Regional metallogenic studies for base and precious metals in geologic settings in the northern São Francisco craton

Ricardo Ramos Spreafico
Companhia Baiana de Pesquisa Mineral - CBPM

Ouro Preto, November 2022

Introduction

1 - **Case study 1** – Mundo Novo greenstone belt (Faz. Coqueiro Zn-Pb deposit).

2 - **Case study 2** – Contendas-Mirante volcano-sedimentary belt (Faz. Eldorado gold deposit).

3 - **Comparative geochemistry study (Th-Nb proxy of metabasalts)** – Mundo Novo and Contendas-Mirante belts:

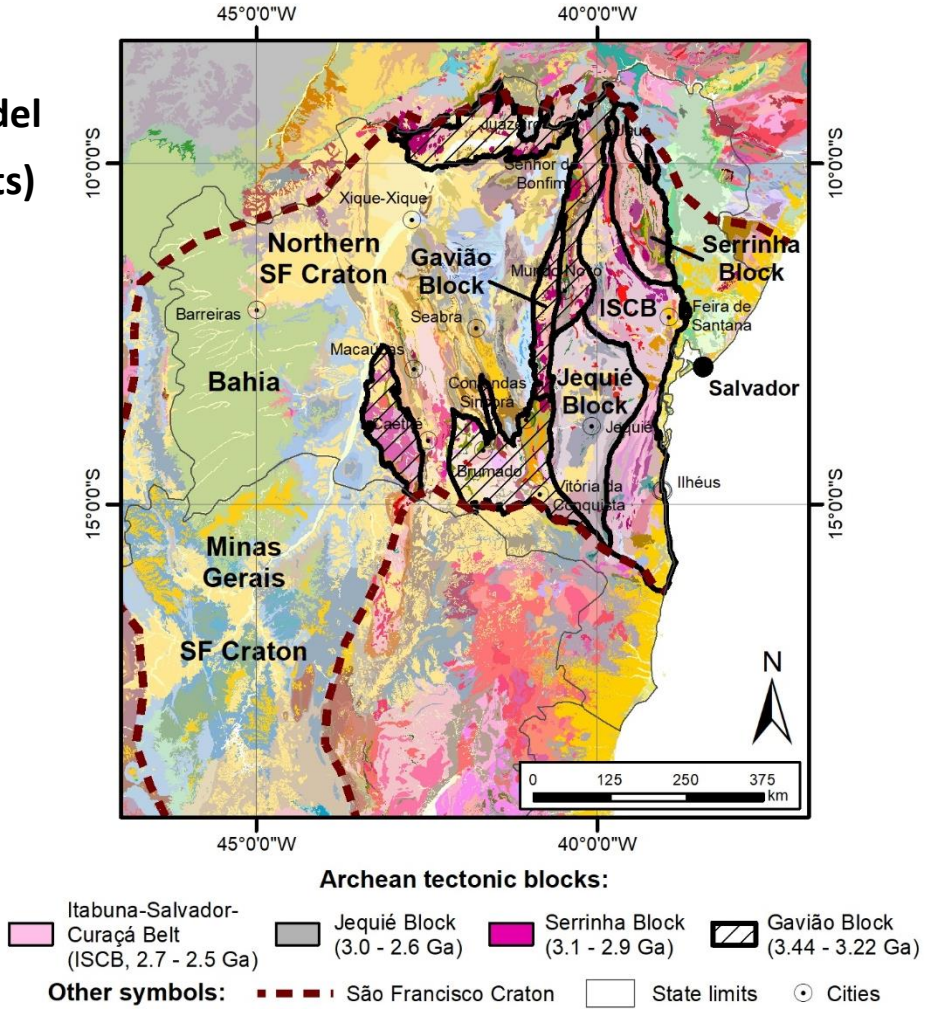
- Continental and oceanic provenance studies (tectonic and metallogenic settings);
- Regional-scale exploration model for base and precious metals in Neoarchean and Paleoproterozoic greenstone and volcanic belts;
- Improvements on regional exploration programs.

4 - **Use of Th-Nb proxy on provenance study** – Rio Salitre greenstone belt.

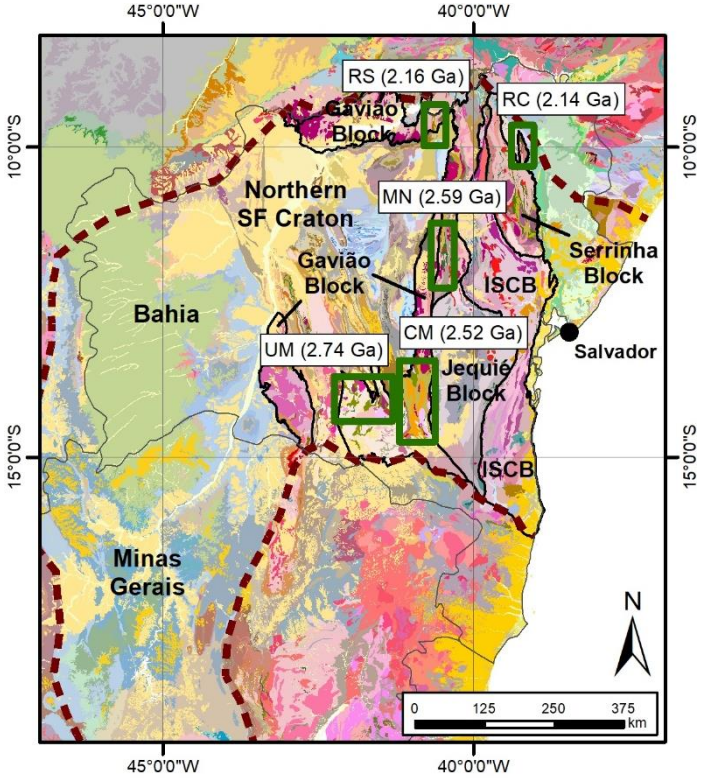
5 - **Use of Th-Nb proxy on provenance study** – Umburanas greenstone belt.

6 - **Use of Th-Nb proxy on provenance study** – Rio Capim greenstone belt.

Archean tectonic blocks model (regional tectonic lineaments)



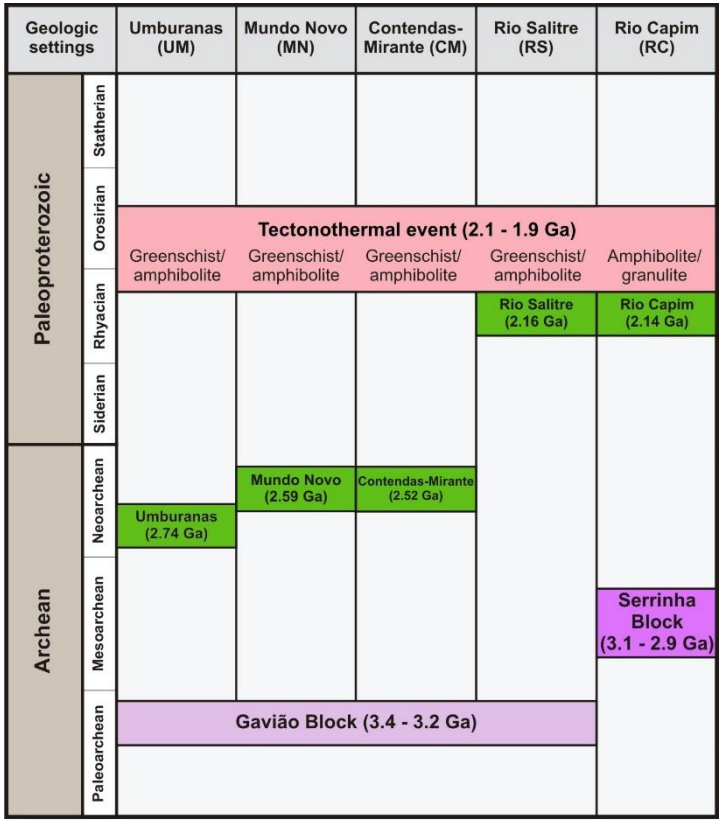
Source: Melo et al. (2014), Spreafico et al. (2019), and Barbosa et al. (2021)



Geologic settings from Neoarchean to Paleoproterozoic:

- São Francisco Craton
- **CM** - Contendas-Mirante Volcano-Sedimentary Belt (2.52 Ga, Sm-Nd, BIF)
- **RC** - Rio Capim Greenstone Belt (2.14 Ga, U-Pb, zircon-metadacite)
- **MN** - Mundo Novo Greenstone Belt (2.59 Ga, U-Pb, zircon-metadacite)
- **RS** - Rio Salitre Greenstone Belt (2.16 Ga, U-Pb, zircon-metarhyolite)
- **UM** - Umburanas Greenstone Belt (2.74 Ga, Pb-Pb, zircon-metaandesite)

Ages: Leal et al. (2003), Oliveira et al. (2010), Silva Filho (2017), Spreafico et al. (2019), and de Paula Garcia et al. (2021)



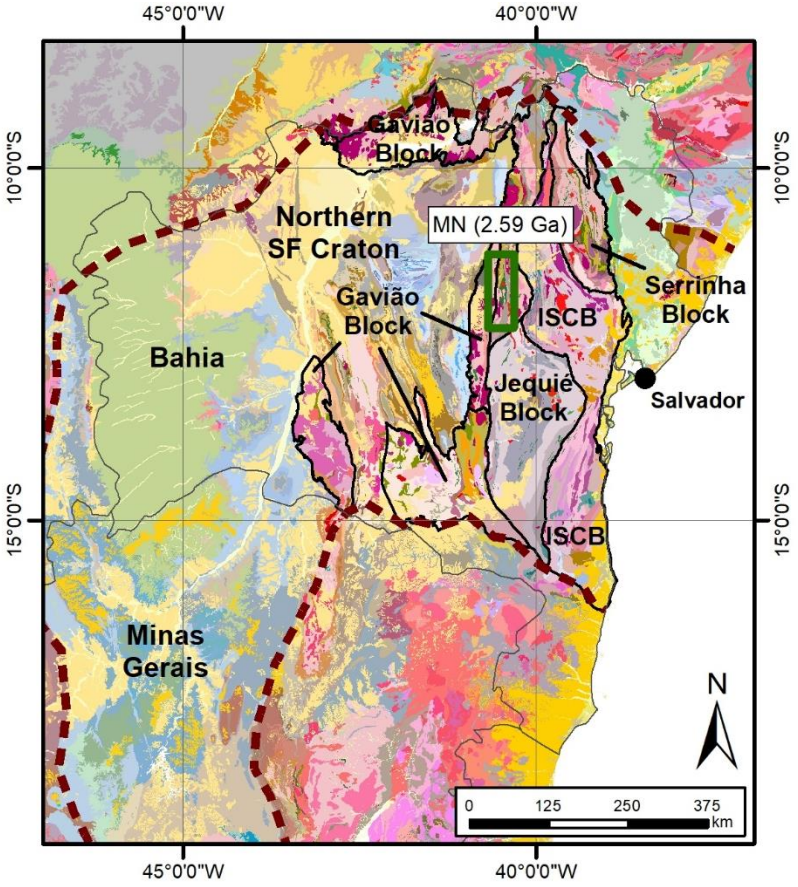
Neoarchean to Paleoproterozoic geologic settings (northern São Francisco craton)

Ages: Leite (2002), Leal et al. (2003), Oliveira et al. (2010), Silva Filho (2017), Spreafico et al. (2019), and de Paula Garcia et al. (2021)

1 - Mundo Novo greenstone belt – 2.59 Ga (Gavião Block)

Case study 1

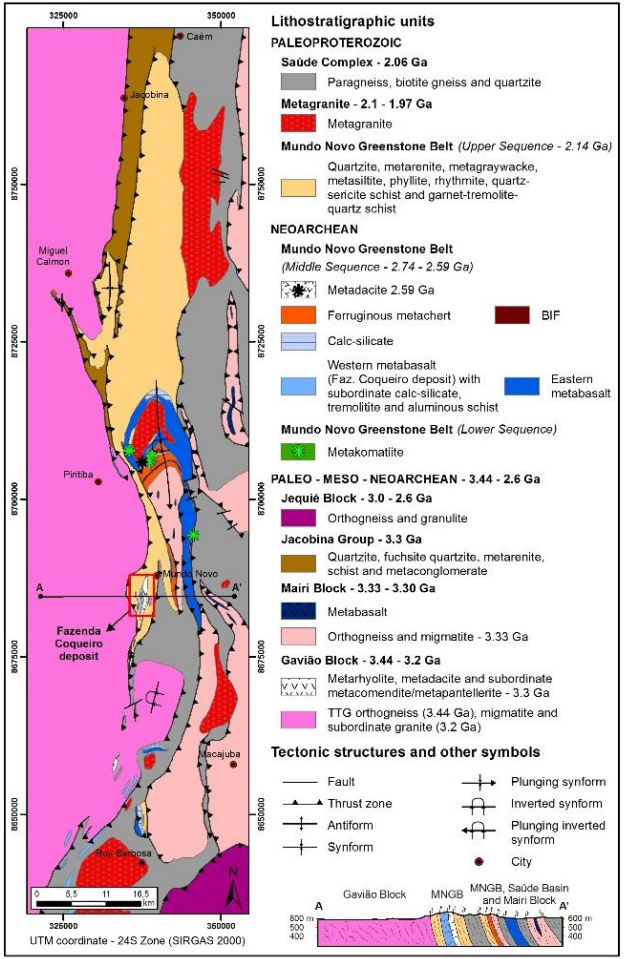
Neoarchean

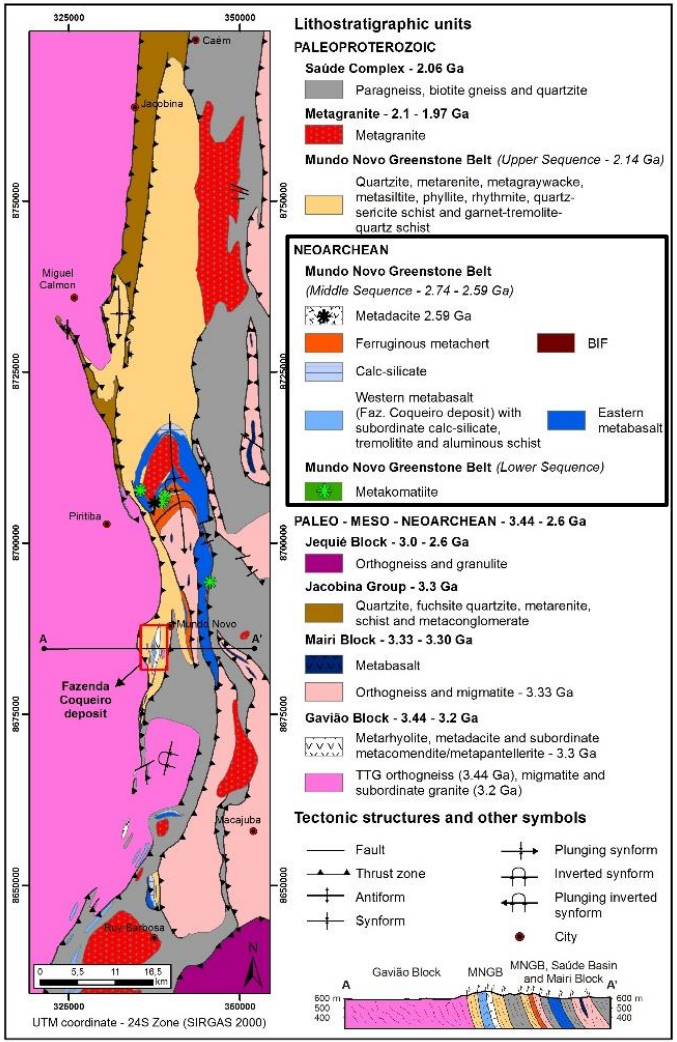


MN - Mundo Novo Greenstone Belt (2.59 Ga, U-Pb, zircon-metadacite)

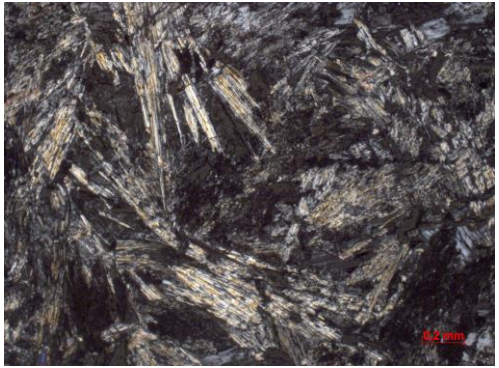
Eastern border of the Gavião Block/ Northern Contendas-Jacobina lineament

Geologic map of the Mundo Novo greenstone belt



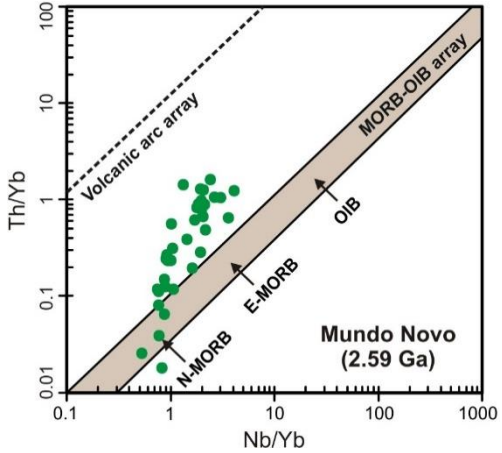


Lower and Middle Sequences



Relict fine-grained spinifex texture in metakomatiite

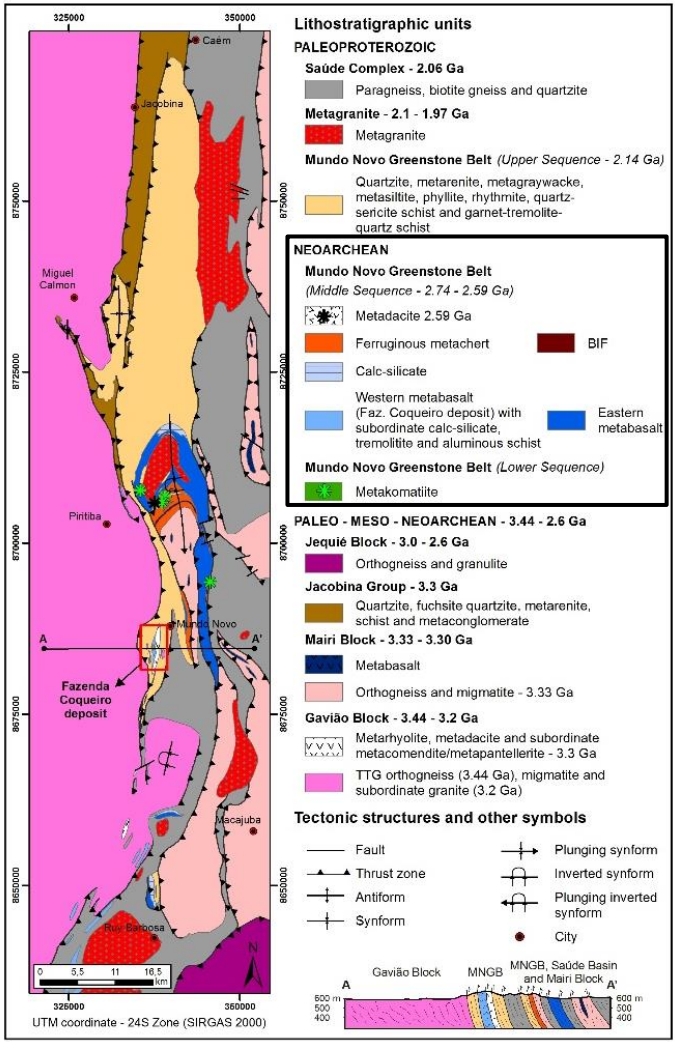
Metabasalt with pillow lava structure

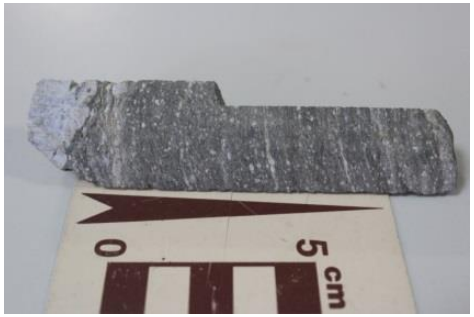


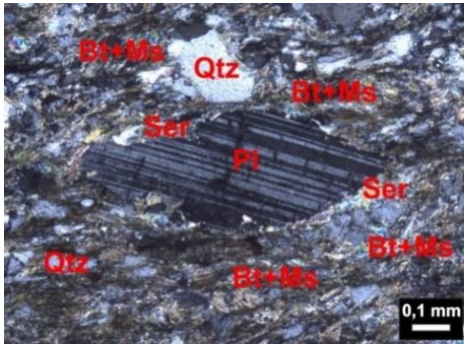
Source: Spreafico et al. (2019)

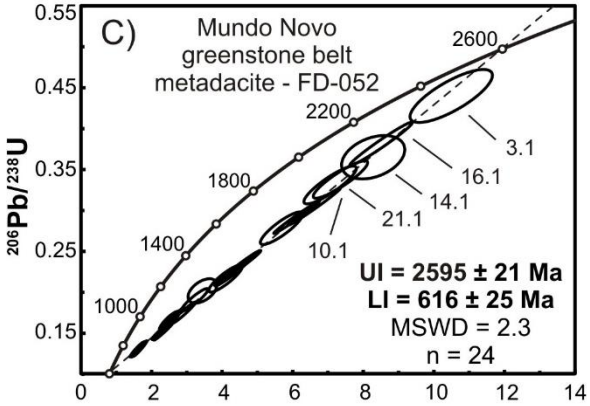
Diagram: Pearce (2008)

Middle Sequence





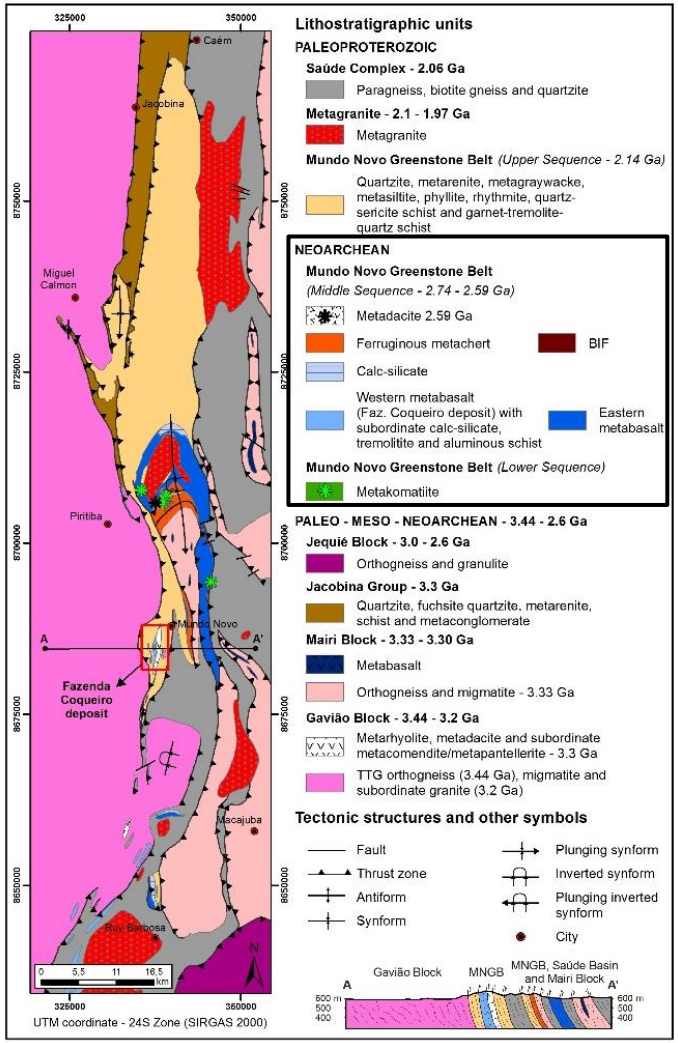


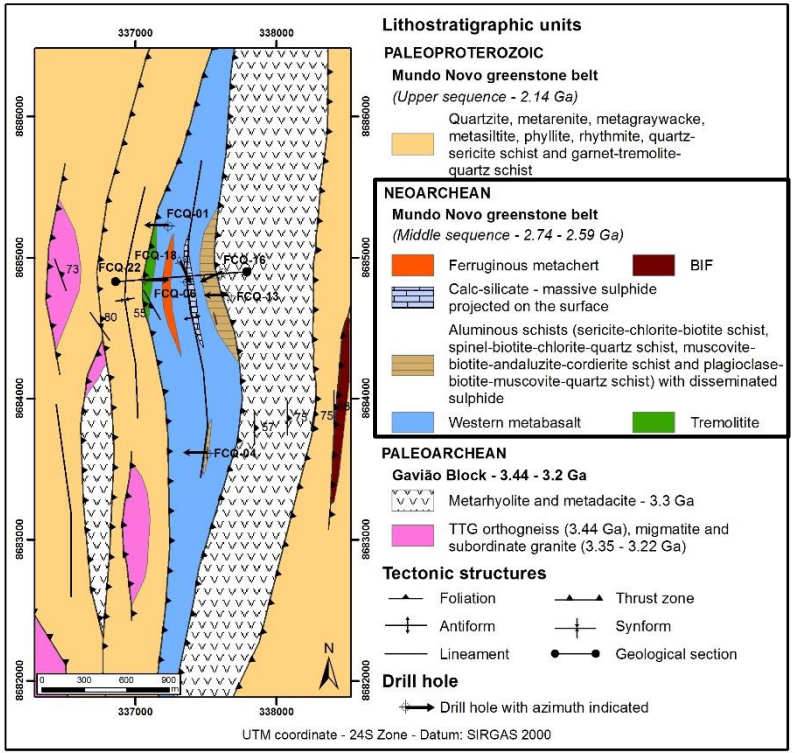


Metadacite: 2595 ± 21 Ma (U-Pb zircon age)

Source: Spreafico et al. (2019)

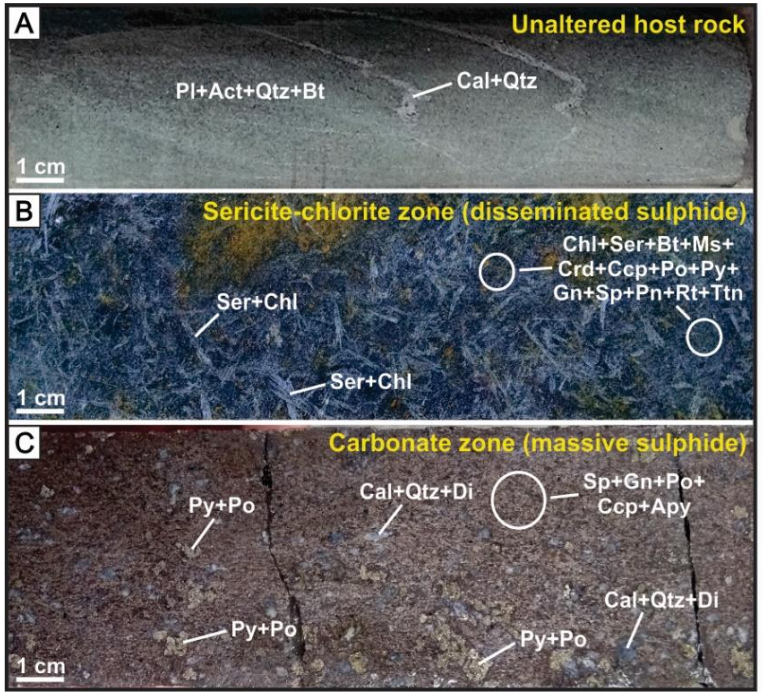
Geologic map of the Fazenda Coqueiro Zn-Pb deposit





Source: Spreafico et al. (2019), and Spreafico et al. (2020)

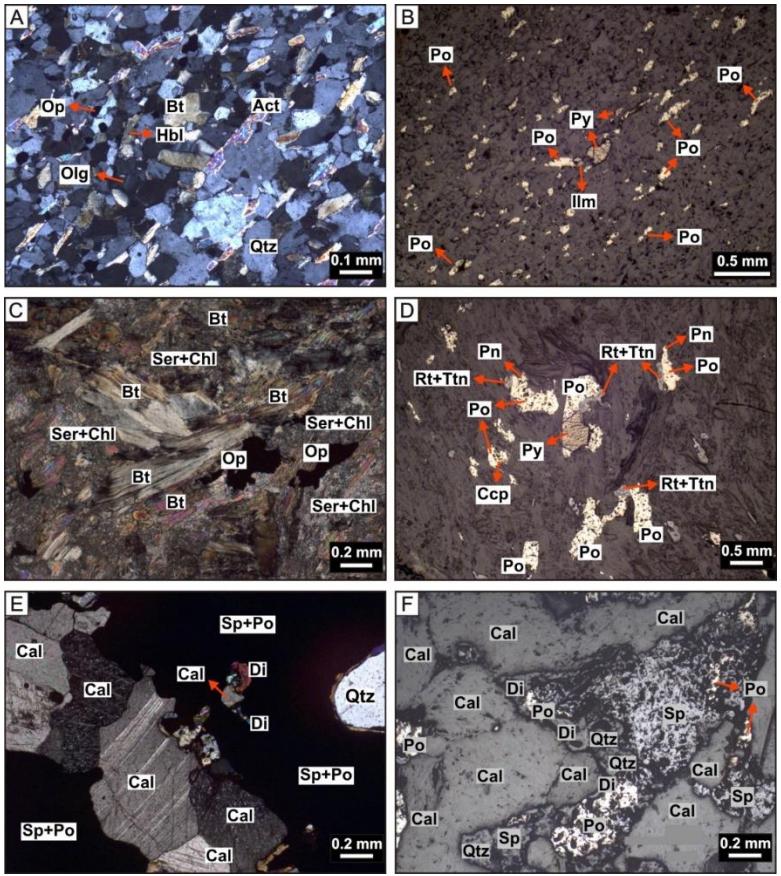
Typical drill core sample features from the Fazenda Coqueiro Zn-Pb deposit



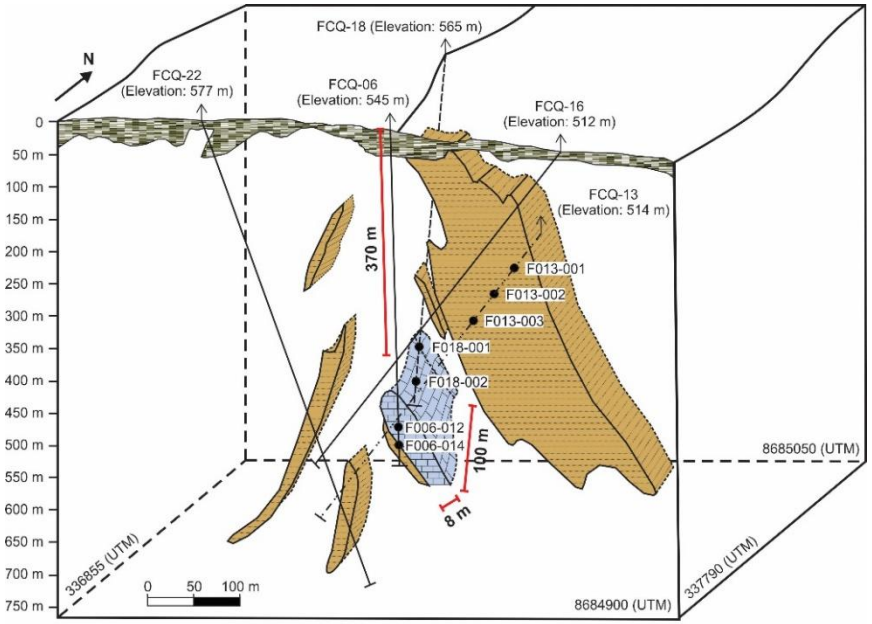
6.12% Zn @ 4.2 Mt

Hydrothermal alteration increasing

Petrographic images



Fazenda Coqueiro Zn-Pb deposit:



Geology

- Soil

Neoarchean

Mundo Novo greenstone belt (2.74 - 2.59 Ga)

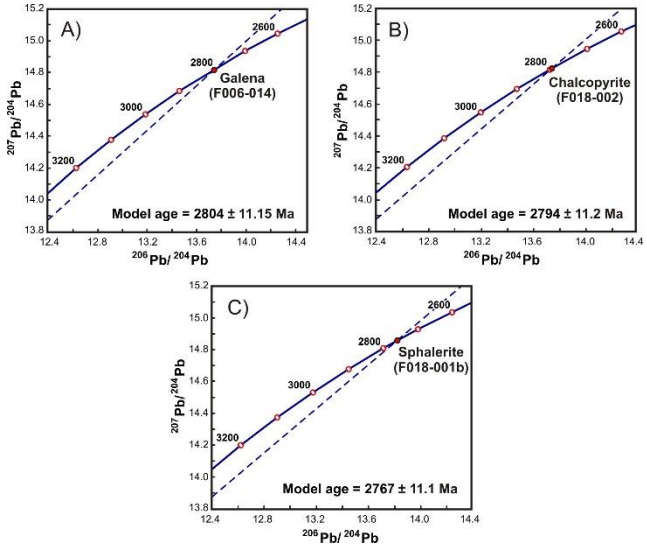
Middle sequence

- Carbonate zone (calc-silicate): massive sulphide - Zn-Pb
- Sericite-chlorite zone (aluminous schist): disseminated sulphide - Cu-(Pb-Zn)

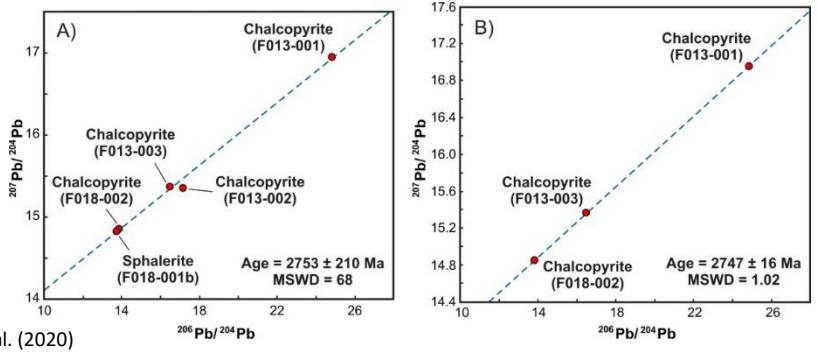
Drill hole

- Collar
- Drill holes along the front plane of the diagram block
- Drill holes inside the diagram block
- Drill holes outside the diagram block
- Defined geologic contact
- Infered geologic contact
- Site sampled for Pb-Pb analysis

Age model for sulfide samples: 2.8 Ga (TIMS)



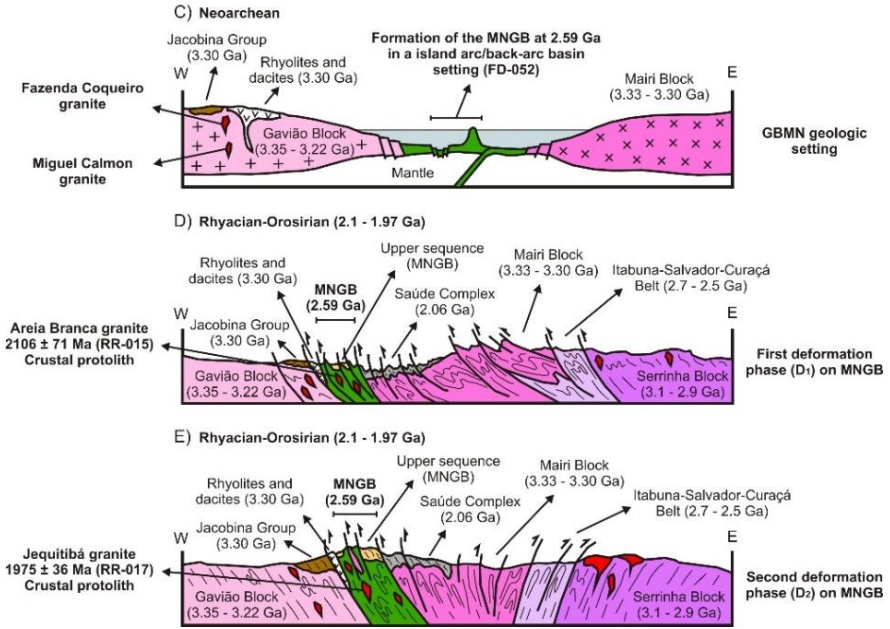
Crystallization age for sulfide samples: 2.74 Ga (TIMS)



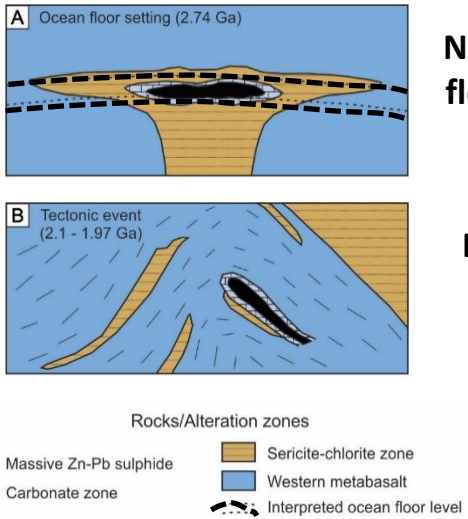
Source: Spreafico et al. (2020)

Tectonic and metallogenic model in the Mundo Novo greenstone belt

Mundo Novo greenstone belt



Fazenda Coqueiro Zn-Pb VHMS deposit



Neoarchean ocean-floor hydrothermal activity

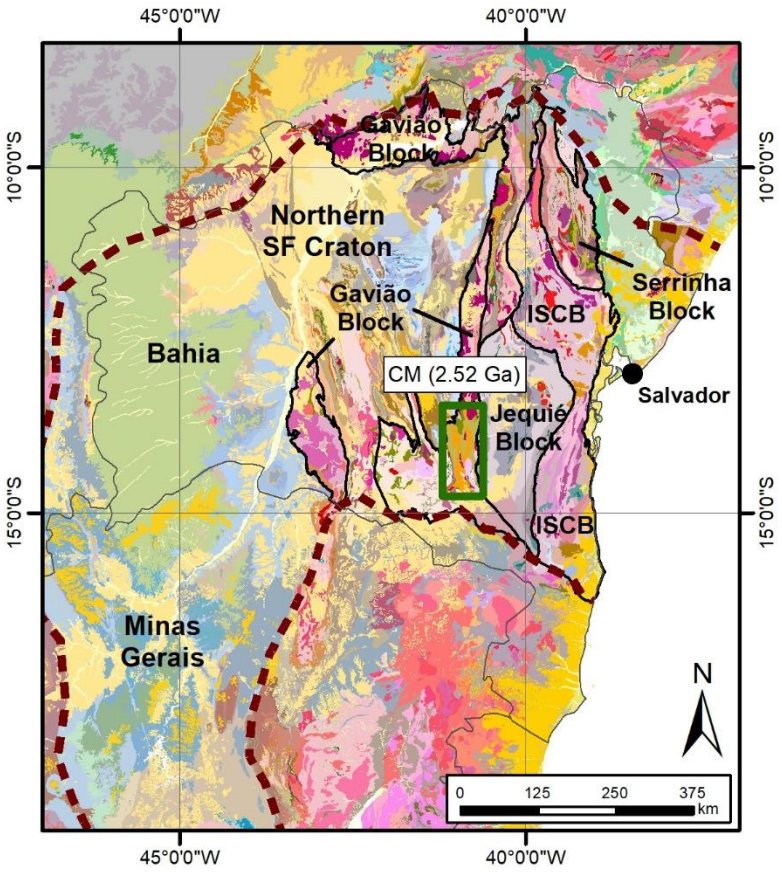
Paleoproterozoic tectonothermal event

Source: Spreafico et al. (2019), and Spreafico et al. (2020)

2 - Contendas-Mirante belt – 2.52 Ga (Gavião Block)

Case study 2

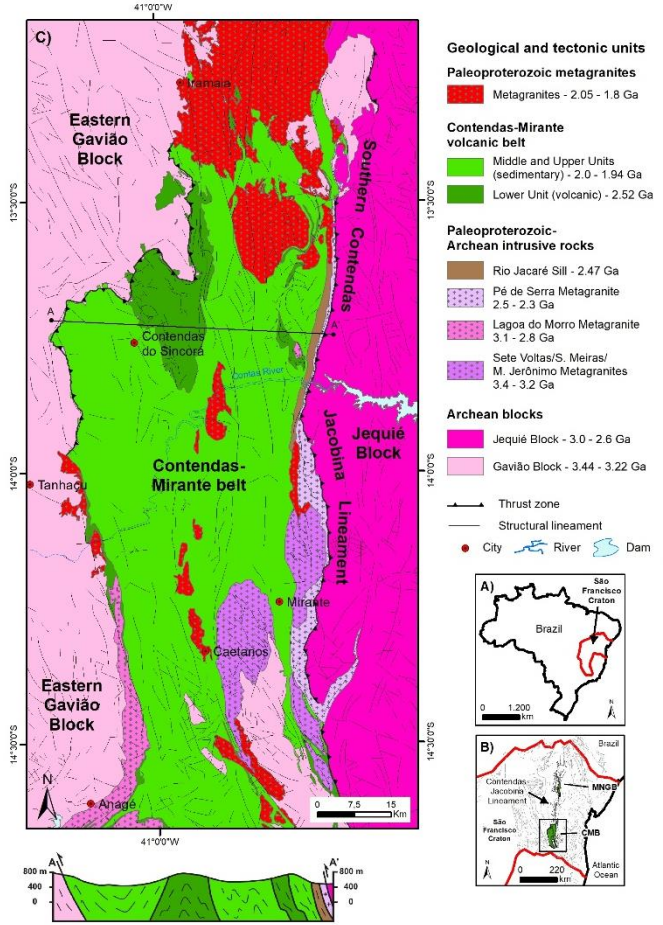
Neoarchean

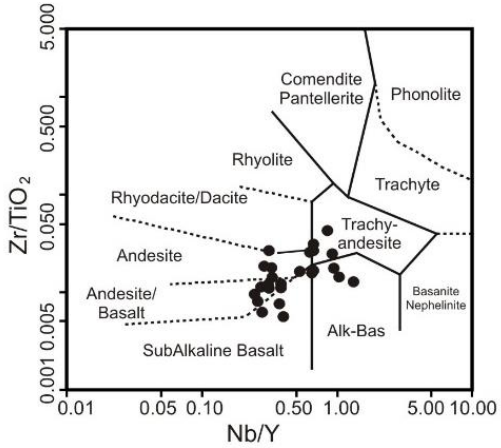


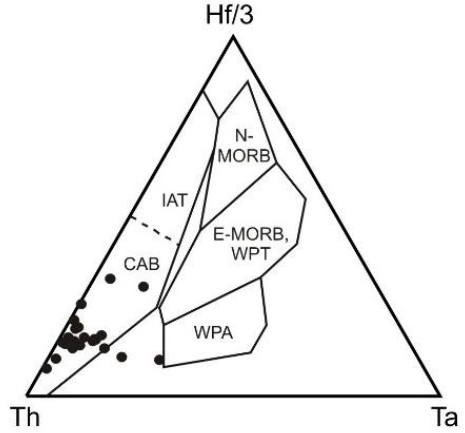
CM - Contendas-Mirante Volcano-Sedimentary Belt (2.52 Ga, Sm-Nd, BIF)

Eastern border of the Gavião Block/ Southern Contendas-Jacobina lineament

Simplified geologic map of the Contendas-Mirante belt

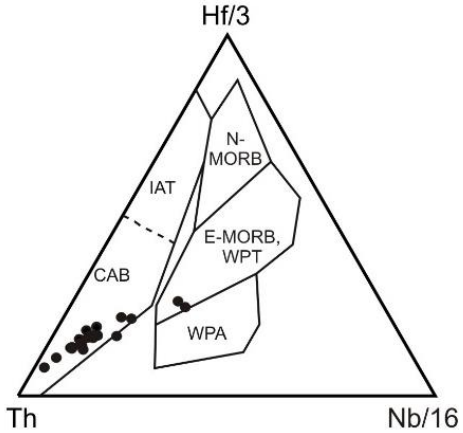


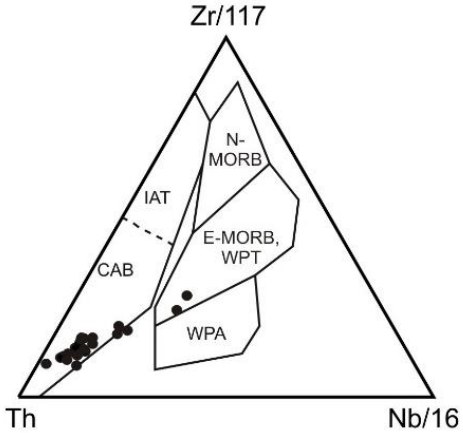


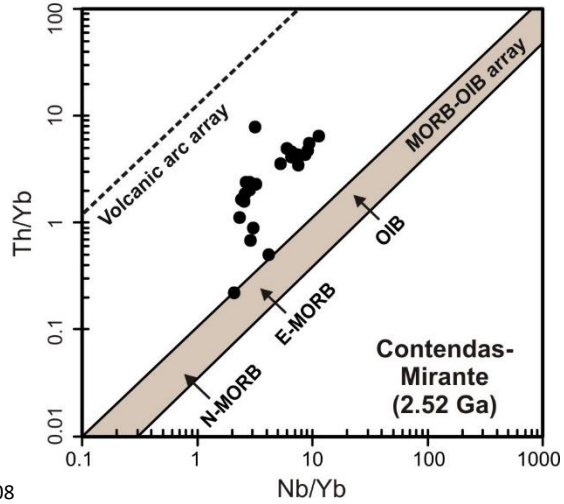


● Contendas-Mirante belt

Contendas-Mirante metabasalt

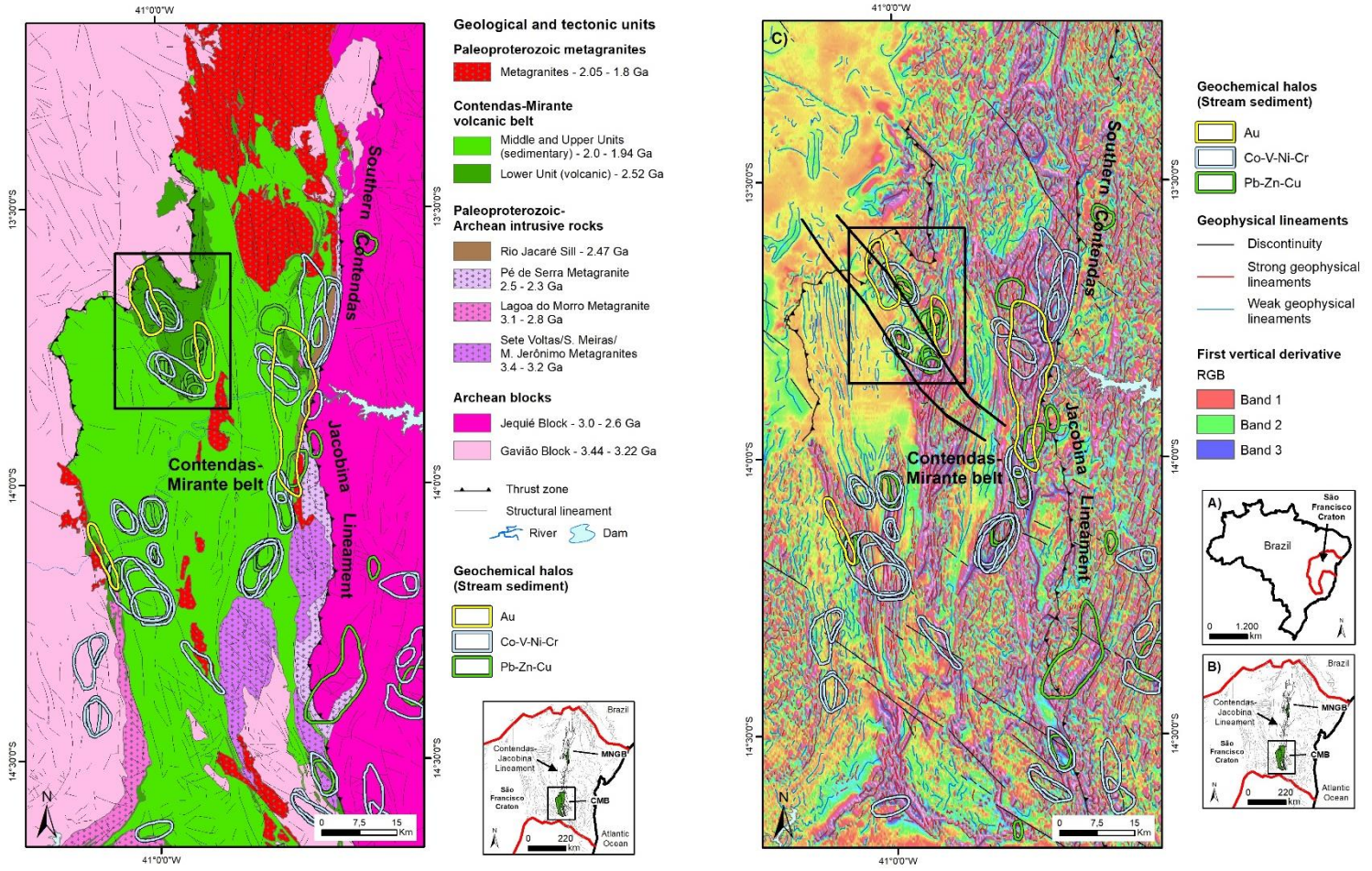






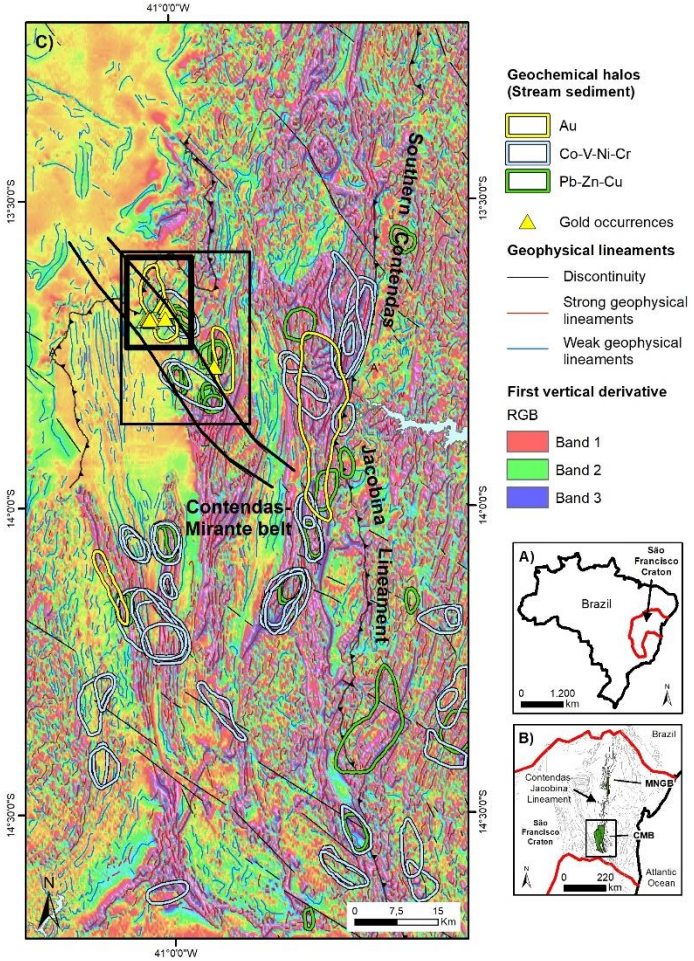
Geochemical data source: Spreafico et al. (2022). Diagrams: Winchester and Floyd (1977), Wood (1980), and Pearce 2008

Selected area based on geological parameters, geochemical anomalies and geophysical signatures

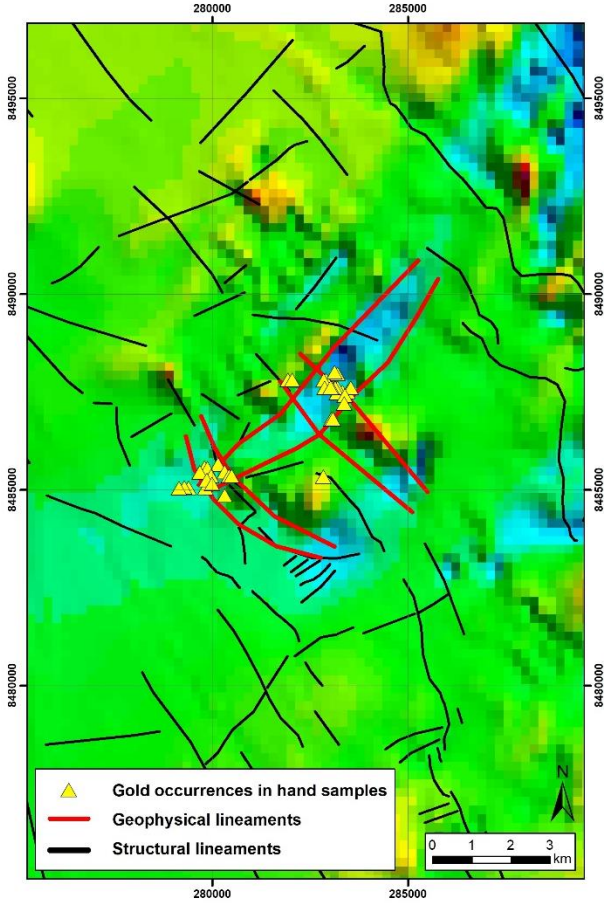


Maps modified, adapted and interpreted from Santos et al. (2021)

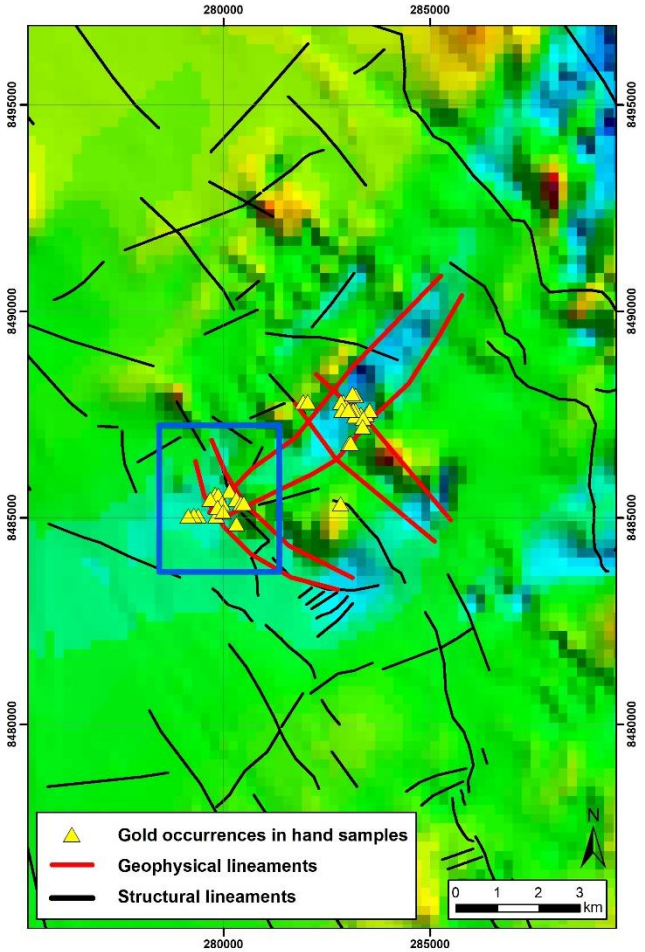
Paleoproterozoic second-order structure indicated by magnetic lineaments

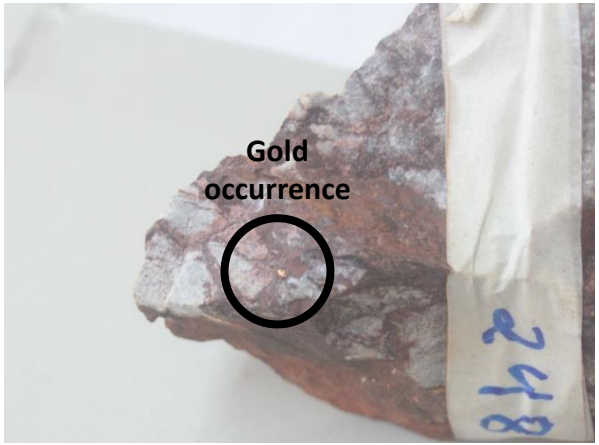


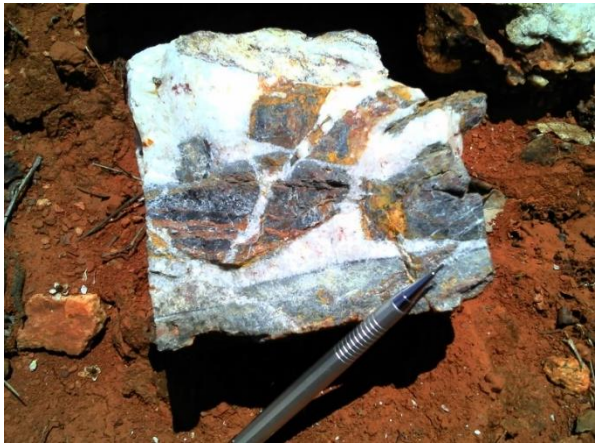
Gold occurrences in the intersection of Paleoproterozoic regional lineaments (second and third-order) highlighted by magnetic geophysical signatures



Gold occurrences in the intersection of Paleoproterozoic regional lineaments and the detailed study area indicated

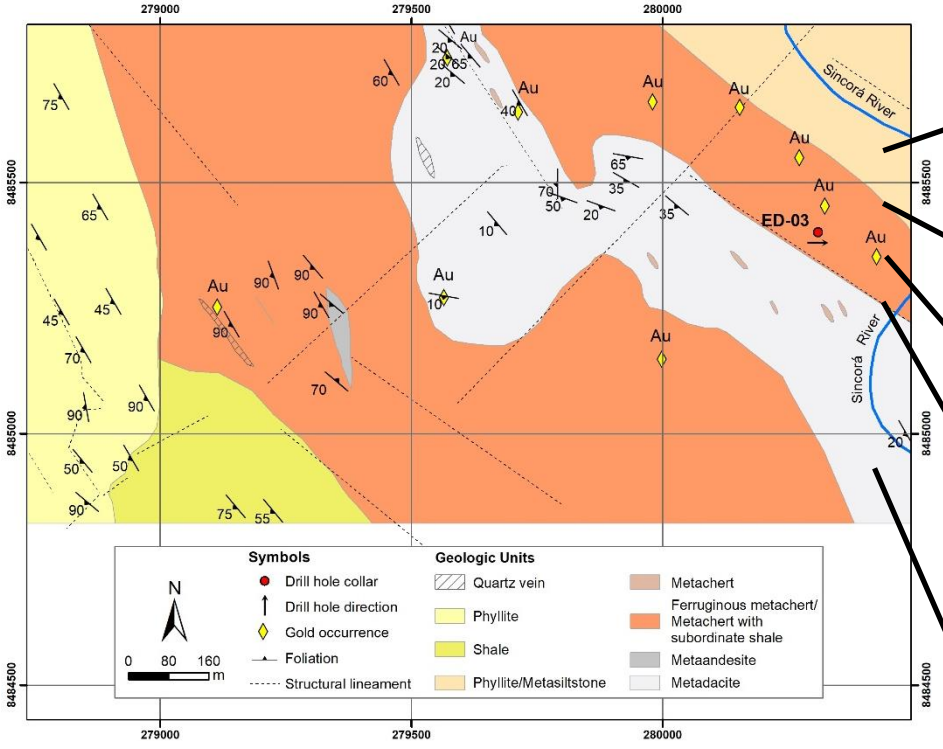






Brecciated gold-bearing ferruginous metachert

Geologic map of the detailed study area (Faz. Eldorado)



Phyllite

Gold-bearing qtz sericite schist (alteration zone)

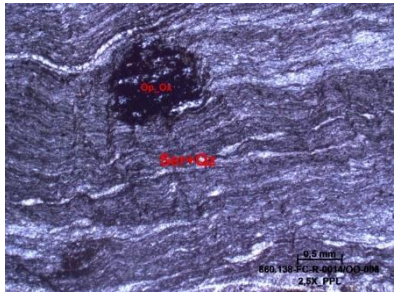
Brecciated gold-bearing ferruginous metachert

Metadacite

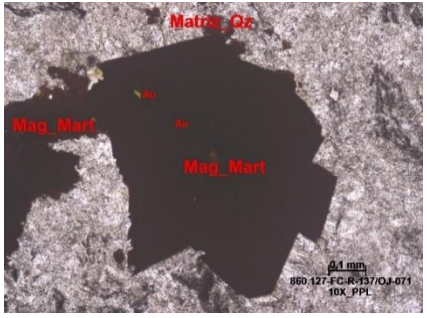
Gold-bearing qtz sericite schist (alteration zone)

Drill core samples from the detailed study area (Faz. Eldorado gold deposit)

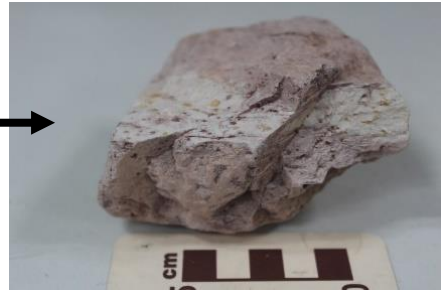
0.6 g/t Au @ 2.0 m

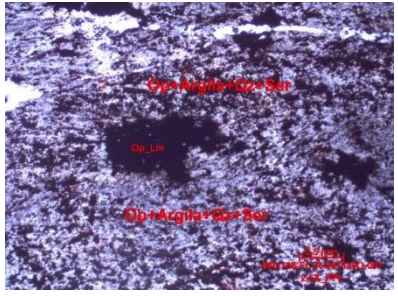


Sericite alteration zone with gold occurrences

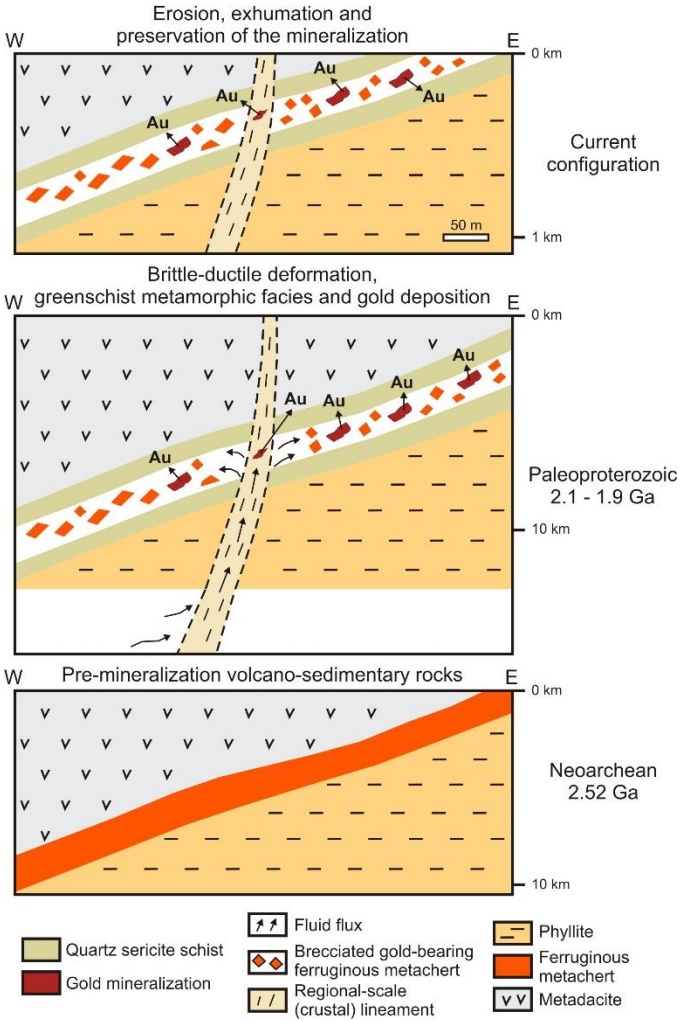


Brecciated gold-bearing ferruginous metachert (Au-As)





Sericite alteration zone with gold occurrences



Tectonic and metallogenic model in the Contendas-Mirante belt (Faz. Eldorado gold deposit)

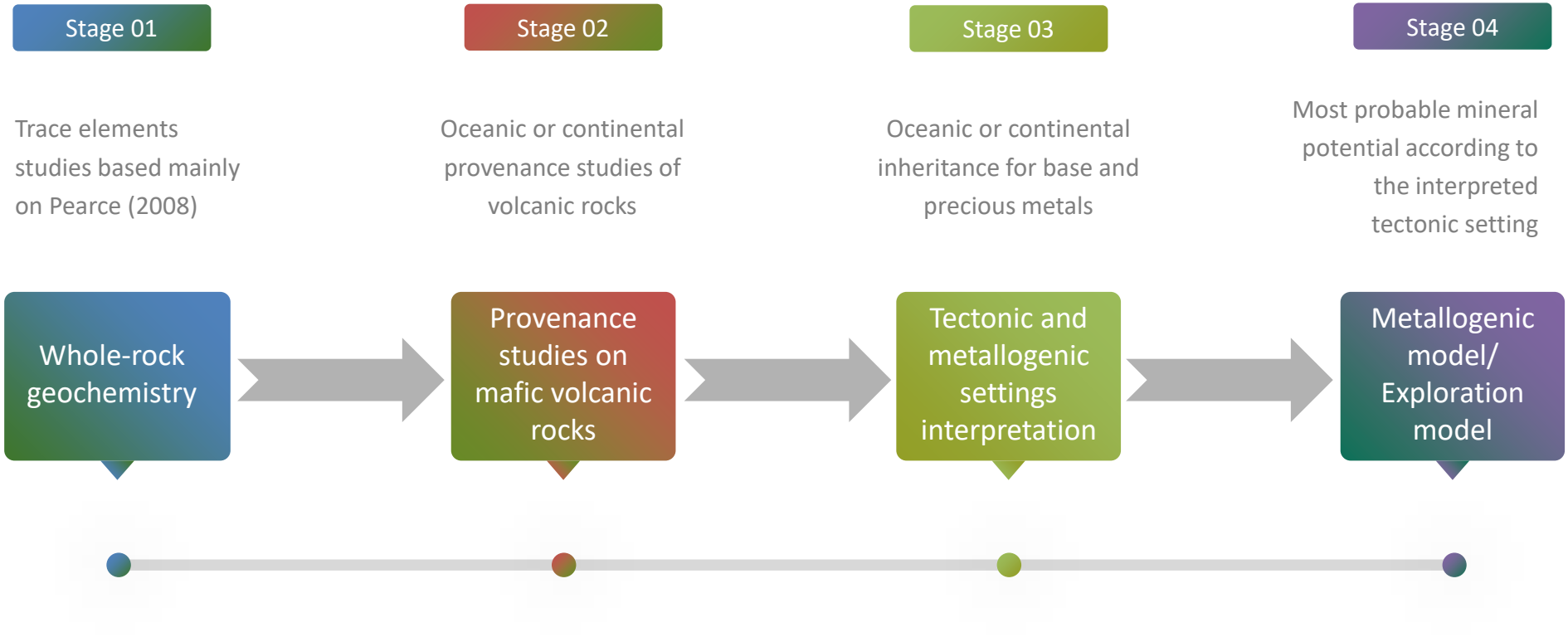
- Neoarchean volcano-sedimentary rocks deformed and metamorphosed during the Paleoproterozoic tectonothermal event;
- Auriferous fluid flux upward along deep crustal faults (deep crustal source) during seismic activity;
- Intersection of deep second and third-order regional lineaments;
- Rheological and geochemical contrasts resulting on hydraulic brecciation of ferruginous cherts at the brittle-ductile transition crustal level (~10 km), high fluid pression and mineralization;
- Fragments of As gold-bearing ferruginous metachert, low Hg content and lack of Sb;
- **Orogenic gold deposit**.

(Groves et al., 2020)

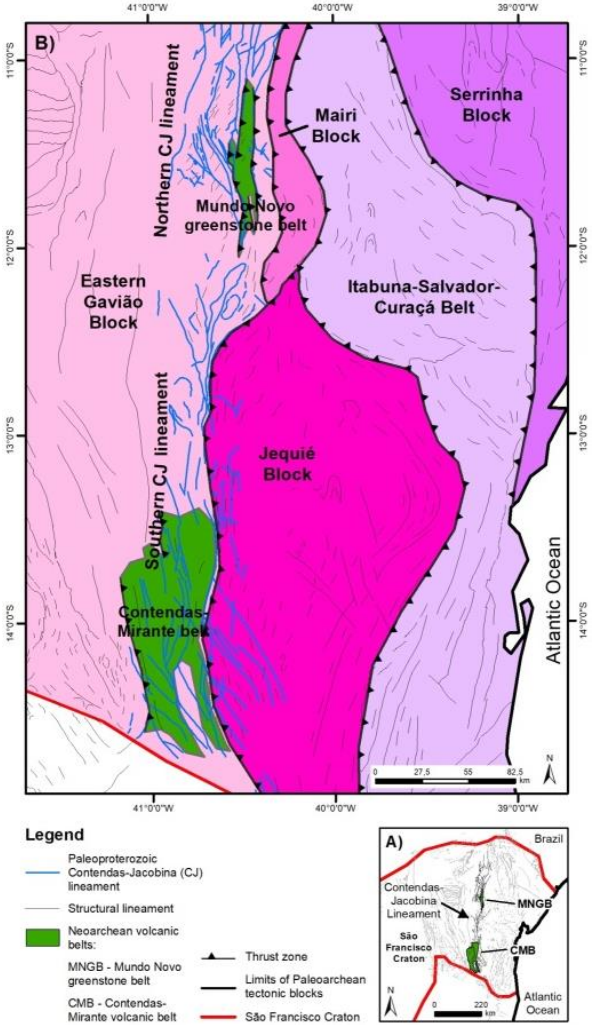
3 – Comparative study and Th-Nb proxy in metabasalts for provenance characterization

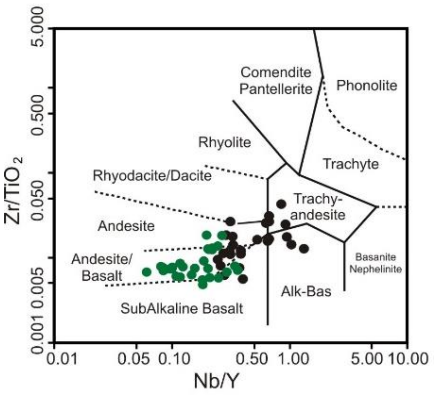
Mundo Novo greenstone belt/Contendas-Mirante belt

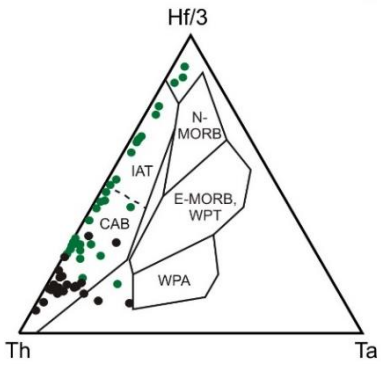
Mundo Novo greenstone belt/Contendas-Mirante belt

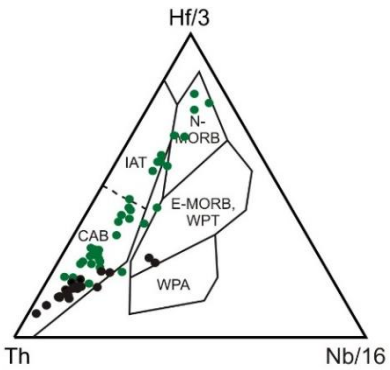


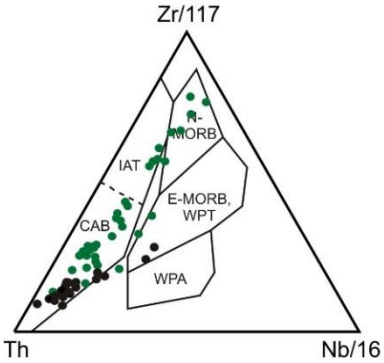
Stage 1

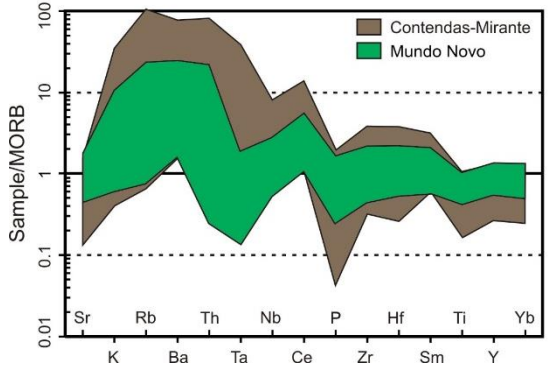












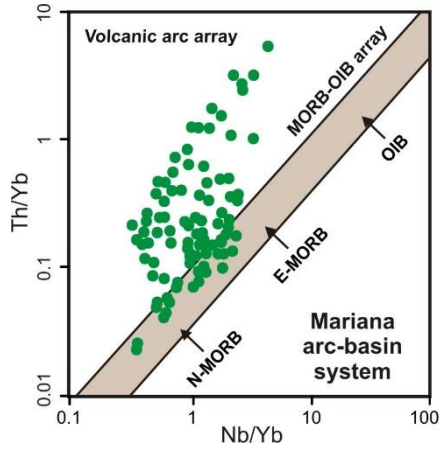
Contendas-Mirante belt

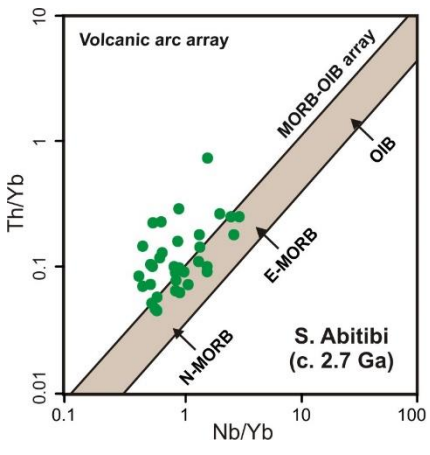
Mundo Novo greenstone belt

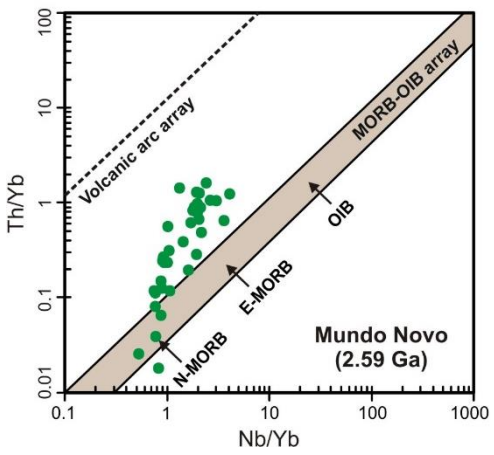
Geochemical data source: Spreafico et al. (2019), and Spreafico et al. (2022)

Diagrams: Winchester and Floyd (1977), Pierce (1983), and Wood (1980)

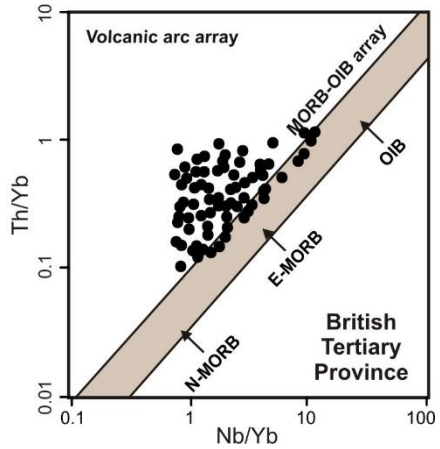
Stages 1 and 2

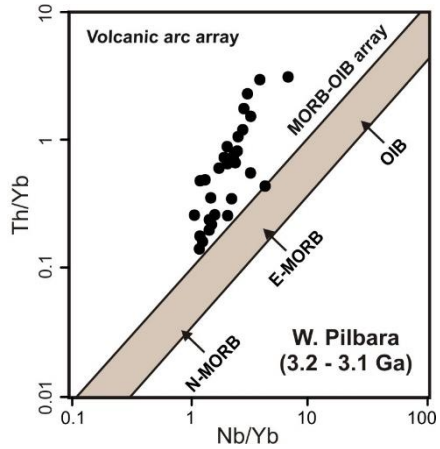


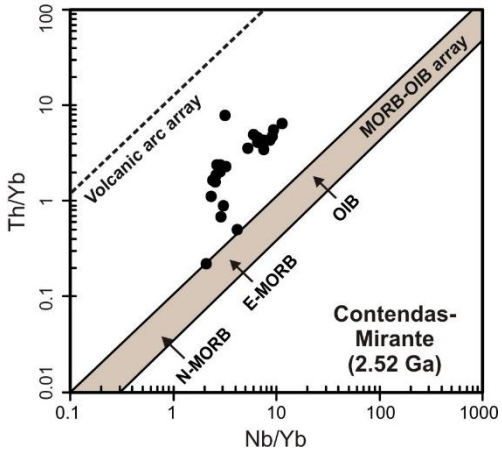




Oceanic provenance (source) interpreted



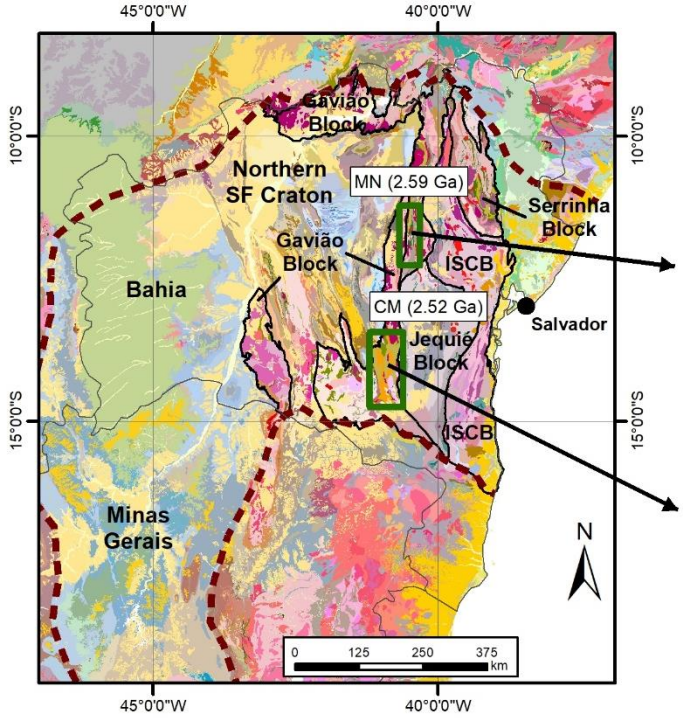




Continental provenance (source) interpreted

Geochemical data source: Xie and Kerrich (1994), Polat and Kerrich (2001), Kerrich and Xie (2002), Pearce (2008), Spreafico et al. (2019), and Spreafico et al. (2022)

Stages 3 and 4



Geologic settings from Neoarchean to Paleoproterozoic:

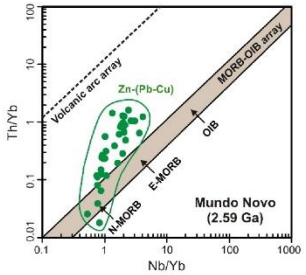
RS - Rio Salitre Greenstone Belt (2.16 Ga, U-Pb, zircon-metarhyolite)

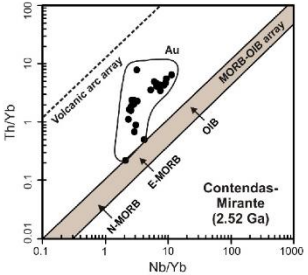
MN - Mundo Novo Greenstone Belt (2.59 Ga, U-Pb, zircon-metadacite)

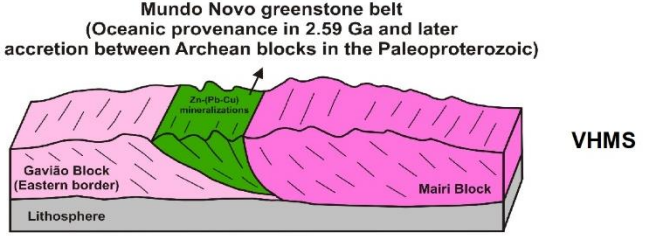
CM - Contendas-Mirante Volcano-Sedimentary Belt (2.52 Ga, Sm-Nd, BIF)

UM - Umburanas Greenstone Belt (2.74 Ga, Pb-Pb, zircon-metaandesite)

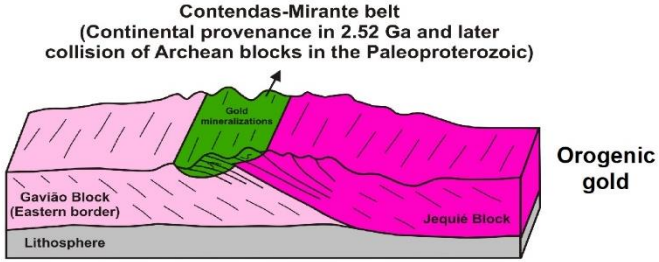
Other symbols: São Francisco Craton; State limits







VHMS



Orogenic gold

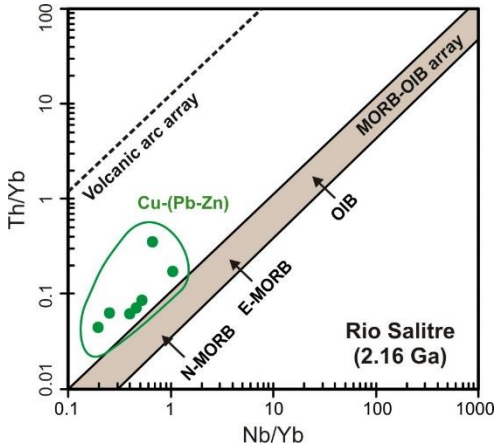
Provenance study based on Th-Nb proxy for metabasalts

4 - Rio Salitre greenstone belt – 2.16 Ga (Gavião Block)

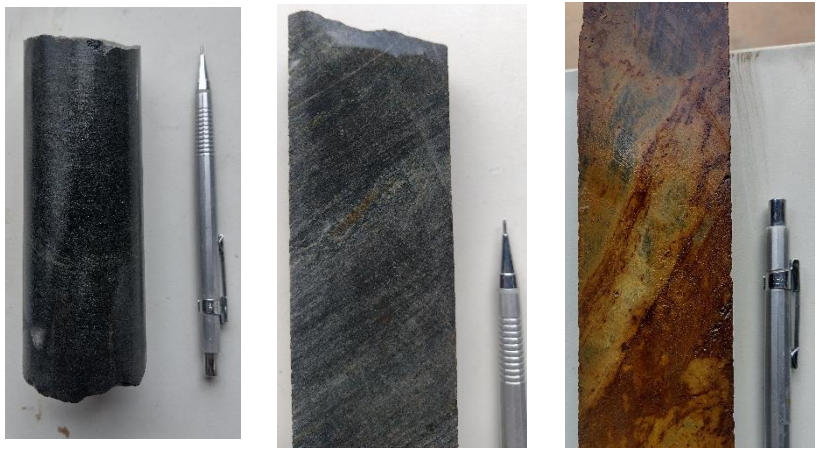
Use of Th-Nb proxies in metabasalts for provenance study (tectonic and metallogenic settings)

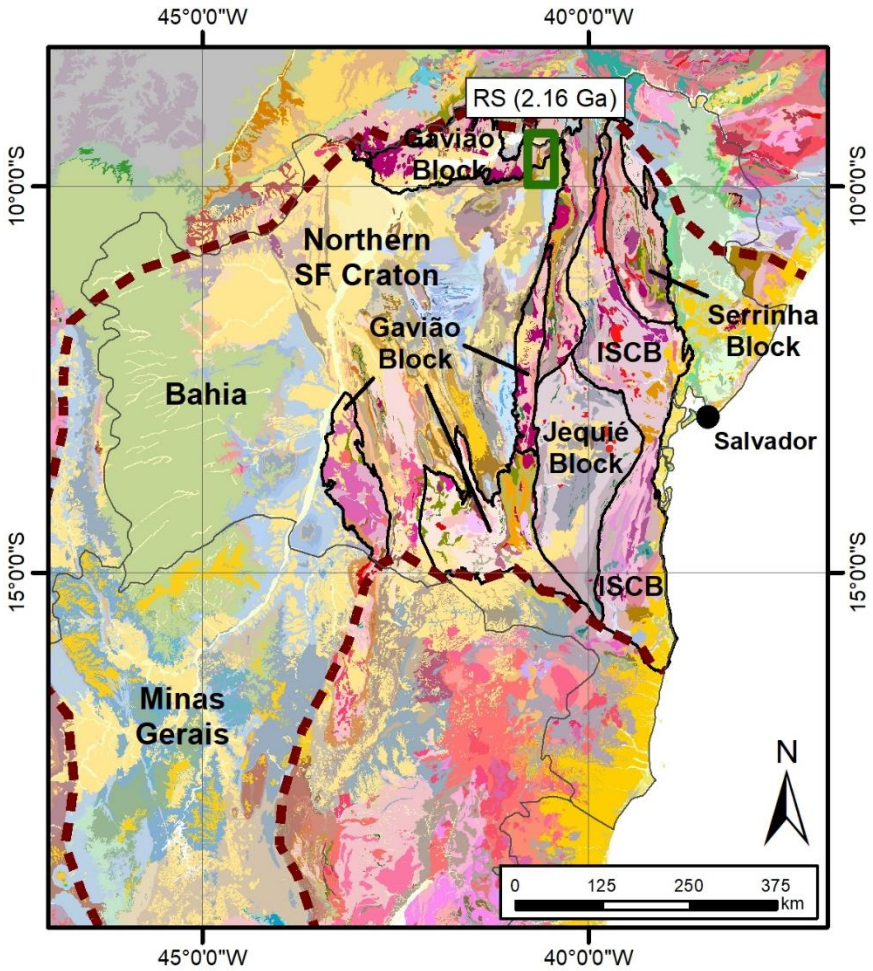
Paleoproterozoic

Th-Nb proxy of metabasalts applied on provenance study



Geochemical data source: Ribeiro (1998)





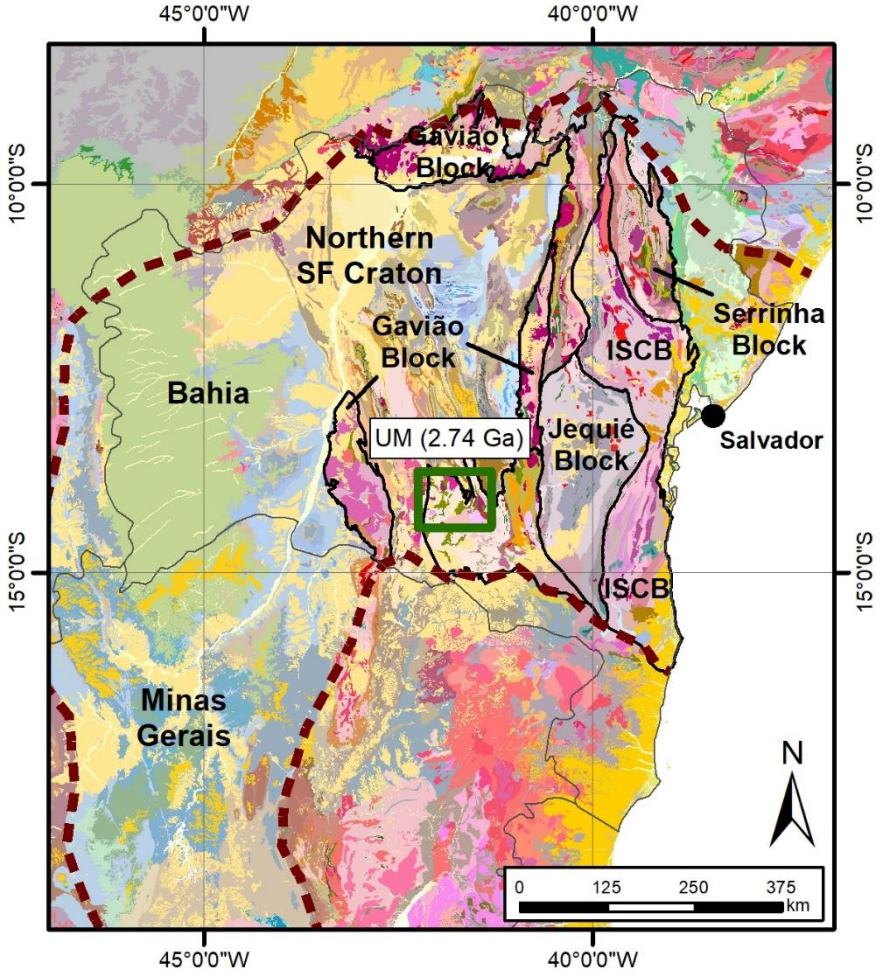
RS - Rio Salitre Greenstone Belt (2.16 Ga, U-Pb, zircon-metarhyolite)

Metabasalt / Detrital metasedimentary rock / Py and Ccp

5 - Umburanas greenstone belt – 2.74 Ga (Gavião Block)

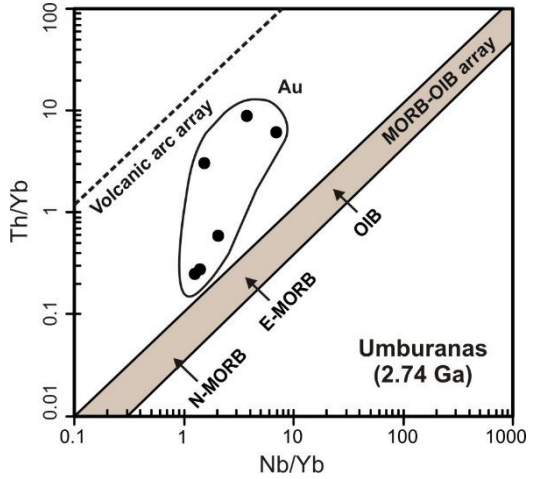
Use of Th-Nb proxies in metabasalts for provenance study (tectonic and metallogenic settings)

Neoarchean



UM - Umburanas Greenstone Belt (2.74 Ga, Pb-Pb, zircon-metaandesite)

Th-Nb proxy of metabasalts applied on provenance study

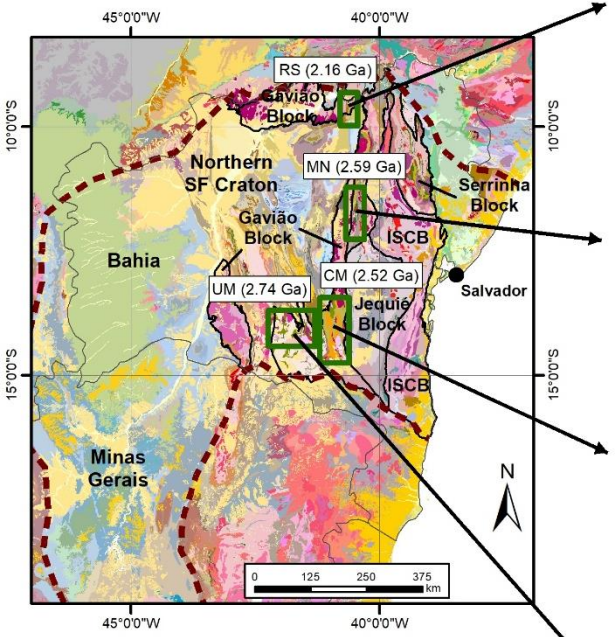


Geochemical data source: Santos (2012)

Ccp, Py and gold disseminated in metapelitic rock

Malachite and gold hosted in brecciated quartz vein

Provenance study based on Th-Nb proxy for metabasalts



Geologic settings from Neoarchean to Paleoproterozoic:

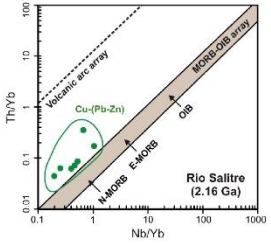
RS - Rio Salitre Greenstone Belt (2.16 Ga, U-Pb, zircon-metarhyolite)

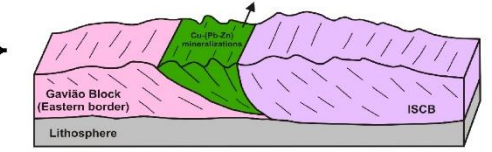
MN - Mundo Novo Greenstone Belt (2.59 Ga, U-Pb, zircon-metadacite)

CM - Contendas-Mirante Volcano-Sedimentary Belt (2.52 Ga, Sm-Nd, BIF)

UM - Umburanas Greenstone Belt (2.74 Ga, Pb-Pb, zircon-metaandesite)

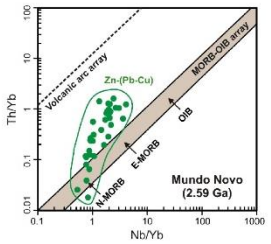
Other symbols: São Francisco Craton; State limits

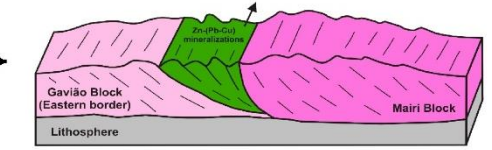




Rio Salitre greenstone belt
(Oceanic provenance in 2.16 Ga and later accretion between Archean blocks in the Paleoproterozoic)

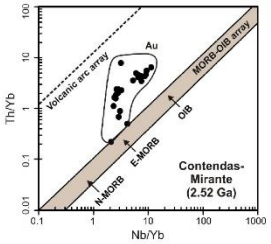
VMS

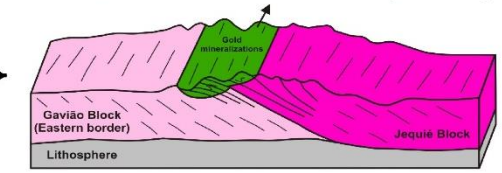




Mundo Novo greenstone belt
(Oceanic provenance in 2.59 Ga and later accretion between Archean blocks in the Paleoproterozoic)

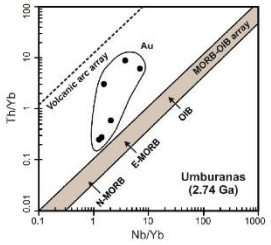
VHMS

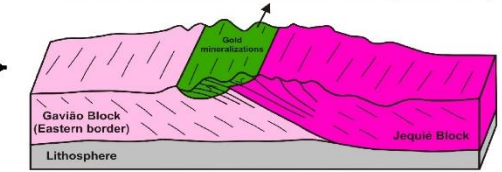




Contendas-Mirante belt
(Continental provenance in 2.52 Ga and later collision of Archean blocks in the Paleoproterozoic)

Orogenic gold





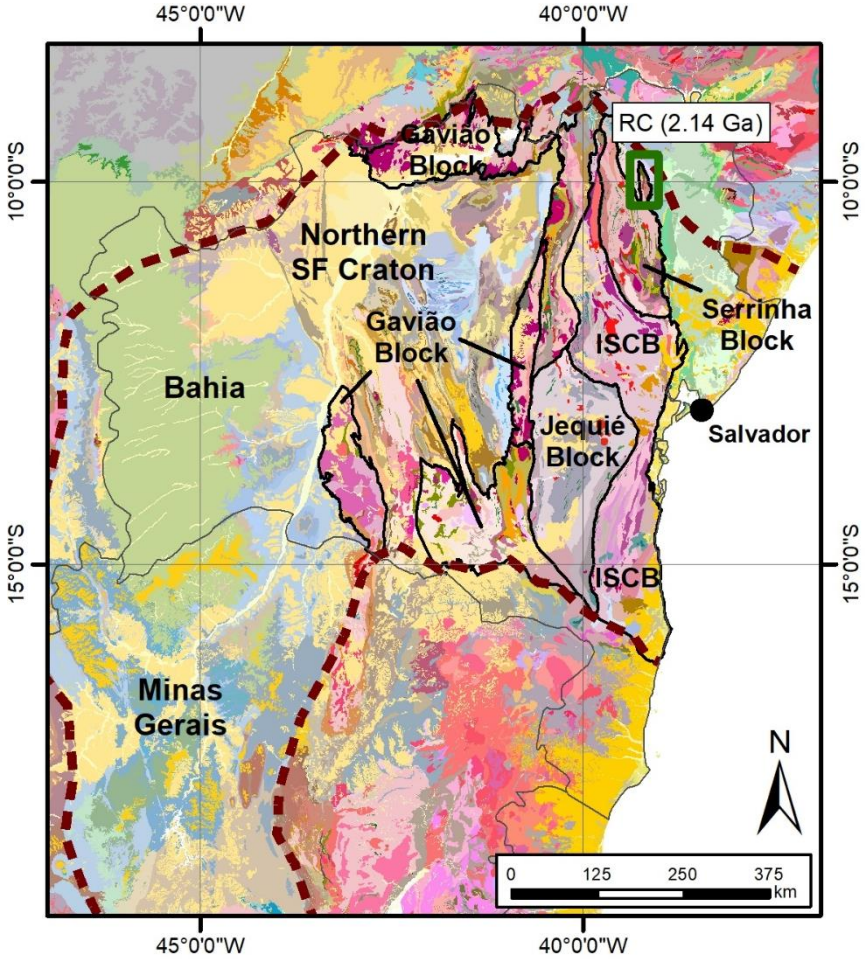
Umburanas greenstone belt
(Continental provenance in 2.74 Ga and later collision of Archean blocks in the Paleoproterozoic)

Orogenic gold

6 - Rio Capim greenstone belt – 2.14 Ga (Serrinha Block)

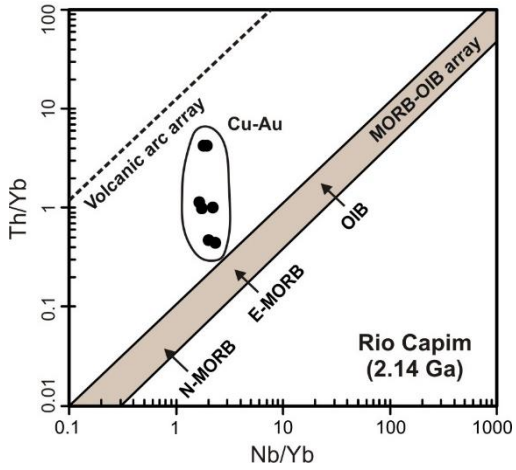
Use of Th-Nb proxies in metabasalts for provenance study (tectonic and metallogenic settings)

Paleoproterozoic

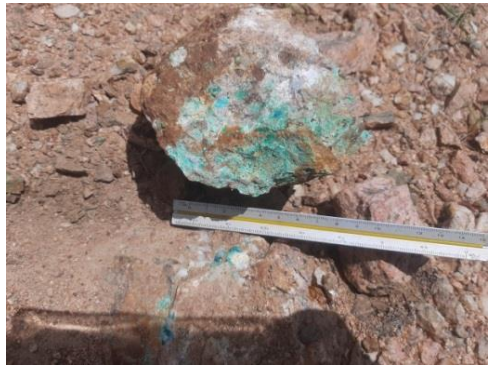


RC - Rio Capim Greenstone Belt (2.14 Ga, U-Pb, zircon-metadacite)

Th-Nb proxy of metabasalts applied on provenance study



Geochemical data source: Oliveira et al. (2010)

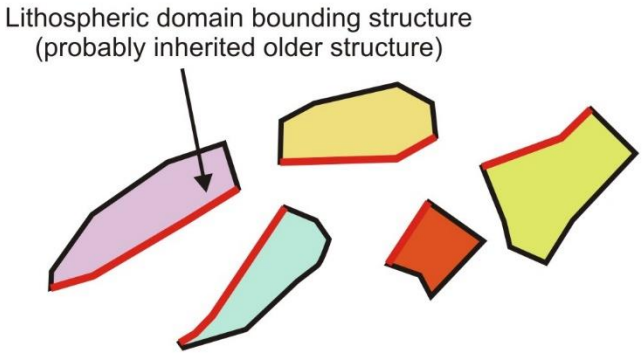


Malachite and traces of gold hosted in metatonalite

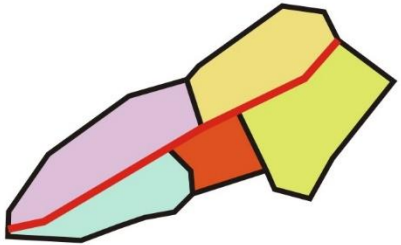
Epidote and potash alteration in metatonalite

Integrated tectonic, metallogenic and exploration overview in the northern São Francisco craton

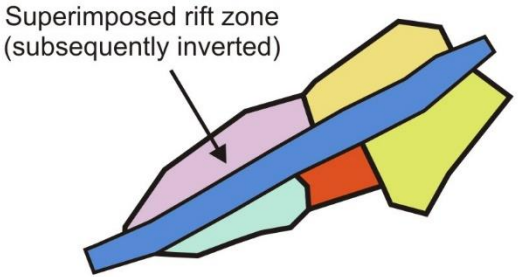
Simple model for the formation of a continental-scale lineament



Stage 1: Lithospheric domains bounded by translithospheric structures, within an evolving accretionary orogen

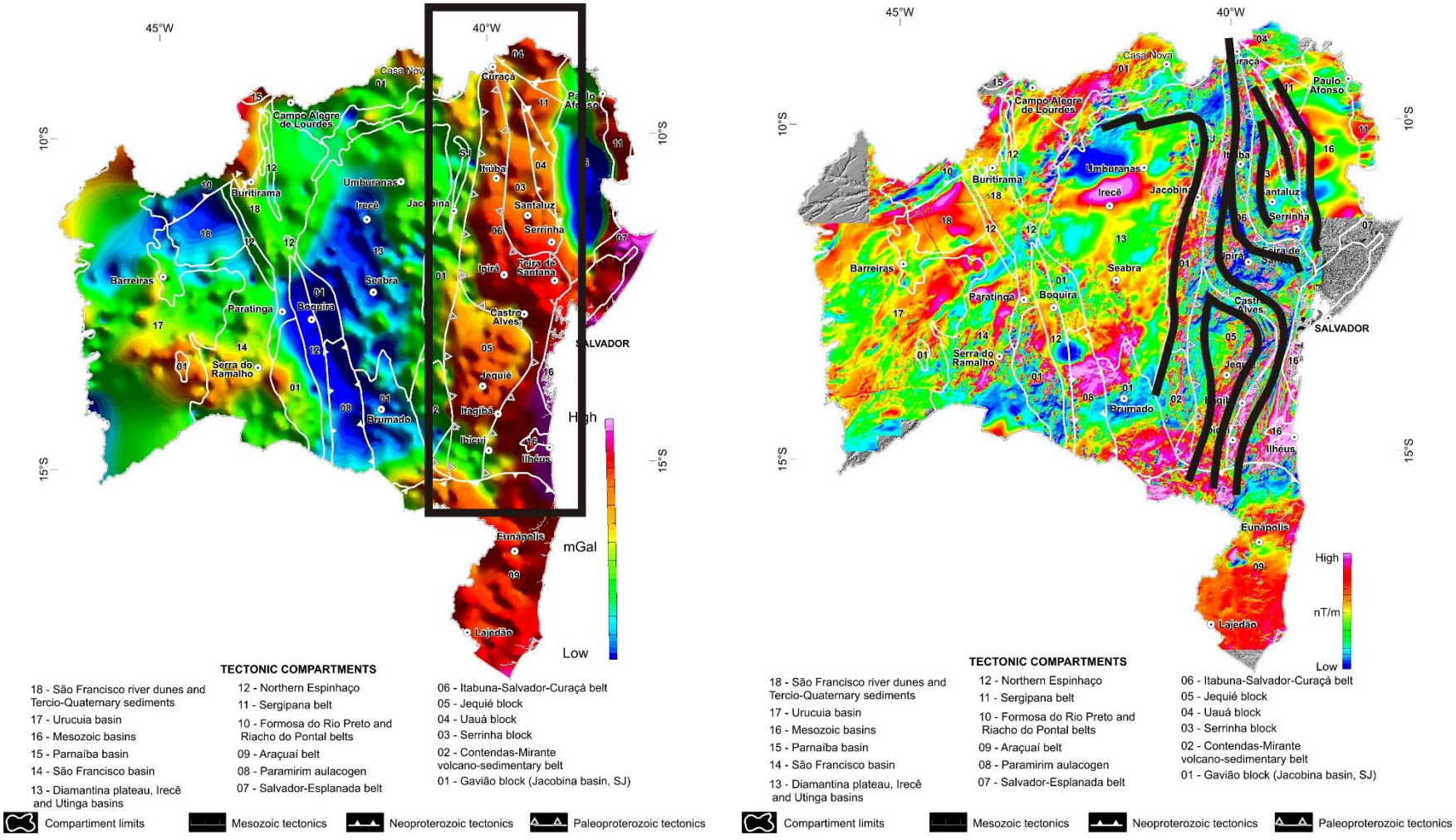


Stage 2: Alignment and organisation of lithospheric domain boundaries during termination of accretionary orogen and continental assembly



Stage 3: Reactivation of lineament by rifting and subsequent inversion. In some cases rifting may produce an ocean that closes in the same position

(Source: Hronsky, 2013)



Bouguer and Total Magnetic Field images from Silva and Sampaio (2017)

Concluding remarks

- **The Paleoproterozoic regional lineaments, developed between Archean blocks, play an important role as regional scale controls for base (for example, the VHMS type) and precious (for example, the orogenic gold type) metals in the northern São Francisco craton for hosting potential Neoarchean to Paleoproterozoic volcanic belts;**
- **The detailed study of metallogenic settings, such as that performed for the Mundo Novo and Contendas-Mirante belts, was relevant to create the first correlations among cratonic, regional and local scales geologic features;**
- **In this sense, the continental or oceanic provenance study showed consistency with regard to the exploration results and was able to improve regional exploration programs. In addition, this study seems to be effective to indicate both tectonic and metallogenic settings as well as exploration guides, such as suggested for the Rio Salitre, Umburanas and Rio Capim greenstone belts;**
- **We consider this study in the northern São Francisco craton as also being applied in other similar settings, both in already known mineralized areas or in still unexplored domains as well.**

Thank you!

#SIMEXMIN2022

Ricardo Ramos Spreafico (ricardo.spreafico@cbpm.ba.gov.br)
Companhia Baiana de Pesquisa Mineral - CBPM