

Production, reserves and operations

Metals and minerals production	270
Ore reserves	273
Mineral resources	277
Competent Persons	280
Mines and production facilities	282



A train at our Brockman 4 iron ore mine in the Pilbara, Western Australia
Christian Sprogue photography

progress



Production, reserves and operations

Metals and minerals production

	Rio Tinto % share ^(a)	2019 Production		2018 Production		2017 Production	
		Total	Rio Tinto share	Total	Rio Tinto share	Total	Rio Tinto share
Alumina ('000 tonnes)							
Jonquière (Vaudreuil) (Canada) ^(b)	100.0%	1,413	1,413	1,444	1,444	1,448	1,448
Jonquière (Vaudreuil) specialty plant (Canada)	100.0%	109	109	124	124	122	122
Queensland Alumina (Australia)	80.0%	3,454	2,763	3,697	2,958	3,735	2,988
São Luis (Alumar) (Brazil)	10.0%	3,679	368	3,509	351	3,697	370
Yarwun (Australia)	100.0%	3,091	3,091	3,103	3,103	3,203	3,203
Rio Tinto total			7,744		7,980		8,131
Aluminium ('000 tonnes)							
Alma (Canada)	100.0%	472	472	465	465	457	457
Alouette (Sept-Îles) (Canada)	40.0%	602	241	584	234	598	239
Arvida (Canada)	100.0%	175	175	173	173	171	171
Arvida AP60 (Canada)	100.0%	60	60	52	52	57	57
Bécancour (Canada)	25.1%	77	19	136	34	438	110
Bell Bay (Australia)	100.0%	189	189	189	189	187	187
Boyne Island (Australia)	59.4%	499	296	497	295	508	302
Dunkerque (France) ^(c)	–	–	–	227	227	284	284
Grande-Baie (Canada)	100.0%	233	233	233	233	229	229
ISAL (Reykjavik) (Iceland)	100.0%	184	184	212	212	212	212
Kitimat (Canada)	100.0%	385	385	436	436	433	433
Laterrière (Canada)	100.0%	257	257	257	257	249	249
Sohar (Oman)	20.0%	391	78	380	76	253	51
Tiwai Point (New Zealand)	79.4%	351	279	341	270	337	267
Tomago (Australia)	51.6%	588	303	592	305	590	304
Rio Tinto total			3,171		3,458		3,551
Bauxite ('000 tonnes)							
Gove (Australia)	100.0%	12,201	12,201	12,540	12,540	11,201	11,201
Porto Trombetas (MRN) (Brazil)	12.0%	11,060	1,327	13,134	1,576	14,698	1,764
Sangaredi (Guinea)	23.0 ^(d)	13,701	6,165	13,039	5,868	15,409	6,934
Weipa (Australia)	100.0%	35,411	35,411	30,437	30,437	30,898	30,898
Rio Tinto total			55,105		50,421		50,796
Borates ('000 tonnes)^(e)							
Rio Tinto Borates – Boron (US)	100.0%	520	520	512	512	517	517
Coal (hard coking) ('000 tonnes)							
Rio Tinto Coal Australia							
Hail Creek Coal (Australia) ^{(f)(g)}	–	–	–	2,700	2,214	5,247	4,303
Kestrel Coal (Australia) ^{(f)(g)}	–	–	–	2,217	1,774	4,252	3,402
Rio Tinto total hard coking coal			–		3,988		7,704
Coal (semi-soft coking) ('000 tonnes)							
Rio Tinto Coal Australia							
Hunter Valley (Australia) ^(h)	–	–	–	–	–	1,529	1,034
Mount Thorley (Australia) ^(h)	–	–	–	–	–	876	700
Warkworth (Australia) ^(h)	–	–	–	–	–	514	286
Rio Tinto total semi-soft coking coal			–		–		2,020

Please see note on page 272.

Metals and minerals production

	2019 Production			2018 Production		2017 Production	
	Rio Tinto % share ^(a)	Total	Rio Tinto share	Total	Rio Tinto share	Total	Rio Tinto share
Coal (thermal) ('000 tonnes)							
Rio Tinto Coal Australia							
Hail Creek Coal (Australia) ^{(f)(g)}	–	–	–	2,760	2,264	4,134	3,390
Hunter Valley (Australia) ^(h)	–	–	–	–	–	8,502	5,747
Kestrel Coal (Australia) ^{(f)(g)}	–	–	–	329	263	843	674
Mount Thorley (Australia) ^(h)	–	–	–	–	–	2,011	1,609
Warkworth (Australia) ^(h)	–	–	–	–	–	4,521	2,512
Rio Tinto total thermal coal			–		2,527		13,933
Copper (mined) ('000 tonnes)							
Bingham Canyon (US)	100.0%	186.8	186.8	203.9	203.9	148.9	148.9
Escondida (Chile)	30.0%	1,138.6	341.6	1,167.9	350.4	902.7	270.8
Grasberg – Joint Venture (Indonesia) ⁽ⁱ⁾	–	–	–	64.8	25.9	14.3	5.7
Oyu Tolgoi (Mongolia) ^(j)	33.5%	146.3	49.1	159.1	53.3	157.4	52.8
Rio Tinto total			577.4		633.5		478.1
Copper (refined) ('000 tonnes)							
Escondida (Chile)	30.0%	250.2	75.0	266.8	80.0	238.0	71.4
Rio Tinto Kennecott (US)	100.0%	184.6	184.6	194.7	194.7	125.8	125.8
Rio Tinto total			259.6		274.8		197.2
Diamonds ('000 carats)							
Argyle (Australia)	100.0%	12,999	12,999	14,069	14,069	17,135	17,135
Diavik (Canada)	60.0%	6,719	4,031	7,264	4,358	7,486	4,492
Rio Tinto total			17,030		18,427		21,627
Gold (mined) ('000 ounces)							
Bingham Canyon (US)	100.0%	234.7	234.7	196.7	196.7	177.9	177.9
Escondida (Chile)	30.0%	246.7	74.0	265.6	79.7	146.2	43.9
Grasberg – Joint Venture (Indonesia) ⁽ⁱ⁾	–	–	–	666.8	266.7	–	–
Oyu Tolgoi (Mongolia) ^(j)	33.5%	241.8	81.1	285.4	95.7	114.3	38.3
Rio Tinto total			389.7		638.8		260.1
Gold (refined) ('000 ounces)							
Rio Tinto Kennecott (US)	100.0%	218.7	218.7	198.0	198.0	203.7	203.7
Iron Ore ('000 tonnes)							
Hamersley mines (Australia)	^(k)	209,392	209,392	220,612	220,612	206,760	206,760
Hamersley – Channar (Australia)	60.0%	7,970	4,782	7,173	4,304	10,798	6,479
Hope Downs (Australia)	50.0%	48,264	24,132	45,368	22,684	46,941	23,470
Iron Ore Company of Canada (Canada)	58.7%	17,943	10,536	15,245	8,952	19,016	11,166
Robe River – Robe Valley (Australia)	53.0%	26,951	14,284	31,947	16,932	31,182	16,526
Robe River – West Angelas (Australia)	53.0%	34,086	18,066	32,672	17,316	34,116	18,082
Rio Tinto total			281,192		290,800		282,484

Please see note on page 272.

Metals and minerals production continued

	Rio Tinto % share ^(a)	2019 Production		2018 Production		2017 Production	
		Total	Rio Tinto share	Total	Rio Tinto share	Total	Rio Tinto share
Molybdenum ('000 tonnes)							
Bingham Canyon (US)	100%	11.2	11.2	5.8	5.8	5.0	5.0
Salt ('000 tonnes)							
Dampier Salt (Australia)	68.4%	7,931	5,422	9,001	6,153	7,446	5,090
Silver (mined) ('000 ounces)							
Bingham Canyon (US)	100.0%	2,815	2,815	2,520	2,520	2,156	2,156
Escondida (Chile)	30.0%	7,687	2,306	9,433	2,830	5,707	1,712
Grasberg – Joint Venture (Indonesia) ⁽ⁱ⁾	–	–	–	634	253	–	–
Oyu Tolgoi (Mongolia) ^(j)	33.5%	867	290	914	306	974	326
Rio Tinto total			5,412		5,910		4,194
Silver (refined) ('000 ounces)							
Rio Tinto Kennecott (US)	100.0%	2,853	2,853	2,865	2,865	2,378	2,378
Titanium Dioxide Slag ('000 tonnes)							
Rio Tinto Iron & Titanium (Canada/South Africa) ^(k)	100.0%	1,206	1,206	1,116	1,116	1,315	1,315
Uranium ('000 lbs U3O8)							
Energy Resources of Australia (Australia) ^(m)	68.4%	3,860	2,640	4,407	3,014	5,056	3,458
Rössing (Namibia) ^{(m)(n)}	–	3,080	2,114	5,465	3,750	4,652	3,192
Rio Tinto total			4,754		6,764		6,650

Production data notes:

Mine production figures for metals refer to the total quantity of metal produced in concentrates, leach liquor or doré bullion irrespective of whether these products are then refined onsite, except for the data for bauxite and iron ore which can represent production of marketable quantities of ore plus concentrates and pellets. Production figures are sometimes more precise than the rounded numbers shown, hence small differences may result from calculation of Rio Tinto share of production.

- (a) Rio Tinto percentage share, shown above, is as at the end of 2019. The footnotes below include all ownership changes over the three years.
- (b) Jonquière's (Vaudreuil's) production shows smelter grade alumina only and excludes hydrate produced and used for specialty alumina.
- (c) Rio Tinto sold its 100 per cent interest in the Dunkerque aluminium smelter with an effective date of 14 December 2018. Production data are shown up to that date.
- (d) Rio Tinto has a 22.95 per cent shareholding in the Sangaredi mine but benefits from 45.0 per cent of production.
- (e) Borate quantities are expressed as B₂O₃.
- (f) Kestrel and Hail Creek produced hard coking coal and thermal coal through their mining operations. Both mines blended coal types at ports.
- (g) On 1 August 2018, Rio Tinto completed the sale of its entire interest in the Hail Creek and Kestrel mines. Production is reported up to the date of completion.
- (h) On 1 September 2017, Rio Tinto completed the sale of Coal & Allied, a wholly owned subsidiary of Rio Tinto Coal Australia (RTCA) and production from these assets is included to this date. This included Coal & Allied's 67.6 per cent interest in the Hunter Valley Operations mine, 80 per cent interest in the Mount Thorley mine and 55.6 per cent interest in the Warkworth mine. In an earlier restructuring of the Coal & Allied group completed on 3 February 2016, Rio Tinto had obtained 100 per cent of Coal & Allied and retained a 67.6 per cent interest in the newly created Hunter Valley Operations joint venture. Prior to restructuring, Rio Tinto's interest in the Hunter Valley Operations, Mount Thorley and Warkworth mines was 80 per cent, 64 per cent and 44.46 per cent respectively.
- (i) On 21 December 2018, Rio Tinto completed the sale of its entire interest in the Grasberg mine in Indonesia to PT Indonesia Asahan Aluminium (Persero) (Inalum). Production is reported up to 30 November 2018. Through a joint venture agreement with Freeport-McMoRan (FCX), Rio Tinto was entitled to 40 per cent of additional material mined as a consequence of expansions and developments of the Grasberg facilities since 1998. Total production reflects the quantities attributable to the joint venture.
- (j) Rio Tinto owns a 33.52 per cent indirect interest in Oyu Tolgoi through its 50.79 per cent interest in Turquoise Hill Resources Ltd.
- (k) Includes 100 per cent of production from Paraburdoo, Mt Tom Price, Marandoo, Yandicoogina, Brockman, Nammuldi, Silvergrass and the Eastern Range mines. Whilst Rio Tinto owns 54 per cent of the Eastern Range mine, under the terms of the joint venture agreement, Hamersley Iron manages the operation and is obliged to purchase all mine production from the joint venture and therefore all of the production is included in Rio Tinto's share of production.
- (l) Quantities comprise 100 per cent of Rio Tinto Fer et Titane and Rio Tinto's 74 per cent share of Richards Bay Minerals' production. Ilmenite mined in Madagascar is processed in Canada.
- (m) ERA and Rössing report drummed U₃O₈.
- (n) On 16 July 2019, Rio Tinto completed the sale of its entire interest in the Rössing uranium mine in Namibia to China National Uranium Corporation Limited.

Ore reserves

Ore Reserves and Mineral Resources for Rio Tinto managed operations are reported in accordance with the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves, December 2012 (the JORC Code) as required by the Australian Securities Exchange (ASX). Codes or guidelines similar to JORC with only minor regional variations have been adopted in South Africa, Canada, the US, Chile, Peru, the Philippines, the UK, Ireland and Europe. Together these Codes represent current best practice for reporting Ore Reserves and Mineral Resources.

The JORC Code envisages the use of reasonable investment assumptions, including the use of projected long-term commodity prices, in calculating Ore Reserve estimates. However, for US reporting, the US Securities and Exchange Commission requires historical price data to be used. For this reason, some Ore Reserves reported to the SEC in the Form 20-F may differ from those reported below.

Ore Reserve and Mineral Resource information in the tables below is based on information compiled by Competent Persons (as defined by JORC), most of whom are full time employees of Rio Tinto or related companies. Each has had a minimum of five years relevant estimation experience and is a member of a recognised professional body whose members are bound by a professional code of ethics. Each Competent Person consents to the inclusion in this report of information they have provided in the form and context in which it appears.

Competent Persons responsible for the estimates are listed on pages 280 to 281, by operation, along with their professional affiliation, employer and accountability for Ore Reserves and/or Mineral Resources. Where operations are not managed by Rio Tinto, the Ore Reserves are published as received from the managing company. The Ore Reserve figures in the following tables are as of 31 December 2019. Summary data for year end 2018 are shown for comparison. Metric units are used throughout. The figures used to calculate Rio Tinto's share of Ore Reserves are often more precise than the rounded numbers shown in the tables, hence small differences might result if the calculations are repeated using the tabulated figures.

Type of mine ^(a)	Proved ore reserves at end 2019				Probable ore reserves at end 2019				Total ore reserves 2019 compared with 2018				Average mill recovery %	Interest %	Rio Tinto share
	Tonnage		Grade		Tonnage		Grade		2019	2018	2019	2018			
	of tonnes	% Al ₂ O ₃	of tonnes	% Al ₂ O ₃	of tonnes	of tonnes	% Al ₂ O ₃	% Al ₂ O ₃	Tonnage	Tonnage	Grade	Grade			
Bauxite^(b)	millions of tonnes	% Al ₂ O ₃	millions of tonnes	% Al ₂ O ₃	millions of tonnes	millions of tonnes	% Al ₂ O ₃	% Al ₂ O ₃	millions of tonnes	millions of tonnes	% Al ₂ O ₃	% Al ₂ O ₃			Recoverable mineral
															millions of tonnes
Reserves at operating mines															
Gove (Australia) ^(c)	O/P	127	49.3	4	49.5	131	142	49.3	49.3				100.0		131
Porto Trombetas (MRN) (Brazil) ^(d)	O/P	29	48.3	4	48.8	33	48	48.3	50.1				12.0		4
Sangaredi (Guinea) ^(e)	O/P	341	47.0	87	47.1	428	466	47.1	47.3				23.0		98
Weipa (Australia) ^(f)															
– Amrun ^(g)	O/P	273	52.7	981	53.2	1,253	1,104	53.1	53.2				100.0		1,253
– East Weipa and Andoom ^(h)	O/P	146	50.8			146	163	50.8	50.5				100.0		146
Total															1,632
															Marketable product
															millions of tonnes
Borates⁽ⁱ⁾		millions of tonnes		millions of tonnes		millions of tonnes	millions of tonnes								
Reserves at operating mine															
Rio Tinto Borates – Boron (US)	O/P	12		4.4		16	15						100.0		16
															Recoverable metal
															millions of tonnes
Copper		millions of tonnes	% Cu	millions of tonnes	% Cu	millions of tonnes	millions of tonnes	% Cu	% Cu						
Reserves at operating mines															
Bingham Canyon (US)	O/P	399	0.45	213	0.38	612	619	0.43	0.42				87	100.0	2,277
Escondida (Chile)															
– sulphide	O/P	3,517	0.70	1,849	0.56	5,366	5,564	0.65	0.66				85	30.0	8,841
– sulphide leach	O/P	1,308	0.42	335	0.41	1,642	1,728	0.42	0.41				39	30.0	0,793
– oxide	O/P	102	0.65	122	0.54	224	247	0.59	0.60				62	30.0	0,246
Oyu Tolgoi (Mongolia)															
– Oyut open pit ^(j)	O/P	307	0.52	477	0.39	783	878	0.44	0.43				78	33.5	0,907
– Oyut stockpiles		48	0.33			48	53	0.33	0.31				73	33.5	0,038
Total															13,103
Reserves at development projects															
Oyu Tolgoi (Mongolia)															
– Hugo Dummett North ^(k)	U/G			447	1.64	447	464	1.64	1.66				93	33.5	2,283
– Hugo Dummett North Extension	U/G			32	1.64	32	35	1.64	1.59				93	29.5	0,144
Total															2,428

Ore reserves continued

Type of mine ^(a)	Total ore reserves 2019 compared with 2018								Average mill recovery %	Interest %	Rio Tinto share	
	Proved ore reserves at end 2019		Probable ore reserves at end 2019		2019		2018					
	Tonnage	Grade	Tonnage	Grade	Tonnage	Grade	Tonnage	Grade				
Diamonds^(b)	millions of tonnes	carats per tonne	millions of tonnes	carats per tonne	millions of tonnes	carats per tonne	millions of tonnes	carats per tonne			Recoverable diamonds	
											millions of carats	
Reserves at operating mines												
Argyle (Australia) ⁽ⁱ⁾	U/G			5.1	1.9	5.1	11	1.9	2.2	100.0	9.5	
Diavik (Canada) ^(m)	O/P + U/G	5.2	2.4	5.3	2.4	11	12	2.4	2.4	60.0	14.9	
Total											24.4	
Reserves at development projects												
		millions of tonnes	grammes per tonne	millions of tonnes	grammes per tonne	millions of tonnes	grammes per tonne	grammes per tonne	grammes per tonne		Recoverable metal	
Gold											millions of ounces	
Reserves at operating mines												
Bingham Canyon (US)	O/P	399	0.17	213	0.15	612	619	0.16	0.17	67	100.0	2.158
Oyu Tolgoi (Mongolia)												
– Oyut open pit ⁽ⁱ⁾	O/P	307	0.39	477	0.23	783	878	0.29	0.27	67	33.5	1.622
– Oyut stockpiles		48	0.12			48	53	0.12	0.13	44	33.5	0.028
Total												3.807
Reserves at development projects												
Oyu Tolgoi (Mongolia)												
– Hugo Dummett North ^(k)	U/G			447	0.34	447	464	0.34	0.34	79	33.5	1.287
– Hugo Dummett North Extension	U/G			32	0.57	32	35	0.57	0.55	81	29.5	0.140
Total												1.427
Reserves at development projects												
		millions of tonnes	% Fe	millions of tonnes	% Fe	millions of tonnes	millions of tonnes	% Fe	% Fe		Marketable product	
Iron Ore^{(n)(b)}											millions of tonnes	
Reserves at operating mines												
Hammersley Iron (Australia)												
– Greater Brockman 2 Nammuldi (Brockman and Marra Mamba ore) ^(o)	O/P	192	61.8	105	59.9	298	362	61.1	61.5	100.0	298	
– Brockman 4 (Brockman and Marra Mamba ore)	O/P	264	62.3	81	60.4	345	365	61.9	62.1	100.0	345	
– Marandoo (Marra Mamba ore)	O/P	149	63.9	47	58.2	196	192	62.5	62.9	100.0	196	
– Greater Tom Price (Brockman and Marra Mamba ore)	O/P	194	62.4	119	61.6	313	332	62.1	62.0	100.0	313	
– Paraburdoo (Brockman ore) ^(p)	O/P	2	61.6	5	62.4	7	9	62.2	62.6	100.0	7	
– Yandicoogina (Pisolite ore)	O/P	509	58.3			509	549	58.3	58.4	100.0	509	
Channar JV (Australia)												
– Channar (Brockman ore) ^(q)	O/P	10	61.7	6	61.0	16	24	61.4	61.1	60.0	9	
Eastern Range JV (Australia)												
– Eastern Range (Brockman ore) ⁽ⁱ⁾	O/P	23	61.8	5	60.8	28	43	61.6	61.3	54.0	15	
Hope Downs JV (Australia)												
– Hope Downs 1 (Marra Mamba ore) ^(s)	O/P	85	62.7	81	60.1	165	188	61.4	61.5	50.0	83	
– Hope Downs 4 (Brockman ore) ⁽ⁱ⁾	O/P	50	63.7	65	63.2	116	133	63.4	63.4	50.0	58	
Robe River JV (Australia)												
– Robe Valley (Pisolite ore)	O/P	127	56.7	217	56.2	344	370	56.4	56.4	53.0	182	
– West Angelas (Marra Mamba ore) ⁽ⁱ⁾	O/P	128	62.1	74	61.4	201	233	61.9	61.9	53.0	107	
Iron Ore Company of Canada (Canada) ^(v)	O/P	237	65.0	291	65.0	528	545	65.0	65.0	58.7	310	
Total												2,431
Reserves at development projects												
Hammersley Iron (Australia)												
– Koodaideri (Brockman ore) ^(w)	O/P	214	62.4	302	61.2	516	549	61.7	61.8	100.0	516	
– Turee Central (Brockman ore)	O/P	72	62.0	6	61.4	78	78	61.9	61.9	100.0	78	
– Western Range (Brockman ore) ^(x)	O/P	171	62.7	29	61.4	201	–	62.5	–	100.0	201	
Total												795

Ore reserves

	Type of mine ^(a)	Proved ore reserves at end 2019		Probable ore reserves at end 2019		Total ore reserves 2019 compared with 2018				Average mill recovery %	Interest %	Rio Tinto share
		Tonnage	Grade	Tonnage	Grade	2019	2018	2019	2018			
						Tonnage	Tonnage	Grade	Grade			
Molybdenum		millions of tonnes	% Mo	millions of tonnes	% Mo	millions of tonnes	millions of tonnes	% Mo	% Mo			Recoverable metal millions of tonnes
Reserves at operating mine												
Bingham Canyon (US) ^(b)	O/P	399	0.041	213	0.020	612	619	0.034	0.035	66	100.0	0.136
Silver												
		millions of tonnes	grammes per tonne	millions of tonnes	grammes per tonne	millions of tonnes	millions of tonnes	grammes per tonne	grammes per tonne			Recoverable metal millions of ounces
Reserves at operating mines												
Bingham Canyon (US)	O/P	399	2.03	213	2.04	612	619	2.04	2.04	72	100.0	28.840
Oyu Tolgoi (Mongolia)												
– Oyut open pit ^(c)	O/P	307	1.32	477	1.14	783	878	1.21	1.18	52	33.5	5.356
– Oyut stockpiles		48	0.93			48	53	0.93	0.95	47	33.5	0.226
Total												34.422
Reserves at development projects												
Oyu Tolgoi (Mongolia)												
– Hugo Dummett North ^(d)	U/G			447	3.35	447	464	3.35	3.37	81	33.5	13.078
– Hugo Dummett North Extension	U/G			32	3.84	32	35	3.84	3.72	83	29.5	0.969
Total												14.047

Ore reserves continued

Type of mine ^(a)	Total ore reserves 2019 compared with 2018								Average mill recovery %	Interest %	Rio Tinto share
	Proved ore reserves at end 2019		Probable ore reserves at end 2019		2019		2018				
	Tonnage	Grade	Tonnage	Grade	Tonnage	Grade	Tonnage	Grade			
Titanium Dioxide Feedstock^(c)	millions of tonnes	%Ti Minerals	millions of tonnes	%Ti Minerals	millions of tonnes	%Ti Minerals	millions of tonnes	%Ti Minerals			Marketable product millions of tonnes
Reserves at operating mines											
QMM (Madagascar)	D/O	369	3.5	13	3.5	382	405	3.5	3.5	80.0	5.3
RBM (South Africa)	D/O+O/P	878	2.3	622	2.5	1,500	1,584	2.4	2.4	74.0	11.7
RTFT (Canada) ^(aa)	O/P			149	80.3	149	119	80.3	83.2	100.0	47.4
Total											64.4
Uranium	millions of tonnes	% U ₃ O ₈	millions of tonnes	% U ₃ O ₈	millions of tonnes	% U ₃ O ₈	millions of tonnes	% U ₃ O ₈	% U ₃ O ₈		Recoverable metal millions of tonnes
Reserves at operating mines											
Energy Resources of Australia (Australia)											
– Ranger #3 stockpiles ^(bb)			2.4	0.071	2.4	4.9	0.071	0.076	85	68.4	0.0010
Rössing SJ (Namibia) ^(cc)	O/P					–	72	–	0.039	–	–
Total											0.0010
Zircon^(dd)	millions of tonnes	% Zircon	millions of tonnes	% Zircon	millions of tonnes	% Zircon	millions of tonnes	% Zircon	% Zircon		Marketable product millions of tonnes
Reserves at operating mines											
QMM (Madagascar)	D/O	369	0.2	13	0.2	382	405	0.2	0.2	80.0	0.4
RBM (South Africa)	D/O+O/P	878	0.3	622	0.4	1,500	1,584	0.3	0.3	74.0	3.0
Total											3.4

- (a) Type of mine: O/P = open pit, O/C = open cut, U/G = underground, D/O = dredging operation.
- (b) Reserves of bauxite, diamonds and iron ore are shown as recoverable Reserves of marketable product after accounting for all mining and processing losses. Mill recoveries are therefore not shown.
- (c) Gove Reserves are stated as dry tonnes and total alumina grade.
- (d) Porto Trombetas (MRN) Reserves are stated as dry tonnes and available alumina grade. Reserve tonnes decreased following mining depletion and an updated life of mine plan.
- (e) Sangaredi Reserves tonnes are reported on a 3% moisture basis and alumina grades are reported as total alumina.
- (f) Weipa Reserves are stated as dry tonnes and total alumina grade.
- (g) Amrun Reserves tonnes increased as a result of updated mining cost assumptions and a new geological model incorporating additional drilling.
- (h) East Weipa and Andoom Reserves tonnes decreased following mining depletion, technical risk assessment and cut-off grade changes.
- (i) Reserves of borates are expressed in terms of marketable product (B₂O₃) after all mining and processing losses.
- (j) Oyut open pit Reserves tonnes decreased following mining depletion and an update to operating cost assumptions.
- (k) The Hugo Dummett North underground mine is currently under construction.
- (l) Argyle Reserves are based on a 1.4 millimetre lower cut-off size and a final re-crushing size of 8 millimetres. The decrease in Reserves tonnes and grade follows mining depletion.
- (m) Diavik Reserves are based on a nominal 1 millimetre lower cut-off size and a final re-crushing size of 5 millimetres.
- (n) Australian iron ore Reserves tonnes are reported on a dry weight basis. As Rio Tinto only markets blended iron ore products from multiple mine sources, a detailed breakdown of constituent elements by individual deposit is not reported.
- (o) Greater Brockman 2 Nammuldi (Brockman and Marra Mamba ore) Reserves tonnes decreased due to mining depletion and updates to the geological model, Resource classification and mining recovery factors. The reductions are partially offset by pit design changes.
- (p) Paraburdoo (Brockman ore) Reserves tonnes decreased following mining depletion.
- (q) Channar (Brockman ore) Reserves tonnes decreased due to mining depletion, updated pit designs and mining recovery factors.
- (r) Eastern Range (Brockman ore) Reserves tonnes decreased due to mining depletion, updates to the geological model and pit designs, and cut-off grade changes.
- (s) Hope Downs 1 (Marra Mamba ore) Reserves tonnes decreased following mining depletion.
- (t) Hope Downs 4 (Brockman ore) Reserves tonnes decreased following mining depletion.
- (u) West Angelas (Marra Mamba ore) Reserves tonnes decreased following mining depletion and an updated geological model, partially offset by the addition of a satellite pit.
- (v) Reserves at Iron Ore Company of Canada are reported as marketable product (57% pellets and 43% concentrate for sale) at a natural moisture content of two per cent. The marketable product is derived from mined material comprising 560 million dry tonnes at 38.6% iron (Proved) and 693 million dry tonnes at 38.1% iron (Probable) using process recovery factors derived from current IOC concentrating and pellet operations.
- (w) The Koodaideri (Brockman ore) mine is currently under construction.
- (x) Western Range (Brockman ore) Reserves are reported for the first time following completion of a Pre-Feasibility Study. A JORC Table 1 in support of this change will be released to the market contemporaneously with the release of this Annual report and can be viewed at riotinto.com/invest/financial-news-performance/resources-and-reserves. Discussions about a Joint Venture covering the Western Range mining hub with China Baowu Group are continuing.
- (y) Bingham Canyon Reserves molybdenum grades interpolated from exploration drilling assays have been factored based on a long reconciliation history to blast hole and mill samples.
- (z) The marketable product (TiO₂ slag) is shown after all mining and processing losses. The Reserves are expressed as in situ tonnes.
- (aa) RTFT Reserves tonnes increased following a decrease in the cut-off grade.
- (bb) The decrease in Ranger #3 stockpiles Reserves tonnes follows processing depletion.
- (cc) Released to the market by Rio Tinto on 16 July 2019, Rio Tinto sold its interest in the Rössing uranium mine.
- (dd) The marketable product (zircon at RBM and zirsil at QMM) is shown after all mining and processing losses. The Reserves are expressed as in situ tonnes.

Mineral resources

As required by the Australian Securities Exchange, the following tables contain details of other mineralisation that has a reasonable prospect of being economically extracted in the future but which is not yet classified as Proved or Probable Ore Reserves. This material is defined as Mineral Resources under the JORC Code. Estimates of such material are based largely on geological information with only preliminary consideration of mining, economic and other factors. While in the judgment of the Competent Person there are realistic expectations that all or part of the Mineral Resources will eventually become Proved or Probable Ore Reserves, there is no guarantee that this will occur as

the result depends on further technical and economic studies and prevailing economic conditions in the future. As in the case of Ore Reserves, managed operations' estimates are completed using or testing against Rio Tinto long-term pricing and market forecasts/scenarios. Mineral Resources are stated as additional to the Ore Reserves reported earlier. Where operations are not managed by Rio Tinto, the Mineral Resources are published as received from the managing company. Where new project Mineral Resources or Ore Reserves are footnoted as being reported for the first time, additional information about them can be viewed on the Rio Tinto website.

	Likely mining method ^(a)	Measured resources at end 2019		Indicated resources at end 2019		Inferred resources at end 2019		Total resources 2019 compared with 2018				Rio Tinto Interest %
								2019	2018	2019	2018	
		Tonnage	Grade	Tonnage	Grade	Tonnage	Grade	Tonnage	Tonnage	Grade	Grade	
Bauxite		millions of tonnes	% Al ₂ O ₃	millions of tonnes	% Al ₂ O ₃	millions of tonnes	% Al ₂ O ₃	millions of tonnes	millions of tonnes	% Al ₂ O ₃	% Al ₂ O ₃	
Gove (Australia) ^(b)	O/P	15	48.9	12	47.5	1	48.2	28	28	48.2	48.2	100.0
Porto Trombetas (MRN) (Brazil) ^(c)	O/P	281	49.7	41	48.9	134	49.9	456	456	49.7	49.7	12.0
Sangaredi (Guinea) ^(d)	O/P	165	43.9	5,835	46.6	785	45.8	6,785	5,660	46.5	47.2	23.0
Weipa (Australia) ^(e)												
– East Weipa and Andoom ^(f)	O/P	11	52.1					11	15	52.1	49.5	100.0
– North of Weipa	O/P					1,330	52.0	1,330	1,330	52.0	52.0	100.0
– Amrun	O/P	35	48.7	271	49.8	274	50.5	580	635	50.1	49.9	100.0
Borates^(g)		millions of tonnes		millions of tonnes		millions of tonnes		millions of tonnes	millions of tonnes			
Jadar (Serbia) ^(h)	U/G			10		11		21	21			100.0
Copper		millions of tonnes	% Cu	millions of tonnes	% Cu	millions of tonnes	% Cu	millions of tonnes	millions of tonnes	% Cu	% Cu	
Bingham Canyon (US)												
– Open Pit ⁽ⁱ⁾	O/P	14	0.46	18	0.44	11	0.22	42	82	0.39	0.28	100.0
– North Rim Skarn	U/G	1	3.50	9	3.60	10	3.70	20	20	3.65	3.65	100.0
Escondida (Chile)												
– Chimborazo sulphide	O/P			139	0.50	84	0.60	223	223	0.54	0.54	30.0
– Escondida sulphide	O/P	523	0.59	1,255	0.44	10,156	0.53	11,934	11,763	0.52	0.51	30.0
– Escondida mixed ^(j)	O/P	13	0.53	17	0.47	26	0.43	56	55	0.47	0.41	30.0
– Escondida oxide ^(j)	O/P	22	0.76	8	0.55	5	0.49	35	23	0.67	0.63	30.0
– Pampa Escondida sulphide	O/P	294	0.53	1,150	0.55	6,000	0.43	7,444	7,444	0.45	0.45	30.0
– Pinta Verde sulphide	O/P			23	0.50	37	0.45	60	60	0.47	0.47	30.0
– Pinta Verde oxide	O/P	109	0.60	64	0.53	15	0.54	188	188	0.57	0.57	30.0
La Granja (Peru)	O/P			130	0.85	4,190	0.50	4,320	4,320	0.51	0.51	100.0
Oyu Tolgoi (Mongolia)												
– Heruga ETG ^(k)	U/G					1,448	0.41	1,448	1,700	0.41	0.39	29.5
– Heruga OT ^(k)	U/G					105	0.42	105	117	0.42	0.41	33.5
– Hugo Dummett North ^(l)	U/G	41	1.58	349	1.18	765	0.80	1,155	1,213	0.94	0.91	33.5
– Hugo Dummett North Extension	U/G			87	1.59	167	1.02	254	263	1.21	1.19	29.5
– Hugo Dummett South ^(m)	U/G					724	0.84	724	839	0.84	0.77	33.5
– Oyut Open Pit	O/P	16	0.39	80	0.34	318	0.29	413	449	0.31	0.31	33.5
– Oyut Underground ⁽ⁿ⁾	U/G	14	0.47	69	0.38	175	0.39	257	300	0.39	0.37	33.5
Resolution (US)	U/G			530	1.92	1,257	1.36	1,787	1,787	1.53	1.53	55.0
Diamonds		millions of tonnes	carats per tonne	millions of tonnes	carats per tonne	millions of tonnes	carats per tonne	millions of tonnes	millions of tonnes	carats per tonne	carats per tonne	
Diavik (Canada) ^(o)	O/P+U/G			0.1	3.2	1.3	2.6	1.5	2.6	2.7	2.6	60.0
Gold		millions of tonnes	grammes per tonne	millions of tonnes	grammes per tonne	millions of tonnes	grammes per tonne	millions of tonnes	millions of tonnes	grammes per tonne	grammes per tonne	
Bingham Canyon (US)												
– Open Pit ⁽ⁱ⁾	O/P	14	0.13	18	0.15	11	0.24	42	82	0.17	0.10	100.0
– North Rim Skarn	U/G	1	2.10	9	1.70	10	1.50	20	20	1.62	1.62	100.0

Mineral resources continued

	Likely mining method ^(a)	Measured resources at end 2019		Indicated resources at end 2019		Inferred resources at end 2019		Total resources 2019 compared with 2018				Rio Tinto Interest %
		Tonnage	Grade	Tonnage	Grade	Tonnage	Grade	2019	2018	2019	2018	
		millions of tonnes	grammes per tonne	millions of tonnes	grammes per tonne	millions of tonnes	grammes per tonne	Tonnage	Tonnage	Grade	Grade	
Gold (continued)												
Escondida (Chile)												
– Pampa Escondida sulphide	O/P	294	0.07	1,150	0.10	6,000	0.04	7,444	7,444	0.05	0.05	30.0
Oyu Tolgoi (Mongolia)												
– Heruga ETG ^(k)	U/G					1,448	0.40	1,448	1,700	0.40	0.37	29.5
– Heruga OT ^(k)	U/G					105	0.30	105	117	0.30	0.29	33.5
– Hugo Dummett North ^(l)	U/G	41	0.42	349	0.31	765	0.28	1,155	1,213	0.29	0.28	33.5
– Hugo Dummett North Extension	U/G			87	0.54	167	0.36	254	263	0.42	0.41	29.5
– Hugo Dummett South ^(m)	U/G					724	0.07	724	839	0.07	0.07	33.5
– Oyut Open Pit	O/P	16	0.41	80	0.29	318	0.17	413	449	0.21	0.18	33.5
– Oyut Underground ⁽ⁿ⁾	U/G	14	0.88	69	0.59	175	0.40	257	300	0.48	0.48	33.5
Iron Ore^(a)												
		millions of tonnes	% Fe	millions of tonnes	% Fe	millions of tonnes	% Fe	millions of tonnes	millions of tonnes	% Fe	% Fe	
Hamersley Iron (Australia)												
– Brockman	O/P	267	62.1	786	62.4	2,309	62.1	3,362	3,289	62.2	62.2	100.0
– Brockman Process Ore	O/P	259	57.2	221	57.1	695	57.4	1,175	1,170	57.3	57.3	100.0
– Marra Mamba	O/P	205	62.2	315	61.7	1,105	61.3	1,625	1,685	61.5	61.5	100.0
– Detrital	O/P			113	61.5	668	61.0	781	814	61.1	61.0	100.0
– Channel Iron Deposit	O/P	512	56.8	264	56.6	1,962	56.7	2,738	2,999	56.7	56.8	100.0
Channar JV (Australia)												
– Brockman	O/P	25	62.1	5	61.9	9	61.7	39	41	62.0	62.0	60.0
– Brockman Process Ore ^(o)	O/P	12	57.4	2	57.0	1	56.9	15	17	57.3	57.4	60.0
Eastern Range JV (Australia)												
– Brockman	O/P	14	61.9	5	61.8	1	61.3	20	21	61.8	61.8	54.0
– Brockman Process Ore	O/P	11	56.8	3	57.0	1	57.0	15	15	56.9	56.7	54.0
Hope Downs JV (Australia)												
– Brockman	O/P	101	62.5	325	62.4	245	62.1	671	666	62.3	62.4	50.0
– Brockman Process Ore	O/P	44	57.0	168	56.8	175	55.9	387	384	56.4	56.5	50.0
– Marra Mamba	O/P	136	62.9	124	61.6	154	60.7	414	423	61.7	61.7	50.0
– Detrital	O/P			23	59.2	83	59.6	106	106	59.5	59.4	50.0
Rhodes Ridge JV (Australia)												
– Brockman	O/P			565	63.9	1,462	62.6	2,027	2,027	62.9	62.9	50.0
– Brockman Process Ore	O/P			176	57.6	484	56.5	660	660	56.8	56.8	50.0
– Marra Mamba	O/P			25	61.3	2,566	62.0	2,591	2,614	62.0	61.9	50.0
– Detrital	O/P					328	60.1	328	328	60.1	60.1	50.0
Robe JV (Australia)												
– Brockman	O/P			156	62.5	490	61.3	646	618	61.6	61.6	53.0
– Brockman Process Ore	O/P			75	56.8	415	56.7	490	488	56.7	56.7	53.0
– Marra Mamba	O/P	151	61.9	197	61.4	166	61.5	514	527	61.6	61.4	53.0
– Detrital	O/P			22	59.5	100	61.1	122	124	60.8	60.8	53.0
– Channel Iron Deposit	O/P	211	55.2	1,625	58.6	2,442	55.7	4,278	4,303	56.8	56.8	53.0
Iron Ore Company of Canada (Canada) ^(s)	O/P	151	41.0	669	38.4	972	38.1	1,792	1,916	38.4	38.5	58.7
Simandou (Guinea) ^(t)	O/P	324	66.8	1,709	65.3	723	65.1	2,757	2,757	65.5	65.5	45.1
Lithium												
		millions of tonnes	% Li ₂ O	millions of tonnes	% Li ₂ O	millions of tonnes	% Li ₂ O	millions of tonnes	millions of tonnes	% Li ₂ O	% Li ₂ O	
Jadar (Serbia)	U/G			53	1.8	83	1.9	136	136	1.9	1.9	100.0
Molybdenum												
		millions of tonnes	% Mo	millions of tonnes	% Mo	millions of tonnes	% Mo	millions of tonnes	millions of tonnes	% Mo	% Mo	
Bingham Canyon (US)												
– Open Pit ^(u)	O/P	14	0.031	18	0.017	11	0.003	42	82	0.018	0.043	100.0
Oyu Tolgoi (Mongolia)												
– Heruga ETG ^(k)	U/G					1,448	0.012	1,448	1,700	0.012	0.011	29.5
– Heruga OT ^(k)	U/G					105	0.011	105	117	0.011	0.011	33.5
Resolution (US)	U/G			530	0.039	1,257	0.035	1,787	1,787	0.036	0.036	55.0

Mineral resources

	Likely mining method ^(a)	Measured resources at end 2019		Indicated resources at end 2019		Inferred resources at end 2019		Total resources 2019 compared with 2018				Rio Tinto Interest %
								2019		2018		
		Tonnage	Grade	Tonnage	Grade	Tonnage	Grade	Tonnage	Grade	Tonnage	Grade	
Silver		millions of tonnes	grammes per tonne	millions of tonnes	grammes per tonne	millions of tonnes	grammes per tonne	millions of tonnes	grammes per tonne	millions of tonnes	grammes per tonne	
Bingham Canyon (US)												
– Open Pit ^(b)	O/P	14	1.90	18	2.21	11	2.18	42	82	2.10	1.54	100.0
– North Rim Skarn	U/G	1	20.00	9	21.00	10	21.00	20	20	20.95	20.95	100.0
Oyu Tolgoi (Mongolia)												
– Heruga ETG ^(k)	U/G					1,448	1.46	1,448	1,700	1.46	1.39	29.5
– Heruga OT ^(k)	U/G					105	1.58	105	117	1.58	1.56	33.5
– Hugo Dummett North ^(l)	U/G	41	3.74	349	2.92	765	2.40	1,155	1,213	2.61	2.54	33.5
– Hugo Dummett North Extension	U/G			87	4.11	167	2.78	254	263	3.24	3.18	29.5
– Hugo Dummett South ^(m)	U/G					724	1.88	724	839	1.88	1.78	33.5
– Oyut Open Pit	O/P	16	1.21	80	1.17	318	1.03	413	449	1.06	1.04	33.5
– Oyut Underground ⁽ⁿ⁾	U/G	14	1.27	69	1.11	175	1.21	257	300	1.19	1.18	33.5
Titanium dioxide feedstock		millions of tonnes	% Ti Minerals	millions of tonnes	% Ti Minerals	millions of tonnes	% Ti Minerals	millions of tonnes	millions of tonnes	% Ti Minerals	% Ti Minerals	
QMM (Madagascar)												
	D/O	469	4.2	804	4.3	154	3.1	1,427	1,427	4.1	4.1	80.0
RBM (South Africa)^(o)												
	D/O+O/P			13	13.3			13	15	13.3	13.8	74.0
RTFT (Canada)^(w)												
	O/P			11	84.9	16	79.2	27	19	81.6	84.6	100.0
Uranium		millions of tonnes	% U ₃ O ₈	millions of tonnes	% U ₃ O ₈	millions of tonnes	% U ₃ O ₈	millions of tonnes	millions of tonnes	% U ₃ O ₈	% U ₃ O ₈	
Energy Resources of Australia (Australia)												
– Jabiluka	U/G	1.2	0.887	14	0.520	10	0.545	25	25	0.547	0.547	68.4
– Ranger #3 Deeps	U/G	3.7	0.272	10	0.218	5.4	0.203	20	20	0.224	0.224	68.4
– Ranger #3 stockpiles				27	0.040			27	27	0.040	0.040	68.4
Zircon		millions of tonnes	% Zircon	millions of tonnes	% Zircon	millions of tonnes	% Zircon	millions of tonnes	millions of tonnes	% Zircon	% Zircon	
QMM (Madagascar)												
	D/O	469	0.2	804	0.2	154	0.2	1,427	1,427	0.2	0.2	80.0
RBM (South Africa)^(o)												
	D/O+O/P			13	8.3			13	15	8.3	8.2	74.0

(a) Likely mining method: O/P = open pit; O/C = open cut; U/G = underground; D/O = dredging operation.

(b) Gove Resources are stated as dry tonnes and total alumina grade.

(c) Porto Trombetas (MRN) Resources are stated as dry tonnes and available alumina grade.

(d) Sangaredi Resources tonnes are reported on a 3% moisture basis and alumina grades are reported as total alumina. The increase is a result of a geological model update based on additional drilling and cut-off grade changes.

(e) Weipa Resources are stated as dry tonnes and total alumina grade.

(f) East Weipa and Andoom Resources tonnes decreased following the conversion of Resources to Reserves.

(g) Borates Resources are reported as in situ B₂O₃, rather than marketable product as in Reserves.

(h) Jadar equivalent in situ Resource is 52.7 million tonnes at 19.2% B₂O₃ (Indicated) and 83.4 million tonnes at 13.2% B₂O₃ (Inferred).

(i) The conversion of Resources to Reserves, together with mine design changes, resulted in a decrease in Bingham Canyon – Open Pit Resources tonnes at a higher grade.

(j) The increase in Escondida – oxide Resources tonnes and Escondida – mixed Resources grade is due to a pit design update in response to higher copper price forecast, lower production cost and a Resource model estimate update incorporating additional drilling.

(k) Heruga ETG and Heruga OT Resources tonnes decreased and grade increased following a review of mining costs and subsequent changes to the cut-off grade.

(l) The Hugo Dummett North Resources include approximately 0.68 million tonnes of stockpiled material at a grade of 1.17% copper, 0.46 grammes per tonnes gold and 3.16 grammes per tonnes silver.

(m) Hugo Dummett South Resources tonnes decreased and grade increased following a review of mining costs and subsequent changes to the cut-off grade.

(n) Oyut Underground Resources tonnes decreased and grade increased following a review of mining costs and subsequent changes to the cut-off grade.

(o) Diavik Resources tonnes decreased following the conversion of Resources to Reserves.

(p) Oyut Open Resource gold grade increased following a review of mining costs and subsequent changes to the cut-off grade. The other impacts included annual production and a pit design update.

(q) Iron ore Resource tonnes are reported on a dry weight basis. As Rio Tinto only markets blended iron ore products from multiple mine sources, a detailed breakdown of constituent elements by individual deposit is not reported.

(r) Channar JV Brockman Process Ore Mineral Resources tonnes have decreased following updates to the geological models.

(s) Resources at Iron Ore Company of Canada are reported as in-situ material on a dry basis. This in-situ material has the potential to produce marketable product (57% pellets and 43% concentrate for sale at a natural moisture content of two per cent) comprising 64 million tonnes at 65% iron (Measured), 279 million tonnes at 65% iron (Indicated) and 394 million tonnes at 65% iron (Inferred) using process recovery factors derived from current IOC concentrating and pellet operations

(t) Rio Tinto and Chinalco, who respectively own 45.05% and 39.95% of Simandou Blocks 3 and 4, are working with the government of Guinea to realise value from the world-class iron ore deposit. The government of Guinea owns a 15% stake in the project.

(u) The conversion of Resources to Reserves, together with a mine design change, resulted in a decrease in Bingham Canyon – Open Pit Resources tonnes and grade. Bingham Canyon open pit molybdenum grades interpolated from exploration drilling assays have been factored based on a long reconciliation history to blast hole and mill samples.

(v) RBM Resources tonnes decreased following mining depletion of stockpiled mineral separation plant tailings.

(w) RTFT Resources tonnes increased following the addition of a new deposit, reported for the first time. A JORC Table 1 in support of this change will be released to the market contemporaneously with the release of this Annual report and can be viewed at riotinto.com/invest/financial-news-performance/resources-and-reserves.

Mineral resources and ore reserves corporate governance

Mineral Resources and Ore Reserves corporate governance

Rio Tinto has well established governance processes in place to support the generation and publication of Mineral Resources and Ore Reserves, which includes a series of structures and processes independent of operational reporting through business units and product groups.

Audit Committee

The Audit Committee has in its remit the governance of Resources and Reserves. This includes an annual review of Mineral Resources and Ore Reserves at a Group level, as well as review of findings and progress from the Group Resources and Reserves internal audit programme within the regular meeting schedule.

Ore Reserves Steering Committee

The Ore Reserves Steering Committee (ORSC) meets at least quarterly, chaired by the Group Executive, Growth and Innovation, and comprises senior representatives from technical, financial, governance and business groups within the Group. The ORSC role includes oversight of the appointment of Competent Persons nominated by the business units, review of Exploration Results, Mineral Resource or Ore Reserve data prior to public reporting and development of Group Resource and Reserves standards and guidance.

Orebody Knowledge Centre of Excellence

In 2019, Rio Tinto formed the Orebody Knowledge Centre of Excellence, which contains a dedicated Orebody Technical Assurance team. Orebody Knowledge Technical Assurance in conjunction with the ORSC is the guardian and author of Group Resource and Reserve standards and guidance and is responsible for governance and compilation of Group Resource, Reserve and reconciliation reporting. The Technical Assurance team also monitors the external reporting environment, and facilitates internal audits and monitors actions with Group Internal Audit.

Group Internal Audit

The Resource and Reserve internal audit programme is conducted by independent external consulting personnel in a programme managed by Group Internal Audit with the assistance of the Orebody Knowledge Centre of Excellence and the ORSC. In 2019, four internal audits were completed. Material findings are reported outside of the product group reporting line to the Audit Committee, and all reports and action plans are reviewed by the ORSC for alignment to internal and external reporting standards.

JORC compliance

Rio Tinto has continued the development of internal systems and controls in order to meet JORC (2012) compliance in all external reporting including the preparation of all reported data by

2019 highlights

- Orebody Knowledge Centre of Excellence formed
- Dedicated Orebody Knowledge Technical Assurance team
- K2fly's RCubed Mineral Resources and Ore Reserves reporting solution agreement signed: Next gen platform for governance and reporting
- Ongoing professional development with two Competent Persons workshops

Competent Persons as members of The Australasian Institute of Mining and Metallurgy (The AusIMM), Australian Institute of Geoscientists (AIG) or recognised professional organisations (RPOs). JORC Table 1 reports for new or materially upgraded significant deposits are released to market by Rio Tinto and are also available on the Group's website. JORC Table 1 and NI 43-101 technical reports generated by non-managed units or joint venture partners are referenced within the reporting footnotes with the location and initial reporting date identified.

Mineral Resources and Ore Reserves from externally managed operations, where Rio Tinto holds a minority share, are reported as received from the managing entity. Figures from Rio Tinto managed operations are the responsibility of the managing directors of the business units and estimates are carried out by Competent Persons as defined by JORC.

Competent persons

	Association ^(a)	Employer	Accountability	Deposits
Bauxite				
G Rogers	AusIMM	Rio Tinto	Resources	Gove, East Weipa and Andoom, North of Weipa, Amrun
W Saba	AusIMM		Reserves	Gove, East Weipa and Andoom, Amrun
M Keerseemaker	AusIMM	CBG Consultant – Aluminpro	Reserves	
M A Diallo	EFG	Compagnie des Bauxites de Guinée	Resources	Sangaredi
M A H Monteiro	AusIMM	Mineração Rio do Norte	Resources and Reserves	Trombetas
Borates				
B Griffiths	SME	Rio Tinto	Resources and Reserves	Rio Tinto Borates – Boron
R Torres	AusIMM		Resources	
Copper				
A Schwarz	SME	Rio Tinto	Resources	Resolution ^(c)
M Bixley	AusIMM		Reserves	
O Dendev	AusIMM	Rio Tinto	Resources	Oyu Tolgoi ^{(b)(c)(d)}
F Prince	AusIMM		Reserves	
R Hayes	AusIMM		Resources	
E Mader	AusIMM		Reserves	
P Rodriguez	AusIMM	Rio Tinto	Resources	Bingham Canyon ^{(b)(c)(d)}
K Schroeder	AusIMM		Resources	
J Vickery	AusIMM		Resources and Reserves	
E Woods	AusIMM		Reserves	
R Maureira	AusIMM	Minera Escondida Ltda.	Resources	Escondida, Escondida – Chimborazo – sulphide, Pampa Escondida – sulphide ^(b) , Pinta Verde
F B Vargara	AusIMM		Reserves	Escondida
J Marshall	AusIMM	Rio Tinto	Resources	La Granja

Competent Persons

	Association ^(a)	Employer	Accountability	Deposits	
Diamonds					
S Brennan	AusIMM	Rio Tinto	Resources and Reserves	Argyle	
M Rayner	AusIMM		Resources and Reserves		
K Pollock	NAPEG	Rio Tinto	Resources and Reserves	Diavik	
C Auld	NAPEG		Reserves		
Iron ore					
K Tindale	AusIMM	Rio Tinto	Resources	Simandou	
M McDonald	PEGNL	Rio Tinto	Resources	Iron Ore Company of Canada	
B Power	PEGNL		Resources		
S Roche	AusIMM		Reserves		
R Way	PEGNL		Resources		
R Williams	PEGNL		Reserves		
P Ziemendorf	AusIMM		Reserves		
H McLean	AusIMM		Resources		Rio Tinto Iron Ore – Hamersley, Channar, Eastern Range, Hope Downs, Robe, Rhodes Ridge
P Savory	AusIMM		Resources		
B Sommerville	AusIMM		Resources		
R Bleakey	AusIMM		Rio Tinto		Reserves
L Couto	AusIMM	Reserves			
R Sarin	AusIMM	Reserves			
R Verma	AusIMM	Reserves			
Lithium					
J Garcia	EFG	Rio Tinto	Resources	Jadar ^(e)	
N Grubin	EFG		Resources		
M Sweeney	AusIMM		Resources		
Titanium dioxide feedstock					
F A Consuegra	NAPEG	Rio Tinto	Resources and Reserves	Rio Tinto Fer et Titane (RTFT)	
J Dumouchel	OGQ		Resources		
D Gallant	OIQ	Rio Tinto	Reserves	Rio Tinto Fer et Titane (RTFT)	
T Daling	SAIMM	Rio Tinto	Reserves	Richards Bay Minerals (RBM) ^(f)	
A Louw	SACNASP		Resources		
S Mnuu	SACNASP		Resources		
P De Kock	SAIMM		Reserves		
F Hees	AusIMM	Rio Tinto	Resources	QMM Madagascar Minerals ^(f)	
Uranium					
S Pevely	AusIMM	Rio Tinto	Resources and Reserves	Energy Resources of Australia – Ranger 3, Jabiluka	

- (a) AusIMM: Australasian Institute of Mining and Metallurgy
AIG: Australasian Institute of Geoscientists
APGO: Association of Professional Geoscientists of Ontario
EFG: European Federation of Geologists
NAPEG: Association of Professional Engineers; Geologists and Geophysicists of the Northwest Territories
OGQ: Ordre des Géologues du Québec
OIQ: L'Ordre des Ingénieurs du Québec
PEGNL: Professional Engineers and Geoscientists Newfoundland and Labrador
PEO: Professional Engineers Ontario
SACNASP: South African Council for Natural Scientific Professions
SAIMM: South African Institute of Mining and Metallurgy
SME: Society of Mining, Metallurgy and Exploration

- (b) Includes gold
(c) Includes molybdenum
(d) Includes silver
(e) Includes borates
(f) Includes zircon

Mines and production facilities

Group mines as at 31 December 2019 (Rio Tinto's interest is 100% unless otherwise shown)

Mine	Location	Access	Title/Lease
Iron Ore			
Hamersley Iron Brockman 2 Brockman 4 Marandoo Mount Tom Price Nammuldi Paraburdoo Silvergrass Western Turner Syncline Yandicoogina	Pilbara region, Western Australia	Hamersley Iron/Robe railway and port network	Agreements for life of mine with Government of Western Australia, save for the Yandicoogina mining lease, which expires in 2039 with an option to extend for 21 years.
Eastern Range (54%)	Pilbara region, Western Australia	Hamersley Iron/Robe railway and port network	Mineral lease expires in 2028 with successive options to extend by 21 years.
Channar (60%)	Pilbara region, Western Australia	Hamersley Iron/Robe railway and port network	Mining lease expires in 2028 with an option to extend by five years.
Hope Downs 1 (50%)	Pilbara region, Western Australia	Hamersley Iron/Robe railway and port network	Mining lease expires in 2027 with two options to extend of 21 years each.
Hope Downs 4 (50%)	Pilbara region, Western Australia	Hamersley iron/Robe railway and port network	Mining lease expires in 2027 with two options to extend of 21 years each.
Robe River Iron Associates (53%) Robe Valley (Mesa A, and Mesa J) West Angelas	Pilbara region, Western Australia	Hamersley Iron/Robe railway and port network	Agreements for life of mine with Government of Western Australia.
Dampier Salt (68.4%)	Dampier, Lake MacLeod and Port Hedland, Western Australia	Road and port	Mining Leases expiring in 2034 at Dampier; 2029 at Port Hedland and 2021 at Lake MacLeod. Lake MacLeod's lease renewal until 2031 currently being progressed.

History	Type of mine	Power source
Iron Ore		
Mount Tom Price began operations in 1966, followed by Paraburdoo in 1974. In the 1990s, Channar, Brockman 2, Marandoo and Yandicoogina achieved first ore. Since 2000, Eastern Ranges, Nammuldi, Brockman 4, Western Turner Syncline and Silvergrass have joined the network of Hamersley Iron mines.	Open pit	Hamersley Iron/Robe power network
The Bao-Hi joint venture was established in 2002 and has delivered sales of more than 180 million tonnes of iron ore to China. The joint venture is 54% owned by Rio Tinto and 46% by China Baowu Group.	Open pit	Hamersley Iron/Robe power network
The Channar Mining Joint Venture, established in 1987, was the first large-scale mining joint venture between Chinese and Australian companies. The joint venture is 60% owned by Rio Tinto and 40% by Sinosteel Corporation. It has delivered sales of more than 270 million tonnes of iron ore to China.	Open pit	Hamersley Iron/Robe power network
Joint venture between Rio Tinto and Hancock Prospecting. Construction of Stage 1 to 22 million tonnes per annum commenced 2006 and first production occurred 2007. Stage 2 to 30 million tonnes per annum completed 2009.	Open pit	Hamersley Iron/Robe power network
Joint venture between Rio Tinto and Hancock Prospecting. Construction of wet plant processing to 15 million tonnes per annum commenced 2011 and first production occurred 2013.	Open pit	Hamersley Iron/Robe power network
First shipment in 1972 from Robe Valley. Interest acquired in 2000 through North Limited acquisition. First ore was shipped from West Angelas in 2002.	Open pit	Hamersley Iron/Robe power network
Construction of the Dampier field started in 1969; first shipment in 1972. Lake MacLeod was acquired in 1978 as an operating field. Port Hedland was acquired in 2001 as an operating field.	Solar evaporation of seawater and underground brine; extraction of gypsum	Long-term contracts with Hamersley Iron and Horizon Power and on-site generation

Mines and production facilities continued

Group mines as at 31 December 2019 (Rio Tinto's interest is 100% unless otherwise shown)

Mine	Location	Access	Title/lease
Copper and Diamonds			
Copper			
Escondida (30%)	Atacama Desert, Chile	Pipeline and road to deep sea port at Coloso; road and rail	Rights conferred by Government under Chilean Mining Code.
Rio Tinto Kennecott Bingham Canyon	Near Salt Lake City, Utah, US	Pipeline, road and rail	Owned.
Oyu Tolgoi (51% of Turquoise Hill Resources Ltd. which owns 66% of Oyu Tolgoi LLC)	Khanbogd soum, Umnugovi province, Mongolia	Air and road	Three mining licences are held by Oyu Tolgoi LLC and two further licences are held in joint venture with Entrée Gold LLC. The licence term under the Minerals Law of Mongolia is 30 years with two 20-year extensions. First renewals are due in 2033 and 2039 for the Oyu Tolgoi and Entrée Gold licences respectively.
Diamonds			
Argyle	Kimberley Ranges, Western Australia	Road and air	Interest increased from 59.7% following purchase of Ashton Mining in 2000. Underground mine project approved in 2005 to extend economic mine life to 2020.
Diavik (60%)	Northwest Territories (NWT), Canada	Air, ice road in winter	Mining leases are issued by the NWT Government. One lease was renewed in 2017 and two leases were renewed in February 2018. The new leases will expire in 2038-2039.
Energy and Minerals			
Industrial minerals			
Rio Tinto Borates – Boron	California, US	Road and rail	Owned.
Rio Tinto Fer et Titane Lac Tio	Havre-Saint-Pierre, Province of Quebec, Canada	Rail and port (St Lawrence River)	Mining covered by two concessions granted by Province of Quebec in 1949 and 1951 which, subject to certain Mining Act restrictions, confer rights and obligations of an owner.
QIT Madagascar Minerals (80%)	Fort-Dauphin, Madagascar	Road and port	Mining lease granted by central government.
Richards Bay Minerals (74%)	Richards Bay, KwaZulu-Natal, South Africa	Rail, road and port	Mineral rights for Reserve 4 and Reserve 10 issued by South African State and converted to new order mining rights from 9 May 2012. Mining rights run until 8 May 2041 for both lease areas.
Iron ore			
Iron Ore Company of Canada (IOC) (58.7%)	Labrador City, Province of Newfoundland and Labrador, Canada	Railway and port facilities in Sept-Îles, Quebec (owned and operated by IOC)	Sublease with the Labrador Iron Ore Royalty Corporation, which has lease agreements with the Government of Newfoundland and Labrador that are due to be renewed in 2020, 2022, 2025 and 2031.
Uranium			
Energy Resources of Australia (68.4%) Ranger	Northern Territory, Australia	Road, rail and port	Mining tenure granted by Federal Government.

History	Type of mine	Power source
Copper and Diamonds		
Copper		
Production started in 1990 and since then capacity has been expanded numerous times. Today, copper concentrate is produced by three concentrator plants, the most recent of which was commissioned in 2016. Copper Cathode is produced by both oxide leach and sulphide leach plants. A desalination plant supplies water to the mine site.	Open pit	Supplied from grid under various contracts with local generating companies. In 2019 Escondida announced the migration to renewable energy power sources from 2021.
Interest acquired in 1989. In 2012, the pushback of the south wall commenced, extending the mine life to 2032.	Open pit	Supplied from grid under long-term contracts with Rocky Mountain Power, supplemented by onsite power
Oyu Tolgoi was first discovered in 1996. Construction began in late 2009 after signing of an Investment Agreement with the Government of Mongolia, and first concentrate was produced in 2012. First sales of concentrate were made to Chinese customers in 2013. In 2015, Underground Development Plan was signed with Government of Mongolia.	Open pit and underground	Grid power from China and supplementary diesel power generation at site. Signed Tavan Tolgoi Power Plant Power Source Framework agreement in December 2018.
Diamonds		
Interest increased from 59.7% following purchase of Ashton Mining in 2000. Underground mine project approved in 2005 to extend economic mine life to 2020.	Underground (previously open pit)	Long-term contract with Ord Hydro Consortium and on-site generation
Deposits discovered 1994-1995. Construction approved 2000. Diamond production started 2003. Fourth pipe commenced production in 2018. Mine life is up to 2025.	Underground (previously open pit) and new A21 pipe is open pit	On-site diesel generators; installed capacity 44MW and 9.2MW of wind capacity
Energy and Minerals		
Industrial minerals		
Deposit discovered in 1925 and acquired by Rio Tinto in 1967.	Open pit	On-site co-generation units and local power grid
Production started 1950; interest acquired in 1989.	Open pit	Supplied by Hydro Quebec at regulated tariff
Exploration project started in 1986; construction approved 2005. Ilmenite and zirsil production started 2008. QMM intends to extract ilmenite and zirsil from heavy mineral sands over an area of about 6,000 hectares along the coast over the next 40 years.	Mineral sand dredging	On-site heavy fuel oil generators
Production started 1977; initial interest acquired 1989. Fifth mining plant commissioned in 2000. One mining plant decommissioned in 2008. In September 2012, Rio Tinto doubled its holding in Richards Bay Minerals to 74% following the acquisition of BHP Billiton's entire interests.	Dune sand dredging	Contract with ESKOM
Iron ore		
Interest acquired in 2000 through North. Current operation began in 1962 and has processed over one billion tonnes of crude ore since. Annual capacity 23 million tonnes of concentrate of which 12.5 million tonnes can be pelletised.	Open pit	Supplied by Newfoundland and Labrador Hydro
Uranium		
Mining commenced 1981. Interest acquired through acquisition of North 2000. Open pit mining ended 2012, since then ERA has been processing ore stockpiles.	Stockpile	On-site diesel generation

Mines and production facilities continued

Group smelters and refineries (Rio Tinto's interest 100% unless otherwise shown)

Smelter/refinery	Location	Title/lease	Plant type/product	Capacity as of 31 December 2019 (based on 100% ownership)
Aluminium				
Alma	Alma, Quebec, Canada	100% freehold	Aluminium smelter producing aluminium rod, t-foundry, molten metal, high purity, remelt	471,000 tonnes per year aluminium
Alouette (40%)	Sept-Îles, Quebec, Canada	100% freehold	Aluminium smelter producing aluminium high purity, remelt	606,000 tonnes per year aluminium
Arvida	Saguenay, Quebec, Canada	100% freehold	Aluminium smelter producing aluminium billet, molten metal, remelt	174,000 tonnes per year aluminium
Arvida AP60	Saguenay, Quebec, Canada	100% freehold	Aluminium smelter producing aluminium high purity, remelt	60,000 tonnes per year aluminium
Bécancour (25.1%)	Bécancour, Quebec, Canada	100% freehold	Aluminium smelter producing aluminium slab, billet, t-foundry, remelt, molten metal	446,000 tonnes per year aluminium
Bell Bay	Bell Bay, Northern Tasmania, Australia	100% freehold	Aluminium smelter producing aluminium slab, molten metal, small form and t-foundry, remelt	195,000 tonnes per year aluminium
Boyne Smelters (59.4%)	Boyne Island, Queensland, Australia	100% freehold	Aluminium smelter producing aluminium billet, EC grade, small form and t-foundry, remelt	584,000 tonnes per year aluminium
Grande-Baie	Saguenay, Quebec, Canada	100% freehold	Aluminium smelter producing aluminium slab, molten metal, high purity, remelt	233,000 tonnes per year aluminium
ISAL	Reykjavik, Iceland	100% freehold	Aluminium smelter producing aluminium remelt, billet	212,000 tonnes per year aluminium
Jonquière (Vaudreuil)	Jonquière, Quebec, Canada	100% freehold	Refinery producing specialty alumina and smelter grade alumina	1,570,000 tonnes per year alumina
Kitimat	Kitimat, British Columbia, Canada	100% freehold	Aluminium smelter producing aluminium slab, remelt, high purity	432,000 tonnes per year aluminium
Laterrière	Saguenay, Quebec, Canada	100% freehold	Aluminium smelter producing aluminium slab, remelt, molten metal	257,000 tonnes per year aluminium
Queensland Alumina (80%)	Gladstone, Queensland, Australia	73.3% freehold; 26.7% leasehold (of which more than 80% expires in 2026 and after)	Refinery producing alumina	3,950,000 tonnes per year alumina
São Luis (Alumar) (10%)	São Luis, Maranhão, Brazil	100% freehold	Refinery producing alumina	3,700,000 tonnes per year alumina
Sohar (20%)	Sohar, Oman	100% leasehold (expiring 2039)	Aluminium smelter producing aluminium, high purity, remelt	390,000 tonnes per year aluminium
Tiwai Point (New Zealand Aluminium Smelters) (79.4%)	Invercargill, Southland, New Zealand	19.6% freehold; 80.4% leasehold (expiring in 2029 and use of certain Crown land)	Aluminium smelter producing aluminium billet, slab, small form foundry, high purity, remelt	373,000 tonnes per year aluminium
Tomago (51.6%)	Tomago, New South Wales, Australia	100% freehold	Aluminium smelter producing aluminium billet, slab, remelt	590,000 tonnes per year aluminium
Yarwun	Gladstone, Queensland, Australia	97% freehold; 3% leasehold (expiring 2101 and after)	Refinery producing alumina	3,200,000 tonnes per year alumina
Copper and Diamonds				
Rio Tinto Kennecott	Magna, Salt Lake City, Utah, US	100% freehold	Flash smelting furnace/Flash convertor furnace copper refinery and precious metals plant	335,000 tonnes per year refined copper
Energy and Minerals				
Boron	California, US	100% freehold	Borates refinery	576,000 tonnes per year boric oxide
IOC Pellet Plant (58.7%)	Labrador City, Newfoundland and Labrador, Canada	100% freehold (asset), 100% leasehold (land) under sublease with Labrador Iron Ore Royalty Corporation for life of mine.	Pellet induration furnaces producing multiple iron ore pellet types	12.5 million tonnes per year pellet
Rio Tinto Fer et Titane Sorel Plant	Sorel-Tracy, Quebec, Canada	100% freehold	Ilmenite smelter	1,300,000 tonnes per year titanium dioxide slag, 1,000,000 tonnes per year iron
Richards Bay Minerals (74%)	Richards Bay, South Africa	100% freehold	Ilmenite smelter	1,050,000 tonnes per year titanium dioxide slag, 565,000 tonnes per year iron

Information on Group power plants (Rio Tinto's interest 100% unless otherwise shown)

Power plant	Location	Title/lease	Plant type/product	Capacity as of 31 December 2019 (based on 100% ownership)
Iron Ore				
Cape Lambert power station (67%)	Cape Lambert, Western Australia, Australia	Lease	Two LM6000PF gas-fired turbines	80MW
Paraburdoo power station	Paraburdoo, Western Australia, Australia	Lease	Three LM6000PC gas-fired turbines One Frame5 dual-fuel turbine	138MW
Yurralyi Maya power station (84.2%)	Dampier, Western Australia, Australia	Miscellaneous licence	Four LM6000PD gas-fired turbines One LM6000PF gas-fired turbine (dual-fuel potential)	200MW
West Angelas power station (67%)	West Angelas, Western Australia, Australia	Miscellaneous licence	Two LM6000PF dual-fuel turbines	80MW
Aluminium				
Gladstone power station (42%)	Gladstone, Queensland, Australia	100% freehold	Thermal power station	1,680MW
Gove power station	Nhulunbuy, Northern Territory, Australia	100% leasehold	Diesel generation	24MW
Kemano power station	Kemano, British Columbia, Canada	100% freehold	Hydroelectric power	896MW
Quebec power stations	Saguenay, Quebec, Canada (Chute-à-Caron, Chute-à-la-Savane, Chute-des-Passes, Chute-du-Diable, Isle-Maligne, Shipshaw)	100% freehold (certain facilities leased from Quebec Government until 2058 pursuant to Peribonka Lease)	Hydroelectric power	3,147MW
Yarwun alumina refinery co-generation plant	Gladstone, Queensland, Australia	100% freehold	Gas turbine and heat recovery steam generator	160MW
Weipa power stations and solar generation facility	Lorim Point, Andoom, and Weipa, Australia	100% leasehold	Diesel generation supplemented by solar generation facility	38MW
Amrun power station	Amrun, Australia	100% leasehold	Diesel generation	24MW
Copper and Diamonds				
Rio Tinto Kennecott power stations	Salt Lake City, Utah, US	100% freehold	Thermal power station idled through December 31 2025, per Rocky Mountain Power supply contract provision	75MW
			Steam turbine running off waste heat boilers at the copper smelter	31.8MW
			Combined heat and power plant supplying steam to the copper refinery	6.2MW
Energy and Minerals				
Boron co-generation plant	Boron, California, US	100% freehold	Co-generation uses natural gas to generate steam and electricity, used to run Boron's refining operations	48MW
Energy Resources of Australia (Rio Tinto: 68.4%)	Ranger Mine, Jabiru, Northern Territory, Australia	Lease	Five diesel generator sets rated at 5.17MW; one diesel generator set rated at 2MW; four additional diesel generator sets rated at 2MW	35.8MW
IOC power station	Sept Îles, Quebec, Canada	Statutory grant	Hydroelectric power	22MW
QMM power plant	Fort Dauphin, Madagascar	100% freehold	Diesel generation	24MW