BRAZIL mineral

MINING - METALLURGY

Special Issue - 2024 - ISSN 0102-4728

BRAZIL'S POTENTIAL IN CRITICAL MINERALS

WHAT ARE CANADIAN COMPANIES DOING IN BRAZIL?

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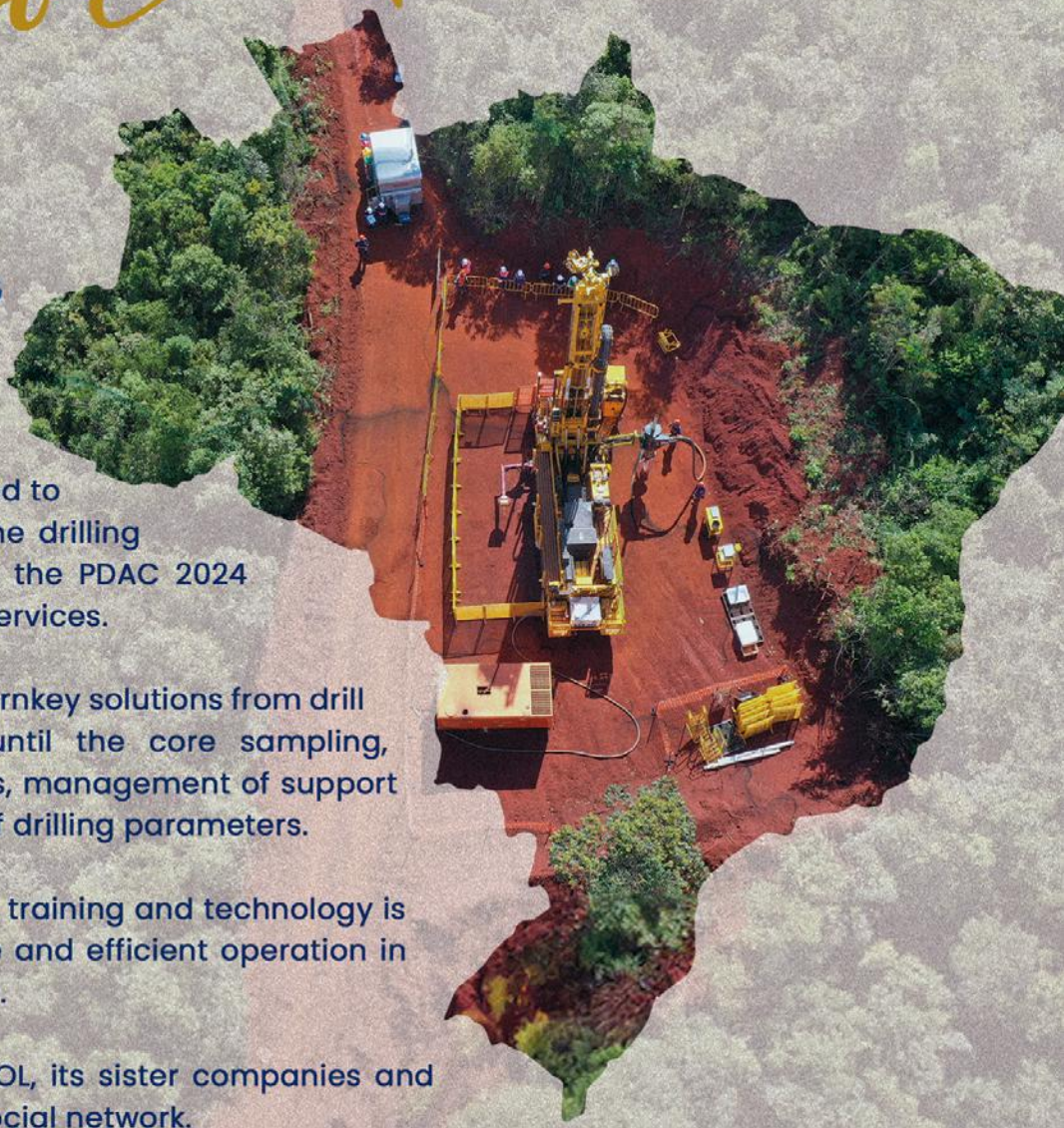

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WHAT GIVES BRAZIL ITS EDGE?

Gradually, Brazil is beginning to diversify its mineral output. While iron ore, gold, and limestone are still in the top three places, in value terms, other products are making their mark, such as copper, nickel, niobium, lithium, and graphite, all five considered strategic for the energy transition.

Brazil is obviously not about to cease being an important global player in the production of iron ore, of which it has large reserves, of good quality, and where large companies operate, such as Vale, Anglo American, CSN, and others. Brazil will also not lose its status as a gold producer — even though today's output is far below the production levels it recorded in the past — because there are still reserves to be explored, particularly in the Amazon region. Several companies are now prospecting for gold in this region and, in addition to the existing mining operations, there are projects that are due to begin production soon.

The great prospect now opening up for Brazilian mining lies, however, in the minerals needed for the energy transition. In the case of copper, some geologists believe that the Carajás Mineral Province could become an important production hub, in view of the deposits that are already known and the projects now being implemented (see article in this issue).

In lithium, there is a rush of companies looking for promising areas for production, especially in the state of Minas Gerais, with new projects scheduled for startup in the course of the next few years. In rare earths, of which the country has recently become an industrial-scale producer, there are also companies working to bring some deposits into production. In graphite, areas that are entering production in the state of Bahia will further strengthen Brazil's position in the global context of this mineral, important for electric vehicle batteries. In the case of nickel, although Brazil does not seem to have the vocation to be a prominent producer, especially of sulphide nickel, some new deposits are expected to come into production in the next few years, both in the Carajás region and in the state of Bahia. And in niobium, of which Brazil is by far the ranking producer, the development of technologies for new uses of the metal, including in electric vehicle batteries, are leading the main producing company, CBMM, to expand its output capacity.

Brazil's geology gives it the potential to be an important supplier of all these minerals. The government wants to see more vertical integration. That does not, however, look likely to happen, unless global players who need these minerals as inputs decide to set up manufacturing operations in Brazilian territory, which does not seem feasible, at least in the short term. Perhaps some Chinese manufacturer will set up a factory in Brazil, but it is unlikely to go much further than that.

Brazil will be able to differentiate itself from other global suppliers, due to something that is very costly for global businesses today, which is sustainability, especially in environmental and social terms. There are important examples of this.

Even in the case of traditional iron ore, producers operating in Brazil are also differentiating themselves from others, with products that contribute to the reduction of carbon emissions from the steel industry and through waste management practices, with the elimination of tailings dams.

It seems likely, therefore, that the Brazilian mining industry is entering a new cycle in which, in addition to maintaining its position as a supplier of traditional commodities, it will become an important supplier of so-called critical or strategic minerals, now needed for the world to transition to a low-carbon economy. □

Francisco Alves, Editor

AN OVERVIEW OF

CRITICAL AND STRATEGIC MINERALS POTENTIAL OF BRAZIL

2024 EDITION

Discover the brazilian potential for critical and strategic minerals.

Explore how Brazil's mineral wealth can contribute to a low-carbon economy and food security.

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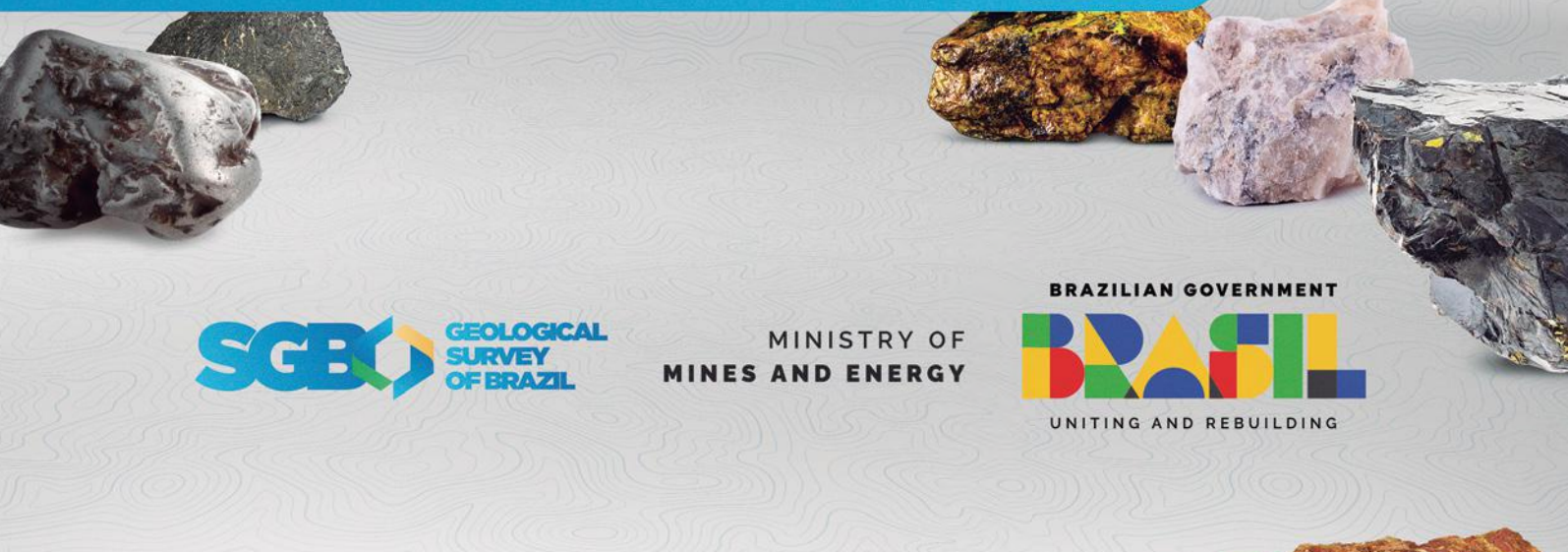

SGB GEOLOGICAL SURVEY OF BRAZIL

MINISTRY OF MINES AND ENERGY

BRAZILIAN GOVERNMENT

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MASTHEAD

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BRAZILIAN MINING DOES NOT LIVE BY IRON ORE AND GOLD ALONE

Francisco Alves

To judge by new investment projects, Brazil is on the way to diversifying its range of mining products in the next few years, adding several of the strategic minerals for the energy transition. While iron ore, gold, bauxite, and limestone still dominate Brazil's mining output, others such as copper, niobium, and lithium are gaining ground and already feature among the country's top ten mining products, in value terms. Beginning next year, rare earths are expected to appear as a new addition to the list.

In exports, copper, gold, nickel, and niobium also feature prominently among the minerals supplied to world markets, making their own contribution to Brazil's balance of trade. In 2023, the mining industry exported US$ 62.05 billion (including the primary transformation of minerals, a category that includes steelmaking and metallurgy), giving a trade surplus of US$ 21.93 billion. Looking at mining alone, the result was more favorable, with exports amounting to US$ 32.24 billion, accounting for 10.4 percent of all Brazilian exports

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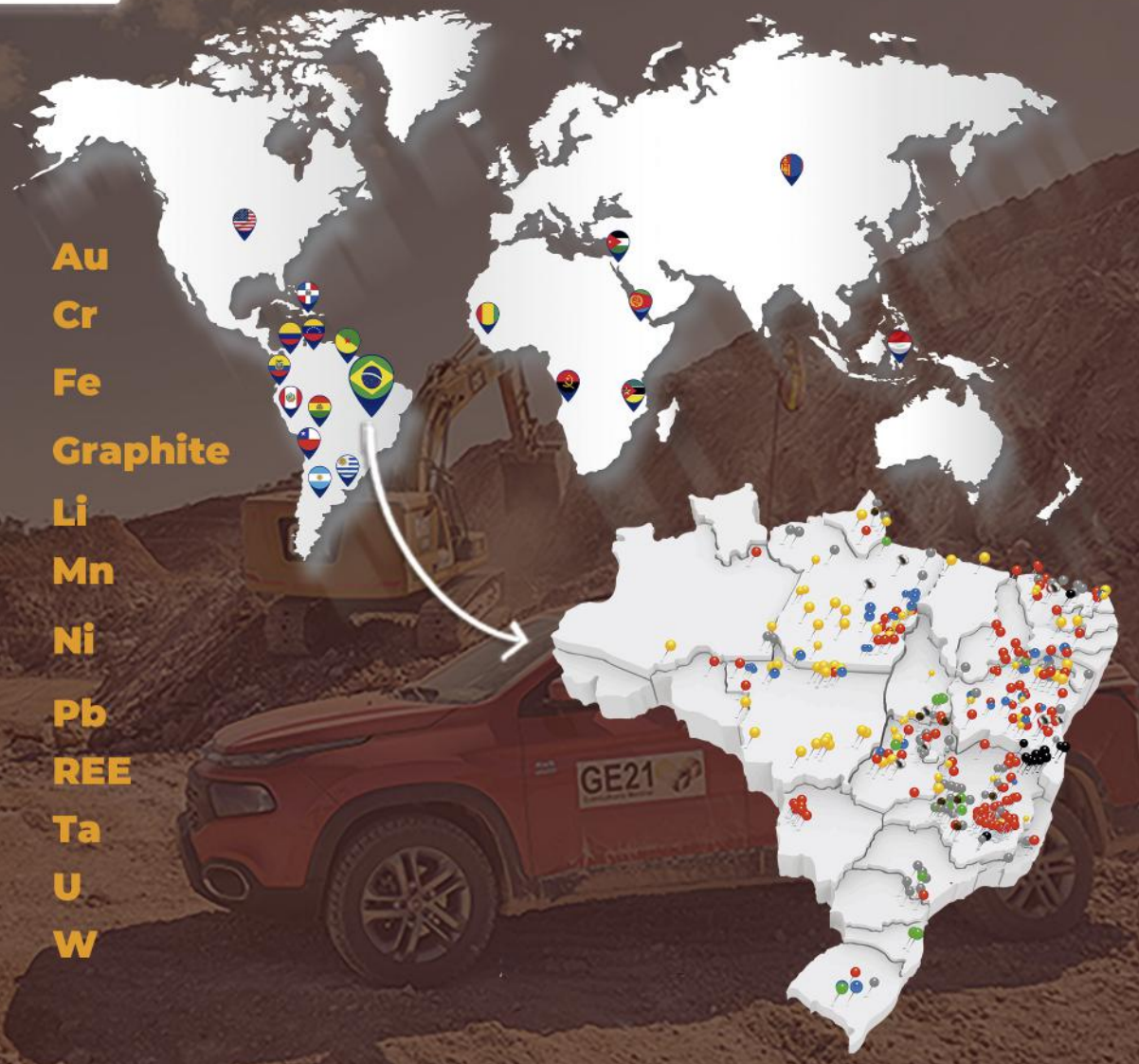

Ag
Bauxite
Cu
Gemstones
K
Mg
Nb
P
PGM
Sn
Ti
V
Zn

Au
Cr
Fe
Graphite
Li
Mn
Ni
Pb
REE
Ta
U
W

Mineral Exploration	Mineral Resources and Reserves
Geometallurgy and Process	JORC, CIM NI43- 101, S-K 1300 e CBRR
ESG	MRE - PEA/SS - PFS - FS

THE 100 LARGEST MINING COMPANIES IN BRAZIL

	COMPANY	PRODUCT	% CFEM
1	VALE S.A.	IRON ORE AND NICKEL	53,1861%
2	ANGLO AMERICAN MINERIO DE FERRO BRASIL S/A	IRON ORE	5,5730%
3	CSN MINERAÇÃO S.A.	IRON ORE	5,5447%
4	SALOBO METAIS SA.	COPPER	2,8959%
5	KINROSS BRASIL MINERACAO S/A	GOLD	1,2558%
6	MINERACAO USIMINAS S.A.	IRON ORE	1,2283%
7	MINERAÇÃO PARAGOMINAS S A	BAUXITE	1,0283%
8	MOSAIC FERTILIZANTES P&K LTDA.	PHOSPHATE AND POTASSIUM	0,9878%
9	SAMARCO MINERACAO S A	IRON ORE	0,9114%
10	VALLOUREC TUBOS DO BRASIL LTDA.	IRON ORE	0,8765%
11	MINERAÇÃO CORUMBAENSE REUNIDA SA	IRON ORE	0,8417%
12	MINERACAO RIO DO NORTE S A	BAUXITE	0,7883%
13	CIA DE MINERAÇÃO SERRA DA FAROFA	IRON ORE	0,7470%
14	ARCELORMITTAL BRASIL S.A.	IRON ORE	0,7262%
15	GERDAU ACOMINAS S/A	IRON ORE	0,6730%
16	MOSAIC FERTILIZANTES P&K LTDA.	PHOPHATE AND POTASSIUM	0,6142%
17	ATLANTIC NICKEL	NICKEL	0,5735%
18	AMG BRASIL S.A.	FELDSPAR, TANTALUM, LITHIUM	0,5558%
19	ANGLOGOLD ASHANTI CÓRREGO DO SÍTIO MINERAÇÃO S.A.	GOLD	0,5496%
20	FERRO + MINERAÇÃO S.A	IRON ORE	0,5237%
21	MINERACAO CONEMP LTDA	IRON ORE	0,4876%
22	MINERAÇÃO MARACÁ INDUSTRIA E COMERCIO SA	COPPER AND GOLD	0,4834%

	COMPANY	PRODUCT	% CFEM
23	CMOC BRASIL MINERACAO, INDUSTRIA E PARTICIPACOES LTDA.	PHOSPHATE AND NIOBIUM	0,4601%
24	ALCOA WORLD ALUMINA BRASIL LTDA.	BAUXITE	0,4484%
25	MINERACAO CARAIBA S/A (ERO BRASIL CARAÍBA)	COPPER	0,4095%
26	FERROMAR INDUSTRIA E COMERCIO S.A./ITAMINAS	IRON ORE	0,4092%
27	JACOBINA MINERACAO E COMERCIO LTDA	GOLD	0,3975%
28	MINERITA MINÉRIOS ITAÚNA LTDA.	IRON ORE	0,3648%
29	EXTRATIVA MINERAL S/A	IRON ORE	0,3644%
30	BEMISA HOLDING S.A.	IRON ORE	0,3498%
31	VOTORANTIM CIMENTOS S.A.	LIMESTONE	0,3423%
32	MINERAÇÃO VALE VERDE DO BRASIL LTDA	COPPER	0,3340%
33	ANGLO AMERICAN NIQUEL BRASIL LTDA	NICKEL	0,3204%
34	CIPLAN CIMENTO PLANALTO S/A	LIMESTONE	0,2877%
35	NEXA RECURSOS MINERAIS S A	ZINC, COPPER AND SILVER	0,2721%
36	MINERAÇÃO TABOCA S.A.	TIN, TANTALUM,NIOBIUM	0,2682%
37	COMPANHIA BRASILEIRA DE METALURGIA E MINERAÇÃO	NIOBIUM	0,2519%
38	JMN MINERAÇÃO S.A.	IRON ORE	0,2489%
39	MINERACAO AURIZONA S/A	GOLD	0,2482%
40	MINERACAO SERRA GRANDE S A	GOLD	0,1886%
41	SAMA SA MINERAÇÕES ASSOCIADAS EM RECUPERAÇÃO JUDICIAL	ASBESTOS	0,1767%
42	COMPANHIA BRASILEIRA DE LÍTIO	LITHIUM	0,1717%
43	SAFM MINERAÇÃO LTDA	IRON ORE	0,1657%
44	AVB MINERACAO LTDA.	COPPER AND GOLD	0,1579%
45	IMERYS RIO CAPIM CAULIM S.A.	CHINA CLAY	0,1463%
46	MINERAÇÃO SERRAS DO OESTE EIRELI	GOLD	0,1459%
47	CEDRO MINERAÇÃO MARIANA LTDA	GOLD	0,1405%
48	SIGMA MINERAÇÃO S.A.	LITHIUM	0,1395%

	COMPANY	PRODUCT	% CFEM
49	FAZENDA BRASILEIRO DESENVOLVIMENTO MINERAL LTDA	GOLD	0,1374%
50	NX GOLD S.A.	GOLD	0,1258%
51	GSM MINERAÇÃO LTDA	IRON ORE	0,1234%
52	TOMBADOR IRON MINERACAO LTDA	IRON ORE	0,1195%
53	WHITE SOLDER METALURGIA E MINERAÇÃO LTDA	TIN	0,1182%
54	MINERAL DO BRASIL LTDA.	IRON ORE	0,1125%
55	CALTINS CALCÁRIO TOCANTINS LTDA	LIMESTONE	0,1086%
56	MINÉRIOS NACIONAL S.A.	IRON ORE	0,1085%
57	NACIONAL DE GRAFITE LTDA	GRAPHITE	0,1063%
58	MINERACAO VALE DO JACURICI S A	CHROMITE	0,1009%
59	MINERACAO BELOCAL LTDA	LIMESTONE	0,1002%
60	MORGAN MINERACAO INDUSTRIA E COMERCIO LTDA	IRON ORE	0,0978%
61	MINERACAO RIACHO DOS MACHADOS LTDA.	GOLD	0,0974%
62	MINERAÇÃO APOENA S A	GOLD	0,0954%
63	VETRIA MINERACAO S.A.	IRON ORE	0,0891%
64	POLIMIX CONCRETO LTDA	AGGREGATES	0,0827%
65	MINERAÇÃO JUNDU LTDA.	QUARTZ SAND	0,0806%
66	LAFARGEHOLCIM (BRASIL) S.A.	LIMESTONE	0,0806%
67	RIO MINAS MINERAÇÃO S.A.	AGGREGATES	0,0804%
68	CARBONÍFERA BELLUNO LTDA.	COAL	0,0785%
69	VANÁDIO DE MARACÁS SA	VANADIUM	0,0772%
70	EMAL EMPRESA DE MINERAÇÃO ARIPUANÃ LTDA	LIMESTONE	0,0743%
71	MSM MINERAÇÃO SERRA DA MOEDA LTDA.	BAUXITE, IRON ORE, MANGANESE	0,0740%
72	COPELMI MINERAÇÃO LTDA	COAL	0,0734%
73	INDÚSTRIA CARBONÍFERA RIO DESERTO LTDA	COAL	0,0718%
74	CADAM S.A.	CHINA CLAY	0,0700%

	COMPANY	PRODUCT	% CFEM
75	COMPANHIA BRASILEIRA DE ALUMINIO	BAUXITE	0,0673%
76	MINERACAO COMISA LTDA	IRON ORE	0,0661%
77	BAHIA MINERAÇÃO S.A.	IRON ORE	0,0643%
78	SERRA LESTE MINERACAO LTDA	IRON ORE	0,0620%
79	EMBU S A ENGENHARIA E COMERCIO	AGGREGATES	0,0593%
80	HERCULANO MINERACAO LTDA	IRON ORE	0,0584%
81	CARBONIFERA METROPOLITANA S/A	COAL	0,0574%
82	SERABI MINERAÇÃO S.A.	GOLD	0,0521%
83	COMPANHIA RIOGRANDENSE DE MINERAÇÃO	COAL	0,0517%
84	INTERCEMENT BRASIL S.A.	LIMESTONE	0,0513%
85	MINERAÇÃO ITAIPÚ INDÚSTRIA E COMÉRCIO LTDA.	AGGREGATES	0,0488%
86	DOW BRASIL INDUSTRIA E COMERCIO DE PRODUTOS QUIMICOS LTDA	ROCK SALT	0,0485%
87	MINERAÇÃO SANTA ELINA INDUSTRIA E COMERCIO S A	ZINC	0,0482%
88	PIRECAL PIRENOPOLIS CALCARIO LTDA	LIMESTONE	0,0465%
89	MAGNESITA MINERACAO S.A.	MAGNESITE	0,0448%
90	SEIVAL SUL MINERAÇÃO LTDA.	COAL	0,0426%
91	AVG EMPREENDIMENTOS MINERARIOS S.A.	IRON ORE	0,0409%
92	MASSARI MINERAÇÃO PARTICIPAÇÕES LTDA.	LIMESTONE	0,0408%
93	CALCÁRIO VALE DO ARAGUAIA LTDA.	LIMESTONE	0,0408%
94	MINERAX MINERAÇÃO XAMBIOÁ LTDA.	LIMESTONE	0,0402%
95	MINERACAO FLORESTA DO ARAGUAIA S. A.	IRON ORE	0,0401%
96	BRITACAL IND E COM DE BRITA E CALCARIO BRASILIA L	LIMESTONE	0,0384%
97	INDÚSTRIA E COMÉRCIO DE CALCÁRIO CUIABÁ LTDA	LIMESTONE	0,0383%
98	CIA DE FERRO LIGAS DA BAHIA FERBASA	CHROMITE	0,0374%
99	MINERAÇÃO SERRA DOURADA LTDA	LIMESTONE	0,0371%
100	GICS INDÚSTRIA COMÉRCIO E SERVIÇOS S.A.	PHOSPHATE	2542082,99

in the period, compared with an import total of US$ 5.3 billion, leaving a US$ 27.1 billion surplus. The mineral transformation industry alone exported US$ 29.81 billion in 2023, which was 9.6 percent of the country's overall exports, while imports in the same category ended the year at US$ 34.88 billion. The resulting trade deficit, in the amount of US$ 5.07 billion, had the effect of reducing the overall trade surplus in minerals. The trade flow (exports plus imports) for the mineral transformation industry amounted to US$ 64.69 billion, while imports of minerals were 15.8 percent of overall Brazilian imports in the year.

Among mineral substances, either raw or transformed, **iron** once again headed the export list with US$ 38.8 billion, followed by **aluminium** with US$ 4.17 billion, **copper** with US$ 3.80 billion, **gold** with US$ 3.16 billion, **niobium** with US$ 2.02 billion, **nickel** with US$ 1.1 billion, and **dimension stones** with US$ 1.04 billion. On the import side, the categories weighing most heavily on the trade deficit were **coal** with US$ 5.85 billion, **phosphate** with US$ 5.24 billion, and **potash** with US$ 4.86 billion.

Mining output shrank in 2023, in value terms, to R$ 248.2 billion, down 0.7 percent from the previous year's R$ 250 billion. Ranked by states, Minas Gerais led with R$ 103.6 billion, followed by Pará with R$ 85.4 billion, Bahia with R$ 9.7 billion, São Paulo with R$ 9.2 billion, and Goiás with R$ 8.4 billion.

Iron ore was once again the top-ranking mining product with a 2023 figure of R$ 148 billion, followed by gold with R$ 21.1 billion, copper with R$ 16.2 billion, limestone with R$ 9.5 billion, granite with R$ 6.5 billion, and bauxite with R$ 5.7 billion.

Substantial growth in mining output is expected in the next few years, in view of companies' planned capital spending. A survey conducted by Ibram, the Brazilian Mining Institute, the representative body of the country's major mining companies, shows that over the five-year period from 2024 to 2028, programmed investments add up to US$ 64.5 billion. This is a hefty 28 percent increase over the corresponding figure reported last year, when investments planned for 2023-2027 were stated as US$ 50 billion. Iron ore accounts for over one-quarter of the new total, with a figure of US$ 17.28 billion. Next come social and environmental projects, mostly concerned with dismantling tailings dams or with improvements in processing plants so as to dispense with the need for tailings dams. These projects account for one-sixth of the total, or RS$ 10.67 billion. Then come investments in logistics, mainly railways and port facilities, at US$ 10.36 billion, ahead of copper projects (US$ 6.74 billion), fertilizers (US$ 5.58 billion), nickel (US$ 4.44 billion), bauxite (US$ 1.82 billion), gold (US$ 1.54 billion), rare earths (US$ 1.46 billion), lithium (US$ 1.19 billion), titanium (US$ 600 million), manganese (US$ 249 million), and zinc (US$ 59 million).

In terms of CFEM revenues (the Financial Contribution on Mineral Exploitation), mining royalties stood 2.3 percent lower in 2023 than in the previous year, at R$ 6.853 billion. The products paying

the highest royalties were iron ore (74.9 percent of the total), copper (4.7 percent), gold (4.6 percent), limestone (2.9 percent), bauxite (2.4 percent), phosphate (1.0 percent), granite (0.9 percent), nickel (0.9 percent), lithium (0.8 percent), and niobium (0.6 percent).

The interest in exploring other minerals has brought about an increase in mineral research activities. In 2023, according to statistics from the National Mining Agency (ANM), the number of exploration permits (*alvarás de pesquisa*) issued was 9,952, a slight increase from the previous year's 9,732. The states with most permits issued were Minas Gerais with 2,736, followed by Bahia with 1,969, Ceará with 742, Goiás (including the Federal District) with 651, São Paulo with 461, and Mato Grosso with 407. The corresponding figure for exploration reports (the statistic for exploration activities effectively concluded) was 1,354 in 2023, a significant decrease from the previous year's 1,510. Minas Gerais again appears in first place with 353 reports, ahead of São Paulo with 307, Paraná with 114, and Santa Catarina with 111. In the case of mining permits (*portarias de lavra*), which are the starting point for opening a new mine, the 2023 total was 612, down from the previous year. Minas Gerais, with 152 permits, once again was in the lead, followed by São Paulo with 93, Santa Catarina with 65, Bahia with 50, and Goiás-Federal District with 28.

THE 100 LARGEST MINING COMPANIES IN BRAZIL - BY PRODUCT

PRODUCT	POSITION IN THE RANKING	COMPANY	%CFEM
AGGREGATES	64	POLIMIX CONCRETO LTDA	0,0827%
AGGREGATES	67	RIO MINAS MINERAÇÃO S.A.	0,0804%
AGGREGATES	79	EMBU S A ENGENHARIA E COMERCIO	0,0593%
AGGREGATES	85	MINERAÇÃO ITAIPÚ INDÚSTRIA E COMÉRCIO LTDA.	0,0488%
ASBESTOS	41	SAMA SA MINERAÇÕES ASSOCIADAS EM RECUPERAÇÃO JUDICIAL	0,1767%
BAUXITE	7	MINERAÇÃO PARAGOMINAS S A	1,0283%
BAUXITE	12	MINERACAO RIO DO NORTE S A	0,7883%
BAUXITE	24	ALCOA WORLD ALUMINA BRASIL LTDA.	0,4484%
BAUXITE	75	COMPANHIA BRASILEIRA DE ALUMINIO	0,0673%
BAUXITE, IRON ORE, MANGANESE	71	MSM MINERAÇÃO SERRA DA MOEDA LTDA.	0,0740%
CHINA CLAY	45	IMERYS RIO CAPIM CAULIM S.A.	0,1463%
CHINA CLAY	74	CADAM S.A.	0,0700%
CHROMITE	58	MINERACAO VALE DO JACURICI S A	0,1009%
CHROMITE	98	CIA DE FERRO LIGAS DA BAHIA FERBASA	0,0374%
COAL	68	CARBONÍFERA BELLUNO LTDA.	0,0785%
COAL	72	COPELMI MINERAÇÃO LTDA	0,0734%
COAL	73	INDÚSTRIA CARBONÍFERA RIO DESERTO LTDA	0,0718%
COAL	81	CARBONIFERA METROPOLITANA S/A	0,0574%
COAL	83	COMPANHIA RIOGRANDENSE DE MINERAÇÃO	0,0517%
COAL	90	SEIVAL SUL MINERAÇÃO LTDA.	0,0426%
COPPER	4	SALOBO METAIS SA.	2,8959%
COPPER	32	MINERAÇÃO VALE VERDE DO BRASIL LTDA	0,3340%
COPPER	25	MINERACAO CARAIBA S/A (ERO BRASIL CARAÍBA)	0,4095%
COPPER AND GOLD	22	MINERAÇÃO MARACÁ INDUSTRIA E COMERCIO SA	0,4834%
COPPER AND GOLD	44	AVB MINERACAO LTDA.	0,1579%
FELDSPAR, TANTALUM, LITHIUM	18	AMG BRASIL S.A.	0,5558%

PRODUCT	POSITION IN THE RANKING	COMPANY	%CFEM
GOLD	5	KINROSS BRASIL MINERACAO S/A	1,2558%
GOLD	19	ANGLOGOLD ASHANTI CÓRREGO DO SÍTIO MINERAÇÃO S.A.	0,5496%
GOLD	27	JACOBINA MINERACAO E COMERCIO LTDA	0,3975%
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GOLD	46	MINERAÇÃO SERRAS DO OESTE EIRELI	0,1459%
GOLD	47	CEDRO MINERAÇÃO MARIANA LTDA	0,1405%
GOLD	49	FAZENDA BRASILEIRO DESENVOLVIMENTO MINERAL LTDA	0,1374%
GOLD	50	NX GOLD S.A.	0,1258%
GOLD	61	MINERACAO RIACHO DOS MACHADOS LTDA.	0,0974%
GOLD	62	MINERAÇÃO APOENA S A	0,0954%
GOLD	82	SERABI MINERAÇÃO S.A.	0,0521%
GRAPHITE	57	NACIONAL DE GRAFITE LTDA	0,1063%
IRON ORE AND NICKEL	1	VALE S.A.	53,1861%
IRON ORE	2	ANGLO AMERICAN MINERIO DE FERRO BRASIL S/A	5,5730%
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IRON ORE	21	MINERACAO CONEMP LTDA	0,4876%
IRON ORE	26	FERROMAR INDUSTRIA E COMERCIO S.A./ITAMINAS	0,4092%
IRON ORE	28	MINERITA MINÉRIOS ITAÚNA LTDA.	0,3648%
IRON ORE	29	EXTRATIVA MINERAL S/A	0,3644%
IRON ORE	30	BEMISA HOLDING S.A.	0,3498%
IRON ORE	38	JMN MINERAÇÃO S.A.	0,2489%

PRODUCT	POSITION IN THE RANKING	COMPANY	%CFEM
IRON ORE	43	SAFM MINERAÇÃO LTDA	0,1657%
IRON ORE	51	GSM MINERAÇÃO LTDA	0,1234%
IRON ORE	52	TOMBADOR IRON MINERACAO LTDA	0,1195%
IRON ORE	54	MINERAL DO BRASIL LTDA.	0,1125%
IRON ORE	56	MINÉRIOS NACIONAL S.A.	0,1085%
IRON ORE	60	MORGAN MINERACAO INDUSTRIA E COMERCIO LTDA	0,0978%
IRON ORE	63	VETRIA MINERACAO S.A.	0,0891%
IRON ORE	76	MINERACAO COMISA LTDA	0,0661%
IRON ORE	77	BAHIA MINERAÇÃO S.A.	0,0643%
IRON ORE	78	SERRA LESTE MINERACAO LTDA	0,0620%
IRON ORE	80	HERCULANO MINERACAO LTDA	0,0584%
IRON ORE	91	AVG EMPREENDIMENTOS MINERARIOS S.A.	0,0409%
IRON ORE	95	MINERACAO FLORESTA DO ARAGUAIA S A	0,0401%
LIMESTONE	31	VOTORANTIM CIMENTOS S.A.	0,3423%
LIMESTONE	34	CIPLAN CIMENTO PLANALTO S/A	0,2877%
LIMESTONE	55	CALTINS CALCÁRIO TOCANTINS LTDA	0,1086%
LIMESTONE	59	MINERACAO BELOCAL LTDA	0,1002%
LIMESTONE	66	LAFARGEHOLCIM (BRASIL) S.A.	0,0806%
LIMESTONE	70	EMAL EMPRESA DE MINERAÇÃO ARIPUANÃ LTDA	0,0743%
LIMESTONE	84	INTERCEMENT BRASIL S.A.	0,0513%
LIMESTONE	88	PIRECAL PIRENOPOLIS CALCARIO LTDA	0,0465%
LIMESTONE	92	MASSARI MINERAÇÃO PARTICIPAÇÕES LTDA.	0,0408%
LIMESTONE	93	CALCÁRIO VALE DO ARAGUAIA LTDA.	0,0408%
LIMESTONE	94	MINERAX MINERAÇÃO XAMBIOÁ LTDA.	0,0402%
LIMESTONE	96	BRITACAL IND E COM DE BRITA E CALCARIO BRASILIA L	0,0384%
LIMESTONE	97	INDÚSTRIA E COMÉRCIO DE CALCÁRIO CUIABÁ LTDA	0,0383%
LIMESTONE	99	MINERAÇÃO SERRA DOURADA LTDA	0,0371%
LITHIUM	42	COMPANHIA BRASILEIRA DE LÍTIO	0,1717%
LITHIUM	48	SIGMA MINERAÇÃO S.A.	0,1395%
MAGNESITE	89	MAGNESITA MINERACAO S.A.	0,0448%
NICKEL	17	ATLANTIC NICKEL	0,5735%
NICKEL	33	ANGLO AMERICAN NIQUEL BRASIL LTDA	0,3204%

PRODUCT	POSITION IN THE RANKING	COMPANY	%CFEM
NIOBIUM	37	COMPANHIA BRASILEIRA DE METALURGIA E MINERAÇÃO	0,2519%
PHOPHATE AND POTASSIUM	16	MOSAIC FERTILIZANTES P&K LTDA.	0,6142%
PHOSPHATE	100	GICS INDÚSTRIA COMÉRCIO E SERVIÇOS S.A.	0,0371%
PHOSPHATE AND NIOBIUM	23	CMOC BRASIL MINERACAO, INDUSTRIA E PARTICIPACOES LTDA.	0,4601%
PHOSPHATE AND POTASSIUM	8	MOSAIC FERTILIZANTES P&K LTDA.	0,9878%
QUARTZ SAND	65	MINERAÇÃO JUNDU LTDA.	0,0806%
ROCK SALT	86	DOW BRASIL INDUSTRIA E COMERCIO DE PRODUTOS QUIMICOS LTDA	0,0485%
TIN	53	WHITE SOLDER METALURGIA E MINERAÇÃO LTDA	0,1182%
TIN, TANTALUM,NIOBIUM	36	MINERAÇÃO TABOCA S.A.	0,2682%
VANADIUM	69	VANÁDIO DE MARACÁS SA	0,0772%
ZINC	87	MINERAÇÃO SANTA ELINA INDUSTRIA E COMÉRCIO SA	0,0482%
ZINC, COPPER AND SILVER	35	NEXA RECURSOS MINERAIS S A	0,2721%

Iron ore in the lead

Despite the advances of other mining products, iron ore maintains its leadership position in terms of its share in Brazil's mining output, a long way ahead of second-ranking gold. Given the large number of projects that are going to boost production in the next few years, iron ore seems certain to maintain its lead. Of all the planned investment projects in the Brazilian mining industry, including the infrastructure needed for shipping the ore from the mines to the markets, more than half are for iron ore.

Iron ore also accounts for the largest share in Brazil's trade surplus in mining products, amounting in 2023 to US$ 21.93 billion. Including iron ore in both its raw and processed forms, exports added up to US$ 38.8 billion.

To give an idea of the importance of iron ore in Brazil's total mining output, it may be noted that, out of the ten largest mining companies operating in the country, seven are iron ore producers: Vale, Anglo American, CSN, Mineração Usiminas, Samarco Mineração, Vallourec, and Mineração Corumbaense Reunida.

An important feature of the new iron ore projects in Brazil is that they all incorporate filtration and dry stacking of tailings, replacing the tailings dams that in recent years proved to be the Achilles heel of the Brazilian mining industry in general and of iron ore producers in particular, with accidents occurring at two dams, one belonging to Samarco and the other to Vale. To this day those two accidents continue to inflict great damage to the industry's reputation. In parallel, companies are investing considerable financial resources in dismantling the tailings dams that have now been decommissioned. Vale alone, Brazil's and the world's leading iron ore producer, has budgeted US$ 4.36 billion for this expenditure, continuing until 2035, to complete the dismantling of twenty-three tailings dams built on the upstream embankment method, out of its total thirty dams of this type, pointing out that dams of this kind are no longer allowed under Brazilian law. The other seven tailings dams have been dismantled yet.

Iron ore stockpile at CSN

Most of the growth projects are in the state of Minas Gerais, with smaller numbers in Bahia and Mato Grosso do Sul. In Minas Gerais, the main expansion projects now in execution are those of CSN, Vale, Anglo American, Itaminas, ArcelorMittal, Gerdau, the AVG group, Mineração Morro do Ipê, Mineração Herculano, the J. Mendes group, and Mineração Serra Leste.

Samarco is also implementing a project that will enable it to make full use once again of its installed capacity, in suspense since the Mariana accident. In Bahia, a state where iron ore mining began only recently, the main venture is that of BAMIN, though there are other, smaller ventures as well. In Mato Grosso do Sul, the main projects are those of the JBS group.

CSN Mineração is proceeding with the implementation of a business plan that proposes to triple its production capacity to 108 million tons a year by 2032, from a present figure of around 34 million tons. Stage One of the plan, begun in 2022 and due to be completed by 2028, is budgeted at R$ 15.3 billion (US$ 3.12 billion) and will double the current capacity from 34 million to 68 million tons a year, including ore purchased from other producers. This stage comprises six separate projects: recovery of ultrafine ore, with a planned output of 1 million tons a year of ore having a 66 percent iron content, with startup scheduled for the fourth quarter of 2024; Itabirito P15, capacity 15 million tons a year of ore with a 67 percent iron content, with production to begin in late 2025; recovery of tailings from the Pires dam, with an expected capacity of 1.5 million tons a year with a 65 percent iron content, also to start producing at the end of 2025; recovery of tailings from the B4 dam, expected capacity 2.5 million tons a year of ore with a 66 percent iron content, to begin operating in the second quarter of 2025; Itabirito P4+, with a production target of 4.4 million tons a year of ore with a 65 percent iron content, beginning in the second quarter of 2026; and finally the CdP fine ore recovery project for 2.5 million tons a year of ore with a 66 percent iron content, planned to start up in the first quarter of 2028.

Vale has budgeted a 2024 capex adding up to approximately US$ 6.5 billion, of which US$ 3.5 billion to US$ 4.0 billion is earmarked for the iron ore area (which the company has now renamed Steelmaking Solutions). The balance, in the range from US$ 2.5 billion to US$ 3.0 billion, is for energy transition metals. Some US$ 2.0 billion to US$ 2.5 billion will go to growth projects and US$ 4.0 billion to U$ 4.5 billion to the maintenance of existing operations. Vale's target is to raise its overall iron ore output to a volume in the range from 340 million to 360 million tons per year. To this end, in Minas Gerais, located within the company's Southeast System, it is developing solutions to boost its output of pellet feed, installing tailings filtration plant, and adopting dry stacking. The company's main project in Minas Gerais is maximizing output at Capanema, a unit that operated in the past and is now to be reequipped and reopened, for an investment of US$ 913 million. Operations are scheduled to begin in the second half of 2024, with a production capacity of 18 million tons a year.

Vale's S11D mine in Carajás

Anglo American's Minas-Rio complex

Also in Minas Gerais, **Vale** is in the process of licensing its Serpentina project, a new iron ore venture with a planned capacity of 26.5 million tons a year of pellet feed, requiring 47 million tons a year of raw ore. The mining areas are in eleven municipalities in the northern and northeastern regions of Minas Gerais, the company says, about 110 miles from Belo Horizonte, the state capital: Conceição do Mato Dentro, Dom Joaquim, Morro do Pilar, Carmésia, Santo Antônio do Rio Abaixo, São Sebastião do Rio Preto, Itambé do Mato Dentro, Passabém, Santa Maria de Itabira, Nova Era, and Antônio Dias.

In December 2023 **Vale** brought on stream the world's first iron ore briquettes plant, at its Tubarão unit in Vitória, in the state of Espírito Santo. Vale says its briquettes have the potential to revolutionize the steel industry, cutting greenhouse gas emissions by as much as 10 percent in the blast furnace or enabling zero-emissions steel production at a future date, once green hydrogen becomes available. Investment in the first plant amounted to US$ 256 million; a second plant of the same type, also at Tubarão, is scheduled to begin operating in early 2024. Jointly, the two plants will have the capacity to produce 6 million tons of briquettes per year, with 2024 output estimated at 2.5 million tons.

Anglo American is investing in a tailing's filtration plant at Conceição do Mato Dentro, with a capacity of 24.5 million tons a year and a processing plant with a capacity of 31 million tons a year, which will extend the productive lifetime of the mine. Scheduled for completion in 2026, the venture is budgeted at around US$ 758 million. The company is also installing a recleaner unit and Vertimill (vertical mill) equipment, adding 1.7 million tons per year to its present capacity. The investment will amount to US$ 153 million, with 2025 as the planned completion date.

ArcelorMittal is engaged in expanding output at its two Brazilian mines, both in Minas Gerais. The Serra Azul mine at Itatiaiuçu and the Andrade mine at Bela Vista de Minas currently produce 3.1 million tons a year; the expansion program will raise that to 8 million tons. The investment budget for Serra Azul is R$ 2 billion (about US$ 400 million), in a project that the company has named Compact Itabirite, modernizing the processes while almost tripling its output from the current 1.6 million tons to 4.5 million tons a year. A new pellet feed plant (high-grade ore fines) will boost capacity and extend the mine's productive lifetime until 2053. The purpose of the project, the company says, is to supply ore to a pelletizing plant that the company operates in Mexico and that, in its turn, supplies the group's own steel mills in Mexico. The entire planned output, stated as 4.5 million tons,

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will be exported to the Mexico unit. At the Andrade mine, which supplies ArcelorMittal's Monlevade steel mill, output will more than double, from the present 1.5 million tons to 3.5 million tons a year.

Itaminas is engaged in a wide-ranging investment program aimed at increasing its output capacity, to reach a targeted 15 million tons a year by 2030. The total cost of the investment is estimated at R$ 1.35 billion (approximately US$ 280 million), to fund expansion projects spread over a period of years.

Herculano Mineração is planning three new projects, involving a total investment budget of approximately R$ 750 million (US$ 153 million), that will double its output capacity from the present 5 million tons to 10 million tons a year. First on the list is the Serro project, currently awaiting environmental licensing for which the company has applied to the Minas Gerais state government. The company's expectation is that this project will become operational in the second half of 2024. The investment is estimated at R$ 300 million. A second project is João Monlevade, budgeted at R$ 150 million and currently at the stage of completing the environmental impact assessment known by the acronym EIA/RIMA. The planned startup date is 2026. The third Herculano venture is the Vila Rica project, also at the stage of environmental analysis. Herculano proposes to invest R$ 200 million in Vila Rica, with a 2025 startup.

Mineração Morro do Ipê is ramping up its Tico-Tico project, in which it invested R$ 1.3 billion. This new mine will have the effect of raising production capacity from the present 3.5 million tons to over 9 million tons per year, of which 6 million tons is premium grade ore for export.

The **AVG group** is implementing two projects to expand its iron ore output capacity. The first is the Brumado mine, located in the municipalities of Caeté and Sabará, both within the Belo Horizonte metropolitan area. The project calls for an investment of some R$ 500 million (about US$ 102 million). When it is fully completed, Brumado will have a capacity of approximately 3.5 million tons of run-of-mine ore per year. Another AVG project is the Dois Irmãos mine, located in the neighbouring municipality of Barão de Cocais, where the investment amounts to about R$ 200 million. The initial capacity will be 1.5 million tons a year, rising to 2 million tons once the project is fully completed. Both projects are to be finalized in the fourth quarter of 2024, at which point AVG's overall production capacity will have risen to 7.8 million tons a year.

Gerdau has announced a R$ 3.2 billion (just over US$ 650 million) investment to expand production capacity at its Miguel Burnier mine to 5.5 million tons, beginning in late 2025. A pipeline will be laid to carry the iron ore, all of which will supply Gerdau's four steel mills in the same state of Minas Gerais, located at Ouro Branco, Barão de Cocais, Divinópolis, and Sete Lagoas.

Samarco's operation at Mariana, in Minas Gerais, had been halted since the 2015 accident when the Fundão tailings dam collapsed, but since December 2020 it has been gradually and cautiously bringing the mine back into production. It is now operating

at 30 percent of capacity, with a pelletizing plant and a concentrates plant. The company has approved an investment budget of R$ 1.3 billion (US$ 265 million) to reach 60 percent of the installed capacity. Looking further ahead, Samarco's plans show the Mariana mine gradually and cautiously increasing its output year by year, finally achieving 100 percent of capacity by 2028.

Bemisa expects to bring its Mongais project, in Minas Gerais, on stream by March 2024. It will add an extra 1 million tons a year to the Baratinha mine's present capacity of 2.5 million tons. Apart from the Baratinha complex, Bemisa has two further iron ore mines in development, to be brought on stream in the next few years. These are the Pedra Branca project, in the municipality of João Monlevade, currently at the environmental licensing stage, and Picarrão, in the municipalities of Nova Era and Antônio Dias, the fruit of a partnership deal signed in 2023.

The **J. Mendes** group intends to invest a total R$ 580 million in mining and logistics projects in Minas Gerais. By far the largest of them, budgeted at R$ 440 million, is the Guariba stacking tailings and wastes project, in the municipalities of Congonhas and Ouro Preto, which is operated by Ferro+, another company in the same group. The other investment in mining, in the amount of R$ 81.4 million, is for expansion at the Baú mine, operated by JMN Mineração, located at Santa Bárbara and Barão de Cocais. For the Ferro+ project in Ouro Preto and Congonhas, implementation is scheduled to begin in May 2024, to be concluded in May 2025. Another significant investment by the same company is a rail terminal for transporting ore, to be built at Entre Rios de Minas. This will improve the logistics for the Morro dos Coelhos mine, while it will also act as a commercial carrier serving other companies operating in the area.

Cedro Participações, acting through its subsidiary Cedro Mineração, is investing US$ 300 million, between now and 2026, to expand its iron ore production capacity. The aim is to multiply by five its present capacity of around 4 million tons a year. Cedro Mineração operates a mine at Nova Lima, in Minas Gerais, which it acquired from Extrativa Mineral. To expand its capacity, the company can rely on its four new mines, all in Minas Gerais: Cedro Mariana, with a capacity of 1.5 million tons a year; Sapé, 3.5 million tons; and two others, Patrimônio and Dois Irmãos. The group is also planning to invest R$ 1.8 billion in a short railway link between Itaúna and São Joaquim de Bicas, both in Minas Gerais and just 32.4 kilometers (20.1 miles) apart. The rail link will connect with MRS's railway, enabling Cedro to deliver its ore to the main ports in Brazil's southeast region.

Mineração Serra Leste is beginning operations at its Candonga mine, located in the municipality of Guanhães, in Minas Gerais,

BAMIN iron ore mine, in Bahia

with a capacity of 1.055 million tons a year of iron ore using dry processing. The deposit was acquired from Centaurus Brasil Mineração.

In the state of Bahia, **BAMIN** is one of the mining companies with Brazil's biggest investment budgets. The company has announced an increase of its investments in its home state from R$ 14 billion to R$ 20 billion, to develop an integrated mine, railway, and port terminal project. BAMIN also released a new projection for production capacity, rising from 18 million to 26 million tons per year. The integrated project comprises the Pedra de Ferro mine, the FIOL-1 railway linking Caetité to the port of Ilhéus, and the Porto Sul facility at Ilhéus. The mine will exploit certified reserves amounting to 647 million tons of ore averaging a 40.5 percent iron content (in accordance with JORC Code standards), a processing plant with separate lines for hematite ore and itabirite concentrate, resulting in products with a 65.5 percent and a 68.5 percent Fe content respectively, producing 26 million tons per year. All tailings will be placed in stockpiles, with no dams. The 537-kilometre (334-mile) railway will link the mine at Caitité to the company's private port terminal located 12 kilometres (7.5 miles) north of Ilhéus. The storage yard is designed to hold up to 1.4 million tons of ore. Other features include a turntable for rolling stock; an ore stacker and reclaimer, a 5.7-kilometre (3.5-mile) conveyor belt; a ship loader, pier, and breakwater. The terminal will accommodate vessels of up to 250,000 tons and is designed to facilitate a future expansion to handle grain exports and fertilizer imports. The total investment

Santa Fé iron ore sample

in the project amounts to around US$ 4 billion, with completion planned to occur in 2027. At present, the mine has an installed capacity of 2 million tons a year.

Santa Fé Mineração is awaiting only the installation licence (*licença de instalação*) to begin work, before the end of 2024, on the first stage of a high-grade (65 percent Fe) pellet feed plant, in the southeast of the state of Bahia. The first plant, with a capacity of 1 million tons a year, will be joined by others of the same size until their total capacity reaches 10 million tons, with the possibility of further expansions in the future. The whole Santa Fé deposit, spread over several areas, holds proven reserves of 1 billion tons of mineral resources.

In the state of Mato Grosso do Sul, iron ore production is set to post substantial growth rates in the next few years. **MCR**, a mining company in the **J&F Group**, expects to raise its output to 12 million tons in 2024.

Also in Mato Grosso do Sul, **MPP Mineração** has announced a R$ 50 million investment in expanding its iron and manganese ore operations in Corumbá, where next year's iron ore output is estimated at 1.2 million tons.

Gold remains attractive

Holding on to its second place in Brazil's mining output, gold is still attracting investments, from large, medium, and small-scale mining companies alike. The main producers currently active in Brazil are Kinross Brasil (Kinross), AngloGold Ashanti, Jacobina Mineração (Panamerican Silver), Mineração Serra do Oeste (Jaguar Mining), Fazenda Brasileiro (Equinox Gold), NX Gold (Ero Copper), Mineração Apoena (Aura Minerals), Serabi Mineração, Mineração Maracá (Lundin Mining), Aura Almas Mineração (Aura Minerals) and Santa Luz Desenvolvimento Mineral (Equinox Gold). The outlook for the next few years is for continued growth in gold output, in the light of companies' projects now in execution or at the planning stage.

Kinross Brasil is implementing its Gravity project, which will add some 20,000 ounces a year to the capacity of its mine at Paracatu, on the western edge of Minas Gerais. The project calls for a US$ 30 million capex. The company plans to instal a gravity gold recovery circuit in the circulating load of the grinding circuit in Plants 1 and 2. Four centrifugal concentrators will be installed at Plant 2 and another one in Plant 1, together with an intensive leaching reactor.

GMIN (G Mining Ventures Corp.) had completed 51 percent of its Tocantinzinho project by January 2024. Located in the state of Pará, the plant is expected to begin producing on a commercial sale before the end of the year. The open pit mine and processing plant will have the capacity to produce 175,000 ounces a year over a ten-year productive lifetime from a reserve

Construction of the Tocantinzinho project, by GMIN

stated as 2 million ounces of gold in an ore having an average content of 1.31 grams per ton. Capex is around US$ 481 million, and the average production cost is expected to be US$ 681 per ounce.

Hochschild's R$ 900 million Posse project is now nearing completion in the municipality of Mara Rosa, Goiás. Posse is an open pit mine and processing plant with the capacity to produce 900,000 ounces of gold over a ten-year period. Startup is planned for the first half of 2024, with commercial deliveries expected to begin toward the end of that period.

Aura Minerals has been pursuing a rapid growth policy since 2018, aiming at an output of 450,000 ounces per year, to be achieved by 2025. That will almost double its 2023 result of a little over 235,000 ounces. In 2023 the company brought on stream its Almas project in the state of Tocantins, for a capex of US$ 73 million. It is planned to produce 51,000 ounces in each of the first four years. The company is also beginning to implement its Borborema project, in the state of Rio Grande do Norte, acquired from Big River, which will require a capex of US$ 188 million. Borborema holds 812,000

Aura Minerals' Matupá Project

ounces in proven and probable reserves and resources (measured and indicated) of 2,077,000 ounces. Output is projected at 83,000 ounces a year, at a cost of US$ 862 per ounce. Another project in Aura's portfolio of new investments is Matupá, in Mato Grosso, where implementation may begin before the end of 2024. The feasibility study, now concluded, shows an investment of US$ 107 million for an output of 54,700 ounces in each of the first four years and a seven-year productive lifetime, based on reserves estimated in accordance with Canadian National Instrument 43-101. The all-in sustained cost (AISC) is stated as US$ 710 per ounce in the first four years. Startup is planned for the last quarter of 2025.

Equinox Gold, having restarted operations at its Santa Luz mine in the state of Bahia, in 2022, now plans to invest US$ 154 million in starting underground operations at its Aurizona mine in the state of Maranhão, and in exploring satellite deposits while continuing to operate the open pit mine, which today has the capacity to process 8,000 tons of ore per day. The new project has a forecast output of 137,000 ounces of gold per year for eleven years. The planned expansion is expected to raise Equinox's total Brazilian output to 400,000 ounces a year. In 2023, its Brazilian mines produced 296,800 ounces, accounting for nearly 53 percent of the group's worldwide production in the year.

Mineração Castelo dos Sonhos, a **TriStar Gold** subsidiary, held the public hearing required for the issue of a preliminary licence (*licença prévia*) for is planned gold mining venture in the state of Pará. A prefeasibility study concluded in 2021 presented the Castelo dos Sonhos venture as an open pit mine with a productive lifetime of eleven years, averaging 121,000 ounces of gold per year in two stages, with an AISC of US$ 900 per ounce. The deposit holds reserves of 1.4 million ounces of gold. The planned investment is approximately US$ 261 million, including a 20 percent margin for contingencies.

Cerrado Gold, acting through Serra Alta Mineração, is planning to invest US$ 186.6 million (including a US$ 15.8 million contingency fund) to implement an open pit mine and processing plant in the state of Tocantins, with the capacity to produce 94,700 ounces of gold per year, over a nine-year period, at an AISC of US$ 711 per ounce. Initial reserves, proven and probable, amount to 895,000 ounces of gold, calculated as 16.8 million tons of ore having a gold content of 1.66 grams per ton. Measured and indicated reserves are stated as 1,01 million ounces, based on 18.4 million tons of ore and a gold content of 1.72 grams per ton, plus inferred resources of 66,000 ounces of gold (1.1 million tons at 1.95 grams per ton).

Tucano Gold, controlled by Pilar Gold in partnership with a group of shareholders, is restarting operations at its Tucano mine located in Pedra Branca do Amapari, in

the state of Amapá. The mining operation had been halted following an application for protection from creditors by the former controlling shareholder. The company says the operation will resume only gradually, beginning with grinding the low-grade ore and later proceeding to the AB pit. At the same time, the company is planning to develop underground mining at the Urucum Norte deposit. The cash cost is estimated at US$ 1,000 per ounce. In the medium term, the scale of production is planned to reach 100,000 ounces per year. The processing plant was modernized in 2020 and can now handle a volume of 10,000 tons per day. Resources now remaining at Tucano amount to 1.8 million ounces, though the company believes the potential is greater, since the known ore bodies indicate the possibility of high-grade underground reserves. In addition, Tucano holds the mining rights to an area of 2,000 square kilometers (770 square miles) in the Guiana Shield, potentially favorable to the discovery of gold.

Facilities of the Tucano Mine in Amapá

Belo Sun, controlled by the Forbes & Manhattan group, is still seeking to obtain

the environmental license for its Volta Grande project, located in the municipality of Senador José Porfírio, adjoining Altamira in the state of Pará. With a capex originally budgeted at US$ 298 million, the venture is planned to produce an average 268,000 ounces in the first ten years for a total 3.53 million ounces over its productive lifetime, at an AISC of US$ 779 per ounce of gold. The feasibility study stated reserves as 3.8 million ounces and resources (measured and indicated) as 5.0 million ounces.

Altamira Gold is focusing on the exploration and development of gold projects in the central region of Brazil. It has six projects covering an area of approximately 1,900 square kilometres (730 square miles) in the prolific Juruena gold belt, which historically produced between 7 million and 10 million ounces of alluvial gold. Altamira's most advanced project is Cajueiro, holding indicated resources (in accordance with NI 43-101) of 5.66 million tons of ore at 1.02 grams of gold per ton, giving a total 185,000 ounces. Inferred resources are 12.66 million tons at 1.26 grams per ton, giving a further 515,000 ounces.

Advances in strategic minerals

Gradually, Brazil is advancing in the production of what a market consensus now labels "critical" or "strategic" minerals, referring to those that will have an important role to play in the energy transition, being needed in the manufacture of electric vehicles and for the storage of renewable energies such as solar and wind power. Copper has already become the country's third most important mining product and looks certain to go on growing; several new nickel projects are on the way; and one of the world's largest lithium projects was recently brought into operation, with expansions already being planned, while others of the same kind are in the pipeline. There are expansion projects for niobium mining, needed for the manufacture of electric vehicle (EV) batteries; and Brazil has the only vanadium mine found anywhere in the Americas.

Copper

In copper, **Ero Brasil** (controlled by Ero Copper) is progressing in its implementation of its Tucumã project, in Pará, with the expectation that commercial production will begin in the second half of 2024. The total investment is now expected to rise to US$ 310 million, a little higher than the original budget. Once the project is brought on stream, with the capacity to produce 55,000 tons a year, Ero Brasil's overall copper capacity will have grown to more than 100,000 tons. Another Ero Brasil project, named Deepening, calls for drilling a shaft to access ore reserves lying deep in its Pilar underground mine. Located in the state of Bahia and budgeted at R$ 1.4 billion, the project is expected to take three years to be completed.

Vale Base Metals, a newly created subsidiary to act in the base metals business, and which is the country's leading copper producer with its Salobo and Sossego mines in Pará, is investing heavily in expanding its copper capacity. The company recently brought on stream its Salobo 3 project,

in which it invested around US$ 1.1 billion, raising its ore crushing capacity to 36 million tons a year and yielding 30,000 to 40,000 tons of copper. The company is looking at the option of implementing its Salobo 4 project, which would boost its capacity by a further 30,000 tons per year of copper content in concentrate. Yet another project in its portfolio is Alemão, also in the Carajás region, with a copper capacity of 60,000 tons a year. Vale's third copper project in Brazil is Cristalino, located close to the Sossego mine in the area the company calls its Southern Hub. Currently at the feasibility study stage, the project is expected to bring 80,000 tons of copper a year and will have the effect of lengthening the productive lifetime of the Sossego processing plant. As part of the Southern Hub extension program, Vale Base Metals is looking at ways to make use of the satellite deposits such as Bacaba, Visconde, and 118, which would call for a new processing plant in the same area. Near Salobo, Vale is studying the feasibility of its Northern Hub, drawing on several deposits — Paulo Afonso Sul, Pojuca, Gameleira, Furnas, and Grota Funda — that together might add some 70,000 to 100,000 tons of copper per year.

Nickel

Brazil has only three nickel producers currently active: Anglo American, Vale Base Metals, and Atlantic Nickel. Only one of the three produces sulfide nickel, while both the others produce ferronickel. Horizonte Minerals is now implementing a project, having recently decided to suspend the implementation of its Araguaia project

Horizonte Minerals Araguaia Project

in Pará due to a cost overrun. Instead of the approved budget of US$ 433 million, it found the project was going to call for US$ 537 million. Startup had originally been scheduled for 2024, but the timing is now under review. Initial capacity had been planned as 14,500 tons a year, but this will now probably be doubled. At the same time, the company is seeking to gain environmental licensing for its Vermelho project, also in Pará, to produce nickel-cobalt. The feasibility study is due to be published by the end of June 2024.

Vale Base Metals has given the go-ahead for construction of a second furnace at Onça-Puma, in Pará. The investment is budgeted at US$ 555 million, with a planned startup date in the first half of 2025. The project will bring an additional volume of nickel output estimated in the **range from 12,000 to 15,000 tons a year**.

Atlantic Nickel, controlled by Appian Capital Brazil, has completed a preliminary economic assessment (PEA) for its proposal to extend operations at its Santa Rita mine at Itagibá, in Bahia. The plan now is to keep it in operation for 34 years instead of just

eight years, which was the original intention. The new PAE shows a potential 26-year lifetime for underground mining, in addition to the original eight years planned for the open-pit mine only. The PAE shows that the company plans to invest US$ 355 million along first five years.

Jervois Mining is investing US$ 65 million in rebuilding and reequipping its zinc and cobalt refinery at São Miguel Paulista, in the state of São Paulo, acquired from Companhia Brasileira de Alumínio (CBA), part of the Votorantim group. Jervois expects the plant to restart operations in the first quarter of 2024, with an annual capacity of 10,000 tons of nickel and 2,000 tons of cobalt cathodes.

Centaurus Metals has already obtained the Preliminary License for its Jaguar project, in the Carajás region, where it intends to produce 20,000 tons/year of sulphide nickel. The project foresees the use of a deposit with resources of 109.2 million tons of ore at 0.87% Ni, equivalent to 948.9 thousand tons of metal. The Capex value must be defined in the DFS, which is to be completed in the first quarter of 2024.

Niobium

CBMM, the worldwide market leader in niobium, is currently engaged in publicizing its pioneering new technology, developed in partnership with Toshiba of Japan, enabling the use of niobium in EV batteries and creating a new market for their product. The new technology uses niobium and titanium oxide instead of carbon in battery cells, slashing recharging time from eight hours or more to as little as ten minutes. In addition, the new product greatly improves safety, since the lithium battery presents no danger of overheating, which can sometimes cause a conventional battery to catch fire or even explode.

Confirmation that the technology was feasible encouraged CBMM to set up a laboratory and pilot plant at Araxá, in Minas Gerais, to produce samples of the niobium-titanium oxide, to be sent for testing. At the same time, the company has built a pilot plant in Japan to produce battery cells and has already distributed 5,000 of them to prospective users, for them to conduct their own tests.

CBMM also sought to form a partnership with a Brazilian heavy vehicle manufacturer. The choice fell on Volkswagen's truck and bus division, which has a factory in the state of Rio de Janeiro, and which has successfully developed the first electric bus running on a battery that uses niobium-titanium oxide for the negative pole. A significant characteristic of the new technology is that charging the battery is very much quicker, compared with the earlier carbon anode technology.

Readying its facilities to meet the new demand that is expected to arise for niobium oxide, and in line with its strategy to always plan ahead to meet a forecast surge in demand, CBMM is investing US$ 80 million in setting up a new plant with the capacity to produce 3,000 tons per year of niobium oxide, having the characteristics required for use in batteries. In addition, the company already has an engineering project ready for a capacity expansion to 20,000 tons a year.

In addition to the use of niobium oxide in batteries, CBMM is still pursuing the expansion of niobium use in energy transition applications and in decarbonization. A few examples are high-resistance cables for use in the building industry, micro alloyed specialty steels for wind towers, and niobium for use in nanomaterials for magnetic applications and even in fungicides. To develop these programs, CBMM's annual research and development budget ranges from R$ 250 million to R$ 300 million, apart from some R$ 700 million in capex.

Is the time right for rare earths?

Rare earths mining in Brazil has attracted the attention of a few companies, mainly junior companies with a stock exchange listing in either Canada or Australia. Recent discoveries of ionic clays open a new prospect for Brazil as a future producer of rare earth elements (REEs).

In January 2024, **Mineração Serra Verde** began commercial production of a mixed rare earths concentrate under the first stage of its Pela Ema deposit, located in the municipality of Minaçu, in Goiás. Once it reaches full capacity, the company hopes to be producing 5,000 tons a year of rare earth oxides (REOs), used in the manufacture of high-efficiency permanent magnets needed in both EVs and wind turbine generators. Pela Ema is a large deposit of ionic clay, with a long productive lifetime and holding a high proportion of valuable heavy and light rare earths, notably neodymium (Nd), praseodymium (Pr), terbium (Tb), and dysprosium (Dy), all four deemed essential for the energy transition. Serra Verde has

Serra Verde mining industrial plant

conducted studies for a capacity expansion in the first stage of the venture by optimizing procedures in the plant, and is now assessing the potential for a further, second stage, expansion, which could double gross output by the end of the twenties. To bring the first stage into operation, the company invested some US$ 170 million. A significant feature of the Pela Ema operation is that, until now, no secondary ionic clay deposit had been brought into production in any country except China.

Meteoric Resources, an Australian junior company that acquired the Caldeira ionic clay deposit at Poços de Caldas, in Minas Gerais, is developing the engineering needed to work the deposit, which holds inferred resources of 409 million tons of ionic clay with a total rare-earths oxides (TREO) content of 2.626 parts per million. In 2023 the company announced that it may invest as much as R$ 1.5 billion to bring the Caldeira project into production by 2027. The plan is start with a capacity of 10,000 tons of rare-earth oxides, corresponding to approximately 5 percent of worldwide demand for neodymium and praseodymium. The project can easily be scaled up, the

company says, if that should be required, with the possibility of reaching 20,000 tons of rare-earth oxides including 7,000 tons of neodymium and praseodymium, by 2030.

Bemisa is investing in detailed geological research in the area where it is developing its Bambuí project, extending through four municipalities in the northeast of Minas Gerais: Carmo do Paranaíba, Arapuá, Matutina and Tiros. The area holds resources of over 1 billion tons of high-content rare-earth oxides. The company is simultaneously developing tests for the recovery of ionic clay. The venture covers three mining permits, covering an area of approximately 36 square kilometers (14 square miles), where fourteen boreholes were drilled to an average depth of 96 meters (315 feet). The TREO content was found to average 0.45 percent, with some samples yielding a content above 1 percent. Leaching tests gave positive results, with Bemisa now having good expectations for the future of the project. It has programmed further drilling in the first half of 2024 and further laboratory tests, in the confident expectation that the deposit will emerge as a world-class source of rare-earth elements.

Viridis Mining is pressing ahead with an exploration program at its Colossus project in Poços de Caldas, Minas Gerais. It has contracted consultants to estimate the mineral resources in compliance with the Australian JORC Code, with early findings described as "excellent" in view of the high REE content. Viridis says it is confident that Colossus will become a significant source of REEs, in particular of magnetic rare-earth oxides (MREOs), needed for high-tech and green energy applications.

Brazilian Rare Earths is a mining venture still at the pre-operational stage, supported by Gina Rinehart, a mining magnate and Australia's richest woman. With a market valuation of around US$ 200 million, the company holds the concession to extract rare earths in an area of over 1,400 square kilometres (540 square miles) in the Jequié region in Bahia, considered highly promising for rare earths and other minerals. Resources, assessed in accordance with the JORC Code, amount to 510 million tons of ore with a TREO content of 1.513 parts per million, in an area of which only one-twentieth has been explored so far. The Monte Alto project alone is assessed at 25.2 million tons of monazite sands with a 1 percent TREO content.

Equinox Resources, another Australian company, reports the discovery of "convincing initial evidence" of the presence of rare-earth minerals in ionic clay at its Campo Grande project in the Jequié region in Bahia. The company says its two projects combined, Mata da Corda and Campo Grande, cover an exploration area of approximately 2,550 square kilometers (980 square miles) in that rapidly developing region of ionic clays.

Appia Rare Earth & Uranium Corp., listed on the Toronto Stock Exchange, has signed an agreement with Beko Invest Ltd. acquiring a share of up to 70 percent in its Cachoeirinha rare earths project, located in the Tocantins structural province, part of the Brasília fold belt in the Arenópolis Magmatic Arc in the state of Goiás. Covering an area of 176 square kilometers (68 square miles), Cachoeira is classified as a

highly anomalous occurrence of intrusive alkaline rock holding REEs and niobium. The company reports that recent geochemical exploration indicated a good potential for both REEs and niobium in lateritic ion-adsorption clays.

Aclara Resources, also listed in Toronto, has announced the results of a PEA for its Carina project, extracting ion-adsorption clay, located at Nova Roma in Goiás. The initial capital cost is budgeted at US$ 576 million. The net after-tax present value is close to US$ 1.2 billion. The company also projects an average net annual revenue of US$ 474 million and Ebitda of US$ 340 million, with an average production cost of US$ 13.1 per ton. The expectation is that the project will be commissioned by the end of 2029. The company is confident that the venture has an essential role to play in meeting growing demand for high-quality rare earths. The processing plant will have an average output capacity stated as 4,498 tons per year of REOs in concentrates. The mineralized area at Carina covers around 14 square kilometers (5.5 square miles), with the potential for future enlargement. The company will use its own technological process that is pioneering and environmentally sustainable.

Rainbow Rare Earths has signed a memorandum of understanding with The Mosaic Company for the joint development of a process flowsheet and to conduct a PEA for extracting REEs from Mosaic's phosphogypsum stack in the Uberaba

area in Minas Gerais. The stack contains valuable REEs that occur as byproducts of the manufacture of phosphoric acid. The material at Uberaba is like that at Rainbow's Phalaborwa project in South Africa, based on a carbonatite phosphate hard rock deposit. Although hard rock carbonatite does not contain rare earths in sufficient quantities to be mined for those elements alone, the process that they undergo serve to concentrate the rare earths contained in them, resulting in higher concentrations than were present in the original hard rock.

Alvo Minerals has reported that it achieved highly promising results from auger drilling at its Bluebush project, seeking to ascertain the presence of rare earths in the northern half of the Serra Dourada granite, which hosts the Serra Verde ionic clay deposit. The project is located in the municipality of Palmeirópolis in the state of Tocantins.

Mineração Taboca and the University of São Paulo's Laboratory for Recycling, Waste Disposal, and Extraction (Larex) are jointly working on a project to process the tailings from tin mining to recover valuable materials such as REEs. The company is also active in the niobium and tantalum markets, operating two main units, the Pitinga mine, producing tin, niobium, and tantalum in the state of Amazonas and a metallurgical plant at Pirapora do Bom Jesus in the state of São Paulo.

Canada Rare Earth Corp. has reported that it has acquired the right to increase its shareholding, to 52 percent, in the ownership of the tailings at Bom Futuro, in Rondônia, and that it will be in charge of operating the venture. The company's rights include a licence for extractive activity and the recovery of 70 million tons of tailings accumulated in the course of twenty-five years of tin mining by Paranapanema S.A. as well as by artisanal operators. The tailings occupy an area of 590 hectares on a rented property measuring 9,960 hectares. Marketable minerals that can be economically recovered from the tailings include cassiterite (tin ore), ilmenite, zircon, and rare earths. Included in the contract are all tailings arising from any present or future mining activities conducted during the 26-year term of the contract. In addition, the company has a preferential option to purchase the mining rights to any underground deposits found anywhere on the property.

Resouro, a Canadian company, has announced "significant" initial results from its exploration of the Tiros project, a deposit holding titanium and rare earths at Tiros, in Minas Gerais. The project covers an area of 152 square kilometers where ten separate mining concessions are thought to hold — according to surveys conducted by previous owners — potentially 630 million tons with a 12 percent titanium oxide content, in addition to REOs.

Foxfire Metals Ltda. discovered REEs at a site in the so-called Brazilian Lithium Valley in the north of Minas Gerais. Recent laboratory tests demonstrate the presence of REEs at content levels ranging as high as 3,050 ppm, and also of lithium, rubidium, niobium, and zirconium. Soil and rock samples were collected from thirteen points around an area of 35 square kilometers (13.5 square miles). The analysis

showed that sixteen of the seventeen REEs were present in all thirteen samples. All the samples, similarly, showed niobium, rubidium, and zirconium at high content levels, while twelve of the thirteen samples also contained lithium.

Vatic Ventures, also a Canadian company, has signed a deal to acquire the sole prospection rights to a property where lithium is found in hard rock. The location is a well-known pegmatite mining area, 40 kilometers from Solonópole in the state of Ceará. The property includes a number of extensive pegmatite dikes where samples have given results showing a lithium oxide content ranging from 3.41 percent up to 5.03 percent. Named Solonópole Sul, the property comprises four blocks covering 48.1 square kilometers.

Urânio Energy Fuels has acquired seventeen mining concessions in a string of three coastal municipalities — Prado, Alcobaça, and Caravelas — in Bahia, at a cost of US$ 27.5 million. Covering 151 square kilometers, the area holds significant quantities of heavy mineral sand (HMS), including monazite, that will enter the parent company's REE supply chain in the United States. More than 3,300 boreholes have already been drilled, showing significant concentrations of titanium (in ilmenite and rutile), zirconium (in zircon), and REEs (in monazite). The company says the project has the potential to supply from 3,000 up to as much as 10,000 tons of monazite sand concentrate per year, depending on the production scale, plus from 1,500 to 5,000 tons of REOs, possibly over a period of decades. Energy Fuels' main interest is monazite, which contains REEs and uranium. Preliminary tests suggest that the monazite content in the HMS ranges from a minimum 0.62 percent up to a maximum 12.82 percent. The uranium content of the monazite is thought to be on a comparable level to that found in the typical Colorado Plateau uranium deposits.

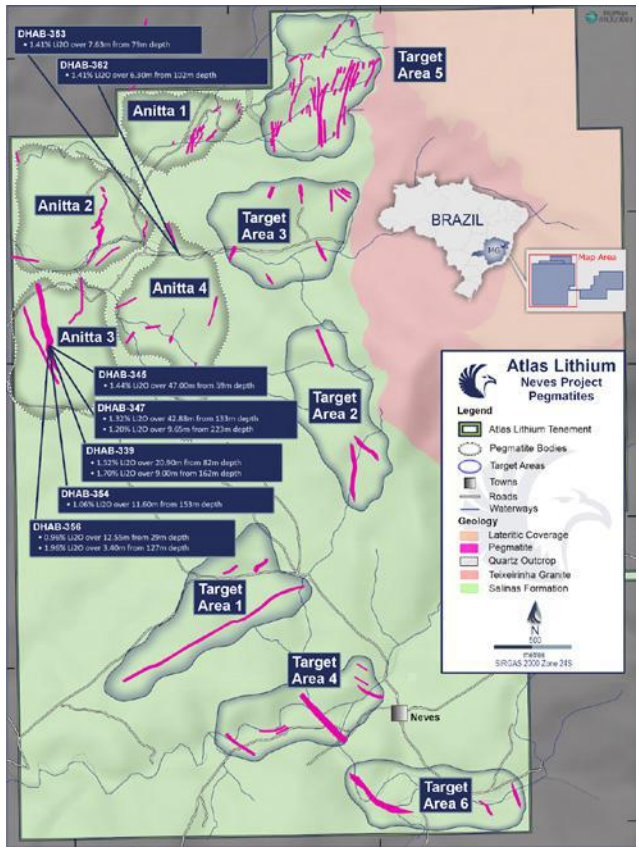
Mineradora Tabuleiro, in partnership with Umyne, a U.S. company, and with two private-sector organizations, Senai Cimatec and Embrapii, has set up a pilot plant to investigate the recovery of rare earths using

innovative technology for processing minerals that, until now, had been disregarded because they were thought to be uneconomical. The aim is to process tailings that hold varying levels of light REEs such as neodymium, praseodymium, lanthanum, and cerium. The plant is located within Senai Cimatec's complex at Camaçari, in the state of Bahia.

Lithium rush

In 2023 Brazil became a producer of battery-grade greentech lithium, having until then produced chemical-grade lithium only. The change came with the startup of **Sigma Lithium**'s Grota do Cirilo project, located in the municipalities of Itinga and Araçuaí, in Minas Gerais. In the initial stage, the installed capacity is 270,000 tons a year of lithium, corresponding to 36,700 tons a year of lithium carbonate equivalent (LCE). Meanwhile, a technical report has demonstrated the feasibility of an expansion at Grota do Cirilo to 510,000 tons a year of lithium. Capex required for the expansion would be US$ 155 million.

AMG Mineração, another leading lithium producer in Brazil, has brought on stream its lithium concentrate processing plant, the first stage of a project located in the municipalities of Nazareno and São Tiago, in Minas Gerais. This will increase the company's overall capacity from 30,000 to 90,000 tons a year by the end of the first quarter of 2024, for a US$ 50 million investment. The lithium concentrate shipped from this plant undergoes further processing on its arrival in China or Europe, to complete its transformation into the lithium required for industrial applications. Another AMG project calls for a lithium carbonate conversion plant, extending the company's production chain in Brazil. The project was begun in 2022, with completion planned for the last quarter of 2026. The lithium carbonate produced in Brazil will be shipped for further processing at an AMG facility in Germany. The end product will be lithium hydroxide, widely used in battery manufacture. Once this conversion unit becomes operational, AMG Brasil expects to produce around 15,000 tons per year. The venture will require an investment in the range from US$ 250 million to US$ 270 million.



Atlas Lithium Exploration Areas

Atlas Lithium is in line to become Brazil's next lithium producer, with an end-2024 date in view for startup of the first stage of its Lítio Mineiro project, located in six municipalities in Minas Gerais — Araçuaí, Itinga, Coronel Murta, Rubelita, Taiobeiras, and Virgem da Lapa — where it holds 54 mining rights. Budgeted at US$ 49.5 million, this first stage will have an output capacity of 150,000 tons per year of spodumene concentrate. A second stage of the project, for which the timetable and the budget have not yet been defined, would double the capacity to 300,000 tons a year. The company has signed sales contracts, in exchange for investment capital, with two Chinese companies, Chengxi Lithium Group and Yahua Industrial Group, both of which are suppliers of lithium hydroxide to major EV manufacturers.

Lithium Ionic plans to become one of Brazil's largest lithium producers. It is currently readying its Bandeira project, a long-term (20 years), low-cost, and highly profitable underground mine located at Araçuaí and Itinga in the so-called Lithium Valley in Minas Gerais, where the company holds reserves amounting to some 60 million tons. Planned capacity is 200,000 tons a year of spodumene concentrate. Feasibility studies first presented in October 2023 and now being updated suggest that the capex for construction of the venture will be in the range from US$ 200 million to US$ 230 million. To provide the necessary funding, Lithium Ionic will negotiate pre-sales agreements to supply the concentrates to prospective buyers, a common practice in the market. Licensing applications — for both an environmental license and an installation license — were duly filed in February 2024, with the expectation that both will be forthcoming by the end of June. As soon as both licenses are issued, it is the company's intention to start work immediately on constructing the mine and the processing plant, in addition to the required infrastructure, with detailed basic engineering. The venture is expected to become operational in the early weeks of 2026 at the latest. The company has already signed a contract with Cemig, the Minas Gerais electric power utility, to guarantee the energy supply beginning on October 1, 2025. This will enable the venture to become operational either in the last quarter of 2026 or, at the latest, at the beginning of 2026.

Lithium Ionic also has another lithium project, named Baixa Grande Salinas, in the municipality of Salinas, Minas Gerais. The company expects to announce shortly the scale of the lithium reserves. The plan is to conclude implementation of the project within two years.

Fertilizers: Brazil still dependent on imports

Raw materials for fertilizers, principally phosphate and potash, needed to keep agribusiness on its upward course, are still a challenge for Brazil, which remains heavily dependent on imports. In 2023, phosphate and potash imports amounted to US$ 10.1 billion, split roughly half and

half between US$ 5.24 billion for phosphate and US$ 4.86 billion for potash.

Government officials and private-sector representatives, meeting together as the National Council for Fertilizers and Plant Nourishment (Confert), adopted in November 2023 a National Fertilizer Plan, aimed at reducing import dependence and enabling Brazilian producers to improve their competitiveness while also enhancing sustainability, thus contributing to food security. The intention is that, by 2050, domestic producers should be supplying between 45 and 50 percent of demand. With this aim in view, the plan laid down five guidelines, twenty-seven targets, and 168 short-, medium-, and long-term actions. The principal short- and medium-term actions call for reactivating, building, or enlarging facilities that produce those fertilizers deemed of strategic importance for the country, in particular nitrogen- and phosphate-based fertilizers.

In addition to increasing the domestic output of chemical fertilizers, the plan also calls for measures to increase the supply of organic and organomineral nutrients and to reuse solid waste and remineralizer, or rock powder, that can make chemical fertilizers more effective.

The plan calls for extensive geological mapping to assess the potential for phosphate and potash production in Brazil, proposing sixty named areas to be surveyed over a period of decades, located mainly in the states of Goiás, Tocantins, Bahia, and Mato Grosso. It also recommends that companies should seek to form partnerships with science and technology institutes, to engage in scientific research focusing on the production and use of sustainable inputs.

The main producers of raw materials for fertilizers in Brazil are Mosaic, CMOC Brasil, Fosnor/Galvani, Eurochem, and Morro Verde. Phosphate offers the best chances for reducing Brazil's import dependence, though there are important projects in potash too. Several major investment projects are planned, that have encountered difficulties in obtaining environmental licensing. That has caused setbacks in implementing the original timetables, which in turn has led to even greater dependence on imports.

In phosphate, **Eurochem** is starting up a major project, its Serra do mining and industrial complex, which will produce around 1 million tons a year of phosphate-based fertilizers, adding 15 per cent to Brazil's total present-day output. It will make a substantial contribution to reducing the degree of import dependence, which today stands at around 85 percent. Investment in the Salitre complex amounted to approximately US$ 1 billion. This will be the EuroChem group's first mining venture anywhere outside Europe.

Fosnor/Galvani is progressing with its R$ 200 million expansion project that will double its output of phosphate-based fertilizers at Luís Eduardo Magalhães, in Bahia. In a separate project, the company will invest R$ 340 million to implement a further stage of its phosphate mining venture at Irecê, also in Bahia. A third

project, named Santa Quitéria, is currently at the licensing stage. Budgeted at R$ 2.3 billion, this project is for a mining and industrial complex in the state of Ceará. When it comes on stream, Santa Quitéria will produce 1.05 million tons per year of phosphate-based fertilizers, enabling the company to supply 25 percent of fertilizer demand in the Northern and Northeastern regions of Brazil.

Morro Verde has a mine at Pratápolis, in Minas Gerais, holding 50 million tons in proven reserves of phosphate having an average 10 percent content, which is twice the Brazilian average. Output capacity is currently 400,000 tons a year, but the company is planning to almost quadruple that to 1.5 million tons a year, at which level the reserves will last 60 years. Morro Verde's plan is to invest more than R$ 500 million in the course of the next five years, partly in an expansion of mine output and partly to launch new products.

In potash, **Potássio do Brasil** is in the process of obtaining the necessary licences for building a complex at Autazes, in the state of Amazonas, where it has already invested US$ 230 million. The facility is planned to produce 2.2 million tons a year of potassium chloride, which would supply around 20 percent of the total demand in Brazil at the present level. By the time construction is completed, the company will have invested a further US$ 2.5 million, covering an underground mine and a processing plant plus a road and a port terminal. ❑

Kinross Morro do Ouro mine facilities in Paracatu

WHAT ARE THE CANADIANS DOING IN BRAZIL?

Francisco Alves and Mara Fornari

Apart from Brazil itself, Canada is the country with the strongest presence in the Brazilian mining industry. Listings on the Toronto Stock Exchange (TSX) and the Toronto Stock Exchange Venture (TSXV) include at least thirty-five companies now active in producing and exploring mining products in several regions in Brazil.

Among the hundred largest mining companies in Brazil, ranked in accordance with their 2023 output in value terms, twelve are listed on the two Toronto exchanges. These twelve are active in gold, copper, graphite, lithium, and vanadium. Canadian companies are also active in mineral exploration in Brazil, with their investments focusing on strategic minerals for the energy tran-

Pioneers

We are proud to become Brazil's first large scale rare earths producer, starting a new phase in the country's proud mining history.

We are the only company outside Asia to produce at scale all four critical rare earths used in the production of permanent magnets. Our product can play a critical role in supporting the growth in production of electric vehicles and wind turbines that are vital to the energy transition.

As we develop our operations, we aim to become the most sustainable rare earths operation in the world and create measurable benefits for all stakeholders.

Lundin Mining's Chapada Mine in Goiás

sition such as copper, nickel, lithium, and rare earths.

Kinross is the foremost Canadian company in output terms. For many years it has been operating an open pit mine at Paracatu, in Minas Gerais, where the ore is reputed to have the world's lowest gold content. Kinross is also Brazil's top gold producer, a position it is expected to maintain for many years into the future. Between now and 2032 it expects to produce an average 540,000 ounces of gold per year.

Lundin Mining is in second place among Canadian companies operating in Brazil. Its Chapada mine, in Goiás, which Lundin acquired from Yamana in 2019, produces copper and gold, on a scale of 45,000 tons a year of copper and 60,000 ounces a year of gold.

Ero Copper comes next, operating through Mineração Caraíba (Ero Caraíba). Its main mine is Pilar, in the municipality of Jaguarari, in Bahia. It also has other, smaller mines in the same state. Ero Copper has plans to expand its activities in the Brazilian mining industry in the next few years, increasing its output to 100,000 tons of copper concentrate, when it brings on stream its Tucumã project now under construction in Pará (see *Overview* article). Ero Copper is also active in gold mining, operating an underground mine at Nova Xavantina, in Mato Grosso. The ore in this deposit has one of the highest gold contents found anywhere in Brazil. The unit has an output capacity of 60,000 ounces per year.

Pan American Silver, acting though Jacobina Mineração, is Brazil's fourth largest producer of mining products. Its mine at Jacobina in Bahia was acquired from Yamana Gold in 2023 and produced 147,800 ounces of gold in that year. The company is currently investing in improvements to its processing plant at Jacobina, seeking to optimize capacity utilization.

Equinox Gold controls three companies listed among Brazil's top hundred in the mining industry, all three engaged in gold mining: Mineração Aurizona (39th place), Fazenda Brasileiro Desenvolvimento Mineral (49th place), and Mineração Riacho dos Machados (61st place). A fourth company in the group, Mineração Santa Luz, operates in Bahia. In 2023 Equinox Gold's four Brazilian mines produced a total 296,800 ounces of gold, which was more than Equinox produced in any other country. Mineração Aurizona operates in the municipality of Godofredo Viana, in the state of Maranhão, where its current expansion project includes an underground mine (see *Overview* article). Mineração Fazenda Brasileiro has a gold mine in Bahia, as does Equinox Gold's other company in Brazil, Mineração Santa

Luz, in the municipality of Teofilândia, while Riacho dos Machados Mineração has a gold mine in the neighbouring state of Minas Gerais.

Jaguar Mining is another company that mines only gold. It ranks among Brazil's leading producers, acting through Mineração Serras do Oeste. The company's main operating assets are all located in the Iron Quadrangle, in Minas Gerais, among them the Turmalina complex and the Caeté complex, which comprises the Pilar and Roça Grande mines and the Caeté processing plant. The Roça Grande mine has been in temporary maintenance since April 2019. Jaguar also has its Pitangui project in Minas Gerais, acquired from Iamgold in 2023. In that year, the company's overall Brazilian output amounted to 70,702 ounces, a decline from the previous year.

Sigma Lithium, through its subsidiary Sigma Brasil, appears in 48th place in the 2023 ranking of the largest mining companies in Brazil. Sigma was the first Brazilian company to produce battery-grade lithium, operating in the Jequitinhonha River Valley region in northern Minas Gerais, with the capacity to produce 270,000 tons a year of sustainable lithium concentrate. The company has plans to double its output capacity in the course of the next few years and is now working on the engineering for the project.

Aura Minerals is a major gold producer in Brazil, with a 2023 output of 236,000 ounces. Aura currently operates in two states, Mato Grosso and Tocantins. In Mato Grosso it acts through Mineração Apoena, located in the municipality of Pontes e Lacerda. In Tocantins, Aura's Almas project became operational in mid-2023. More recently still, the company has started work on implementing its Borborema project at Currais Novos in the state of Rio Grande do Norte. The investment is budgeted at US$ 188 million (see *Overview* article). A further project is planned in the municipality of Matupá, in Mato Grosso. Both these projects are for gold mining.

Facilities at Aura Minerals' Almas mine in Tocantins

Largo Inc., also with a Toronto listing, is the only company producing vanadium anywhere in the Americas. Its subsidiary Vanádio de Maracás operates in the municipality of Maracás, in Bahia, where it also has an ilmenite plant that processes the tailings from the vanadium mine. Now at the ramp-up stage, the ilmenite plant produced 8,470 tons in the fourth quarter of 2023. Output capacity is approximately 10,000 tons a year of vanadium pentoxide, with a 2023 total of 9,681 tons.

Another Toronto-listed gold producer in Brazil is **Serabi**, which operates two mines, Palito and São Chico, both located in the municipality of Itaituba, in Pará. Together they produced 33,100 ounces in 2023. Serabi has also formed a joint venture with Vale to explore the geology of the same region in search of copper deposits.

Future producers

In addition to companies with Brazilian mines already in production, numerous others are listed on either the TSX or the TSXV that are either now conducting geological exploration in Brazil or have projects under construction that will shortly be brought on stream as productive mining ventures. Names on this list include Altamira Gold, Belo Sun, Bravo Mining, Cabral Gold, Canada Rare Earth, Cerrado Gold, G Mining, Gratomic Inc., Horizonte Minerals, JZR Gold, Lara Exploration, Lavras Gold, Lithium Ionic, Meridian Mining, South Atlantic Gold, South Star Battery Metals, TriStar Gold Inc., and ValOre Metals.

Altamira Gold has six exploration projects for gold and other metals in the Tapajós region, three of which are particularly significant: Cajueiro, Santa Helena, and Apiacás. Cajueiro holds oxide resources assessed in accordance with NI 43-101 as 850,000 tons at 0.92 grams per ton (indicated) plus 1.67 million tons at 1.12 grams per ton (inferred) and sulphide resources of 4.81 million tons at 1.04 grams per ton (indicated) plus 10.99 million tons at 1.29 grams per ton (inferred). Santa Helena covers an area of 590 square kilometres holding surface deposits with high levels of both gold content (1,72 grams per ton) and copper (0.96 percent). The area is described as highly propitious for the mineralization of porphyry copper. The Apiacás project is located 50 kilometres west of Cajueiro, in the Alta Floresta Belt. This is an assemblage of areas totaling 820 square kilometres. The Apiacás district has historically produced over 1 million ounces of alluvial gold. It is the largest alluvial goldfield in the Alta Floresta Belt.

Belo Sun has been kept waiting several years so far for the licences required to begin work on its Volta Grande project, located at Senador José Porfírio in the state of Pará, where future output is estimated at 205,000 ounces of gold per year with an expected productive lifetime of twelve years (see *Overview* article).

Bravo Mining, first set up in 2020, acquired in the following year the Luanga project, located in the municipality of Curionópolis within the Carajás mineral province in the state of Pará. Luanga is a deposit of platinum group minerals plus gold and nickel, with a mineralized length of around 8.1 kilometres. Its age and geological environment are said to be broadly similar to those of other PGM deposits and productive mines around the world.

Cabral Gold is developing its Cuiú Cuiú project in the Tapajós region, where two gold deposits have been identified, five kilometres apart, holding total indicated resources (NI 43-101) of 19.8 million tons at 0.87 grams per ton (604,000 ounces of gold) and inferred resources of 19.8 million tons at 0.84 grams per ton (534,500 ounces). Cuiú Cuiú is close to G Mining's Tocantinzinho project, with reserves of 2.06 million ounces of gold, currently under construction, which promises to be Brazil's third largest goldmine.

Canada Rare Earth Corp. has acquired a 52 percent ownership stake in the tailings from the Bom Futuro tin mine, in the state of Rondônia. Seventy million tons of tailings have accumulated over 25 years of tin mining by Paranapanema S.A. as well as by artisanal

operators. Marketable minerals that can be economically recovered from the tailings include cassiterite (tin ore), ilmenite, zircon, and rare earths.

Cerrado Gold is focusing, in Brazil, on its Monte do Carmo project, which will mine the Serra Alta gold deposit in the state of Tocantins. A feasibility study estimates an average annual output of 94,797 ounces of gold over the course of a nine-year productive lifetime. The initial capex is budgeted at US$ 186.6 million, including a US$ 155.8 million contingency fund. Initial reserves, proven and probable, amount to 895,000 ounces of gold (16.8 million tons of ore at 1.66 grams of gold per ton). An updated figure for measured and indicated resources is 1,012,000 ounces of gold (18.4 million tons at 1.72 grams per ton) and inferred resources of 66,000 ounces of gold (1.1 million tons at 1.95 grams per ton).

G Mining is concluding work on its Tocantinzinho project, in which it has invested US$ 430 million (see *Overview* article). The company now has two further areas in view, named Santa Patrícia and KRB. The former is an intercept, 102.5 meters long, with a 0.25 percent copper content, in an area where G Mining is surveying a seven-kilometer gold and copper anomaly. KRB shows promising indicators of gold, with a content stated as 1.73 grams per ton of ore.

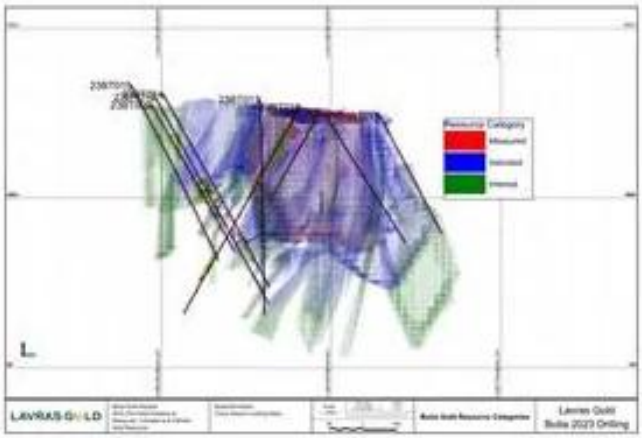
Gratomic Inc. has two projects in the state of Bahia, where its Zumbi Mineração unit is planning to produce graphite. The bigger of the two is Capim Grosso, cover-

ing an area of 426 hectares, where surveys have detected a graphite content at levels ranging as high as 21 percent. Resources are estimated under NI 43-101 rules at 7.9 million tons of ore with an average content of 5.86 percent, corresponding to 466,600 tons of graphite.

Horizonte Minerals, which has two projects in Brazil, is working to achieve its aim of becoming a major world nickel producer, in the form of ferronickel and also of nickel sulphate with cobalt. At the end of 2023 Horizonte halted construction work at its Araguaia project, in the municipality of Conceição do Araguaia, in Pará, pending an extensive review of the project. The plant is expected to have a total capacity of approximately 900,000 tons a year of dry ore, to yield 52,000 tons a year of ferronickel containing 14,500 tons of nickel. Horizonte's other asset is the Vermelho nickel-cobalt project, a high-grade resource that can readily be scaled up, with a long productive lifetime for the mine and a low-cost source of nickel sulphate for the battery industry. Horizonte is now readying a feasibility study.

JZL Gold says its Vila Nova project, in the state of Amapá, holds an estimated 9 million tons of tailings holding an average gold content of 2.7 grams per ton, which translates as 700,000 ounces of gold. The project includes a processing plant with the capacity to handle 800 tons of material per day.

Lara Exploration is now engaged in drilling boreholes to assess the two copper deposits, named Homestead and Cupuzeiro, which jointly form its Cobre Planalto project located within the Carajás mineral province, in Pará. Early findings suggest that Homestead and Cupuzeiro are probably two parts of a single mineralization body. Lara has now started work on assessing the resources. It plans to conduct further technical and environmental research for several more months.



Lavras Gold exploration area in Butiá, Rio Grande do Sul

Lavras Gold operates mainly in the municipality of Lavras do Sul, a historic gold mining locality in the state of Rio Grande do Sul. It already has a full infrastructure in place to support its twenty-four known deposits, nine of which are now at an advanced stage of exploration, including seven that were discovered only recently, since mid-2022. One of these is Fazenda do Posto, where the gold content has been assessed at 1.09 grams per ton.

Lithium Ionic has two projects in Minas Gerais. Its Bandeira lithium project, located in the municipalities of Araçuaí and Itinga, both in the Jequitinhonha River Valley, holds reserves of 60 million tons. The company says its underground mine will have the capacity to produce 200,000 tons a year of spodumene concentrate. Its Baixa Grande Salinas project, located at nearby Salinas, is a separate venture (see *Overview* article).

Meridian Mining is focusing on developing and operating its Cabaçal gold and cop-

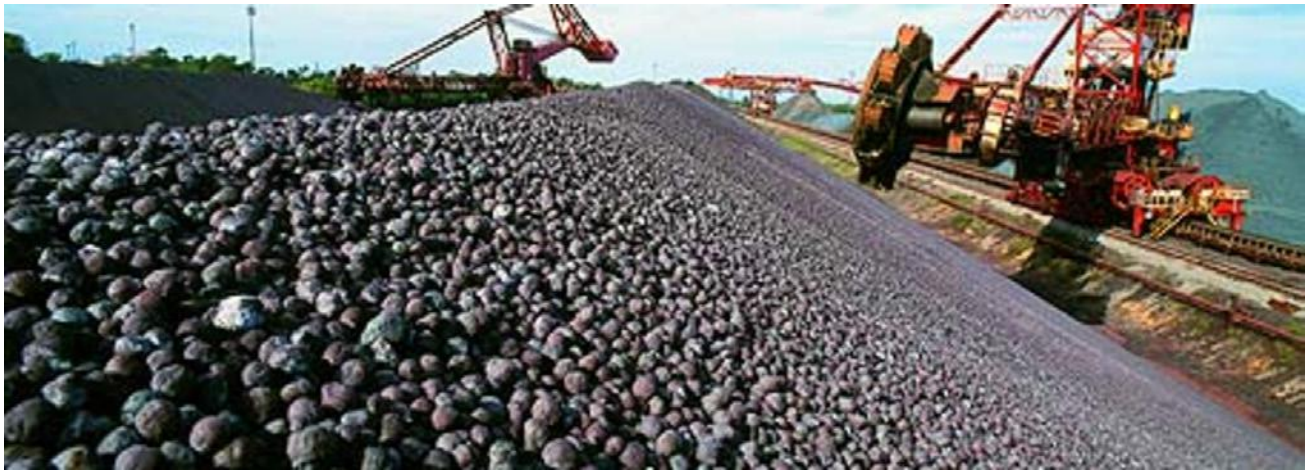
per project, now at an advanced stage, and also on geological exploration on a regional level in the Cabaçal Belt in Mato Grosso. Cabaçal is a deposit rich in gold, copper, and silver, with the potential to be operated as an independent mine within a 50 kilometer belt. It holds indicated resources of 52.9 million tons with a gold content of 0.6 grams per ton, 1.4 grams of silver per ton, and a 0.3 percent copper content. It includes a higher-grade area close to the surface, thought to justify sinking an initial shaft.

South Atlantic Gold is conducting trial drilling at its Pedra Branca project in the state of Ceará. The 49-hectare property is located on a 50-kilometre shear zone. Drilling has found resources at a depth of around 30 metres, estimated at an inferred 4 million tons at 1.38 grams of gold per ton.

South Star Battery Metals is a Canadian project developer for battery metals acting in the selection, acquisition, and development of short-term projects in the Americas. Its Santa Cruz graphite project, in the south of Bahia, is on course to become the first new graphite producer in the Americas since 1996. The project is currently at its first stage, with a 5,000-ton capacity, but the company is working on a feasibility study with the aim of boosting output to 50,000 tons a year, beginning in 2028.

TriStar Gold has completed a pre-feasibility study for its Castelo dos Sonhos project in the state of Pará, indicating an open-pit mine with an eleven-year productive lifetime. Reserves amount to 1.4 million ounces of gold, with output forecast at an average 121,000 ounces a year over the period. The project would call for a capex estimated at US$ 261 million.

ValOre Metals holds the rights to the Pedra Branca district in Ceará, where it plans to produce platinum-group minerals and gold. An initial estimate of inferred resources, conducted in accordance with NI 43-101 when TriStar first acquired the rights in 2019, found 1,067,000 ounces of PGMs plus gold in 27.2 million tons at 1.22 grams per ton. Three years later, however, ValOre reported a revised estimate that was twice as high, now stating inferred resources as 2,198,000 ounces of palladium plus platinum plus gold, in 63.57 million tons at 1.08 grams per ton. ❑



BRAZILIAN GOVERNMENT SETS TARGETS FOR STRENGTHENING MINING INDUSTRY

Francisco Alves

The Brazilian government plans to develop programs to boost the supply of strategic minerals for the energy transition and for the industrial processing of these minerals, resulting in higher value-added products to be shipped to export markets. The plan will include issuing new guidelines for the geological mapping of Brazilian territory, giving priority to areas potentially holding strategic minerals. In addition, the government aims to assure greater juridical and regulatory security for the mining industry, by strengthening the National Mining Agency (ANM).

That is what Mining and Energy Minister Alexandre Silveira sets out in this interview with **Brasil Mineral**. In his view, mining will play a decisive role in the government's new plan for the next stage of industrialization in Brazil, and in the energy transition, both of which depend on minerals such as lithium, graphite, nickel, copper, rare earths, cobalt, iron and steel, aluminium, niobium, manganese, and titanium, among others. In the minister's own words:

BRASIL MINERAL — Where does mining fit into the government's recently announced industrialization plan?

MINISTER ALEXANDRE SILVEIRA — At a moment when the whole of Brazil has its eyes on an energy transition that we want to be both fair and inclusive, the new industrialization plan focuses precisely on the sectors that support this important and necessary process, such as batteries, solar panels, and electric or hybrid vehicles. The value chains of these industries begin with mining, especially in the extraction of strategic minerals for the energy transition: lithium, graphite, nickel, copper, rare earths and cobalt. Other minerals

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The Company is focused on rapidly advancing its flagship Bandeira Lithium Project, a 175-hectare property within its large 14,182-hectare land package, located in Minas Gerais state, Brazil, which is emerging as a globally significant hard rock lithium-producing district. Over 100,000 metres have been drilled at this deposit since exploration activities began in April 2022.

The Bandeira Lithium Project is located in the same region as CBL's Cachoeira lithium mine, which has produced lithium for +30 years, as well as Sigma Lithium Corp.'s Grota do Cirilo project, which is among the largest lithium producers in the world.

In October 2023, the company completed a PEA demonstrating robust economics (Post-tax NPV_8 of $1.6Billion), a strong foundation for future growth.

Several other regional targets show promising potential, including the Salinas target where drilling is currently underway. An initial mineral resource estimate is planned for completion in H1 2024.

We are committed to supporting the global energy transition by developing a long-life, low-cost project with near-term production of high-quality lithium concentrate to support the EV and battery supply chains.

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Mining and Energy Minister Alexandre Silveira

THE PUBLIC DEBATE ON GEOLOGICAL MAPPING PRIORITIES NEEDS TO CONSIDER THE INTERACTIONS OF THE UNIVERSITIES, INVESTORS, AND CIVIL SOCIETY TO ORGANIZE EFFORTS TO INCREASE OUR GEOLOGICAL KNOWLEDGE OF OUR TERRITORY

play an important role in these chains, such as iron and steel, aluminum, niobium, manganese, and titanium, among others.

BRASIL MINERAL — What measures is the government adopting, or does it intend to adopt, to stimulate the growth of the mining industry and increase the production of strategic minerals for the energy transition?

MINISTER — The Mining and Energy Ministry is working to strengthen Brazilian mining, with the focus on developing this activity in a sustainable, social, and safe way. Programs will be launched to incentivize the supply of those minerals considered strategic for the energy transition and the further industrial processing of these minerals, to enhance value-added in the country. The ministry will also issue guidelines on the geological mapping of Brazilian territory, giving priority to areas potentially holding strategic minerals.

BRASIL MINERAL — In the government's view, what will be Brazil's role in supplying the minerals necessary for this transition?

MINISTER — The Brazilian government understands that the world needs an energy transition and therefore needs to have the means to make it a reality. That includes strategic minerals for the energy transition, Brazil being an important source for many of them. This ministry, along with all Brazilian government departments that are involved in this policy area, will help the planet in the mission of decarbonizing energy models.

BRASIL MINERAL — Knowledge of the country's geology is still a bottleneck that tends to restrict the growth of production of these minerals, and of other minerals too. How does the government intend to broaden this knowledge?

MINISTER — The Mining and Energy

Ministry has several initiatives underway on this topic. The first one involves defining geological mapping priorities in the country. This is a ten-year mapping plan, carried out cooperatively by the public and private sectors together, to guide mineral exploration carried out in Brazil. The public debate on geological mapping priorities needs to consider the interactions of the universities, investors, and civil society to organize efforts to increase our geological knowledge of our territory. Other initiatives involve the production and storage of all geological data produced in Brazil and the structuring of the Brazil Geological Survey (SGB).

BRASIL MINERAL — What is the government doing, or what can it do, to attract more investment in the mining industry?

MINISTER — The ministry is working to ensure greater juridical and regulatory security. To make the industry more secure, the ministry is seeking ways to strengthen the National Mining Agency (ANM), since it is only possible to build a strong industry if the regulatory agency is also robust. The ministry is pushing for a bigger budget for the ANM, more personnel, and more recruitment. In 2023, the ministry achieved salary equality for ANM personnel with the employees of other regulatory agencies. It was given the green light to appoint forty applicants who had already successfully passed the competitive examination, and, in addition, it was able to extend the term of an earlier examination, ensuring the appointment of twenty-four others who had successfully applied for the post of specialist in mineral resources. ❑

Rare Earth

BRAZIL IS WELL PLACED IN THE RACE FOR STRATEGIC MINERALS, ACCORDING TO BRAZIL GEOLOGICAL SURVEY

Francisco Alves

"Brazil finds itself in a privileged position in the race for strategic minerals," says Valdir Silveira, the director of geology and mineral resources at the Brazil Geological Survey, still generally known by the extended acronym SGB-CPRM.

Brazil owes its advantage, Silveira says, to "its impressive geological diversity. The present moment affords a unique opportunity, he says, for the country to enlarge its market share, particularly in lithium, graphite, rare earth elements, copper, and nickel."

Lithium is a case in point, he says. The Jequitinhonha River Valley, in the northeast of Minas Gerais, "is outstanding for the size and number of its deposits, while other promising areas such as the Borborema province, particularly the Seridó region [in Rio Grande do Norte], have the potential to assure Brazil of a place among the world's leading lithium producers."

The Brazil Geological Survey's mapping shows that, in Brazil, lithium occurs in pegmatite deposits of the LCT type (lithium-cesium-tantalum), in which

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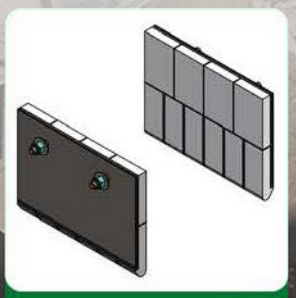

CONVEYOR BELT GUIDE IN ALUMINA CERAMIC

INVERTED CHUTE PYRAMID STEM

MINING RECLAIMER BUCKET

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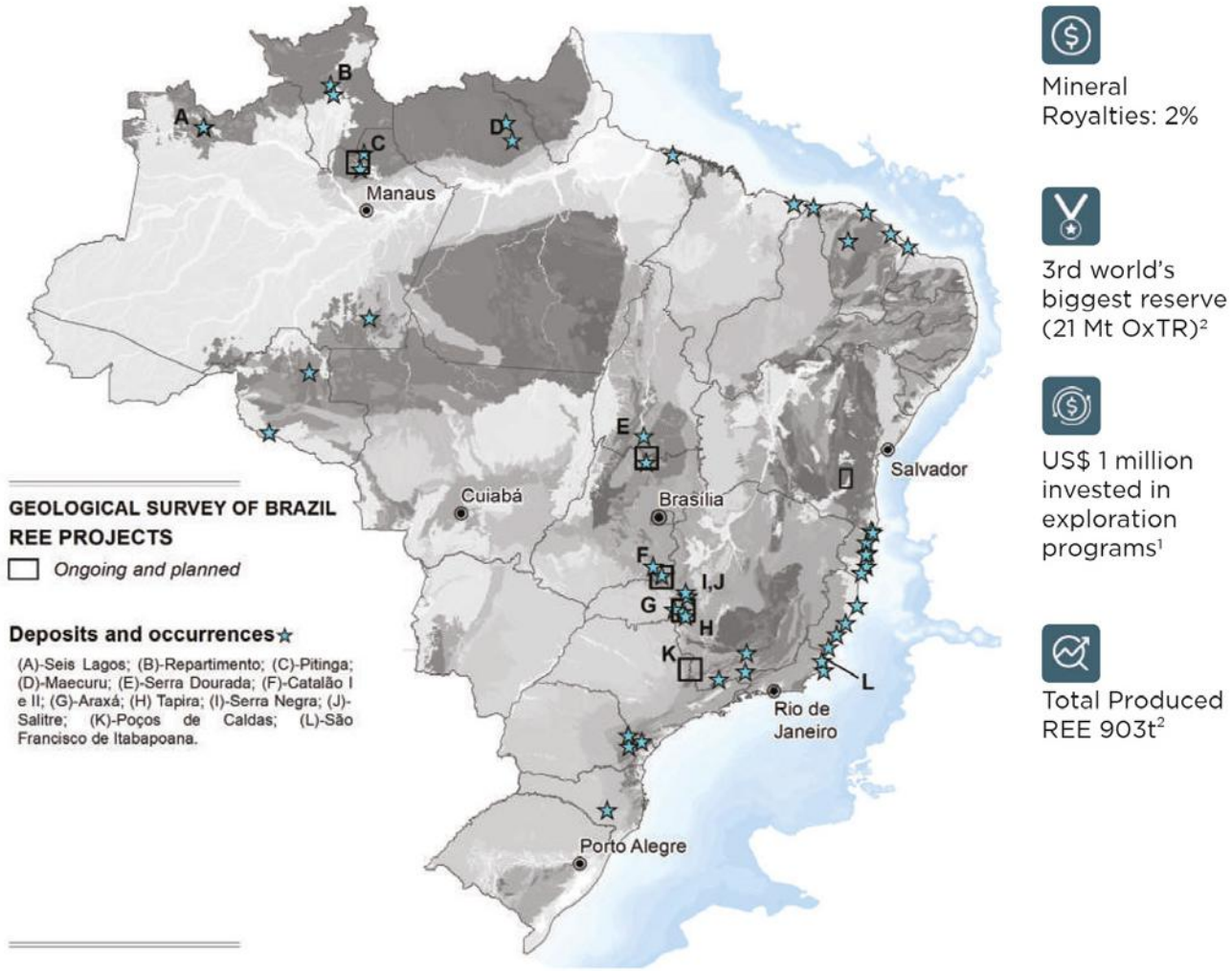
Rare Earth Elements



the predominant mineral is spodumene, followed by ambligonite, petalite, and lepidolite. At this moment Minas Gerais is the state hosting the largest lithium projects, but there are other areas with great potential as well, particularly in three northeastern states, Ceará, Rio Grande do Norte, and Paraíba, where more than a hundred pegmatite bodies with lithium content have been identified. And then there are greenfield areas along both sides of the Goiás-Tocantins state line, and in some parts of the Borborema pegmatite province in Rio Grande do Norte, where new targets for lithium mineralization have been identified. Two other projects are now under way, one in the east of Minas Gerais and the other in the Solonópole province in Ceará.

In addition to lithium, Silveira notes, there are new potential areas for other minerals essential for the energy transi-

tion, such as copper, nickel, tantalum, REEs, and others, including the Tapajós, Alta Floresta, Juma, Nova Brasilândia, and Seridó provinces and the Goiás Magmatic Arc.

Brazil also has great potential as a graphite producer, Silveira says. Graphite now finds a growing number of applications in several industries, such as batteries and electronic components. Graphite occurrences are concentrated in the states of Minas Gerais and Bahia, one of the most promising regions for graphite production worldwide. These occurrences are mainly confined to metamorphosed environments, he says, with metamorphism being considered the first variable in the analysis of graphite potential, as it regulates the degree of crystallization and the ore content.

"Considering the potential," he says, "graphite production in Brazil needs to be improved and there is room for industry growth. The government has shown interest in the development of graphite production. Our expectation is that investments in this sector will increase in the next few years."

He is confident that, in the long term, Brazil will attract investments in graphite exploration and strengthen its position as the world's third largest graphite producer, and the second largest producer of graphite flakes used in electric vehicles.

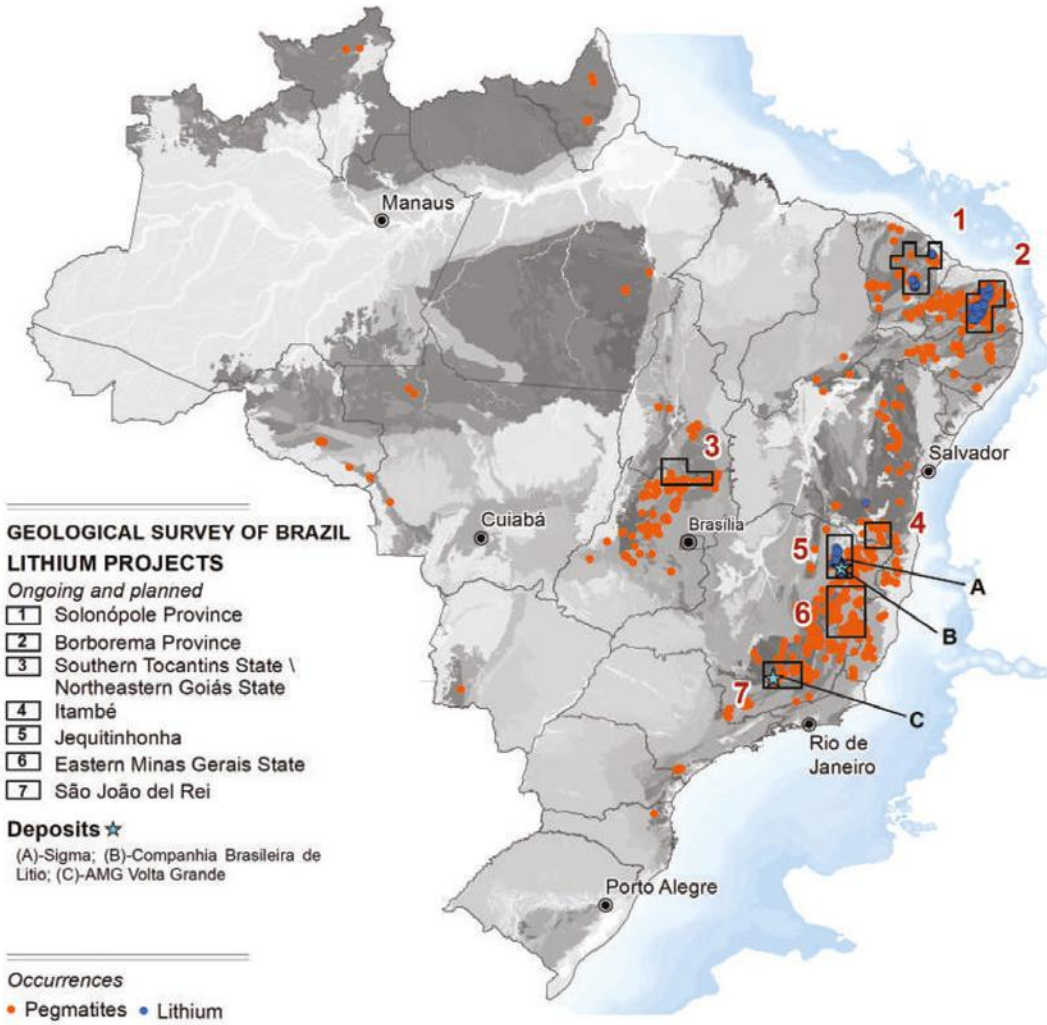
Brazil also has the potential to become an important producer of rare earth elements (REEs). It holds the third largest known reserve in the world, estimated at 21 million tons, according to the Geological Survey, but Silveira notes that the true figure could be much larger, a possibility that is emerging from the mineral exploration programs now being carried out by companies.

Valdir Silveira, director of Geology and Mineral Resources

Most of the REE reserves in Brazil are located in alkaline-carbonatite rocks, such as those found in six places, among others: three in Minas Gerais (Araxá, Poços de Caldas, and Tapira), two in the state of São Paulo (Jacupiranga and Itapirapuã), and Catalão in Goiás.

REEs are also present in granites, for example at Pitinga in Amazonas and at Minaçu and Montividio do Norte in Goiás. To a lesser extent, they occur in sedimentary deposits in the São Gonçalo do Sapucaí region in Minas Gerais and São Francisco do Itabapoana in the state

Lithium



Mineral Royalties: 2%

US$ 1 million in collected taxes[1]

7th world's biggest reserve (505 kt LCE)[2]

5th world's largest producer (1.4 kt LCE)[2]

US$ 500 thousand invested in exploration programs[1]

890 Full-time Employments[2]

1180 Indirect Employments[2]

of Rio de Janeiro. Studies had been started in the Seis Lagos region in Amazonas and the Serra do Repartimento in the neighbouring state of Roraima, but in both cases they had to be halted because they are in environmental preservation areas.

Despite the great potential for producing these minerals, Brazil still faces challenges, in the short and medium term, which Silveira lists as "expanding our nationwide geological knowledge, based on geological mapping and geophysical,

geochemical, and mineral resource surveys, in regions with a smaller scale of geological knowledge, especially in the Amazon region, in the domains of the Amazon Craton and the Guiana Shield."

"In mature and emerging mineral provinces with recognized mineral potential," he adds, "we have acted to expand our knowledge of mineral systems, seeking to improve metallogenetic models, especially with work focused on the analysis of mineral potential through the generation of favorability maps, the acquisition of new geophysical data, and the use of artificial intelligence tools. In 2024, the SGB intends to resume a series of high-resolution aerial geophysical surveys, to fully cover the entire crystalline basement of the country. At the same time, other aerial surveys will use new methodologies, such as electromagnetics, in selected mineral provinces."

The SGB has been a pioneer, Silveira says, in providing information on the Brazilian potential for lithium-bearing minerals and rare earths, in the form of several projects published over the years, including the Lithium Potential Assessment project. In 2016 it published a report on the lithium potential of the Jequitinhonha River Valley and in 2022 a report on the Borborema Province. These publications — and other work on lithium carried out by the SGB — can be accessed at https://www.sgb.gov.br/litio/

On the subject of rare earths, the SGB also conducted a Rare Earth Potential Assessment, publishing its findings in 2015. This was followed by a number of more

Lithium

detailed studies, Silveira says, such as one on Seis Lagos in the state of Amazonas, published in 2016, and a prospectivity map of the Goiás tin-bearing province (2023).

These SGB reports (in Portuguese only) can be accessed at the following links:

Assessment of Brazil's Potential in Rare Earths, https://rigeo.cprm.gov.br/handle/doc/16923

Morro dos Seis Lagos Deposit, https://rigeo.cprm.gov.br/handle/doc/17142

Map of the Goiás Tin-bearing Province, https://rigeo.cprm.gov.br/handle/doc/24521 ❑

Mauro Souza, General Director of ANM

ANM TO SPEED UP PROCEDURES FOR APPROVAL OF COMPANIES' PROJECTS

With the aim of speeding up the approval of mining rights applications, particularly in the case of critical minerals, the National Mining Agency (ANM) intends to make the procedures for approving Exploration Reports, Economic Development Plans, and Assignment of Mining Rights more flexible. In parallel, the regulatory body for mining activity in Brazil has undertaken to resume, in the first half of 2024, auctions of available areas, which will lead to greater activity in research and mining alike.

Mauro Souza, director-general of the ANM, gives these promises, mentioning that, despite the structural difficulties — insufficient personnel and a shortage of funding — the Agency is developing projects aimed at automating these processes, including the use of artificial intelligence (AI). In 2024, he says, "we already have the prospect of launching a first project on the assignment of mining rights, because we have now accumulated a very large backlog of applications that we have been unable to handle with the personnel and resources available to us. We need something that is both more agile and more user-friendly. We want to develop platforms where the user receives a much quicker answer. And we will take care to differentiate between critical or strategic minerals on the one hand and the bulk of our operations on the other. That way we can align with the needs, not of Brazil alone, but of the world market. We can be a player that the world can interact with, to make those minerals available. The list may include minerals needed for building and for infrastructure, which have an important place in government programs such as the PAC

[Growth Acceleration Program] and Minha Casa Minha Vida [for social housing]."

The Agency also intends, as soon as possible, to retain outside consultants to evaluate Research Reports, a move that will help to speed up the handling of applications. It is not acceptable, Souza says, that when a company files a Final Exploration Report that may have taken it three or four years to produce, ANM is not required to meet any deadline for examining the report and giving its approval. That creates insecurity for the entrepreneur. At the same time, no ANM official, no matter how experienced he may be, can be expected to evaluate every Exploration Report in just two or three days. And even if he did, "would his analysis be as thoroughgoing as the work the company itself had done in the first place?" That is the reason, he says, why entrusting the task to a qualified outside consultant will speed up the process.

"The same argument holds, and even more forcefully, in the case of an Economic Use Plan," Souza says, because the business risk is that much greater. "We have to honour the entrepreneur's ability to seek out the best practices and design the best business plan for his venture, recruiting the best professionals for the job." Either the company is drawing on its own financial resources or it has to seek outside financing for its venture, which means a debenture issue or a bank loan. The feasibility of his venture is dependent on the outcome of a screening process.

"So I don't think it's our job, the Agency's job," Souza says, "to certify that this is the best Economic Use Plan that the company could make. Our job is to check that the plan is in accordance with the rules that have been laid down and then to monitor compliance, to make sure the company acts in accordance with its duly approved plan, while bearing in mind that the nuances of implementing its plan will require changes and that we cannot tell the company to join a queue, to submit a new plan and to go through the evaluation procedure all over again."

Souza says the ANM has already been authorized to accredit companies and professionals, entitling them to evaluate companies' plans. This will be done by the end of 2024. "With this mechanism in place," he says, "we can reserve higher-ranking activities for ANM personnel, such as introducing new practices and new procedures to improve the business environment, enabling us to provide more business-friendly conditions for the development of the Brazilian mining industry."

Souza expects to make a formal announcement about the next availability auctions on the occasion of the PDAC 2024 convention in Toronto. "Today we have around 75,000 areas available and we have programmed offers, with different models". Problems occurred, he says, with the SOPLE system that operates the auctions, but they have now been solved and are not only working but have been improved. "We plan to announce one auction in the first half of 2024 and another in the second half, with five thousand areas on offer each time. Our expectation is that we will enter a higher level of security, with a more appropriate procedure. This retention of areas is not good for the state nor for the market," he says, adding that among the available areas there are many that have already been duly researched and have generated a great deal of interest. "This is the answer we need to give," he concludes. ❑

ADIMB SEES PROMINENT ROLE FOR BRAZIL IN ENERGY TRANSITION

Francisco Alves

Brazil is well positioned to become a leading player in the energy transition, says Marcos André Gonçalves, chairman of Adimb, the Brazilian Mining Industry Development and Innovation Agency.

In terms of geology, Brazil is very similar to Australia, he says. Just as Australia is mining ionic clay for rare earths, so also Brazil has many areas with lateritic clayey soils and has the opportunity to research the surface, at least, of deposits holding these soils.

A factor that can facilitate this exploration is that most of these deposits are found in areas that are already licensed under mining legislation. This will speed up the procedure, because companies can skip the slow bureaucratic approval of an application for an exploration permit. "We are talking about a reevaluation of thousands of mineral occurrences and even some deposits," Gonçalves points out, "because until very recently almost no one was interested in exploring rare earths."

Brazil is now witnessing a race for already licensed areas in several states, Gonçalves says, naming five: Rondônia, Bahia, Ceará,

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Marcos André Gonçalves chairman of Adimb

"WE ARE TALKING ABOUT A REEVALUATION OF THOUSANDS OF MINERAL OCCURRENCES AND EVEN SOME DEPOSITS, BECAUSE UNTIL VERY RECENTLY ALMOST NO ONE WAS INTERESTED IN EXPLORING RARE EARTHS."

Minas Gerais, and Goiás. "There is an opportunity", he says, "and that is what we are seeing, a series of new entrants numbering maybe about eighty or a hundred companies that have assets in Brazil."

One observation that corroborates the interest of companies in researching strategic minerals in Brazil, Gonçalves says, is their presence in the activities that Adimb is organizing for PDAC 2024. Among the approximately thirty companies sponsoring the Adimb event, around one-third of them are active in lithium, rare earths, and graphite.

On the question of mineral exploration, Gonçalves believes that companies will be able to carry out their work quickly and identify potential deposits. The big challenge, therefore, will be processing this material to obtain marketable products. Another challenging aspect, especially for junior companies and even medium-sized companies, is the capital cost of these projects, which can run to hundreds of millions of dollars. This will result in projects ending up under the control of large players since, for a mineral exploration company, it is no easy task to raise funding to pay for the work that will demonstrate the technical and economic feasibility of mining an identified discovery, and harder still to finance the processing and testing costs. One way forward, he says, might be through the Invest Mining network, which brings mining industry bodies together with the BNDES (National Bank for Economic and Social Development), which is already looking for mechanisms for financing the initial stages of mining projects. One alternative now under review would be an investment fund (under BNDES management) similar to existing tax-exempt funds for agribusiness and the building industry,

Another possibility, in the case of strategic minerals such as lithium, would be to seek the cooperation of industrial users, which might become a partner in the venture or even acquire the project. This would clearly be a departure from the path normally followed by junior companies, which discover a promising mineral deposit, do the exploration and the test drilling with the support of a private backer, and then sell a

controlling share in the venture to one of the major mining corporations.

Gonçalves says he is optimistic that Brazil will eventually find a way to provide financial support for mining development, a search that began as long ago as 2012, with a plan to recreate in Brazil Canada's flow-through shares, a mechanism that grants tax exemptions to investors in companies engaged in exploring natural resources on Canadian territory.

What Brazil wants to create, he says, is a business environment — he calls it an "ecosystem" — that would allow investors to participate in the initial stages that are an essential part of a mining project, such as reconnaissance of the locality, prospecting, target identification, and discovery, followed by a full description of what has been discovered. "We know it is difficult," he says, "to convince people to put their money into a variable-income investment when you can earn an 11 to 12 percent profit by leaving your money sitting in CDBs [bank deposit certificates]. But if there are investment funds for agribusiness and for housing construction, why can't there be an investment fund for mining?"

Privileged position

Roberto Perez Xavier, Adimb's executive director, agrees that Brazil is in a privileged position in the field of essential minerals for the energy transition. It is one of the ten largest world producers of these minerals and metals. Brazil is the third largest producer of aluminium, which, together with copper, is a highly important metal for the energy transition. It is the second largest producer of graphite, needed for electric vehicle batteries. In the case of lithium, now in fashion, Brazil ranks fifth among producers of lithium from hard rock. It ranks sixth in both tin and titanium, both now seen as critical minerals. "So," he says, "we are already suppliers of a long list of raw materials for these critical or strategic metals."

Brazil also holds large reserves of several other strategic metals, though not ranking as a leading producer. Xavier cites nickel and rare earths. In both cases, Brazil ranks third in terms of the world's largest reserves. "Furthermore," he says, "if we look at the lists of critical minerals as defined by the European Union, the United States, and China, we see there is a set of them that is common to the three regions, which are aluminium, graphite, rare earths, lithium, and nickel. In all these minerals, we hold a prominent position, either in terms of production or of reserves. This means we are in an extremely privileged position to be a very important player in terms of supplying raw materials for the energy transition."

Xavier recalls that some important projects have recently entered, or are about to enter, production, citing the instances of Mineração Serra Verde's rare earths project in the state of Goiás, where production has now begun; of Centaurus Metals, awaiting the licence to implement a nickel project at Carajás, a US$ 400 million investment; of Sigma Lithium, which has been producing lithium in Minas Gerais since 2023; of Meteoric Resources, whose project to extract rare earths from ionic clays in the Poços de Caldas region, in Minas Gerais, is now at an

"THAT IS PROGRESSING, INCLUDING INVESTMENTS. BUT FOR THESE PROJECTS TO DEVELOP, UP UNTIL THEY BECOME OPERATIONAL, WE NEED CELERITY IN OUR JURIDICAL FRAMEWORK."

Roberto Perez Xavier, executive director of Adimb

advanced stage; of Viridis, which also has a rare earths project in Minas Gerais; and of Bravo Mining, which is investing heavily in its platinum-group elements (PGE) project in the Carajás mineral province, soon to be brought into production.

"This shows we have the potential to produce," Xavier says. "And there is, at a global level, a mismatch: the demand is very high, there are enough resources worldwide to meet that demand up until 2030 or 2050, depending on output, but for this to happen, those projects need to be brought into operation. That means there is a time frame: the demand exists, the reserves exist, but bringing the projects into production at the right time to meet that demand is no simple task. It is an obstacle that each country will have to overcome in its own way."

Xavier argues that to be brought into production these projects need to have at their disposal a legal framework that is flexible, dynamic, and timely. "This is perhaps one of the biggest problems we are facing today," he says. "To attract greater investments, we need to provide investors with a juridical framework that gives them the assurance they need to be willing to invest. Projects need to be analysed more quickly. And this may be where we are going wrong, for several reasons arising from our government policies. Our policies need to be more effective in support of the development of the mining industry. Mineral research is not the issue. That is progressing, including investments. But for these projects to develop, up until they become operational, we need celerity in our juridical framework."

Adimb's role

In this context, Adimb has sought to develop an important role in supporting companies in making their projects feasible, engaging in similar actions to those performed in Australia by Amira. "One of Adimb's main missions," he says, "is to encourage actions that generate new knowledge, that add value to mining projects, especially by enabling a company's professionals to make more accurate decisions in regard to their assets. To achieve this,

in efforts to generate new knowledge, we adopt collaborative projects, which bring together companies, universities, and research institutions. A collaborative project begins with a conversation with the company or companies, to define more clearly what their geological and technological demands would be along the length of the mineral chain in which they are operating. Based on the understanding and clarity of these requirements, Adimb assembles a group of professionals who will form a research team, from which a project emerges that is then submitted to the company. It is not an academic project, it is a professional project that involves deadlines, periodical reports, and a budget. Once this project is approved by the company, it is put into operation, with Adimb managing the financial and technical-scientific side and being audited by a committee on the company's behalf. Projects vary from two to four years. There are four of them so far. The biggest of the four is a copper project with Vale. There are two other copper projects, one with Oz Minerals/BHP and the other with Centaurus Metals; all three are located in the Carajás mineral province, each dealing with its own problem, some of them more specific and others more comprehensive. A fourth, more recent, project is with Meteoric Resources in Poços de Caldas. These are multi-institutional projects that are not just about mineral exploration, not just about the upstream. They also address the question of ore utilization. This is the case, for example, of ionic clay deposits rich in rare earths where we have a combined team of geologists and mining engineers, gathering all the relevant information that will enable the company to make its decisions."

In addition to collaborative projects, Adimb is engaged in other actions, including specialist training for company personnel, notes Marcos André Gonçalves. In 2024 it will introduce, in partnership with Ibmec, a higher education institution in the area of economics and finance, an MBA course in the economic management of mining projects.

In addition, lithium and graphite courses have been held, which were in great demand. Adimb is also resuming scientific visits to other countries whose geology is significantly different from Brazil's. "We are holding intensive talks with Australia's AusIMM," Gonçalves reports, "for the exchange of knowledge in a form of further education for industry professionals." Also, in alternate years Adimb hosts its International Symposium on Mineral Exploration, known by the acronym Simexmin, which is the main discussion forum on mineral research in Brazil. ❑

"WE ARE HOLDING INTENSIVE TALKS WITH AUSTRALIA'S AUSIMM," GONÇALVES REPORTS, "FOR THE EXCHANGE OF KNOWLEDGE IN A FORM OF FURTHER EDUCATION FOR INDUSTRY PROFESSIONALS."

Raul Jungmann, president of IBRAM

"MINING INDUSTRY IS PROSPERING IN BRAZIL, BUT MUCH MORE WORK NEEDS TO BE DONE"

Francisco Alves

The mining industry in Brazil is riding a wave of prosperity, says Raul Jungmann, the president of Ibram, the Brazilian Mining Institute. Investments are growing, in new mineral exploration, in capacity expansion, and in new projects. One of the world's largest producers of minerals and also one of the countries holding the largest mineral reserves, with one of the most diverse geologies to be found anywhere, Brazil attracts the interest of investors within the country and around the world, and can make a contribution to meeting the growing demand for minerals for the energy transition, for food security, for technological solutions in health, comfort and well-being, and for infrastructure.

In addition to the quality, quantity, and diversity of resources, reserves, and ores, Jungmann lists other points favoring the growth of mining activity in Brazil, such as advances in technology, more detailed knowledge of the country's geology, legislation on a range of issues including the management of tailings, socio-environmental investments, and a conflict-free interna-

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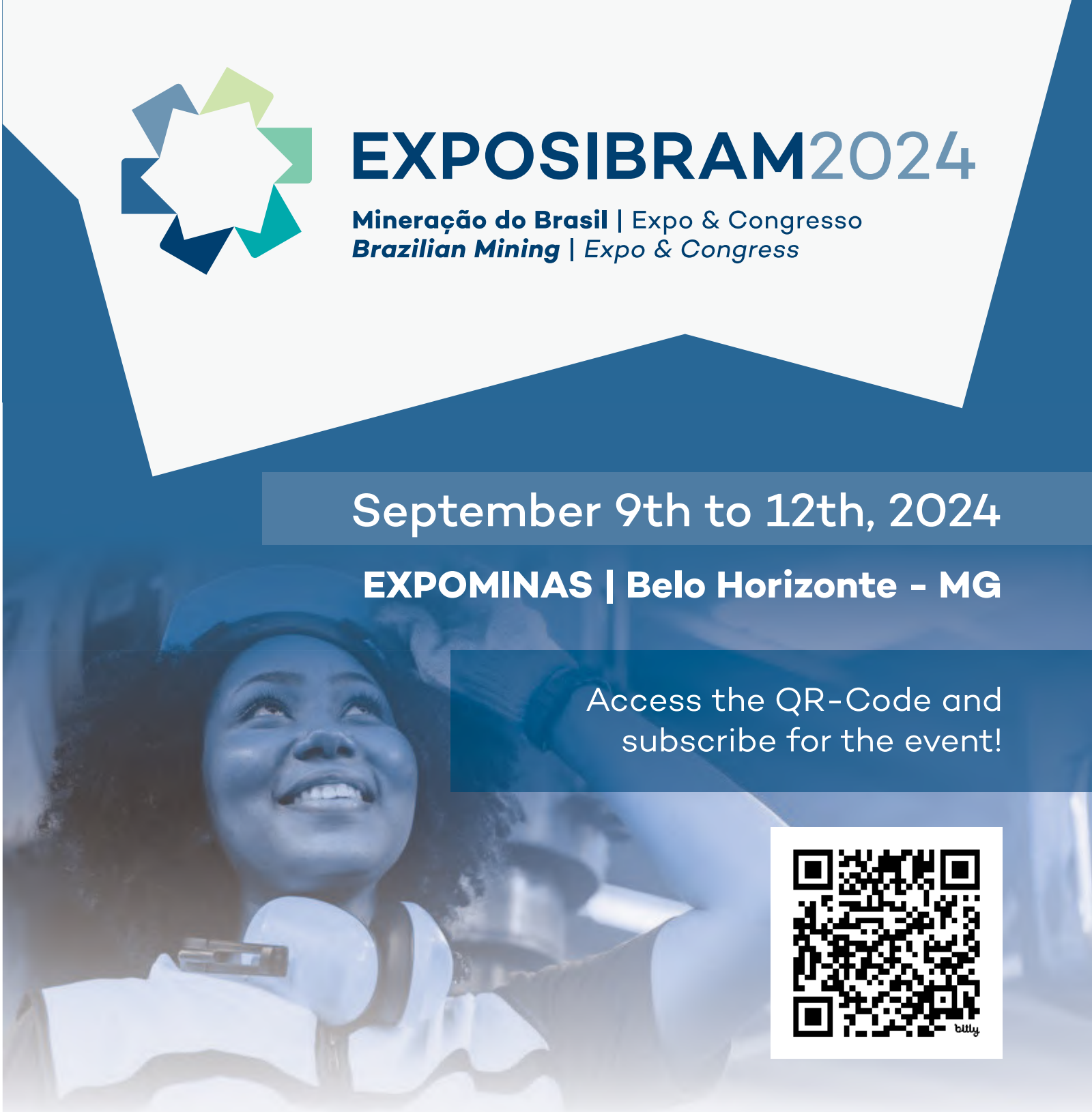

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tional geopolitical and trade relationship.

He points out, however, that there is still much to be done, as there are gaps in the policies needed to support the development of the mining industry. In the question of juridical security, he singles out "the gigantic volume of laws all dealing with the same subject, mainly in matters of the environment and taxation," creating bureaucracy and complexity for mining companies. "Although we have built up, in recent years, a firm and up-to-date regulatory environment, especially in the environmental aspects, the industry still needs a juridical framework giving greater stability, clarity, and objectivity."

Jungmann also regrets the lack of financial incentives for mining. High taxation, too, is a problem. "Brazil has one of the highest tax burdens among mining countries," he notes. "That is bad for an industry that makes a hefty contribution to social and economic development, not only by paying taxes and royalties but by creating jobs, income, knowledge, training, social projects, and so many more benefits, which the government seems not to take into account when it raises taxes even higher."

Brazil has no tradition of encouraging investment in mining, Jungmann points out. "We do not have specific investment funds to finance the development of new ventures, though we do in other industries. We do not have credit lines to finance mineral research projects. We need to develop a capital market that can spread out the risks of mineral research, increasing the share of Brazilian investors in this activity."

In comparison with other countries, Jungmann says, Brazil makes little investment in mineral research. "We need to expand our geological knowledge of Brazilian territory," he says. "No more than about 4 percent of our total land area has been covered by geological mapping at a scale of 50,000 to 1, which is what mining needs." Another obstacle is the delay in environmental licensing, which he considers "slow, bureaucratic, complex, and antiquated. Our international competitiveness is significantly reduced by the slowness and complexity of the environmental licensing procedure for mining projects. Other countries handle this much more quickly, enabling them to respond to the demands and updates of projects and investments. They bring their projects on stream more quickly," he says, "and they improve their position in the investment attraction rankings, while we always lag behind."

Infrastructure is yet another bottleneck, in Jungmann's opinion. While he recognizes that there has been growth in transport infrastructure in Brazil, he says there is still a great deal of progress to be made. "Several prospective projects have been shelved," he recalls, "due to the lack of infrastructure for shipping the minerals out and for deliveries of inputs and supplies."

Finally, he mentions labour legislation, which he considers outdated for underground mining, impeding Brazil's competitiveness in several mineral chains. "The impact is in placing limits on depth and on the advance of operations," he says, "because the laws were designed to deal with the operating conditions prevailing several decades ago, whereas today mines

and operating conditions are extremely technological and controlled."

Strategic minerals

Brazil has the potential to increase its output of strategic minerals, Jungmann says, but it needs to adopt a wide-ranging policy specifically designed for this specialized sector of the industry, "that removes the obstacles we have been experiencing for decades and that have been left unsolved." These are regulatory obstacles in the environmental, tax, and financial spheres, where far-reaching actions are called for, "such as scaling back the licensing bureaucracy, in the production and dissemination of quality geological information, in tax compensation for risky investments in exploration and production, and incentives for entrepreneurship in the mining industry."

As part of this policy, Jungmann lists a half-dozen specific proposals: funds and credits to be introduced for financing, on the scale required by the mining industry, and that can be accessed and executed quickly and effectively; reduce bureaucracy in mining processes; update and reduce bureaucracy in environmental licensing legislation for mining; develop transport infrastructure, especially in those regions with the greatest production potential for strategic minerals; ensure the juridical stability of the regulatory environment, especially in the areas of taxation and the issue of environmental and mining licenses; and, finally, speed up the auctions of mining rights for available areas, held by the National Mining Agency (ANM), halted more than a year ago, so that more areas can be handed over to companies for their research activities.

"The mining industry has it within its power to place Brazil among the global protagonists of technological innovation and the transition to a green economy," Jungmann insists. "Minerals are indispensable if the world is to meet its targets for mitigating climate change, for enhanced preservation of the environment, for renewable energy sources, for the development of electric vehicles, and for artificial intelligence systems. The trend towards decarbonization of the economy and the new global energy matrix point to new opportunities for the mining industry, particularly in the supply of new materials."

"Brazil has a high vocation as a mining country," Jungmann says, "with its mineral provinces spread out all over its territory. While in several commodities the country is already a leading player, its true mineral potential is still, to this day, not yet fully known. The main provinces and mining districts are known to have great potential for ferrous metals (Fe, Mn), nonferrous minerals (Al, Cr, graphite, talc, Sn, W), precious metals (Au), base metals (Pb, Cu, Zn), special minerals (Co, Li, Ta, ETR, Pt, Pd, Ti, Nb, Ni, V) and aggregates for civil construction. In the light of our present-day knowledge of Brazil's mineral potential, it is clearly in everyone's interest to create a favourable investment and financing environment for mineral research." ❑

FOR ABPM, MINERAL POTENTIAL IS STILL UNEXPLORED

Francisco Alves

Although the environment for mining investments in Brazil has remained stable for years, the circumstances that had been favouring investments in strategic minerals aimed at the energy transition, with strong demand exerting upward pressure on prices, has changed in recent months, leading to a marked realignment in the market, reflecting the decline in lithium and nickel prices. Investors' enthusiasm cooled down slightly after they had seized the window of opportunity in which Brazil benefited greatly, mainly with the profusion of lithium companies attracted by the success of Sigma, AMG, and CBL. Now, with the end of the lithium

rush, we are witnessing a rush for rare earths, in yet another manifestation of the country's enormous unexplored mineral potential.

This is the view of Luís Maurício Azevedo, the chairman of the Brazilian Association of Mineral Research and Mining Companies (ABPM). Brazil has several positive points, he notes, that give it an edge over the vast majority of countries. "First of all," he says, "is our innate resources. Brazil possesses a mineral diversity not always found elsewhere. Additionally, we have a network of technology centers that provide technical and technological capacity for analysis, technological characterization of ores, and the development of mining projects."

Prominent among these centers is the National Service for Industrial Training (Senai), whose presence and performance ensure that we have a reliable supply of qualified labour and the ability to train professionals to operate any cutting-edge technology that companies may wish to develop or to bring to Brazil."

Brazil's energy matrix is another favourable point, he says, since more than 70 percent of the country's electric power comes from renewable and non-polluting sources. "You could certainly say that a number of companies would like to have access to an energy matrix like ours, and several countries would like to have these assets, too."

From an environmental perspective, Azevedo notes that Brazil's legislation in this area ranks among the most advanced anywhere in the world. This can sometimes make compliance burdensome, but that, in turn, brings peace of mind to the investor, because an installation license or operating license issued within such a strict environmental framework gives reassurance to investors.

Azevedo also highlights the fact that Brazil is a socially, politically, and economically stable country. "We have strong institutions, clear rules, and respect for private capital. We have a Mining Code and subsidiary regulations that, while there is certainly room for improvement, has been in force since 1967, ensuring juridical security for investors. These factors combine to provide institutional stability and competitiveness for Brazilian mining, characteristics that are not seen everywhere."

In comparison with other, more developed, countries in the mineral sector, Azevedo concedes that Brazil still has areas in need of improvement: first and foremost, full geological knowledge of the territory, closely followed by advanced financing mechanisms for the mining industry. "We have this gigantic territory," he notes, "with a few potentialities already clearly defined, but with many more yet to be identified. We need to advance in geological mapping, so as not to miss opportunities for productive investments."

In the case of financing mechanisms, Azevedo argues that Brazil could follow the lead of Canada and Australia. "Undeniably, the closeness and the activities of the Toronto Stock Exchange (TSX) and the Australian Stock Exchange (ASX) encourage investment in mineral research and make a positive contribution to the image

Luíz Maurício Azevedo, president of ABPM

of mining. The ABPM has been working with the Brazilian Stock Exchange (B3), the National Economic and Social Development Bank (BNDES) and other partners in the Invest Mining Network, seeking to develop financing mechanisms in Brazil through the intermediary of the capital market and private-sector banks. Our aim is to create in Brazil a capital market targeting venture capital, along the same lines as Canada and Australia."

"Two important pieces of draft legislation are currently before the Chamber of Deputies, in Brasilia," Azevedo notes. "One, introduced by Deputy Laura Carneiro and Deputy Zé Silva, aims to encourage investment in mining. I am confident we will soon have new ways of accessing capital for mineral research in Brazil, in addition to possible tax incentives that are outlined in other bills now on their way through Congress."

Asked about the Brazilian government's intention to stimulate the production of critical or strategic minerals, Azevedo replies, "The demand for critical minerals and the manufactured products that use them will increase significantly in the coming years. This is a global trend and several countries have been preparing to meet this challenge. Projections of supply and demand for these minerals indicate future shortages that will necessarily have to be overcome by increasing the supply. Countries with a more highly developed mining industry will have difficulty meeting this demand. It is precisely at this point that Brazil can make an outstanding contribution. With its large territory, still not fully explored, this is one of the new frontiers for success, calling for relatively less investment in mineral research. But for this to bear fruit, it will be essential to open new fronts, to do away with the restrictions on research and mining in border areas, and also to do away with the government monopoly in nuclear fuels."

The present moment affords "a generational opportunity for Brazil," Azevedo says, given its still unexplored mineral potential. "The strategic position we adopt now is likely to define our position as a nation. Will we define ourselves as food suppliers or as suppliers of mineral inputs in high value-added global chains? Why not technology and manufactured goods as well? We face the urgent task of establishing a national strategy that positions Brazil as a country that produces critical minerals and provides inputs, technologies, and manufactured goods

that derive from those minerals." In this connection, he regrets that mining has not been included in the new industrial policy proposed by the government, "which is worrying, but it is not too late to correct the omission."

He also warns of the need to set a clear course, and then to follow it. "The country has to define a list of critical minerals based on its mining potential, market demands, and possible production chains. Based on this identification, it is necessary to invest in the generation of information on areas with the potential to attract investors to the discovery of critical mineral deposits. The regulatory agencies involved must offer the private sector priority on the agenda, by speeding up the technical analyses for authorizations and licensing."

Another recommendation is to create and maintain a business environment that is attractive to international investors. "Considering the long time lag between discovering a mineral deposit and bringing it into production," he say, "it is essential that the National Mining Agency (ANM) should speed up its analyses for issuing research authorizations, as well as mining concessions for strategic minerals. In the same way, the coordinated action of federal, state, and municipal authorities is a necessary requirement to streamline the various authorization and licensing procedures for research and production of strategic minerals. Delays in these processes create the risk of missing the window of opportunity that is now emerging."

The ABPM also calls for coordinated action between government authorities in assigning public-sector investments in infrastructure needed for the implementation of projects for producing critical minerals.

Finally, Azevedo adds that "We need to think about what role we want to play in the face of these opportunities. If we want to be more than exporters of basic raw materials, we need to invest in research, development, and innovation. We need to create incentives for the processing of ore into finished products. After all, we have a market, we have energy, and we have an industrial base of great and recognized competence."

The ABPM also asks questions about the role that Brazil wants to play in the energy transition and decarbonization of the economy. "Certainly, we have immense potential," Azevedo says. "Whatever role we choose, whether as a supplier of basic inputs, or of manufactured products, or as a major developer of technologies, the Brazilian mining industry must be ready to fulfill its role and continue generating wealth for the country and jobs and income for the population. To this end, we cannot waste time in adopting the necessary actions to position Brazil in this global energy transition scenario. However," he adds, "it is also essential for mining to bring inclusive and sustainable practices. It is not reasonable for us to produce minerals with the destruction of our own environment." □

BEMISA INVESTS IN A WORLD-CLASS PROJECT IN MINAS GERAIS

Francisco Alves

Bemisa has been investing in the development and raised geological knowledge of a Rare Earth project in the northwest region of the state of Minas Gerais, between the municipalities of Carmo do Paranaíba, Arapuá, Matutina, and Tiros. The Bambuí project, which has resources of over one billion tons of rare earth oxide with world-class grades and is currently in the geological research and process testing phase for the recovery of ionic clay. As the company's CEO, Augusto Lopes, informs, "the venture holds three mining rights, covering approximately 3,600 hectares. Fourteen diamond drilling holes were carried out, with an average depth of 96 meters. The average grades range from 0.45% TREO (Total Rare Earth Oxides), with regions showing grades above 1% TREO. Given the positive results of the leaching tests, we have good expectations for the project's continuity, also, we have planned a new drilling campaign in the first half of 2024 and new tests in renowned laboratories, with which we hope to make a world-class rare earth deposit viable."

In addition to this project, Bemisa is investing in expanding its iron ore production capacity, entering gold production, and seeking opportunities in other minerals considered strategic for the energy transition, such as copper, nickel, graphite, and lithium.

Regarding iron ore production, in the first quarter of 2024 the company will be operating the Mongais project in Minas Gerais, which will add 1 million tons/year of iron ore to the current capacity of 2.5 million tons/year of the Baratinha mine. "In addition to the Baratinha Complex, we have two more iron ore areas under development that will be implemented in the coming years. Among them, I emphasize the Pedra Branca Project, in the municipality of João Monlevade, currently in the environmental licensing phase, and another one, resulting from a partnership signed in 2023, known as the Piçarrão project, in the municipalities of Nova Era and Antônio Dias," says Augusto Lopes.

Augusto Lopes, CEO of Bemisa

Pertaining gold, Bemisa has already started the commissioning process and expects to ramp up production throughout 2024 for the Agua Azul do Norte project in the state of Pará, within the Carajás polymetallic district.

Finally, Bemisa is conducting exploration studies on 65 mining rights acquired in 2023 in the provinces of Alta Floresta and Tapajós, with high potential for copper and other minerals. Augusto Lopes explains that the company has been evaluating various projects over the past year. "Overall, we received over 32 projects, involving more than 15 mineral substances, among which copper,

nickel, graphite, and lithium assets stand out. The company sees great potential for discovering new deposits of strategic minerals in Brazil, therefore, it has created a dedicated email (novosnegocios@bemisa.com.br) and also it holds a department dedicated to evaluating potential assets to eventually incorporate into its portfolio."

BRASIL MINERAL - Are there opportunities for growth in iron ore in Minas Gerais, or is the idea just to maintain (and perhaps expand) the Baratinha project?

AUGUSTO LOPES - The Baratinha Complex comprises 20 mining rights, and the Baratinha Mine is just one of them. The complex totals over 100 million tons of iron ore resources, which gives a perfect dimension of the potential for exploiting these assets. Baratinha, I always like to say to our employees, is a great source of pride for Bemisa, the result of many years of hard work and persistence from a well-trained team focused on results.

The Baratinha concentration plant has the capacity to annually produce 2.5 million tons of premium quality sinter feed and does not use tailings dams. The operation is certified by international standards of quality, environmental management, and safety (ISO 9001, 14001, and 45001), and it has rigorous governance standards, with more than 3,500 days without lost-time accidents.

Still within our complex, we have the Mongais project, which is under development and is scheduled to start production in the first quarter of 2024. With the operation of this project, an additional production capacity of 1 million tons will be added to the Baratinha Complex.

In this context, Bemisa has two railway terminals located less than 40 kilometers from the complex, bringing competitiveness and reinforcing our value of socio-environmental responsibility, reducing the need for road transportation in the current and future demand.

In addition to the complex, we have two more iron ore areas under development that will be implemented in the coming years. I emphasize the Pedra Branca Project, in the municipality of João Monlevade, in the environmental licensing phase, and the other, resulting from a partnership signed in 2023, known as the Piçarrão project, in the municipalities of Nova Era and Antônio Dias.

This perspective reinforces our commitment to increasing our iron ore production, bringing our values to a safer, more modern, and sustainable mining approach to our projects in Minas Gerais.

BRASIL MINERAL - The Água Azul do Norte project marks the company's entry into the gold segment. Are there plans to grow in this sector?

AUGUSTO LOPES - Our first gold operation, called the Agua Azul Project, is located in Pará, in the Carajas polymetallic district, and began its commissioning phase in the second half of 2023, with our expectation to ramp up production in 2024. We believe in the potential of the gold mineral and in diversifying our portfolio.

Bemisa has been investing in geological and metallurgical research for over five years to ensure the technical, economic, and socio-environmental viability for the start of this operation.

The exploration program includes over 52,000 meters of drilling activities, and the results have been consolidated in an Independent Resource Report based on the NI 43-101 standard. Most of the drilling was conducted at the Abelhas target, aiming to ensure the project's payback. In this regard, there are still three other mining rights in the region owned by the company that have excellent potential for increasing the resources of the Água Azul Complex.

We are in the development phase of research activities in other areas as well. In the northern part of the state of Mato Grosso, for example, there are drilling campaigns in the Novo Mundo complex. This venture includes the Raimunda, with defined resources, and Flor da Serra and Paranaíta targets, which are currently in the exploratory research phase. The first drilling campaign for the Flor da Serra target was completed in 2023, indicating potential for high-grade ore.

Água Azul confirms our perception that gold brings significant added value to our company and society, generating employment and income in a remote region of the country.

BRASIL MINERAL - Bemisa is one of the companies that heavily focus on mineral research. What is the focus of the current research efforts?

AUGUSTO LOPES - Throughout our 16-year history, we have accumulated extensive geological knowledge of the Brazilian territory. We have been involved in the exploration of various mineral assets at different stages of development, conducting geological mapping, extensive geochemical and geophysical survey campaigns, as well as exploratory and detailed drilling programs for the definition of mineral resources and reserves.

The updated numbers indicate that, from the first drill hole in 2008 until the end of 2023, Bemisa has executed over 215,000 meters of drilling, totaling more than 1,800 boreholes. These indicators demonstrate the company's commitment to the continuous search for mineral opportunities in Brazil.

We have always been attentive to the market needs, as the technological evolution of the world demands, on a large scale, the consumption of mineral commodities. With this broad vision, a range of opportunities opens up for the development of mineral assets such as high-grade iron ore and rare earths, considered today as strategic minerals, the basis for the development of the much-touted energy transition. This new low-carbon world will increasingly demand the supply of mineral commodities.

Trends point towards the transition of the energy matrix of industries and the new paradigm of consumption preferences in productive chains. We understand that in this scenario, the supply of basic metals will be necessary for the world to move towards sustainable development.

For this reason, Bemisa invests in the development and increased geological knowledge of our Rare Earth project. Located in the northwest region of the state of Minas Gerais, between the municipalities of Carmo do Paranaíba, Arapuá, Matutina, and Tiros, the Bambuí project has resources of over one billion tons of rare earth oxides with world-class grades and is in the geological research and process testing phase for the recovery of ionic clay.

The project comprises three mining rights, covering approximately 3,600 hectares. Fourteen diamond drilling holes were carried out, with an average depth of 96 meters. The average grades range from 0.45% TREO (Total Rare Earth Oxides), with regions showing grades above 1% TREO. Given the positive results of the leaching tests, we have high expectations for the project's continuity, with a new drilling campaign planned for the first semester of 2024 and further tests in renowned laboratories, aiming to make a world-class rare earth deposit viable.

Towards the end of last year, in 2023, we closed an agreement to acquire 65 mining rights in the provinces of Alta Floresta and Tapajós, with high potential for copper and other minerals. Exploration studies in these areas have already begun.

Furthermore, Bemisa has evaluated various projects over the past year. Overall, we have received over 32 projects involving more than 15 mineral substances. Among the sought-after mineral substances, we highlight the company's interest in copper, nickel, graphite, and lithium assets.

We see enormous potential for the discovery of new deposits of strategic minerals in Brazil. To expedite the receipt of new opportunities, we have created an exclusive email (novosnegocios@bemisa.com.br) for this purpose and we also have a dedicated area for evaluating these potential assets to eventually incorporate them into our portfolio. ❑

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WHAT IS DECISIVE FOR A SUCESSFULL MININC COMPANY IPO IN BRAZIL?

The Aura Minerals Experience

Francisco Alves

What are the determining factors for a mining company to be successful in listing its securities on the Brazilian stock exchange, B3? For Rodrigo Barbosa, CEO of Aura Minerals, the first gold mining company to make a successful IPO on B3, one of the decisive factors is that the company is generating cash and being able to distribute dividends to those who bet on its shares. This was what mattered, in the case of Aura, which made the IPO in a delicate period, when the world was grappling with the Covid-19 pandemic.

He narrates that, at the time when the company - which was already listed on the Toronto Stock Exchange, in Canada - decided to go for dual listing, aiming to obtain funding to finance its growth projects, the Canadian market, where the vast majority of junior mining companies and medium-sized mining companies raise funds, was on a phase of scarcity of capital for mining. "Toronto no longer saw a thriving market for mining as occurred in the first decade of the 2000s, as a large part of the resources were being

invested in Fintechs, Cannabis and several other industries. We, at Aura, had been successful through a turn-around, and we wanted to retell this story through an IPO", says the CEO.

At the time, Aura even thought about the New York and London markets as possibilities. However, it was still a small company for these markets. And he decided to return to Brazil. "At that time, Brazil was experiencing a decline in interest rates, which were reduced, and there was a very strong migration from the debt capital market to the equity capital market, with new funds being formed, capturing, and looking for investment alternatives. in Brazil, several IPOs were taking place, but all in sectors (retail and others) that were already raising capital. We then realized that there was a lot of capital in Brazil migrating to Equity and a shortage of companies with different stories on the stock market. There was no one, as we presented ourselves, with a truly countercyclical factor. Therefore, anyone who wanted to be protected in the dollar and even above the dollar (gold) could have an alternative to investing in Aura. Furthermore, we have Brazilian DNA. Based on these reasons, we judged that we would be successful. We also had conversations with some investment funds, which showed interest and even anchored our Deal", says Barbosa.

He adds that, for the IPO to be successful, the company had to carry out "investor education", because gold mining, for Brazilians, is something new as an investment. Investors are more accustomed to investing in gold as an asset, but not in gold mining. Aura Minerals had in its favor the fact that it had a track record of cash generation and had growth projects. The Aranzazu operation, in Mexico, had been resumed and there were other projects in the pipeline, in Brazil. "The fact that we were generating cash and paying dividends was very important to provide the necessary comfort for investors to enter a different segment, which is gold mining. If it weren't for this track-record of cash generation and dividend payments, investors wouldn't be prepared to enter."

One of the advantages of gold projects, according to Rodrigo Barbosa, is that, as they do not require investment in logistics, in addition to costing less, they can be implemented more quickly. In the case of Aura, its growth is based on simple-to-execute projects (open pit mine operations, processing by CIL -- Carbon In Leach and medium scale) and on a team and management culture that makes quick decisions, has agility, delivery commitment. "This combination allowed us to carry out the Almas project in 16 months and the ramp up in five months, setting new benchmarks for the industry. It was the first project we did after the IPO", says the executive. Another important point that helped Aura's success was the fact that it is already listed on the Toronto stock exchange (TSX), adopts the highest standards of corporate governance, and submits to 43.101, which is the Canadian standard for certification of resources and reserves. "So, for those who had doubts about how resources and reserves are certified, there was already a

Rodrigo Barbosa, CEO of Aura Minerals

very well-defined process monitored by the Canadian authorities so that those resources and reserves could be reported. It was this combination of factors that ended up contributing to our success in the IPO", observes the CEO.

Asked about listing costs in Brazil, he said they are not very different from those in Toronto. "Of course, the cost increases because we are listed in both countries and in Brazil we went to a higher listing level, the BDRs (Brazilian Depositary Receipts), adhering to the highest standards of the CVM (Securities Commission), which obliges us to have reports in Portuguese, publications with Portuguese and English versions, bilingual Conference-Cals. We are also required to have an auditor present in Brazil and a local statutory director to sign documents. Therefore, there is an entire regulatory framework in Brazil that ends up increasing costs a little."

Mechanisms for encouraging investments in mining

Rodrigo Barbosa considers that it is very important for Brazil, if it wants to develop mining, to create mechanisms that allow funds to be made available under better conditions. "In the 2000s, the Canadian market -- and even the Australian one -- was very strong for investments in mining and much of this capital ended up in Brazil. Many important companies on a global scale invested in the country. And these resources, which were accessed mainly in Canada, from 2013/2014/2015, dwindled. So, if Brazil wants this sector to develop, it needs to find alternative solutions so as not to depend excessively on external capital. Making this funding viable locally is a key factor for the sector to develop over the next ten years", he says.

Regarding Brazilian investor appetite for mining assets, Barbosa states that it still takes time for it to mature. He recalls that until ten years ago, the capital market in Brazil raised little for mining, except for Vale and large iron mining companies. "Brazil had almost nothing, but mining companies began to enter that generate cash (Aura Minerals, CBA, Sigma) and allow investors to begin to understand more about mining and the issue of mineral ex-

ploration. However, we are still in the first phase, in which investors do not know as much but have the comfort of generating cash in parallel. Sigma was another company already successfully listed abroad and which had a growth plan outlined. It was not an Exploration Company", says Barbosa, adding that the next phase will be that of companies that are still in the exploration phase. "But I think it's still a little far from that. The market needs to experiment more with this cash-generating mining. And here I'm talking about the Equity market, with listed companies, so that later we can start experimenting more with the issue of exploration. Investment in the exploration phase will happen, but it will be more private, from private equity partners, but not from listed companies. At least for the next five years."

Regarding investment funds, the CEO of Aura says that a "change in mood" can already be seen, remembering that the last ten years were marked by a shortage of capital for mining. "Companies stopped investing, doing M&A, investing in exploration, shares ended up falling a lot, and now the whole issue of ESG has come up, establishing that only companies that have high standards end up being able to capture. Those that don't have it fall by the wayside. There was also a discussion about where mining fits into ESG. There were banks, like BNP Paribas, that stopped financing mining, due to ESG. But on the other hand, it's all about understanding. Mining does have an impact on nature, but the problem can be minimized and then all the nature that was affected can be restored. But during the process, people end up interfering and this has a negative impact. On the other hand, there is already an understanding that there is, for example, no migration of the energy matrix from carbon to electricity if there is no copper and a series of other elements. There are no high-tech products without gold. There is no migration to lithium-free electric batteries. Then the understanding begins that without mining there are no important products because humanity continues to develop and innovate. So, we see the mood changing. But, with the exception perhaps of lithium and other minerals closely linked to batteries, mining companies today have very depressed valuations. And at the same time, commodities are at a good price. Gold is close to the high. Copper, although not close to its maximum, is at a value that allows cash generation. This is the first time I have seen an environment in which there are commodities at attractive prices and company valuations being relatively depressed. Therefore, I think it is a good opportunity for new investors to look closely, because it is a necessary sector. Without investment over decades, there is no way to grow supply in the next three, five, or ten years. Demand is coming with strength, prices tend to become more elastic, and I gradually understand that companies will recover their valuations, which are currently very depressed", concludes Rodrigo Barbosa.❑

Construction of Ero Copper's Tucumã project

COULD THE CARAJÁS MINERAL PROVINCE BE A FUTURE GLOBAL CENTER FOR PRODUCTION OF STRATEGIC MINERALS?

Francisco Alves

Does the Carajás mineral province, in the northern Brazilian state of Pará, have the potential to become a world hub to produce strategic minerals? According to some experts on the region, it does.

David Strang, the CEO of Ero Copper, currently engaged in setting up a new copper project in the area, points that Carajás is already one of the world's largest mining districts, outperforming widely cited areas such as Sudbury (in Canada), Norilsk (in Russia), and the Witwatersrand Basin (in South Africa). "Carajás is potentially the world's most prolific production area for iron ore, copper, and nickel," Strang says, "although to this day it remains underexplored, mainly because one company, Vale, has been there from the outset."

Breno Augusto dos Santos, a geologist who has been in the forefront of discoveries at Carajás since the beginning and who has dedicated decades of work to surveying the region, says the potential for copper is very great. Salobo, now being worked by Vale, is a world-class deposit, he says, while there are at least five other known medium-sized deposits holding somewhere between 200 million and 400 million tons of ore with a copper grade of approximately 0.8 percent.

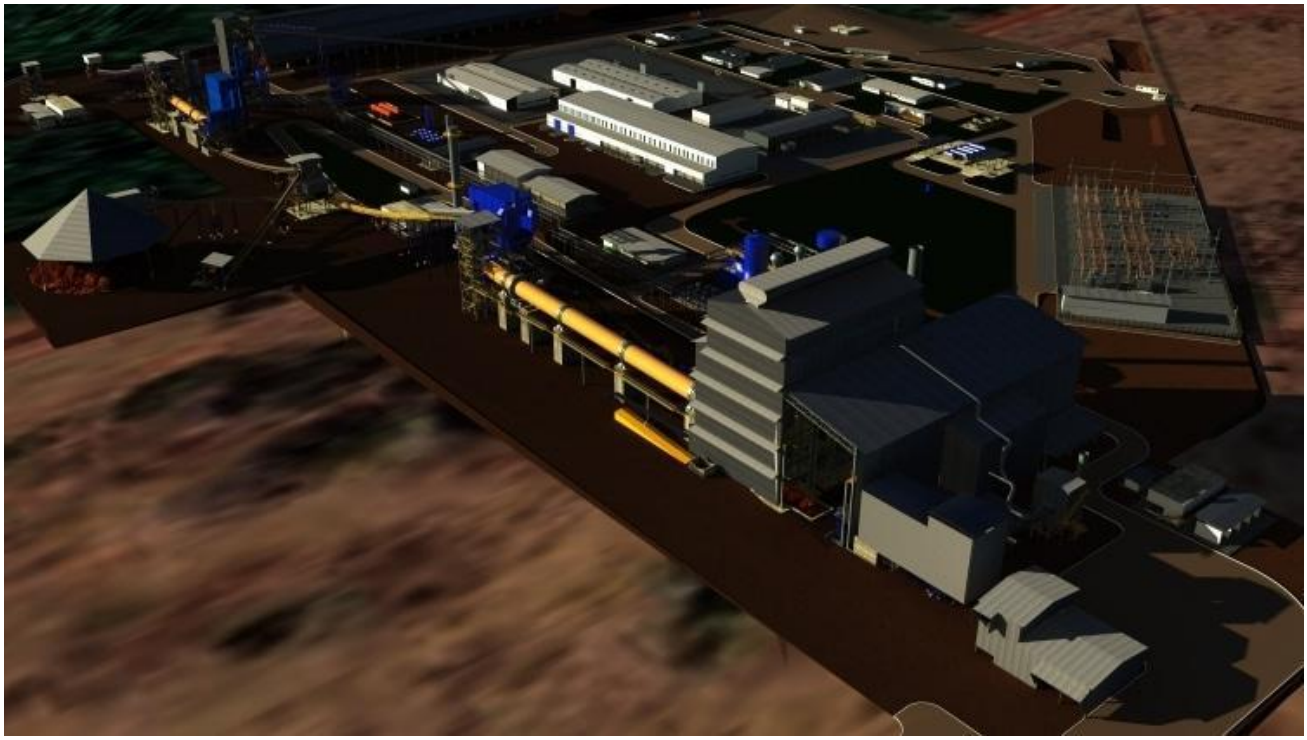
The Brazil Geological Survey, still officially known by the extended acronym SGB-CPRM, has published a report under the title Assessment of the Geoeconomic Potential of the Carajás Mineral Province, in which the current figure for copper resources plus reserves in the Carajás area adds up to 23 million tons of metal content. Reserves (proven and probable) are stated as 2.55 billion tons, with a copper content ranging from 0.6 percent up to 2.1 percent. Of the thirteen deposits that have been identified, nine are held by Vale: Alemão, Cristalino, Furnas, Paulo Afonso, Pojuca, Salobo, Sequeirinho, Sossego, and 118. The other four are Antas and Pedra Branca (both held by Oz Minerals), Jaguar (Centaurus), and Tucumã, formerly known as Boa Esperança (Ero Copper). In all thirteen, the copper is found in association with gold, with grade ranging from 0.30 to 0.86 grams per ton, the latter figure being observed at Alemão. In the same report, the Brazil Geological Survey notes that mining has now begun at four of those deposits, namely Salobo, Sequeirinho, Sossego, and Pedra Branca.

Geologist Breno Augusto dos Santos

Salobo is now Brazil's top copper mine

Salobo is currently the star performer in Brazilian copper mining, with 1.11 billion tons of reserves having a 0.62 percent copper grade, in addition to 0.35 grams of gold per ton. Resources are stated as 529.8 million tons with 0.46 percent Cu and a gold content of 0.23 grams per ton. Its installed capacity is 200,000 tons per year of copper contained in concentrate, in addition to 200,000 ounces of gold per year — though gold output is now declining, having dropped from 331,000 ounces in 2020 to 215,000 ounces in 2022. The mine has been in operation since 2012 and has been through several expansion programs. The most recent of these, now in the ramp-up stage, raised capacity at the processing plant to 30 million tons of ore per year.

Thirty-eight years elapsed between the first discoveries at Salobo and startup of the mining operation. Mineralization of copper was discovered in 1974 in the vicinity of the Salobo River, and detailed exploration began in 1977. In the words of a Vale report, "A conceptual study was concluded in 1981, followed by pilot studies from



3D plant of Horizonte Minerals Araguaia project

1985 to 1987, culminating in the award of a mining concession. A pre-feasibility study was concluded in 1988, the initial feasibility study was presented in 1998, followed by updates in 2001 and 2002. A final study was concluded in 2004. Operations at Salobo began with pre-stripping in 2009, and the first concentrate was produced in 2012." For a time, the project was operated as a joint venture between the then state owned Companhia Vale do Rio Doce and Anglo American. The partnership was subsequently discontinued, leaving Vale in sole control of Salobo.

Although it was the first to be discovered, Salobo was not the first copper mine to be brought on stream in the Carajás mineral province. That was Sossego, a much smaller deposit, holding reserves of 86.2 million tons of ore having a 0.58 percent copper content and 0.19 grams of gold per ton, and resources of 322.6 million tons with a 0.80 percent copper content and 0.19 grams of gold per ton. Installed capacity is 100,000 tons per year of copper contained in concentrates, drawing on the output of the Sequeirinho deposit, where mining is fully integrated with the Sossego operation. The project became operational in 2004. Sossego and Sequeirinho are both open-pit mines, sharing a single processing plant. There are further satellite deposits in the region — Cristalino, 118, Bacaba, and Mata II, which may be mined in the future, once again with the ore being processed at the Sossego unit.

The Antas Norte project, belonging to Oz Minerals/BHP, is a processing plant that used to be supplied with ore from the Antas deposit, declared exhausted in 2021. Now it takes its ore from Pedra Branca, the first underground mine to have been opened in the Carajás mineral province, located in the municipality of Água Azul do Norte. The

production plan for the Pedra Branca mine calls for mining a total 16.2 million tons of ore over a period of thirteen years, yielding 1.026 million tons of copper concentrate having an average 30 percent content, in addition to 216,600 ounces of gold and 31,000 ounces of silver.

Alemão will be Vale's next copper deposit to be brought into production. This will be the second underground mine in the Carajás region, since the top of the deposit lies at a depth of about 200 metres from the surface, according to geologist Breno dos Santos. Vale's figures show resources at Alemão amounting to 115.4 million tons of ore with a 1.49 percent copper content and gold assessed at 1.11 grams per ton. The Alemão deposit lies beneath the now exhausted Igarapé Bahia mine, from which Vale used to produce an average 10 tons of gold per year.

The Cristalino deposit, holding reserves of 379 million tons, with a 0.66 percent copper content, may possibly be the next on Vale's list, after Alemão, to be brought into production, says Breno dos Santos, in view of the nearby Rabo da Serra Sul iron ore deposit, where the company is already planning to start mining. There are other possibilities as well. With the single exception of Alemão, where the top of the deposit lies 200 metres below the surface, all the other copper deposits at Carajás are outcropping. In Santos' words, "There is no other copper-bearing district in the world, where the deposits are of hydrothermal origin, in which all the deposits are outcropping." At the same time, he is careful to point out that, "With more advanced research methods and using the appropriate geophysical prospection technologies, there remains the possibility that major copper-gold deposits may be detected at lower levels."

Even earlier than Alemão, however, Ero Copper's Tucumã project (previously named Boa Esperança) is due to come on stream before the end of 2024, implementation having started in the second quarter of 2022. With a useful lifetime estimated at 12 years, the venture is expected to yield 326,000 tons of copper, for a budgeted investment of US$ 305 million. The company says it expects that the potential for copper recovery, identified within an underexplored area at the edge of the pit, will improve the project by confirming that further mineralization is to be found between the high-content areas close to the surface and the areas adjoining the edges of the pit.

In the light of the large number of discoveries, the Carajás mineral province has attracted a rush of applications for mining rights. The same report from the Brazil Geological Survey notes that "a high density of mining rights, numbering almost 3,000, most of them still at the exploration stage, almost 700 now entitled to apply for a mining licence, 180 holding a mining licence, and 259 on a waiting list for availability. São Félix do Xingu is the muncipality with the greatest number of mining rights, followed by Marabá and Parauapebas. More than half of the mineral deposits have now been licensed." Out of a total 2,992 mining licence in the region, 1,173 (39 percent) are for gold (including silver and minerals in the platinum group), 866 (29 percent) for copper, 217 (7 percent) for tin, 176 (6

percent) for manganese ore, and 137 (5 percent) for iron ore. Out of the 180 mines for which mining rights have already been awarded, seven are for iron ore, two for manganese ore, seventeen for copper, five for nickel, and 51 for gold.

Optimistic forecast

In the opinion of geologist Roberto Perez Xavier, the executive director of Adimb, the Brazilian Mining Industry Development and Innovation Agency, the outlook for Carajás voiced by David Strang, the CEO of Ero Copper, who sees the prospect of the area becoming a world hub for production of strategic minerals, is "rather optimistic, particularly if one is thinking in terms of a ten-year horizon." At the same time, he says, it is beyond doubt that Carajás has the potential to become, at some future date, "a world-class productive province, ranking among the ten most productive in the world." In terms of its geological age, he adds, the Carajás mineral province is the oldest of all those within the geological nucleus named the Amazonian craton, with large number of copper deposits, running east and west, within the so-called South Copper Sector and North Copper Sector.

Xavier estimates that, adding all the copper deposits together, the province holds approximately 4 billion tons of ore having an average 0.9 percent copper content by weight, plus 0.2 grams of gold per ton. The Carajás mineral province, he stresses, does not hold copper alone. It is a polymetallic province in which iron ore predominates, but it also holds manganese, nickel, copper, and gold, among other metals. From east

Geologist Rodrigo Martins

to west, the province measures about 300 kilometers; from north to south, at its widest point, it measures about 100 kilometers.

Xavier recalls a further hindrance in the way of the full realization of the province's potential: the infrastructure question for bringing the more distant deposits into production, given that most of the deposits rank as medium or small and are consequently unlikely to attract any of the major mining companies.

He notes that the projects now in operation in Carajás, such as Sossego, Salobo, Pedra Branca, and Pantera, are of the polymetallic IOCG type. In addition to copper, they may also contain gold, silver, or anomalous grades of nickel, cobalt, rare earths, or uranium. Approaching the question from the geological side, he says, there are many questions that remain unanswered, including the evolution of the province itself. "We still have to identify the main controls that

have impacted these deposits over time and trace the evolution of the province over the course of geological time."

A comment often heard at mining industry events, Xavier says, is that the worldwide trend is toward deposits having a lower and lower metal content. The result is a growing awareness that a deeper understanding is needed about low-content deposits of that kind. Another frequent observation is that it is becoming harder and harder to find deposits reaching all the way up to the surface or at least to a depth of no more than 100 meters. While that may be true on a worldwide scale, Xavier says, it is not the case in Brazil, and that includes Carajás, where it is possible that a surface survey may still yield signs of an ore deposit. "In my view," he says, "there is still room for that in Carajás, despite the great intensity of exploration work that Vale has conducted there. It is my belief that, in Brazil, there is still a good chance of finding deposits that are up near the surface."

Unrealized potential

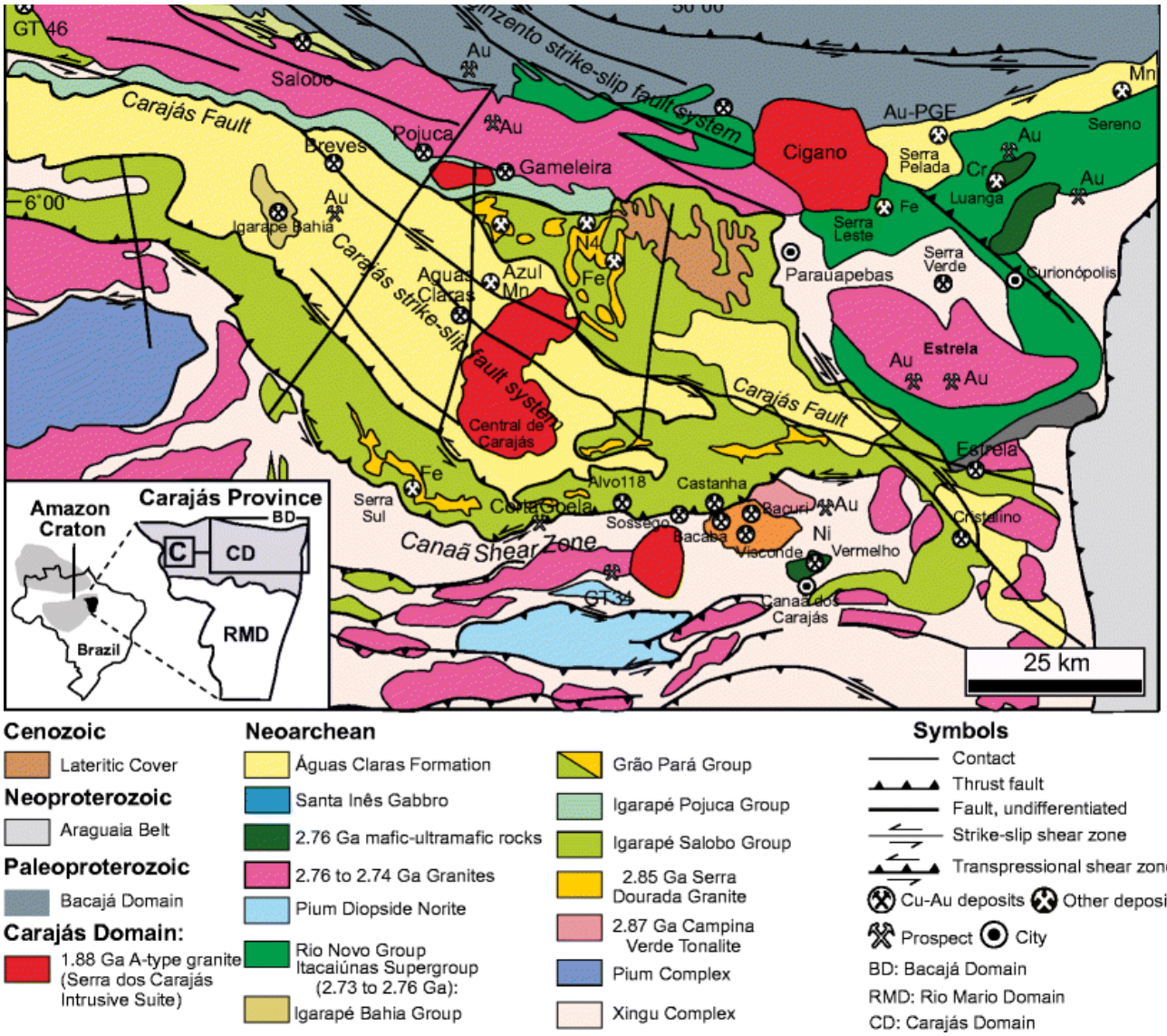
Marcos André Gonçalves, the chairman of Adimb, is another geologist who worked many years on the Carajás geological environment. He says he understands perfectly Strang's remark about the potential for energy transition minerals in the region. The Tucumã project is a case in point, he says. The discovery in 2006 of the copper deposit then known as Boa Esperança came as a surprise. He asks rhetorically, "How could somebody discover a copper deposit, holding 80 million to 100 million tons, right there in Vale's backyard?"

He agrees that Carajás still has great potential. "We have the star deposits, Furnas, Salobo, Sossego-Sequeirinho, and Igarapé do Gelado, but there is also a series of deposits that are already known though not in detail. They hold considerable volumes, in addition to other deposits such as Tucano, G34, and Pantera." He points out that, in a mineral province that Brazilians consider to be well-known, discoveries are still being made. The work that Centaurus is now doing at the Jaguar deposit, for instance, "brings a new dynamic in which good research interacts with entities such as Adimb itself, in the form of a joint project."

It is a long road, Gonçalves warns. It can sometimes take ten or twelve years, or even longer, to bring a deposit into operation. In his view, however, things are happening. "How many geologists working at Carajás can there be, he asks, "who don't know of deposits or smaller areas, holding maybe 60 million tons with a 0.8 percent metal content? There is the Pantera deposit, with a content of around 2.3 percent, of a size that might be too small for Vale, but not for some other company. So, I believe that Carajás still has potential, not only in copper but in nickel, too."

Like Roberto Xavier, Gonçalves too warns of the obstacles in the way of bringing the potential to full realization, in particular the infrastructure required, such as a second railway to ship out the ore — the existing railway is almost fully occupied by Vale alone —good roads and persuading the public of the benefits that realizing the potential will bring.

Like other geologists, Gonçalves has no doubt that, geologically, the province is bound to yield many further discoveries, although



"discovery" does not necessarily imply "economic feasibility". "The discoveries already exist," he says. "What may still be lacking, either as the result of internal company policy or current market conditions or poor logistics, is the development of all these deposits. Many of them have, in fact, been known for quite some time. Some of the smaller ones, holding 50 million or 60 million tons, might have become operational by now if they were in a different state, such as Minas Gerais, especially in the context of present-day market conditions, with the energy transition and everything else."

One important difference is that the IOCG-type copper deposits in Carajás come with the bonus that they include recoverable quantities of gold. Some studies indicate a gold content of around 0.41 grams per ton, which in terms of feasibility can help to make up for a relatively low copper content, Gonçalves says. He also believes the region holds yet undiscovered copper deposits at greater depths. "

Rodrigo Martins, another experienced geologist with a good knowledge of the Carajás geological environments, notes that

Brazil in general, and the Carajás mineral province in particular, still has abundant potential for new copper discoveries. He argues that Brazil's current output of around 400,000 tons a year represents no more than 3 to 4 percent of world copper production, and that 80 percent of Brazil's copper output comes from Carajás, mainly from two mines, Salobo and Sossego. That means there is the potential for expanding output. "Vale has its growth strategy," Martins says, "and, once all the projects are in place, I believe Carajás has the possibility of reaching 500,000 to 600,000 tons of copper a year. It would have the potential for even greater growth, if it were not for the questions of economics, logistics, and project feasibility. There are many deposits there, but there is no way that they can all be explored at the same time."

Martins recalls a time when he was still working for Vale and an assessment of the general potential of the area concluded that it was very great. "But it's a long way," he says, "from that point on to the feasibility of every project. Vale is now readying Alemão, which is a new project, the Paulo Afonso group of deposits, and others. Supposing that the company achievea a copper output of 500,000 tons a year during a certain period, there are other projects, such as a small to medium-scale Ero Copper project, with an expected average output of 30,000 tons a year, among other small projects. In my view, we are going to hit a ceiling of 600,000 tons. That would be a good tonnage, but it is a long way from turning Carajás into a major player. It will be an important mining area, but there are now several porphyry mines in Chile and Peru with an output half that size, between 300,000 and 400,000 tons of copper."

There remains the challenge, he says, of bringing more projects to fruition, because all the major discoveries have now been made. "What there is in Carajás today is extensions at greater depth, that may possibly become underground mines. Alemão will be Vale's first underground mine at Carajás, and that is highly important, with a potential of around 60,000 tons of copper, but the other deposits, in the eastern and western sectors alike, face the challenge of feasibility. One way to balance this would be increasing copper output in the area."

One possible route to boosting copper output, Martins says, would be placing the development of these small deposits in the hands of junior companies, following the lead given by Oz Minerals and Vale. "There are a number of small deposits that may be of no interest to the major companies," he says, "but they might attract small companies. However, that still does not open a realistic prospect of Carajás reaching a copper output of 800,000 or 1 million tons a year. In conclusion, there is potential, but realizing that potential is going to be a challenge."

Nickel

In the case of nickel sulphide for transition materials, Martins names Jaguar as an important deposit, which he expects Centaurus — the company now holding the rights — to bring into operation in due course, either on its own or in association with another company. He estimates Jaguar's future output at around 30,000 tons per year.

BHP/OZ Minerals Pedra Branca Mine

In the case of lateritic nickel, the Brazil Geological Survey has identified three main deposits in the western sector of the Carajás mineral province: Onça Puma (assigned to Vale), Vermelho (formerly Vale but now Horizonte Minerals), and Jacaré (Anglo American). The three deposits together hold total resources more than 562.5 million tons of ore, with a nickel content ranging from 1.0 to 1.6 percent in addition to a cobalt content of 0.05 to 0.15 percent. "Additional resources are known in the Jacarezinho, Itapitanga, and Mundial Carapanã deposits. Sulphide ore reserves have been found in the Luanga deposit, now undergoing reassessment," the report states, adding that currently known resources and reserves in the Carajás mineral province are estimated at 7.17 million tons of nickel content.

However, all the laterite nickel deposits are being tapped to supply the steel industry. Unless significant changes are made to the processing facility, these deposits will not be able to supply the nickel required for the energy transition. Among these deposits, the most substantial is Jacaré, which Martins describes as one of the largest known laterite nickel deposits anywhere in the world. Bravo Mining has also reported a new nickel discovery, still at the exploration stage, whose true potential remains unknown.

Martins is confident that Carajás has the potential for new nickel discoveries, given the geology and the hydrothermal nickel in Centaurus's Jaguar deposit. "But testing this potential is going to take time," he warns. "Sulfide nickel exploration is lagging. Copper, for instance, is much more advanced. And then, of course, nickel has less potential than copper, and the research work is a little more challenging. I believe Carajás may become an important nickel producer, though not on a large scale, unless metallurgical solutions can be found for processing the laterite nickel found in these deposits."

Although it is now fifty-three years since Carajás was discovered and it has been very closely surveyed during all that time, the exploration has been comparatively superficial or "shallow", in Martins' words. "When I was working for Vale," he recalls, "I did an analysis that showed 95 percent of the

boreholes were less than 500 metres deep. We then did some deep drilling, which confirmed the continuity of the copper mineralization. There is still a lot of exploration work to be done at Carajás, mainly in the western sector of the province, because the eastern sector is beginning to get exhausted. There remains the question of economics: can these deep deposits be feasibly mined? Martins repeats that he has no doubt about the potential of deep reserves at Carajás, based on his experience with gold when he was working for Anglo Gold Ashanti in Minas Gerais. At that time, he oversaw the deepest drilling ever conducted in Brazil, at depths of up to 1,400 metres (4,600 feet). "We detected the continuity of mineralization in the Cuiabá mine," he recalls, "bases on the same concept that was applied in the same company's Velha mine, which reached a depth of more than 2,000 metres. We thought, 'If there's one known deposit at a depth of over 2,000 metres, why can't there be a second one?' So, we did the drilling to find out."

The IOCG system, such as is found at Carajás, is known worldwide for being deep-rooted, Martins says, citing the example of Olympic Dam, in Australia. The continuity of mineralization at Carajás is now mapped and confirmed down to a depth of 1,500 meters (5,000 feet), showing a metal content that in every case is at least of some interest. "However," he warns, "this has been done at only three deposits, Salobo, Sossego, and Alemão. It hasn't been done in any other region. Now Centaurus is drilling boreholes between 700 and 1.000 meters deep, and I have no doubt they will bring results. We have covered only the upper layer at Carajás, down to 400 or 500 meters. The surface is relatively well mapped. That means nobody is going to stumble across a new Salobo or a new Sossego. At the same time, there are other interesting prospects, mainly in areas held by Vale. And there's the possibility that something that doesn't look interesting on the surface may yield better geological results lower down. It's something to be looked into."

Summarizing, Martins is confident that Carajás has potential, though not to the point of joining the list of the world's leading players. "But it may possibly make a substantial contribution to Brazil's copper and nickel output," he says.

In some of the deposits, the gold content will be sufficient to tip the scales and make a mining project viable, Martins says. "Suffice it to say that Alemão is going to produce 60,000 tons a year of copper and 120,000 ounces of gold. Vale has sometimes used advance sales of gold to fund a new project, in some instances raising practically the whole amount of the capex. Gold can be a useful counterweight in times of crisis. When other metals are going down in price, gold goes up. That means the presence of gold in the system is a factor to be considered. There can be no doubt that, in the case of these IOCG deposits, gold will help with feasibility. Even in places where the mineralization of copper is capped with a very thick layer of altered soil," he adds, "sometimes gold that has been enriched through the supergene process will improve the prospects of the investment."

Vale's Onça-Puma Project

THE PROMISE OF PORPHYRIES

In addition to Carajás, two other mineral provinces, Alta Floresta and Tapajós, have recently gained prominence for their copper potential. Located in the states of Mato Grosso and Pará, both have been found to hold deposits of the porphyry type, now being mined on a large scale in Chile and other Andean countries. According to Roberto Xavier, indications of these deposits in Brazil were first detected by academics, researchers from the universities of São Paulo and Campinas. Shortly afterwards, Anglo American, which was then exploring the same region, discovered the Jaca deposit. "There was great rejoicing at that discovery, which is only natural. But how did it turn out in the end? Jaca is still a copper deposit, though it is too small to be of any interest to Anglo American. Now it is the hands of Ero Copper, which has a completely different dynamic from that of Anglo American, a company that only aims at big targets. The Jaca deposit seems to be on the way to turning into a mine."

Xavier makes the reservation that what has been found at Alta Floresta and Tapajós are gold deposits with associated copper. Even so, he sees the rush for copper of the porphyry type, at Tapajós and Alta Floresta, as a favorable development. "Maybe not for major companies," he adds, "which had been led to expect something stronger, but for small and medium-scale companies. We have already seen Fides starting to open its União do Norte gold mine. That mine holds copper too, but it is primarily a gold mine. Another example is Paraíba, at Peixoto de Azevedo, a much older mine that always produced gold, but there are large quantities of copper found there in association. A third example, where mining has not yet begun, though it soon will, is Aura Minerals' X1 deposit at Matupá, which is rich in gold and holds a great deal of copper, and silver as well. Yet another example of gold with associated copper is the Palito mine at Serabi. And then there's Meteoric Resources' deposit at Juruena, where the gold and the associated copper are concentrates in a porphyry."

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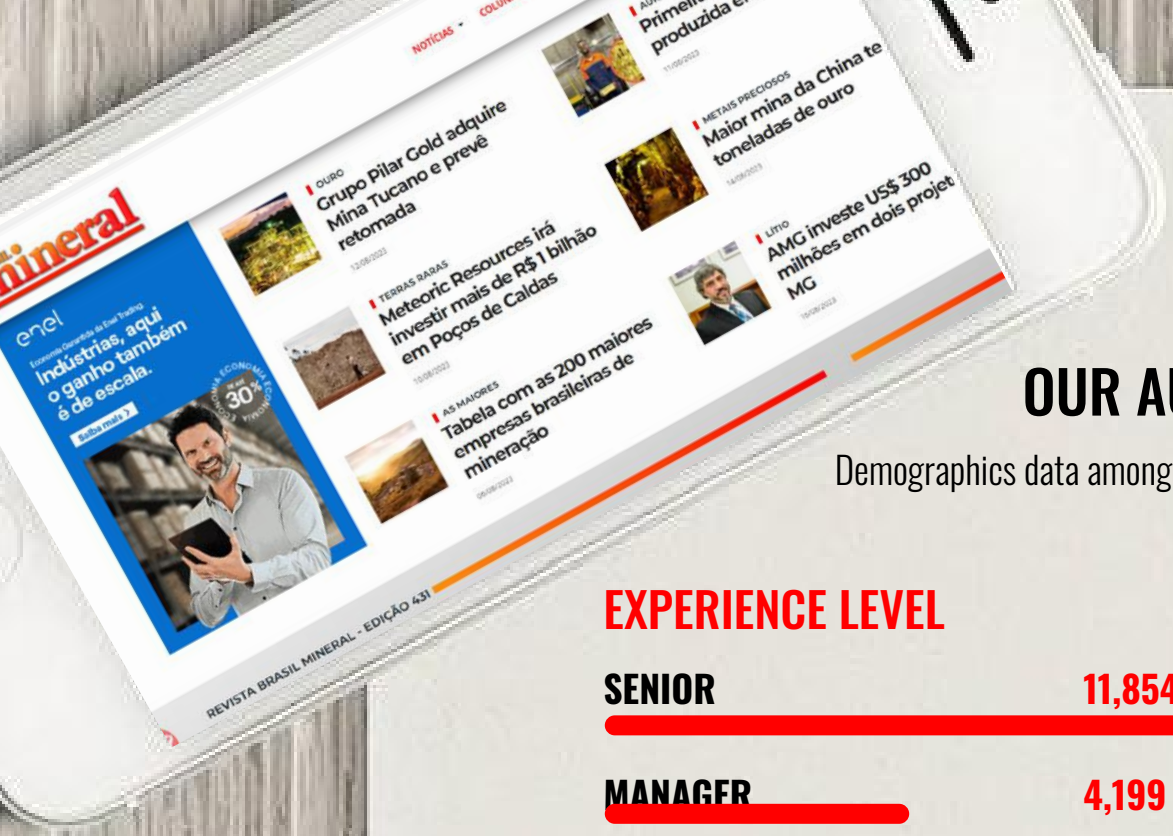

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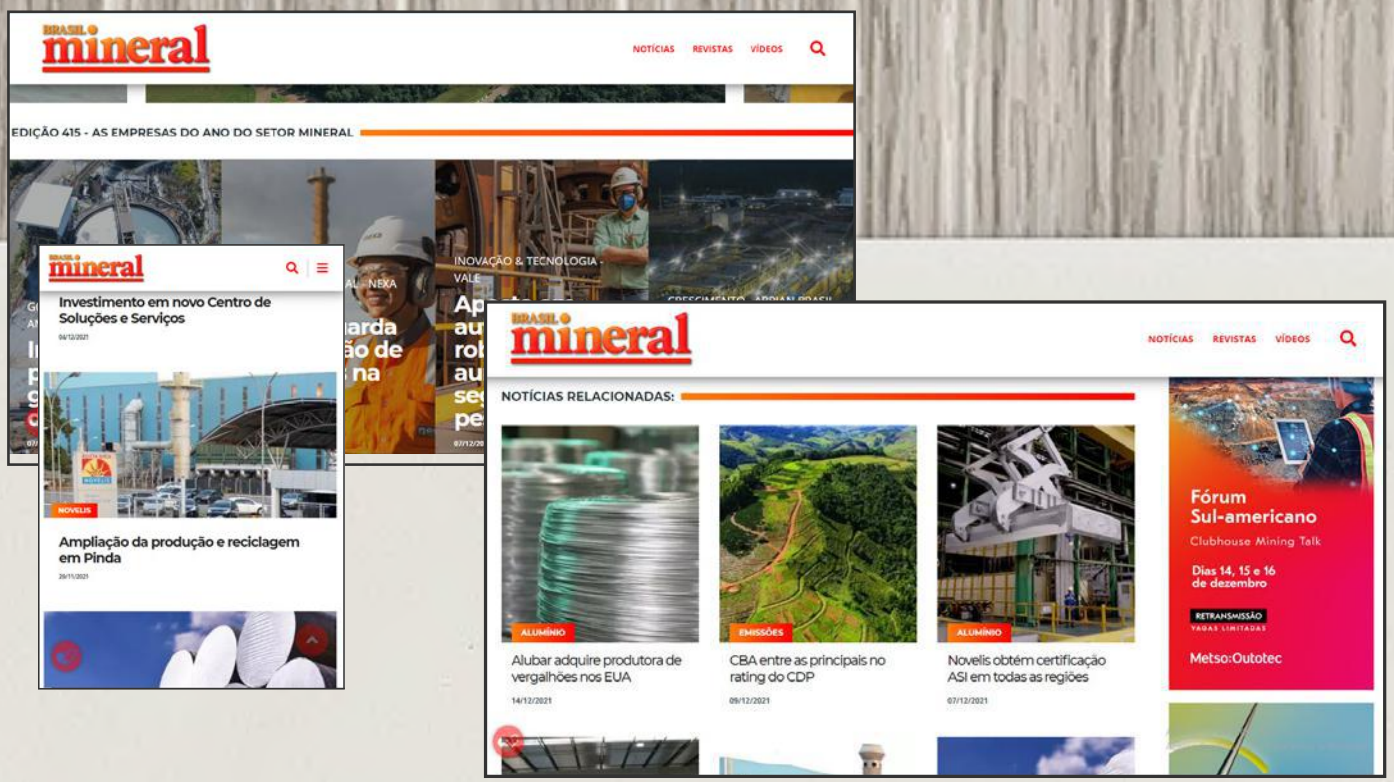

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