promise abundant supply if technologic improvements in extraction and processing can overcome certain economic disadvantages.

In a major end-use application, pigments, numerous substances vigorously compete with titanium for present and foreseeable expanding markets. Process improvements that promise cost advantages or product improvement would tend to insure a share of this market for titanium pigments. Adoption of a hydrochloric acid method for pigment production by all newly constructed titania plants, coupled with steadily increasing demand for titanium metals, has created unprecedented demands for rutile (TiO_2).

The unique properties of the metal foretell expanding and diversified use. Such expansion will be magnified by technologic improvements that affect cost reduction in metal production, forming or fabrication.

Secondary recovery from nondissipative forms is, at present, accomplished effectively. However, diversified uses and volume will present future problems in handling and processing scrap and alloys.

The known occurrences of commercial deposits of ilmenite and rutile in beach sands suggests that additional resources of titanium minerals may be found offshore and conceivably may be commercially workable. It also seems likely that rutile in significant quantities may occur both on and offshore along beaches in many countries and new discoveries of workable deposits, especially in Africa, appear probable.

Only about 2 percent of the material mined from sand deposits for titanium minerals is recovered, the remainder being mud and slimes consisting of silica, kaolin and organic matter. Some 11-acre feet of this waste material are generated each month in Florida and impounded in large mud lakes. Hence, it seems certain that the potential for expanding operations in Florida because of solid waste and land use conflicts will soon become severely limited.

Tungsten

Except for production as a coproduct of molybdenum, and an instance or two where tungsten is produced as a primary objective, known domestic sources do not compete effectively with foreign sources in normal domestic or world markets. Moreover, known domestic resources are not large in comparison to present or projected demands. With the exception of the resources of China and certain other locations presently not considered available the extent of known world resources available at reasonable costs in relation to projected requirements is uncomfortably small. Improvments in extraction and processing techniques that offer cost reductions in the employment of low grade ores would permit some expansion in domestic production. The specter of a potential flood of low cost tungsten from China tends to discourage investment in the development of higher cost sources.

The real domestic resources position is not fully understood. Under government incentive programs in the mid-1950's, approximately 750 mines produced tungsten in the United States. The exact circumstances under which any of these or others could again become productive is subject to considerable speculation.

The unique properties of tungsten promise increased demand in all of the three predominant end-use forms; alloys, carbides, and metal. Substitution, even at increased price levels, is not likely to modify the demand to any substantial degree. However, advancement in the procedures and technology for recovering tungsten from scrap, worn out end products and other secondary sources would substantially extend supplies.

The marine environment offers some potential for diversifying sources of supply (see section on nickel). Similarly, minute quantities known to be present in certain brines would, if shown to be commercially recoverable, improve the long-term supply outlook.

Processes that depart from traditional extraction through utilization squences might, if shown to be technologically feasible, minimize certain economic advantages presently attaching to low grade occurrences. Specifically, advances made in producing metal or carbide directly from concentrates or impure compounds promise much if the metals associated with the tungsten can be simultaneously recovered.

Better ways of reducing oxidation of tungsten at elevated temperatures would extend the end-use life, and indirectly the supply, of the commodity. Similarly, means of accommodating to the absence of ductility at normal temperatures would improve efficiencies in consumption.