Table 1. Systems-Deposits-Commodities-Critical Minerals Table for the Earth Mapping Resources Initiative.

[±, present (absent); —, not applicable; ?, maybe; Ag, silver; Al, aluminum; As, arsenic; Au, gold; B, boron; Ba, barium; Be, beryllium; Bi, bismuth; Br, bromine; Ca, calcium; Cd, cadmium; Co, cobalt; CO_2, carbon dioxide; Cs, cesium; Cr, chromium; Cu, copper; F, fluorine; Fe, iron; Ga, gallium; Ge, germanium; Hf, hafnium; Hg, mercury; I, iodine; IAEA, International Atomic Energy Agency; In, indium; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IS, intermediate sulfidation; K, potassium; LCT, lithium-cesium-tantalum; Li, lithium; Mg, magnesium; Mn, manganese; Mo, molybdenum; Na, sodium; Nb, niobium; Ni, nickel; NYF, niobium-yttrium-fluorine; P, phosphorus; Pb, lead; PGE, platinum group elements; R, replacement; Rb, rubidium; Re, rhenium; REE, rare earth elements; S, skarn; Sb, antimony; Sc, scandium; SE, selenium; Sn, tin; Sr, strontium; Ta, tantalum; Te, tellurium; Th, thorium; Ti, titanium; Tl, thallium; U, uranium; V, vanadium (in “Principal commodities” column); V, vein (in “Deposit types” column); W, tungsten; Y, yttrium; Zn, zinc; Zr, zirconium]

[1] Elements in **bold** have been produced from some deposits, whereas those in *italics* are potential critical minerals.

System name	Synopsis	Deposit types	Principal commodities	Critical minerals[1]	Reference(s)
Placer (riverine-marine, residual-eluvial-alluvial- shoreline, paleo)	Placer systems operate in drainage basins and along shorelines where there is either topographic relief and gravity-driven turbulent flow of surface water or tidal and wind-driven wave action. Placer systems concentrate insoluble resistate minerals liberated from various rock types and mineral occurrences by the chemical breakdown and winnowing away of enclosing minerals by the movement of water. The distribution of insoluble resistate minerals is controlled by their size, density, and the turbulence of fluid flow.	**Gold**	Au	—	Sloan, 1964; Levson, 1995; Van Gosen and others, 2014; Sengupta and Van Gosen, 2016; Jones and others, 2017; Wang and others, 2021
		Uraninite, autunite-group minerals	U	**U**	
		PGE	PGE	**PGE**	
		Cassiterite	Sn	**Sn**, *Sc*	
		Wolframite/scheelite	W	**W**, *Sc*	
		Barite	Barite	**Barite**	
		Fluorite	Fluorite	**Fluorite**	
		Monazite/xenotime	REE, Y, Th	**REE**	
		Columbite/tantalite	Nb, Ta	**Nb, Ta,** *Mn*	
		Zircon	Zr, Hf	**Zr, Hf**	
		Ilmenite/rutile/leucoxene	Ti	**Ti**, *Sc*	
		Magnetite/hematite/goethite	Fe	—	
		Diamond	Diamond gems and abrasive	—	
		Sapphire	Sapphire gems	—	
		Garnet	Garnet gems and abrasive	—	
Chemical weathering (unsaturated zone, in situ)	Chemical weathering systems operate in stable areas of low to moderate relief with sufficient rainfall to chemically dissolve and concentrate elements present in various rock types and mineral occurrences by the downward percolation of surface water in the unsaturated zone. Chemical gradients cause different elements to be concentrated at different positions in the weathering profile and at the water table. Bauxite, Ni-laterite, and carbonatite laterite are restricted to tropical climatic zones; others form in temperate and arid climates. Dissolved uranium is reduced on carbonaceous material in lakes and swamps. Dissolved manganese precipitates at redox interfaces in lakes.	**Nickel-cobalt laterite**	Ni, Co	**Co**, *Mn, Sc*	Otton and others, 1990; Long and others, 1992; Marsh and others, 2013; Foley and Ayuso, 2015; Bruneton and Cuney, 2016; Sanematsu and Watanabe, 2016; IAEA, 2020; Wang and others, 2021
		Bauxite	Al	**Al**, *Ga, REE*	
		Clay	Kaolin	*Ga, Li, REE*	
		Carbonatite laterite	Nb, REE	**Nb, REE**, *Sc*	
		Regolith (Ion adsorption) REE	REE	**REE**, *Sc*	
		Surficial uranium	U	**U**	
		Lacustrine carbonaceous uranium	U	**U**	
		Coal uranium	U	**U**	
		Lacustrine manganese	Mn	**Mn**	
		Supergene (and laterite) gold	Au	—	
		Supergene silver	Ag	*?*	
		Supergene lead	Pb	*?*	
		Supergene zinc	Zn	*?Ge, Ga, In?*	
		Supergene (and exotic) copper	Cu	*?Te, Bi?*	
		Supergene cobalt	Co	**Co**	
		Supergene PGE	PGE	**PGE**	
		Supergene manganese	Mn	**Mn,** *Co*	
		Supergene iron	Fe	*Mn*	
Meteoric recharge	Meteoric recharge systems operate where oxidized meteoric groundwater displaces reduced connate water in sandstone aquifers that often contain volcanic ash or where such groundwater evaporates at the surface. As oxidized water descends through sandstone aquifers, it scavenges uranium and other elements from detrital minerals and (or) volcanic glass. Uranium and other elements precipitate at the redox front with reduced connate water, on carbonaceous material in the aquifers, or at the surface in calcrete by evaporation. In granite, descending oxidized meteoric groundwater leaches uranium from zircon, apatite, and other minerals that precipitate by reactions with ferrous Fe minerals. In ultramafic rocks, dissolved CO_2 in descending meteoric groundwater reacts with Mg-silicates to form magnesite, which may also precipitate in permeable sediment or rocks nearby.	**Sandstone uranium**	U, V	**U, V, Re, Sc, REE, Mn,** *Co , PGE*	Zachmann and Johannes, 1989; Skirrow and others, 2009; Breit, 2016; Bruneton and Cuney, 2016; Hall and others, 2019; IAEA, 2020
		Carbonate uranium	U, V	**U, V, Re, Sc, REE,** *Co , PGE*	
		Calcrete uranium	U, V	**U, V,** *Sr*	
		Granite uranium	U	**U**	
		Cryptocrystalline magnesite	Mg	**Mg**	
Meteoric convection	Low-sulfidation Au-Ag deposits associated with mantle plume volcanic rocks form under relatively low oxygen and sulfur fugacities, and have low base metal contents and high Au/Ag ratios and selenium contents. Low-sulfidation deposits also occur along extensional fault zones that are not associated with proximal, coeval magmatic activity.	**Low sulfidation epithermal gold-silver**	Au, Ag, Hg, Sb	**Sb**, *Te*	Simmons and others, 2005; John and Henry, 2020
		Low sulfidation epithermal antimony	Sb	**Sb**	
		Low sulfidation epithermal mercury	Hg	—	
Lacustrine evaporite	Lacustrine evaporite systems operate in closed drainage basins in arid to hyperarid climatic zones. Elements present in meteoric surface, ground, and geothermal recharge water are concentrated by evaporation. As salinity increases, evaporite minerals typically precipitate in the following sequence: gypsum or anhydrite, halite, sylvite, carnallite, borate. Nitrates are concentrated in basins that accumulate sea spray. Residual brines enriched in lithium and other elements often accumulate in aquifers below dry lake beds. Li-clay and Li-B-zeolite deposits form where residual brine reacts with lake sediment, ash layers, or volcanic rocks.	**Trona**	Soda ash (Na_2CO_3)	—	Dyni, 1991; Sheppard, 1991a,b; Williams-Stroud, 1991; Orris, 1995; Warren, 2010; Bradley and others, 2013; Hofstra and others, 2013b; Munk and others, 2016; Bradley and others, 2017b; Power and others, 2019
		Gypsum	Gypsum ($CaSO_4{\cdot}2H_2O$)	—	
		Salt	Salt (NaCl)	—	
		Potash	Potash (KCl)	**Potash**	
		Carnallite	Carnellite ($KMgCl_3{\cdot}6H_2O$)	**Potash, Mg**	
		Magnesite	$MgCO_3$	**Mg**	
		Borate	Borax, boric acid	*Li*	
		Nitrate	[Na, K, Ca, Mg][NO_3 nitrate, IO_3 iodate, BO_3 borate]	*Mg*	
		Residual brine	Salt, potash, borax, boric acid, soda ash, sodium sulfate, Li, Rb, Cs, Mg, Mn, Sr, Br, I, W, Zn	**Potash, Li,** *Mn, Rb, Cs, Mg, Sr, W*	
		Lithium clay	Li	**Li**	
		Lithium-boron zeolite	Zeolite, B, Li	*Li*	
Marine evaporite	Marine evaporite systems operate in shallow restricted epicontinental basins in arid to hyperarid climatic zones. Sabkha dolomite and sedimentary magnesite form in coastal salt flats and lagoons. Elements present in seawater are concentrated by evaporation. As salinity increases, evaporite minerals typically precipitate in the following sequence: gypsum or anhydrite, halite, sylvite. Residual basin brines are enriched in conserved elements, such as Mg and Li. Incursion of freshwater or seawater can produce halite dissolution brines.	**Sabkha dolomite**	Building stone, aggregate, Mg	**Mg**	Raup 1991a,b; Mountney, 2005; Warren, 2010; Horn and others, 2017
		Sedimentary magnesite	Mg	**Mg**	
		Gypsum	Gypsum ($CaSO_4{\cdot}2H_2O$)	—	
		Salt	Salt (NaCl)	—	
		Potash	Potash (KCl)	**Potash**	
		Dissolution brine	Petroleum, salt (NaCl)	—	
	Basin brine path systems emanate from marine evaporite basins and extend downward and laterally through permeable strata to discharge points in the ocean. Limestone is replaced by reflux dolomite at low	**Basin brine**	Petroleum, salt, potash, Li, Rb, Cs, Mg, Sr, Br, I, Zn	**Potash**, *Li, Rb, Cs, Mg, Sr*	
		Reflux and hydrothermal dolomite	Building stone, aggregate, Mg	**Mg**	

Basin brine path	temperatures and hydrothermal dolomite at high temperatures. Basin brines evolve to become ore fluids by scavenging metals from various rock types along gravity-driven flow paths. The mineralogy of the aquifers controls the re-dox and sulfidation state of the brine and the suite of elements that can be scavenged. Cu- and Pb-Zn sulfide deposits form where oxidized brines encounter reduced S. Unconformity U deposits form where oxidized brines are reduced. Ba and Sr deposits form where reduced brines encounter marine sulfate or carbonate.	**Zinc-lead** (MVT and sedex)	Zn, Pb, Ag, Cu, Co	**Sn, Ge, Co,** *Ga, In*	Cox and Singer, 2007; Skirrow and others, 2009; Alpine, 2010; Leach and others, 2010; Hayes and others, 2015; Emsbo and others, 2016a; Marsh and others, 2016; Johnson and others, 2017; Manning and Emsbo, 2018
		Copper (sed-hosted and replacement)	Cu, Co, Ag, Pb, Zn	**Co, PGE, Re, Ge, Ga,** *V, U*	
		Uranium (unconformity and breccia pipe)	U, V, Cu, Co, Mo, Re, Se, Sc, REE	**U, V, Re, Sc, REE,** *Co*	
		Barite (replacement and bedded)	Barite (witherite)	**Barite**	
		Strontium (replacement and bedded)	Sr (celestite, strontianite)	**Sr**	
Marine chemocline (bathtub rim)	Marine chemocline systems operate where basin brines discharge into the ocean. Consequent increases in bioproductivity produce metalliferous black shales. Changes in ocean chemistry (oceanic anoxic events) and development of chemoclines result in chemical sedimentation of phosphate and Mn and Fe carbonates and oxides.	**Black shale**	Stone coal, petroleum, V, Ni, Mo, Au, PGE	**V,** *Re , PGE, Cr, U*	Lefebure and Coveney, 1995; Force and others, 1999; Emsbo, 2000; Emsbo and others, 2015, 2016b; Cannon and others, 2017
		Phosphate	Phosphate fertilizer	*F* **,** *REE, Cr, U*	
		Iron-manganese	Fe, Mn, Co	**Mn, Co**	
		Superior iron	Fe	*Mn*	
Petroleum	Ni and V in poprhyrin complexes are the most abundant metals in plant and animal remains in source rocks and in derived petroleum. Helium is produced by radioactive decay of U and Th in felsic igneous rocks and siliciclastic rocks derived from them. It is released by magmatic heat and (or) fracturing and accumulates in gas reservoirs below an impermeable seal.	**Petroleum**	Asphalt, Petroleum, V, Ni	**V**	Magoon and Dow, 1994; Hunt, 1996; Brennan and East, 2015; Craddock and others, 2017; King, 2020
		Natural Gas	Natural gas, He	**Helium**	
Hybrid magmatic REE / basin brine path	This hybrid system operates where CO_2- and HF-bearing magmatic volatiles condense into basinal brines that replace carbonate with fluorspar ± barite, REE, Ti, Nb, Be as in the Illinois-Kentucky Fluorspar District and Hicks Dome.	**Fluorspar**	Fluorite	**Fluorite**, *barite, REE, Ti, Nb, Be*	Plumlee and others 1995; Denny and others, 2015, 2016; Hayes and others, 2017
Arsenide	Arsenide systems form in continental rifts where deep-seated, oxidized, metal-rich, metamorphic basement brines ascend to shallow levels. Native elements (Ag, Bi, As), Ni-, Co- and Fe-mono-, di- and sulf-arsenides precipitate by reduction as hydrocarbons, graphite, or sulfide minerals are oxidized to form carbonates and barite.	**Five element veins**	Ag, As, Co, Ni, Bi, U, Sb	**Co, Bi, U,** *As, Sb*	Kissin, 1992, Markl and others, 2016; Burisch and others, 2017; Scharrer and others, 2019
Volcanogenic seafloor	Volcanogenic seafloor systems are driven by igneous activity along spreading centers, back-arc basins and magmatic arcs. In spreading centers and back-arc basins, seawater evolves to become an ore fluid by convection through hot volcanic rocks. In magmatic arcs, ore fluids exsolved from subvolcanic intrusions may mix with convecting seawater. Ore deposits form where hot reduced ore fluids vent into cool oxygenated seawater. Sulfides and sulfates precipitate in or near vents. Mn and Fe precipitate at chemo- clines over wide areas in basins with seafloor hydrothermal activity.	**Copper-zinc sulfide**	Cu, Zn	*Co, Bi, Te, In, Sn, Ge, Ga, Sb*	Levson, 1995; Shanks and Thurston, 2012; Monecke and others, 2016; Cannon and others, 2017; DSM Observer, 2020
		Zinc-copper sulfide	Zn, Cu	*Ge, Ga, Sb, Co, Bi, Te, In, Sn*	
		Polymetallic sulfide	Cu, Zn, Pb, Ag, Au	*Sn, Bi, Te, In, Ge, Ga, Sb, As*	
		Barite	Barite	*Barite*	
		Manganese oxide (layers, crusts, nodules)	Mn, Fe, Ni	**Mn,** *Co, Ge , Te, REE , Sc*	
		Algoma iron	Fe	?	
Orogenic	Metamorphic dewatering of sulfidic volcanic and (or) sulfidic, carbonaceous, and (or) calcareous siliciclastic sequences during exhumation with fluid flow along dilatant structures. Iron minerals in host rocks are often sulfidized. Metavolcanic host rocks often contain volcanogenic seafloor sulfide deposits.	**Gold**	Au, Ag	**W,** *Te, As, Sb*	Groves and others, 1998; Gray and Bailey, 2003; Goldfarb and others, 2005, 2016; Luque and others, 2014
		Antimony	Sb, Au, Ag	**Sb**	
		Mercury	Hg, Sb	*Sb*	
		Graphite	Graphite (lump)	**Graphite (lump)**	
Coeur d'Alene-type	Metamorphic dewatering of moderately oxidized siliciclastic sequences during exhumation with fluid flow along dilatant structures. Metasedimentary host rocks may contain basin brine path Pb-Zn and Cu±Co deposits.	**Polymetallic sulfide**	Ag, Pb, Zn, Cu	**Sb, Co,** *Ge, Ga, In*	Wallace and Whelan, 1986; Leach and others, 1988, 1998; Beaudoin and Sangster, 1992, 1996; Balistrieri and others, 2002; Zartman and Smith, 2009; Hofstra and others, 2013a; Seal and others, 2017; IAEA, 2020
		Antimony	Sb	**Sb**	
		Uranium	U	**U**	
Metamorphic	Metamorphic systems recrystallize rocks containing organic carbon or REE phosphate minerals or uranium minerals. Crystalline magnesite forms by carbonation of peridotite.	**Graphite** (coal or carbonaceous sed)	Graphite (amorphous and flake)	**Graphite (amorphous and flake)**	Sutphin, 1991a,b,c; Luque and others, 2014; McKinney and others, 2015; Sutherland and Cola, 2016; Robinson and others, 2017; Menzel and others, 2018; IAEA, 2020
		Magnesite	Mg	**Mg**	
		Gneiss REE (monazite, xenotime)	Th, U, REE, Y	**REE**, *U*	
		Gneiss uranium	U	**U**	
Porphyry Cu-Mo-Au	Porphyry copper-molybdenum-gold systems operate in oceanic and continental magmatic arcs with calc-alkaline compositions. Aqueous supercritical fluids exsolved from felsic plutons and the apices of subvolcanic stocks form a variety of deposit types as they move upward and outward, split into liquid and vapor, react with country rocks, and mix with groundwater. The broad spectrum of deposit types results from the large thermal and chemical gradients in these systems.	**Greisen**	Mo, W, Sn	*W, Sn*	Seedorff and others 2005; John and others, 2010, 2017; Sillitoe, 2010; Taylor and others, 2012; John and Taylor, 2016; London, 2016; Wang and others, 2021
		S-R-V tungsten	W	**W, Bi,** *Mn, Sc*	
		Porphyry/skarn molybdenum	Mo, W, Sn	*W, Re, Bi*	
		Porphyry/skarn copper	Cu, Au, Ag, Mo	**PGE, Te, Re, U, Sc,** *Co, Bi*	
		Skarn iron	Fe, Cu	*Ge*	
		Skarn magnesite	Mg	**Mg**	
		R-V manganese	Mn	**Mn**, *Co*	
		Polymetallic sulfide S-R-V-IS	Cu, Zn, Cd, Pb, Ag, Au	*Mn, Ge, Ga, In, Bi, Sb, As, W, Te*	
		Distal disseminated silver-gold	Ag, Au	*Sb, As*	
		High sulfidation gold-silver	Cu, Ag, Au	*As, Sb, Te, Bi, Sn, Ga*	
		Intermediate sulfidation antimony	Sb, Hg	**Sb**, *As*	
		Lithocap alunite	Al, K_2SO_4 (potash)	*Al,* K_2SO_4*, Ga*	
		Lithocap kaolinite	Kaolin	*Ga*	
Alkalic porphyry	Alkalic porphyry systems form in oceanic and continental magmatic arcs and in continental rifts by similar processes from fluids exsolved from more fractionated alkalic plutons and stocks. Resulting ore deposits tend to be more enriched in Au, Te, Bi, and V.	**Greisen**	Mo, Bi	*Bi*	Jensen and Barton, 2000; Kelley and Spry, 2016; Wang and others, 2021
		S-R-V tungsten	W	**W**, *Bi, Mn, Sc*	
		Porphyry/skarn copper-gold	Cu, Mo, Au	*PGE, Te, Bi*	
		Polymetallic sulfide S-R-V-IS	Au, Ag, Pb, Zn, Cu	*Ge, Ga, In, Bi, Te*	
		Fluorspar	Fluorite	**Fluorite**	
		Distal disseminated silver-gold	Ag, Au	*Sb, As*	
		High sulfidation	Cu, Ag, Au	*Te, Bi, As, Sb*	
		Low sulfidation	Au	*Te, Bi, V, F*	
		Lithocap alunite?	Al, K_2SO_4 (potash)	*Al,* K_2SO_4*, Ga*	
		Lithocap kaolinite?	Kaolin	*Ga*	
Porphyry Sn (granite-related)	Granite-related porphyry Sn systems form in back-arc or hinterland settings by similar processes from fluids exsolved from more crustally contaminated S-type peraluminous plutons and stocks. At deep levels, LCT pegmatites emanate from plutons. Resulting ore deposits tend to be Cu and Mo poor and enriched in Li, Cs, Ta, Nb, Sn, W, Ag, Sb, and In.	**Pegmatite LCT**	Li-Cs-Ta	**Li, Cs, Ta, Nb, Sn, Be**, *Sc*	Panteleyev, 1996; Sillitoe and others, 1998; Černý and Ercit, 2005; Martin and Devito, 2005; London, 2008, 2016; Bradley and others, 20171a; Kamilli and others, 2017; Hulsbosch, 2019; Wang and others, 2021
		Greisen	Sn, W, Be	**Sn, W, Be**, *Sc*	
		Porphyry/skarn	Sn, W, Be	**Sn, W, Be**, *Sc*	
		Polymetallic sulfide S-R-V-IS	Cu, Zn, Pb, Ag, Au	*Sn, Mn, Ge, Ga, In, Bi, Sb, As*	
		Distal disseminated silver-gold	Ag, Au	*Sb, As*	
		High sulfidation	Cu, Ag, Au	*Sn, Sb, As, Te, Bi*	
		Lithocap alunite	Al, K_2SO_4 (potash)	*Al,* K_2SO_4*, Ga*	
		Lithocap kaolinite	Kaolin	*Ga*	
		Pegmatite LCT	Li-Cs-Ta	**Li, Cs, Ta, Nb, Sn, Be,** *Sc*	

Reduced intrusion-related	Reduced intrusion-related systems form in continental magmatic arcs by similar processes from fluids exsolved from calc-alkaline plutons and stocks that assimilated carbonaceous pyritic country rocks. Resulting ore deposits tend to be poor in Cu, Mo, and Sn and enriched in W, Au, Ag, Te, Bi, Sb, and As.	**Gold**	Au, Ag	*Te, Bi, Sb, As*	Hart, 2007; Nutt and Hofstra, 2007; Luque and others, 2014; Wang and others, 2021
		Greisen-V tungsten	W, Mo	**W**, *Sc*	
		Skarn copper-molybdenum-tungsten	W, Mo, Cu, Au, Ag	**W**, *Te, Bi, Re*	
		Polymetallic sulfide S-R-V-IS	Au, Ag, Pb, Zn, Cu	*Mn, Ge, Ga, In, Bi, Sb, As*	
		Distal disseminated silver-gold	Ag, Au	*Te, Bi, Sb, As*	
		Intermediate sulfidation	Au, Ag, Pb, Zn, Cu	*Mn, Ge, Ga, In, Bi, Sb, As*	
		Intermediate sulfidation antimony	Sb	**Sb**	
		Graphite	Graphite (lump)	**Graphite (lump)**	
Carlin-type	Carlin-type systems occur in continental magmatic arcs but are remote from subjacent stocks and plutons. Consequently, ore fluids consist largely of meteoric water containing volatiles discharged from deep intrusions. Ore fluids scavenge elements from carbonaceous pyritic sedimentary rocks as they convect through them. Gold ore containing disseminated pyrite forms where acidic reduced fluids dissolve carbonate and sulfidize Fe-bearing minerals in host rocks. As, Hg, and Tl minerals precipitate by cooling. Stibnite precipitates with quartz by cooling from Au-, As-, Hg-, and Tl-depleted fluids.	**Gold**	Au, Ag, Hg	*As, Sb*	Hofstra and Cline, 2000; Goldfarb and others, 2016; Muntean, 2018
		Antimony	Sb	**Sb**	
		Arsenic-thallium-mercury	As, Tl, Hg	**As**	
Climax-type	Climax-type systems occur in continental rifts with hydrous bimodal magmatism. Aqueous supercritical fluids exsolved from A-type topaz rhyolite plutons, and the apices of subvolcanic stocks form a variety of deposit types as they move upward and outward, split into liquid and vapor, react with country rocks, and mix with groundwater. The broad spectrum of deposit types results from the large thermal and chemical gradients in these systems. At deep levels, NYF pegmatites emanate from plutons.	**Pegmatite NYF**	Nb, Y, F, Be	**Nb, Ta, Be, Sc**	Černý and Ercit, 2005; Martin and Devito, 2005; London, 2008, 2016; Ludington and Plumlee, 2009; Breit and Hall, 2011; Foley and others, 2012; Hofstra and others, 2014; Audétat and Li, 2017; Wang and others, 2021
		Greisen	Mo, W, Sn	**W, *Sn***, *Bi, Be, Sc*	
		Porphyry molybdenum	Mo, W, Sn	**W, Sn, Re, REE**, *Sc*	
		Skarn molybdenum	Mo, W, Sn	**W, Sn**, *Be, Sc*	
		Greisen-S-R beryllium	Be, F	**Be, F**	
		Polymetallic sulfide S-R-V-IS	Cu, Zn, Pb, Ag, Au	*Mn, Ge, Ga, In, Bi, Sb, As*	
		Distal disseminated silver-gold	Ag, Au	*Sb, As*	
		High sulfidation	Cu, Ag, Au	*Sn, Sb, As, Te, Bi*	
		Lithocap alunite	Al, K_2SO_4 (potash)	**Al, K_2SO_4**, *Ga*	
		Lithocap kaolinite	Kaolin	*Ga*	
		Fluorspar	Fluorite	**Fluorite**	
		Volcanogenic berylium	Be, U	**Be,** *U, Li*	
		Volcanogenic uranium	U	**U,** *Li, Be*	
		Rhoylite tin	Sn	**Sn**	
IOA-IOCG	IOA-IOCG systems form in both subduction- and rift-related magmatic provinces. IOA deposits form as hot brine discharged from subvolcanic mafic to intermediate composition intrusions reacts with cool country rocks. Albitite uranium deposits form at deeper levels where brines albitize country rocks. IOCG deposits form on the roof or periphery of IOA mineralization at lower temperatures, often with involvement of external fluids. Polymetallic skarn, replacement, and vein deposits occur outboard from IOCG deposits. Mn replacement and lacustrine Fe deposits form near or at the paleosurface.	**Albitite uranium**	U	**U**	Williams and others, 2005; Cox and Singer, 2007; Groves and others, 2010; Slack, 2013; Barton, 2014; Slack and others, 2016
		Iron oxide apatite	Fe	*REE*	
		Iron oxide copper gold	Cu, Au, U, Co, Se	**U,** *Co*	
		Skarn iron	Fe, P	*REE, Ge*	
		Polymetallic sulfide S-R-V	Ni, Co, Mo, Cu, Zn, Pb, Ag, Au	**Co,** *Re, Ge, Ga, In, Bi, Te, Sb, As*	
		Replacement manganese	Mn	**Mn,** *Co*	
		Lacustrine iron	Fe	—	
Magmatic REE	Magmatic REE systems typically occur in continental rifts or along translithospheric structures. REE and other elements in mantle-derived ultrabasic, alkaline, and peralkaline (agpaitic) intrusions are enriched by fractionation and separation of immiscible carbonatite melts ± saline hydrothermal liquids. Exsolved magmatic fluids or heated external fluids may deposit REE and other elements in adjacent country rocks.	**Peralkaline syenite/ granite/rhyolite /alaskite/pegmatites**	REE, Y, Zr, Hf, Nb, Ta, Be, U, Th, Cu	**REE, Zr, Hf, Nb, Ta, Be, U**, *V, Te, fluorite*	Verplanck and others, 2014, 2016; Dostal, 2016, 2017; Wang and others, 2021
		Carbonatite	REE, P, Y, Nb, Ba, Sr, U, Th, Cu	**REE, Nb, Sc, U, Sr, Ba, P, Cu, Zr, magnetite, vermiculite, fluorite**	
		Phosphate	REE, P	*REE*	
		Fluorspar	Flourite	**Fluorite,** *barite, Ti, Nb, Zr, REE, Sc, U, Be*	
Mafic magmatic	Mafic magmatic systems generally form in large igneous provinces related to mantle plumes or meteorite impacts. Nickel-copper sulfide ores with PGEs result from settling and accumulation of immiscible sulfide liquids in mafic layered intrusions and ultramafic magma conduits. In layered intrusions, Fe-Ti oxides, chromite, and PGE minerals crystalize from evolving parental magmas and are concentrated by physical processes in cumulate layers. In anorthosites, Fe-Ti oxides ± apatite crystalize from residual magmas entrained in plagioclase-melt diapirs. In convergent settings, Alaskan-type intrusions with Fe-Ti oxides and PGE form from mantle melts.	**Chromite**	Cr	**Cr**	Ash, 1996; Schulte and others, 2012; Ernst and Jowitt, 2013; Woodruff and others, 2013; Zientek and others, 2017; Mondal and Griffin, 2018
		Nickel-copper-PGE sulfide	Ni, Cu, Co, PGE, Ag, Au, Se, Te	**Co, PGE,** *Te*	
		PGE (low sulfide)	PGE	**PGE**	
		Iron-titanium oxide	Fe, Ti, V, P	**Ti, V,** *REE*	