Arizona Department of Mines and Mineral Resources
Metallogenic Map Series , MM-17
June, 1991

PROGRAM OVERVIEW

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The Metallogenic Province of Arizona Map is the first product in a series designed to study the distribution of metals in Arizona. This map outlines those areas of the State where metallic mineralization is present. Metallogenic zoning maps of each province, with accompanying tables, will be generated in a series of commodity overlays at a 1:250,000 scale.

INTRODUCTION

Metallogeny is the study of mineral deposits in time and space. Much of the data used in metallogenic studies, including mineral assemblages, assays, isotopic dates, relative age inferences, and production data, is fragmentary and reported in different formats for each property. The compiler of a metallogenic study must weight the various components of the data to determine the primary commodity for each property. Usually the compiler weights either production data or mineral assemblage, with or without assays, more strongly depending upon the scale and goal of the project.

Production data is an economic partition of the nature of the deposit that is based upon commodity price, smelter penalties, extraction technology, and government policies at the time of production. This economic information ignores chemical information from prospects. Mineral assemblage with or without assay data are quantifiable variables that provide insight into the nature of the chemistry and geology of a particular metallogenic model. Weighting data between the economic or chemical end members depends on the type of data available, the scale of the metallogenic model, and the final goal of the project. Production data is weighted heavily in classifying deposits or districts in small scale metallogenic models, such as the world metallogenic map, because local variance in metal partitioning even on the district level becomes insignificant. Production statistics also predominate in the creation of exploration metallogenic models for industry, because the economic component of this data is most important.

In a situation where a larger scale metallogenic model is generated, the study of zoning within districts and provinces becomes viable. In this case, the stronger weighting of mineral assemblage with or without assay data allows inferences to be generated concerning the geology and geochemistry of local hydrothermal systems. The large scale nature of the Arizona Mineral Industry Location System (AZMILS) data is appropriate to determine province scale metallogeny and zoning in this program.

PREVIOUS WORK

During the early 1950's, Bilibin updated the concept of metallogeny and generated the first modern metallogenic models at Leningrad State University (Alexandrov, 1968; translation of Bilibin's notes). By the mid-1960's Smirnov and co-workers at Lomonosov State University in Moscow had further modified Bilibin's model (Alexandrov, 1971; translation of Smirnov, 1963), summarized metallogenic concepts and divided the Soviet Union into metallogenic provinces or regions. These provinces were subdivided into metallogenic zones based upon commodity. These zones contained notes constraining the age of mineralization, but no effort was made to derive zonation for metallogenic epochs by this date. Later metallogenic studies concentrated on zonation within epochs, following the availability of precise isotopic dates.

Guild and others (1981) generated the metallogenic map of North America. On this map, various commodities are represented by specific symbols with symbol size representing variations in production. The base map is a geologic summary of rock type, structure, age, and metamorphic condi-

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tions. Combining all the above information together often results in a map that is complex, unreadable, and confusing to the end user.

Keith and others (1983) used production data to delineate metallic mineral districts for Arizona based upon age and style of mineralization. The metallogenic map (scale 1:1,000,000) generated by their study is based upon a geological approach to the subject of mine district definition and suggests that mineral districts are ultimately geological phenomena (Keith and others, 1983). It is an excellent study of elemental distribution in time and space between mineral districts in Arizona. The current project concentrates on elemental distribution between prospects or mines within districts and provinces.

ARIZONA METALLOGENIC MAP SERIES

The concepts of metallogeny pioneered by Soviet geologists are used to generate the metallogenic map series for Arizona. The outline of metallogenic provinces (those areas where metallic mineralization is present) was generated for Arizona exclusive of most of the Colorado Plateau (O'Hara and others, 1989). The outline of the provinces is being generated at 1:250,000 scale (Figure 1) using U.S. Geological Survey base maps. At the 1:250,000 scale, zoning maps are being generated within each province as a series of commodity overlays. These maps are accompanied by tables summarizing AZMILS data for each mine and prospect.

The AZMILS database contains location coordinates and primary commodity (weighed more strongly by mineral as-

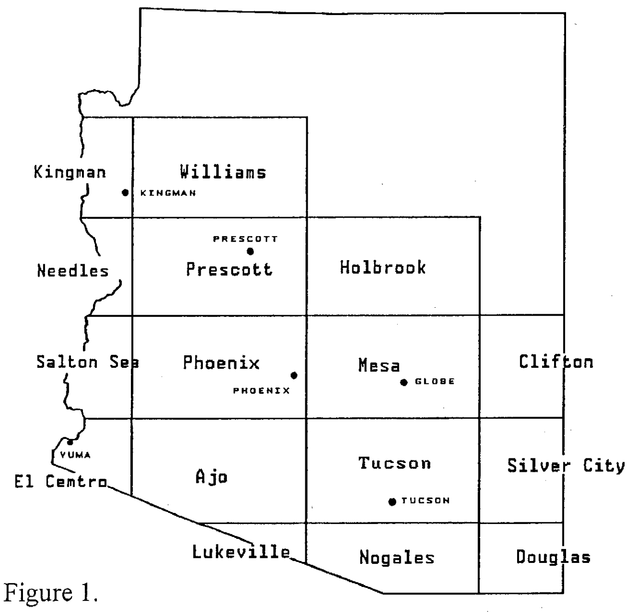

Figure 1.
Location map of 1° X 2°quadrangles included in study area.

semblage with or without assay data) classifications for over 10,000 mines and prospects within Arizona. This database was compiled by the Arizona Department of Mines and Mineral Resources (ADMMR) plus two subcontractors during 1978-1980 for the U.S. Bureau of Mines. ADMMR continues to add information to the database and update the original 1980 database (Niemuth and others, 1989).

These data were compiled by reviewing the ADMMR's mine file collection, the publications of the Arizona Bureau of Geology and Mineral Technology, publications of the U.S. Bureau of Mines and U.S. Geological Survey, and other published and unpublished sources of information on Arizona mineral occurrences. Information cataloged included deposit name(s), commodities, operation type, latitude and longitude, public land survey description, elevation, U. S. Geological Survey topographic map, property file number, and references.

The original data is available from the U.S. Bureau of Mines on mainframe computer tape. The ADMMR has continuously updated the database and organized it by county. It is available from ADMMR either as hard copy or as files on IBM compatible disks. These data were plotted on the county road atlas series maps (scale 1" = 2 miles) of the Arizona Department of Transportation and are available through ADMMR.

In the future, additional maps will be generated at 1:250,000 scale as overlays for comparison with the metallogenic zonation maps. The maps will utilize National Uranium Resource Evaluation (NURE) Hydrogeochemical and Stream Sediment Reconnaissance (HSSR), air radiometric, air magnetic, residual bouguer gravity (Lysonski and others, 1981) as well as Decade of North American Geology (DNAG) ground based gravity and magnetic data (Hittleman and others, 1990).

Site specific areas within several metallogenic provinces will be selected for detailed zonation studies (Ryberg and others, 1991). These studies will be combined with analysis of the U.S. Geological Survey's Mineral Resource Data System (MRDS) to generate zonation maps by age within individual metallogenic provinces (Figure 2). The final study of the AZMILS database in this series will use trend surface analysis to predict potential metallogenic zone extensions under cover for pediment exploration.

The use of base maps with an overlay for each specific data set is preferred to the more complex format of earlier compilations. Earlier maps projected many types of data onto one map that was difficult to use for detailed analysis. The Arizona Metallogenic Map Series uses base maps with overlays for each specific data set. This is preferred, as it allows easy correlation and precise analysis.

METALLOGENIC PROVINCES AND ELEMENTAL ZONATION IN ARIZONA

The Basin and Range and Transition Zone in Arizona are subdivided into over thirty metallogenic provinces. This area, which covers portions of sixteen 1 x 2 degree quadrangles (Figure 1), accounts for the production of 14 million ounces of gold, 70 billion pounds of copper, and significant quantities of other metals.

AZMILS contains primary mineral commodity data for gold, silver, beryllium, copper, fluorine, mercury, lithium, molybdenum, manganese, lead, uranium, tungsten, and zinc. Province boundaries are based upon the presence of metal prospects associated with geologic controls. Distribution of primary element data internally within provinces delineates spatial zonation patterns (Figure 2) that are related to the distribution of magmatic rocks, evolution of hydrothermal fluids, and tectonic features. In some provinces overlap of several ages of mineralization generate complex zoning patterns. In these cases it is necessary to subdivide the data set by age (Ryberg and others, 1991) in order to derive meaningful results (Figure 2).

Some major trends are revealed on the state-wide scale (Niemuth and others, 1989). Gold is concentrated along the

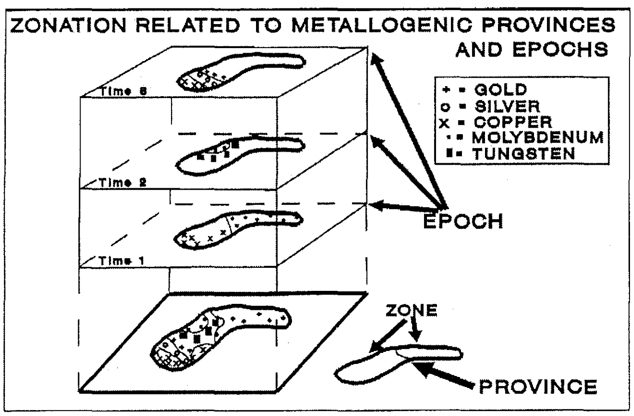

Figure 2.

Colorado River Valley and in the north central Transition Zone, while copper is prevalent in southeastern Arizona. Tungsten, beryllium, lithium, and fluorine are associated predominantly with granitoids in the Transition Zone, while manganese and uranium occurrences are restricted to sedimentary environments.

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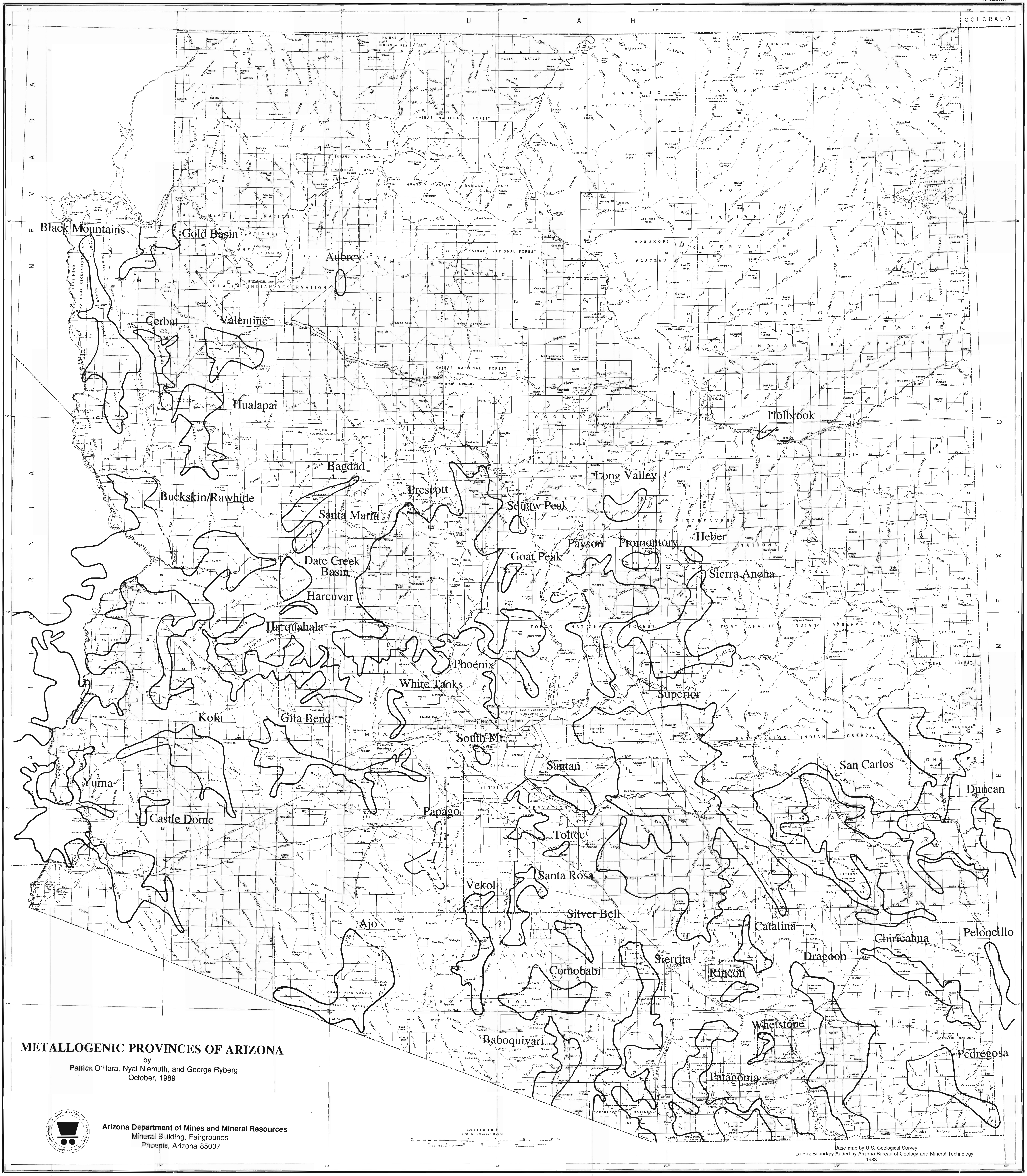

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October, 1989

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Base map by U.S. Geological Survey
La Paz Boundary Added by Arizona Bureau of Geology and Mineral Technology
1983