CHAPTER 1

INTRODUCTION

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This report, the result of a cooperative project between the U.S. Geological Survey and the Nevada Bureau of Mines and Geology, presents both more and less than the title suggests. Not only does the report contain remarkable information about the known and undiscovered mineral resources of Nevada, but it also provides new insights concerning the geologic evolution of Nevada and how it has resulted in mineral wealth.

Nevada's position as the nation's largest silver producer 120 years ago and as the largest gold producer in 1988 is striking considering that over 50% of Nevada's 286,200 km^2 surface is covered with apparently barren rocks and sediments. Because the majority of mineral deposits exposed at the surface are believed to have already been found, a prime concern of this study has been the nature of and the depth to possible mineralized systems under this cover.

Although we recognize the importance and complexity of nonmetallic resources, we have not tried to assess them in this report. Instead, we have focused on estimating where, how many, and what types of metal-bearing mineral deposits remain to be discovered in Nevada. Specific locations of undiscovered resources are not identified, but general regions where deposits could occur are located. Frequency distributions of tonnages and average grades of well-explored deposits of each type are employed as models for grades and tonnages of undiscovered deposits of the same type in geologically similar settings. Estimates of numbers of undiscovered deposits are consistent with the grade and tonnage models.

The goal of this report is to provide an analysis of Nevada's mineral resources that can be used to help plan economic development, consider alternate uses of land, plan exploration, and estimate the availability of minerals under different conditions. Due to the extent of cover, a very important condition affecting the value of minerals in Nevada is the depth to the deposits. Depth affects: (1) the chances of discovery in that deeper deposits are much more difficult (and therefore more costly) to discover, and (2) economic viability in that deeper deposits are significantly more costly to mine. Somewhat arbitrarily, we have limited our analysis to deposits and their permissive geologic environments that occur within the upper 1 km of the earth's crust. This limit means that if any part of a deposit exists in the upper 1 km, it is counted.

The three-part resource assessment form (Singer and Cox, 1988; Singer, 1993) is used because of its ability to respond to each of the diverse problems mentioned above and because it allows the use of a variety of information and resource assessment methods. In three part assessments (fig. 1-1):

1. Areas are delineated according to types of deposits their geology will permit;
2. The number of undiscovered deposits of each type in delineated areas is estimated; and
3. The amount of metal and some characteristics of ore are estimated by means of grade and tonnage models.

Areas or domains are delineated that may contain particular deposit types as inferred by analogy with deposits in similar geologic settings elsewhere. In order to construct the boundaries of these areas it is necessary to have a geologic map and it is desirable to have mineral occurrence, geophysical, exploration, and geochemical information (fig. 1-2). This information must be integrated with information about the geologic environment of different types of mineral deposits to perform the delineation. The keystone to combining the diverse information is the mineral deposit model. Documented deposit models in Bulletin 1693, *Mineral Deposit Models* (Cox and Singer, 1986) and Bulletin 2004, *Developments in Deposit Modeling* (Bliss, 1992) allow linkage of deposit types to geologic environments.

In order to make the connection of deposit type to geologic environment, it is necessary to recognize and map the permissive and relevant geologic settings in Nevada. This is the primary purpose of the sections of this report that address gravity field, magnetic field, pre-Tertiary geology, Cenozoic geology, ages of young volcanic deposits and related mineral deposits, intrusive rocks, neotectonics, and known mineral deposits and occurrences.

The geologic maps used and presented in this report are modified from that published by Stewart and Carlson (1978) in that rock units are grouped to represent geologic environments permissive for different types of mineral deposits. The maps presented here also include new information on the ages of igneous rocks and some changed contacts and unit designations. Because the geologic map represents the geology that is exposed and therefore best known, it is the foundation for most of the other studies reported here.

The analysis of magnetic data (in chapter 2) focuses on the distribution of near-surface magnetic sources in order to delineate bodies of shallowly buried magnetic rock. Typically these are Tertiary and Quaternary volcanic rocks. The information provided by this analysis affects the mineral resource analysis in that certain types of mineral deposits are associated with magnetic rocks.

Many kinds of mineral deposits are genetically related to intrusive igneous rocks. Knowledge of where these plutonic rocks occur is critical in identifying where these types of deposits could exist. A new geophysical tool relying primarily on magnetic data is used to locate unexposed plutonic rocks (chapter 7).

Analysis of regional gravity data is used here (chapter 2) to estimate the thickness of Cenozoic cover and to produce a gravity map from which the effects of thick deposits of

THREE PART MINERAL RESOURCE ASSESSMENT

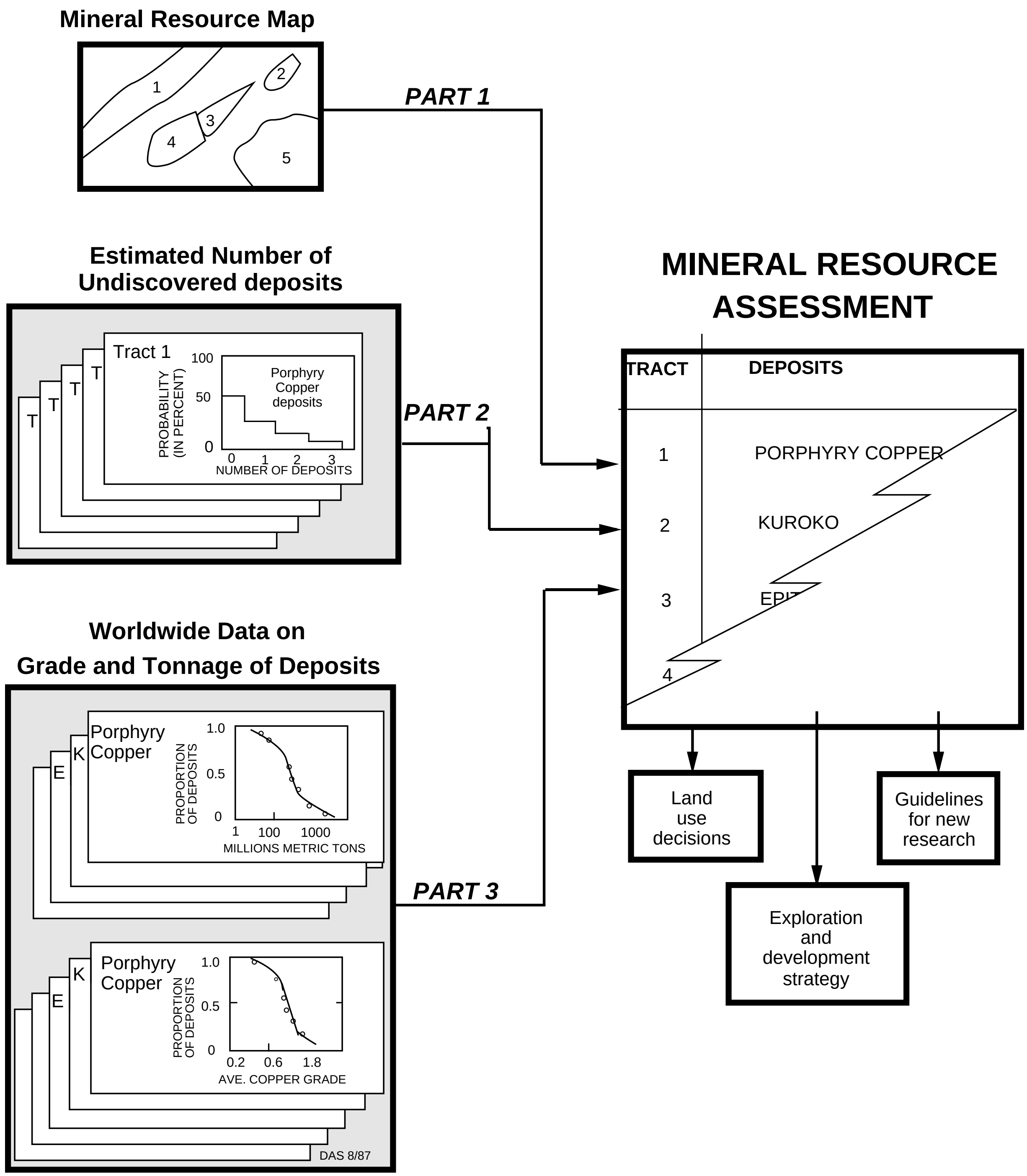

Figure 1-1. Three parts of a quantitive mineral resource assessment.

MINERAL RESOURCE MAP

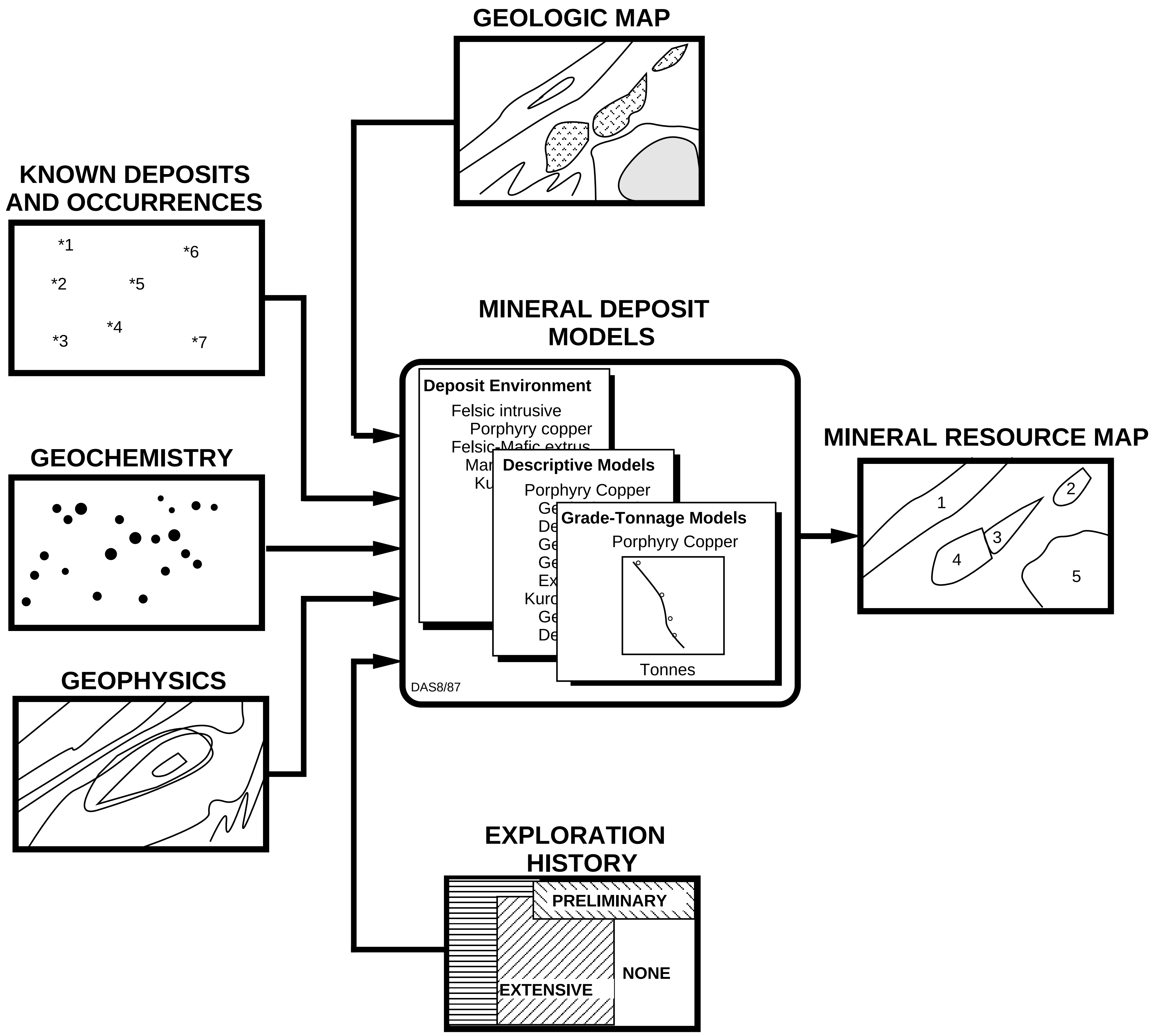

Figure 1-2. Integration of diverse geoscience information by means of mineral deposit models to produce the resource delineation map.

young rock and unconsolidated sediments have been removed. This map is also used to help identify the lithology of the concealed basement, to delineate major crustal structures and boundaries, and to identify plutons and concealed calderas, all of which can reflect geologic environments permissive for certain types of mineral deposits.

Geologic, geomorphic, geophysical, and well-log data are analyzed to infer the approximate subsurface geometry of fault-bounded basins in Nevada. This neotectonic analysis (chapter 8) provides information about the depth of environments permissive for older deposits and about the spatial distributions of younger faults (chapter 9)) and rocks that may be associated with the mineral deposits formed at shallow depths, possibly near faults related to the basins.

In order to explicitly consider depth in this study, we must deal with volumes of rock and must combine the rock units so that they represent consistent geologic environments. A new type of geologic map is required to portray these rock groups (fig. 1-4) because a number of different geologic environments may overlap in the 1 km beneath any given locality on the surface. The complexity of display requires two different maps. The first map of the Pre-Tertiary geology (plate III), shows older rocks that may host mineral deposits related to later igneous activity or may contain coeval mineral deposits. The second map, Cenozoic geology of Nevada (plate IV), concentrates on the young igneous rocks and related calderas which are closely related to many of the mineral deposits of Nevada.

Types of mineral deposits and occurrences that have already been found in specific geologic environments in Nevada (chapter 10) not only confirm that the environments are permissive for the same deposit types, but also suggest the possibility of genetically related deposit types. For the first time, a large number (1,427) of mineral deposits and occurrences in Nevada are classified by deposit type. As noted above, specific geologic environments suggest the possibility of certain types of mineral deposits. The converse is also true; the distribution of different types of known mineral deposits suggest the presence of geologic environments that may not be evident from existing geologic maps.

Ages of young volcanic rocks (chapter 6), when compared with the ages of different kinds of mineral deposits, provide key information about the development and nature of the mineral deposits and also provide new light on the geologic development of Nevada.

The mineral resource analysis portions of this study consist of three maps showing tracts delineated as permissive for most metal-bearing deposit types and an accompanying text that describes the delineations and provides the estimates of the numbers of undiscovered deposits (chapter 12). Part of the resource analysis includes a chapter concerning grades and tonnages of deposits appropriate for Nevada (chapter 11). The analysis was built on each of the other sections and, like the other sections, contains new results that will require many to reexamine their concepts of mineral resources in Nevada.

Each of the following chapters represents the results of the authors' efforts to address part of the overall problem of analyzing and predicting Nevada's mineral resources. Each chapter has its own authorship, but each also reflects the influences of other members of the total group. The analysis in each of these products has been amplified and reinforced by the interdisciplinary nature of the research situation; the interaction has led to products not otherwise obtainable.

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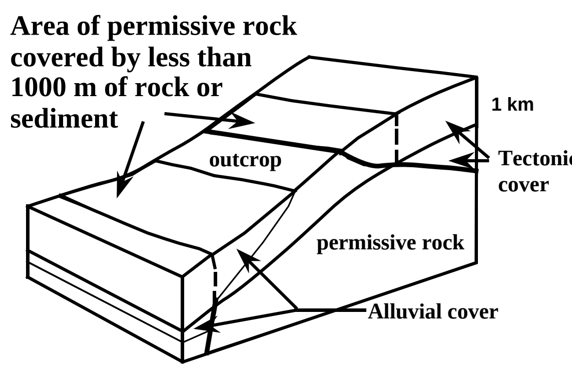

Figure 1-3. Schematic diagram showing the relation between exposed permissive rock and permissive rock covered by less than 1 km of barren rocks and sediment.