alluvial deposits occur in the sands and gravels of streams, rivers, beaches, and deltas. Alluvial deposits are further subdivided into classes by Wells and Wootton (1932): hillside (valley slopes not in discrete channels), gulch or creek, bench or terrace, river-bar, gravel-plain, and buried placers. The aeolian deposits accumulate in windblown sand deposits and are relatively minor and unimportant. Most of the gold deposits in New Mexico are alluvial deposits, but some eluvial deposits are found in many districts. There are no known aeolian gold placer deposits in New Mexico.

This report presents a summary of continuing research on placer gold deposits in New Mexico. Johnson (1972) published one of the most comprehensive compilations of information on placer gold deposits in the state. This study updates the work by Johnson (1972) and North and McLemore (1986, 1988) and incorporates additional field observations and other data

deposits in New Mexico were discovered by 1900. Early production from placer deposits is poorly documented, and total production can only be estimated. It is estimated that 662,000 oz of gold have been produced from placer deposits throughout New Mexico from 1828 to 1991 (updated from Johnson, 1972). This production is insignificant compared to larger placers found in Alaska, California, New Zealand, and South America that contain millions of ounces of gold. Only four districts here have yielded more than 100,000 oz of placer gold production: Elizabethtown–Baldy, Hillsboro, Old Placers, and New Placers. Currently only one district is yielding some minor production (White Oaks) although small exploration activities and recreational gold panning are occurring in most areas of the state. ☞

Also in this issue

http://geoinfo.nmt.edu/publications/periodicals/nmg/downloads/16/n2/nmg_v16_n2_p21.pdf

Decision Makers Field Guides

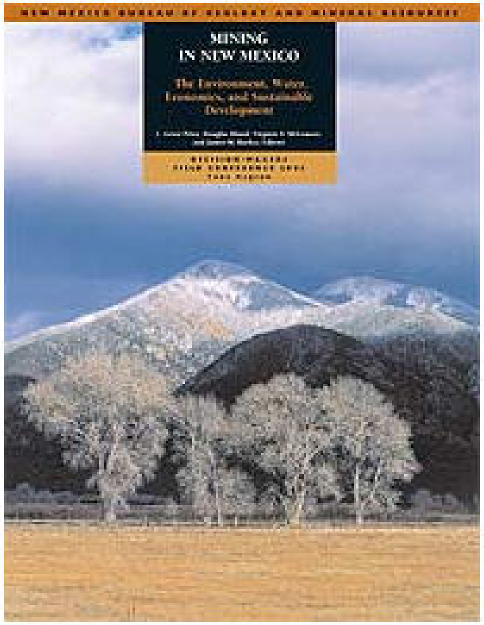
The New Mexico Bureau of Geology and Mineral Resources is joining with several state and local governmental agencies and organizations in conducting a series of field conferences for influential New Mexico decision makers. The purpose of these conferences is to present decision makers with the opportunity to learn first-hand about geological problems, opportunities, and potential solutions from some of the state's top experts, and to hear impartial (or at least balanced) opinions regarding current scientific knowledge about these matters.

Mining in New Mexico—The Environment, Water, Economics, and Sustainable Development

Decision-Makers Field Guide 2005

Edited by L. Greer Price, Douglas Bland, Virginia T. McLemore, and James M. Barker

Mining has played a significant role in the history and develop- ment of New Mexico and continues to play an important role in the state's economic prosperity. The future of this industry will depend upon achieving a balance between our needs and desires, the changing economy, and our growing concern over environmental and social issues. This anthology of 30 articles is a timely look at some of those science and policy issues. 176 pages with tables, diagrams, maps, and color photographs throughout.



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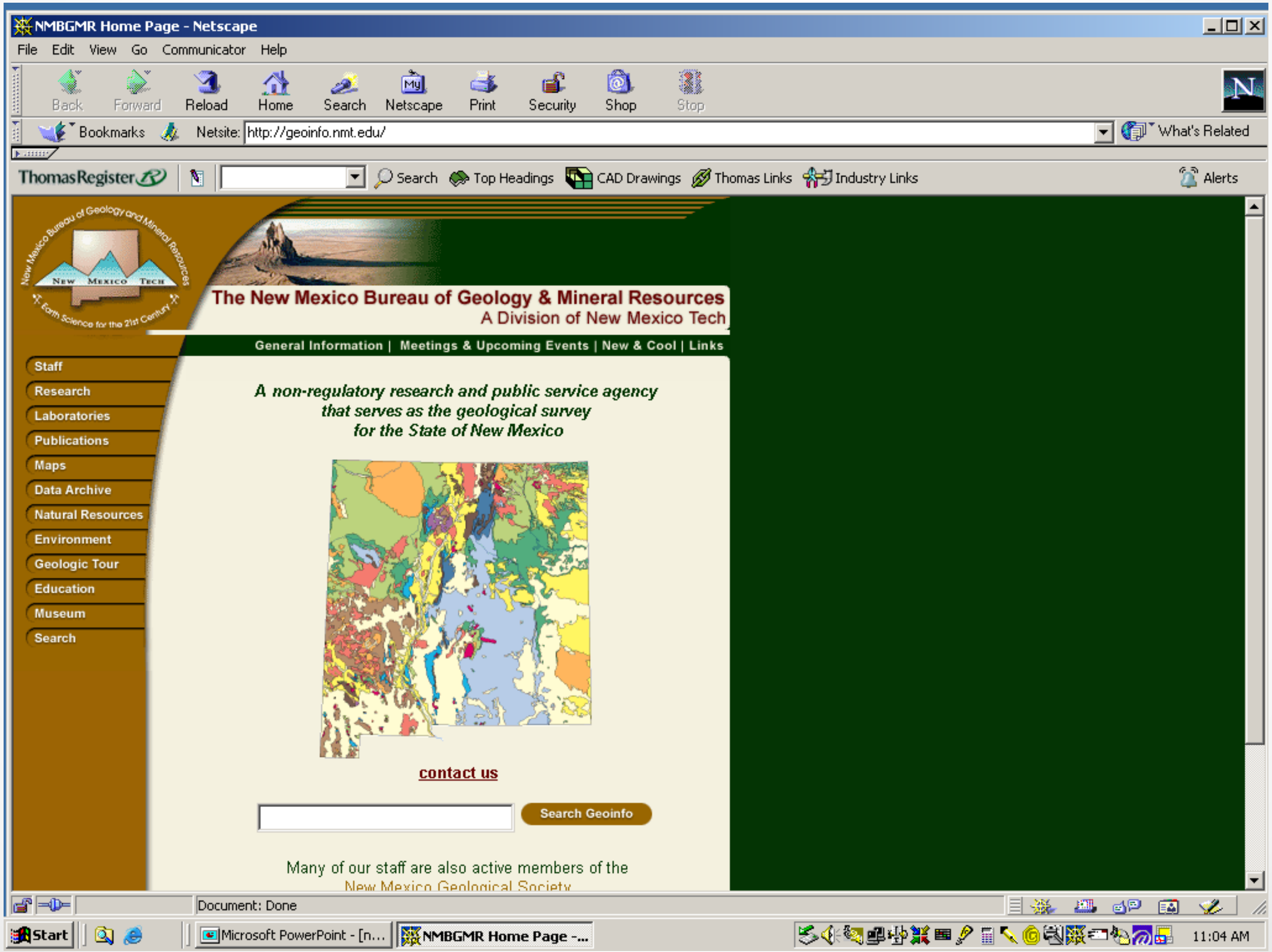

More Information

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QUESTIONS?