

## GLOSSARY

**Agglomeration** . . . . . The formation of a lump by the coalescence of smaller globules, refers to briquetting, nodulizing, sintering, etc.

**Alumina** . . . . . Aluminum oxide processed from bauxite ore; used as raw material in aluminum production.

**Anode** . . . . . In copper, nickel, cobalt and zinc production a rectangular metal plate with positive charge cast in a shape suitable for refining by the electrolytic process. In the electrorefining process the anode is made of the impure metal to be refined and in the electrowinning process it is made of material inert in the process.

**Anode furnace** . . . . . A copper (or more seldom nickel) refining furnace, in which blister copper (or impure nickel) is fire refined.

**Anode slime** . . . . . Metals or metal compounds left at, or falling from, the anode during electrolytic refining, normally containing gold, silver and platinum group metals.

**Atmospheric reactor** . . . . . A hydrometallurgical reactor working at normal atmospheric pressure.

**Autoclave** . . . . . A hydrometallurgical reactor working at elevated pressure and temperature.

**Bacterial leaching, bioleaching** . . The extraction of metals from their ores or concentrates using microorganisms. Microbial technology offers an economic alternative for the mining industry, at a time when high-grade mineral resources are being depleted.

**Ball mill** . . . . . A steel cylinder containing steel balls used to grind ore. The mill is rotated causing the balls to cascade and grind the ore.

**Base metals** . . . . . Metals usually considered to be of lower value, such as copper, lead, zinc and nickel, when compared with the noble metals gold, silver and platinum.

**Bauxite** . . . . . The main ore of aluminum.

**Beneficiation** . . . . . The treatment of mined material, making it more concentrated or rich.

**Blast furnace** . . . . . A tall, refractory lined vertical shaft furnace for the production of pig iron or hot metal for direct conversion into steel.

**Brownfield** . . . . . Brownfield investments are carried out at the existing site consisting mainly of expansion, modernization and maintenance.

**Calcination, calcining** . . . . . Heating ores, concentrates, precipitates or residues to decompose carbonates, hydrates or other gas forming compounds.

**Carbon plant** . . . . . Plant for the production of baked anode blocks, for use in the

aluminum smelting electrolysis process. The “carbon plant” is made up of the sectors: green anode plant, anode baking plant, carbon scrap recycling plant and rodding shop.

**Cathode** . . . . . In copper, nickel, cobalt and zinc production, a rectangular metal plate with a negative charge used in electrolytic refining. The deposited metal recovered onto this plate is called cathode metal and is melted and cast into commercial shapes such as bars, ingots or rod.

**Cathode copper** . . . . . Electrolytically refined copper that has been deposited on the cathode of an electrolytic bath of acidified copper sulfate solution. Such sheet formed copper is usually marketed in bundles of approximately 2.5 tons.

**Caustic** . . . . . Sodium hydroxide solution, used for the extraction of alumina from bauxite in the Bayer process.

**Chromite** . . . . . An isometric chromium containing oxide ore mineral; also in black sands, the major source of chromium.

**Chromium** . . . . . An element that increases the hardenability of steel and in association with high carbon gives resistance to wear and abrasion. Chromium has an important effect on corrosion resistance and is present in stainless steels in amounts of 12 percent to 20 percent.

**Circulating fluidized bed (CFB), fluidized bed (FB)** . . . . . A bed of small solid particles suspended and kept in motion by an upward flow of a fluid (as a gas). In CFB — in contrast to the conventional stationary fluid bed (FB) — the bed is continuously renewed by circulating the solids with gas stream in a controlled way. Fluidized-bed roasters have found wide acceptance because of their high capacity and efficiency.

**Clarifier** . . . . . A settling tank or other vessel for separating suspended solid matter from a liquid to produce clean liquid.

**Concentrate** . . . . . A mineral product containing valuable metals from which most of the waste rock has been separated.

**Concentrator, concentrating plant** . . . . . A plant for the recovery of valuable minerals from ore in the form of concentrate. Located typically at the mine site, adjacent to the mine.

**Converting** . . . . . In pyrometallurgy a process of removing impurities from molten metal or metallic compounds by blowing air through the melt. The impurities are transformed either to gaseous compounds, which are removed by volatilization, or to liquid compounds which are removed as slags.

**Conversion process** . . . . . A hydrometallurgical process in which a less noble metal element in a sulfidic ore or concentrate having no value (e.g., iron) is substituted by a more noble, valuable metal element (e.g., copper, nickel) dissolved in the solution; thus enriching the ore or concentrate. Outokumpu Technology has developed unique processing technologies based on this process.

**Crude steel** . . . . . The first solid steel product upon solidification of liquid steel in a steel mill.

**Direct leaching** . . . . . A hydrometallurgical processing technology that directly dissolves

metals from sulfidic concentrates in a special leaching process without normal preceding pyrometallurgical treatment.

**Direct reduction** . . . . . An iron making process in which iron oxide pellets and/or lump iron ore, are reduced (oxygen removed) in solid state by a reducing gas, producing direct reduced iron (DRI). Only high-grade ores and pellets are suitable for direct reduction.

**DRI (direct reduced iron)** . . . . . Solid metallic iron product obtained upon direct reduction of high grade iron ore in solid state itself without being converted into liquid form like that in blast furnace.

**Direct smelting** . . . . . A pyrometallurgical process involving coal based direct smelting and reduction of iron ore to produce reduced molten pig iron that may be immediately refined to steel. Direct smelting is a new alternative process for hot metal production to substitute the conventional capital intensive blast furnace process.

**Downstream** . . . . . Processes that occur later on in a production sequence, for example, from ore to metal.

**Effluent** . . . . . Generally considered to be pollution, such as the discharge from industrial works.

**Electrolysis** . . . . . An electrochemical process in which electric current is passed through a solution containing dissolved metals (electrolyte), causing the metals to be deposited onto a cathode.

**Electrolytic refining, electrorefining** . . . . . A hydrometallurgical process to refine metals, typically copper, by electrochemically dissolving the impure metal (as cast) anode into to the acidic electrolyte and coincidentally precipitating it selectively onto the cathode as pure metal.

**Electrowinning** . . . . . A hydrometallurgical process in which a valuable metal, typically copper, nickel, cobalt or zinc, dissolved in the acidic electrolyte is selectively recovered as pure metal by electrochemically depositing it on the cathode.

**EPC** . . . . . Engineering, procurement and construction.

**EPCM** . . . . . Engineering, procurement, and construction management.

**Extraction** . . . . . In mining and metallurgical industry, a term describing commonly separating and upgrading steps or series of steps in the production chain of a desired metal from ore towards pure metal.

**Feasibility study** . . . . . An engineering study designed to define the technical, economic, and legal viability of a capitalization project — like a mining project — with a degree of predicted reliability.

**Ferroalloy** . . . . . Metal alloy products such as ferrochrome, ferronickel, ferromolybdenum that are commonly used as tradeable raw materials for alloying in steel making.

**Ferrous metals** . . . . . A classification of a certain group metals commonly having chemical and physical properties next to iron, in addition to iron itself, such as chromium, manganese and vanadium.

**Fire refining** . . . . . A pyrometallurgical process used for the removal of impurities from impure molten metals produced by the smelting process by introducing air and possibly fluxes into the molten metal.

**Flash converting** . . . . . A process whereby copper concentrate is first smelted in a primary smelting furnace to produce high-grade copper matte. The finegrained ground solid matte is oxidized and smelted in the flash converting furnace to blister copper and slag using pure oxygen or high oxygen enrichment.

**Flash smelting** . . . . . A smelting process in which dried metal sulfide concentrates are blown with oxygen or oxygen-rich air in a hot hearth-type furnace such that the particles react rapidly with the oxygen to generate a large amount of heat, partially (controlled) oxidizing the concentrates and producing a molten matte phase containing the metal values, which will be further processed, and a molten slag.

**Flotation, froth flotation** . . . . . A method of separating metal-containing minerals from gangue, by adding chemicals to a pulp mixture of water and mineral rendering metal-containing minerals hydrophobic. The hydrophobic particles will cling to introduced air bubbles which pass through the mixture thus separating them from other particles.

**Flow sheet** . . . . . An illustration showing the sequence of operations, step by step, in the production chain.

**Flue gas desulfurization** . . . . . A technology that employs a sorbent, usually lime or limestone, to remove sulfur dioxide from the gases produced by burning fossil fuels. State-of-the art technology for major sulfur dioxide emitting power plants.

**Fluidized bed (fluid bed, FB)** . . . See circulating fluidized bed.

**Froth control** . . . . . A control system dedicated to enhancing the performance of the flotation process.

**Galvanizing** . . . . . A chemical process that is used to coat steel or iron with zinc to reduce corrosion.

**Green anode plant** . . . . . Plant sector in the primary aluminum smelter to produce “green” (that is, “raw” or unbaked) anode blocks from calcined petroleum coke or recycled carbon material, using liquid coal tar pitch as binder These blocks are used — after baking — as consumable anode in the aluminum smelting electrolysis.

**Greenfield** . . . . . Greenfield investments are carried out at a site where no mining or metals processing activity is carried out by the time of the investment.

**Grinding** . . . . . Size reduction into fine solid particles in a mill

**Heap leaching** . . . . . A hydrometallurgical process whereby valuable metals, usually copper or gold, are leached from a heap of crushed ore by continuously irrigated leaching solution percolating down through the heap dissolving the metal and subsequently collected from a sloping, impermeable liner below in the form of a pregnant leach solution.

**Hot metal** . . . . . Molten carbon saturated raw iron (pig iron) tapped from a blast furnace or from a direct smelting furnace to be sent to the following steel making process.

**HydroCopper** . . . . . A new hydrometallurgical process developed by Outokumpu Technology for producing high-quality copper directly from sulfidic copper concentrate using chloride leaching.

**Hydrometallurgy** . . . . . The treatment of ores, concentrates, and other metal-bearing materials by aqueous based wet chemical and physical processes, usually involving leaching, leach solution purification and desired metal(s) recovery as the main process steps.

**Ilmenite** . . . . . Iron and titanium bearing oxide mineral; the major valuable mineral for titanium; also in mineral sands.

**Indurating** . . . . . A pyrometallurgical process whereby unfired pellets are hardened at high temperature in an indurating furnace to give them mechanical strength for transportation and for further downstream processing.

**Industrial minerals** . . . . . Usually non-metallic minerals used in industry and manufacturing processes in their natural state, for example clays, silica sand, talc, limestone/chalk, gypsum and potash.

**IPR** . . . . . Intellectual property rights.

**Laterite** . . . . . Red soil developed in humid, tropical, and subtropical regions of good drainage, contains concentrations of iron oxides and hydroxides and aluminum hydroxides and can be exploited due to its aluminum, manganese, or nickel contents — depending on the composition of the laterite.

**Leaching** . . . . . Dissolution from ore or concentrates typically after suitable comminution to expose the valuable minerals, by aqueous and chemical attack targeting to get desired metals into the solution. If heat and pressure are used to intensify or speed this, the work is called pressure leaching.

**Lime saturator** . . . . . A device that makes clarified saturated lime solution for drinking water plants.

**Lump ore** . . . . . Beneficiated high-grade ore in a lumpy form (typically 8-30 mm in diameter) for further downstream processing; in contrast to the finegrained ore concentrate. Term used especially in iron, ferrochrome and ferromanganese production.

**Magnetic separation** . . . . . Separation of magnetic materials from non-magnetic materials, using a magnet. An important process in the beneficiation of iron ores to separate magnetite from other minerals.

**Matte** . . . . . An intermediate product of a smelter, being a mixture of metals (e.g., iron and copper or/and nickel and cobalt) with some contained sulfur. It must be further refined to obtain the pure metal.

**Metallurgical feedstock** . . . . . Raw material supplied to a metallurgical processing plant.

**Metallurgy** . . . . . Science/art of extracting metals from their ores. Also used to refer to the science of metals processing.

**Mineral deposit** . . . . . A mineral occurrence of sufficient size and grade that it might, under favorable circumstances, be considered to have economic potential.

**Mineral** . . . . . An inorganic compound occurring naturally in the earth's crust, with a distinctive set of physical properties, and a definite chemical composition.

**Ore** . . . . . A mineral deposit that can be mined economically.

**Oxide** . . . . . A compound of oxygen with another element. Also referring to a mineral compound characterized by the linkage of oxygen with one or more metallic elements, such as iron (magnetite) and chromium (chromite).

**Paste thickener** . . . . . A thickener, which concentrates solids much higher than conventional and high rate thickeners, but with an underflow that can be pumped. As an alternative to filtration, paste thickening offers additional water recovery compared to conventional thickening in a continuous process and is therefore a good method in dry areas.

**Pellet** . . . . . Spherical agglomerates (typically 8-18 mm in diameter) made (pelletized) of fine-grained particles to allow the suitability of the material for more beneficial downstream processing.

**Pelletizing** . . . . . A method in which fine-grained moist material is rolled in a drum or on an inclined disk, so that the particles cling together and roll up into small, spherical pellets. The addition of a binder may be required to produce a pellet of acceptable mechanical strength. The green ore concentrate pellets are practically always heat hardened (sintered) for the same reason. Pelletizing is used especially for iron and chromite ore fines.

**Permanent cathode** . . . . . Stainless steel plates (approximately 1m x 1m) used as reusable cathodes for copper electrorefining and electrowinning processes. High-quality permanent cathodes made of special stainless steel are used to maximize the productivity of the copper refinery. Permanent cathodes simplify the production and offer a better operational safety and enhanced working environment in the refinery.

**Physical separation** . . . . . Covers a wide range of techniques, such as magnetic, electrical, thermal, gravity and dense medium separation, filtration and liberation, which are applied to mineral beneficiation, waste treatment and recycling.

**Pig iron** . . . . . The product of the blast furnace.

**Pilot plant** . . . . . A non-commercial scale plant in which processing steps are systematically investigated under conditions simulating a full production unit to obtain engineering and other data needed, establish finished product technical specifications, or design special equipment required by a new or improved production process.

**Pressure leaching** . . . . . See leaching.

**Pyrite** . . . . . The most common iron sulfide mineral. An important gold bearing mineral and a source of sulfur for sulfuric acid production. Occurs commonly also in sulfidic copper ores.

**Pyrometallurgy** . . . . . Metallurgical operations that involve processing at temperatures above ambient conditions, generally involving chemical reactions, for example fluid bed roasting of zinc concentrates, smelting of copper concentrates and fire refining of blister copper.

**Recovery** . . . . . The amount of ore, mineral or element finally obtained through various processes in relation to its original amount. Usually expressed in percentage.

**Reduction** . . . . . In chemistry and metallurgy strictly, the process step when an element captures electrons and reduces to a lower reduction stage; meaning for metal elements closer to metallic stage. In practical pyrometallurgical terminology, removal of oxygen from oxygen-containing compounds (oxides).

**Refining** . . . . . The removal of impurities from a metal to be refined. Both pyrometallurgical and hydrometallurgical refining methods are used.

**Roasting** . . . . . In pyrometallurgy, a pre-treatment process at elevated temperature to oxidize the ore or concentrate to be more suitable for the following downstream processing. Roasting is in practice most often conducted with air (oxidizing roasting); called dead roasting when thoroughly done for sulfidic concentrates and sulfatizing roasting if the valuable metals are transformed to (water soluble) sulfates.

**Rod mill** . . . . . A mill for fine grinding, somewhat similar to the ball mill, but employing long steel rods instead of balls as the grinding medium.

**Rodding shop** . . . . . Plant sector in the primary aluminum smelter to process used anode assemblies, separate the bath (flux) and carbon residue, recondition the metallic electric current conductor bar ("rod"), and seal the "rods" into new baked carbon anode blocks for use in the aluminum electrolysis.

**RTD** . . . . . Research and technology development.

**Selenium** . . . . . A non-metallic element that closely resembles sulfur in its properties. A typical by-product recovered when processing copper concentrates; reporting at the end to copper anode slime in the copper electrorefining process. Recovered as a part of anode slime treatment process called selenium process.

**Sinter** . . . . . In pyrometallurgy, baked agglomerates of fine-grain particles that stick together in roughly one to two-inch lumpy chunks to allow more suitable downstream processing. Typically used for iron ore concentrates and iron containing dust collected from the blast furnaces.

**Sintering** . . . . . A pyrometallurgical process used to agglomerate fine ore. This is necessary because in their original condition fine ores would choke the downstream processing furnace (e.g., blast furnace).

**Slag** . . . . . The vitreous mass of molten glass-like material separated floating from the molten metals in the smelting, converting or fire refining process. Slags, insoluble in the metal, typically absorb desired impurities or/and protects the molten metal from oxidizing and/ or cooling by losing radiant heat. The composition of slag is carefully adjusted with additives called fluxes.

**Slime treatment** . . . . . Anode slimes are the metals or metal compounds left at, or falling

from, the anode during electrolytic refining of metals, typically copper. These metals, often gold, silver and platinum group metals, are recovered in an anode slime treatment process.

**Slurry sampling** . . . . . Sampling of water or a liquid containing a high concentration of suspended solids. Often referring to sampling of different process phases of a flotation sequence in a minerals processing plant (concentrator).

**Smelting** . . . . . A pyrometallurgical thermal processing operation in which the metal (or matte) is separated in molten form from non-metallic materials or other undesired metals with which it is associated. Smelting always includes coincidentally necessary and desired chemical reactions, melting typically not or in a much lesser degree.

**Solution purification** . . . . . An essential part of hydrometallurgical processing chain, after the first leaching step, where impurities are separated by different means from the leach solution containing also the desired main metal. As an example in the zinc leaching process also other metallic components nobler than zinc like copper, cobalt, nickel and cadmium are leached and must be removed in the solution purification process before final electrowinning to recover pure zinc.

**Solvent extraction (SX)** . . . . . A wet chemical/hydrometallurgical process to extract selectively desired species, typically desired dissolved metal, from an aqueous pregnant leach solution (PLS) with the aid of a reagent dissolved in an organic solvent phase (insoluble in the PLS). PLS and organic solvent, typically kerosene, are first mixed intensively together in a mixer where the desired metal is captured from the PLS to the organic phase by the reagent in the latter phase. Lighter, water insoluble organic phase with the now dissolved desired metal is next let to separate on the top in a settler and then removed for the following stripping stage. The desired metal is stripped, through the adjustment of acidity (pH), from the organic phase as pure to a new aqueous phase for final recovery—typically electrowinning (EW) for copper and zinc.

**Spent acid regeneration** . . . . . A recovery process that re-produces sulfuric acid from contaminated, used (spent) sulfuric acid. Costs are much higher compared to the acid produced from conventional raw materials, but sometimes it is more economical than the ecologically acceptable disposal of spent acids.

**Stripping machine** . . . . . A device for removing the refined metal, typically copper or zinc, from the (permanent) cathode.

**Sulfide** . . . . . A mineral compound characterized by the linkage of sulfur with a metal (or metals) or semimetal (semimetals), for example, pyrite.

**Sulfur dioxide** . . . . . Poisonous gas, which has a pungent, irritating odor and which is a typical by-product of a (copper, nickel, zinc) sulfide smelter used as raw material for consequent sulfuric acid production.

**Sulfuric acid** . . . . . A dense, colorless liquid base chemical of the chemical industry. Used extensively for production of fertilizers and to leach stockpiles of oxidized copper ore. Sulfuric acid is primarily produced as a byproduct of smelting, but it is also be generated by other means starting from elemental sulfur.

**Synthetic rutile** . . . . . A synthetic tetragonal oxide mineral in which titanium replaces iron; an intermediate raw material of titanium.

**Tank farm** . . . . . A plant section between solvent extraction and electrowinning phases in hydrometallurgical copper production, used for circulating the solvents and purifying the electrolyte.

**Thickening** . . . . . The concentration of the solids in a suspension with a view to recovering (most of) the solids in a fraction (underflow) with a higher concentration of solids than in the original suspension.

**Titanium** . . . . . A metallic element found in nature only in compounds; occurs chiefly in ilmenite, rutile and titanite.

**Traveling grate** . . . . . A type of furnace in which assembled links of grates are joined together in a perpetual belt arrangement, typically used for iron ore sintering and pelletizing.

**Upstream** . . . . . Early activities of the production chain, for example, mine to metal value chain.