



GEOLOGY & MINERAL RESOURCES OF THE KINGDOM OF SAUDI ARABIA

PRESENTED BY RALPH STAGG

BSc MSc DIC FAusIMM MIM3 C Eng

SMEDG on Thursday, 13th June 2024



وزارة الصناعة
والثروة المعدنية
Ministry of Industry and Mineral Resources



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Expertise: Mark Gordon (presentation); Chris Spencer (Industrial Minerals)

Websites: Barrick Gold Corporation; Ma'aden (and subsidiaries); Al Masane Al Kobra Mining Company

EXPLORATION AND MINING IN SAUDI ARABIA

Today's Landscape

Saudi Arabia's mining sector is **growing rapidly** under **Vision 2030**.

US\$2.5 trillion of **untapped mineral wealth** offers significant exploration opportunities.

Rapidly growing **demand for minerals**: Pipeline **11 Mega projects** exceeding US\$1 trillion until 2030.

Aim to **increase** mining sectors **GDP contribution** by 175% to SAR 176 bn (US\$47 bn).

Financial incentives: **Exploration Enablement Program (EEP)**; and Saudi Industrial Development Fund (SIDF) **co-funding up to 75% of capital expenditure (CAPEX)**

New **modernized mining code** aligns with global standards.

Robust infrastructure and **skilled workforce** strengthen Saudi Arabia's global mining status.

Cost advantages including **low energy costs** and **low labour costs**.

The Kingdom's Goal: **Mining sector** to become **3rd pillar** of the **Kingdom's economy** by fostering mutual growth and prosperity.

EXPLORATION AND MINING IN SAUDI ARABIA

Today's Landscape

Saudi Geological Survey Advancements

2.7 bn SAR (US\$720 m) committed for surveys and exploration to further advance:

- National Geological Database (NGD)
 - Geophysics/chem survey completed across 50% Arabian-shield
- Regional Geological Survey Program
- National Core Library (digitised)
- Accelerated Exploration Program
- Mining Centre of Excellence
- Geothermal energy exploration (GTEE)

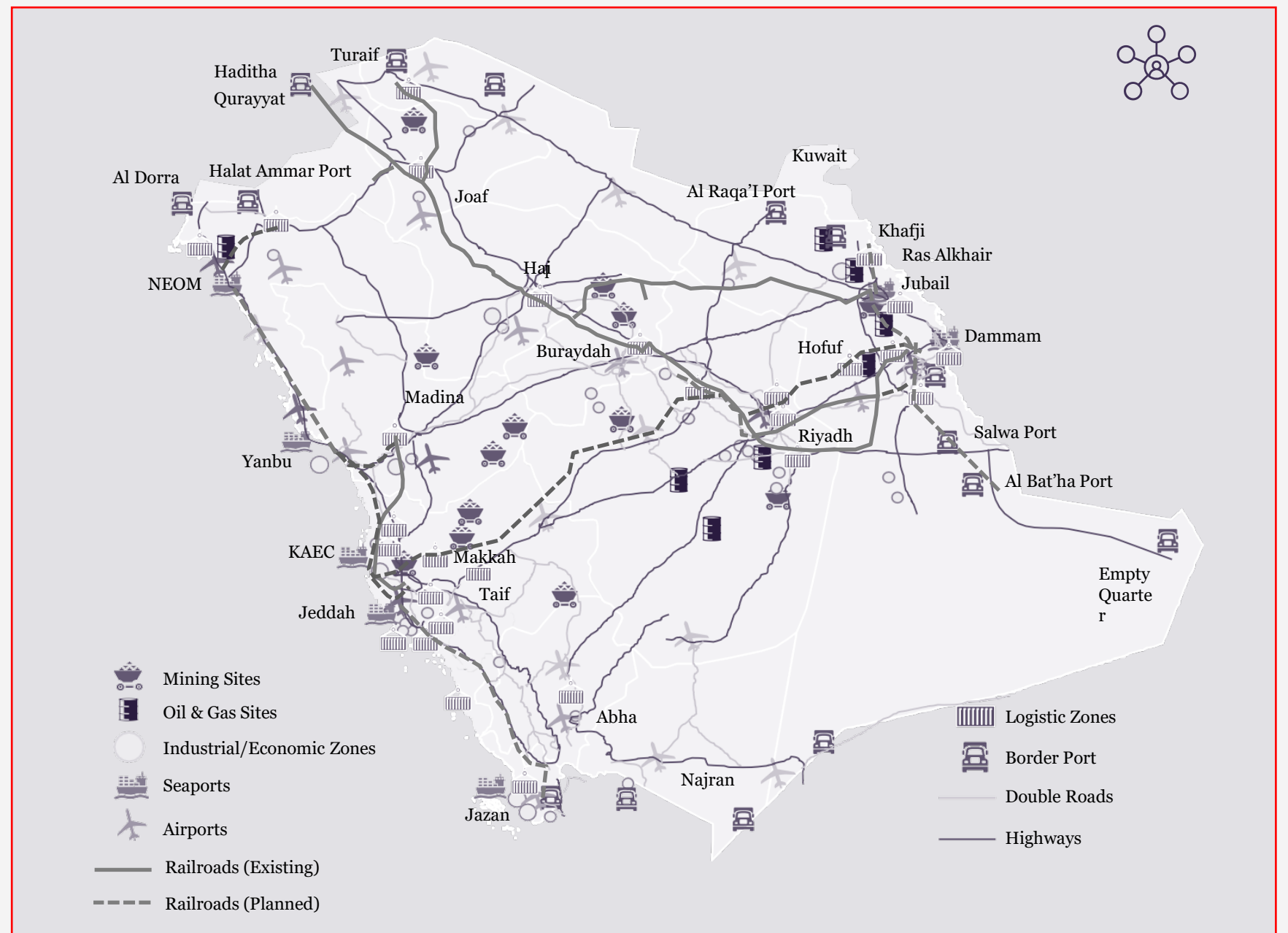
New Investor-Friendly Mining Regime

- Modernized mining code aligning with **global standards**
- Streamlined, **transparent** licensing and permitting process
- **Security of tenure** assured
- Direct application for licenses on a **first-come, first-served** basis
- **100% foreign direct ownership** allowed

Advanced Infrastructure

- Superior infrastructure networks include:
 - roads (73,000 km)
 - seaports (10 for non-oil trade)
 - airports (28)
 - railroads (4,500 km)

Logistics network connecting and enabling all sectors across the Kingdom Domestically, Regionally and Internationally

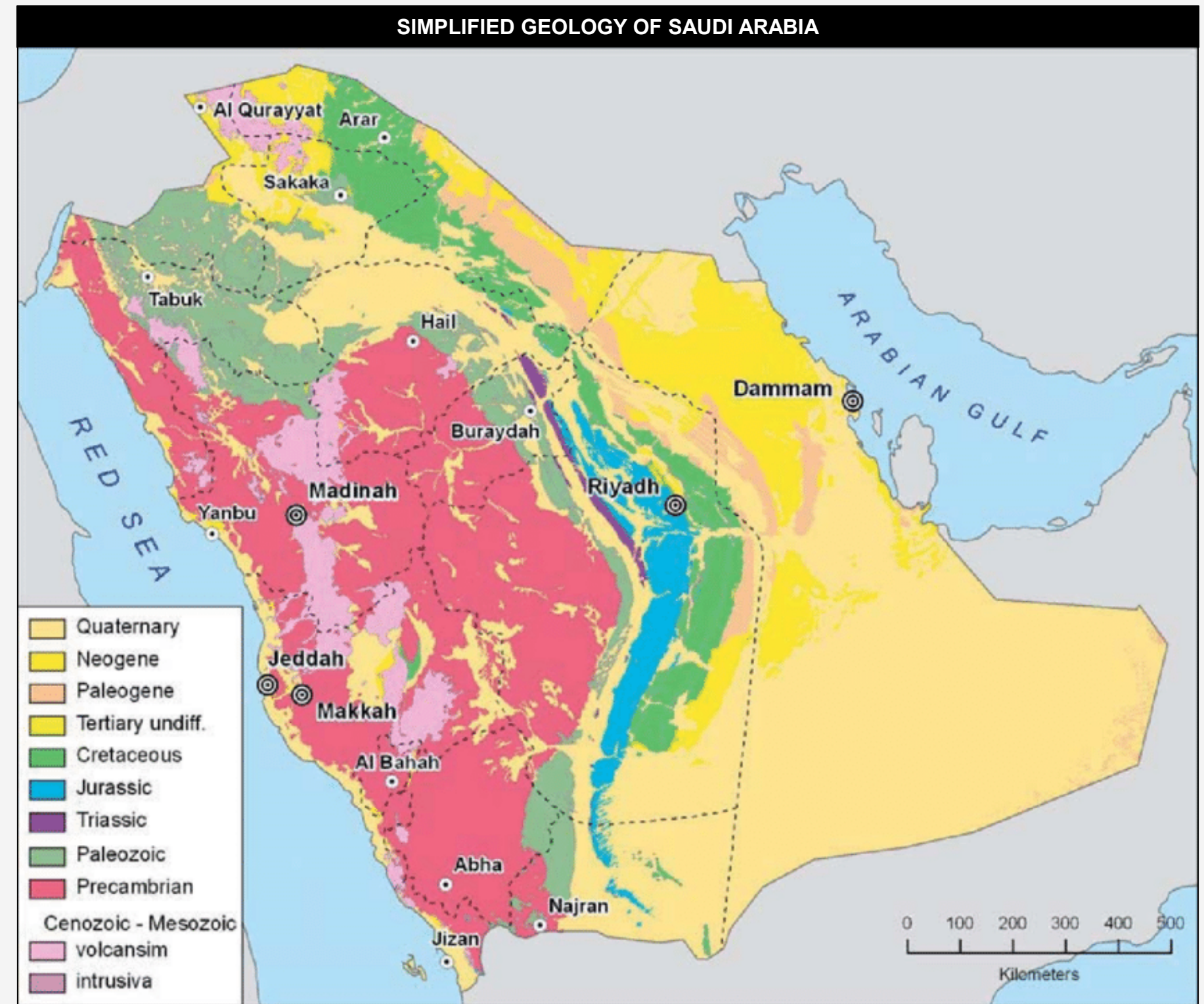


Source: Saudi Arabia's Ministry of Industry and Mineral Resources

GEOLOGICAL LANDSCAPE

Regional Geology

- Arabian – Nubian Shield – East African Orogen – core of the end Precambrian Gondwana Super Continent
- Proterozoic Arabian Shield; comprising metamorphosed volcano-sedimentary successions intruded by granite & gabbro
- Phanerozoic Arabian Platform; Arabian platform of clastic, calcareous & and evaporitic successions
- Tertiary Harrats; extensive basalt plateaus)
- Tertiary and Quaternary Red Sea Coastal Plain; sedimentary rocks & coral reefs
- Significant areas of the Shield also covered by Quaternary units, including sand/gravel plains and wadi sediments
- Arabian Shield is about 1,800 Km long and a maximum width of 700 Km

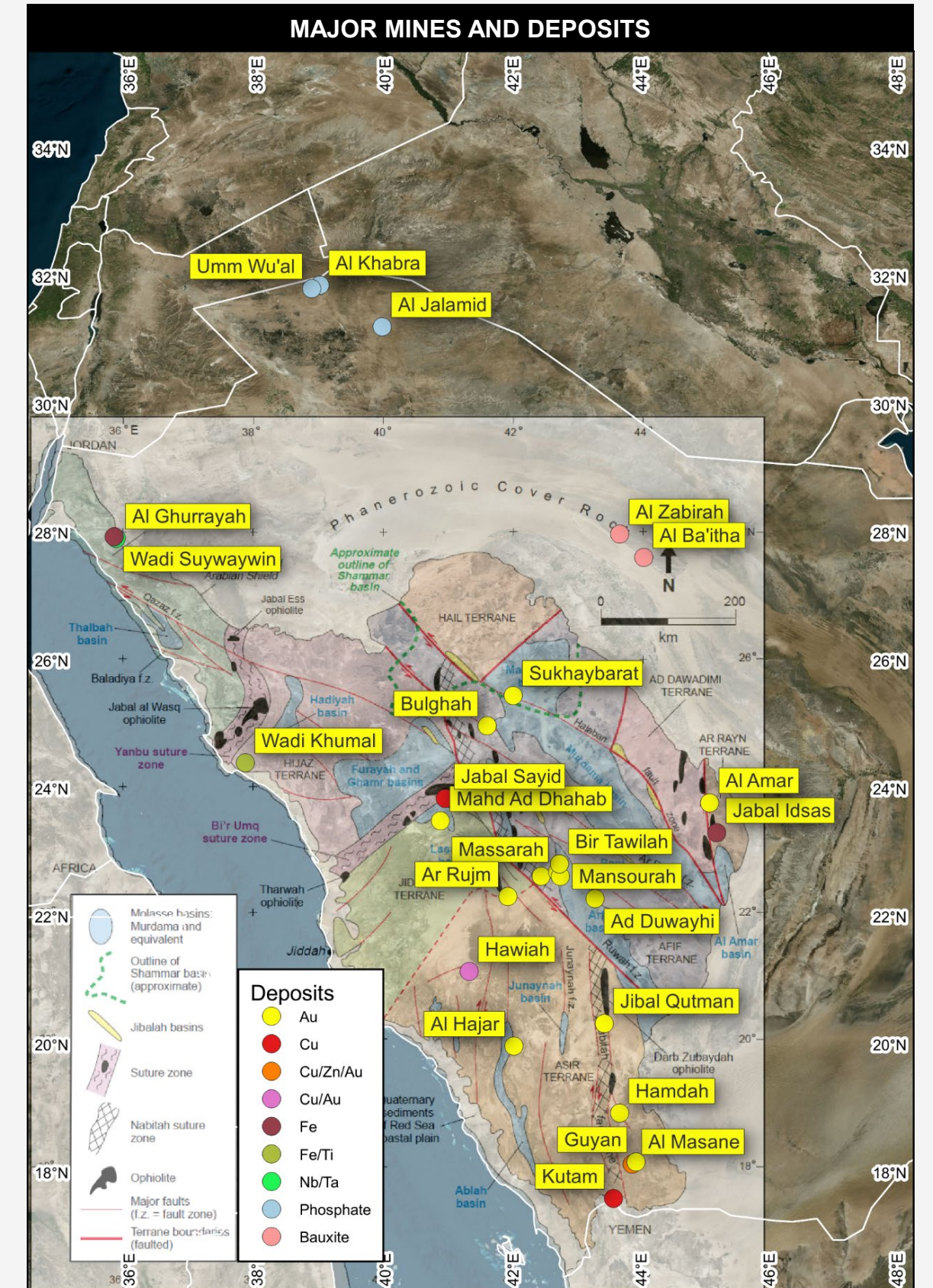


Source: Al Saud & Rausch (2012). Proceedings “Hydrology of Arid Environments” Stuttgart, March 2012

MINERAL INTEREST

Metallic and Non-Metallic Minerals

- Mineral deposits are widespread ranging from gold to lightweight aggregate
- Arabian Shield hosts majority of metallic minerals
- Non-metallic resources are contained in both PreCambrian and Phanerozoic rocks
- Metallic Minerals
 - Base Metals Cu, Zn, Pb
 - Precious Metals Au, Ag, PGM
 - Ferrous Metals Fe, Ti
- Other Minerals
 - Aluminium, Mg
 - Tin, Ta
 - Rare Earths
- Industrial Minerals
 - Phosphate
 - Lime, dolomite, limestone
- Oil & Gas

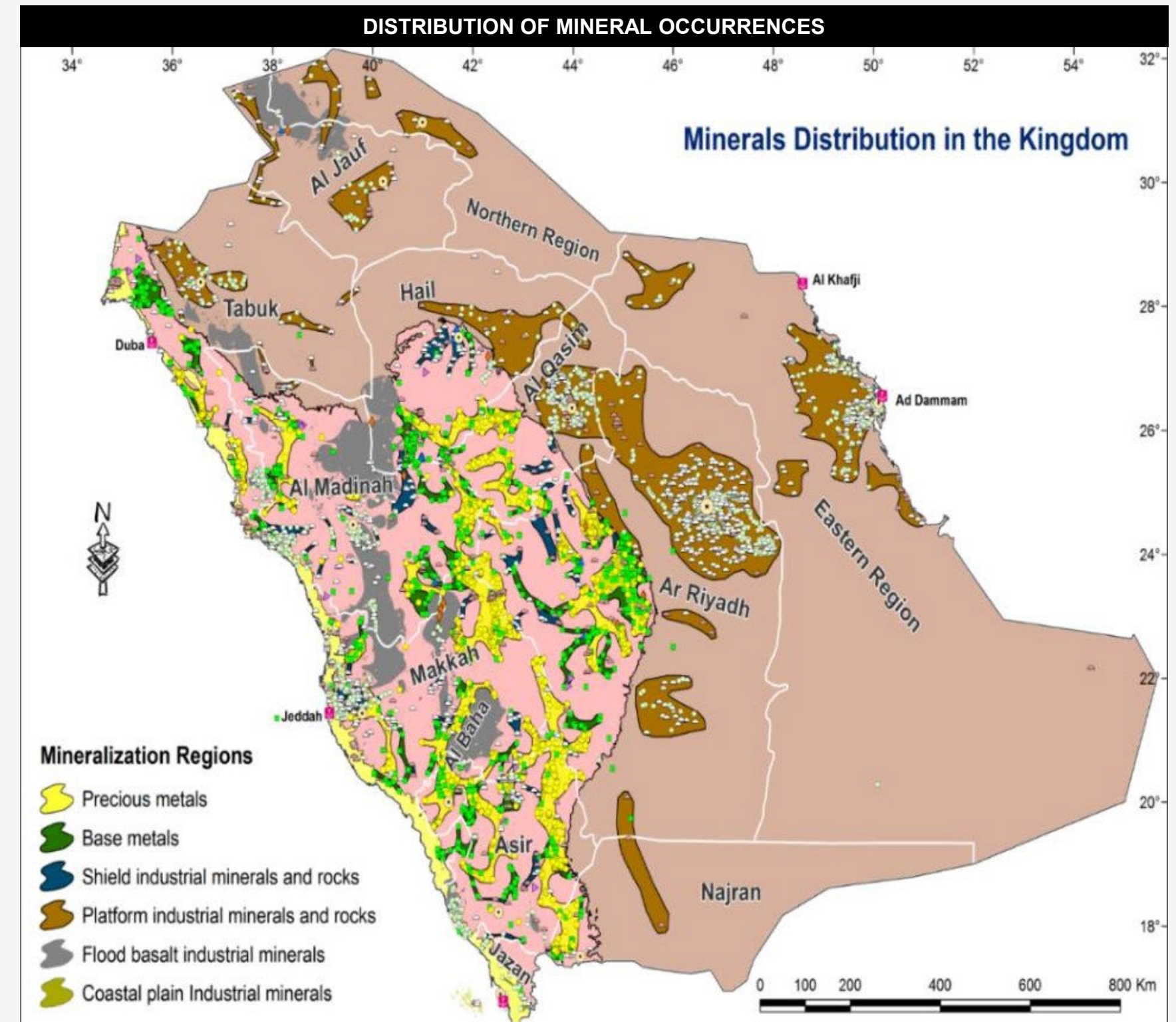


Source: Adapted from Nehlig et al (2002) GeoArabia Vol 7, No 1, Bing aerial image

MINERAL OCCURRENCES

Wide range of commodities

- Mineral occurrences widespread throughout the shield and platform rocks
- These are catalogued in the “MODS” database of the Saudi Geological Survey, which can be sourced through the National Geological Database Portal
- Largely mapped by the USGS and BRGM in the 1960s and 1970s, with the mapping forming the basis of the current published geological maps; Riofinex and WGM data reviews; Cover rock Project (London University)
- Also, large areas under recent cover, so potential for blind deposits
- There has been little overall follow up work, however that which has been done has led to significant discoveries, including Jabal Sayid, and several gold deposits amongst others including Industrial Minerals

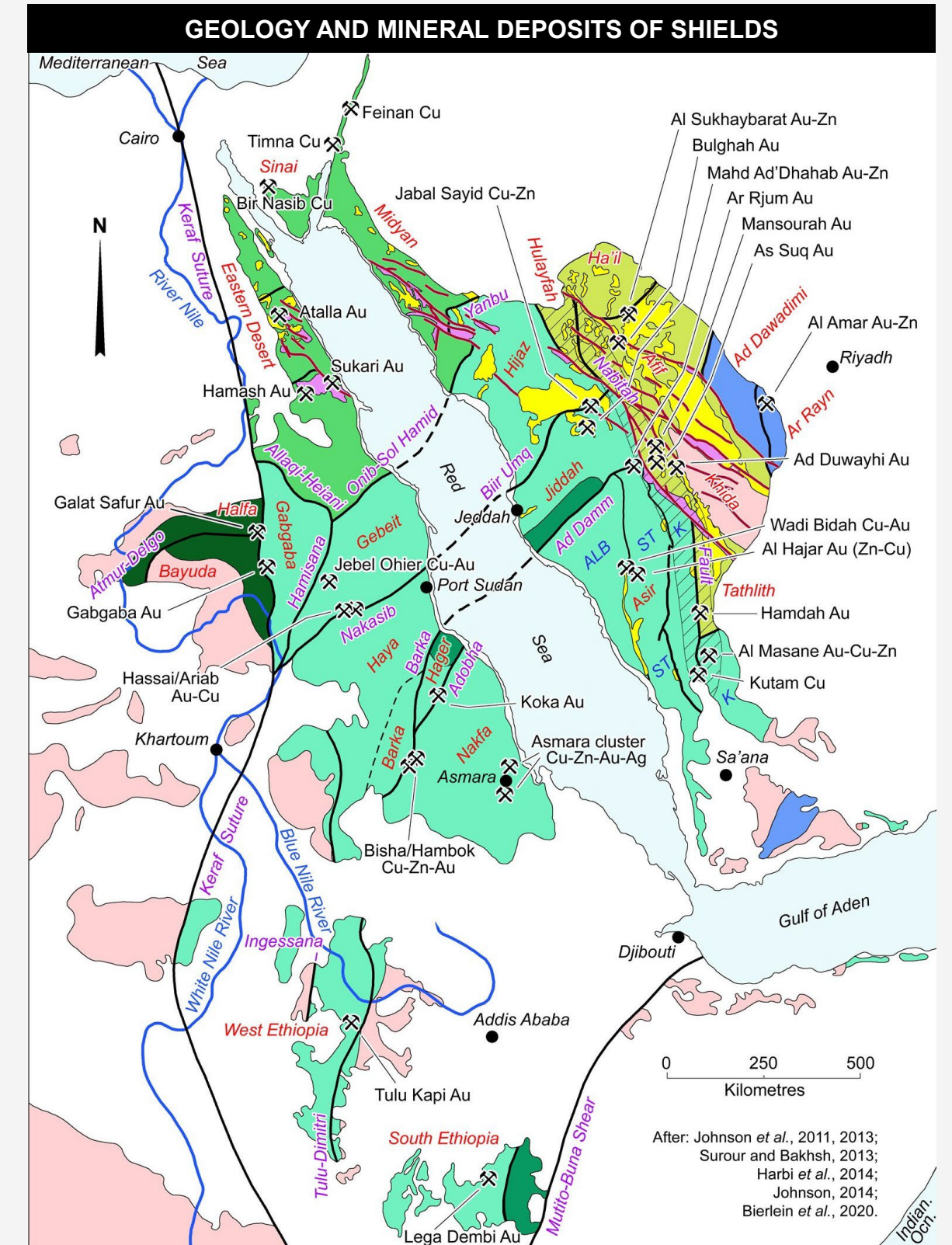


Source: MIMR, MODS database

PRE-CAMBRIAN (PROTEROZOIC) ARABIAN SHIELD

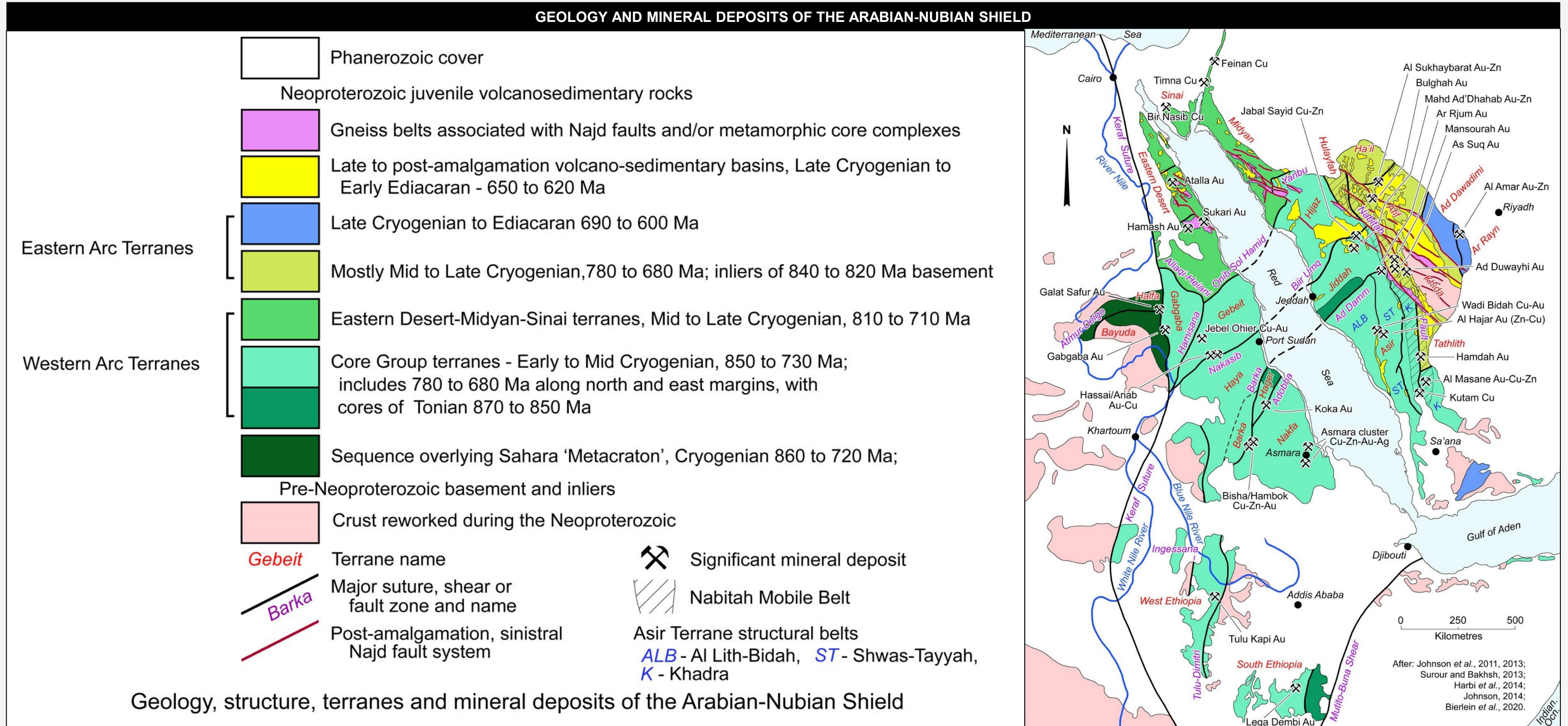
Comparison with Australian Shield areas

- Red Sea Rift splits the Arabian and Nubian Shields
- Trapezoidal Shaped area of about 575,000Km² (1,800 km x 700 km) – overlain by 81,000 Km² of Cenozoic basaltic lava fields (Harrats)
- Similar size to the Archaean Yilgarn Craton of Western Australia, which has an annual gold production of ~ 7 Mozpa, whereas the Arabian Shield currently produces ~430,000 ozpa
- Smaller areas in Jordan and Yemen
- Basement of the Arabian Peninsula – represents more than 1,200 M years of geological time
- Mining in the Arabian Shield taken place up to 5,000 years bp (Timna Cu) and Mahd Adh Dhahab ('Cradle of Gold') – 3,000 -5,000 years bp



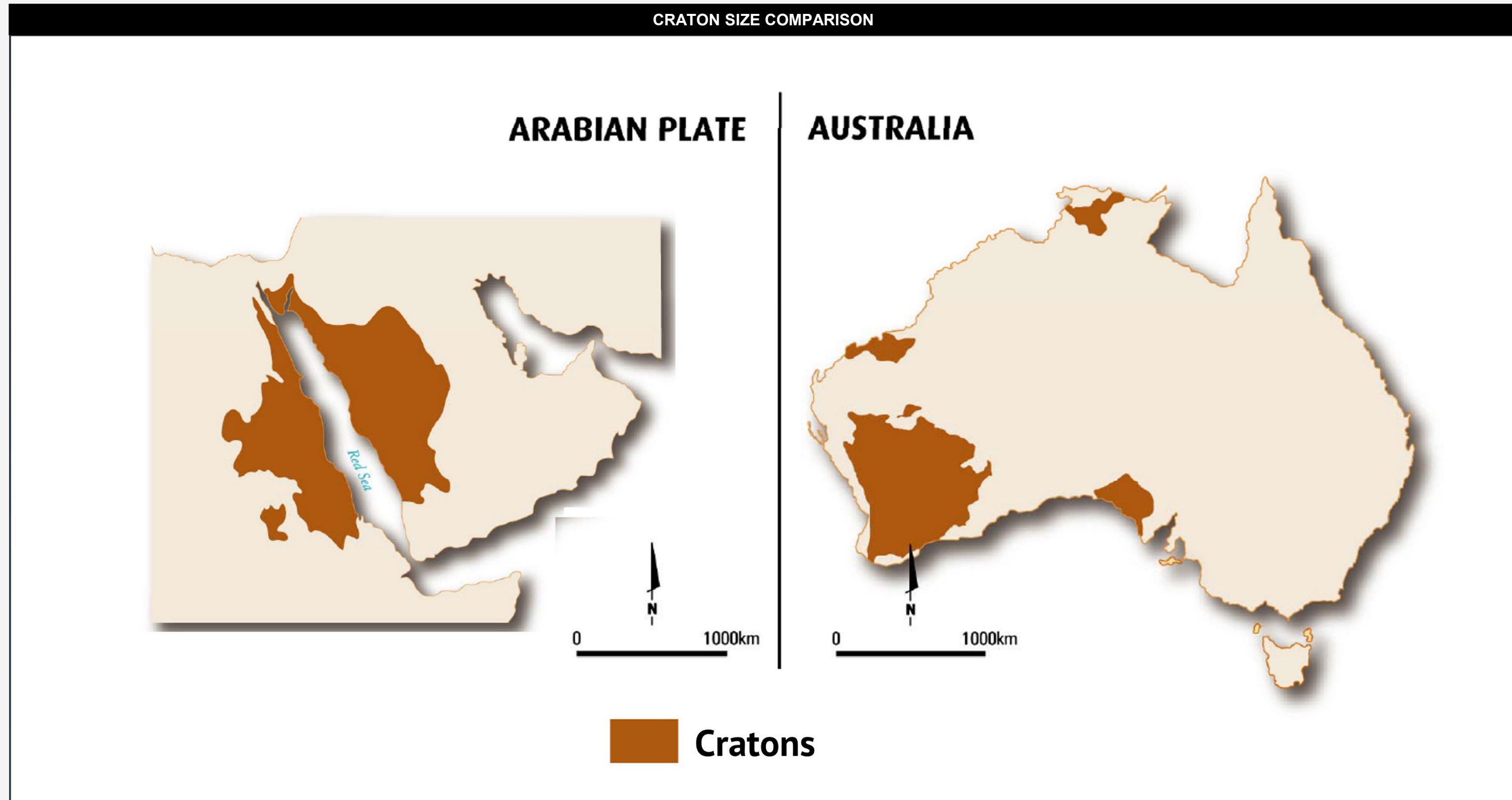
Source: Porter Geodatabase

PRE-CAMBRIAN (PROTEROZOIC) ARABIAN SHIELD



Source: Porter Geodatabase

CRATON SIZE COMPARISON

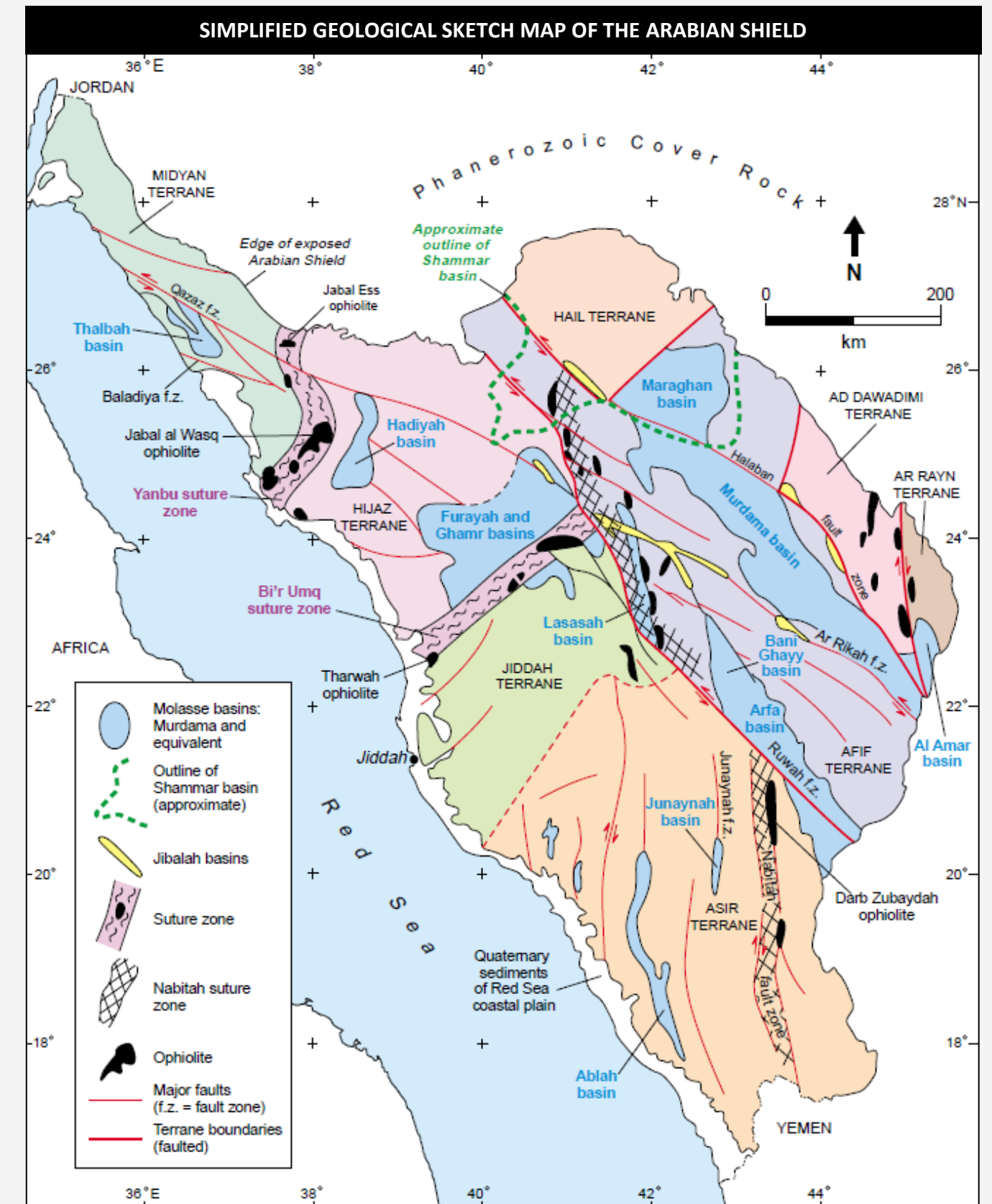


Source: Citadel Resource Group April 2008 presentation

GEOLOGICAL EVOLUTION OF THE SHIELD

Neoproterozoic, Pan-African events

- Deposition of sedimentary and volcanic rocks and intrusion of plutonic rocks in a series of magmatic arcs
- Folding, faulting and recrystallisation of the rocks in a series of orogenic events
- Collapse and extension of the orogenic belt; deposition of younger sedimentary and volcanic molasse basins and intrusion of late granites
- Eight or more terranes are postulated separated by four suture zones
- Terranes in the west are made up of oceanic arcs; in the east – continental affinity
- NW-trending faults – Najd Fault System – extensive strike-slip movement, with the latest being sinistral
- Represents more than 1,200 M years of geological time
- Amalgamation of Shield terranes took place from about 715 to 630 M years
- Granitic rocks intruded during 640 to 550 M years
- Major Najd fault system operated in similar timeframe displacing parts of the orogen to the N-W

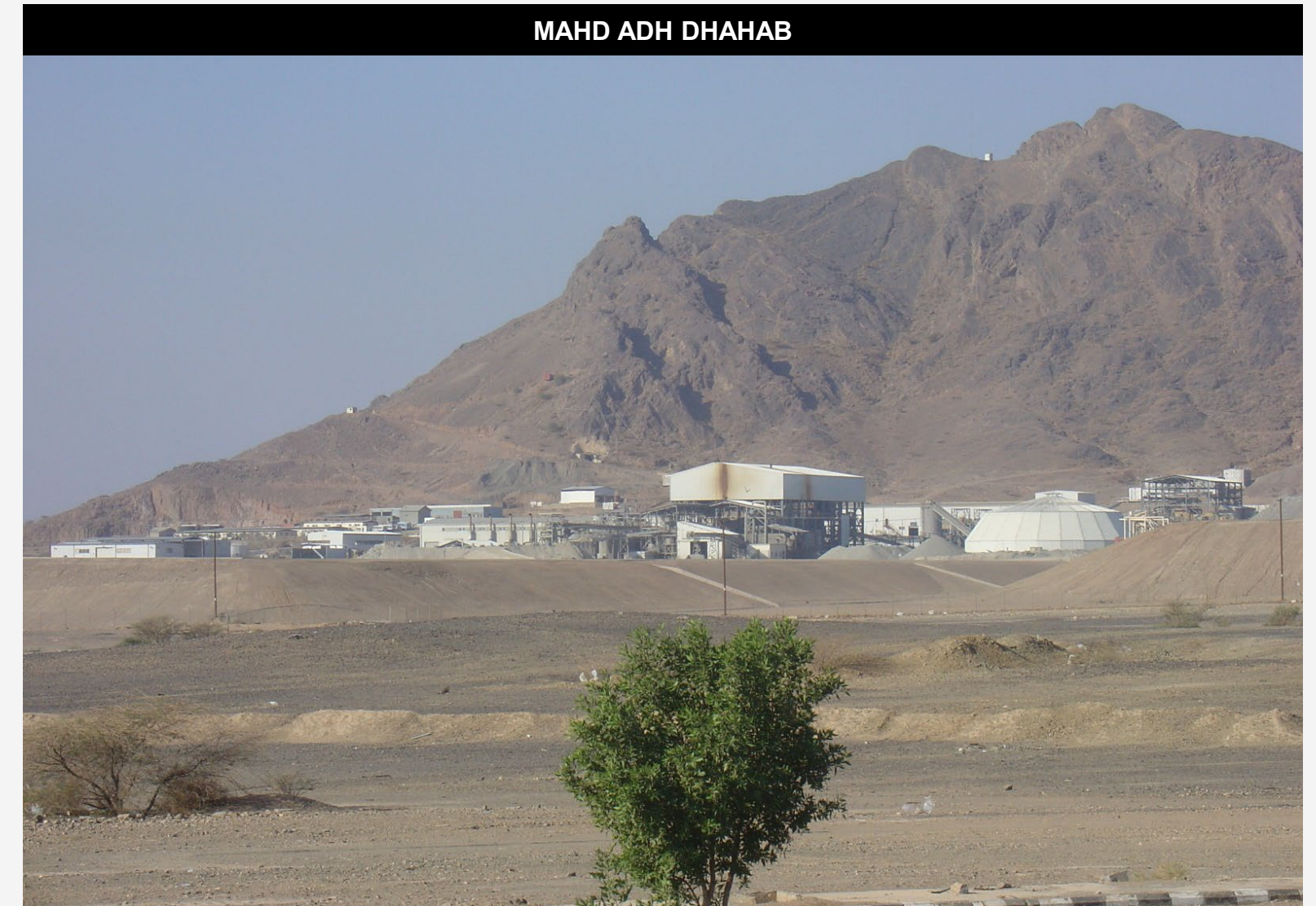


Source: Nehlig et al (2002) GeoArabia Vol 7, No 1

GOLD

Numerous occurrences in the Shield

- History dates back 5,000 years – ‘King Solomons Mines!’ – Ma’hd Adh Dhahab
- Currently 7 operating Gold Mines (~406,903 oz in 2023) – Ma’aden and 2 mines (Al Masane/Guyan, 26,352 oz in 2023) – AMAK (Al Masane Al Kobra)
- Ma’aden mines at Ad Duwayhi (O/C & CIL), Al Amar (UG & Dore + Cu/Zn con), Bulgah and Sukhaybarat (O/C, CIL & Heap Leach), As Suq (O/C & Heap Leach), Madh Ad Dhahab (UG, CIL and Dore + Cu/Ag conc.), Mansourah and Massarah Mine (O/C & CIL + Pox)
- Host rocks and Geological Settings: Mafic to Felsic Volcanic and volcanoclastic rocks; diorite, granodiorite and granite plutons; dikes, veins and shear zones
- Mesothermal deposits dominant gold-deposit type (no of deposits)
- Epithermal deposits hosted in continental margin volcanic arcs in the central and eastern parts of the shield – include Al Amar
- VMS deposits include Cu, Zn, (Pb), Au and Ag occur in submarine volcanic centres of oceanic-island arc or back-arc origins
- Small enriched oxide zones over sulphides and alluvial occurrences
- High potential for untapped resources. Imports to meet local demand



Source: R Stagg

COPPER

Widespread in the Arabian Shield

- Numerous Ancient workings and smelting sites up to 3,000 bp
- Jabal Sayid Cu-Zn deposit hosted in volcanic rocks near Jabal Sayid
- Production (2023) 70,158 t Cu owned 50:50 Barrick Gold:Ma'aden
- Also, Zn, Ag and Au resources (not reported)
- Known resources at Kutam, and Jabal Ash Shizm
- Exploration at Umm Ad Damar (Barrick 100%)
- Framework drill program confirms presence of copper rich VMS systems
- No Zn or Cu smelting and refining – concentrates exported

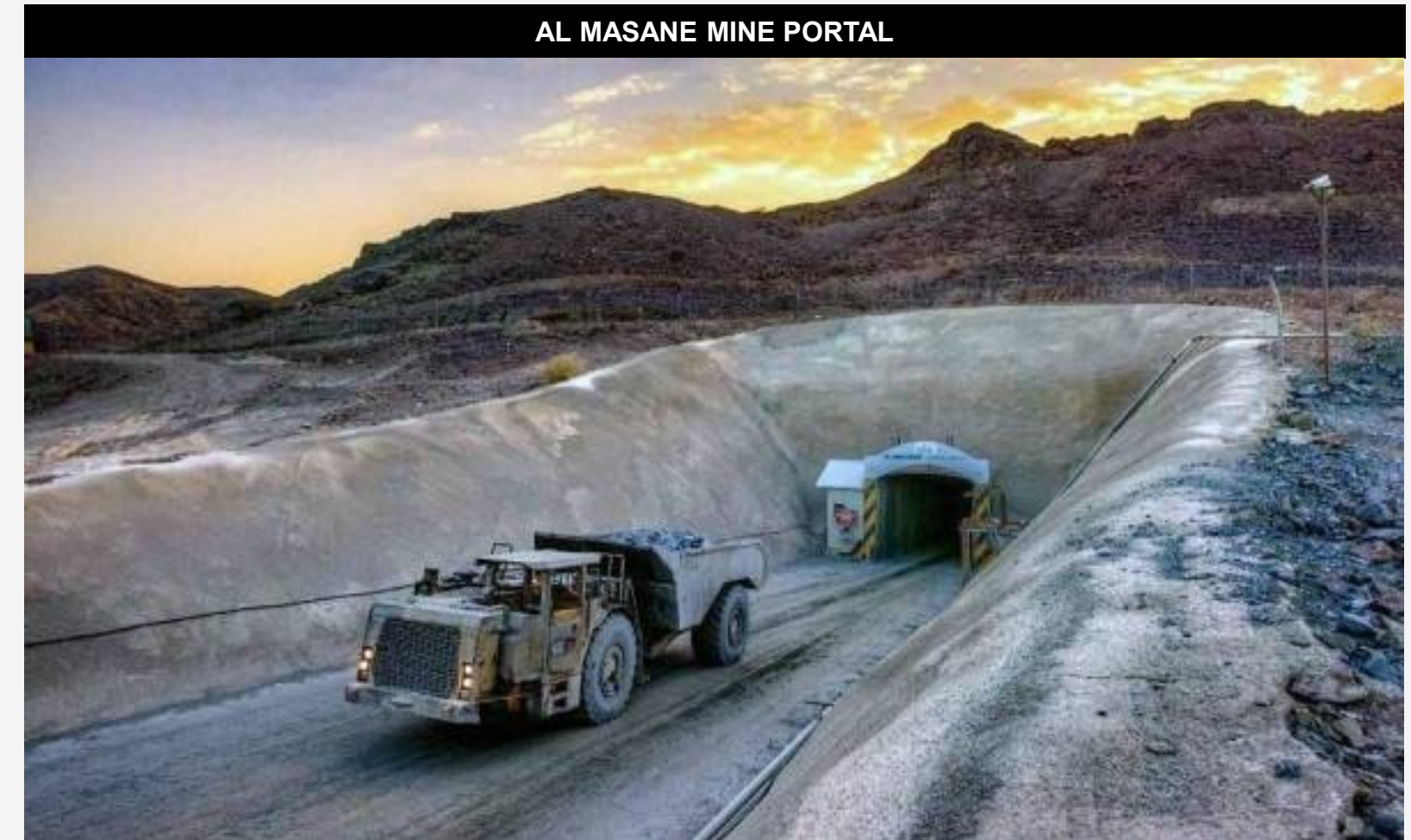


Source: Barrick Gold website

ZINC

Varied deposits

- Mostly occur in volcano-sedimentary rocks in volcanic-arc terranes
- Sphalerite occurrences in deep boreholes East of the shield. Some potential for Mississippi Valley-type Zn-Pb deposits in the Arabian platform
- By product concentrates ~3,000 t Zn pa from Mahd Adh Dhahab
- One operating mine - 45,700 t Zn conc., 19,505 t Cu conc., 75,509 oz Ag and 5,343 oz Au at Al Masane in 2023
- Deposits with resources at Al Amar, Khnaiguiyah, Kutam and Baydan. Numerous other occurrences in the Proterozoic
- Jabal Dhaylan deposit hosts Pb-Zn oxide mineralisation in reef limestone in the Tertiary coastal plain
- Atlantis II Deep in the Red Sea midway between Saudi Arabia and Sudan contains Holocene mineralised mud with a resource of 89.5 Mt at 2.06% Zn, 0.45% Cu, and 38.4 g/t Ag

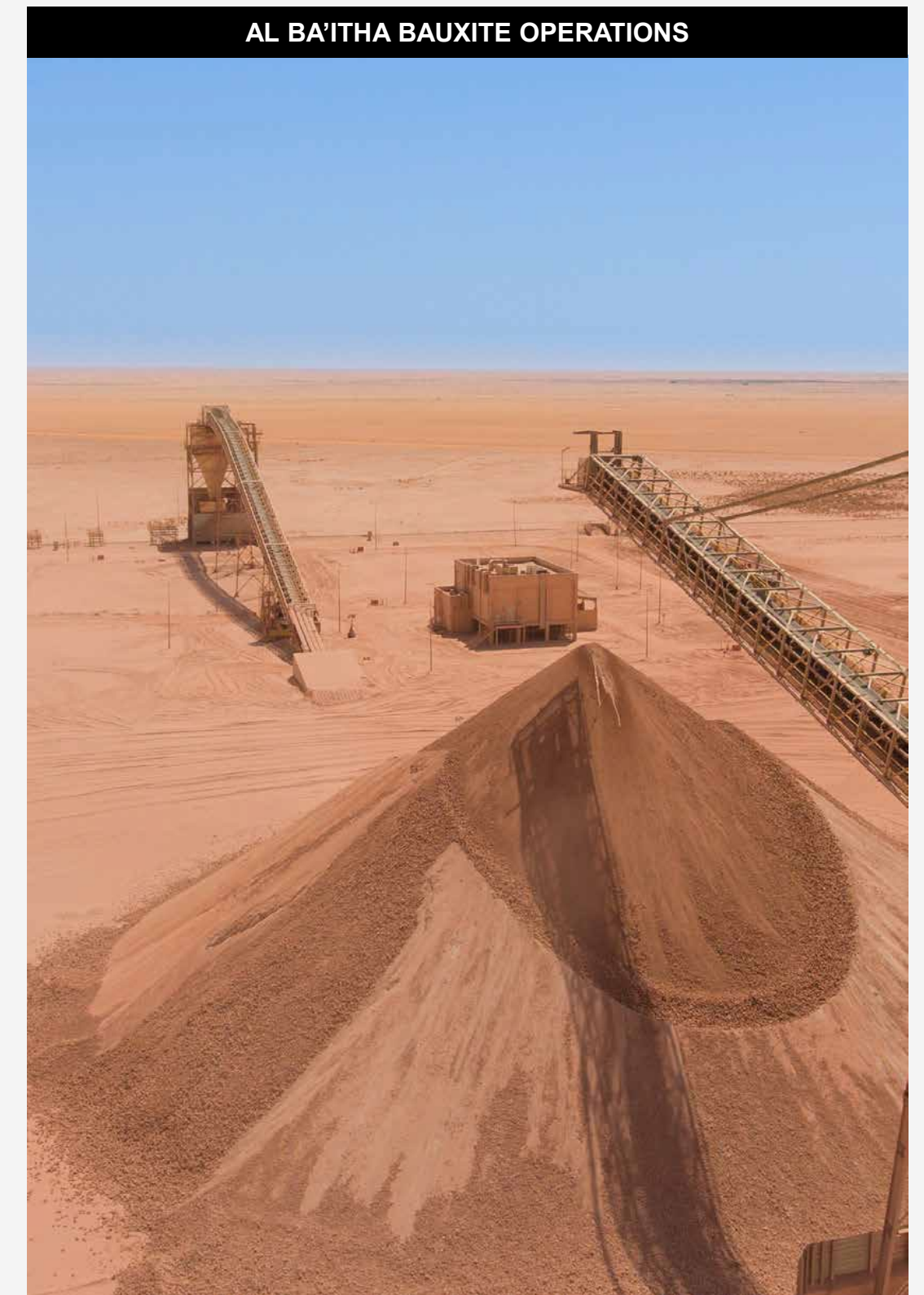


Source: Saudi Gazette, 4 April 2022

ALUMINIUM

Maximising the minerals and metals value chain

- Az Zabirah and Al Ba'itha bauxite deposits and other occurrences
- Joint Venture with Alcoa in 2009. Capex of USD10.8 billion to build a bauxite mine, a refinery, a casthouse, a can recycling unit and the world's most advanced rolling mills
- Bauxite mined at Al Ba'itha producing 5 Mtpa of dry weight bauxite. Railed to Ras Al Khair Industrial City and refined to produce 1.8 Mtpa of alumina. 80% processed in Ma'aden's smelter
- Smelter consists of 2 potlines 1.2 km long producing 780,000 tpa of aluminium
- Power from 2.4 GW gas-fired generation, and sea water desalination
- Casthouse has total capacity of 1.2 Mtpa producing standard ingot, extrusions billet, T-Bar and rolling slab
- Fully integrated Al value chain

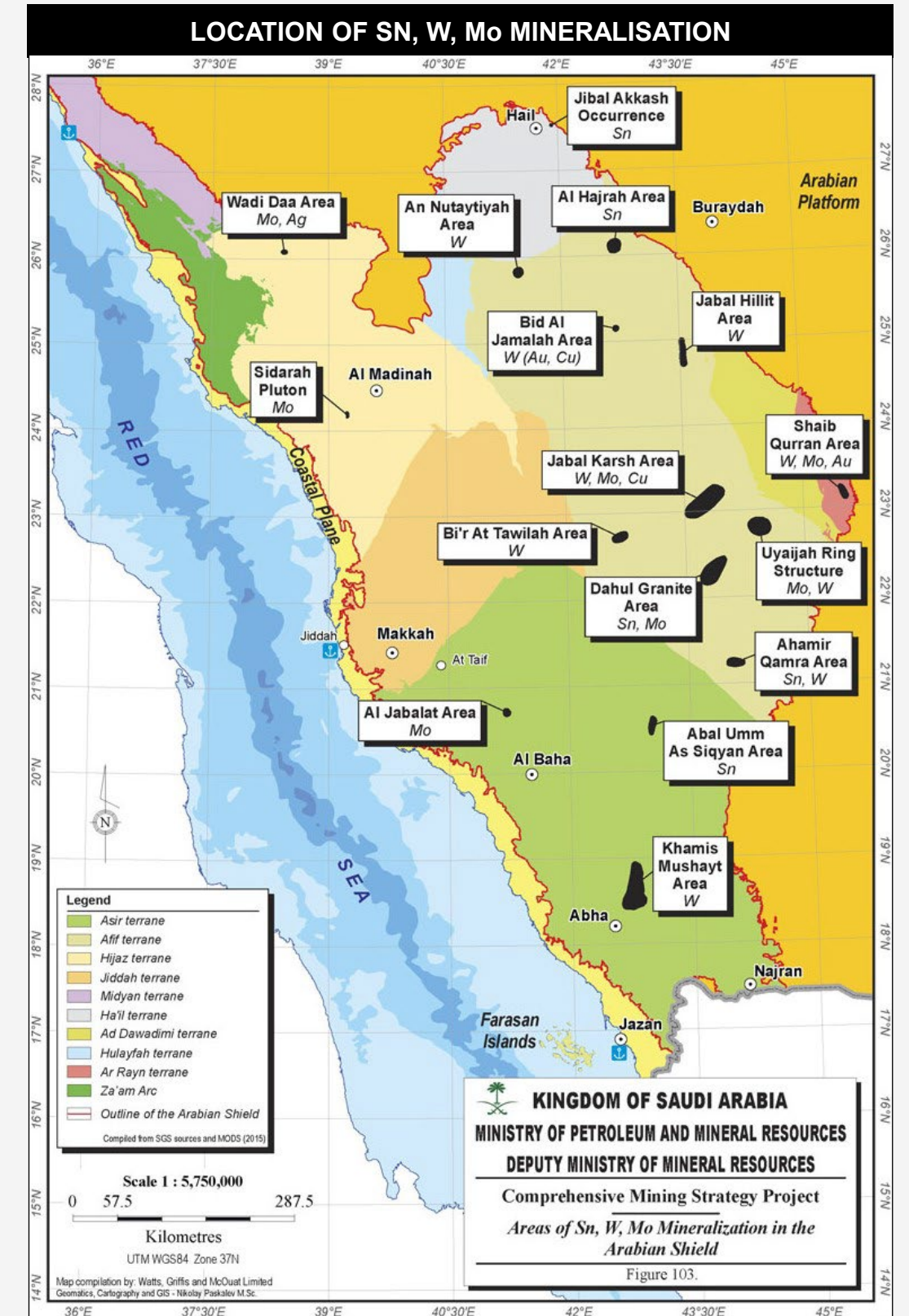


Source: Ma'aden 2023 Annual Report

Nb, Ta, REE, Co etc

Late stage, fractionated granites are widespread

- Nb, Ta & Rare Earth Elements
 - Ghurayyah deposit 400Mt at 2250 ppm Nb, 212 ppm Ta, 290 ppm Sn, 390 ppm Th and 117 ppm U in an alkali, felspar porphyritic granite
 - Ta (Sn-W) mineralisation related to peraluminous post-collisional granite
- Other Minerals
 - REE-Th-U mineralisation related to (syeno) granites
 - Cr-Ti-Fe-Ni-Cu-Co (PGE) mineralisation related to mafic-ultramafic rocks

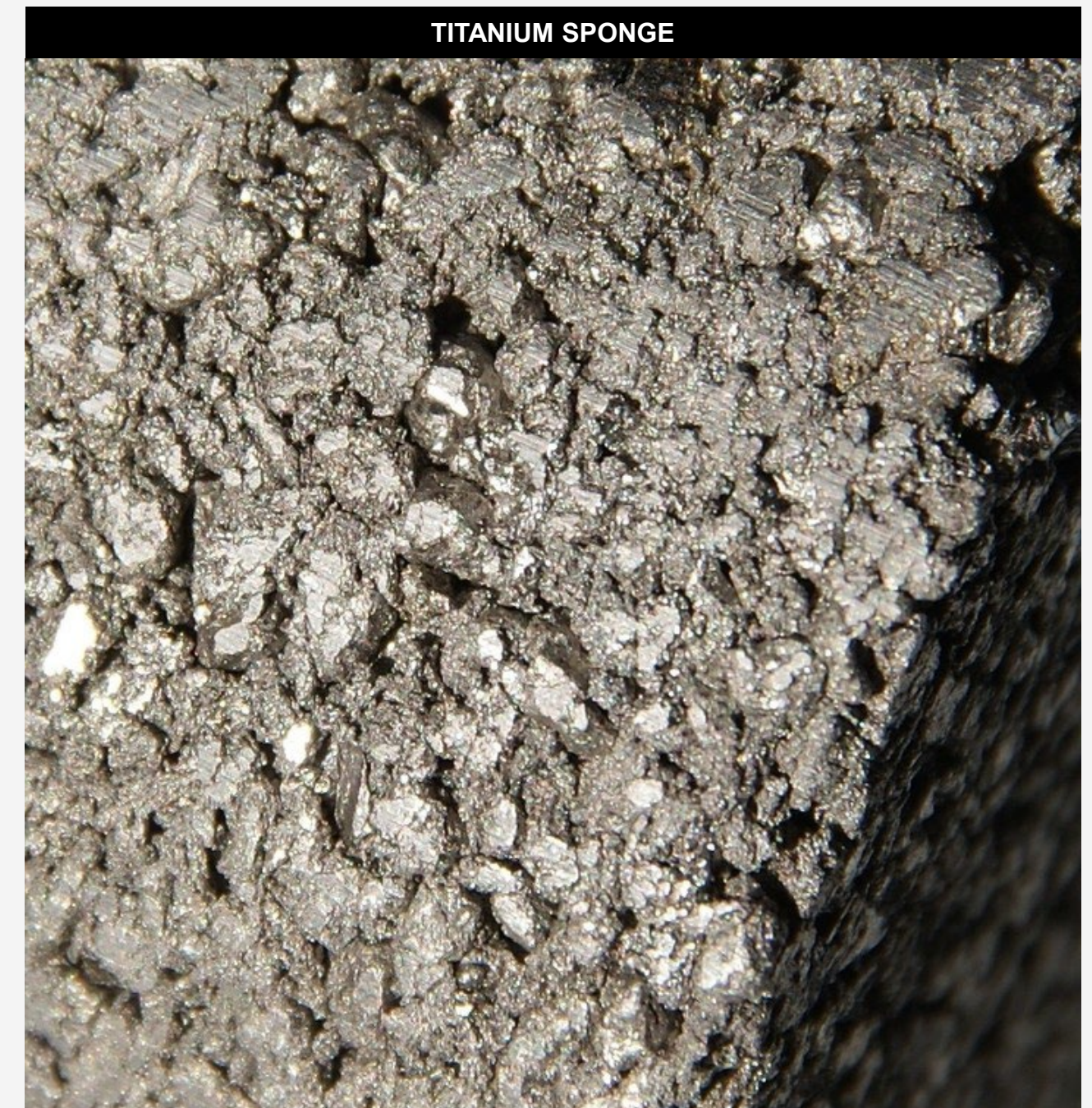


Source: WGM, 2016

IRON, TITANIUM & MAGNESIUM

Largely downstream processing of imported raw materials

- Iron deposits substantial tonnages found at Al Aflaj and Wadi Fatima (oolitic ironstones), Wadi Sawawin (BIF) and Jabal Idsas (disseminated magnetite)
- Large deposits of Pyrite at Wadi Wassat and Nickeliferous Pyrite occur at Wadi Qatan
- No local mining; crude steel output 12-13 Mtpa
- Titanium occurs in magnetite and is difficult to separate. One deposit Lakathal hosts 175 Mt at 6.2% TiO_2 / 100m of depth
- Ilmenite resources 191 Mt
- Production of Ti slag (500 ktpa), TiO_2 (140 ktpa) & Ti sponge (15 ktpa)
- Magnesite mine at Al Ghazalah (Zargat)
- Multiple hearth furnace at Madinah Industrial City
- Production of 39,000 tpa of caustic calcine magnesia - vertical shaft kiln to produce dead burned magnesia for production of monolithic refractories

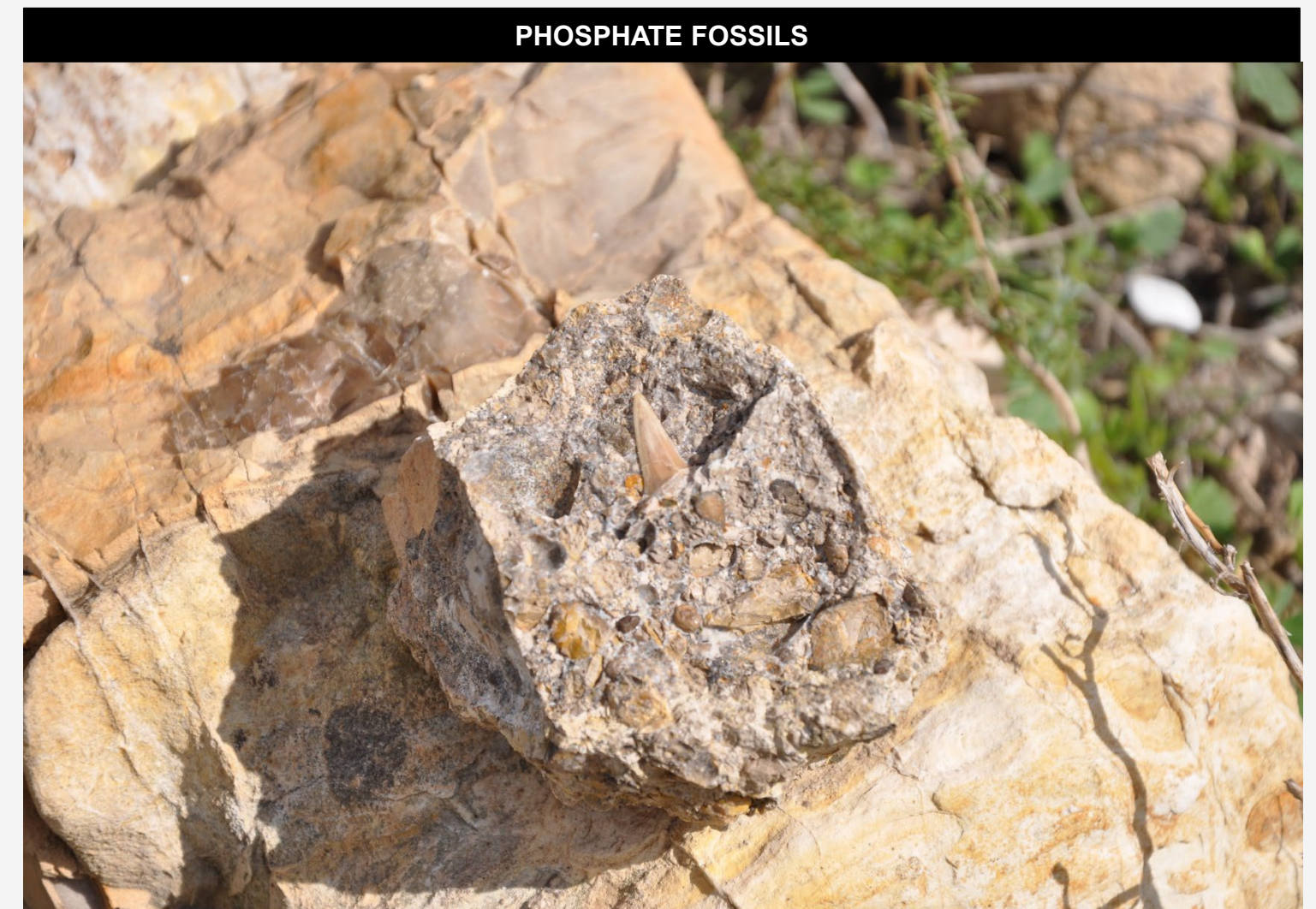


Source: http://commons.wikimedia.org/wiki/File:Titanium_sponge_cylinder,_120_grams.jpg

PHOSPHATE

Deposit, mine & fertilizer company

- Ma'aden (70% JV) at Al Jalamid mine and Ras al Khair Industrial City - US\$ 5.6 billion joint investment
- Phosphate Mine ~11.6 Mtpa - Beneficiation Plant up to 5 Mtpa concentrated phosphate rock
- Conc Phosphate rock railed 1,200 Km to Ras Al Khair to be processed at Integrated Fertilizer Production Complex including Phosphoric Acid Plant, Sulfuric Acid Plant, Ammonia Plant, Di-Ammonium Phosphate Granulation Plant and Desal Plant
- Production of 3 Mtpa of DAP, MAP, Nitro Phosphate, and Nitrogen and Phosphate & Potassium fertilizers NPK & NPKS sold annually through a number of different entities



Source: R Stagg

INDUSTRIAL MINERALS

Largely sourced from platform and coastal areas

- Gypsum for plaster and board in Miocene gypsum anhydrite deposits of Red Sea Coast. 10 Companies including Knauff and San Gobain (World Majors)
- Limestone for cement (55 Mt/year – 25 plants)
- Cement grade limestone in sedimentary monocline and paleocoral beaches along the Red Sea Coast
- Pure white limestone for filler occurs north of Jeddah and also in Jurassic cliffs near Riyadh
- Pozzolana from ash in the volcanic cones in the Harrats
- Huge resources of glass sand, also silica sand for manufacture of sodium silicate
- High grade Kaolin from Az Zabirah bauxite mine
- Exporter and importer of dimension stone (21 companies with over 40 licenses)
- Salt production exceeds 2 Mtpa - exports compounds related to the petrochemical industry

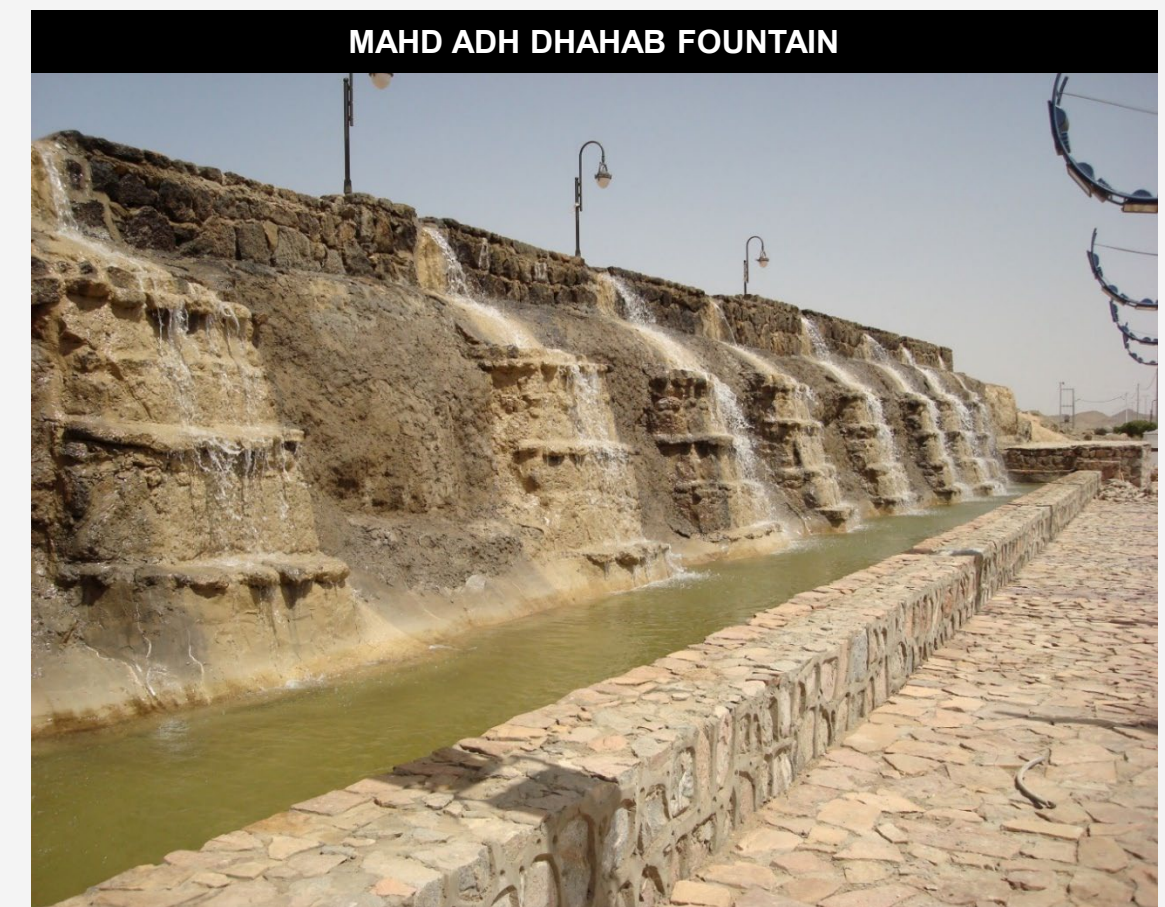


Source: saudidolomite.net, 8/6/24

WATER RESOURCES

Scarce and valuable

- Saudi has no permanent rivers or lakes – water is scarce and extremely valuable
- Desalination
 - From the sea
 - 27 desalination stations produce more than 3 Mm³ /day of potable water
- Groundwater
 - Aquifers are a major source of water
 - Non-renewable from deep fossil aquifers
 - Renewable from shallow alluvial aquifers
 - Mean annual rainfall ranges from 50-100 mm/ year
 - Evaporation between 6 mm/day (Winter) and 20 mm/day (Summer)
 - Aquifer recharge is inefficient in most areas
 - Water resources contained in the Phanerozoic Arabian Platform
 - Deep resources mainly used for agriculture
- Surface water
 - More than 200 dams collect an estimated 16 Bn ft³ / annum. Used primarily for agriculture through thousands of miles of irrigation canals and ditches
 - Recycled water is a growing use. Aim to re-cycle >40% of water used for domestic purposes and used for irrigation



Source: Embassy of the Kingdom of Saudi Arabia-Washington DC & SGS

HOT OFF THE PRESS!!!

SAUDI ARABIA HAS BEEN RANKED IN WORLD RISK REPORT 2023

**FASTEST GROWING
INVESTMENT HUB
GLOBALLY IN PAST 5
YEARS**

**AMONG TOP 10
COUNTRIES FOR
FISCAL RISK
MITIGATION
WORLDWIDE**













**SECOND HIGHEST
COUNTRY IN THE
PERMITTING INDEX
GLOBALLY**

**TOP-TIER MINING
JURISDICTION FOR
INVESTMENT**

Source: World Risk Report 2023 by Mining Journal Intelligence MineHutte

SAUDI MINISTRY OF INDUSTRY & MINERAL RESOURCES

Competitive Tender Rounds Completed

Auction Round	Site Name	Commodities	Region	Area (Km ²)	Awarded Company
Round 1, 2022	Khnaiguiyah	Zn (Cu)	Riyadh	353	 + 
Round 2, 2023	Umm Ad Damar	Cu (Ag, Zn)	Madinah	40	 + 
Round 3, 2023	Muhaddad	Cu (Pb, Zn, Au)	Asir	15	
Round 3, 2023	Ar Ridaniyah	Zn	Riyadh	44	
Round 4, 2023	Um Hadid	Ag (Pb, Zn, Cu)	Riyadh	246	 + 
Round 4, 2023	Bir Umq	Cu (Zn)	Madinah	187	 + 
Round 4, 2023	Jabal Shabiah	Zn (Pb, Cu, Fe)	Asir	283	 + 
Round 5, 2024	Al Halahilah	Zn, Cu (Pb, Au)	Najran	34.70	WINNER TO BE ANNOUNCED
Round 5, 2024	Jabal Qaran	Au, Cu, Zn, Ag (Pb)	Najran	57.72	WINNER TO BE ANNOUNCED
Round 5, 2024	Makman Hejab	Au, Ag	Riyadh	118.40	WINNER TO BE ANNOUNCED
Round 5, 2024	An Nimas	Au, Cu (Ag, Zn, Ni)	Asir	222.22	WINNER TO BE ANNOUNCED
Round 5, 2024	Almiyah Shaib Burayk	Cu, Au (Zn, Pb, Ag)	Makkah	234.44	WINNER TO BE ANNOUNCED
Round 5, 2024	Al Hajirah	Ag, Cu, Zn (Pb, Au)	Asir	274.00	WINNER TO BE ANNOUNCED

Source: Saudi Arabia's Ministry of Industry and Mineral Resources

SAUDI MINISTRY OF INDUSTRY & MINERAL RESOURCES

Competitive Tender Round 6 – 24 June 2024*

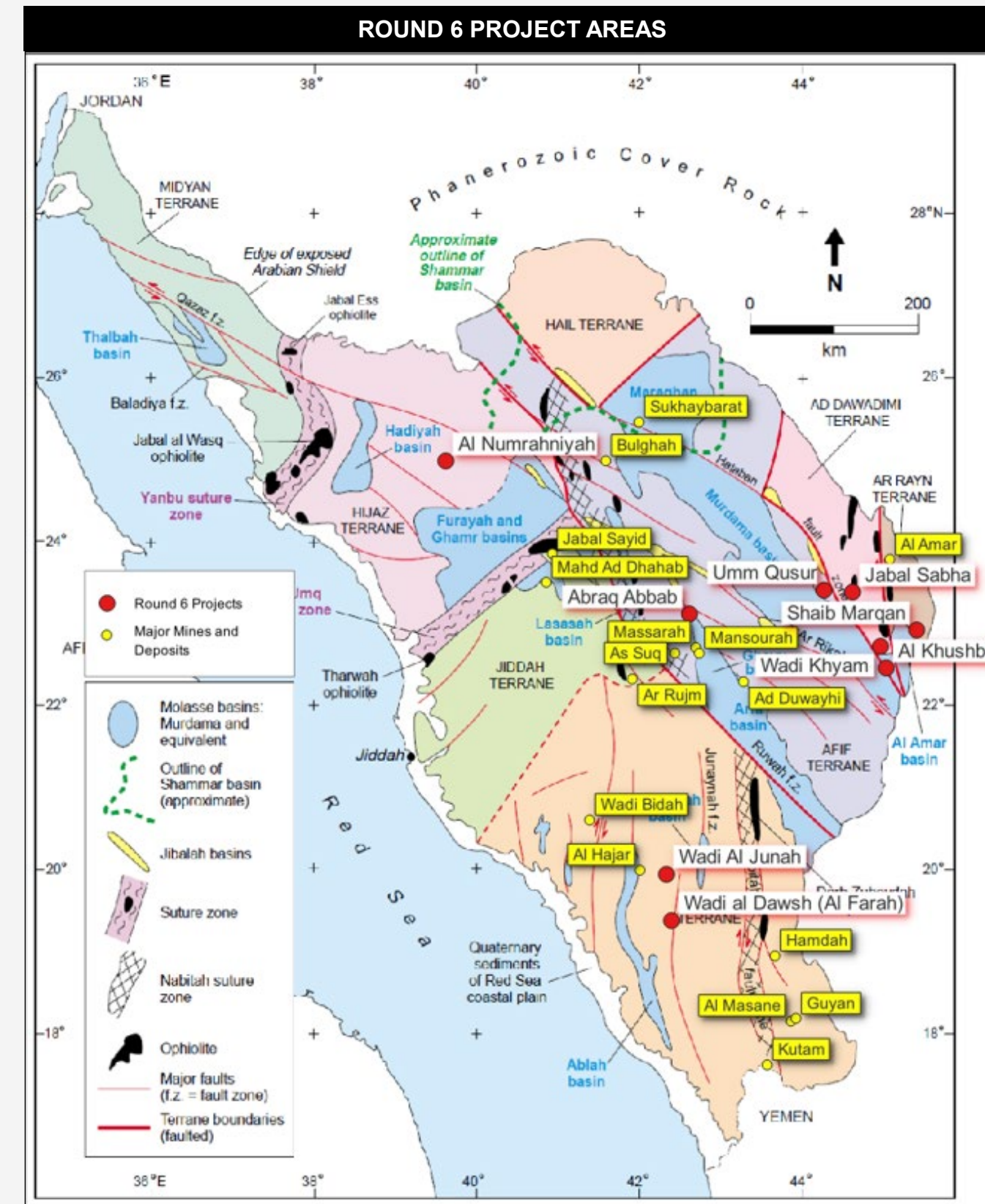
PROPOSED SITES UNDER UPCOMING TENDER ROUND 6*			
Project	Commodity	Area km ²	Region
Abraq Abbab	Au	189.66	Afif
Al Numrahniyah	Au (Cu, Ag)	103.40	Ar Riyadh
Al-Khushbi	Au (Cu, Pb, Zn)	157.58	Ar Riyadh
Jabal Sabha	Ag, Pb, Zn (REE)	171.50	Ar Riyadh
Shaib Marqan	Au (Ag, Cu)	91.81	Riyadh
Umm Qusur	Au, Ag (Pb, Zn)	20.00	Riyadh
Wadi Ad Dawsh (Al Farah)	Au (Ag, Cu)	157.76	Asir
Wadi Al Junah	Ag Cu (Zn, Au)	425.37	Asir
Wadi Khyam	Au (Zn)	91.94	Ar Riyadh

Belt Exploration Licensing Rounds – EOI – Opens 24 June 2024*

Belt	Commodity	Area (km ²)	Region
Jabal Sayid	Cu, Au	2,892	Jiddah Terrane
Al Hajar	Au, Cu	1,896	Asir Terrane

Source: Saudi Arabia's Ministry of Industry and Mineral Resources

*Note: The exploration licenses and date are proposed by the Ministry of Industry and Mineral Resources and may be subject to change.



Source: Nehlig et al (2002) GeoArabia Vol 7, No 1



Q&A

REACH OUT

Presenters Details

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FOR INFORMATION REGARDING SAUDI ARABIA'S
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