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RECOVERY OF NICKEL AND COBALT BY REDUCTION AND LEACHING

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This invention relates to the recovery of nickel, and also cobalt if the same be present, contained in iron-bearing oxygenated mineral ores including silicate ores and other ores which have been brought to an oxidic form by roasting or an equivalent process. In a most important embodiment, it relates to a method of treating nickeliferous, lateritic serpentine type mineral either alone or in combination with nickeliferous, lateritic limonite ore whereby a high yield of nickel may subsequently be obtained therefrom by ammoniacal leaching, the process being especially adapted to those lateritic ores containing up to about 2 percent nickel which cannot be economically treated by the conventional smelting process ordinarily applied to high-grade nickel ores.

It has already been proposed in the literature that nickel be extracted from high-grade nickeliferous garnierite ore, in which the nickel occurs as a hydrated silicate containing nickel (about 6%) and usually also iron oxides, by heating the same at high temperatures in the presence of a reducing gas, and that the products obtained be treated with solutions of ammonium compounds to recover nickel. Whereas these prior processes are said to lead to the recovery of a substantial proportion of the nickel, they are not satisfactory for the treatment of low-grade ores, for the processes could not be operated to remove more than about 70 percent of the nickel content, thereby leaving much of the nickel in the residue from such treatment.

A modification of this prior process described in U.S. Patent No. 2,400,098 to Vas Hubert Brogdon and assigned to Nicaro Nickel Company involves as its feature the controlled simultaneous decomposition and reduction of hydrous silicate ore carried out by raising the temperature to a level between 1200° and 1400° F. at a rate not greater than about 6° F. per minute. This method has the disadvantage of requiring an elaborate furnace system to effect adequate control of temperatures and gas compositions, and of requiring means for supplying large amounts of reducing gas. In actual practice of said process on a large scale, it is difficult if not impossible to control the furnace conditions such as to secure recoveries of better than 70% of the nickel.

An object of the present invention is to secure a more complete reduction of the nickel of the serpentine content of the ore than has been possible by prior processes. Another object of the invention is to secure more complete selective reduction of the nickel and cobalt content of the ore than has heretofore been possible.

A further object is to make unnecessary the use of a producer gas or a reducing gas as such for reducing the nickel content of the core. Another object is to permit the use of simple furnace equipment or to increase the capacity of existing types of equipment.

An ultimate object is to provide a process whereby the quantity of nickel recovered from ores may be increased and whereby the nickel recovered from low-grade ores may amount to as much as 95% leaving as little as 0.2% or even 0.1% nickel in the residue.

Broadly expressed, the invention may be considered to involve processes for recovering nickel, and also cobalt if the same be present, from iron-bearing nickeliferous oxygenated ores and concentrated ores derived therefrom wherein the ore is heated in finely divided form in a non-oxidizing atmosphere in the presence of a hydrocarbon, preferably a hydrocarbon oil or other mixture, added to the ore, up to and at a temperature at which the nickel (and cobalt if present) is reduced to a form selectively soluble and leachable from the iron content in a leaching step later to be applied, the amount of hydrocarbon used being carefully controlled such that it is adequate to reduce the nickel and cobalt content but not the iron to the soluble state, and after said reduction step is completed the ore is cooled and leached in known manner. The reduced mass is particularly amenable to the selective recovery action of known ammoniacal leach operations accompanied by aeration wherein the reduced nickel and cobalt contents are dissolved and are separated from the gangue containing the iron.

The process of the invention is applicable to the treatment of iron-bearing nickeliferous oxygenated ores in general and concentrates derived therefrom. It is particularly applicable to low-grade lateritic, serpentine and limonite ores and mixed ores containing both of these minerals. It is also applicable to asbolite ores such as are found in New Caledonia and concentrates of the same.

The leaching processes of the present invention are applicable to oxidic minerals other than those hereinbefore disclosed including ores found in Brazil, Venezuela, New Caledonia, the Philippines, and Indonesia.

The hydrocarbons operable in the present invention may be any such non-gaseous compound or mixture of compounds of sufficiently high molecular weight or low volatility that the hydrocarbon is not vaporized off before the temperature employed in effecting the reduction is reached. The preferred hydrocarbon is Bunker C fuel oil, this oil not only being effective in accomplishing the desired reduction but also it is low in cost. Other hydrocarbons at least as heavy as those classified as fuel oils may also be employed including lubricating and cylinder oils. Another important class of hydrocarbons are bituminous materials which liquefy at some temperature below about 600° F. but do not volatilize appreciably below this temperature and which liquefy during the step of heating and reducing the nickel and cobalt, examples of these solid or semi-solid materials being residues and natural products such as asphalts, asphaltites, tars, pitches, and mineral waxes. Furthermore, coal, either hard or soft, and other solid hydrocarbons may be employed, but these solids are less efficient than the other hydrocarbons mentioned.

The amount of hydrocarbon used in any particular operation depends generally upon the amount of nickel, cobalt and iron present in the ore being treated. The amount preferably utilized may be described as that amount of hydrocarbon which will bring about the reduction of the nickel and cobalt content to a leachable state while leaving the iron in a state insoluble in the leach solution to be used. With the proper amount of hydrocarbon present, the nickel and cobalt but not the iron will be reduced to the metallic state or substantially to such state. If excessive hydrocarbon is present the iron also will be reduced to the metallic form or to a form also soluble in the leach solution. The amount can be approximated by calculating the quantity of hydrocarbon required to provide the reducing action required to convert the nickel and cobalt compounds to metallic nickel and the ferric oxide to ferroso-ferric oxide through balanced equations recording the chemical reactions involved. Since the theoretical reducing action is not quantitatively attained, an excess of hydrocarbon is actually required. The optimum amount of hydrocarbon which should be used in any specific operation of the process can be determined by test.