Phases and Processes

HIGHLIGHTING CURRENT
DEVELOPMENTS IN METALS

The Columbium Supply

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Columbium is rapidly becoming the best-known refractory metal. Its reputation is well founded, for government, universities, and a large number of major companies in basic industries are active in its technology. Their interest is based on high confidence in its versatile future—in jet and rocket engines, in nuclear reactors, in space vehicle structures, and in a variety of less-glamorous uses.

Most refractory metals are fairly scarce. This causes potential users to hesitate before moving into refractory metals for any massive application. Scarcity also guarantees a high price picture. Until recently, columbium was no exception. However, new data show columbium can step out of the traditionally *rare* role of most refractory metals, and will be positively available in quantity.

NATURAL OCCURRENCE

Reactive and refractory metals of interest for space and nuclear applications have the following relative abundance in the earth's crust, using zirconium as a basis, and including nickel for comparison:

Relative Availability of Reactive and Refractory Metals				
Information Source				Calculated from MAB Report
Mason	Urey	Gold-schmidt		
Zr	100	100	100	100
Cr	91	59	81	—
Ni	36	28	33	—
W	31	9	10	—
Cb	11	0.5	5	30
Mo	3	4	7	3
Hf	2	1	1	—
Ta	1	0.2	0.3	3

Depending upon the information source, columbium is 0.5 to 30 pct as available as zirconium. Urey, himself, who originated the lowest abundance estimates for columbium, throws doubt on his own data. Gold-schmidt's data has been the standard until now. However, the MAB report is based on extensive new ore findings, making it the most reliable document available. For the present, it seems conservative and proper to consider the abundance of columbium in the earth's crust to be 30 pct of zirconium, which is about the same as nickel.

RESERVES

Several estimates of actual free-world columbium ore reserves have been compiled recently. Of these, the most recent and authoritative appears to be the two Materials Advisory Board reports, *Summary Report of the Committee on Refractory Metals* and a second volume, *Report of the Committee on Refractory Metals*. Representatives of leading US industrial companies, research organizations, and universities contributed to provide these consensus reports on various aspects of refractory metals technology. The *Summary Report* makes several facts clear about reserves, as follows:

1) The metal content of known mineral resources of non-communist countries "provides a total of 7 million tons of columbium metal contained in such reserves." This is more than Mo, V, W, and Ta combined, and only Cr and Zr are more plentiful;

2) The 7-million short tons of presently-known ore reserves is equivalent to 4 million tons of mill products;

3) The "known deposits of columbite- and pyrochlore-containing ores have not been completely explored, and the probable potential may be much greater"; and

4) Major reserves are in Nigeria, Brazil, Canada, Uganda, Tanganyika, Kenya, Norway, and the United States. "The Brazilian deposits of columbium in the form of pyrochlore are the world's greatest known resources."

In addition to this information, the more detailed MAB report which includes a large section entitled, *The Panel Report on Columbium and Tantalum*, makes other facts clear. This report states that the estimated South American ore reserves of Wah Chang Corp., a leading US producer, are approx 4 million tons of contained columbium. Work to prove these reserves is progressing, and the numbers given are now believed to be conservative. Another South American source may have about 5 million ton reserves. Continental US has about 100,000 short tons of proven reserves held by duPont, and Canada 500,000 tons, held by a variety of mining companies.

The Western Hemisphere sources,

obviously of importance to the US for strategic reasons, are about four times richer in columbium than the rest of the world combined.

SEPARATION OF PYROCHLORES

The majority of the Western Hemisphere ores are of the pyrochlore-type, from which it is more difficult to separate columbium than the traditional columbites, usually imported from Africa. However, several US and Canadian companies now have commercially-feasible separation processes, although at the present time these processes are presumed to be expensive compared to separation from columbite. Ultimately, they will be competitive.

PRICE AND PRODUCTION

A relatively large number of US companies are marketing, or are active in some other commercial aspect of columbium metal.

Delivery of experimental quantities to consumers has been excellent for the last two to three years. The leading companies are confident in their ability to supply potential engine, airframe, space, and nuclear power plant needs.

In 1956, the price of *high purity* sheet was about \$100 to 125 per lb. The principal US producer was Fansteel, utilizing powder metallurgy processing. Now, arc-melting and electron-beam melting processes have been introduced and have a heavy share of the market. Bar and sheet, of improved quality over the 1956 product, cost in the neighborhood of \$35 per lb, down from \$65 per lb less than 18 months ago.

The MAB Summary Report estimates 1000 tons per year production is attainable in two years, and 10,000 tons per year attainable in two to five years, providing pyrochlore ores are expolited more completely, controlled-atmosphere rolling mills are developed, and alloy sheet rolling improves. At maturity of the industry (10,000 tons per year), a price of \$5 per lb is predicted. This means that columbium will be down to the price level of zirconium and molybdenum (\$10 to \$20 per lb) in a very few years. Columbium is fabricated with less difficulty than zirconium and less scrap loss occurs; so, a maturity price considerably less than for zirconium and near titanium does, indeed, seem feasible.