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Field, petrographic, and geochemical studies of sedimentary copper deposits in New Mexico indicate that at the start of both Permian and Triassic deposition, the sedimentary environment was a moderate to low gradient alluvial plain. Precambrian highlands composed of metavolcanic rocks with high copper contents were the original source. Some copper was incorporated into clays or transported short distances in surface waters before precipitating as oxide copper minerals in stream sediments as is shown by a comparison of mineralization in recent alluvial gravels and the Permian Abo Formation at the Zuni District.

During diagenesis, copper and other ions were released by dissolution of silicates, sulfides, and oxides to form a copper-rich groundwater (<1 ppm). Deposition of copper occurred in paleo stream channels by sulfur associated with woody debris (Triassic Agua Zarca Sandstone at the Nacimiento Mine).

Permian channels are smaller, commonly lack large concentrations of coarse woody debris, and are closely associated with backswamp and fine grain channel-fill deposits. Field relations indicate that discharging groundwater can precipitate copper in organic-rich, often calcareous, reduced muds and silts adjacent to channel deposits (Scholle and High Rolls Districts), or down gradient in organic supratidal sands (Pintada Mine) or in beach and nearshore marine sands with H_2S (Rayo District). Discharge of groundwater into marine sediments may form copper-rich shale, or the copper may be dispersed. However, copper deposits such as those at the Lisbon Valley District, Utah, may represent later remobilization of copper during the dissolution of evaporites or compaction of sediments.

ADVANTAGES OF COMPOSITE THIN-SECTIONS FOR TEACHING OPTICAL MINERALOGY AND PETROGRAPHY

Larsen, Leonard H., Department of Geology, University of Cincinnati, Cincinnati, Ohio 45221

Composite thin-sections of minerals and rocks are economical to make and use, and permit rapid, strategic study.

Thirty-six rock-forming minerals, as randomly-oriented grains (-80+120 mesh) indurated by epoxy, were prepared as six thin-sections with six minerals per slide. These were used to teach Optical Mineralogy as a prerequisite to Thin-Section Petrography, and to transition students from grain-in-oil mounts to thin-sections. Minerals on each slide were grouped for rapid strategic comparisons and to illustrate thin-section identification techniques.

Composite thin-sections of fine- and medium-grained rocks have similar advantages of economy and comparison. Examples of application are: a rock suite - Palisades Sill, ten rocks on one slide; serial relations - Bouma cycle, five rocks on one slide; catalog of textures - ash-flow tuffs, twenty-four rocks on three slides.

In all cases students can have identical thin-sections and work in unison. Two or four specimens can be compared simultaneously. Projection-discussion enhances the method which can be extended to ore-microscopy. Composite thin-sections have analogous advantages in research, as well.

CURRENT STATUS OF THE LOS ALAMOS DRY HOT ROCK GEOTHERMAL ENERGY EXPERIMENT

Laughlin, A. William, University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87545; Pettitt, Roland A., University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87545; West, Francis G., University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87545

Los Alamos Scientific Laboratory (L
actively investigating the potenti
the extraction of geothermal energ
essentially dry, rock at moderate d
is to drill a deep hole into hot,
hydraulic fracture. A second hol
fracture, creating a circulation loop f
drilling site LASL drilled four shall
deeper holes were drilled into the
these, GT-1, reached a total depth o
Precambrian rocks. The second hole,
m. This hole penetrated 2199 m of
bottomhole temperature of 197°C. Hydra
successful in GT-1 and at two levels in
a radius of about 60 m has been ge
fracture is currently being extend
started in May, 1975. This hole has a
a projected bottomhole temperature
this hole will be completed in Aug
been initiated to locate new drilli
western United States.

TECTONIC IMPLICATIONS OF THE FORT UNION
RIVER BASIN, WYOMING AND MONTANA

Law, B. E., U.S. Geological Survey,
Barnum, B. E., U.S. Geological Sur
Galyardt, G. L., U.S. Geological S

The Big Horn Mountains are general
uplifted in the late Paleocene, providi
River Member, as mapped by Baker, of th
subsurface mapping of the Lebo Shal
Fort Union Formation in the northwe
Wyoming and Montana has resulted in a c
the segment of the Bighorn Uplift,
Wyoming north to the Wyoming-Montana St
evidence is more compatible with the te
Uplift of the Big Horn Mountains wa
River event, and (2) Tongue River sands
northern source area.

Cross sections show that the upper
the lower part of the Tongue River
members rises stratigraphically from t
southwestward to Sheridan, Wyo., resul
Lebo and thinning of the Tongue River.
becomes less sandy and finer grained.
depositional center of the basin d
west of Sheridan, possibly near th
that the source area for the Tongue
Sheridan-Birney area. Cross-stratific
different channel sandstone units in t
River indicates that streams flowed so
present mountain front, during Tongue
conclusion of a northern source area.

DEPOSITIONAL PROCESSES IN THE TERMINUS

Lawson, Daniel E., Department of Ge
Urbana, Illinois 61801

80302

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ONS FOR TEACHING OPTICAL MINERALOGY

of Geology, University of Cincinnati,

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RY HOT ROCK GEOTHERMAL ENERGY

y of California, Los Alamos Scientific
exico 87545; Pettitt, Roland A., Uni-
mos Scientific Laboratory, Los Alamos,
is G., University of California, Los
Los Alamos, New Mexico 87545

Los Alamos Scientific Laboratory (LASL) has for the past four years
actively investigating the potential for and the problems associated
the extraction of geothermal energy from regions containing hot,
essentially dry, rock at moderate depths. In brief, the LASL con-
is to drill a deep hole into hot, impermeable rock and create a
ge hydraulic fracture. A second hole is drilled to intersect the
cture, creating a circulation loop for the injected water. To locate
rilling site LASL drilled four shallow heat-flow holes. Subsequently,
deeper holes were drilled into the Precambrian basement. The first
these, GT-1, reached a total depth of 785 m and penetrated about 47 m
Precambrian rocks. The second hole, GT-2, has a total depth of
9 m. This hole penetrated 2199 m of Precambrian rocks and had a
tomhole temperature of 197°C. Hydraulic fracturing experiments were
cessful in GT-1 and at two levels in GT-2. A small hydraulic fracture
a radius of about 60 m has been generated at the bottom of GT-2.
fracture is currently being extended. A third deep hole, EE-1, was
rted in May, 1975. This hole has a projected depth of about 3800 m
a projected bottomhole temperature of about 250°C. It is expected
t this hole will be completed in August 1975. An exploration program
been initiated to locate new drilling sites in both the western and
tern United States.

TONIC IMPLICATIONS OF THE FORT UNION FORMATION, NORTHWESTERN POWDER
ER BASIN, WYOMING AND MONTANA

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Galyardt, G. L., U.S. Geological Survey, Denver, Colorado 80225

The Big Horn Mountains are generally considered to have been
ifted in the late Paleocene, providing a source area for the Tongue
er Member, as mapped by Baker, of the Fort Union Formation. Surface
subsurface mapping of the Lebo Shale and Tongue River Members of
Fort Union Formation in the northwestern Powder River Basin of
ming and Montana has resulted in a different conclusion. Relative
the segment of the Bighorn Uplift, from the Piney Creek Thrust in
ming north to the Wyoming-Montana State Line, the accumulated
dence is more compatible with the tentative conclusions that:
Uplift of the Big Horn Mountains was principally a post-Tongue
er event, and (2) Tongue River sandstone units were derived from a
thern source area.

Cross sections show that the upper part of the Lebo intertongues
h the lower part of the Tongue River. The contact between the
bers rises stratigraphically from the area around Birney, Mont.,
thwestward to Sheridan, Wyo., resulting in a thickening of the
o and thinning of the Tongue River. In addition, the Tongue River
omes less sandy and finer grained. These relationships suggest that
depositional center of the basin during Lebo and Tongue River time
west of Sheridan, possibly near the site of the Big Horn Mountains,
that the source area for the Tongue River was north of the
ridan-Birney area. Cross-stratification from two stratigraphically
ferent channel sandstone units in the upper part of the Tongue
er indicates that streams flowed southeastward, sub-parallel to the
sent mountain front, during Tongue River time, supporting the
clusion of a northern source area.

POSITIONAL PROCESSES IN THE TERMINUS OF THE MATANUSKA GLACIER, ALASKA

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