Deciphering geochemical and mineralogical changes of a Miocene sedimentary basin infill, Mendoza province, Argentina

UNIVERSITÉ DE GENÈVE – FACULTÉ DES SCIENCES
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EGU

Geochemistry and Mineralogy

Introduction

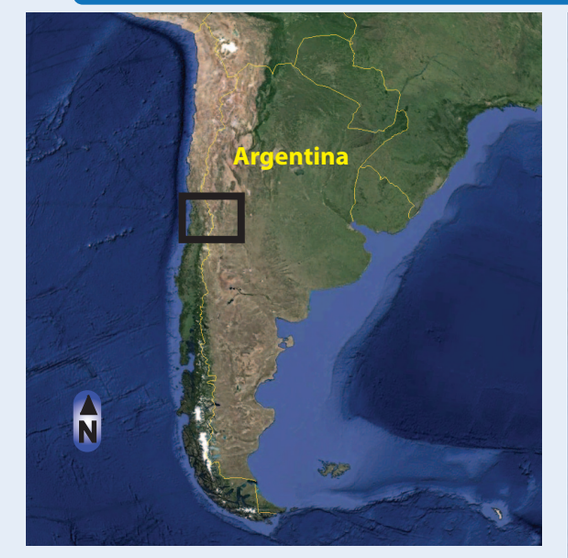


Fig 1a. Location of the investigated area

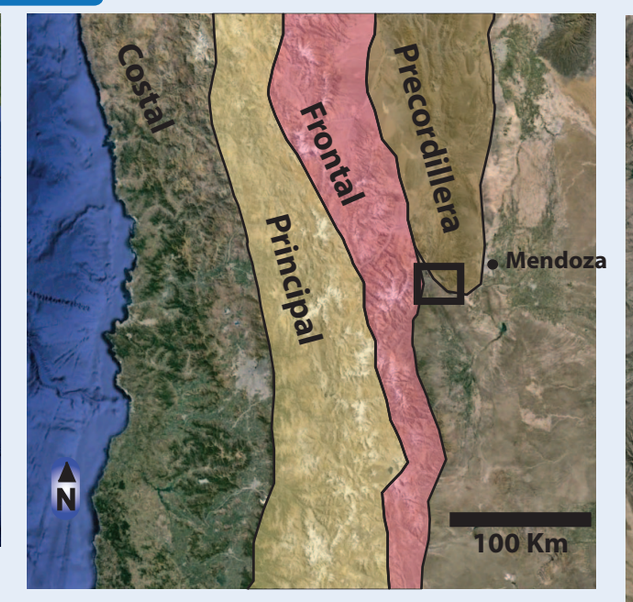


Fig 1b. Geological provinces of the Andean Cordillera

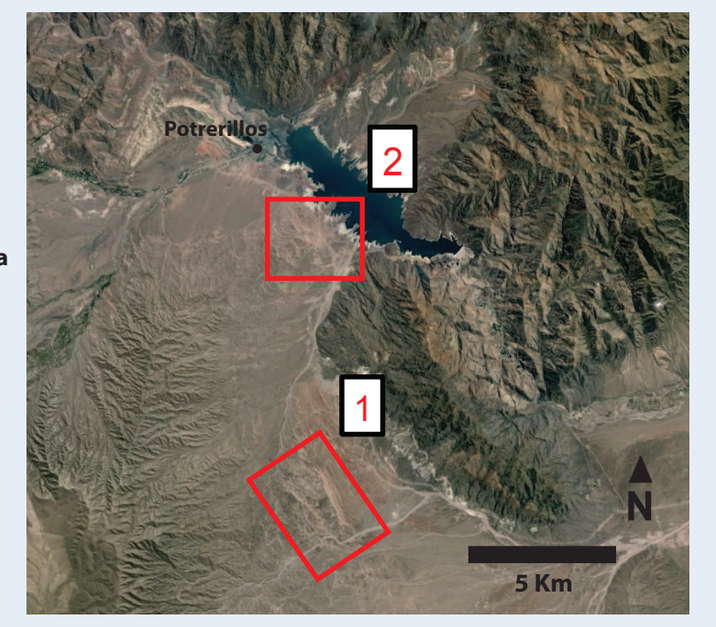


Fig 1c. Potrerillos region, red insets: the two outcrops studied

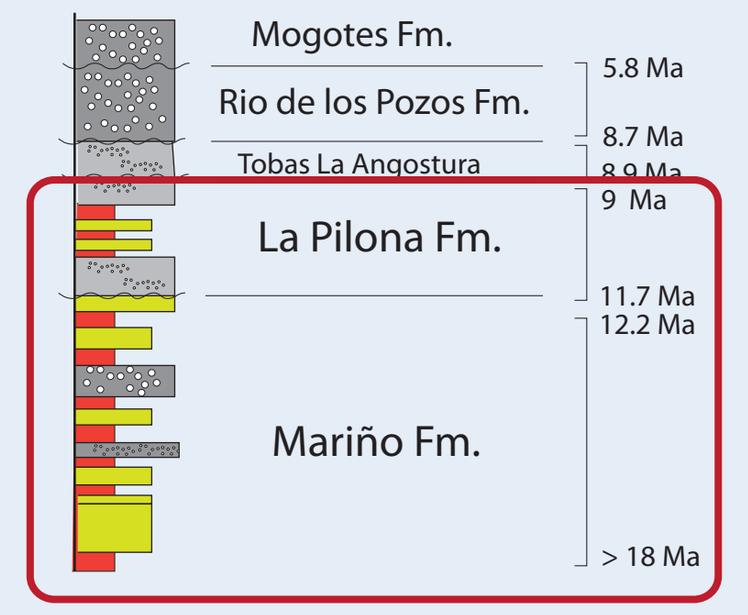


Fig 2. Stratigraphy of the Central Argentinian Foreland basin

- The study area is located in the **Mendoza Province of Argentina** and is delimited by the **Precordillera** to the North and the **Frontal Cordillera** to the west (**Fig 1a-b-c**). This region has long been a sedimentary basin, first during the Mesozoic **rifting phase** and later as part of the Cenozoic **Andean foreland**.

- The **Mariño** and **La Pilona formations** comprise a large part of the Neogene sediments in the **Central Argentinian Foreland**, dating from prior to 18 Ma to 9 Ma *(Irigoyen et al. ,2000; Porras et al., 2016)* (**Fig 2.**) and extending over more than 1400 m in stratigraphy.

- Extensively exposed as the surface expression of folds related to Plio-Pleistocene **uplift** of the **Precordillera**.

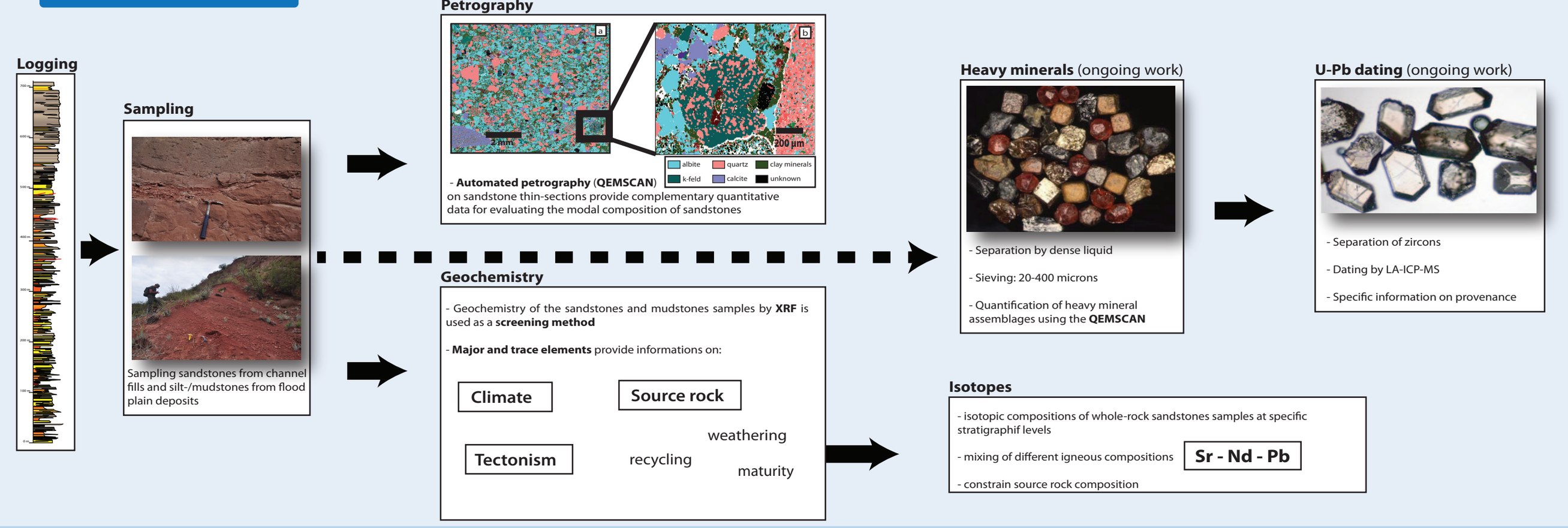
- The infill comprises a continuous stratigraphic record of **aeolian** and **ephemeral fluvial environments** developed during the uplift of the main Andean range

- Display of highly differentiated facies associations and architectures

Main goals

- Provide a detailed **reconstruction of paleoenvironmental dynamics**
- Unravel the relative **roles of climate and tectonics** through a high-resolution, compositional and sedimentological analysis
- Recognize the **effects of different allogenic** drives on sedimentary processes and local environmental change.
- Track **changes in sediment provenance** and relative information on magmatism and exhumation in the uplifting Andes

Methods



Tectonic setting

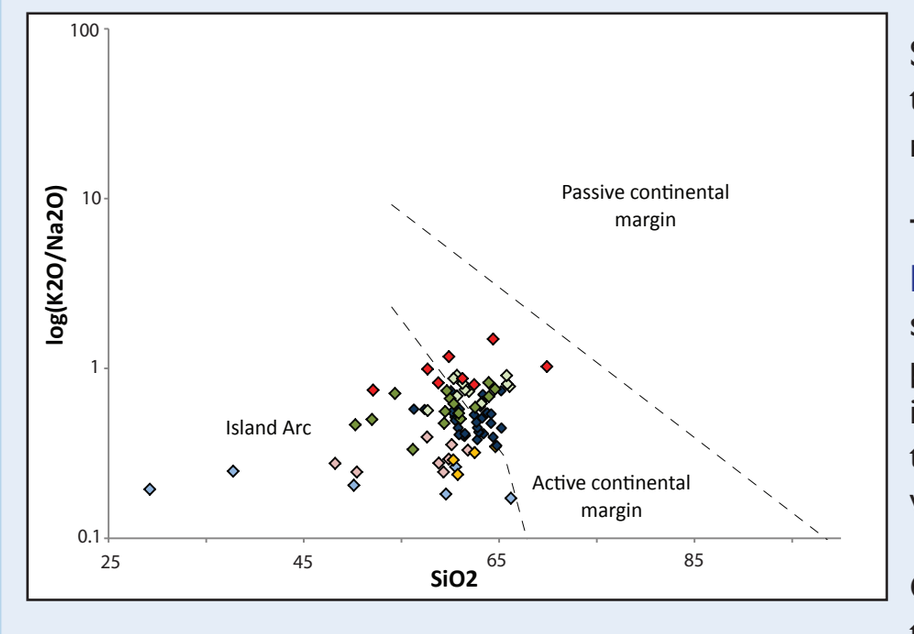


Fig 3. Diagram by Roser and Korsch (1986) very used for tectonic setting classification. In our case the major elements used are biased by the high amount of calcite in the samples

Samples plot in the island arc field, and the evolution toward the top of the stratigraphic column shows a trend toward active continental margin (**Fig. 3**).

The Th-Sc-Zr/10 ternary diagram proposed by Bhatia and Crook (1986; **Fig. 4**) is based on the study of immobile trace elements that are not sensitive to remobilization during weathering, diagenesis and metamorphism. The samples from the lower part of the succession plot in the island arc field. However, samples from stratigraphic intervals overlying the aeolian member show higher concentrations of Th and Zr and plot within the field of active continental margin.

Overall, the evolution of the tectonic setting compositional signature through the basin infill shows a progressive trend towards a more mature and evolved composition.

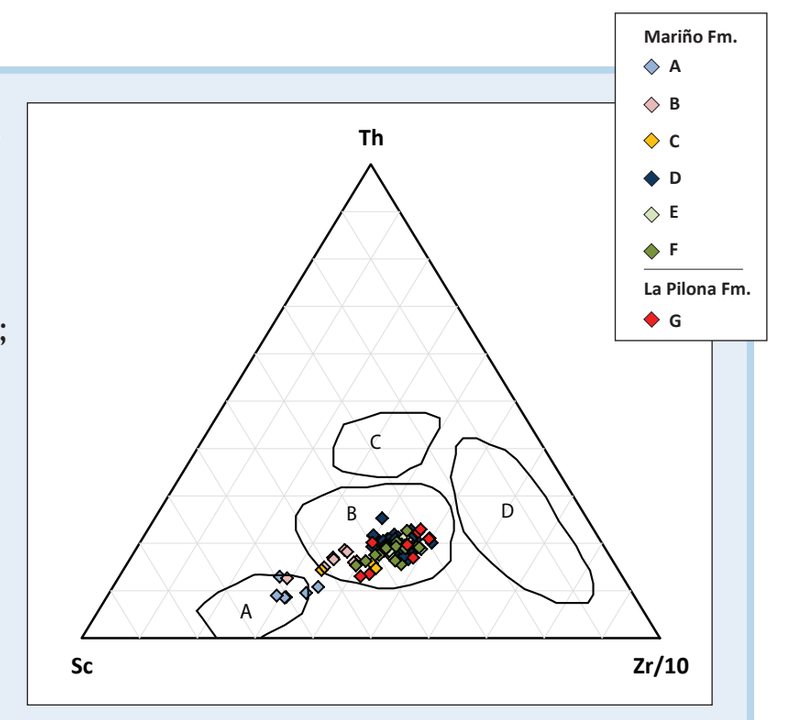


Fig 4. A: oceanic island arc, B: active continental margin, C: continental island arc, D: passive margin (Bhatia and Crook 1986).

Classification of the sandstones

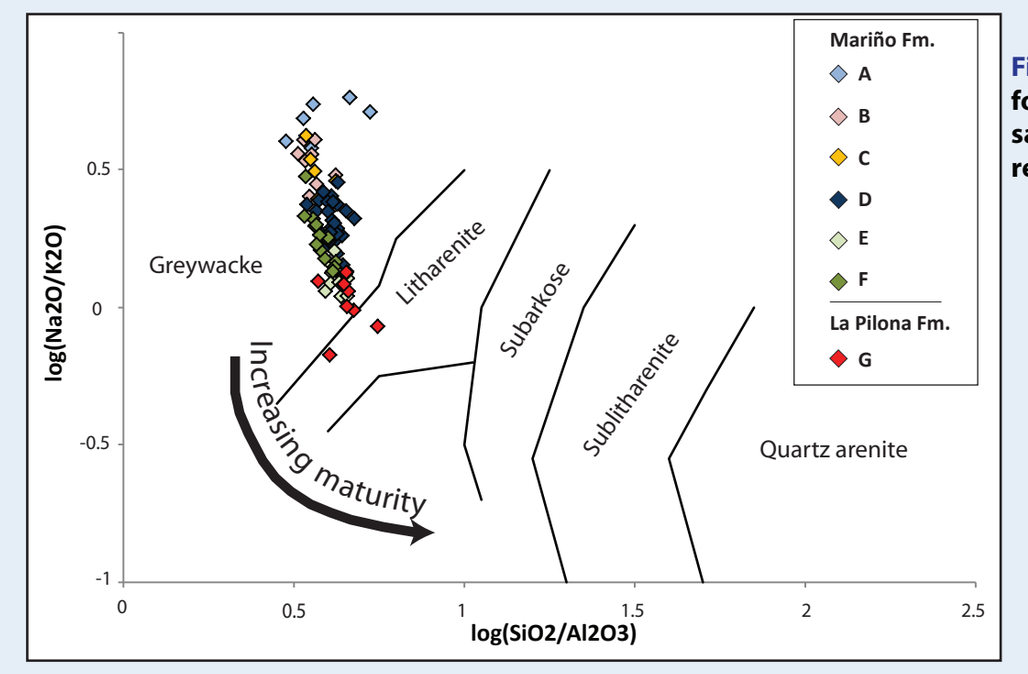


Fig 5. Log(Na2O/K2O) vs. log(SiO2/Al2O3) diagram for the geochemical classification of terrigenous sands proposed by Pettijohn et al. (1972) and redrawn by Herron et al. (1988).

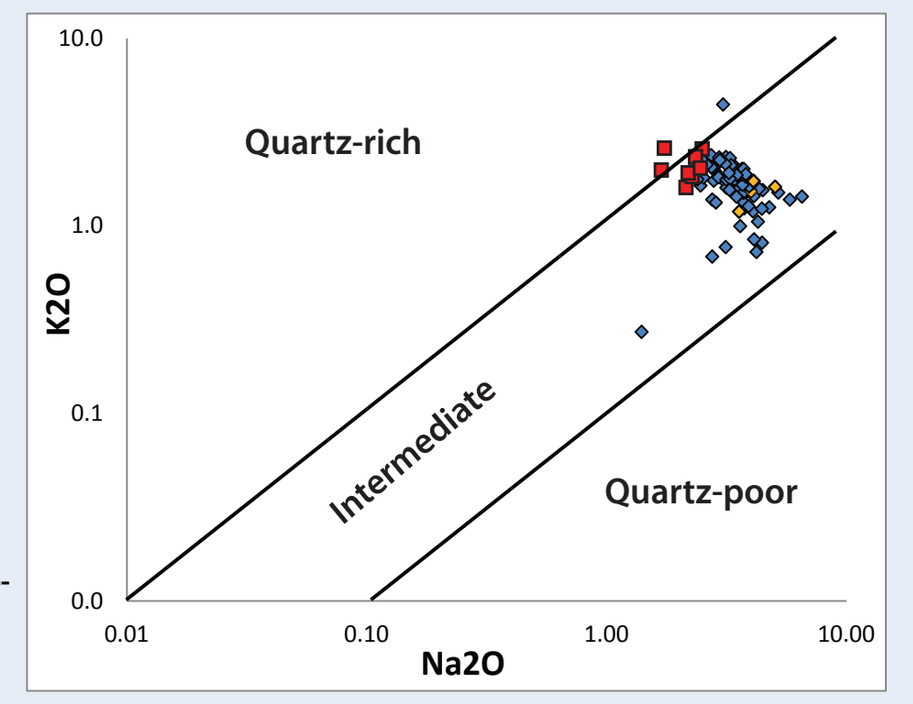


Fig 6. Geochemical composition and theoretical quartz composition of sandstones, infered from K2O and Na2O

The samples from the Mariño and La Pilona formations plot mostly in the greywacke field (**Fig. 5**) and quartz-arenite composition (**Fig. 6**) showing a low compositional maturity consistent with their syntectonic origin (Irigoyen et al., 2000). Along the stratigraphic succession, the maturity slightly increases towards the top of the Mariño Formation, with samples from the La Pilona Formation appearing more mature.

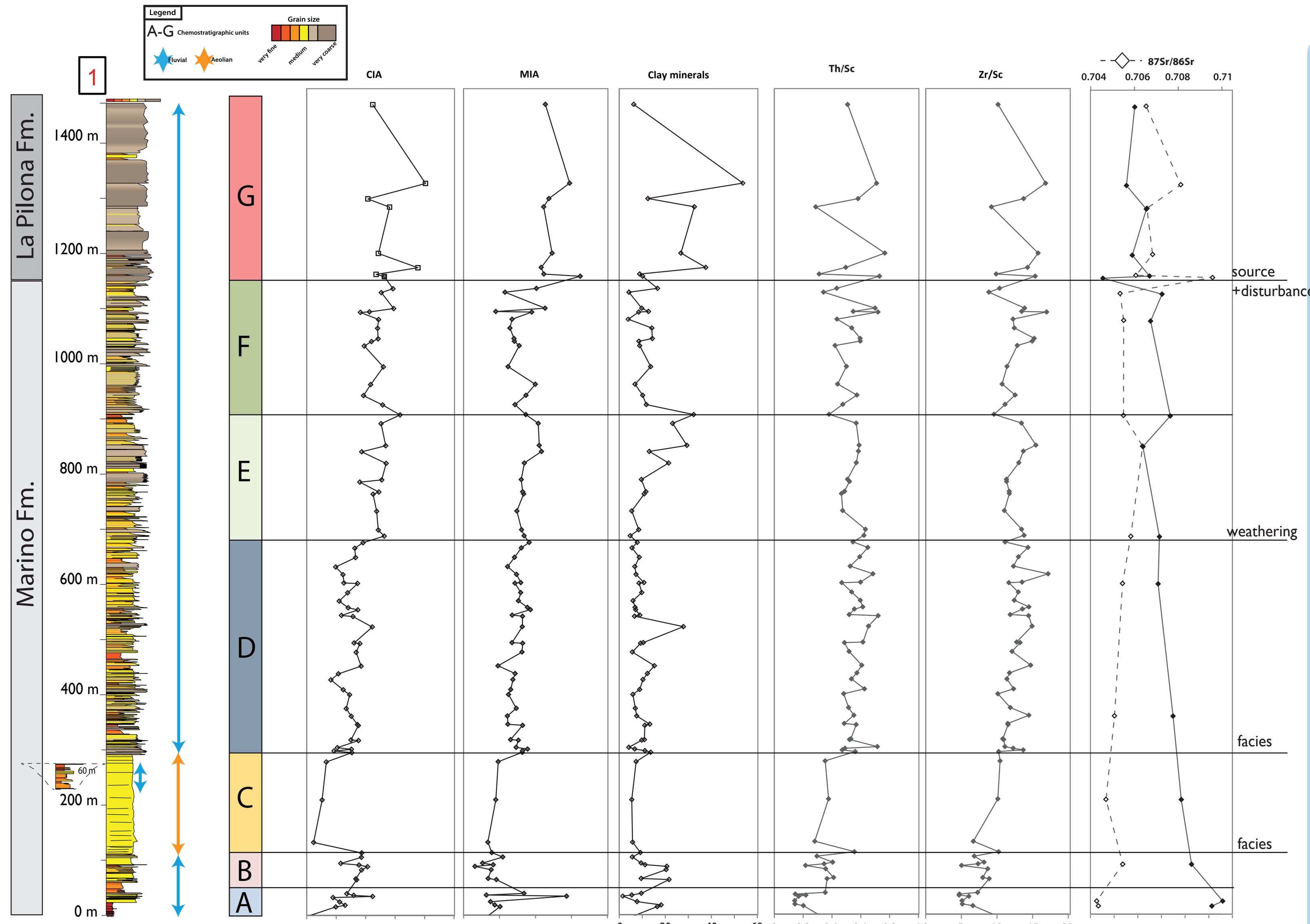


Fig 7. CIA and MIA represent ing, respectively, the chemical and mineralogical maturity of the sandstones. Clay mineral content given in area % (sum of kaolinite, illite and smectite content in the samples). The CIA trend of sandstones from the La Pilona Formation is very similar to that of the clay-mineral content, suggesting an influence of the hydrodynamic concentration of clays in the weathering index. Th/Sc, Zr/Sc ratios and isotopic ratios of strontium and neodymium (epsilon notation) providing information on the igneous character of the source-rocks.

Weathering and maturity

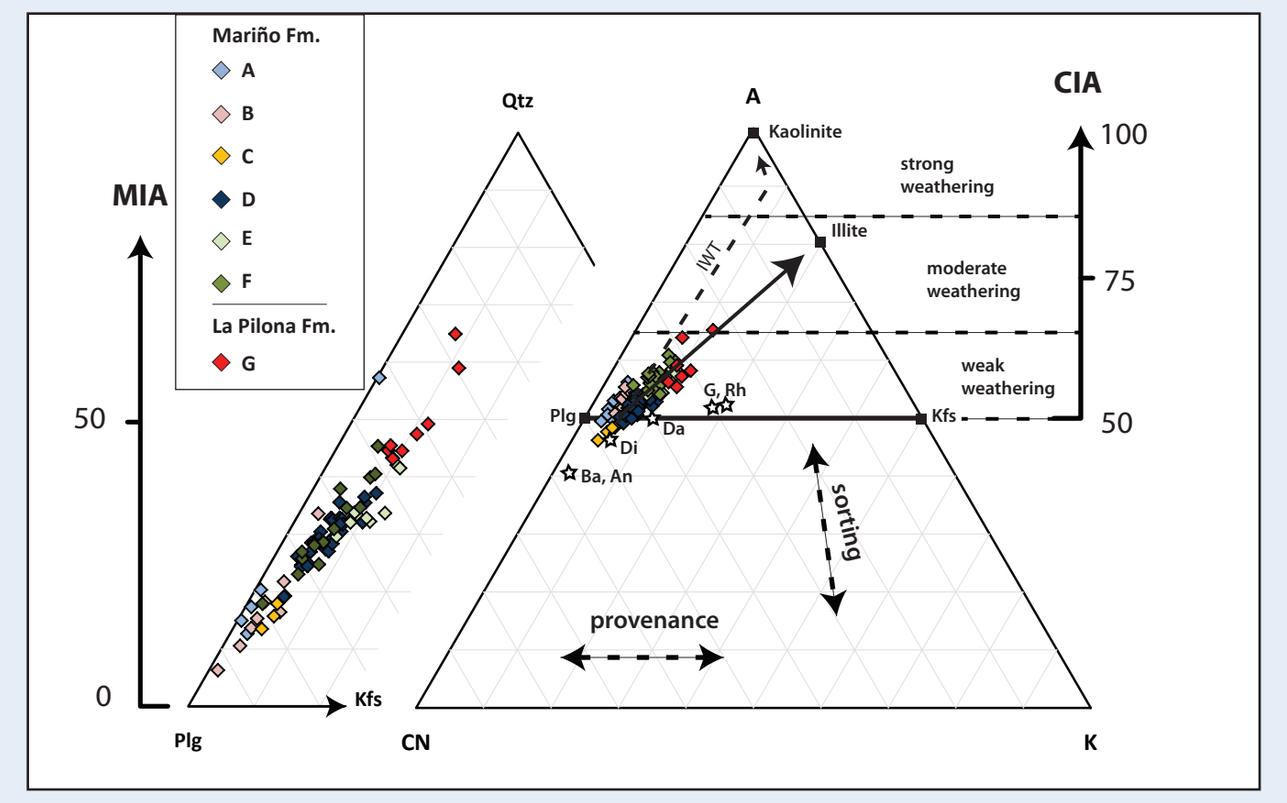


Fig 9. Mineralogical and compositional variations of the sandstones from the Mariño and La Pilona formations. MIA is illustrated in the Qtz-Plg-Kfs (Quartz – Plagioclase - K-feldspar) mineralogical space and CIA is illustrated in the A-CN-K (Al2O3-CaO+Na2O-K2O) compositional space. Based on Nesbitt and Young (1986), Rieu et al. (2007).

Increasing trend of weathering going towards to illite pole (**Fig. 9**), confirmed by the increase in illite content as seen in the petrographic data (QEMSCAN).

The data are deviated from the ideal weathering trend (IWT) probably due to a progressive change in the source-rock composition.

This diagram allows the recognition of the primary source rock, values indicate andesitic composition.

The first and second dimensions (**Fig. 10**; PC1 and PC2 respectively) showthe importance of the weathering and maturity signals and the concentration of heavy-minerals (positive PC2). The samples follow a trend towards the weathering and maturity pole.

Variability of the compsoition

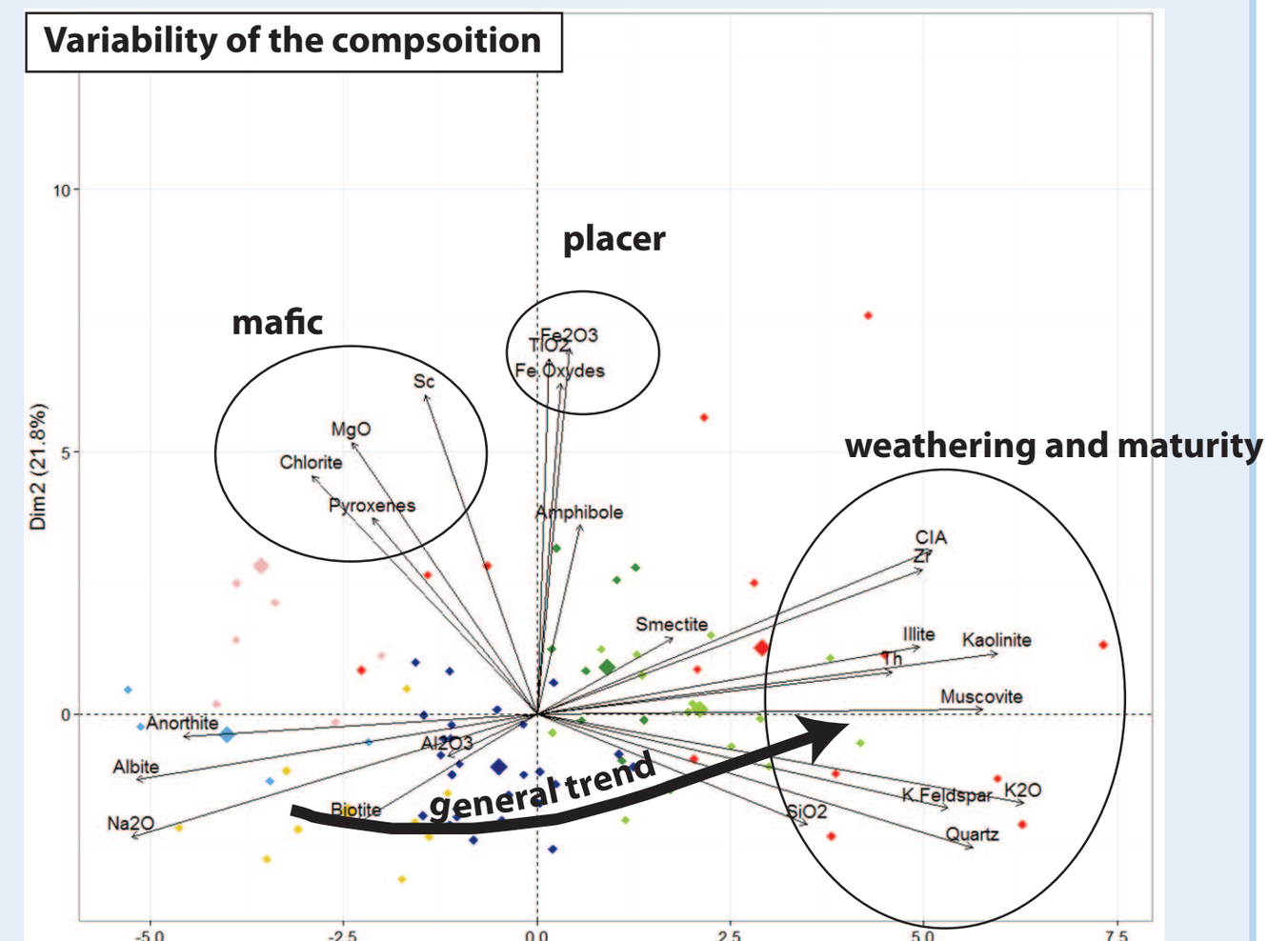
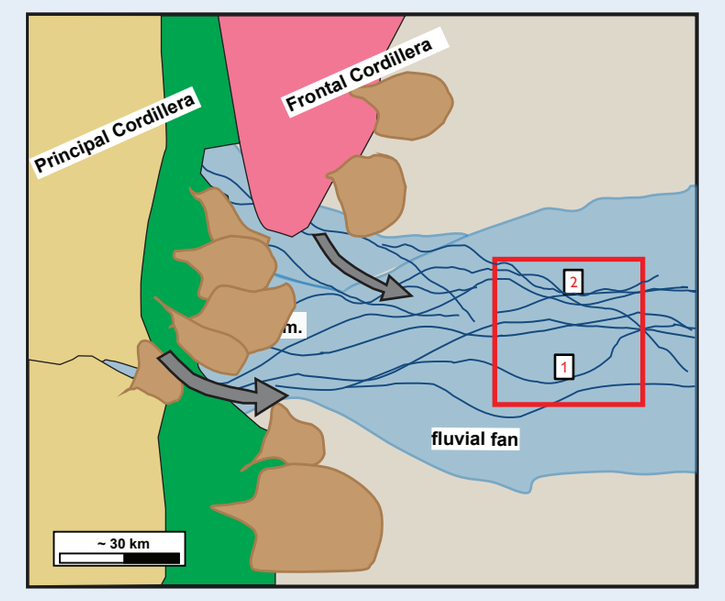


Fig 10. Principal component analysis (PCA) done using the mineralogical and geochemical composition of the sandstones from the Mariño and La Pilona formations. Pole are recognized by their compositional associations.

Evolution of the fluvial-fan

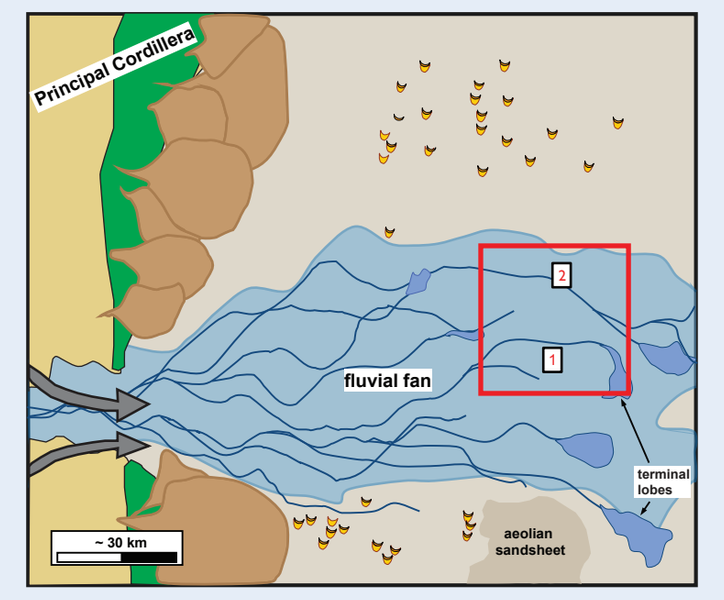


G

Variation of the composition due to the proximity of the mountain range and the contribution of sediments coming from the first stages of the uplift of the Frontal Cordillera.

Migration of the deformation towards the foreland. Progressive unroofing of Paleozoic sequences

Giambiagi and Ramos (2003) reported, in the cogenetic Palomares Formation (Alto Tunuyan Basin), the first arrival of clasts coming from the Frontal Cordillera



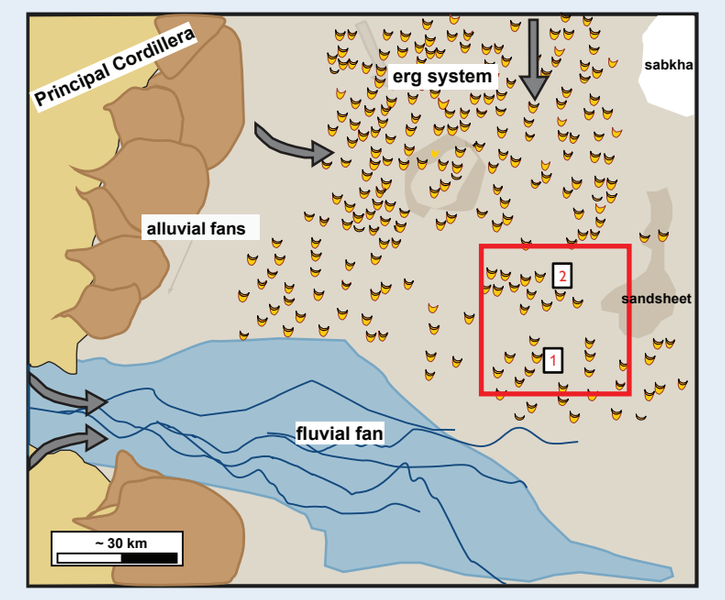
Coarsening upward trend of the sandstone units showing the progradation of the fluvial-fan system during the uplift of the Principal Cordillera.

F

The top of the Marino fm. is characterized by amalgamated coarse-grained channel fills with some conglomeratic levels. The fine-grained deposits are less laterally continuous

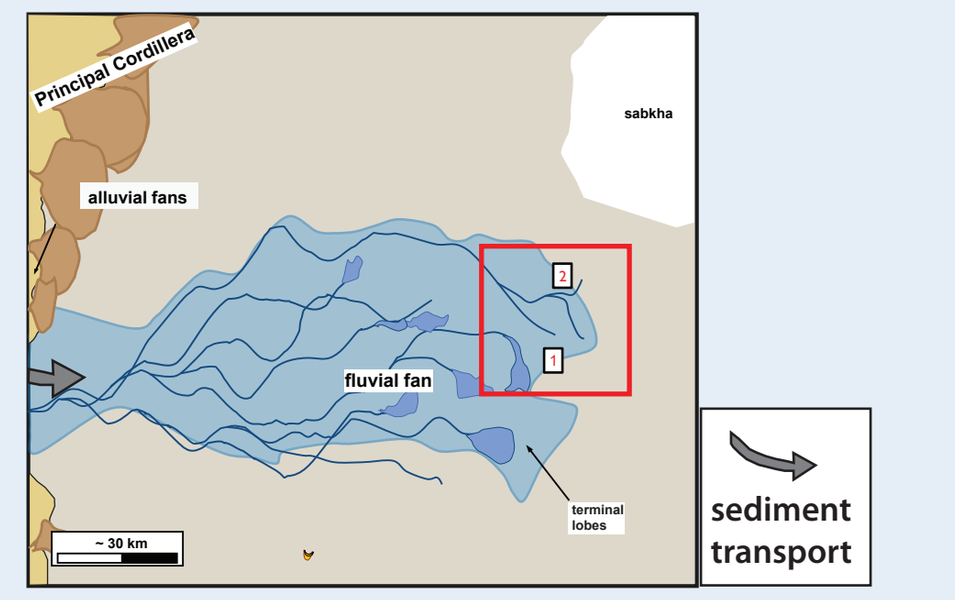
D-E

Fluvial system: amalgamated channel fills and overbank deposits, with tabular geometry and increased lateral connectivity. A few interactions with aeolian deposits at the base. Gradual transition to more coarse-grained deposits



C

Abrupt establishment of an erg system of wide geographic extent but probably of relatively long duration.
Development of a dune field and marginal sand sheets, induced by climatic aridification and/or shift of the main fluvial system.



A-B

Beginning of the fluvial-fan deposition, dominancemuddy deposits intercallated with rare channel fills. Distal environment

Sediments are comming from the erosion of the Principal Cordillera

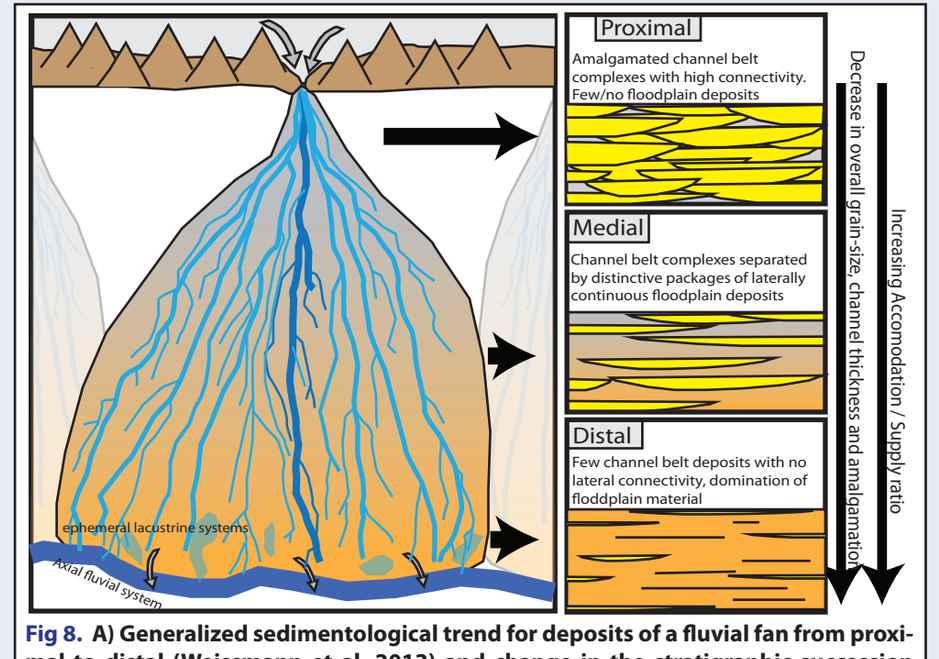


Fig 8. A) Generalized sedimentological trend for deposits of a fluvial fan from proximal to distal (Weissmann et al. 2013) and change in the stratigraphic succession from the apex to the distal part of the system (Owen et al. 2015)

The overal stratigraphic picture shows a gradual transition from distal to proximal facies associations recording the progradation/aggradation of a large fluvial-fan in semi-arid/arid environment during the Miocene.

Provenance

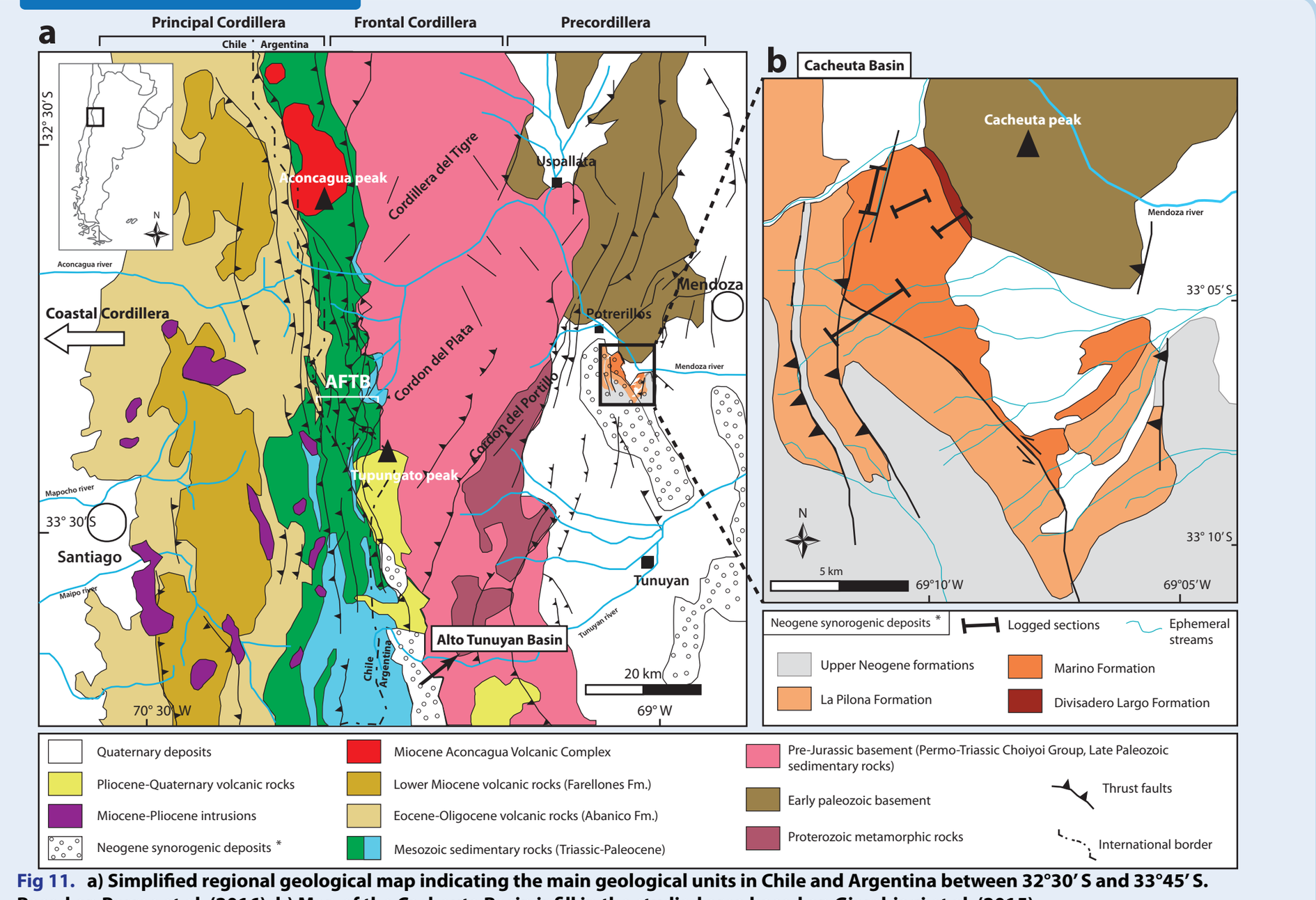


Fig 11. a) Simplified regional geological map indicating the main geological units in Chile and Argentina between 32°30' S and 33°45' S. Based on Porras et al. (2016). b) Map of the Cacheuta Basin infill in the studied area based on Giambiagi et al. (2015).

The progressive evolution through stratigraphy of the whole-rock isotopic composition towards relatively more felsic sources is gradual. For the basal part of the Mariño Formation (units A and B) the main source could be the andesites and basalts of the Abanico Formation in the western Principal Cordillera.
Units D, E and F reveal sources related to the Farellones Formation and the Aconcagua Volcanic Complex In agreement with the progressive eastward advance of the volcanic front by approximately 50 km from the Farellones Arc in the Middle Miocene
Sandstone from the La Pilona Formation have very variable composition, possibly reflecting a contribution from the Choiyoi Group, in the Frontal Cordillera. However, the exact provenance of sand fraction from the La Pilona Formation is masked by the effects of heavy-mineral concentrations (mostly Fe-Ti oxides) as placer deposits within laminae of sampled sandstones

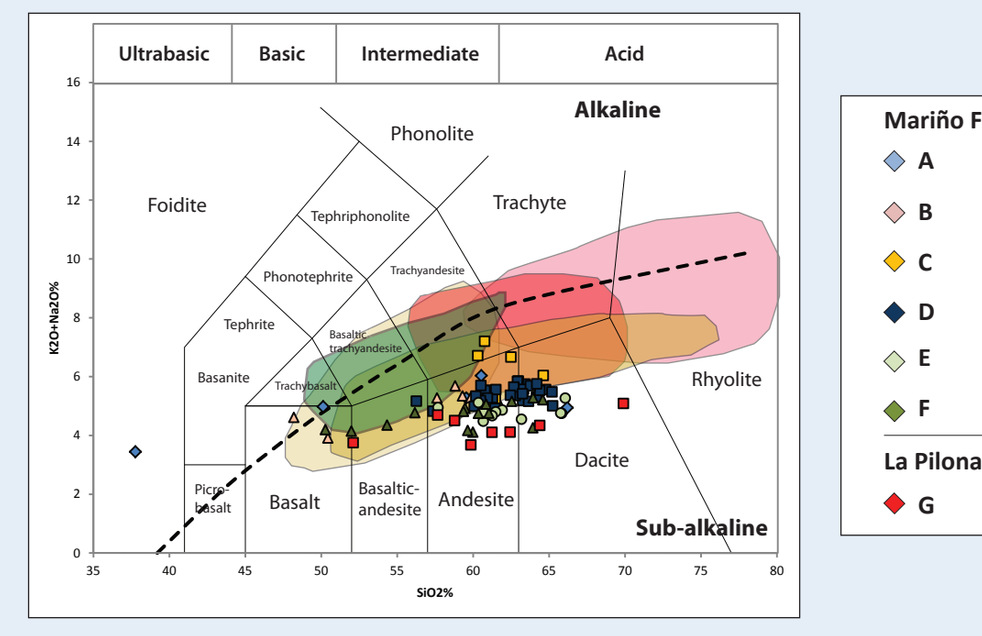


Fig 12. K2O+Na2O vs. SiO2 (TAS) diagram for the nomenclature of volcanic rocks after Le Maitre et al. (1989). Modified after Alarcon and Pinto (2015).

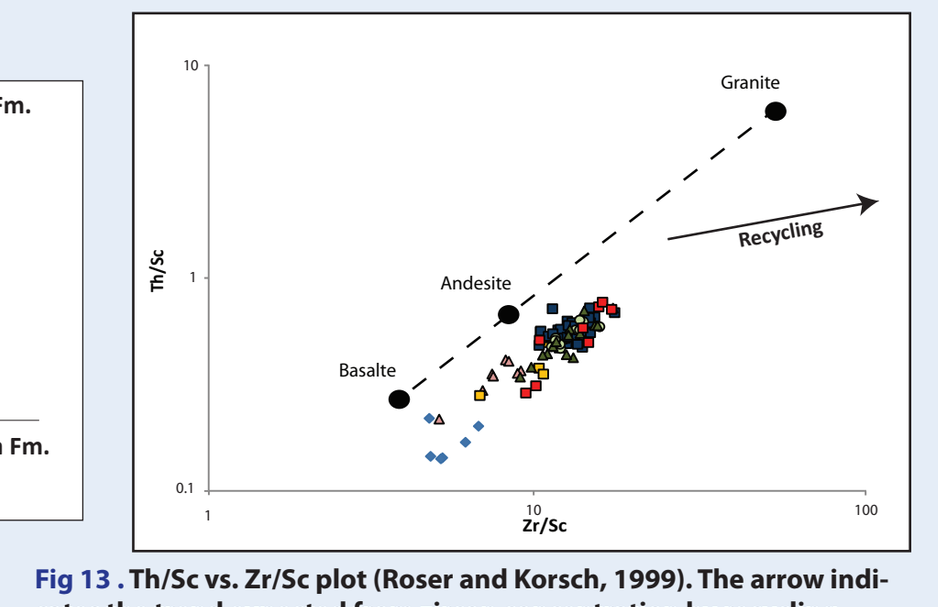
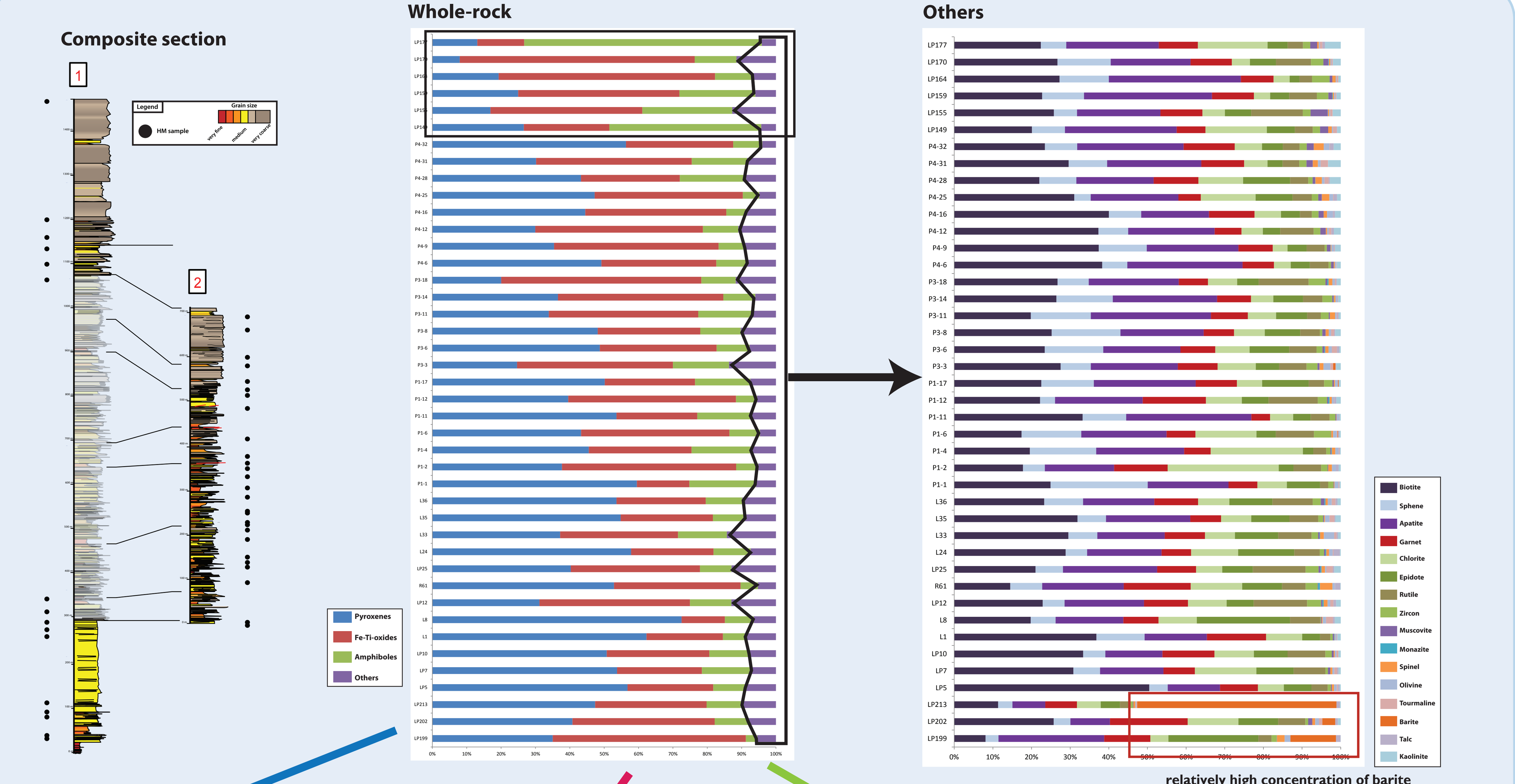
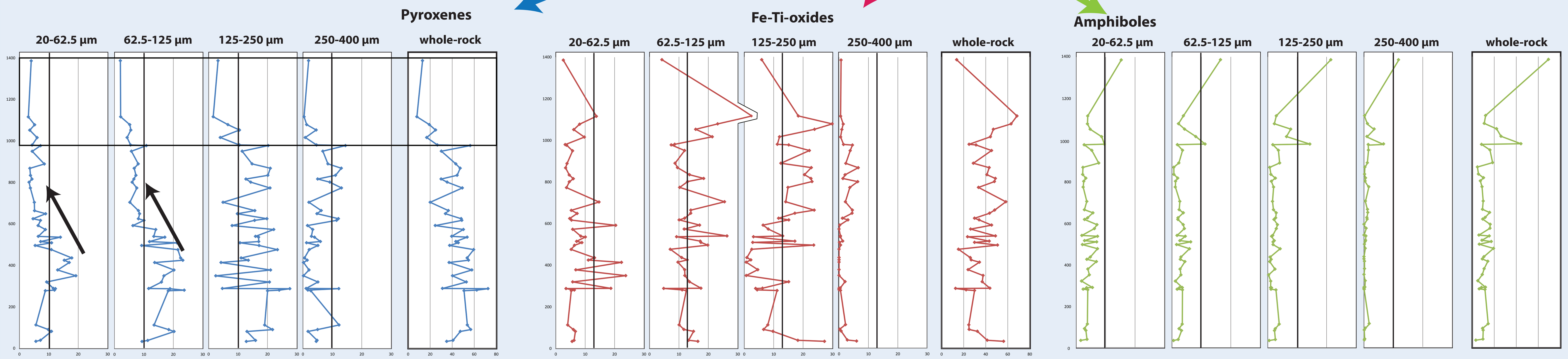


Fig 13. Th/Sc vs. Zr/Sc plot (Roser and Korsch, 1999). The arrow indicates the trend expected from zircon concentration by recycling processes. In dashed line the compositional trend from basalt to granite proposed by Mongelli et al. (2006)

Heavy minerals (ongoing work)





- Heavy-minerals study based on QEMSCAN results, confirmed by conventional petrographic tools
- Wide range of grain-size (from 20 to 400 µm) in order to better represent the whole distribution
- Assemblage dominated by pyroxenes, Fe-Ti-oxides and amphiboles
- Others heavy-minerals represent, in average, less than 10 %. Their variabilityiis mostly blurred
- Pyroxene very low in La Pilona Formation

General trends:
- Pyroxene is decreasing
- Amphibole is increasing

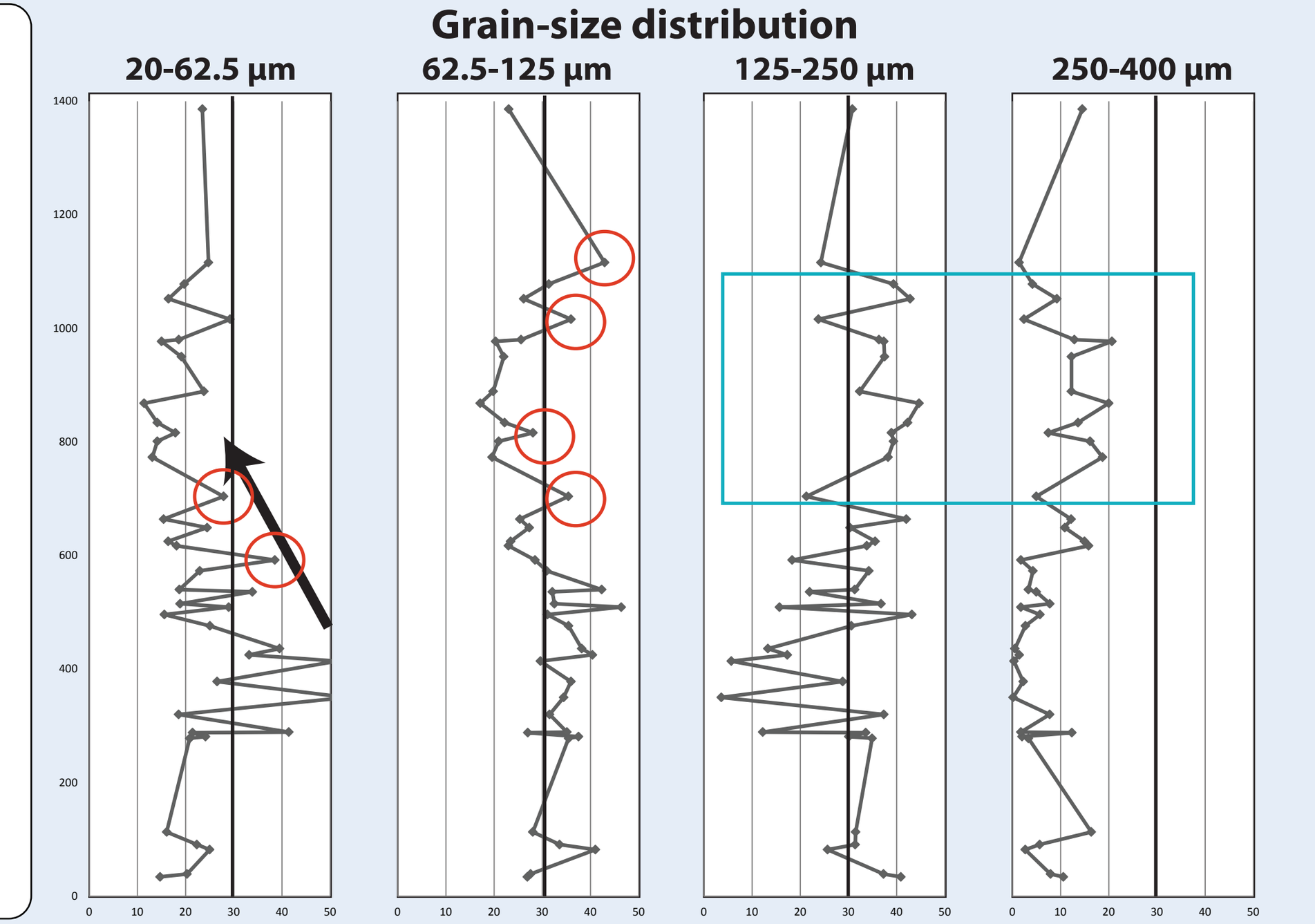
very low pyroxene high amphibole

isolated peaks of Fe-Ti-oxides

Fe-Ti-oxides defines the variations, but Pyroxene defines the general trends

overall grain-size increase

Grain-size distribution



Next step:

- Interpretation of the grain-size distribution of the main heavy-minerals
- Zircon dating for precise provenance investigation, to understand the relationships between deposition in the bassin and exhumation of the Andes

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