FIELD NOTES FROM THE ARIZONA BUREAU OF MINES

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PIMA COUNTY MOVES ON GEOLOGIC HAZARDS

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From the *Arizona Daily Star,* Tucson, Dec. 24, 1965:

"FLOWING WELLS STUNNED BY WILD RILLITO — The roiled, brown waters of the flooding Rillito Creek tore into two trailer parks in the Flowing Wells area yesterday, demolishing two trailers.

"A third was about to crumble into the rampaging waters late last night. No one was injured.

"More than 50 trailer residents evacuated the two areas yesterday.

"Residents bitterly termed it a disaster and scorned public officials for apathy about their plights."

Since this 1965 hydrologic event in Pima County, the State has acquired over 600,000 new residents, approximately 125,000 of which have been added to Pima County, the Tucson metropolitan area in particular.

Most newcomers are not familiar with the special attributes and characteristics of our desert setting beyond its summertime high temperatures. Lack of knowledge contributes to predicaments which allow naturally occurring phenomena to threaten life and property as exampled in the above newspaper quote. The only shortcut for learning by experience is by taking advantage of the experience of others, either by reading or by direct communication. Unfortunately, lessons are often learned the hard way. Knowing what to be sensitive about requires an appropriate mixture of knowledge of physical laws, observational curiosity, intuition, common sense, and plain good luck. This is true anytime an active person is transposed from a familiar environment to one that is not. Examples are numerous. Many stories have been told about the contrasts between boating along the coast of Southern California and the Sea of Cortez, two water bodies not far apart, but so different in tidal habits. Another familiar environmental contrast suggests that one used to fishing from barely emerged rocks along certain coastlines can be subject to a surprise if one tries similar tactics in Hawaii where, at intervals, a much larger swell than normal leads to a wipe-out of

Fig. 1. What happened? Try to explain the position of the concrete slab. There is an answer inside — somewhere. 1975.

the unwary. Again, such environmental contrasts do not become obvious until advantage is taken of either personal experience or the experience of others.

Much of Southern Arizona's population is housed in single-family dwellings that necessarily require land. Most populated regions are characterized by terrain contrasts and the terrain that is developed first is that which is convenient and presents the least complications to construction. Continued expansion literally uses up the most favorable land so that, of necessity, there is encroachment onto lands of different environmental character, e.g., steeper slopes, poorer soils, more serious drainage problems, floodplains, etc.

In this southern Arizona desert environment, WATER is a subject of much discussion because, on the one hand, it is essential to survival, and, on the other, its actions due to intermittent surface flow constitute the major geologic hazard of the region (FIELDNOTES, Geologic Hazards, vol. 2, no. 3).

Floodplains have received, and will continue to receive, considerable attention by organized citizenry, especially within the Tucson metropolitan area of Pima County. The newspaper account quoted at the beginning of this article included the comment that residents *"scorned public officials for apathy about their plights."* There are numerous predictable responses to such a comment that do not need specific disclosure except to say that they lay the *"blame"* in different laps. At the root, however, is the question of responsibility. Who has it, elements of government, the individual, or a combination of these?

The Board of Supervisors of Pima County approved *The Floodplain Management Ordinance*, and it was duly filed with the Pima County Recorder on January 2, 1975. The ordinance is designed *"to promote and protect the public health, peace, safety, comfort, convenience, and general welfare of the citizens of Pima County."* The ordinance deals with and is sensitive to more than is generally implied in the word *"floodplains."* For instance, one of the stated purposes is *"to promote and protect groundwater recharge conditions,"* and to *"enhance wildlife and recreation values where appropriate by preserving vegetation in green belts along watercourses and floodplains."* The inclusion and definition of *"watercourses"* apparently extends management authority beyond that of floodplains to that of creeks, streams, washes, arroyos, and ground depressions giving direction to storm water runoff where the drainage area is one square mile or more in extent.

The words *"floodplain"* and *"watercourses"* are not simply defined by, nor understood from, legal descriptions; therefore, additional discussion concerning these terms seems warranted.

The lead-off newspaper quote contained the expression *"flooding Rillito River."* Actually, the river did not leave (flood) its banks; it simply eroded them along an impingement zone until the trailers were undercut. Regarding the bank evolution process, the reported 1965 hydrologic event, in two days of intense action near Swan Road, straightened one bank over a distance of 1200 feet while moving this bank laterally a maximum distance of 600 feet. In so doing it ripped up a sewer line that served approximately 100,000 people. As an aside it might be instructive to note that this sewer washout was mentioned in an environmental protection study done for the Pima Association of Governments (June 1973) by J. S. Ward and Associates, consulting engineers from New Jersey. Their report categorically (p. 51, paragraph g) concludes, by subjective reasoning, that the sewer washout would not have occurred if the river bottom had not been lowered by downstream sand and gravel removal operations. Actually, the sewer line was buried in the floodplain and the surging river got to it only after bank migration at Swan Road allowed the river to change its position. Once the river was positioned over the sewer line a combination of factors were at work, such as (1) saturation of the loose, sandy material in which the line was buried, (2) a tendency of the line to float upward because of the buoyant effect of contained air, and (3) the disturbing effects of surging water that influences a zone of loose sediments several feet beneath the normal dry channel surface.

The significance of a difference in professional opinion, such as is expressed above, is in highlighting the difficulty in ascribing factually an accurate set of causes in a cause and effect relationship. In such matters there is no substitute for experience blended with on-the-spot acquaintance with a given situation. Inexperience and remoteness cannot serve the cause of accuracy.

Regarding the problem of wandering channels, the Floodplain Ordinance reads: *"Along reaches of streams or watercourses where hazards from eroding banks and/or channel meandering are considered by the County Engineer to be severe, special engineering studies shall be made by the property owner or developer and requirements for setback from banks of streams or watercourses and/or protection shall be established in accordance with findings that are concurred in by the County Engineer."*

As it now stands, the Floodplain Ordinance is not an easy document to understand in detail. Apparently there is some attempt being made to clarify meanings and intent as well as a likelihood of other modifications being made through the formal hearing procedure. However, some generalizations may be useful.

Prior to this ordinance, Federal flood insurance was not available to Pima County residents. Now, however, it is available, not only to future floodplain occupants in compliance with the regulations, but to the old occupants as well. However, the rate to those in compliance will be lower than for the old occupants.

Fundamental to floodplain management is the concept of the Regulatory Flood, Elevation, and Floodplain. These are all defined on the basis of a so-called 100-year flood, its anticipated elevation, and that part of the floodplain expected to be covered by it. Depending upon locality, the 100-year flood may occupy all of the existing floodplain, or, only a small portion of it, the remaining higher portion being assignable to the geologic floodplain. The line that divides the floodplain is determined by engineering studies and calculations and cannot be determined by a simple eyeball observation. The geologic floodplain (that part above the 100-year flood elevation) is not subject to the *"flood-proofing"* requirements of the Floodplain Ordinance, but there are circumstances, in the case of high banks, where the *"Setback from Channels Section"* of this ordinance should be applicable.

Development on the Regulatory Floodplain must comply with conditions that include protection to the height of the Regulatory Flood, setbacks from banks subject to radical changes, and development on the floodplain no closer to the main channel than would raise the Regulatory Flood one foot if both sides of a reach of drainage were similarly developed. Seldom are the sides mirror images; therefore, it might be more proper to say that development of the Regulatory Floodplain, considering both sides of the channel, is to be be done in such a way as to not raise the Regulatory Flood more than one foot. This stipulation results in the restriction of development on a part of the floodplain closest to the main channel and in the main channel itself (build on stilts?). These two parts, the channel and the undeveloped inner portion of the Regulatory Floodplain, constitute the Floodway.

In the recent past, homes have been constructed in drainage lowlands that do not have definable, classic floodplains. Apparently, this ordinance permits regulation of such activity provided that the watercourse has a drainage basin of at least one square mile.

The long-range effects of this ordinance depend upon the County's commitment to enforce these regulations in a direction that is deemed in the interest of the larger community. Perhaps the greatest threat lies in possible piecemeal development that could lead to eventual chaos sufficient to create demand for an overall remedy such as channelization. It should be remembered at all times that, perhaps, the most vital use for our larger sandy drainages is as major zones of ground water re-supply and in no way should the piecemealing development process be allowed to significantly compromise this life-sustaining natural process. It

will be necessary, however, for County officials to manage this constructive ordinance with sensitivity and dedication.

In addition to the Floodplain Ordinance, Pima County is doing preliminary work on natural geologic hazards other than floodplains. Included is an attempt at completing the water runoff management problem by defining a condition and process called "sheetflooding." The term suggests the movement of water in other than a well-defined watercourse. It is a process that takes place on planar (relatively smooth) slopes as contrasted with foothills country that characteristically is incised with steepwalled arroyos, washes, etc. The planar condition encourages dense development whereas the cut-up nature of foothills terrain places a natural limit on developmental density. However, on some planar slopes, there is a tendency for both watercourses (as defined in Floodplain Ordinance: having a greater than one-square-mile drainage basin) and sheetflooding processes to tend to interplay. Preliminary aspects of the sheetflooding regulations consider that development should be sensitive to those who are already resident as well as those who might come after. There is a hint here that there are correct and incorrect ways for development on planar slopes to evolve. Inherent in this setting are all of the upslope-downslope problems associated with moving water. Here again, if piecemeal development is to be avoided, as well as the aggravations that attend it, overall planning is a necessity. Progress will have been made if the idea is established that downslope land users are entitled to some attention whenever new upslope development takes place. Currently, it appears as though a developer is obligated only to demonstrate drainage adequacy for the particular development being planned. Perhaps this is as it should be and, if so, it is up to government to see to the major interests of others exterior to the particular development. Any such obligation requires that authority be established by ordinance. Here, and elsewhere, there is need for a common understanding between city and county governments because jurisdictional boundaries do occur on planar slopes. This means that one basic integrated terrain type must be administered by two governmental entities operating under different regulations. In the resulting confusion it is the innocent downstream dweller that often suffers the frustrations not only of jurisdictional buck-passing but a threat to property in case of upstream drainage manipulation across the boundary.

Pima County is also considering the possibility of developing some sensitivity to unstable slopes. This would include areas of possible rock fall near steep cliffs and areas that might be rendered unstable by certain excavation methods and dimensional parameters.

Although not a natural hazard, frequently, near bedrock outcrops such as along the Catalina-Rincon front and various places in and near the Tucson Mountain area, etc., prospecting activity has resulted in various holes and pits that, in some cases, remain as unprotected, attractive hazards. Population expansion has resulted in residential encroachment into these once remote locations. The State Mine Inspector has the authority to order property owners of record to fence, post, and/or cover these man-made dangers. Any citizen has the right (duty?) to notify the Inspector of anything of this sort that is considered dangerous to the curious, young or old!

We have suggested in this article that, in the interest of citizens, a local government is attempting to understand natural hazards inherent to our Southern Arizona environment and to erect ordinances sensitive to their findings. There are, however, satellite requirements that obligate the total population.

The development of *"hazard"*-related ordinances increases the need for trained manpower and, necessarily, the wherewithal to finance these as well as the research and planning required if the job is to be done correctly over the longer haul. It is, we think, in the general citizen interest to encourage and support such activities of local government. Too, local government needs to perform sensitively and efficiently in its efforts to plan and police a growing community that is equally important to all.

[The pictures in this issue, pages 6-9, relate to the material discussed above.

The front page puzzlement is the upper part of a water well that has been exposed by bank erosion along the Santa Cruz River. The well was measured in 1963 but not in 1964, for obvious reasons. Data from Jim Posedly – Dept. of Soils, Water and Engineering, Univ. of Arizona.]

CONTINUING GRADUATE RESEARCH ASSISTANTSHIP CREATED IN BUREAU

R. T. Budden first recipient

A half-time Arizona Bureau of Mines staff position for a Graduate Research Assistant was initiated during fiscal 1974-1975.

The first recipient is R.T. Budden, a candidate for the degree of Master of Science in Geosciences, College of Earth Sciences, University of Arizona, Tucson. Terry received his undergraduate degree from California Lutheran College, Thousand Oaks, California. There, the Geology Department is headed by Dr. Jim Evensen, a former student at the University of Arizona.

Mr. Budden's research efforts are primarily directed at field studies of the east flank of the Tortolita Mountains and adjacent Canada del Oro Valley about 15 miles northwest of Tucson. This region has not been mapped in detail before and the geologic data gathered will be applied to local and regional considerations that include:

1. The geologic nature and history of the Tortolita Mountains.
2. Environmental geology of the interface zone between the eastern Tortolita Mountains pediment surface (bedrock shoulder) and the western side of the Canada del Oro Valley.
3. Structural nature and significance of the Canada del Oro Valley.
4. Petrologic, stratigraphic, tectonic, and geomorphic relationships between the Tortolita and Santa Catalina Mountains.

Mr. Budden plans to run two gravity survey lines across Canada del Oro Valley in order to assist interpretation of the structure of this valley block that lies between mountain ranges of contrasting geomorphic characteristics.

In a preliminary report to the Bureau, Mr. Budden notes a strong relationship between a N 20°-30° W zone of faults exposed in the eastern pediment zone of the Tortolita Mountains and wells that have encountered ground waters at relatively shallow depths.

ENERGY NOTES

ENERGY POLICY-- WESTERN GOVERNORS TO ORGANIZE

The following is taken verbatim from *Land Use Planning Reports,* V. 3, No. 5, February 3, 1975:

"The governors of 11 Western states have moved to create a regional energy office to forge a coordinated policy on the development of natural resources.

"The move by the governors comes in the wake of a January 24 meeting in Denver, Colo., with Interior Secretary Rogers C. B. Morton. The governors were briefed by Morton on federal energy plans.

"Morton warned that state land use and environmental plans face federal preemption on energy policy issues. However, he said, 'If energy production is meeting the national interest and environmental protections meet standards set by national policy, I can't see any reason for the federal government to preempt the states.'

"Morton did not challenge an assertion by Colorado Gov. Richard Lamm that the federal government is already taking steps

to preempt state authority over energy facilities siting. Morton replied that federal siting of nuclear power and oil refinery facilities is necessary because the facilities are almost universally shunned. He said, 'If every state has the power to veto, you won't get the first drop of oil.'

"None of the governors present were reported satisfied with the meeting with Morton. New Mexico Gov. Jerry Apodaca said he is still concerned that his state will be exploited.

"An aide to Gov. Lamm said the governors hope to have a regional energy policy statement ready for the National Governors Conference in Washington, D.C., February 18-20.

"Four governors have been named as a committee to lay the foundations for a regional energy office: Wyoming Gov. Ed Herschler, Montana Gov. Thomas Judge, Idaho Gov. Cecil Andrus, and Nebraska Gov. James Exon. Another governor will also be added to the panel.

"Lamm said the regional approach 'is a matter of building coalitions and packaging our concerns.' But, he cautioned, 'you can't have a confrontation with the federal government except as a policy of last resort.'

"In addition to Lamm, Apodaca, Herschler, Judge, Andrus, and Exon, other governors attending the meeting were Raul Castro (Ariz.), Arthur Link (N.D.), Richard Kniep (S.D.), Calvin Rampton (Utah), and Mike O'Callaghan (Nev.)."

The above raises again the omnipresent questions of interests and levels of concern. What, in fact, is in the interest of Cities, Counties, States, Nations, Continents, or, the World? Are they all identical? It seems a fundamental truth that the wellbeing of a larger entity is dependent upon the capacity of its parts to furnish vital needs. Any part should have an interest in the well being of the whole because it is the part that is expendable, not the reverse. The role that a particular part plays in assisting survival might not be equal to the role of other parts because some are more important than others. Some are net providers--others net users.

National land use and state and local government land use questions can be quite different in emphasis such that misunderstandings are possible. On the one hand, considering Secretary Morton's national interest regarding energy logistics, and, on the other, each governor's more provincial concerns, contrasts in points of view are easily understood.

Surely, the concerns of all are legitimate and it remains to define that course of action that serves the nation's energy requirements while at the same time preserving as much of any given region's land, air, and water integrity as is possible under existing circumstances.

In spite of technology we still can't produce blood from a turnip or make them is when they "ain't."

NUCLEAR

According to the U.S. Atomic Energy Commission, a 1974 year-end inventory revealed that 235 electrical power generating nuclear reactors were either operable (55), being built (73), or planned (107) for the United States to the year 1992. The power capacity represented in these units is 232,720,000 Kilowatts (232,720 megawatts, or Mw). Presently, three reactor units are planned for Arizona Public Service's Palo Verde Generating Station site located west of Phoenix. One 1,238 Mw unit is scheduled for each of the years 1981, 82, and 84.

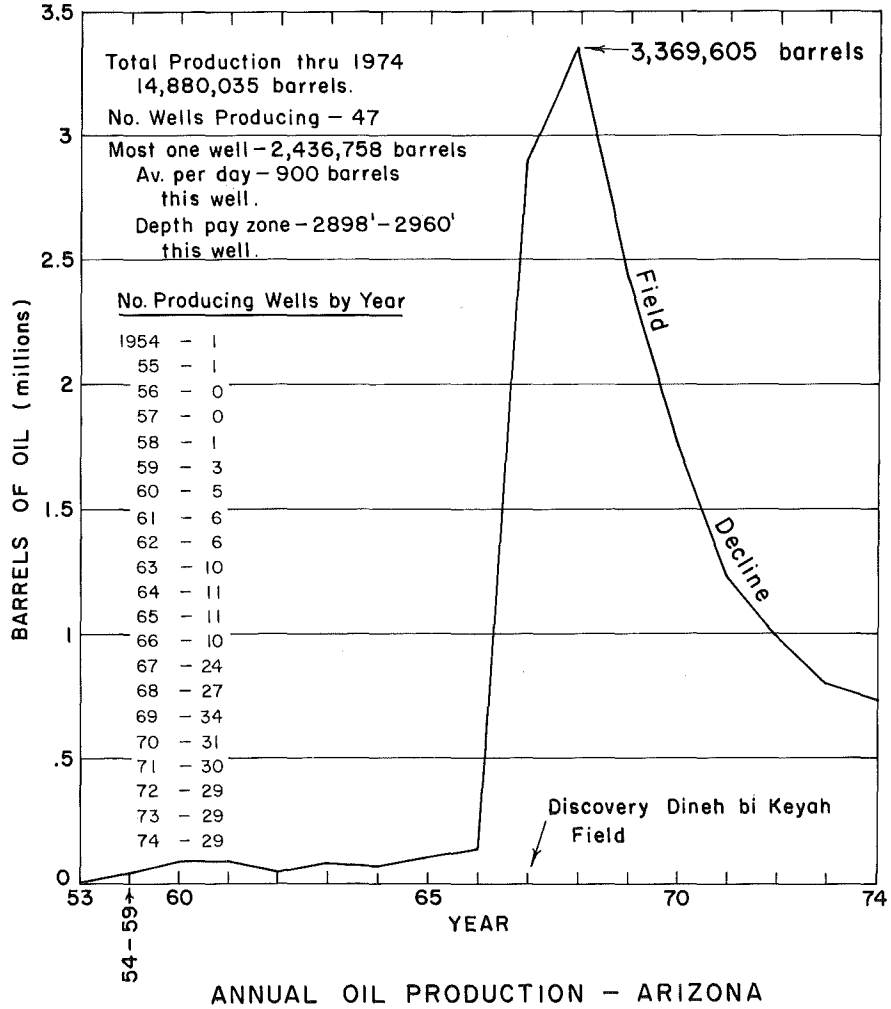
GEOTHERMAL

Although the Geothermal Steam Act was passed in December 1970, it wasn't until January 1974 that Federal lands first became available for geothermal exploration. Prior to this date all leasing was restricted to fee and state lands. However, in Arizona, only three holes have been completed and all are on fee lands. The State, through the State Land Department in Phoenix, has yet to initiate geothermal leasing on state lands.

In Arizona, small areas of Federal acreage recently were made available for noncompetitive bidding. However, because evidence of competitive interest resulted, the area is now subject to reclassification which could require competitive bidding.

Pacific Gas and Electric Company has been producing geothermal power (the only such in the U.S.) from the Geysers Field since 1960. Today's capacity is 396 Mw and the Company estimates that the ultimate may reach 2,000 Mw. For comparison it might be noted that this is less than the generating capacity represented by two of the three nuclear reactors projected for Arizona.

Geothermal exploration activity is picking up with the result that wildcat activity is being extended over more of the western U.S. Much of the exploration effort is being conducted by petroleum companies.



ANNUAL OIL PRODUCTION – ARIZONA
1954 – 1974

(Data from Arizona Oil & Gas Conservation Commission)

GEOSCIENCE DAZE--GEOLOGISTS NOTE!

April 3rd and 4th, 1975, mark the dates for the third annual Geoscience Daze organized by the students in the Department of Geosciences at the University of Arizona. Presentation of papers begins each day at 8:30 a.m. in the Arizona Ballroom of the Student Union Building on the campus.

Not surprisingly, with 29 faculty, 167 graduate students and about 170 undergraduates, it's difficult for anyone to keep up with what's happening in the Department. Geoscience Daze is convened each Spring to provide an opportunity for an interchange of ideas among students, a factor that should enhance one's overall educational and general research experience. At this meeting graduate and undergraduate students alike portray the creative outgrowth of their Masters, PhD, or independent research studies over the past years.

An amazing variety of work will be represented during Geoscience Daze. To appreciate the papers one needs to attend all sessions; nevertheless, here's a preview.

This year the focus for the structural geologists will be the Tortolita Mountains. Both papers on the fascinating deformational history recorded in the rocks of the Tortolita-Catalina complex, and the following Saturday field trip, will constructively illuminate the geology of that nearby mountain range. Also, the significance of solar shadow maps to solar power plant siting, glaciers, and vegetative zoning will be discussed along with the regional geophysical patterns in Arizona and Fourier analysis in geophysical data processing. Did you know that tree-rings record flood events, along with everything else, and that Happy Valley is happy because it's being pinched on one side and pulled on the other?

One fellow says that molybdenum in phreatophytes may lead you to orebodies. Then, there's the age of the Martin Formation in south central Arizona and the origin of the El Paso Group, the paleocurrent direction of the Dakota Group, and the camels in the Brown's Park Formation. Can you fathom fish, frogs, lizards, snakes, rabbits, beaver, rats, and mice, all in the late Cenozoic Bidahochi Formation of northeastern Arizona and, nearby, braided streams in the Chinle Formation of late triassic age?

Geographically speaking, the talks will take us to Jamaica copper mineralization, and then to the Yuma desert for a look at multiple stage depositional and erosional events of alluvium and the evidence buried in landforms that the desert has existed since Mid-Tertiary time. Then, on to Puerto Peñasco for a look at the environments of deposition for the beachrock. Closer to home, the Quiburis Formation in the San Pedro Valley has a story to tell concerning the valley's history.

On to the kinematics of deformation along faults which define a corner of the Monument Upwarp, gold in 2.6 billion year old coal-like matter, and 201 species of marine microplankton. These, and other things, will be expounded on aided by professional (?) illustrations. Use of the Scanning Electron Microscope to define rodent incisor microstructure and the use of a proton beam for trace element analysis will also be contemplated.

Last, but not least, an interesting variety of papers will entertain ideas on aspects of ore deposition. Some characteristics of mineralization at the Bruce orebody will be illustrated. Too, a detailed look at the nature of fluid flow through plutonic rocks and water-rock interactions will be considered using mathematical techniques and the Sr 87/86 ratios in the Kalamazoo orebody to test the convective hydrothermal concept against the magmatic hydrothermal hypothesis.

So, don't forget April 3rd and 4th, and contact the Department of Geosciences at (602)884-1819 for further information! Or, if FIELDNOTES is late, there's always next year.

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(Note: The reference numbers indicate volume-number, page; for example: 3-1, 6 indicates vol. 3-no. 1, page 6.)

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FLOODPLAINS

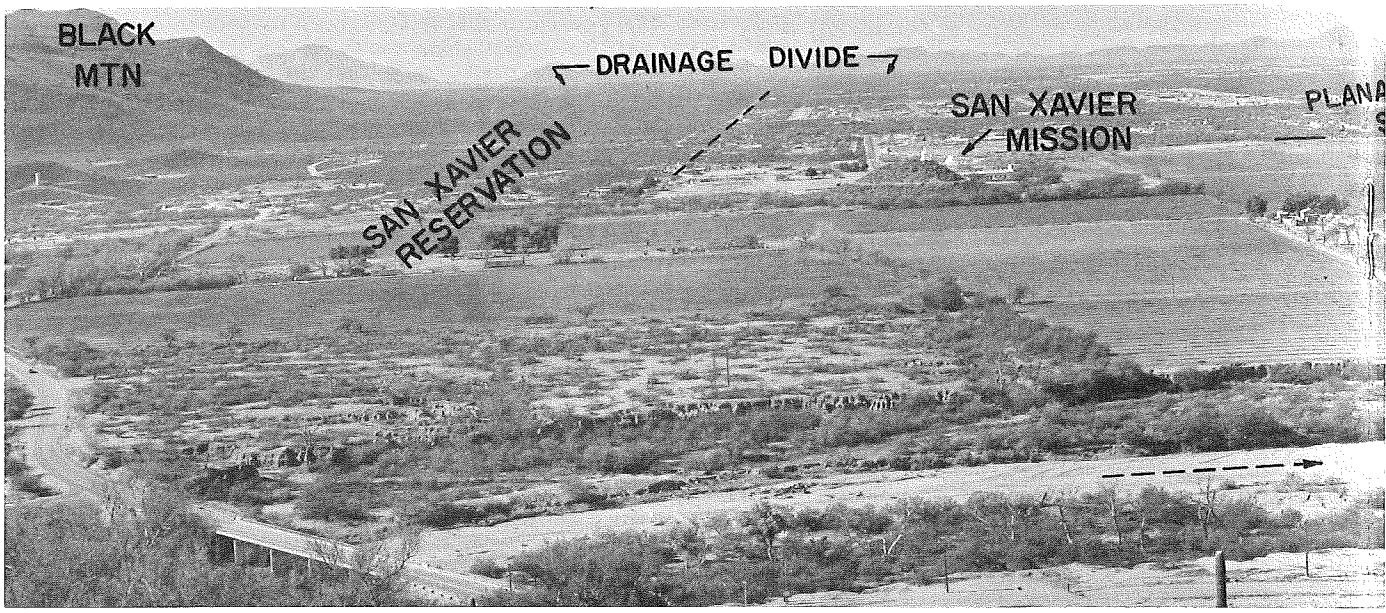


Fig. 2. View westerly toward San Xavier Mission and southern Tucson Mountain region showing: (1) normally dry Sa by both vegetation contrasts and the degree of secondary erosion of each bank segment (oldest to left), (3) plana (4) scattered development, and (5) isolated bedrock hills (inselbergs) rising from a shallowly buried bed shou

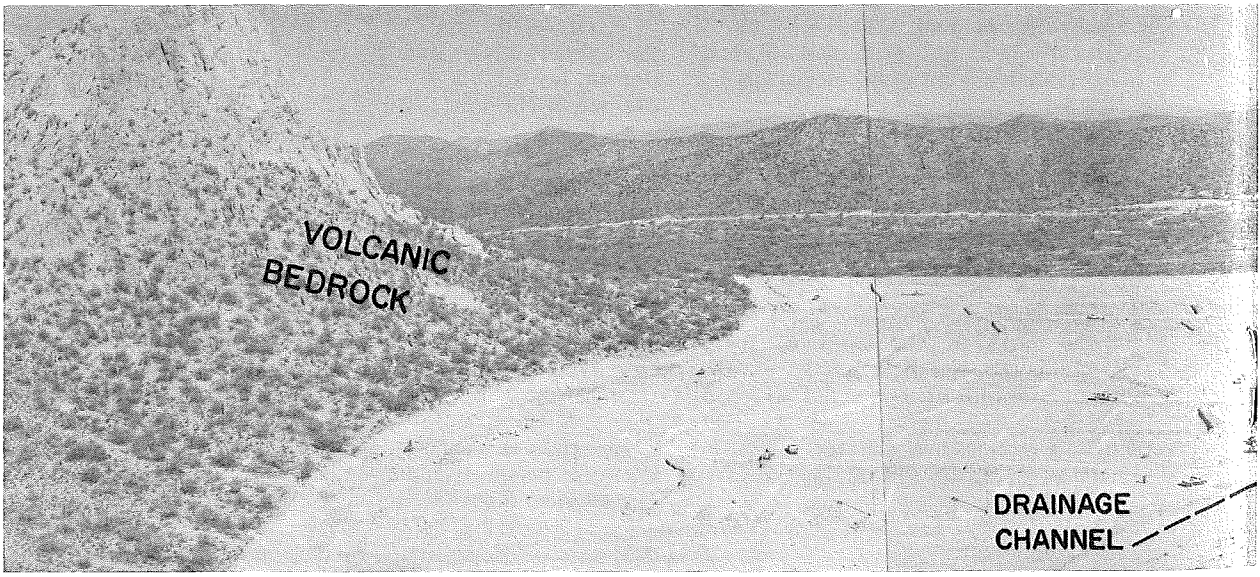
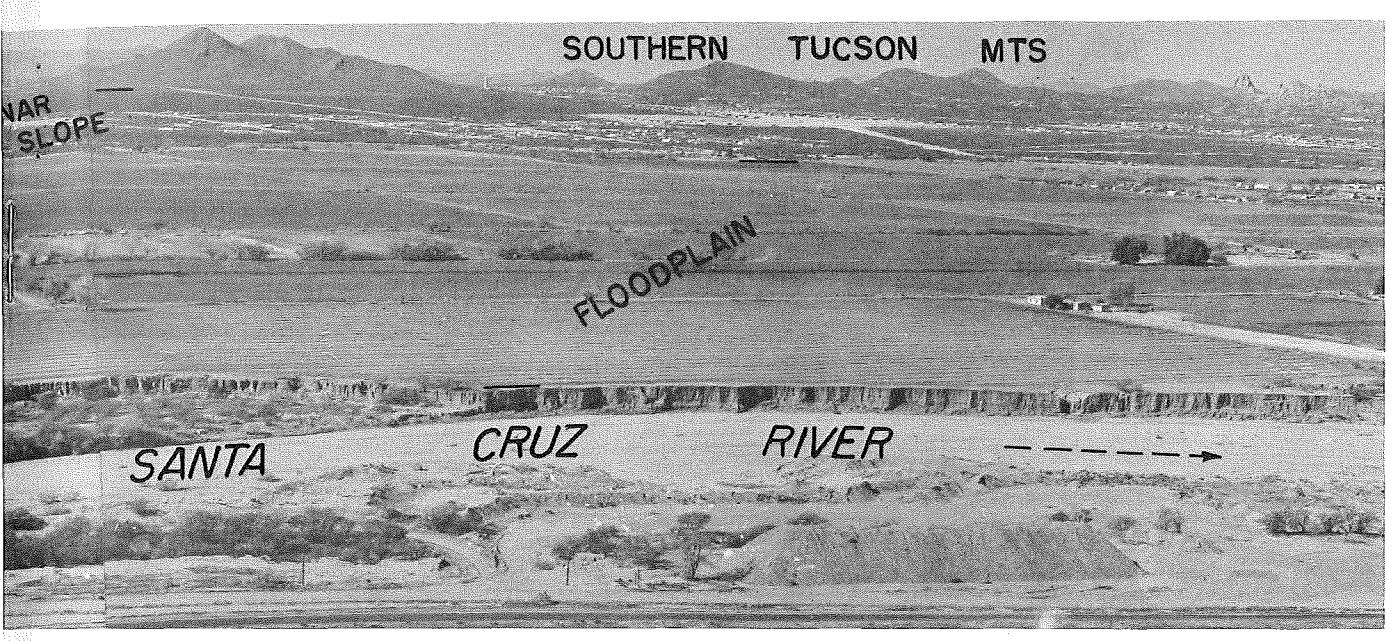


Fig. 3. View northerly from east side of southern Tucson Mountains showing: (1) housing densit ssible the upper slope. They are terraces or steps made from leveled fill dirt, (3) residential encroachmen nto hil community is constructed above a shallowly buried bedrock shoulder. 1975.

S AND SLOPES



Santa Cruz River channel (flows left to right) and adjacent tilled floodplain, (2) three ages of bank erosion as reflected
nar slope rising from the floodplain up to the base of the bedrock hills and to a drainage divide between the hills,
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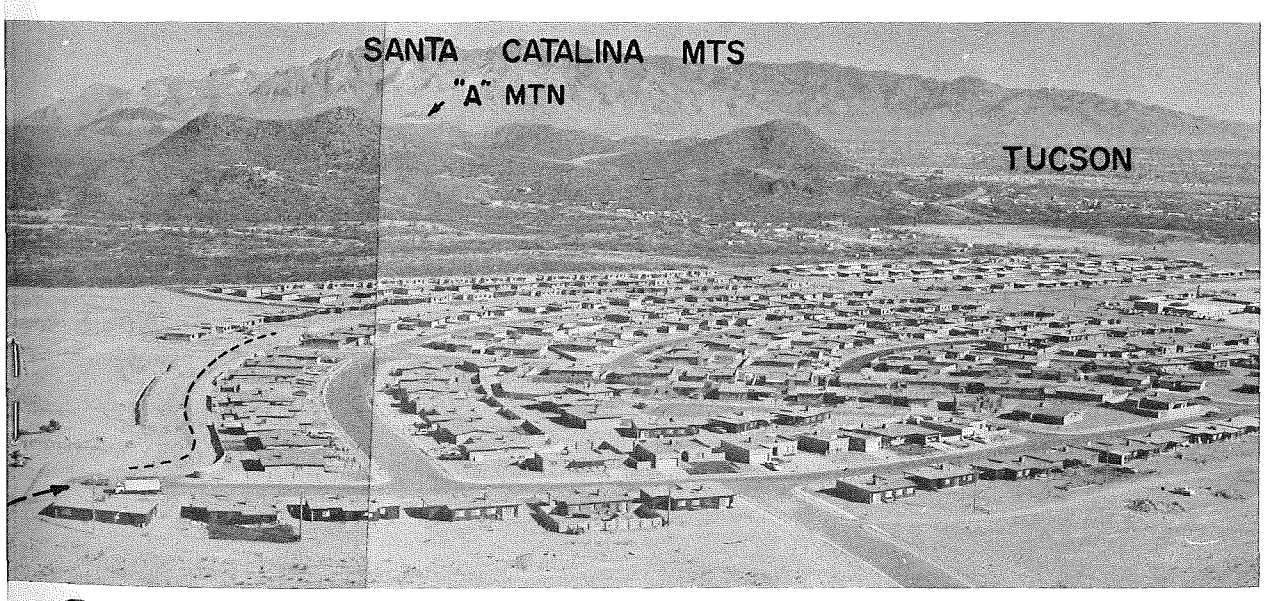
ELDNOTES, vol. 3, no. 4). 1975.



le on
ively undissected planar slopes, (2) building pads being constructed on the undeveloped portion of
hills in
iddle distance. The elevation change over the upper one mile of slope is about 130 feet. This entire

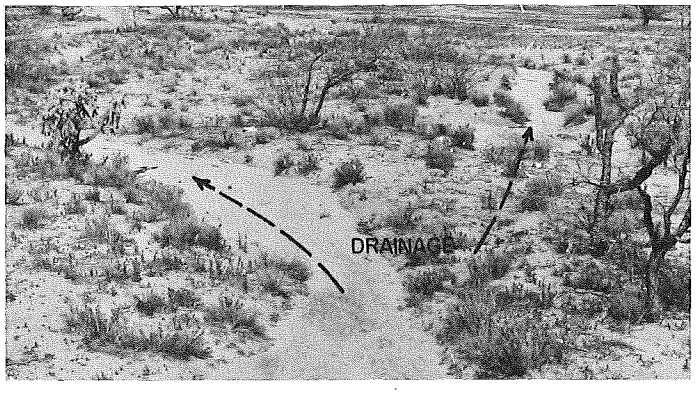


Fig. 4. Shallow, sand-floored (no boulders) drainages characteristic of sheetflood-prone areas that develop on planar slopes surrounding the low-elevation mountain blocks in the desert region. An excess of water spreads out in "sheets." Southern Tucson Mountains region. 1975.

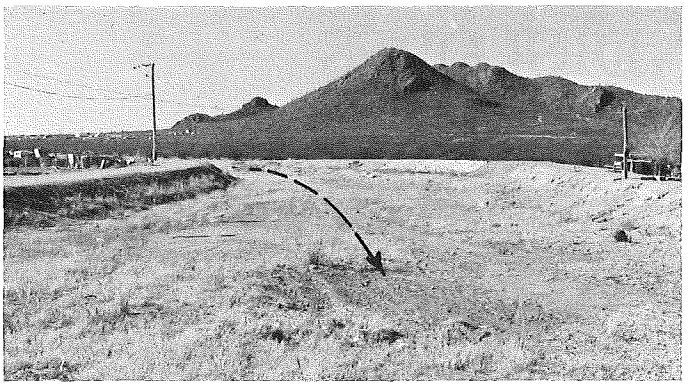


Fig. 5. Man-made drainage system designed to channel sheetflood waters collected by a dike erected on a planar slope at the upper edge of a residential area. Looking westerly, upslope, southern end Tucson Mountains. 1975.

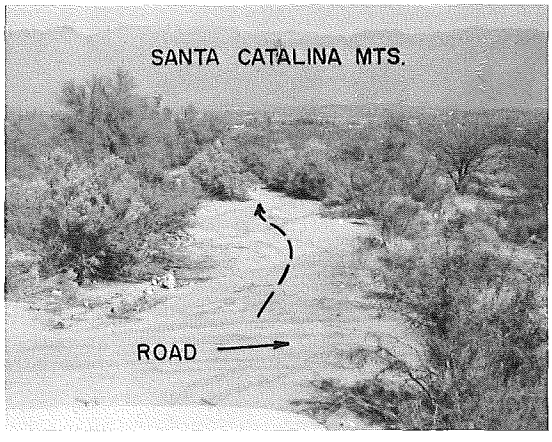


Fig. 6. Looking north down a shallow, sand-filled (no boulders), vegetated "watercourse" (as defined in Floodplain Ordinance) that is subject to overflow, or spreading similar to sheetflooding. Drainage is developed on a planar slope that terminates to the north at the Tanque Verde Wash floodplain. This particular drainage can be traced for over four miles and has an elevation difference of near 400 feet. Late 1973.

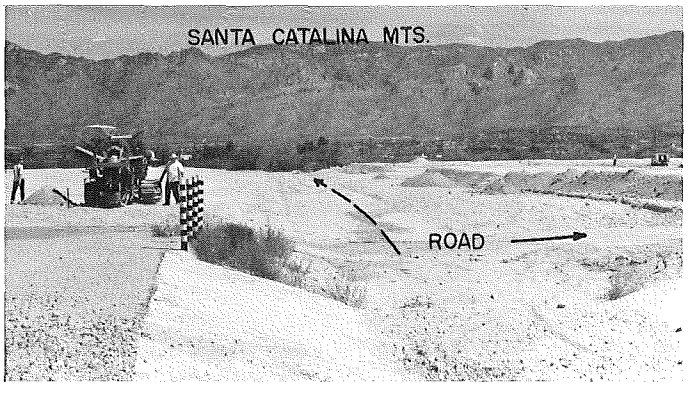


Fig. 7. Same locality as Fig. 6, in late 1974, being prepared for development of a rezoned area in the city. The boundary with Pima County runs left-right near uncleared vegetation downstream. Changes made in the natural watercourse include: (1) straightening, (2) devegetating, and (3) construction of higher confining banks. None of these changes is comforting to the first-come County occupants that are adjacent to the unchanged natural drainage downstream. The new development is tacked onto a previously modified (concrete sides) reach of the watercourse. Much of the upstream area is undeveloped which portends additional future pressure on this piecemealed drainage.

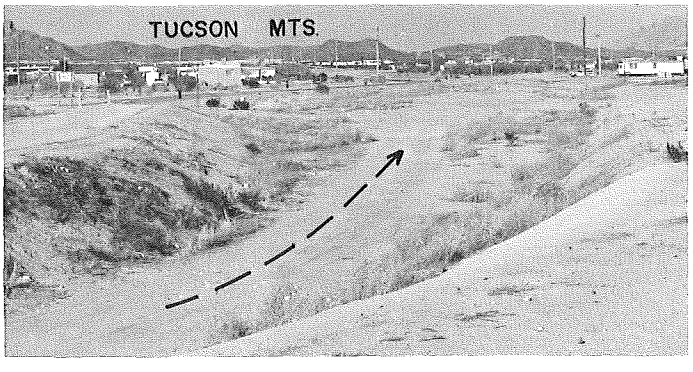


Fig. 8. Terminated lower end of man-made channel created to carry sheetflood flow collected from higher upslope. From here, drainage is less formalized and disgorging waters are less efficiently managed to the detriment of late-coming down-drainage occupants.

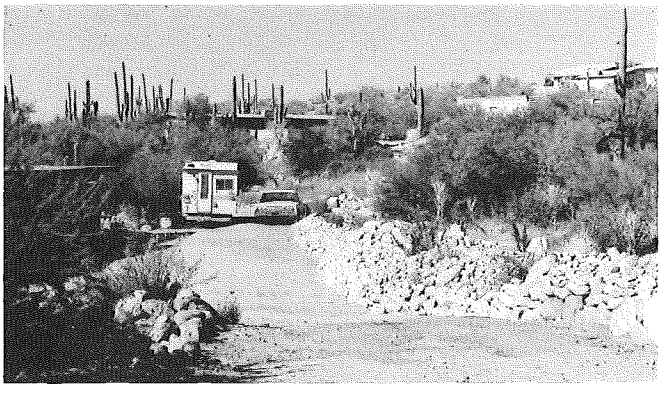


Fig. 9. Catalina foothills resident defends self from low flows that move from right to left. High flows will result in much apprehension. Note boulders here as compared to sand in the lower energy drainages characteristic of the planar slope areas (Figs. 4 and 6.) Hopefully, by sensitive application of the new Floodplain Ordinance that pertains to watercourses, County officials will be able to minimize such conflicts in the future. Incidentally, owner did not know what he was getting into. This drainage rises over 4,000 feet above this point. No wonder there are boulders! 1973.

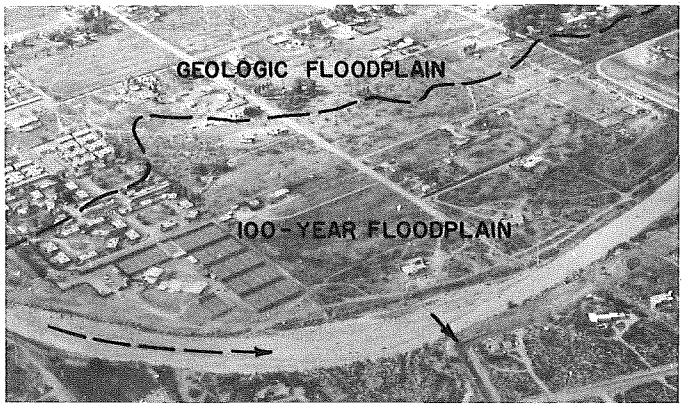


Fig. 10. Looking southwest across Rillito River channel (flows left to right) onto floodplain surface that is subdivided into the 100-year floodplain and the geologic floodplain. Although the north bank (near side) is high, it is the bank subject to erosion. The new sewer line route is shown. (See Fig. 13.) At its closest point to the eroding bank (arrow), the center line of the sewer is at the same elevation as the river bottom. This positioning is a function of right-of-way considerations. 1973.

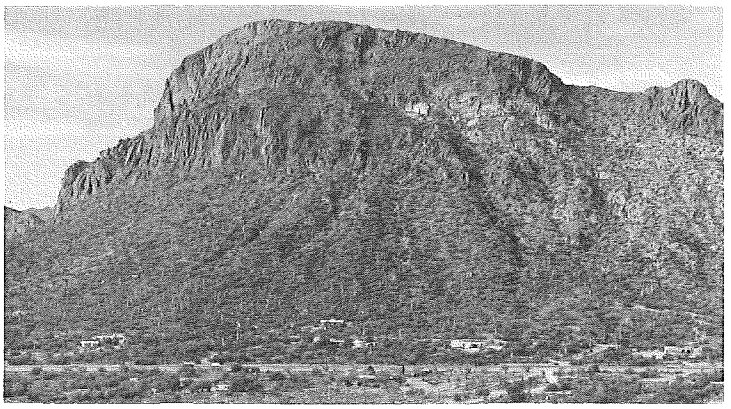


Fig 11. Dwellings near base of steep slope, below cliffs of 65-million-year-old Cat Mountain Rhyolite. Relief is over 1,000 feet. Fracturing divides rock into blocks, some of which have rolled beyond dwellings. Ajo road in foreground — looking northwest. Pima County is reviewing this type of natural hazard. 1975.

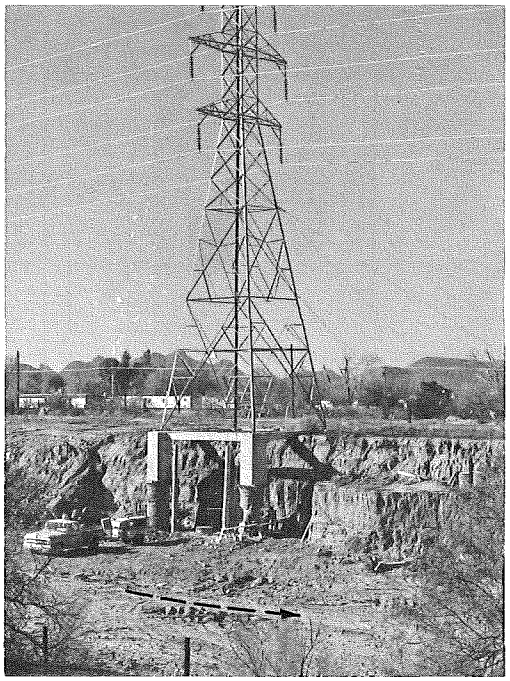


Fig. 12. Bank erosion along Santa Cruz River exposes supports for pillars holding up tower. Workers undertaking repairs. 1975.

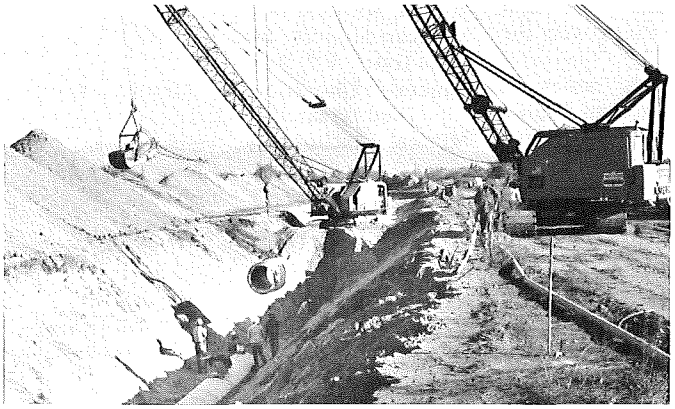


Fig. 13. Planting a 40-inch sewer line in soft sediments below Rillito River floodplain surface near north approach to Campbell Ave. bridge. 1973.

Fig. 14. A cautious look at an abandoned prospect pit (30 feet deep) in Saginaw Hill mineralized area of the southwestern Tucson Mountains. 1975.

GEOLOGIC MAP COVERAGE IN ARIZONA AT VARIOUS SCALES

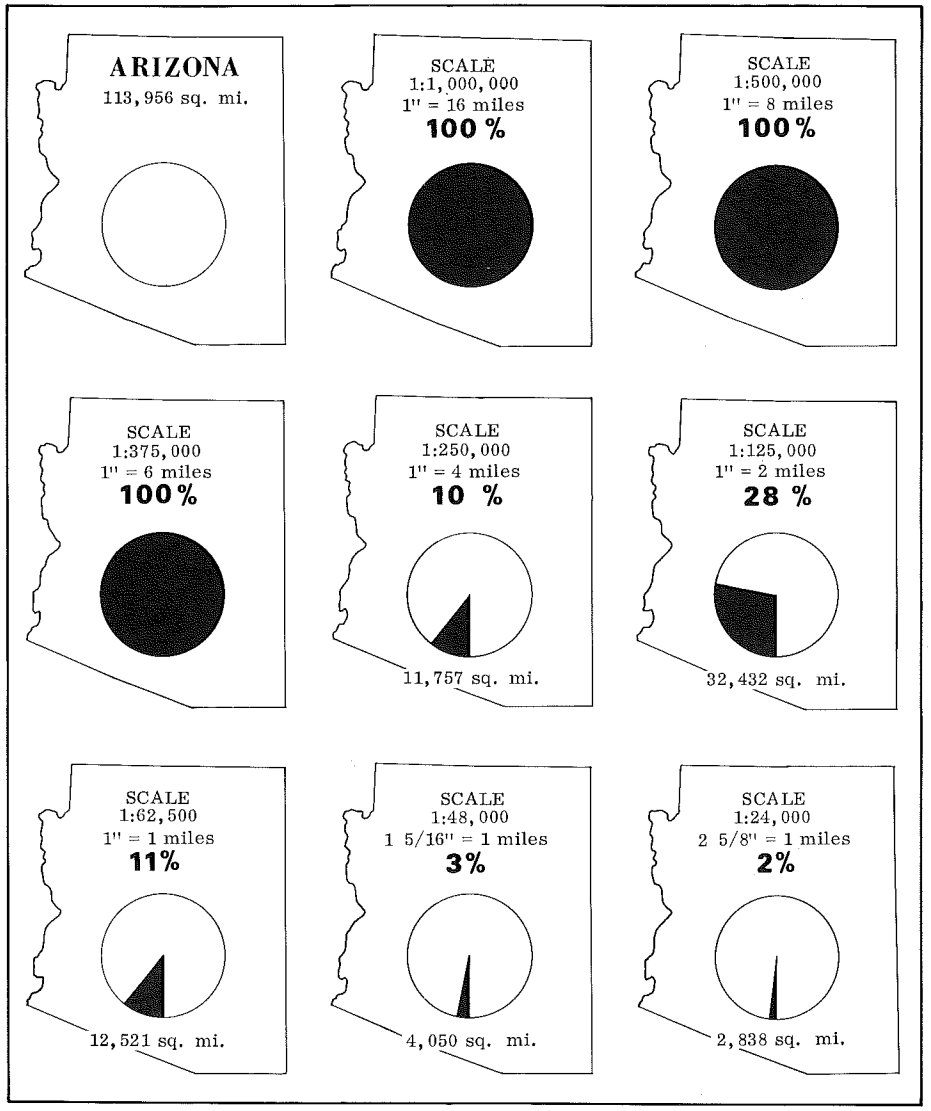


Fig. 15.

GEOLOGIC MAPPING IN ARIZONA

A general geologic map is one that depicts the nature of the earth's surface in as much detail as the map scale allows. It is axiomatic that the more detailed the mapping the more costly it is in terms of time-manpower (personpower if you prefer), and, therefore, expenditure of funds.

The first geologic map of the entire State was published in 1924 at a scale of 1:500,000 (1 map inch approximately equal to 8 miles on the ground). The project was a cooperative venture between the Arizona Bureau of Mines and the U.S. Geological Survey. Again, in 1969, an updated geologic map was published, at the same scale, also as a cooperative State-Federal project. However, an intermediate step was taken in that geologic maps of the Counties were produced separately at a scale of 1:375,000 (1 map inch equal to 6 miles on the ground). To date this is the most detailed geologic mapping that covers the entire State.

The popularity of this series is indicated by the sale of more than 40,000 individual maps since the first one (Maricopa County) was issued in 1957.

Fig. 15 shows the percentage of Arizona covered by published geologic maps (doesn't include photogeologic maps) at various mapping scales ranging from 100% coverage at 1:1,000,000 (1 map inch approximately equal to 16 miles on the ground--this is a map compiled from more detailed mapping) to 2% coverage at 1:24,000 (1 map inch approximately equal to one-third mile on the ground).

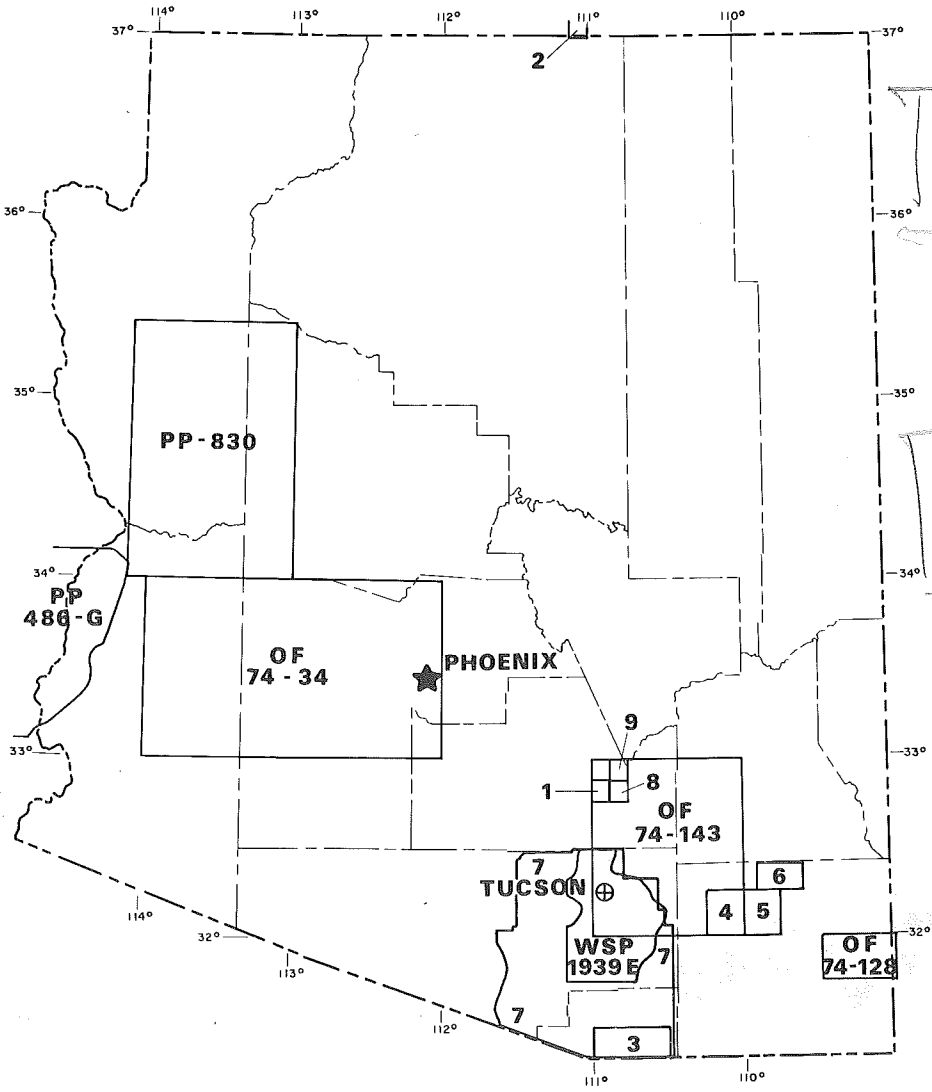
Geologic mapping at scales less than 1:375,000 has and is being done largely by the U.S. Geological Survey in connection with field and laboratory studies designed to better understand the geologic setting of the State's copper resources. It might be said that the extent of National interest in Arizona's copper resources is reflected both by the longevity of study and by the level of Federal effort and funding devoted to basic research, much of which is geologic field mapping. The U.S. Geological Survey has been involved in studying the geology of copper districts since about the turn of the century and their regional efforts continue.

It is quite true that the absolute geology of most regions doesn't change much over the span of a human lifetime but what we think about it does change, often drastically. Ferreting out the "absolute" geology never ends and the reevaluation of old data in the light of new serves as a stimulus that defeats the onset of stagnation.

The most systematic process for ferreting out and developing new ideas about the earth stems from geologic mapping. The combination of excellent exposures and a general paucity of detailed geologic mapping in Arizona guarantees that much remains to be learned about what this State really is. Remote sensing studies are useful but there is, as yet, no substitute for a face to face encounter with Arizona rocks and the secrets that relate to them.

FIELDNOTES INDEX *Continued*

NEW GEOLOGIC MAPS OF ARIZONA



KEY TO MAP

NOTE

The following are sold at the price indicated by the U.S. Geological Survey and should be ordered from:

U.S. Geological Survey
Map Sales Office
Bldg. 41, Federal Center
Denver, CO 80225

1. 1974. Medora H. Krieger: Geological Map of the Black Mountain Quadrangle, Pinal County, Arizona; U.S.G.S. Map GQ-1108, Scale 1:24,000, price $1.00.
2. 1973. Fred Peterson and B. E. Barnum: Geologic Map of the Southeast Quarter of the Cummings Mesa Quadrangle, Kane and San Juan Counties, Utah, and Coconino County, Arizona; U.S.G.S. Map I-758, Scale 1:24,000, price 50 cents.
3. 1974. Franks S. Simons: Geologic Map and Sections of the Nogales and Lochiel Quadrangles, Santa Cruz County, Arizona; U.S.G.S. Map I-762, Scale 1:48,000,price $1.00.
4. 1963. W.J. Dempsey, W.D. Fackler, and others: Aeromagnetic Map of the Dragoon Quadrangle, Cochise County, Arizona; U.S.G.S. Map GP-412, Scale 1:62,500, price 50 cents.
5. 1963. W.J. Dempsey, W.D. Fackler, and others: Aeromagnetic Map of the Cochise Quadrangle, Cochise County, Arizona; U.S.G.S. Map GP-413, Scale 1:62,500, price 50 cents.
6. 1963. W.J. Dempsey and M.E. Hill: Aeromagnetic Map of Parts of the Willcox and Luzena Quadrangles, Cochise County, Arizona; U.S.G.S. Map GP-418, Scale 1:62,500, price 50 cents.
7. 1974. Richard T. Moore, William C. Jones, and John W. Peterson,

Arizona Bureau of Mines: Maps Showing Non-metallic Mineral Deposits in the Tucson Area, Arizona; Folio of the Tucson Area, Arizona, Map I-844-J, Scale 1:250,000, price 75 cents.

8. 1974. Medora H. Krieger: Geologic Map of the Putnam Wash Quadrangle, Pinal County, Arizona; U.S.G.S. Map GQ-1109, Scale 1:24,000, price $1.00.
9. 1974. Medora H. Krieger: Geologic Map of the Winkelman Quadrangle, Pinal and Gila Counties, Arizona; U.S.G.S. Map GQ-1106, Scale 1:24,000, price $1.00.

PUBLICATIONS

NOTE

The following U.S. Geological Survey publications are sold at the prices indicated and should be ordered from:

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

1973. D. G. Metzger, O.J. Loeltz, and B. Irelna: Geohydrology of the Parker-Blythe-Cibola Area, Arizona and California; U.S.G.S. Professional Paper 486-G, 130 p., 6 plates, price $5.00. (Area shown on adjoining map.)

1973. R.A. Sheppard and A.J. Gude 3d: Zeolites and Associated Authigenic Silicate Minerals in Tuffaceous Rocks of the Big Sandy Formation, Mohave County, Arizona; U.S.G.S. Professional Paper 830, 36 p., price $1.05. (Area shown on adjoining map.)

1973. E.S. Davidson: Geohydrology and Water Resources of the Tucson Basin, Arizona, U.S.G.S. Water-Supply Paper 1939-E, 81 p., 7 plates, price $6.40. (Area shown on adjoining map.)

OPEN FILE

The following Open File Reports may be seen at the Arizona Bureau of Mines office in the Geology Building, room 324, University of Arizona, Tucson.

1974. Harold Drewes: Preliminary Report on Analytical Data of Plutonic Rocks of the Santa Rita Mountains, Southeast of Tucson, Arizona; U.S.G.S. Open-file report 74-260.

1974. U.S. Geological Survey: Aeromagnetic Map of Parts of the Chiricahua Peak and Portal Quadrangles, Cochise County, Arizona; U.S.G.S. Open-file report 74-128, Scale 1:62,500. (Area shown on adjoining map.)

1974. U.S. Geological Survey: Preliminary Map Showing Potential for Copper Deposits in the East Half of the Tucson 2° Quadrangle, Arizona; U.S.G.S. Open-file report 74-143, Scale 1:250,000. (Area shown on adjoining map.)

1974. A.F. Bateman, Jr., E.G. Allen, and V.C. Indermuhle: Leasable Mineral and Waterpower Land Classification Map, Phoenix 2° Quadrangle, Arizona; U.S.G.S. Open-file report 74-34, Scale 1:250,000. (Area shown on adjoining map.)

OTHER PUBLICATIONS

1974. Arizona Water Commission Bulletin 7: Annual Report on Ground Water in Arizona, Spring 1972 to Spring 1973; Prepared under the direction of H. M. Babcock, District Chief of the U.S. Geological Survey in Arizona. This bulletin can be obtained from:

Executive Director
Arizona Water Commission
222 North Central Avenue
Suite 800
Phoenix, AZ 85004

DESERT MUSEUM

EARTH SCIENCES CENTER

The underground Stephen H. Congdon Memorial Earth Sciences Center is well underway at the Arizona-Sonora Desert Museum located 12 miles west of Tucson. The Center's exhibit *"rooms"* will have a cave and underground mine motif. The unique building and general exhibit design are the ideas of Museum Director Mervin W. Larson. Considering the staff's talents in making *"true to life"* rocks, we predict that underground integrity and realism will prevail. Interior exhibits will feature minerals, gems, and fossils *"native"* to this region and also its general geologic history. These general exhibit areas are planned for completion in 1975 after which innovative displays can be installed as funds become available.

PANCZNER ADDED TO STAFF

Mr. William D. Panczner has recently been added to the Museum staff. Bill is married to Sharon and they have two *"pebble pups,"* Chris and Shawna. Bill is particularly well experienced in the world of minerals, and is creative in their exhibition. Arranging displays at the Museum is one of his assignments.

Bill graduated from the University of South Florida, and since 1971 has taught high school earth science in Florida. He is a former resident of Phoenix and we understand that he is very pleased to be back in the southwest.

FIELD NOTES
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President ..... John P. Schaefer
Arizona Bureau of Mines
Director .. .. William H. Dresher
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