science for a changing world

Geological Survey of Canada
Natural Resources Canada

Queensland Government

Australian Government
Geoscience Australia

Prepared as part of a joint research program between the U.S. Geological Survey, Geological Survey of Canada, Geological Survey of Queensland, and Geoscience Australia

Deposit Classification Scheme for the Critical Minerals Mapping Initiative Global Geochemical Database

Open-File Report 2021–1049

U.S. Department of the Interior
U.S. Geological Survey

Deposit Classification Scheme for the Critical Minerals Mapping Initiative Global Geochemical Database

By Albert Hofstra, Vladimir Lisitsin, Louise Corriveau, Suzanne Paradis, Jan Peter, Kathleen Lauzière, Christopher Lawley, Michael Gadd, Jean-Luc Pilote, Ian Honsberger, Evgeniy Bastrakov, David Champion, Karol Czarnota, Michael Doublier, David Huston, Oliver Raymond, Simon VanDerWielen, Poul Emsbo, Matthew Granitto, and Douglas Kreiner

Prepared as part of a joint research program between the U.S. Geological Survey, Geological Survey of Canada, Geological Survey of Queensland, and Geoscience Australia

Open-File Report 2021–1049

U.S. Department of the Interior
U.S. Geological Survey

U.S. Geological Survey, Reston, Virginia: 2021

Suggested citation:
Hofstra, A., Lisitsin, V., Corriveau, L., Paradis, S., Peter, J., Lauzière, K., Lawley, C., Gadd, M., Pilote, J., Honsberger, I., Bastrakov, E., Champion, D., Czarnota, K., Doublier, M., Huston, D., Raymond, O., VanDerWielen, S., Emsbo, P., Granitto, M., and Kreiner, D., 2021, Deposit classification scheme for the Critical Minerals Mapping Initiative Global Geochemical Database: U.S. Geological Survey Open-File Report 2021–1049, 60 p., https://doi.org/10.3133/ofr20211049.

ISSN 2331-1258 (online)
eCat ID: 145396

Acknowledgments

The authors thank their associates for valuable input and discussions that improved this report, especially Jean-François Montreuil as part of his collaboration with the Geological Survey of Canada and Mike Zientek of the U.S. Geological Survey. We also appreciate the reviews provided by Laurel Woodruff, Ryan Taylor, and Janet Slate, as well as the editorial review provided by Sally Almeria, all of the U.S. Geological Survey.

Contents

Tables

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Mass	
ton, short (2,000 lb)	0.9072	metric ton (t)
ton, long (2,240 lb)	1.016	metric ton (t)

Abbreviations

CMMI Critical Minerals Mapping Initiative

E.O. Executive Order

USGS U.S. Geological Survey

Deposit Classification Scheme for the Critical Minerals Mapping Initiative Global Geochemical Database

By Albert Hofstra,[1] Vladimir Lisitsin,[2] Louise Corriveau,[3] Suzanne Paradis,[3] Jan Peter,[3] Kathleen Lauzière,[3] Christopher Lawley,[3] Michael Gadd,[3] Jean-Luc Pilote,[3] Ian Honsberger,[3] Evgeniy Bastrakov,[4] David Champion,[4] Karol Czarnota,[4] Michael Doublier,[4] David Huston,[4] Oliver Raymond,[4] Simon VanDerWielen,[4] Poul Emsbo,[1] Matthew Granitto,[1] and Douglas Kreiner[1]

Abstract

A challenge for the global economy is to meet the growing demand for commodities used in today's advanced technologies. Critical minerals are commodities (for example, elements, compounds, minerals) deemed vital to the economic and national security of individual countries that are vulnerable to supply disruption. The national geological agencies of Australia, Canada, and the United States recently joined forces to advance understanding and foster development of critical mineral resources in their respective countries through the Critical Minerals Mapping Initiative (CMMI). An initial goal of the CMMI is to fill the knowledge gap on the abundance of critical minerals in ores. To do this, the CMMI compiled modern multielement geochemical data generated by each agency on ore samples collected from historical and active mines and prospects from around the world. To identify relationships between critical minerals, deposit types, deposit environments, and mineral systems, a unified deposit classification scheme was needed. This report describes the scheme developed by the CMMI to classify the initial release of geochemical data. In 2021, the resulting database—along with basic query, statistical analysis, and display tools—will be served to the public through a web-based portal managed by Geoscience Australia. The database will enable users to trace critical minerals through mineral systems and identify individual deposits or deposit types that are potential sources of critical minerals.

Background

The Critical Minerals Mapping Initiative (CMMI) involving Australia, Canada, and the United States was solidified by participants from all three countries in a workshop held in Ottawa, Canada, in December 2019 (Kelley, 2020). Before and after establishment of the CMMI, Australia, Canada, and the United States took steps to identify, and ensure the supply of, critical minerals as described below. As a result, the CMMI is a high priority for the premier geoscience agencies of the three countries: Geoscience Australia, the Geological Survey of Canada, and the U.S. Geological Survey (USGS).

Australia

In 2019, the Australian Department of Industry, Innovation and Science, jointly with the Australian Trade and Investment Commission, issued Australia's Critical Minerals Strategy (Commonwealth of Australia, 2019b). This document, together with the Australian Critical Minerals Prospectus (Commonwealth of Australia, 2019a), formed the basis of Australia's response to growing global requirements for a reliable supply of critical minerals. These key documents build on previous work by Geoscience Australia to catalogue Australia's critical mineral resources and potential (for example, Skirrow and others, 2013). In response to the global need for critical commodities, the Australian Government launched several initiatives, including the establishment of the Critical Minerals Facilitation Office (Commonwealth of Australia, 2020b) and the extension and expansion of Geoscience Australia's Exploring for the Future program (Commonwealth of Australia, 2020c). Australia is currently a supplier of many critical (and other) minerals and seeks to strengthen and extend its capability as a reliable supplier to global partners. As part of Australia's Critical Minerals Strategy, Australia has identified 24 critical minerals for which it has significant potential to be a major supplier (table 1). The 2020 edition of the Australian Critical Minerals Prospectus (Commonwealth of Australia, 2020a) showcases more than 200 investment opportunities for a wide range of these 24 critical minerals.

[1]U.S. Geological Survey.

[2]Geological Survey of Queensland, Australia.

[3] Geological Survey of Canada.

[4]Geoscience Australia.

Table 1. Critical minerals of Australia, Canada, and the United States.

[This list of identified critical minerals has been compiled from Commonwealth of Australia (2019b), Government of Canada (2021), and Fortier and others (2018). —, not applicable; X, identified as a critical mineral]

Critical mineral	Australia	Canada	United States
Aluminum (Al)	—	X	X
Antimony (Sb)	X	X	X
Arsenic (As)	—	—	X
Barite ($BaSO_4$)	—	—	X
Beryllium (Be)	X	—	X
Bismuth (Bi)	X	X	X
Cesium (Cs)	—	X	X
Chromium (Cr)	X	X	X
Cobalt (Co)	X	X	X
Copper (Cu)	—	X	—
Fluorspar (CaF_2)	—	X	X
Gallium (Ga)	X	X	X
Germanium (Ge)	X	X	X
Graphite (C)	X	X	X
Hafnium (Hf)	X	—	X
Helium (He)	X	X	X
Indium (In)	X	X	X
Lithium (Li)	X	X	X
Magnesium (Mg), Magnesite ($MgCO_3$)	X	X	X
Manganese (Mn)	X	X	X
Molybdenum (Mo)	—	X	—
Nickel (Ni)	—	X	—
Niobium (Nb)	X	X	X
Platinum group elements (PGEs)	X	X	X
Potash (K_2CO_3, KCl, K_2SO_4, or KNO_3)	—	X	X
Rare earth elements (REEs)	X	X	X
Rhenium (Re)	X	—	X
Rubidium (Rb)	—	—	X
Scandium (Sc)	X	X	X
Strontium (Sr)	—	—	X
Tantalum (Ta)	X	X	X
Tellurium (Te)	—	X	X
Tin (Sn)	—	X	X
Titanium (Ti)	X	X	X
Tungsten (W)	X	X	X
Uranium (U)	—	X	X
Vanadium (V)	X	X	X
Zinc (Zn)	—	X	—
Zirconium (Zr)	X	—	X

Canada

On December 18, 2019, Canada announced that it had joined the U.S.-led multilateral Energy Resource Governance Initiative. The goals of the initiative are to support secure and resilient supply chains for critical minerals by identifying options to diversify supply chains and facilitate trade and industry connections. On January 9, 2020, the Canada-U.S. Joint Action Plan on Critical Minerals Collaboration was finalized and aimed to facilitate development of secure supply chains for critical minerals (Amm and others, 2020). The Canada-U.S. Joint Action Plan was reaffirmed on June 17, 2020 (Natural Resources Canada, 2020). Later that year, focus on critical minerals was reiterated and emphasized in the Canadian Minerals and Metals Plan (Mines Canada, 2020). Canada's list of 31 critical minerals was released on March 11, 2021 (table 1; Government of Canada, 2021). These critical minerals are considered essential for the sustainable economic success of Canada and its allies and to maintain Canada's position as a leading mining nation. A key platform for delivering minerals geoscience knowledge at the Geological Survey of Canada is its Targeted Geoscience Initiative Program, now in Phase 6. The focus of the program is on developing next-generation ore deposit models and methods to support enhanced efficiency in mineral exploration for buried mineral deposits in emerging and existing mining areas. The focus of the current phase is on critical minerals and digital geoscience, as described in the Canadian Minerals and Metals Plan (Mines Canada, 2020).

United States

In 2017, the President issued Executive Order (E.O.) 13817—A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals. The E.O. directs the USGS to develop a plan to improve the Nation's understanding of domestic critical mineral resources. To implement E.O. 13817, the Secretary of the Interior issued Order No. 3359—Critical Mineral Independence and Security. In response, a list of 35 critical minerals (table 1) with a high risk for supply disruption were identified by the USGS National Minerals Information Center (Fortier and others, 2018). In 2018, Congress allocated funds to the USGS Mineral Resources Program for the Earth Mapping Resources Initiative. The purpose of this initiative is to generate topographic, geologic, geochemical, and geophysical maps and data that are needed to increase the inventory of domestic critical minerals (Day, 2019). Several other Mineral Resources Program projects are currently underway that are designed to advance knowledge of critical minerals, including their abundance in the Nation's ore deposits and mine waste, their sources, the processes that concentrate them in mineral systems, and how to assess their potential in known mining districts and frontier areas. In 2020, the President determined that the United States' undue reliance on critical mineral imports, in processed or unprocessed form, constitutes an unusual and extraordinary threat. As a result, the President declared a National emergency, and issued E.O. 13953—Addressing the Threat to the Domestic Supply Chain From Reliance on Critical Minerals From Foreign Adversaries and Supporting the Domestic Mining and Processing Industries. The 2020 E.O. directed the Department of Interior (which includes the USGS) to investigate our Nation's undue reliance on critical minerals, submit a report that summarizes the conclusions from this investigation, and provide recommendations for executive action. On January 15, 2021, the U.S. Department of Energy announced the establishment of a Division of Minerals Sustainability to enable the ongoing transformation of the U.S. energy system and help secure a U.S. critical minerals supply chain (U.S. Department of Energy, 2021).

Problem

An initial goal of the CMMI (Kelley, 2020; Emsbo and others, 2021; Kelley and others, 2021) is to compile multielement geochemical data on ore samples collected from myriad deposit types and provide the data to the public with basic query, statistical analysis, and display tools that show the abundance and dollar value of critical minerals in ore. To effectively sort and use multielement geochemical data for this purpose, a unified deposit type classification scheme was needed. This report explains the approach used to standardize deposit type nomenclature and demonstrates the hierarchical relationships that exist between system types, deposit environments, deposit groups, and deposit types. The resulting classification scheme and its potential uses are then discussed.

Approach

To track critical minerals through mineral systems and identify ore deposits that concentrate them, a mineral systems approach based on current understanding of how ore deposits form and relate to broader geologic frameworks and the tectonic history of the Earth was used (for example, Wyborn and others, 1994; Goodfellow, 2007; Dulfer and others, 2016; Huston and others, 2016b). This approach was recently applied in the United States and Canada to aid delineation of system-based focus areas with critical mineral resource potential (Day, 2019; Hammarstrom and Dicken, 2019; Hammarstrom and others, 2020; Hofstra and Kreiner, 2020; Lawley and others, 2021). Herein, the systems approach provides a framework within which to consider the hierarchical relationships that are known, or inferred, to exist between system types, deposit environments, deposit groups, and deposit types that contain a variety of primary and secondary commodities, some of which are critical minerals. This exercise required the CMMI working group to agree on terminology for system types, deposit environments, deposit groups, and deposit types. The result presented in this report is a compromise that was deemed useful for classification of geochemical data generated by the CMMI on ore samples from myriad mines and prospects around the world.

System Type (Genetically Related Features)

To capture the relationship that exists between system types and distinct deposit types that are generated by them, system-type nomenclature was needed. As of spring 2021, the CMMI working group is still working on system-type names. To facilitate their eventual placement in the classification scheme, a descriptive proxy was developed, called genetically related features, that lists key attributes of each system type. For example, the genetically related features entry for calc-alkalic porphyry-epithermal systems is "Arc, magnetite series, calc-alkaline volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism, and myriad deposit types." The attributes listed in genetically related features are self-explanatory to the intended audience of economic geologists.

Deposit Environment

The CMMI working group agreed on deposit-environment terms because they follow current usage. "Deposit environment" is more or less synonymous with ore-forming environment and is used to classify deposit types that form under distinct physiochemical conditions, from different fluids, or by different processes in the crust. Deposit environments differ from system types because they are more generic. For example, an intrusion-related rare metal system may generate magmatic lithium-cesium-tantalum-bearing pegmatites and magmatic-hydrothermal tin-bearing greisen and vein deposits. Although most of the deposit environment terms are self-explanatory, they are defined below to avoid confusion:

- In erosional environments, gravity-driven turbulent flow of surface water or tidal- and wind-driven wave action concentrate heavy, insoluble, or hard minerals by winnowing away light, soluble, or soft minerals.
- In supergene environments, elements released by chemical weathering of soluble minerals are concentrated by chemical gradients associated with the downward percolation of meteoric water in the unsaturated zone.
- In infiltrational environments, elements dissolved from soluble minerals by gravity-driven flow of oxidized meteoric groundwater are concentrated by chemical gradients encountered in aquifers.
- In basin evaporative environments, elements present in closed lacustrine or silled marine basins are concentrated by evaporation in arid to hyperarid climatic zones until they precipitate from brines.
- In basin chemical environments, elements dissolved in freshwater or seawater precipitate at redox fronts in sedimentary basins.
- In basin hydrothermal environments, elements are dissolved from minerals by gravity-driven and (or) heat-driven flow of brines produced by the evaporation of seawater or dissolution of minerals; elements are concentrated by chemical gradients encountered in basin aquifers or at the seawater-sediment interface.
- In metamorphic environments, ore minerals are produced by metamorphic transformation of precursor minerals that contain valuable commodities.
- In metamorphic hydrothermal environments, elements dissolved in metamorphic (± magmatic) fluids are concentrated by physical and chemical gradients encountered along flow paths.
- In regional metasomatic environments, elements dissolved in magmatic, metamorphic, or basinal brines are concentrated by chemical and thermal gradients encountered along heat-, tectonic-, and gravity-driven flow paths.
- In volcanic basin hydrothermal environments, elements dissolved from volcanic-floored basins by heat-driven convection of seawater (± magmatic fluid) are concentrated by steep chemical and thermal gradients near seafloor vents.
- In magmatic hydrothermal environments, elements dissolved in magmatic fluids, brines, and vapors, or in heated external fluids, are concentrated by the steep chemical and thermal gradients around volcano-plutonic centers.
- In magmatic environments, ore minerals crystallize directly from igneous melts, including immiscible silicate, carbonate, sulfide, or other melts.

Deposit Group and Deposit Type

The CMMI working group began by considering past and current nomenclature for deposit types in each of the three countries. During this process, it became apparent that the classification principles and names applied to deposit types were often inconsistent, creating communication problems that needed to be resolved. For example, how can we characterize the critical mineral endowment of different system types and individual deposit types on the basis of the compiled geochemical data if geologically similar deposit types, and ore samples collected from them, are inadvertently ascribed to different deposit and system types based purely on differences in terminology? Such characterizations would also fail if distinct deposit types are ascribed to the same type because of inconsistent classification principles. The aim of this report is not to replace existing deposit classification schemes or resolve all the geological arguments about deposit genesis; rather, the aim is to minimize confusion caused by the use of inconsistent terminology by members of the CMMI, so that compiled geochemical data can be assigned and interpreted effectively. The classification scheme presented herein may stimulate conversations in the economic geology community about standardization of terminology to avoid confusion.

Although we strived for hierarchical uniformity, as described in the ensuing paragraphs, the deposit types adopted in the classification scheme are not all at the same level.

We found that some of the deposit type names in common use actually represent mineral systems, rather than distinct deposit types. For example, intrusion-related gold systems generate an assemblage of distinct deposit types (Hart, 2007) that are all commonly referred to as “intrusion-related gold deposits.” The same goes for the array of distinct deposit types that are commonly referred to as “iron oxide-copper-gold deposits” (Barton, 2014), though more detailed classifications exist for these and their affiliated deposit types (Porter, 2010; Williams, 2010; Corriveau and others, 2016). In such cases, we split out deposit types with distinct characteristics and assigned names.

Other deposit types were considered to be subtypes, but this level of detail was deemed too fine for the intended purposes of this classification scheme. For example, Naldrett (2004) distinguished several subtypes of magmatic nickel-copper-platinum group element deposits based on magma composition. Some of the more commonly used subtypes are listed in the “Synonyms” column in table 2.

We also noted that some deposit types occur in more than one system type. For example, intermediate sulfidation epithermal silver-gold deposits occur in both subduction-related calc-alkaline porphry-epithermal systems and rift-related high silica A-type porphyry-epithermal systems. We did not give such deposit types different names because their system type affiliations (that is, genetically related features) define their genetic relation to other deposit types.

We found that most of the deposit type names in common use consist of a term that describes a key attribute of the deposit type (for example, epithermal) that is preceded or followed by one or more commodities (for example, silver-gold) that are typically recovered from the ore. We refer to such terms as “deposit groups.” In several cases, the deposit group term is preceded by a modifier that describes another characteristic that enables further discrimination (for example, high sulfidation). Thus, most deposit type names consist of the deposit group term followed by the typical commodities (for example, porphyry copper), with or without a preceding modifier (for example, high sulfidation epithermal silver-gold). To standardize deposit type nomenclature, we adopted the following convention:

Optional modifier + deposit group + typical commodities.

However, we made a few exceptions for deposit type names in common use that do not follow this convention. For example, “Heavy mineral sands” is a deposit type in the placer deposit group that is typically mined for several commodities, such as titanium, zirconium-hafnium, rare earth elements, or abrasives.

Given that the deposit group terms used in this scheme mimic those in common use, the classification scheme reflects the hierarchical inconsistencies that currently exist among deposit types.

To make it clear what the deposit type names used in this classification scheme refer to, synonyms, examples, and references to reports that describe each deposit type are provided.

The resulting classification scheme (table 2) consists of seven columns with the following headers: Genetically related features, Deposit environment, Deposit group, Deposit type, Synonyms, Examples, and References. Table 2 contains information on 189 deposit types.

Uses

The classification scheme (table 2) is designed to accompany the initial release of the global geochemical database on ore samples compiled by geologists from the CMMI, which will be augmented periodically as new data are compiled and classified. The scheme covers most of the significant deposit types mined historically, or currently, in Australia, Canada, and the United States. The intended use of table 2 is to classify multielement geochemical data obtained on ore samples collected from historical and active mines by deposit type, deposit group, deposit environment, and eventually system type, and provide it to the public through a web portal (URL).

The resulting database of classified multielement geochemical analyses together with auxiliary information will enable the following:

- Recognition of the abundance of critical minerals in each deposit and their relation to the primary and secondary commodities that are known to be present in, or produced from, each deposit.

- Calculation of the dollar value of critical minerals present in ore in each deposit, which may foster recovery of critical minerals.

- Calculation of average critical mineral/average primary commodity ratios for each deposit, which can be multiplied by the tons of primary commodity produced, or in resources, to estimate the critical mineral endowment of processed mine waste and unmined resources.

- Recognition of the deposit types that have been geochemically well characterized, poorly characterized, or remain to be characterized.

- Recognition of the critical minerals that are typically present in each deposit type.

- Identification of individual deposits that have been misclassified.
- Development of grade and tonnage models for critical minerals in each deposit type.
- Comparison of critical mineral abundances in deposit types that occur in more than one system type.
- Tracing of critical minerals through each system type and identification of the deposit types that concentrate them.
- Portrayal of such data on a map or in a deposit or system model.
- Identification of geochemical data that merit explanation and research, such as the geometallurgy of samples that are enriched in critical minerals or the origin of individual deposits or systems that are unusually enriched in critical minerals.
- Identification of geochemical signatures that can refine the deposit classification scheme.

Table 2. Deposit classification scheme.

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Chemical weathering, erosion of soft material, and concentration of resistate minerals in situ, preexisting mineralization	Erosional	Placer	Residual placer tin	Lag tin	AUS: Renison Bell; BRA: Pitinga	Morland, 1990; Alves and others, 2018
Chemical weathering, erosion of soft material, and concentration of resistate minerals in situ, preexisting mineralization	Erosional	Placer	Residual placer lead	Lag lead	MEX: Santa Eulalia; U.S.: Upper Mississippi Valley Pb, Wis. and Ill.	Megaw, 2009
Exhumation, topographic relief, drainage network, preexisting mineralization	Erosional	Placer	Fluvial placer gold	Alluvial gold	AUS: Victorian goldfields, VIC; CAN: Atlin, BC; Carriboo, BC; Klondike, YT; U.S.: American River Au, Calif.	Yeend, 1986
Exhumation, topographic relief, drainage network, preexisting mineralization	Erosional	Placer	Fluvial placer PGE	Alluvial PGE	U.S.: Goodnews Bay PGE-Au, Alaska	Yeend and Page, 1986
Exhumation, topographic relief, drainage network, preexisting mineralization	Erosional	Placer	Fluvial placer tin	Alluvial tin	AUS: Pilbara, WA; North Queensland, QLD; U.S.: Seward Peninsula Sn, Alaska	Reed, 1986a
Exhumation, topographic relief, drainage network, preexisting mineralization	Erosional	Placer	Fluvial placer niobium-tantalum	Alluvial niobium-tantalum	NGR: Jos Plateau	Pastor and Turaki, 1985

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Exhumation, topographic relief, drainage network, preexisting mineralization	Erosional	Placer	Fluvial placer tungsten	Alluvial tungsten	CAN: Boulder Creek, BC; U.S.: Alder Creek, Alaska	Bundtzen, 1986
Exhumation, topographic relief, drainage network, specific rock types	Erosional	Placer	Fluvial placer REE	Alluvial REE	AUS: Charleys Creek, NT; U.S.: Idaho, Carolina Piedmont	Sengupta and Van Gosen, 2016
Exhumation, topographic relief, drainage network, kimberlite pipe	Erosional	Placer	Fluvial placer diamond	Alluvial diamond	AUS: Upper Smoke Creek (from Argyle diamond pipe), WA; Namibia: Orange River	Cox, 1986b
Exhumation, topographic relief, drainage network, specific rock type	Erosional	Placer	Fluvial placer gemstones	Alluvial gemstones	AUS: Anakie, QLD; Glen Innes, NSW; US: Yogo, Mont.	Clabaugh, 1952
Exhumation, topographic relief, drainage network, specific rock type	Erosional	Placer	Fluvial placer garnet	Alluvial garnet	AUS: Harts Range garnet, NT; U.S.: Emerald Creek, Idaho	Evans and Moyle, 2006
Exhumation, topographic relief, drainage network, delta, shoreline, barrier island, specific rock types	Erosional	Placer	Heavy mineral sands	Mineral sands	AUS: Keysbrook, WA; WIM150, VIC; Jacinth, SA; U.S.: Boise REE-Th-Ti-Nb-Ta, Idaho	Levson, 1995; Van Gosen and others, 2014
Exhumation, topographic relief, drainage network, delta, shoreline, barrier island, preexisting mineralization	Erosional	Placer	Shoreline placer gold	Beach placer gold	CAN: Graham Island, BC; Queen Charlotte Islands, BC; County Harbour, NS; U.S.: Nome Au, Alaska	Bundtzen and others, 1994

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Exhumation, topographic relief, drainage network, delta, shoreline, barrier island, specific rock types	Erosional	Placer	Paleoplacer heavy mineral sands	Lithified mineral sands; indurated mineral sands	CAN: Elliot Lake-Blind River, ON; U.S.: Sanostee Mesa Ti, N. Mex.	Van Gosen and others, 2014
Exhumation, topographic relief, drainage network, delta, shoreline, barrier island, specific rock types	Erosional	Placer	Paleoplacer tin	NA	AUS: Kikoira-Gibearvale, NSW	Campbell and others, 2003; Burton and Downes, 2005
Exhumation, topographic relief, drainage network, delta, shoreline, barrier island, preexisting mineralization	Erosional	Placer	Paleoplacer gold ± uranium	Quartz pebble conglomerate Au-U	CAN: Elliot Lake-Blind River, ON; Mulvehill, BC.; U.S.: Cambrian Deadwood Fm., S. Dak.; ZAF: Witwatersrand	Cox, 1986e; Roscoe, 1995; Taylor and Anderson, 2018
Stable area with low relief, tropical climate, Al-bearing rock types, unsaturated zone, water table	Supergene	Laterite	Bauxite	Lateritic bauxite	AUS: Weipa, QLD; BRA: Pocos de Caldas district; CAN: Florence, BC; U.S: Arkansas bauxite	Gordon and others, 1958; Bárdossy and Aleva, 1990
Stable area with low relief, tropical climate, Al-bearing rock types above carbonate rocks, unsaturated zone, water table	Supergene	Laterite	Karst bauxite	Carbonate bauxite	EU: Mediterranean bauxite belt; CHN: Yunnan deposits	Bárdossy, 1982; Hou and others, 2017
Stable area with low relief, tropical climate, ultramafic rocks, unsaturated zone, water table	Supergene	Laterite	Laterite nickel	Nickel-cobalt laterite: Lateritic nickel	AUS: Murrin Ni laterite, WA; U.S.: Puerto Rico Ni laterite	Berger and others, 2011; Marsh and others, 2013
Stable area with low relief, tropical climate, carbonatites, unsaturated zone, water table	Supergene	Laterite	Carbonatite laterite REE	NA	AUS: Mt. Weld, WA	Cocker, 2014; Verplanck and others, 2016

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Stable area with low relief, tropical climate, carbonatites, unsaturated zone, water table	Supergene	Laterite	Laterite magnesite	NA	AUS: Thuddungra, NSW	Diemar, 1998
Variable climate, unsaturated zone, Al-bearing rock types, water table	Supergene	Clay	Residual clay	Secondary clay	AUS: Pittong, VIC; Scottsdale, TAS; CAN: Lang Bay, BC; Sumas Mountain, BC; Buse Lake, BC; Saint Remi, QC; U.S.: Secondary clay Minn.	Hosterman, 1998
Variable climate, unsaturated zone, Al- or REE-bearing shales adjacent to coal seams, water table	Supergene	Clay	Underclay, overclay	Gob	CAN: Quinsam Mine, BC; CHN: Chongqing, Daqinshan, Lincang, Yishan; MNG: Jungar; U.S.: Coal underclay Ill.-Ky.-W. Va.	Seredin and Finkelman, 2008; Zhao and others, 2019; Yang and others, 2020
Variable climate, unsaturated zone, Al- or REE-bearing granitic, peralkaline, or carbonatite rocks, water table	Supergene	Clay	Ion adsorption REE	NA	CAN: Grande-Vallée, QC; CHN: Jiangxi, Guangdong, Fujiang, Guangxi; U.S.: Piedmont ion adsorption REE	Foley and Ayuso, 2015; Sanematsu and Watanabe, 2016
Variable climate, unsaturated zone, preexisting Ag-rich mineralization, water table	Supergene	Supergene	Supergene silver	NA	AUS: Wonawinta, NSW; CAN: Murray Brook, NB; MEX: Sierra Mojada	Skirka, 2005; Sillitoe, 2009; Ahn, 2010
Variable climate, unsaturated zone, preexisting Pb-rich mineralization, water table	Supergene	Supergene	Supergene lead	NA	AUS: Magellan, WA	McQuitty and Pascoe, 1998; Pirajno and others, 2010

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Variable climate, unsaturated zone, preexisting U-rich mineralization, water table	Supergene	Supergene	Supergene uranium	NA	AUS: Angela, NT	Lally and Bajwah, 2006; Bolonin and Gradovsky, 2012; Edgoose, 2013
Variable climate, unsaturated zone, preexisting V-rich mineralization, water table	Supergene	Supergene	Supergene vanadium	NA	NAM: Otavi Mountainland	Schwellnus, 1945; Verwoerd, 1957; Boni and others, 2007
Variable climate, unsaturated zone, preexisting Au-rich mineralization, water table	Supergene	Supergene	Supergene gold	Regolith gold	CAN: Murray Brook, NB	Rennick and Burton, 1992
Variable climate, unsaturated zone, preexisting Zn-rich mineralization, water table	Supergene	Supergene	Supergene zinc	Non-sulfide Zn, oxidized Zn (Pb)	AUS: Magellan, WA; CAN: Redbird, Lomond, Reeves MacDonald, Caviar, HB, Oxide, Cariboo Zinc, Flipper Creek, Dolomite Flats, Main, Gunn and Que, BC; U.S.: Leadville, Colo.; Balmat, N.Y.	Boni and Mondillo 2015; Paradis and others, 2015
Variable climate, unsaturated zone, preexisting Cu-rich mineralization, water table	Supergene	Supergene	Supergene copper	NA	CAN: Afton, BC; Windy Craggy, BC; U.S.: Santa Rita (Chino) Cu, N. Mex.; Morenci, Ariz.	Titley and Marozas, 1995
Variable climate, unsaturated zone, preexisting Mn-rich mineralization, water table	Supergene	Supergene	Supergene manganese	NA	AUS: Woodie Woodie, WA	Jones, 2017

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Variable climate, unsaturated zone, preexisting Fe-rich mineralization, water table	Supergene	Supergene	Supergene iron	NA	AUS: Hamersley iron province, WA; CAN: Labrador Trough, NL and QC; U.S.: Lake Superior, Minn.-Mich.-Wis.	Leith, 1931
Infiltration of surface water, aquifers, preexisting Cu mineralization, redox interface	Infiltrational	Exotic	Exotic copper	Paleochannel copper	MEX: El Pilar	Münchmeyer, 1998
Infiltration of surface water, fluvial paleochannels, preexisting Fe, Mn mineralization, redox interface	Infiltrational	Paleochannel	Paleochannel iron	Ferricretes, manganocretes	AUS: Hamersley iron province, WA; U.S.: New World, Mont.	Ramanaidou and others, 2003
Infiltration of surface water, aquifers, preexisting volcanic ash-bearing sedimentary rocks, redox interface	Infiltrational	Uranium	Sandstone uranium	Roll front, and others	AUS: Angela, NT; U.S.: Colorado Plateau, Utah-Colo.	Lally and Bajwah, 2006; Edgoose, 2013; Breit, 2016; IAEA, 2020
Infiltration of surface water, aquifers, preexisting volcanic ash-bearing sedimentary rocks, redox interface	Infiltrational	Uranium	Carbonate uranium	NA	U.S.: Grants, N. Mex.	IAEA, 2020
Infiltration of surface water, aquifers, preexisting volcanic ash-bearing sedimentary rocks, redox interface	Infiltrational	Uranium	Coal/peat/bog uranium	NA	U.S.: Williston Basin, Mont.-N. Dak.-S. Dak.	IAEA, 2020

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Infiltration of surface water, aquifers, preexisting volcanic ash-bearing sedimentary rocks, lacustrine evaporite	Infiltrational	Uranium	Calcrete uranium	Surficial uranium, evaporite uranium	AUS: Yeelirrie, WA; U.S.: Southern High Plains, N. Mex., Okla., Tex.	Hall and others, 2019; IAEA, 2020
Infiltration of CO_2-bearing surface water into fractured ultramafic rocks	Infiltrational	Magnesite	Nodular magnesite	Cryptocrystalline magnesite	AUS: Kunwarara, QLD; CAN: Mount Brussilof, BC; U.S.: Red Mtn., Calif.	Page, 1998b; Simandl and Hancock, 1999
Silled marine basin, arid climate, pinnacle reefs, evaporites, sabkha dolomites	Basin evaporative	Evaporite	Marine evaporite gypsum	NA	CAN: Windsor, NS; Elkhorn, BC; U.S.: Oklahoma	Raup, 1991a; Warren, 2010
Silled marine basin, arid climate, pinnacle reefs, evaporites, sabkha dolomites	Basin evaporative	Evaporite	Marine evaporite salt	NA	CAN: Goderich, ON; Grosse-Île, QC; U.S.: Gulf Coast, Tex.	Raup, 1991b; Warren, 2010
Silled marine basin, arid climate, pinnacle reefs, evaporites, sabkha dolomites	Basin evaporative	Evaporite	Marine evaporite potash	NA	CAN: Elk Point Basin, SK; U.S.: Carlsbad, N. Mex.	Williams-Stroud, 1991; Warren, 2010
Silled marine basin, arid climate, pinnacle reefs, evaporites, sabkha dolomites	Basin evaporative	Evaporite	Marine evaporite magnesite	Sedimentary magnesite	AUS: Witchelina and Mount Hutton, SA	Horn and others, 2017
Closed lacustrine drainage basin, arid climate, salt flats	Basin evaporative	Evaporite	Lacustrine evaporite trona	NA	U.S.: Green River, Wyo.	Dyni, 1991; Warren, 2010
Closed lacustrine drainage basin, arid climate, salt flats	Basin evaporative	Evaporite	Lacustrine evaporite salt	NA	U.S.: Bonneville, Utah	Orris, 1992; Warren, 2010
Closed lacustrine drainage basin, arid climate, salt flats	Basin evaporative	Evaporite	Lacustrine evaporite potash	NA	EU: Rhine graben	Warren, 2010

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Closed lacustrine drainage basin, arid climate, salt flats	Basin evaporative	Evaporite	Lacustrine evaporite carnallite-bischofite	NA	CAN: Wynyard, SK; EU: Rhine graben	Warren, 2010
Closed lacustrine drainage basin, arid climate, salt flats	Basin evaporative	Evaporite	Lacustrine evaporite borate	NA	U.S.: Rio Tinto (U.S. Borax), Calif.	Orris, 1995; Warren, 2010
Closed lacustrine drainage basin, arid climate, salt flats	Basin evaporative	Evaporite	Lacustrine evaporite magnesite	Sedimentary magnesite	U.S.: Needles, Calif.	Vitaliano, 1950
Closed lacustrine drainage basin, arid climate, sea spray, salt flats	Basin evaporative	Evaporite	Lacustrine evaporite nitrate	NA	So. Am.: Central Andes	Williams-Stroud, 1991; Warren, 2010
Silled marine basin, arid climate, pinnacle reefs, evaporites, sabkha dolomites	Basin evaporative	Brine	Marine brine potash (±Mg, Li, and so on)	NA	U.S.: Kane Creek potash, Utah; Michigan Basin potash, Mich.	Warren, 2010
Closed lacustrine drainage basin, arid climate, salt flats	Basin evaporative	Brine	Lacustrine brine potash	NA	AUS: Lake Wells, WA; U.S.: Searles Lake, Calif.	Orris, 2011
Closed lacustrine drainage basin, arid climate, salt flats	Basin evaporative	Brine	Lacustrine brine lithium	NA	CAN: Swan Hill, AB; CHL: Atacama; U.S.: Clayton Valley, Nev.	Bradley and others, 2013; Munk and others, 2016
Closed lacustrine drainage basin, arid climate, salt flats, volcanic rocks	Basin evaporative	Zeolite	Lacustrine zeolite (± Li, B)	NA	U.S.: Rhyolite Ridge, Nev.	Sheppard, 1991; Ioneer, 2020
Closed lacustrine drainage basin, arid climate, salt flats, ash and clay layers	Basin evaporative	Clay	Lacustrine clay lithium	NA	U.S.: McDermitt, Nev.	Asher-Bolinder, 1991; Castor and Henry, 2020

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Marine chemoclines, anoxic or euxinic lows, bioproductivity, seawater	Basin chemical	Black shale	Black shale vanadium ± Mo ± Ni	Metalliferous black shale, stone coal, carbonaceous marl	AUS: Julia Creek, QLD; CAN: Tar Sands, AB; U.S.: Gibellini V, Nev.; Phosphoria Fm. V, Mont.-Idaho-Wyo.	Granitto and others, 2017
Marine chemoclines, anoxic or euxinic lows, bioproductivity, seawater	Basin chemical	Black shale	Black shale nickel ± Mo-PGE	Metalliferous black shale	CAN: Nick Ni-Mo-PGE, YT	Hulbert and others, 1992; Lefebure and Coveney, 1995; Gadd and others, 2020
Marine chemoclines, anoxic or euxinic lows, bioproductivity, seawater	Basin chemical	Black shale	Black shale gold	NA	U.S.: Upper Rodeo Au, Nev.	Emsbo, 2000
Marine chemoclines, anoxic or euxinic lows, bioproductivity, seawater	Basin chemical	Black shale	Black shale uranium	NA	U.S.: Chattanooga U, Tenn.	IAEA, 2020
Marine chemoclines, ocean currents bioproductivity, wave base, seawater	Basin chemical	Phosphorite	Phosphorite	Phosphate	AUS: Ammaroo, NT; D-Tree, QLD; Phosphate Hill/ Duchess, QLD; CAN: Athabasca Basin, SK; U.S.: Phosphoria Fm., Mont.-Idaho-Wyo.	Emsbo and others, 2016a
Atmospheric oxidation, oceanic oxidation event, seawater	Basin chemical	Iron formation	Superior-type banded iron formation	Lake Superior	AUS: Hamersley iron province, WA; CAN: Labrador Trough, NL and QC; U.S.: Mesabi, Minn.	Cannon, 1986b

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Oceanic anoxic events, marine chemoclines, ocean currents, wave base, seawater	Basin chemical	Iron formation	Oolitic iron formation	Ironstone, Clinton-type, Minette-type	AUS: Train Range, QLD; CAN: Clear Hills, AB, Bell Island, NL; U.S.: Clinton, N.Y.	Maynard and Van Houten, 1992
Regional-scale and intense Fe-Na-(Ca±K) metasomatism and magnetic/gravity anomalies, caldera lakes	Basin chemical	Iron formation	Lacustrine iron formation	NA	U.S.: Upper Pilot Knob, Mo.	Nold and others, 2014
Atmospheric oxidation, oceanic oxidation event, seawater	Basin chemical	Manganese	Superior-type banded manganese	Mamatwan-type; gondite	CAN: Woodstock, NB; ZAF: Kalahari	Cairncross and Beukes, 2013
Oceanic anoxic events, marine chemoclines, ocean currents, wave base, seawater	Basin chemical	Manganese	Sedimentary manganese	Shelf sequence manganese, Nikopol-type manganese	AUS: Groote Eylandt and Bootu Creek, NT; UKR: Chiatura, Nikopol-Tokmak; U.S.: Cuyuna Range, Minn.; Aroostock County, Maine	Force and others, 1999; Cannon and others, 2017; Harvey and others, 2017
Marine chemoclines, ocean currents, atolls and plateaus, seawater	Basin chemical	Manganese	Crust manganese	Ferromanganese crusts	U.S. EEZ: Blake Plateau	Bau and others, 2014; Mizell and Hein, 2016
Marine chemoclines, ocean currents, abyssal plains, seawater	Basin chemical	Manganese	Nodule manganese	Ferromanganese nodules	U.S. EEZ: near Johnson Island, Hawaii	Hein and Koschinsky, 2014
Closed lacustrine drainage basin, redox interface	Basin chemical	Manganese	Lacustrine manganese	NA	U.S.: Artillery Mountains Mn, Ariz.	Long and others, 1992

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Unconformity, epicontinental basin fill, arid climate, evaporites, basin brine, extensional faults, alkali and magnesium metasomatism	Basin hydrothermal	Unconformity-related	Unconformity-related uranium	NA	AUS: Jabiluka, NT; Ranger, NT; Coronation Hill, NT; CAN: McArthur River, SK; Cigar Lake, SK; Rabbit lake, SK; Key Lake, SK	Skirrow and others, 2009
Unconformity, epicontinental basin fill, arid climate, evaporites, basin brine, extensional faults, alkali and magnesium metasomatism	Basin hydrothermal	Unconformity-related	Unconformity-related REE	NA	AUS: Browns Range, WA; CAN: Maw zone, SK	Nazari-Dehkordi and others, 2018
Collapse breccia, epicontinental basin fill, arid climate, evaporites, basin brine, extensional faults, alkali and magnesium metasomatism	Basin hydrothermal	Collapse breccia pipe	Collapse breccia pipe uranium	NA	U.S.: Grand Canyon, Ariz.	Alpine, 2010; Van Gosen and others, 2016; IAEA, 2020
Continental rift basin, initial phase, volcanics, conglomerates, and siliciclastics, arid climate, evaporites, basin brine, growth faults, salt tectonics, alkali and magnesium metasomatism	Basin hydrothermal	Volcanic-hosted	Volcanic-hosted copper	Volcanic-red bed copper; basaltic copper	CAN: Sustut, BC and Copper River, YT; U.S.: Calumet-Hecla and Kearsarge Mich.	Cox, 1986a; Lefebure and Church, 1996

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Continental rift basin, initial phase, volcanics, conglomerates and siliciclastics, arid climate, evaporites, basin brine, growth faults, salt tectonics, alkali and magnesium metasomatism	Basin hydrothermal	Sediment-hosted	Sediment-hosted copper ± Co	Sediment-hosted Cu-Ag-Co, shale-hosted Cu, Kupferschiefer-type, redbed Cu	AUS: Nifty, WA; CAN: Redstone, NT; COD: copper belt; DEU: Kupferschiefer district U.S.: White Pine, Mich.; Rock Creek and Montanore, Mont.	Hayes and others, 2015
Continental rift basin, fill phase, turbidite sequences, arid climate, evaporites, growth faults, mafic magmatism, basinal brine, alkali and magnesium metasomatism, seafloor vents	Basin hydrothermal	Sediment-hosted	Siliciclastic-mafic zinc-lead	Metamorphosed SEDEX, CD, Sullivan-type, Broken Hill-type (BHT)	AUS: Broken Hill, NSW; Cannington, QLD; CAN: Sullivan and Kechika Trough, BC; MacMillan Pass, YT	Lydon and others, 2000; Spry and Teale, 2021
Continental rift basin, fill phase, turbidite sequences, arid climate, evaporites, growth faults, mafic magmatism, basinal brine, alkali and magnesium metasomatism, seafloor vents	Basin hydrothermal	Sediment-hosted	Siliciclastic-mafic barite	NA	U.S.: Northumberland barite, Nev.	Clark and Orris, 1991

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Continental rift (or passive margin) basin, sag phase, carbonate shelf and siliciclastic slope sequences, arid climate, evaporites, growth faults, basin brine, alkali and magnesium metasomatism, seafloor vents	Basin hydrothermal	Sediment-hosted	Siliciclastic-carbonate zinc-lead	Sedex, CD, McArthur, bedded	AUS: Mt. Isa, QLD; McArthur River, NT; CAN: Howard's Pass, YT; U.S.: Red Dog Zn, Alaska; Balmat-Edwards Zn-Pb, N.Y.	Emsbo, 2009; Emsbo and others, 2016b
Continental rift (or passive margin) basin, sag phase, carbonate shelf and siliciclastic slope sequences, arid climate, evaporites, growth faults, basin brine, alkali and magnesium metasomatism, seafloor vents	Basin hydrothermal	Sediment-hosted	Irish-type sediment-hosted zinc-lead	NA	IRE: Irish zinc belt (Navan, Lisheen, Tynagh, Silvermines, Galmoy, Ballinalack)	Hitzman, 1995; Hõy, 1996
Continental rift basin, initial phase, conglomerates and siliciclastics, arid climate, evaporites, basin brine, growth faults, salt tectonics, alkali and magnesium metasomatism	Basin hydrothermal	Sediment-hosted	Kipushi-type sediment-hosted copper-zinc-lead	Kipushi, salt dome	U.S.: Ruby Creek, Alaska; Apex, Utah	Cox and Bernstein, 1986; De Magnee and Francois, 1988
Contractional orogeny, foreland basin, forebulge faults, arid climate, evaporites, basin brine, alkali and magnesium metasomatism	Basin hydrothermal	Mississippi Valley-type (MVT)	MVT zinc-lead	NA	AUS: Lennard Shelf, WA; Admiral Bay, WA; CAN: Polaris and Nanisivik, NU; Pine Point, NT; Robb Lake, BC; Gays River, NS; U.S.: Viburnum trend, Mo.	Leach and others, 2010

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Contractional orogeny, foreland basin, forebulge faults, arid climate, evaporites, basin brine, alkali and magnesium metasomatism	Basin hydrothermal	Mississippi Valley-type (MVT)	MVT barite	NA	CAN: Walton, NS; U.S.: SE Missouri barite district	Leach and others, 2010
Contractional orogeny, foreland basin, forebulge faults, arid climate, evaporites, basin brine, alkali and magnesium metasomatism	Basin hydrothermal	Mississippi Valley-type (MVT)	MVT fluorspar	NA	CAN: Liard, BC; U.S.: Illinois-Kentucky fluorspar	Plumlee and others, 1995; Denny and others, 2015, 2016; Hayes and others, 2017
Contractional orogeny, foreland basin, forebulge faults, arid climate, evaporites, basin brine, alkali and magnesium metasomatism	Basin hydrothermal	Mississippi Valley-type (MVT)	MVT strontium	NA	TUR: Sivas basin celestite	Ucurum and others, 2017
Contractional orogeny, foreland basin, forebulge faults, arid climate, evaporites, basin brine, alkali and magnesium metasomatism	Basin hydrothermal	Mississippi Valley-type (MVT)	Sandstone-hosted zinc-lead	NA	CAN: Wigwam, BC; George Lake, SK; SWE: Laisvall Zn-Pb	Briskey, 1986
More oxidized and (or) metamorphosed equivalents of features noted in the previous row	Basin hydrothermal	Non-sulfide	Non-sulfide zinc-lead ± Mn	Oxide zinc	AUS: Beltana, SA; BRA: Vazante; U.S.: Franklin-Sterling Hill, N.J.	Hitzman and others, 2003

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Crystalline basement, extensional faults, basin brine, natural gas, redox interface, hydrolytic ± CO_2 metasomatism, arsenides, regional iron and alkali-calcic metasomatism	Basin hydrothermal	Five-element	Vein five-element	Ag-Bi-Co-Ni arsenide	CAN: Beaver and Timiskaming, ON; Cobalt, ON; Silver Islet, ON; Echo Bay and Eldorado, NT; U.S.: Wickenburg, Ariz.; Black Hawk, N Mex.	Kissin, 1992; Mumin and others, 2010; Markl and others, 2016; Burisch and others, 2017; Scharrer and others, 2019; Corriveau and others, in press
Contractional orogen, metamorphic belts, dilatant structures, metamorphic fluid, hydrolytic, CO_2, H_2S metasomatism	Metamorphic hydrothermal	Orogenic	Hypozonal orogenic gold	Mesothermal gold; low-sulfide gold-quartz-vein, shear zone gold	CAN: Borden Lake, ON	Groves and others, 1998; Goldfarb and others, 2005, 2016
Contractional orogen, metamorphic belts, dilatant structures, metamorphic fluid, hydrolytic, CO_2, H_2S metasomatism	Metamorphic hydrothermal	Orogenic	Mesozonal orogenic gold	Mesothermal gold; low-sulfide gold-quartz-vein, shear zone gold	AUS: Golden Mile, WA; Bendigo, VIC; CAN: Sigma, QC; Timmins and Detour Lake, ON; Bridge River, BC; U.S.: Mother Lode, Calif.; Alaska-Juneau, Alaska	Groves and others, 1998; Goldfarb and others, 2005, 2016
Contractional orogen, metamorphic belts, dilatant structures, metamorphic fluid, hydrolytic, CO_2, H_2S metasomatism	Metamorphic hydrothermal	Orogenic	Epizonal orogenic gold	Refractory orogenic gold, Carlin-style gold	AUS: Wiluna, WA; Fosterville, QLD; CAN: Rackla and Coffee, YT; CHN: Qiuling; U.S.: Donlin Creek, Alaska	Groves and others, 1998; Goldfarb and others, 2005, 2016

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Contractional orogen, metamorphic belts, dilatant structures, metamorphic fluid, hydrolytic, CO_2, ± H_2S metasomatism	Metamorphic hydrothermal	Orogenic	Epizonal orogenic antimony ± gold	NA	AUS: Hillgrove, NSW; CAN: Bridge River-Bralorne, BC; U.S.: U.S. Antimony Mine, Mont.	Bliss and Orris, 1986; Groves and others, 1998; Goldfarb and others, 2005, 2016; Hofstra and others, 2013
Contractional orogen, metamorphic belts, dilatant structures, metamorphic fluid, hydrolytic, CO_2, ± H_2S metasomatism	Metamorphic hydrothermal	Orogenic	Epizonal orogenic mercury	NA	CAN: Pinchi Lake, BC; U.S.: Southwest, Alaska	Gray and Bailey, 2003
Contractional orogen, metamorphic belts, dilatant structures, metamorphic fluid, hydrolytic, CO_2, ± H2S, ± alkali metasomatism	Metamorphic hydrothermal	Orogenic	Orogenic silver-lead-zinc-copper-antimony	NA	AUS: Endeavor (Elura), NSW; Woodcutters, NT; U.S.: Coeur d'Alene district, Idaho-Mont.	Leach and others, 1988, 1998; Beaudoin and Sangster, 1992, 1995
Contractional orogen, metamorphic belts, dilatant structures, metamorphic fluid, hydrolytic, CO_2, ± H_2S, alkali metasomatism	Metamorphic hydrothermal	Orogenic	Orogenic copper ± gold	NA	AUS: Cobar, NSW; Mt. Isa Cu, QLD	Lawrie and Hinman, 1998
Contractional orogen, metamorphic belts, dilatant structures, metamorphic fluid, carbon metasomatism	Metamorphic hydrothermal	Orogenic	Orogenic graphite	vein, lump graphite	CAN: Buckingham, QC; Lac-des-Îles, QC; Calumet, QC; Miller, QC; U.S.: Crystal Graphite, Mont.	Luque and others, 2014; Simandl and others, 2015

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Regional metamorphic belts	Metamorphic	Metamorphic	Metamorphic graphite	Flake graphite, amorphous graphite	AUS: Campoona Shaft, SA; CAN: Lac Knife, QC; U.S.: Graphite Cr. Alaska; Alabama Graphite, Ala.	Luque and others, 2014; Simandl and others, 2015
Regional metamorphic belts	Metamorphic	Metamorphic	Metamorphic kyanite	NA	CAN: Crocan Lake, ON; U.S.: Dillwyn, Va.	Marr, 1992
Continental arc or rift, mafic to felsic or alkalic magmatism, sedimentary basins, dilatant faults, magmatic and basinal or lacustrine brines, iron alkali calcic metasomatism, high amplitude magnetic, gravity, and MT anomalies	Regional metasomatic	Alkali-calcic	Low Iron alkali-calcic	NA	AUS: Merlin Mo-Re, Mount Dore Cu-Ag-Au-Zn, Tick Hill Au, QLD; BRA: Alvo 118 Cu-Au	Xavier and others, 2012; Babo and others, 2017; Le, 2019
Continental arc or rift, mafic to felsic or alkalic magmatism, sedimentary basins, dilatant faults, magmatic and basinal or lacustrine brines, iron alkali calcic metasomatism, high amplitude magnetic, gravity, and MT anomalies	Regional metasomatic	Alkali-calcic	Albitite-hosted uranium	Albitite-type metasomatic U	AUS: Valhalla U, QLD; CAN: Michelin U, NL	Gandhi, 1978; Polito and others, 2009; Sparkes and others, 2017

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Continental arc or rift, mafic to felsic or alkalic magmatism, sedimentary basins, dilatant faults, magmatic and basinal or lacustrine brines, iron alkali calcic metasomatism, high amplitude magnetic, gravity, and MT anomalies	Regional metasomatic	Metasomatic iron	Ferroan carbonate polymetallic	NA	MRT: Guelb Moghrein Cu-Au	Kirschbaum and Hitzman, 2016
Continental arc or rift, mafic to felsic or alkalic magmatism, sedimentary basins, dilatant faults, magmatic and basinal or lacustrine brines, iron alkali calcic metasomatism, high amplitude magnetic, gravity, and MT anomalies	Regional metasomatic	Metasomatic iron	Iron sulfide polymetallic	ISCG	AUS: Lorena Co-As-Bi-Au, Mount Cobalt Co-As, QLD; CAN: Delhi Pacific Cu-Ag-Au, QC; IND: Akwali Cu; U.S.: Iron Creek Co-Cu, Idaho	Sarkar and Dasgupta, 1980; McLaughlin and others, 2016; Ristorcelli and Schlitt, 2019
Continental arc or rift, mafic to felsic or alkalic magmatism, sedimentary basins, dilatant faults, magmatic and basinal or lacustrine brines, iron alkali calcic metasomatism, high amplitude magnetic, gravity, and MT anomalies	Regional metasomatic	Metasomatic iron	Iron silicate polymetallic	NA	BRA: Sossego Cu-Au-Ag; CAN: Scadding Au, ON; FIN: Haveri Au; PER: Raul-Condestable Cu-Au-Ag; U.S.: Blackbird Co-Cu-Au, Idaho	Strauss, 2003; De Haller and others, 2006; Schandl and Gorton, 2007; Monteiro and others, 2008; Slack, 2013; Corriveau and others, in press

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Continental arc or rift, mafic to felsic or alkalic magmatism, sedimentary basins, dilatant faults, magmatic and basinal or lacustrine brines, iron alkali calcic metasomatism, high amplitude magnetic, gravity, and MT anomalies	Regional metasomatic	Metasomatic iron	Iron oxide polymetallic	NA	BRA: Jatoba Ni; CAN: NICO Au-Co-Bi-Cu, NT; U.S.: Iron Creek Co-Cu, Idaho	Slack, 2013; Acosta-Góngora and others, 2015; Montreuil and others, 2016; Ristorcelli and Schlitt, 2019; Veloso and others, 2020
Continental arc or rift, mafic to felsic or alkalic magmatism, sedimentary basins, dilatant faults, magmatic and basinal or lacustrine brines, iron alkali calcic metasomatism, high amplitude magnetic, gravity, and MT anomalies	Regional metasomatic	Metasomatic iron	Iron oxide uranium	NA	AUS: Mount Gee U, SA; CAN: Southern Breccia U, NT	Youles and Oilmin, 1986; Montreuil and others, 2015
Continental arc or rift, mafic to felsic or alkalic magmatism, sedimentary basins, dilatant faults, magmatic and basinal or lacustrine brines, iron alkali calcic metasomatism, high amplitude magnetic, gravity, and MT anomalies	Regional metasomatic	Metasomatic iron	Iron oxide gold	NA	AUS: Prominent Hill Au, SA; White Devil Au-Cu-Bi, Noble Nob Au, Juno Au-Cu-Bi-Ag, NT; U.S.: Detachment Au, Calif.	Schandl and Gorton, 2007; Spencer and Duncan, 2015

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Continental arc or rift, mafic to felsic or alkalic magmatism, sedimentary basins, dilatant faults, magmatic and basinal or lacustrine brines, iron alkali calcic metasomatism, high amplitude magnetic, gravity, and MT anomalies	Regional metasomatic	IOCG	Hematite-dominant IOCG	NA	AUS: Olympic Dam Cu-Au-Ag-U; Prominent Hill Cu-Au; Carrapateena Cu-Au; Oak Dam West, SA; CHL: Mantoverde Cu-Au	Rieger and others, 2010; Skirrow, 2010; Ehrig and others, 2012; Oz Minerals, Ltd., 2013; Schlegel and Heinrich, 2015; King, 2019
Continental arc or rift, mafic to felsic or alkalic magmatism, sedimentary basins, dilatant faults, magmatic and basinal or lacustrine brines, iron alkali calcic metasomatism, high amplitude magnetic, gravity, and MT anomalies	Regional metasomatic	IOCG	Magnetite-dominant IOCG	NA	AUS: Ernest Henry Cu-Au, QLD; BRA: Salobo Cu-Au-Ag; CAN: Sue Dianne, NT; CHL: Candelaria; CHN Dahongshan Fe-Cu-(Ag-Au); MRT: Guelb Morghein Cu-Co-Au; U.S.: Boss-Bixby Cu, Mo.; Yerington Cu, Nev.; Lights Creek Cu, Calif.	Barton and others, 2000; Marschik and Fontboté, 2001; Camier, 2002; Mark and others, 2006; Mumin and others, 2010; Kirschbaum and Hitzman, 2016; deMelo and others, 2017; Zhao and others, 2017
Continental arc or rift, mafic to felsic or alkalic magmatism, sedimentary basins, dilatant faults, magmatic and basinal or lacustrine brines, iron alkali calcic metasomatism, high amplitude magnetic, gravity, and MT anomalies	Regional metasomatic	IOA	Hematite-dominant IOA	NA	AUS: Oak Dam Fe; U.S.: Iron Mtn., Mo.; Cortez Mtns., Nev.	Barton and others, 2000; Davidson and others, 2007

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Continental arc or rift, mafic to felsic or alkalic magmatism, sedimentary basins, dilatant faults, magmatic and basinal or lacustrine brines, iron alkali calcic metasomatism, high amplitude magnetic, gravity, and MT anomalies	Regional metasomatic	IOA	Magnetite-dominant IOA	NA	AUS: Lightning Creek Fe, QLD; CAN: Josette Fe-REE, Marmoraton Fe, and Lac Marmont Fe, QC; Mag Hill Fe-(REE-V) and Terra Fe- (REE), NT; CHL: El Laco Fe; CHN: Middle-Lower Yangtze Metallogenic Belt; PER: Marcona Fe; SWE: Kiirunavaara Fe; U.S.: Pea Ridge, Mo.; Mineville Fe-REE, N.Y.; Humboldt complex, Nev.	McKeown and Klemic, 1956; Leonard and Buddington, 1964; Hildebrand, 1986; Johnson and Barton, 2000; Perring and others, 2000; Edfelt and others, 2005; Clark and others, 2010; Mumin and others, 2010; Chen and others, 2011; Yu and others, 2011; Harlov and others, 2016; Tornos and others, 2017; Corriveau and others, in press; Zhao and others, in press
Oceanic rift or arc volcanism, ±fluid exsolution, dilatant faults, convecting seawater, seafloor vents	Volcanic basin hydrothermal	Volcanogenic massive sulfide (VMS)	Mafic-ultramafic VMS	Volcanic-hosted massive sulfide (VHMS), volcanic-associated massive sulfide (VAMS), seafloor massive sulfide (SMS), Cyprus-type	CAN: Betts Cove, York Harbour, and Tilt Cove, NL; Potterdoal, ON; Chu Chua, BC; Norway: Lokken; U.S.: Turner-Albright, Oreg.	Shanks and Thurston, 2012; Hannington, 2014; Monecke and others, 2016

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Oceanic rift or arc volcanism, ±fluid exsolution, dilatant faults, convecting seawater, seafloor vents	Volcanic basin hydrothermal	Volcanogenic massive sulfide (VMS)	Mafic-siliciclastic VMS	Volcanic-hosted massive sulfide (VHMS), volcanic-associated massive sulfide (VAMS), seafloor massive sulfide (SMS), Besshi-type	AUS: Tritton, NSW; DeGrussa, WA; CAN: Windy Craggy, BC; Goldstream, BC; Standard, BC; True Blue, BC; JPN: Besshi; U.S.: Ducktown, Tenn.	Shanks and Thurston, 2012; Hannington, 2014; Monecke and others, 2016
Oceanic rift or arc volcanism, ±fluid exsolution, dilatant faults, convecting seawater, seafloor vents	Volcanic basin hydrothermal	Volcanogenic massive sulfide (VMS)	Bimodal-mafic VMS	Volcanic-hosted massive sulfide (VHMS), volcanic-associated massive sulfide (VAMS), seafloor massive sulfide (SMS), Noranda-type	AUS: Mount Lyell, TAS; Sulphur Springs, WA; CAN: Horne, Quemont, and Noranda, QC; Kidd Creek, ON; Flin Flon, MB; Buchans, NL; Bathurst-Newcastle, NB; JPN: Kuroko; Spain: Rio Tinto; Sweden: Kristieberg; U.S.: Shasta King, Calif.; Lockwood, Wash.; Bald Mountain, Maine	Shanks and Thurston, 2012; Hannington, 2014; Monecke and others, 2016
Oceanic rift or arc volcanism, ±fluid exsolution, dilatant faults, convecting seawater, seafloor vents	Volcanic basin hydrothermal	Volcanogenic massive sulfide (VMS)	Bimodal felsic VMS	Volcanic-hosted massive sulfide (VHMS), volcanic-associated massive sulfide (VAMS), seafloor massive sulfide (SMS), Kuroko-type	AUS: Rosebery, Mount Read, TAS; Gossan Hill, WA; CAN: Myra Falls, BC; Eskay Creek, BC; Izok Lake, NU; CHN: Gacun; JPN: Hokuroku; U.S.: Jerome, Ariz.	Shanks and Thurston, 2012; Hannington, 2014; Monecke and others, 2016

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Oceanic rift or arc volcanism, ±fluid exsolution, dilatant faults, convecting seawater, seafloor vents	Volcanic basin hydrothermal	Volcanogenic massive sulfide (VMS)	Felsic-siliciclastic VMS	Volcanic-hosted massive sulfide (VHMS), volcanic-associated massive sulfide (VAMS), seafloor massive sulfide (SMS), Bathhurst-type, Iberian-type	CAN: Bathurst, NB; Brunswick No 12, NB; ESP: Iberian Pyrite Belt; U.S.: Bonnifield, Alaska	Shanks and Thurston, 2012; Hannington, 2014; Monecke and others, 2016
Oceanic rift or arc volcanism, ±fluid exsolution, dilatant faults, convecting seawater, seafloor vents	Volcanic basin hydrothermal	Volcanogenic	Algoma-type banded iron formation	Volcanogenic iron formation	AUS: Koongie Park Formation, WA; BRA: Carajas; CAN: Mary River, NU; Helen Mine, ON; Sherman, ON; Adams, ON; Griffith, ON; Iron Hill, ON; Adam River, ON; Woodstock, NB; Austin Brook, NB; IND: Kudremuk; U.S.: Vermilion, Minn.; VEN: Cerro Bolivar	Cannon, 1986a
Oceanic rift or arc volcanism, ±fluid exsolution, dilatant faults, convecting seawater, seafloor vents	Volcanic basin hydrothermal	Volcanogenic	Volcanogenic manganese	Franciscan, Cuban, Olympic Peninsula, and Cyprus manganese	CRI: Nicoya; U.S.: Franciscan Complex, Calif.; Olympic Mtns., Wash.	Mosier and Page, 1988
Occurs in more than one system type	Magmatic hydrothermal	Epithermal	Low-sulfidation (LS) epithermal gold-silver	Adularia-sericite gold-silver; hot-spring gold-silver; epizonal intrusion-related gold	AUS: Pajingo, QLD; Cracow, QLD; CAN: Mallery Lake, NU; Bakers Mine, BC; Lawyers, BC; U.S.: Sleeper, Nev.	John, 2001; Simmons and others, 2005

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Occurs in more than one system type	Magmatic hydrothermal	Epithermal	Intermediate-sulfidation (IS) epithermal silver-gold ± Zn, Pb, Cu, Sn, Mn	Adularia-sericite silver-gold	AUS: Lake Cowal, NSW; CAN: Silbak-Premier, BC; U.S.: Comstock and Tonopah, Nev.; Creede, Colo.	Sillitoe and Hedenquist, 2003; Simmons and others, 2005
Occurs in more than one system type	Magmatic hydrothermal	Epithermal	High-sulfidation (HS) epithermal silver-gold ± Cu	Quartz-alunite gold, enargite-gold	AUS: Mt. Carlton, QLD; U.S.: Goldfield, Nev.	Sillitoe and Hedenquist, 2003; Simmons and others, 2005
Arc or rift, alkaline volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Epithermal	Alkalic epithermal gold ± Ag	Au-Ag-Te veins	FIJ: Emperor; PNG: Porgera; U.S.: Cripple Creek, Colo.	Jensen and Barton, 2000; Kelley and Spry, 2016; Kelley and others, 2020
Occurs in more than one system type	Magmatic hydrothermal	Epithermal	Epithermal mercury	Hot spring Hg	U.S.: McDermitt, Nev.	Rytuba, 1986
Continental rift, hydrous bimodal magmatism, A-type volcano-plutonic center, magmatic fluid, meteoric water	Magmatic hydrothermal	Epithermal	Epithermal beryllium	Volcanogenic Be	U.S.: Spor Mtn., Utah	Barton and Young, 2002; Foley and others, 2012
Continental rift, hydrous bimodal magmatism, A-type volcano-plutonic center, magmatic fluid, meteoric water	Magmatic hydrothermal	Epithermal	Epithermal uranium	Volcanogenic U, volcanic-related U	AUS: Ben Lomond, QLD; CAN: Sagar, QC; U.S.: Marysvale, Utah; Anderson Mine, Ariz.	Nash, 2010; Andrews and Parker, 2017; IAEA, 2020
Occurs in more than one system type	Magmatic hydrothermal	Vein	Vein ± replacement nickel	Avebury-style Ni, ophiolite-hosted Ni, hydrothermal Ni	AUS: Avebury, TAS	Callaghan and others, 2017

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Occurs in more than one system type	Magmatic hydrothermal	Vein	Vein cobalt ± Ni	Hydrothermal Ni-Co-As	MRT: Bou Azzer	Ahmed and others, 2009
Occurs in more than one system type	Magmatic hydrothermal	Vein	Vein copper	NA	AUS: Cayley, VIC; CAN: Temagami, ON; U.S.: Magma, Ariz.	Friehauf and Pareja, 1998
Continental back arc or hinterland, S-type volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Vein	Vein tin	Cornwall-type	CAN: Kalzas, YT; Mount Pleasant, NB; GBR: Cornwall	Reed, 1986e
Continental back arc or hinterland, S-type volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Vein	Vein tungsten	NA	CAN: Burnt Hill, NB; PER: Pasto Bueno	Cox and Bagby, 1986
Continental back arc or hinterland, S-type volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Vein	Vein tin polymetallic	Bolivian-type	AUS: Baal Gammon, QLD; BOL: Oruro	Togashi, 1986
Occurs in more than one system type	Magmatic hydrothermal	Vein	Vein fluorite	Fluorspar	AUS: Meentheena and Speewah, WA; U.S.: Western Kentucky	Anderson, 2019
Occurs in more than one system type	Magmatic hydrothermal	Vein	Vein polymetallic	NA	CAN: Hector-Calumet and Elsa, Mayo district, YT; Slocan-New Denver-Ainsworth district, BC	Cox, 1986d

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Occurs in more than one system type	Magmatic hydrothermal	Breccia pipe	Breccia pipe copper	Igneous-hydrothermal breccia	CAN: Tribag, ON; Croxall, ON; CHL: El Teniente	Skewes and others, 2002; Stern and others, 2011
Continental back arc or hinterland, regional felsic magmatism of ilmenite to magnetite series, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Breccia pipe	Breccia pipe gold	Intrusion-related gold	AUS: Kidston, QLD; Mt. Leyshon, QLD	Baker and Andrew, 1991; Allan and others, 2011
Continental rift, hydrous bimodal magmatism, A-type volcano-plutonic center, magmatic fluid	Magmatic hydrothermal	Breccia pipe	Breccia pipe molybdenum	NA	U.S.: Cave Peak Mo, Tex.	Sharp, 1979
Arc or rift, alkaline volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Breccia pipe	Breccia pipe REE	NA	U.S.: Pea Ridge REE, Mo.	Nuelle and others, 1991
Slab rollback, arc migration, magmatic volatiles, extensional faults, reduced slope facies, meteoric water, CO_2, H_2S and hydrolytic metasomatism, jasperoids	Magmatic hydrothermal	Carlin-type	Carlin-type gold	Sediment-hosted disseminated gold, sediment-hosted micron gold	CAN: Rackla, YT; CHN: Golden triangle; U.S.: Carlin trend, Battle Mtn.-Eureka trend, Getchell trend, Nev.	Hofstra and Cline, 2000; Cline and others, 2005; Muntean, 2018
Occurs in more than one system type	Magmatic hydrothermal	Distal-disseminated	Distal-disseminated silver-gold	Carlin-like, Carlin-style	U.S.: Lone Tree Ag-Au, Nev.	Cox, 1992

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Occurs in more than one system type	Magmatic hydrothermal	Replacement	Replacement polymetallic	NA	CAN: Midway, BC; Bluebell, BC; Sa Dena Hes, YT; MEX: Santa Eulalia, Naica, Fresnillo, Velardena, Providencia; U.S.: Leadville district, Colo.; East Tintic district, Utah; Eureka district, Nev.	Morris, 1986; Titley, 1997
Occurs in more than one system type	Magmatic hydrothermal	Replacement	Replacement gold-silver	Sulfide manto Au	CAN: Ketza River, YT; Mosquito Creek, BC	Abercrombie, 1990
Continental back arc or hinterland, S-type volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Replacement	Replacement tin	NA	AUS: Renison, TAS; CAN: Mount Pleasant, NB	Reed, 1986c; Hammarstrom and others, 1995a
Occurs in more than one system type	Magmatic hydrothermal	Replacement	Replacement copper	NA	U.S.: Bisbee, Ariz.	Stegen and others, 2005
Occurs in more than one system type	Magmatic hydrothermal	Replacement	Replacement zinc-lead	NA	U.S.: Bingham Canyon, Tintic, Park City, Deer Trail, Utah; Pima, Ariz.	Beaty and others, 1986; Titley, 1997
Occurs in more than one system type	Magmatic hydrothermal	Replacement	Replacement manganese	NA	U.S.: Butte, Mont.; Leadville, Colo.	Mosier, 1986
Arc, magnetite series, calc-alkaline volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Replacement	Replacement magnesium	Crystalline magnesite	CAN: Mount Bussilof, BC; U.S.: Premier Magnesia (Gabbs), Nev.	Page, 1998a; Simandl and Hancock, 1999

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Occurs in more than one system type	Magmatic hydrothermal	Replacement	Replacement fluorite	NA	U.S.: McCulloghs Butte, Nev.	Barton, 1982
Occurs in more than one system type	Magmatic hydrothermal	Skarn	Skarn iron	NA	AUS: Paddys River, ACT; AZE: Dashkesan; CAN: Tasu, Jessie, Merry Widow, Iron Crown, Iron Hill, Yellow Kid, and Prescott, BC; CHN: Jinshandian, Middle Lower-Yangtze River Metallogenic Belt; CUB: Daiquiri; ITA: San Leone; JPN: Shinyama; RUS: Magnitogorsk, Perschansk, Sheregesh, and Teya; U.S.: Santa Rita, N. Mex.; Cornwall Iron Springs, Utah; Eagle Mountain, Calif.	Cox, 1986c; Hammarstrom and others, 1995c; Meinert and others, 2005; Zeng and others, 2020
Occurs in more than one system type	Magmatic hydrothermal	Skarn	Skarn copper	NA	CAN: Craigmont, BC; Phoenix, BC; Old Sport, BC; Queen Victoria, BC; Mines Gaspé, QC; U.S.: Copper Canyon, Nev.; Carr Fork Cu, Utah	Cox and Theodore, 1986; Meinert and others, 2005

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Occurs in more than one system type	Magmatic hydrothermal	Skarn	Skarn tungsten ± Mo	NA	AUS: Molyhil, NT; O'Calaghans, WA; CAN: Cantung, NT; MacTung, YT; Emerald Tungsten, Didger, Feeney, Invinsible, and Dimac, BC; RUS: Tyrnyauz; U.S.: Pine Creek, Calif.; Tem Piute district, Nev.	Hammarstrom and others, 1995a; Meinert and others, 2005
Continental back arc or hinterland, S-type volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Skarn	Skarn tin ± copper ± Mo	NA	CAN: Silver Diamond, BC; Atlin Magnetite, BC; Daybreak, BC; JC, YT; U.S.: Lost River, Alaska; Majuba Hill, Nev.	Reed and Cox, 1986; Meinert and others, 2005
Occurs in more than one system type	Magmatic hydrothermal	Skarn	Skarn gold ± copper ± tungsten	Intrusion-related gold	AUS: Red Dome, QLD; CAN: Banks Island, BC; Hedley, BC; Ketza River, Marn and Horn, YT; Nickel Plate, BC; French, BC; Canty, BC; Good Hope, BC; Quesnel River, BC; U.S.: Fortitude and McCoy, Nev.	Ewers and Sun, 1989; Sillitoe, 1991; Theodore and others, 1991; Hart and others, 2002; Meinert and others, 2005; Hart, 2007
Occurs in more than one system type	Magmatic hydrothermal	Skarn	Skarn zinc-lead-silver	NA	CAN: Piedmont, BC; Midway, BC; Contact, BC; Quartz Lake, YT; U.S.: Groundhog, N. Mex.	Hammarstrom and others, 1995b; Meinert and others, 2005

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Occurs in more than one system type	Magmatic hydrothermal	Skarn	Skarn molybdenum	NA	CAN: Coxey, BC; Novelty, BC; U.S.: Little Boulder Creek, Idaho; Cannivan Gulch, Mont.	Ray, 1995; Meinert and others, 2005
Continental rift, hydrous bimodal magmatism, A-type volcano-plutonic center, magmatic fluid	Magmatic hydrothermal	Skarn	Skarn beryllium-fluorite	NA	U.S.: Iron Mtn., N. Mex.	Barton and Young, 2002; Meinert and others, 2005
Peralkaline volcano-plutonic center	Magmatic hydrothermal	Skarn	Skarn uranium-REE	NA	AUS: Mary Kathleen REE-U, QLD	Oliver and others, 1999; Meinert and others, 2005
Arc or rift, alkaline volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Porphyry	Porphyry copper ± gold	Alkaline porphyry copper	AUS: Cadia, NSW; Northparkes, NSW; CAN: Galore Creek, BC; Copper Mountain, BC; Afton-Ajax, BC	Seedorff and others, 2005; Sillitoe, 2010
Arc, magnetite series, calc-alkaline volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Porphyry	Porphyry copper-molybdenum	Calc-alkaline porphyry copper	CAN: Highland Valley, BC; Gibraltar, BC; Brenda, BC; Highmont, BC; U.S.: Butte, Mont.; Bingham Canyon, Utah	Seedorff and others, 2005; Sillitoe, 2010
Continental back arc or hinterland, felsic magmatism of ilmenite to magnetite series, calc-alkaline volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Porphyry	Porphyry gold ± copper	Intrusion-related gold	AUS: Mungana, QLD; CAN: Kerr, BC; U.S.: Palmetto, Nev.	Hollister, 1992; Nethery and Barr, 1998; Seedorff and others, 2005

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Continental rift, hydrous bimodal magmatism, A-type volcano-plutonic center, magmatic fluid	Magmatic hydrothermal	Porphyry	Climax-type porphyry molybdenum	Alkali-feldspar rhyolite-granite porphyry molybdenum; high-fluorine porphyry molybdenum	AUS: Unicorn, VIC; U.S.: Climax and Henderson, Colo.	Seedorff and others, 2005; Ludington and Plumlee, 2009; Audétat and Li, 2017
Arc, magnetite series, calc-alkaline volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Porphyry	Low-fluorine porphyry molybdenum	Arc-related porphyry molybdenum; low-fluorine stockwork molybdenite	CAN: Endako, BC; MAX, BC; Boss Mountain, BC; U.S.: Pine Nut, Nev.; Thompson Creek, Idaho	Theodore, 1986; Sinclair, 1995a; Seedorff and others, 2005; Taylor and others, 2012
Continental arc, back arc, or hinterland, felsic magmatism of ilmenite series, calc-alkaline volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Porphyry	Porphyry tungsten	NA	CAN: Mount Pleasant, NB	Sinclair, 1995b; Seedorff and others, 2005
Continental back arc, or hinterland, felsic S-type volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Porphyry	Porphyry tin	NA	CAN: Mount Pleasant, NB; U.S.: Majuba Hill, Nev.	Reed, 1986b; Sinclair, 1995c; Seedorff and others, 2005
Continental back arc or hinterland, felsic S-type volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic-Magmatic hydrothermal	Greisen	Greisen tin ±W-Mo	NA	AUS: Anchor, TAS; CAN: Kemptville, NS; RUS: Spokoininskoye; SAU: Silsilah Sn	Reed, 1986d

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Continental back arc or hinterland, felsic magmatism of ilmenite series, felsic calc-alkaline volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Greisen	Greisen tungsten-molybdenum ±Bi	NA	AUS: Wolfram Camp, QLD; CAN: Sisson, NB; Mount Pleasant, NB; KAZ: Akchatau; U.S.: Indian Springs, Nev.	Kotlyar and others, 1995
Continental rift, hydrous bimodal magmatism, A-type volcano-plutonic center, magmatic fluid	Magmatic hydrothermal	Greisen	Greisen beryllium ±Li	NA	U.S.: McCulloghs Butte, Nev.	Barton and Young, 2002
Continental back arc or hinterland, regional felsic magmatism of ilmenite series, calc-alkaline volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Intrusion-related	Reduced intrusion-related gold	Plutonic-related gold: intrusion- centered gold; sheeted vein gold; shear-related gold veins	CAN: Tombstone, YT; U.S.: Fort Knox, Alaska; Bald Mountain, Nev.	Sillitoe, 1991; McCoy and others, 1997; Thompson and others, 1999; Hart and others, 2002; Hart, 2007; Nutt and Hofstra, 2007
Continental back arc or hinterland, regional felsic magmatism of ilmenite to magnetite series, calc-alkaline volcano-plutonic center, magmatic fluid, alkali and hydrolytic metasomatism	Magmatic hydrothermal	Intrusion-related	Oxidized intrusion-related gold	Plutonic-related gold; disseminated gold; plutonic gold; intrusion-related gold veins	AUS: Ravenswood, QLD; Timbarra, NSW; Dargues Reef, NSW; CAN: Côté, ON, Malartic, QB	Sillitoe, 1991; Mustard, 2001; Blevin, 2004; Helt and others, 2014

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Anatexis or any felsic pluton	Magmatic	Pegmatite	Simple pegmatite	NA	CAN: Buckingham, QC	Černý and Ercit, 2005; Martin and De Vito, 2005; London, 2008, 2016
Continental back arc or hinterland, S-type plutonic center	Magmatic	Pegmatite	LCT pegmatite	NA	AUS: Greenbush, WA; Wodgina, WA; Pilgangoora, WA; CAN: Tanco, MB; US: King Lithia, So. Dak.	Černý and Ercit, 2005; Martin and De Vito, 2005; London, 2008, 2016
Continental rift, hydrous bimodal magmatism, A-type plutonic center	Magmatic	Pegmatite	NYF pegmatite	NA	CAN: Bancroft, ON; Little Nahanni, YT	Černý and Ercit, 2005; Martin and De Vito, 2005; London, 2008, 2016
Anatexis associated with high grade metamorphism	Magmatic	Pegmatite	Abyssal pegmatite REE	NA	CAN: Fraser Lakes, SK	London, 2008
SCLM partial melt, alkalic-peralkaline magmatic center, carbonatites	Magmatic	Carbonatite	Carbonatite REE	NA	AUS: Mt. Weld, WA; CAN: Wicheeda Lake, BC; Nisikkatch Lake, SK; Montviel, QC; Lac Shortt, QC; Saint Honoré, QC; China: Bayan'obo; U.S.: Mountain Pass, Calif.	Verplanck and others, 2014, 2016; Simandl and Paradis, 2018
SCLM partial melt, alkalic-peralkaline magmatic center, carbonatites	Magmatic	Carbonatite	Carbonatite niobium	NA	CAN: Eldor, QC; Niobec, QC; Aley, BC; Blue River, BC; St. Lawrence Columbium Mine, QC	Verplanck and others, 2014, 2016; Simandl and Paradis, 2018

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
SCLM partial melt, alkalic-peralkaline magmatic center and related pegmatites	Magmatic	Peralkaline igneous	Peralkaline igneous HFSE-REE	NA	AUS: Dubbo, NSW; CAN: Strange Lake, QC; Misery Lake, QC; Kipawa, QC; Thor Lake, NT	Dostal, 2016
Zoned alkalic plutonic center	Magmatic	Apatite-nepheline-titanite intrusion	Apatite-nepheline-titanite intrusion	Alkaline massif, nepheline-syenite-foyaite complex	RUS: Apatyty	Kalashnikov and others, 2016
Alkalic dike complex	Magmatic	Apatite intrusion	Apatite intrusion REE	Apatite vein	AUS: Nolans Bore, NT	Hussey and Dean, 2013; Huston and others, 2016a
SCLM partial melt, diatreme, kimberlite	Magmatic	Kimberlite	Kimberlite diamond	NA	AUS: Argyll, WA; CAN: Ekati, Gahcho Kue, Snap Lake, and Diavik, NT; Renard, QC; Victor, ON	Michalski and Modreski, 1991; Pell, 1999
Archean to early Proterozoic continental rift or plume, high degree mantle melts, greenstone belts, ultramafic-mafic volcanic center	Magmatic	Komatiite	Komatiite nickel-copper-PGE	Kambalda-type, raglan-type	AUS: Kambalda; CAN: Langmuir, ON; Alexo-Dundonald, ON; Raglan, QC; Thompson, MB; ZWE: Damba	Page, 1986b; Naldrett, 2004; Zientek and others, 2017
Continental rift or plume, high degree mantle melts, LIP, ultramafic-mafic layered intrusion	Magmatic	Ultramafic and (or) mafic-layered intrusion	U-M layered intrusion chromium	NA	AUS: Coobina, WA; CAN: Bird River, MB; Ring of Fire, ON; ZAF: Bushveld Complex	Schulte and others, 2012

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Continental rift or plume, high degree mantle melts, LIP, ultramafic-mafic layered intrusion	Magmatic	Ultramafic and (or) mafic-layered intrusion	U-M layered intrusion nickel-copper-PGE	Contact-type	AUS: Savannah, WA; Radio Hill, WA; CAN: Muskox, NU; Crystal Lake, ON; U.S.: Maturi, Spruce Road, Minn.	Naldrett, 2004; Zientek and others, 2017
Continental rift or plume, high degree mantle melts, LIP, ultramafic-mafic layered intrusion	Magmatic	Ultramafic and (or) mafic-layered intrusion	U-M layered intrusion PGE	Reef-type and (or) brecciated	CAN: Lac des Îles, ON; Marathon, ON	Zientek and others, 2017
Continental rift or plume, high degree mantle melts, LIP, ultramafic-mafic layered intrusion	Magmatic	Ultramafic and (or) mafic-layered intrusion	U-M layered intrusion iron-titanium-vanadium	NA	AUS: Balla Balla, WA; CAN: Grader, QC; Lac Doré, QC; Iron-T, QC; Sept Iles, QC; La Blache, QC	Page, 1986a
Continental rift or plume, high degree mantle melts, LIP, ultramafic-mafic stock or pluton (maybe zoned)	Magmatic	Ultramafic and (or) mafic intrusion	U-M intrusion nickel-copper-PGE	NA	CAN: Lynn Lake, MB	Naldrett, 2004
Continental rift or plume, high degree mantle melts, LIP, ultramafic-mafic sills, dikes, chonoliths	Magmatic	Ultramafic and (or) mafic conduit	U-M conduit nickel-copper-PGE	Flood basalt Ni-Cu-PGE, ferropicrite Ni-Cu-PGE, picrite-tholeiite N-Cu-PGE	AUS: Nebo-Babel, Expo-Savannah; CHN: Kalatongke; RUS: Norilsk; US: Eagle, Mich.; Tamarack, Minn.	Naldrett, 2004; Barnes and others, 2016; Zientek and others, 2017
Obducted oceanic or back arc crust	Magmatic	Ophiolite	Ophiolite chromium	Podiform chromite	CAN: Thetford Mines QC, Castle Mountain Nickel, BC; Scottie Creek, BC; PHL: Acoje	Duke, 1995; Ash, 1996; Mosier and others, 2012

Table 2. Deposit classification scheme.—Continued

[ACT, Australian Capital Territory; Ag, silver; Al, aluminum; Ala., Alabama; Ariz., Arizona; As, arsenic; Au, gold; AUS, Australia; AZE, Azerbaijan; B, boron; BC, British Columbia; Be, beryllium; BHT, Broken Hill type; Bi, bismuth; BOL, Bolivia; BRA, Brazil; Ca, calcium; Calif., California; CAN, Canada; CD, clastic-dominated; CHL, Chile; CHN, China; Co, cobalt; CO_2, carbon dioxide; COD, Democratic Republic of the Congo; Colo., Colorado; Cr, chromium; CRI, Costa Rica; Cu, copper; CUB, Cuba; DEU, Germany; EEZ, Exclusive Economic Zone; ESP, Spain; EU, European Union; Fe, iron; FIJ, Fiji; FIN, Finland; Fm., Formation; GBR, United Kingdom of Great Britain and Northern Ireland; HFSE, high field strength elements; Hg, mercury; HS, high sulfidation; H_2S, hydrogen sulfide; Ill., Illinois; IND, India; IOA, iron oxide-apatite; IOCG, iron oxide-copper-gold; IRE, Ireland; IS, intermediate sulfidation; ISCG, iron sulfide-copper-gold; ITA, Italy; JPN, Japan; K, potassium; Ky., Kentucky; LCT, lithium-cesium-tantalum; Li, lithium; LIP, large igneous province; LS, low sulfidation; MB, Manitoba; MEX, Mexico; Mg, magnesium; Mich., Michigan; Minn., Minnesota; Mn, manganese; MNG, Mongolia; Mo, molybdenum; Mo., Missouri; Mont., Montana; MRT, Mauritania; MT, magnetotelluric; MVT, Mississippi Valley type; Na, sodium; NA, not applicable; Nb, niobium; NB, New Brunswick; N. Dak., North Dakota; Nev., Nevada; NGA, Nigeria; Ni, nickel; N.J., New Jersey; NL, Newfoundland and Labrador; N. Mex., New Mexico; NS, Nova Scotia; NSW, New South Wales; NT, Northern Territory in AUS and Northwest Territories in CAN; NU, Nunavut; N.Y., New York; NYF, niobium-yttrium-fluorine; Okla., Oklahoma; ON, Ontario; Oreg., Oregon; Pb, lead; PER, Peru; PGE, platinum group elements; PHL, Philippines; PNG, Papua New Guinea; QC, Quebec; QLD, Queensland; REE, rare earth elements; RUS, Russia; SA, South Australia; SAU, Saudi Arabia; SCLM, subcontinental lithospheric mantle; S. Dak., South Dakota; SEDEX, sedimentary exhalative; SK, Saskatchewan; SMS, seafloor massive sulfide; Sn, tin; So. Am., South America, SWE, Sweden; Ta, tantalum; TAS, Tasmania; Te, tellurium; Tenn., Tennessee; Tex., Texas; Th, thorium; Ti, titanium; TUR, Turkey; U, uranium; UKR, Ukraine; U-M, ultramafic and (or) mafic; U.S., United States; V, vanadium; VAMS, volcanic-associated massive sulfide; VEN, Venezuela; VMS, volcanogenic massive sulfide; VHMS, volcanic-hosted massive sulfide; VIC, Victoria; W, tungsten; WA, Western Australia; Wash., Washington; W. Va., West Virginia; Wis., Wisconsin; Wyo., Wyoming; YT, Yukon Territory; ZAF, South Africa; Zn, zinc; ZWE, Zimbabwe]

Genetically related features	Deposit environment	Deposit group	Deposit type	Synonym(s)	Example(s)	Reference(s)
Obducted oceanic or back arc crus.	Magmatic	Ophiolite	Ophiolite nickel-copper-PGE	Picrite-tholeiite Ni-Cu-PGE	PHL: Acoje	Yumul, 2001; Naldrett, 2004; Zientek and others, 2017
Convergent margin, ultramafic-mafic magmatic center	Magmatic	Ultramafic and (or) mafic intrusion	Arc U-M intrusion titanium-vanadium	Alaskan-type, uralian-type	CAN: Lac Allard, QC	Page and Gray, 1986
Convergent margin, ultramafic-mafic magmatic center	Magmatic	Ultramafic and (or) mafic intrusion	Arc U-M intrusion nickel-copper-PGE	Alaskan-type, uralian-type, picrite-tholeiite Ni-Cu-PGE	CAN: Tulameen Complex, BC; Turnagain, BC	Page and Gray, 1986; Naldrett, 2004
Convergent margin, late extension, intermediate plutonic center	Magmatic	Anorthosite massif	Anorthosite massif titanium	Anorthosite pluton	CAN: Lac Doré, QC; Lac Tio, QC; Norway: Tellnes	Woodruff and others, 2013
Convergent margin, late extension, intermediate (± granitic) dikes, sills, chonoliths	Magmatic	Anorthosite conduit	Anorthosite conduit nickel-copper-PGE	Anorthosite-granite-troctolite Ni-Cu-PGE	CAN: Voiseys Bay, NL	Naldrett, 2004; Barnes and others, 2016
Meteorite impact, ultramafic-mafic magmatism	Magmatic	Ultramafic and (or) mafic intrusion	Impact U-M intrusion nickel-copper-PGE	Impact melt Ni-Cu-PGE	CAN: Sudbury, ON	Keays and Lightfoot, 2004; Naldrett, 2004

References Cited

Abercrombie, S.M., 1990, Geology of the Ketza River gold mine, *in* Abbott, J.G., and Turner, R.J.W., eds., Mineral deposits of the Northern Canadian Cordillera, Yukon-Northeastern British Columbia: Geological Survey of Canada Open File 2169, 8th IAGOD Symposium Field Trip 14 Guidebook, p. 259–282.

Acosta-Góngora, P., Gleeson, S.A., Samson, I.M., Corriveau, L., Ootes, L., Taylor, B.E., Creaser, R.A., and Muehlenbachs, K., 2015, Genesis of the Paleoproterozoic NICO iron oxide-cobalt-gold-bismuth deposit, Northwest Territories, Canada—Evidence from isotope geochemistry and fluid inclusions: Precambrian Research, v. 268, p. 168–193.https://doi.org/10.1016/j.precamres.2015.06.007

Ahmed, A.H., Arai, S., and Ikenne, M., 2009, Mineralogy and paragenesis of the Co-Ni arsenide ores of Bou Azzer, Anti-Atlas, Morocco: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 104, no. 2, p. 249–266.

Ahn, H.I., 2010, Mineralogy and geochemistry of the non-sulfide Zn deposits in the Sierra Mojada district, Coahuila, Mexico: Austin, Texas, University of Texas at Austin, M.Sc. thesis, 179 p., accessed March 3, 2021, at https://repositories.lib.utexas.edu/handle/2152/ETD-UT-2010-08-1856.

Allan, M.M., Morrison, G.W., and Yardley, B.W.D., 2011, Physicochemical evolution of a porphyry-breccia system—A laser ablation ICP-MS study of fluid inclusions in the Mount Leyshon Au deposit, Queensland, Australia: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 106, no. 3, p. 413–436.

Alpine, A.E., ed., 2010, Hydrological, geological, and biological site characterization of breccia pipe uranium deposits in northern Arizona: U.S. Geological Survey Scientific Investigations Report 2010–5025, 353 p., 1 pl., scale 1:375,000, accessed April 18, 2020, at https://doi.org/10.3133/sir20105025.

Alves, M.A.D.S., Pereira, V.P., Bastos Neto, A.C., and Menegotto, E., 2018, Weathering of the Madeira world-class Sn-Nb-Ta (cryolite, REE, U, Th) deposit, Pitinga Mine (Amazon, Brazil): Journal of Geochemical Exploration, v. 186, p. 61–76, accessed March 3, 2021, at https://doi.org/10.1016/j.gexplo.2017.12.003.

Amm, M.D., Pickersgill, M., Caparelli, C.M., and Klinkhoff, C., 2020, Canada and the U.S. announce Joint Action Plan on Critical Minerals: Torys LLP, 4 p., accessed March 9, 2021, at https://www.torys.com/insights/publications/2020/01/canada-and-the-us-announce-joint-action-plan-on-critical-minerals.

Anderson, W.H., 2019, Mineralogy and chemistry of rare earth elements in alkaline ultramafic rocks and fluorite in the western Kentucky fluorspar district: Kentucky Geological Survey Report of Investigations 8, 55 p., accessed March 3, 2021, at https://uknowledge.uky.edu/kgs_ri/55.

Andrews, W.L., and Parker, S., 2017, Ben Lomond uranium deposit, *in* Phillips, N., ed., Australian Ore Deposits (6th ed.): Australasian Institute of Mining and Metallurgy Monograph 32, p. 711–713.

Ash, C., 1996, Podiform chromite, *in* Lefebure, D.V., and Höy, T., eds., Selected British Columbia mineral deposit profiles, volume 2—Metallic deposits: British Columbia Ministry of Employment and Investment, Open File 1996–13, p. 109–111.

Asher-Bolinder, S., 1991, Descriptive model of lithium in smectites of closed basins, *in* Orris, G.J., and Bliss, J.D., eds., Some industrial mineral deposit models—Descriptive deposit models: U.S. Geological Survey Open-File Report 91–11A, p. 11–12.

Audétat, A., and Li, W., 2017, The genesis of Climax-type porphyry Mo deposits—Insights from fluid inclusions and melt inclusions: Ore Geology Reviews, v. 88, p. 436–460, accessed March 3, 2020, at https://doi.org/10.1016/j.oregeorev.2017.05.018.

Babo, J., Spandler, C., Oliver, N., Brown, M., Rubenach, M., and Creaser, R.A., 2017, The high-grade Mo-Re Merlin deposit, Cloncurry District, Australia—Paragenesis and geochronology of hydrothermal alteration and ore formation: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 112, no. 2, p. 397–422.

Baker, E.M., and Andrew, A.S., 1991, Geologic, fluid inclusion, and stable isotope studies of the gold-bearing breccia pipe at Kidston, Queensland, Australia: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 86, no. 4, p. 810–830.

Bárdossy, G., 1982, Karst bauxites—Bauxite deposits on carbonate rocks: Amsterdam, Elsevier Science, Developments in Economic Geology 14, 441 p.

Bárdossy, G., and Aleva, G.J.J., 1990, Lateritic bauxites: Amsterdam, Elsevier Science, Developments in Economic Geology 27, 624 p.

Barnes, S.J., Cruden, A.R., Arndt, N., and Saumur, B.M., 2016, The mineral system approach applied to magmatic Ni-Cu-PGE sulphide deposits: Ore Geology Reviews, v. 76, p. 296–316.

Barton, M.D., 1982, Some aspects of the geology and mineralogy of the fluorine-rich skarn at McCullough Butte, Eureka County, Nevada: *in* Carnegie Institution of Washington, Annual Report of the Director, Geophysical Laboratory, 1981–1982: Washington, D.C., Carnegie Institution, p. 324–328.

Barton, M.D., 2014, Iron oxide(–Cu–Au–REE–P–Ag–U–Co) systems, chap. 13.20 *of* Holland, H.D., and Turekian, K.K., eds., Treatise on geochemistry, 2nd ed.: Amsterdam, Elsevier Ltd., 27 p.

Barton, M.D., Johnson, D.A., and Zurcher, L., 2000, Phanerozoic iron-oxide(-REE-Cu-Au-U) systems in southwestern North America and their origins, *in* Roberts, M.D., and Fairclough, M.C., eds., Fe-oxide-Cu-Au deposits—A discussion of critical issues and current developments: North Queensland, Australia, James Cook University, Economic Geology Research Unit Contribution 58, p. 5–11.

Barton, M.D., and Young, S., 2002, Non-pegmatitic deposits of beryllium—Mineralogy, geology, phase equilibria and origin: Reviews in Mineralogy and Geochemistry, v. 50, no. 1, p. 591–691.

Bau, M., Schmidt, K., Koschinsky, A., Hein, J., Kuhn, T., and Usui, A., 2014, Discriminating between different genetic types of marine ferro-manganese crusts and nodules based on rare earth elements and yttrium: Chemical Geology, v. 381, p. 1–9.

Beaty, D.W., Cunningham, C.G., Rye, R.O., Steven, T.A., and Gonzalez-Urien, E., 1986, Geology and geochemistry of the Deer Trail Pb-Zn-Ag-Au-Cu manto deposits, Marysvale District, west-central Utah: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 81, no. 8, p. 1932–1952.

Beaudoin, G., and Sangster, D.F., 1992, A descriptive model for silver-lead-zinc veins in clastic metasedimentary terranes: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 87, no. 4, p. 1005–1021, accessed April 18, 2020, at https://doi.org/10.2113/gsecongeo.87.4.1005.

Beaudoin, G., and Sangster, D.F., 1995, Clastic metasediment-hosted vein silver-lead-zinc, *in* Eckstrand, O.R., Sinclair, W.D., and Thorpe, R.I., eds., Geology of Canadian mineral deposit types: Geological Survey of Canada, Geology of Canada, no. 8, p. 393–398. [Also available at https://doi.org/10.4095/208008.]

Berger, V.I., Singer, D.A., Bliss, J.D., and Moring, B.C., 2011, Ni-Co laterite deposits of the world—Database and grade and tonnage models: U.S. Geological Survey Open-File Report 2011–1058, 26 p., accessed March 3, 2021, at https://doi.org/10.3133/ofr20111058.

Blevin, P.L., 2004, Redox and compositional parameters for interpreting the granitoid metallogeny of eastern Australia—Implications for gold-rich ore systems: Resource Geology, v. 54, no. 3, p. 241–252.

Bliss, J.D., and Orris, G.J., 1986, Descriptive model of simple Sb deposits, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 183–184.

Bolonin, A.V., and Gradovsky, I.F., 2012, Supergene processes and uranium ore formation in the Ronneburg ore field, Germany: Geology of Ore Deposits, v. 54, no. 2, p. 122–131, accessed March 3, 2021, at https://doi.org/10.1134/S1075701512020031.

Boni, M., and Mondillo, N., 2015, The “calamines” and the “others”—The great family of supergene nonsulfide zinc ores: Ore Geology Reviews, v. 67, p. 208–233.

Boni, M., Terracciano, R., Evans, N.J., Laukamp, C., Schneider, J., and Bechstadt, T., 2007, Genesis of vanadium ores in the Otavi Mountainland, Namibia: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 102, no. 3, p. 441–469.https://doi.org/10.2113/gsecongeo.102.3.441

Bradley, D., Munk, L., Jochens, H., Hynek, S., and Labay, K., 2013, A preliminary deposit model for lithium brines: U.S. Geological Survey Open-File Report 2013–1006, 6 p., accessed April 18, 2020, at https://doi.org/10.3133/ofr20131006.

Breit, G.N., 2016, Resource potential for commodities in addition to uranium in sandstone-hosted deposits, chap. 13 *of* Verplanck, P.L., and Hitzman, M.W., eds., Reviews in economic geology, volume 18—Rare earth and critical elements in ore deposits: Littleton, Colo., Society of Economic Geologists, Inc., p. 323–338. [Also available at https://doi.org/10.5382/Rev.18.13.]

Briskey, J.A., 1986, Descriptive model of sandstone-hosted Pb-Zn, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 201–202.

Bundtzen, T.K., 1986, Prospect examination of a gold-tungsten placer deposit at Alder Creek, Vinasale Mountain area, western Alaska: Fairbanks, Alaska, Alaska Division of Geological & Geophysical Surveys, Public Data File 86–15, 10 p., accessed March 3, 2021, at https://doi.org/10.14509/1190.

Bundtzen, T.K., Reger, R.D., Laird, G.M., Pinney, D.S., Clautice, K.H., Liss, S.A., and Cruse, G.R., 1994, Progress report on the geology and mineral resources of the Nome mining district, Alaska: Fairbanks, Alaska, Alaska Division of Geological & Geophysical Surveys, Public Data File 94–39, 21 p., 2 sheets, scale 1:63,360.

Burisch, M., Gerdes, A., Walter, B.F., Neumann, U., Fettel, M., and Markl, G., 2017, Methane and the origin of five-element veins—Mineralogy, age, fluid inclusion chemistry and ore forming processes in the Odenwald, SW Germany: Ore Geology Reviews, v. 81, p. 42–61, accessed April 18, 2020, at https://doi.org/10.1016/j.oregeorev.2016.10.033.

Burton, G.R., and Downes, P.M., 2005, Mineralisation, *in* Colquhoun, G.P., Meakin, N.S., and Cameron, R.G., comps., Cargelligo 1:250 000 Geological Sheets SI/55-6, 3rd edition, explanatory notes: Maitland, New South Wales, Geological Survey of New South Wales, 291 p.

Cairncross, B., and Beukes, N.J., 2013, The Kalahari Manganese Field—The adventure continues: Cape Town, South Africa, Struik Nature, 384 p.

Callaghan, T., Sloan, M., and Mackay-Scollay, B., 2017, Avebury nickel sulfide deposit, *in* Phillips, N., ed., Australian Ore Deposits (6th ed.): Australasian Institute of Mining and Metallurgy Monograph 32, p. 813–816.

Camier, J., 2002, The Sue-Dianne Fe-oxide Cu-Ag-Au breccia complex, southern Great Bear magmatic zone, Northwest Territories, Canada: London, Ontario, Canada, University of Western Ontario, M.Sc. thesis, 210 p.

Campbell, I.B., Cochrane, G.W., Hughes, M.J., Judkins, D., Lynn, S., Kotsonis, A., Olshina, A., Ferguson, J.A., Summons, T.J., McHaffie, I.W., and King, R.L., 2003, Other non-energy resources—Materials in abundance, *in* Birch, W.D., ed., Geology of Victoria: Geological Society of Australia Special Publication 23, p. 435–467.

Cannon, W.F., 1986a, Descriptive model of Algoma Fe, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 198.

Cannon, W.F., 1986b, Descriptive model of Superior Fe, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 228.

Cannon, W.F., Kimball, B.E., and Corathers, L.A., 2017, Manganese, chap. L *of* Schulz, K.J., DeYoung, J.H., Jr., Seal, R.R., II, and Bradley, D.C., eds., Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply: U.S. Geological Survey Professional Paper 1802, p. L1–L28, accessed April 18, 2020, at https://doi.org/10.3133/pp1802L.

Castor, S.B., and Henry, C.D., 2020, Lithium-rich claystone in the McDermitt caldera, Nevada, USA—Geologic, mineralogical, and geochemical characteristics and possible origin: Minerals (Basel), v. 10, no. 1, article no. 68, accessed March 3, 2021, at https://www.mdpi.com/2075-163X/10/1/68.

Černý, P., and Ercit, T.S., 2005, The classification of granitic pegmatites revisited: Canadian Mineralogist, v. 43, no. 6, p. 2005–2026, accessed April 18, 2020, at https://doi.org/10.2113/gscanmin.43.6.2005.

Chen, H., Kyser, T.K., and Clark, A.H., 2011, Contrasting fluids and reservoirs in the contiguous Marcona and Mina Justa iron oxide–Cu (–Ag–Au) deposits, south-central Perú: Mineralium Deposita, v. 46, no. 7, p. 677–706.

Clabaugh, S.E., 1952, Corundum deposits of Montana: U.S. Geological Survey Bulletin 983, 100 p.

Clark, S.H.B., and Orris, G.J., 1991, Descriptive model of sedimentary exhalative barite, *in* Orris, G.J., and Bliss, J.D., eds., Some industrial mineral deposit models—Descriptive deposit models: U.S. Geological Survey Open-File Report 91–11A, p. 24–25.

Clark, T., Gobeil, A., and Chevé, S., 2010, Alterations in IOCG-type and related deposits in the Manitou Lake area, Eastern Grenville Province, Québec, *in* Corriveau, L., and Mumin, A.H., eds., Exploring for iron oxide copper-gold deposits—Canada and global analogues: Newfoundland, Canada, Geological Association of Canada, Short Course Notes 20, p. 127–146.

Cline, J.S., Hofstra, A.H., Muntean, J.L., Tosdal, R.M., and Hickey, K.A., 2005, Carlin-type gold deposits in Nevada—Critical geologic characteristics and viable models, *in* Hedenquist, J.W., Thompson, J.F.H., Goldfarb, R.J., and Richards, J.P., eds., Economic Geology—One Hundredth Anniversary v. 1905–2005: Littleton, Colo., Society of Economic Geologists, Inc., p. 451–484.

Cocker, M.D., 2014, Lateritic, supergene rare earth element (REE) deposits, *in* Conway, F.M., ed., 48th Annual Forum on the Geology of Industrial Minerals, Scottsdale, Ariz., April 30–May 4, 2012, Proceedings: Arizona Geological Survey Special Paper #9, chap. 4, p. 1–18, accessed March 3, 2021, at https://repository.arizona.edu/handle/10150/629374.

Commonwealth of Australia, 2019a, Australian Critical Minerals Prospectus: Australian Government, Australian Trade and Investment Commission, 76 p., accessed March 11, 2021, at https://www.austrade.gov.au/ArticleDocuments/5572/Australian_Critical_Minerals_Prospectus_01.pdf.aspx.

Commonwealth of Australia, 2019b, Australia's Critical Minerals Strategy: Australian Government, Department of Industry, Innovation and Science, Australian Trade and Investment Commission, 18 p., accessed March 11, 2021, at https://www.industry.gov.au/sites/default/files/2019-03/australias-critical-minerals-strategy-2019.pdf.

Commonwealth of Australia, 2020a, Australian Critical Minerals Prospectus 2020: Australian Government, Australian Trade and Investment Commission, Geoscience Australia, Department of Industry, Science, Energy and Resources, 169 p., accessed March 11, 2021, at https://www.austrade.gov.au/ArticleDocuments/5572/Australian_Critical_Minerals_Prospectus.pdf.

Commonwealth of Australia, 2020b, Critical Minerals Facilitation Office: Australian Government, Department of Industry, Science, Energy and Resources website, accessed March 11, 2021, at https://www.industry.gov.au/policies-and-initiatives/critical-minerals-facilitation-office.

Commonwealth of Australia, 2020c, Exploring for the Future: Australian Government, Geoscience Australia website, accessed March 11, 2021, at https://www.ga.gov.au/eftf.

Corriveau, L., Montreuil, J.-F., and Potter, E.G., 2016, Alteration facies linkages among IOCG, IOA and affiliated deposits in the Great Bear magmatic zone, Canada, *in* Slack, J., Corriveau, L., and Hitzman, M., eds., Proterozoic iron oxide-apatite (± REE) and iron oxide-copper-gold and affiliated deposits of Southeast Missouri, USA, and the Great Bear magmatic zone v. 111: Northwest Territories, Canada, Economic Geology and the Bulletin of the Society of Economic Geologists, p. 2045–2072.

Corriveau, L., Montreuil, J.-F., Potter, E.G., Blein, O., and De Toni, A.F., in press, Mineral systems with IOCG and affiliated deposits—Part 3—Metal pathways and ore deposit model, *in* Corriveau, L., Potter, E.G., and Mumin, A.H., eds., Mineral systems with iron oxide copper-gold (IOCG) and affiliated deposits: Newfoundland, Canada, Geological Association of Canada, Special Paper 52.

Cox, D.P., 1986a, Descriptive model of basaltic Cu, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey, Bulletin 1693, p. 130.

Cox, D.P., 1986b, Descriptive model of diamond placers, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 274.

Cox, D.P., 1986c, Descriptive model of Fe skarn deposits, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 94.

Cox, D.P., 1986d, Descriptive model of polymetallic veins, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 125.

Cox, D.P., 1986e, Descriptive model of quartz pebble conglomerate Au-U, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 199.

Cox, D.P., 1992, Descriptive model of distal disseminated Ag-Au, *in* Bliss, J.D., ed., Developments in mineral deposit modeling: U.S. Geological Survey Bulletin 2004, p. 19.

Cox, D.P., and Bagby, W.C., 1986, Descriptive model of W veins, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 64.

Cox, D.P., and Bernstein, L.R., 1986, Descriptive model of Kipushi Cu-Pb-Zn, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 227.

Cox, D.P., and Theodore, T.G., 1986, Descriptive model of Cu skarn deposits, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 86.

Davidson, G.J., Paterson, H., Meffre, S., and Berry, R.F., 2007, Characteristics and origin of the Oak Dam East breccia-hosted, iron oxide Cu-U-(Au) deposit—Olympic Dam region, Gawler Craton, South Australia: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 102, no. 8, p. 1471–1498.

Day, W.C., 2019, The Earth Mapping Resources Initiative (Earth MRI)—Mapping the Nation’s critical mineral resources (ver. 1.2, September 2019): U.S. Geological Survey Fact Sheet 2019–3007, 2 p., accessed April 18, 2020, at https://doi.org/10.3133/fs20193007.

De Haller, A., Corfu, F., Fontboté, L., Schaltegger, U., Barra, F., Chiaradia, M., Frank, M., and Alvarado, J.Z., 2006, Geology, geochronology, and Hf and Pb isotope data of the Raúl-Condestable iron oxide-copper-gold deposit, central coast of Perú: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 101, no. 2, p. 281–310.

De Magnee, I., and Francois, A., 1988, The origin of the Kipushi (Cu, Zn, Pb) deposit in direct relation with a Proterozoic salt diapir, copperbelt of central Africa, Shaba, Republic of Zaire, *in* Friedrich, G.H., and Herzig, P.M., eds., Base metal sulphide deposits in sedimentary and volcanic environments—Proceedings of the DMG-GDMB-SGA-Meeting, Aachen, 1985: Berlin, Springer-Verlag, p. 74–93.

deMelo, G.H.C., Monteiro, L.V.S., Xavier, R.P., Moreto, C.P.N., Santiago, E.S.B., Dufrane, S.A., Aires, B., and Santos, A.F.F., 2017, Temporal evolution of the giant Salobo IOCG deposit, Carajás Province (Brazil)—Constraints from paragenesis of hydrothermal alteration and U-Pb geochronology: Mineralium Deposita, v. 52, no. 5, p. 709–732.

Denny, F.B., Guillemette, R.N., and Lefticariu, L., 2015, Rare earth mineral concentrations in ultramafic alkaline rocks and fluorite within the Illinois-Kentucky Fluorite District—Hicks Dome cryptoexplosive complex, southeast Illinois and northwest Kentucky (USA), *in* Lasemi, Z., ed., Proceedings of the 47th Forum on the Geology of Industrial Minerals: Illinois State Geological Survey Circular 587, p. 77–92.

Denny, F.B., Devera, J.A., and Seid, M.J., 2016, Fluorite deposits within the Illinois-Kentucky Fluorspar District and how they relate to the Hicks Dome cryptoexplosive feature, Hardin County, Illinois, *in* Lasemi, Z., and Elrick, S., eds., 1967–2016—Celebrating 50 years of geoscience in the mid-continent, Guidebook for the 50th Annual Meeting of the Geological Society of America, North-Central Section, April 18–19, 2016: Champaign, Ill., Illinois State Geological Survey, Prairie Research Institute, Guidebook no. 043, p. 39–54.

Diemar, V.A., 1998, Thuddungra magnesite deposits, *in* Berkman, D.A., and Mackenzie, D.H., eds., Geology of Australian and Papua New Guinean mineral deposits: Victoria, Australia, Australasian Institute of Mining and Metallurgy Monograph 22, p. 655–660.

Dostal, J., 2016, Rare metal deposits associated with alkaline/peralkaline igneous rocks, chap. 2 *of* Verplanck, P.L., and Hitzman, M.W., eds., Reviews in economic geology, volume 18—Rare earth and critical elements in ore deposits: Littleton, Colo., Society of Economic Geologists, Inc., p. 33–54.

Duke, J.M., 1995, Podiform (ophiolitic) chromite, *in* Eckstrand, O.R., Sinclair, W.D., and Thorpe, R.I, eds., Geology of Canadian mineral deposit types: Geological Survey of Canada, Geology of Canada Series no. 8, p. 621–624, accessed March 3, 2021, at https://doi.org/10.4095/208050.

Dulfer, H., Skirrow, R.G., Champion, D.C., Highet, L.M., Czarnota, K., Coghlan, R., and Milligan, P.R., 2016, Potential for intrusion-hosted Ni-Cu-PGE sulfide deposits in Australia—A continental-scale analysis of mineral system prospectivity: Canberra, Australia, Geoscience Australia, Record 2016/01, 137 p., accessed April 30, 2021, at https://doi.org/10.11636/Record.2016.001.

Dyni, J.R., 1991, Descriptive model of sodium carbonate in bedded lacustrine evaporites—Deposit subtype—Green River, *in* Orris, G.J., and Bliss, J.D., eds., Some industrial mineral deposit models—Descriptive deposit models: U.S. Geological Survey Open-File Report 91–11A, p. 46–50.

Edfelt, Å., Armstrong, R.N., Smith, M., and Martinsson, O., 2005, Alteration paragenesis and mineral chemistry of the Tjårrojåkka apatite–iron and Cu (-Au) occurrences, Kiruna area, northern Sweden: Mineralium Deposita, v. 40, no. 4, p. 409–434.

Edgoose, C.J., 2013, Amadeus Basin, chap. 23 *of* Ahmad, M., and Munson, T.J., comps., Geology and mineral resources of the Northern Territory: Darwin, Northern Territory, Australia, Northern Territory Geological Survey Special Publication 5, p. 23-1–23-70.

Ehrig, K., McPhie, J., and Kamenetsky, V.S., 2012, Geology and mineralogical zonation of the Olympic Dam iron oxide Cu-U-Au-Ag deposit, *in* Hedenquist, J.W., Harris, M., and Camus, F., eds., Geology and genesis of major copper deposits and districts of the world—A tribute to Richard H. Sillitoe—Littleton, Colo., Society of Economic Geologists, Inc., Special Publication Number 16: South Australia, p. 237–267.

Emsbo, P., 2000, Gold in sedex deposits, chap. 13 *of* Hagemann, S.G., and Brown, P.E., eds., Reviews in economic geology, volume 13—Gold in 2000: Littleton, Colo., Society of Economic Geologists, Inc., p. 427–437.

Emsbo, P., 2009, Geologic criteria for the assessment of sedimentary exhalative (sedex) Zn-Pb-Ag deposits: U.S. Geological Survey Open-File Report 2009–1209, 21 p., accessed March 3, 2021, at https://doi.org/10.3133/ofr20091209.

Emsbo, P., Lawley, C., and Czarnota, K., 2021, Geological surveys unite to improve critical mineral security: Eos (Washington, D.C.), v. 102, accessed March 3, 2021, at https://doi.org/10.1029/2021EO154252.

Emsbo, P., McLaughlin, P.I., du Bray, E.A., Anderson, E.D., Vandenbroucke, T.R.A., and Zielinski, R.A., 2016a, Rare earth elements in sedimentary phosphorite deposits—A global assessment, chap. 5 *of* Verplanck, P.L, and Hitzman, M.W., eds., Reviews in economic geology, volume 18—Rare earth and critical elements in ore deposits: Littleton, Colo., Society of Economic Geologists, Inc., p. 101–114.

Emsbo, P., Seal, R.R., Breit, G.N., Diehl, S.F., and Shah, A.K., 2016b, Sedimentary exhalative (sedex) zinc-lead-silver deposit model, chap. N *of* Mineral deposit models for resource assessment: U.S. Geological Survey Scientific Investigations Report 2010–5070, 57 p., accessed April 18, 2020, at https://doi.org/10.3133/sir20105070N.

Evans, J.G., and Moyle, P.R., 2006, U.S. industrial garnet, chap. L *of* Contributions to industrial-minerals research: U.S. Geological Survey Bulletin 2209, 60 p., accessed March 3, 2021, at https://pubs.usgs.gov/bul/b2209-l/.

Ewers, G.R., and Sun, S.-S., 1989, Genesis of the Red Dome gold skarn deposit, Northeast Queensland, chap. 16 *of* Keays, R.R., Ramsay, R.H., and Groves, D.I., eds., The geology of gold deposits—The perspective in 1988: Economic Geology Publishing Company, Economic Geology Monograph 6, p. 218–232.

Foley, N.K., and Ayuso, R.A., 2015, REE enrichment in granite-derived regolith deposits of the southeast United States–Prospective source rocks and accumulation processes, *in* Simandl, G.J., and Neetz, M., eds., Symposium on Strategic and Critical Materials, Victoria, B.C., November 13–14, 2015, Proceedings: British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Paper 2015–3, p. 131–138.

Foley, N.K., Hofstra, A.H., Lindsey, D.A., Seal, R.R., II, Jaskula, B., and Piatak, N.M., 2012, Occurrence model for volcanogenic beryllium deposits, chap. F *of* Mineral deposit models for resource assessment: U.S. Geological Survey Scientific Investigations Report 2010–5070–F, 43 p., accessed April 18, 2020, at https://pubs.usgs.gov/sir/2010/5070/f/SIR10-5070F.pdf.

Force, E.R., Paradis, S., and Simandl, G.J., 1999, Sedimentary manganese, *in* Simandl, G.J., Hora, Z.D., and Lefebure D.V., eds., Selected British Columbia mineral deposit profiles, volume 3—Industrial minerals and gemstones: British Columbia Ministry of Energy and Mines, Open File 1999–10, p. 47–50.

Fortier, S.M., Nassar, N.T., Lederer, G.W., Brainard, J., Gambogi, J., and McCullough, E.A., 2018, Draft critical mineral list—Summary of methodology and background information—U.S. Geological Survey technical input document in response to Secretarial Order No. 3359: U.S. Geological Survey Open-File Report 2018–1021, 15 p., accessed April 18, 2020, at https://doi.org/10.3133/ofr20181021.

Friehauf, K.C., and Pareja, G.A., 1998, Can oxygen isotopic halos be produced around high-temperature dolostone-hosted ore deposits? Evidence from the Superior District, Arizona: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 93, no. 5, p. 639–650.

Gadd, M.G., Peter, J.M., Hnatyshin, D., Creaser, R., Gouwy, S., and Fraser, T., 2020, A Middle Devonian basin-scale precious metal enrichment event across northern Yukon (Canada): Geology, v. 48, no. 3, p. 242–246, accessed April 30, 2021, at https://doi.org/10.1130/G46874.1.

Gandhi, S.S., 1978, Geological setting and genetic aspects of uranium occurrences in the Kaipokok Bay–Big River area, Labrador: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 73, no. 8, p. 1492–1522.

Goldfarb, R.J., Baker, T., Dubé, B., Groves, D.I., Hart, C.J.R., and Gosselin, P., 2005, Distribution, character, and genesis of gold deposits in metamorphic terranes, *in* Hedenquist, J.W., Thompson, J.F.H., Goldfarb, R.J., and Richards, J.P., eds., Economic Geology—One Hundredth Anniversary v. 1905–2005: Littleton, Colo., Society of Economic Geologists, Inc., p. 407–450.

Goldfarb, R.J., Hofstra, A.H., and Simmons, S.F., 2016, Critical elements in Carlin, epithermal, and orogenic gold deposits, chap. 10 *of* Verplanck, P.L., and Hitzman, M.W., eds., Reviews in economic geology, volume 18—Rare earth and critical elements in ore deposits: Littleton, Colo., Society of Economic Geologists, Inc., p. 217–244. [Also available at https://doi.org/10.5382/Rev.18.10.]

Goodfellow, W.D., ed., 2007, Mineral deposits of Canada—A synthesis of major deposit-types, district metallogeny, the evolution of geological provinces, and exploration methods: Newfoundland, Canada, Geological Association of Canada, Mineral Deposits Division, Special Publication No. 5, 1,061 p.

Gordon, M., Jr., Tracey, J.I., Jr., and Ellis, M.W., 1958, Geology of the Arkansas bauxite region: U.S. Geological Survey Professional Paper 299, 268 p., 33plates. [Also available at https://pubs.usgs.gov/pp/0299/report.pdf.]

Government of Canada, 2021, Critical minerals: Natural Resources Canada web page, accessed March 11, 2021, at https://www.nrcan.gc.ca/criticalminerals.

Granitto, M., Giles, S.A., and Kelley, K.D., 2017, Global geochemical database for critical metals in black shales: U.S. Geological Survey data release, accessed March 3, 2021, at https://doi.org/10.5066/F71G0K7X.

Gray, J.E., and Bailey, E.A., 2003, The southwestern Alaska mercury belt, *in* Gray, J.E., ed., Geologic studies of mercury by the U.S. Geological Survey: U.S. Geological Survey Circular 1248, p. 19–22.

Groves, D.I., Goldfarb, R.J., Gebre-Mariam, M., Hagemann, S.G., and Robert, F., 1998, Orogenic gold deposits—A proposed classification in the context of their crustal distribution and relationship to other gold deposit types: Ore Geology Reviews, v. 13, no. 1–5, p. 7–27. [Also available at https://doi.org/10.1016/S0169-1368(97)00012-7.]

Hall, S.M., Van Gosen, B.S., Paces, J.B., Zielinski, R.A., and Breit, G.N., 2019, Calcrete uranium deposits in the Southern High Plains, USA: Ore Geology Reviews, v. 109, p. 50–78, accessed April 18, 2020, at https://doi.org/10.1016/j.oregeorev.2019.03.036.

Hammarstrom, J.H., and Dicken, C.L., 2019, Focus areas for data acquisition for potential domestic sources of critical minerals—Rare earth elements, chap. A *of* U.S. Geological Survey, Focus areas for data acquisition for potential domestic sources of critical minerals: U.S. Geological Survey Open-File Report 2019–1023, 11 p., accessed April 18, 2020, at https://doi.org/10.3133/ofr20191023A.

Hammarstrom, J.M., Dicken, C.L., Day, W.C., Hofstra, A.H., Drenth, B.J., Shah, A.K., McCafferty, A.E., Woodruff, L.G., Foley, N.K., Ponce, D.A., Frost, T.P., and Stillings, L.L., 2020, Focus areas for data acquisition for potential domestic resources of 11 critical minerals in the conterminous United States, Hawaii, and Puerto Rico—Aluminum, cobalt, graphite, lithium, niobium, platinum-group elements, rare earth elements, tantalum, tin, titanium, and tungsten, chap. B *of* U.S. Geological Survey, Focus areas for data acquisition for potential domestic sources of critical minerals: U.S. Geological Survey Open-File Report 2019–1023, 67 p., accessed March 3, 2021, at https://doi.org/10.3133/ofr20191023B.

Hammarstrom, J.M., Elliott, J.E., Kotlyar, B.B., Theodore, T.G., Nash, J.T., John, D.A., Hoover, D.B., and Knepper, D.H., Jr., 1995a, Sn and (or) W skarn and replacement deposits, *in* du Bray, E.A., ed., Preliminary compilation of descriptive geoenvironmental mineral deposit models: U.S. Geological Survey Open-File Report 95–831, p. 54–61.

Hammarstrom, J.M., Kotlyar, B.B., Theodore, T.G., Elliott, J.E., John, D.A., Doebrich, J.L., Nash, J.T., Carlson, R.R., Lee, G.K., Livo, K.E., and Klein, D.P., 1995b, Cu, Au, and Pb-Zn skarn deposits, *in* du Bray, E.A., ed., Preliminary compilation of descriptive geoenvironmental mineral deposit models: U.S. Geological Survey Open-File Report 95–831, p. 90–111.

Hammarstrom, J.M., Theodore, T.G., Kotlyar, B.B., Doebrich, J.L., Elliott, J.E., Nash, J.T., John, D.A., and Livo, K.E., 1995c, Fe skarn deposits, *in* du Bray, E.A., ed., Preliminary compilation of descriptive geoenvironmental mineral deposit models: U.S. Geological Survey Open-File Report 95–831, p. 112–120.

Hannington, M.D., 2014, Volcanogenic massive sulfide deposits, chap. 18 *of* Holland, H.D., and Turekian, K.K., eds., Treatise on geochemistry, 2d ed., volume 13: Amsterdam, The Netherlands, Elsevier, p. 463–488.

Harlov, D.E., Meighan, C.J., Kerr, I.D., and Samson, I.M., 2016, Mineralogy, chemistry, and fluid-aided evolution of the Pea Ridge Fe oxide-(Y + REE) deposit, Southeast Missouri, USA: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 111, no. 8, p. 1963–1984.

Hart, C.J.R., 2007, Reduced intrusion-related gold systems, *in* Goodfellow, W.D., ed., Mineral deposits of Canada—A synthesis of major deposit-types, district metallogeny, the evolution of geological provinces, and exploration methods: Newfoundland, Canada, Geological Association of Canada, Mineral Deposits Division, Special Publication 5, p. 95–112.

Hart, C.J.R., McCoy, D.T., Goldfarb, R.J., Smith, M., Roberts, P., Hulstein, R., Bakke, A.A., and Bundtzen, T.K., 2002, Geology, exploration, and discovery in the Tintina gold province, *in* Goldfarb, R.J., and Nielsen, R.L., eds., Integrated methods for discovery—Global exploration in the twenty-first century—Littleton, Colo., Society of Economic Geologists, Inc., Special Publication No. 9: Alaska and Yukon, p. 241–274.

Harvey, J.D., Reddell, C.D., and Swindell, E.P.W., 2017, Groot Eylant and Bootu Creek manganese deposits, *in* Phillips, N., ed., Australian Ore Deposits (6th ed.): Australasian Institute of Mining and Metallurgy Monograph 32, p. 543–546.

Hayes, T.S., Cox, D.P., Piatak, N.M., and Seal, R.R., II, 2015, Sediment-hosted stratabound copper deposit model: U.S. Geological Survey Scientific Investigations Report 2010–5070–M, 147 p., accessed March 3, 2021, at https://doi.org/10.3133/sir20105070M.

Hayes, T.S., Miller, M.M., Orris, G.J., and Piatak, N.M., 2017, Fluorine, chap. G *of* Schulz, K.J., DeYoung, J.H., Jr., Seal, R.R., II, and Bradley, D.C., eds., Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply: U.S. Geological Survey Professional Paper 1802, p. G1–G80, accessed April 18, 2020, at https://doi.org/10.3133/pp1802G.

Hein, J.R., and Koschinsky, A., 2014, Deep-ocean ferromanganese crusts and nodules, chap. 11 *of* Holland, H.D., and Turekian, K.K., eds., Treatise on geochemistry, 2d ed., volume 13: Amsterdam, The Netherlands, Elsevier, p. 273–291.

Helt, K.M., Williams-Jones, A.E., Clark, J.R., Wing, B.A., and Wares, R.P., 2014, Constraints on the genesis of the Archean oxidized, intrusion-related Canadian Malartic gold deposit, Quebec, Canada: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 109, no. 3, p. 713–735.

Hildebrand, R.S., 1986, Kiruna-type deposits—Their origin and relationship to intermediate subvolcanic plutons in the Great Bear magmatic zone, Northwest Canada: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 81, no. 3, p. 640–659.

Hitzman, M.W., 1995, Mineralization in the Irish Zn-Pb-(Ba-Ag) orefield, *in* Anderson, K., Ashton, J., Earls, G., Hitzman, M., and Tear, S., eds., Irish carbonate-hosted Zn-Pb deposits—Society of Economic Geologists and the Irish Association for Economic Geology Field Conference, May 13–19, 1995, Guidebook Series 21: Littleton, Colo., Society of Economic Geologists, p. 25–61.

Hitzman, M.W., Reynolds, N.A., Sangster, D.F., Allen, C.R., and Carman, C.E., 2003, Classification, genesis, and exploration guides for nonsulphide zinc deposits: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 98, no. 4, p. 685–714.

Hofstra, A.H., and Cline, J.S., 2000, Characteristics and models for Carlin-type gold deposits, chap. 5 *of* Hagemann, S.G., and Brown, P.E., eds., Reviews in economic geology, volume 13—Gold in 2000: Littleton, Colo., Society of Economic Geologists, Inc., p. 163–220.

Hofstra, A.H., and Kreiner, D.C., 2020, Systems-Deposits-Commodities-Critical Minerals Table for the Earth Mapping Resources Initiative: U.S. Geological Survey Open-File Report 2020–1042, 24 p., accessed March 3, 2021, at https://doi.org/10.3133/ofr20201042.

Hofstra, A.H., Marsh, E.E., Todorov, T.I., and Emsbo, P., 2013, Fluid inclusion evidence for a genetic link between simple antimony veins and giant silver veins in the Coeur d'Alene mining district, ID and MT, USA: Geofluids, v. 13, no. 4, p. 475–493, accessed April 18, 2020, at https://doi.org/10.1111/gfl.12036.

Hollister, V.F., 1992, On a proposed plutonic porphyry gold deposit model: Nonrenewable Resources, v. 1, no. 4, p. 293–302.

Horn, C.M., Keeling, J.L., and Oliver, J.G., 2017, Sedimentary magnesite deposits, *in* Phillips, N., ed., Australian Ore Deposits (6th ed.): Australasian Institute of Mining and Metallurgy Monograph 32, p. 671–672.

Hosterman, J.W., 1998, Preliminary descriptive model of residual kaolin, *in* Orris, G.J., ed., Additional descriptive models of industrial mineral deposits: U.S. Geological Survey Open-File Report 98–505, p. 41–43.

Hou, Y.L., Zhong, Y.T., Xu, Y.G., and He, B., 2017, The provenance of late Permian karstic bauxite deposits in SW China, constrained by the geochemistry of interbedded clastic rocks, and U-Pb–Hf–O isotopes of detrital zircons: Lithos, v. 278–281, p. 240–254.

Hõy, T., 1996, Irish-type carbonate-hosted Zn-Pb, *in* Lefebure, D.V., and Hõy, T, eds., Selected British Columbia mineral deposit profiles, volume 2—Metallic deposits: British Columbia Ministry of Employment and Investment, Open File 1996–13, p. 21–24.

Hulbert, L.J., Carne, R.C., Gregoire, D.C., and Paktunc, D., 1992, Sedimentary nickel, zinc, and platinum-group-element mineralization in Devonian black shales at the Nick property, Yukon, Canada—A new deposit type: Exploration and Mining Geology, v. 1, p. 39–62.

Hussey, K.J., and Dean, R.A., 2013, New insights on the geology of the Nolans Bore rare earths deposit [abs.], *in* Munson, T.J., and Johnston, K.J., eds., Northern Territory Geological Survey, Annual Geoscience Exploration Seminar, 2013, Record of Abstracts: Darwin, Australia, Northern Territory Geological Survey, p. 77–80.

Huston, D.L., Maas, R., Cross, A., Hussey, K.J., Mernagh, T.P., Fraser, G., and Champion, D.C., 2016a, The Nolans Bore rare-earth element-phosphorus-uranium mineral system—Geology, origin and post-depositional modifications: Mineralium Deposita, v. 51, no. 6, p. 797–822.

Huston, D.L., Mernagh, T.P., Hagemann, S.G., Doublier, M.P., Fiorentini, M., Champion, D.C., Jaques, A.L., Czarnota, K., Cayley, R., Skirrow, R., and Bastrakov, E., 2016b, Tectono-metallogenic systems—The place of mineral systems within tectonic evolution, with an emphasis on Australian examples: Ore Geology Reviews, v. 76, p. 168–210, accessed April 2020 at https://doi.org/10.1016/j.oregeorev.2015.09.005.

International Atomic Energy Agency [IAEA], 2020, Descriptive uranium deposit and mineral system models: Vienna, Austria, International Atomic Energy Agency, 313 p.

Ioneer, 2020, Overview—Rhyolite Ridge: Ioneer web page, accessed March 3, 2021, at https://www.ioneer.com/rhyolite-ridge/overview.

Jensen, E.P., and Barton, M.D., 2000, Gold deposits related to alkaline magmatism, chap. 8 *of* Hagemann, S.G., and Brown, P.E., eds., Reviews in economic geology, volume 13—Gold in 2000: Littleton, Colo., Society of Economic Geologists, Inc., p. 279–314.

John, D.A., 2001, Miocene and early Pliocene epithermal gold-silver deposits in the northern Great Basin, western United States—Characteristics, distribution, and relationship to magmatism: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 96, no. 8, p. 1827–1853.

Johnson, D.A., and Barton, M.D., 2000, Time-space development of an external brine-dominated, igneous-driven hydrothermal system—Humboldt mafic complex, western Nevada, *in* Dilles, J.H., Barton, M.D., Johnson, D.A., Proffett, J.M., and Einaudi, M.T., eds., Contrasting styles of intrusion-associated hydrothermal systems: Guidebook Series 32: Littleton, Colo., Society of Economic Geologists, p. 127–143.

Jones, S.A., 2017, Woodie Woodie manganese deposits, *in* Phillips, N., ed., Australian ore deposits (6th ed.): Australasian Institute of Mining and Metallurgy Monograph 32, p. 381–384.

Kalashnikov, A.O., Konopleva, N.G., Pakhomovsky, Y.A., and Ivanyuk, G.Y., 2016, Rare earth deposits of the Murmansk Region, Russia—: Reviews in Economic Geology, v. 111, no. 7, p. 1529–1559.

Keays, R.R., and Lightfoot, P.C., 2004, Formation of Ni-Cu-platinum group element sulfide mineralization in the Sudbury impact melt sheet: Mineralogy and Petrology, v. 82, no. 3–4, p. 217–258.

Kelley, K.D., 2020, International geoscience collaboration to support critical mineral discovery: U.S. Geological Survey Fact Sheet 2020–3035, 2 p., accessed March 3, 2021, at https://doi.org/10.3133/fs20203035.

Kelley, K.D., Huston, D.L., and Peter, J.M., 2021, Toward an effective global green economy—The Critical Minerals Mapping Initiative (CMMI): SGA News, no. 48, p. 1–5, accessed March 3, 2021, at https://e-sga.org/fileadmin/sga/newsletter/news_48/SGANews48_low.pdf.

Kelley, K.D., and Spry, P.G., 2016, Critical elements in alkaline igneous rock-related epithermal gold deposits, chap. 9 *of* Verplanck, P.L, and Hitzman, M.W., eds., Reviews in economic geology, volume 18—Rare earth and critical elements in ore deposits: Littleton, Colo., Society of Economic Geologists, Inc., p. 195–216.

Kelley, K.D., Spry, P.G., McLemore, V.T., Fey, D.L., and Anderson, E.D., 2020, Alkalic-type epithermal gold deposit model: U.S. Geological Survey Scientific Investigations Report 2010–5070–R, 74 p., accessed March 3, 2021, at https://doi.org/10.3133/sir20105070R.

King, J., 2019, Oak Dam—An early exploration opportunity, *in* South Australian Exploration and Mining Conference, Adelaide, Australia, November 29, 2019, Proceedings: South Australian Exploration and Mining Conference, 13 p., accessed April 21, 2021, at http://saemc.com.au/archive/2019/2019_03_king.pdf.

Kirschbaum, M.J., and Hitzman, M.W., 2016, Guelb Moghrein—An unusual carbonate-hosted iron oxide copper-gold deposit in Mauritania, northwest Africa: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 111, no. 3, p. 763–770.

Kissin, S.A., 1992, Five-element (Ni-Co-As-Ag-Bi) veins: Geoscience Canada, v. 19, p. 113–124.

Kotlyar, B.B., Ludington, S.D., and Mosier, D.L., 1995, Descriptive, grade, and tonnage models for molybdenum-tungsten greisen deposits: U.S. Geological Survey Open-File Report 95–584, 30 p., accessed March 3, 2021, at https://pubs.usgs.gov/of/1995/0584/report.pdf.

Lally, J.H., and Bajwah, Z.U., 2006, Uranium deposits of the Northern Territory: Darwin, Australia, Northern Territory Geological Survey, Report 20.

Lawley, C.J.M., Tschirhart, V., Smith, J.W., Pehrsson, S.J., Schetselaar, E.M., Schaeffer, A.J., Houlé, M.G., and Eglington, B.M., 2021, Prospectivity modelling of Canadian magmatic Ni (±Cu ± Co ± PGE) sulphide mineral systems: Ore Geology Reviews, v. 132, article no. 103985, accessed April 30, 2021, at https://www.sciencedirect.com/science/article/abs/pii/S016913682100010X.

Lawrie, K.C., and Hinman, M.C., 1998, Cobar-style polymetallic Au–Cu–Ag–Pb–Zn deposits: AGSO Journal of Australian Geology & Geophysics, v. 17, p. 169–187.

Le, T., 2019, Geological setting of the Tick Hill Au deposit, New Discovery Technical Workshop—Mount Isa: North Queensland, Australia, James Cook University, 31 p., accessed March 3, 2021, at https://smi.uq.edu.au/files/43704/1903_Isa_D2_05_Le_Tick-Hill-Deposit.pdf.

Leach, D.L., Hofstra, A.H., Church, S.E., Snee, L.W., Vaughn, R.B., and Zartman, R.E., 1998, Evidence for Proterozoic and Late Cretaceous-early Tertiary ore-forming events in the Coeur d'Alene district, Idaho and Montana: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 93, no. 3, p. 347–359. [Also available at https://doi.org/10.2113/gsecongeo.93.3.347.]

Leach, D.L., Landis, G.P., and Hofstra, A.H., 1988, Metamorphic origin of the Coeur d'Alene base- and precious-metal veins in the Belt basin, Idaho and Montana: Geology, v. 16, no. 2, p. 122–125. [Also available at https://doi.org/10.1130/0091-7613(1988)016<0122:MOOTCD>2.3.CO;2.]

Leach, D.L., Taylor, R.D., Fey, D.L., Diehl, S.F., and Saltus, R.W., 2010, A deposit model for Mississippi Valley-type lead-zinc ores, chap. A *of* Mineral deposit models for resource assessment: U.S. Geological Survey Scientific Investigations Report 2010–5070–A, 52 p., accessed April 18, 2020, at https://pubs.usgs.gov/sir/2010/5070/a/pdf/SIR10-5070A.pdf.

Lefebure, D.V., and Church, B.N., 1996, Volcanic Redbed Cu, *in* Lefebure, D.V., and Höy, T., eds., Selected British Columbia mineral deposit profiles, volume 2—Metallic deposits: British Columbia Ministry of Employment and Investment, Open File 1996–13, p. 5–7.

Lefebure, D.V., and Coveney, R.M., Jr., 1995, Shale-hosted Ni-Zn-Mo-PGE, *in* Lefebure, D.V., and Ray, G.E., eds., Selected British Columbia mineral deposit profiles, volume 1—Metallics and coal: British Columbia Ministry of Energy of Employment and Investment, Open File 1995–20, p. 45–48.

Leith, C.K., 1931, Secondary concentration of Lake Superior iron ores: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 26, no. 3, p. 274–288, accessed March 3, 2021, at https://doi.org/10.2113/gsecongeo.26.3.274.

Leonard, B.F., and Buddington, A.F., 1964, Ore deposits of the St. Lawrence County magnetite district, northwest Adirondacks New York: U.S. Geological Survey Professional Paper 377, 259 p.

Levson, V.M., 1995, Marine placers, *in* Lefebure D.V., and Ray G.E., eds., Selected British Columbia mineral deposit profiles, volume 1—Metallics and coal: British Columbia Ministry of Energy of Employment and Investment, Open File 1995–20, p. 29–31.

London, D., 2008, Pegmatites: Mineralogical Association of Canada, The Canadian Mineralogist, Special Publication 10, 347 p.

London, D., 2016, Rare-element granitic pegmatites, chap. 8 *of* Verplanck, P.L, and Hitzman, M.W., eds., Reviews in economic geology, volume 18—Rare earth and critical elements in ore deposits: Littleton, Colo., Society of Economic Geologists, Inc., p. 165–194.

Long, K.R., Wynn, J.C., Fritz, F., and Corbett, J., 1992, Lacustrine manganese—A supplement to U.S. Geological Survey Bulletin 1693: U.S. Geological Survey Open-File Report 92–239, 12 p.

Ludington, S., and Plumlee, G.S., 2009, Climax-type porphyry molybdenum deposits: U.S. Geological Survey Open-File Report 2009–1215, 16 p.

Luque, F.J., Huizenga, J.-M., Crespo-Feo, E., Wada, H., Ortega, L., and Barrenechea, J.F., 2014, Vein graphite deposits—Geological settings, origin, and economic significance: Mineralium Deposita, v. 49, no. 2, p. 261–277. [Also available at https://doi.org/10.1007/s00126-013-0489-9.]

Lydon, J.W., Paakki, J.J., Anderson, H.E., and Reardon, N.C., 2000, An overview of the geology and geochemistry of the Sullivan deposit: Newfoundland, Canada, Geological Association of Canada, Mineral Deposits Division, Special Publication 1, p. 505–522.

Mark, G., Oliver, N.H.S., and Williams, P.J., 2006, Mineralogical and chemical evolution of the Ernest Henry Fe oxide-Cu-Au ore system, Cloncurry district, northwest Queensland, Australia: Mineralium Deposita, v. 40, no. 8, p. 769–801.

Markl, G., Burisch, M., and Neumann, U., 2016, Natural fracking and the genesis of five-element veins: Mineralium Deposita, v. 51, no. 6, p. 703–712. [Also available at https://doi.org/10.1007/s00126-016-0662-z.]

Marr, J.D., 1992, Geology of the kyanite deposits at Willis Mountain, Virginia, *in* Sweet, P.C., ed., 26th Forum on the Geology of Industrial Minerals, Charlottesville, Va., May 14–18, 1990, Proceedings: The Forum on the Geology of Industrial Minerals, Virginia Division of Mineral Resources Publication 119, p. 129–134.

Marschik, R., and Fontboté, L., 2001, The Candelaria–Punta del Cobre iron oxide Cu–Au (–Zn–Ag) deposits, Chile: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 96, p. 1799–1826.

Marsh, E., Anderson, E., and Gray, F., 2013, Nickel-cobalt laterites—A deposit model, chap. H *of* Mineral deposit models for resource assessment: U.S. Geological Survey Scientific Investigations Report 2010–5070–H, 38 p., accessed April 18, 2020, at https://pubs.usgs.gov/sir/2010/5070/h/.

Martin, R.F., and De Vito, C., 2005, The patterns of enrichment in felsic pegmatites ultimately depend on tectonic setting: Canadian Mineralogist, v. 43, no. 6, p. 2027–2048. [Also available at https://doi.org/10.2113/gscanmin.43.6.2027.]

Maynard, J.B., and Van Houten, F.B., 1992, Descriptive model of oolitic ironstones, *in* Bliss, J.D., ed., Developments in mineral deposit modeling: U.S. Geological Survey Bulletin 2004, p. 39–40.

McCoy, D., Newberry, R.J., Layer, P., DiMarchi, J.J., Bakke, A., Masterman, J.S., and Minehane, D.L., 1997, Plutonic-related gold deposits of interior Alaska, *in* Goldfarb, R.J., and Miller, L.D., eds., Economic Geology Monograph 9—Mineral deposits of Alaska: Stanford, Calif., Economic Geology Publishing Company, p. 191–241.

McKeown, F.A., and Klemic, H., 1956, Rare-earth-bearing apatite at Mineville Essex County New York: U.S. Geological Survey Bulletin 1046–B, 24 p.

McLaughlin, B., Montreuil, J.-F., and Desrochers, J.-P., 2016, Exploration report (summer and fall 2014 drill program) on the Sagar Property, Romanet Horst, Labrador Trough, Québec, Canada: Toronto, Canada, Energizer Resources, Inc., 65 p.

McQuitty, B.M., and Pascoe, D.J., 1998, Magellan lead deposit, *in* Berkman, D.A., and Mackenzie, D.H., eds., Geology of Australian and Papua New Guinean mineral deposits: Victoria, Australia, Australasian Institute of Mining and Metallurgy Monograph 22, p. 293–296.

Megaw, P.K.M., 2009, Evaluation of oxidized Pb-Zn-Ag carbonate replacement deposits of Mexico in light of supergene zinc and residual lead enrichment processes, chap. 5 *of* Titley, S.R., ed., Supergene environments, processes, and products: Littleton, Colo., Society of Economic Geologists, Special Publication No. 14, p. 51–58.

Meinert, L.D., Dipple, G.M., and Nicolescu, S., 2005, World skarn deposits, *in* Hedenquist, J.W., Thompson, J.F.H., Goldfarb, R.J., and Richards, J.P., eds., Economic Geology—One Hundredth Anniversary v. 1905–2005: Littleton, Colo., Society of Economic Geologists, Inc., p. 299–336.

Michalski, T.C., and Modreski, P.J., 1991, Descriptive model of diamond-bearing kimberlite pipes, *in* Orris, G.J., and Bliss, J.D., eds., Some industrial mineral deposit models—Descriptive deposit models: U.S. Geological Survey Open-File Report 91–11A, p. 1–5.

Mines Canada, 2020, The Canadian Minerals and Metals Plan—Update to Action Plan 2020: Mines Canada, 9 p., accessed March 9, 2021, at https://www.minescanada.ca/sites/default/files/pictures/PDF/cmmp-actionplan2020_update_en_final.pdf.

Mizell, K., and Hein, J.R., 2016, Ferromanganese crusts and nodules—Rocks that grow, *in* White, W.M., ed., Encyclopedia of Geochemistry: Cham, Switzerland, Springer International Publishing, p. 477–482.

Monecke, T., Petersen, S., Hannington, M.D., Grant, H., and Samson, I.M., 2016, The minor element endowment of modern sea-floor massive sulfides and comparison with deposits hosted in ancient volcanic successions, chap. 11 *of* Verplanck, P.L., and Hitzman, M.W., eds., Reviews in economic geology, volume 18—Rare earth and critical elements in ore deposits: Littleton, Colo., Society of Economic Geologists, Inc., p. 245–306. [Also available at https://doi.org/10.5382/Rev.18.11.]

Monteiro, L.V.S., Xavier, R.P., de Carvalho, E.R., Hitzman, M.W., Johnson, C.A., de Souza Filho, C.R., and Torresi, I., 2008, Spatial and temporal zoning of hydrothermal alteration and mineralization in the Sossego iron oxide-copper-gold deposit, Carajás Mineral Province, Brazil—Paragenesis and stable isotope constraints: Mineralium Deposita, v. 43, no. 2, p. 129–159.

Montreuil, J.-F., Corriveau, L., and Potter, E.G., 2015, Formation of albitite-hosted uranium within IOCG systems—The Southern Breccia, Great Bear magmatic zone, Northwest Territories, Canada: Mineralium Deposita, v. 50, no. 3, p. 293–325.

Montreuil, J.-F., Corriveau, L., Potter, E.G., and De Toni, A.F., 2016, On the relation between alteration facies and metal endowment of iron oxide–alkali-altered systems, southern Great Bear magmatic zone (Canada), *in* Slack, J.F., Corriveau, L., and Hitzman, M.W., eds., A special issue devoted to Proterozoic iron oxide-apatite (±REE) and iron oxide-copper-gold and affiliated deposits of Southeast Missouri, USA, and the Great Bear magmatic zone v. 111: Northwest Territories, Canada, Economic Geology, p. 2139–2168.

Morland, R., 1990, Renison Bell tin deposit, *in* Hughes, F.E., ed., Geology of the mineral deposits of Australia and Papua New Guinea: Australasian Institute of Mining and Metallurgy Monograph 14 p. 1249–1251.

Morris, H.T., 1986, Descriptive model of polymetallic replacement deposits, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 99–100.

Mosier, D.L., 1986, Descriptive model of replacement Mn, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 105–107.

Mosier, D.L., and Page, N.J., 1988, Descriptive and grade-tonnage models of volcanogenic manganese deposits in oceanic environments—A modification: U.S. Geological Survey Bulletin 1811, 28 p., accessed March 3, 2021, at https://pubs.usgs.gov/bul/b1811/b1811.pdf.

Mosier, D.L., Singer, D.A., Moring, B.C., and Galloway, J.P., 2012, Podiform chromite deposits—Database and grade and tonnage models: U.S. Geological Survey Scientific Investigations Report 2012–5157, 45 p. and database, accessed March 3, 2021, at https://pubs.usgs.gov/sir/2012/5157/.

Mumin, A.H., Somarin, A.K., Jones, B., Corriveau, L., Ootes, L., and Camier, J., 2010, The IOCG-porphyry-epithermal continuum of deposits types in the Great Bear Magmatic Zone, Northwest Territories, Canada, *in* Corriveau, L., and Mumin, A.H., eds., Exploring for iron oxide copper-gold deposits—Canada and global analogues: Newfoundland, Canada, Geological Association of Canada, Short Course Notes 20, p. 59–78.

Münchmeyer, C., 1998, Exotic deposits—Products of lateral migration of supergene solutions from porphyry copper deposits, chap. 4 *of* Camus, F., Sillitoe, R.M., and Petersen, R., eds., Andean copper deposits—New discoveries, mineralization, styles and metallogeny: Littleton, Colo., Society of Economic Geologists, Special Publication No. 5, p. 43–58.

Munk, L., Hynek, S.A., Bradley, D.C., Boutt, D., Labay, K., and Jochens, H., 2016, Lithium brines–A global perspective, chap. 14 *of* Verplanck, P.L, and Hitzman, M.W., eds., Reviews in economic geology, volume 18—Rare earth and critical elements in ore deposits: Littleton, Colo., Society of Economic Geologists, Inc., p. 339–365.

Muntean, J.L., 2018, The Carlin gold system—Applications to exploration in Nevada and beyond, chap. 2 *of* Muntean, J.L., ed., Reviews in economic geology, volume 20—Diversity of Carlin-style gold deposits: Littleton, Colo., Society of Economic Geologists, Inc., p. 39–88. [Also available at https://doi.org/10.5382/rev.20.02.]

Mustard, R., 2001, Granite-hosted gold mineralization at Timbarra, northern New South Wales, Australia: Mineralium Deposita, v. 36, no. 6, p. 542–562.

Naldrett, A.J., 2004, Magmatic sulfide deposits—Geology, geochemistry and exploration: Berlin, Heidelberg, Springer-Verlag Berlin Heidelberg, 728 p., accessed March 3, 2021, at https://doi.org/10.1007/978-3-662-08444-1.

Nash, J.T., 2010, Volcanogenic uranium deposits—Geology, geochemical processes, and criteria for resource assessment: U.S. Geological Survey Open-File Report 2010–1001, 99 p., accessed March 3, 2021, at http://pubs.er.usgs.gov/publication/ofr20101001.

Natural Resources Canada, 2020, Canada and the United States advance collaboration on critical minerals: Government of Canada, 1 p., accessed March 9, 2021, at https://www.canada.ca/en/natural-resources-canada/news/2020/06/canada-and-the-united-states-advance-collaboration-on-critical-minerals.html.

Nazari-Dehkordi, T., Spandler, C., Oliver, N.H.S., and Wilson, R., 2018, Unconformity-related rare earth element deposits—A regional-scale hydrothermal mineralization type of northern Australia: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 113, no. 6, p. 1297–1305.

Nethery, J.E., and Barr, M.J., 1998, Red Dome and Mungana gold-silver-copper-lead-zinc deposits, *in* Berkman, D.A., and Mackenzie, D.H., eds., Geology of Australian and Papua New Guinean mineral deposits: Victoria, Australia, Australasian Institute of Mining and Metallurgy Monograph 22, p. 723–728.

Nold, J.L., Dudley, M.A., and Davidson, P., 2014, The Southeast Missouri (USA) Proterozoic iron metallogenic province—Types of deposits and genetic relationships to magnetite–apatite and iron oxide–copper–gold deposits: Ore Geology Reviews, v. 57, p. 154–171.

Nuelle, L.M., Day, C.M., and Sidder, G.B., 1991, Rare earth element- and gold-bearing breccia pipes of the Pea Ridge iron ore mine, Washington County Missouri, *in* Society of Mining, Metallurgy & Exploration, Denver, Colo., 1991, Proceedings: Littleton, Colo., Society of Mining, Metallurgy & Exploration, p. 91–109.

Nutt, C.J., and Hofstra, A.H., 2007, Bald Mountain gold mining district, Nevada—A Jurassic reduced intrusion-related gold system: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 102, no. 6, p. 1129–1155.

Oliver, N.H.S., Pearson, P.J., Holcombe, R.J., and Ord, A., 1999, Mary Kathleen metamorphic-hydrothermal uranium–rare–earth element deposit—Ore genesis and numerical model of coupled deformation and fluid flow: Australian Journal of Earth Sciences, v. 46, no. 3, p. 467–484.

Orris, G.J., 1992, Preliminary descriptive model of lacustrine halite, *in* Orris, G.J., ed., Industrial minerals deposit models—Descriptive models for three lacustrine deposit types: U.S. Geological Survey Open-File Report 92–593, p. 11–14.

Orris, G.J., 1995, Borate deposits: U.S. Geological Survey Open-File Report 95–842, 57 p.

Orris, G.J., 2011, Deposit model for closed-basin potash-bearing brines: U.S. Geological Survey Open-File Report 2011–1283, 11 p., accessed March 3, 2021, at https://doi.org/10.3133/ofr20111283.

Oz Minerals, Ltd., 2013, Annual Carrapateena Resource Update—2013: Melbourne, Australia, Oz Minerals, Ltd., 25 p.

Page, N.J., 1986a, Descriptive model of Bushveld Fe-Ti-V, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 15.

Page, N.J., 1986b, Descriptive model of komatiitic Ni-Cu, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 18.

Page, N.J., 1998a, Preliminary descriptive model of metasomatic and metamorphic replacement magnesite, *in* Orris, G.J., ed., Additional descriptive models of industrial mineral deposits—U.S. Geological Survey Open-File Report 98–505 p. 12–14.

Page, N.J., 1998b, Preliminary descriptive model of ultramafic hosted magnesite, *in* Orris, G.J., ed., Additional descriptive models of industrial mineral deposits—U.S. Geological Survey Open-File Report 98–505, p. 2–4.

Page, N.J., and Gray, F., 1986, Descriptive model of Alaskan PGE, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 49–50.

Paradis, S., Keevil, H., Simandl, G.J., and Raudsepp, M., 2015, Carbonate hosted nonsulphide Zn-Pb mineralization of southern British Columbia, Canada: Mineralium Deposita, v. 50, no. 8, p. 923–951.

Pastor, J., and Turaki, U.M., 1985, Primary mineralization in Nigerian ring complexes and its economic significance: Journal of African Earth Sciences, v. 3, no. 1, p. 223–227.

Pell, J., 1999, Kimberlite-hosted Diamonds, *in* Simandl, G.J., Hora, Z.D., and Lefebure D.V., eds., Selected British Columbia mineral deposit profiles, volume 3—Industrial minerals and gemstones: British Columbia Ministry of Energy and Mines, Open File 1999–10, p. 77–80.

Perring, C.S., Pollard, P.J., Dong, G., Nunn, A.J., and Blake, K.L., 2000, The Lightning Creek sill complex, Cloncurry district, northwest Queensland—A source of fluids for Fe oxide Cu-Au mineralization and sodic-calcic alteration: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 95, no. 5, p. 1067–1089.

Pirajno, F., Burlow, R., and Huston, D., 2010, The Magellan Pb deposit, Western Australia—A new category within the class of supergene non-sulphide mineral systems: Ore Geology Reviews, v. 37, no. 2, p. 101–113.

Plumlee, G.S., Goldhaber, M.B., and Rowan, E.L., 1995, The potential role of magmatic gases in the genesis of Illinois-Kentucky fluorspar deposits—Implications from chemical reaction path modeling: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 90, no. 5, p. 999–1011. [Also available at https://doi.org/10.2113/gsecongeo.90.5.999.]

Polito, P.A., Kyser, T.K., and Stanley, C., 2009, The Proterozoic, albitite-hosted, Valhalla uranium deposit, Queensland, Australia—A description of the alteration assemblage associated with uranium mineralization in diamond drill hole V39: Mineralium Deposita, v. 44, no. 1, p. 11–40.

Porter, T.M., 2010, Current understanding of iron oxide associated-alkali altered mineralised systems—Part 1, An overview, *in* Porter, T.M., ed., Hydrothermal iron oxide copper-gold and related deposits—A global perspective, v. 3—Advances in understanding of IOCG deposits: Adelaide, Australia, PGC Publishing, p. 5–32.

Ramanaidou, E.R., Morris, R.C., and Horwitz, R.C., 2003, Channel iron deposits of the Hamersley Province, Western Australia: Australian Journal of Earth Sciences, v. 50, no. 5, p. 669–690.

Raup, O.B., 1991a, Descriptive model of bedded gypsum—Deposit subtype—Marine evaporite gypsum, *in* Orris, G.J., and Bliss, J.D., eds., Some industrial mineral deposit models—Descriptive deposit models: U.S. Geological Survey Open-File Report 91–11A, p. 39–41.

Raup, O.B., 1991b, Descriptive model of bedded salt—Deposit subtype—Marine evaporite salt, *in* Orris, G.J., and Bliss, J.D., eds., Some industrial mineral deposit models—Descriptive deposit models: U.S. Geological Survey Open-File Report 91–11A, p. 33–35.

Ray, G.E., 1995, Mo skarns, *in* Lefebure, D.V., and Ray, G.E., eds., Selected British Columbia mineral deposit profiles, volume 1—Metallics and coal: British Columbia Ministry of Employment and Investment, Open File 1995–20, p. 77–78.

Reed, B.L., 1986a, Descriptive model of alluvial placer Sn, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 275.

Reed, B.L., 1986b, Descriptive model of porphyry Sn, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 108.

Reed, B.L., 1986c, Descriptive model of replacement Sn, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 61.

Reed, B.L., 1986d, Descriptive model of Sn greisen deposits, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 70.

Reed, B.L., 1986e, Descriptive model of Sn veins, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 67.

Reed, B.L., and Cox, D.P., 1986, Descriptive model of Sn skarn deposits, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 58.

Rennick, M.P., and Burton, D.M., 1992, The Murray Brook deposit, Bathurst Camp, New Brunswick—Geologic setting and recent development: Exploration and Mining Geology, v. 1, p. 137–142.

Rieger, A.A., Marschik, R., and Díaz, M., 2010, The Mantoverde district, northern Chile—An example of distal portions of zoned IOCG systems, *in* Porter, T.M., ed., Hydrothermal iron oxide copper-gold and related deposits—A global perspective v. 3: Adelaide, Australia, Porter Geoscience Consultancy Publishing, p. 273–284.

Ristorcelli, S.J., and Schlitt, J., 2019, Technical report with updated estimate of mineral resources for the Iron Creek Cobalt-Copper project, Lemhi County, Idaho, USA: 43-101 report prepared for First Cobalt, 124 p., accessed March 3, 2021, at https://www.firstcobalt.com/_resources/pdf/NI43-101-Iron_Creek_Final-2019.pdf?v=0.512.

Roscoe, S.M., 1995, Paleoplacer uranium, gold, *in* Eckstrand, O.R., Sinclair, W.D., Thorpe, R.I., eds., Geology of Canadian mineral deposit types: Geological Survey of Canada, Geology of Canada Series no. 8, p. 10–23, accessed March 3, 2021, at https://doi.org/10.4095/207948.

Rytuba, J.J., 1986, Descriptive model of hot-spring Hg, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 178.

Sanematsu, K., and Watanabe, Y., 2016, Characteristics and genesis of ion adsorption-type rare earth element deposits, chap. 3 *of* Verplanck, P.L., and Hitzman, M.W., eds., Reviews in economic geology, volume 18—Rare earth and critical elements in ore deposits: Littleton, Colo., Society of Economic Geologists, Inc., p. 55–80. [Also available at https://doi.org/10.5382/Rev.18.03.]

Sarkar, S.C., and Dasgupta, S., 1980, Geologic setting, genesis and transformation of sulfides deposits in the northern part of Khetri copper belt, Rajasthan, India—An outline: Mineralium Deposita, v. 15, no. 2, p. 117–137.

Schandl, E.S., and Gorton, M.P., 2007, The Scadding gold mine, east of the Sudbury igneous complex, Ontario—An IOCG-type deposit?: Canadian Mineralogist, v. 45, no. 6, p. 1415–1441.

Scharrer, M., Kreissl, S., and Markl, G., 2019, The mineralogical variability of hydrothermal native element-arsenide (five-element) associations and the role of physicochemical and kinetic factors concerning sulfur and arsenic: Ore Geology Reviews, v. 113, article no. 103025, accessed April 18, 2020, at https://doi.org/10.1016/j.oregeorev.2019.103025.

Schlegel, T.U., and Heinrich, C.A., 2015, Lithology and hydrothermal alteration control the distribution of copper grade in the Prominent Hill iron oxide-copper-gold deposit (Gawler Craton, South Australia): Economic Geology and the Bulletin of the Society of Economic Geologists, v. 110, no. 8, p. 1953–1994.

Schulte, R.F., Taylor, R.D., Piatak, N.M., and Seal, R.R., II, 2012, Stratiform chromite deposit model, chap. E *of* Mineral deposit models for resource assessment: U.S. Geological Survey Scientific Investigations Report 2010–5070–E, 131 p., accessed March 3, 2021, at https://pubs.usgs.gov/sir/2010/5070/e/.

Schwellnus, C.M., 1945, Vanadium deposits in the Otavi Mountains, southwest Africa: Transactions - Geological Society of South Africa, v. 48, p. 49–73.

Seedorff, E., Dilles, J.H., Proffett, J.M., Jr., Einaudi, M.T., Zurcher, L., Stavast, W.J.A., Johnson, D.A., and Barton, M.D., 2005, Porphyry deposits—Characteristics and origin of hypogene features, *in* Hedenquist, J.W., Thompson, J.F.H., Goldfarb, R.J., and Richards, J.P., eds., Economic Geology—One Hundredth Anniversary Volume, 1905–2005: Littleton, Colo., Society of Economic Geologists, Inc., p. 251–298, accessed April 18, 2020, at https://doi.org/10.5382/AV100.10.

Sengupta, D., and Van Gosen, B.S., 2016, Placer-type rare earth element deposits, chap. 4 *of* Verplanck, P.L., and Hitzman, M.W., eds., Reviews in economic geology, volume 18—Rare earth and critical elements in ore deposits: Littleton, Colo., Society of Economic Geologists, Inc., p. 81–100.

Seredin, V.V., and Finkelman, R.B., 2008, Metalliferous coals—A review of the main genetic and geochemical types: International Journal of Coal Geology, v. 76, no. 4, p. 253–289.

Shanks, W.C., III, and Thurston, R., eds., 2012, Volcanogenic massive sulfide occurrence model: U.S. Geological Survey Scientific Investigations Report 2010–5070–C, 345 p., accessed April 18, 2020, at https://pubs.usgs.gov/sir/2010/5070/c/SIR10-5070-C.pdf.

Sharp, J.E., 1979, Cave Peak, a molybdenum-mineralized breccia pipe complex in Culberson County, Texas: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 74, no. 3, p. 517–534.

Sheppard, R.A., 1991, Descriptive model of sedimentary zeolites—Deposit subtype—Zeolites in tuffs of saline, alkaline-lake deposits, *in* Orris, G.J., and Bliss, J.D., eds., Some industrial mineral deposit models—Descriptive deposit models: U.S. Geological Survey Open-File Report 91–11A, p. 19–21.

Sillitoe, R.H., 1991, Intrusion-related gold deposits, *in* Foster, R.P., ed., Gold metallogeny and exploration: Glasgow, Blackie and Son, p. 165–209.

Sillitoe, R.H., 2009, Supergene silver enrichment reassessed, chap. 2 *of* Titley, S.R., ed., Supergene environments, processes, and products: Littleton, Colo., Society of Economic Geologists, Special Publication No. 14, p. 15–32.

Sillitoe, R.H., 2010, Porphyry copper systems: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 105, no. 1, p. 3–41. [Also available at https://doi.org/10.2113/gsecongeo.105.1.3.]

Sillitoe, R.H., and Hedenquist, J.W., 2003, Linkages between volcanotectonic settings, ore-fluid compositions, and epithermal precious metal deposits, chap. 16 *of* Simmons, S.F., and Graham, I., eds., Volcanic, geothermal, and ore-forming fluids—Rulers and witnesses of processes within the Earth: Littleton, Colo., Society of Economic Geologists, Special Publication Number 10, p. 315–343.

Simandl, G.J., and Hancock, K., 1999, Sparry magnesite, *in* Simandl, G.J., Hora, Z.D., and Lefebure D.V., eds., Selected British Columbia mineral deposit profiles, volume 3—Industrial minerals and gemstones: British Columbia Ministry of Energy and Mines, Open File 1999–10, p. 39–41.

Simandl, G.J., and Paradis, S., 2018, Carbonatites—Related ore deposits, resources, footprint, and exploration methods: Transactions of the Institution of Mining and Metallurgy Section B. Applied Earth Science, v. 127, no. 4, p. 123–152, accessed April 30, 2021, at https://doi.org/10.1080/25726838.2018.1516935.

Simandl, G.J., Paradis, S., and Akam, C., 2015, Graphite deposit types, their origin, and economic significance, *in* Simandl, G.J., and Neetz, M., eds., Symposium on Strategic and Critical Materials, Victoria, B.C., November 13–14, 2015, Proceedings: British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Paper 2015–3, p. 163–171.

Simmons, S.F., White, N.C., and John, D.A., 2005, Geological characteristics of epithermal precious and base metal deposits, *in* Hedenquist, J.W., Thompson, J.F.H., Goldfarb, R.J., and Richards, J.P., eds., Economic Geology—One Hundredth Anniversary v. 1905–2005: Littleton, Colo., Society of Economic Geologists, Inc., p. 485–522.

Sinclair, W.D., 1995a, Porphyry Mo (low-F-type), *in* Lefebure, D.V., and Ray, G.E., eds., Selected British Columbia mineral deposit profiles, volume 1—Metallics and coal: British Columbia Ministry of Employment and Investment, Open File 1995–20, p. 93–96.

Sinclair, W.D., 1995b, Porphyry Sn, *in* Lefebure, D.V., and Ray, G.E., eds., Selected British Columbia mineral deposit profiles, volume 1—Metallics and coal: British Columbia Ministry of Employment and Investment, Open File 1995–20, p. 97–100.

Sinclair, W.D., 1995c, Porphyry W, *in* Lefebure, D.V., and Ray, G.E., eds., Selected British Columbia mineral deposit profiles, volume 1—Metallics and coal: British Columbia Ministry of Employment and Investment, Open File 1995–20, p. 101–104.

Skewes, M.A., Arévalo, A., Floody, R., Zuñiga, P.H., and Stern, C.R., 2002, The giant El Teniente breccia deposit—Hypogene copper distribution and emplacement, chap. 14 *of* Goldfarb, R.J., and Nielsen, R.L., eds., Integrated methods for discovery—Global exploration in the twenty-first century: Littleton, Colo., Society of Economic Geologists, Inc., p. 299–332.

Skirka, M., 2005, Wonawinta Zn-Pb-Ag prospect, Cobar District, New South Wales, *in* Butt, C.R.M., Robertson, I.D.M., Scott, K.M., and Corneliu, M., eds., Regolith expression of Australian ore systems—A compilation of exploration case histories with conceptual dispersion, process and exploration models: Perth, Australia, Cooperative Research Centre for Landscape Environments and Mineral Exploration, 2 p., accessed March 3, 2021, at http://crcleme.org.au/RegExpOre/Wonawinta.pdf.

Skirrow, R., 2010, "Hematite-group" IOCG ± U ore systems—Tectonic settings, hydrothermal characteristics, and Cu-Au and U mineralizing processes, *in* Corriveau, L., and Mumin, H., eds., Exploring for iron oxide copper-gold deposits—Canada and global analogues: Newfoundland, Canada, Geological Association of Canada, Short Course Notes 20, p. 39–57.

Skirrow, R.G., Huston, D.L., Mernagh, T.P., Thorne, J.P., Dulfer, H., and Senior, A.B., 2013, Critical commodities for a high tech world—Australia's potential to supply global demand: Canberra, Geoscience Australia, 118 p.

Skirrow, R.G., Jaireth, S., Huston, D.L., Bastrakov, E.N., Schofield, A., van der Wielen, S.E., and Barnicoat, A.C., 2009, Uranium mineral systems—Processes, exploration criteria and a new deposit framework: Geoscience Australia, Geoscience Australia Record 2009, v. 20, 44 p.

Slack, J.F., ed., 2013, Descriptive and geoenvironmental model for cobalt-copper-gold deposits in metasedimentary rocks, chap. G *of* Mineral deposit models for resource assessment (ver. 1.1, March 14, 2014): U.S. Geological Survey Scientific Investigations Report 2010–5070–G, 218 p., accessed April 18, 2020, at https://doi.org/10.3133/sir20105070G.

Sparkes, G.W., Dunning, G.R., and Langille, A., 2017, The Michelin deposit—An example of albitite-hosted uranium mineralization within the Central Mineral Belt of Labrador: Newfoundland and Labrador Department of Natural Resources, Geological Survey Report 17–1, p. 219–238.

Spencer, J.E., and Duncan, J.T., 2015, Fluid-inclusion characteristics of Oligocene to Miocene iron-oxide Cu-Au (IOCG) deposits in central western Arizona: Arizona Geological Survey Open-File Report 15–05, 16 p.

Spry, P.G., and Teale, G.S., 2021, A classification of Broken Hill-type deposits—A critical review: Ore Geology Reviews, v. 130, article no. 103935, accessed March 3, 2021, at https://doi.org/10.1016/j.oregeorev.2020.103935.

Stegen, R.J., Wright, E., and Bryant, D.G., 2005, The Warren (Bisbee) Mining District, Cochise County, Arizona—Arizona Geological Society Spring Field Trip, Bisbee, Ariz., April 30, 2005, Guidebook: Tucson, Ariz., Arizona Geological Society, 33 p.

Stern, C.R., Skewes, M.A., and Arévalo, A., 2011, Magmatic evolution of the giant El Teniente Cu–Mo deposit, central Chile: Journal of Petrology, v. 52, no. 7–8, p. 1591–1617.

Strauss, T.A.L., 2003, The geology of the Proterozoic Haveri Au-Cu deposit, southern Finland; Eastern Cape, South Africa, Ph.D. thesis, 372 p.

Taylor, R.D., and Anderson, E.D., 2018, Quartz-pebble-conglomerate gold deposits: U.S. Geological Survey Scientific Investigations Report 2010–5070–P, 34 p., accessed March 3, 2021, at https://doi.org/10.3133/sir20105070P.

Taylor, R.D., Hammarstrom, J.M., Piatak, N.M., and Seal, R.R., II, 2012, Arc-related porphyry molybdenum deposit model, chap. D *of* Mineral deposit models for resource assessment: U.S. Geological Survey Scientific Investigations Report 2010–5070–D, 64 p.

Theodore, T.G., 1986, Descriptive model of porphyry Mo, low-F, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 120.

Theodore, T.G., Orris, G.J., Hammarstrom, J.M., and Bliss, J.D., 1991, Gold-bearing skarns: U.S. Geological Survey Bulletin 1930, 61 p.

Thompson, J.F.H., Sillitoe, R.H., Baker, T., Lang, J.R., and Mortensen, J.K., 1999, Intrusion-related gold deposits associated with tungsten-tin provinces: Mineralium Deposita, v. 34, no. 4, p. 323–334.

Titley, S.R., 1997, Characteristics of high temperature, carbonate-hosted replacement ores and some comparisons with Mississippi Valley-type ores, *in* Sangster, D.F., ed., Reviews in economic geology—Carbonate-hosted lead-zinc deposits: Littleton, Colo., Society of Economic Geologists, Inc., Special Publication No. 4, p. 244–254.

Titley, S.R., and Marozas, D.C., 1995, Processes and products of supergene copper enrichment, *in* Pierce, F.W., and Bolm, J.G., eds., Porphyry copper deposits of the American Cordillera—Arizona Geological Survey, Arizona Geological Society Digest 20 p. 156–168.

Togashi, Y., 1986, Descriptive model of Sn-polymetallic veins, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 109.

Tornos, F., Velasco, F., and Hanchar, J.M., 2017, The magmatic to magmatic-hydrothermal evolution of the El Laco deposit (Chile) and its implications for the genesis of magnetite-apatite deposits: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 112, no. 7, p. 1595–1628.

Ucurum, A., Demir, C.S., Hofstra, A.H., Arehart, G.B., and Pernicka, E., 2017, Sr, O, D, and S isotopic compositions of celestine deposits from the Tertiary Sivas basin, Turkey [abs.], in Society of Economic Geologists, SEG Annual Meeting, Beijing, China, April 17–20, 2017, Proceedings: Society of Economic Geologists, 1 p., accessed March 3, 2021, at https://www.segweb.org/SEG/_Events/Conference_Archive/2017/Conference_Proceedings/files/pdf/Poster-Presentations/Abstracts/P214-Ucurum.pdf.

U.S. Department of Energy, 2021, Department of Energy launches Minerals Sustainability Division to enable the ongoing transformation of the U.S. energy system and help secure a U.S. critical minerals supply chain: U.S. Department of Energy, 1 p., accessed March 9, 2021, at https://www.energy.gov/articles/department-energy-launches-minerals-sustainability-division-enable-ongoing-transformation.

Van Gosen, B.S., Fey, D.L., Shah, A.K., Verplanck, P.L., and Hoefen, T.M., 2014, Deposit model for heavy-mineral sands in coastal environments: U.S. Geological Survey Scientific Investigations Report 2010–5070–L, 51 p., accessed April 18, 2020, at https://doi.org/10.3133/sir20105070L.

Van Gosen, B.S., Johnson, M.R., and Goldman, M.A., 2016, Three GIS datasets defining areas permissive for the occurrence of uranium-bearing, solution-collapse breccia pipes in northern Arizona and southeast Utah: U.S. Geological Survey data release, accessed March 3, 2021, at https://doi.org/10.5066/F76D5R3Z.

Veloso, A.S.R., Monteiro, L.V.S., and Juliani, C., 2020, The link between hydrothermal nickel mineralization and an iron oxide-copper-gold (IOCG) system—Constraints based on mineral chemistry in the Jatoba deposit, Carajas Province: Ore Geology Reviews, v. 121, article no. 103555, accessed March 3, 2021, at https://doi.org/10.1016/j.oregeorev.2020.103555.

Verplanck, P.L., Mariano, A.N., and Mariano, A., Jr., 2016, Rare earth element ore geology of carbonatites, chap. 1 *of* Verplanck, P.L., and Hitzman, M.W., eds., Reviews in economic geology, volume 18—Rare earth and critical elements in ore deposits: Littleton, Colo., Society of Economic Geologists, Inc., p. 5–32.

Verplanck, P.L., Van Gosen, B.S., Seal, R.R., and McCafferty, A.E., 2014, A deposit model for carbonatite and peralkaline intrusion-related rare earth element deposits: U.S. Geological Survey Scientific Investigations Report 2010–5070–J, 58 p., accessed April 18, 2020, at https://doi.org/10.3133/sir20105070J.

Verwoerd, W.J., 1957, The mineralogy and genesis of the lead-zinc-vanadium deposit of Abenab West in the Otavi Mountains, south west Africa, *in* Taljaard, M.S., ed., Annals of the University of Stellenbosch v. 33: Stellenbosch, South Africa, University of Stellenbosch, p. 235–319.

Vitaliano, C.J., 1950, Needles magnesite deposit, San Bernardino County, California: California Journal of Mines and Geology, v. 46, p. 357–372.

Warren, J.K., 2010, Evaporites through time—Tectonic, climatic and eustatic controls in marine and nonmarine deposits: Earth-Science Reviews, v. 98, no. 3-4, p. 217–268. [Also available at https://doi.org/10.1016/j.earscirev.2009.11.004.]

Williams, P.J., 2010, Classifying IOCG deposits, *in* Corriveau, L., and Mumin, A.H., eds., Exploring for iron oxide copper-gold deposits—Canada and global analogues: Newfoundland, Canada, Geological Association of Canada, Short Course Notes 20, p. 13–21.

Williams-Stroud, S., 1991, Descriptive model of iodine-bearing nitrate, *in* Orris, G.J., and Bliss, J.D., eds., Some industrial mineral deposit models—Descriptive deposit models: U.S. Geological Survey Open-File Report 91–11A, p. 51–52.

Woodruff, L.G., Nicholson, S.W., and Fey, D.L., 2013, A deposit model for magmatic iron-titanium-oxide deposits related to Proterozoic massif anorthosite plutonic suites: U.S. Geological Survey Scientific Investigations Report 2010–5070–K, 47 p., accessed April 18, 2020, at https://pubs.usgs.gov/sir/2010/5070/k.

Wyborn, L.A.I., Heinrich, C.A., and Jaques, A.L., 1994, Australian Proterozoic mineral systems—Essential ingredients and mappable criteria, *in* Australasian Institute of Mining and Metallurgy Annual Conference, Darwin, Australia, 1994, Proceedings: Darwin, Australia, Australasian Institute of Mining and Metallurgy, p.109–115.

Xavier, R.P., Monteiro, L.V.S., Moreto, C.P.N., Pestilho, A.L.S., deMelo, G.H.C., da Silva, M.A.D., Aires, B., Ribeiro, C., and Freitas e Silva, F.H., 2012, The iron oxide copper-gold systems of the Carajás mineral province, *in* Hedenquist, J.W., Harris, M., and Camus, F., eds., Geology and genesis of major copper deposits and districts of the world—A tribute to Richard H. Sillitoe—Littleton, Colo., Society of Economic Geologists, Inc., Special Publication Number 16: Brazil, p. 433–454.

Yang, J., Montross, S., Britton, J., Stuckman, M., Lopano, C., and Verba, C., 2020, Microanalytical approaches to characterizing REE in Appalachian Basin underclays: Minerals, v. 10, no. 6, article no. 546, 15 p., accessed March 3, 2021, at https://www.mdpi.com/2075-163X/10/6/546/pdf.

Yeend, W.E., 1986, Descriptive model of placer Au-PGE, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 261.

Yeend, W.E., and Page, N.J., 1986, Descriptive model of placer PGE-Au, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 265.

Youles, I.P., and Oilmin, N.P., 1986, Mt. Painter uranium deposits, *in* Fuchs, H., ed., Vein type uranium deposits—Report of the Working Group on Uranium Geology organized by the International Atomic Energy Agency: Vienna, Austria, International Atomic Energy Agency Technical Document 361, IAEA-TECODOC-361, p. 101–112.

Yu, J., Chen, Y., Mao, J., Pirajno, F., and Duan, C., 2011, Review of geology, alteration and origin of iron oxide-apatite deposits in the Cretaceous Ningwu basin, Lower Yangtze River Valley, eastern China—Implications for ore genesis and geodynamic setting: Ore Geology Reviews, v. 43, no. 1, p. 170–181.

Yumul, G.P., Jr., 2001, The Acoje block platiniferous dunite horizon, Zambales Ophiolite Complex, Philippines—Melt type and associated geochemical controls: Resource Geology, v. 51, no. 2, p. 165–174.

Zeng, L.-P., Zhao, X.-F., Hammerli, J., Fan, T.-W.-T., and Spandler, C., 2020, Tracking fluid sources for skarn formation using scapolite geochemistry—An example from the Jinshandian iron skarn deposit, Eastern China: Mineralium Deposita, v. 55, no. 5, p. 1029–1046.

Zhao, L., Dai, S., Nechaev, V.P., Nechaeva, E.V., Graham, I.T., French, D., and Sun, J., 2019, Enrichment of critical elements (Nb-Ta-Zr-Hf-REE) within coal and host rocks from the Datanhao mine, Daqingshan Coalfield, northern China: Ore Geology Reviews, v. 111, 15 p., accessed April 30, 2021, at https://doi.org/10.1016/j.oregeorev.2019.102951.

Zhao, X.-F., Chen, H., Zhao, L., and Zhou, M.-F., in press, Linkages among IOA, skarn, and magnetite-group IOCG deposits in China—From deposit studies to mineral potential assessment, *in* Corriveau, L., Potter, E.G., and Mumin, A.H., eds., Mineral systems with iron oxide copper-gold (IOCG) and affiliated deposits: Newfoundland, Canada, Geological Association of Canada, Special Paper 52.

Zhao, X.-F., Zhou, M.-F., Su, Z.-K., Li, X.-C., Chen, W.-T., and Li, J.-W., 2017, Geology, geochronology, and geochemistry of the Dahongshan Fe-Cu-(Au-Ag) deposit, southwest China—Implications for the formation of iron oxide copper-gold deposits in intracratonic rift settings: Economic Geology and the Bulletin of the Society of Economic Geologists, v. 112, no. 3, p. 603–628.

Zientek, M.L., Loferski, P.J., Parks, H.L., Schulte, R.F., and Seal, R.R., II, 2017, Platinum-group elements, chap. N *of* Schulz, K.J., DeYoung, J.H., Jr., Seal, R.R., II, and Bradley, D.C., eds., Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply: U.S. Geological Survey Professional Paper 1802, p. N1–N91, accessed April 18, 2020, at https://doi.org/10.3133/pp1802N.

Publishing support provided by the Science Publishing Network,
Denver Publishing Service Center

For more information concerning the research in this report, contact the
Center Director, USGS Geology, Geophysics, and Geochemistry Science Center
Box 25046, Mail Stop 973
Denver, CO 80225
(303) 236-1800
Or visit Geology, Geophysics, and Geochemistry Science Center website at https://www.usgs.gov/centers/gggsc

Hofstra and others—**Deposit Classification Scheme for the Critical Minerals Mapping Initiative Global Geochemical Database**—OFR 2021–1049

ISSN 2331-1258 (online)
https://doi.org/10.3133/ofr20211049