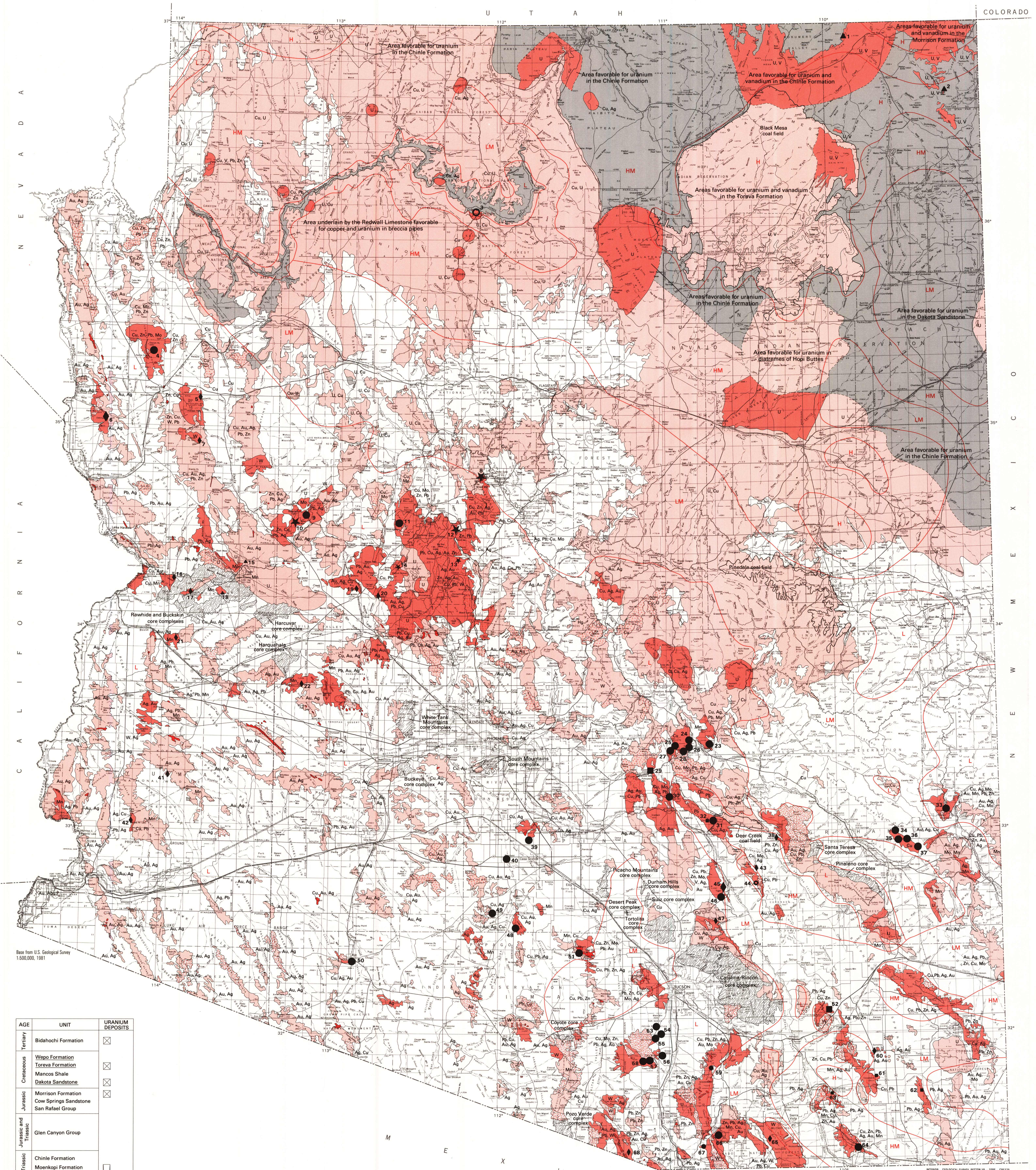
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MINERAL INVESTIGATIONS
RESOURCE MAP MR-94



SCALE 1:1 000 000

25 0 25 50 MILES

25 0 25 50 KILOMETERS

NATIONAL GEODETIC VERTICAL DATUM OF 1929

AGE	UNIT	URANIUM DEPOSITS
Tertiary	Bidahochi Formation	☒
Cretaceous	Wepo Formation	
	Toreva Formation	☒
	Mancos Shale	
	Dakota Sandstone	☒
Jurassic	Morrison Formation	☒
	Cow Springs Sandstone	
	San Rafael Group	
Jurassic and Triassic	Glen Canyon Group	
Triassic	Chinle Formation	
	Moenkopi Formation	Breccia pipes containing uranium deposits transgress formational boundaries from the Redwall Limestone to the Chinle Formation
Permian	Kaibab Formation	
	Toroweap Formation	
	Coconino Sandstone	
	Hermit Shale	
Pennsylvanian and Permian	Supai Formation or Group	
Mississippian	Redwall Limestone	

GENERALIZED STRATIGRAPHIC COLUMN FOR THE COLORADO PLATEAU AREA SHOWING ROCK UNITS WITH KNOWN URANIUM DEPOSITS AND COAL-BEARING UNITS (UNDERLINED)

EXPLANATION

METALLIC MINERAL RESOURCE POTENTIAL

Potential for metallic mineral resources was determined by comparing the number of mines that produced the metals, as shown on maps from the Arizona Mineral Resources Data System records (Peterson, 1984), with the geology as shown on the Geologic Map of Arizona (Wilson and others, 1969). Commodities on the map are those that have been produced in the past and are shown in decreasing order of importance. These commodities were determined by identifying the mining districts encompassed by favorable areas using the map of mining districts by Keith and others (1983), and the accompanying tables to identify major commodities produced. Commodities for which there is potential may in some instances differ from those produced in the past. Dashed lines indicate the subsurface extent of area favorable for uranium and vanadium deposits.

AREA WITH NUMEROUS KNOWN MINERAL DEPOSITS AND GEOLOGICALLY FAVORABLE FOR METALS LISTED—Favorable geologic terranes have characteristics that are associated with specific types of mineral deposits. For example, porphyry copper deposits are known to be associated with Laramide-age granitic intrusions; therefore, areas whose geologic setting includes Laramide granitic intrusive rocks, and which also have numerous known mineral deposits, may have undiscovered deposits and are classified as favorable

AREA WITH SPARSE OR NO KNOWN MINERAL DEPOSITS, BUT GEOLOGIC TERRANE IS FAVORABLE OR POSSIBLE FOR THE OCCURRENCE OF METALS LISTED—For example, geologic terranes that include Laramide granitic intrusive rocks but sparse or no known mineral deposits, are considered favorable for undiscovered porphyry deposits and geologic terranes underlain by the Redwall Limestone may contain undiscovered copper-uranium breccia-pipe deposits

AREA WITH VERY SPARSE OR NO KNOWN MINERAL DEPOSITS AND GEOLOGICALLY UNFAVORABLE FOR MINERAL DEPOSITS

AREA CONCEALED BY SUPERJACENT OR SURFICIAL DEPOSITS—Concealed areas immediately adjacent to known mineral deposits may also be favorable for mineral deposits. San Xavier North (**53**) and Mission-Palo Verde (**54**) are examples of concealed deposits

MAJOR MINERAL DEPOSITS

Mineral deposits are numbered from north to south and numbers accompanying symbols are referred to on table 1. The symbol for each type of deposit is shown in two sizes: one for large-size deposits and a smaller one for medium-size deposits (see table 1 for definitions).

53 ● • PORPHYRY DEPOSIT—Mineralization is associated with Late Cretaceous and early Tertiary intrusive and volcanic rocks (Laramide age; 75–55 m.y. old), except at Bisbee where mineralization is associated with Jurassic intrusive rocks

8 ★ ✶ MASSIVE SULFIDE DEPOSIT (EARLY PROTEROZOIC)—Mineralization is associated with volcanic rocks of the Yavapai Series (Early Proterozoic)

45 ◆ ♦ VEIN DEPOSIT—Mineralization is associated predominantly with rocks of Tertiary age, but ranges in age from Precambrian to Tertiary

29 ■ ▪ REPLACEMENT DEPOSIT—Mineralization is associated with rocks of Cretaceous and Tertiary ages that replace carbonate rocks of Paleozoic age

1 ▲ ▴ SEDIMENTARY DEPOSIT—Uranium and vanadium mineralization is associated with rocks of Triassic, Jurassic, and Cretaceous ages and manganese mineralization is associated with rocks of Tertiary age

3 ○ ◦ BRECCIA-PIPE DEPOSITS—Collapse-breccia pipes, such as Orphan (**3**) lode, occur in sedimentary formations from the Redwall Limestone to the Chinle Formation. In breccia pipes of igneous origin, such as Bunker Hill-Copper Creek (**44**), mineralization is associated with Laramide-age intrusive rocks

GEOLOGIC FEATURES RELATED TO MINERAL RESOURCES

GRANITIC ROCKS—Laramide-age intrusive rocks with which porphyry copper and other mineral deposits may be associated

Intrusive rocks

Dikes, sills, and plugs

EARLY PROTEROZOIC METAVOLCANIC AND METAVOLCANICLASTIC ROCKS—Primarily of the Yavapai Series; may contain metavolcanic rhyolite and greenstone that may have potential for volcanogenic massive sulfide deposits such as the Deception Rhyolite at Jerome and the Dick Rhyolite at the Old Dick mine

METAMORPHIC CORE COMPLEX—Domal, archlike, isolated uplifts of anomalously deformed metamorphic and plutonic rocks overlain by detached and distended cover. Within core complexes, in most cases, rocks below detachment faults are unfavorable for mineral deposits; however, faults and sheer zones along and near these detachment faults may be mineralized

COAL BASIN—Hachured line indicates outcrops of coal-bearing strata and encloses area favorable for coal

METALLIC MINERAL SYMBOLS USED ON THE MAP AND IN TABLE 1

Ag	Silver	Mo	Molybdenum
Au	Gold	Pb	Lead
Cu	Copper	U	Uranium
Hg	Mercury	V	Vanadium
Mn	Manganese	W	Tungsten
		Zn	Zinc

PRE-CENOZOIC ECONOMIC PETROLEUM POTENTIAL

By William C. Butler

Factors considered in determining probability of future oil and (or) gas discoveries in pre-Cenozoic strata include: (a) thickness of Paleozoic and Mesozoic sedimentary rocks; (b) thermal maturity of surface strata as indicated by vitrinite reflectance and conodont alteration indices; (c) wells drilled to Precambrian basement and wells that had significant oil or gas shows; (d) outcrop patterns of plutons and Precambrian crystalline rocks (e) structural configuration of Precambrian basement; (f) generalized source-rock stratigraphy (g) inferences from aeromagnetic, Bouguer gravity, and magnetotelluric data; and (h) location of existing oil and gas fields. Sediments of Tertiary and younger age, such as in the Safford and Yuma rift basins, were not considered in relative ranking. Site-specific reservoir rocks, oil migration dynamics, trap characteristics, and amount of land presently under lease by the petroleum industry were factors excluded from the rationale. For petroleum appraisal, the Cordilleran overthrust belt of western United States and the Chihuahua Tectonic belt of Mexico are not perceived to extend northwest to southeast through central Arizona's Mogollon Rim, but are considered to be connected by megashears, or transform-type lineaments, or a subduction (underthrusting) zone at various times in the geologic past.

L LOW

LM LOWER MEDIUM

HM HIGHER MEDIUM

H HIGH

REFERENCES CITED

Keith, S.B., Gest, D.E., Dewitt, Ed, Toll, N.W., and Everson, B.A., 1983, Metallic mineral districts and production in Arizona: Arizona Bureau of Geology and Mineral Technology Bulletin 194, 58 p.

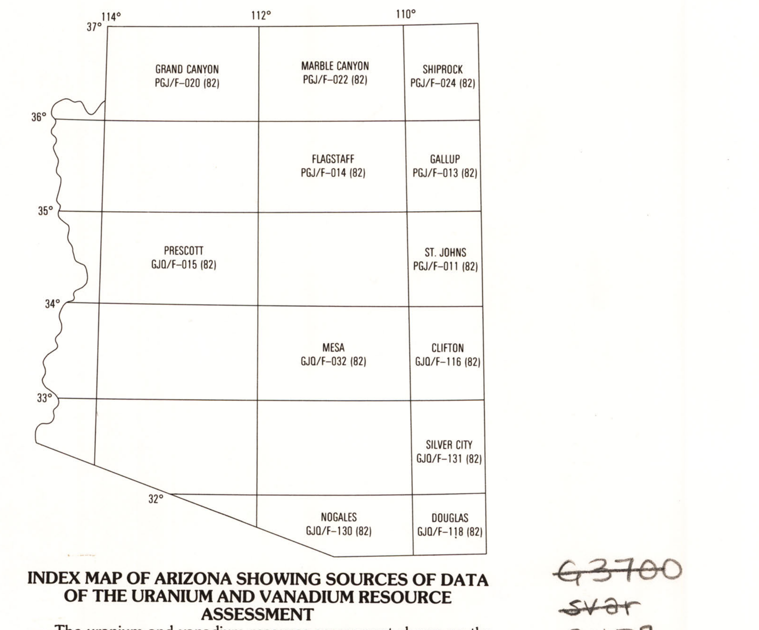
Peterson, J.A., 1984, Arizona mineral resource data: Information available through the U.S. Geological Survey Resources Data System: U.S. Geological Survey Circular 931, 31 p.

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

Table 1.—*Major mineral deposits*

[**Large-size deposits** have produced or have reserves of more than 100 million pounds of Cu, Pb, Zn, or Mn; more than 50 million pounds of Mo; more than one million ounces of Au; more than 50 million ounces of Ag; or more than one million pounds of U and V. **Medium-size deposits** have produced or have reserves of 10 to 100 million pounds of Cu, Pb, Zn, or Mn; 10 to 50 million pounds of Mo; 200,000 to one million ounces of Au; 10 to 50 million ounces of Ag; or more than 10,000 short tons of W. Data on which it was determined whether a particular deposit is large or medium in size are from Keith and others (1983) and from Cox, D.P. (written commun., 1984)]

LARGE-SIZE Deposit and commodity	Map No.	MEDIUM-SIZE Deposit and commodity	Map No.
Porphyry deposits			
Ajo (Cu, Ag)	50	Copper Basin (Cu)	11
Bluebird (Cu)	28	Helvetia-Rosemont (Cu)	59
Cactus (Cu)	27	Palmetto (Pb, Zn)	67
Casa Grande (Cu)	40		
Castle Dome-Pinto Valley (Cu)	25		
Christmas (Cu)	31		
Copper Cities (Cu)	24		
Copper Mountain-Morenci (Cu, Ag)	33		
Dos Pobres (Cu)	34		
Esperanza (Cu, Mo)	57		
Eureka-Bagdad (Cu, Mo)	9		
Globe Hills-Old Dominion (Cu, Au)	23		
Harshaw-Red Mountain (Zn, Pb)	66		
Lakeshore (Cu)	48		
Miami-Inspiration (Cu, Mo)	26		
Mineral Creek-Ray (Cu, Pb)	30		
Mission-Palo Verde (Cu, Mo)	54		
Pima (Cu, Mo)	55		
Sacaton (Cu)	39		
Safford (Cu)	36		
Sanchez (Cu)	37		
San Juan (Cu)	35		
San Manuel (Cu, Mo)	46		
San Xavier North (Cu, Mo)	53		
Sierrita (Cu, Mo)	58		
Silver Bell (Cu, Zn)	51		
Twin Buttes (Cu, Mo)	56		
Vekol (Cu)	49		
Wallapai-Mineral Park (Cu, Zn)	4		
Warren-Bisbee (Cu, Zn)	64		
Vein deposits			
Mammoth (Pb, Zn)	45	Aguila (Mn)	22
Oatman (Au, Ag)	6	Aravaipa (Pb, Zn)	38
		Boriana (W)	7
		Bouse (Mn)	21
		Castle Dome (Pb)	42
		Hualapai-Maynard (Zn, Cu)	5
		Kofa (Au, Ag)	41
		Martinez-Congress (Au, Ag)	19
		Oracle-Camp Bonito (W)	47
		Oro Blanco (Pb, Zn)	68
		Pearce (Ag)	60
		Planet (Cu)	16
		Reef (W)	65
		Rich Hill (Au, Ag)	20
		Swansea (Cu)	17
		Table Mountain (Cu)	43
Massive sulfide deposits			
Big Bug-Iron King (Zn, Pb)	12	Mayer-Bluebell (Cu)	13
Old Dick (Zn, Cu)	10	Zonia (Cu)	14
Verde-Jerome (Cu, Zn)	8		
Replacement deposits			
Pioneer-Superior (Cu, Zn)	29	Banner (Pb, Cu)	32
Cochise-Johnsons Camp (Cu, Zn)	52	Swisshelm (Pb)	62
		Tombstone (Pb, Ag)	63
		Turquoise-Courtland (Cu, Pb)	61
Sedimentary deposits			
Cane Valley-Monument Valley (U, V)	1	Artillery Peak (Mn)	15
Lukachukai (U, V)	2	Lincoln Ranch-Doyle (Mn)	18
Breccia pipes			
Orphan (U, Cu)	3	Bunker Hill-Copper Creek (Cu, Pb)	44



INDEX MAP OF ARIZONA SHOWING SOURCES OF DATA OF THE URANIUM AND VANADIUM RESOURCE ASSESSMENT

The uranium and vanadium resource assessment shown on the accompanying map was taken from reports published by the U.S. Geological Survey as part of the National Uranium Resource Evaluation (NURE) program. The index shows the quadrangle name and the number of the corresponding report that covers it.

METALLIC MINERAL AND MINERAL-FUEL RESOURCE POTENTIAL MAP OF ARIZONA SHOWING MAJOR MINERAL DEPOSITS

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