Rifting Evolution of the Malvinas Basin, Offshore Argentina: New Constrains from Zircon U-Pb Geochronology and Seismic Characterization*

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Abstract

The Malvinas Basin, emplaced in southern South America, is an asymmetrical extensional basin formed by NNW-striking, westerly-dipping normal faults, formed during the Mesozoic breakup of SW Gondwana. Two new U-Pb zircon ages, for the prerift and synrift units respectively, are presented in this contribution. A volcanic breccia within the prerift section, in the Río Chico High area, yielded a Late Triassic crystallization age (215 Ma, U-Pb in zircon), which is the first Triassic age in the basin and was correlated with the El Tranquilo Basin in the Deseado Massif. The synrift Serie Tobífera unit had been correlated to the Middle Jurassic Chon Aike Magmatic Province. The U-Pb zircon age for Serie Tobífera in the Malvinas Basin, here presented for the first time, confirms this interpretation. A tuff level near the top of the synrift unit yielded a crystallization age of 169.6±2.1 Ma (U-Pb in zircon).

In a more regional perspective, the synextensional emplacement of the retroarc Chon Aike Magmatic Province is associated with trench-ward migration of the coetaneous volcanic arc. A vertical tear in the Paleo-Pacific subducting slab, between South America and the Antarctic Peninsula, is proposed to explain the rotational extension observed in the Chon Aike Magmatic Province structural fabric at continental plate-scale. This slab tear would have initiated in the latest Triassic and continued active during the Early-Mid Jurassic, the time of opening of the Malvinas, Austral/Magallanes, Cañadón Asfalto, and other basins in

the Patagonian retroarc. This tear would have allowed differential slab roll-back of the subducting plate below Patagonia inducing the rotational extension observed in the Chon Aike Magmatic Province and related volcanism. As observed in other examples of slab tears (notably the Aegean Sea) a surface response of the tear is usually a strike-slip deformation zone. In the case of the Patagonian slab tear, this deformation zone would have permitted the lateral displacement of Eastern Antarctica with respect to southern Africa during the Early-Mid Jurassic opening of the Mozambique channel. The thermal anomaly produced by an asthenospheric window opened by the slab tear would have triggered plate separation and the opening of an oceanic basin between Eastern and Western Gondwana in the Late Jurassic: the Weddell Sea.

Rifting evolution of the Malvinas basin, offshore Argentina: new constrains from zircon U-Pb geochronology and seismic characterization

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Agenda

1. *Jurassic Rifting in SW Gondwana*
2. *Regional Framework*
3. *Database and Workflow*
4. *Malvinas Basin Seismic characterization*
5. *U-Pb Zircon Geochronology*
6. *Rifting Evolution and Geodynamic Model*
7. *Conclusions*

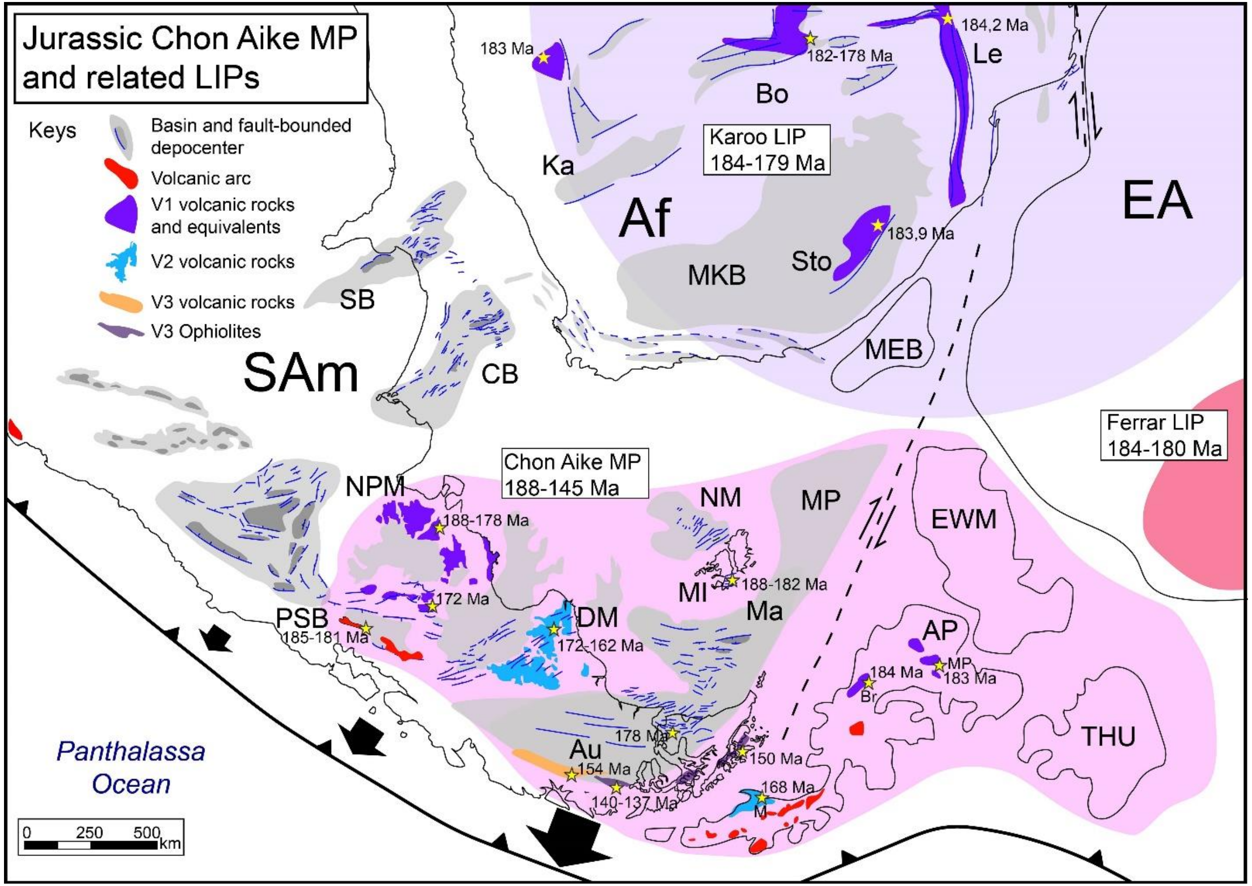
Jurassic Rifting in SW Gondwana

***Karoo II rifting** in Africa*

- ✓ *impingement of the Karoo plume in SE Africa in the Early Jurassic*

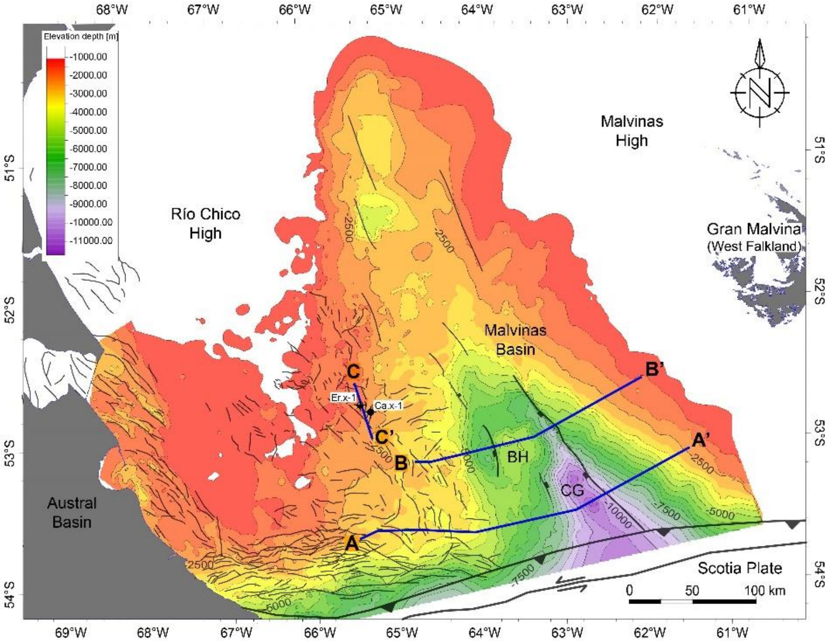
Retroarc extension

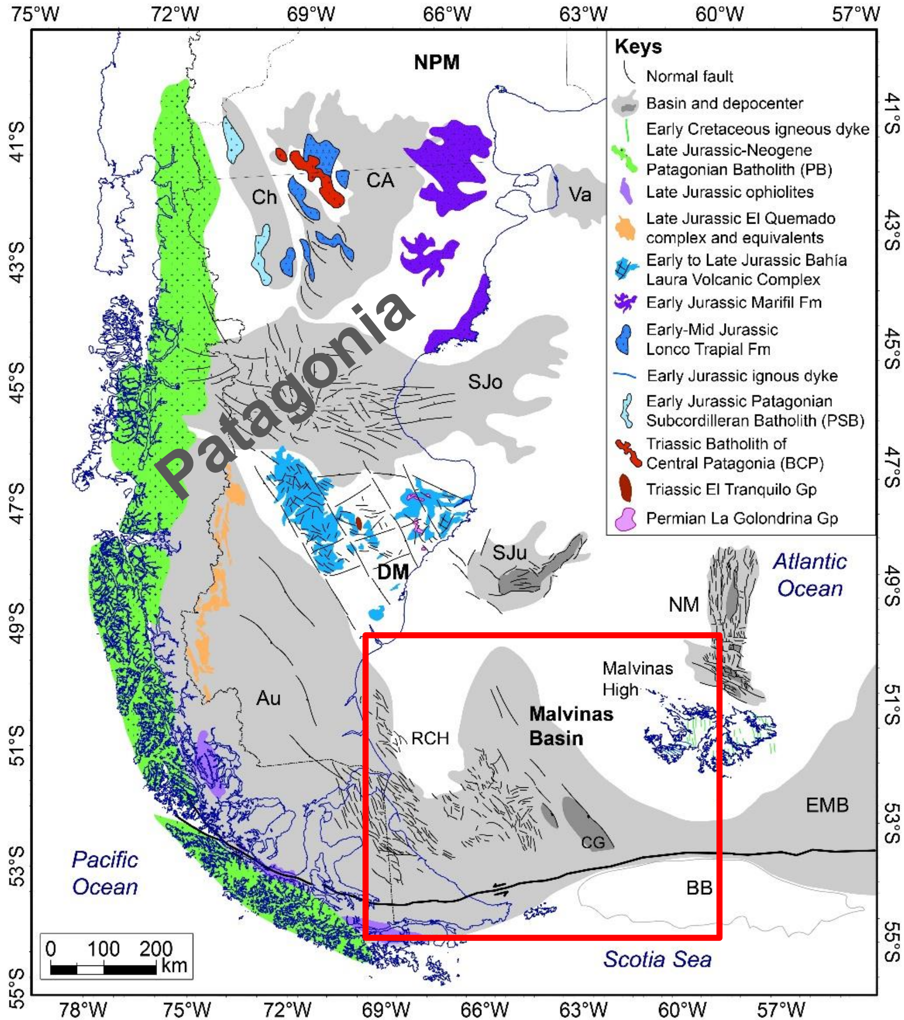
- ✓ *Differential trenchward arc migration: Subcordilleran Batholith (Early Jurassic) → Patagonian Batholith (Late Jurassic).*
- ✓ ***Chon Aike Magmatic Province**, in Patagonia and the Antarctic Peninsula, synextensional emplacement.*
- ✓ *Formation of the Cañadón Asfalto and Chubut basin, and the Malvinas and Austral basins (Serie Tobífera).*
- ✓ *Peak of silicic magmatism in the Middle Jurassic. Rotational extension: differential rollback (Echaurren et al., 2017).*



Malvinas basin Regional Framework

- ✓ *Triangular-shaped basin, located between the Malvinas Islands (E) and the Río Chico High (W).*
- ✓ *Jurassic retroarc extension (NNW-oriented faults), profuse volcanism associated with Chon Aike MP,*
- ✓ *Development of a passive margin open to the south (Weddell Sea) during the Cretaceous,*
- ✓ *Compression from the south produced a Cenozoic fold-and-thrust belt and foreland basin setting (E-W oriented faults).*





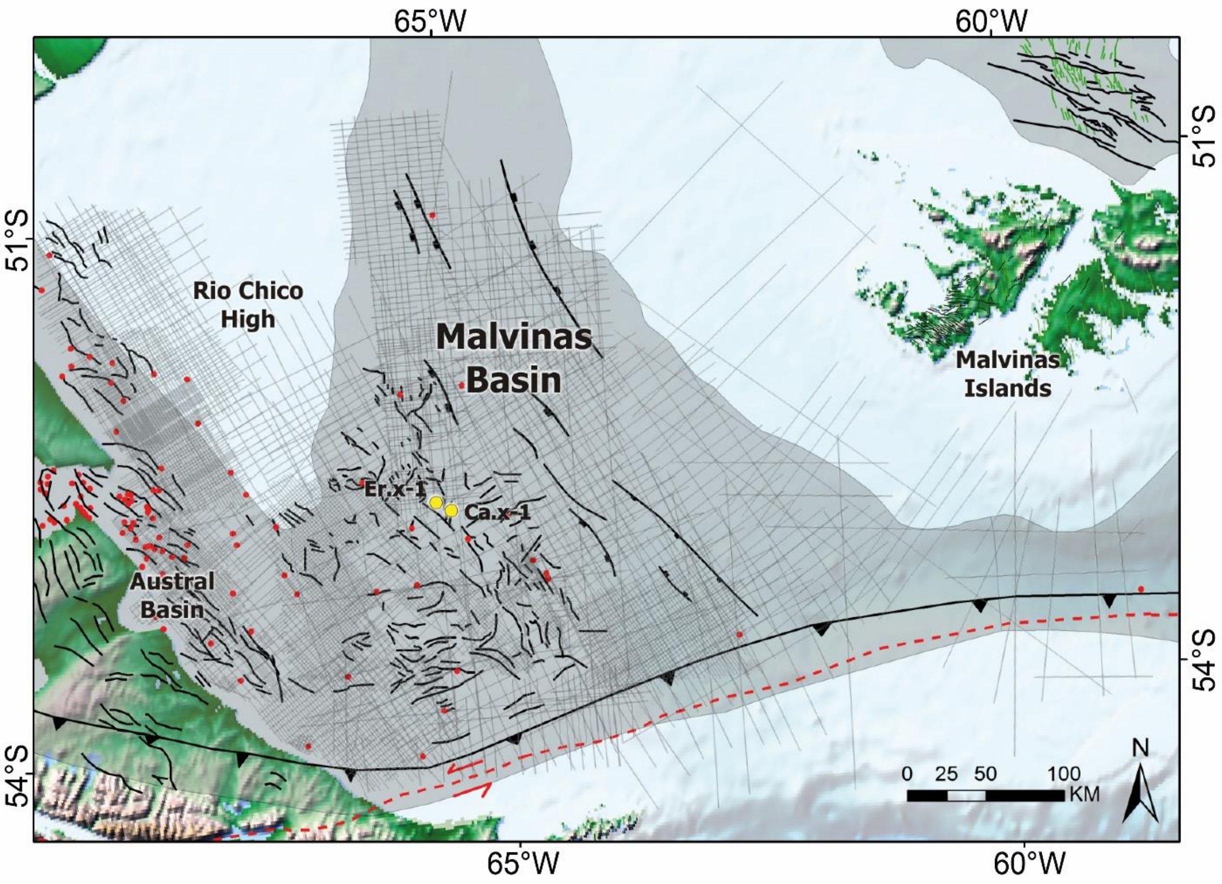
Database

- ✓ *2D PSTM and stack seismic data*
- ✓ *20 exploration wells*
- ✓ *Well cores from the synrift unit in two exploration wells.*

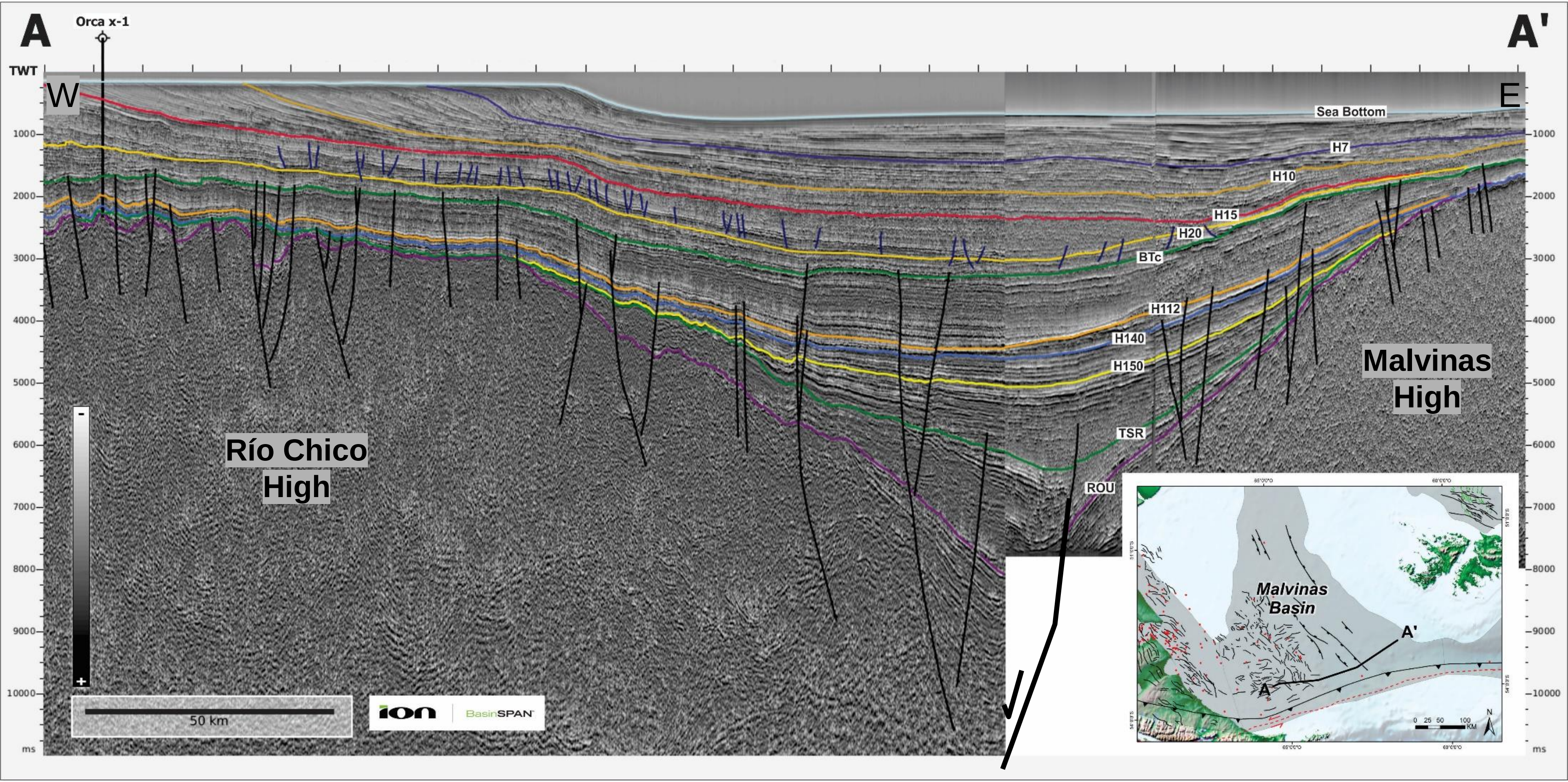
Workflow

- ✓ *2D seismic transect preparation*
- ✓ *Seismic interpretation*
- ✓ *Well calibration*
- ✓ *Seismic attribute calculation (tecVA), blended with amplitude*
- ✓ *Generation of structural maps*
- ✓ *Core sampling*
- ✓ *Zircon separation and characterization*
- ✓ *Zircon dating (U-Pb, LA ICP MS)*
- ✓ *Data integration*

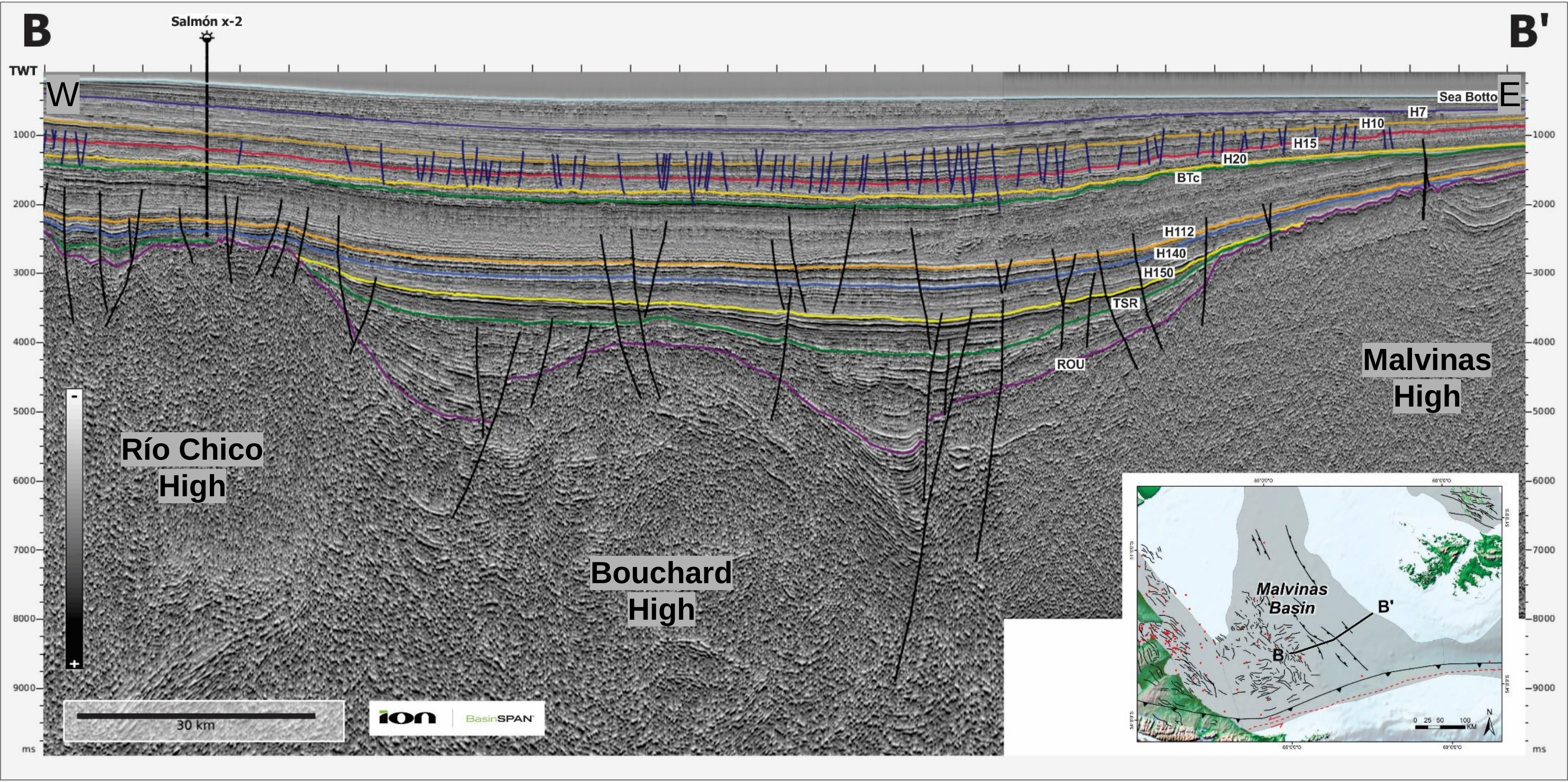
Malvinas basin: Database



Malvinas basin: Seismic characterization

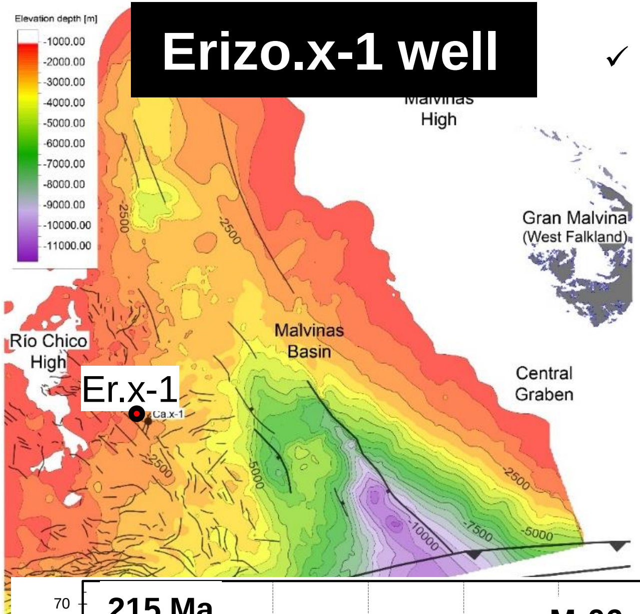


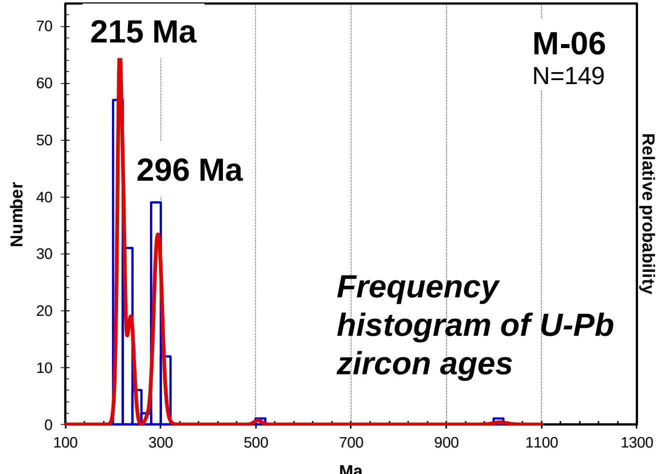
Malvinas basin: Seismic characterization



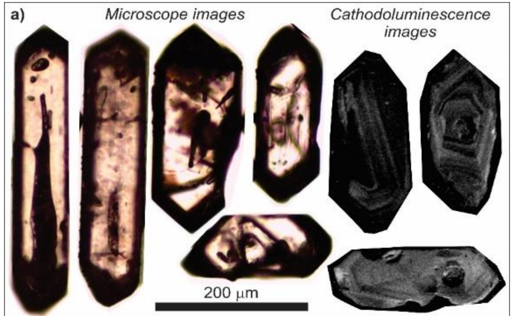
Erizo.x-1 well

✓ *Core sample of a **volcanic breccia** at total depth*

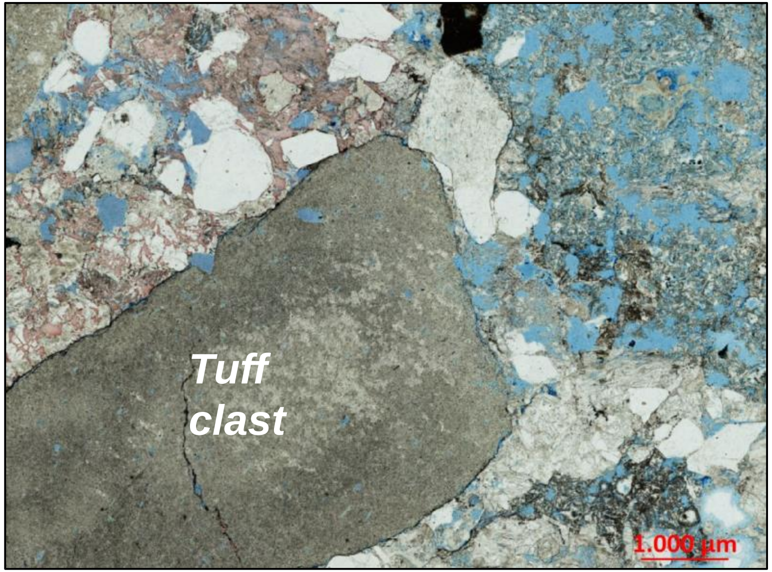




Zircon microscopy

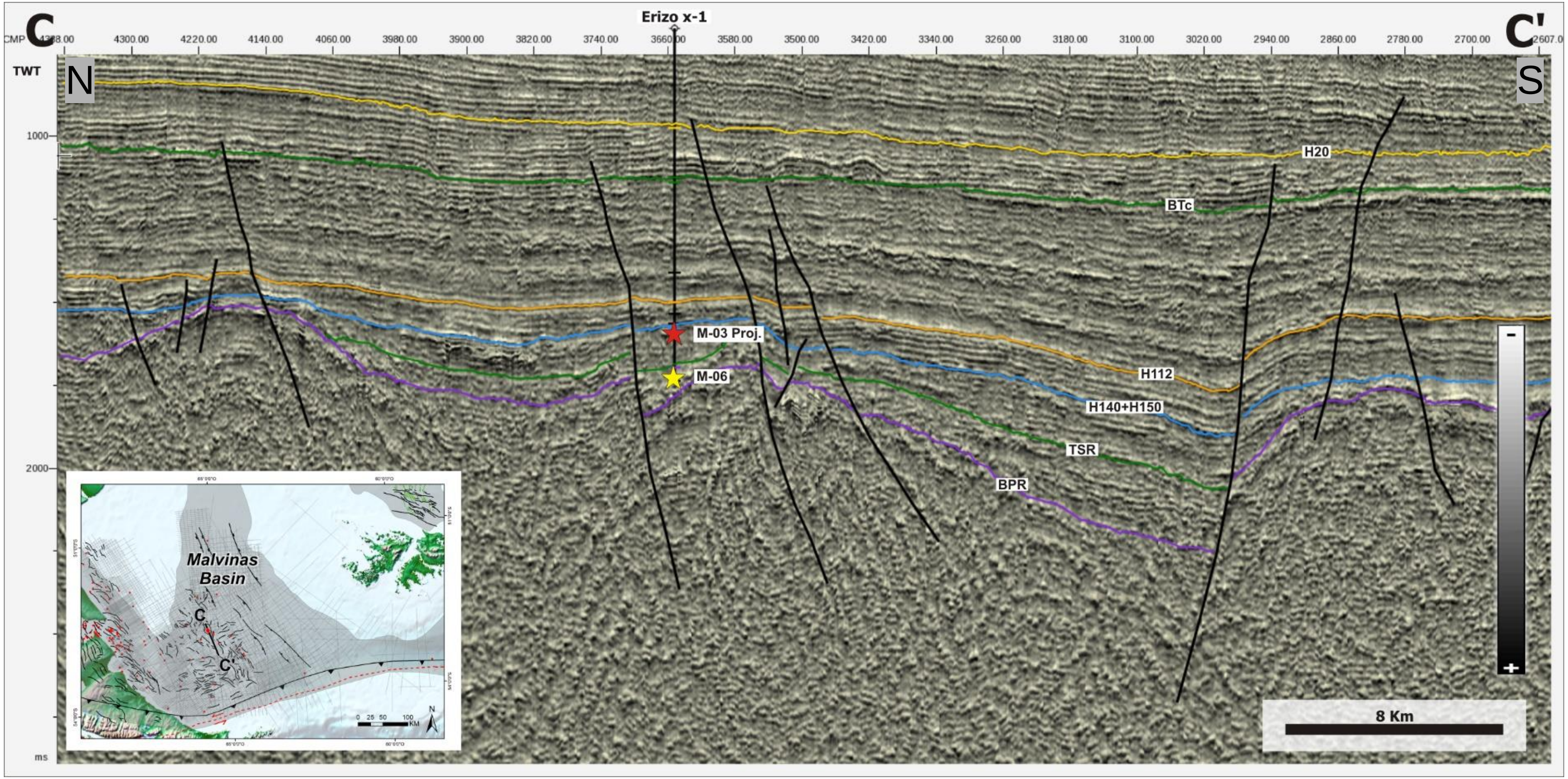


Thin section

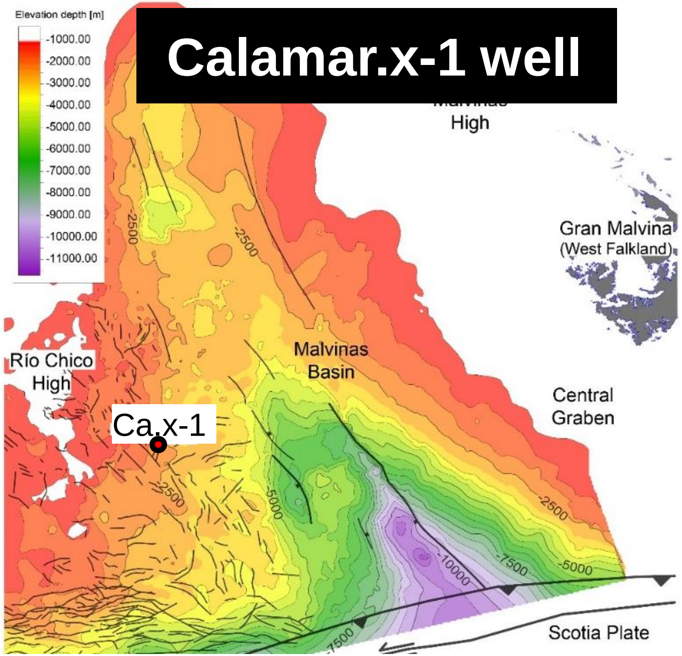


Core photo

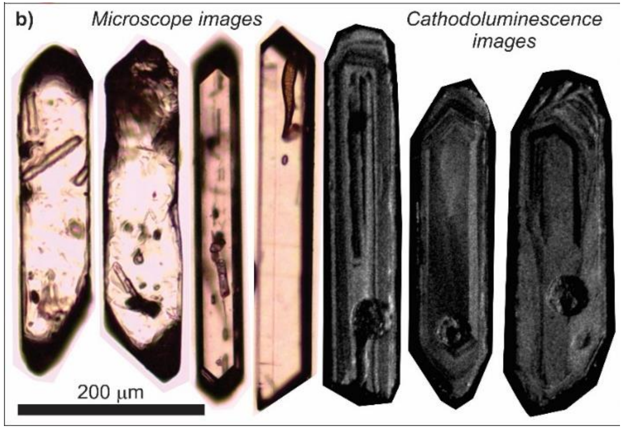
Malvinas Basin: Triassic rifting stage

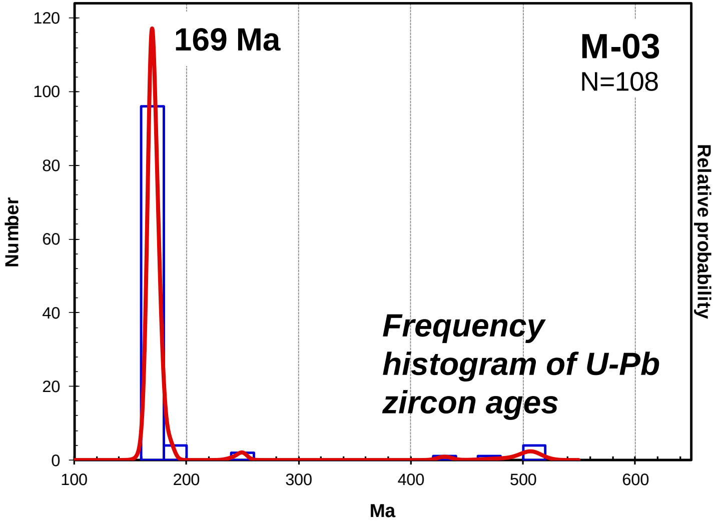


Calamar.x-1 well



Zircon microscopy

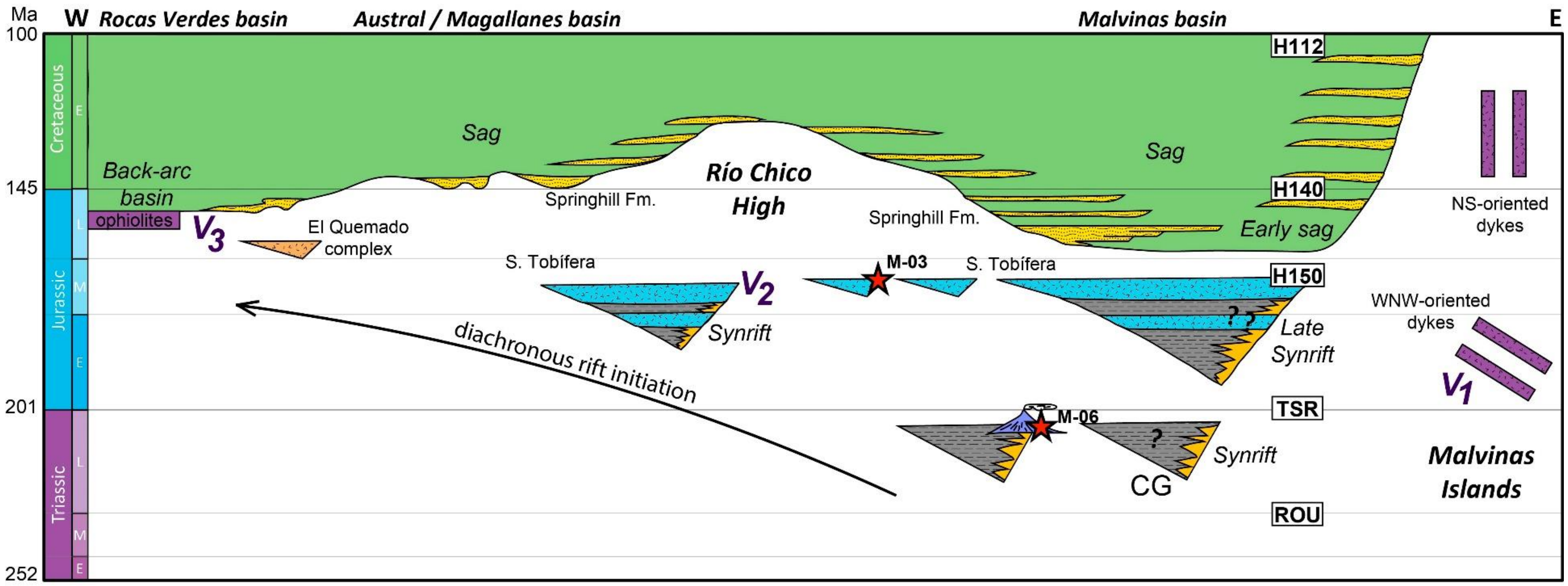




Core photo

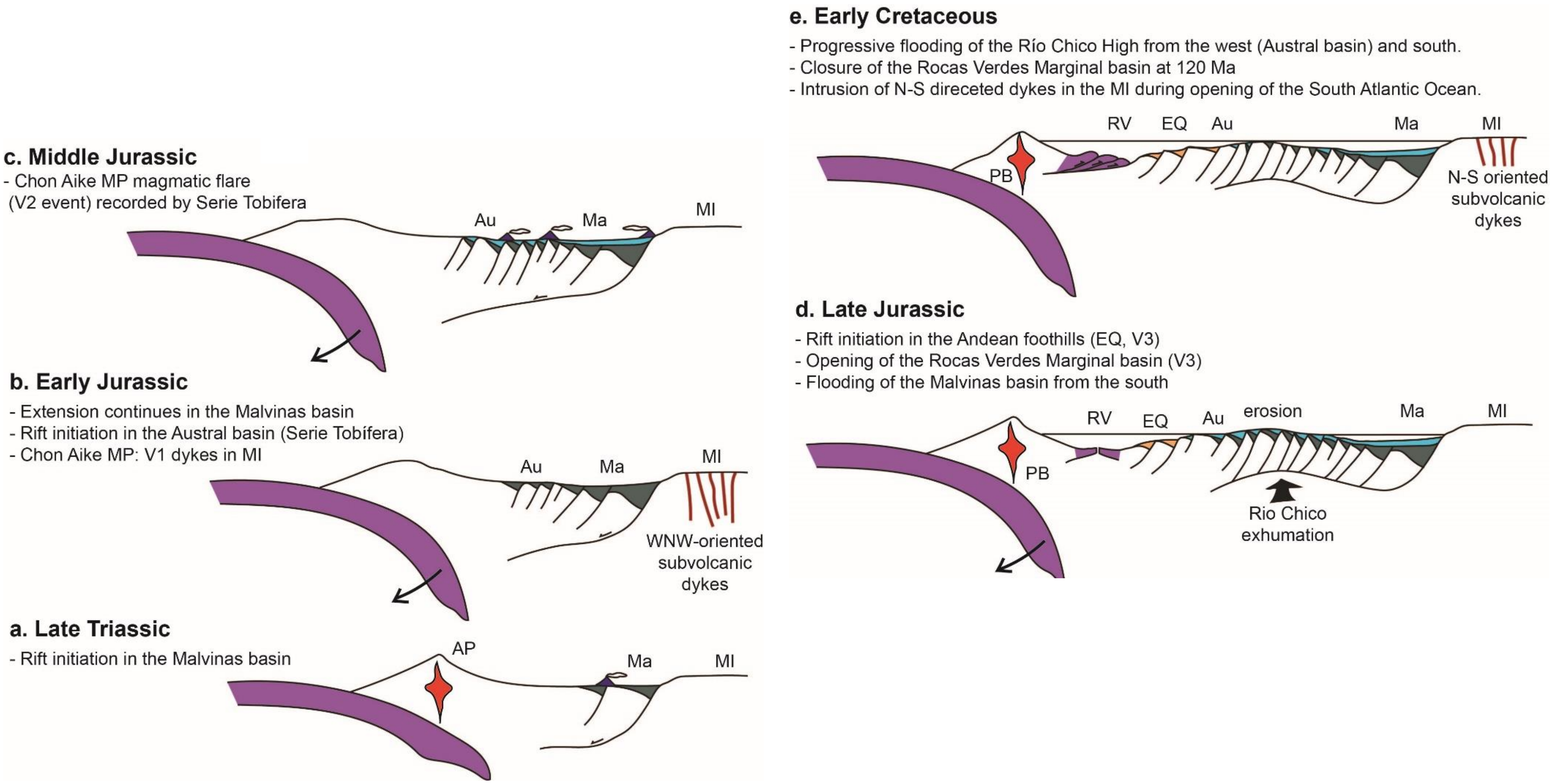
- ✓ *Core sample from a **tuff** bed at the top of the synrift Serie Tobífera*
- ✓ *Confirmed Middle Jurassic age for Serie Tobífera as part of the Chon Aike Magmatic Province.*

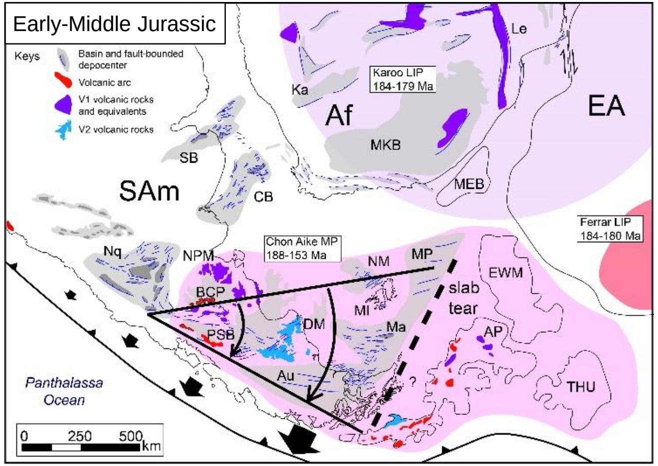
Malvinas Basin Rifting History

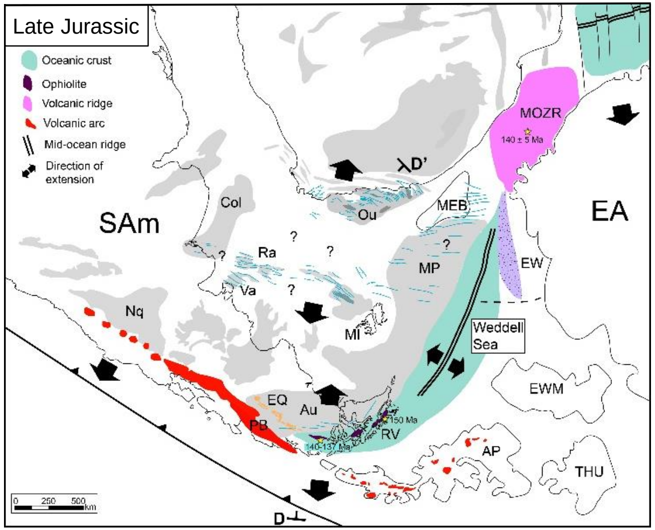


- ✓ *Diachronous rift initiation from east to west.*
- ✓ *Triassic rifting in the Malvinas basin and Río Chico high area (Erizo well)*
- ✓ *Early-Middle Jurassic rifting in the Malvinas and Austral basin (synextensional Chon Aike MP emplacement).*
- ✓ *Late Jurassic bimodal rifting and oceanic spreading to the west (El Quemado and equivalents, Rocas Verdes marginal basin)*

Malvinas Basin Evolution





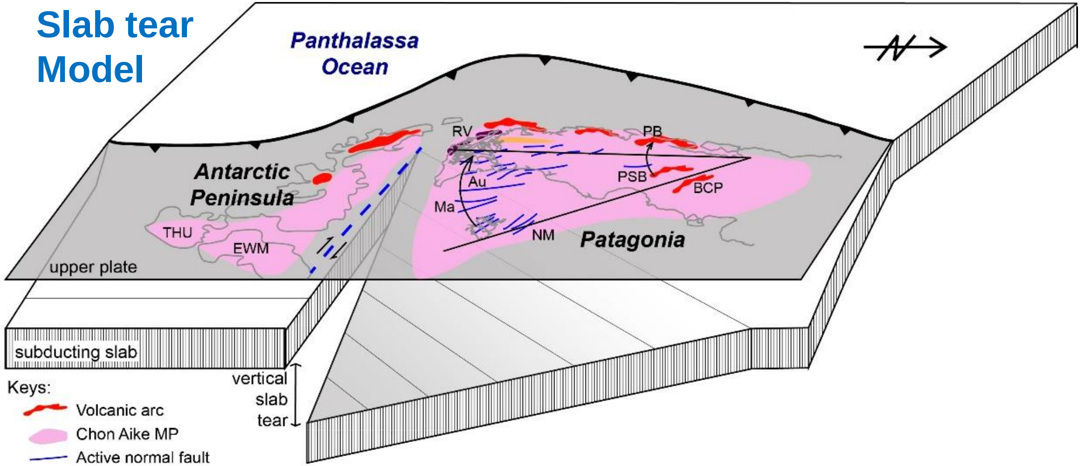


Geodynamic Model

Early-Middle Jurassic:

- ✓ *Synextensional emplacement of the retroarc Chon Aike MP.*
- ✓ *Clockwise rotation, trenchward migration of the volcanic arc*
- ✓ *Strike-slip fracture zone between Antarctic territories and South America to accommodate the opening of the Mozambique basins*

Slab tear Model



Late Jurassic:

- ✓ *Opening of the back-arc Rocas Verdes basin in the Late Jurassic*
- ✓ *Opening of the Weddell Sea between Antarctica and South America*
- ✓ *Oblique rifting in the Rawson/Valdés-Outeniqua segment*

Conclusions

1. *The rifting evolution of the Malvinas basin was characterized from seismic data and geochronology or well cores.*

2. *Rifting started at least in the Late Triassic, as indicated by the volcanic breccia of the synrift unit dated 215 Ma (U-Pb in zircon). This unit should be differentiated from the Jurassic S. Tobífera.*

3. *A tuff sample recovered from the top of Serie Tobífera confirmed a Middle Jurassic crystallization age of 169.6±2 Ma (U-Pb in zircon), coincident with the Chon Aike Magmatic Province flare-up.*

4. *A slab tear model :*
   - ✓ *Explains the rotational extension associated with the Chon Aike Magmatic Province emplacement,*
   - ✓ *Provides a border condition for the differential slab rollback in Patagonia,*
   - ✓ *Explains the lateral displacement between Eastern and Western Gondwana,*
   - ✓ *And is an alternative explanation for the origin of the Weddell Sea.*