September 21-23, 2001

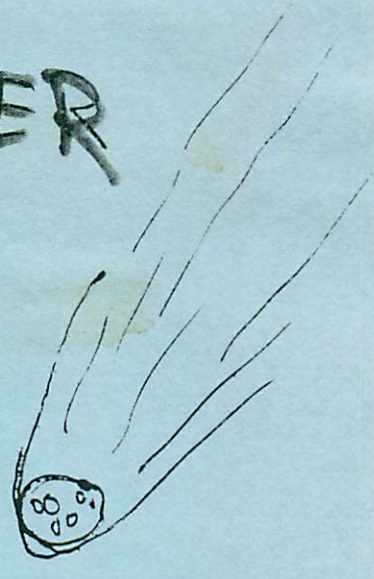
University of ARIZONA

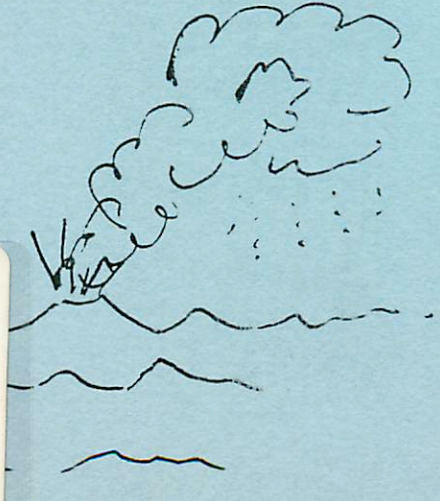
LUNAR AND PLANETARY LAB

METEOR CRATER

and San Francisco Volcanic Field

FIELD TRIP





Ptys 554 Fall Field Trip

21-23 September, 2001

APPROXIMATE ITINERARY

8:30 am, Friday, September 21--Depart LPL Loading Dock

Drive West on Speedway to Oracle Road
9:30 Drive North, stop briefly at El Capitan slide, mile 153 on Rte 77, en route to Globe
Drive through Tonto Basin and Payson, then toward Mormon Lake
3:30 Turn off at Tilton, Proceed West 9 mi to Stoneman Lake
4:00 Descend into Stoneman Lake collapse depression
6:00 Make camp on Anderson Mesa

7:30 AM Saturday, September 22--Break Camp

Drive East ca. 30 mi on I-40 to Meteor crater turnoff
9:00 AM Arrive Meteor Crater, register at Visitor Center and walk from visitor platform to East part of crater rim. Return to vehicles, drive to South Rim to view shocked quartz outcrops.
1:00 PM lunch at ruined mine buildings.
1:30 Depart for San Francisco Volcanic Field and Merriam Crater
3:00 Arrive at Grand Falls of the Little Colorado
7:00 Camp near Government Knoll (milepost 230 on State rte 180, 2 mi East on Forest road 245, 1 mi south on 171)

8:00 AM Sunday, September 23--Break Camp

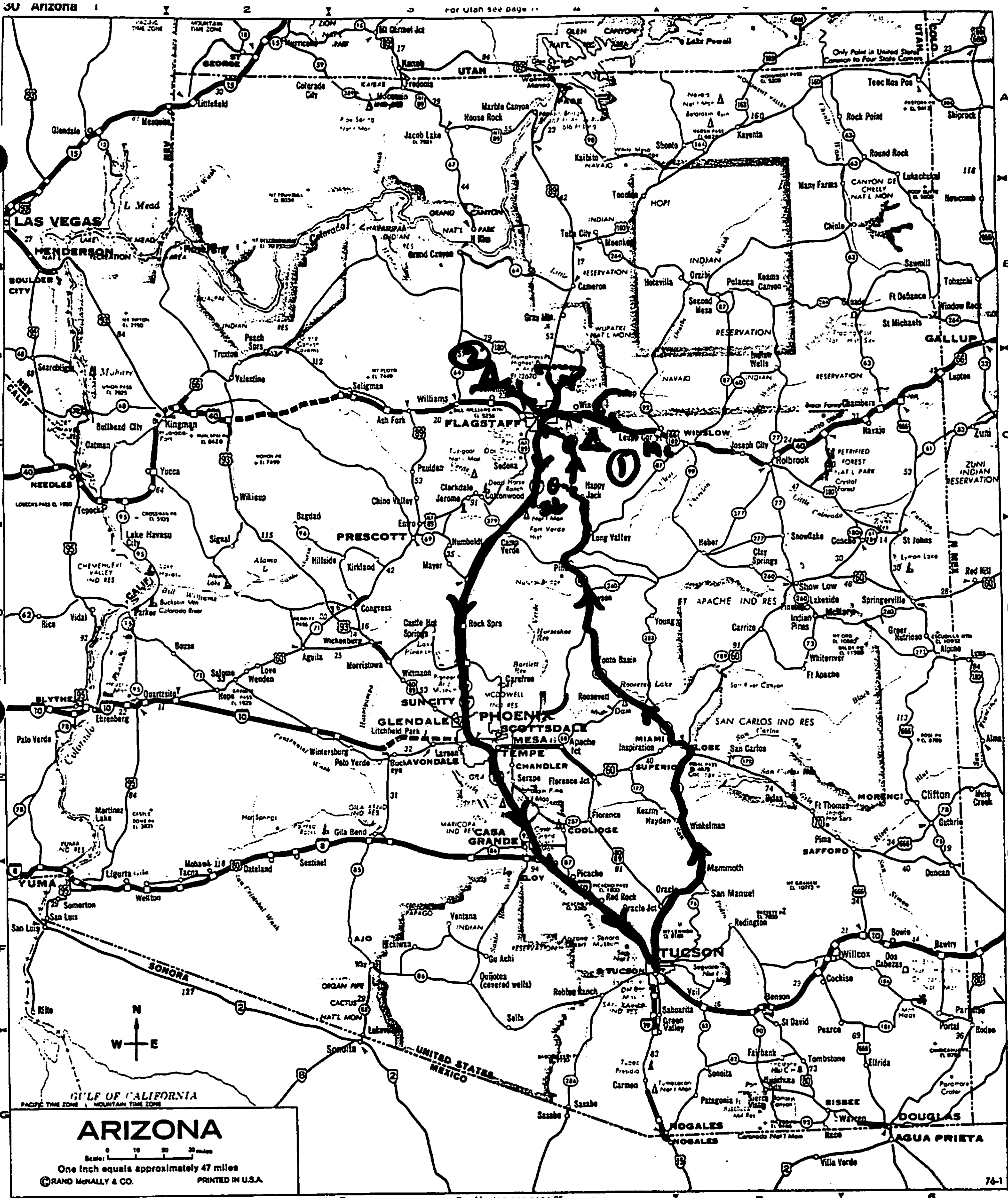
Explore Government Cave lava tube
11:00 ArriveSunset National Monument for tour of San Francisco volcanic field
(State rte 89 North from Flagstaff)

Stops (See Map): O'Leary Peak (Lunch)
Bonito aa lava flow
Drive through cinder field
Strawberry crater
SP Crater (if there is time)

3:30 PM Depart for Tucson via I-17 and I-10
8:00 PM Arrive Tucson, unload vehicles

=FINIS=

Tentative Drivers: Milazzo, Zavacky.



ARIZONA
Population: 1,787,620
(1970 Census)
Area: 113,909 Sq. Miles
Capital: Phoenix

Cities and Towns

Aguila.......D-2
Ajo.......F-3
Apache Jct.......E-4
Ash Fork.......C-3
Avondale.......E-3
Bagdad.......C-2
Bisbee.......G-5
Buckeye.......E-3
Camp Verde.......D-4
Casa Grande.......E-4
Chandler.......E-4
Chino Valley.......C-3
Clarkdale.......C-3
Clifton.......E-6
Clay Springs.......D-5
Colorado City.......A-2
Coolidge.......E-4
Cottonwood.......C-3
Douglas.......G-6
Duncan.......F-6
Ehrenberg.......E-1
Eloy.......F-4
Flagstaff.......C-4
Florence.......E-4
Ft. DeFiance.......B-6
Ft. Thomas.......E-5
Fredonia.......A-3
Glendale.......E-3
Globe.......E-5
Grand Canyon.......B-3
Green Valley.......G-4
Gu Achi.......F-3
Happy Jack.......C-4
Hayden.......E-4
Heber.......D-5
Holbrook.......C-5
Huachuca City.......G-5
Humbolt.......D-3
Jerome.......C-3
Joseph City.......C-5
Kayenta.......A-5
Keams Canyon.......B-5
Kearny.......E-4
Kingman.......C-2
Lakeside.......D-5
Litchfield Park.......E-3
McNary.......D-5
Mayer.......D-3
Mesa.......E-4
Miami.......E-4
Moenkopi.......B-4
Morenci.......E-6
Morristown.......D-3
Naco.......G-5
Nogales.......G-4
Nutrioso.......D-6
Oracle.......F-5
Page.......A-4
Patagonia.......G-5
Payson.......D-4
Peach Springs.......B-2
Phoenix.......E-3
Picacho.......F-4
Pima.......E-5
Pinetop.......D-5
Polacca.......B-5
Prescott.......D-3
Quartzsite.......E-1
Safford.......E-6
St. David.......G-5
St. Johns.......D-6
Salome.......D-2
San Carlos.......E-5
Scottsdale.......E-4
Sedona.......C-4
Seligman.......C-3
Sells.......G-4
Show Low.......D-5
Snowflake.......D-5
Somerton.......F-1
S. Tucson.......F-4
Springerville.......D-6
Superior.......E-4
Tempe.......E-4
Tombstone.......G-5
Tuba City.......B-4
Tucson.......F-4
Wellton.......F-1
Whiteriver.......D-5
Willcox.......F-5
Williams.......C-3
Window Rock.......B-6
Winslow.......C-5
Yuma.......F-1

(1) Arizona Road Map

Fig. i Landforms of Arizona. A physiographic diagram of Arizona showing the relative positions of major structural-physiographic features. This style of illustrating features takes on more meaning when compared to the geologic map. Elevations are given in feet. Redrawn from Erwin Raisz, 1939.

Generalized section of S. Arizona Metamorphic Core Complex

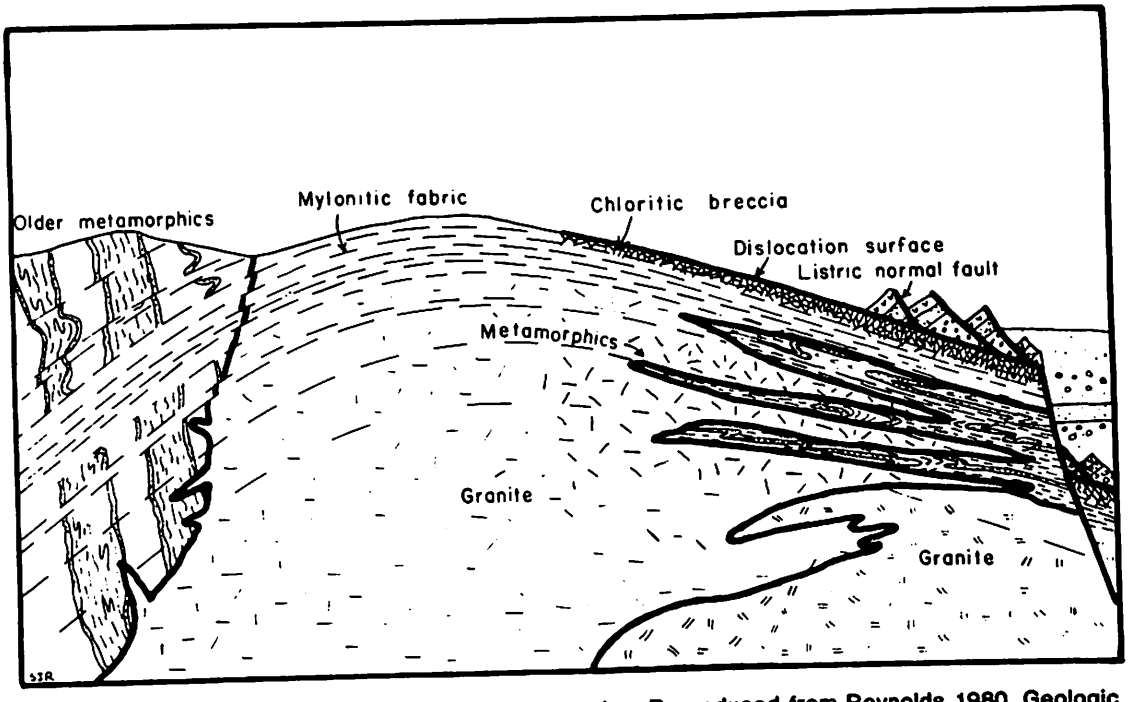


Figure 12–11. Diagram of a metamorphic core complex. Reproduced from Reynolds 1980, Geologic framework of west-central Arizona: *Arizona Geological Society Digest* 12.

Examples on our Route:
- Santa Catalina Mts (Tucson)
- Tortolita Hills
- South Mountain (Phoenix)

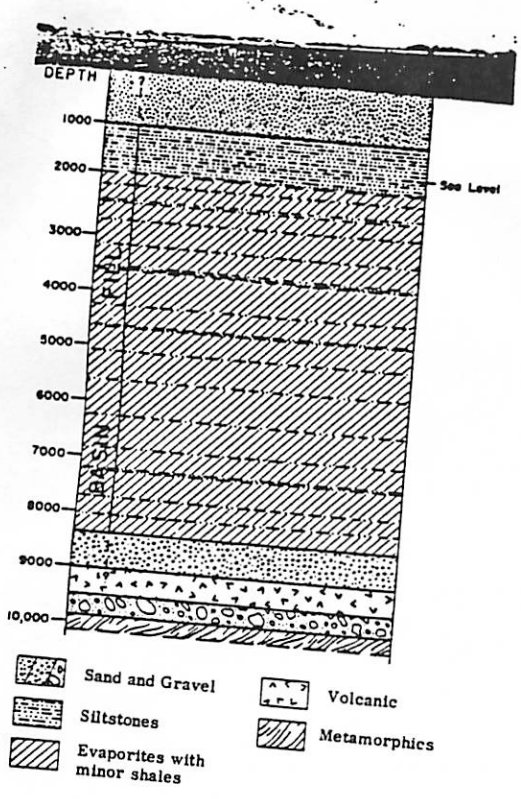


Fig. 10.3 Picacho Mountains and cultivated surface of the Picacho Basin with diagrammatic representation of the rock sequence beneath the surface as determined by deep drilling — looking eastward.

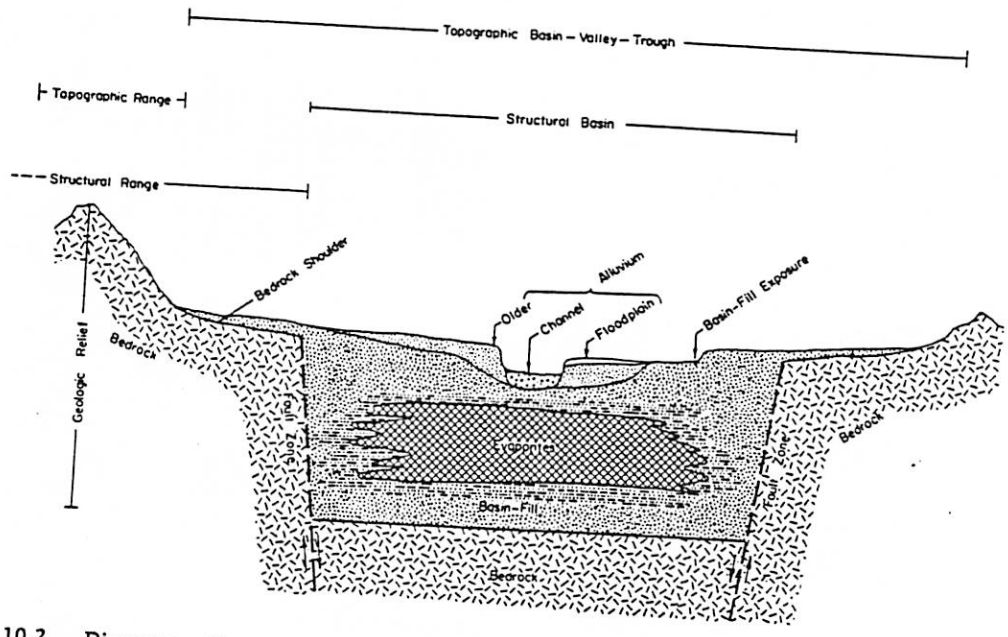


Fig. 10.2 Diagrammatic representation of features associated with range and basin structural blocks and surface topographic expression.

Geologic Map of Arizona
see p 4 for sections

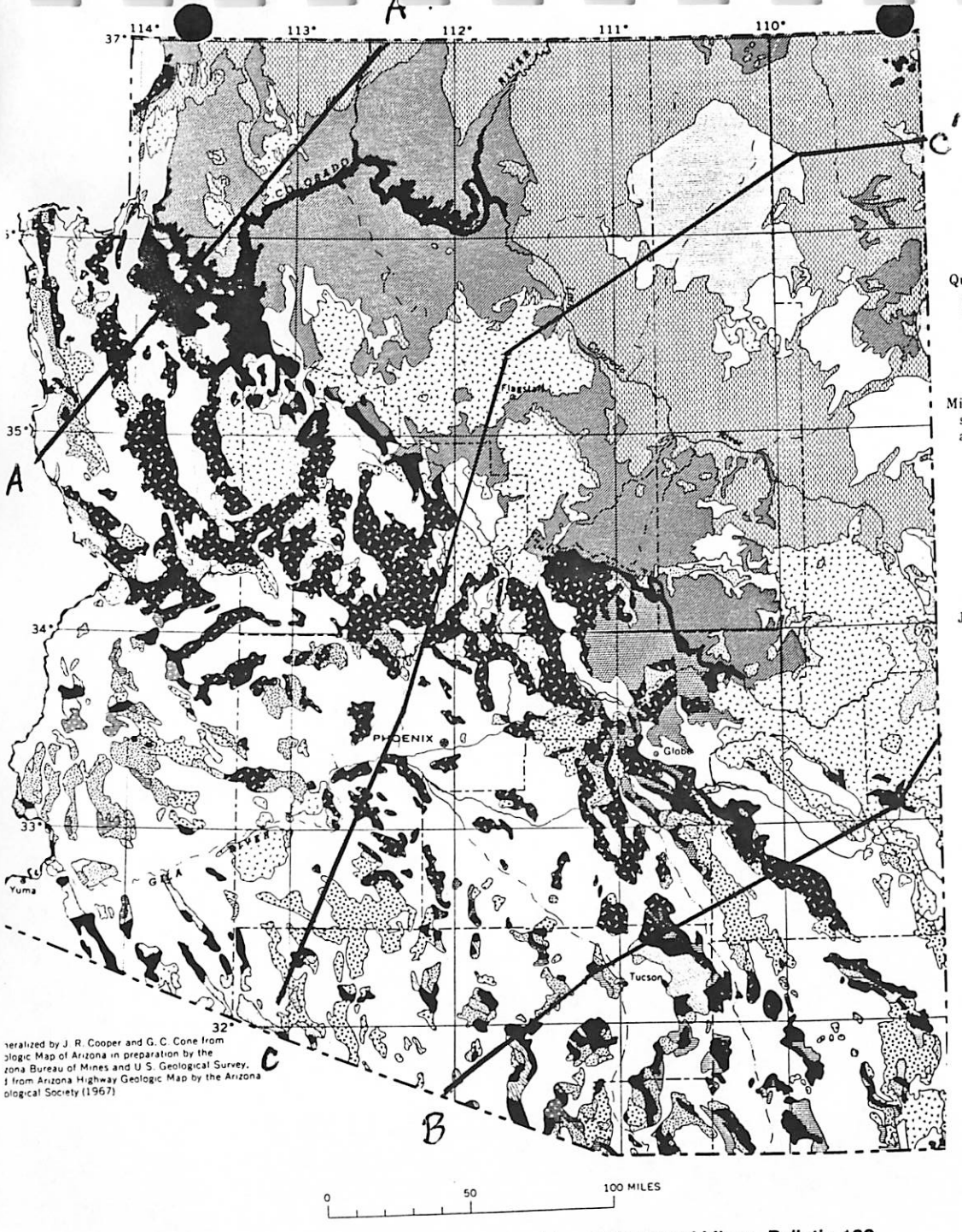


Plate I. Generalized geologic map of Arizona. From Arizona Bureau of Mines, Bulletin 180. Reproduced by permission of publisher.

EXPLANATION

SEDIMENTARY AND VOLCANIC ROCKS

Quaternary and upper Tertiary (Pliocene) sedimentary rocks, mostly unconsolidated; includes scarce lava and silicic tuff

Quaternary and upper Tertiary volcanic rocks, mostly basaltic in composition

Middle Tertiary (Miocene and Oligocene) sedimentary rocks; locally includes lava and tuff

Middle Tertiary volcanic rocks of silicic to basaltic composition; includes related intrusive rocks

Cretaceous sedimentary rocks

Lower Tertiary to Triassic volcanic rocks; includes some sedimentary rocks

Jurassic and Triassic sedimentary rocks

Mesozoic sedimentary rocks

Permian and Pennsylvanian sedimentary rocks; shown only on Colorado Plateau

Mississippian through Cambrian sedimentary rocks on Colorado Plateau; all Paleozoic sedimentary rocks in Basin and Range province

Younger Precambrian sedimentary rocks and intrusive diabase

Older Precambrian rocks of all types, including schist, gneiss, and fine- to coarse-grained igneous intrusive rocks

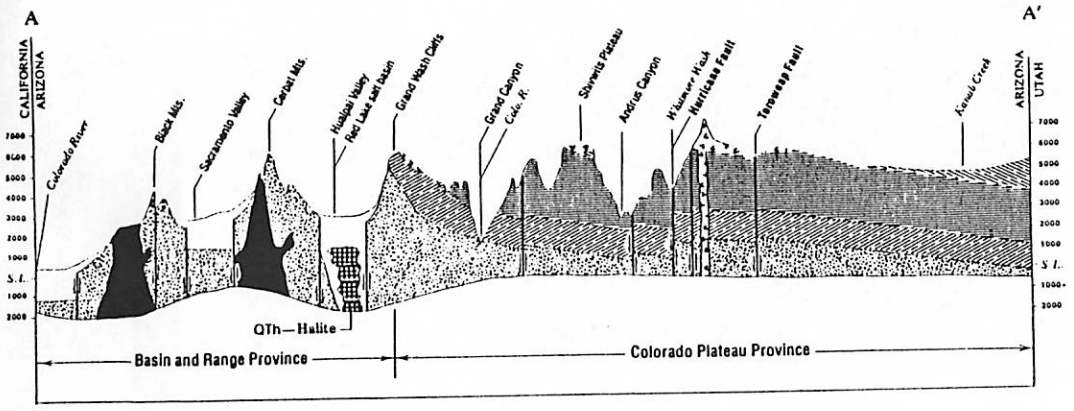
METAMORPHIC AND INTRUSIVE IGNEOUS ROCKS

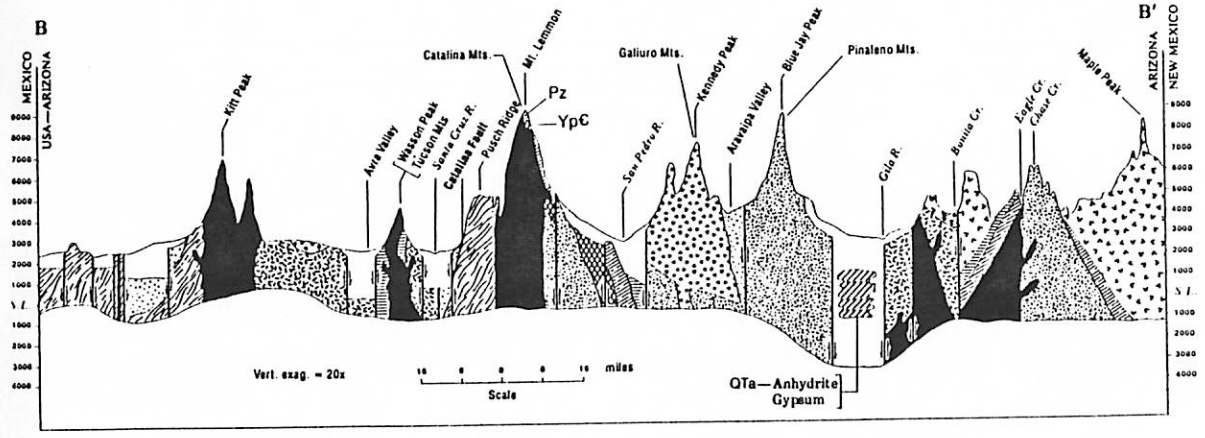
Tertiary and Upper Cretaceous intrusive igneous rocks

Post-Paleozoic gneiss and schist

Mid-Cretaceous to Triassic intrusive igneous rocks

Pre cambrian, Paleozoic, Mesozoic





EXPLANATION

SEDIMENTARY AND VOLCANIC ROCKS

QTs — Quaternary and upper Tertiary (Upper Miocene-Pliocene) sedimentary rocks, mostly unconsolidated; includes scarce lava and silicic tuff

QTh / QTa — *Evaporites*
QTh—Halite
QTa—Anhydrite
Gypsum

QTv — Quaternary and upper Terti
rocks, mostly basaltic in compe

Ts — Middle Tertiary (Miocene and Oligocene) sedimentary rocks; locally include lava and tuff

Tv — Middle Tertiary volcanic rock
basaltic composition; includes
sive rocks

Ks — Cretaceous sedimentary rocks

TMzv — Lower Tertiary to Triassic volc
cludes some sedimentar

JRs — Jurassic and Triassic sedimentary rocks

PPs — Permian and Pennsylvanian sedimentary rocks; shown only on Colorado Plateau

MC / Pz — Mississippian through Cambrian sedimentary rocks on Colorado Plateau; all Paleozoic sedimentary rocks in Basin and Range province

YpC — Younger Precambrian sedimentary rocks and intrusive diabase

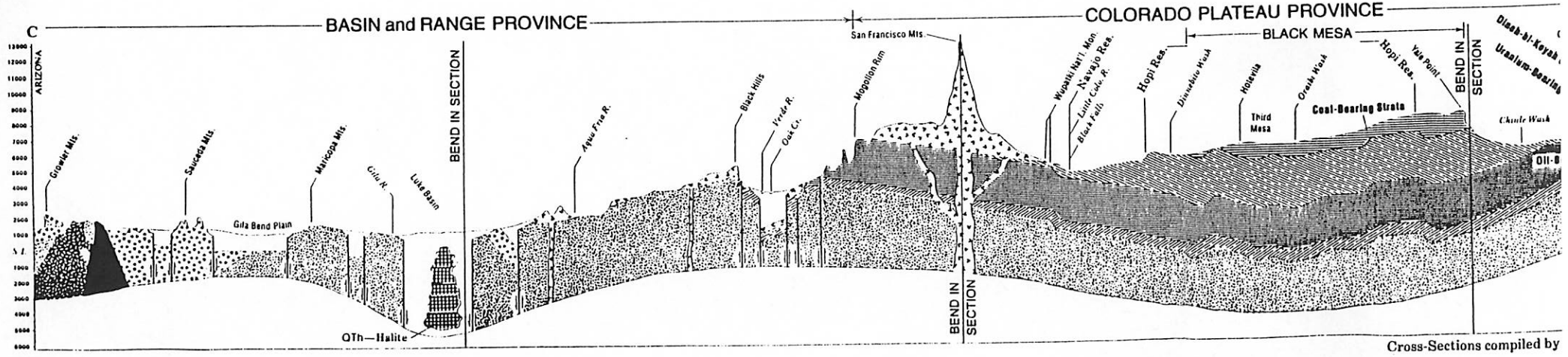
OpC — Older Precambrian rocks of all types, including schist, gneiss, and fine- to coarse-grained igneous intrusive rocks

OTHER METAMORPHIC AND INTRUSIVE IGNEOUS ROCKS

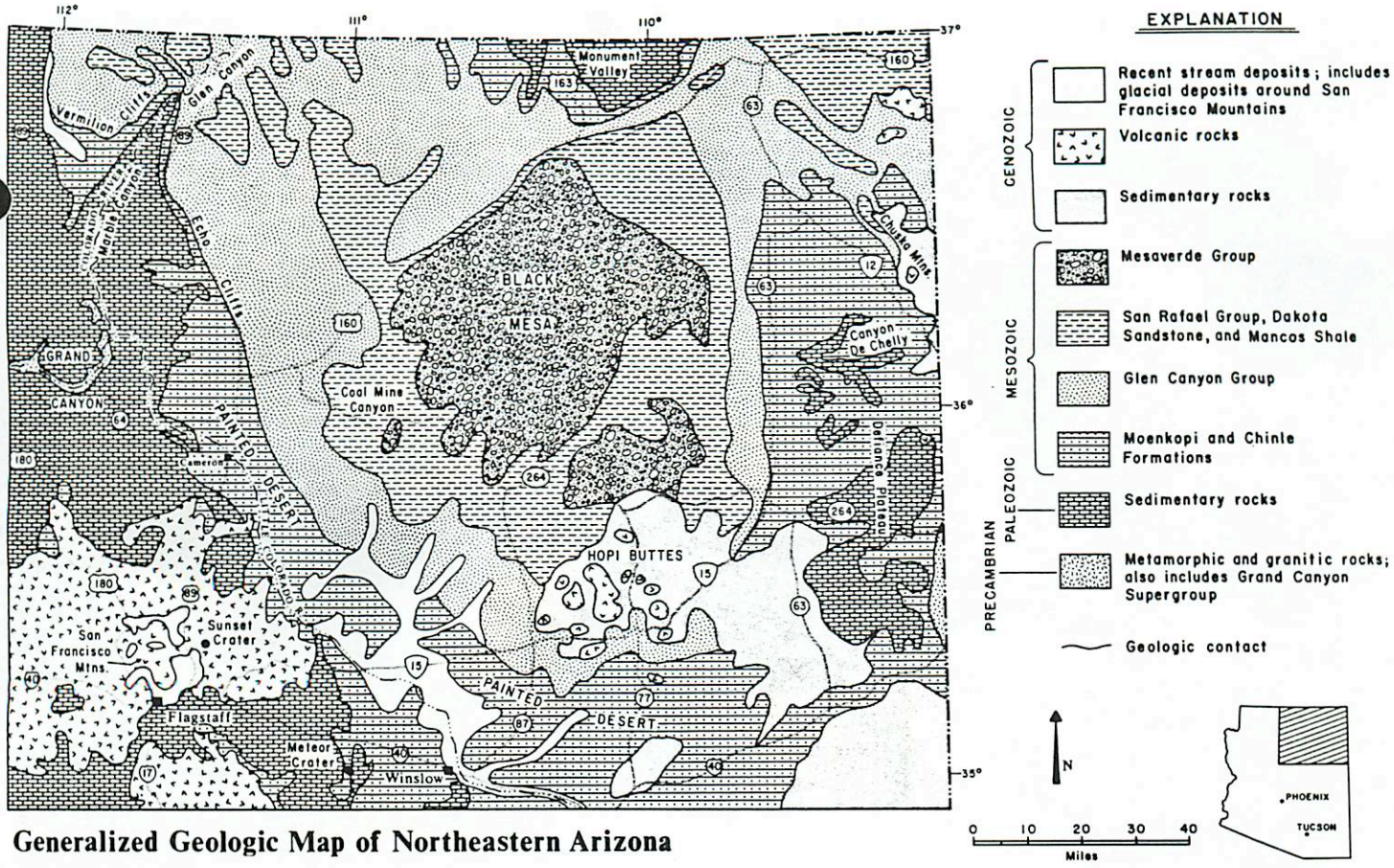
Tku — Tertiary and Upper Cretaceous intrusive igneous rocks

TMz — Post-Paleozoic gneiss and schist

Kti — Mid-Cretaceous to Tri
Intrusive igneous ro



Cross-Sections compiled by



Generalized Geologic Map of Northeastern Arizona

Stratigraphic Position of Geologic Features

Sunset Crater
San Francisco Mountains
Hopi Buttes

Black Mesa

Coal Mine Canyon

Glen Canyon

Vermilion Cliffs – Paria Canyon

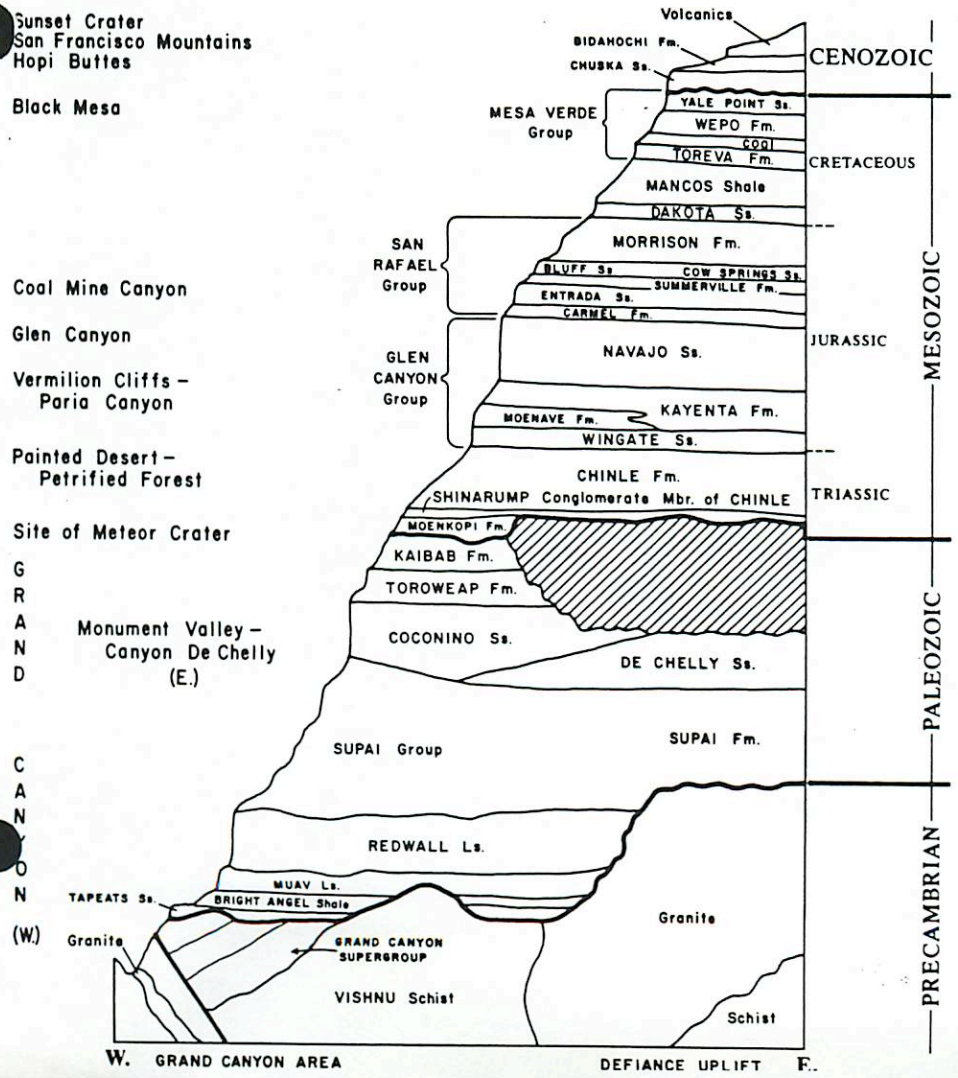
Painted Desert – Petrified Forest

Site of Meteor Crater

GRAND CANYON (W.)

Monument Valley – Canyon De Chelly (E.)

COMPOSITE STRATIGRAPHIC SECTION



Geology of Northern Arizona

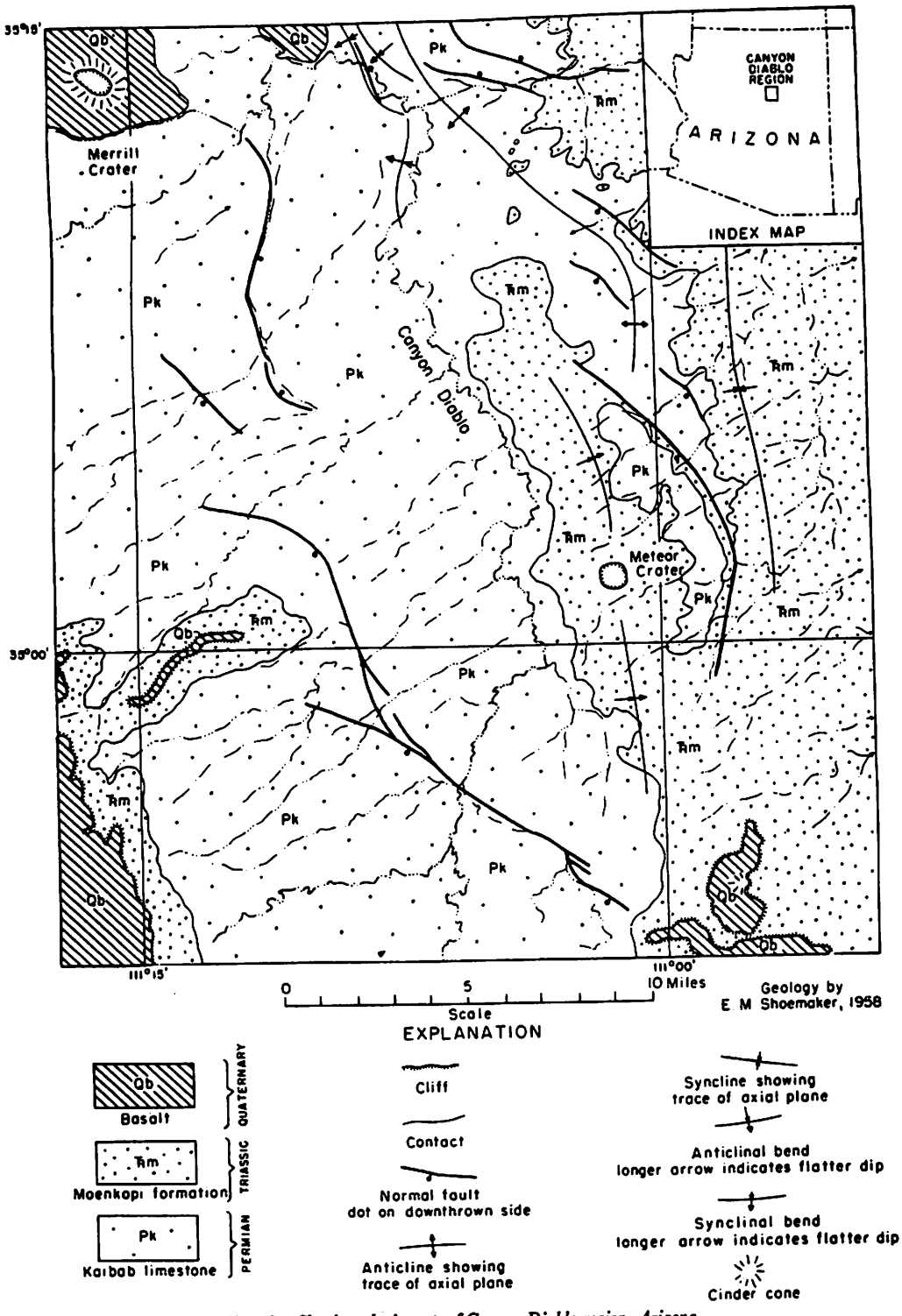


FIG. 1—*Sketch geologic map of Canyon Diablo region, Arizona.*

Geology, Vicinity of Meteor Crater

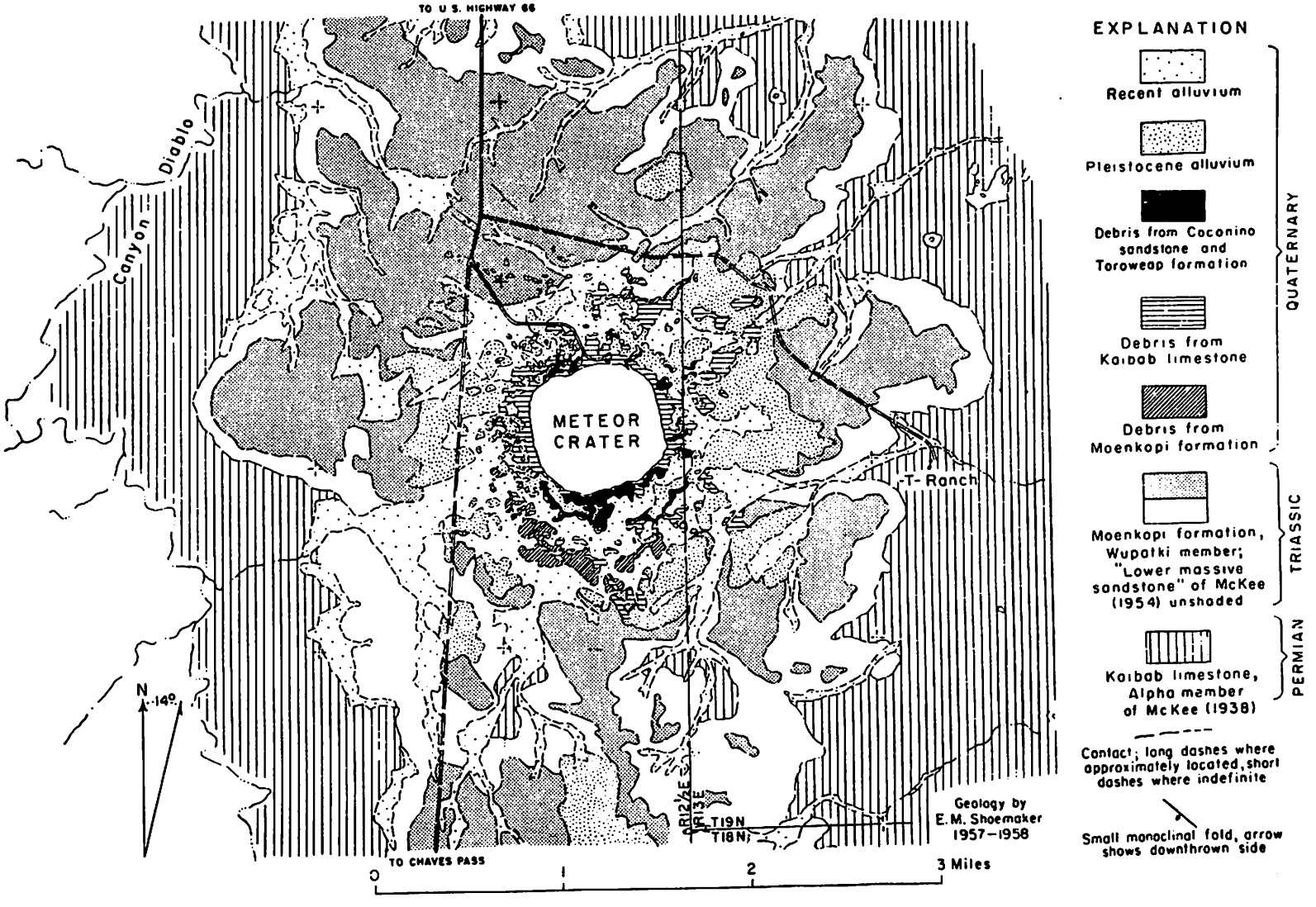
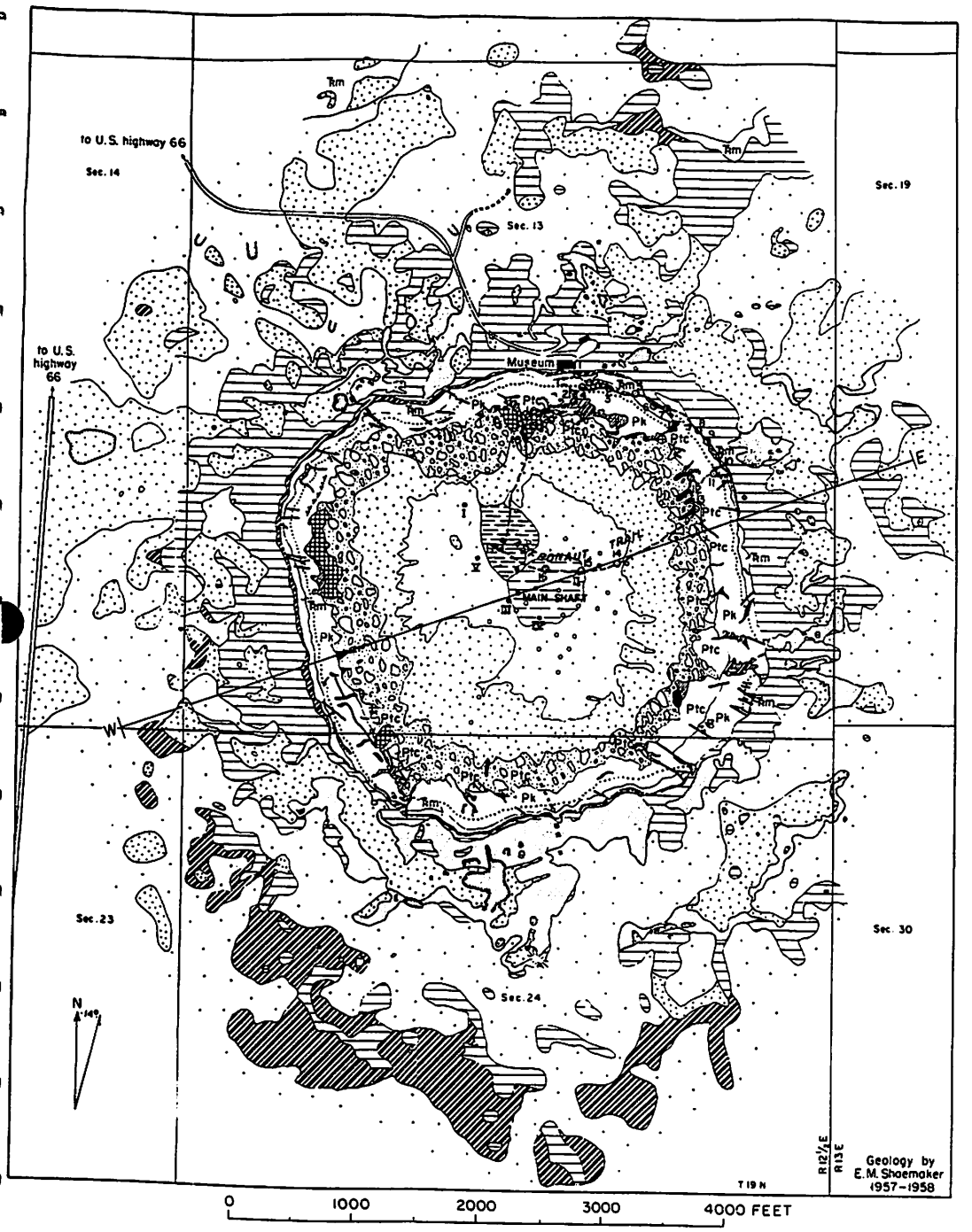


FIG. 2.—Geologic map of area around Meteor Crater, Arizona

PLATE I



GEOLOGIC MAP OF METEOR CRATER, ARIZONA

EXPLANATION

Recent
- Alluvium
- Playa beds

UNCONFORMITY

Pleistocene
- Alluvium
- Talus
- Lake beds

UNCONFORMITY

QUATERNARY
- Mixed debris from Coconino, Toroweap, Kaibab, and Moenkopi formations; includes lechatelierite and meteoritic material
- Debris from Coconino sandstone and Toroweap formation
- Debris from Kaibab limestone
- Debris from Moenkopi formation

UNCONFORMITY

TRIASSIC
- Rm — Moenkopi formation

UNCONFORMITY

PERMIAN
- Pk — Kaibab limestone; dotted line is sandstone bed
- Ptc — Toroweap formation and Coconino sandstone

Contact

Faults, nearly vertical or normal

Thrust fault; teeth are on side of upper plate

Authigenic breccia; fragments not mixed; occurs mostly along faults

Allogenic breccia; fragments mixed, includes lechatelierite and meteoritic material

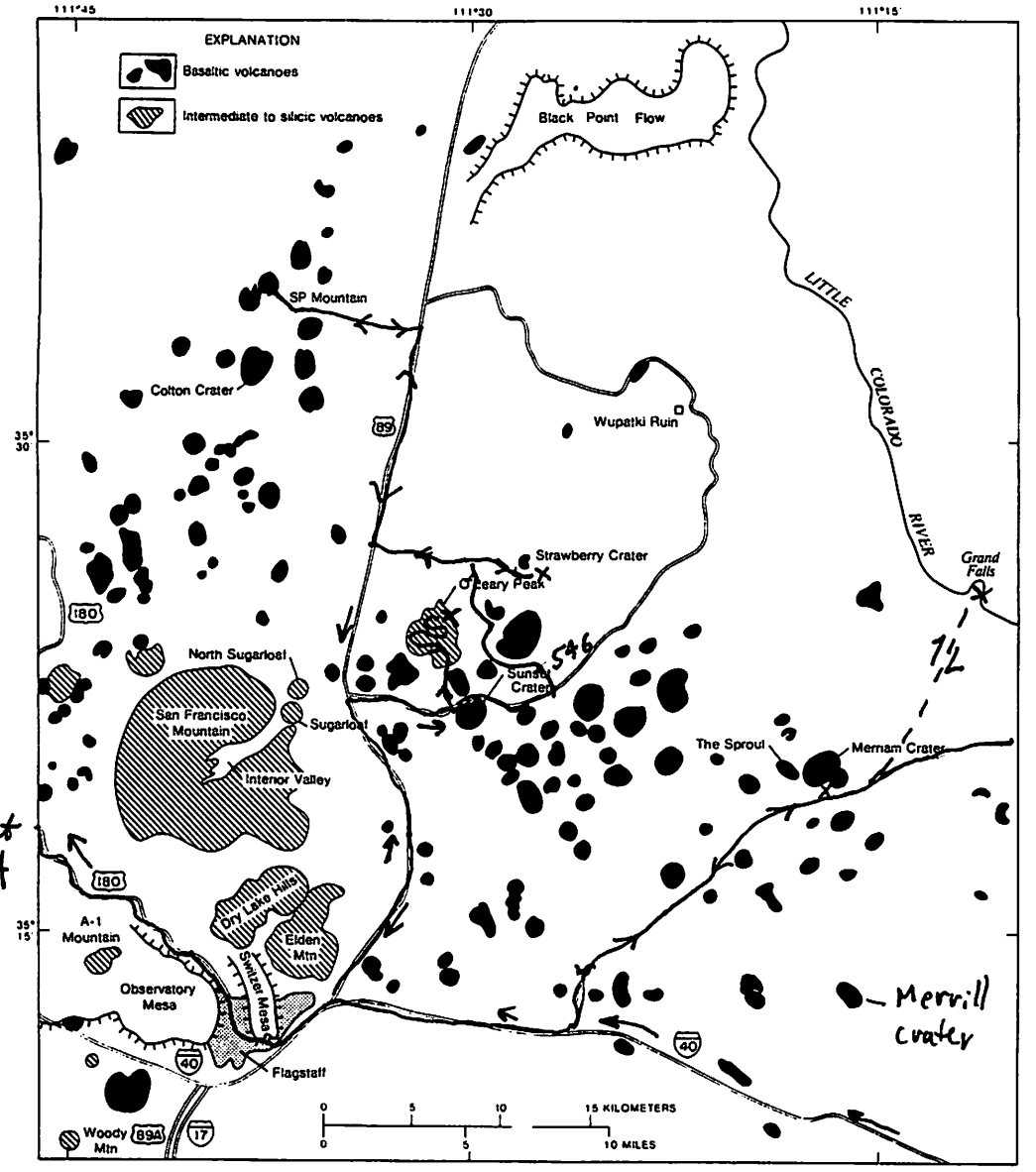
Shaft

Adit

Pit

Dump

Drill hole



A camp at government cave

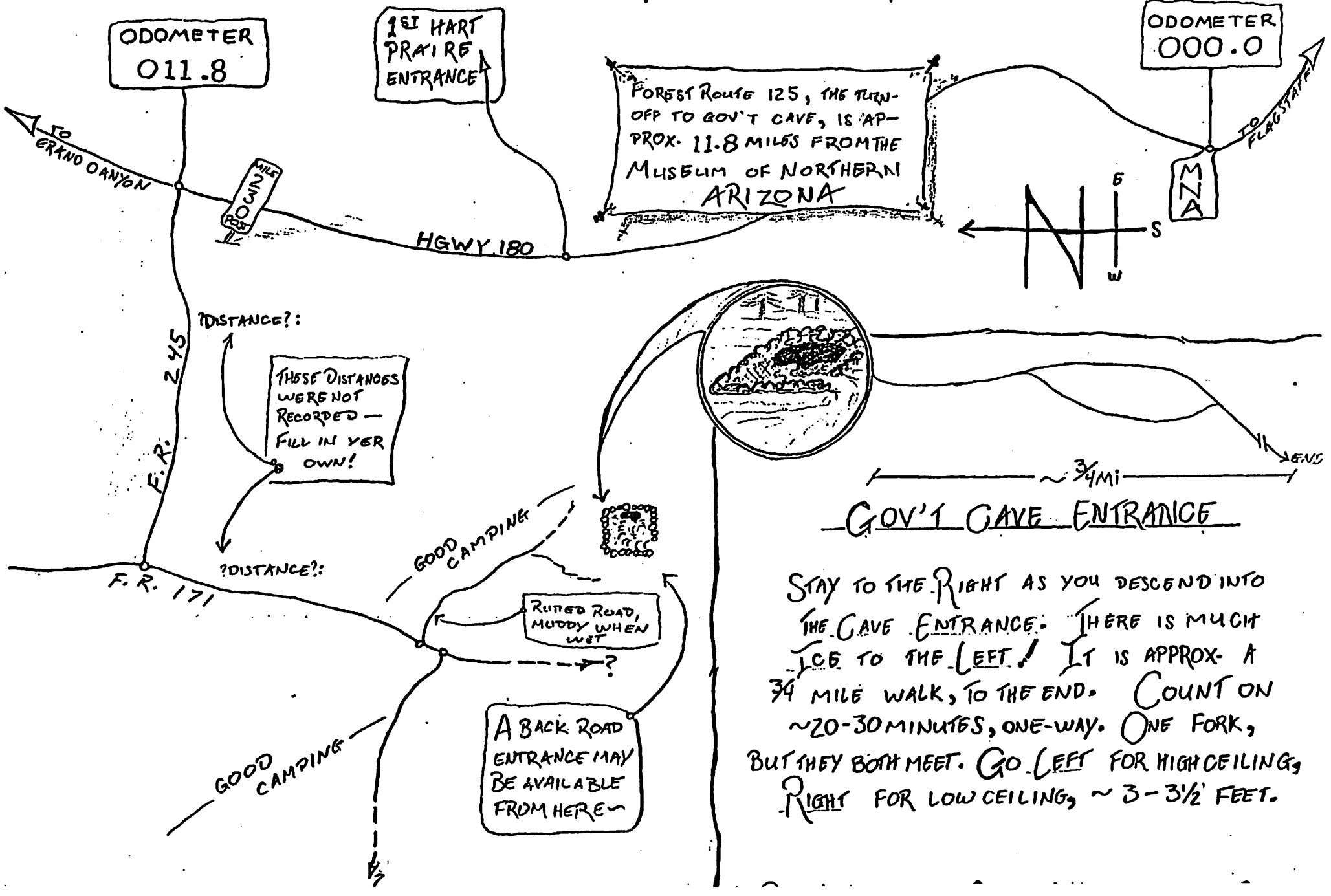
→ to Meteor crater

Merrill crater

Fig. 6.3 Map showing the distribution of basaltic vents and of volcanoes of intermediate to silicic composition in the central and eastern parts of the San Francisco volcanic field.

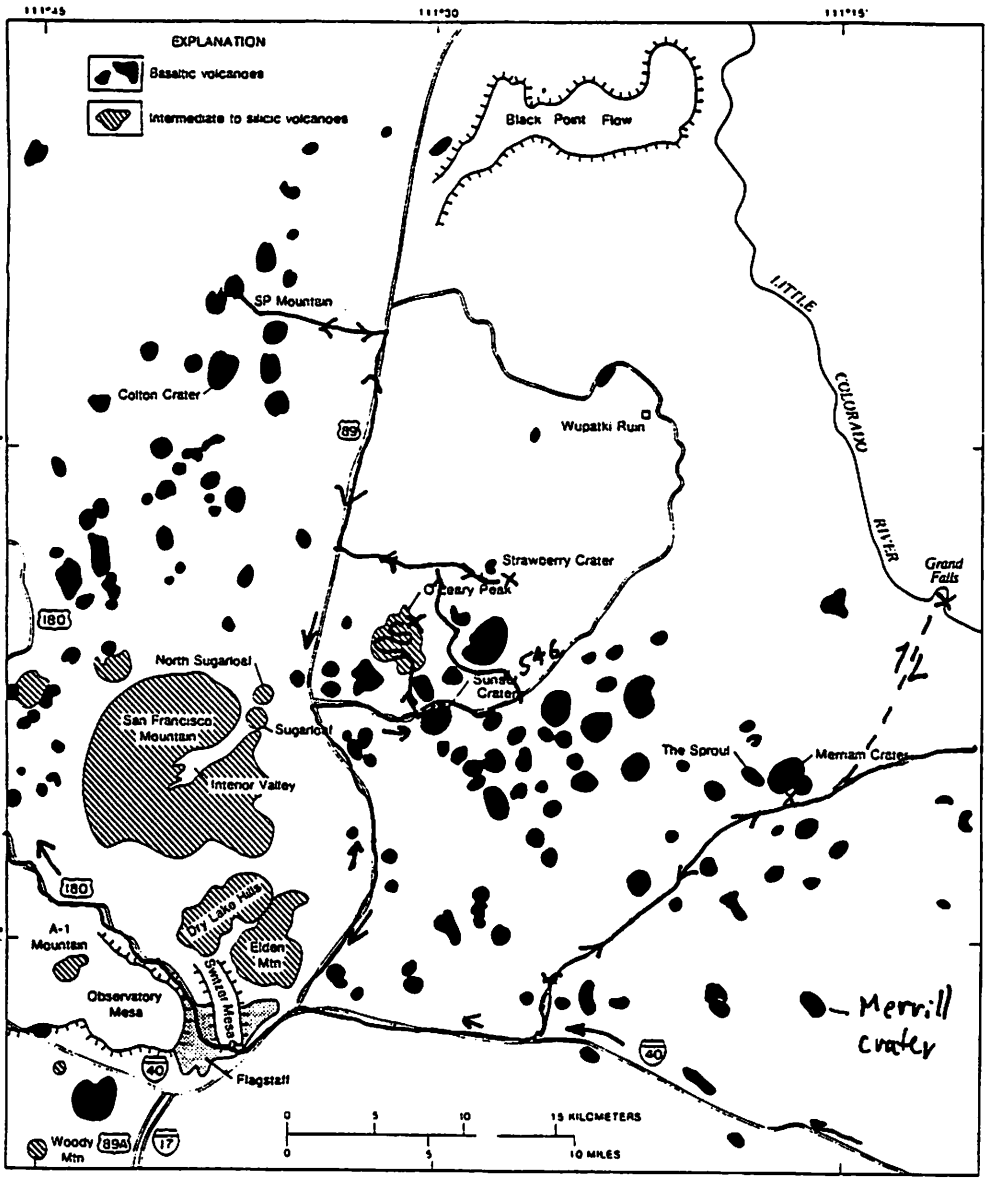
GOVERNMENT · CAVE

BEING EAST OF THE SANFRANSICO PEAKS; NORTH-EAST OF FLAGSTAFF, ARIZONA



GOV'T CAVE ENTRANCE

STAY TO THE RIGHT AS YOU DESCEND INTO THE CAVE ENTRANCE. THERE IS MUCH ICE TO THE LEFT! IT IS APPROX. A 3/4 MILE WALK, TO THE END. COUNT ON ~20-30 MINUTES, ONE-WAY. ONE FORK, BUT THEY BOTH MEET. GO LEFT FOR HIGH CEILING, RIGHT FOR LOW CEILING, ~ 3-3½ FEET.



A camp at government cave

Merrill crater

→ to Meteor crater

Fig. 6.3 Map showing the distribution of basaltic vents and of volcanoes of intermediate to silicic composition in the central and eastern parts of the San Francisco volcanic field.

(9)

SAN FRANCISCO VOLCANIC FIELD CHRONOLOGY

Age	Feature
12 Myr	Hickey basalts on S. plateau edge
6 Myr	Basalts capping Switzer mesa, downtown Flagstaff
4-6 Myr	Oldest basalt flows on S. edge of SF volcanic field
2-3 Myr	Bulk of SF field basalt flows
2.8 Myr	N. Sugarloaf dacite and rhyolite flows
2.4 Myr	Black point flow
1-0.4 Myr	Main construction of SF peaks composite cone
0.5-0.6 Myr	Elden mountain dacites
0.5 Myr	Lowest basalt flows near Wupatki ruin
340,000 yr	Youngest flows near Merriam crater
245,000-175,000 yr	O'Leary peak silic flows
220,000 yr	Sugarloaf dacite dome
150,000 yr	Basalt flow dams Grand Falls
70,000	SP crater block lava flows
50,000	Strawberry Crater flows
1,065 AD	First ash falls, Sunset Crater. Sinagua pit houses crushed
1,250 AD	Bonito flow, end of Sunset Crater activity
2001+ AD	???