One of the major premises on which the Heavy Metals program is based is that large, low-grade deposits will be identified which may be mined using surface methods. This will require high-tonnage (ranging from 25,000–100,000 tons per day) production systems not presently in use for heavy metals output. (The largest open-pit gold mine at Carlin, Nevada, has a daily production of 2,500 tons.) The Bureau's mining research centers are all doing research that will provide the best methods of fragmentation, ground control, materials handling and waste disposal. These will be integrated through a systems engineering approach to provide the optimum mining method for any given set of conditions. This will be particularly essential when you are mining large, low-grade ores where minimal unit costs are required.

The Bureau of Mines is also devoting a significant effort to developing new techniques of recovering heavy metals. One interesting aspect of this work by the metallurgical research groups is that of in situ leaching, or solution mining, as it is sometimes called. This technique consists of passing a leaching agent through an alluvial deposit which will bring the heavy metal into solution. This metal-bearing solution must then be collected and treated to recover the gold or other heavy metals. The obvious advantage of such a system is that it could totally eliminate the mining costs (including disposal). There are potential disadvantages, principally that of water pollution if toxic leaching agents such as cyanide are used. The Bureau's metallurgy research center at Reno has developed a new leaching agent of minimal toxicity which is presently undergoing comprehensive testing.

The Bureau of Mines also is presently involved in a two-pronged economic analysis of the possibilities of increasing gold production at a price of $35 an ounce from known mining properties through research resulting in mining cost reductions. One part of the study is concerned with developing an economic model of the gold industry which will make it possible to simulate the effect on total U.S. gold production and reserves of a given percentage reduction in a certain general category of mining cost. This national model will point to the general type of cost category, for either lode or placer mines, which will give the greatest increase in U.S. gold production from a given percentage cost reduction, as well as point to the geographic area of the country that can provide such production increases. The second part of the study is concerned with developing detailed engineering and economic models for each type of mining system (i.e. open pit, placer dredging, underground methods, etc.). These models are designed to simulate, in detail, the effect of a reduction in specific types of costs upon the rate of return of a mining property. Depending upon the specific type of mining system applicable to the particular properties in the geographic areas pointed out by the national model, the detailed information concerning these properties can be derived and used in the relevant micro-economic and engineering model. This model will then point to the specific mining costs, which if they are reduced by a certain percentage will increase the rate of return of the properties enough to make them profitable at a $35-an-ounce price for gold. The cost data indicated in the model will serve as a guide to the areas in which research efforts should be concentrated.

Expected benefits

The Heavy Metals program is relatively new and its ultimate benefits cannot yet be predicted with any certainty. To date, however, work under the program has led to the discovery of an ore deposit at Cortez, Nev., which contains at least 660,000 ounces of gold; to identification of substantial marginal resources in the Cripple Creek district of Colorado; and to recognition of large submarginal resources in conglomerates of northwestern Wyoming.

USE OF NUCLEAR EXPLOSIVES IN MINERAL EXTRACTION

Situation and outlook and technical objectives

The depletion of high-grade mineral reserves and the growth of our population have made necessary the utilization of increasingly lower grade mineral deposits to sustain an expanding economy. So far, improvements in technology have met these demands admirably. However, the economic limits of existing technology are rapidly being reached in many areas of mineral extraction and processing, and further marked advances are necessary if we are to continue to have available the variety and quantities of mineral products that we require.

Utilization of nuclear explosives offers a key to an assured future supply. Moreover, while such utilization may make possible economic extraction of