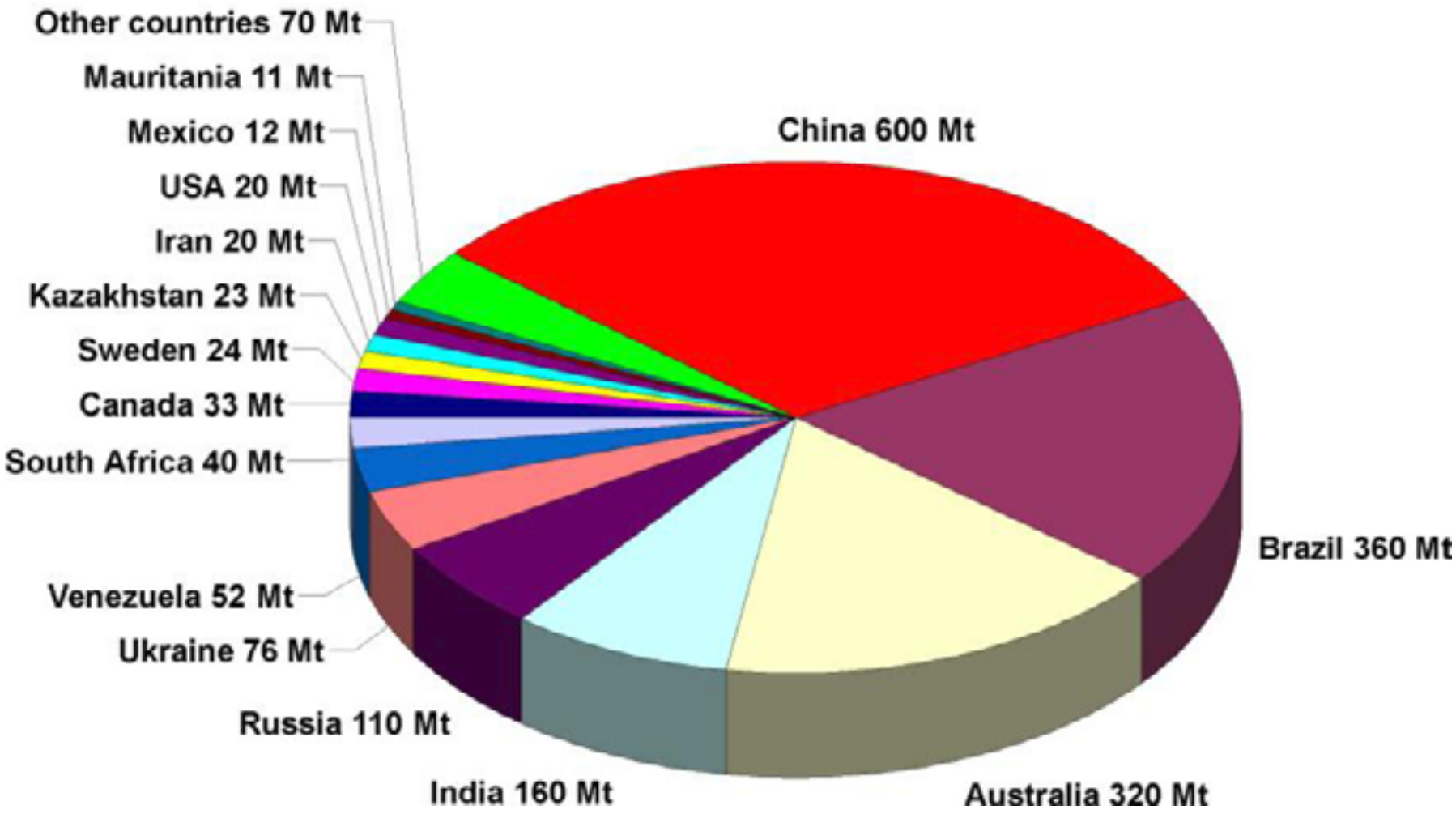
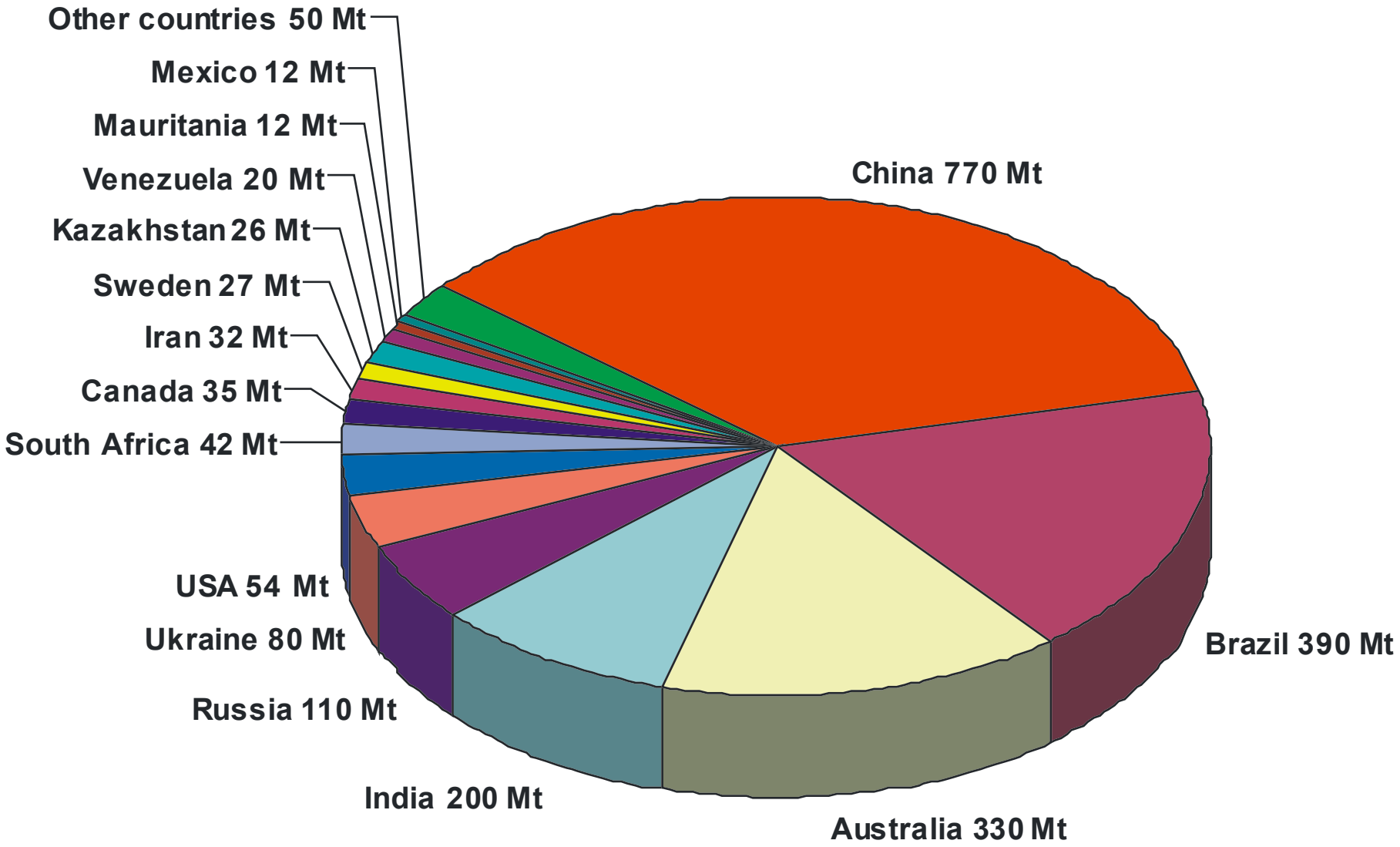
IRON ORE WORLD MINE PRODUCTION 2007 (1.93 Gt)



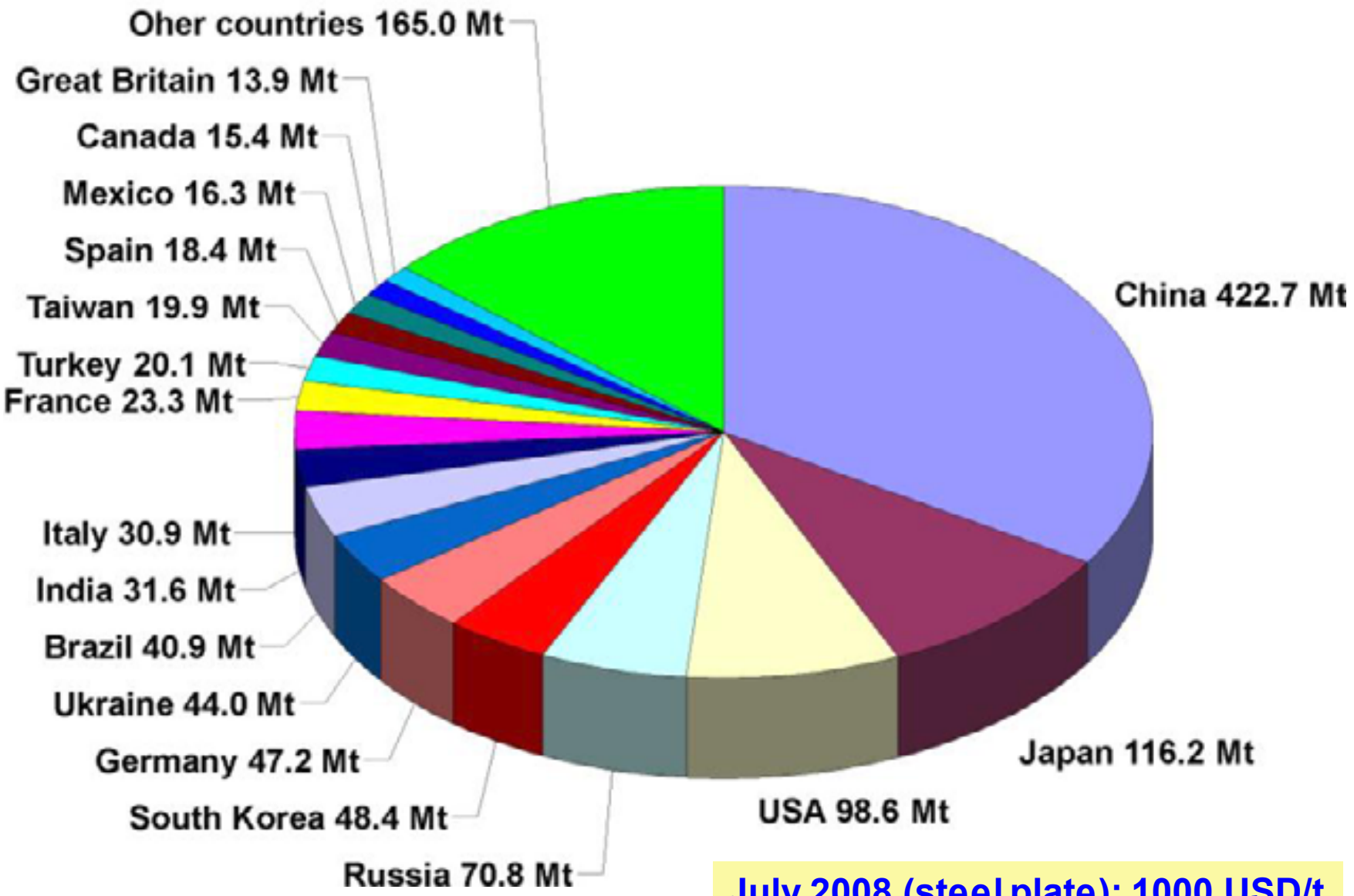
July 2008 (64 % Fe): 125 USD/t

IRON ORE WORLD MINE PRODUCTION 2008 (2.19 Gt)



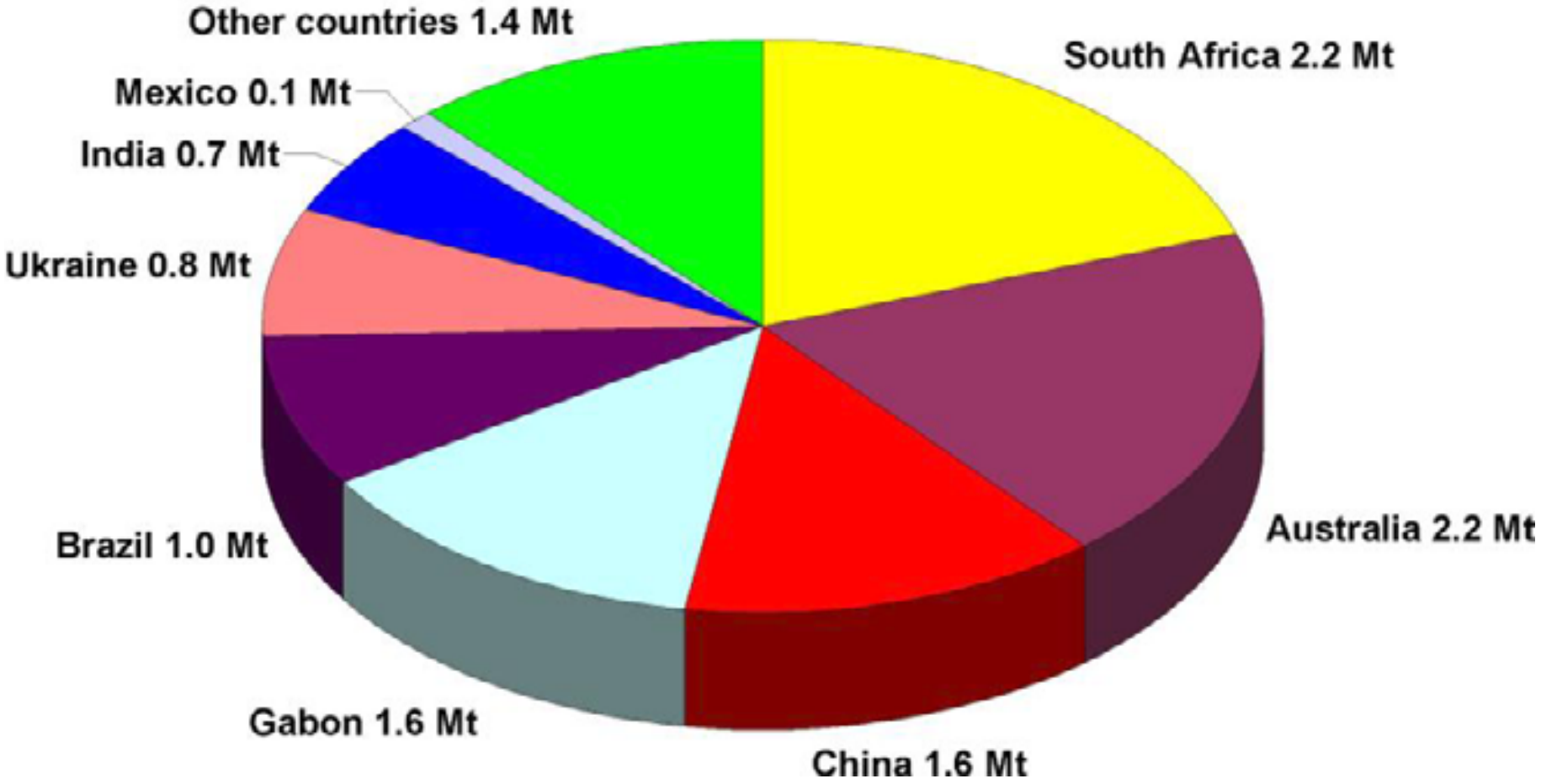
Feb 2009, Fines (64.5 % Fe), fob Europe: 86 USD/t

CRUDE STEEL PRODUCTION 2006 (1,243.6 Mt)

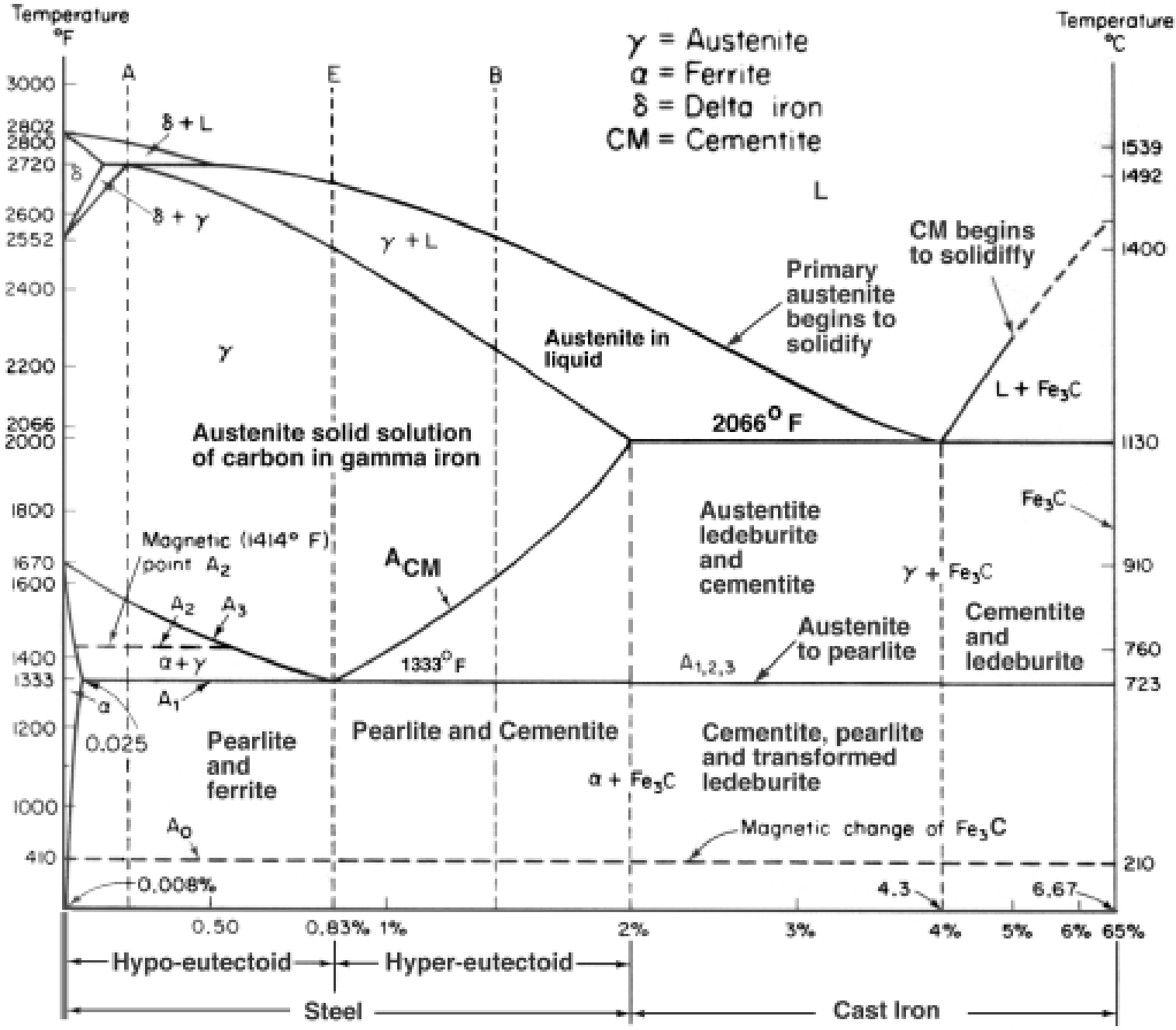


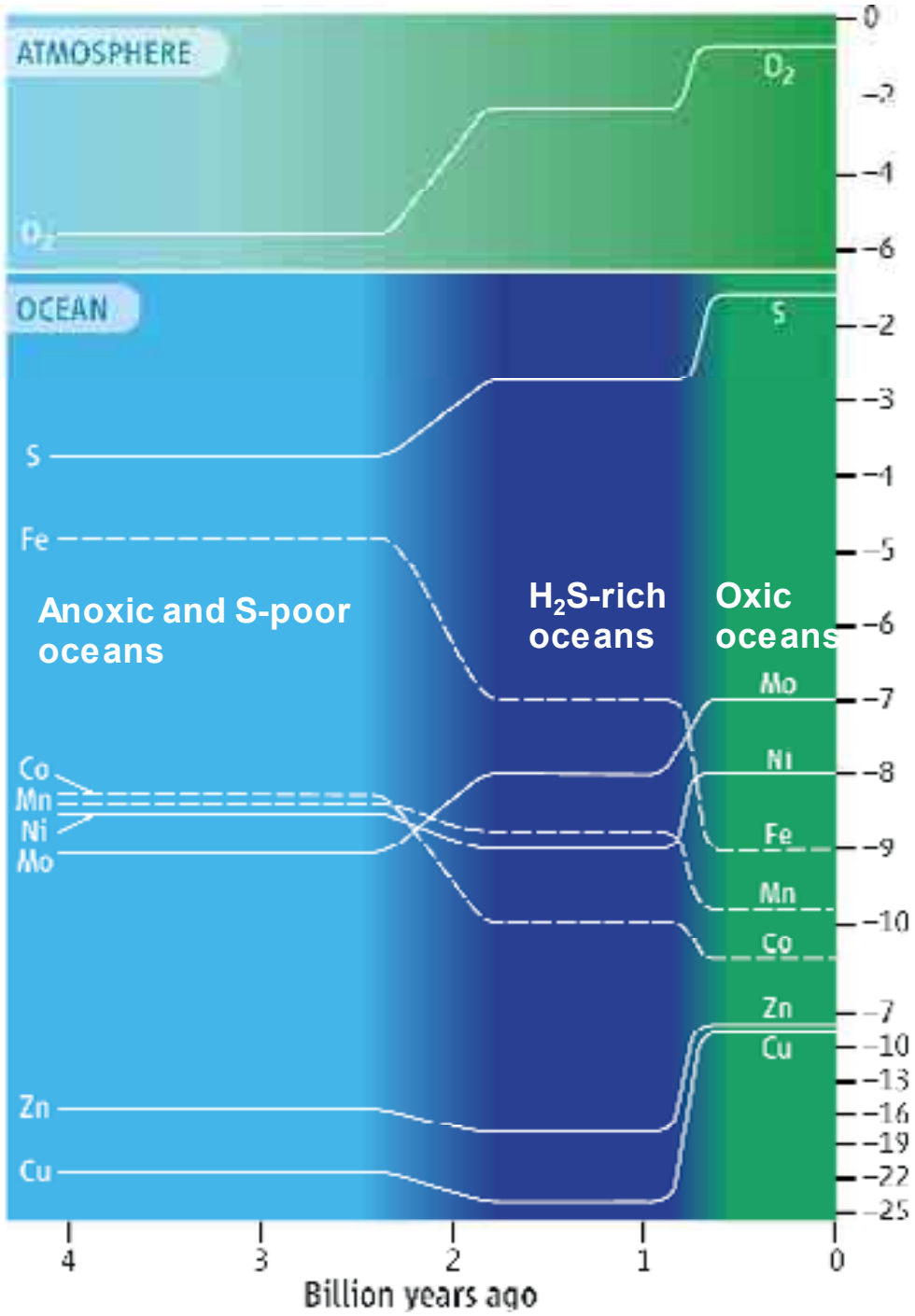
July 2008 (steel plate): 1000 USD/t

MANGANESE WORLD MINE PRODUCTION 2007 (11.6 Mt)



Feb 2008: Ferro-manganese with 78 % Mn: 1700 EUR/t


Temperature °F
Temperature °C
γ = Austenite
α = Ferrite
δ = Delta iron
CM = Cementite
A
E
B
δ + L
δ
δ + γ
γ + L
L
CM begins to solidiffy
Primary austenite begins to solidify
Austenite in liquid
γ
L + Fe3C
2066° F
Austenite solid solution of carbon in gamma iron
Austentite ledeburite and cementite
Fe3C
Magnetic (1414° F) point A2
ACM
γ + Fe3C
Cementite and ledeburite
A2
A3
α + γ
1333° F
A1,2,3
Austenite to pearlite
A1
α
0.025
Pearlite and ferrite
Pearlite and Cementite
α + Fe3C
Cementite, pearlite and transformed ledeburite
A0
Magnetic change of Fe3C
0.008%
4.3
6.67
3000
2802
2800
2720
2600
2552
2400
2200
2066
2000
1800
1670
1600
1400
1333
1200
1000
410
1539
1492
1400
1130
910
760
723
210
0.50
0.83%
1%
2%
3%
4%
5%
6%
65%
Hypo-eutectoid
Hyper-eutectoid
Steel
Cast Iron



Changes in element abundances through time. These histories are approximate, based on simple geochemical models and inferences from ancient sediments. An expansion in H_2S-rich ocean regions after 2.4 billion years ago is assumed (*2*, *5*). Color gradations indicate a transition from anoxic, S-poor oceans before 2.4 billion years ago (light blue) to H_2S-rich oceans between 1.8 billion and 800 million years ago (dark blue), subsequently giving way to complete ocean oxygenation (green). Different line styles are for clarity only; dashed lines are for elements with falling concentrations. [Adapted from (*26*), based on data from (*2*, *5*, *9*, *10*)].

Anbar (2008) Science 322: 1482

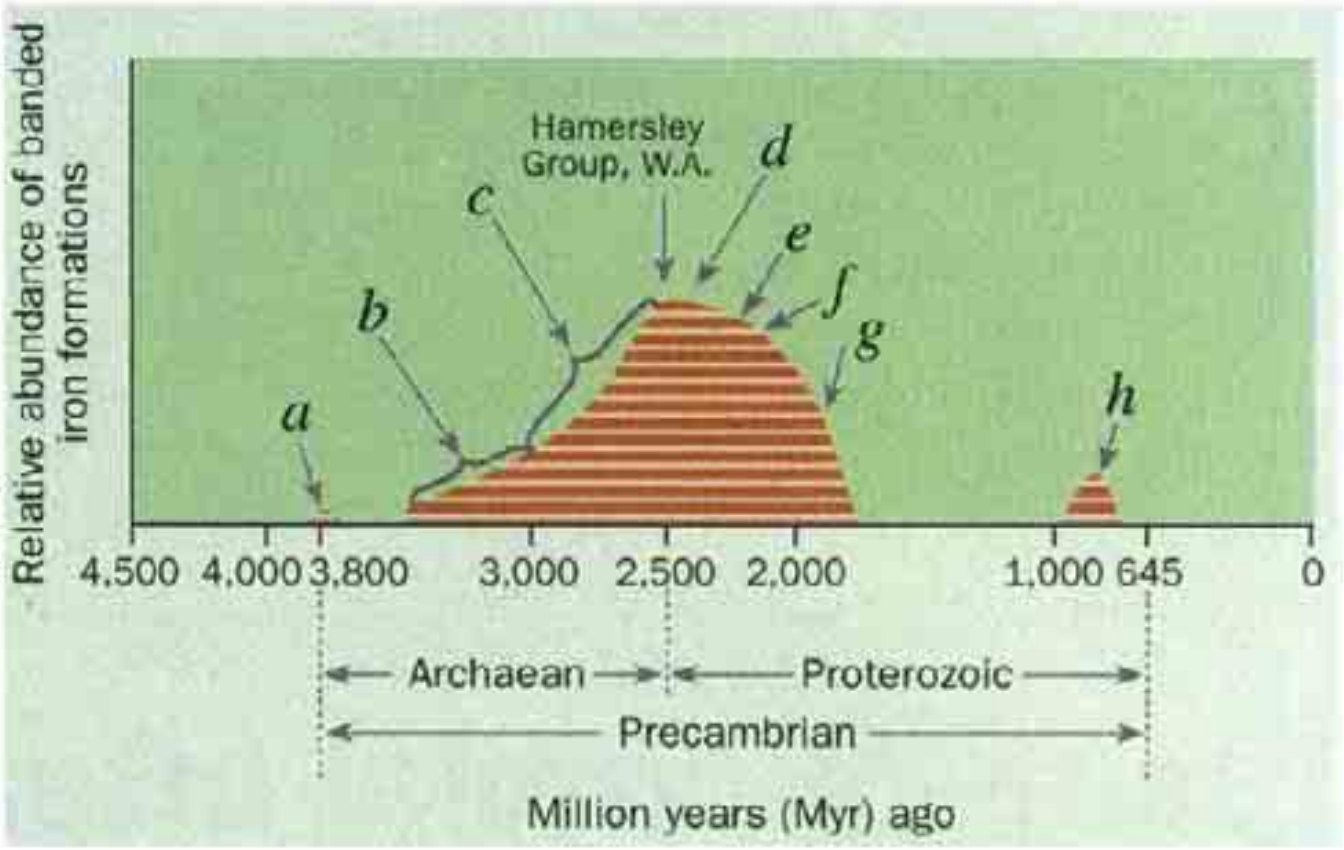


FIG. 1 The relative abundance of banded iron formations in the Precambrian. Estimated values are relative to those of the Hamersley Province, which is the largest BIF province in the world[2,3]. *a*, Isua (West Greenland); *b*, Zimbabwe, South Africa, Ukraine, Venezuela, Western Australia; *c*, Canadian greenstone belts, Yilgarn block (Western Australia); *d*, Transvaal Supergroup (South Africa); *e*, Lake Superior region (USA); *f*, Krivoy Rog series (Russia); *g*, Labrador Trough (Canada); *h*, Rapitan Group (Canada), Urucum region (Brazil), Damara Supergroup (Namibia).

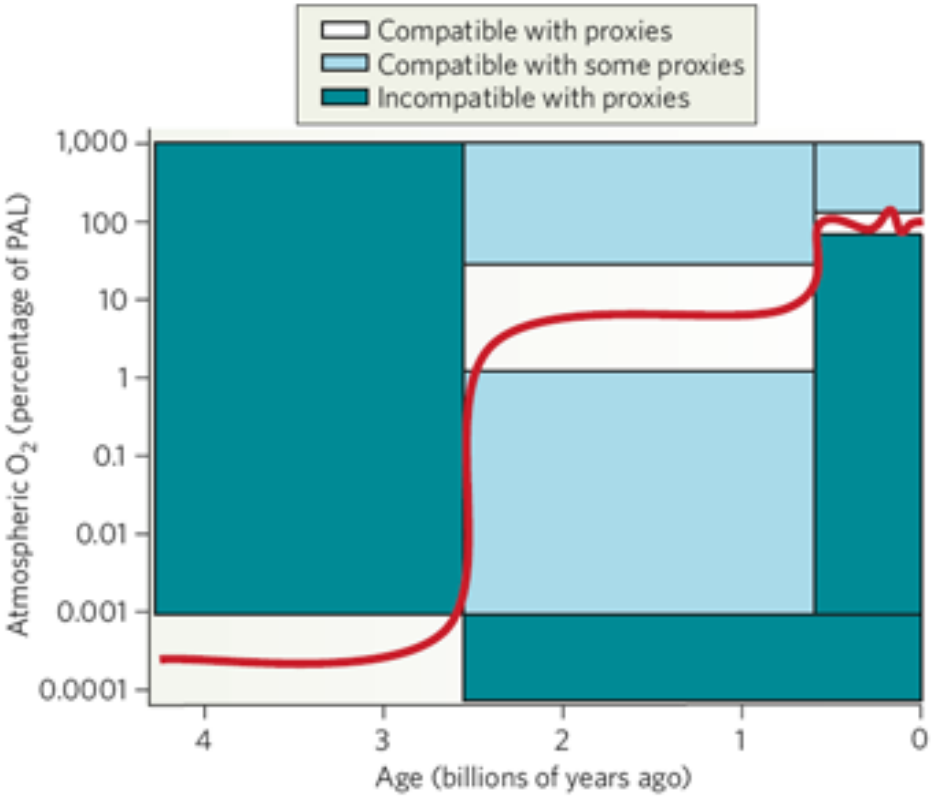
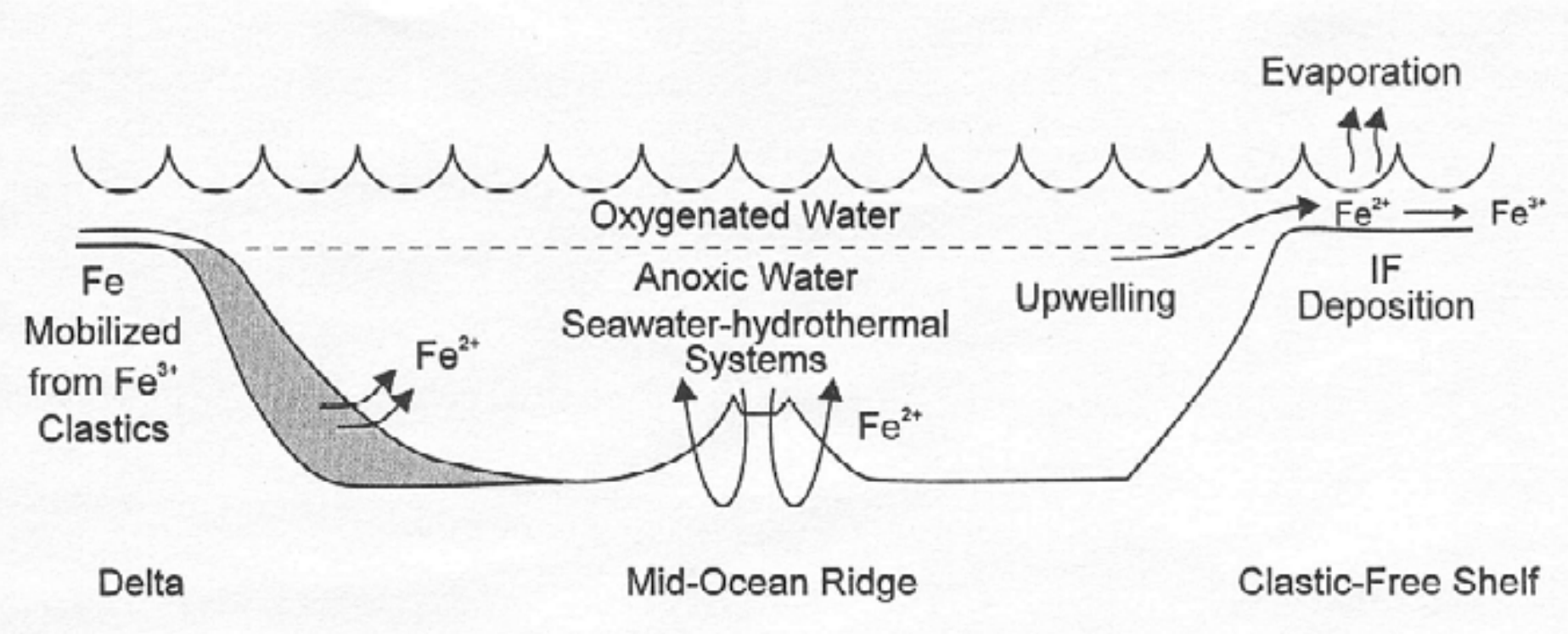


Figure 2 | Prevailing view of atmospheric oxygen evolution over time. The red line shows the inferred level of atmospheric oxygen bounded by the constraints imposed by the proxy record of atmospheric oxygen variation over Earth's history[2,20]. The signature of mass-independent sulphur-isotope behaviour sets an upper limit for oxygen levels before 2.45 billion years ago and a lower limit after that time. The record of oxidative weathering after 2.45 billion years ago sets a lower limit for oxygen levels at 1% of PAL, whereas an upper limit of 40% of PAL is inferred from the evidence for anoxic oceans during the Proterozoic. The tighter bounds on atmospheric oxygen from 420 million years ago to the present is set by the fairly continuous record of charcoal accumulation[19]: flames cannot be sustained below an oxygen level of 60% of PAL, and above about 160% of PAL the persistence of forest ecosystems would be unlikely because of the frequency and vigour of wildfires[21].

Kump (2008)
Nature 451: 278

Banded Iron Formation (BIF)



Model for the deposition of Lake Superior-type iron formations (Holland 1995:181): Deeper water, enriched in Fe^{2+} from either volcanic or diagenetic sources, moves up onto a shallow shelf, where iron minerals and SiO_2 are precipitated as a result of oxidation, mixing, and possibly evaporation.

Pico de Itabirito, Minas Gerais, Brazil: Hard hematite ore (subvertical) with soft hematite ore at the Pico mine to the left, and Sapecado mine to the right

a Quartz itabirite

b Saprolite: Hematitization

c Hbl itabirite (limonite)

d Dolomite itabirite

e Pisolite

Caue pit

Dois Corregos pit

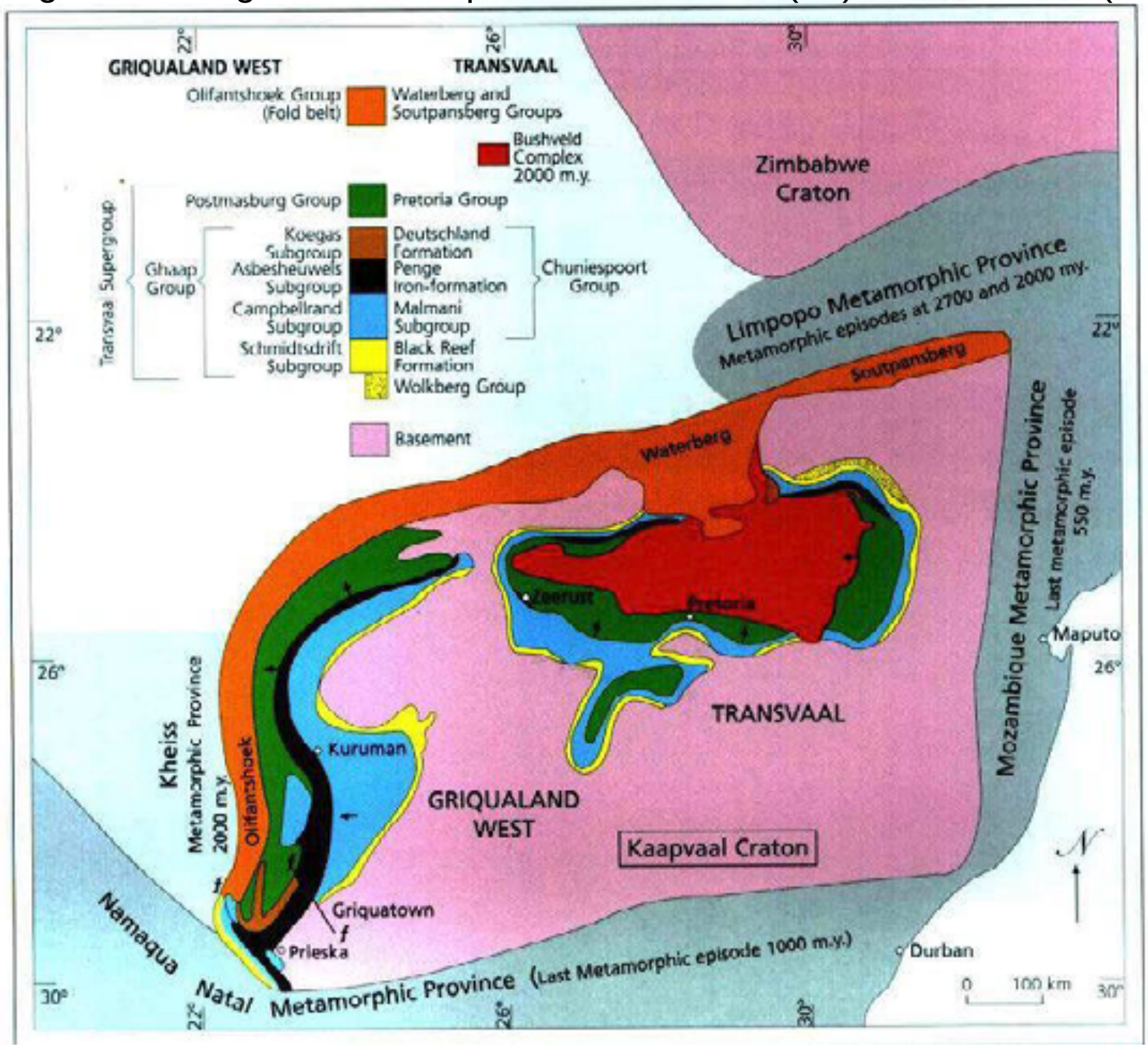
Conceicao pit

Itabira Syncline

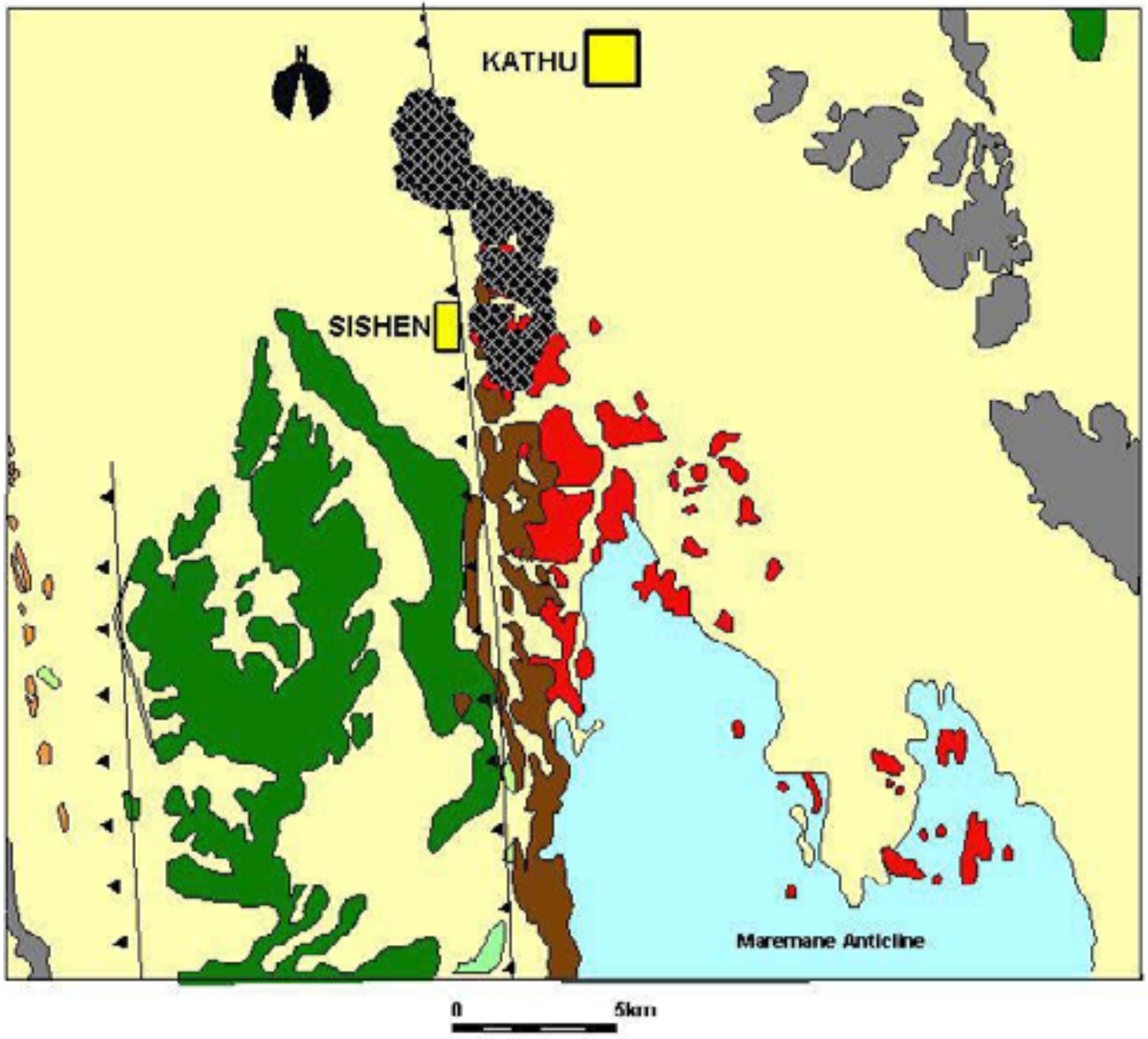
Conceicao
pit

Mount Tom Price, Hamersley Basin, Western Australia

Regional setting of the Paleoproterozoic Sishen (Fe) and Kuruman (Mn) districts on the passive margin of the Kaapvaal craton



GEOLOGY OF THE SISHEN AREA



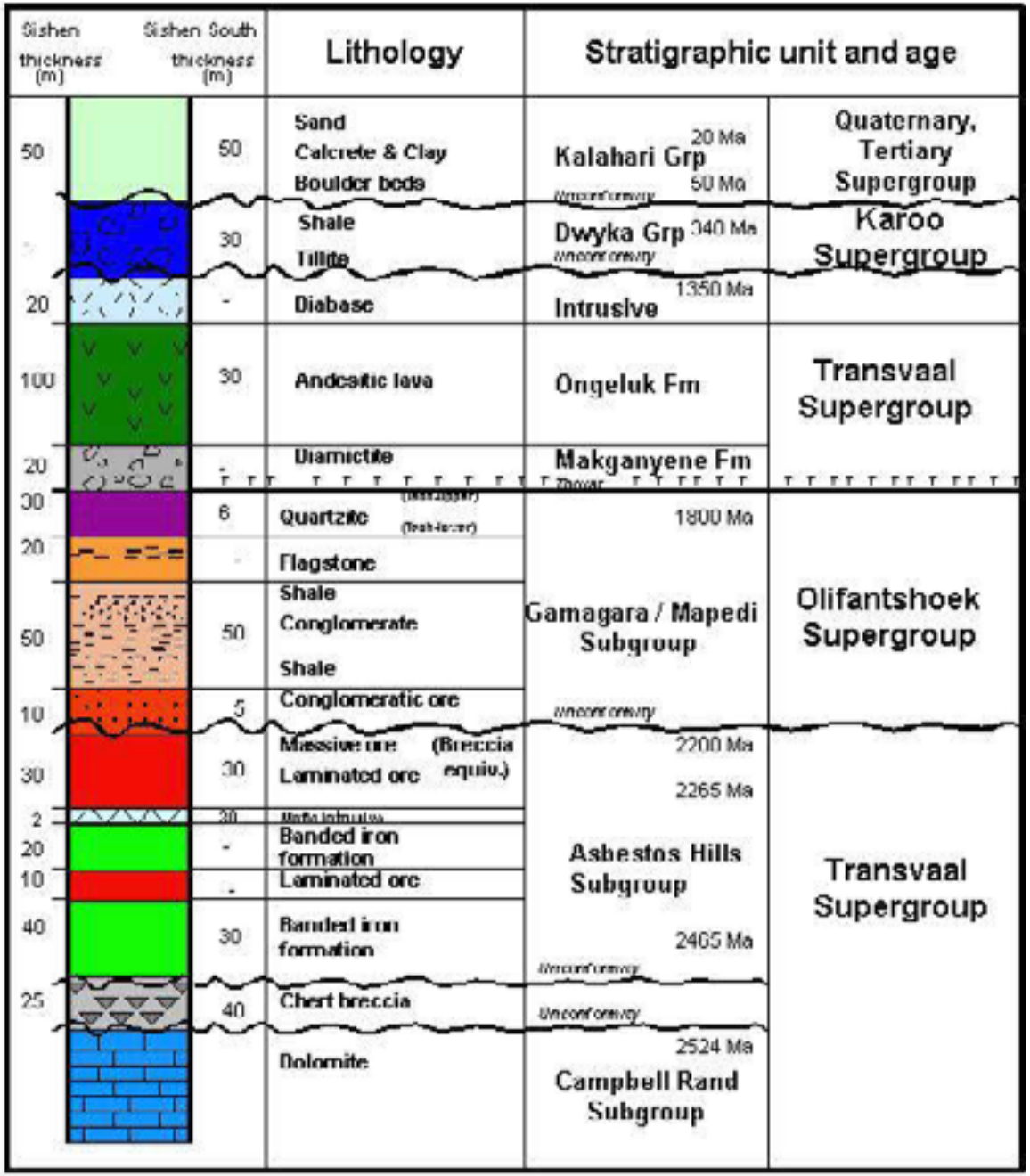
LEGEND

- Kalahari Group
- *Unconformity*
- Olifantshoek Supergroup
- *Thrust*
- Ongeluk Formation
  Makganyene Formation
- *Thrust*
- Gamagara Formation
- *Unconformity*
- Asbestos Hills Subgroup
  (Potential mineralization)
- Campbell Rand Subgroup

Sishen current pit

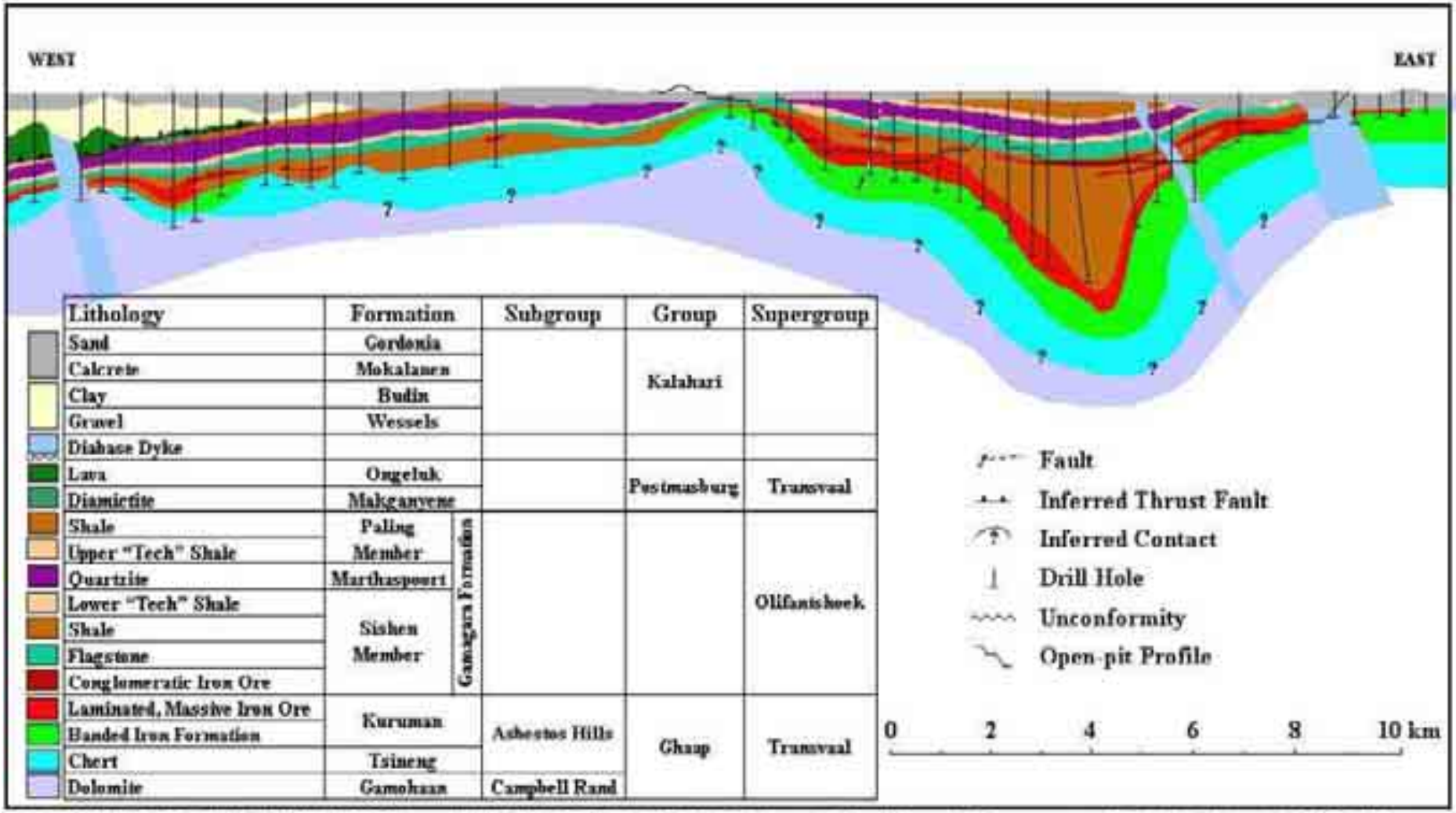
30 Mt/a

Local Stratigraphy



SECTION AROUND SISHEN

North mine



Lithology	Formation		Subgroup	Group	Supergroup
Sand	Gordonia			Kalahari	
Calcrete	Mokalanen				
Clay	Budin				
Gravel	Wessels				
Diabase Dyke					
Lava	Ongeluk			Postmasburg	Transvaal
Diamictite	Makganyene				
Shale	Paling Member	Gamagara Formation			Olifantshoek
Upper "Tech" Shale					
Quartzite	Marthaspoort				
Lower "Tech" Shale	Sishen Member				
Shale					
Flagstone					
Conglomeratic Iron Ore					
Laminated, Massive Iron Ore	Kuruman		Asbestos Hills	Ghaap	Transvaal
Banded Iron Formation					
Chert	Tsineng				
Dolomite	Gamohaan		Campbell Rand		

J. ASTRUP, E.C.I. HAMMERBECK and H. VAN DEN BERG, 1998. Iron in The Mineral Resources of South Africa (M.G.C. Wilson and C.R. Anhaeusser, eds). Handbook, Council for Geoscience, 16, p. 402-416

Typical Ore Chemistry

Ore type	Fe	SiO_2	Al_2O3	K_2O	P
Conglomeratic	62.16	5.34	2.87	0.279	0.055
Breccia	63.39	3.91	1.98	0.388	0.078
Massive	65.16	2.99	1.35	0.136	0.044
Laminated	66.27	2.39	0.83	0.074	0.056

Ore Distribution

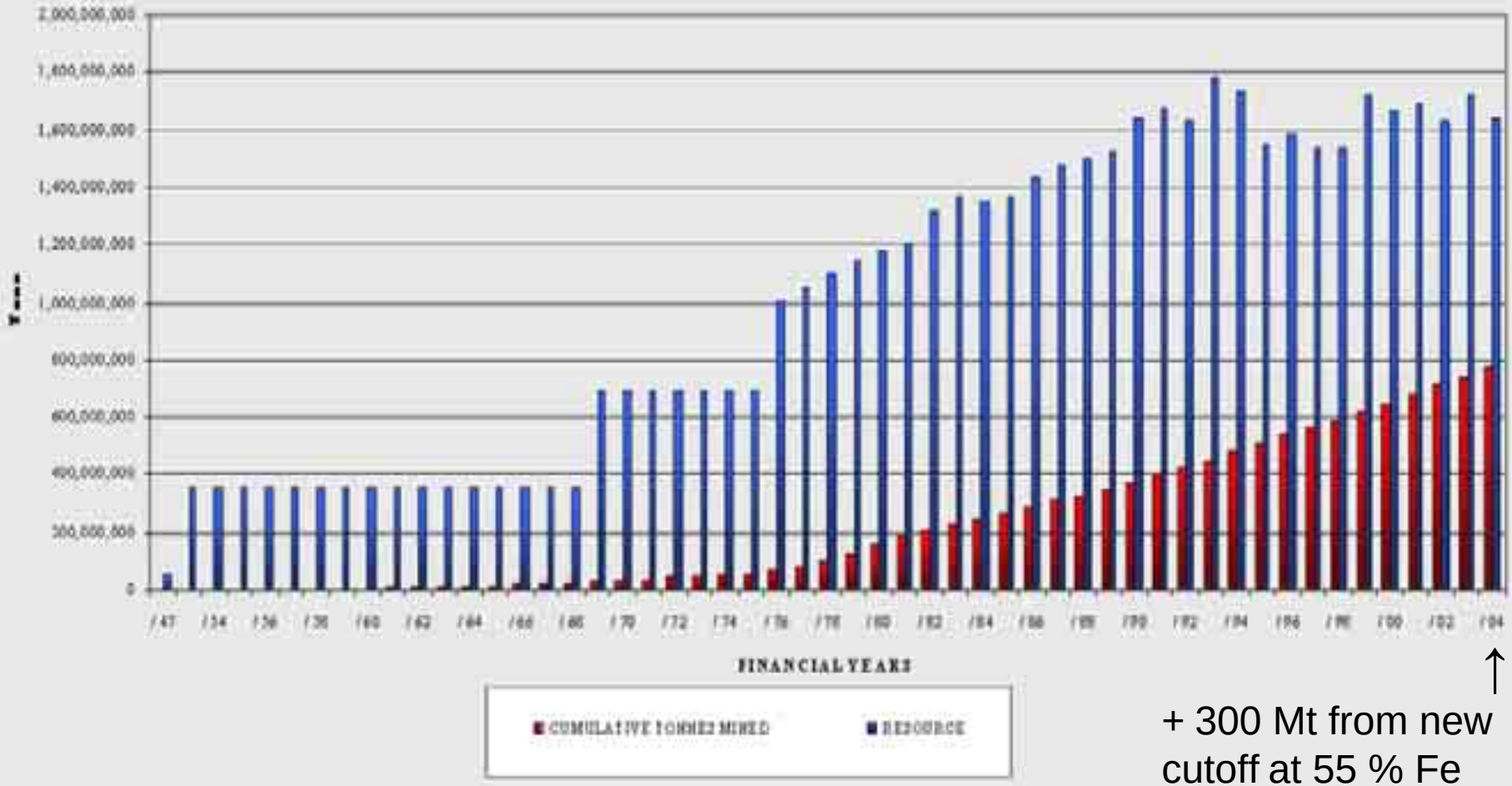
Ore type	Sishen
Conglomeratic	16
Breccia	8
Massive	18
Laminated	58

Sishen's Product Specifications

	Product	Fe %min	SiO_2 %max	Al_2O_3 %max	K_2O %max	P %max	Oversize % max	Undersize % Max	Moisture % max
Current Sishen products	Sishen 66% Lump	66.0	3.7	1.5	0.15	0.057	5.0% +25mm	10.0% -8mm	1.0%
	Sishen 65% Fine	65.0	4.2	2.0	0.24	0.066	7.5% +5mm	18.0% -0.2mm	2.5%
Optimal SEP products	Sishen 64.0% Lump	64.0	5.9	1.5	0.16	0.065	5.0% +25mm	12.0% -8mm	1.0%
	Sishen 63.5% Fine	63.5	6.3	2.0	0.25	0.074	10.0% +8mm	18.0% -0.2mm	2.5%

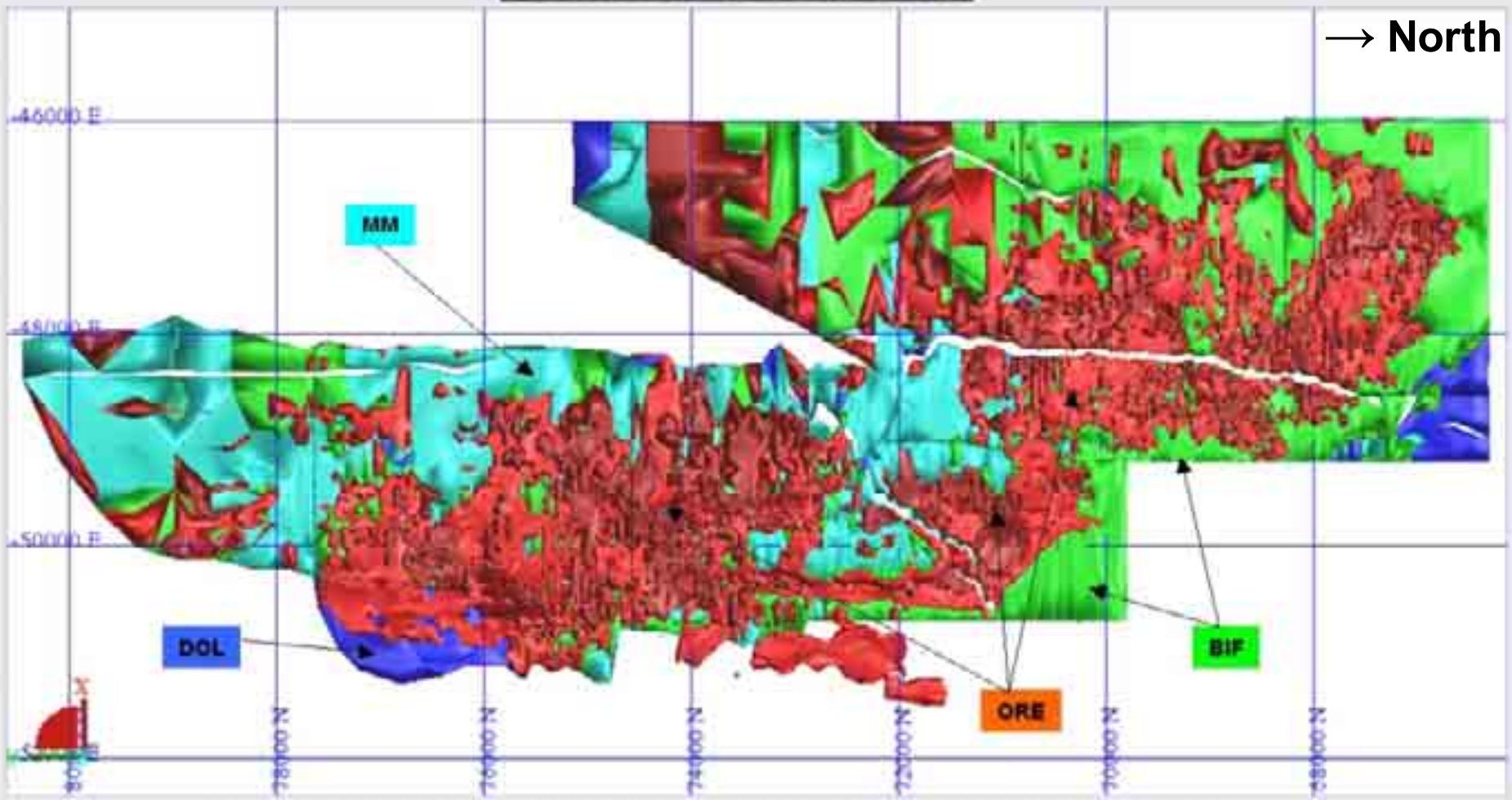
Mineral Resources/Reserves and Production

Sishen Iron Ore Mine (Kumba Resources)



+ 300 Mt from new cutoff at 55 % Fe (earlier: 60 % Fe)

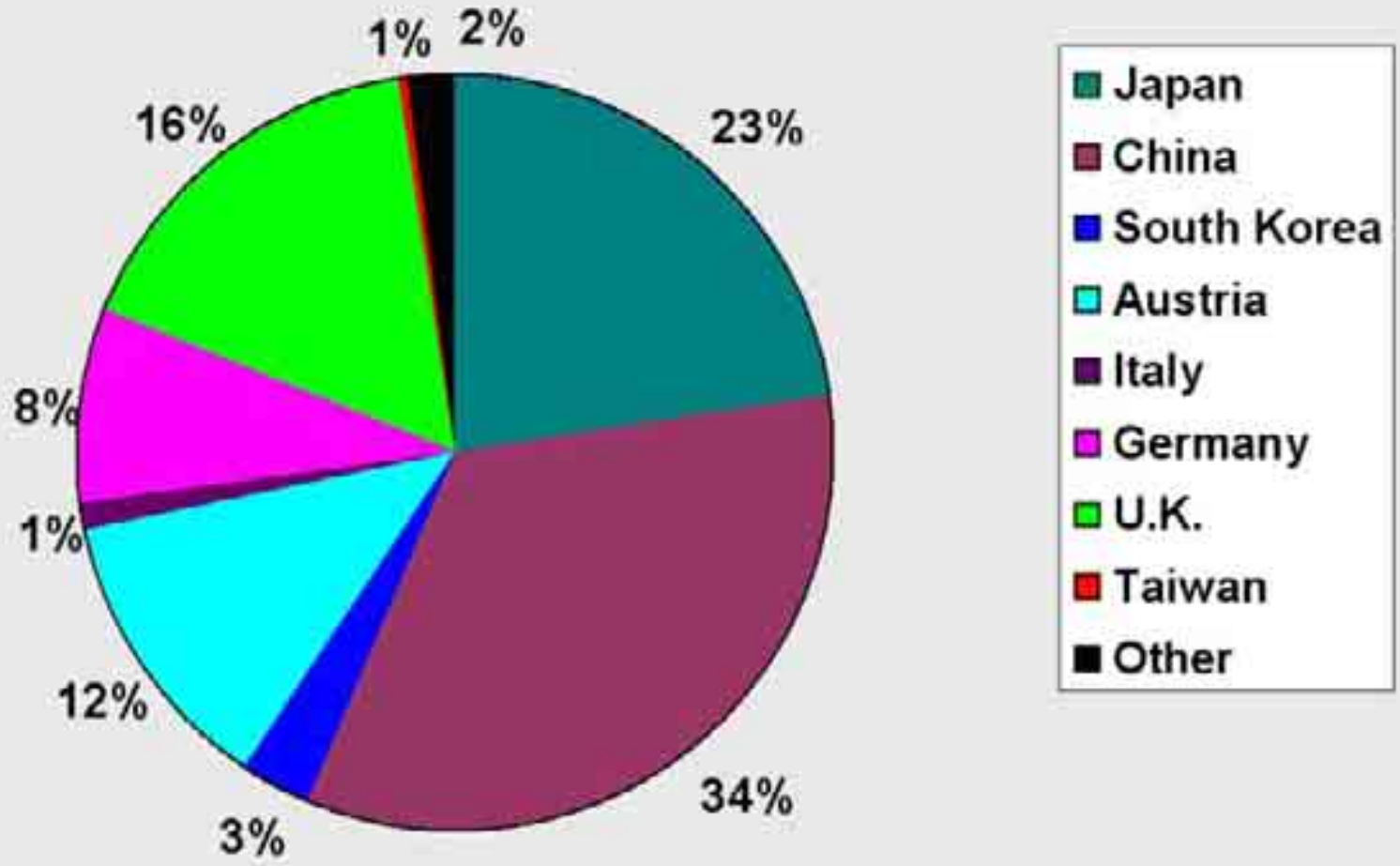
Sishen Orebody



- North Mine: **±8.6km** long, **±3.2km** wide and **±400m** below surface at deepest position.
- Middle Mine: **±2.7km** long, **±0.8km** wide and **±480m** below surface at deepest position.
- South Mine: **±8.1km** long, **±2.4km** wide and **±370m** below surface at deepest position

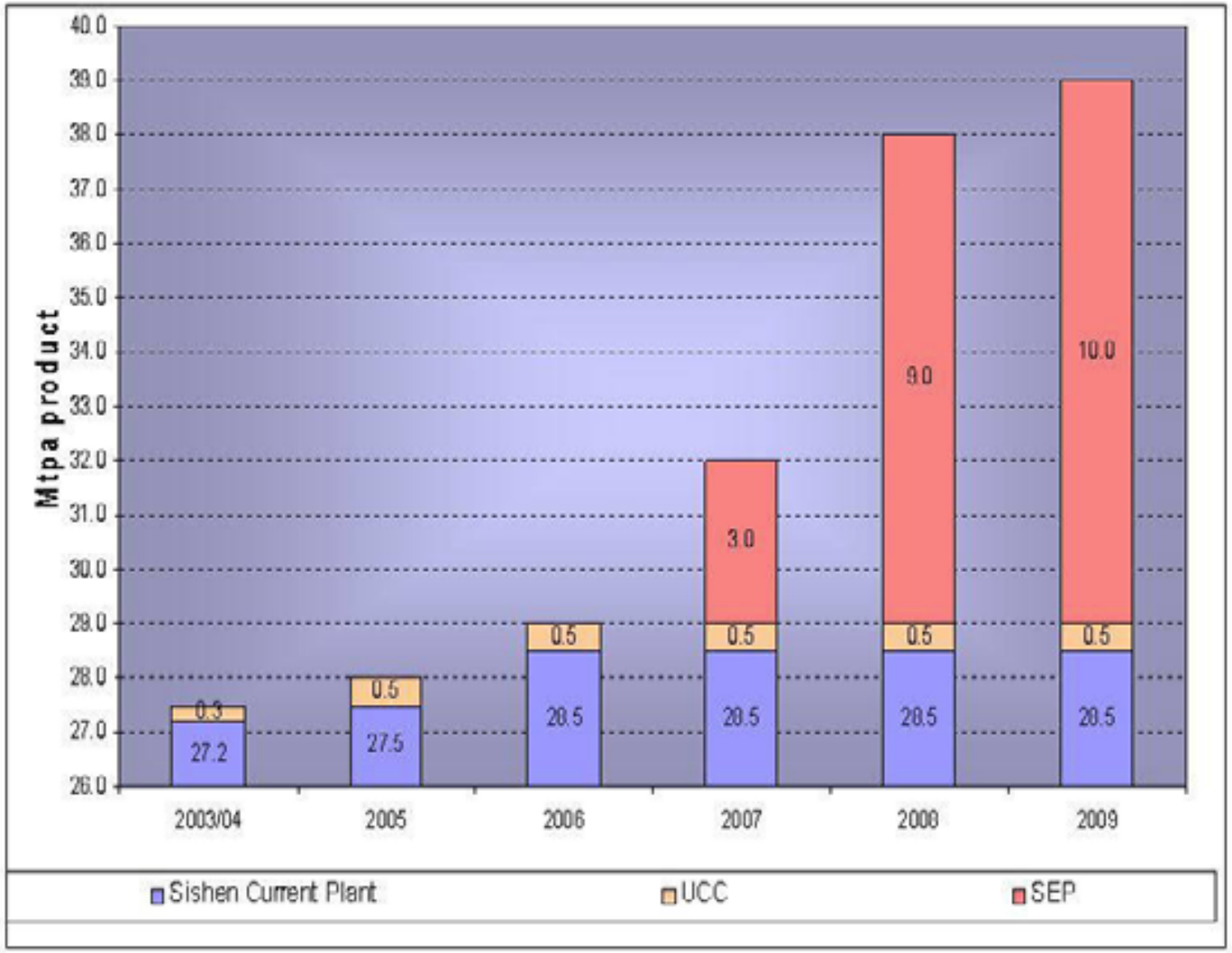
Ore occurrences

Kumba Resources: Exports per Target Market



Total: 32 Mt/a

Projected Growth at Sishen Mine

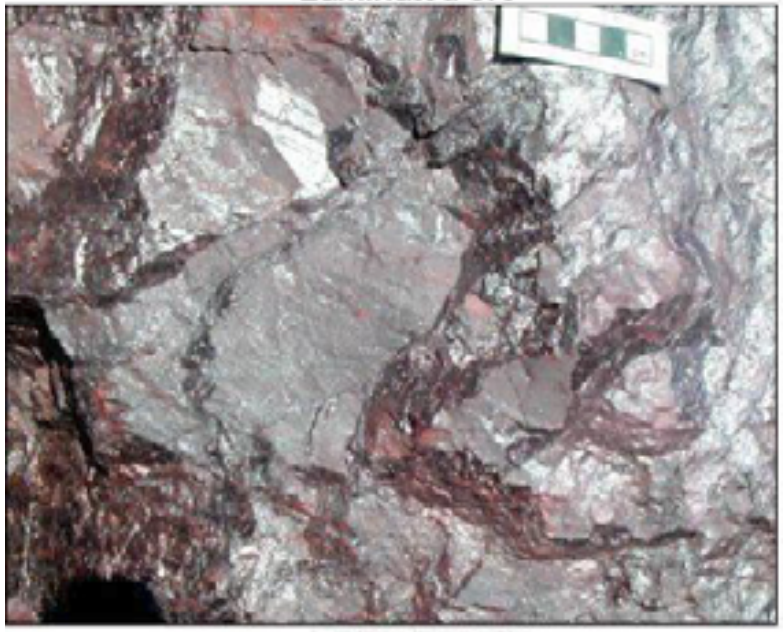


Production in 2007: 32.4 Mt; Stripping ratio: 1.9; 500 M EUR operating profit

Sishen Ore Types

Laminated ore

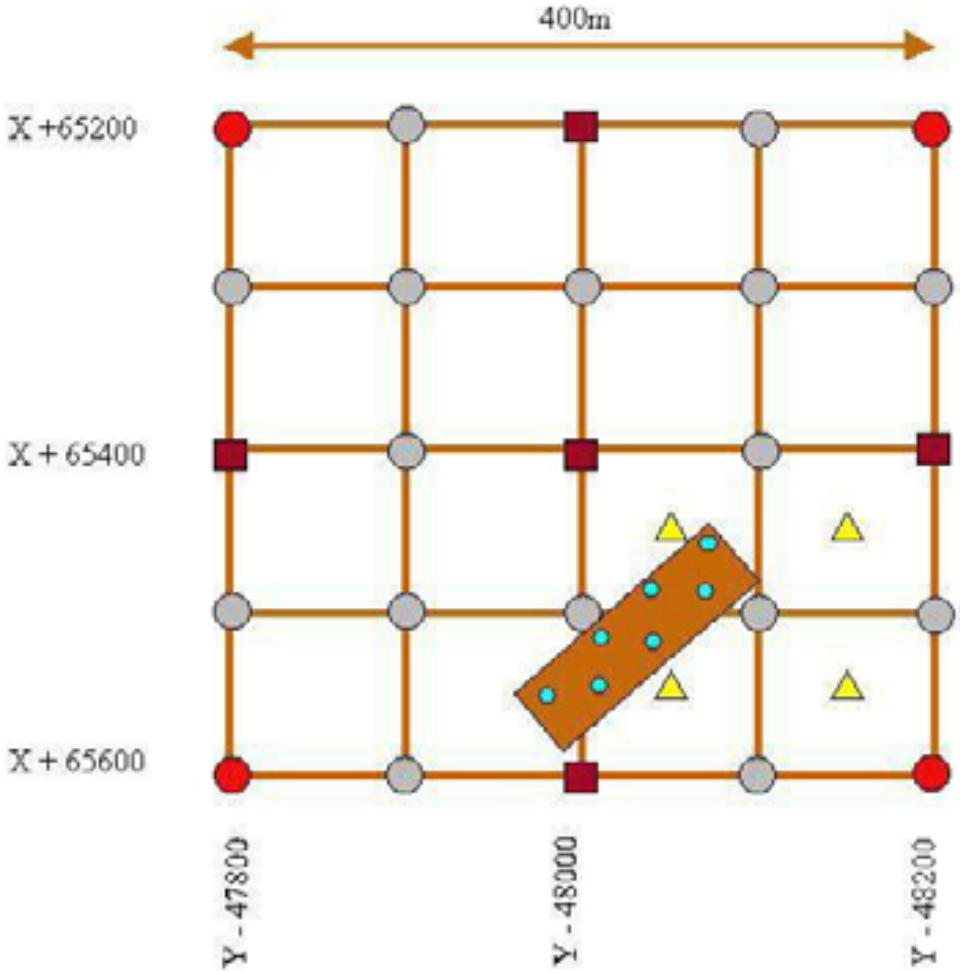
Massive ore



Brecciated ore

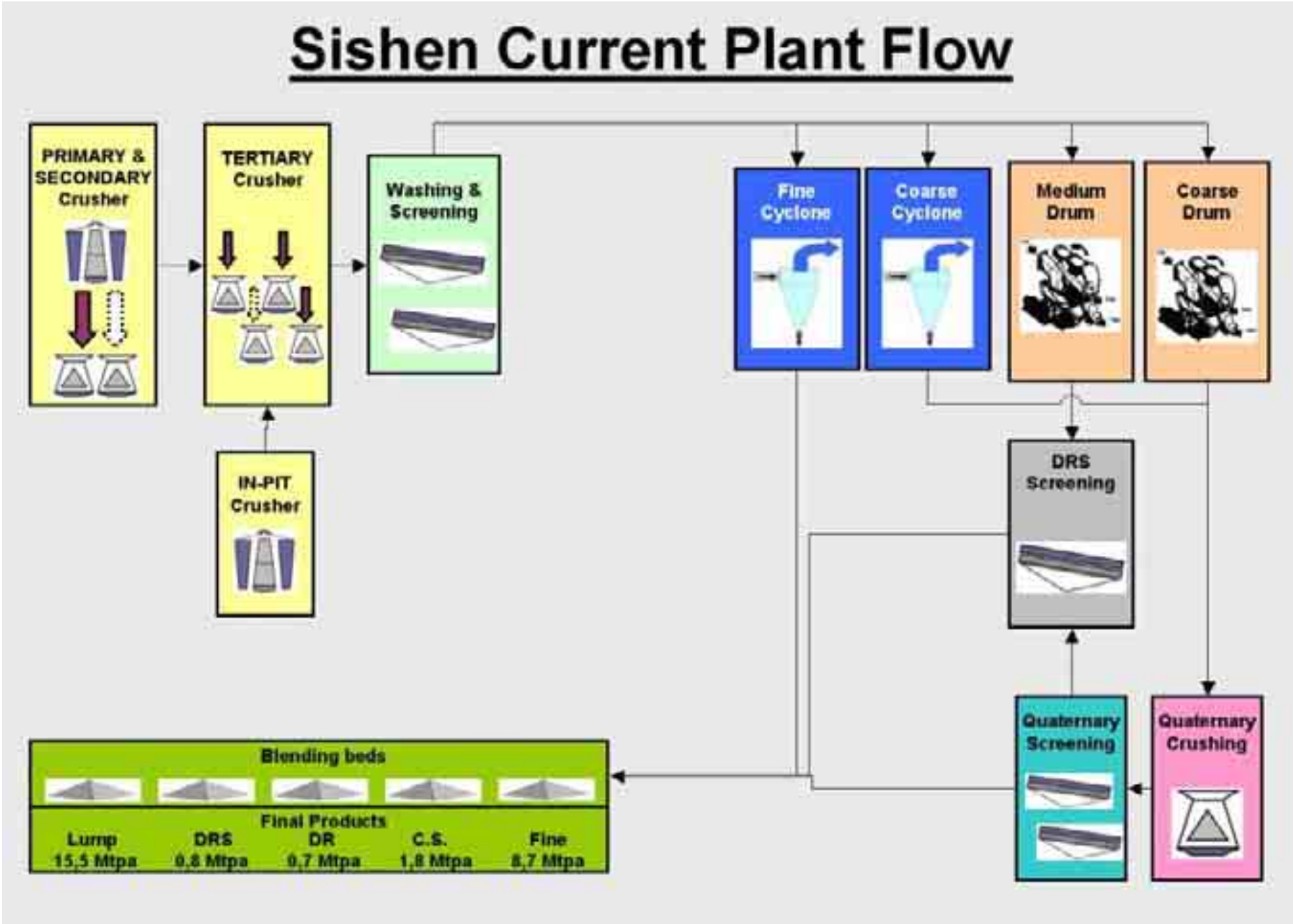
Conglomeratic ore

Exploration Grid

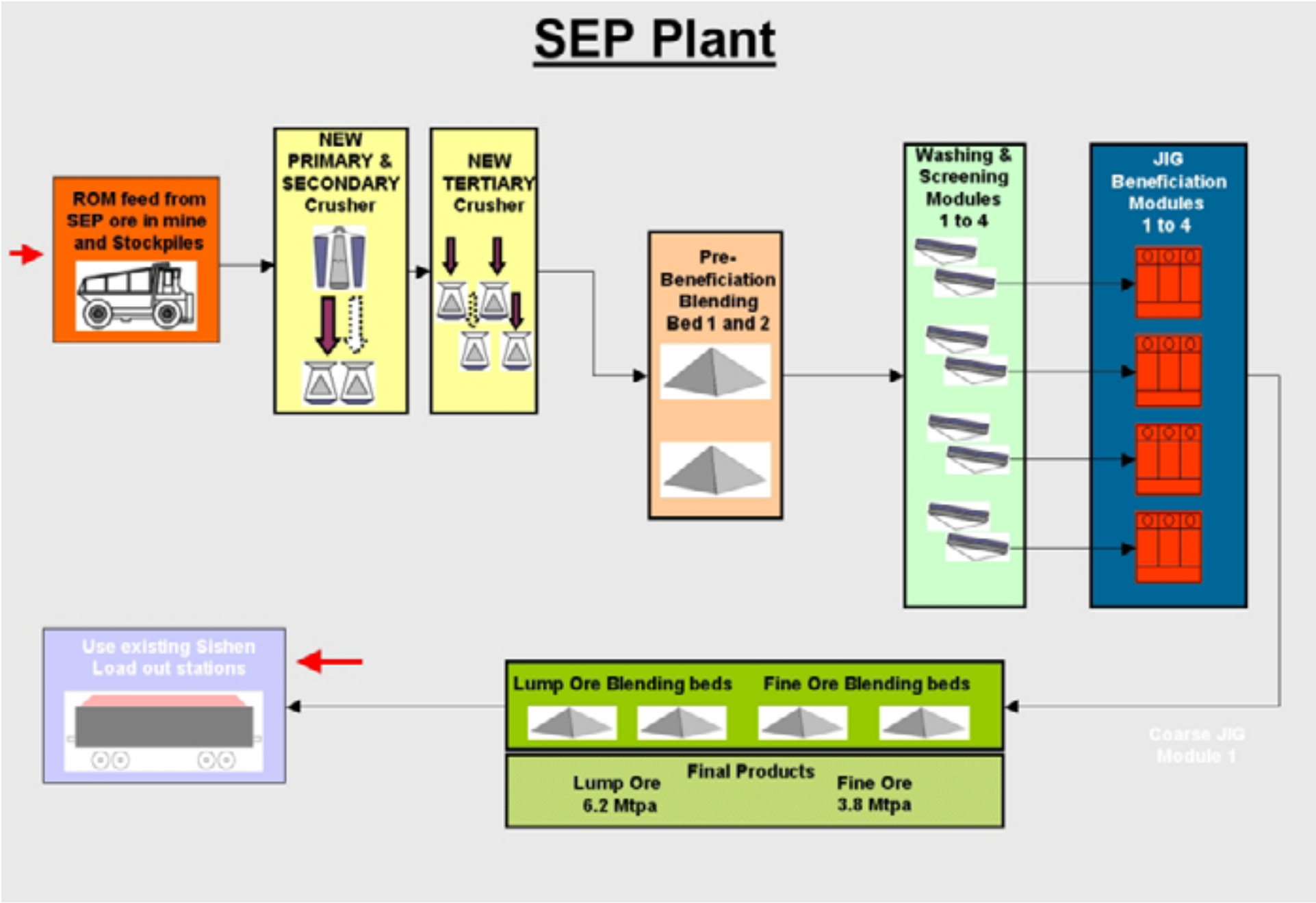


- Phase 1 ±400m x 400m (speculative resource)
- Phase 2 ±200m x 200m (inferred resource)
- Phase 3 ±100m x 100m (indicated resource)
- Phase 4 ±50m x 50m (measured resource)
- Phase 5 ±20m x 20m (proven reserve)

Sishen Current Plant Flow

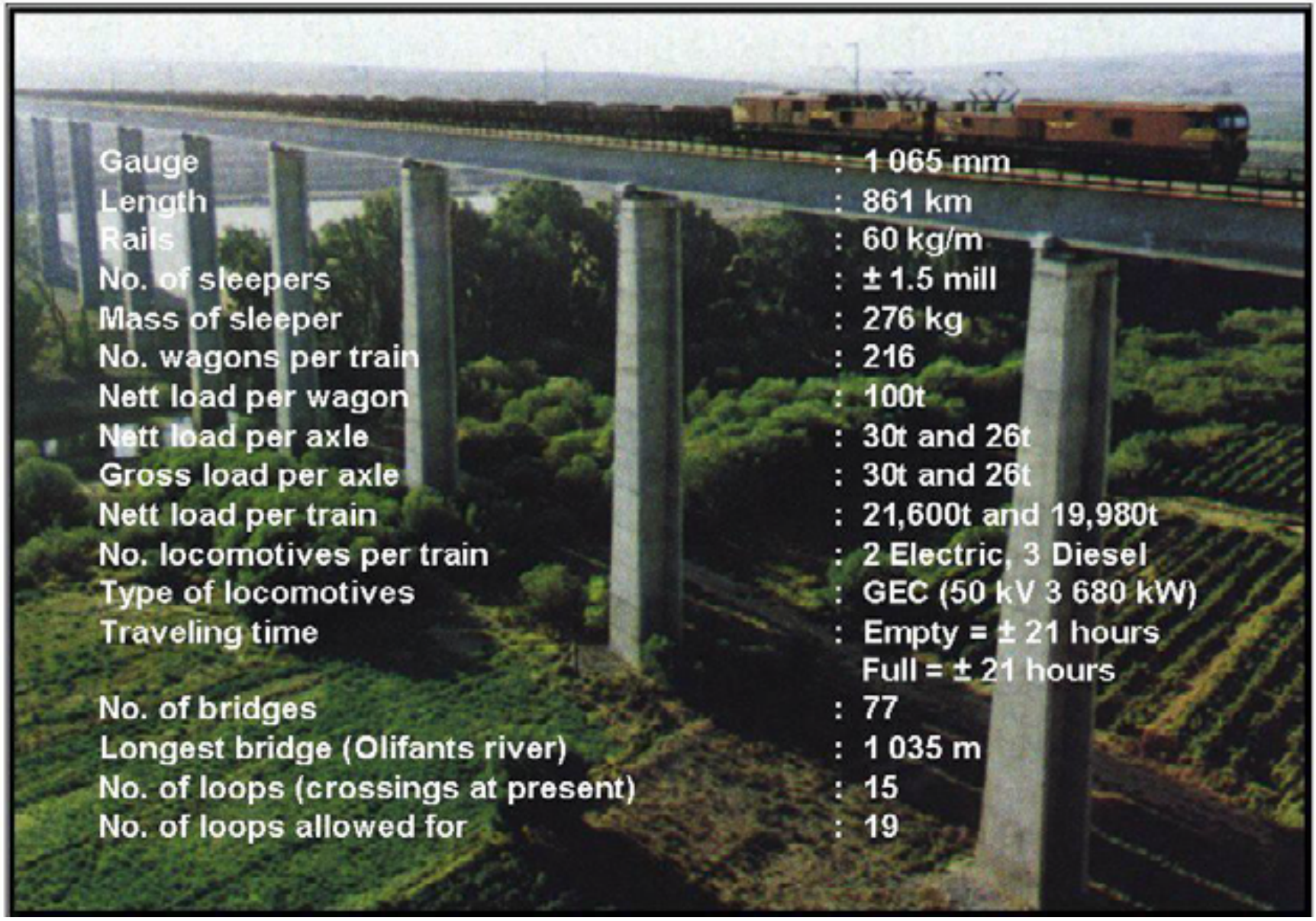


Current Beneficiation Plant



SEP= Sishen Expansion Project (the jigs allow lowering the cutoff from 60 to 55 % Fe)

General Information: Sishen-Saldanha Railway



Gauge	: 1 065 mm
Length	: 861 km
Rails	: 60 kg/m
No. of sleepers	: ± 1.5 mill
Mass of sleeper	: 276 kg
No. wagons per train	: 216
Nett load per wagon	: 100t
Nett load per axle	: 30t and 26t
Gross load per axle	: 30t and 26t
Nett load per train	: 21,600t and 19,980t
No. locomotives per train	: 2 Electric, 3 Diesel
Type of locomotives	: GEC (50 kV 3 680 kW)
Traveling time	: Empty = ± 21 hours Full = ± 21 hours
No. of bridges	: 77
Longest bridge (Olifants river)	: 1 035 m
No. of loops (crossings at present)	: 15
No. of loops allowed for	: 19

Saldanha Harbour

Iron Ore Quay:	500 m
Maximum Draft:	20,5 m
Channel Depth:	23,45 m
Total Quay length:	3,5 km
Largest cargo:	293 182 t
Design load rate:	8 000 tph


519
519


519
519


G
1300

Caue pit

Dois Corregos pit

Conceicao pit

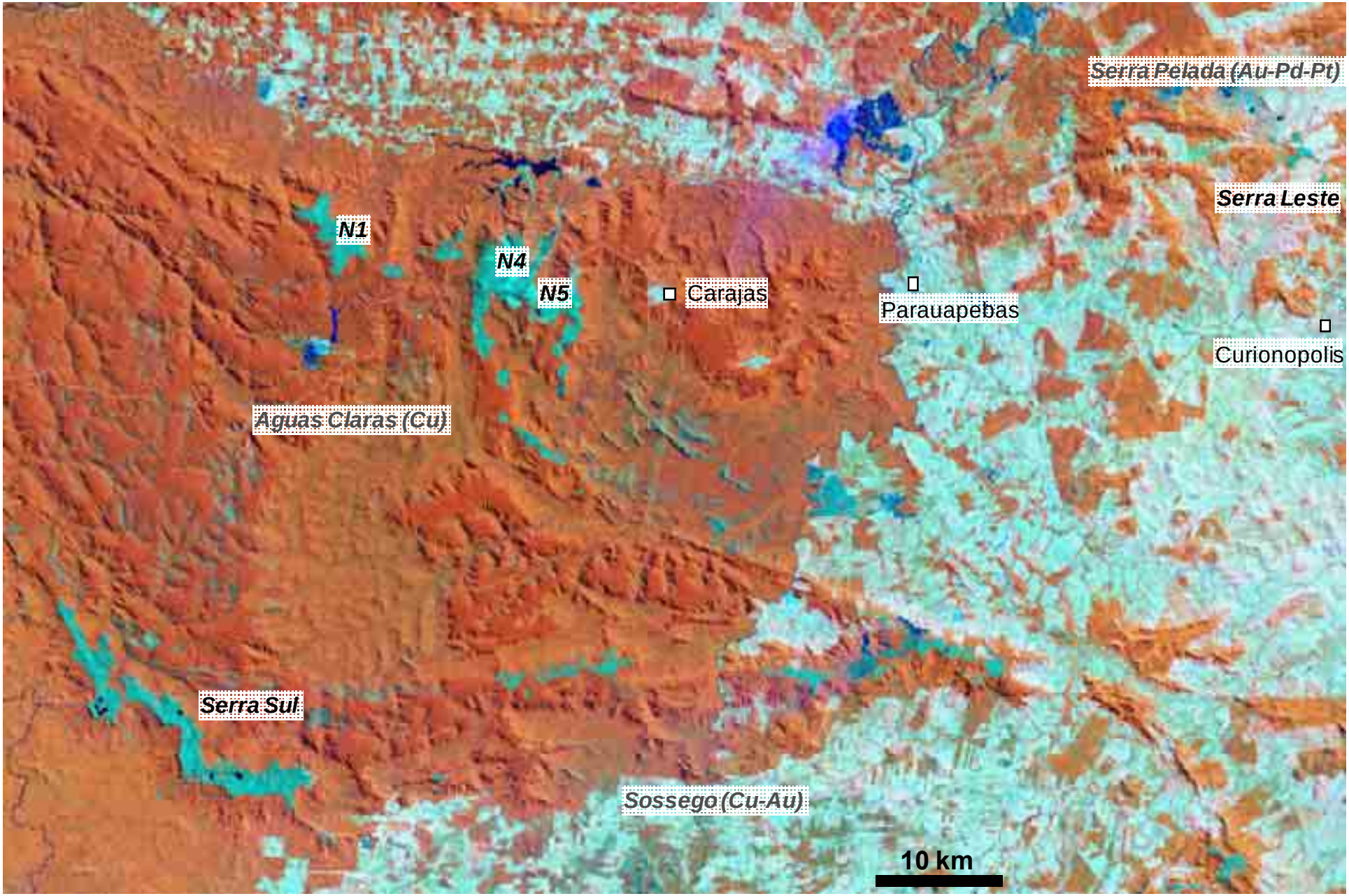
Itabira Syncline

Conceicao
pit

Gongo Soco, Minas Gerais

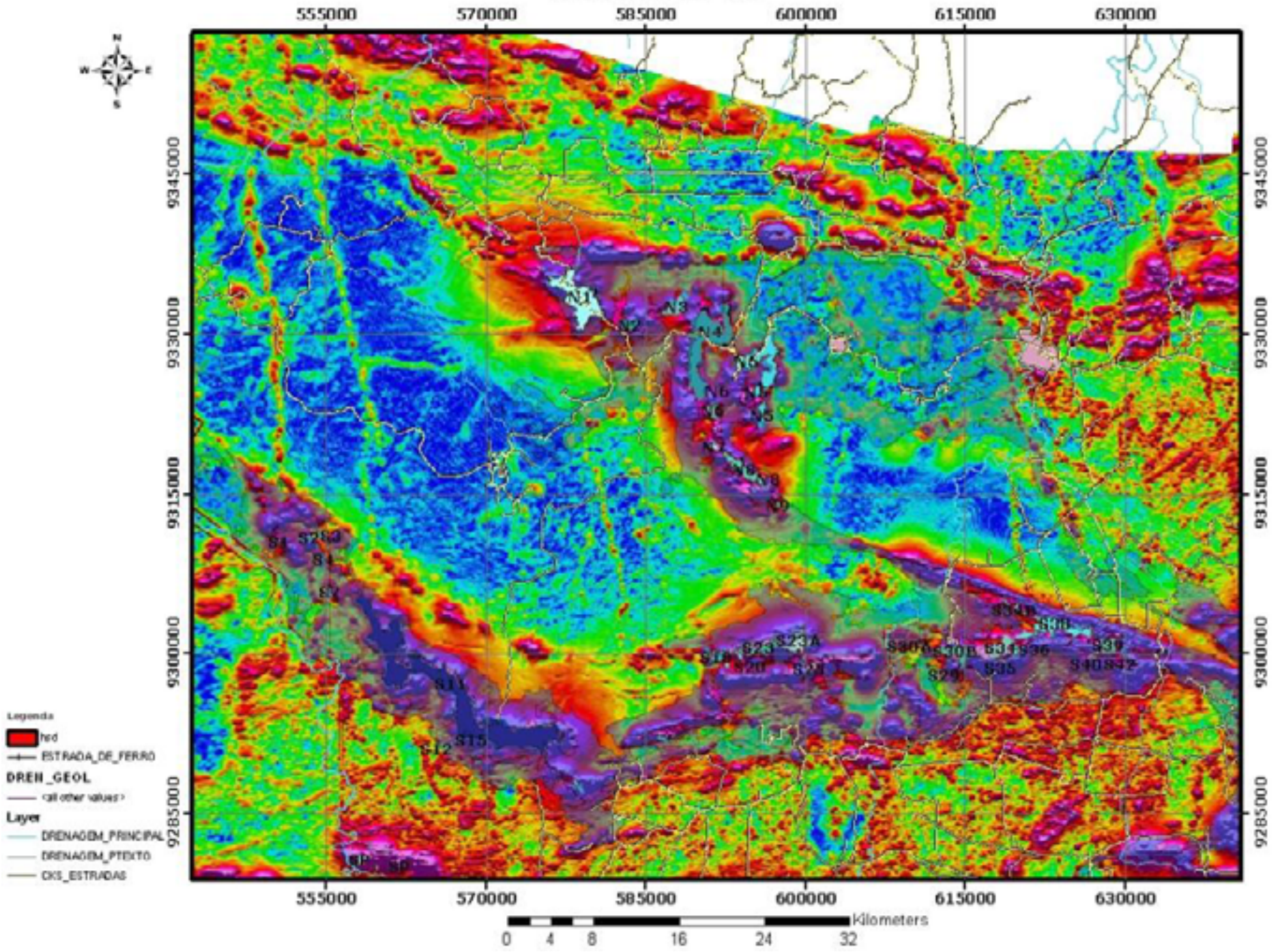
Gongo Soco, Minas Gerais

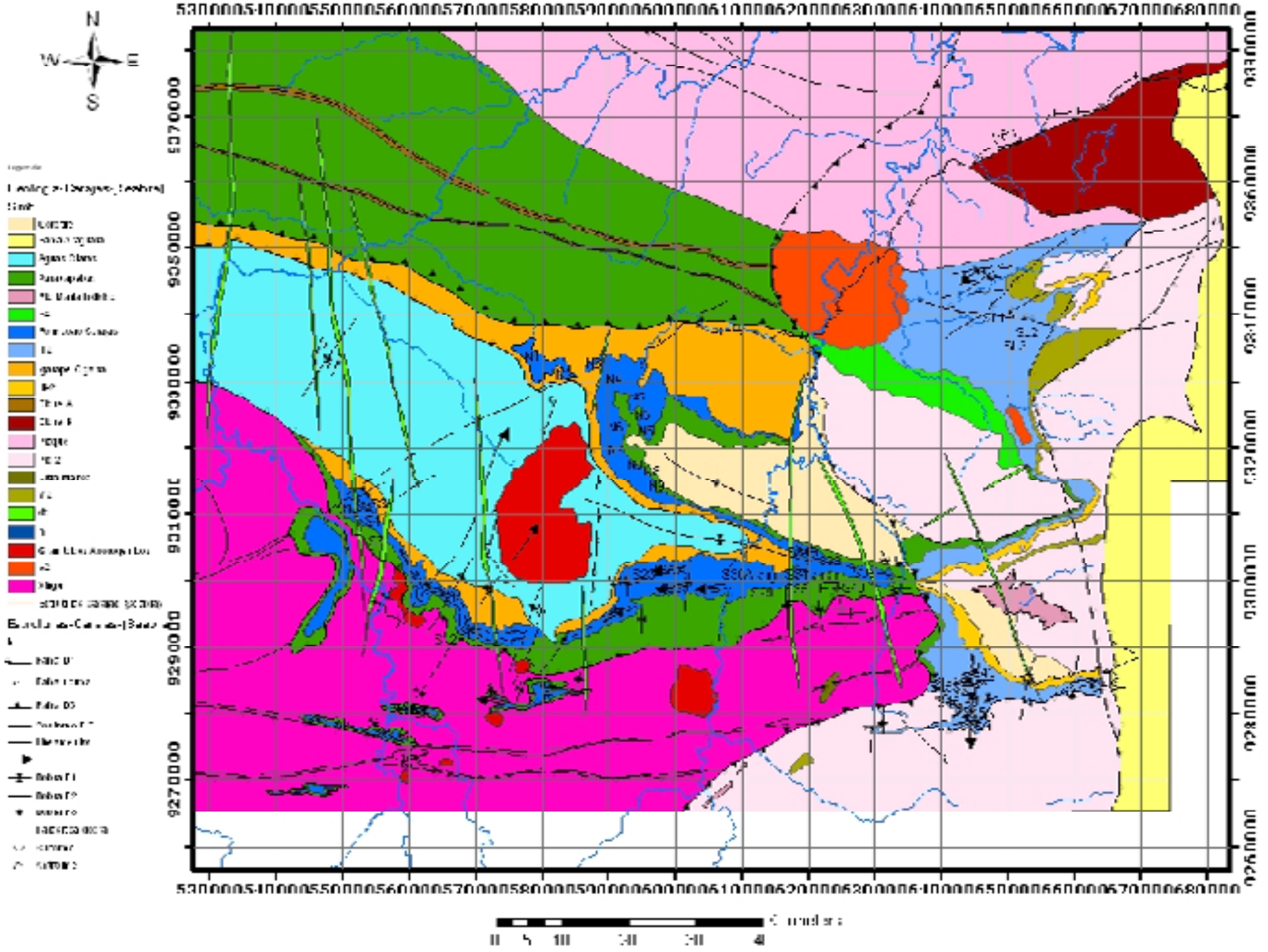
Central part of the Carajas mineral province



Landsat ETM7+ (August 1999)

Localizacao BIF




N
W
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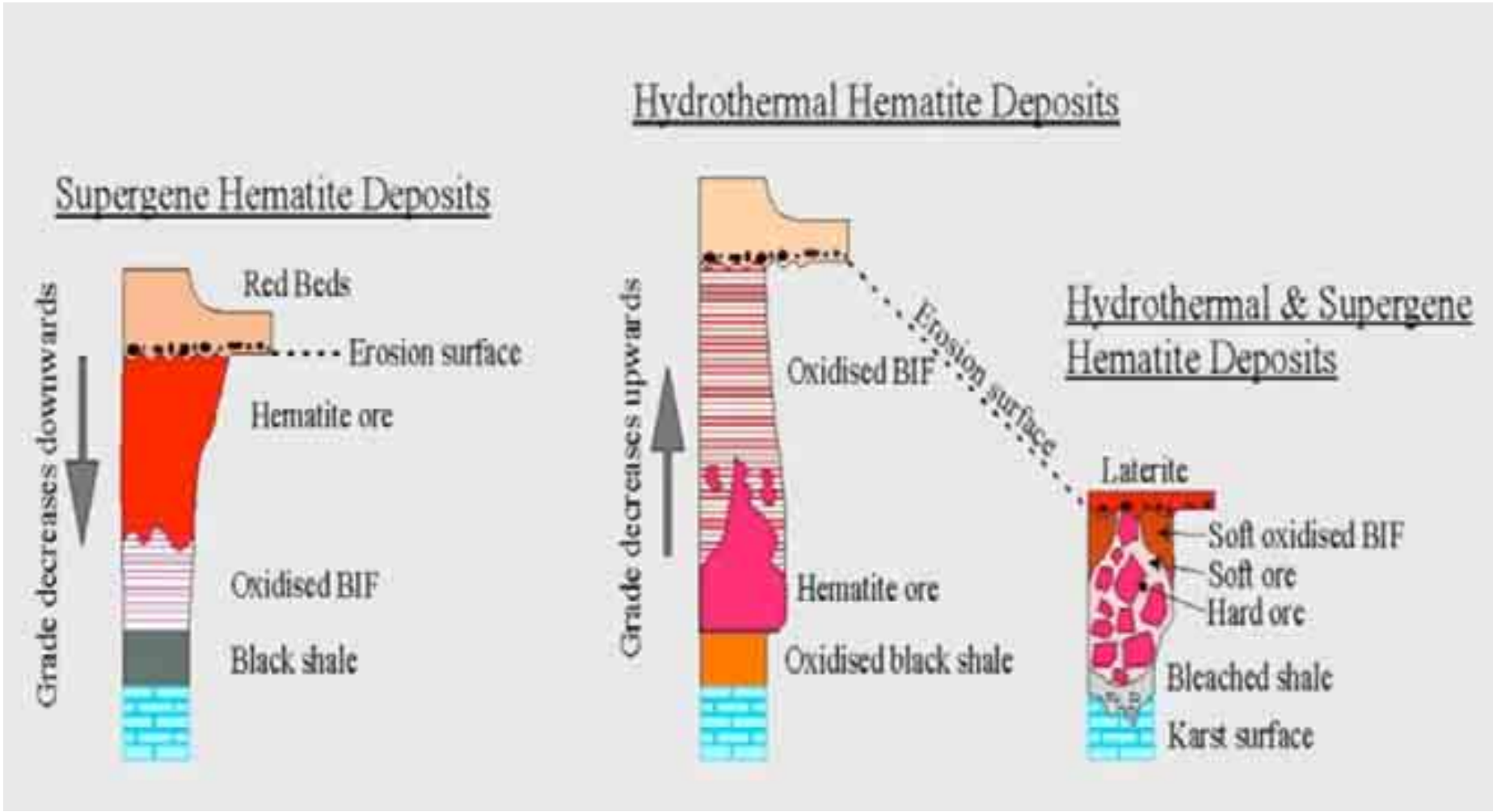
5300000 5400000 5500000 5600000 5700000 5800000 5900000 6000000 6100000 6200000 6300000 6400000 6500000 6600000 6700000 6800000
9270000
9280000
9290000
9300000
9310000
9320000
9330000
9340000
9350000
9360000
9370000


Mina N4E


N5E pit


Greenstone
Serra Sul, Orebody A


Serra Sul: Foliated high-grade hematite ore


Supergene Hematite Deposits
Grade decreases downwards
Red Beds
Erosion surface
Hematite ore
Oxidised BIF
Black shale
Hydrothermal Hematite Deposits
Grade decreases upwards
Oxidised BIF
Erosion surface
Hematite ore
Oxidised black shale
Hydrothermal & Supergene Hematite Deposits
Laterite
Soft oxidised BIF
Soft ore
Hard ore
Bleached shale
Karst surface