

resources will have important economic and social benefits and should be pursued energetically. In a geographic sense, areas of low employment or below-average economies deserve a priority of attention.

(See section on aluminum.) The potential employment of clays as aluminum ores would completely alter traditional use-patterns and demand production of many millions of tons of clay (particularly kaolin and fireclay types) above presently projected totals. Aluminum (alumina) from this source is already the subject of substantial research effort and, in view of the impact upon supply-demand relationships for aluminum, deserves continued attention. In particular, more specific knowledge is required of the precise location of clay deposits that are of the required size and quality to support the production of alumina.

Most clays are produced from open-pits and the industry is particularly susceptible to increasing land-use conflicts. Zoning regulations, waste disposal and pollution factors will affect the economics of production in a growing number of instances. Devising practices that minimize the instances of such conflict demands immediate and concerted attention.

Price (cost) changes have substantial relationships to use of several of the clay types and, incidentally, to employment levels in the industry. Inquiries and innovations that would tend to reduce extraction (mining) costs would be particularly effective in this regard.

COBALT

Occurring essentially as a coproduct in ores processed mainly for other metals—like copper, nickel and iron—the rate of cobalt production is a function of other commodity production. Only a small percentage of domestic needs are met from domestic sources, and this is likely to be the future pattern, too. The degree of reliability of major foreign sources is difficult to predict and, in the case of this commodity, in particular, some improvement, however small, in the domestic productive capacity would tend to minimize future recurring supply problems. In particular, the development of new or better ways of concentrating, extracting, and producing metal from low-grade ores and cobalt-bearing scrap merits attention. Two major non-technical uncertainties affect producers and consumers alike and discourage development of alternate sources: the political instability of the Congo; and the surplus cobalt in United States Government stockpiles (5 years supply). The effect of recent sales from the stockpile has been to reduce imports by 50 percent over recent months.

On the world market cobalt supplies will tend to exceed requirements as production of copper and nickel increases and shifts to ores with higher cobalt content. Presuming that costs will concurrently decrease, the question of substitutability for other alloying metals deserves attention in the interest of minimizing reliance on the commodity for specialized uses, reducing requirements for other commodities with spot supply problems, and broadening use-patterns.

The opportunity to substitute advanced technology for reliance on the uncertainties of the geography of indigenous mineralogical occurrence is particularly attractive in this instance (see item 4, nickel). The marine environment promises a fairly universal source. While data are speculative, the apparent economic margin is such that relatively minor technological developments would permit commercial exploitation. Among all metallic commodities (not in solution) identified in the marine environment, cobalt would seem to deserve a priority of attention.

The association of nickel and cobalt continues to present either technologic or economic problems in effecting separation, and recovery of the latter is relatively poor. Moreover, the effective separation of cobalt from secondary sources, either for the purpose of winning the cobalt or eliminating it from other associated metals, is difficult and costly. Problems in this area will increase as cobalt use is diversified and as it finds its way into more end products. The problem of effectively separating closely associated metals, at costs that are commercially attractive, is general to the problem of recycling metals and minimizing waste. It deserves particular attention in this instance.

Technology for recovery of cobalt from laterites could extend and diversify world resources (see section on chromium).

COLUMBIUM

The recent evolvement of pyrochlore as a major source of columbium has substantially expanded the world reserve concepts and ultimate production patterns but the United States will continue to rely almost entirely upon imports for its