ME589/Geol571/GEOC 589-04D/GEOL 589-04/GEOL 589-04D Advanced Topics

Mineral Deposits in New Mexico
Virginia T. McLemore

CRETACEOUS HEAVY MINERAL, BEACH-PLACER DEPOSITS IN THE SAN JUAN BASIN, NEW MEXICO

ACKNOWLEDGEMENTS

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USGS
science for a changing world

Deposit Model for Heavy-Mineral Sands in Coastal Environments

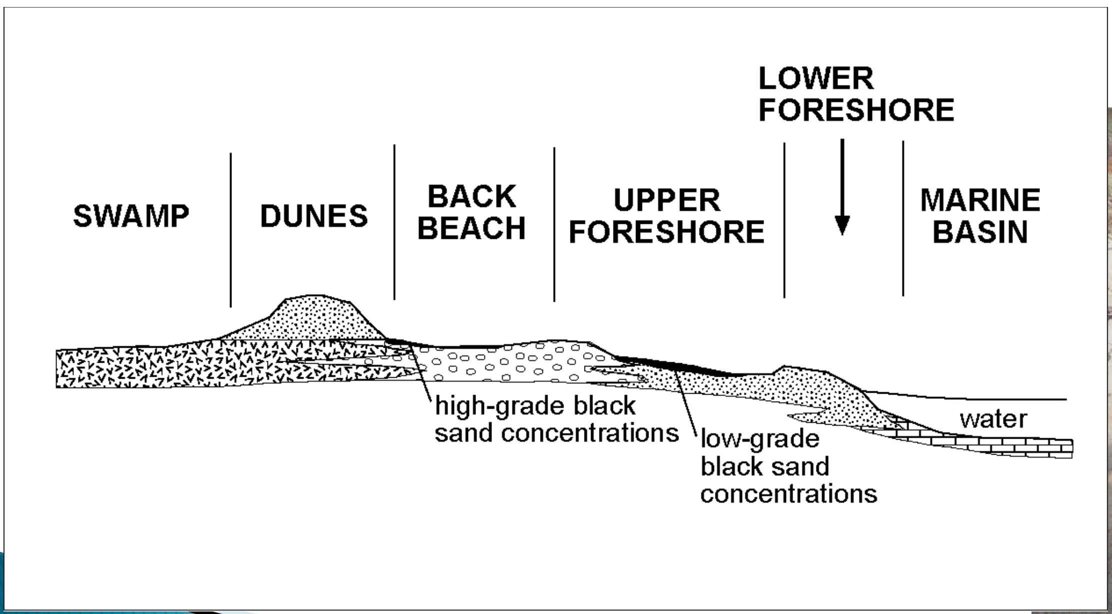
Chapter L of
Mineral Deposit Models for Resource Assessment

Scientific Investigations Report 2010–5070–L

U.S. Department of the Interior
U.S. Geological Survey

Beach-placer sandstone deposits

- accumulations of heavy, resistant minerals (i.e. high specific gravity) that form on upper regions of beaches or in long-shore bars in a marginal-marine environment
- known in the industry as mineral sands



Modern beach-placer sandstone deposits in Virginia

Figure 2. Two views of an area of Assateague Island, Maryland, photographed before and after Hurricane Sandy, which hit the region October 28–30, 2012. The storm surge moved sand over and through the low dunes at this location and deposited considerable sand in the parking lot. Yellow arrow (*A*, *B*) points to same feature; red arrow (*B*) points to dark concentrations of heavy minerals on the upper shoreface. Photographs courtesy of U.S. Geological Survey St. Petersburg Coastal and Marine Science Center (*http://coastal.er.usgs.gov/hurricanes/sandy/photo-comparisons/delaware-maryland.php*).

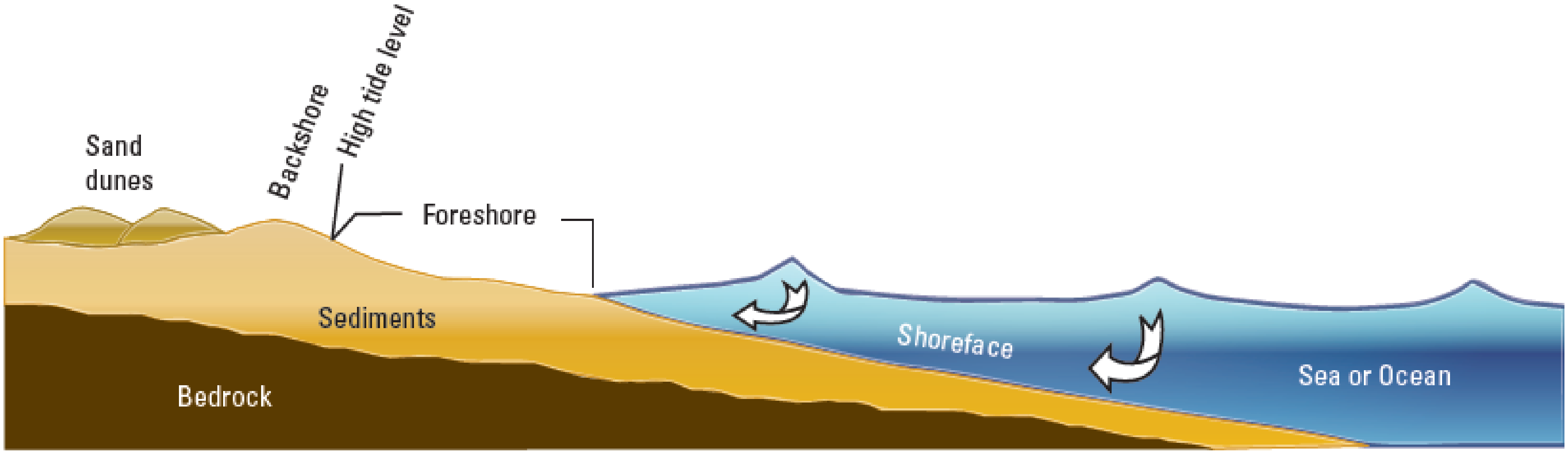


Figure 3. Features commonly used to describe shoreline (strandline) depositional environments associated with deposits of heavy-mineral sands. Not to scale.

Beach-placer sandstone deposits

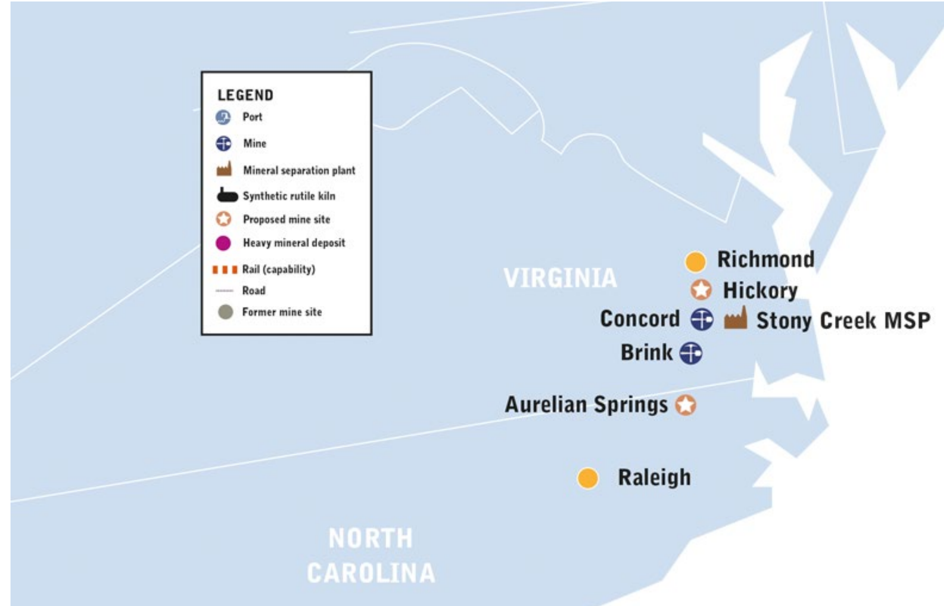
- form by mechanical concentration (i.e. settling) of heavy minerals by the action of waves, currents, and winds
- composed of rutile, titanite, ilmenite, zircon, magnetite, monazite, apatite, xenotime, garnet, and allanite, among other minerals
- Ti, Zr, Fe, are important economically
- Nb, Th, U, Sc, Y, and REE also can be important

Modern beach-placer sandstone deposits in Virginia

Modern examples

- Atlantic Coast, USA
- southeastern Australia
- Andhra Pradesh, India

- mined for titanium, zircon, and monazite (a Ce-bearing REE mineral)



Stony Creek beach-placer sandstone deposit, Virginia

Economics of modern mineral sands

- Economic deposits are 10 million tons of >2% heavy minerals

- Zirconium as zircon (1-50%)
  - Ceramic tiles, bricks used to line steel making furnaces, mold and chill sands, alloying agent in steel, laboratory crucibles
- Titanium as ilmenite (10-60%), rutile, leucoxene (titanium, 5-25%)
  - white pigment found in toothpaste, paint, paper, glazes, and some plastics, heat exchangers in desalination plants, alloys in aircraft, welding rods
- REE as monazite $(Ce,La,Y,Th)PO_4$) (<15%)
  - catalyst, glass, polishing, re-chargeable batteries, magnets, lasers, glass, TV color phosphors
- Other minerals
  - garnet, starolite, kyanite trace-50%

Economics of mineral sands

19 deposits found along the upper coastal plain of Virginia and North Carolina contain 25 million short tons with a grade of 80% ilmenite, 11.5% limonite, 2.5% rutile, 12.5% zircon, 8.5% staurolite, 0.7% tourmaline, 3% kyanite, and 1.3% sillimanite

New Mexico

Beach-placer sandstone deposits in the San Juan Basin and are restricted to Late Cretaceous rocks belonging to the Gallup, Dalton, Point Lookout, and Pictured Cliffs Sandstones

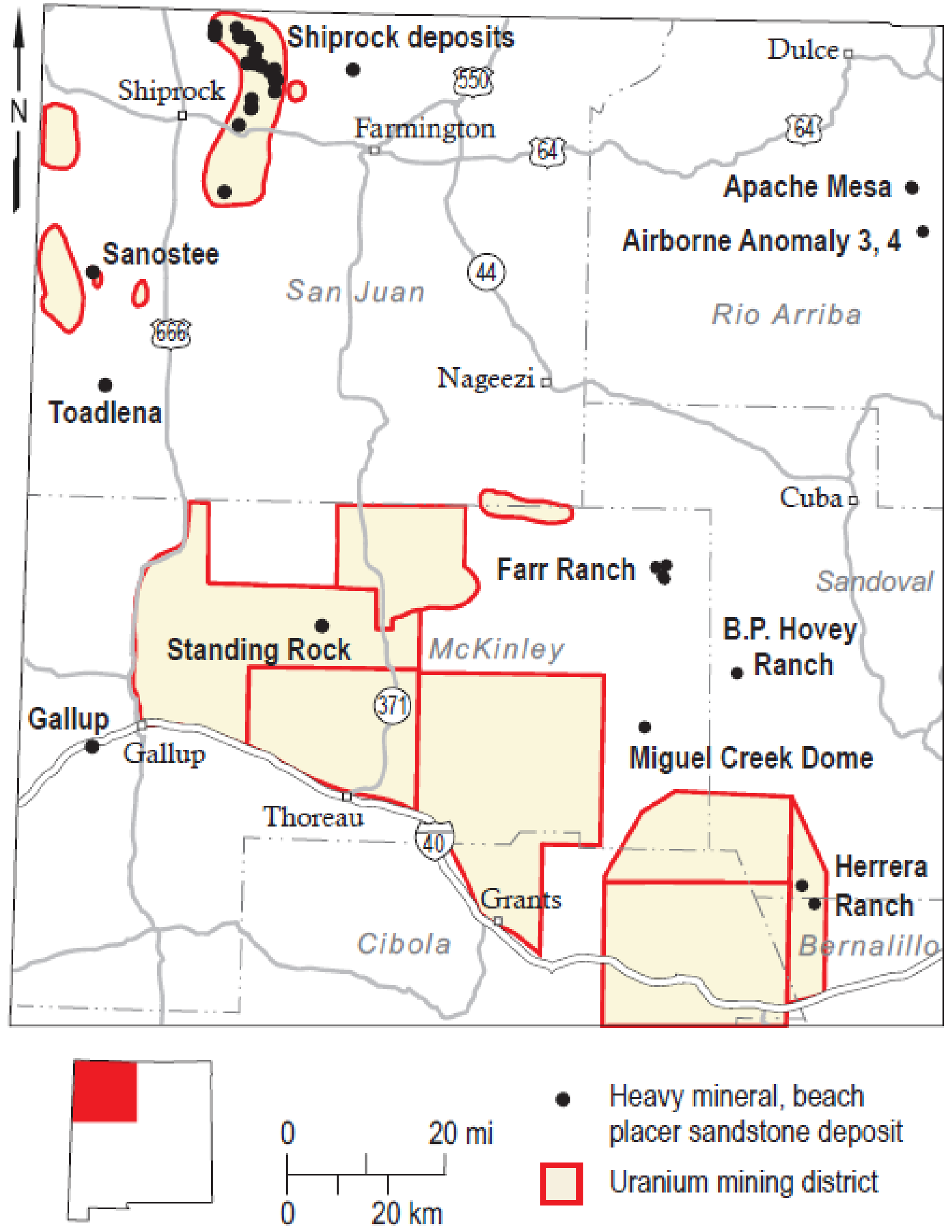


Figure 15. Location of Late Cretaceous heavy mineral, beach-placer sandstone deposits in the north-central San Juan Basin, New Mexico. More detailed location of the deposits are in McLemore (2010a).

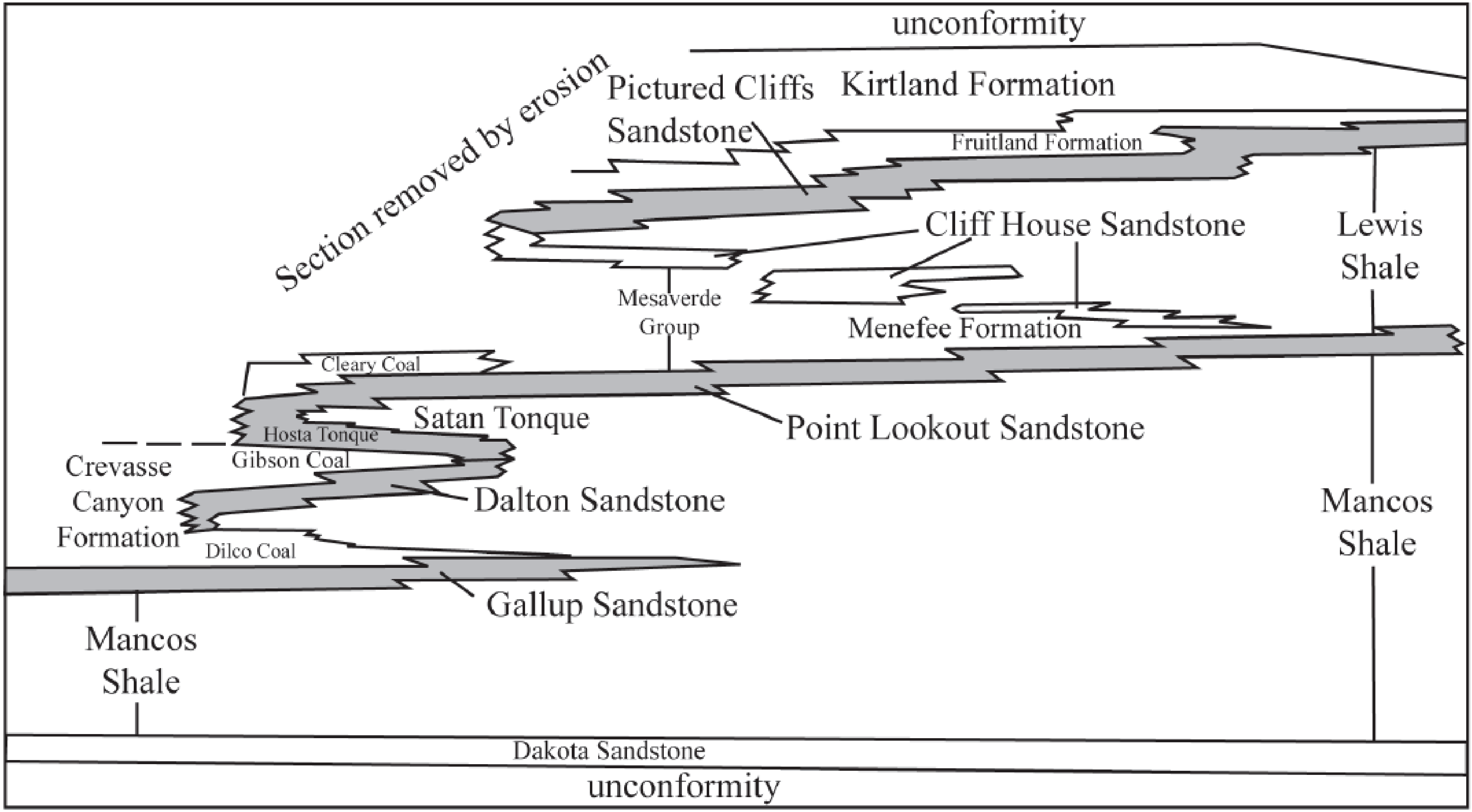
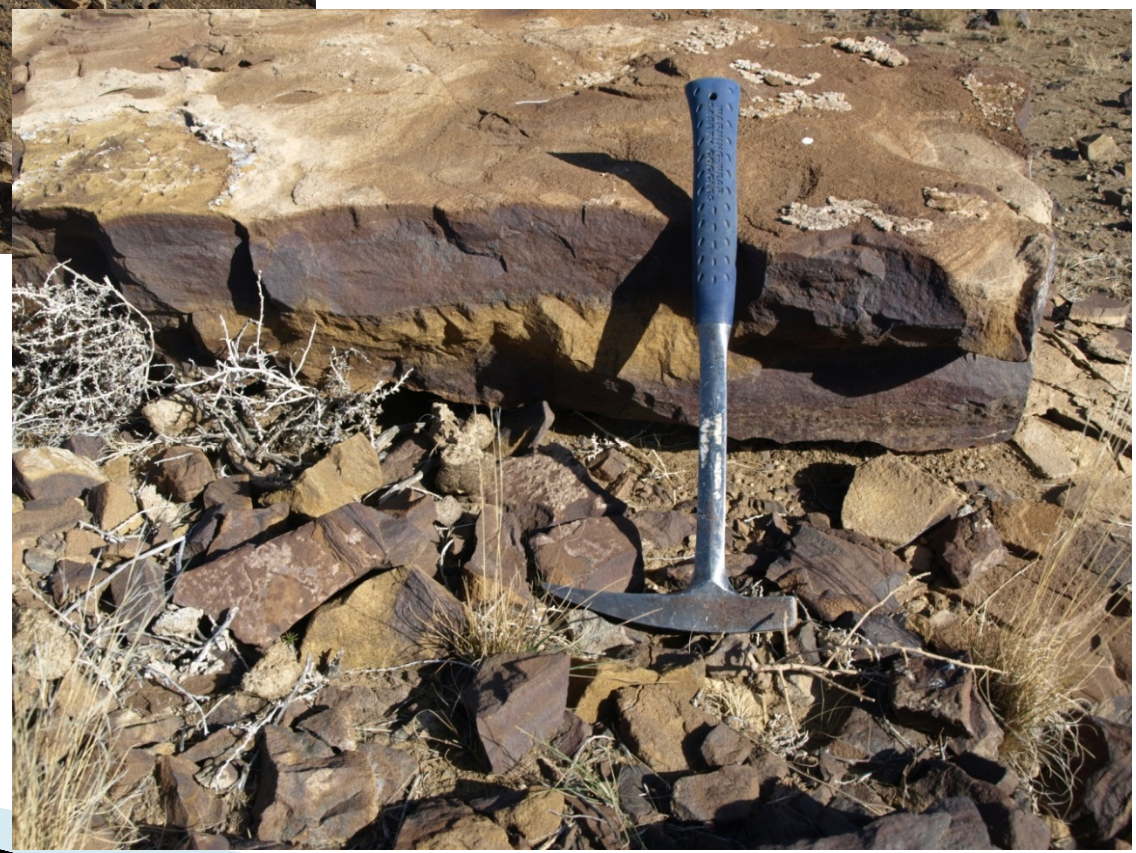


FIGURE 3. Stratigraphic framework and nomenclature of the Late Cretaceous sedimentary rocks in the San Juan Basin (simplified from Molenaar, 1989; Craigg et al., 1990). Gray-shaded sandstone units are hosts of known beach-placer sandstone deposits in the San Juan Basin.

History of exploration in NM

- Most were discovered during airborne gamma-ray radiometric surveys in the 1950s by the U.S. Atomic Energy Commission (AEC)
- Verified by field examinations (1950s by AEC and others, 1980s-2010 by author)
  - Geologic mapping, stratigraphic studies and sampling for mineralogical and chemical analyses
- Apache Mesa—detailed stratigraphic analyses, geologic mapping, mineralogical and chemical analyses, drilling, calculation of resources in 2015-2016

Resources are estimated by the USBM as 4,741,200 short tons of ore containing 12.8% TiO_2, 2.1% Zr, 15.5% Fe and less than 0.10 ThO_2 with some REE (USBM files)



Sanostee deposit, San Juan County

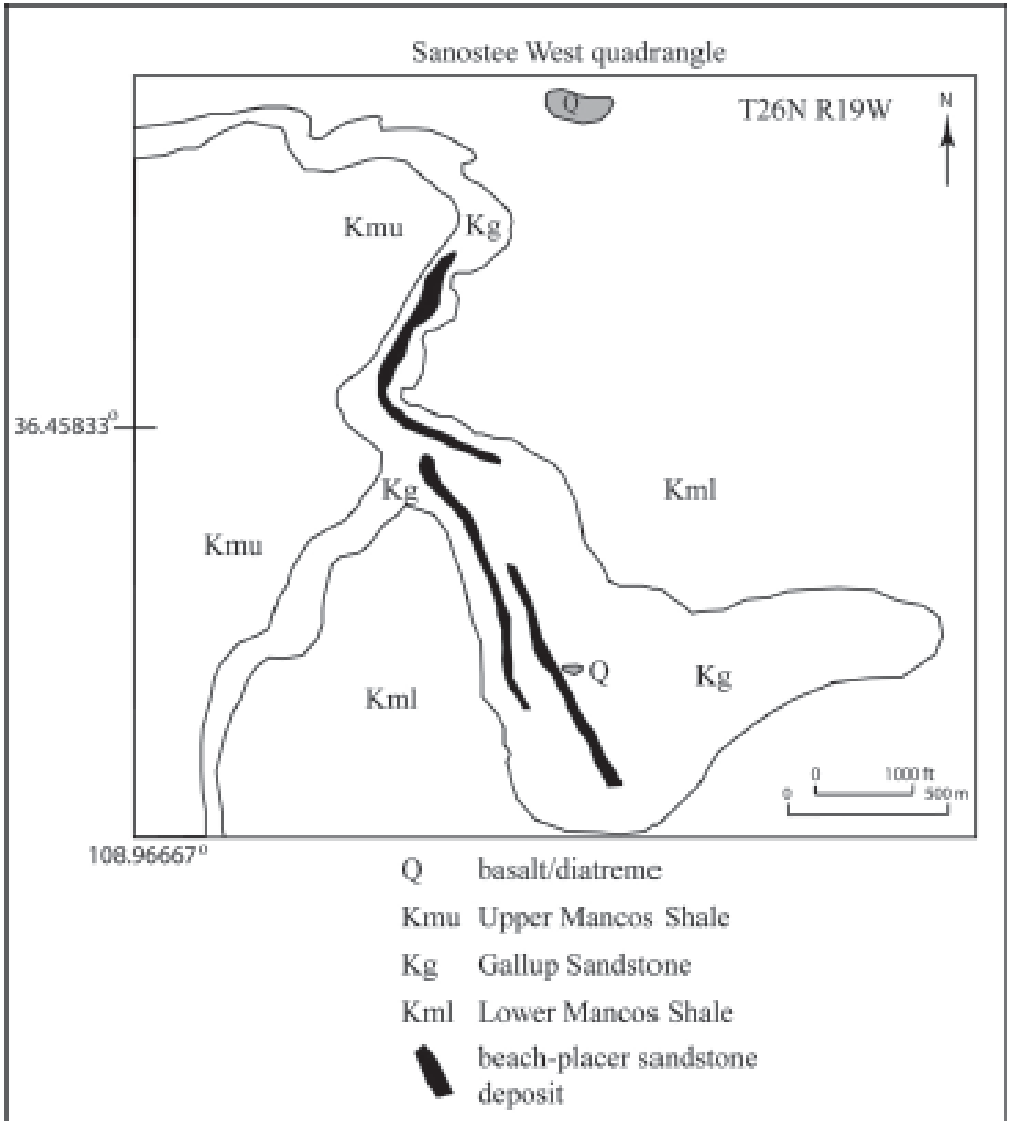


FIGURE 4. Geologic map of the Sanostee beach-placer sandstone deposits, in section 31, T26N, R19W. Mapping of the deposit was by V.T. McLemore in 2009, modified from Beaumont (1954), Dow and Batty (1961), Bingler (1963), and Force (2000).

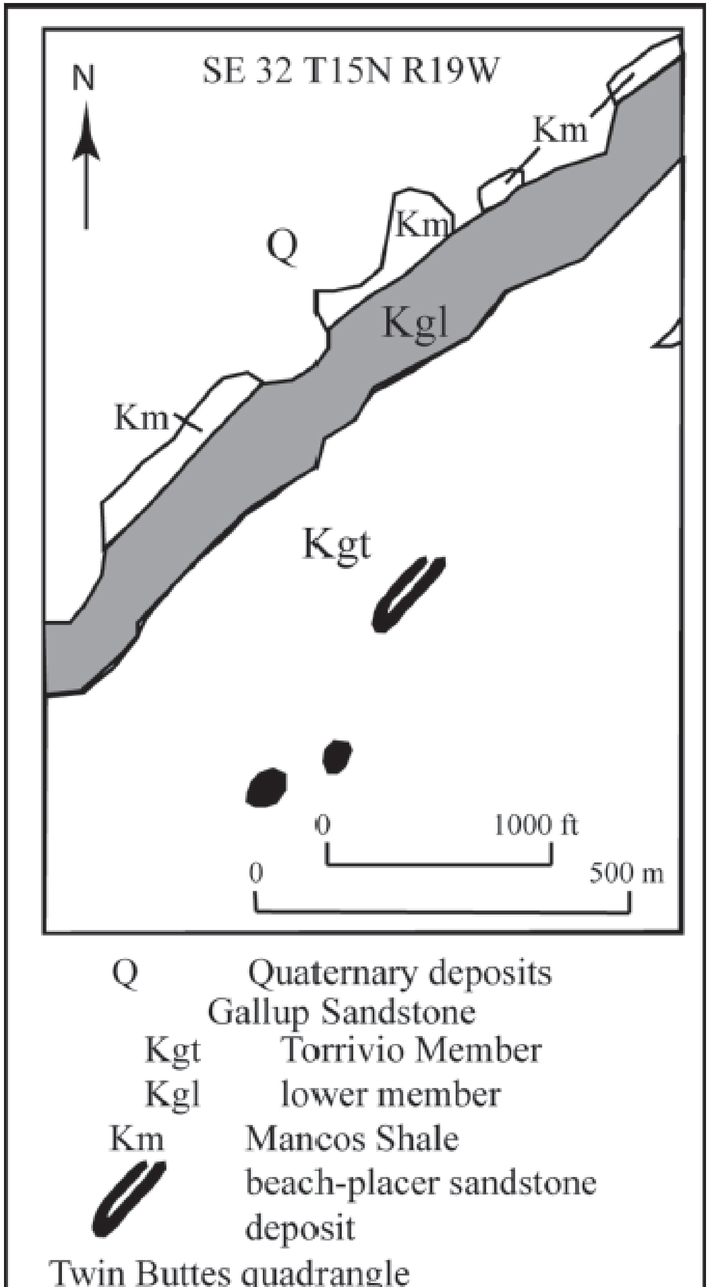


FIGURE 3. Geologic map of the Gallup beach-placer sandstone deposits. Mapping of the deposit was by V.T. McLemore in 2009, sedimentary geology simplified from Millgate (1991).

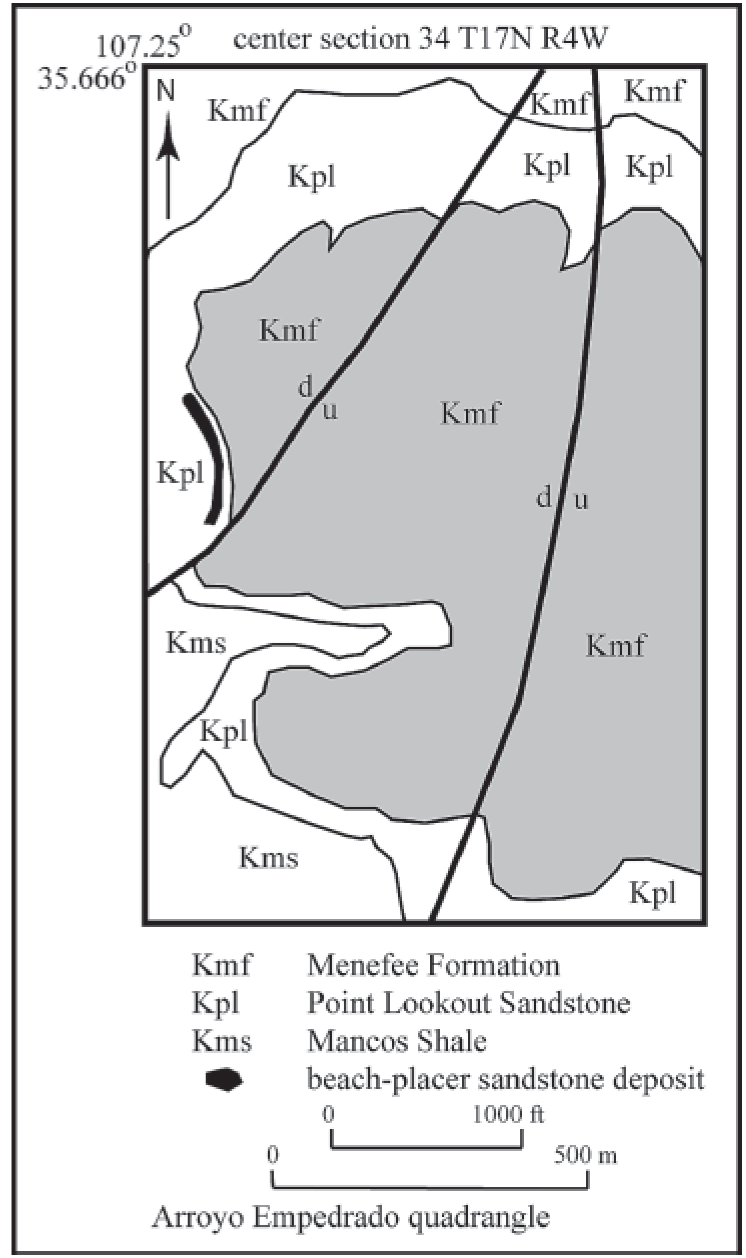


FIGURE 5. Geologic map of the B. P. Hovey beach-placer sandstone deposit. Mapping of the deposit was by V.T. McLemore in 1981, sedimentary geology modified from Tabet and Frost (1979).

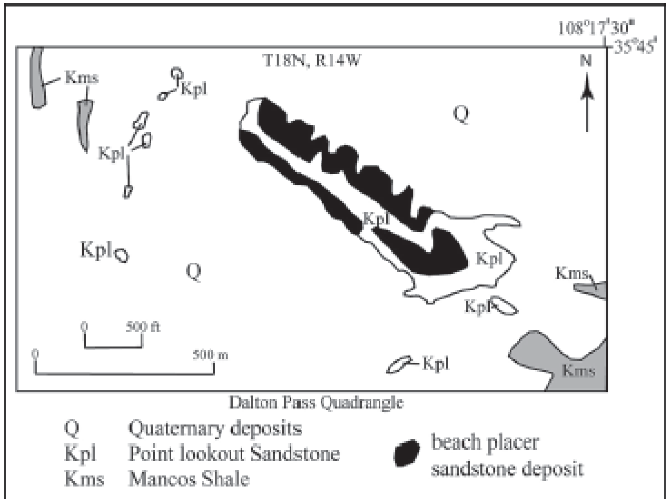


FIGURE 6. Geologic map of the Standing Rock beach-placer sandstone deposit in section 35, T18N, R14W. Mapping of the deposit was by V.T. McLemore in 2009, sedimentary geology modified from Kirk and Sullivan (1987).

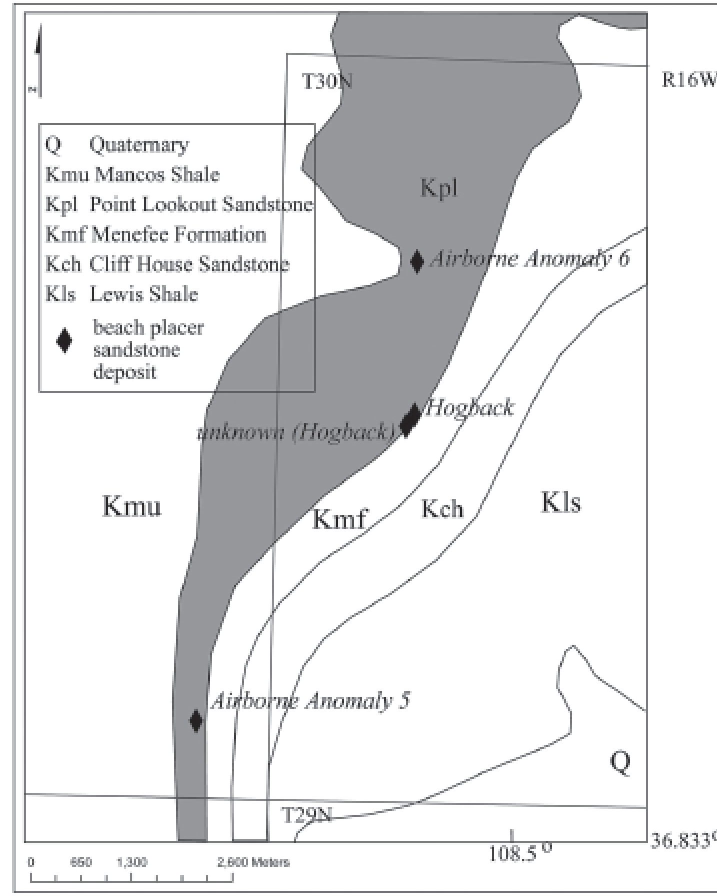


FIGURE 7. Geologic map of the Hogback beach-placer sandstone deposit. Mapping of the deposit was by V.T. McLemore in 2009, sedimentary geology modified from Strobell et al. (1980) and New Mexico Bureau of Geology and Mineral Resources (2003).

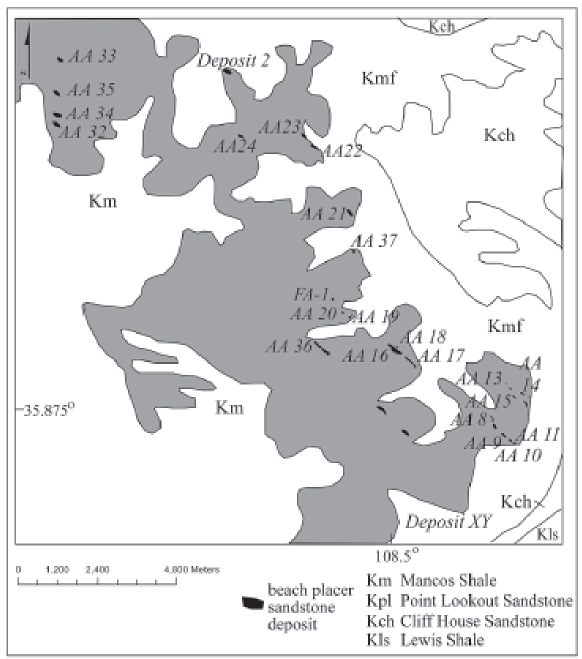


FIGURE 8. Geologic map of the beach-placer sandstone deposits on the Ute Indian Reservation and adjacent area (modified from AEC records; Strobell et al., 1980; Zech et al., 1994; New Mexico Bureau of Geology and Mineral Resources, 2003).

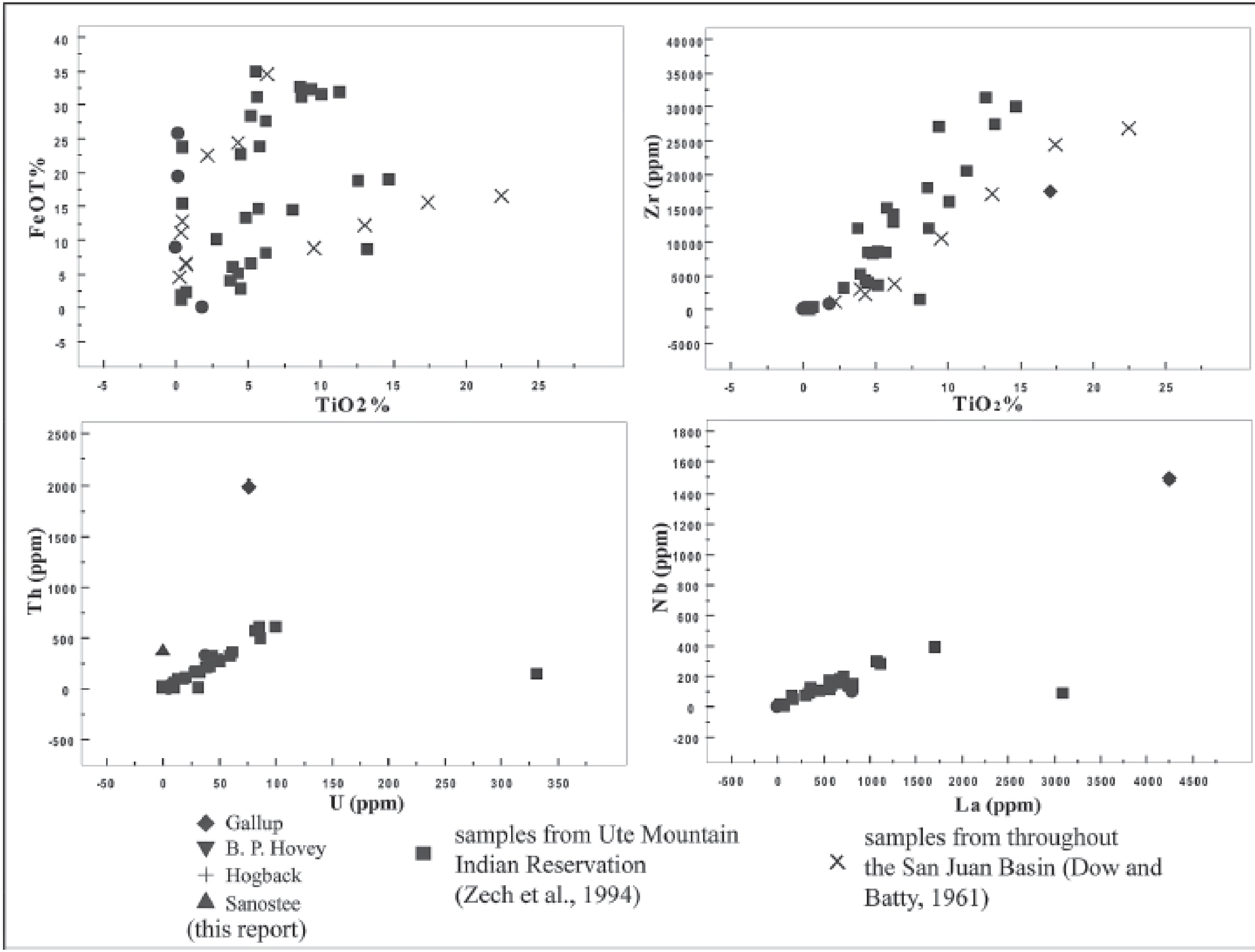


FIGURE 9. Scatter plots of chemical analyses of selected beach-placer deposits, San Juan Basin, New Mexico. Chemical analyses are in Appendix 1 and McLemore (2010) and correlation coefficients are in Table 3.

Apache Mesa, Jicarilla Indian Reservation

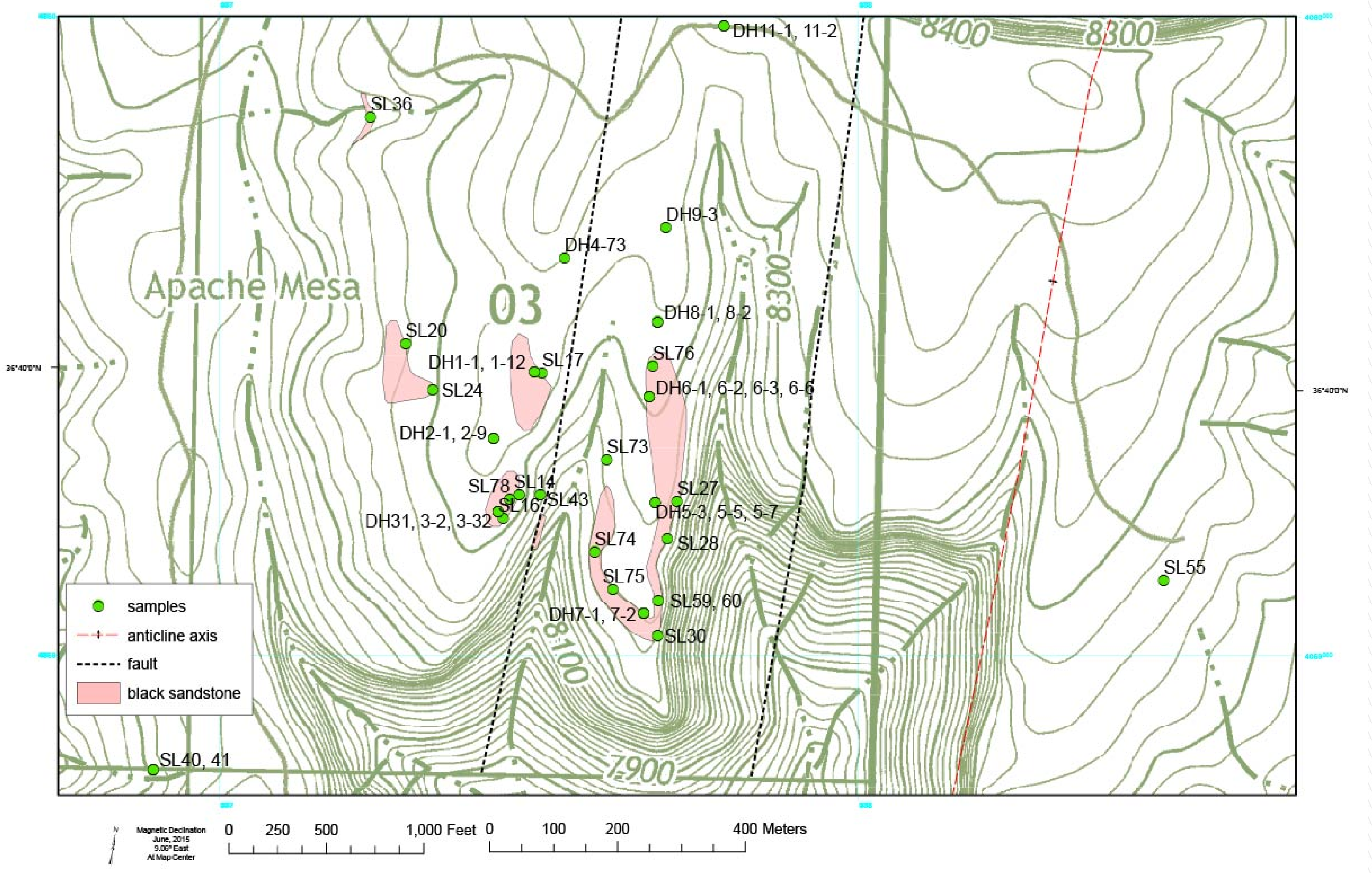
Apache Mesa

Drilled in August 2015

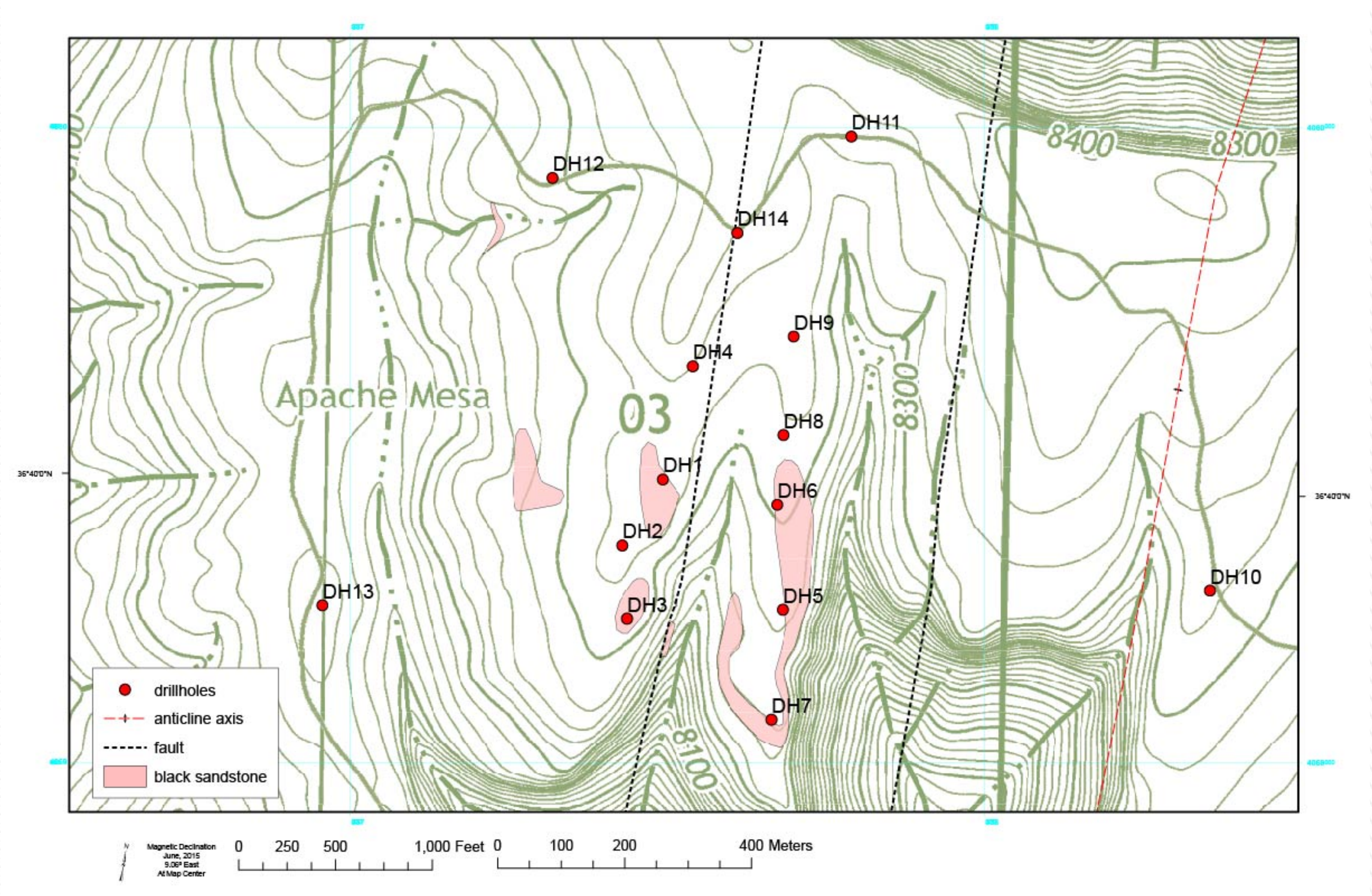
Small footprint with little land disturbance

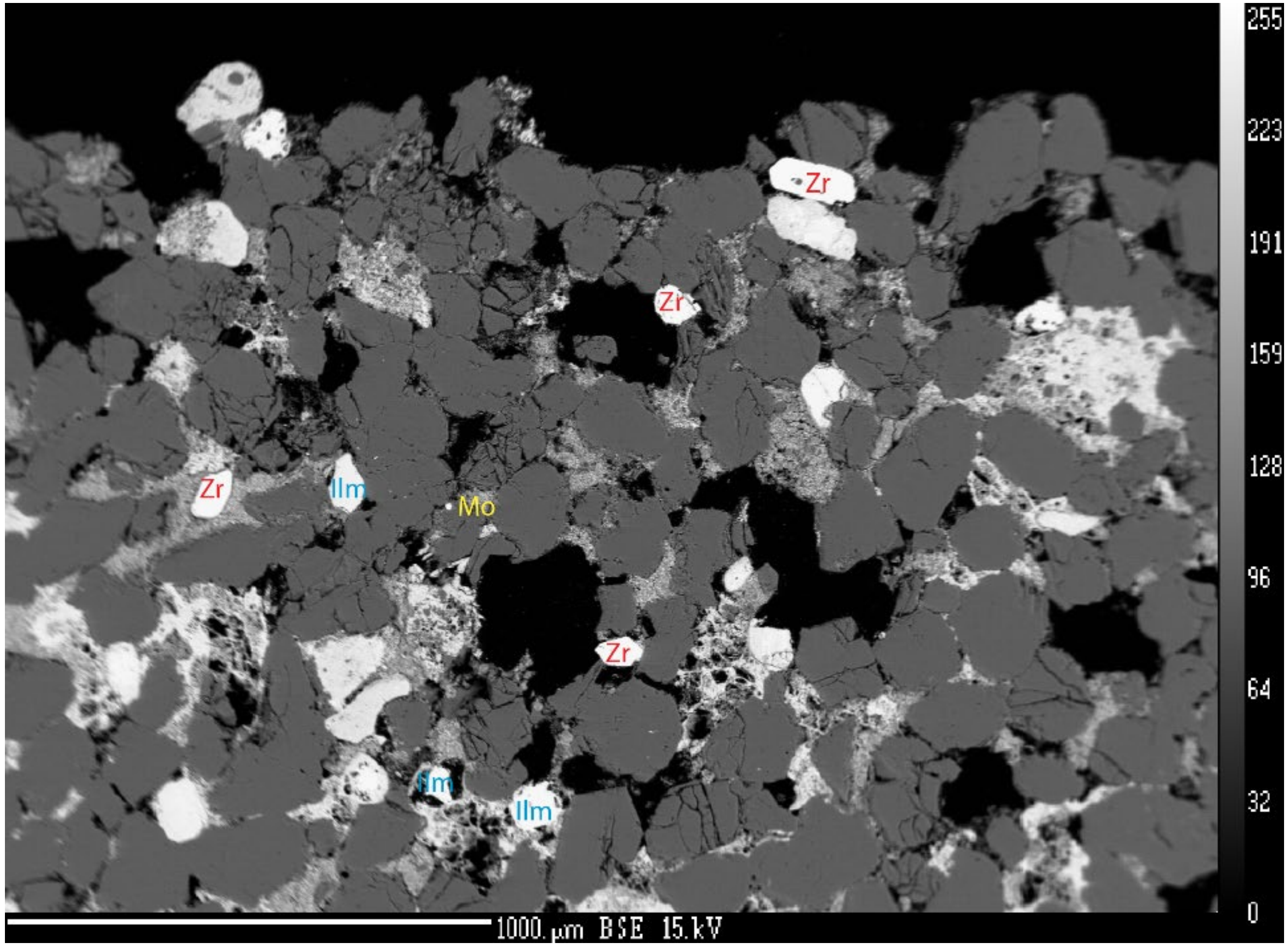
CS 14 track drill rig by Layne Drilling Co.

Apache Mesa samples

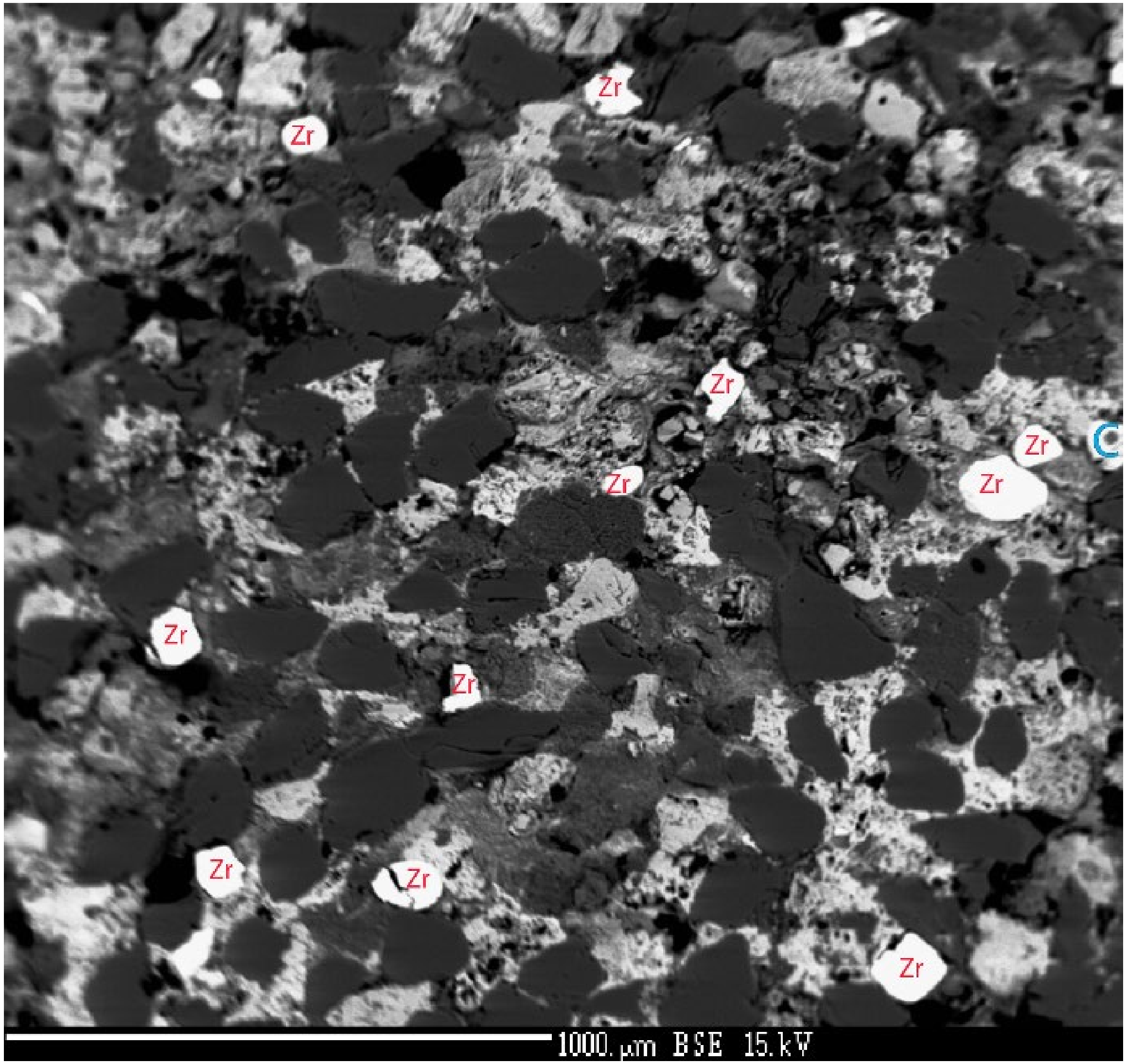


Apache Mesa drill holes



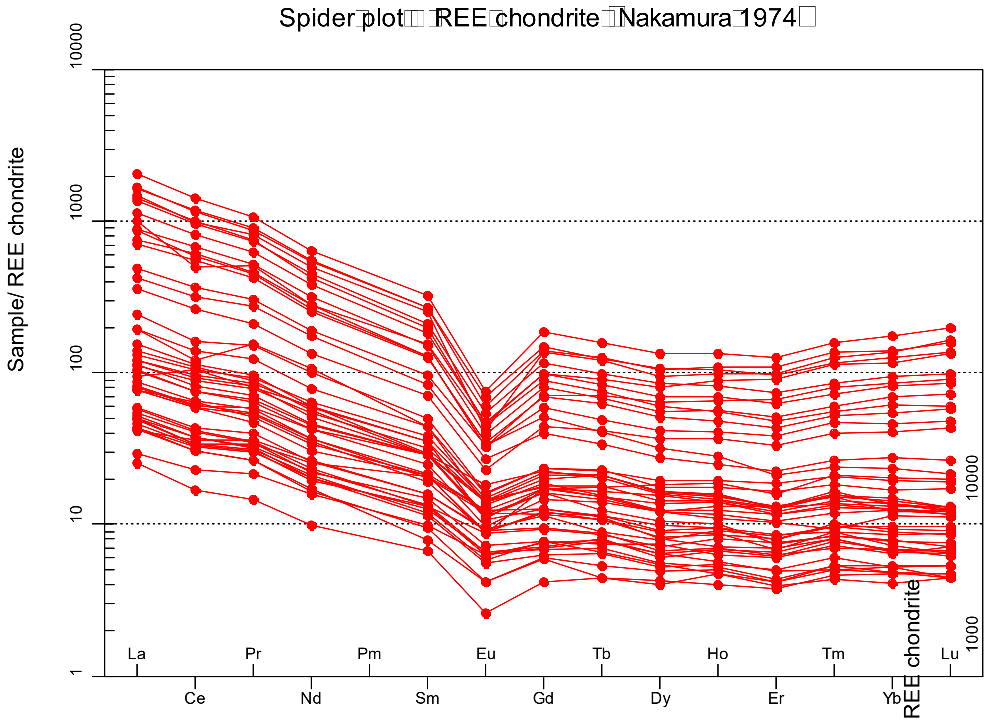


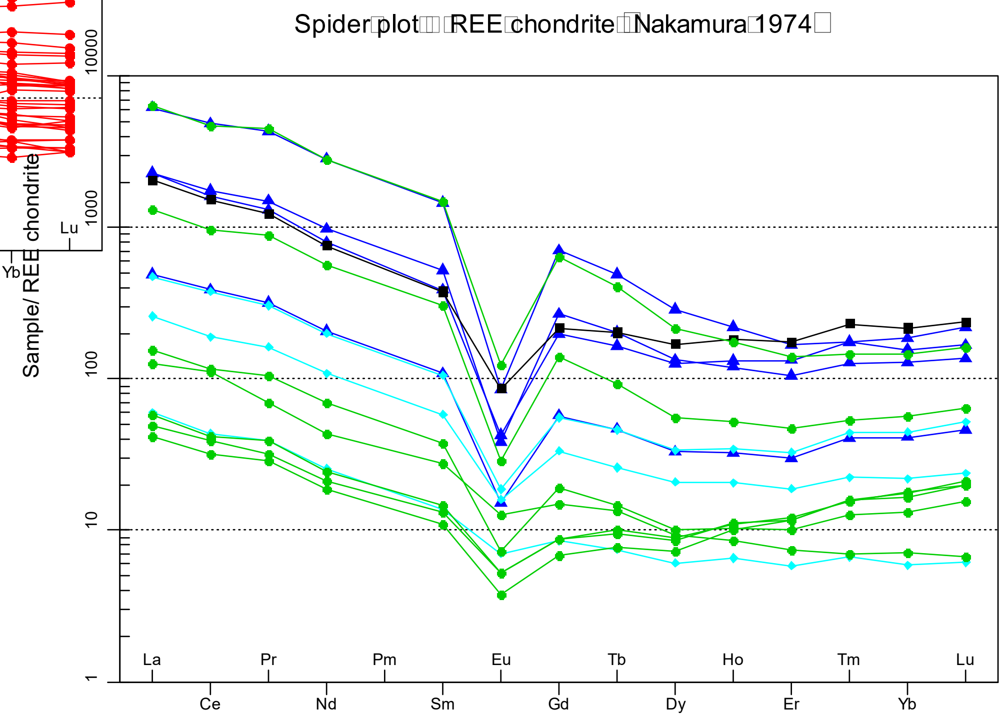
Electron microprobe photo of sample SAN 6 (Sanostee). **Zircon** =red, **ilmenite**=blue, and **monazite**=yellow. Mottled, lighter colored cement=iron oxide (hematite). Dark grey grains=quartz. Black areas=pore spaces.



Electron microprobe picture of sample SL 16 (Apache Mesa).

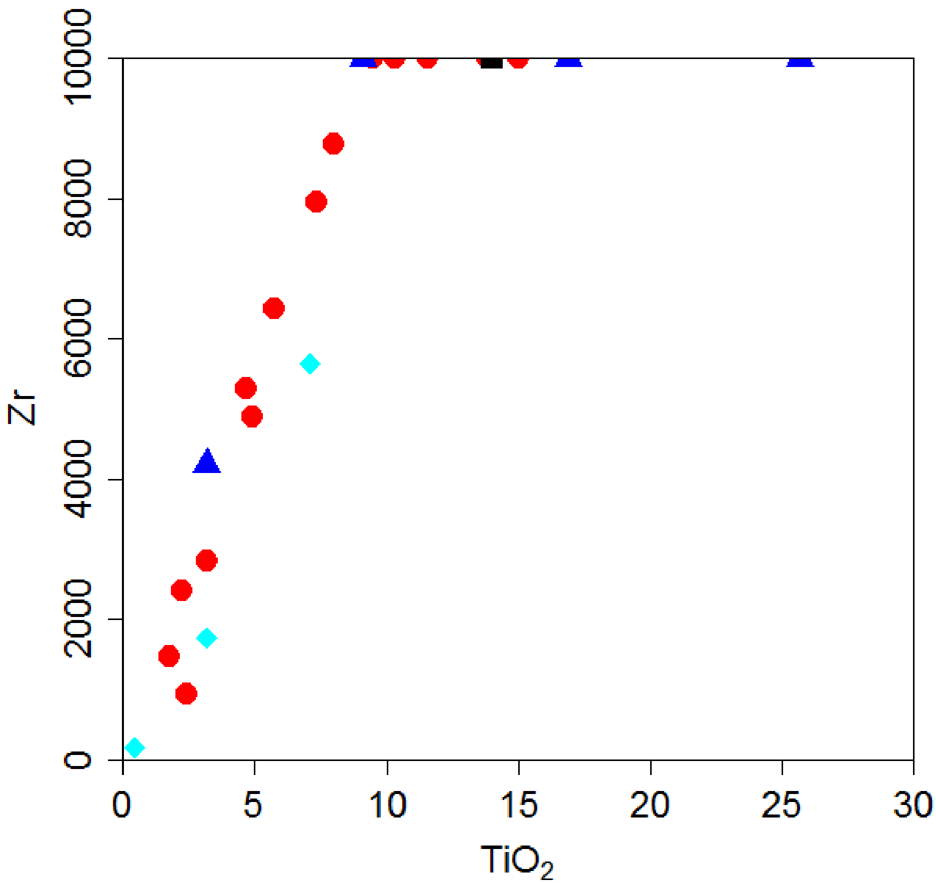
GEOCHEMISTRY

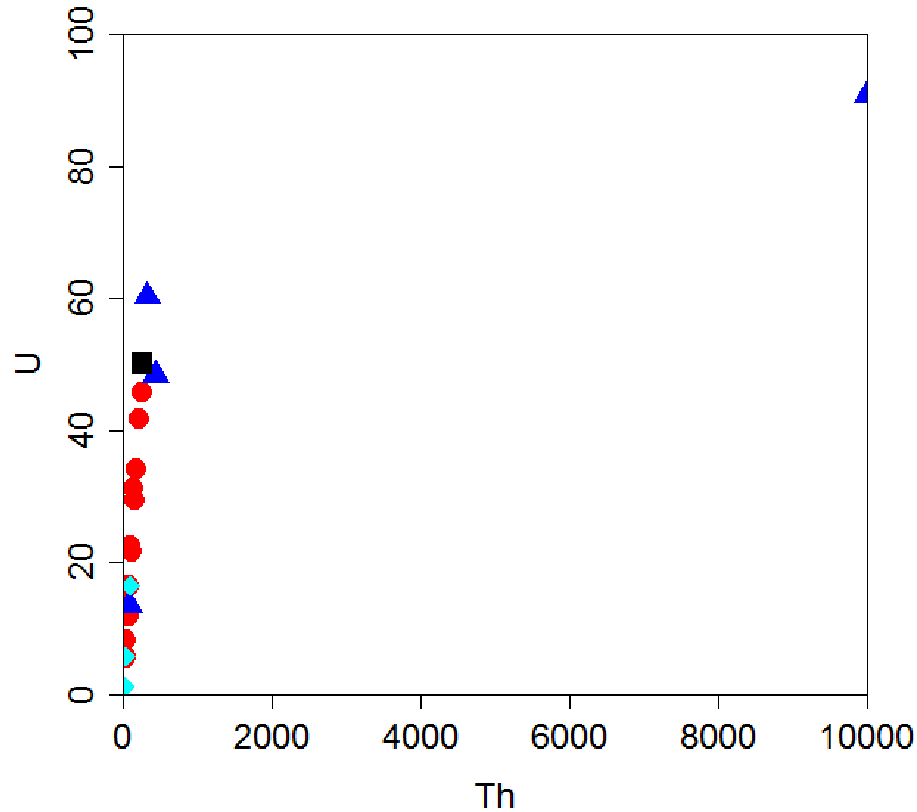




Chondrite-normalized REE plot of selected beach-placer deposits, Apache Mesa (red), Standing Rock (light blue), Sanostee (dark blue), and B.P. Hovey (black), San Juan Basin, New Mexico. Chondrite values are from Nakamura (1974).

GEOCHEMISTRY

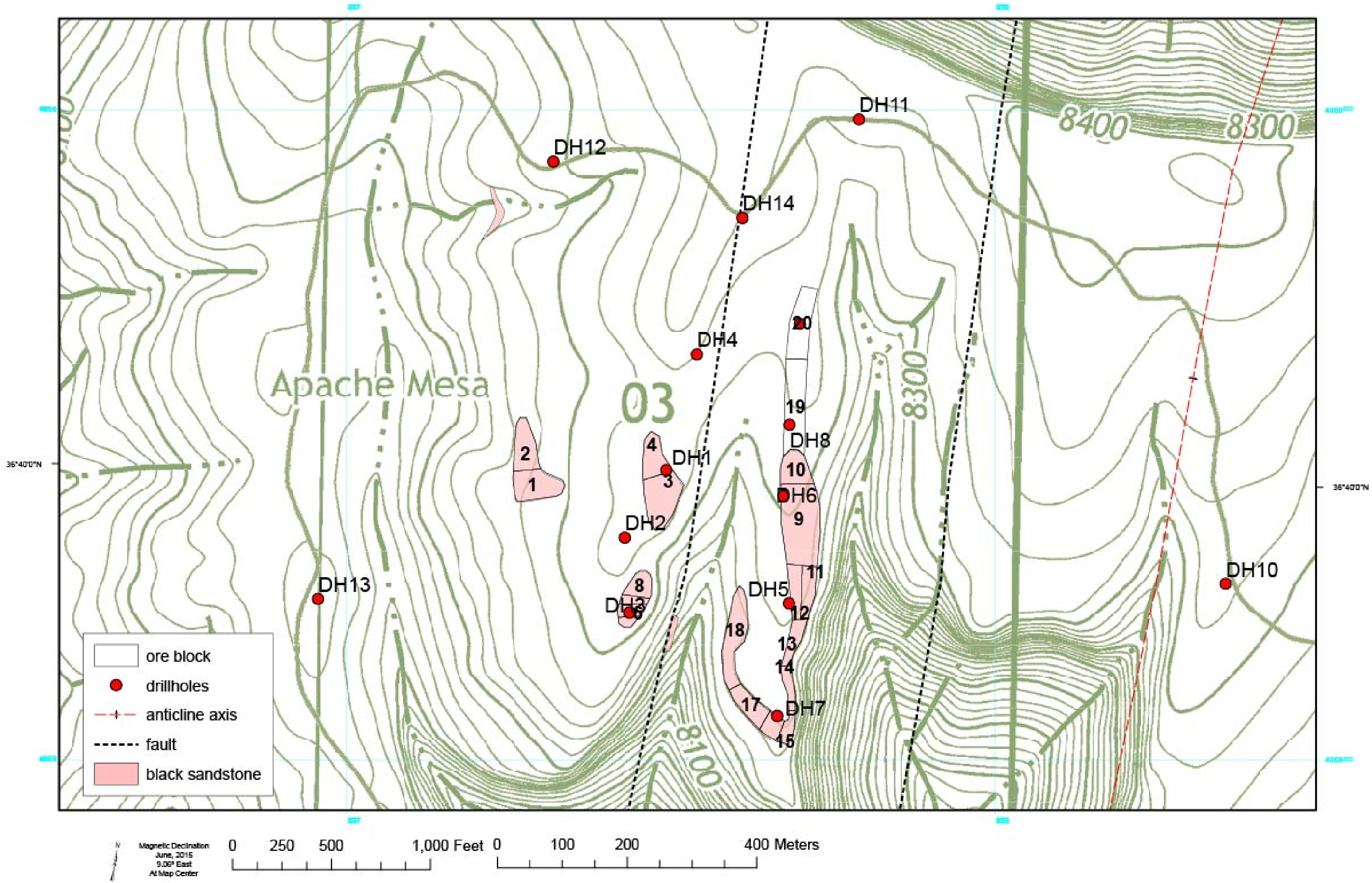




TiO_2=%, Zr, U, Th=ppm

Zr-TiO_2 and U-Th plot of selected beach-placer deposits, Apache Mesa (red), Standing Rock (light blue), Sanostee (dark blue), and B.P. Hovey (black), San Juan Basin, New Mexico.

Apache Mesa ore blocks

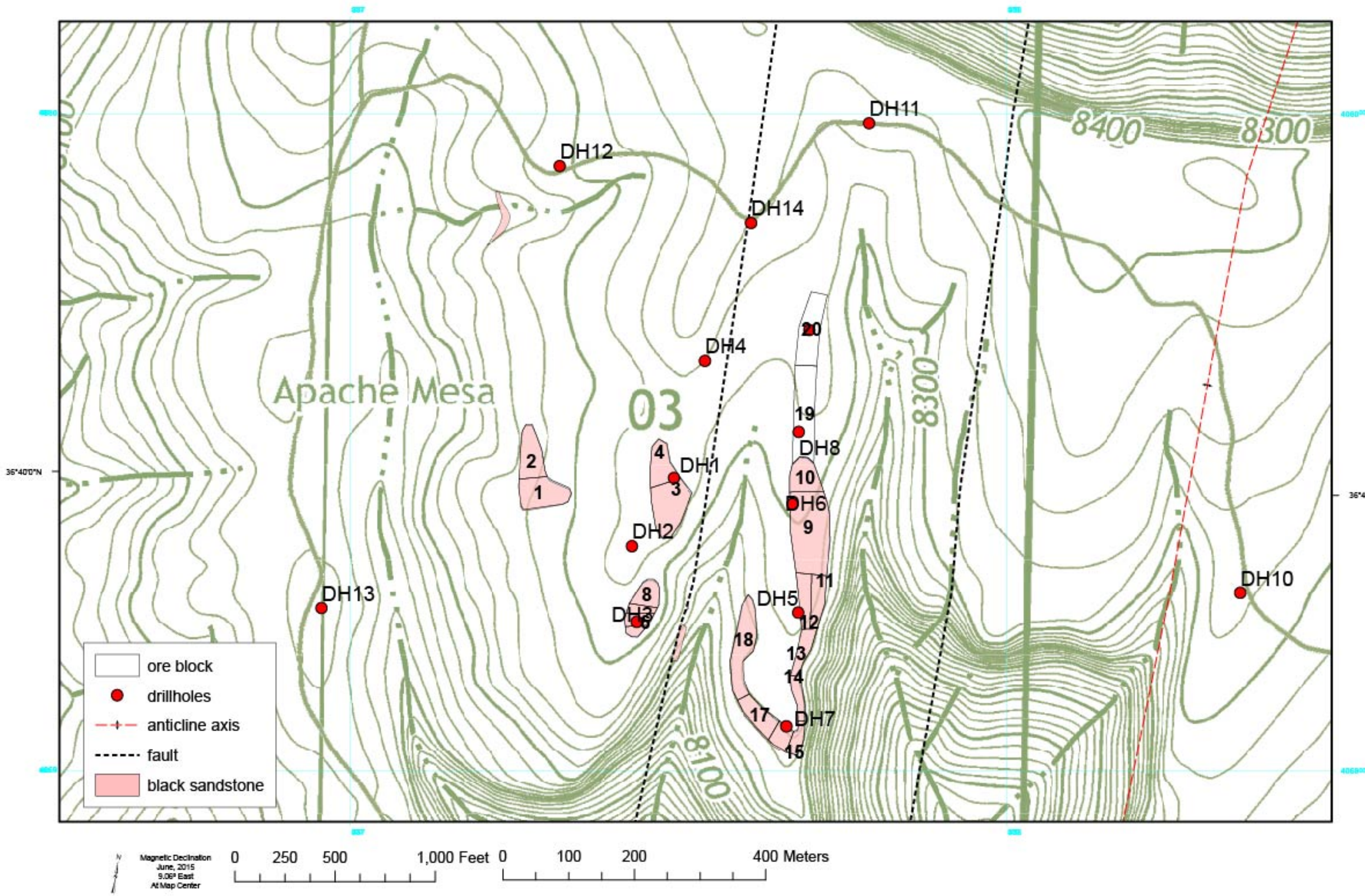


Procedure

- Chemistry as a proxy to mineralogy
- Each ore block has at least one sample
- Calculate area using GIS tools
- Measured thickness in field and/or by drilling
- Measured specific gravity
- Calculate tonnage and grade for each polygon, for each element
- Total for the entire deposit

Economics of Apache Mesa deposit

- 132,900 short tons (120,564 metric tons) of ore with grades of 3% TiO_2, 108 ppm Cr, 46 ppm Nb, 2,187 ppm Zr, 40 ppm Th, and 522 ppm TREE



Summary

- Although, some individual analyses of samples from Apache Mesa contained high concentrations of TiO_2 (15%), Cr (590 ppm), Nb (260 ppm), Zr (10,000 ppm), Th (258 ppm), and TREE (2,692 ppm)
- The Apache Mesa beach-placer sandstone deposit contains only 132,900 short tons (120,564 metric tons) of ore with grades of 3% TiO_2, 108 ppm Cr, 46 ppm Nb, 2,187 ppm Zr, 40 ppm Th, and 522 ppm TREE

Summary

- In conclusion, the Apache Mesa heavy mineral, beach-placer sandstone deposit is too small, well cemented and low grade to be economic in today’s market. No further investigation is recommended at this time

SOURCE

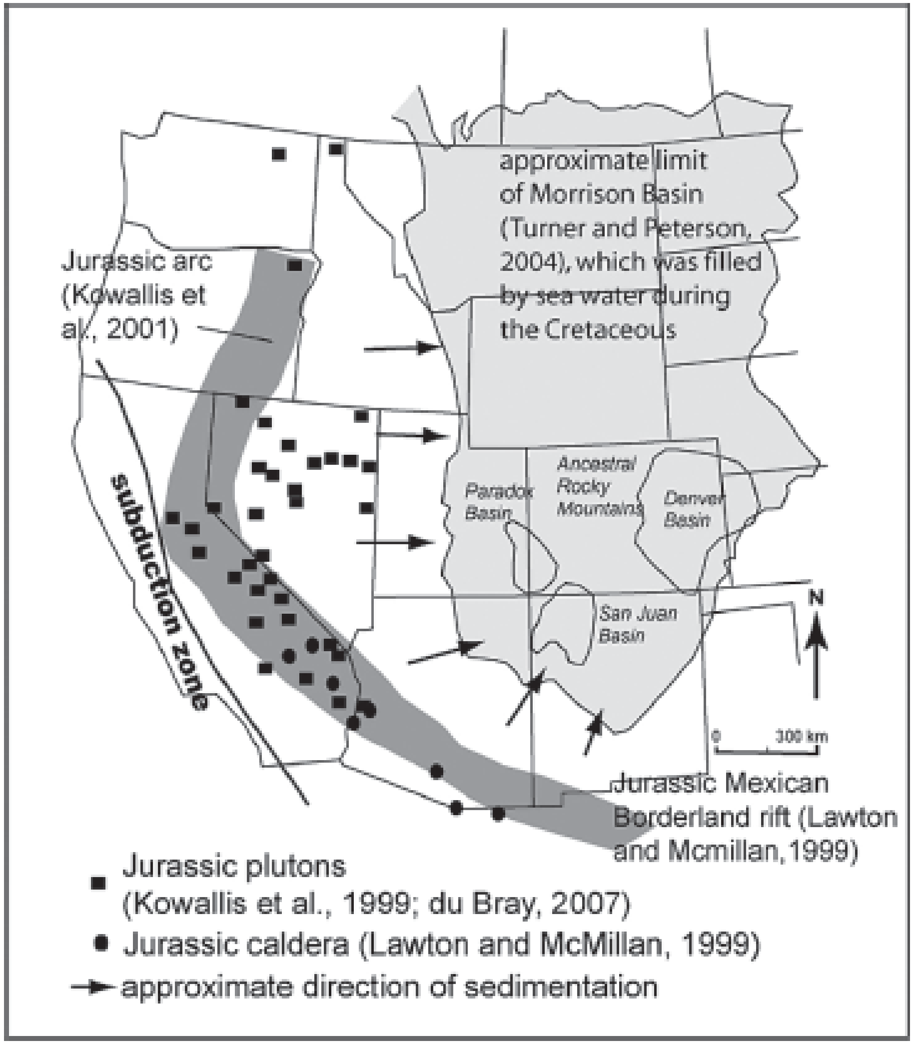


FIGURE 11. Approximate location of the Jurassic arc in relation to the Morrison Basin. This arc provided a highland consisting of granitic rocks that could have been a source for the Cretaceous beach-placer sandstone deposits in the San Juan Basin. Modified from Lawton and McMillan (1999), Kowallis et al. (1999, 2001), Turner and Peterson (2004) and du Bray (2007).

Issues for NM deposits

- Numerous but small tonnage
- Land access
  - Wilderness areas
  - Potential endangered species
  - Private lands, locally used for hunting, and no interest in mining or exploration
  - Indian reservations
- Permitting, even for exploration drilling, can in some areas take a long time
  - Apache Mesa project was approved in 3 months
- Closure of areas during spring and summer due to wildfire danger or potential flooding

Future research

- Detailed geologic mapping including alteration and mineral zoning at other NM deposits (similar to work in progress at Apache Mesa)
  - geochemical analyses
- Mineralogical studies
- Isotopic studies
- Understanding of NM beach placer sandstone deposits is important to identify future resources and adds to our understanding of how these deposits form
- Potential for Zr, Ti, REE, Nb

CONCLUSIONS

Although, local high concentrations of Ti, Zr, REE, U, and Th are found in some heavy mineral, beach-placer sandstone deposits in the San Juan Basin, it is unlikely that any of the San Juan Basin beach-placer sandstone deposits will be mined in the near future because of small tonnage, high degree of cementation through lithification, high iron content, and distance to processing plants and markets.

CONCLUSIONS

- However, as the demand for some of these elements increases because of increased demand and short supplies, the dollar value per ton of ore may rise, enhancing deposit economics.
- Exploration drilling of some of the other larger deposits, especially the Sanostee deposit and the deposits on the Ute Mountain Indian Reservation in the northern San Juan Basin could be warranted in the future to fully evaluate the economic potential.
- Ultimately, economic potential will most likely depend upon production of more than one commodity and more than one deposit in the San Juan Basin.

For more information

- http://geoinfo.nmt.edu/publications/periodicals/earthmatters/11/EM11n2.pdf
- http://geoinfo.nmt.edu/publications/periodicals/nmg/37/n3/nmg_v37_n3_p59.pdf
- http://geoinfo.nmt.edu/staff/mclemore/projects/mining/REE/documents/12-146.pdf
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