Magmatic and structural evolution of the Peruvian lithosphere: Implications for favourable sites for gold-rich mineral systems through time

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Huaguruncho, 5723 m
Huachon Gold prospect area
Eastern Cordillera, Central Peru

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Wiemer/Hagemann

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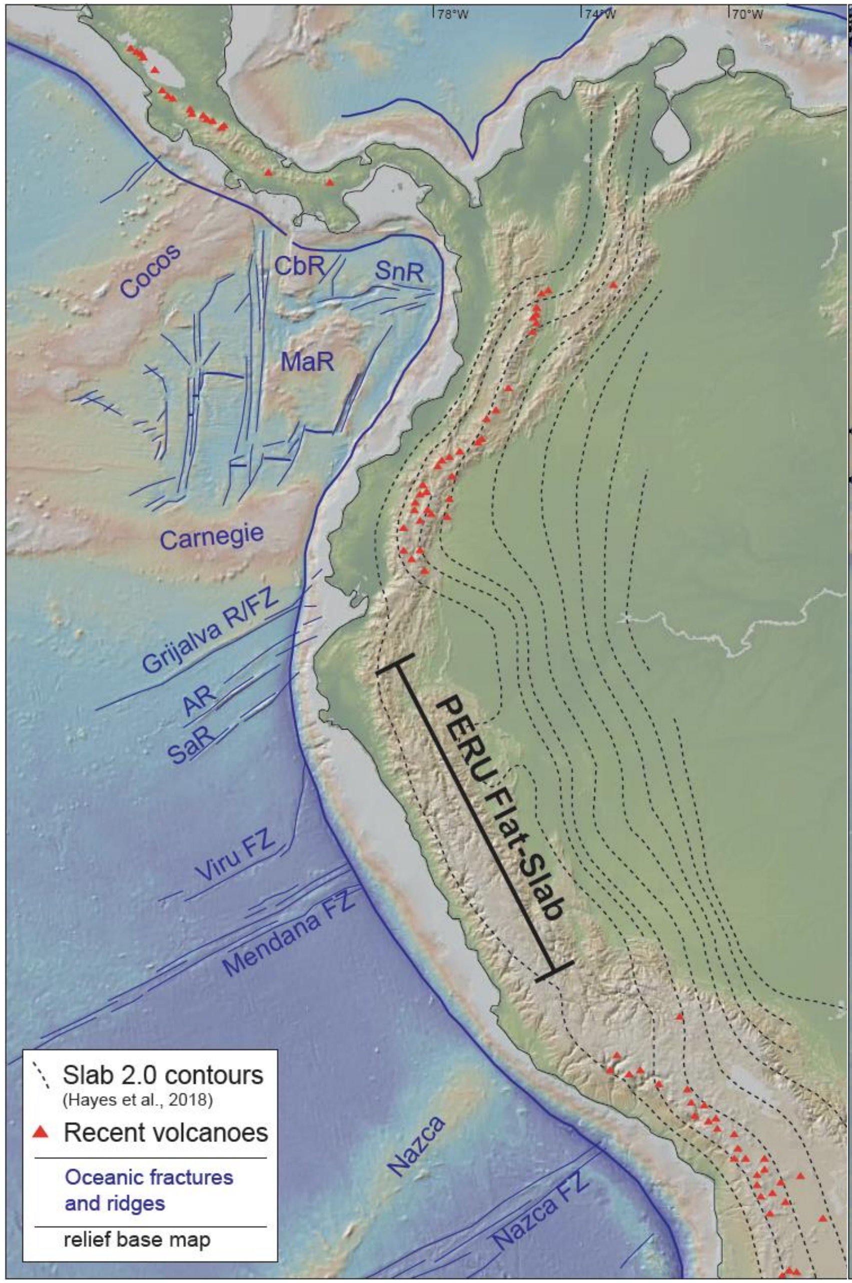
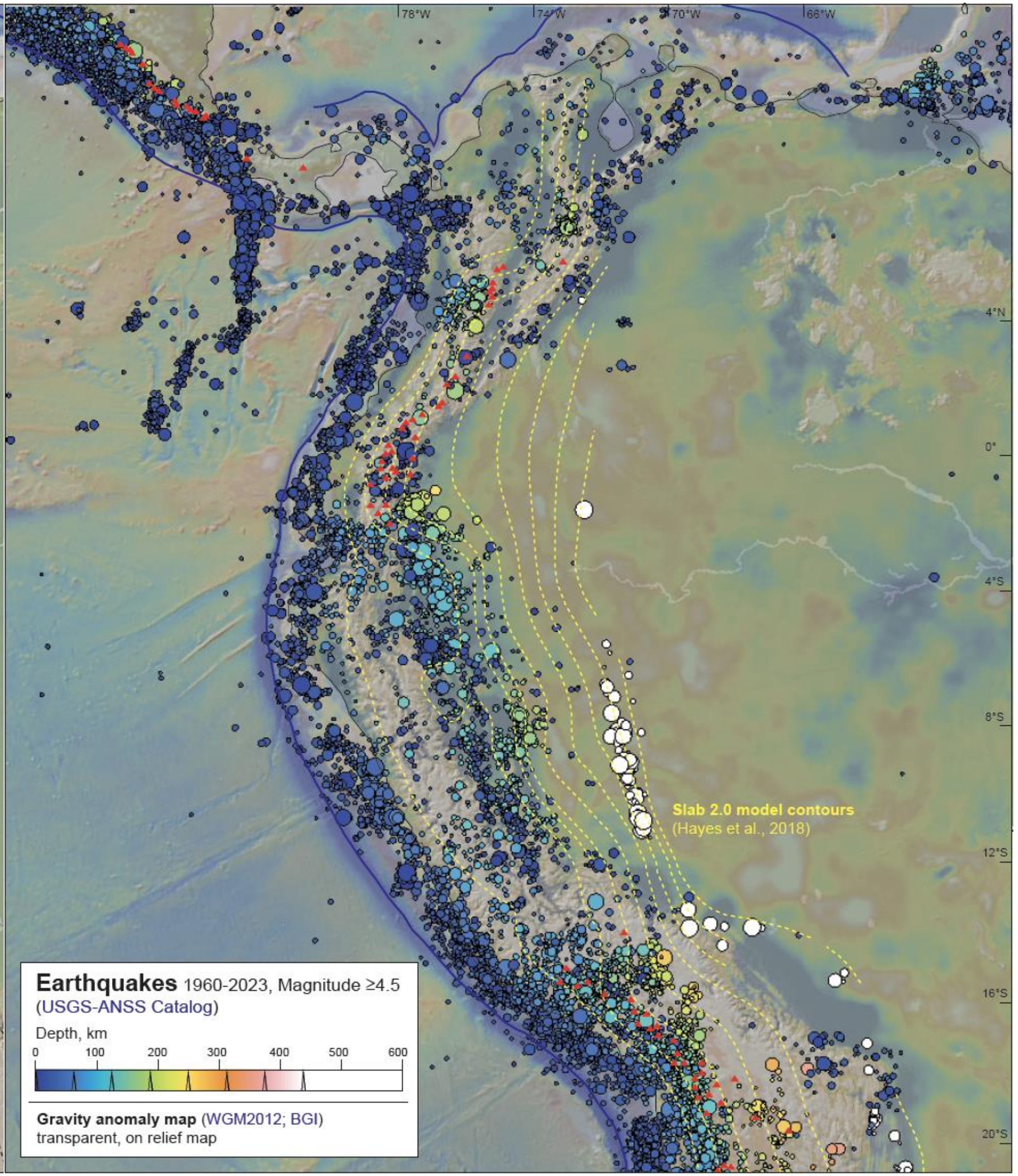
Present-Day – *Andean slab geometry*





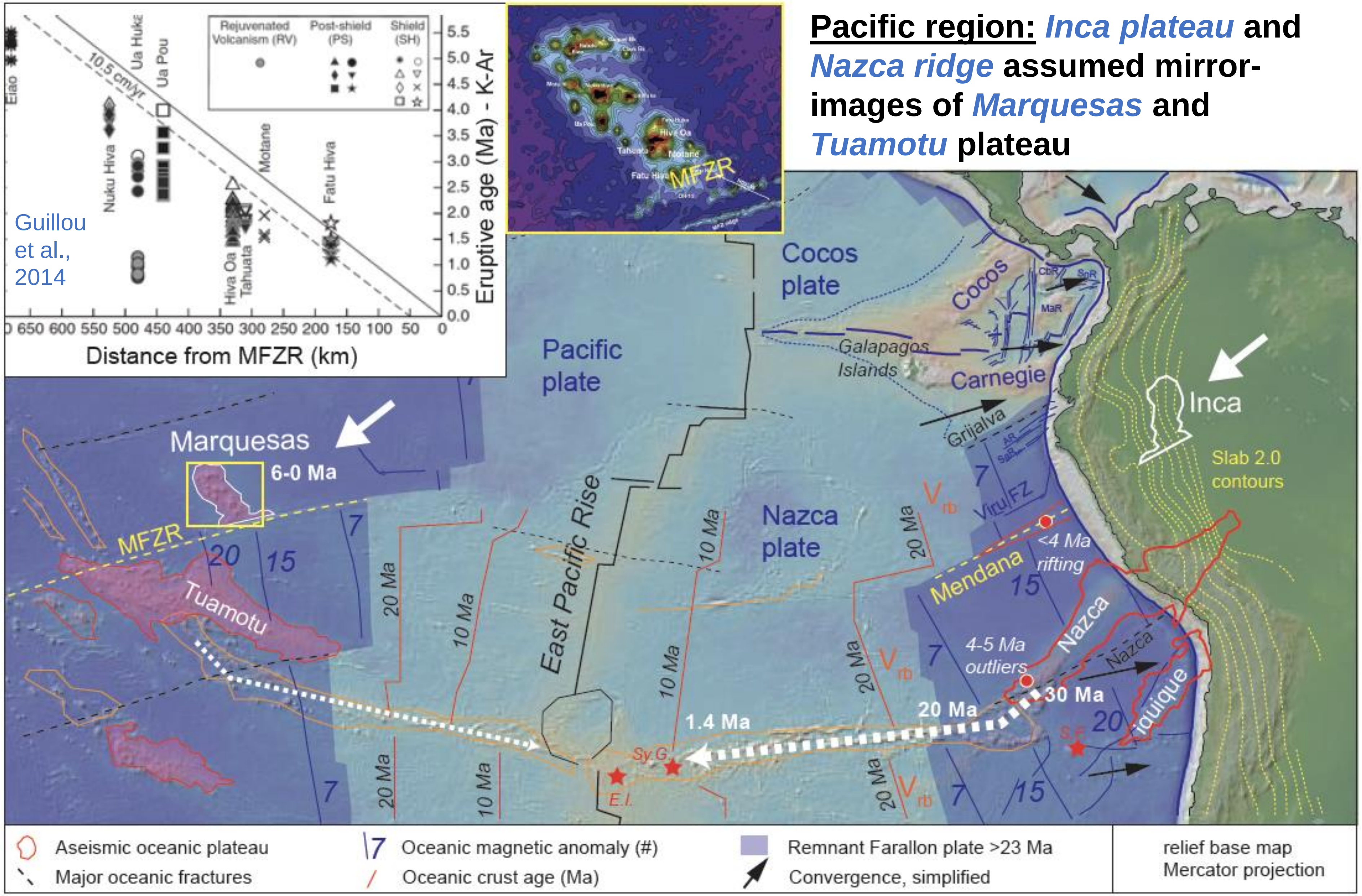
Peru Flat-Slab

- **Gap in recent volcanic activity**
- **Most pronounced between 80-120 km depth** (i.e., lithospheric mantle?)

Observation:

- **Slab 2.0 model = "smooth"**
- **Some anomalous EQ loci transect at perpendicular or oblique strike directions**

Previous model for Peru flat-slab - *Deconstructing the Myth of the Inca Plateau*



Pacific region: ***Inca plateau*** **and** ***Nazca ridge*** **assumed mirror-images of** ***Marquesas*** **and** ***Tuamotu*** **plateau**

Wiemer, compiled from: Gutscher et al., 1999; Hampel, 2002; Lonsdale, 2005; Rosenbaum et al., 2005; Ray et al., 2012; Hochmuth & Gohl, 2017

Problems:

1) Marquesas plateau

- Younger (<6 Ma)
- Inconsistent spatial age trend (e.g., Guillou et al., 2014)
- Formation associated with pre-existing 'leaky fracture zone' (e.g., Smith, 2003)

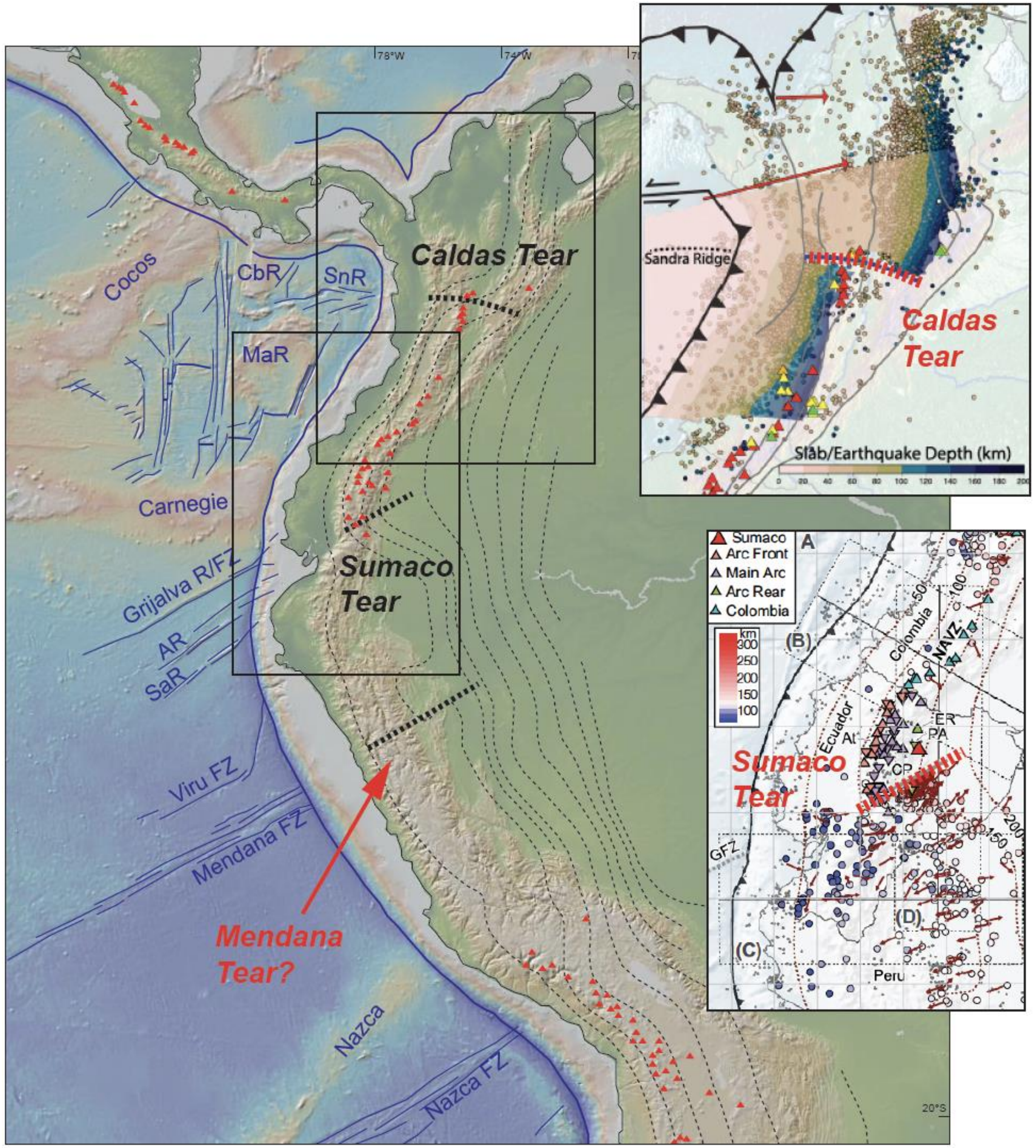
2) General consideration

- Size/buoyancy not sufficient for flat-slab development; better explained by wedge dynamics, viscosity, water, or rapid convergence (e.g., Cross & Pilger, 1982; Skinner & Clayton, 2011)

→ No Inca Plateau

How to explain the Peru flat slab?

Slab segmentation – Slab tear



Caldas Tear

- ➢ **accommodates slab steepening and new arc** (Vargas & Mann, 2013; Wagner et al., 2017)

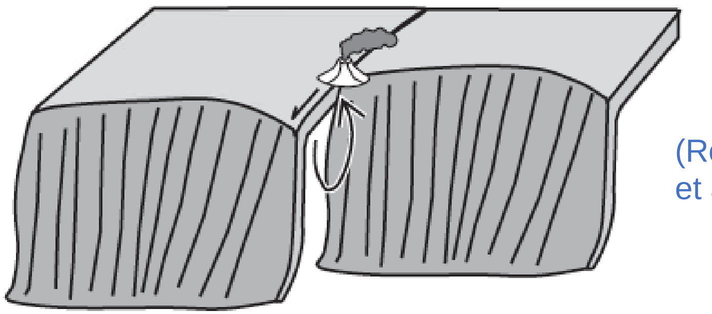
Sumaco Tear

- ➢ **trapdoor style slab tearing** (Rosenbaum et al., 2018)

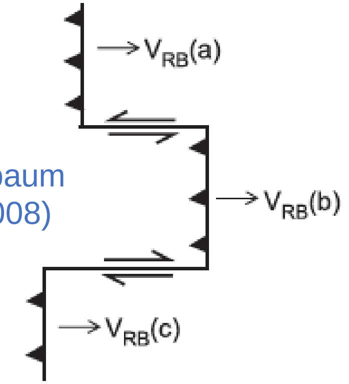
Flat-slab segments:

- **Rapid convergence**
- **Increased rollback velocity**
- **Young low-density oceanic crust**
- **Sites of deflection; shape of continent or incoming indenter**

→ Promoted by pre-existing architecture/lithosphere anisotropy



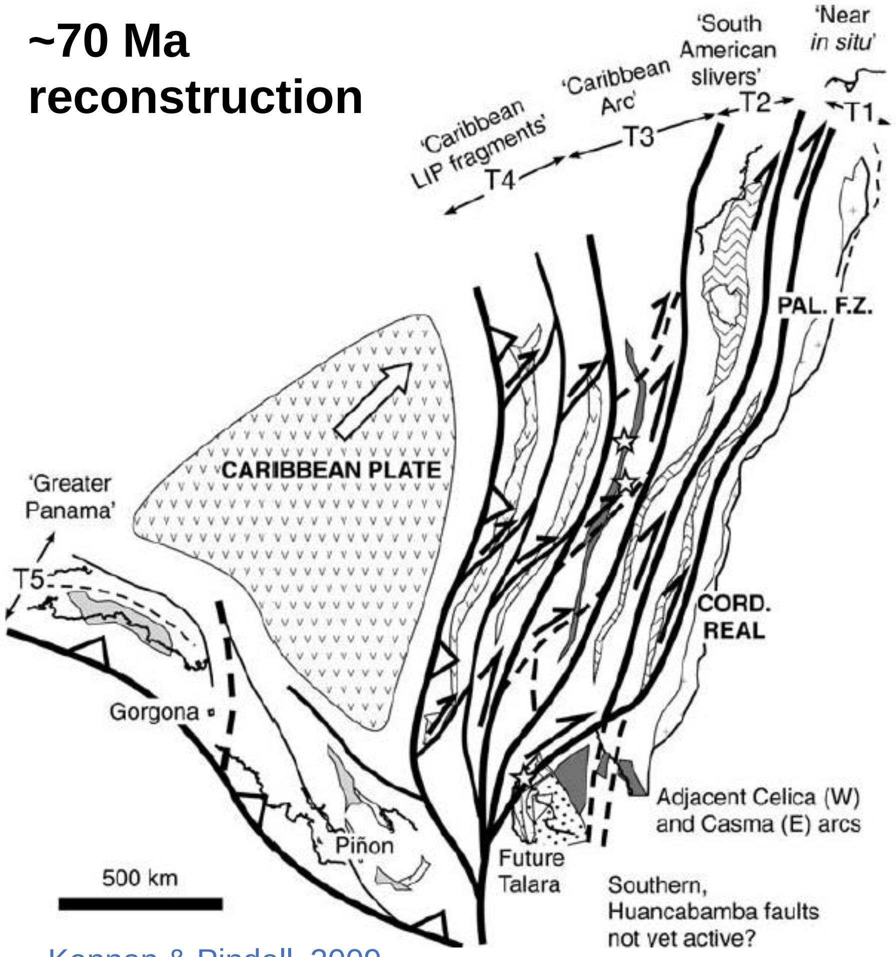
(Rosenbaum et al., 2008)



North Andes Escape Tectonics

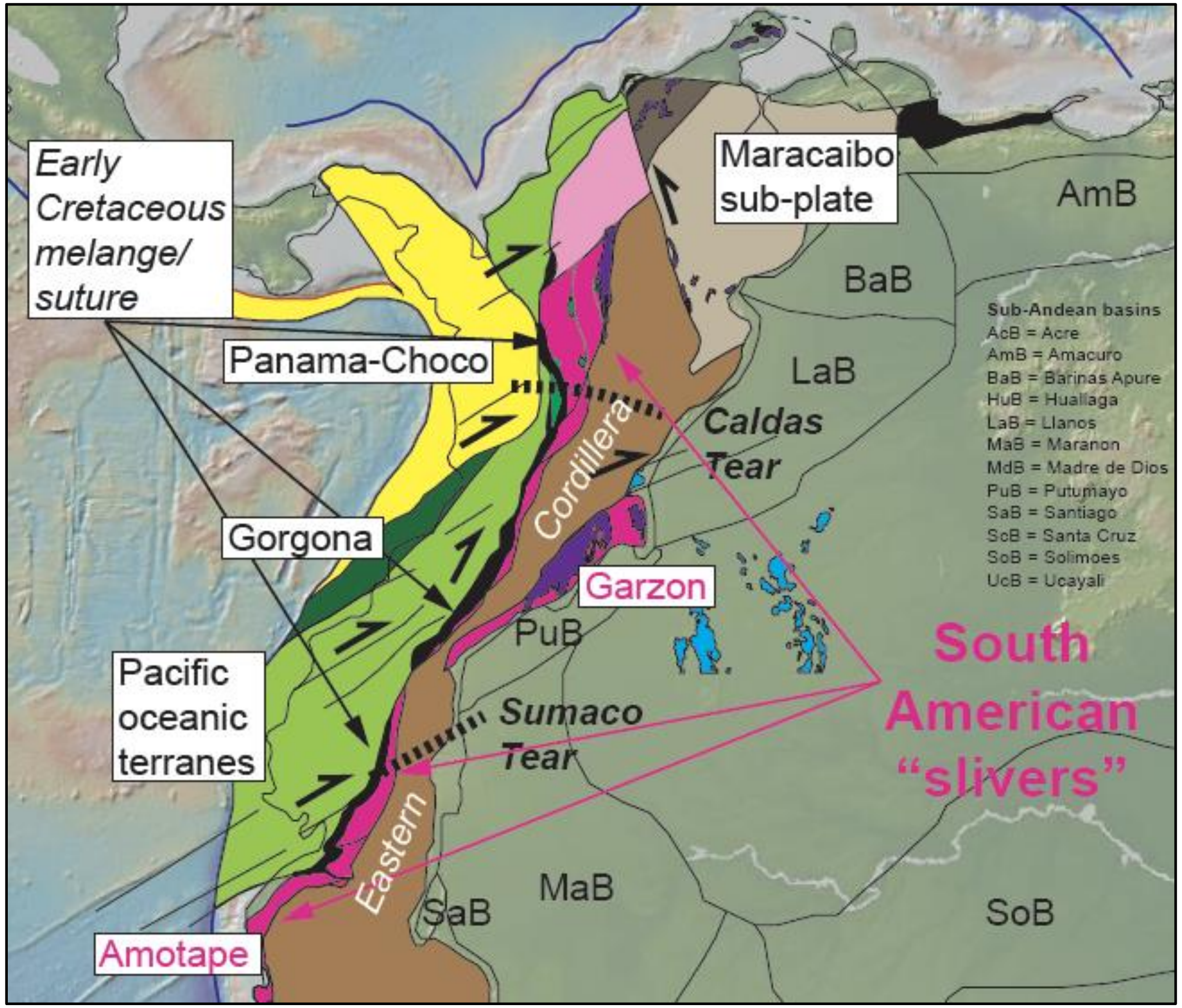
→ **NW-margin of South American continental/cratonic nucleus acts as "rigid indenter"**
→ **Increased velocity "escape" tectonics**
→ **Major dextral displacements along structural corridors that align with sub-Andean basin boundaries**

~70 Ma reconstruction



Kennan & Pindell, 2009

modified from: Cediel et al., 2003; review in Wiemer et al., 2023



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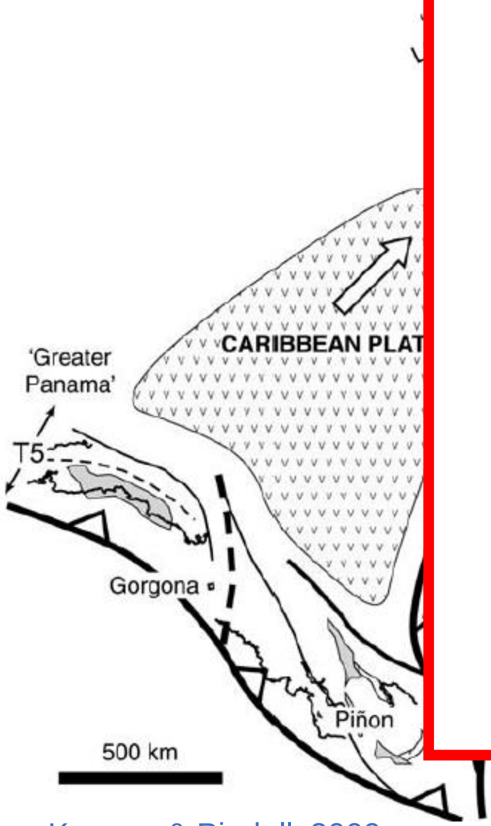


Kennan & Pindell, 2009

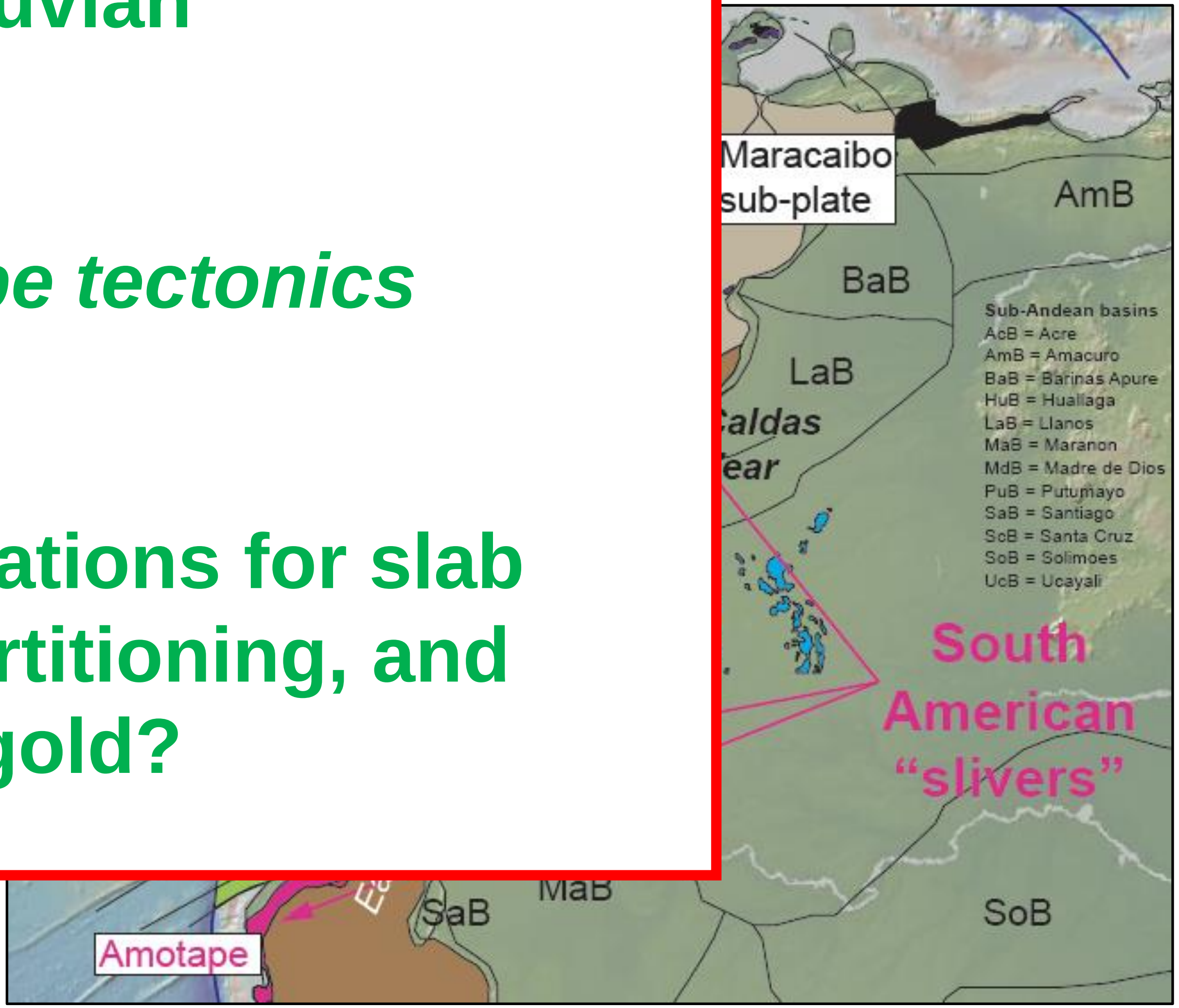
What about the Peruvian lithosphere?

When did the *escape tectonics* initiate?

What are the implications for slab geometry, strain partitioning, and favorable sites for gold?

Huancabamba faults not yet active?

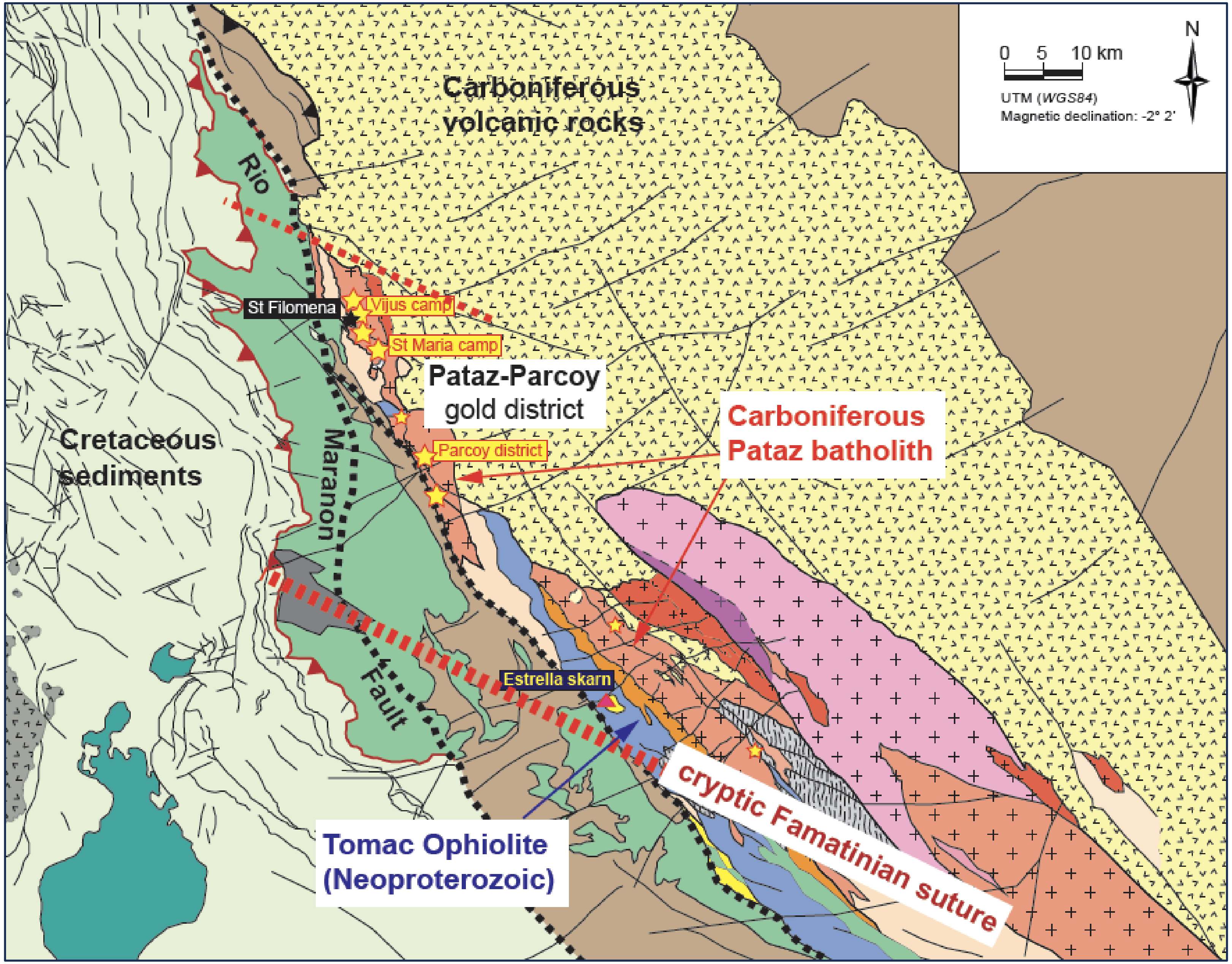
2003; review in Wiemer et al., 2023



Northern Peru – Carboniferous Pataz Gold Region

- **Pre-Carboniferous basement inheritance, controlling gold vein system geometry within dilational jog**
- **Hanging-wall of cryptic Famatinian suture**

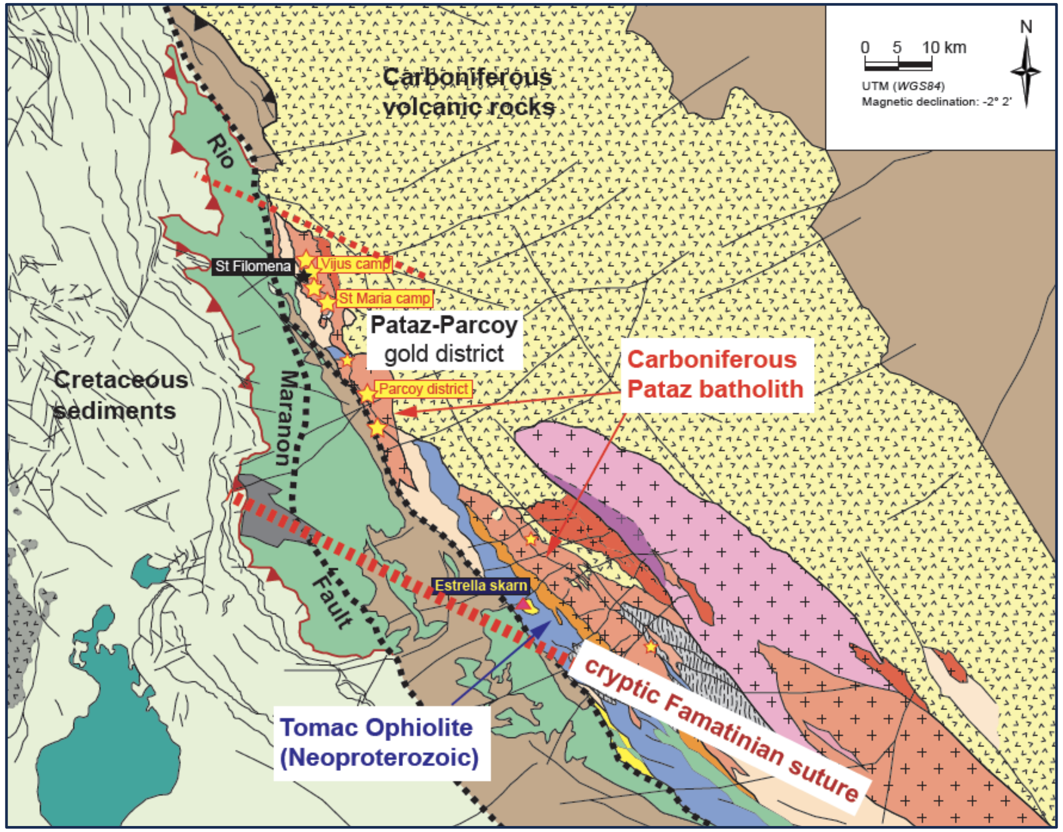
Wiemer et al., 2021; 2022

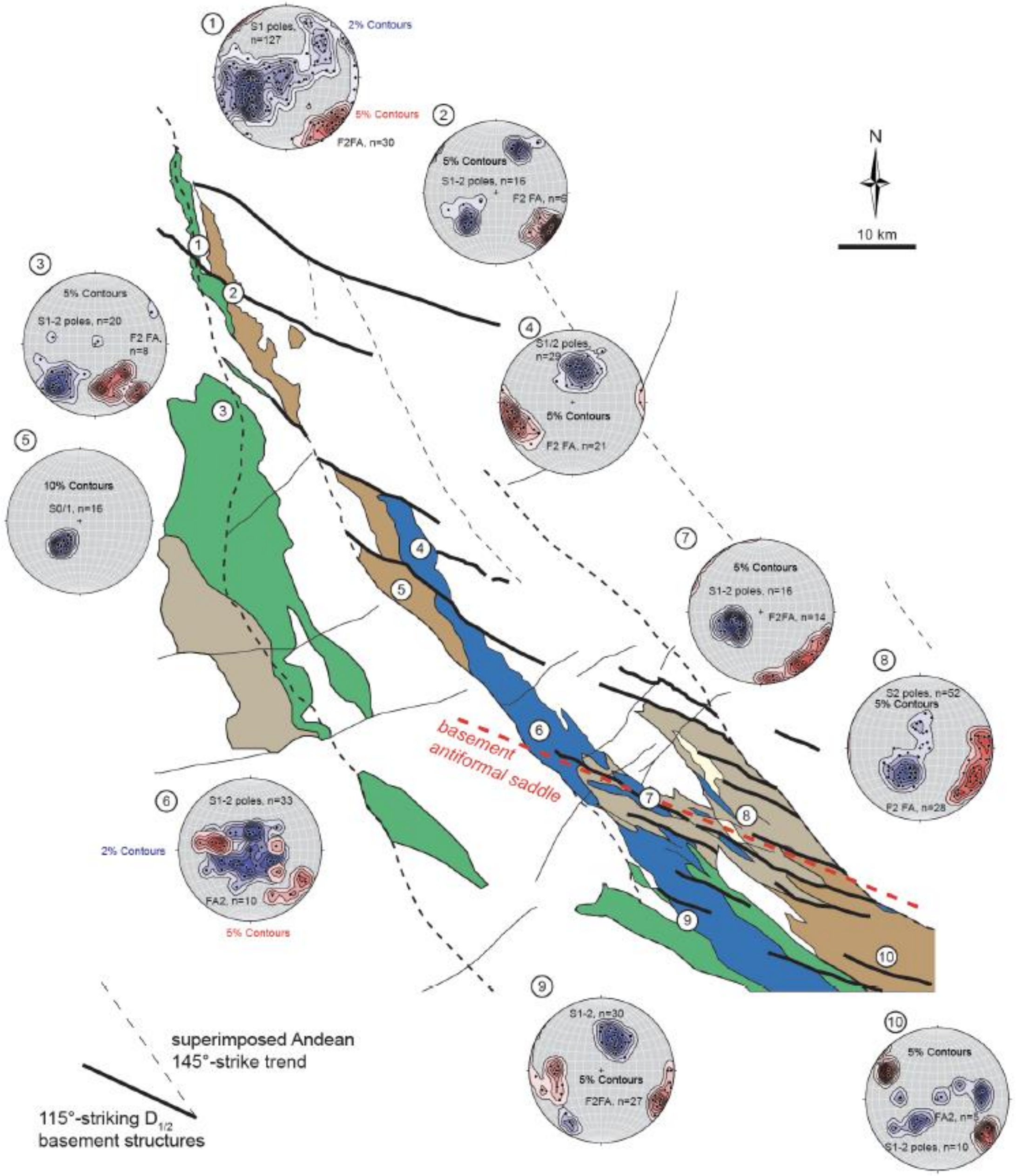


Northern Peru – Carboniferous Pataz Gold Region

NW strike direction of basement structural grain, parallel to proposed suture; oblique to superimposed NNW - “Andean” strike direction

Wiemer et al., 2021; 2022

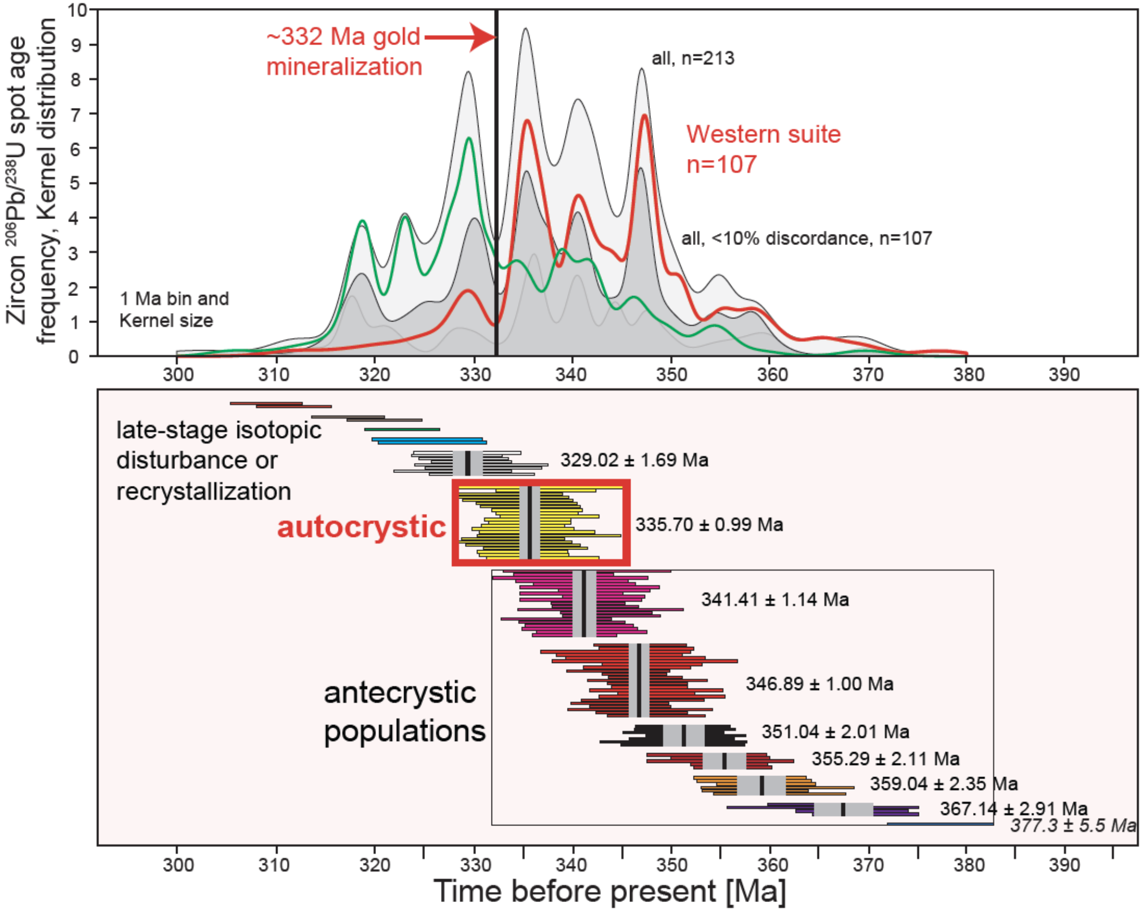




Northern Peru – Geochronology

Pataz batholith

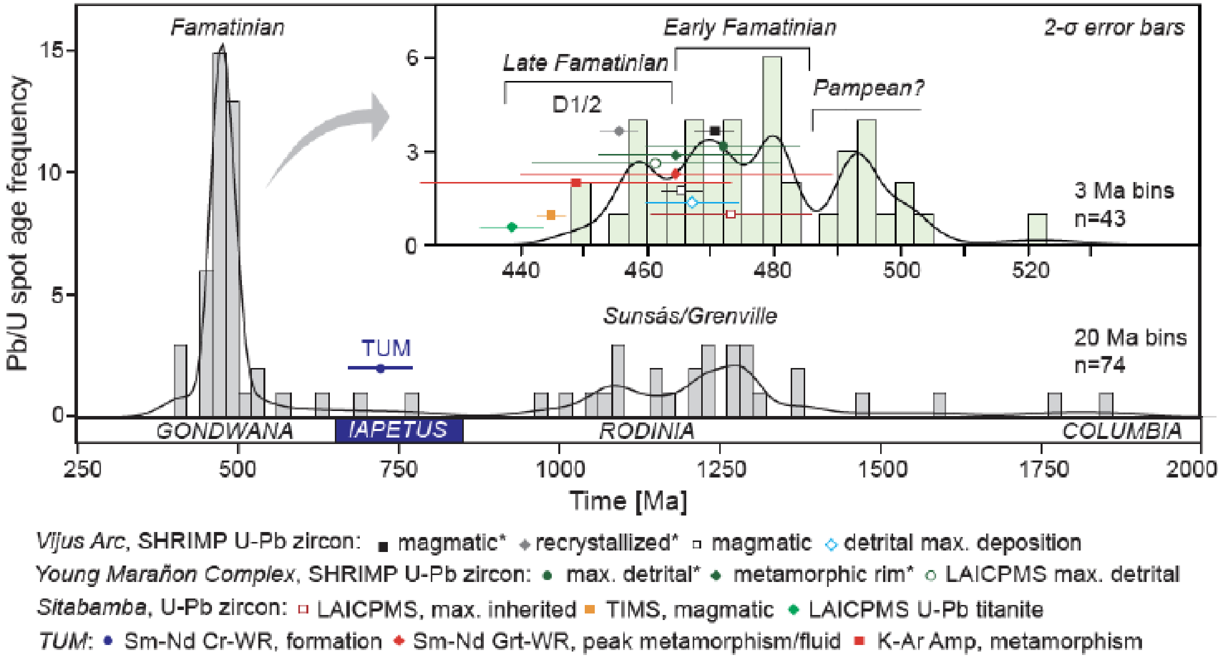
Wiemer et al., 2022; 2023



>370 to 310 Ma magmatic arc

Gold vein system formation at 332 Ma during tectonic switch

Basement



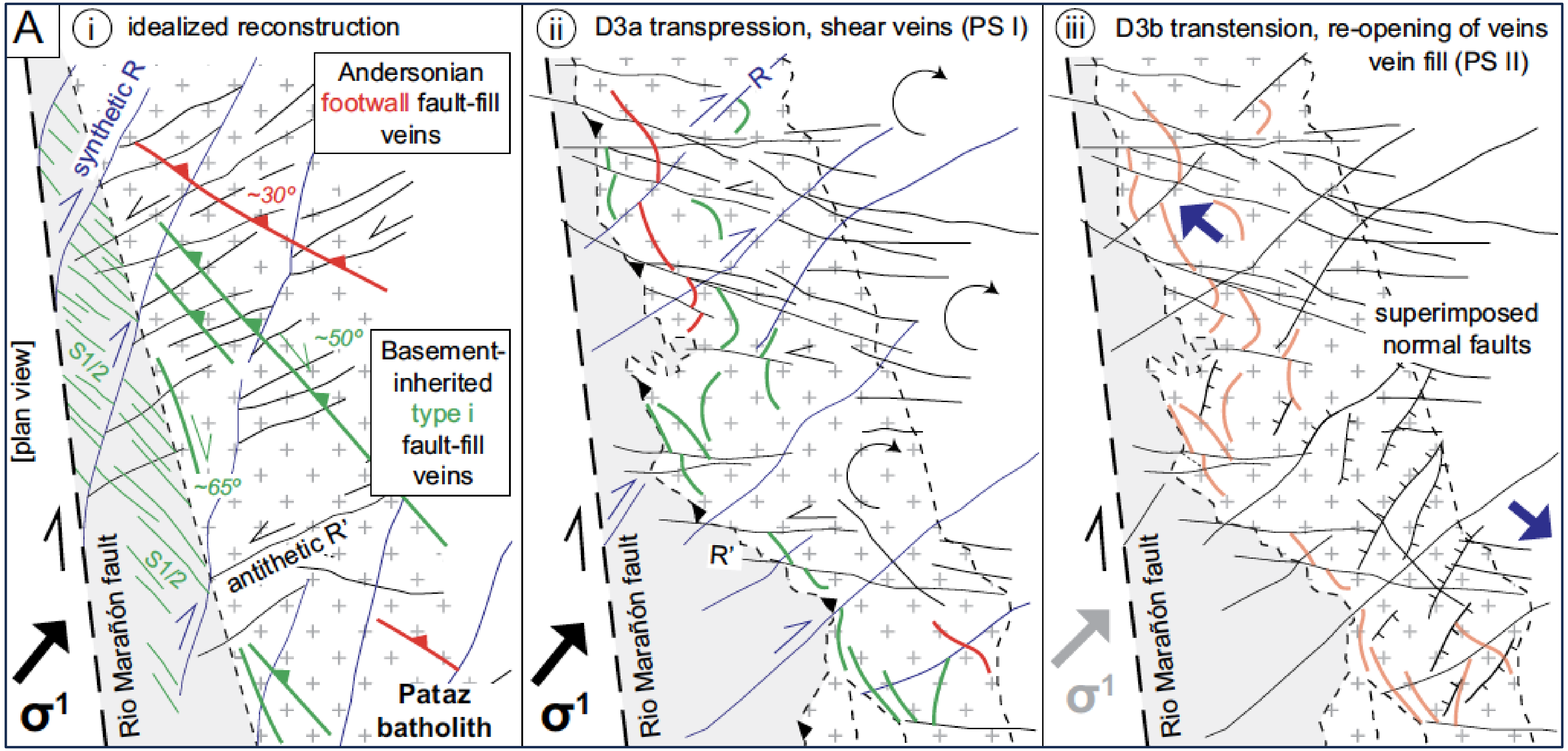
Neoproterozoic Tomac Ophiolite
~460 Ma max deposition of marine sediments
~480-460 Ma arc magmatism
450-440 Ma metamorphism and D2 deformation
→ M/HP – HT collisional paired metamorphic belt
→ Accretion of Paracas micro-terrane

Northern Peru – Carboniferous Pataz Gold Region

Wiemer et al., 2022; 2023

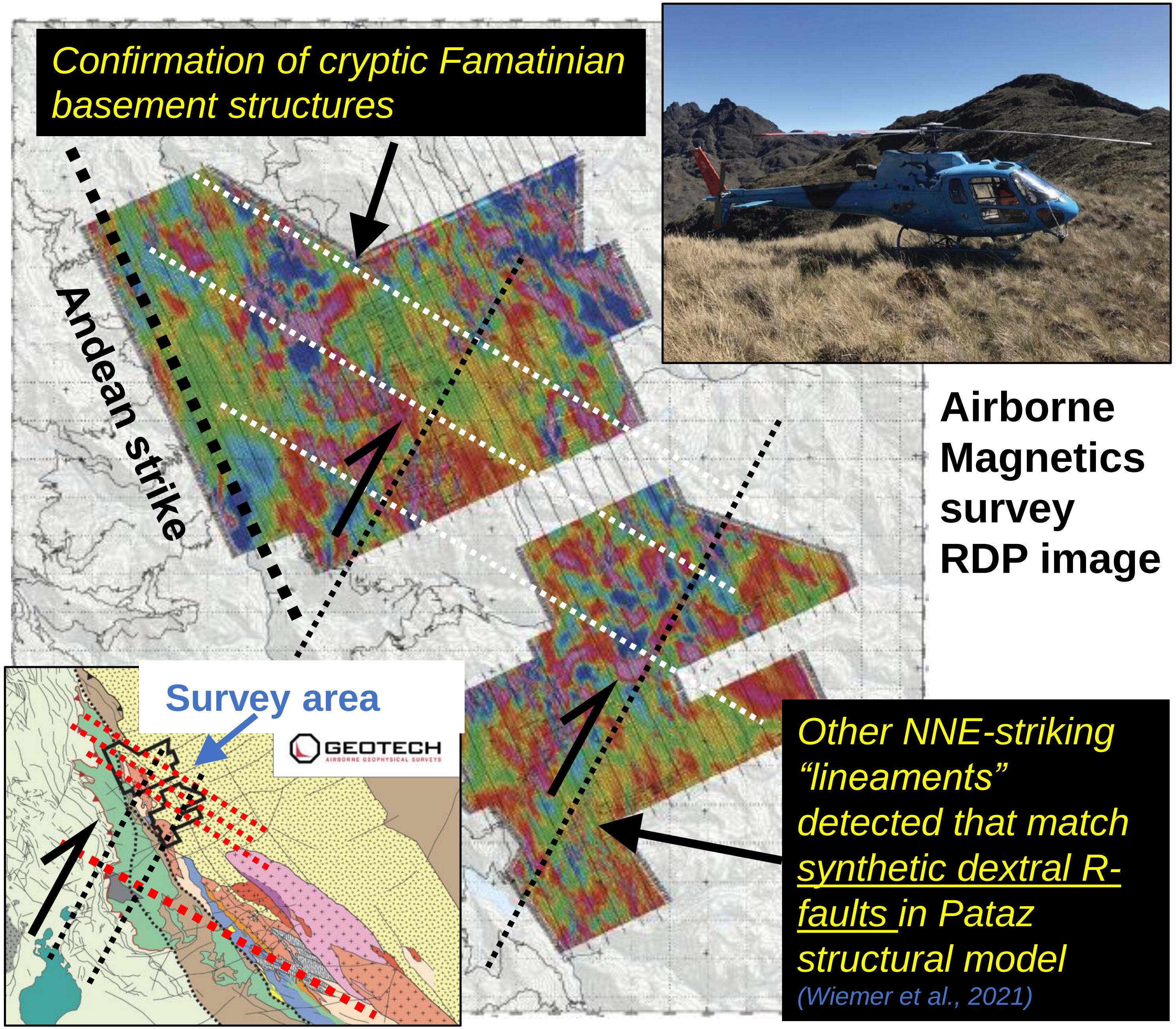
→ **2-stage vein system development during tectonic switch from transpression to transtension at ca. 332 Ma**

→ **Strike-slip control; block (and vein) rotations**



Northern Peru – Carboniferous Pataz Gold Region

Confirmation of cryptic Famatinian basement structures



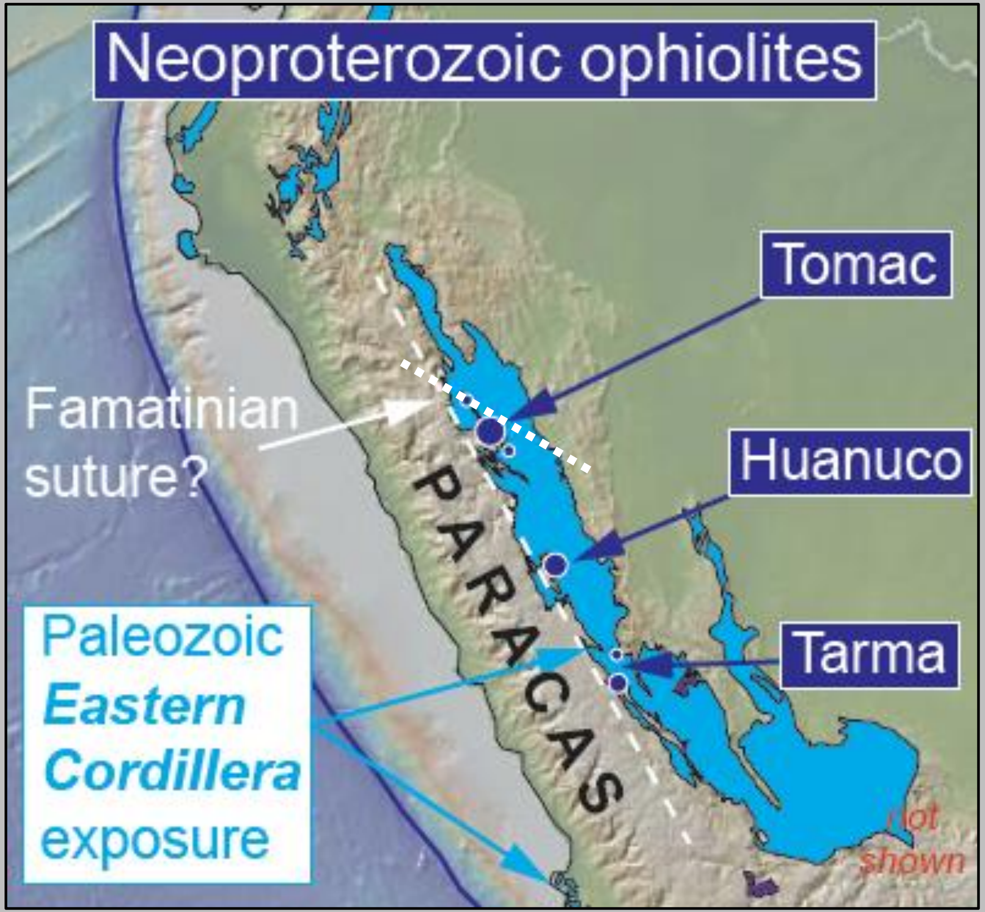
Airborne Magnetics survey RDP image

Other NNE-striking "lineaments" detected that match *<u>synthetic dextral R-faults</u> in Pataz structural model*

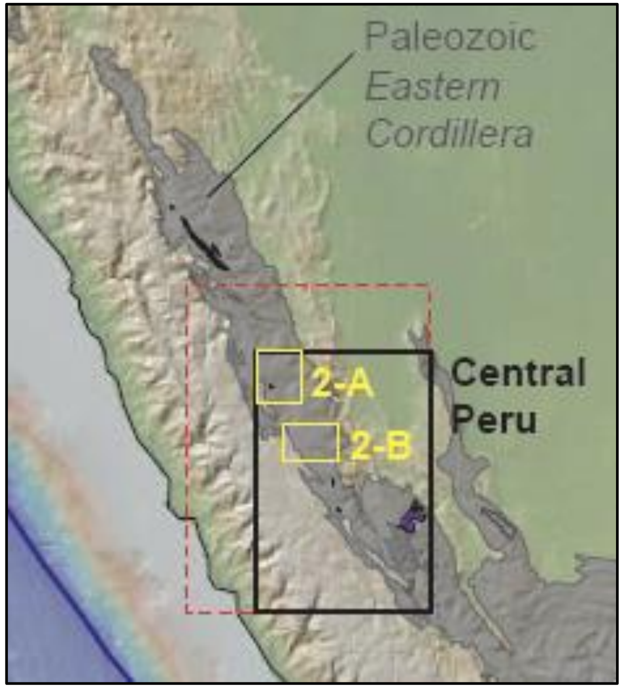
(Wiemer et al., 2021)

→ Why the oblique strike direction?

Other Neoproterozoic ophiolites appear to align with the *Tomac Ophiolite* along the common NNE-Andean strike direction → Famatinian suture?



Central Peru

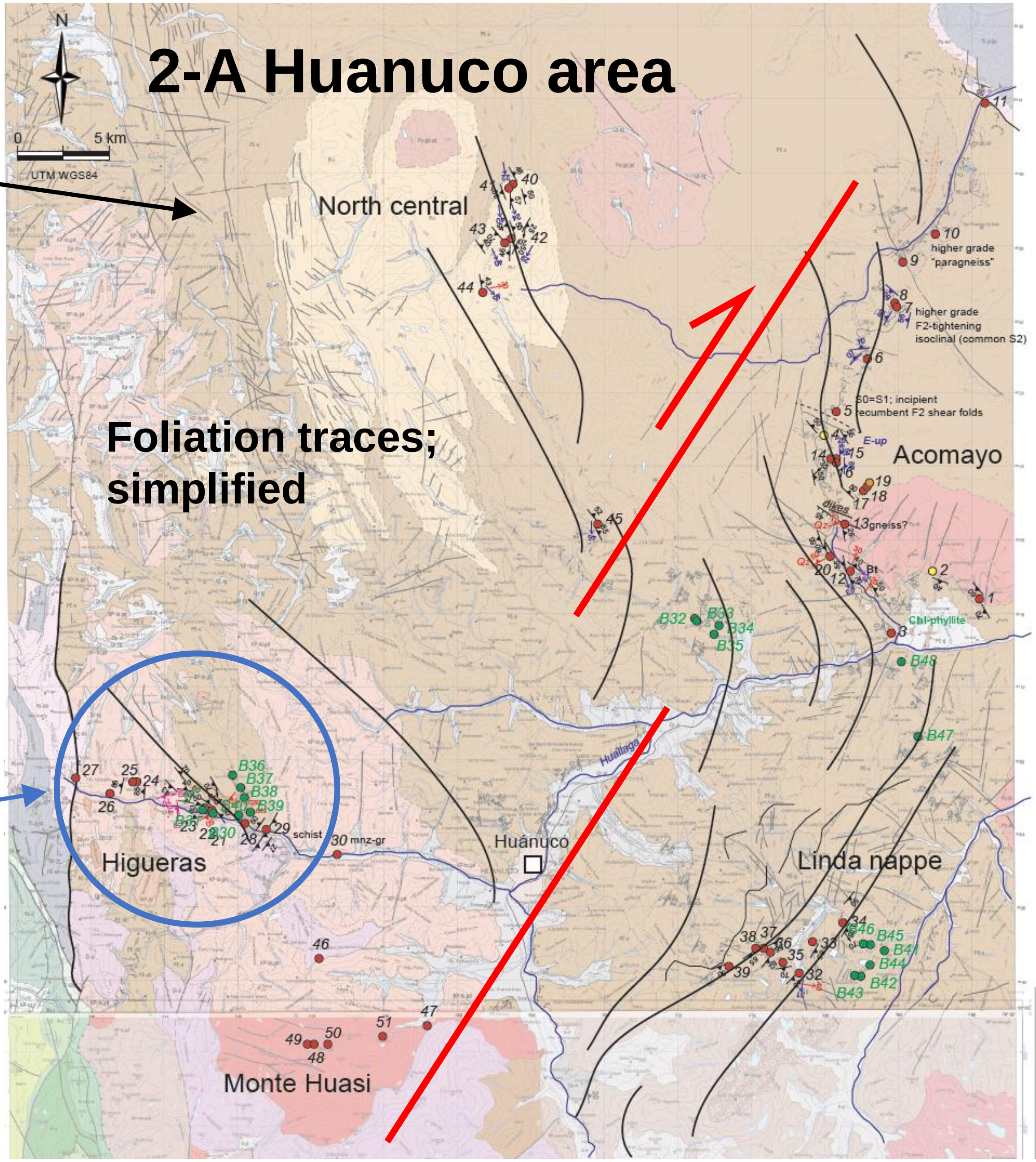


marine metasediments

Dextral synthetic R faults/shear zones cause regional-scale drag folds within basement (up to 90 degree rotation; <u>similar to Pataz basement</u>)

Huanuco Ophiolite metaperidotite-serpentinite melange

Note: map still in development



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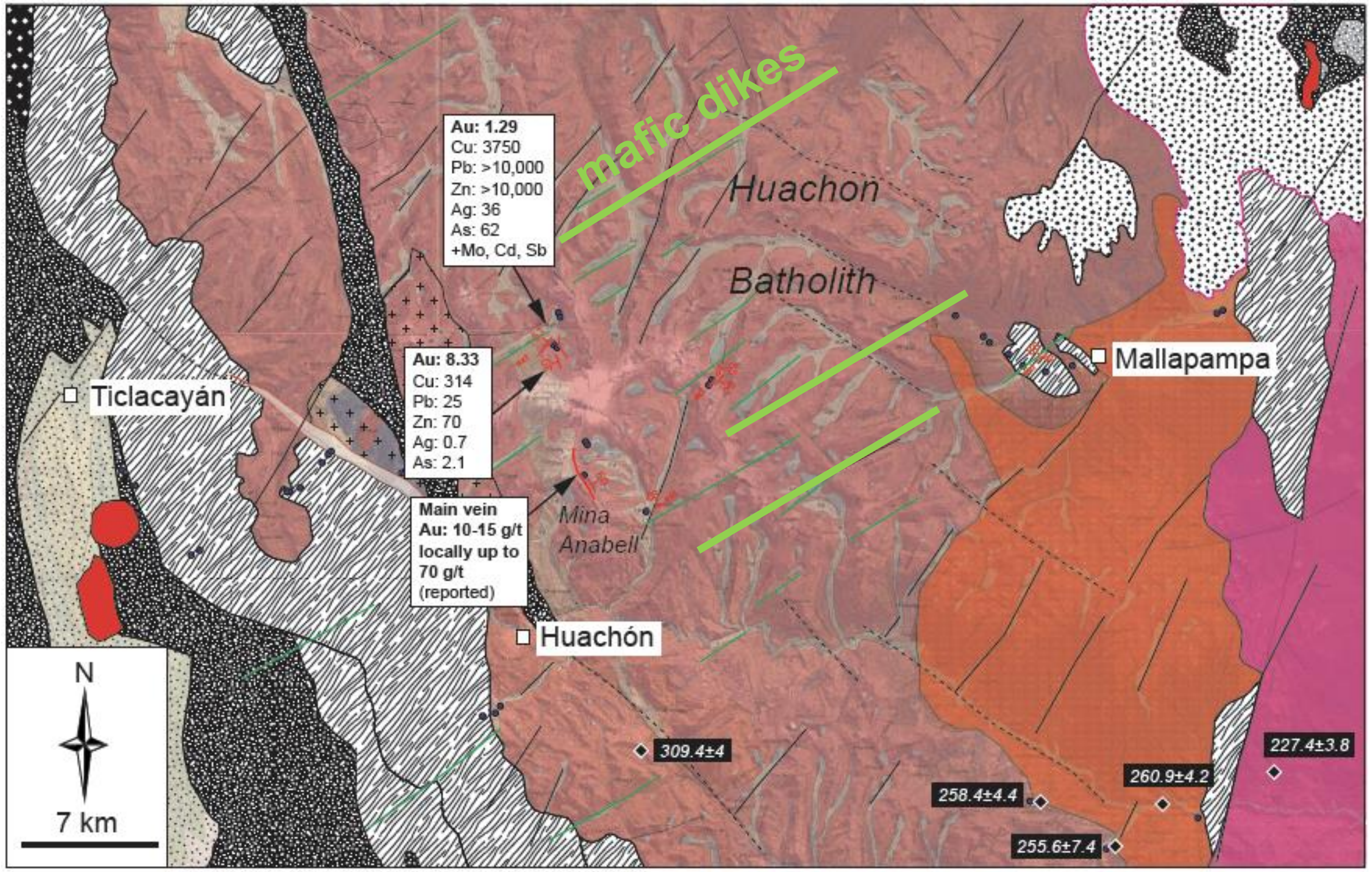
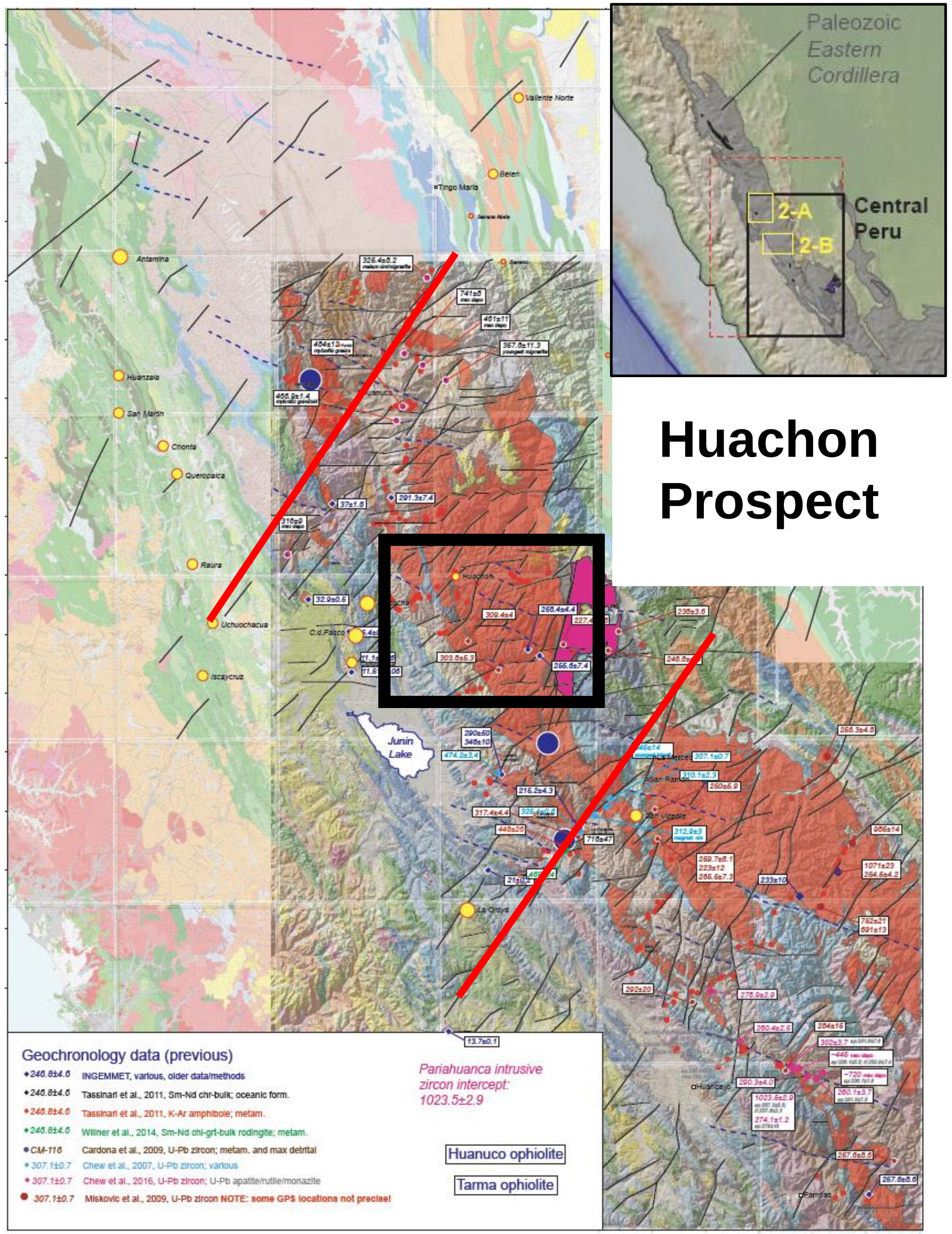




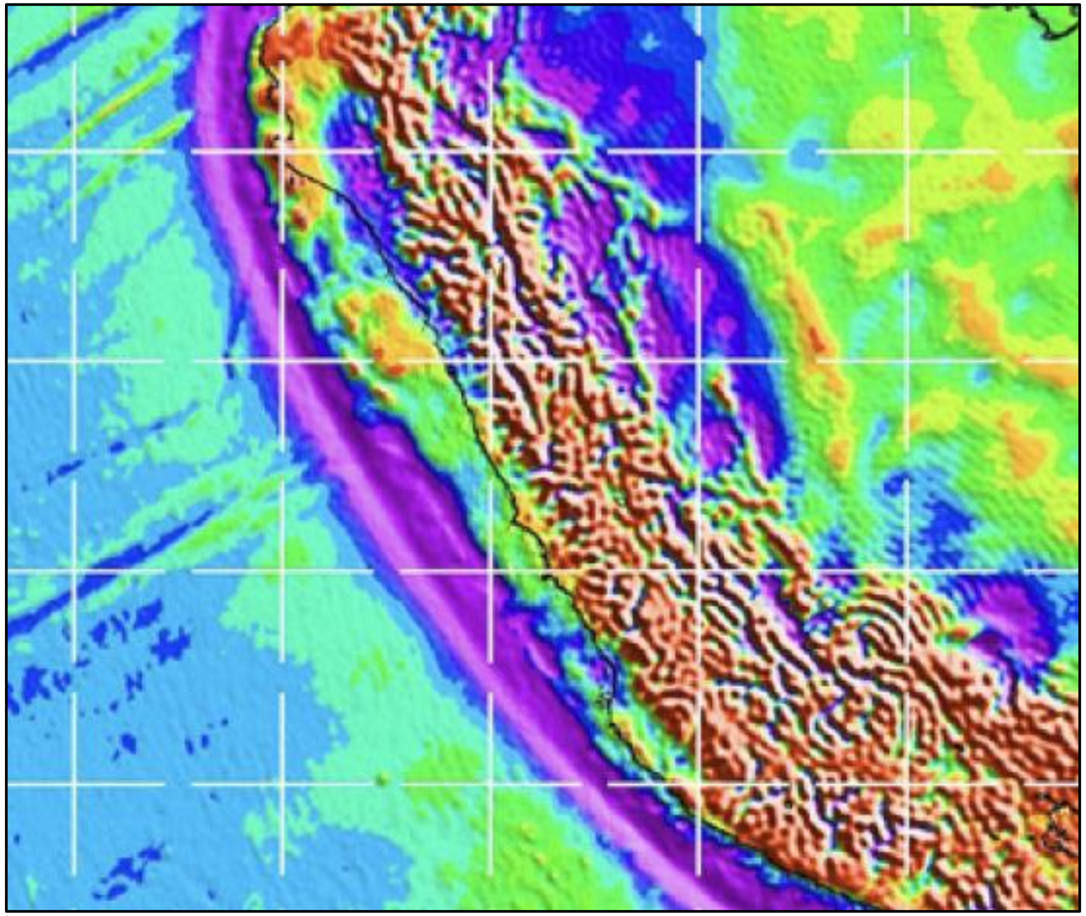
Huachon Prospect

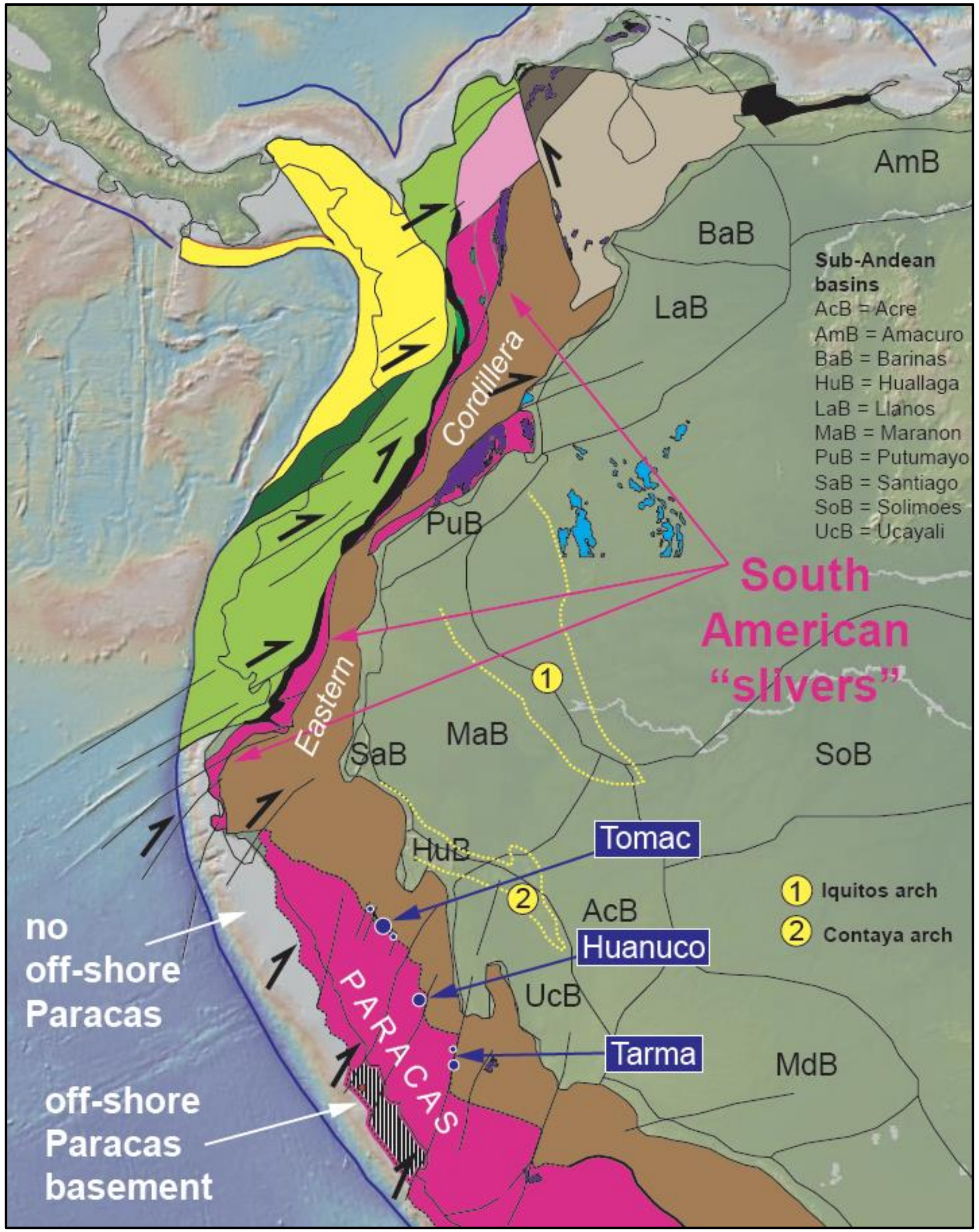
- ➢ **Au-rich Qz-sulphide fault-fill veins**
- ➢ **Late-stage mafic dikes and extension veins indicate switch to NW-extension within NE-corridor (same as in Pataz)**

Paracas suture displacement along synthetic dextral R faults

Free-air Gravimetry

Lemenkova, 2019



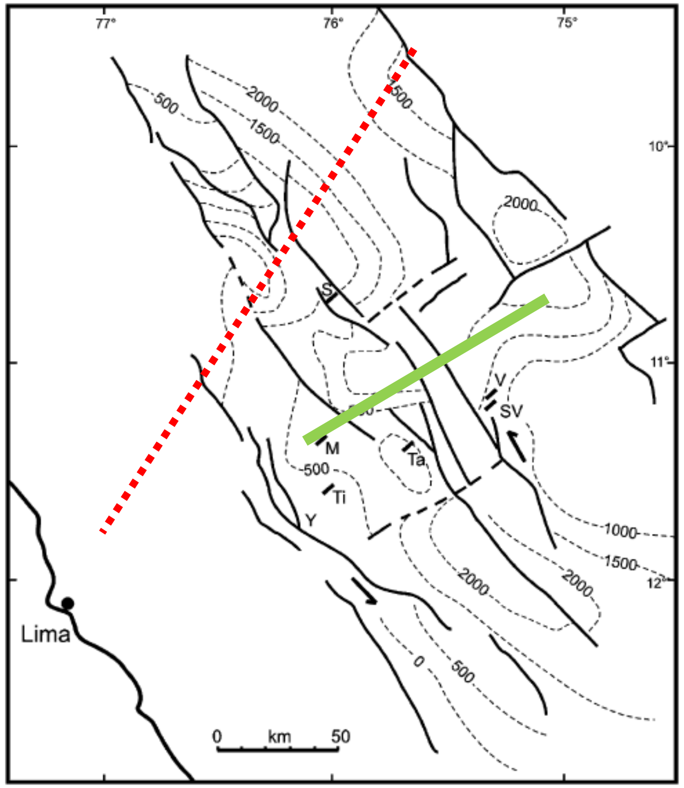


NE-trending transtensional corridors

NE trending sub-basin orientation

Triassic-Jurassic basins (Mitu, Pucara formations); isopachs
(Rosas et al., 2007)

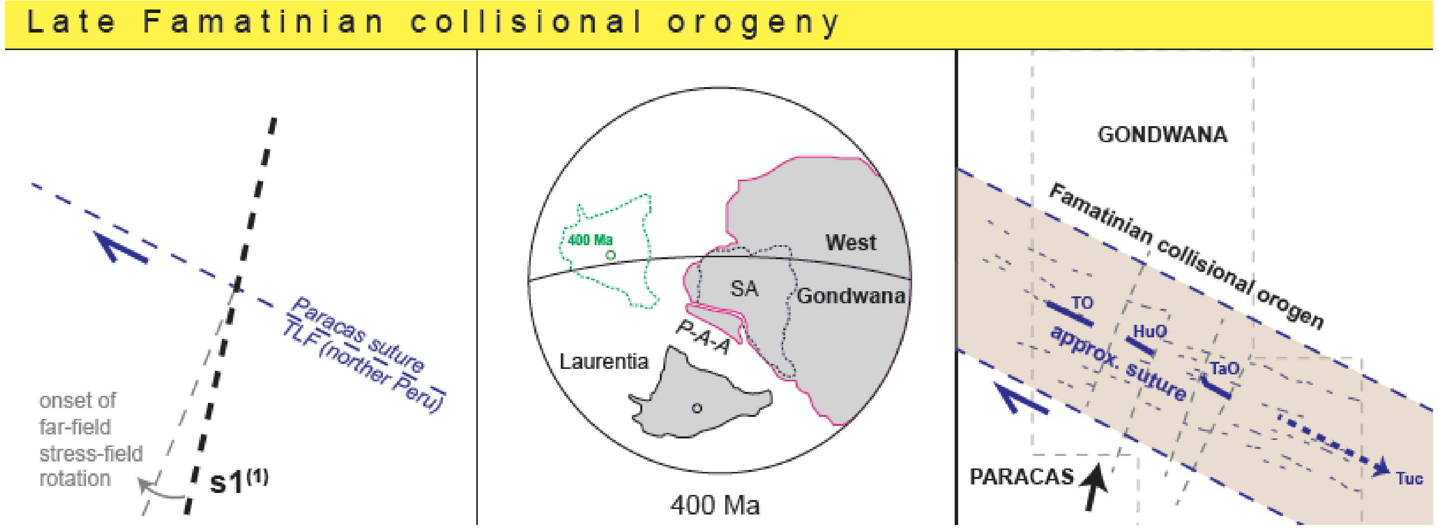
Punctuated Triassic alkaline granite intrusions along sub-basin margins
(Miskovic et al., 2009)

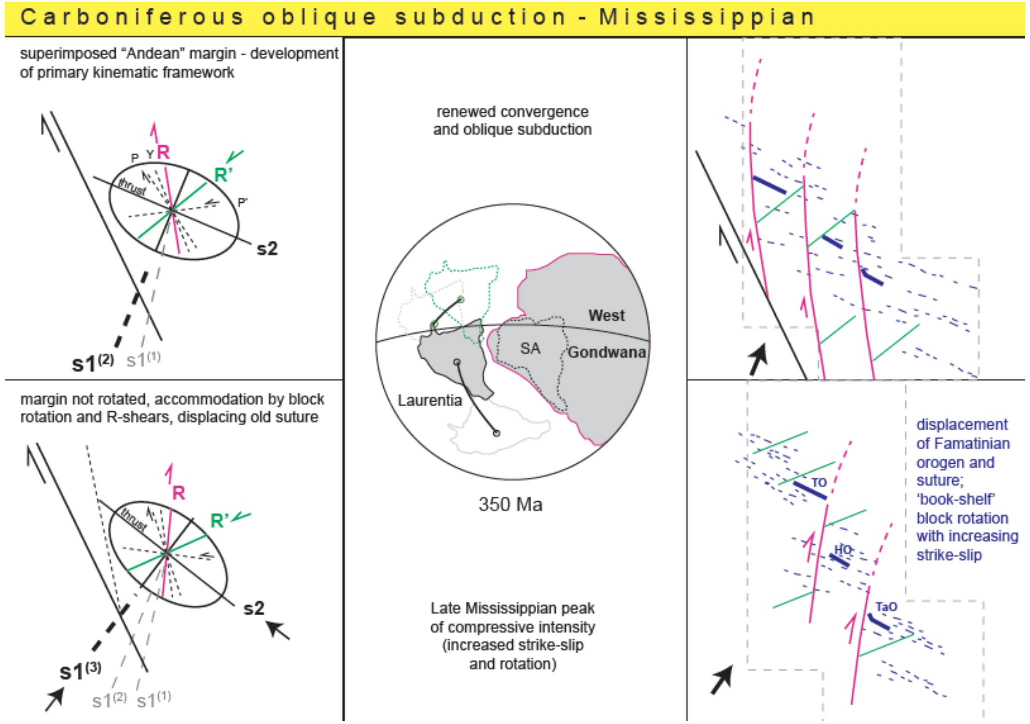


Relative timing:

- **Dextral R responsible for Pataz dilational jog since mid-Carboniferous**
- **Structures controlling sub-basin geometry established at least during the Early Triassic**
- **Pre-Carboniferous basement rotations of up to 90° and associated dextral off-sets in displacements not observed to affect Cenozoic thin-skinned thrust nappes**

Consistent global Plate Kinematic Framework

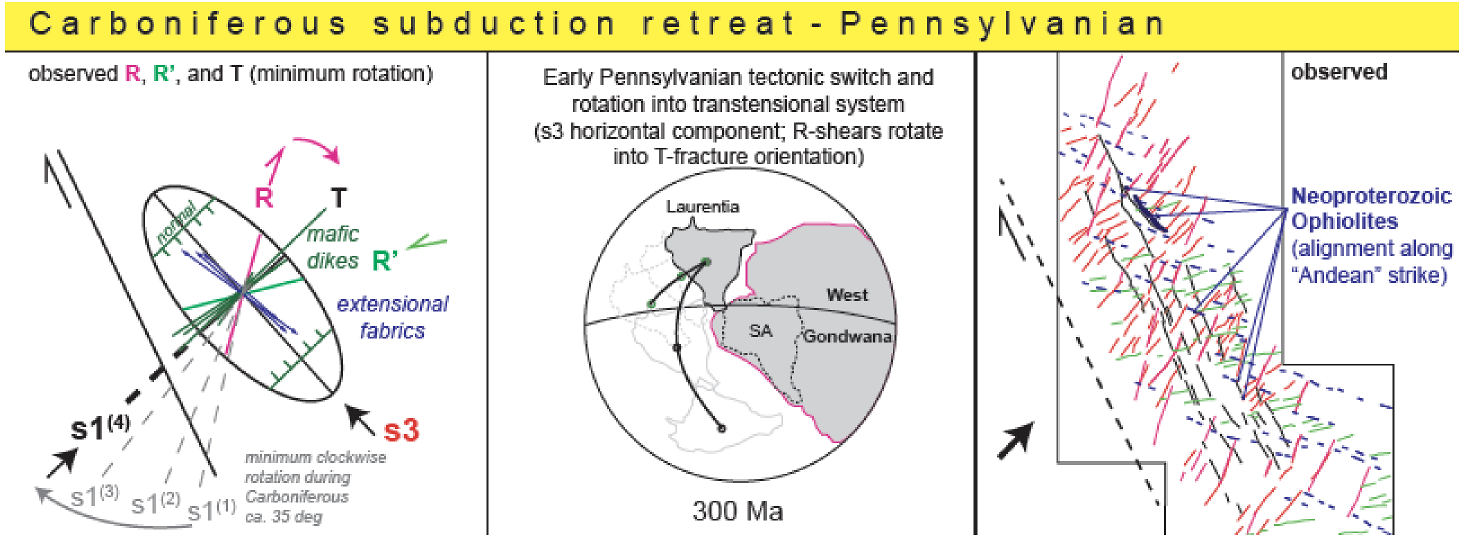




Rotation of global 'far-field' kinematic framework initiates during Carboniferous!

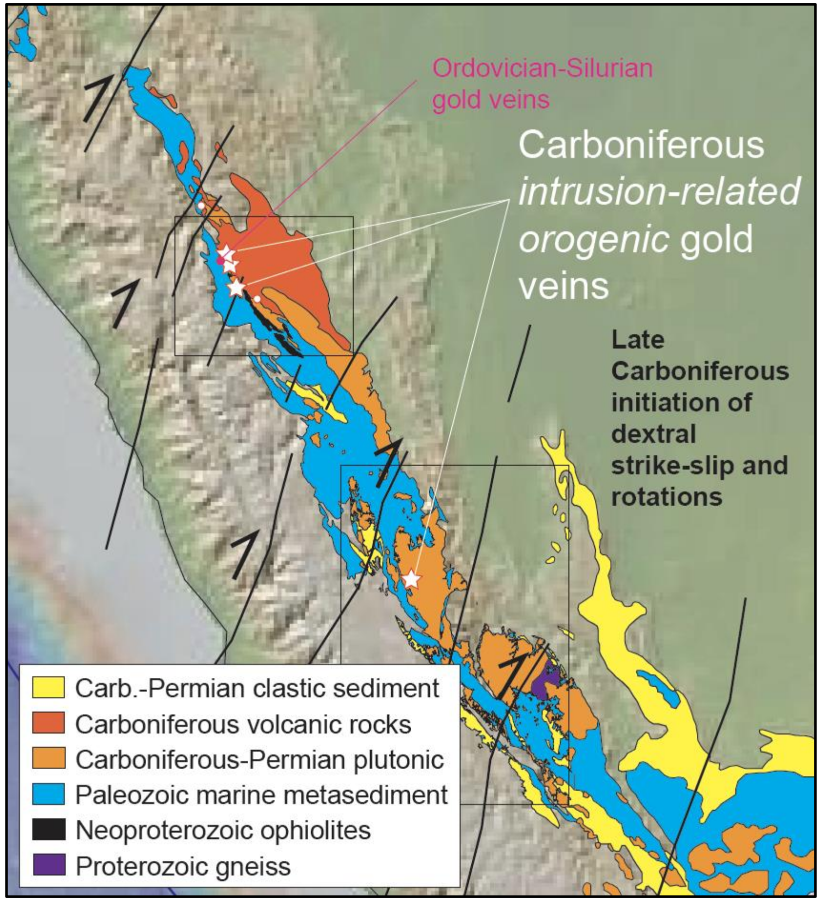
(e.g., Young et al., 2018)

NE-transtensional corridors = T-fractures, induced by strike-slip dynamics

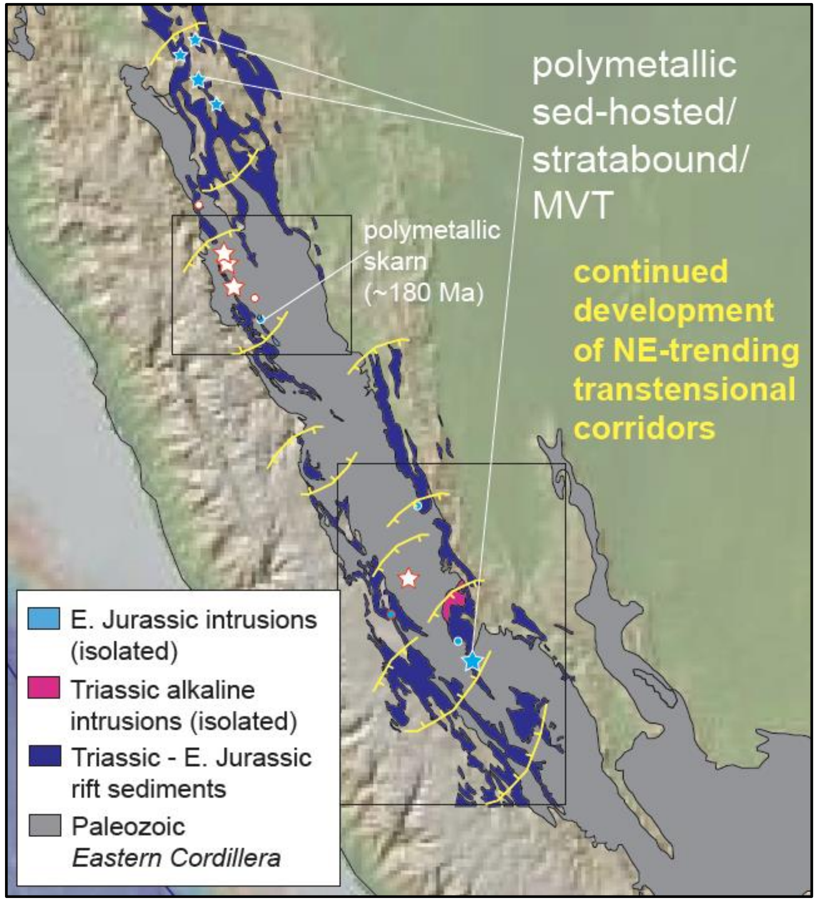


>350 Myr of Au-rich deposit formation and architecture development

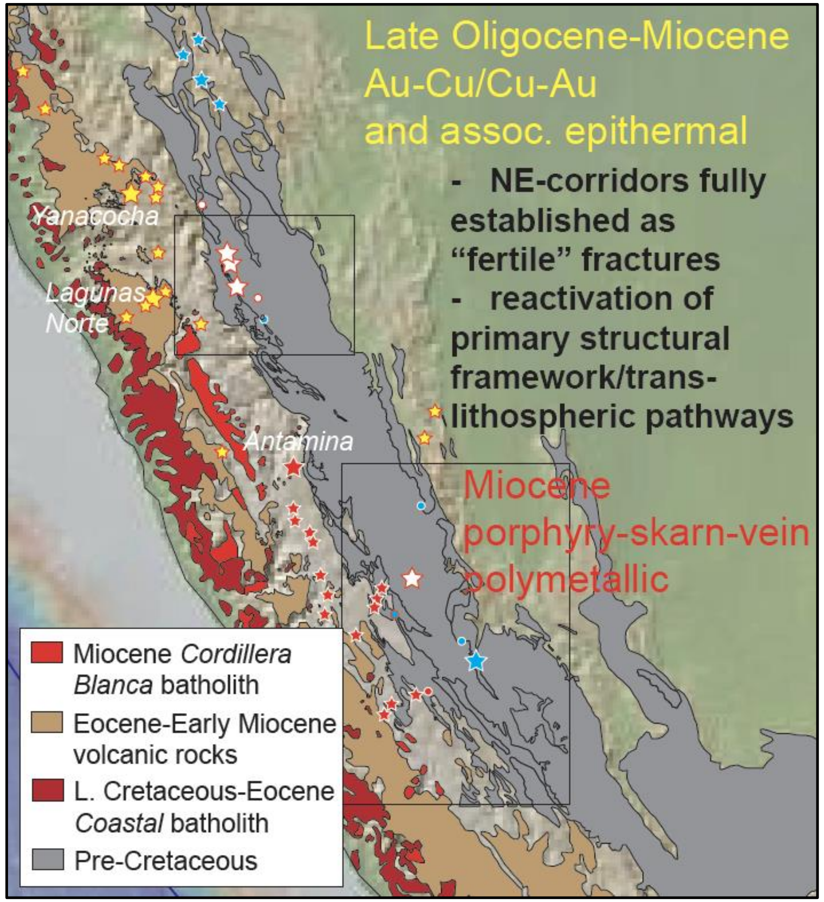
Mid-Late Paleozoic



Early-Mid Mesozoic



Cenozoic



Conclusions

- Peruvian lithosphere primary kinematic framework result of long-lived strike-slip dynamics due to oblique subduction towards edge of continental indenter (Gondwana/Amazonia)
- Initiation of escape tectonics during the Carboniferous
- Increased convergence velocity in northern Peru = increased flat slab; possibly extended metasomatized SCLM region
- Establishment of NE-trending T-fracture corridors and transtensional sub-basins
- Preferred sites of ore-fertile upper mantle lithosphere-derived (potassic, hydrous) mafic intrusions and dike swarms
- Preferred sites of Au-rich mineral deposits with formation ages spanning >400 Ma