CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
520-770-3500
http://www.azgs.az.gov
inquiries@azgs.az.gov

The following file is part of the

James Doyle Sell Mining Collection

**ACCESS STATEMENT**

These digitized collections are accessible for purposes of education and research. We have indicated what we know about copyright and rights of privacy, publicity, or trademark. Due to the nature of archival collections, we are not always able to identify this information. We are eager to hear from any rights owners, so that we may obtain accurate information. Upon request, we will remove material from public view while we address a rights issue.

**CONSTRAINTS STATEMENT**

The Arizona Geological Survey does not claim to control all rights for all materials in its collection. These rights include, but are not limited to: copyright, privacy rights, and cultural protection rights. The User hereby assumes all responsibility for obtaining any rights to use the material in excess of "fair use."

The Survey makes no intellectual property claims to the products created by individual authors in the manuscript collections, except when the author deeded those rights to the Survey or when those authors were employed by the State of Arizona and created intellectual products as a function of their official duties. The Survey does maintain property rights to the physical and digital representations of the works.

**QUALITY STATEMENT**

The Arizona Geological Survey is not responsible for the accuracy of the records, information, or opinions that may be contained in the files. The Survey collects, catalogs, and archives data on mineral properties regardless of its views of the veracity or accuracy of those data.

Abstracts - Geol. Assoc of Canada
Vancouver, April 25-27, 1977

LONGSHORE CURRENTS NEAR THE TSAWWASSEN JETTY.

Daniel, P. and LeBlond, P.H., Institute of Oceanography, University of British Columbia, Vancouver, B.C., V6T 1W5

Wave-induced longshore currents play a major role in the sediment transport along beaches. The current system occuring in the angle formed by the Tsawwassen ferry jetty and the shore of Point Roberts (southern Strait of Georgia) has been calculated for a range of angles of incidence ot the wind wave field.

One salient result of the calculations is that the narrow longshore currents generated along the shoreline and along the jetty, and directed towards their point of intersection, discharge their flow only in the immediate vicinity of that apex. The apex thus acts as a source of water ( and of suspended sediments) which is discharged beyond the surf zone onto Roberts Bank.

The combined flow from the pair of longshore currents spreads over the mud flats and is strongly influenced by the bottom topography. In particular, a long trench providing access from a small boat basin to the deep water channels the return flow towards the sea.

Observations of drifters released in the longshore current and followed beyond their point of discharge confirm the results of the analytical model, and also illustrate the strong influence of the tidal currents which are superimposed on the wave induced flow pattern.

The implications of the above results to the sediment balance of the southern part of Roberts Bank are readily drawn.

PALEOSTRAIN ANALYSIS OF THE NEOHELIKIAM FLATROCK RAPIDS SHEET, MUSKOKA DISTRICT, ONTARIO

Davidson, Donald M. Jr., Geology Department, University of Minnesota, Duluth, Duluth, Minnesota 55812.

The Flatrock Rapids sheet is an eliptically-shaped, concordant, porphyritic granite body 750 m. long and 150 m. wide which has intruded arkosic metasediments of undetermined thickness along the northeast edge of Go Home Lake, Ontario.

A minimum of sixty two-dimensional measurements (length, width and angle) from orthogonal faces were carried out on deformed microcline phenocrysts from the sheet as well as K-feldspar grains from the metaarkose. Paleostrain analysis included Ramsay $\sqrt{R}/a$ and center-point plots as well as Elliot plots from which best-fit strain ellipsoids were computed. K values (Flinn) range from 0.85 (least deformed) to >5 (most deformed) but with small values of total strain. Values on HSU plots show comparable ranges.

Although the pattern of strain measured in the phenocrysts is consistent with that observed in the field, the low values of total strain may indicate that either deformation within the matrix or metamorphic crystal growth were significant during deformation.

*DETERMINATION OF THE $^{87}$Rb DECAY CONSTANT

Davis, Don W., Gray, John, Cumming, George L., Department of Physics, and Baadsgaard, Halfdan, Department of Geology, University of Alberta, Edmonton, Alberta, T6G 2J1.

The decay constant $^{87}$Rb has been redetermined by measuring the amount of radiogenic $^{87}$Sr produced over a period of 19 years, in 20 gram samples of purified $RbClO_4$, using isotope dilution techniques. The rubidium sample was spiked with $^{84}$Sr and the nanogram quantities of strontium separated by coprecipitation with $Ba(NO_3)_2$. Analyses were carried out on a 25 cm, 90° sector mass spectrometer equipped with a Spiraltron electron multiplier. Measurement of three independent ratios permitted continuous monitoring of the ion beam fractionation. The average of eleven determinations gives a value for the decay constant of $1.417(\pm 0.011) \times 10^{-11}$ yr$^{-1}$ (95%) ($\tau_{1/2} = 4.89(\pm 0.04) \times 10^{10}$ yr).

A FIELD AND LABORATORY INVESTIGATION OF THE GROUNDWATER CONTAMINATION POTENTIAL OF A SANITARY LANDFILL SITE.

*Davison, Cliff C., Alberta Agriculture, Drainage Section. Agriculture Centre, Lethbridge, Alberta; Grisak, G. E., Alberta Environment, Earth Sciences and Licensing Division, Science Building, S. S. 1, Lethbridge, Alberta.*

During the summer of 1976 a study of the groundwater contamination potential of a proposed regional sanitary landfill site was carried out near Cowley, Alberta, Canada. A detailed hydrogeochemical investigation was undertaken in the field to establish the background physico-chemical groundwater references of the study area. The hydrochemical patterns supported the piezometric evidence that mineralized water from underlying bedrock sources was entering the groundwater flow system in the unconsolidated surficial deposits. Core samples were investigated in the laboratory to determine the chemical sorption-exchange characteristics of the unconsolidated materials underlying the landfill site. Batch-type sorption studies were carried out using leachate collected from beneath an existing landfill site in Alberta in an attempt to evaluate distribution coefficients. The results of the field and laboratory investigations were combined to estimate the values of input parameters for a finite-element contaminant transport model of the landfill-groundwater system.

HOW LEAKY IS THE LAKE AGASSIZ CLAY?

Day, Michael J., Cherry, J. A., and Fritz, P., Department of Earth Sciences, University of Waterloo, Waterloo, Ontario, N2L 3G1; Render, F. W., Water Resources Branch, Department of Mines, Resources and Environmental Management, Winnipeg, Manitoba R3E 3J5

Lake Agassiz glaciolacustrine clay and glacial till, averaging 12m. in thickness, confine an extensive carbonate aquifer underlying metropolitan Winnipeg. Groundwater withdrawals have depressed the aquifer piezometric surface in the central industrial area by up to 20m., creating a downward hydraulic gradient in the confining beds.

Laboratory determinations of the intergranular hydraulic conductivity of clay-loam till and glaciolacustrine clay in the Interior Plains are in the range of $6 \times 10^{-9}$ to $2.7 \times 10^{-9}$ cm.s$^{-1}$ The effective bulk hydraulic conductivities of the fractured till and clay, as determined by piezometer recovery analysis, are about $6 \times 10^{-7}$ and $1.5 \times 10^{-7}$ cm.s$^{-1}$ respectively. Observed fractures in the glacial deposits are coated with gypsum and oxides which indicate that che fractures are significant groundwater conduits. Vertical isotopic and chemical variations in the glacial deposits suggest sluggish groundwater movement indicating poor hydraulic connection within the fracture network.

Increasingly negative $\delta^{18}O$ values (-11 to -18 per mil SMOW) in the direction of flow are present in the underlying carbonate aquifer as a result of lateral replacement of isotopically light fossil groundwater by modern recharge. A similar trend of $\delta^{18}O$ values (-11 to -19 per mil SMOW) downgradient in the glacial deposits indicates slow modern infiltration such that fossil groundwater is preserved at the base of the deposits. Tritium and chemical data substantiate this interpretation.

The study enables the flow system within the glacial deposits to be deliniated, and provides additional information for interpreting the groundwater flow system of the Winnipeg region in general.

CONCENTRATION AND RESIDENCE OF METALS IN THE MEADE PEAK MEMBER OF THE PHOSPHORIA FORMATION, EASTERN IDAHO—POTENTIAL METAL RESOURCES OF THE FUTURE

Desborough, George A., and Maughan, Edwin K., U.S. Geological Survey, Box 25046, Denver Federal Center, Denver, Colorado 80225.

Anomalous concentrations of Ag, Cr, and V in certain organic-rich units of the Meade Peak Member have long been recognized, although the quantity and the mineralogical residence of these metals have been poorly known. Samples from 3 localities about 60 km apart along the regional depositional strike show values of 0.22-0.84 weight percent V (0.4-1.5 percent $V_2O_5$), 0.5-1.6 weight percent Cr, and 9.0-117 grams/tonne (0.3-3.9 oz/ton) Ag in certain beds 1 m or greater in thickness. Organic carbon in these beds ranges from 10 to 32 weight percent and is present principally as poorly ordered graphite. Sulfur content ranges from about 2 to 4 weight percent. Organic-rich strata enriched in Ag, Cr, and V are interbedded with phosphorites and phosphatic mudstones. The phosphate-rich zones are currently mined in the region, and vanadium is recovered from ferrophos slag at one plant site. Vanadium and chromium in these rocks may reside in mica of the illite type, in organic materials, or in sulfides. Chromium occurs in concentrations of as much as several percent in the mica, apparently substituting for Al. Although the residence of V and/or Cr within finely admixed organics and mica is poorly understood, the concentration of either metal may be as much as 2 weight percent according to electron microprobe analyses.

The concentrations of Ag and Cr cited here have not been previously reported for beds of possible economic thickness. Potential resources are indicated for Ag and Cr as well as for V.

Abstracts: Geol. Assoc of Canada
Vancouver, April 25-27, 1977

REGIONAL DISTRIBUTION OF SELECTED TRACE ELEMENTS IN THE PHOSPHATIC SHALE MEMBERS OF THE PHOSPHORIA FORMATION, EASTERN IDAHO AND PARTS OF ADJACENT STATES

Maughan, Edwin K., U.S. Geological Survey, Box 25046, Denver Federal Center, Denver Colorado 80225

The Meade Peak and the Retort Phosphatic Shale Members of the Phosphoria Formation locally have a high content (a maximum average of 9.7 weight percent) of organic carbon. Semiquantitative analyses by six-step emission spectrography show relative values for trace elements within these organic-rich strata. Concentrations of some of the trace metals are also high, especially Ag (13 ppm), Cr (1,500 ppm), Sr (1,500 ppm), V (1,300 ppm), Y (500 ppm), and Zn (2,100 ppm). Average values for these elements are plotted geographically and isopleth lines are constructed to show their regional distributions.

Highest concentrations for organic carbon and most trace elements in the Meade Peak are along the Idaho-Wyoming border, whereas those of the Retort are in southwestern Montana. Concentrations decrease radially away from these centers. Presumably the organic-carbon and trace-metal concentrations, like the phosphorites, are genetically related to sapropelic accumulations on the seafloor in areas of upwelling marine currents and biotic efflorescences in the Permian Sea. Similar distributional patterns are seen for organic C, Ag, Cr, Cu, Mo, Ni, V, Yb, and Zn. Phosphorus (as carbonate fluor-apatite in phosphorite-rich beds), although distributed somewhat similarly to the organic carbon, shows some divergence that probably reflects greater chemical stability of apatite. Distributions of La, Sr, and Y are similar to that of P. Distributions of Pb and possibly Mg are approximately inverse to that for P. Anomalous distribution seems indicated for Ba, K, Nd and Ti.

ALKALIC VOLCANISM IN THE HORSEFLY AREA, SOUTH CENTRAL BRITISH COLUMBIA

Morton, Ronald L. and Moore, John M., Jr., Department of Geology, Carleton University, Ottawa, Ontario.

In the central portion of the Quesnel Trough, Lower Jurassic alkalic rocks form a central volcanic belt that varies from 8-38 km in width, composed of a complex succession of flow and pyroclastic rocks, intrusive and flow breccias, laharic deposits, stocks, dykes, sills, and coarse-grained volcaniclastic rocks. Volcanic and intrusive rocks are subdivided into three distinct successions, each believed to represent products of a continuous period of volcanism.

The oldest cycle ranges in composition from ankaramite and alkali-olivine basalt to trachyte with accompanying intrusions of olivine gabbro to syenite. Genetically associated with rocks of this cycle are porphyry and pyrometasomatic copper-gold prospects. Rocks of the second cycle contain 5 to 25% modal nepheline. They vary from basalt to trachybasalt with intrusions of tephrite, syenodiorite, and monzonite. Analcime-bearing flow, pyroclastic, and intrusive rocks form the youngest cycle and range from basalt to phonolite. Volcanic and intrusive rocks of each cycle are strongly undersaturated with respect to silica, contain normative nepheline and olivine, and belong to the mildly potassic suite of alkalic rocks. Major and trace element abundances and trends are similar to those of volcanic rocks from islands situated close to the Mid-Atlantic Ridge: Tristan da Cunha, Gough, and St. Helena.

The alkalic rocks are believed to have formed as a result of uplift and rifting of the Permo-Triassic Cache Creek Group. Rifting was initiated by structural readjustment of the oceanic Cache Creek rocks as a result of collision or overriding by the leading edge of the North American continent.

TERRAIN STUDIES IN THE ARCTIC ISLANDS AND NORTHERN MAINLAND CANA

Barnett, D.M., Hodgson, D.A., Netterville, J.A., Terrain Scie
Division, Geological Survey of Canada, Ottawa, Ontario K1A 0E

Surficial geological and geomorphological mapping is conducted i northern Canada by the Terrain Sciences Division, as part of a na inventory of unconsolidated deposits and landforms. Information ed is expected to be used as baseline data for engineering/geotec studies, the mineral industry and environmental management (inclu land use and environmental impact studies). Three examples of co projects, with slightly different approaches, are described.

The maps and legends may initially appear to be complex. We a attempting to reduce information describing a large number of te parameters onto documents of manageable size, while retaining muc potentially important detail. Simplified maps, describing only parameter, e.g. vegetation, are drawn up for a specific land use e.g. trafficability, may be derived from the basic documents.

A standard mapping system is not in use; methods of presentin ation are still evolving. For example, the Melville project inte geology-botany-wildlife habitat. Although geology was important. information from other disciplines contributed to the delineatio unit boundaries. For Boothia Peninsula and Ellesmere Island, oth disciplines generally contributed only after a geological framew drawn up.

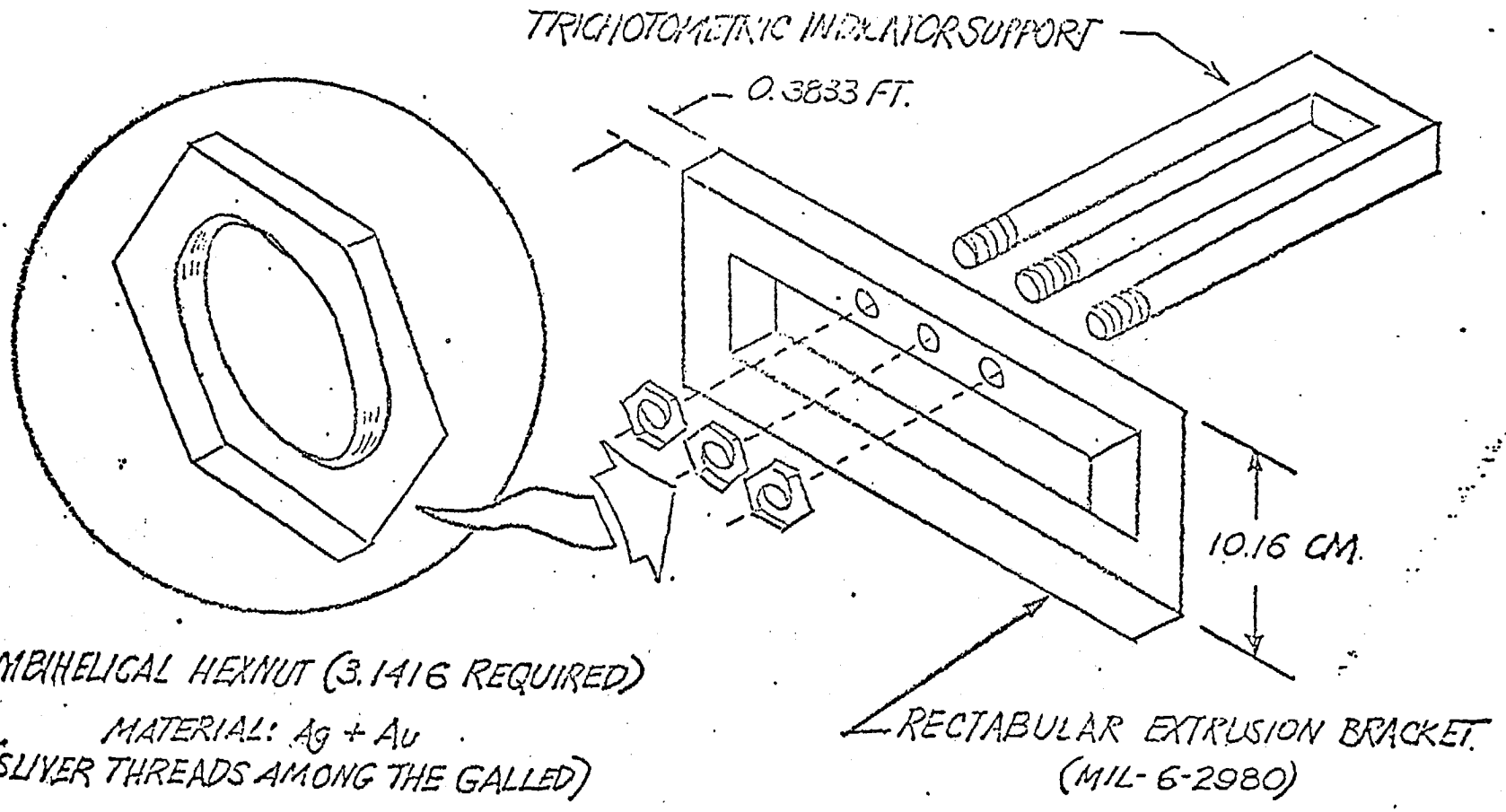
Physical differences between regions led to variations in pre ion. The character and origin of surficial materials in the is differ from those of the mainland. Direct effects of Pleistocen glaciations are not conspicuous on much of the archipelago; iden glacial deposits are rare, weathered and residual bedrock domina landscape. Hence the emphasis on bedrock and its weathering pro the legends of the Melville and Ellesmere projects.

All three areas include: zones of marine sediments deposited post-glacial higher sea levels, and occurring up to 200 m.a.s.l; frost under all land areas; and a shallow active layer which rar exceeds 1 m in summer.

pages 5-8

M.K.K.

# Why Rectabular Excrusions Won't Transmogrify




Inquiries concerning the mounting of the Trichotometric Indicator Support indicate that some difficulty is being experienced with the brackets which attach the support. As an aid toward fabricating the support brackets, the accompanying illustration is provided to show the type of material as well as the dimensional data needed. It will be noted that in attaching the bracket to the support, a special ambihelical hexnut is used. The application of this nut is unique in that any attempt to remove it in the conventional manner only tightens it. Because of this design, the nut must be fully screwed on before it can be screwed off.

# Intrusive Fragmental Rocks
# Directly or Indirectly of Igneous Origin

by

Evans B. Mayo

(Manuscript submitted for publication – AGS Digest 10 (1975).


| | page |
|---|---|
| Abstract | i |
| Introduction | 1 |
| Early Discoveries and Interpretations | 1 |
| Observations in America | 9 |
| Further Observations and Descriptions | 22 |
| The Swabian Tuff Pipes | 33 |
| From Swabia (1941) to Fluidization (1954) | 39 |
| Fluidization | 49 |
| General Statement | 49 |
| The Process | 49 |
| Related Experiments | 52 |
| Geological Examples | 53 |
| Further Contributions (1954-1960) | 54 |
| Observations During the 1960's | 63 |
| Most Recent Reports | 79 |
| Discussion | 80 |
| References | 84 |
| List of Illustrations (Not Attached). | 99 |
| Addendum | 100 |
| Additional References | 102 |


(Attached is B.N. Watson's paper of 1968 from AGS Guidebook III).

Sunday Citizen
11/7/71

J. D. [illegible]ELL

JDS

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

November 27, 1970

Mr. J. J. Collins
Asst. to Vice President, Exploration
ASARCO - New York Office

SUPPLEMENTAL AUTHORIZATION REQUEST
HACHITA VALLEY PROJECT
HIDALGO AND GRANT COUNTIES
NEW MEXICO

Dear Sir:

On November 24 Mr. S.I. Bowditch mailed to Mr. Travis Cravens, who represents the Hodges Trust, an amendment to our Joint Venture Agreement of March 9, 1970. This amendment deletes the eastern and southern portions of our Joint Venture prospecting area and, at the same time, adds ground to the west. You received a copy of this amendment from Mr. Bowditch and are, no doubt, confused concerning our intent.

Our exploration work in Hachita Valley failed to develop any exploration targets which would justify further interest. The IP survey outlined two anomalous areas, one in Sec. 32, T28S, R14W immediately south of Apache Hills, and the other located on the eastern flank of the Little Hatchet Mountains at the edge of the Eureka mining district.

Numerous outcrops exist in the area of the IP anomaly south of Apache Hills. These were mapped and sampled by Mr. B.E. French. Exposures are almost entirely volcanic rocks, exhibiting erratic rather than pervasive alteration. Copper and molybdenum geochemical results from outcrop samples were uniformly low. Prior drilling in this area by American Zinc and Superior Oil confirmed widespread pyritization in the volcanics with no significant economic mineral values. No further exploration is proposed in this zone south of Apache Hills. Reports by Messrs. Farley and French are in progress and will be transmitted after completion.

Our present interest in the Little Hatchet Mountains is largely stimulated by the recent publication "Geology of the Little Hatchet Mountains" by Dr. Robert A. Zeller, Jr. Dr. Zeller was killed last February in a light-plane accident. His work in the Little Hatchet Mountains was published posthumously by the New Mexico Bureau of Mines as

Bulletin #96. A copy of this publication is enclosed.

The Little Hatchets were previously mapped for the USGS by Laske, who interpreted a Cretaceous section aggregating some 15,000 ft. in thickness. His interpretation seemed unreasonable, since the same section in adjacent mountain ranges totaled only 5,000 to 6,000 ft. As shown by Zeller, the apparent thickness of these rocks is the result of repetition due to low-angle imbricate reverse faulting. These low-angle faults are limited to the northern half of the range north of the Copper Dick fault, where structural blocks moved from west to east. The Copper Dick fault is a high-angle structure which forms the southern boundary of this complex area of imbricate thrusts. There is some field evidence which would indicate that these faults are very low-angle gravity slides.

Two mining districts occur within the Little Hatchet Mountains: these are the Eureka District adjacent to Old Hachita in the northern part of the range, and the Sylvanite District located in the south-central portion of the range. The two districts can be identified on Zeller's map as the outcrop areas of monzonite (TKm). The intrusive in both districts is characterized by extensive pyritization and argillic alteration.

I believe these two bodies of monzonite were originally part of the same intrusive, with the Sylvanite portion being in its original location and the Eureka portion having been moved eastward along a gravity slide a distance of five or six miles. The direction of the movement of the Eureka block may have been parallel to the strike of the Copper Dick boundary fault. If this reasoning is correct, the central portion of the monzonite intrusive (which was also displaced) is not presently exposed. It may lie concealed beneath gravels in the western portion of Hachita Valley or beneath another slide block within the mountain range. Mineralization within the exposed portions of the postulated single intrusive appears to contain only trace amounts of copper. We could not justify a search for the presently concealed central portion if it is similarly mineralized. We propose to map and sample the Eureka and Sylvanite Districts to determine whether or not alteration and mineralization improve toward the postulated center, i.e., progressing southeasterly in the Eureka District and northwesterly in the Sylvanite district. If such a zonal pattern could be established, a search for the buried center would be legitimate. Some mapping is also proposed to better understand the nature and attitude of the thrust (or gravity slide) faulting which separates the two mining districts.

The estimated cost of our proposed geological study is $7,000. These figures are itemized on the attached forms 302-MA and 302-MB.

The Hodges Trust does not presently control any ground within the area of interest in the Little Hatchet Mountains which is to be included in the Joint Venture prospect area. Our new exploration target may fall within the original Joint Venture ground. If the concealed portion of the intrusive is beneath one of the slide blocks within the mountain range, it would be just outside the original property boundary. Since our interest in this area was originally developed through the efforts of Donegan and Donegan, who represent the Hodges Trust, we probably have a moral (if not legal) obligation to include the Little Hatchet Mountains in the Joint Venture Agreement.

If you agree, please request a supplemental authorization in the amount of $7,000 to conduct the geological work as proposed, and to amend our Joint Venture property holdings with the Hodges Trust.

Very truly yours,

W. E. Saegart

W. E. Saegart

WES:mt

cc: J.H.Courtright
W.L.Kurtz
J.D.Sell
S.I.Bowditch
B.E.French
W.G.Farley

Dec. 16, 1968.

Ron Ericson, pilot, and ?, photographer
Staying at Con Tiki, Phoenix, Rm 119 & 121, ph. 254-6121.

Requesting permission to overfly restricted bombing range, east of Gila Bend-Ajo road.

I talked to Major Buttyan, Luke AFB,
ph. 935-7411, ext 2230 and/or 2239.

For this week is essentially open from 10 AM to 1 PM.

Called Ericson & he will contact Major Buttyan for full clearance.

AGS Files

# Symposium on Geologic Problems

September 8, 1968

1. Selected guest lecturers
2. Requested publication papers
3. Contributed publication papers and notes.

Assuming: A one-day Symposium, possibly in conjunction with AGS meeting night and banquet (but not limited to being held as Tuesday meeting). If held toward end of AGS season--May, June--possibly having outgoing AGS president as guest lecture in evening giving presidential address?

Selected guest lectures limited to six or so during day Symposium, thus giving those people a chance on doing it up "brown"--ie examining both sides in depth, but also allowing ample opportunity for others to contribute to subject.

All lectures and requested papers to be printed as AGS Digest with as many contributed papers and notes as feasible. If possible have the Digest available at time of Symposium. Taped comments during Symposium would by necessity be placed in later Digest.

(Note: It is interesting that, to date, no digest has had an article of rebuttal or comment on any article appearing in the Digest. Save for Dr. Anthony's rebuttal-or clarification of an idea--on my (Sell) paper in Digest III. This was prompted only (?) because John was editor of the volume and read all the papers for the volume prior to its publication).

As Wes Peirce points out, the Symposium should invite and hold the interest of all workers in Arizona. Thus, all colleges and universities as well as governmental and private institutions should be considered as guest lecturers and requested publication papers.

To my immediate knowledge the following publications reflect the "Problems" thought:

"Problems of American Geology"
Dana Commerative Lectures, Yale Univ. Press
505 pages, 1915 (7 lectures).

"Geology 1888-1938-Fiftieth Ann. Volume"
Geol-Soc. of America. 578 pages, 1941

"The Fabric of Geology-75th Ann. Volume"
Geol. Soc. of America. 372 pages, 1963
C.C. Albretton, Jr., editor. Addison-Wesley Pub. Co.

"Fiftieth Anniversary Volume 1905-1955"
Soc. of Economic Geologists. 1130 pages, 1955
A.M. Bateman, editor. The Econ. Geol. Pub. Co.

Potential affiliate meetings:

Joint GSA-SEG Penrose Conference to be held in Arizona in January 1969. (See p. 430, vol. 63, no. 4, June-July 1968 issues of Economic Geology.)

May 4-7 Ann. Mtg., Assn. of Ameri State Geologist, Tucson, Arizona. (J.D. Forrester). (p. 6. July-Aug 1968 issue of GeoTimes ).

AMERICAN SMELTING AND REFINING COMPANY
EXPLORATION DEPARTMENT
SOUTHWESTERN UNITED STATES DIVISION
P. O. BOX 5795, TUCSON, ARIZONA 85703

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

July 11, 1969

Mr. Larry Loven
Director of Training Programs
College of Business Administration
Northern Arizona University
Box 5736
Flagstaff, Arizona 86001

Management Development Seminar Program

Dear Larry:

Thank you for the letter of June 20, and the suggestion that I might have something to add in the way of programs. As you may have noted from the comments I left behind at the last Seminar meeting, I was certainly on the listening end of things for the first day or so. Primarily, I believe, because I was attempting to relate the lecture and discussion thoughts back into my specific work areas and, as you and Dr. Hughes later learned, many facets of my areas are far out of line from those in a business or productive field, such as the Highway Patrol, Mt. States Telephone and Motorola. Also part of the problem, perhaps, is that in general I act and work as an individual in our line of organizational activities and thus run the whole gauntlet of factors from menial to overall to routine to detail, et al. Thus I am involved in the spectrum and a great difficulty lies in being able to set out objectives and their avenues of solution-----let alone being able, time-wise, to concentrate on any facet during an allotted time.

So, in the concept that geologists work in a somewhat different world and are on the "spending" end of the game rather than being in a straight line productive-profit motive field, it would appear that Management by Objectives would indeed be a great thing with a slant on Geologists and their Role. Knowing too that most geologists come out of school with only a very smattering of ideas and concepts about business, psychology, et al (care to quiz any of the business majors on what they remember about Geology 101 taken as a freshman?), and knowing too that we really must be able to manage our time, thoughts, and deeds, and at time do indeed manage fellow workers, and perhaps ultimate a group, district, division, or organization, I would find a Seminar relating to Geologists one of extreme interest. Such:

MBO- in Exploration Geology

MBO- its Philosophical Objectives.
MBO and you.
MBO in a Non-Monetary Profit Role.
MBO in Personal and Professional Ethics.

MBO con't

MBO and Personal Organization.
MBO-Vertical and Horizontal.
The Manager and You.
You are a Manager.
General Techniques-Manager You to Manager Them.
Communication-Importance and Objectives.
Routine-How to put ten hours back into four.
Problem Solving-What is a problem?
Problem Solving-How much is really routine?
Creative Approaches to Problem Solving.
Creativity Now!
Creativity for Tomorrow?
Personal Risk and You.
Personal Risk and Organization.
Personal Expansion.

Oh well.....Truly though, I find that many of the thoughts discussed by Dr. Hughes on MBO is applicable to the me and I continue to spend some time and thoughts on the organization me and its relation and usefulness to the group, organization us, and organization it.

Sincerely yours,

James D. Sell

James D. Sell

JDS:ir

I don't understand all that I said here!

~~WLC~~

JAS

"Strange Geophysical Geodesic Holes"

Augusta General

The process by which ~~strang~~ "holes" in geodesic or geophysical data can be accounted for ~~how to~~ is a perplexing problem. Two ~~exam~~ examples are tendered: 1) the deep whitetail filled block at Solano with holes AH-1 and AH-2, 2) the block faulted deep gravity areas in the Vekol Valley. Both areas are of apparent deep holes ~~in~~ in basement rock with a rather restricted ~~large~~ lateral width.

A recent paper in GSA Bulletin touched slightly on this problem in the Mohave Desert of California. A possible solution is shown on Figure 7, part "a" where strike slip faulting has ~~turn~~ transformed & offset itself and created an empty void in the movement. It is probably not necessary to have the moved block glide on a ~~basement~~ flat structure although ~~this~~ a flat structure would facilitate the movement.

faults is probably not large and may be offset in part by compressional structures. Therefore, these complexities are assumed not to introduce significant errors in the model.

By far, the most inaccurate assumptions are those about the homogeneity of the deformation and the nature of the northern boundary of the Mojave block. The Garlock fault (which delimits the block on the north) is not straight, and large strike slip occurred on it. Furthermore, the region north of it (that is, the southern part of the Sierra Nevada block and the Tehachapi Mountains) is not rigid (Buwalda, 1954), and neither is the area farther east. It will now be shown that this does not significantly change the main features of the model when $K_0 \geqslant 0.20$ to 0.25.

Left slip on the curved Garlock fault must rotate the Mojave block clockwise in relation to the Sierra Nevada, which is opposite to the rotation envisaged in the model. The rotation resulting from the approximately 60 km of slip on the somewhat irregularly curved Garlock fault is difficult to estimate, but it would not exceed 5° and was probably less.

The structure north of the Garlock fault strongly suggests that the curvature of the fault has somewhat increased in the geologically recent past, which would decrease the above effect. At present, the western extremity of the Garlock fault strikes closer to due west than the part of the fault farther east. However, restoration of the compressional structures in the southern end of the San Joaquin Valley (see below) would rotate this segment of the Garlock fault and better align it with the rest of the fault.

The segment of the Garlock fault east of Searles Lake is conspicuously arcuate. North of the fault, northwest-trending to north-northwest–trending strike-slip faults and north-trending normal faults were active in the geologically recent past (Burchfiel and Stewart, 1966; Wright and Troxel, 1969). Right slip on these faults should rotate the southwestern boundary of the Great Basin, which is here delimited by the arcuate segment of the Garlock fault. Thus, in late Neogene time, this eastern segment was probably more in line with the rest of the Garlock fault.

The main deviations from rigidity immediately north of the Garlock fault are along the southern margins of the San Joaquin Valley. The recent tectonic activity in this region was manifested during the 1952 Arvin-Tehachapi earthquake (Buwalda, 1954; Oakeshott, 1955; Richter, 1958), and recent deformation occurred also on and near the Pleito thrusts (Crowell, 1964). As all these structures are compressional, their restoration requires a relatively southward shift of the Tehachapi Mountains. These mountains have risen, relative to the floor of the adjacent San Joaquin Valley, by possibly as much as 10 km since Miocene time (Hoots and others, 1954; Hackel, 1966). If this structural relief was created by movement on one or several thrusts dipping 30°, then a horizontal displacement of about 17 km occurred; if the thrusts dip 45°, the horizontal displacement was about 10 km. The White Wolf fault, on which the 1952 earthquake originated, dips about 30° to 45° south-southeast (Buwalda and St. Amand, 1955), but the earthquake mechanism of the main shock in 1952 suggests a steeper dip (Gutenberg, 1955). The distance between the surface traces of the White Wolf fault and the Garlock fault is about 35 km. The above estimates suggest that half of this figure is probably a reasonable estimate of the shortening normal to these faults and may be too high. Restoration of this deformation would decrease the size of the gap in this region in the reconstructions shown in Figures 4 and 6a. However, when $K = 0.25$, this gap becomes about 60 km wide, which is considerably larger than the shortening estimated above. Thus, the effect of the deformation north of the Garlock fault is to reduce the value of $\gamma$ by possibly as much as 5°, which is not very large when $K_0 \geqslant 0.25$ (for which $\gamma \geqslant 15°$).

Because the shape of the northern boundary of the Mojave block changed, the assumption of the over-all homogeneity of deformation must also be relaxed: if the slices were to remain in contact with the curved and distorted northern boundary of the Mojave block, then the slip between them could not have been always proportional to their widths. Therefore, $K$ and $K_0$ vary locally, and their values used in the geometric model are only average slip gradients over the entire Mojave block. On the other hand, $\gamma$ is expected to be the same for all slices: if it varied from one slice to another (that is, if adjacent slices rotated differently), then wedge-shaped gaps or overlaps should have developed, but such structures have not been identified. The angle $\gamma$, which in principle can be determined by paleomagnetic measurements, may be used to calculate a corresponding average value of $K$.

The way that the northwest-striking faults and slabs between them terminate deserves special attention. In the reconstructions of Figure 6, the rotation of the slabs leaves triangular gaps along the unfaulted adjacent regions. The size of these gaps depends on the width of the slabs and the amount of rotation. Some structural depressions along the northern boundary of the Mojave block might have resulted in this manner, for instance Harper Lake, Cuddeback Lake, Superior Valley (Jennings and others, 1962), and the Pliocene basin of the Lava Mountains (Smith, 1964). If the faults splay before reaching the boundaries of the Mojave block, then small depressions will form. Additional field studies are required to test this interpretation.

Slip on the irregularly curved Garlock fault should produce local deformation in addition to that resulting from the terminations of the northwest-striking fault slices. The most obvious structure of this type is Cantil Valley. Gravity anomalies (Mabey, 1960) and young fault traces (Clark, 1971) indicate that this valley is a graben and that it was formed between left-stepped en-echelon segments of the left-slip Garlock

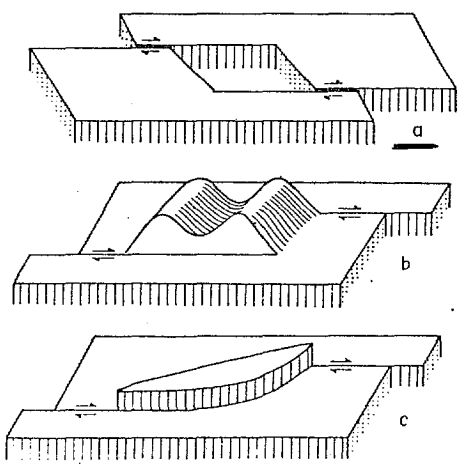



Figure 7. Extensional and compressional structures along en-echelon or curved segments of right-slip faults: a = gap between fault segments stepped to the right. b = folds between fault segments stepped to the left. c = uplifted wedge along fault curved so as to produce left-stepped segments.

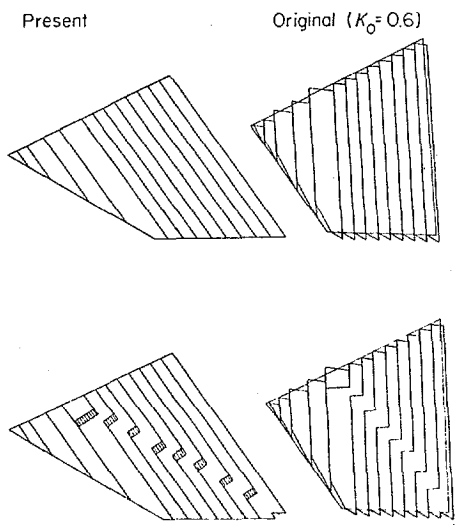



Figure 8. Example of increase in area by right slip on en-echelon faults. Over-all deformation as in Figures 4 and 6.

Garfunkel, Zvi, 1974, Model for the Late Cenozoic Tectonic History of the Mojave Desert, California, and for its Relation to Adjacent Regions: GSA Bulletin, v. 85, n. 12, p. 1931-1944 (December).

Marge 1001

Charles

op, heating and uplift of the doubled

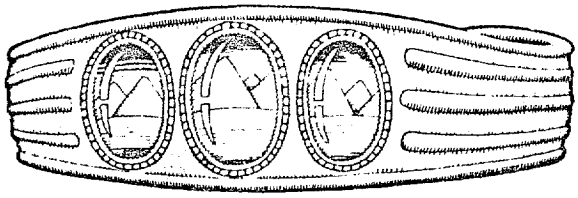
The exposed Precambrian rocks of Missouri constitute a major vol-

each of the two distinct depositional lobes which formed west of a

The fauna of the Conch

Piney Hollow Silverworks

1128 E. 6th St. Tucson, AZ 85719



The silversmiths of Piney Hollow are a cooperative in the Northern Sonoran Desert. Their interests include jewelry of the Zodiac set with considered, appropriate earthen gems and contemporary designs incorporating the finest of stones from around the planet—many of which are hand cut by lapidary companions. Each piece carries our spirit and commitment to the customers we serve.

# FINE, HANDCRAFTED JEWELRY

## Wholesale, Retail, Custom

PINEY HOLLOW SILVERWORKS

1128 E. 6TH STREET, TUCSON, ARIZONA 85719, (602) 622-9048

# Piney Hollow Silverworks

1128 E. 6th St. Tucson, AZ 85719

## PICTURE JASPERS—TURQUOISE—ZODIAC STONES

*The Zodiac provided us with our first organized calendar. Neolithic Civilization identified the color and patterns of gem stones with the seasonal symbols of the Zodiac. An example of this would be the symbolic meaning of the red in green Bloodstone as blood in the emerging green of Earth at Springtime, hence rebirth and Aries. It is the stone of Easter and the early church. Another example is Amethyst as the stone of Pisces. The purple represents wine which has fermented by this time of year when the other food supplies are low. Amethyst is the stone of fasting and drinking and is also the last color of the rainbow.*

1. ARIES—BLOODSTONE. The stone of Christ and the crucifixion; the stone of resurrection. Egyptians wore the Bloodstone on their thumbs because they identified that digit with the planet Mars. The power of the Bloodstone has been credited with arresting bleeding; prolonging life; bringing renown; conferring the favor of the great and protecting against the bite of scorpions.

2. TAURUS—TURQUOISE. A stone of Venus. The stone of early love. It is the ancient amulet for horsemen but must be a gift to grant protection. Turquoise is a pledge of affection and is said to have the power to appease hatred; draw threats from the possessor; warn of poison and prevent headaches. A crack in a Turquoise indicates it has taken a tension otherwise meant for the owner.

3. GEMINI—AGATE. The stone of tillers of the soil. The power of the Agate is said to enhance occult power; strengthen sight; assure success in love or friendship; avert lightning; confer eloquence; cure insanity; make the wearer agreeable; aid in the discovery of treasure and is an antidote for the bite of an Asp.

—CHRYSOPRASE. This green prince of Agates is credited with the power to impart cheerfulness; protect the wearer from evil dreams and the assaults of demons; take away greedy and covetous desires and to protect against rheumatism and gout.

4. CANCER—MOONSTONE. A stone of lovers. The power of the Moonstone is said to reconcile lovers; aid ocnsumption; assist in making decisions; protect the traveller; assure success and good fortune in love and to protect the wearer against dropsy.

—CRYSTAL. The stone of the seer. Crystal imparts the secrets of the future and inhances the natural power of one born under the sign of Cancer.

5. LEO—AMBER. Tears of the daughter of the Sun. Amber is said to protect against poisonous drugs; prevent insanity and is a counter charm against witchcraft.

—SARDONYX. This stone is said to grant fearlessness and courage; warn of scorpions; attracts friends; guarantee conjugal happiness; assure legal success and make a person an agreeable companion.

—PERIDOT. Found only in the Persian Gulf and Arizona, Peridot has been credited with the ability to protect against illusion and enchantment; provide foresight into the future and bring forth divine inspiration and eloquence.

—SUNSTONE. As with all yellow-orange stones it reflects the inner light of the Leo.

6. VIRGO—CORNELIAN. The color of ripened grain, the Cornelian was the stone of the Egyptian Earth Goddess Isis and was an important Egyptian talisman. Among the powers of the Cornelian are the ability to protect against witchcraft; turn away the glances of the envious; ward off the evil eye; protect against the plague; cool the blood; still angry passions; preserve peace; drive away evil thoughts; stop bleeding; enhance courage; protect against lightning, tempest, vice and enchantment. Cornelians are also a power source for astral travel.

—JADE. This gem of Virgo is credited as a talisman for longevity. In addition it has been used to protect from accidents and injury; as a source of defense from witchcraft; to avert opthalmia, epilepsy, stomach and liver trouble. Jade has the power to grant success in racing.

7. LIBRA—LAPIS. Most likely the first stone of the Neolithic Age, Lapis is the stone of Venus and, with the advent of Christianity, a gem of the Virgin. This stone, found in Afghanistan, Russia and Chile, has been endowed with the power to cure apoplexy, epilepsy, skin ailments and blood disorders. It inspires courage in children; cures depression; strengthens affections; offers success in love and fidelity in friends. Lapis is widely used as an aid to prescience.

—CORAL. Powdered and scattered, Coral is said to protect crops from locusts, blight, caterpillars and thunderstorms. This marine stone protects the wearer from delusions of the Devil and hallucinations; is a defense against childhood diseases; prevents fits; keeps evil spirits from the house and prevents mental delusions and nightmare.

—OPAL. This stone strengthens eyesight; arrests envy; clears the brain; strengthens memory; gives foresight and the power of prophecy. Misuse of the Opal brings ill luck in love; disappointment and misfortune in enterprises. When bright, the Opal indicates success and good fortune—when dull, indicates failure. Be careful.

8. SCORPIO—BERYL. The beryl is the stone of purity. By tradition it is a storehouse of the possessor's influence. This gem brings cheer; preserves married love; prevents illness of the throat and jaws; protects against slander; sharpens the intellect; is a remedy against idleness; preserves the owner from danger and sickness and aids in the discovery of hidden things. This stone is useful to clairvoyants and is considered a stone of the seer and mystic.

—CARBUNCLE. This stone, a high domed star garnet or sapphire, gives light from the darkness as the receeding light of Persephone is seen descending into Winter. The Carbuncle was the stone Noah used for a lamp. Its power is a safeguard from poison; represses extravagance; increases popularity and prosperity of the owner; protects against the plague, banishes sadness, dispels evil thoughts; represses sensuality; cures indigestion and sore throat and protects the wearer from wounds in battle.

9. SAGGITARIUS—TOPAZ. The Topaz is known for its power to prevent sudden death; to preserve one from a pestilential atmosphere (read Smoggy); to protect the traveller; as a safeguard against burns and scalding and to bring riches to the wearer. The Topaz is worn by many for health, caution and sagacity.

— PERIDOT. (see Leo)

10. CAPRICORN—MALACHITE. The stone of Saturn and congealing winter days. Malachite attracts sound sleep; averts despondency; is a charm against cholera; a safeguard from colic and rheumatism; aids health, success and constancy in affections; protects the wearer from contagious diseases and averts lightning.

—BLACK ONYX. This stone, representing the long nights of the Winter Solstice, is credited with the gift of spiritual strength and inspiration. It also cures fits.

—JET. A gem that brings assistance from the Winter Mother Earth. Jet protects travellers on land and sea; prevents nightmares, witchcraft and melancholy.

11. AQUARIUS—GARNET. The red sun of Winter. Garnets have been worn as amulets against poison and the plague; to attract health and cheerfulness; to protect the wearer from lightning and to confer constancy, fidelity and cheerfulness. Garnets are said to warn of approaching danger by changes in color.

12. PISCES—AMETHYST. The last stone of the Zodiac, the last color of the rainbow. Widely known as a protection from intoxication, drinking goblets were cut from this gem stone during the middle ages. Among the capabilities of Amethyst are the power to assure success in military exploits; provide calmness in danger; repress evil thoughts and excesses; prevent contagion; bring vigilance and business expertise; gives patience in sorrow; enhances religion and provides an understanding of the location of hidden things. Amethysts can indicate the presence of poison, personal danger or ill health by changing color.

This list of Zodiac stones has been taken from *The Book of Talismans, Amulets and Zodiacal Gems.* The powers given the stones are from traditions in India, China, Greece, Rome, Egypt and Europe of the middle ages. The Zodiacal traditions began in the Tigris-Euphrates crescent of Sumeria.

There are 11 silversmiths at Piney Hollow. Their craftsmanship includes interests in jewelry of the Zodiac set with considered, appropriate stones. Stop by when you can, we'd enjoy visiting with you.

AMERICAN METAL MARKET JULY 11, 1974

W. L. K.

AUG 8 1974

FTG: MISC TECH USGS

THE ANSWER TO OUR PROBLEMS!

(How many of you working type geologists had) knowledge of this symposium?

*RESOURCE NEEDS TO BE DISCUSSED*

# US Geological Survey To Hold Symposium

WASHINGTON — The United States Geological Survey will hold a two-day symposium on resource needs July 10-11 as part of the dedication of the National Survey Building in Reston, Va.

The symposium, which will hear federal, state and university earth science experts, will be held July 10-11.

Concerning metals, a paper to be given by Dr. John D. Ridge, head of the Department of Mineral Economics, Pennsylvania State University, will contend that while it is impossible for the U.S. to become self-sufficient in many metallic raw material areas, "the nation must obtain the best estimate possible of the quantities its subsoil contains of these minerals.

"Only through a systematic drilling program across the entire U.S. can we be certain that all deposits of mineral and fuel materials in the outer three miles of the crust of this country will be found.

"Such a systematic drilling program would be a radical departure from present exploration practices," Ridge contends. Systematic drill prospecting would also be expensive, requiring about 7,500 holes three miles deep at the cost of $3-billion.

Because of the cost and size of such a project, it would have to be conducted by the U.S. Geological Survey with the results being made public property, Ridge asserts.

Other papers to be given at the symposium will consider future land use and geological evaluation, and basic mineral research.

The new geological center, called the John Wesley Powell Federal Building, will be formally dedicated by Interior Secretary Rogers C.B. Morton on July 12.

7500 holes X 15,840'
= 118,800,000 feet.
$3.0 billion ÷ 118,800,000'
= $25.25/ft (!)

Area of U.S. = 3,537,000 $mi^2$
3,537,000 ÷ 7500 = 471.6 $mi^2$/hole
Or one hole per sq. 21.7 mi on side

Shouldn't academic geologists be licensed?

B.F.D.

# FORMS AND PROCEDURES FOR COMPLIANCE WITH BUREAU OF LAND MANAGEMENT MINING CLAIM RECORDING REGULATIONS 43 C.F.R. 3833

(Revised June 1, 1979)

EVANS, KITCHEL & JENCKES, P.C.
363 North First Avenue
Phoenix, Arizona 85003

NEVADA

CERTIFICATE OF LOCATION
(Lode Claim)

_____, whose mailing address is _____, by its undersigned agent, hereby certifies that it has located a mining claim in the _____ Mining District, County of _____ _____, State of Nevada.

The name of the claim is _____.

The general course of said lode or vein as near as it may be described, is _____.

The name of the locator is: _____
Post Office Address: _____
_____

The discovery monument is located _____ feet from the _____ _____ corner of Section _____, Township _____, Range _____, Mount Diablo Meridian, Nevada, and said claim lies within the _____ quarter of said Section.

From this discovery monument the undersigned claims _____ feet in a _____ direction, and _____ feet in a _____ direction, and three hundred feet on each side of the middle of the vein. The claim is _____ feet wide and _____ feet long.

The surface boundaries of the claim are described as beginning at the discovery monument and running thence _____ feet to the
[direction and distance]
center of the _____ end line and the true point of beginning,

thence _____ feet to Corner No. 1, thence _____
[direction and distance] [direction and distance]
feet to the center of the _____ side line, thence _____
[direction and distance]
feet to Corner No. 2, thence _____ feet to Corner No. 3, thence
[direction and distance]
_____ feet to the center of the _____ side line,
[direction and distance]
thence _____ feet to Corner No. 4, thence _____
[direction and distance] [direction and
_____ feet to the point of beginning.
distance]

There are 7 posts at least 4 inches in diameter by 4-1/2 feet long set 1 foot in the ground, one for the discovery monument, one for each of the four corners and one at the center of each side line as prescribed by N.R.S. §517.030.

Location work for this mining claim consisted of preparing and filing a map of said claim as provided in Section 517.040, Nevada Revised Statutes.

Located, dated and posted on the ground this ___ day of _____, 19__.

[Name of corporation] (owner)

By _____
Agent

Requirements for county recording:

1. Record duplicate Location Certificate within 90 days of posting notice.
2. Attach maps with scale not less than 1" = 500' showing and describing claim as provided in N.R.S. §517.040.
3. Pay $15.00 filing fee for each claim.

Requirements for BLM filing:

1. File copy of the official record of the Certificate of Location and U.S. Geological Survey topographic map, sketch or narrative of claim in State Office of BLM within 90 days after location.
2. Pay $5.00 to BLM for each claim.

AMENDED CERTIFICATE OF LOCATION
(Lode Claim)

_____, whose mailing address is _____, by its undersigned agent, hereby certifies that it has located a mining claim in the _____ Mining District, County of _____ _____, State of Nevada.

The name of the claim is _____.

The general course of said lode or vein as near as it may be described, is _____.

The name of the locator is: _____
Post Office Address: _____
_____

The said claim was located on the ____ day of _____, and the discovery monument is located _____ feet from the _____ corner of Section _____, Township _____, Range _____, Mount Diablo Meridian, Nevada, and said claim lies within the _____ quarter of said Section.

From this discovery monument the undersigned claims _____ feet in a _____ direction, and _____ feet in a _____ direction, and three hundred feet on each side of the middle of the vein. The claim is _____ feet wide and _____ feet long.

The surface boundaries of the claim are described as beginning at the discovery monument and running thence _____ feet to the
[direction and distance]
center of the _____ end line and the true point of beginning,

thence _____ feet to Corner No. 1, thence _____
[direction and distance] [direction and distance]
feet to the center of the _____ side line, thence _____
[direction and distance]
feet to Corner No. 2, thence _____ feet to Corner No. 3, thence
[direction and distance]
_____ feet to the center of the _____ side line,
[direction and distance]
thence _____ feet to Corner No. 4, thence _____
[direction and distance] [direction and
_____ feet to the point of beginning.
distance]

There are 7 posts at least 4 inches in diameter by 4-1/2 feet long set 1 foot in the ground, one for the discovery monument, one for each of the four corners and one at the center of each side line as prescribed by N.R.S. §517.030.

Location work for this mining claim consisted of preparing and filing a map of said claim as provided in Section 517.040, Nevada Revised Statutes.

The original location certificate of this claim and amended location certificate, if any, are recorded in the official records of _____ County, Nevada, as follows:

| | Recorded Book | Recorded Page | Recorded Date | BLM Serial No. |
|---|---|---|---|---|
| Original Location Certificate | | | | |
| Amended Location Certificate | | | | |

This amended location is made for the purpose of adjusting the boundaries of said claim correcting irregularities, informalities or errors, supplying omissions and correcting any defects which have existed or do exist in the original location, or the record thereof, hereby waiving no rights acquired under and by virtue of said original location.

Dated and posted on the ground this ____ day of _____, 19__.

[Name of corporation] (owner)

By _____
Agent

Requirements for county recording:

1. Record duplicate Amended Certificate of Location within 90 days of posting notice.
2. Attach amended maps with scale not less than 1" = 500' showing and describing claim as provided in N.R.S. §517.040.

Requirements for BLM filing:

1. File copy of the official record of the Amended Certificate of Location and amended U.S. Geological Survey topographic map, sketch or narrative of claim in State Office of BLM within 90 days after amendment.
2. Attach amended U.S. Geological Survey map sketch or narrative showing claim or claim group and survey or protraction lines.

RELOCATION CERTIFICATE
(Lode Claim)

_____, whose mailing address is _____, by its undersigned agent, hereby certifies that it has located a mining claim in the _____ Mining District, County of _____ _____, State of Nevada.

The name of the claim is _____.

The general course of said lode or vein as near as it may be described, is _____.

The name of the locator is: _____
Post Office Address: _____
_____

The discovery monument is located _____ feet from the _____ _____ corner of Section _____, Township _____, Range _____, Mount Diablo Meridian, Nevada, and said claim lies within the _____ quarter of said Section.

From this discovery monument the undersigned claims _____ feet in a _____ direction, and _____ feet in a _____ direction, and three hundred feet on each side of the middle of the vein. The claim is _____ feet wide and _____ feet long.

The surface boundaries of the claim are described as beginning at the discovery monument and running thence _____ feet to the
[direction and distance]

center of the _____ end line and the true point of beginning,

thence _____ feet to Corner No. 1, thence _____
[direction and distance] [direction and distance]

feet to the center of the _____ side line, thence _____
[direction and distance]

feet to Corner No. 2, thence _____ feet to Corner No. 3, thence
[direction and distance]

_____ feet to the center of the _____ side line,
[direction and distance]

thence _____ feet to Corner No. 4, thence _____
[direction and distance] [direction and

_____ feet to the point of beginning.
distance]

There are 7 posts at least 4 inches in diameter by 4-1/2 feet long set 1 foot in the ground, one for the discovery monument, one for each of the four corners and one at the center of each side line as prescribed by N.R.S.. §517.030.

Location work for this mining claim consisted of preparing and filing a map of said claim as provided in Section 517.040, Nevada Revised Statutes.

This is intended as an original location certificate of the _____ lode mining claim covering all or a part of the same ground included in the ____ _____ lode mining claim, the original location certificate and the amended location certificate, if any, are recorded in the Official records of _____ County, Nevada, as follows:

| | Recorded Book | Recorded Page | Recorded Date |
|---|---|---|---|
| Original Location Certificate | | | |
| Amended Location Certificate | | | |

All of the requirements of law relating to the location of mining claims have been, or within the times required by law will be, complied with by this location, including the performance of new location work, but by this location the locator does not intend to and does not waive any rights it has under and by virtue of the location of the said _____ and other lode mining claims.

Relocated, dated and posted on the ground this ____ day of _____, 19__.

[Name of corporation] (owner)

By _____
Agent

Requirements for county recording:

1. Record duplicate Relocation Certificate within 90 days of posting notice.
2. Attach maps with scale not less than 1" = 500' showing and describing claim as provided in N.R.S. §517.040.
3. Pay $20.00 filing fee for each claim.

Requirements for BLM filing:

1. File copy of the official record of the Relocation Certificate and U.S. Geological Survey topographic map, sketch or narrative of claim in State Office of BLM within 90 days after relocation.
2. Pay $5.00 to BLM for each claim.

NEVADA

AFFIDAVIT OF LABOR PERFORMED
AND IMPROVEMENTS MADE

STATE OF NEVADA )
) ss.
County of _____ )

_____, being first duly sworn, deposes and says that he is a citizen of the United States and more than twenty-one (21) years of age, and resides in _____, County of _____, State of Nevada, and is personally acquainted with the mining claims situated in the _____ Mining District, _____ County, Nevada, the names and books and pages of record in the office of the County Recorder of _____ County, Nevada, and the Bureau of Land Management serial number of the Certificate of Location whereof are as follows:

| Name of Claim | Book | Page | BLM Serial Number |
|---|---|---|---|

That all of said mining claims are owned by _____ _____, the mailing address for which is _____ _____; that between September 1, 19__,

and September 1, 19__, in excess of $_____ worth of work and improvements were done and performed for the benefit of each of the aforementioned claims. Work and improvements consisted of _____ performed by _____

_____

_____.

Said labor was performed and improvements made at the expense of _____ for the benefit of each and all of said mining claims comprising said contiguous groups as part of a general plan of exploration, improvements and development, and they tend to explore, improve and develop each and all of said mining claims. The amount expended for and the value of said labor and improvements is more than One Hundred Dollars ($100.00) for each of the mining claims and at least said amount was allocated to each of the mining claims. Said expenditure was made in good faith for the purpose of exploring, improving and developing said contiguous groups of mining claims, and was intended as annual labor and improvements for each and all of the above-described unpatented lode mining claims for the assessment year ending at 12:00 o'clock Meridian, September 1, 19__.

_____ _____

Witness For _____

_____

Witness

STATE OF NEVADA )
) ss.
County of _____ )

The foregoing instrument was acknowledged before me this ____ day of _____, 1979, by _____.

_____
Notary Public

My Commission Expires:

_____

Requirements for county recording:

1. Record Affidavit within 60 days after performance of labor or making improvements.

Requirements for BLM filing:

1. For claims located on or before October 21, 1976, file copy of Affidavit (or notice of intent) in State Office of BLM on or before October 22, 1979, or on or before December 30 of each calendar year following date of filing Certificate of Location with BLM, whichever date is sooner.

2. For claims located after October 21, 1976, file copy of Affidavit (or notice of intent) in State Office of the BLM on or before December 30 of each calendar year following date of filing Certificate of Location with BLM.

EMERGENCY DIRECTIVE NO. 3 August 9, 1974

DISTRIBUTION: In-Service Holders of FSM 2800

CHAPTER: 2850 - 1872 ACT Use Regulations

POSTING NOTICE: Last Item is No. 2 in FSM 2800

This is the first directive issued under new Chapter 2850. It provides policy and guidance in administration of regulations contained in new Part 252 of Title 36 of the Code of Federal Regulations (36 CFR 252). This directive is effective on the effective date of the regulations. The regulations in their entirety should be considered part of this directive. FSM 2323.7 through 2323.72 are superseded in part (Sec. 2854.9).

Administration of the regulations is a new and dynamic process which challenges the best in each administrator's imagination, tact, patience, fair-mindedness and skill in communications. Several years may pass before miners, prospectors and Forest Officers become accustomed to operating under the regulations. Unexpected problems will arise for which acceptable solutions must be found. Revisions in directives will be needed. Comments and suggestions for changes are welcome on a continuing basis and revisions will be made as necessary. Additional sections in this Chapter are under development and will be issued as soon as possible. After a test period of a year or two, the regulations will be examined to see if changes are appropriate.

One or more court suits challenging the authority to regulate are expected. The prospector and miner have a statutory right (not a mere privilege) under the 1897 Organic Act to enter upon the National Forests for prospecting and mining. Their rights to do this cannot be unreasonably restricted or made excessively burdensome. Unreasonable demands made as conditions for approval of operating plans will hazard court challenges. Administrators are expected to use sound judgment and where critical matters of proof are involved in applying the test of reasonableness, the advice of the Office of the General Counsel should be sought early in the decisionmaking process. Success in defending attacks on the regulations will depend on how well administrators develop and analyze facts, draw conclusions and apply those conclusions in decisionmaking.

It must be kept clearly in mind that it is not intended that the 1872 Act use regulations be enforced through criminal sanctions. The regulations do not prohibit specific activities which cause adverse environmental effects. On the other hand, operations that are unnecessarily or unreasonably causing, or threaten to cause, injury,

loss or damage to surface resources are subject to court action for relief. Also, there are other remedies in Federal and State standards for air and water quality and the disposal of solid wastes. A court may award damages to the extent of the value of the property damaged.

The principal value of the regulations lies in the willingness of the great majority of prospectors and miners to comply with reasonable regulations reasonably administered. That willingness can be lost and the regulations put in jeopardy of revocation through imprudent and careless administration. Carefully nurtured and allowed to grow, it can be a powerful aid in the protection of environmental quality in the National Forests.

2850.2 - Objective. The objectives in administering the 1872 Act use regulations are to:

1. Minimize or prevent, where reasonable, adverse environmental impacts on National Forest System surface resources as a result of operations authorized by the 1872 mining law.

2. Secure the willing cooperation of prospectors and miners in demonstrating that the Forest Service and the mining industry are meeting their environmental protection responsibilities and obligations.

3. Avoid materially endangering or interfering with prospecting, exploration, mining and mineral processing operations, as well as to uses reasonably incident to such uses of National Forest System lands.

4. Keep operating plans as simple to prepare, review and approve as possible so that they can be processed without unnecessary expenditures of time and money by the Forest Service and operators alike.

2850.3 - Policy. The effect of the 1872 Mining Law and 1897 Organic Act is to accord locatable minerals a special place among the resources in National Forests. Most users of the National Forests cannot impact surface resources or secure rights to lands in National Forests without express permission. But the prospector and miner has a right, under the laws, to search for and take valuable deposits of locatable minerals and may, in so doing, secure title to the National Forest lands involved and impact on surface resources incident to such activities, without obtaining permission from the Forest Service.

The Forest Service is not authorized to manage locatable mineral resources in National Forests; it is the responsibility of the Department of the Interior to administer the 1872 Act. Neither is the Forest Service directly concerned with methods and techniques of prospecting, exploration, mining or mineral processing, except

to the extent that certain methods and techniques can have greater or lesser environmental impacts. Minerals are as much a part of the natural resources in National Forests as are outdoor recreation opportunities, fish and wildlife, forage, water, timber and natural beauty.

It is, therefore, Forest Service policy that--

1. The 1872 Act use regulations be administered in a fair, reasonable and consistent manner and not as a means of inhibiting or interfering with legitimate, well-planned mineral operations. Face-to-face dialogue with operators is encouraged.

2. Efforts will continue to be made to end unauthorized occupancy and use of mining claims, but approval of operating plans will not be delayed as a means of solving trespasses.

3. Along with other factors, the economic viability of operations will be considered in determining what are reasonable environmental protection requirements in operating plans.

4. Operators will be requested to supply only the minimum information needed to carry out the purposes of the regulations. Confidential information requested and accepted as such will be protected from unauthorized disclosure.

5. Timely response to submission of operating plans is mandatory. Responses will be made as soon as possible, with the objective of responding in most cases within half or less of the time specified in the regulations. Operators will be encouraged to submit their proposed operating plans as soon as they can accurately describe them, so as to reduce delays in approval.

6. While improvement of the condition or potential for future use of surface resources is a desirable goal of reclamation, such must be an incidental benefit, not forced as an extra cost to operators.

7. All unpatented mining claims, millsites, and tunnel sites are considered to be subject to the 1872 Act use regulations, including those which are not subject to Sec. 4 of the Act of July 23, 1955.

2850.4 - Delegation of Authority. Forest Supervisors are designated as "authorized officers" for the purposes of administering the regulations in 36 CFR 252. Forest Supervisors shall redelegate this authority to District Rangers to the maximum extent practicable,

subject to the following restrictions:

Redelegations will not be made when a bond of $20,000 or more is required as a prerequisite for approval of an operating plan.

Redelegations will not be made when an environmental statement is required as a prerequisite for approval of an operating plan.

2851 - OPERATIONS.

2851.05 - Definitions.

2851.05a - Determining "significant surface resource disturbance." The determination by the authorized officer of what constitutues "significant surface resource disturbance" within the meaning of the 1872 Act use regulations is an important matter. An operator's time and money are involved, since a positive finding triggers the requirement that an operating plan be filed.

A precise definition cannot be given for "significant" in relationship to surface resource disturbance. The determination of what is "significant" can only come from a fair, reasonable, and consistent evaluation of proposed operations on a case-by-case basis. "Significant" is a site-sensitive term: Surface resource-disturbing activity in one area, such as flat sage brush-covered ground might not be significant while the same operation in a high, alpine meadow could cause a highly significant disturbance.

Onsite surface resource disturbance will come almost entirely from earthmoving activities or from site clearance. Such onsite disturbance would be considered "significant" if natural recovery (to a condition of no higher standard than existed before the operation) would not be expected to take place within a reasonable period of time.

Offsite resource disturbance generally will result from movement of solid substances, liquids, gases, or particulate suspensions (in liquids and gases) away from areas of operation as a result of operational activity and/or natural causes. This does not include naturally occurring substances moving from their natural loci wholly

as a result of natural causes. Some examples of offsite disturbances from operations are: movement of rock, soil, mine waste, tailings, etc., away from their site of deposition onto other surface areas or into surface or subsurface waters; surface or subsurface flow of chemical leachates, liquid chemicals, particulate suspension, etc., away from their sites of original use or storage; or, discharge or dispersion of gaseous substances or particulate suspensions into the atmosphere. Offsite resource disturbance would be considered "significant" if it likely would result in unnecessary or unreasonable injury, loss, or damage to National Forest resources; would cause air or water degradation to a degree unacceptable under Federal and State quality standards; or would cause risk to health or safety.

2851.1 - Plan of Operations. A written plan of operations is required from all operators who will likely cause a significant disturbance of surface resources through operations being conducted on or after the effective date of the 1872 Act use regulations. Plans involving mining claims subject to Section 4 of P.L. 167 are subject to the restrictions of that Act. When possible or necessary, the authorized officer or his duly appointed representative shall review the plan of operations with the operator, on a person-to-person basis, to facilitate joint development of a reasonable agreement relative to the proposed operations. Consistent with the objectives in FSM 2851, negotiations to effect changes in the proposed operations may be needed in order to reduce surface resource damage without materially interfering with or endangering the proposed operation. Furthermore, the operator and the authorized forest officer should jointly analyze and, where necessary, modify the reclamation plans included in the plan of operations in a fair, reasonable and consistent manner, with the goal being a reduction in the extent and degree of disturbance of surface resources. This will, in turn, reduce the amount of the surety bond which the operator must file with the appropriate Regional Fiscal Agent before the plan of operations is approved. In some cases, the operator and authorized officer may be able to totally eliminate the bond requirement and, in other cases, they may be able to significantly reduce the amount of the bond.

The authorized officer must be fair, reasonable, and consistent in reviewing plans of operations and determining the need and amount of bonds required for reclamation purposes. Furthermore, the authorized officer shall bear in mind that the Forest Service function is the management of surface resources in a manner compatible with reasonable and logical mining operations and not the management of mineral resources.

Within 30 days after receipt of a plan of operations, the authorized officer shall review the operating plan, prepare an environmental analysis and notify the operator that the operating plan is:

(1) approved

(2) not required

(3) in need of changes or additions

(4) being reviewed, but that more time (up to 60 additional days) is necessary to complete the review, and why the additional time is needed. Days during which the area of operations are inaccessible for inspection are not included when computing the 60-day period.

(5) such that approval must be deferred until a final environmental statement has been prepared and filed by the Forest Service with the Council on Environmental Quality as provided in Section 252.4(f) of the regulations. In cases (3), (4), and (5), pending approval of the plan, the authorized officer must approve any operation which he deems sufficient to meet the environmental protection requirements of the regulations and which must be completed in order for the operator to comply with Federal and State laws. In evaluating a proposed operating plan, the authorized officer will be expected to utilize mining geologists, mining engineers, civil engineers, hydrologists, foresters, fisheries and wildlife biologists, etc., where and when necessary to assist him in evaluating the plan of operations. In most cases, with some help from a mining engineer or mining geologist, the authorized officer should be able to promptly and rapidly process most operating plans well within the 30 days allowed by the regulations.

As a minimum, the plan of operations must include sufficient data to identify the who, where, how, when, and size of the proposed operation and the measures to be taken to meet the requirements for environmental protection described in the regulations (Sec. 252.8).

If an operator includes confidential information in his proposed operating plan, such confidential information would generally be used for determining the justification of the proposed operation and would usually be related to early exploration projects. Access to, interpretation, and evaluation of necessary information identified as confidential by the operator should be on a "need-to-know" basis insofar as Forest Service personnel are concerned. Generally, Forest Service mining experts are best qualified to evaluate such data and insofar as possible should see to it that it remains under the operator's control. When, at the request of the Forest Service, the operator includes and identifies confidential information in a proposed operating plan, said information should be kept to a minimum, labeled as confidential and kept separate from the rest of the operating plan.

To properly serve its intended purpose, the proposed plan of operations must include the following information. Frequently needed information, but not required by the regulations, is enclosed in brackets.

(1) Name, legal address [and telephone number] of the operators, and their lessees, assigns, or designees [and their duly appointed field representative]

(2) Name, legal mailing address [and telephone number] of all owners other than the operator

(3) [Name of mining district or mineralized area; and name of claim(s) and/or property/ies on which operation(s) will take place or will be based.]

(4) A location map of appropriate scale to show accurately the general area in which mining operations might take place (location of claim(s) and/or property) and proposed route of access. In general, a forest recreation map would be adequate.

(5) A surface disturbance map of the area within which onsite and offsite surface resource disturbing activities will [or could] take place. The scale and accuracy of the map must be adequate to permit identification of the site on the ground. A USGS 7½ minute topographic quadrangle map or its equivalent will suffice in most cases and should be tied to the general area location map.

(6) The type and magnitude of the proposed operations should be well documented and closely tied to the information posted on the maps. Such data will permit an informed evaluation of the impact of the proposed operation(s) on the surface resources with the minimum of delay in approval. As a matter of policy (2852), the Forest Service will require only the minimum of information needed (preferably not to include confidential), but will require information on earth-moving and site clearance operations.

(7) The operator must identify the probable beginning and ending dates within which the proposed operation will be conducted [and, when appropriate, whether the operation will be intermittent or continuing].

(8) The plan of operations shall include sufficient detail to identify the precautions which the operator needs to take to reasonably prevent and/or minimize adverse environmental impacts on National Forest surface resources during and after the proposed operations. Although improvement of surface resource conditions or preparations for future use are desirable goals, they cannot be forced on operators as an added cost.

In addition to the above, approval of a plan of operations by the Forest Service shall be accompanied by the following statements:

(1) "Approval of this operating plan does not constitute certification of ownership to any person named as owner herein."

(2) "Approval of this operating plan does not constitute recognition of the validity of any mining claim named herein, or of any mining claim now or hereafter covered by this plan."

2851.11 - Notice of Intention to Operate. A written notice of intention to operate is required from all operators who propose to conduct operations which might cause surface resource disturbance and who have chosen not to file an operating plan. The operation described in the notice must be evaluated and the operator must be informed, within 15 days after the notice is received by the District Ranger, either that his operation is exempt from the requirement for an operating plan or that one is required. The notice of intention must include:

(1) Name and address of the operator.

(2) Information sufficient to identify with reasonable certainty the area involved on the ground.

(3) The route of access to the area of operations.

(4) The nature of the proposed operations.

(5) The proposed method of transport to the area of operations.

(6) Operators should be encouraged to well document and closely tie the information to maps and to describe in some detail any proposed surface disturbing activities such as trenching, drill road and drill site construction or tree cutting.

Where a District Ranger or his duly authorized representative notifies an operator that no operating plan is required for this operation, that notification must be documented with a copy to the operator as promptly and simply as is feasible. The documentation should include the basis for the determination that a plan was not required. The documentation may later be helpful in court or serve as a defense against unwarranted criticisms.

2851.12 - Requirements for Operating Plans. (Reserved)

2851.13 - Approval of Operations. (Reserved)

2851.14 - Bonds. Prior to approval of a plan of operation, including the type and amount of reclamation, the operator must furnish, if required, a guarantee to perform reclamation in an amount equal to the estimated cost of the reclamation work. The guarantee, ordinarily a surety bond, must be filed with the appropriate Regional Fiscal Agent, Forest Service, U.S. Department of Agriculture. If the guarantee is in cash, the check or money order should be drawn payable to the Forest Service, U.S. Department of Agriculture. If a surety bond is submitted, the surety must be among those appearing on the quarterly list of acceptable sureties furnished by the Treasury Department and authorized to do business in the State in which the operation occurs.

Whenever a bond furnished under an approved plan of operations shall be found unsatisfactory, a new bond that is satisfactory will be furnished within 15 days from the date the operator is notified that the original bond or its successor is not satisfactory.

The surety bond or equivalent cash deposit is conditioned upon the Forest Service's acceptance of the operator's reclamation of the disturbed surface resources in accordance with section 252.8 (g) of the regulations.

The authorized Forest Service officer will, in writing, promptly relieve the operator from any further reclamation responsibilities on those areas on which such reclamation requirements agreed upon in the approved plan of operation have been completed and accepted by the Forest Service. This could occur piecemeal, if the reclamation took place in definite stages.

The surety deposit or bond shall be used only to assure compliance with the reclamation requirements agreed upon in the plan of operations by the operator and the Forest Service, and where required must be deposited with the appropriate Forest Service officer before the plan of operations may be approved.

All reasonable effort should be made, through agreements with States which require bonds for reclamation of disturbances in National Forests, to avoid double bonding.

2851.2 - Inspection and Noncompliance. When activities are being conducted under an approved operating plan, regular compliance inspections should be conducted to assure reasonable conformity to the plan and to guard against unforeseen detrimental effects. The frequency, intensity, and complexity of inspection should be commensurate with the potential for irreparable and unreasonable damage to surface resources.

When operations are being conducted without an operating plan because, as a result of a notice of intention, it was determined none was required, the need for regular inspections should be determined on a case-by-case basis. If inspections are warranted and timely, they will assure conformance to the environmental protection requirements of the regulations as well as serve to identify operations that vary from those described in the notice of intention and which may require an operating plan.

All forest officers should make note of, and report, all operations for which there may not have been submitted either a notice of intention or an operating plan. Such operations should be identified and inspected as soon as practicable to assure submission of a notice of intention, or operating plan, and to assure conformance to the environmental protection requirements of the regulations.

Inspections should be conducted by forest officers who are familiar with the equipment and methods needed to find and produce minerals and who can accurately assess the significance of surface resource disturbance. Inspectors should be capable of identifying those activities of an operator which are reasonably necessary to his operation, which ones could perhaps be done differently with less effect on surface resources without endangering or hindering his operation, and which ones are unreasonable or unnecessary.

Wherever practicable, instances of noncompliance should be discussed with the operator, either in person or by telephone, in an attempt to secure willing and rapid correction of the noncompliance. Such discussions should be made a matter of record in the operator's case file. In addition, where the operator fails to take prompt action to comply or where more rapid communications are infeasible, and the noncompliance is unnecessarily or unreasonably causing injury, loss or damage to surface resources, the authorized officer must serve a notice of noncompliance upon the operator or his agent in person, by telegram or by certified mail. The notice must describe what is occurring. If information is available on when and why the noncomplying activities occurred, that information should also be stated in the notice. In every notice, there should be a reasonable time interval stated for compliance to be had. The time selected should be reasonably commensurate with the probable extent of the injury, loss or damage over time.

Where reasonable, continued failure to comply should be followed by additional personal contacts. Legal action to force compliance should be a last resort, but it may be considered to halt unnecessary or unreasonable activities causing irreparable damage to surface resources, to compel reasonable action to minimize surface resource disturbance, or/and to reclaim areas after completion of operations. The Office of the General Counsel should be contacted in every case where legal action is contemplated.

2851.3 - Requirements for Environmental Protection. (Reserved)

2851.4 - Maintenance During Operations, Public Safety. (Reserved)

2851.5 - Cessation of Operations. (Reserved)

2851.6 - Prevention and Control of Fire. (Reserved)

2851.7 - Access. A miner or prospector is entitled to reasonable access across National Forest land for prospecting, locating, and developing mineral resources. The 1872 Act use regulations provide, in the operating plan requirement, a means by which the Forest Service can perform its function of protection of surface resources impacted by exercise of the right of reasonable access.

Access is considered to be reasonable when: evaluation of the mineral potential, thought to justify the access, reveals the existence of a valuable deposit or a likelihood that additional work (aided by improved access) could reveal one; improved access is needed for prospecting, exploration, development, mining, or processing of the indicated deposit; the means of access and mode are commensurate with the degree to which the valuable deposit is demonstrated; and surface resource damage to be sustained is acceptable considering all factors. The assistance of a Forest Service mining engineer should be sought in determining the justification for and nature of access that is reasonable. It is reasonable that operators who propose major impacts on surface resources should be required to justify them in terms of need and relevance to actual mineral operations.

"Access," as used in the regulations, refers to means of ingress and egress such as roads, trails, bridges, tramways, land fields for aircraft; and to cars and trucks, tracked vehicles, all-terrain vehicles, motorcycles and trailcycles, off-road vehicles, fixed-wing aircraft and helicopters, boats, and saddle- and pack-animals. Not all access requires advance approval. (See 36 CFR 252.4(a) and 36 CFR 252.12.)

Approval of an operating plan serves to indicate approval of the means of access and modes of transport as described in the plan.

Use of vehicles on existing public roads or roads used and maintained for National Forest purposes need not be covered by an approved operating plan. Even so, operators must receive advance permission to use roads closed by, or with the approval of, the Forest Service and must otherwise comply with road use regulations applicable to their activities.

Approval of an operating plan providing for use of vehicles off-roads authorizes entry into off-road vehicle closures in the manner described in the operating plan. Reasonably necessary use of an off-road vehicle for prospecting or mining purposes in a closed area, does not in itself require an operating plan. When such use constitutes significant disturbance of surface resources a plan is required.

Provisions in the operating plan for access should be evaluated in light of existing criteria in the FSM governing similar uses for other purposes. This will help maintain consistent treatment of National Forest users.

Access authorized through approval of an operating plan is not subject to charge. However, the cost of maintenance is appropriately borne by the operator to the same extent as would be required for other users under similar circumstances. Likewise, the standard of maintenance required should be the same as for other users under similar circumstances.

An operator may not be required by an approved operating plan to maintain an existing road to a standard higher than existed when his use started. However, he would be expected to maintain the standard to which he may have improved a road.

Evaluation of proposals for construction of means of access should consider the possibility of alternatives. Construction to a lower standard than proposed, or of a different means of access, or use of other modes of transport could cause less resource damage and serve the intended purpose equally well, or even better.

Access across National Forest land needed to support a mining operation on a patented mining claim or other private land cannot be authorized by approval of an operating plan. The controlling point is the fact of private ownership, not the mining operation. This situation should be handled by special use permit if the proposed access is such as to require written authorization.

2851.8 - Operations in Wilderness. Operations within Wilderness are subject to the requirement of an approved operating plan to a greater extent than on National Forest land in general. Those activities generally prohibited within Wilderness shall, when circumstances

warrant, be authorized through approval of an operating plan as required by regulations in 36 CFR 252.

FSM 2323.7 through 2323.72 covers prospecting and mining in Wilderness under authority of the mining laws. To the extent those directives require permits or other authorization for prospecting mining and associated uses, they are superseded by the regulations in 36 CFR 252, and by this Chapter. To the extent they set standards for protection and management of surface resources, environment, and wilderness character, they remain in effect.

2852 - AVAILABILITY OF INFORMATION.

2852.1 - Confidential Information. As a matter of policy, the Forest Service requires only that the minimum information in a proposed operating plan that is necessary to make an informed evaluation of the impact of the proposed operation on the surface resources. Confidential information generally would be required only for determining justification for proposed operations. If confidential information is required, a Forest Service mining engineer or mining geologist should be requested to evaluate the technical data while it remains under operator control. After evaluation of the confidential information, the mineral expert will submit a summary report in which he concurs in or disagrees with the need for the proposed surface resource-disturbing action. The report will be submitted in such form that there will be no need to hold it confidential.

By not having confidential information to protect, the need to guard against unauthorized disclosure does not exist. The Forest Service thus avoids the problem of accidental leakage of information which might seriously reduce its credibility with operators and thereby make administration of the 1872 Act use regulations more difficult.

2853 - APPEALS. (Reserved)

GPO 879-029

J. D. Sell

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

October 4, 1972

MEMORANDUM TO STAFF

Now that all our forces have returned, it is a good time to list areas of work responsibility. As noted below, I am requesting certain men, in addition to their regular duties, to supervise other's work. I should like to accompany the supervisor when field reviews are made.

| Geologist | Area | Supervisor |
|---|---|---|
| King | Rincon-Empire altered Cretaceous Problem (Interstate 80) | Sell |
| | Covered Wells mapping | Sell |
| | Papago Reconnaissance | Sell |
| Cummings | Silver Bell | Graybeal |
| Davis | Complete Safford Report/Recommendations | |
| | Steeple Rock District | Stathis |
| | Wickenburg-Bradshaw Area | Stathis |
| French | Silver City | Sell |
| | Southwest New Mexico | Sell |
| Whaley | Silver State | |
| | Poston Butte | Crist |
| | Land Status Maps | |
| | File Revision | |
| | Aerial Photo Indexing | |
| Stathis | Literature Duties | |
| | Bisbee | |
| | Wickenburg-Bradshaw Area | |
| Graybeal | Patagonia (3R Project; Thunder Mtn. Project) | |
| | Silver Bell/Silver Bell East | |
| Sell | Miami-Superior (Superior East, Bohme, Rawhide) | |
| Giesecke | Regional Structure | |

| | |
|---|---|
| Crittendon | Drilling Coordinator, Contracts, Etc. |
| Crist | Office Manager<br>Feasibility Studies<br>Land Negotiations, Etc. |
| Stone | Assist in geochem., claim staking, drilling, gravity, etc. |
| Benavidez | Assist in geochem., claim staking, drilling, gravity, etc. |

Obviously your main effort is to be directed at locating porphyry copper drill targets. Any other commodity that offers large tonnage potential can be considered. Since direct clues to porphyry copper deposits are hard to find, you must exercise your brain power as well as your hammer power.

The use of biotite has not been as encouraging as we had hoped. Anyone wanting to use this technique within their areas should consult with Stathis and Graybeal. They shall determine whether to sample for biotite and, if so, sample spacing to be used. They also should be consulted in the interpretation of results.

A geologic information drill may be available. You should determine areas where it can be used effectively.

W. L. Kurtz

WLK:lad

cc: JHCourtright

~~RBC~~
JDS
Stathis

cell ~~WLK~~

J. H. Courtright

RECEIVED
MAY 6 1971
EXPLORATION DEPT.

New York, May 4, 1971

MEMORANDUM FOR: Division Supervisors
Exploration Department

Please see to it that passports are obtained for yourself and any of your geologists who might be required to travel overseas on our behalf during the next 5 years. The fee can be put on the expense account. Present holders of passports should keep them up to date. This also applies to the smallpox vaccination.

John J. Collins

CARRIE – RBC, JDS, GJS should comply.
Keep record so that WES can add others if he desires.
cell K

Jour. Research U.S. Geol. Survey
Vol. 2, No. 3, May-June 1974, p. 311—321

# GENERALIZED GEOLOGY AND STRUCTURE OF THE WINKELMAN 15-MINUTE QUADRANGLE AND VICINITY, PINAL AND GILA COUNTIES, ARIZONA

By M. H. KRIEGER, Menlo Park, Calif.

*Abstract.*—A northwest-trending belt of steeply east-dipping Precambrian and Paleozoic sedimentary rocks extends across the Winkelman 15-minute quadrangle and separates areas of contrasting structures. To the southwest for 60 mi is an expanse of Precambrian basement, largely granite; to the northeast the Precambrian and Paleozoic sedimentary rocks are gently tilted and intricately faulted. The structure within the Winkelman 15-minute quadrangle is interpreted as a monocline separated into en echelon segments by strike-slip and normal faults. Other monoclines lie to the north and northwest. Most of the tilting that formed the monoclines occurred after deposition of the early(?) Miocene San Manuel Formation. Structural features that repeat the Precambrian and Paleozoic sedimentary rocks within the area and that resemble high-angle faults are believed to have formed as low-angle thrusts, tilted to their present nearly vertical position during development of the monoclines. Structural features that are younger than the monoclines include low-angle gravity slide surfaces which are older than the high-angle normal faults that formed the basin-and-range topography on which the Pliocene sediments were deposited.

This paper describes and interprets the geologic structure within and adjacent to the Winkelman 15-minute quadrangle (fig. 1). The four 7½-minute quadrangles that make up the 15-minute quadrangle are being published in the quadrangle-map series at a scale of 1:24,000 (Krieger, 1974a-d). The interested reader is referred to these maps for more details on the structure and for fuller descriptions of the stratigraphy of the area. The most obvious structural features are en echelon belts of steeply dipping Precambrian and Paleozoic sedimentary rocks that contrast with structural features to the northeast and southwest. Southwest of the 15-minute quadrangle, Precambrian basement rocks are extensively exposed; northeast of it, Precambrian and Paleozoic sedimentary rocks are gently tilted and intricately faulted. The northwest-trending en echelon belts within the 15-minute quadrangle are interpreted as a single monocline later separated into segments by strike-slip and high-angle normal faults.

*Acknowledgments.*—I thank my colleagues in the U.S. Geological Survey, particularly Max D. Crittenden, Jr., and Norman G. Banks, for stimulating discussion, for many suggestions concerning the structural interpretations, and for critical review of the manuscript.

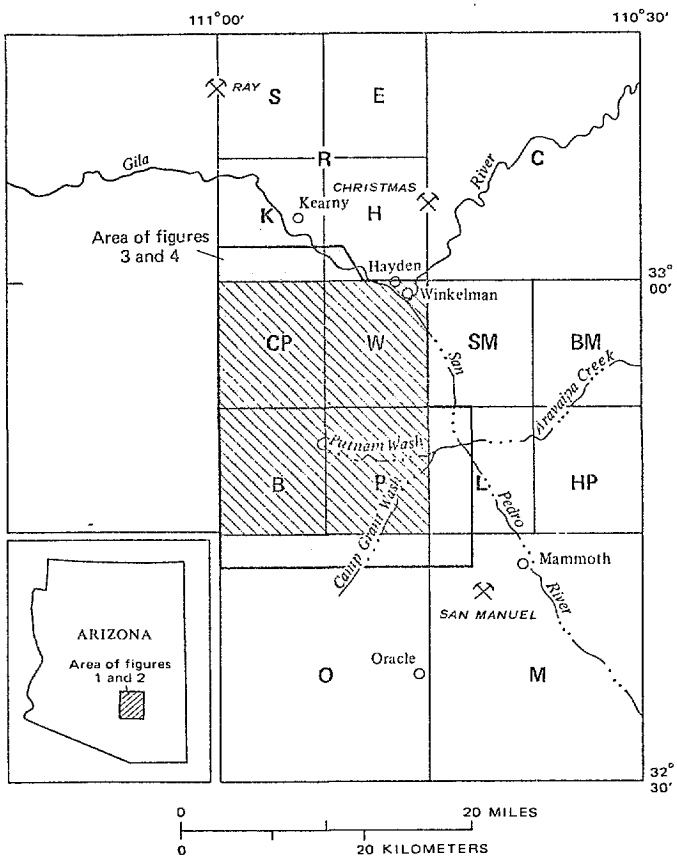



Figure 1.—Index map showing location of the Winkelman 15-minute quadrangle (hatched and shaded) and other quadrangles in southeastern Arizona, and showing location of features referred to in text. Quadrangle names and published data identified as follows: B, Black Mountain (Krieger, 1974c); BM, Brandenburg Mountain (Krieger, 1968a); C, Christmas (Willden, 1964); CP, Crozier Peak (Krieger, 1974b); E, El Capitan; H, Hayden (Ransome, 1919; N. G. Banks and M. H. Krieger, unpub. data, 1973); HP, Holy Joe Peak (Krieger, 1968b); K, Kearny, (Cornwall and Krieger, 1974); L, Lookout Mountain (Krieger, 1968c); M, Mammoth (Creasey, 1965, 1967); O, Oracle (from aerial photographs by U.S. Soil Conservation Service and from Creasey and others, 1961); P, Putnam Wash (Krieger, 1974d); R, Ray (Ransome, 1919); S, Sonora (Cornwall and others, 1971); SM, Saddle Mountain (Krieger, 1968d); W, Winkelman 7½-minute (Krieger, 1974a).

## STRATIGRAPHY

Rocks in the area discussed (figs. 2,3) range in age from Precambrian to Holocene. The oldest Precambrian rocks are the Pinal Schist and intrusive rocks, mostly the Ruin Granite (Oracle Granite of Peterson, 1938). Batholithic masses of Ruin Granite, dated at about 1,430 m.y., by Silver, (1968) and Damon, Livingston, and Erickson (1962), were intruded after a period of intense deformation that produced nearly vertical east-trending foliation and bedding in the schist. The schist and granite are overlain with profound angular unconformity by unmetamorphosed Precambrian sedimentary rocks of the Apache Group and the disconformably overlying Troy Quartzite. Diabase, about 1,200 m.y. old (Silver, 1960; Damon and others, 1962), forms dikes and sills in the Apache Group and Troy Quartzite and sill-like masses in the schist and granite parallel to the pre-Apache erosion surface. The sills inflated the Precambrian sedimentary section but apparently did not perceptibly tilt the strata. Because of their abundance and narrow outcrop width due to steep dips, diabase sills in sedimentary rocks are not shown in figure 3. Sills in granite and schist are shown with exaggerated width to illustrate their relation to the pre-Apache erosion surface.

After a long period of erosion, Cambrian formations were deposited disconformably on the Precambrian sedimentary rocks and diabase. Devonian, Mississippian, and Pennsylvanian rocks overlie the Cambrian strata.

Volcanic rocks of Late Cretaceous age that disconformably overlie older rocks in the area are (1) the Williamson Canyon Volcanics (fig. 3) of andesitic composition, most abundant northeast of the Winkelman quadrangle, (2) the Cloudburst Formation, composed of volcanic rocks of probable latitic composition, fanglomerate, and sedimentary breccias in the southern part of the area and now standing nearly vertically and underlain by a gently dipping gravity slide surface, and (3) a rhyodacitic to quartz latitic pyroclastic unit, found only

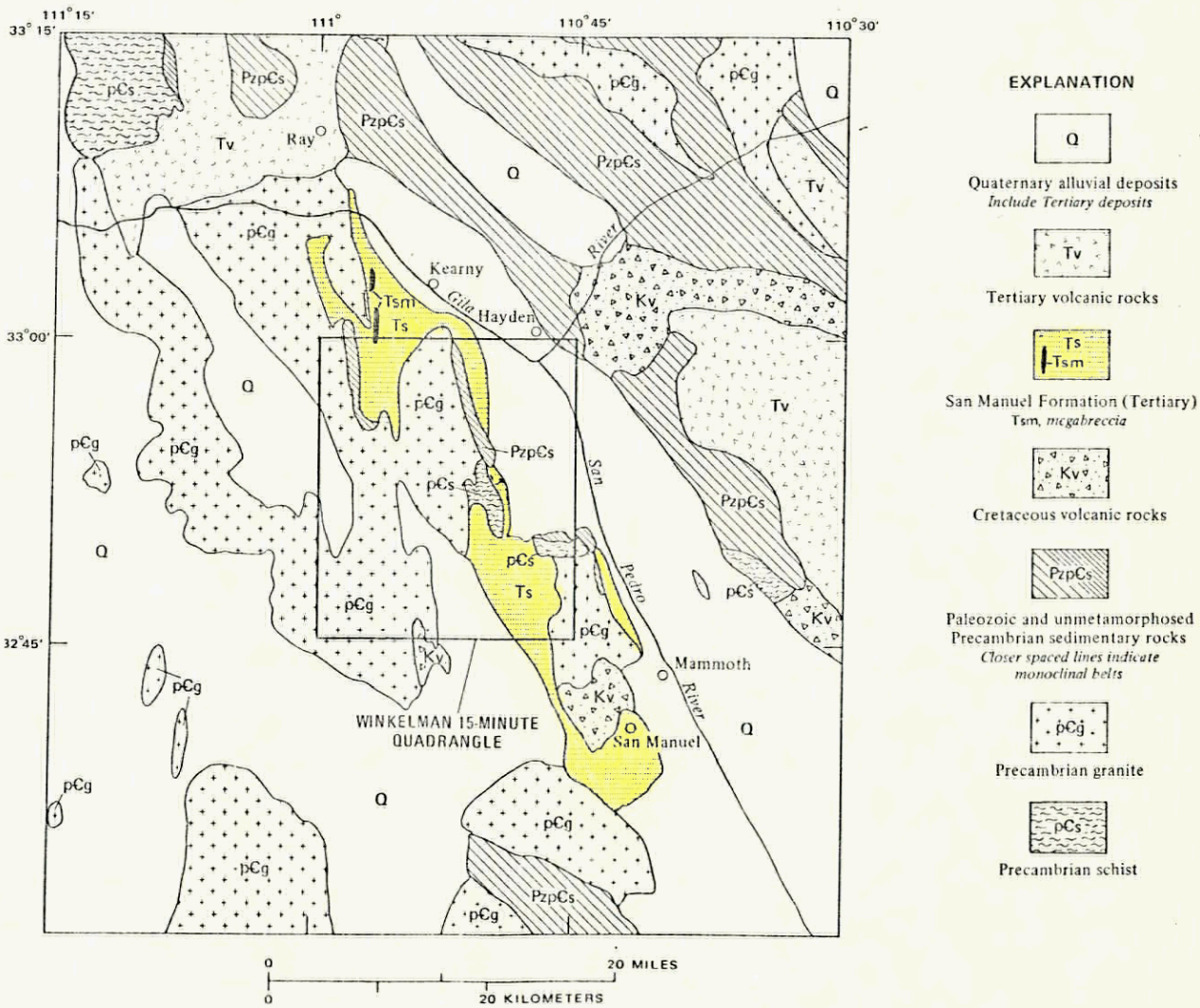



Figure 2.—Regional geologic setting of the Winkelman 15-minute quadrangle. Modified from Wilson, Moore, and Cooper (1969).

in the northwest part of the Crozier Peak quadrangle. The Williamson Canyon Volcanics was considered to be Late Cretaceous by Willden (1964) and Late Cretaceous or early Tertiary by Creasey (1965, 1967). It is now considered to be Late Cretaceous because in the Crozier Peak quadrangle it is intruded by Late Cretaceous diorite (Krieger, 1974b). The Cloudburst Formation is also designated as Late Cretaceous because Creasey (1965, 1967) considered it to be probably the same age as the Williamson Canyon Volcanics in the Christmas quadrangle. The rhyodacitic to quartz latitic volcanic rocks are considered to be Late Cretaceous in age because some of them resemble the Glory Hole Volcanics (east of the area of fig. 3), which is intruded by 69-m.y.-old granodiorite (Simons, 1964; Creasey, 1967).

Late Cretaceous diorite and granodiorite and Late Cretaceous and (or) early Tertiary (Laramide) porphyry masses and dikes of several lithologic types, but largely rhyodacite porphyry, intrude the older rocks. Only the diorite is shown in figure 3. Many of the porphyry dikes and masses are east trending, but older porphyry masses, some possibly of Early Cretaceous age, are conformable and probably were intruded as sills in the Precambrian sedimentary rocks before tilting.

According to the new nomenclature for Cenozoic stratigraphy in eastern Pinal County (Krieger and others, 1974), Tertiary sedimentary deposits in the area (fig. 3), formerly called the Gila Conglomerate or Group, are now divided into the San Manuel Formation (oldest), the Big Dome Formation, and the Quiburis Formation (youngest). Pleistocene and Holocene alluvial deposits, also formerly included in the Gila Conglomerate or Group, overlie these formations.

The San Manuel Formation consists of alluvial and playa deposits and interbedded andesite and megabreccias (not shown separately in fig. 3). The playa deposits and megabreccias are well developed in the Kearny quadrangle (Cornwall and Krieger, 1974). The San Manuel is Miocene (probably early Miocene) in age. Discordant dates on biotite and sanidine from a rhyodacite tuff bed in the upper part of the formation in the Crozier Peak quadrangle are 18 and 24 m.y., respectively. The San Manuel Formation is overlain unconformably by the alluvial Big Dome Formation in the Kearny and Crozier Peak quadrangles. In the Kearny quadrangle, north of the map area, a nonwelded ash-flow tuff in the Big Dome Formation yielded late Miocene K-Ar ages of 14 m.y. on biotite and 17 m.y. on hornblende (Banks and others, 1972). The Quiburis Formation consists of both alluvial and lakebed facies and was deposited in the basin now occupied by the San Pedro River. It contains Hemphillian vertebrate fossils, indicating a middle Pliocene age (John Lance, oral commun., 1963, in Krieger, 1974a). Tertiary volcanic rocks shown in figure 2 include the Galiuro Volcanics (Krieger, 1968, a-d) east of the San Pedro River and the volcanic rocks in the Ray-Superior area. The Galiuro Volcanics has been dated at 22-26 m.y. and probably is about the same age as the San Manuel Formation. The Apache Leap Tuff (part of the volcanic rocks shown in the northwest part of fig. 2) has been dated at 20 m.y. It is older than the Big Dome Formation and probably younger than the San Manuel Formation. Beneath the Apache Leap Tuff is the Whitetail Conglomerate, which contains near its top in the Ray area (Cornwall and others, 1971) a rhyolite tuff bed dated at 32 m.y. (Oligocene).

## STRUCTURE

The most obvious structural features in the area are belts of steeply dipping Precambrian and Paleozoic sedimentary rocks that form a series of en echelon ridges separating extensive exposures of Precambrian granite and minor schist on the west from tilted Tertiary sedimentary rocks and gently tilted and intricately faulted Precambrian and Paleozoic sedimentary rocks on the east (figs. 3,4). The steeply dipping belts formed as monoclines, not as the eastern limbs of anticlines. The belts within the Winkelman 15-minute quadrangle are interpreted as parts of a single monocline, later separated by strike-slip and high-angle normal faults. Monoclinal folding commenced before, but continued during and after, deposition of the early(?) Miocene San Manuel Formation.

Within the steeply dipping belts, the section is locally repeated by faults with steep dips which are considered to have formed as low-angle thrusts and to have been tilted to their present nearly vertical position during monoclinal folding. These thrusts and related tears are the oldest structures recognized. They are intruded by Laramide porphyries that are older than the San Manuel Formation. All the other structures are mainly younger than the San Manuel. Possibly some movement on strike-slip faults that segmented the monocline commenced before San Manuel time, but much of it was later. Low-angle gravity slide surfaces underlie the Cloudburst Formation and part of the San Manuel Formation. North-trending high-angle normal faults cut older structural features; some are younger than the Big Dome Formation.

### Structural Features Older Than The San Manuel Formation

#### Thrusts

Faults interpreted to be tilted thrusts (fig. 4) include (1) Ripsey Wash fault, an imbricate structure in the Crozier Peak and southwestern Kearny quadrangles, (2) Romero Wash fault in the Winkelman 7½-minute quadrangle, (3) a thrust extending southward from the Crozier Peak into the Black Mountain quadrangle, and (4) possibly a thrust in the northwestern part of the Lookout Mountain quadrangle. All now have steeply dipping attitudes that closely follow beds of the monoclinal fold. The Ripsey Wash and Romero Wash faults are intruded by Cretaceous porphyries (not shown in fig. 3). Because the folding occurred largely after deposition of the San Manuel Formation, as shown by steep dips in that formation, and because the San Manuel contains clasts of the porphyries, the structural features cannot have formed as high-angle normal or strikeslip faults after formation of the monocline. The Ripsey Wash and Romero Wash faults may

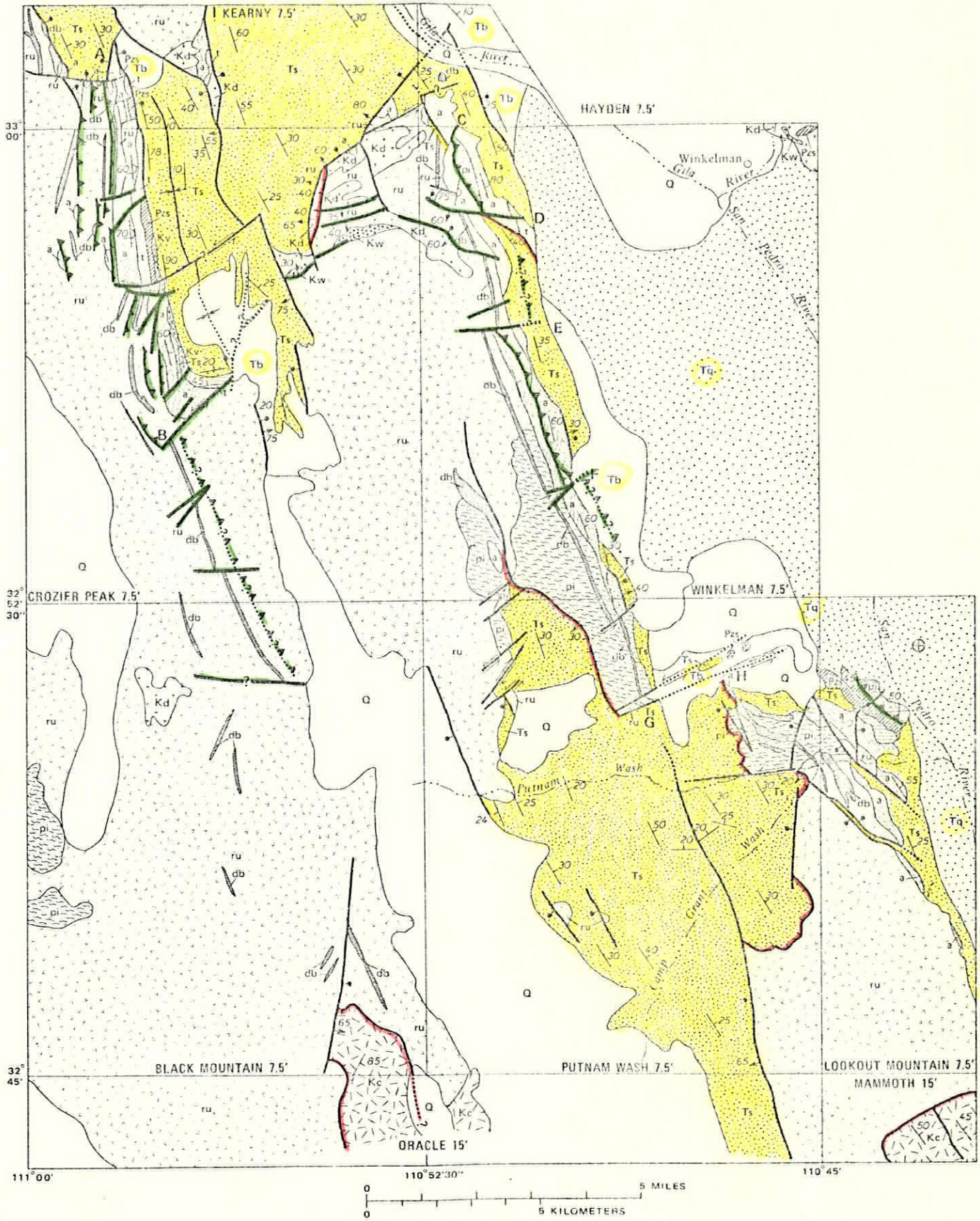
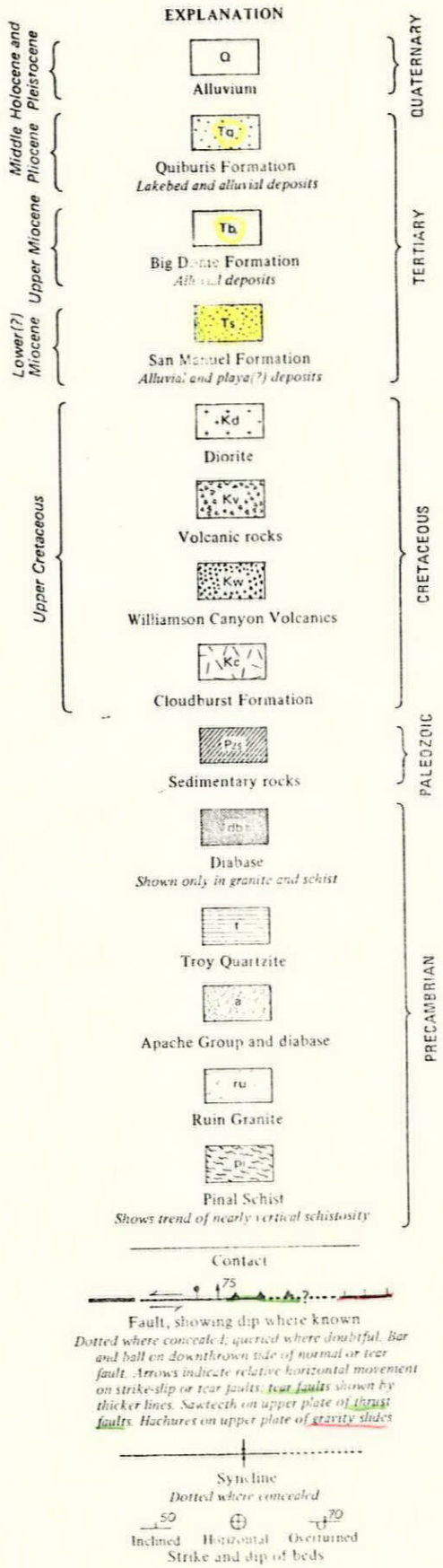



Figure 3.—Generalized geologic map of the Winkelman 15-minute quadrangle and adjacent areas.

— gravity type

— Thrust & Tear type

others normal or strike-slip




have been part of a single thrust zone, cut and displaced by strike-slip and high-angle normal faults that segmented the monocline.

*Ripsey Wash fault*.—A north-trending belt of nearly vertical faults that extends from the southwestern part of the Kearny quadrangle (point A, fig. 4) to the central part of the Crozier Peak quadrangle (point B, fig. 4). This zone consists of several fault strands that separate thin east-facing slices of the basal part of the Apache Group, resting with sedimentary contact on the underlying basement (Ruin Granite), from similar slices to the west. Just north of point B at least three such slices, too small and too poorly exposed to show even on the detailed map (Krieger, 1974b), are spaced at distances of 50–100 ft. It is difficult to interpret this series of faults as anything other than a zone of imbricate thrusts that was later tilted. If the monocline extended upward indefinitely, high-angle normal faults could have downdropped the tilted slivers, but the presence of Cretaceous porphyries in some of the faults proves that faulting preceded tilting. If the monocline flattened upward, as it must have and as is suggested for the separate monocline in the Kearny quadrangle discussed below, the slivers should be nearly horizontal or tilted in discordant directions. Figure 5 represents diagrammatic sections across the fault zone, showing relations before and after tilting.

*Romero Wash fault*.—This fault (fig. 4) is exposed in two segments, a northern segment from south of point C (Hayden quadrangle) to west of point D (Winkelman quadrangle) and a southern segment from west of point E to west of point F. In the northern segment east of the fault the Apache Group rests on the Pinal Schist, and the beds dip steeply east; west of the fault the Apache rests on granite, and the beds are overturned but still occur in normal sequence, except where broken by small faults, most of which are not shown in figures 3 or 4. Some of these faults may be imbricate structures related to the major thrust, not younger high-angle faults as shown on the detailed map (Krieger, 1974a). In the southern segment the beds both east and west of the fault dip steeply east. West of the fault the Apache rests on granite to the north and schist to the south. East of the fault it rests on granite, except at the southern end, where the section is repeated without intervening granite. At the southern end of this segment (point F), two strands of the fault repeat the Apache Group. The southern segment of the fault (points E to F) is occupied by a tabular body of Cretaceous porphyry, whose nearly vertical dip and concordant relations show that the fault formed before or during Cretaceous time. Figure 6 represents a diagrammatic section across the fault, showing relations before and after tilting.

*Other thrusts*.—The occurrence of diabase as sill-like masses in granite and schist parallel to, and generally not more than 500 ft below, the pre-Apache erosion surface is well illustrated in the Winkelman and parts of the Crozier Peak and Putnam Wash 7½-minute quadrangles (fig. 3). This relationship was recognized by Shride (1967, p. 56), who stated that at depths

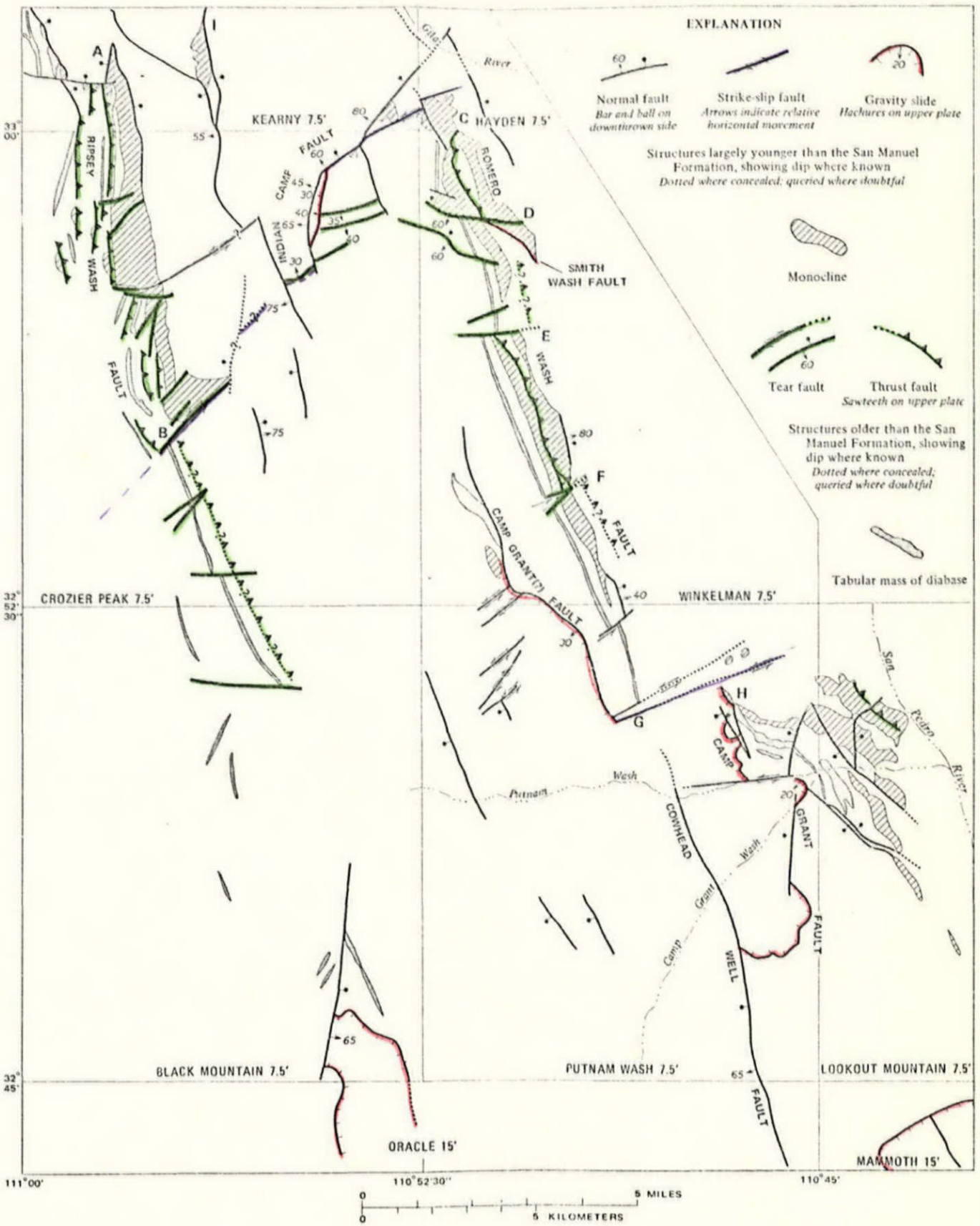



Figure 4.—Generalized structure map of the Winkelman 15-minute quadrangle and adjacent areas.

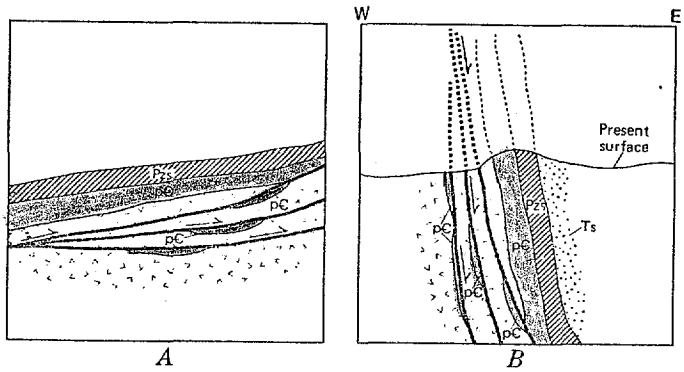



Figure 5.—Diagrammatic sections across Ripsey Wash fault showing suggested relations (*A*) before, and (*B*) after tilting. Ts, sedimentary strata; Pzs, Paleozoic strata; pC, Precambrian sedimentary strata.

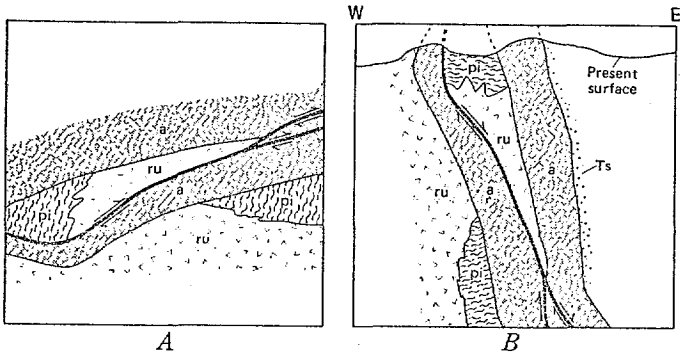



Figure 6.—Diagrammatic sections across Romero Wash fault showing suggested relations (*A*) before, and (*B*) after tilting. Ts, sedimentary strata; a, Apache Group; ru, Ruin Granite; pi, Pinal Schist.

of more than 500 ft below the base of the Apache Group extensive intrusions of diabase are practically nonexistent. It seems likely that the tabular mass of diabase that extends south of point B into the Black Mountain quadrangle may be such a sill originally intruded into the Ruin Granite within 500 ft of the pre-Apache surface. I explain its presence here, apparently miles "below" the nearest Apache Group, as the result of a thrust (fig. 4) perhaps related to a deeper strand of the Ripsey Wash fault; unrecognized normal faults in the granite may complicate the structure. Other tabular masses of diabase, mostly in the Black Mountain quadrangle, may owe their position to unrecognized tilted thrusts, or they may represent feeders to the diabase sills and sill-like masses.

In the northwestern part of the Lookout Mountain quadrangle, the section of steeply dipping Precambrian and Paleozoic rocks is repeated by a series of faults. Some of these faults cut the San Manuel Formation and therefore cannot be thrusts similar to the Ripsey Wash and Romero Wash faults. The beds face east and become progressiely younger, except in the northeasternmost exposures where the beds are overturned and face west or south. This was shown on the map of the Lookout Mountain quadrangle (Krieger, 1968c, sec. *AA'*) as a steeply east-dipping thrust that moved from east to west, or as a high-angle reverse fault. The structure was throught to represent the east limb of a tight syncline in which the west limb had been sheared out. Its relation to the thrusts to the northwest is unknown.

### Tears

Numerous northeast-, east-, and southeast-trending, steeply dipping cross faults cut Precambrian and Paleozoic rocks. Some of them exhibit features characteristic of tear faults related to thrusting; they terminate at a thrust or transfer movement from one thrust surface to another. If they are tears that have been rotated almost 90° during development of the monocline, the typical tear-type displacement, which originally would have been strike slip, may now appear as high-angle dip-slip movement. Examples of this are two east-southeast-trending high-angle faults with apparent reverse movement in the northwest part of the Winkelman quadrangle, west and southwest of point D. They dip about 60° to the south, and both show relative uplift on the south. These same relations may also be obtained by strike-slip or oblique-slip, rather than reverse movement. The northern fault appears to offset the Romero Wash fault but not enough to account for the offset of the Apache Group. Where the fault offsets the San Manuel Formation, the south side has been relatively downdropped; that is, the movement is in the opposite sense.

## Structural Features Younger Than the San Manuel Formation

Structural features that are mostly younger than the San Manuel Formation include (1) folds that tilted the thrusts and the Precambrian and Paleozoic sedimentary rocks to form north-trending, steeply dipping, east-facing monoclines, (2) east- to northeast-trending strike-slip faults that separate the major monocline into en echelon segments, (3) gently dipping gravity slides that placed tilted Cretaceous and Tertiary rocks on the Ruin Granite, and (4) north-trending high-angle normal faults. Folding may have commenced before, but much of it occurred during and after deposition of the San Manuel. Movement on some of the strike-slip faults may also have commenced before, but most of it ocurred after San Manuel time, and some of it is younger than the gravity sliding that postdates the San Manuel. High-angle normal faults are mostly related to deformation that produced the basin and ranges; one of these basins was filled with the Pliocene Quiburis Formation on which the San Pedro River now flows.

### Monoclines

Three north-northwest-trending, en echelon belts of steeply dipping to overturned Precambrian and Paleozoic sedimentary rocks (figs. 3, 4) extend from the Lookout Mountain to the

southwest part of the Kearny quadrangle. A remnant of another belt is exposed in the south-central part of the Kearny quadrangle (figs. 2, 3, and Cornwall and Krieger, 1974). A fourth belt of tilted Precambrian sedimentary rocks is found 15–20 mi northwest of the Kearny quadrangle (fig. 2, and Schmidt, 1966).

The belts that lie mainly within the Winkelman 15-minute quadrangle (from points A to B, points C to G, and southeast of point H, fig. 4) are interpreted to have originally been part of a single monocline later segmented by strike-slip and high-angle normal faults. The steeply dipping Apache Group rocks are not exposed continuously in the middle segment (points C to G). Their presence beneath the San Manuel Formation, however, is suggested by the tabular mass of diabase in granite and schist, which elsewhere lies within 500 ft of the pre-Apache surface; it is also confirmed by small patches of Apache Group (not shown in fig. 3), north of point G.

The monocline near point I is a separate but probably contemporaneous feature. This monocline extends from southwest of point I northward across the Kearny quadrangle (Cornwall and Krieger, 1974) for over 6 mi. Remnants of Precambrian sedimentary rocks resting on granite lie west of the steeply dipping San Manuel Formation near point I. North of point I nearly vertical tabular masses of diabase lie a short distance west of the fault that separates Ruin Granite from the San Manuel Formation and indicate the northward extension of the monocline. The suggestion is untenable that the monocline was originally part of the monocline in the Winkelman 15-minute quadrangle and was moved from point A to south of point I along a southeast-trending strike-slip fault. Two belts of east-trending porphyry dike swarms show no evidence of offset. One belt extends from the northwest part of the Kearny quadrangle (Cornwall and Krieger, 1974), westward across the northeast part of the adjacent Grayback Mountain quadrangle (H. R. Cornwall and M. H. Krieger, unpub. data, 1973); the other extends from the southwestern part of the Kearny quadrangle into the southeast part of the Grayback Mountain quadrangle. The apparent strike-slip fault is a high-angle normal fault that bounds the southwest side of a younger horst block.

These tilted belts are interpreted as the eroded remnants of east-facing monoclinal folds that separate vast areas of granite on the west from Tertiary sediments on the east. The almost complete absence of west-facing beds, as well as the absence of Precambrian or Paleozoic sedimentary rocks for more than 60 mi to the southwest, appear to rule out the possibility that the monocline is the east limb of an anticline. Isolated examples of west-facing beds—southwest part of the Winkelman quadrangle (Krieger, 1974a), northwest part of the Lookout Mountain quadrangle, (Krieger, 1968c), and northwest part of the Crozier Peak quadrangle (Krieger, 1974b, sec 23, T. 5 S., R. 13 E.)—are interpreted as the result of drag or later deformation. The alternate view that the tilted belts are the result of drag along high-angle faults appears improbable because the Apache Group is in normal sedimentary contact with granite and schist and because diabase in the basement, within 500 ft of the base of the Apache, precludes the existence of large high-angle faults west of the belts. In the west-central part of the Kearny quadrangle (Cornwall and Krieger, 1974), a nearly horizontal mass of diabase trends westward from a north-trending diabase mass that marks the trend of the monocline in this area. It is interpreted as a sill intruded not more than 500 ft below the pre-Apache surface and representing the area where the monocline flattened westward. The overlying Precambrian and Paleozoic sedimentary rocks were eroded after formation of the monocline.

The folding occurred before and continued after deposition of the San Manuel Formation because, adjacent to the monoclinal ridges, the San Manuel Formation also dips steeply, though generally 20°–30° less than the older rocks. Although some of the tilting of the San Manuel Formation could have been caused by drag along the faults that separate the San Manuel from older rocks, the extensive areas of tilted San Manuel east of the faults could not have been formed by drag. Deposits of claystone and mudstone with abundant mud cracks and curled mud chips indicate deposition of part of the San Manuel Formation in a flat playa environment. In the Kearny quadrangle (Cornwall and Krieger, 1974), megabreccias (landslide blocks) slid from the west or southwest out onto interfingering playa and alluvial deposits and were immediately buried by additional playa and alluvial deposits. The sediments and interbedded megabreccias now dip steeply to almost vertically east. Away from the monocline the San Manuel Formation dips less steeply because of the eastward flattening of the monocline. Attitudes of the San Manuel Formation away from the monocline may be partly due to later structural features. The fact that the oldest unit in the San Manuel in the Putnam Wash quadrangle is composed largely of clasts of Ruin Granite indicates that Precambrian basement was exposed, before San Manuel time, somewhere west and southwest of the Winkelman 15-minute quadrangle. Likewise, much of the San Manuel Formation in the northwestern half of the Kearny quadrangle is composed of granitic clasts, derived from the northwest and west. However, Paleozoic and Precambrian sedimentary rock clasts are abundant in the San Manuel Formation and form extensive megabreccias, especially in the Kearny quadrangle (Cornwall and Krieger, 1974), proving that these sedimentary rocks had not been entirely stripped from the granite and schist basement by San Manuel time.

### Strike-slip faults

Two major left-lateral strike-slip faults appear to separate into segments what is interpreted to have been a single monoclinal ridge (fig. 4). The northern fault moved the

monoclinal ridge from points B to C, and the southern one moved it from point G to east of point H.

Although conclusive proof is lacking that the northern and middle segments were originally continuous, the following evidence suggests this interpretation: (1) In the Crozier Peak quadrangle, east of point B (fig.3) the strike of vertical to steeply overturned strata changes abruptly from a north to an east-west trend with a gentler northward dip, suggesting drag, and (2) The small patches of Apache Group, not entirely in normal stratigraphic sequence, west of point C (southeast corner of Kearny quadrangle and northeast part of Crozier Peak quadrangle), may have been dragged into their present position by the fault. In this area the fractured condition of granite and diorite bedrock may have been caused by the strike-slip fault. The position of the strike-slip fault across or beneath the San Manuel Formation, northeast of point B, is uncertain because of concealement both by the Big Dome Formation and by colluvial slumping of the San Manuel Formation and because of offset by younger north-northwest-trending high-angle faults. How much of the movement on the strike-slip fault is older than the San Manuel Formation and how much is younger is uncertain. The fold in the older rocks is reflected in the younger deposits, which also swing east.

The following evidence supports a southern strike-slip fault: (1) Small exposures of Paleozoic rocks north of point H lie considerably west of the main outcrops in the northwest part of the Lookout Mountain quadrangle (fig. 3), (2) Apache Group, assumed to be buried beneath the San Manuel Formation, north of point G, is west of the Apache Group near point H, and (3) what is interpreted to be the continuation of the post-San Manuel Camp Grant fault (fig. 4), northwest of point G, is offset westward from the northern exposure of Camp Grant fault near point H. Movement on this strike-slip fault appears to be younger than the Camp Grant fault, which cuts the San Manuel Formation.

## Gravity slides

Gravity slides—décollements or detachments—are concave-upward surfaces that separate sedimentary or volcanic rocks from older rocks. The younger rocks generally dip in the opposite direction from the fault surface. The best example of a gravity slide in the Winkelman 15-minute quadrangle is Camp Grant fault in the Putnam Wash quadrangle. Other probable gravity slides are beneath the Cloudburst Formation (fig. 3) in the Black Mountain and Mammoth quadrangles and involve San Manuel Formation in the northern part of the Winkelman 15-minute quadrangle. The Cloudburst Formation in the southeast part of the Black Mountain quadrangle is nearly vertical and is surrounded on at least the west, north, and east sides by the Ruin Granite. The contact between the Cloudburst and granite is concealed by alluvium, except on the west where it is an east-dipping normal fault. The gravity slide is assumed to be a nearly horizontal concave-upward surface (Krieger, 1974c, sec. *AA'*). In the Mammoth quadrangle, Creasey (1965, 1967) interpreted the structure as a gently east-dipping thrust; the overlying Cloudburst Formation dips mostly 35°–65° eastward. The Indian Camp fault in the northeastern part of the Crozier Peak quadrangle and the Smith Wash fault in the northwest part of the Winkelman 7½-minute quadrangle are questionably interpreted as gravity slides.

A low-dipping gently curved fault surface (fig. 7) is well exposed on the north side of Camp Grant Wash about 2,000 ft southwest of its junction (at the quadrangle boundary) with Putnam Wash. This surface, interpreted as a gravity slide plane, dips 20° west and separates Ruin Granite on the east from the San Manuel Formation on the west. The surface on granite is remarkably smooth. Conglomeratic gouge a few inches thick separates the granite from the overlying conglomerate. Fracture cleavage in the gouge indicates that the upper block moved from east to west. The conglomerate dips about 35° northeast and is cut by by subparallel cycloidal (in section) faults and by steeper west-dipping faults. The steeper faults end downward at the gravity slide plane or at the cycloidal faults. These features are similar to what Anderson (1971, p. 43) has called "thin-skinned distension" in Tertiary rocks in Nevada in which Tertiary volcanic rocks are cut by "a system of closely spaced north- to northwest-striking shingling normal faults (many of which are low angle) that displace younger over older rocks in a west to southwest direction * . * . * . The structural units are floored at or near the present level of exposure by complex low-angle zones of detachment or decollement into which the numerous shingling normal faults merge." Absence of recognizable small stratigraphic units and difficulty in tracing faults in the San Manuel Formation make it impossible to determine whether or not the apparently great thickness of the formation in the Putnam Wash quadrangle is caused by repeated low-angle slicing and rotation.

Camp Grant fault is offset to the west by an eastward-trending strike-slip fault along Putnam Wash and probably by a major strike-slip fault near point G; it is cut by north-trending normal faults (discussed below). What is interpreted to be the offset part of the Camp Grant fault is exposed in the northwest part of the Putnam Wash quadrangle. It separates Pinal Schist on the east from northeast-dipping San Manuel Formation on the west. The fault dips about 30° west. Camp Grant fault was questionably extended into the southwestern part of the Winkelman quadrangle. If the fault in that area is part of the Camp Grant fault, it is unusual in that it involves Precambrian rocks. Most of the gravity slides are believed to flatten downward and for the most part not to extend far into the basement. The attitude of the small mass of Apache Group suggests drag that might accompany faulting or gravity sliding. The Apache is cut by a north-trending fault (not shown in figs. 3, 4). West of the fault the Apache dips steeply eastward; east of the fault it also dips steeply eastward, but the dip flattens

Figure 7.—Camp Grant fault, exposed on north side of Camp Grant Wash, about 2,000 ft southwest of junction of Camp Grant and Putnam Washes. Light-colored outcrop at right is Ruin Granite (ru). Fault surface here dips about 20° west. Overlying conglomerate of San Manuel Formation dips about 35° northeast and is cut by subparallel cycloidal faults and by steeper west-dipping faults that end downward at the cycloidal faults. The fault surface appears to steepen where it approaches the wash, but this is an optical illusion due to foreshortening because of the angle at which it is viewed and to removal of some of the younger rocks, where cut by one of the more steeply dipping small faults at the creek level.

rapidly (Krieger, 1974d, sec. *DD'*), and along the eastern margin of the outcrop, beds dip gently westward.

### High-angle normal faults

High-angle, mostly north-northwest-trending normal faults cut the San Manuel Formation and older rocks. Renewed movement has also occurred since deposition of the Big Dome Formation, and some has occurred since deposition of the Quiburis Formation (east of the San Pedro River). Some of these faults are downthrown on the east, and some on the west. A few of these faults deserve special mention.

The Cowhead Well fault (fig. 4) extends for at least 12 mi, from north of Putnam Wash into the western part of the Mammoth quadrangle (south of the map area). It is younger than both the San Manuel Formation and the Camp Grant fault.

The fault that cuts off the Cloudburst Formation and the thrust that underlies the Cloudburst in the Southeastern part of the Black Mountain quadrangle may also be younger than the San Manuel Formation.

Faults occur between the San Manuel Formation and Precambrian and Paleozoic bedrock in many places, but the amount of displacement within the Winkelman 15-minute quadrangle in most places is believed to be small. The attitude of the San Manuel Formation, therefore, is likely due to folding (tilting), not to drag on the faults. In the Kearny quadrangle, however, considerable post-San Manuel displacement has occurred on the bounding faults. The bedrock mass west of point I is clearly a horst. Uplift on this block may have been responsible for development of the syncline in the San Manuel Formation that extends from the Crozier Peak quadrangle into the southwest part of the Kearny quadrangle. Playa deposits on the east side of the syncline are identical with those east of point I and at one time extended across at least the southern end of the block.

These high-angle normal faults are part of the Basin and Range fault system. Major faults, at least on the east side of the San Pedro River (fig. 2), produced the basin in which the Pliocene Quiburis Formation was deposited. This faulting took place largely after deposition of the San Manuel Formation, and some of it occurred after deposition of the Big Dome

Formation. The early Miocene Galiuro Volcanics east of the San Pedro River has been downdropped at least 5,000 ft from its position at the northern end of the Galiuro Mountains and was later buried by the Quiburis Formation (Krieger, 1968b,c). The change from low-angle gravity sliding and associated low-angle normal faults indicating major extension to high-angle normal faults indicating predominantly vertical displacement took place in the late Tertiary, as noted in Anderson (1971, p. 3534), in southwestern Nevada.

## CONCLUSIONS

Structural features in the Winkelman 15-minute quadrangle are believed to have developed in the following sequence: Imbircate thrusts and related tears were formed in a flat environment and were later tilted, when an east-facing monoclinal fold developed a linear belt of steeply dipping to overturned Precambrian and Paleozoic sedimentary rocks. This folding, which began before but continued after deposition of the Miocene San Manuel Formation, developed other monoclinal folds to the north and northwest of the quadrangle. East-trending strike-slip faults separated the monocline in the Winkelman quadrangle into three en echelon segments. Some of this faulting apparently occurred after large areas of the San Manuel Formation became detached and moved over basement rocks on a low-angle gravity slide surface. All these structures are broken by north-trending high-angle normal faults.

The structural complexity of the area contrasts markedly with the structural features northeast of the Gila and San Pedro Rivers, as was noted by Ransome (1919, p. 82) and as can be seen in figure 2 and by examining published geologic maps of the area (see fig. 1 for references; also Wilson and others, 1969). Northeast of the rivers the beds are mainly gently tilted and intricately faulted; monoclinal flexures, where present, face both east and west. A major northwest-trending fault, approximately beneath the Gila and San Pedro Rivers, follows the boundary between the two blocks.

## REFERENCES CITED


Anderson, R. E., 1971. Thin skin distension in Tertiary rocks of southeastern Nevada: Geol. Soc. America Bull., v. 82, p. 43–58; reply, p. 3533–3536.

Banks, N. G., Cornwall, H. R., Silberman, M. L., Creasey, S. C., and Marvin, H. R., 1972. Chronology of intrusion and ore deposition at Ray, Arizona. Part I, K-Ar ages: Econ. Geology, v. 67, p. 864–878.

Cornwall, H. R., Banks, N. G., and Phillips, C. H., 1971. Geologic map of the Sonora quadrangle, Pinal and Gila Counties, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ-1021, scale 1:24,000.

Cornwall, H. R., and Krieger, M. H., 1974. Geologic map of the Kearny quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ-1188, scale 1:24,000. (In press.)

Creasey, S. C., 1965, Geology of the San Manuel area, Pinal County, Arizona: U.S. Geol. Survey Prof. Paper 471, 64 p.

—— 1967, General geology of the Mammoth quadrangle, Pinal County, Arizona: U.S. Geol. Survey Bull. 1218, 94 p.

Creasey, S. C., Jackson, E. D., and Gulbrandsen, R. A., 1961, Reconnaissance geologic map of parts of the San Pedro and Aravaipa Valleys, south-central Arizona: U.S. Geol. Survey Mineral Inv. Field Studies Map MF-238.

Damon, P. E., Livingston, D. E., and Erickson, R. C., 1962, New K-Ar dates for the Precambrian of Pinal, Gila, Yavapai, and Coconino Counties, Arizona, *in* Guidebook of the Mogollon Rim Region, east-central Arizona, New Mexico Geol. Soc., 13th Field Conf.: Socorro, New Mexico Bur. Mines and Mineral Resources, p. 56–57.

Krieger, M. H., 1968a, Geologic map of the Brandenburg Mountain quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ-668, scale 1:24,000.

—— 1968b, Geologic map of the Holy Joe Peak quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ-669, scale 1:24,000.

—— 1968c, Geologic map of the Lookout Mountain quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ-670, Scale 1:24,000.

—— 1968d, Geologic map of the Saddle Mountain quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ-671, scale 1:24,000.

—— 1974a, Geologic map of the Winkelman quadrangle, Pinal and Gila Counties, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ-1106, scale 1:24,000. (In press.)

—— 1974b, Geologic map of the Crozier Peak quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ-1107, scale 1:24,00. (In press.)

—— 1974c, Geologic map of the Black Mountain quadrangle, Pinal County, Arizona:: U.S. Geol. Survey Geol. Quad. Map GQ-1108, scale 1:24,000. (In press.)

—— 1974d, Geologic map of the Putnam Wash Quadrangle, Pinal County, Arizona: U.S. Geol. Survey Geol. Quad. Map GQ-1109, scale 1:24,000. (In press.)

Krieger, M. H. Cornwall, H. R., and Banks, N. G., 1974, The Big Dome Formation and revised Tertiary stratigraphy in the Ray-San Manuel area, Arizona: U.S. Geol. Survey Bull. 1394-A, 93 p.

Peterson, N. P., 1938, Geology and ore deposits of the Mammoth mining camp area, Pinal County, Arizona: Arizona Bur. Mines Bull. 144, Geol. ser. 11 (Arizona Univ. Bull., v. 9, no. 2), 63 p.

Ransome, F. S., 1919, The copper deposits of Ray and Miami, Arizona: U.S. Geol. Survey Prof. Paper 115, 192 p.

Schmidt, E. A., 1966, Geologic map of the Mineral Mountain quadrangle, Pinal County, Arizona: Arizona Univ., Tucson, M.S. thesis.

Shride, A. F., 1967, Younger Precambrian geology in southern Arizona: U.S. Geol. Survey Prof. Paper 566, 89 p.

Silver, L. T., 1960, Age determinations on Precambrian diabase differentiates in the Sierra Ancha, Gila County, Arizona [abs.]: Geol. Soc. America Bull., v. 71, no. 12, pt. 2, p. 1973–1974.

—— 1968, Precambrian batholiths of Arizona [abs.]: Geol. Soc. America, Cordilleran Sec., 64th Ann. Mtg., Tucson, Ariz., Program, p. 109–110.

Simons, F. S., 1964, Geology of the Klondyke quadrangle, Graham and Pinal Counties, Arizona: U.S. Geol. Survey Prof. Paper 461, 173 p.

Willden, Ronald, 1964, Geology of the Christmas quadrangle, Gila and Pinal Counties, Arizona: U.S. Geol. Survey Bull. 1161-E, p. E1–E64.

Wilson, E. D., Moore, R. T., and Cooper, J. R., 1969, Geologic map of Arizona: Arizona Bur. Mines and U.S. Geol. Survey, scale 1:500,000.