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Short Communication on "A design of gold-bearing metallogenic provinces and districts in Brazil"

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Abstract

There is a lack of consensus on how many and which are the Brazilian gold provinces and districts, and what are their limits or configurations. As an effort of the Geological Survey of Brazil to standardize this subject, we present a compilation of the Brazilian gold-bearing metallogenic/mineral provinces and districts, including those containing polymetallic gold-bearing deposits, and a digital file (shape file) with the design of their respective limits. Because many areas have classic definitions, and even though some of them do not meet the appropriate requirement for a strict definition, their classic names are maintained. However, we strongly suggest that the use of the term metallogenic (province, district), in a broader geotectonic sense, should be preferable in relation to mineral (province, district), which is more generic.

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1. Introduction

The concentration of substances of economic interest, forming mineral/ore deposits, is part of the fundamental processes of rock formation and modification, i.e., magmatism, sedimentation, metamorphism, tectonics, and weathering (e.g., Robb 2005; Pohl 2011; Ridley 2013, and many others). When, in a given region, mineral occurrences and deposits appear in greater quantities or tonnage than what occurs in neighboring regions, these more enriched regions are called (mineral, metallogenic, mining) field (or camp, zone, area), district and province, from smallest to largest feature, respectively. Apart from the usage difference among these concepts, in the Brazilian literature on Economic Geology, these different concepts are present, and there is no consensus on how many and which are the provinces and districts, and what are their limits or configurations.

In order to contribute to this issue, we compile in this Short

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Communication the Brazilian gold-bearing metallogenic or mineral provinces and districts, including those that contain polymetallic gold-bearing deposits, and their respective designs or limits. It is not the aim of the work to discuss the definitions (origin), characteristics, and contents (genetic models, mineral systems) of the provinces and districts, which is part of another ongoing work. For these matters, the reader should consult the references in Appendix 1.

2. Background

In the Economic Geology literature, metallogenic concepts such as (mineral, metallogenic, mining) province and district do not have a single definition and/or are poorly defined. The definitions of a metallogenic province vary from (i) vague to very inclusive (e.g., a region characterized by a particular assemblage of mineral occurrences, or specific types of deposits, or by one or more types of mineralization, formed in one or more events - Thrush 1968; Stanton 1972; Neuendorf et al. 2005; Robb 2005), to (ii) restrictive regarding the dimension (e.g., with a length of at least 1000 km in one direction, Petrascheck 1965; or with an average size of 50,000 km^2, Matos et al. 2009), time and genetic relationship (formed in the same geodynamic cycle, Misra 2000; Pohl 2011), or metallic content (region with distinct mineralization, especially dominated by a single metal, Laznicka 2010). Other terms, such as mineralized area, zone, field, camp, metallogenic belt, metallogen, and metallotect, have widespread but varied in usage. The use of district, should be restricted to a part of a province (Pohl 2011), but is often used only with a geographical or political-administrative connotation (Laznicka 2010). In some places, the hierarchical logic of province-district-area (±zone, field, camp) is not respected or understood, with the inclusion of more than one province in a single mineralized area/zone (e.g., Mikkola and Niini 1968).

Wilkinson and Kesler (2009), in a conceptual review, referred to metallogenic provinces as regions of the Earth that contain a significantly greater number of deposits, or greater tonnage of a specific deposit type, than would have resulted from average rates of mineralization that occurred throughout the Phanerozoic. Although perfectly understandable, the proposition involves statistical distribution (power law) and in-depth knowledge about the age and economic data of mineralization, which makes its application difficult for the Brazilian Precambrian, at least at this stage of knowledge.

Although many areas in Brazil are already classic (e.g., Carajás, Tapajós, Quadrilátero Ferrífero, Seridó), many others are not, or have been defined without known or significant primary deposits (e.g., Parima, Catingueira), and there is often an indiscriminate use of the terms (mineral, metallogenic, mining) province and district for the same area (Dardenne and Schobbenhaus 2001, 2003; Biondi 2003; Carvalho et al. 2004; Matos et al. 2009; Silva et al. 2014; Marini 2016; and many other scientific articles and company reports). In addition, provinces or districts, which have previously been considered to be “mono-mineral” (e.g., gold-bearing), have proved to contain other mineral substances (e.g., polymetallic, cupro-auriferous), including the Tapajós, Juruena-Teles Pires, Vale do Curaçá, and the districts of the Carajás Province, which might require a change of nomenclature. Furthermore, it is common the use of the term “district” without relation to a province, which should not happen, as a district would be part of a province. We also observed the use of the expressions “mineral province” and “metallogenic province” as synonyms (e.g., Seridó, Carajás, Vila Nova). Although this is not a particularity of Brazil or the Portuguese language, this use appears to be more common among Brazilian authors. Furthermore, mineral province can refer, according to this generic usage, both to a large sector of a territory that contains deposits and occurrences of various mineral substances (e.g., Carajás Mineral Province) and for a specific substance (e.g., Seridó Scheelite Province, Rondônia Tin Province, Alta Floresta Auriferous Province). Finally, the limits, and the origin of the definition of each province or district is often difficult to attain from literature.

3. Gold-bearing provinces and districts of Brazil

The proposed 121 gold provinces and/or districts of Brazil (Figure1, Table 1, Appendices 1 and 2) have been compiled and designed taking into account all the issues presented above, in addition to several other sources cited here and/or in Appendix 1. This definition, however, takes into account classic names (modified or not), and those already in use, even where they represent only geographical names, and do not meet the appropriate requirements. In addition, some areas are historically considered provinces or districts and are therefore reported here, even if they do not have known deposits, but only occurrences or artisanal mines (the so-called *garimpos*). Some secondary (alluvial) provinces or districts are considered here, given their historical and even future importance, and because they lie outside any other province or district defined on the basis of primary (epigenetic) mineralization. In general, we used the oldest reference to a given district or province. However, in many cases, the references come from previous compilations on Brazilian metallogeny, which are not necessarily the primary source (first definition). Finally, for the design (shape) of each province or district, we tried to respect geologic-stratigraphic-tectonic limits, as much as possible.

4. Final remarks

The definitions proposed here are not intended to be definitive, but they reflect the effort of the Geological Survey of Brazil to standardize the topic. This can be useful for researchers from the academy and mining industry dealing with economic geology and mineral exploration in Brazil, so that researchers can use the same language and comparisons and correlations can be facilitated. Notwithstanding, geological and metallogenic information is heterogeneous due to the greater or lesser number of studies available for each area. The drawn limits on the shape file (Electronic supplementary file – Appendix 2) are also not definitive, and they can vary as a consequence of advances in the understanding of the geological evolution of each area. For future modifications and improvements, we understand that the use of the term metallogenic (province, district), in a broader geotectonic sense, should be preferable in relation to mineral (province, district), which is more generic, as not all minerals are metallic or ore minerals.

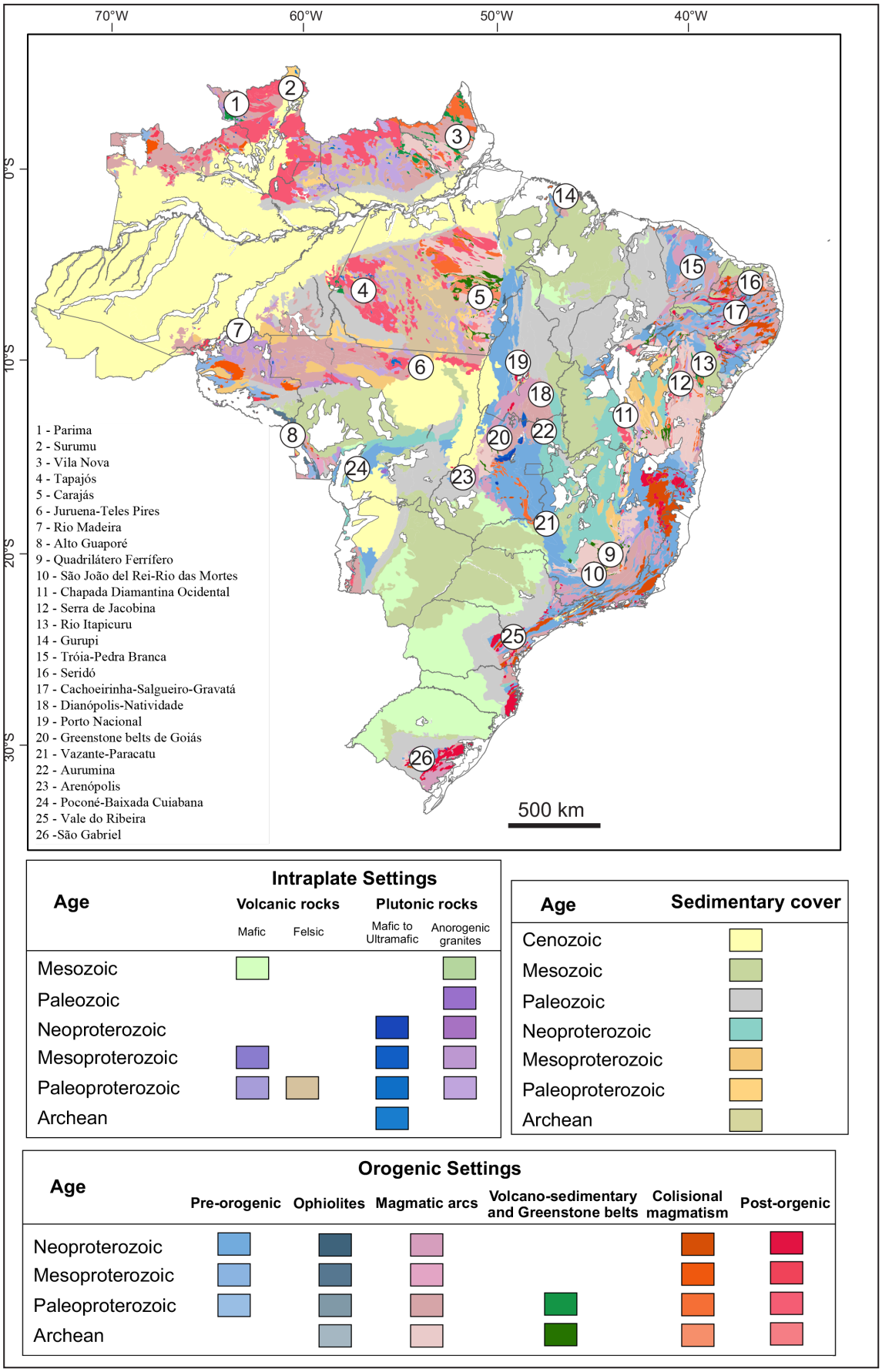

FIGURE 1. Simplified tectonic-chronological map of Brazil with the approximate location of gold-bearing provinces (Modified from Klein et al. 2018). For the complete list and design of the provinces and districts, please see Table 1, and Appendices 1 and 2.

TABLE 1. List of gold-bearing provinces and districts of Brazil. Sequential numbers in the first column refer to Figure 1. For references and design of provinces and districts, please see Appendices 1 and 2.

Seq.*	Major geotectonic unit	Metallogenic (or Mineral) Province	Metallogenic (or Mineral) District
1	Amazonian Craton (Guiana Shield)	Parima	
2	Amazonian Craton (Guiana Shield)	Surumu	
	Amazonian Craton (Guiana Shield)		Anauá
	Amazonian Craton (Guiana Shield)		Tunuí-Caparro
	Amazonian Craton (Guiana Shield)		Traíras
3	Amazonian Craton (Guiana Shield)	Vila Nova	Serra do Ipitinga
	Amazonian Craton (Guiana Shield)	Vila Nova	Serra do Navio - Vila Nova
	Amazonian Craton (Guiana Shield)	Vila Nova	Serra do Cupixi
	Amazonian Craton (Guiana Shield)	Vila Nova	Lourenço - Cassiporé
	Amazonian Craton (Guiana Shield)	Vila Nova	Tartarugalzinho
4	Amazonian Craton (Tapajós Domain)	Tapajós	Cuiu-Cuiu
	Amazonian Craton (Tapajós Domain)	Tapajós	Jardim do Ouro
	Amazonian Craton (Tapajós Domain)	Tapajós	Pacu
	Amazonian Craton (Tapajós Domain)	Tapajós	Marupá
	Amazonian Craton (Tapajós Domain)	Tapajós	Alto Crepori
	Amazonian Craton (Iriri-Xingu Domain)		Madalena-Esperança
	Amazonian Craton (Bacajá Domain)		Três Palmeiras
5	Amazonian Craton (Carajás Domain)	Carajás	Cinturão Norte
	Amazonian Craton (Carajás Domain)	Carajás	Cinturão Sul
	Amazonian Craton (Carajás Domain)	Carajás	Aquiri-Liberdade
	Amazonian Craton (Carajás Domain)	Carajás	São Felix do Xingu
	Amazonian Craton (Rio Maria Domain)	Carajás	Sapucaia - Diadema
	Amazonian Craton (Rio Maria Domain)	Carajás	Andorinhas
	Amazonian Craton (Rio Maria Domain)	Carajás	Cumaru
	Amazonian Craton (Rio Maria Domain)	Carajás	Serra do Trairão
	Amazonian Craton (Rio Maria Domain)	Carajás	Tucumã-Gradaús
	Amazonian Craton (Rio Maria Domain)	Carajás	Serra do Inajá
6	Amazonian Craton (Rondonia-Juruena Province)	Juruena-Teles Pires	Peixoto de Azevêdo
	Amazonian Craton (Rondonia-Juruena Province)	Juruena-Teles Pires	Juruena - Paranaíta
	Amazonian Craton (Rondonia-Juruena Province)	Juruena-Teles Pires	Roosevelt - Aripuanã
	Amazonian Craton (Rondonia-Juruena Province)	Juruena-Teles Pires	Juma
	Amazonian Craton (Rondonia-Juruena Province)	Juruena-Teles Pires	Gavião
7	Amazonian Craton (Rondonia-Juruena Province)	Rio Madeira	
8	Amazonian Craton (Sunsás Province)	Alto Guaporé	Colorado-Cabixi
	Amazonian Craton (Sunsás Province)	Alto Guaporé	Pontes e Lacerda
	Amazonian Craton (Sunsás Province)		Nova Brasilândia
	Amazonian Craton (Sunsás Province)		Costa Marques
	Amazonian Craton (Sunsás Province)		Alto Jauru
9	São Francisco Craton (Quadrilátero Ferrífero)	Quadrilátero Ferrifero	Nova Lima-Caeté
	São Francisco Craton (Quadrilátero Ferrífero)	Quadrilátero Ferrifero	Santa Bárbara-Córrego do Sítio
	São Francisco Craton (Quadrilátero Ferrífero)	Quadrilátero Ferrifero	Paciência
	São Francisco Craton (Quadrilátero Ferrífero)	Quadrilátero Ferrifero	Pitangui-Mateus Leme
	São Francisco Craton (Quadrilátero Ferrífero)	Quadrilátero Ferrifero	Ouro Preto-Mariana
	São Francisco Craton (Quadrilátero Ferrífero)	Quadrilátero Ferrifero	Itabira
10	São Francisco Craton (Mineiro Belt)	São João del Rei - Rio das Mortes	São João del Rei
	São Francisco Craton (Mineiro Belt)	São João del Rei - Rio das Mortes	Congonhas-Itaverava
	São Francisco Craton		São Domingos
11	São Francisco Craton (Chapada Diamantina)	Chapada Diamantina Ocidental	Gentio do Ouro
	São Francisco Craton (Chapada Diamantina)	Chapada Diamantina Ocidental	Ibitiara

*Numbers in column A refer to Figure 1

TABLE 1. List of gold-bearing provinces and districts of Brazil. Sequential numbers in the first column refer to Figure 1. For references and design of provinces and districts, please see Appendices 1 and 2. (Continued)

Seq.*	Major geotectonic unit	Metallogenic (or Mineral) Province	Metallogenic (or Mineral) District
	São Francisco Craton (Chapada Diamantina)	Chapada Diamantina Ocidental	Baixa Funda
	São Francisco Craton (Chapada Diamantina)	Chapada Diamantina Ocidental	Paramirim
	São Francisco Craton (Chapada Diamantina)	Chapada Diamantina Ocidental	Rio de Contas
	São Francisco Craton (Chapada Diamantina)	Chapada Diamantina Ocidental	Catolés
12	São Francisco Craton (Gavião Block)	Serra de Jacobina	Serra de Jacobina
	São Francisco Craton (Gavião Block)	Serra de Jacobina	
13	São Francisco Craton (Serrinha Block)	Rio Itapicuru	Maria Preta
	São Francisco Craton (Serrinha Block)	Rio Itapicuru	Fazenda Brasileiro
	São Francisco Craton (Itabuna-Salvador-Curaçá Orogen)		Rio Curaçá
	São Francisco Craton (Guanambi-Correntina block)		Correntina
14	São Luís cratonic fragment	Gurupi	Aurizona
	Gurupi Belt	Gurupi	
15	Borborema Province (Ceará Central Domain)	Troia-Pedra Branca	Pedra Branca
	Borborema Province (Ceará Central Domain)	Troia-Pedra Branca	
16	Borborema Province (Rio Piranhas-Seridó Domain)	Seridó	Bonfim
	Borborema Province (Rio Piranhas-Seridó Domain)	Seridó	São Francisco
	Borborema Province (Rio Piranhas-Seridó Domain)	Seridó	São Fernando-Caicó
	Borborema Province (Rio Piranhas-Seridó Domain)	Seridó	São Tomé (Roça)
	Borborema Province (Rio Piranhas-Seridó Domain)	Seridó	Bonito
	Borborema Province (Rio Piranhas-Seridó Domain)	Seridó	Itajubatiba
17	Borborema Province (Transversal Zone)	Cachoeirinha-Salgueiro-Gravatá	Serrita-Salgueiro
	Borborema Province (Transversal Zone)	Cachoeirinha-Salgueiro-Gravatá	Itapetim
	Borborema Province (Transversal Zone)	Cachoeirinha-Salgueiro-Gravatá	Cachoeira de Minas
	Borborema Province (Transversal Zone)	Cachoeirinha-Salgueiro-Gravatá	Catingueira
	Borborema Province (Pernambuco-Alagoas Domain)		Riacho Seco
	Borborema Province (Sergipano Belt)		Serrote da Laje
	Araçuaí Belt		São Domingos do Prata
	Araçuaí Belt		Espinhaço Meridional
	Araçuaí Belt		Alvorada de Minas - Serro
	Araçuaí Belt		Cuieté Velho
	Araçuaí Belt		Ribeirão da Folha - Minas Novas
	Araçuaí Belt		Porteirinha
18	Brasília Belt (basement)	Dianópolis-Natividade	Almas
	Brasília Belt (basement)	Dianópolis-Natividade	Dianópolis
	Brasília Belt (basement)	Dianópolis-Natividade	Porto Alegre
	Brasília Belt (basement)	Dianópolis-Natividade	Conceição do Tocantins
	Brasília Belt (basement)	Dianópolis-Natividade	Natividade
19	Brasília Belt (basement)	Porto Nacional	Monte do Carmo
	Brasília Belt (basement)	Porto Nacional	Ipueiras
	Brasília Belt (basement)	Porto Nacional	Pontal
20	Brasília Belt (basement)	Goiás Greenstone belts	Pilar de Goiás
	Brasília Belt (basement)	Goiás Greenstone belts	Guarinos
	Brasília Belt (basement)	Goiás Greenstone belts	Crixás
	Brasília Belt (basement)	Goiás Greenstone belts	Faina-Serra de Santa Rita
21	Brasília Belt (External Zone)	Vazante-Paracatu	Paracatu
	Brasília Belt (External Zone)		Luziânia
	Brasília Belt (External Zone)		Rio do Peixe
	Brasília Belt (External Zone)		Minaçu
22	Brasília Belt (External Zone)	Aurumina	Nova Roma-Pedra Branca

*Numbers in column A refer to Figure 1

TABLE 1. List of gold-bearing provinces and districts of Brazil. Sequential numbers in the first column refer to Figure 1. For references and design of provinces and districts, please see Appendices 1 and 2. (Continued)

Seq.*	Major geotectonic unit	Metallogenic (or Mineral) Province	Metallogenic (or Mineral) District
	Brasília Belt (External Zone)	Aurumina	Cavalcante
	Brasília Belt (Interference zone)		São Gonçalo do Sapucaí
23	Goiás Magmatic Arc (Arenópolis Arc)	Arenópolis	Bom Jardim de Goiás
	Goiás Magmatic Arc (Arenópolis Arc)	Arenópolis	Jaupaci
	Goiás Magmatic Arc (Arenópolis Arc)	Arenópolis	Edeia-Morrinhos
	Goiás Magmatic Arc (Arenópolis Arc)	Arenópolis	Mossamedes-Aurilândia
	Goiás Magmatic Arc (Mara Rosa Arc)		Mara Rosa
24	Paraguai Belt	Poconé-Baixada Cuiabana	
	Paraguai Belt		Nova Xavantina
25	Ribeira Belt (South)	Vale do Ribeira	
	Ribeira Belt (South)		Serra do Itaberaba
	Ribeira Belt (South)		Campo Largo
	Ribeira Belt (South)		Curitiba
	Ribeira Belt (South)		Morretes
	Ediacaran basins		Campo Alegre
	Ediacaran basins		Castro
	Luis Alves Craton		Gaspar
	Dom Feliciano Belt		Botuverá - Ribeirão da Prata
26	Sul-Riograndense Shield	São Gabriel	São Sepé-Caçapava do Sul
	Sul-Riograndense Shield	São Gabriel	Lavras do Sul
	Sul-Riograndense Shield	São Gabriel	Palma
	Sul-Riograndense Shield	São Gabriel	Minas do Camaquã
	Sul-Riograndense Shield	São Gabriel	Vauthier

*Numbers in column A refer to Figure 1

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Authorship credits

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EMSP						
FGC						
FJCL						
FSR						
IPM						
JHL						
MSM						

A - Study design/ Conceptualization **B** - Investigation/ Data acquisition
C - Data Interpretation/ Validation **D** - Writing
E - Review/Editing **F** - Supervision/Project administration

Appendices

1 – List of Provinces and districts with references and examples of deposits (xls file)

2 - Electronic supplementary files - Shape file with the provinces-districts (Also available at https://geosgb.sgb.gov.br/ and https://geoportal.sgb.gov.br/portal/apps/webappviewer/index.html?id=09bff43e0ec5478c977316903a84f842)

References

Biondi J.C. 2003. Processos metalogenéticos e os depósitos minerais brasileiros. São Paulo, Oficina de Textos, 528 p.

Carvalho J.M.A., Macambira E.M.B., Viglio E.P., Klein E.L., Costa E.J.S., Barbosa J.P.O., Rosa-Costa L.T., Vasquez M.L., Rezende N.G.A.M., Araújo O.J.B., Ricci P.S.F., Rodrigues J.L.B., Jorge-João X.S. 2004. Distritos mineiros do estado do Pará. Belém, DNPM, CPRM. Available on line at: https://rigeo.cprm.gov.br/handle/doc/22637 / (accessed on 27 June 2024).

Dardenne M.A., Schobbenhaus C. 2001. Metalogênese do Brasil. Brasília, Editora Universidade de Brasília, CPRM, 392 p. Available on line at: https://rigeo.sgb.gov.br/handle/doc/1291 / (accessed on 27 June 2024).

Dardenne M.A., Schobbenhaus C. 2003. Depósitos minerais no tempo geológico e épocas metalogenéticas. In: Bizzi L.A., Schobbenhaus C., Vidotti R.M., Gonçalves J.H. (eds.). Geologia, tectônica e recursos minerais do Brasil. Brasília, CPRM, p. 365–448.

Klein E.L., Matos D.R., Santos P.A., Correa R.T., Eyben J.S.Z. (orgs.). 2018. Atlas of mineral deposits and selected mineral occurrences of continental Brazil. Brasília, CPRM, 78 p. Available on line at: https://rigeo.sgb.gov.br/handle/doc/19032 / (accessed on 27 June 2024).

Laznicka P. 2010. Giant metallic deposits: future sources of industrial metals. Berlin, Heidelberg, New York, Springer, 732 p.

Marini O.J. 2016. Potencial mineral do Brasil. In: Melfi A.J., Misi A., Campos

D.A., Cordani U.G. (orgs.). Recursos minerais no Brasil: problemas e desafios. Rio de Janeiro, Academia Brasileira de Ciências, p. 18–31.

Matos G.M.M., Mello I.S.C., Gonçalves J.H. (coords.). 2009. Áreas de relevante interesse mineral no Brasil – ARIM. Belo Horizonte, CPRM, 70 p. Available on line at: https://rigeo.sgb.gov.br/handle/doc/10585 / (accessed on 27 June 2024).

Mikkola A.K., Niini H. 1968. Structural position of ore-bearing areas in Finland. Bulletin of the Geological Society of Finland, 40, 17–33. https://doi.org/10.17741/bgsf/40.003

Misra K.C. 2000. Understanding mineral deposits. Berlin, Springer, 845 p. https://doi.org/10.1007/978-94-011-3925-0

Neuendorf K.K.E., Mehl Jr. J.P., Jackson J.A. (eds.). Glossary of geology. 5th ed. Alexandria, VA, American Geological Institute, 800 p.

Petrascheck W.E. 1965. Typical features of metallogenic provinces. Economic Geology, 60(8), 1620–1634. https://doi.org/10.2113/gsecongeo.60.8.1620

Pohl W.L. 2011. Economic geology: principles and practice: metals, minerals, coal and hydrocarbons – introduction to formation and sustainable exploitation of mineral deposits. Oxford, Wiley-Blackwell, 663 p. https://doi.org/10.1002/9781444394870

Ridley J. 2013. Ore deposit geology. Cambridge, Cambrigde University Press, 398 p. https://doi.org/10.1017/CBO9781139135528

Robb L.J. 2005. Introduction to ore-forming processes. Oxford, Blackwell, 373 p.

Silva M.G., Rocha Neto M.B., Jost H., Kuyumjian R.M. 2014. Metalogênese das províncias tectônicas brasileiras. Belo Horizonte, CPRM, 589 p. Available on line at: https://rigeo.sgb.gov.br/handle/doc/19389 / (accessed on 26 June 2024).

Stanton R.L. 1972. Ore petrology. New York, McGraw-Hill, 713 p.

Thrush P.W. 1968. A dictionary of mining, mineral, and related terms. Washington, U.S. Department of the Interior, Bureau of Mines, 1269 p. Available on line at: https://archive.org/details/dictionaryofmini00thru_0 / (access on 27 June 2024).

Wilkinson B.H., Kesler S.E. 2009. Quantitative identification of metallogenic epochs and provinces: application to Phanerozoic porphyry copper deposits. Economic Geology, 104(5), 607–622. https://doi.org/10.2113/gsecongeo.104.5.607