

land. Portable X-ray analyzers are also being developed for use in boreholes to determine presence of gold and silver.

(6) Statistical methods using computers for analyzing sample data and preparing mathematical models of ore bodies, which will be essential in developing optimum mining plans.

(7) Laboratory and in-place testing of properties and character of rock mass that will govern design of open pits, selection of equipment and disposal measures.

(8) Laboratory leaching tests on actual gold placer (alluvial) samples to develop in-place mining methods and a new extractant for leaching gold that was recently discovered through Bureau research.

(9) Economic study of a hypothetical open-pit operation which has been programed on a computer to examine varying conditions to determine optimum return.

Geologic mapping has been carried on by the Geological Survey for nearly a century, and this time-tested tool continues to be the backbone of studies of known deposits and of the search for new ore deposits. To understand fully the occurrence and origin of ore deposits, it is necessary to determine their structural and stratigraphic setting, and this can be accomplished only through careful geologic mapping. Once the setting of a known group of deposits has been determined, well-prepared geologic maps are invaluable in choosing favorable structural and stratigraphic sites in which to concentrate the search for new deposits.

Even before inception of the Heavy Metals program, basic geologic mapping paid off handsomely with the discovery of the Carlin gold mine in north-central Nevada. In 1960, R. J. Roberts of the Geological Survey published a report entitled "Alinement of mining districts in north-central Nevada" which was based on several years of geologic mapping in that area. Roberts noted a relationship between ore deposits and the Roberts Mountain thrust fault and suggested that carbonate units in "windows" in this thrust fault would be favorable places to explore for new deposits. Geologists with the Newmont Mining Company studied Roberts report and decided to explore in the Carlin window. Newmont began a drilling program there in 1962 and ultimately discovered an ore body having estimated reserves of 11 million tons averaging 0.32 ounces of gold per ton. Production from this ore body began in 1965.

Analytical methods far more rapid and sensitive than the old slow and costly fire-assay techniques have been developed and several new methods are under investigation. These more sensitive methods are essential to the program because gold is a material of high value and thus low concentrations constitute ore even by standards of the past. "One-ounce" gold ore, the ambition of many a prospector and mine operator, is a concentration of only 34 parts per million and much gold ore containing only one-third this amount is being mined today. Geochemical anomalies of gold, which are essential clues to new deposits, may be in the parts-per-billion range, as might also be the gold ore of the future.

In order to study adequately the gold-bearing conglomerates of northwestern Wyoming, J. C. Antweiler of the Geological Survey developed a technique based on atomic absorption principles that will measure gold in concentrations as low as 10 parts per billion.

Certain "pathfinder" elements, such as mercury and tellurium often accompany gold in ore deposits, and since these elements are more mobile than gold, they often migrate from a deposit into seemingly barren rock and soil above or adjacent to the ore. Thus, detection of anomalous amounts of these elements may be used as a guide in the search for concealed deposits of gold. A sensitive, wet-chemical method for determining tellurium was developed in Geological Survey Laboratories four years ago and more recently there was developed an instrument, based on the principle of atomic absorption, that can detect mercury in concentrations as low as five parts per billion. The instrument can be mounted in a station wagon and is capable of making 60 to 100 analyses per day.

Mobile chemical labs able to operate in remote and rugged areas have revolutionized the search for new ore deposits. The old-time prospector had to rely on slow and costly assays. If he couldn't see it, he couldn't find it. Not so with the modern exploration geologist who can have with him in the field a fully equipped, self-contained mobile chemical laboratory. These labs, developed by the Field Services section, Exploration Research Branch of the Geological Survey, generate their own electricity and contain crushing and grinding equip-