RECONNAISSANCE ENVIRONMENTAL GEOLOGY OF TONTO FOOTHILLS, SCOTTSDALE

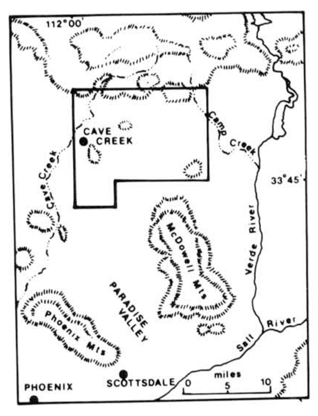
MARICOPA COUNTY, ARIZONA

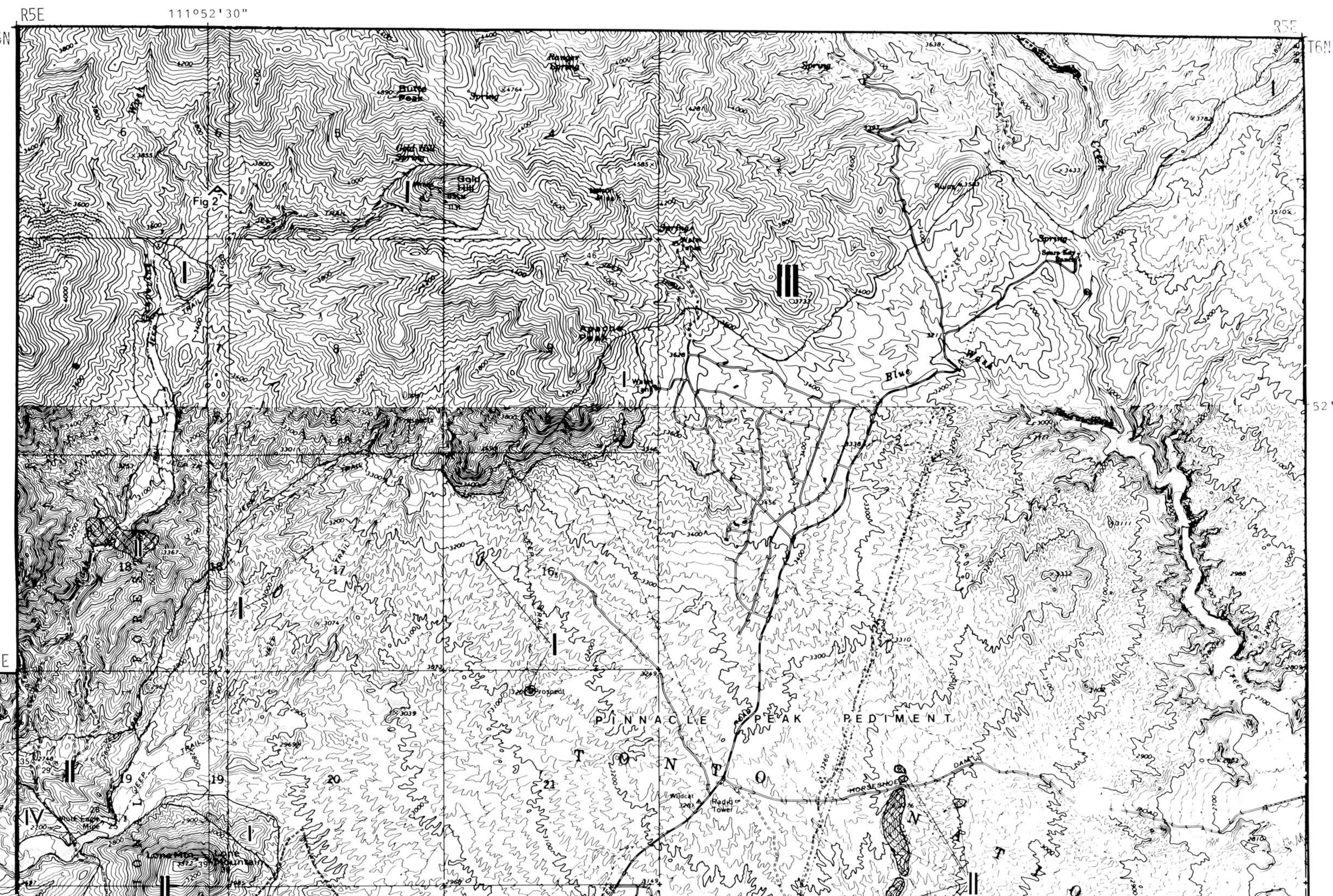
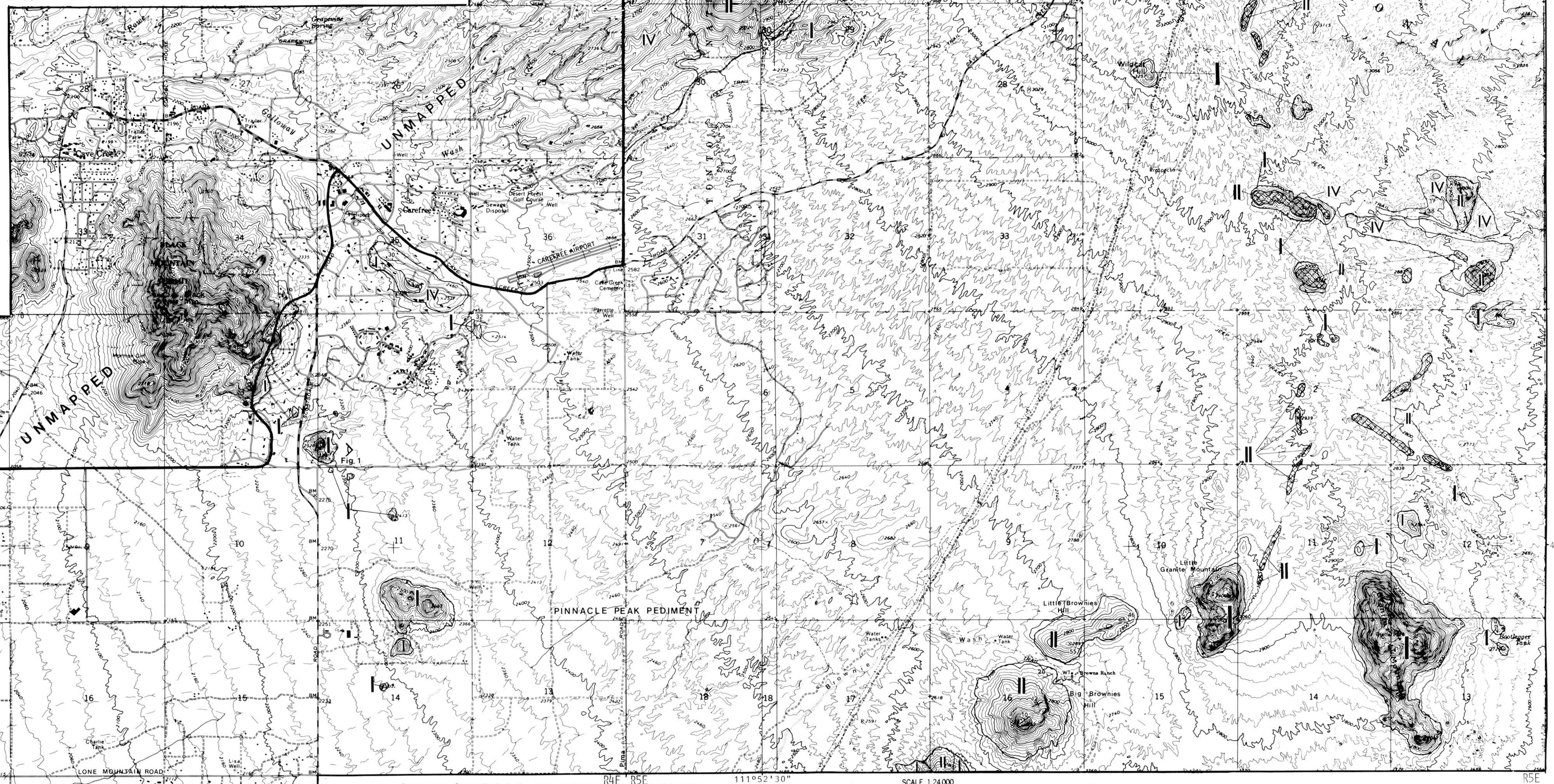
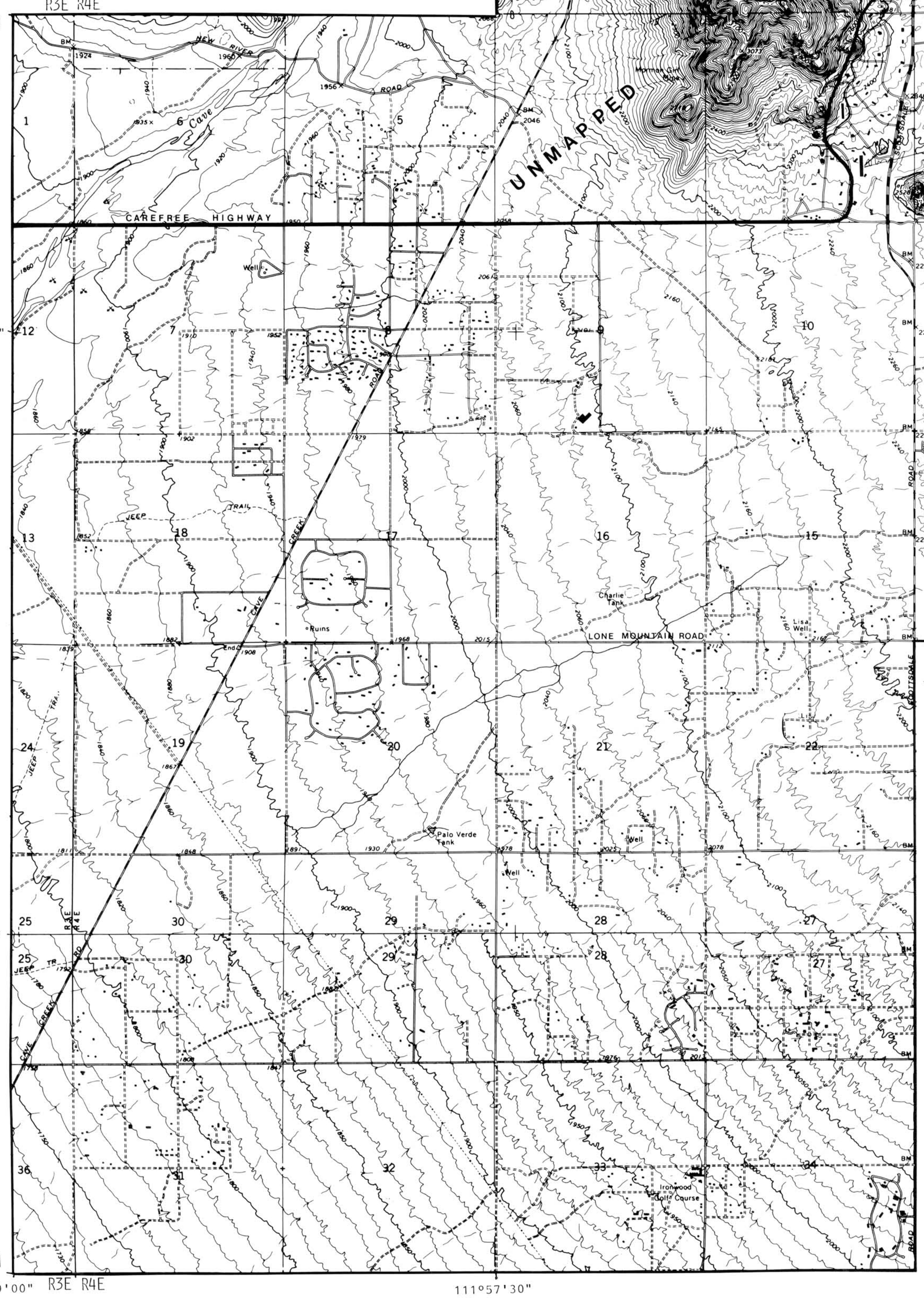
by Troy L. Péwé, Ray Kenny and Jim Bales

1985

GEOLOGIC HAZARDS

Prepared in cooperation with
Department of Geology, Arizona State University
Long Range Planning Department, City of Scottsdale
Arizona State Land Department



Base map from U.S.G.S. topographical maps, 1:24,000
Series; Cave Creek (1965); Currys Corner (1964);
Humboldt Mountain (1964);
New River Mesa (1964); Wildcat Hill (1965).

Figure 1 - View west of granite boulders precariously perched above site development at the Boulders (T5N, R4E, Section 2). Boulders have moved at least 3 feet to the east toward the edge of the cliffs and downhill to the north. Movement can be triggered either by blasting, excessive rains, or tectonic activity (Photograph no. 4707 by T. L. Péwé, Sept. 12, 1982).

INTRODUCTORY STATEMENT*

Geologic hazards are natural geologic processes which continue to reshape the configuration of the land surface, and are called hazards only when man and his geologic environment change, interrupt, or get in the way of these processes. It is the purpose of this map to delineate areas of potential geologic hazards, where special precaution in planning and construction should take place to avoid danger to man's life and property. The activity by which these geologic processes operate can drastically change, and therefore, only the location, but not the timing, of geologic processes can be determined. Land developers, city planners, engineers, or anyone else interested in land use should be aware of these natural geologic processes and their potential detrimental effects. Processes that are potential geologic hazards in the Tonto Foothills area include slope instability, flooding, land subsidence and formation of earth fissures, and earthquakes.

Slope instability

Unstable rock masses (boulders and large rock slabs) large enough to crush houses have, in the past, moved downslope on the steep slopes of the northern part of the area and hills and mountains projecting above Pinnacle Peak Pediment, and will do so in the future. This geologic hazard of slope instability must be seriously considered before undertaking any construction in the area. For protection of man and for aesthetic reasons, Maricopa County and the City of Scottsdale have hillside regulations (Scottsdale Hillside Ordinance) dealing with construction on the slopes and bedrock areas.

Slope instability refers to the tendency of earth materials to move downslope under the influence of gravity. Several types of potential instabilities occur, grouped under the general heading of landslides or mass wasting. On steep slopes mass wasting can and does occur naturally; on the more gentle slopes, the potential for landslides is increased by the undercutting of slopes and the misdirected flow of surface water by man. Generally, erosion is imperceptibly slow, though with certain rock types or deposits on steep slopes, erosional processes can be rapid and destructive. Granitic and basaltic bedrock areas are associated with boulder rolling because of the rounded nature of the boulders; rockslides, on the other hand, are associated with steep slopes of metamorphic rock in the higher mountains. Boulder falling or rolling is a very common type of downslope movement in granitic bedrock areas of the arid southwest, especially Arizona. The granitic outcrops of the steeper slopes of the hills and mountains of the pediment are highly subject to boulder rolling. Rounded granite masses (boulders up to 20 ft (6.1m) or more in diameter) may move down the hillside and roll some distance out onto the gentle slopes. This is a common phenomenon in the area and is an ever-continuing process; boulders can crash down the hillside at any time.

Evidence that huge granitic boulders have rolled down the steep slopes onto the gentle slopes is clearly indicated by the presence of the large rounded blocks at the base of the hills and on the gentle slopes. Some boulders have moved as much as 100-150 ft (30.5 to 45.7m) horizontally as they tumbled from the cliff. There is no question that boulders have rolled down the slopes in the past; the question is whether the process of boulder rolling is continuing. Evidence that the boulder movement did not take place all at one time and is a continuing process exists. The evidence that many of the boulders moved many years ago is that they are greatly rounded and the subsurfaces are very rough from deep weathering. Archaeological features indicate that some boulders have been stable for hundreds of years. Elsewhere, the blocks of boulders have fracture surfaces that are not as weathered and the edges of the rocks are angular, indicating breakage and movement at a much later date. Geologically, it is possible to state that where boulders are now unstable they will eventually move, but like earthquakes, it is not possible to state just when this action (boulder movement) will take place. Movement may be tomorrow or 100 years from now.

Boulders and blocks move downslope when forces are such that they overcome the friction holding the rocks in place. This movement may result from forces pushing or rocking the boulders, such as earthquakes or blasting tremors caused by man; or, a steady force of the pull of gravity, aided by the removal or weakening of the friction holding the boulders in place. Although the Phoenix area has been relatively free of earthquakes since historic time, they have occurred in the geologic past and are probably one of the main causes for the movement of boulders downslope in the area.

The common and ever-present force of gravity probably causes most downslope movement in the long run. Gravity is most effective when friction between the boulders and the slope is reduced through weakening or removal of a weathered clay and silt layer which tends to hold boulders in place. Intense rains over a long period of time reduce friction by lubricating the clay layer. Most mass movement takes place during and after a rainy period.

Flooding

Severe floods do occur in the desert, contrary to common opinion, and an understanding of weather patterns, drainage basin, and stream channel characteristics permits an understanding of quantitative and qualitative overbank and sheet-flow flooding characteristics. Alluvial fan morphology and age relationships can also help qualitatively delineate areas of general flooding in non-mountainous areas. Potential flooding hazard areas are indicated on Plate 3.

Earthquakes

Earthquakes are a result of ground movement along a fault with a sudden release of tension within the earth's crust. Numerous faults exist in the area, but no evidence exists that they have moved for at least 35,000 years, and therefore, they are classified as inactive. Slight tremors may not directly damage structures, but such tremors could instigate rock movement on unstable slopes and cause destruction of buildings on or near hillsides in the area.

Each geologic hazard has its own effect on the landscape and consequently on man's environment. Land users should be aware of these potential problems, and precautions should be taken, including adequate engineering studies and sound planning.

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*This map involves a general investigation on a broad scale and does not preclude the necessity of individual site analysis.

EXPLANATION

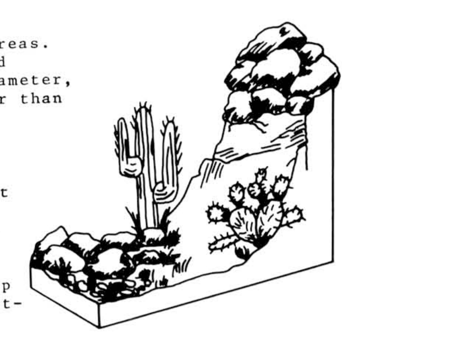
SLOPE STABILITY

Slope instability is the tendency for earth material to move downhill under the influence of gravity. Several types of potential unstable slopes occur: boulder rolling, rock falls, and debris movement. Stability of a slope is in a continual state of change because of the geologic processes which act upon it and, therefore, only the potential areas of failure and not the rates at which these hazards take place can be outlined.

Boulder rolling

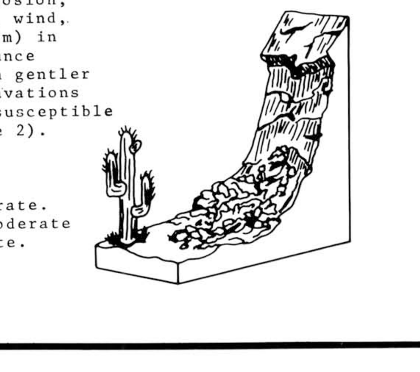
I — Granitic bedrock and boulder rollout areas. Erosion along joints forms subrounded masses 1 to 15 ft (0.3 to 5 m) in diameter, capable of rolling downslopes greater than 15% (see Figure 1).

II — Basalt and tuff bedrock and colluvium. Subrounded masses generally 1 to 4 ft (0.3 to 1.2 m) in diameter. Cross hatched areas: rhyolite tuff, dikes, plugs, and flows. Angular masses 1 to 4 ft (0.3 to 1.2 m) in diameter. Rock masses roll or tumble from steep slopes or unstable talus debris, particularly if undercut or if boulders removed at bottom.



Rock falls and slides

III — Blocky to platy metamorphic rocks. Rock falls caused by loss of support provided by underlying rock or material on precipitous slopes greater than 45° (100%), rocks loose underlying support by erosion, earth vibrations, animal activities, wind, or other causes, blocks to 10 ft (3 m) in diameter that literally fall and bounce down steep slopes, coming to rest on gentler slopes near base of mountains. Excavations parallel to dip of rock especially susceptible to rock falls and slides (see Figure 2).



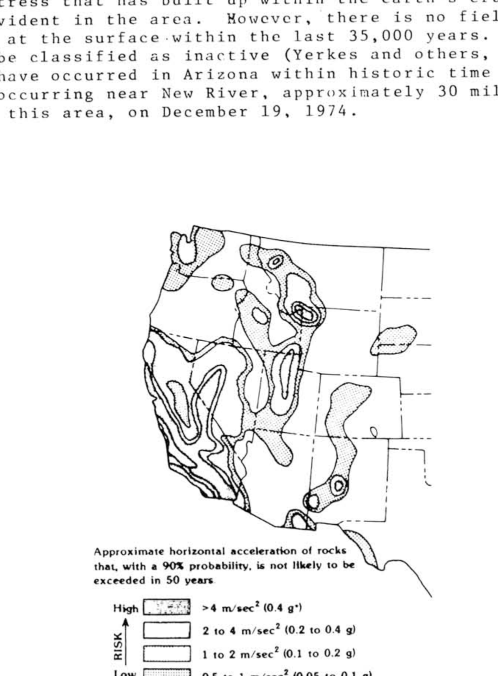
IV — Slope instability hazard weak to moderate. Low slopes on tuff and basalt and moderate slopes on well-indurated fanglomerate.

MAP SYMBOLS

- Contact, dashed where gradational.
- Dip and strike of beds
- Dip and strike of foliation
- Location and orientation of photographs

EARTHQUAKES

An earthquake is the trembling or shaking of the ground produced by rapid differential movement of rocks along a fault. It is caused by a sudden release of stress that has built up within the earth's crust. A number of faults are evident in the area. However, there is no field evidence indicating any movement at the surface within the last 35,000 years. The faults, therefore, would be classified as inactive (Yerkes and others, 1974). Numerous earthquakes have occurred in Arizona within historic time with the nearest, most recent occurring near New River, approximately 30 miles (48 km) to the northwest of this area, on December 19, 1974.



Probabilistic interpretation of seismic hazards in the western U.S. Seismic risk for most of Arizona is very low (Algermissen and Perkins, 1976).

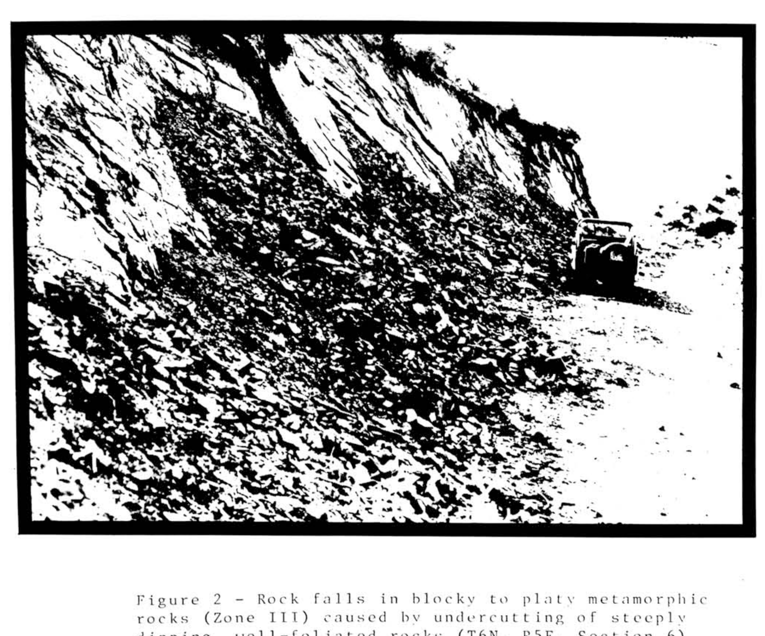


Figure 2 - Rock falls in blocky to platy metamorphic rocks (Zone III) caused by undercutting of steeply dipping, well-foliated rocks (T6N, R5E, Section 6) (Photograph no. 4829 by T. L. Péwé, Feb. 12, 1985).