Overview of Critical Mineral deposits in Namibia

Mining Expo and Conference - Chamber of Mines of Namibia

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Content

- ❑ Context and concepts
- ❑ Brief deep dive in CM Deposits
- ❑ Outlook for CM deposit development
- ❑ Implications for Government & Private sector

Critical mineral deposits

- Geological formations that contain high concentrations of minerals that are essential for modern industries and technologies.
- Various applications, including renewable energy, electronics, defence systems, and transportation.
- Batteries, semiconductors, electric vehicles, and advanced medical equipment.
- Limited global availability, potential supply chain disruptions, high demand

About mineral deposits

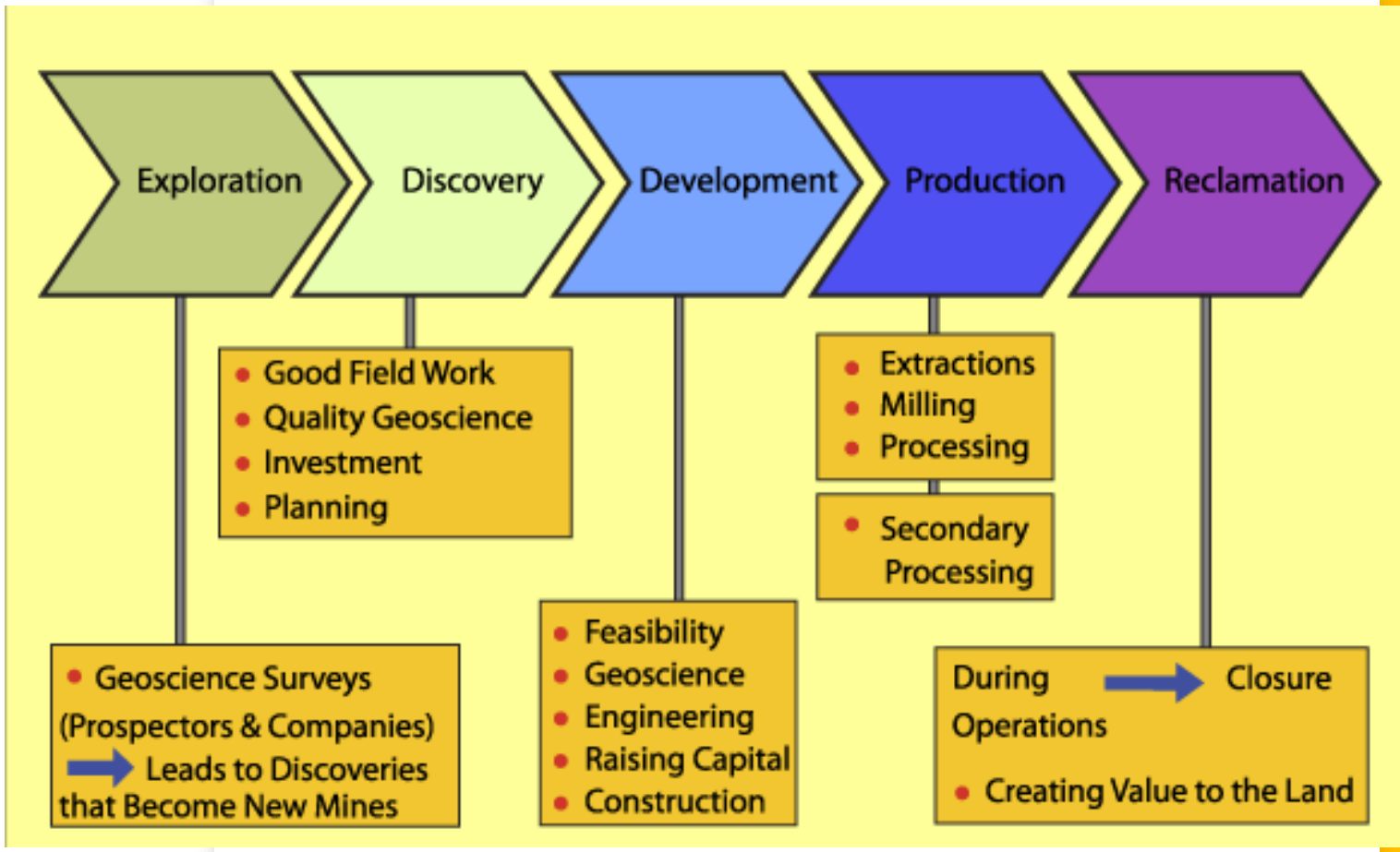
What do we want from our mineral resources?

How do we want to realise it?

- Like a needle in a haystack
- Understanding where and how they come to be is a crucial step
- Exploration activities to discover
- Geological, geophysical, geochemical, & remote sensing techniques to locate potential deposits
- Drilling - once potential targets are identified
- Investment risk consideration
- Value of discovered deposits can fluctuate

Mineral deposit value chain

Sequence of stages provide direct economic stimulus – value creation

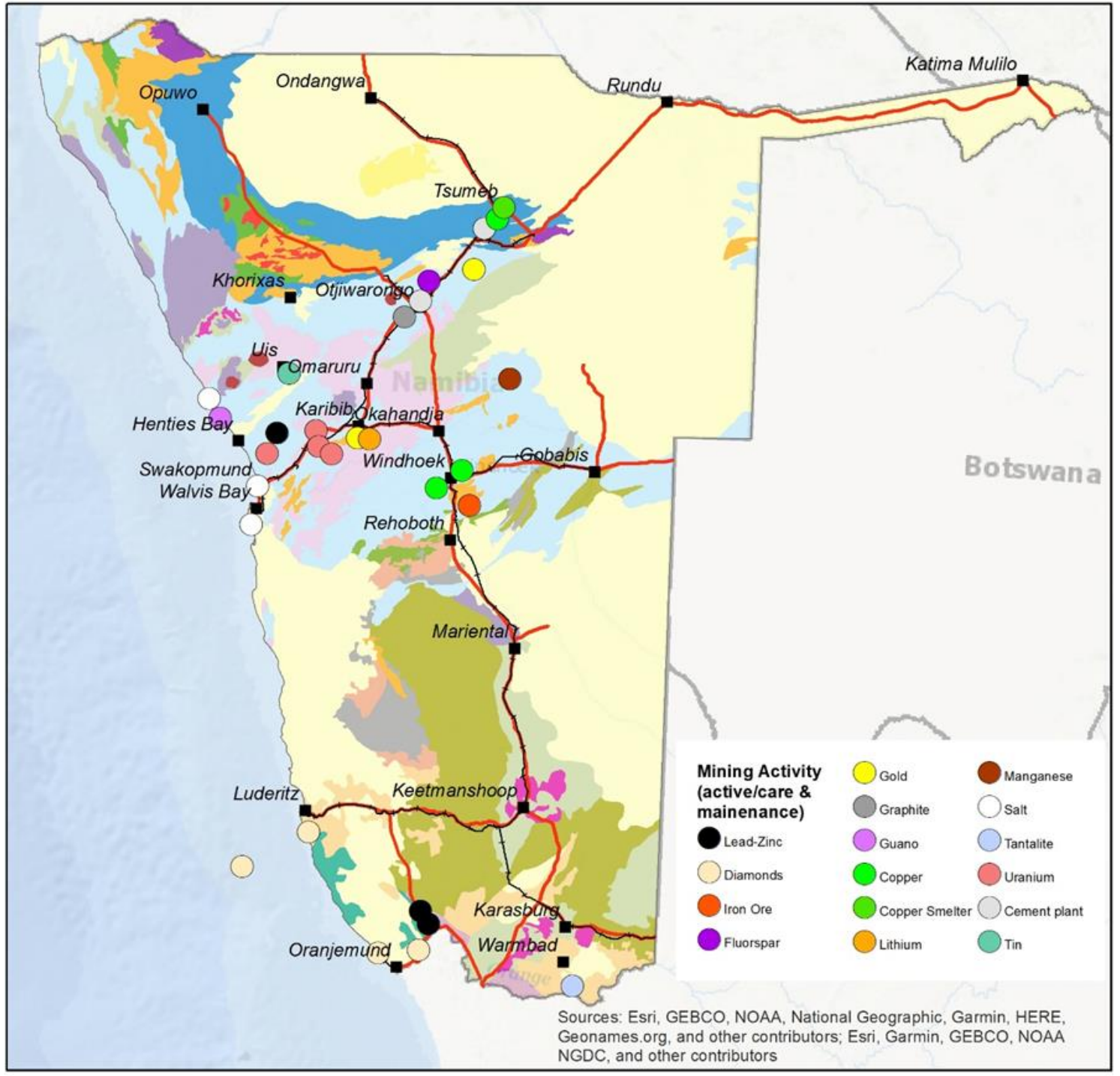


Source: https://novascotia.ca/natr/meb/education/mining-cycle.asp

Facts about minerals

Produced by Minerals Council of Australia

Major Mining Activities in Namibia



Critical minerals: global context

"The United States, the European Union, Japan, Canada, Australia and China have released the lists of critical minerals respectively." (Su and Hu, 2022)

- *54 CM, 5 (Sb, Co, Li, REE, W)…*

- Criticality of a minerals is determined by the economic importance, supply risk, and geopolitical significance
- Several lists of critical minerals exist
- CM designation is not static, changes over time
- Constant research to quantify CM potential
- CM strategies to grow mineral sectors and enhance downstream processing
- Meet global demand

Key critical minerals in Namibia

- Availability of resources
- Demand by major economies
- Other minerals appears on CM lists (V, U, Cu, Zn, P)

- Lithium
- Cobalt
- Graphite
- Tin & tantalum
- REE
- Manganese

ECONOMIC GEOLOGY SERIES

Major Pegmatite Belts of Namibia
2021

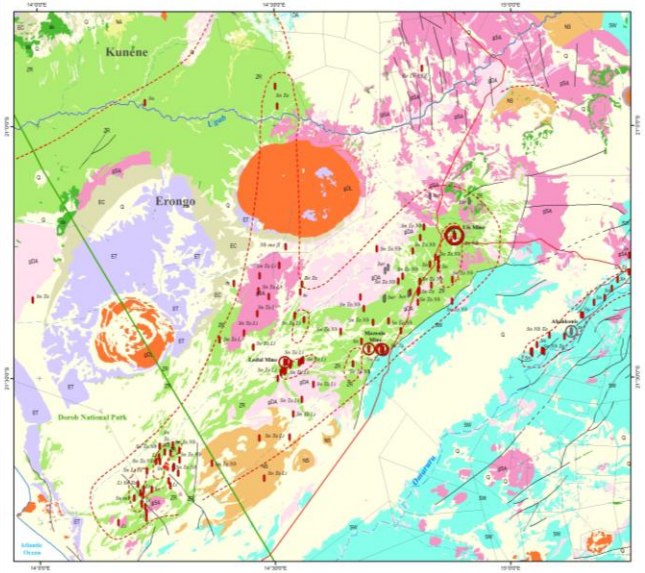
MINISTRY OF MINES AND ENERGY
Geological Survey of Namibia
Deputy Executive Director: Gloria Simubali

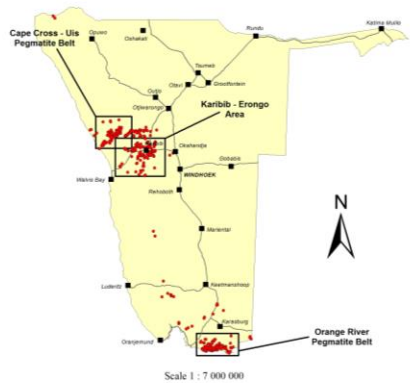
Map compiled by E. Utoni, E. Iiyambo, I. Mbidi, L. Ntema, A. Muyongo & U. Schreiber

Geology based on 1:250 000 digital data set; mineral occurrences from National Geoscience Data Base "Earth Data Namibia"
Map produced as part of the technical co-operation project "Sustainable Use of Namibia's Mineral Potential II"

This map is obtainable from the Geological Survey of Namibia
8 Aviation Road, Windhoek, Tel. +264-61-2845111
E-mail: info@mme.gov.na, Web: www.mme.gov.na

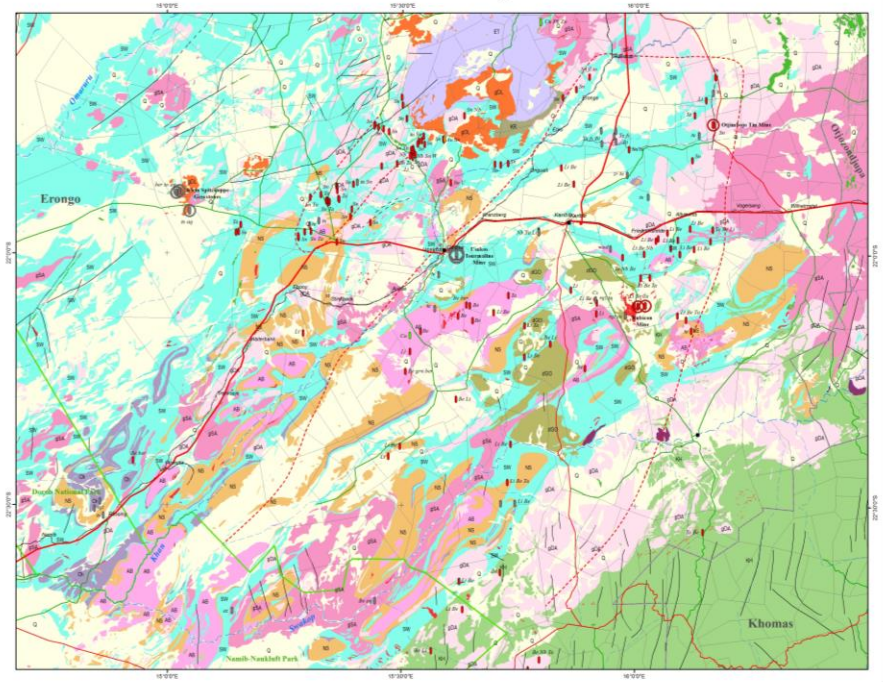
Cape Cross - Uis Pegmatite Belt



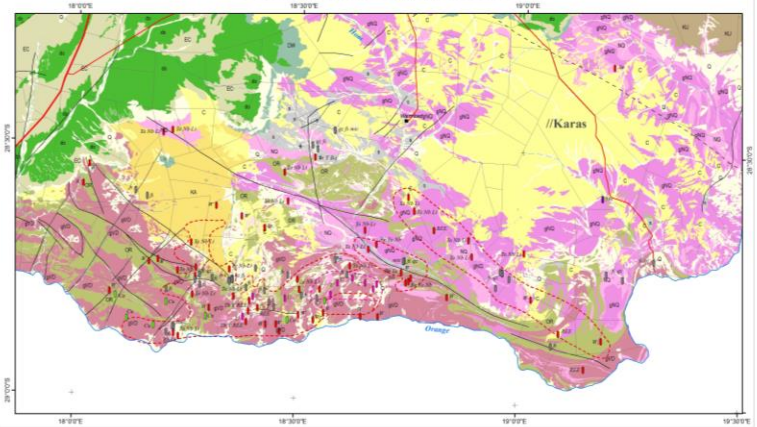


Scale 1 : 7 000 000

Karibib - Erongo Area



Orange River Pegmatite Belt



1:400 000

0 10 20 40 60 80 Kilometers

Projection: UTM 33 S; Datum: WGS 84

Pegmatite-hosted mineralization

Occurrence

Cluster of mineral occurrences/ geochemical halo

Commodities

- Cu Copper, pyrite (+ Au Gold)
- Th Thorium, W Tungsten, Y Yttrium, Be Beryllium, Li Lithium, Nb Niobium, REE Rare earth elements, Sn Tin, Ta Tantalum
- U Uranium
- Au Gold
- Mo Molybdenum
- Industrial minerals, dimension stones and precious stones (for abbreviations see list below)

Symbol size		Symbol only			
Size class		Occurrence	Small	Medium	Large
Commodity	Unit				
Li	t Li_2O	< 1 000	1 000 to 10 000	10 000 to 100 000	> 100 000
Nb	t Nb_2O_5	< 1000	1 000 to 10 000	10 000 to 100 000	--
Sn	t Sn	< 500	500 to 5 000	5 000 to 50 000	> 50 000
REE	t REE	< 10 000	10 000 to 100 000	--	--
W	t W	< 100	100 to 1 000	1 000 to 10 000	> 10 000
F	t CaF_2	< 10 000	10 000 to 100 000	100 000 to 1 Mio	> 1 Mio
U	t U_3O_8	< 100	100 to 1 000	1 000 to 10 000	> 10 000
Cu	t Cu	< 10 000	10 000 to 100 000	100 000 to 1 Mio	> 1 Mio
Au	t Au	< 1	1 to 10	10 to 100	> 100

Abbreviations of mineral names

aq - aquamarine, az - amazonite, ber - beryl, fl - fluorite, fs - feldspar, gm - garnet, mic - mica, mo - monazite, qz - quartz, rqz - rosequartz, sil - sillimanite, to - topaz, tu - tourmaline, wod - wodginite, zr - zircon

REFERENCE

Major Geological Units

- Quaternary Q
- Cenozoic (C)
- Kalahari Group (KA)
- Namib Group (NA)
- Damaraland Igneous Suite (gDL)
- Mesozoic intrusives (mostly dolerite; do)
- Etendeka Group (ET)
- Undifferentiated Karoo Supergroup (KR)
- Karoo/Ecca Group (EC)
- Karoo/Dwyka Group (DW)
- Cambrian intrusives (gC)
- Nama/Schwarzrand Subgroup (SR)
- Nama/Kuibis Subgroup (KU)
- Namibian/Cambrian intrusives (gNC)
- Undifferentiated Damara intrusives (gDA)
- Damara intrusives/Salem Suite (gSA)
- Damara intrusives/Otjimbingwe Complex (eOT)
- Damara intrusives/Goas Suite (dGO)
- Damara intrusives/Matchless Suite (bML)
- Namibian intrusives (gN)
- Undifferentiated Damara Supergroup (DA)
- Damara/Khomas Complex (KH)
- Damara/Swakop Group (SW)
- Damara/Zerrissene Group (ZR)
- Damara/Ghaub Formation (Gh)
- Damara/Chuos Formation (Ch)
- Damara/Nosib Group (NS)
- Abbabis Metamorphic Complex (AB)
- Post-Namaqua intrusives (gPQ)
- Late-Namaqua tectonic rocks (tec)
- Namaqua intrusives (gNQ)
- Namaqua Metamorphic Complex (NQ)
- Vioolsdrif Igneous Suite (gVD)
- Orange River Group (OR)
- Probably Orange River Group (OR?)

Structural Elements

- Fault
- Inferred fault

Topocadastral Features

- Main town
- Regional boundary
- National parks and protected areas
- Farm boundary
- Trunk road
- Main road
- Railway
- Railway siding
- Perennial river
- Major ephemeral river
- Ephemeral river

Typical outcrop of pegmatites (Farm Pelgrimsrus, north of the Orange River)

Pegmatites are known to host a diversity of industrial minerals, such as feldspar, mica, fluorite and quartz, as well as base and rare metals (e. g. tin, niobium, bismuth, tantalum), which are used in the manufacture of an equally wide range of products (e. g. ceramics, batteries, tooth paste). Others have produced a variety of semi-precious stones, such as aquamarine, topaz, common and gem-quality beryl and tourmaline, sought after by jewellers and mineral collectors.

In Namibia, large volumes of late-stage pegmatites are associated with the multi-phase Neoproterozoic Damara and Mesoproterozoic Namaqua Orogenies. Most of these intrusions form distinct belts up to 500 km long and 50 km wide, cutting across orogenic zones with different deformation and metamorphic histories. Individual elongated, rounded or irregular-shaped bodies range from a few centimetres to several kilometres diameter, and may be both concordant or discordant relative to the regional fabric. Others form diffuse intrusions within the host rock. The pegmatites vary in composition and internal structure, ranging from simple, homogeneous rocks to complex zoned, heterogeneous bodies containing exotic minerals such as lepidolite, sillimanite, columbite-tantalite, together with uranium and REE-bearing minerals.

In the central part of the country, where they formed during the final phases of the ca. 550 m. y. Damara Orogeny, the SE - NW striking Goantagab, Cape Cross - Uis, Kohero and Karibib - Erongo tin belts (from north to south) can be differentiated, while the E - W trending Orange River Pegmatite Belt, which originated during the last stages of the ca. 1200 m. y. Namaqua Orogeny, extends from Vioolsdrif on the northern bank of the Orange River eastwards through the //Karas Region of southern Namibia and into South Africa. The pegmatites of both areas, as well as others within the country, have been mined intermittently since colonial times.

Amongst the largest and best-known operations are the Uis Tin Mine, the Rubicon Lithium Mine, the Tantalite Valley Mine and the Usakos Tourmaline Mine, while at Spitzkoppe some of the finest Namibian gemstones have been recovered in small-mining enterprises.

Pegmatites in Namaqua Metamorphic Province

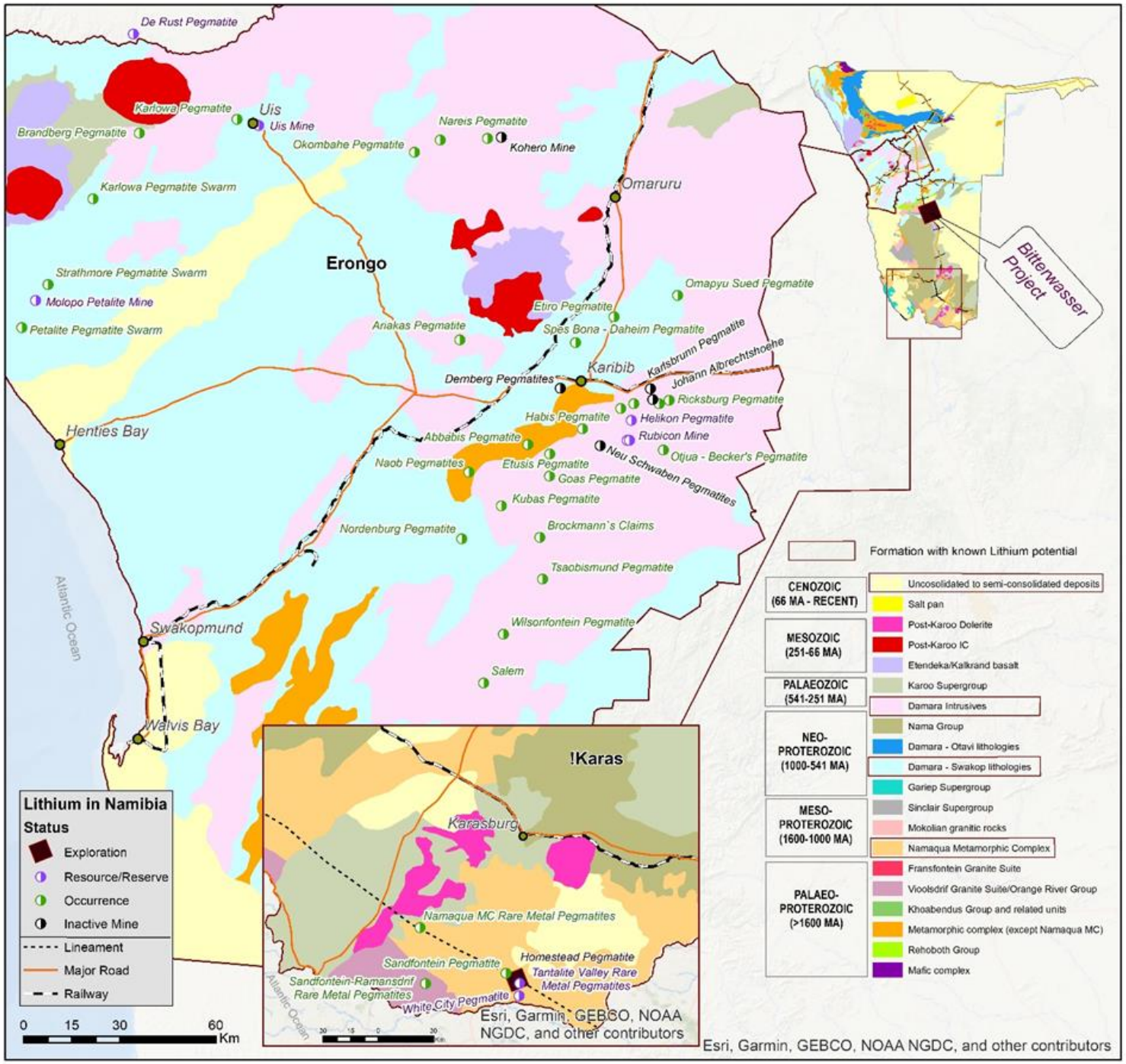
Magmatic-hydrothermal evolution of rare metal pegmatites from the Mesoproterozoic Orange River pegmatite belt (Namaqualand, South Africa)

Ballouard et. al., 2020

- Orange River Pegmatite Belt
- Tantalite Valley pegmatites
- Sandfontein – Ramansdrift pegmatites
- **Age**: 1000 - 980 Ma & 930-880 Ma
- **Prospective:** Younger pegmatites, rare metals and industrial minerals

Pegmatites in the Damara belt

- Brandberg West – Goantagab Tin Belt,
- Cape Cross – Uis pegmatite belt,
- Nainas – Kohero Pegmatite Belt,
- Karibib - Usakos Pegmatite Belt, and Sandamap – Erongo Pegmatite Belt.



Lithium Deposits

- ❑ Pegmatite-hosted
- ✓ Uis
- ✓ Helikon/Rubicon
- ✓ Tantalite Valley
- ✓ Omaruru
- ❑ Potential for Li brine
- ✓ Bitterwasser
- ❑ Mineralogy
- ✓ Petalite, amblygonite-montebrasite, spodumene and lepidolite.

Historic prospecting & Mining - Lithium

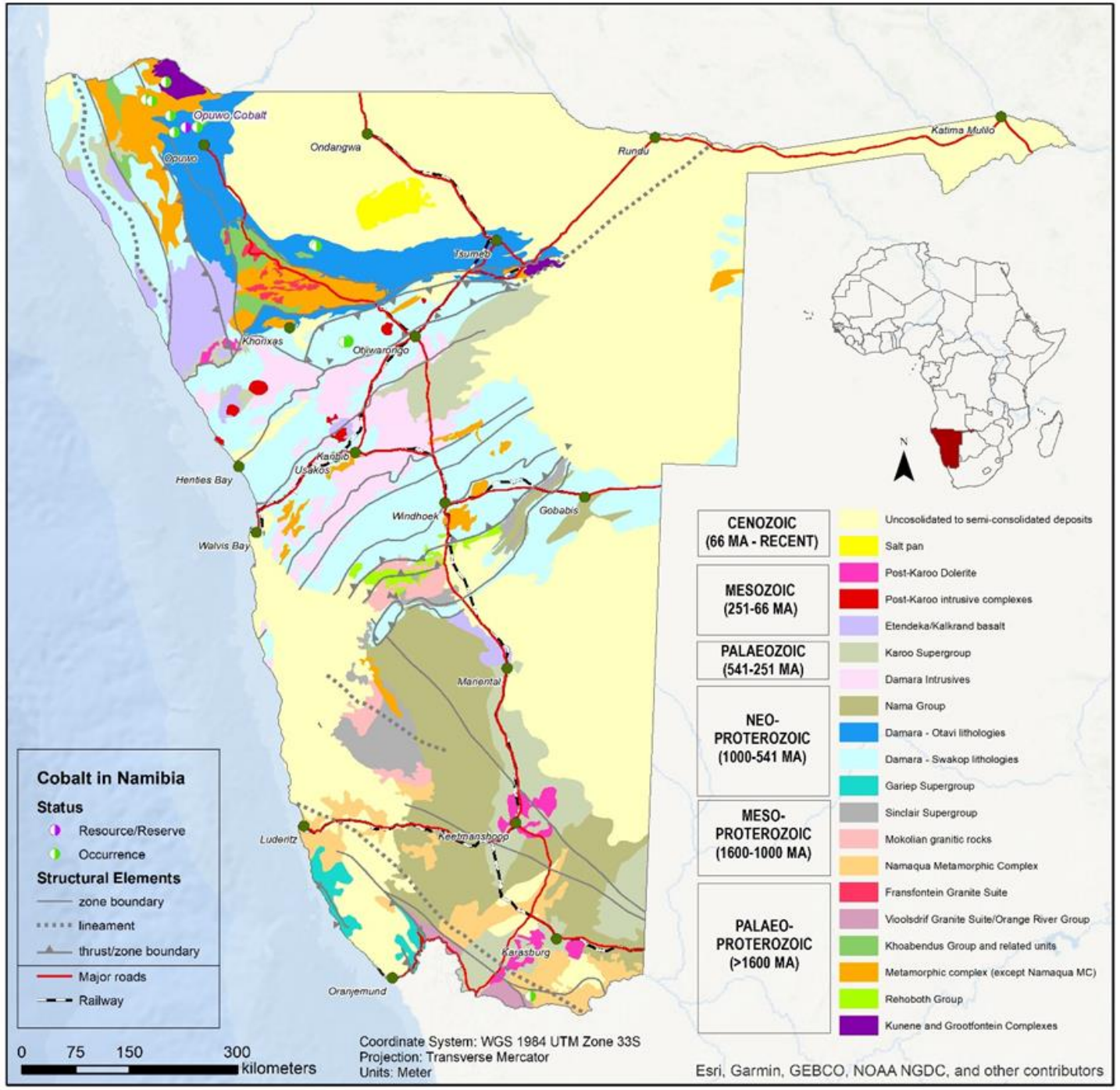
- Dates back to the early 1920s - mainly on tin and tantalum minerals, which are often associated with lithium minerals.
- **Stockpiles** containing lithium minerals that were either not required at the time or did not meet grade requirements may be found on previously mined sites.
- Several operations record production at different stages of operation until the mid-1990s.
- **Rubicon mine,** 1980 and 1994, resources totalling 14,700 t of petalite, 2,000 t of lepidolite, 880 t of amblygonite as well as 9,300 t of quartz.
- **Uis Tin Mine** operated from 1924 to 1990 with confirmed ore tonnage production mined between 1966 and 1981 of 10,657,075 tonnes.
- **Uis Lithium Tin Tailings Project** has been set up to reclaim lithium minerals from stockpiled tailings

Current Projects & Resources

Project	Operation Status	Main Lithium Mineral	Other Significant Minerals	Reserves	Resources
Karibib Lithium Project	Active	Amblygonite, Lepidolite, Petalite, Spodumene	Tantalite, Beryl, Quartz, Pollucite, Bismuth, Fieldspar	Proved 2.29 Mt @ 0.52 % Li_2O Probable 7.14 Mt @ 0.4 % Li_2O (Lepidico 2023)	Measured & Indicated 11.3 Mt @ 0.43% Li_2O (Lepidico 2022)
Uis	Active	Petalite, Spodumene	Lepidolite		Inferred 71.54 Mt @ 0.63% Li_2O (Andrada 2023)
Uis Tailings Project	Resource Delineation	Petalite, Spodumene	Cassiterite, Tantalite		Inferred 17.1 Mt @ 0.31% Li_2O (Montero 2018)
Tantalite Valley	Active	Lepidolite, Amblygomite, Spodumene	Tantalite		Indicated: 104, 800 t @ 0.65% Li_2O Inferred: 219, 800 t @ 0.34% Li_2O (Kazera Global 2019)
Soris Lithium Project/ De Rust	Active, Exploration	Spodumene,Amblygonite, Lepidolite	Tantalite, Cassiterite		To be evaluated, targeting 10 Mt @ 1% Li_2O (Montero 2018)

Occurrences with Lithium mineral potential

Project	Deposite Type	Operation Status	Main Lithium Minerals	Other Significant Minerals	Approximate Size
Petalite/ Molopo Mine	Pegmatite- Hosted	Inactive Mine	Petalite	Eucryptite, Albite	120 m long, 40 m wide
Karlsbrunn	Pegmatite- hosted	Inactive Mine	Petalite, Amblygonite, Lepidolite	Quartz, Cleavelandite, Rubellite, Topaz	330 m long, 30 - 50 m wide
Albrechtshöhe	Pegmatite- Hosted	Inactive Mine	Petalite, Spodumene, Amblygonite, Lepidolite, Albite	Tantalite, Cassiterite, Pollucite	255 m long
Okatjumukuju	Pegmatite- Hosted	Inactive Mine	Spodumene, Amblygonite, Lepidolite, Albite	Tantalite, Cassiterite, Pollucite	Undefined

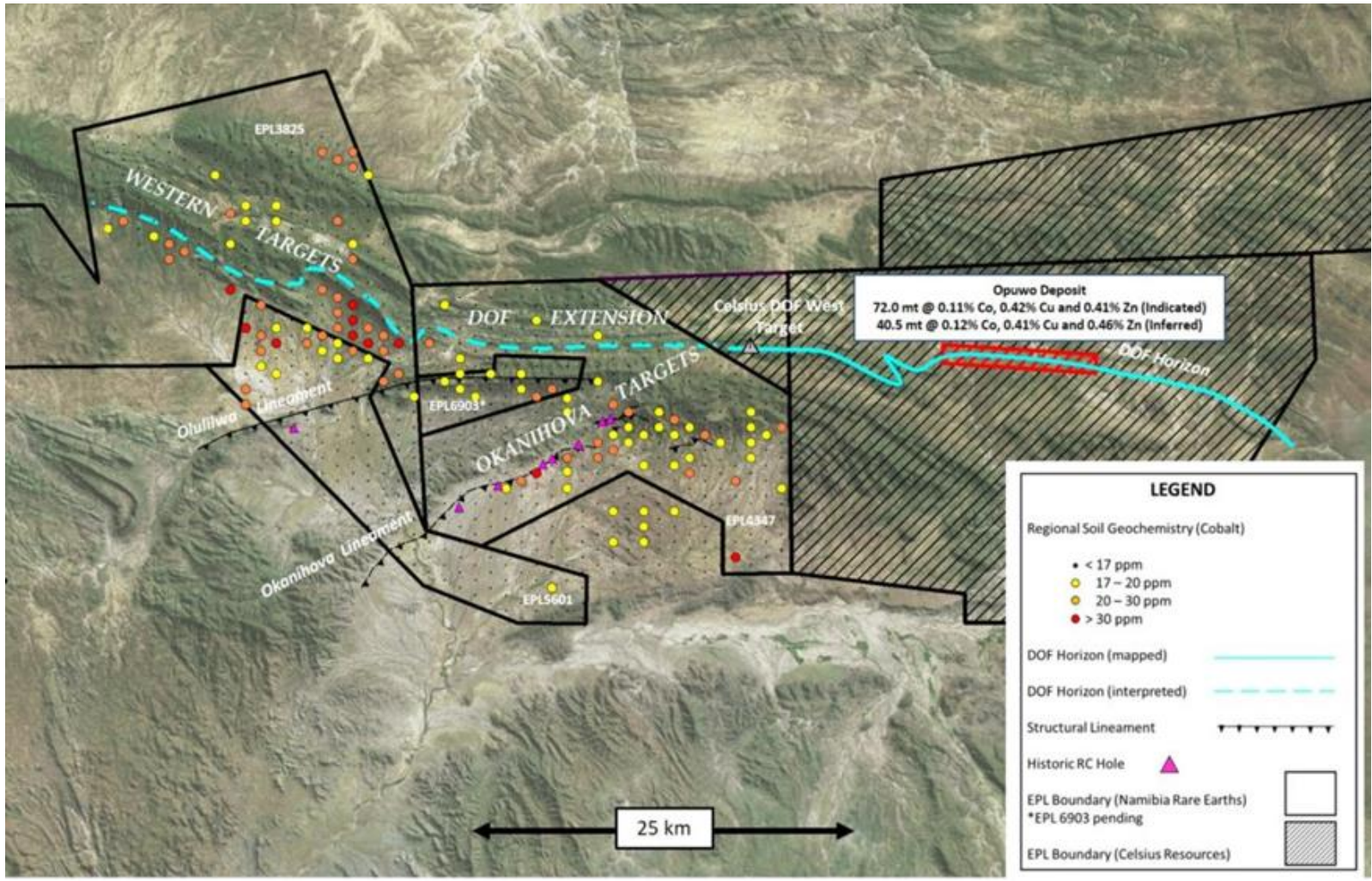


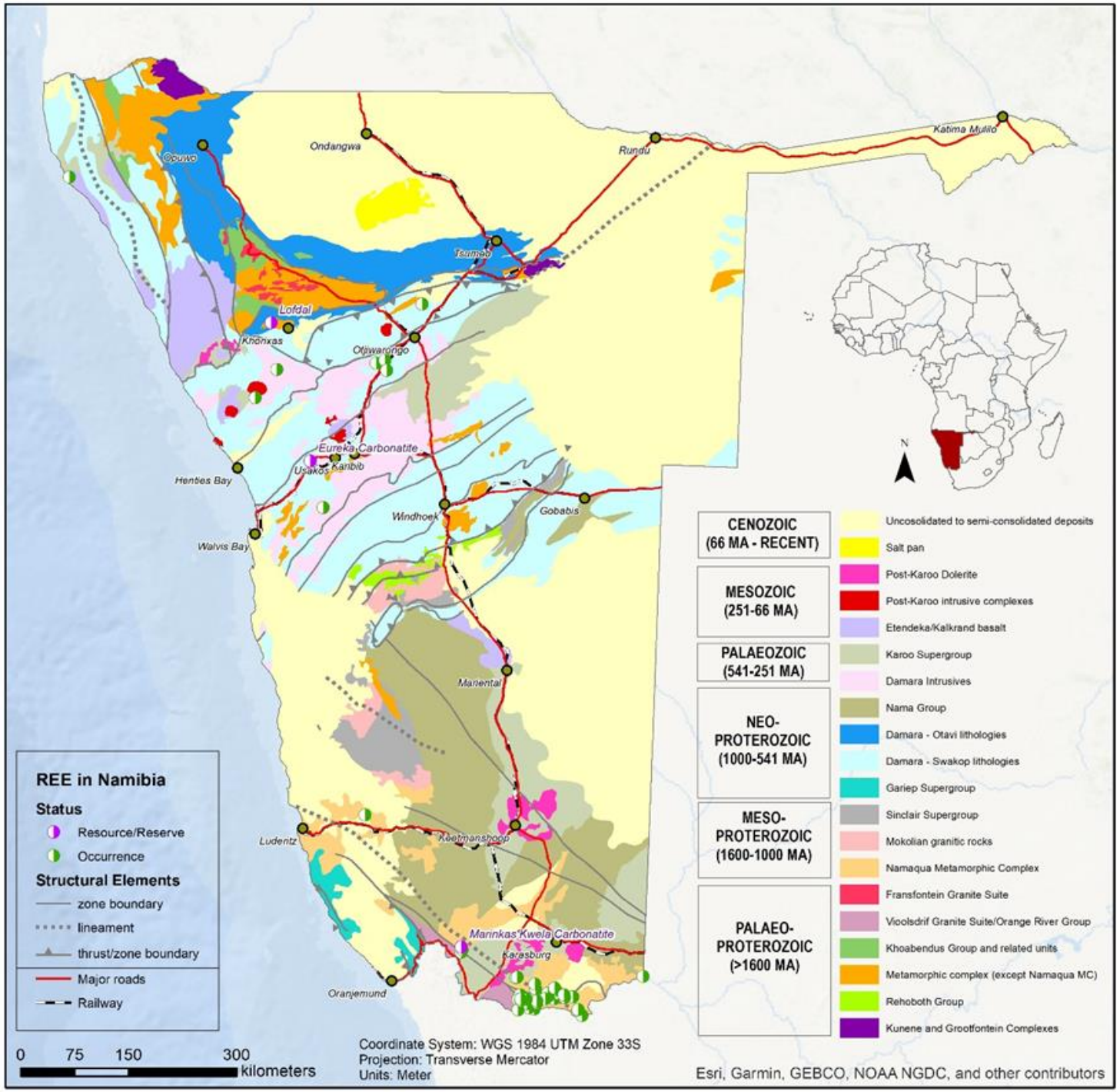
Cobalt deposits

- Upper north-west and north-central Namibia
- Disseminated in sedimentary and igneous rocks
- Sulphides
  - ✓ Linnaeite, Glaucodot and Nickelian Carrollite,
- Hydroxides
  - ✓ Erythrite, Heterogenite, roselite-beta, Cobaltoadamite and Co-Fleischerite,
- Carbonate minerals
  - ✓ Co-Dolomite, Cobaltocalcite and Cobalt-smithsonite
  - ✓ Oxide minerals (Asbolane).
- There are no active mine or mining license granted for cobalt.

Opuwo Cobalt

- Sediment-hosted cobalt and copper, orogenic copper, and stratabound Zn-Pb mineralization
- Mineralization - dolomitic ore formation (“DOF”).
- Indicated Resource:72.0 million tonnes @ 0.11% cobalt, 0.42% copper and 0.41% zinc in the Indicated category.
- Inferred Resource: 40.5 million tonnes @ 0.12% cobalt, 0.41% copper and 0.46% zinc.



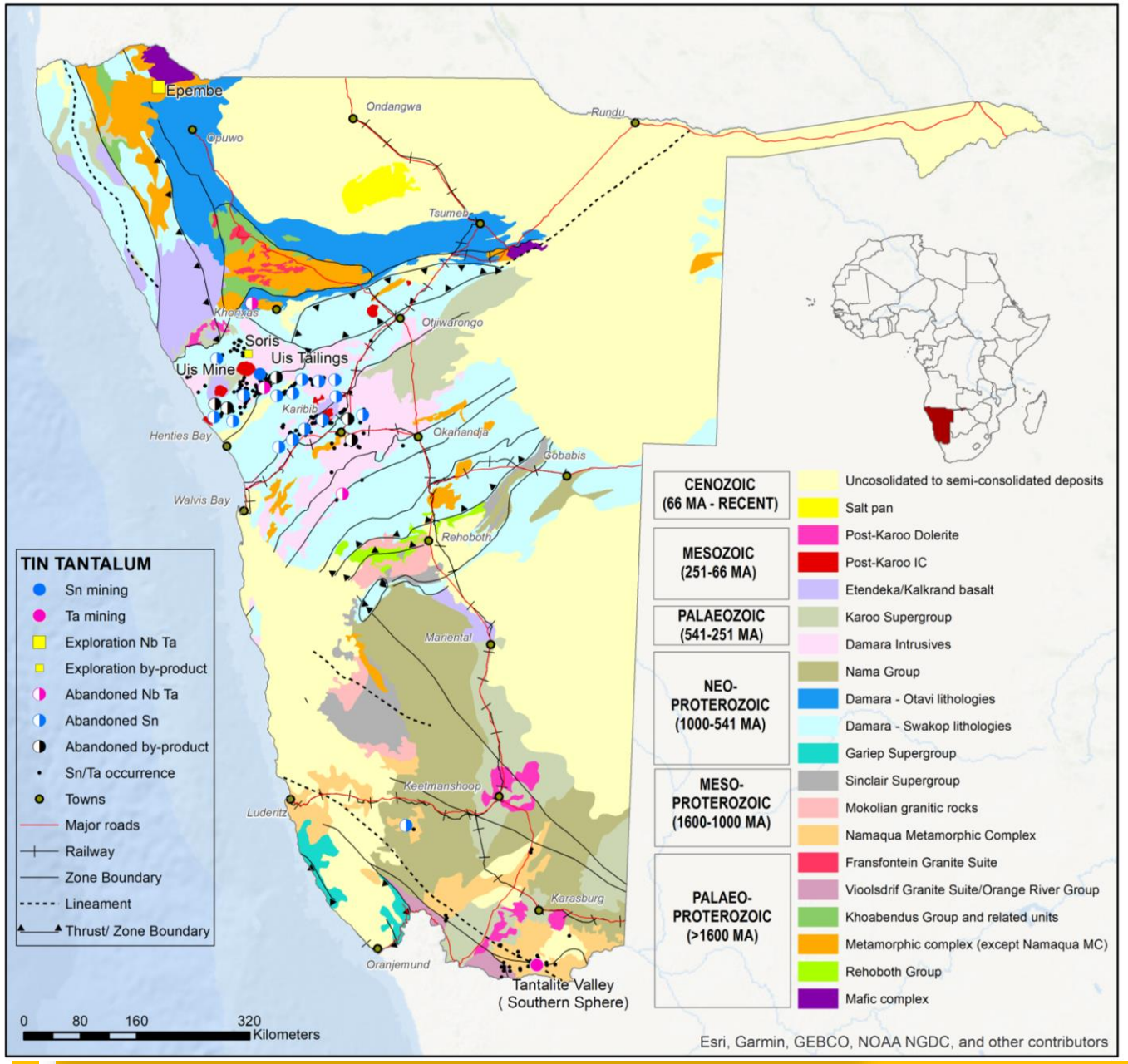


Rare Earth Elements

- Important but scarce
- Cutting edge electronic & defense use

- ❑ Lofdal project
- ❑ Eureka project
- ❑ Marinkas Kwela project

Tin, Tantalum and Niobium



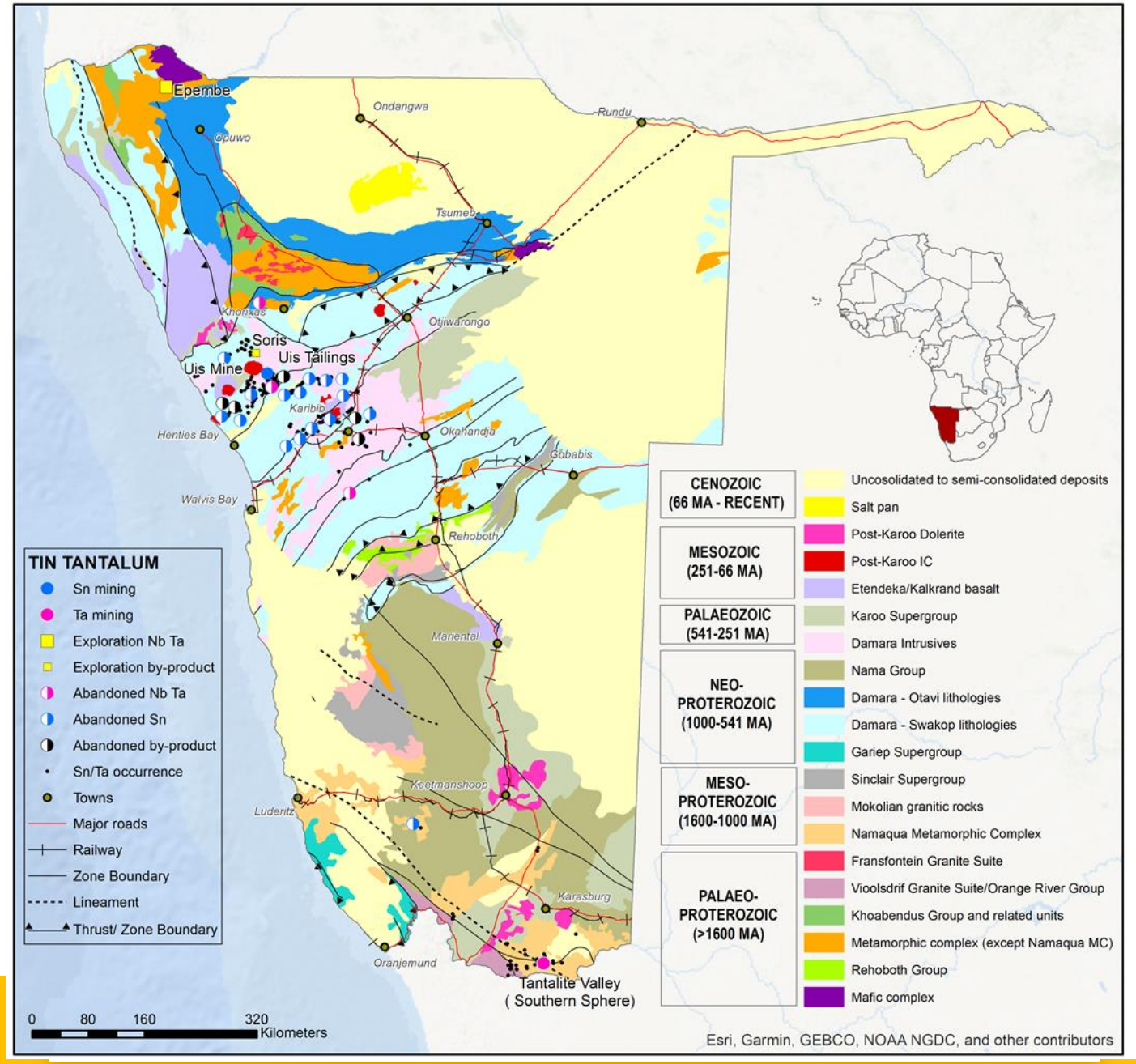
- Pegmatite-hosted rare metal bearing pegmatites
  - ✓Namaqua Metamorphic Province in southern Namibia (Tantalite Valley)
  - ✓Northeast-trending pegmatite belts in the central portion of the Damara Orogen (Uis Tin Mine).

Tin, Tantalum & Niobium

- **Mineralisation:**
  - Disseminated **cassiterite and tantalite** in zoned & unzoned **pegmatites**,
  - Oftentimes related to replacement/greisen zones.
- Cassiterite in hydrothermal vein systems & replacement units associated with **granites** of the Damara (e.g. Brandberg West mine).
- **Tin- and tungsten-bearing quartz veins** occur in fracture systems and breccia zones.
- **Niob-Tantal** in pyrochlore minerals - **carbonatite and granite complexes** of the Damara Alkaline Province in north-central Namibia (e.g. Epembe Exploration Project).

Historic mining –Tin, Tantalum

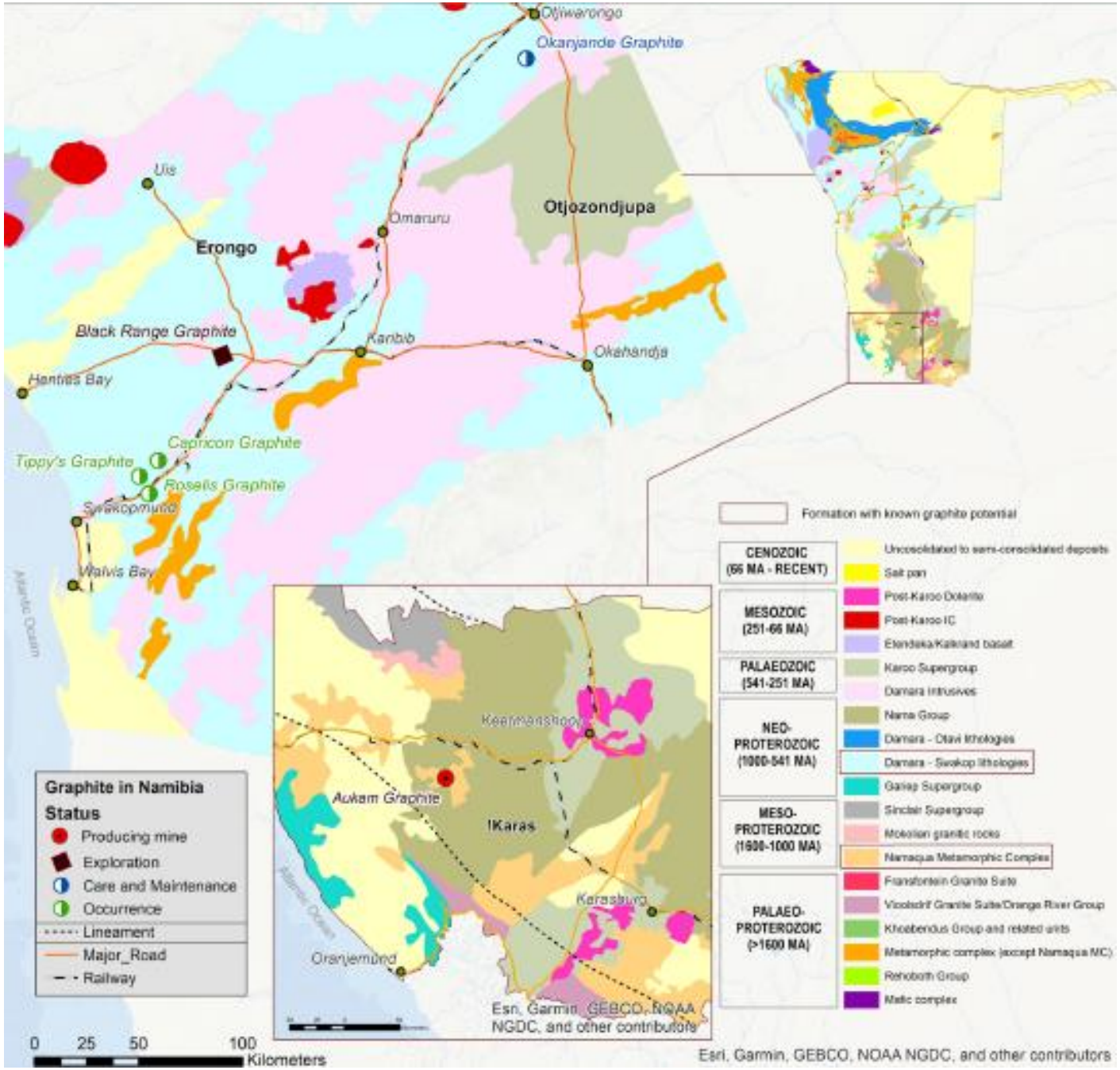
- **Tin** – 1919 and 1991 was mined in central Namibia
- Uis Tin Mine (1924-90) being by far the biggest contributor
- 1770 t/yr of tin concentrate were produced
- Shutdown linked to low commodity prices
- **Brandberg West Mine (1946-1980),** Nainais (-1945 and 1979-86 as “TinTan”), Otjimbojo (1912-45)
- Smaller scale from De Rust pegmatite (1960-1990) and Molopo Mine (1966-1971)
- Strathmore pegmatites (1961-72 and 1980-83), Karlowa Pegmatite (1987), Etiro and Helikon Pegmatite (minor by-product)
- Namaqua Metamorphic Province, historic tantalite mining only took place at Whitkop/Tantalite Valley Pegmatites (1946-1990?)



Current Tin, Tantalum projects

Project	Operation Status	Geology and ore minerals	Reserves	Resources
Uis	Active mining (production of tin concentrate in 2020: 473 t; 2021: 784 t)	Pegmatite: Cassiterite, Tantalite, Petalite		Measured 21.54 Mt @ 0.139 % Sn; Indicated 13.05 Mt @ 0.13 % Sn, Inferred 36.95 Mt @ 0.13% Sn plus 71.54 Mt @ 85 ppm Ta (Andrada 2023)
Uis Tailings	Exploration	Tailings: Cassiterite, Tantalite, Petalite, Spodumene		Target 15 Mt @ 463 ppm SnO_2 (Montero 2018)
Soris/De Rust	Exploration	Pegmatite: Cassiterite, Spodumene, Tantalite, Amblygonite, Lepidolite		Target 10 Mt with Sn and Ta (Montero 2018)
Tantalite Valley	Exploration, Resource development	Pegmatite: Tantalite, Spodumene, Lepidolite		Indicated 104,800 t @ 423 ppm Ta_2O_5, Inferred 219,800 t @ 275 ppm Ta_2O_5 (Kazera Global 2019)
Swanson	Exploration, DFS underway	Pegmatite: Tantalite, Spodumene		Indicated 1.15 Mt @ 472 ppm Ta_2O_5, and 76 ppm Nb_2O_5, Inferred 1.44 Mt @ 498 ppm Ta_2O_5, and 72 ppm Nb_2O_5, (Arcadia Minerals 2022)
Helikon/Rubicon	Resource development	Pegmatite: Lepidolite, Amblygonite, Petalite, Spodumene, Tantalite	Proved 2.29 Mt @ 47 ppm Ta; Probable 7.14	Measured, Indicated + inferred 11.31 Mt @ 51 ppm Ta (Lepidico 2023)

Graphite Deposits



Two types - north central and southern Namibia.

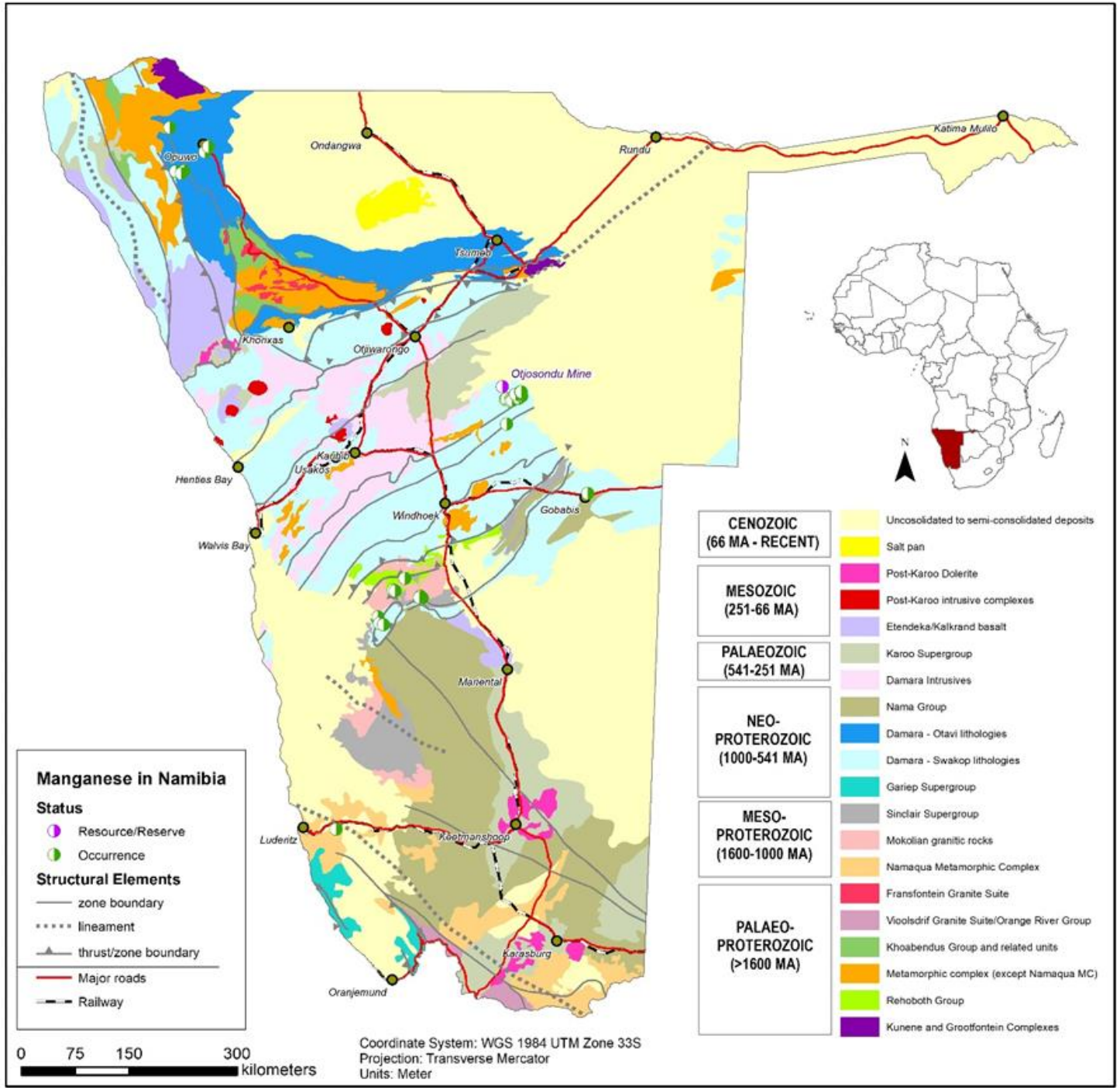
Flake type contains ordered graphite crystals of various sizes disseminated in the host rock.

Okandjande, Black range, Tippy's

Aukam Graphite Mine, the graphite in veins, minor disseminations in altered rocks of the NMP

Graphite Projects

Project	Operation Status	Geology and deposit type	Production	Resources
Okanjande	Care and maintenance, exploration	Flake-type, sediment-hosted: graphite-rich, highly metamorphosed arkoses and feldspathic quartzites of the Nosib Group (Damara Sequence)	Tonnes of graphite flakes in 2017: 2,216 2018: 3,456	Fresh: Measured & indicated 24.2 Mt @ 5.33% TGC; inferred 7.2 Mt @ 5.02% TGC, Transitional: Measured & indicated 1.2 Mt @ 4.35% TGC, inferred 0.1 Mt @ 3.2% TGC, Weathered: Measured & indicated 5.9 Mt @ 4.21% TGC; inferred 0.5 Mt @ 3.45% TGC (Northern Graphite 2021).
Aukam	Active mining, commissioning	High-grade vein/lump: massive lenses/veins within shear zone in altered granite of Garub Sequence (Namaqua metamorphic Complex). Mineralisation is associated with strong alteration	Small-scale mining, commercial production planned for 2023.	Sampling campaign, assay results from historic dumps, channel and bulk samples.
Black Range	Exploration	Flake-type, sediment-hosted: graphite-rich feldspathic quartzites and muscovite-quartz shists/gneisess of Sukses Formation (Swakop Group).		Historic estimate: 13.75 Mt @ 4.52 % C (at 2% cut-off) (GSN 1992)



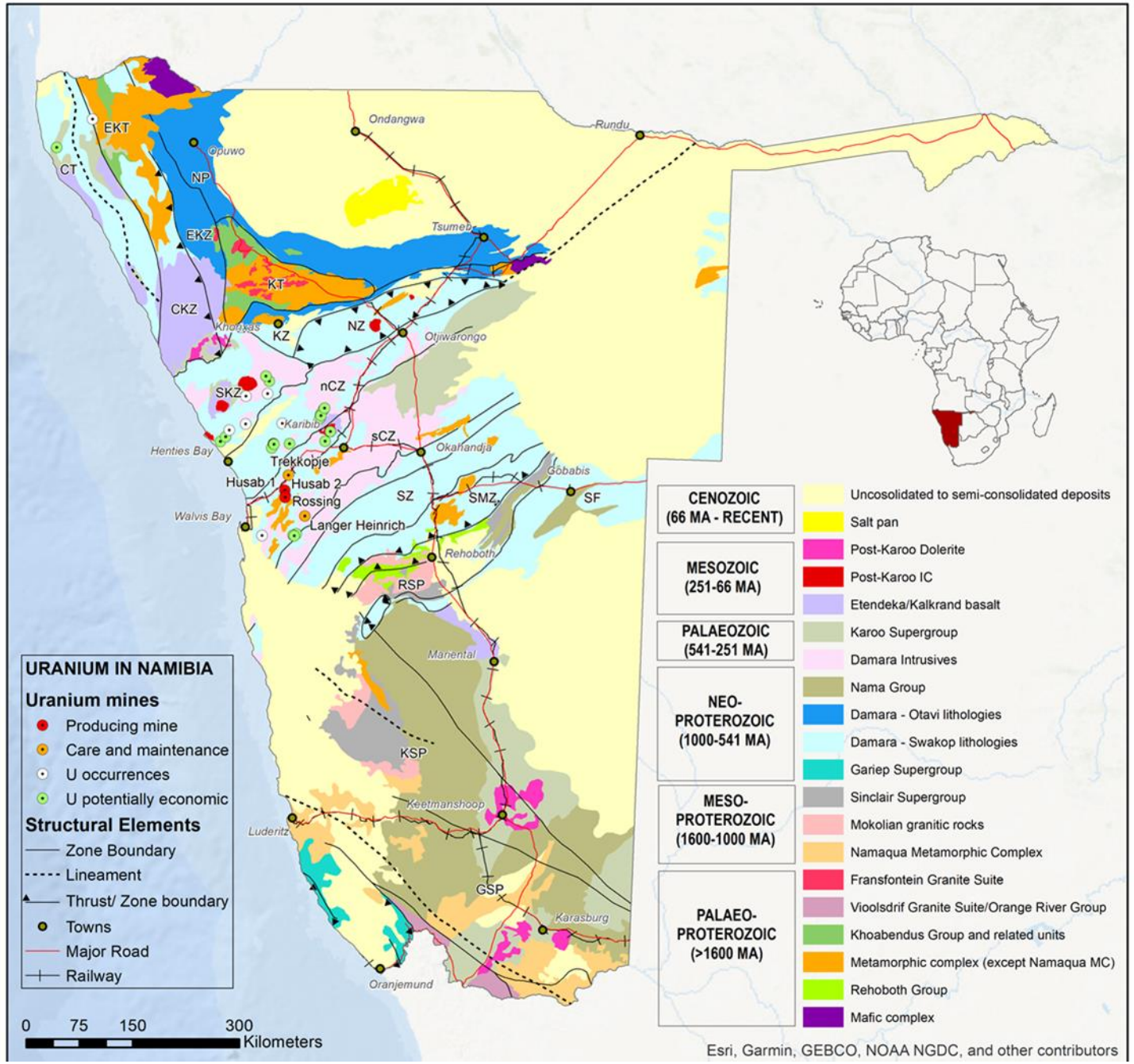
Manganese

- Nickel Manganese Cobalt (NMC) batteries

- ❑ Otjosondu manganese

Uranium potential

- Energy security and clean energy transitions have underscored the role of nuclear in the decades to come.
- U3O3 spot prices spiked to nearly USD 60/pound in march 2022.
- Stabilised above USD 50/pound, higher than 20 -30/pound over past 5 years.

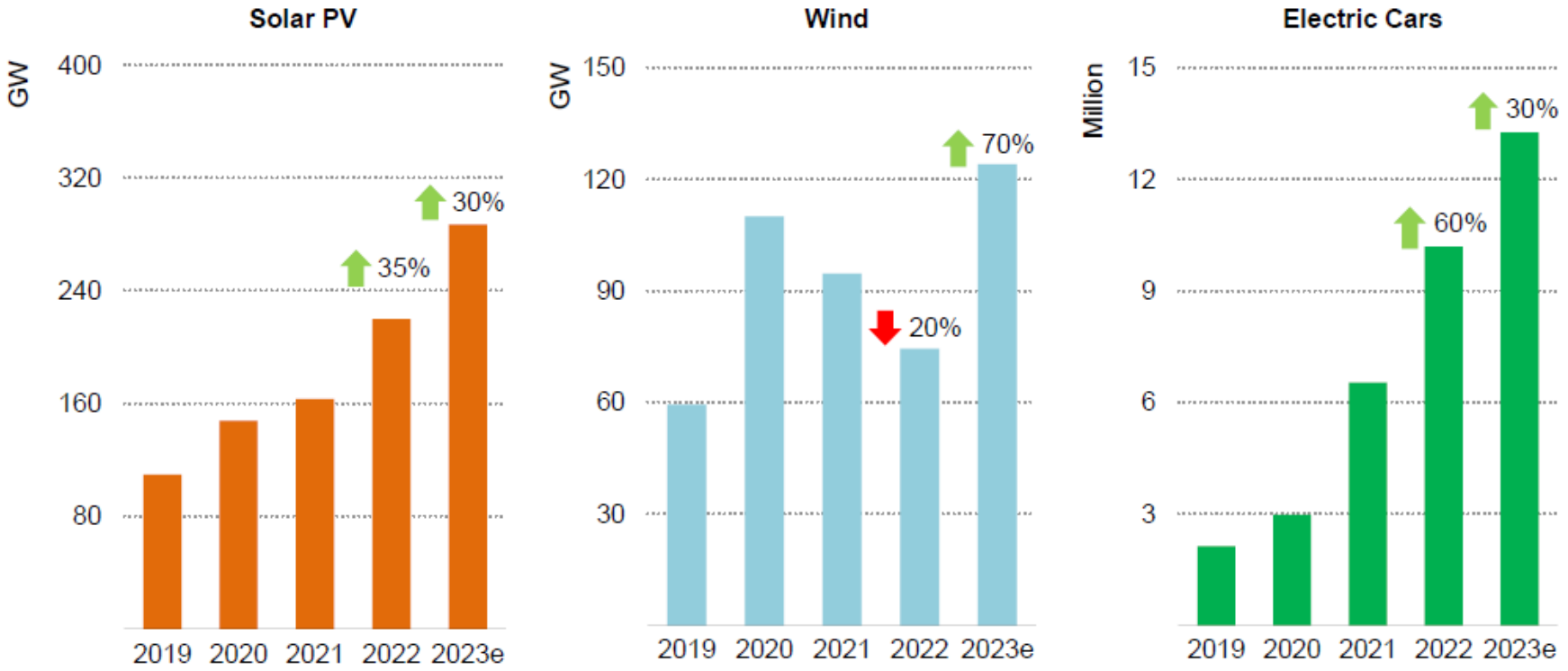


Projections for CM deposit development

- **Market developments**
- **Battery sector developments**
- **Commodity trends** (Lithium, Cobalt, Graphite, REE, Uranium and Manganese)

Clean energy technology deployment continued its upward march in 2022, with momentum expected to continue through 2023 and beyond

Annual capacity additions for solar PV and wind and electric car sales

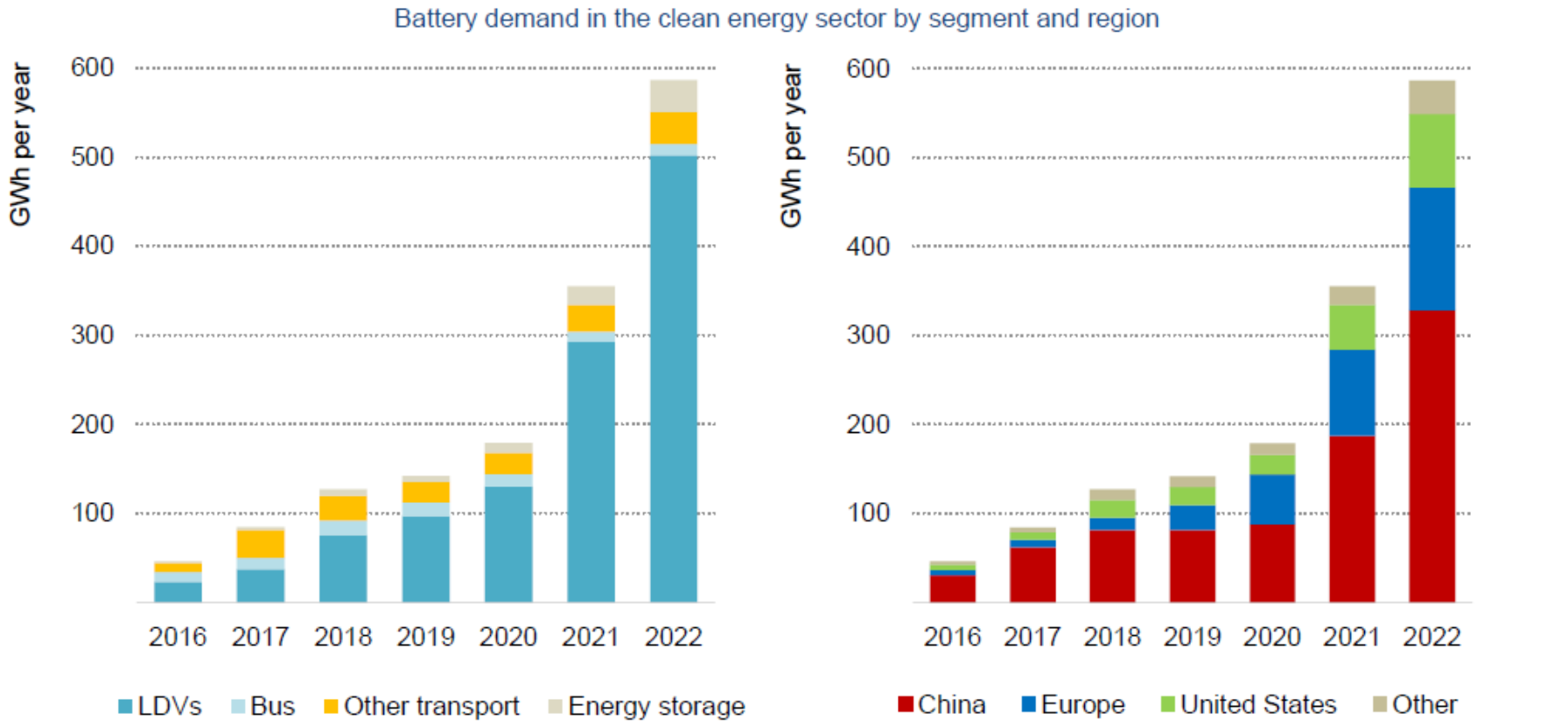


Source: IEA (2023), Renewable Energy Market Update – June 2023, for solar PV and wind capacity additions; IEA (2023), Global EV Outlook 2023 – April 2023, for electric car sales.

Projections for CM deposit developmen

- **Battery sector developments**

Global battery demand for clean energy applications increased by two-thirds in 2022, mainly for transport but with power sector storage growing fast



Notes: LDVs = light-duty vehicles, including cars and vans. Energy storage includes both utility-scale and behind-the-metre storage. In the left chart, Other transport includes medium- and heavy-duty trucks and two-/three-wheelers.

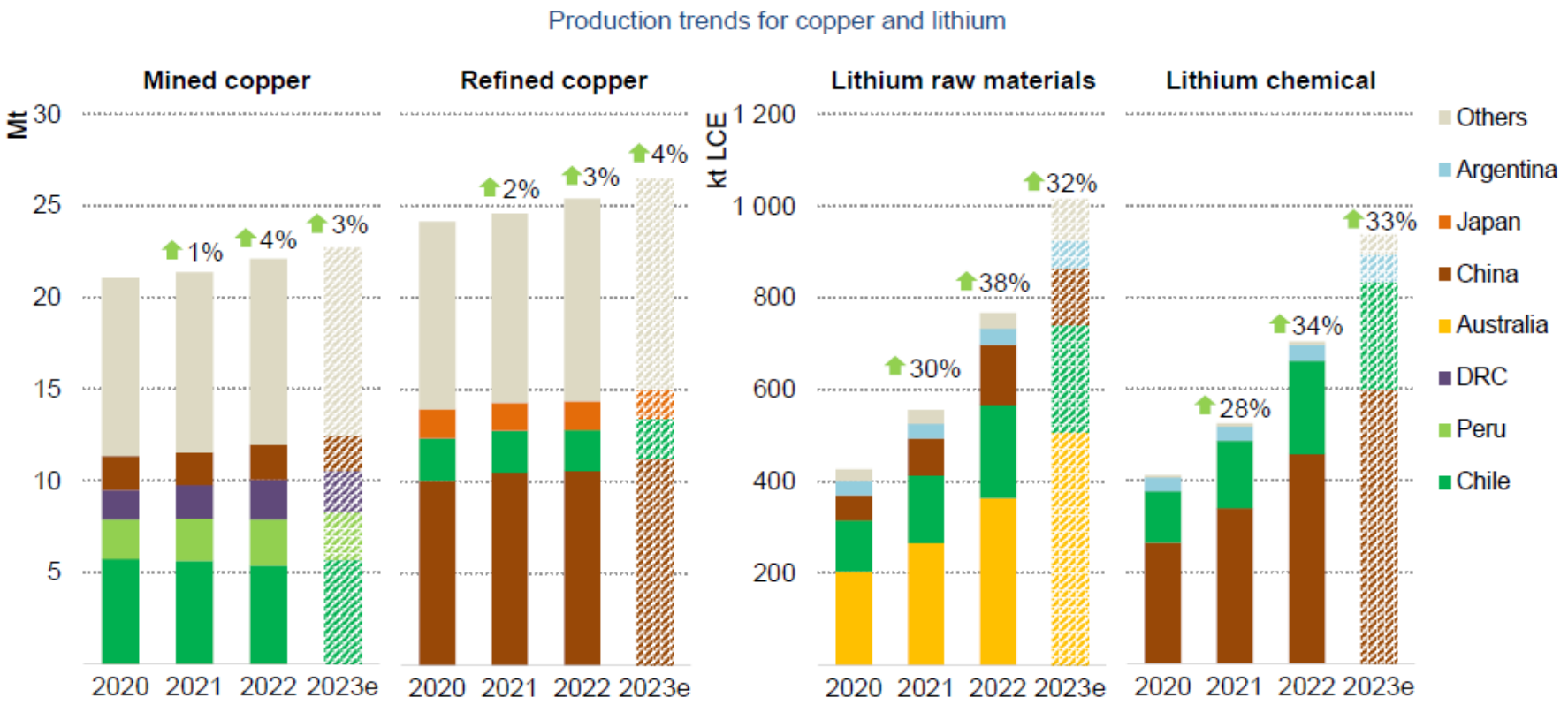
Source: IEA (2023), Global EV Outlook 2023.

Projections for CM deposit development

- **<u>Commodity trends</u>**

(**<u>Copper, Lithium</u>**, Cobalt, Graphite, REE, Uranium, and Manganese)

Copper production is starting to grow after flat years, but medium-term risks remain; lithium supply is continuing its strong upward journey

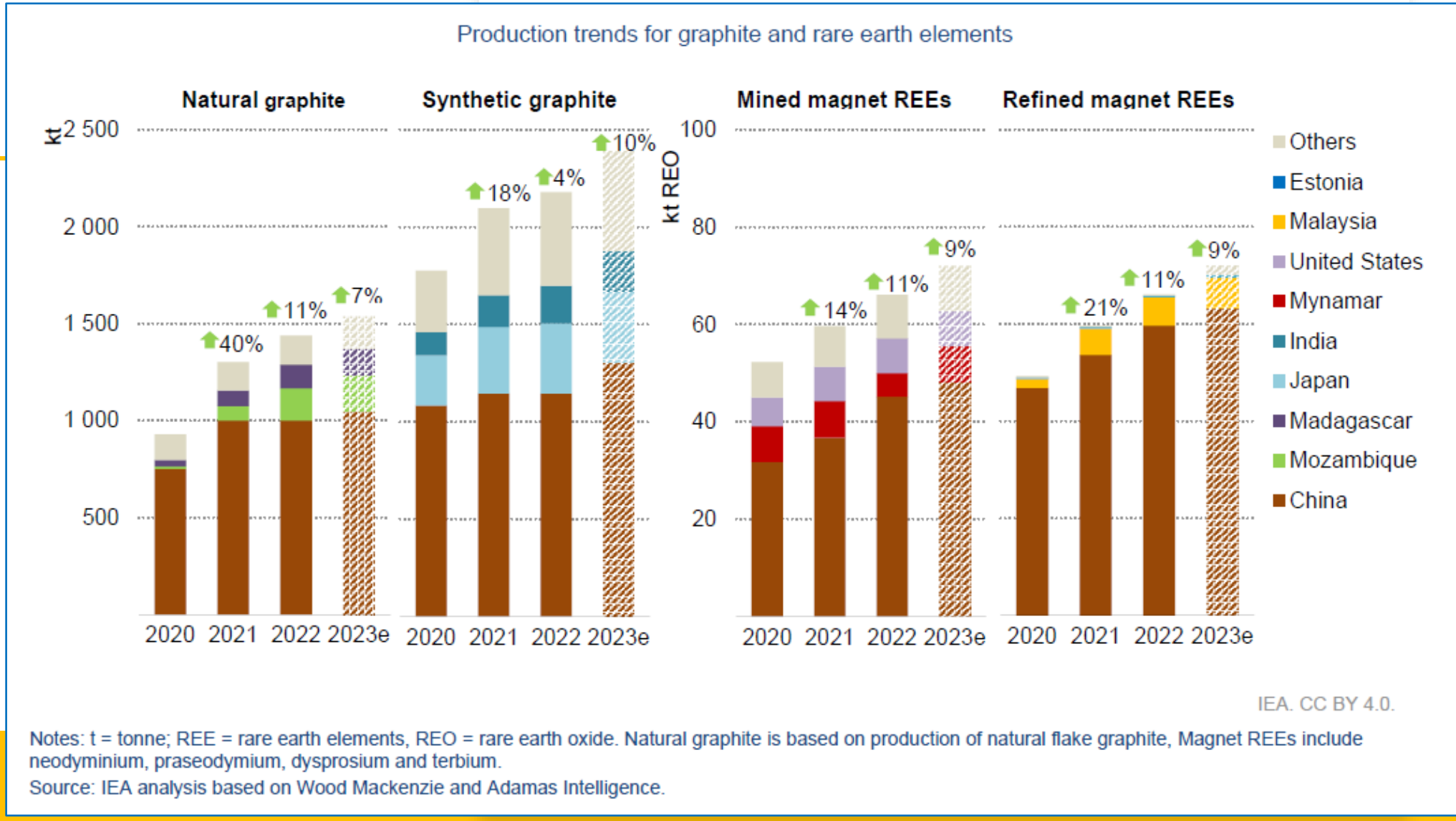


Notes: LCE = lithium carbonate equivalent. DRC = Democratic Republic of the Congo.
Source: IEA analysis based on S&P Global and Wood Mackenzie.

Projections for CM deposit development

- Commodity trends

(Graphite, REE, Uranium and Mangenese)

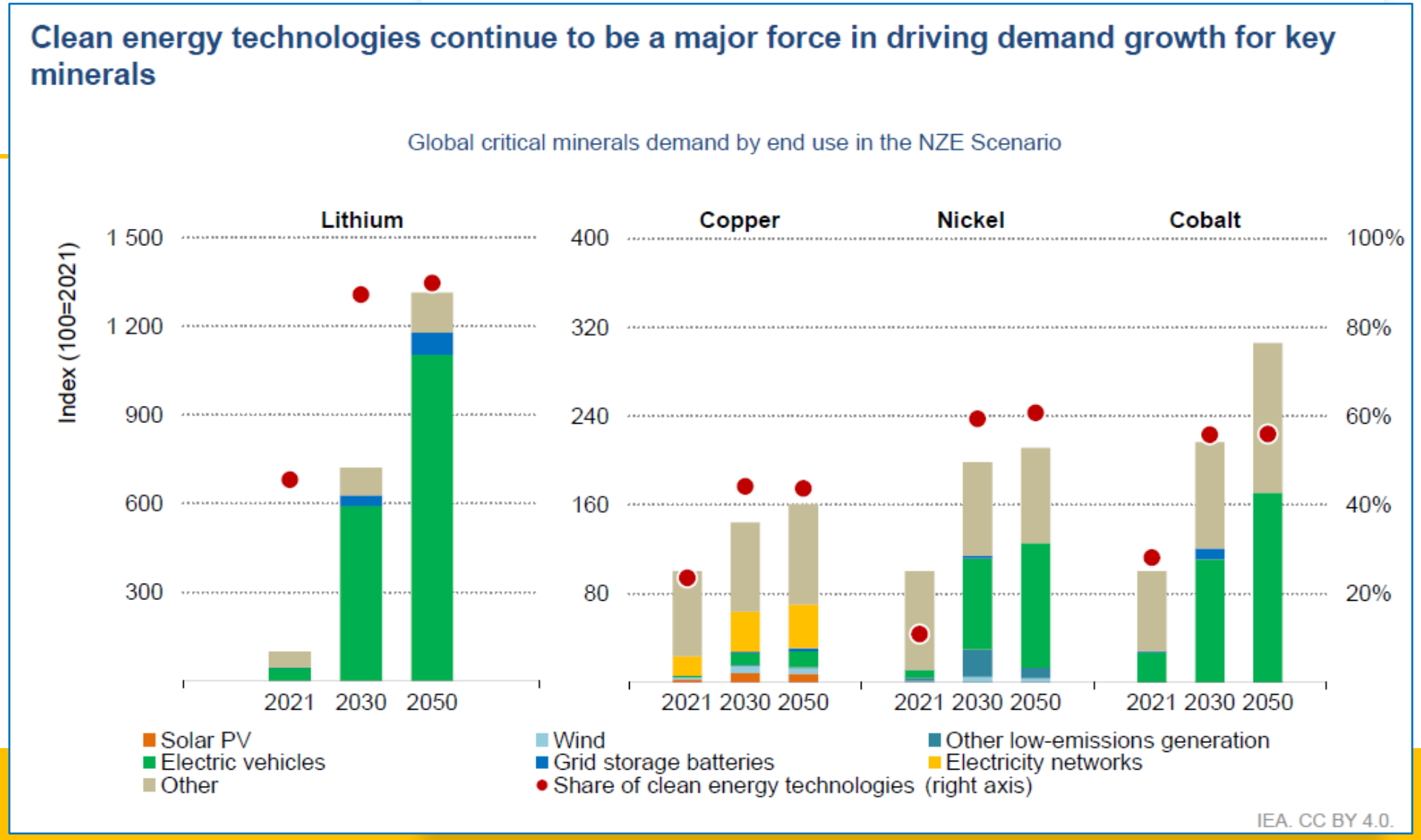


Notes: t = tonne; REE = rare earth elements, REO = rare earth oxide. Natural graphite is based on production of natural flake graphite, Magnet REEs include neodyminium, praseodymium, dysprosium and terbium.

Source: IEA analysis based on Wood Mackenzie and Adamas Intelligence.

Implications for CM deposit development

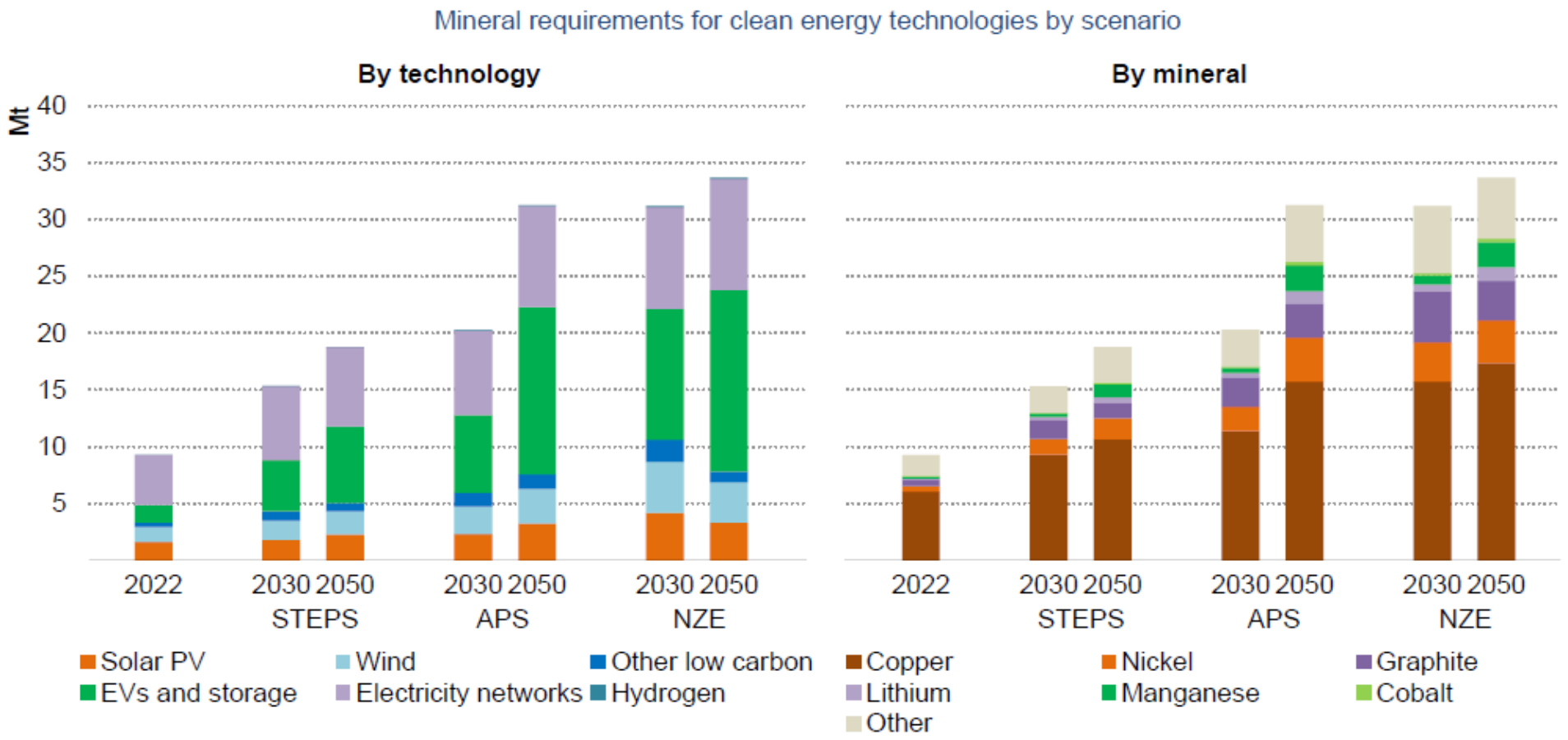
- Clean energy technologies – major demand force
- Critical minerals demand for clean energy is set to grow up to 3 folds by year 2030.
- Limited progress in diversification of supply



Implications for CM deposit development

- Clean energy technologies – major demand force

Critical minerals demand for clean energy is set to grow by up to three-and-a-half times over the period to 2030 as the world moves through energy transitions



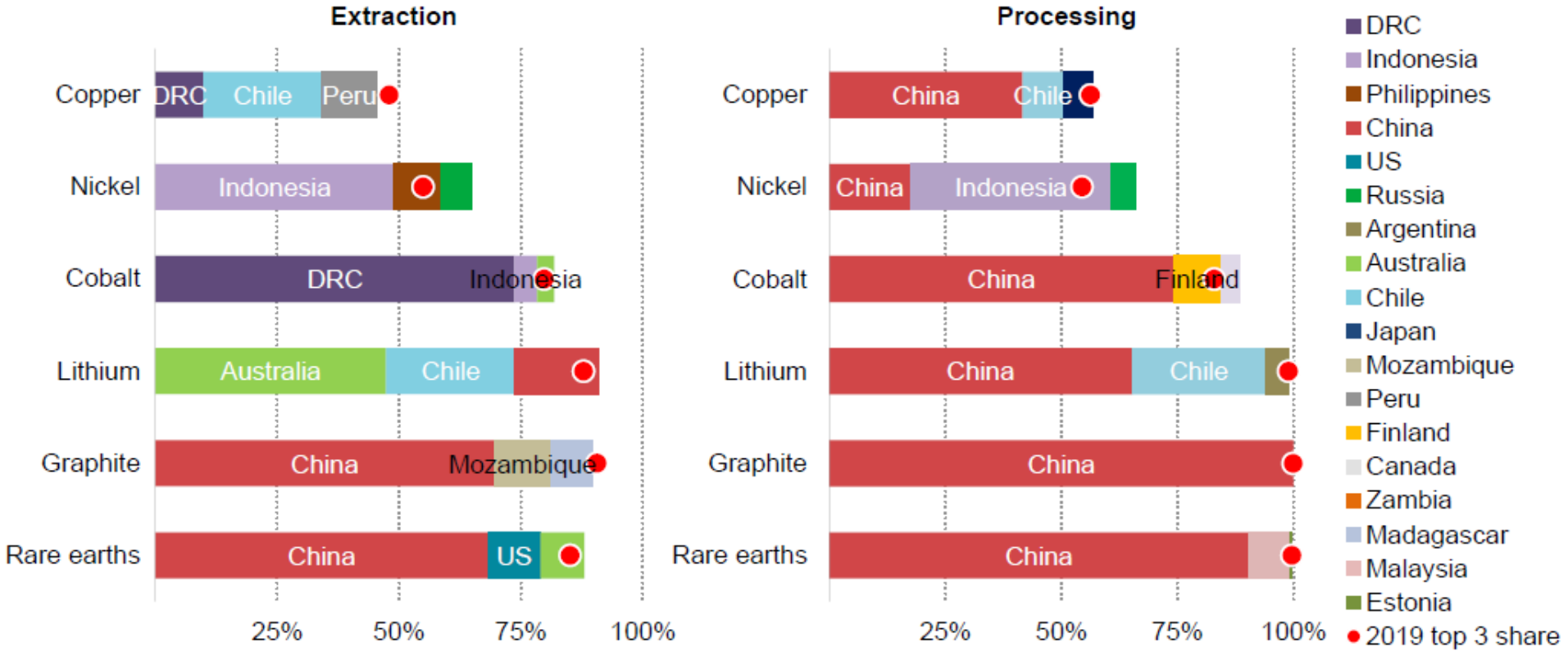
Notes: STEPS = Stated Policies Scenarios; APS = Announced Pledges Scenario; NZE = Net Zero Emissions by 2050 Scenario. Includes most of the minerals used in various clean energy technologies, but does not include steel and aluminium.

Implications for CM deposit development

- Limited progress in diversification of supply

There has been limited progress in terms of diversification over the past three years; concentration of supply has even intensified in some cases

Share of top three producing countries in total production for selected resources and minerals, 2022



Notes: DRC = Democratic Republic of the Congo. Graphite extraction is for natural flake graphite. Graphite processing is for spherical graphite for battery grade.
Sources: IEA analysis based on S&P Global, USGS (2023), Mineral Commodity Summaries and Wood Mackenzie.

Implication for government & private sector

Strengthen	Strengthen Geological Database
Invest in	Invest in acquisition of baseline geoscientific data (green & brown field development)
Intensify	Intensify engagement with private sector and geoscience professionals
Intensify	Intensify efforts to fund exploration, research and development
Expand	Expand exploration investment into green fields
Optimise	Optimise mineral deposit value chain

Conclusion

Namibia's critical mineral sector has substantial growth potential due to its abundant resources, stable political environment, infrastructure development, and the increasing global demand for these minerals.

By harnessing these advantages and pursuing sustainable and responsible mining practices, Namibia can position itself as a significant player in the critical mineral market and drive economic development in the country.

Thank you

Sources

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