

Geochronology of the Nepheline Syenite of el Jordán, Guaviare Colombia, evidences of Neoproterozoic-Cambrian intraplate magmatism and its implications during Pan- African tectonics in western Gondwana.

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Abstract

This study presents the preliminary results of U-Pb dating of large zircon crystals found at the pegmatite phases of the Nepheline Syenite of San José del Guaviare Colombia. The study area locates to the east of the Colombian Andes where most of the Guiana shield is cover by a thick clastic sequence of Cenozoic sediments derived from the Andean exhumation. In this realm are found several ranges, decimated along this extensive area of the Guiana shield that preserve remnants of Paleo and Neoproterozoic outcrops, intruded by granitoids in many cases of unknown ages, these Precambrian units are capped by relicts of Cambrian and Cretaceous sedimentary rocks as well. Nepheline Syenite outcrops were explored in the vicinity of San Jose del Guaviare, at the locality of el Jordán, samples of rock, pegmatite, colluvium deposits and active sediments, were collected. Petrographically, the analyzed syenites are composed mainly of potassium feldspar, nepheline, plagioclase, and traces of biotite and calcite, the rocks are totally depleted of quartz. Whole rock geochemistry (FRX) from 20 samples indicates insaturated and peralkaline rocks. From active sediments and colluvium related to pegmatites from the Nephelinitic Syenite, abundant zircon, magnetite and ilmenite crystals up to 2 cm diameter were recovered. Geochemistry of zircon (FRX, MEB-EDS) showed Hf enrichment, light and heavy rare earth elements as Yb, Dy, Ho, La, Pr, Sm, Nd, Pm, Eu elevated contents as Th and U evidence their metamictic character of these crystals. Cathodoluminescence imagery showed growth and oscillatory zoning, sometimes convolute zoning and deep fracturing, also frequently crystals displayed cores. Even with intense fracture and metamictization, because of crystal size we were able to analyze 20 crystals by LA-ICP-MS U-Pb. Our results showed concordant Neoproterozoic-Cambrian ages that can be correlated with previously obtained ages of c.a. 577.8 ± 6.3 – 9 Ma in a site 17 km towards the NW of our location, confirming thus the extent of this intraplate magmatic unit and its regional character. Such alkaline magmatism is devoid in the rest of the Colombian Andes further to the west, implying that magmatism of this age present in the intracratonic part that currently conforms the Eastern part of Colombia is widespread and could have occurred as consequence of the Pan- African orogeny, as mobile belts accreted to the NW part of Gondwana continental margin. Currently other sites are under our scope since reports of such large zircon crystals can represent a very uncommonore product of very specific tectonics and geochemistry, and a very complex evolutionary history that we intend to unveil.

8.Palaeogeographic Setting

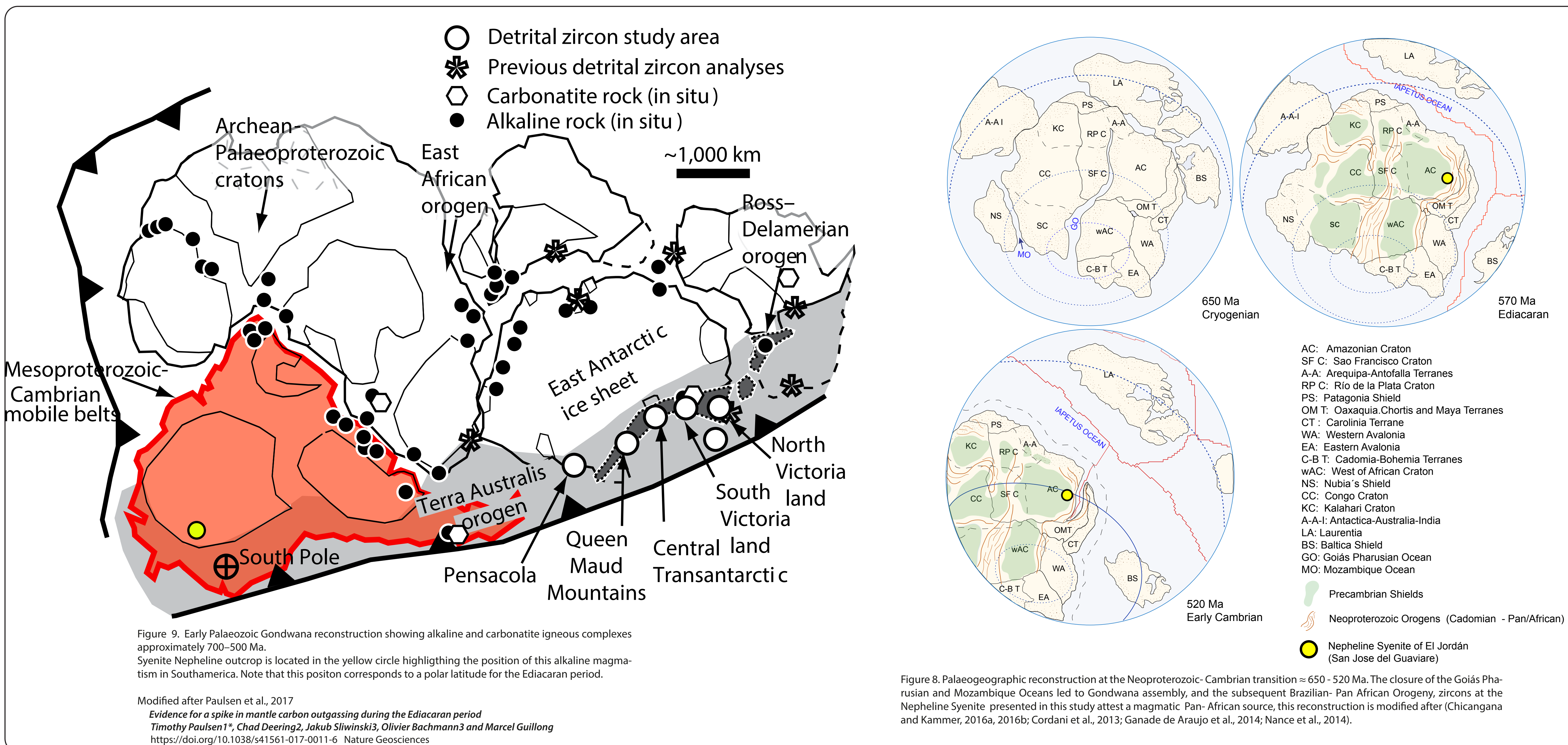


Figure 9. Early Palaeozoic Gondwana reconstruction showing alkaline and carbonatite igneous complexes approximately 700-500 Ma. Syenite Nepheline outcrop is located in the yellow circle highlighting the position of this alkaline magmatism in South America. Note that this position corresponds to a polar latitude for the Ediacaran period. Modified after Paulsen et al., 2017. Evidence for a spike in mantle carbon outgassing during the Ediacaran period. Timothy Paulsen¹*, Chad O'Leary², Jakob Steinwold³, Oliver Bachmann³ and Marcel Gutzler⁴ <https://doi.org/10.1038/s41561-017-0011-6>. Nature Geosciences

9. Conclusions

- The Nepheline Syenite is an Ediacaran alkaline magma emplaced on the Guiana Shield
- These rocks are an ore of large zircon crystals
- High HREE content, including Y and Nb evidence the magmatic origin of this zircons
- Emplacement occurred as intraplate A magmatism, during the Pan -African Orogeny, this process was coeval with the UHP metamorphism at the interior of Gondwana, and barrovian metamorphism in the continental margin of Gondwana (Cadomian-Terra Australis), the later in a subduction setting.
- Alkaline magmatism of the same age is widespread, following the western Gondwana orogen trend, often associated with carbonatites
- The Colombian Nepheline Syenite magmatism occurred during a a global CO₂ excursion into the atmosphere for the Ediacaran period Followed by the Cambrian explosion and the evolution of complex life-forms
- Future in-situ trace element analysis and ¹⁸O ¹³C isotopes, will provide atmospheric constrains, for the polar position of this portion of the continental margin of Gondwana during Ediacaran.

Acknowledgements

The rural and indigenous communities that provided access to the studied locations, U-Pb geochronology was performed at the facilities of the Colombian Geological Survey

1. Location

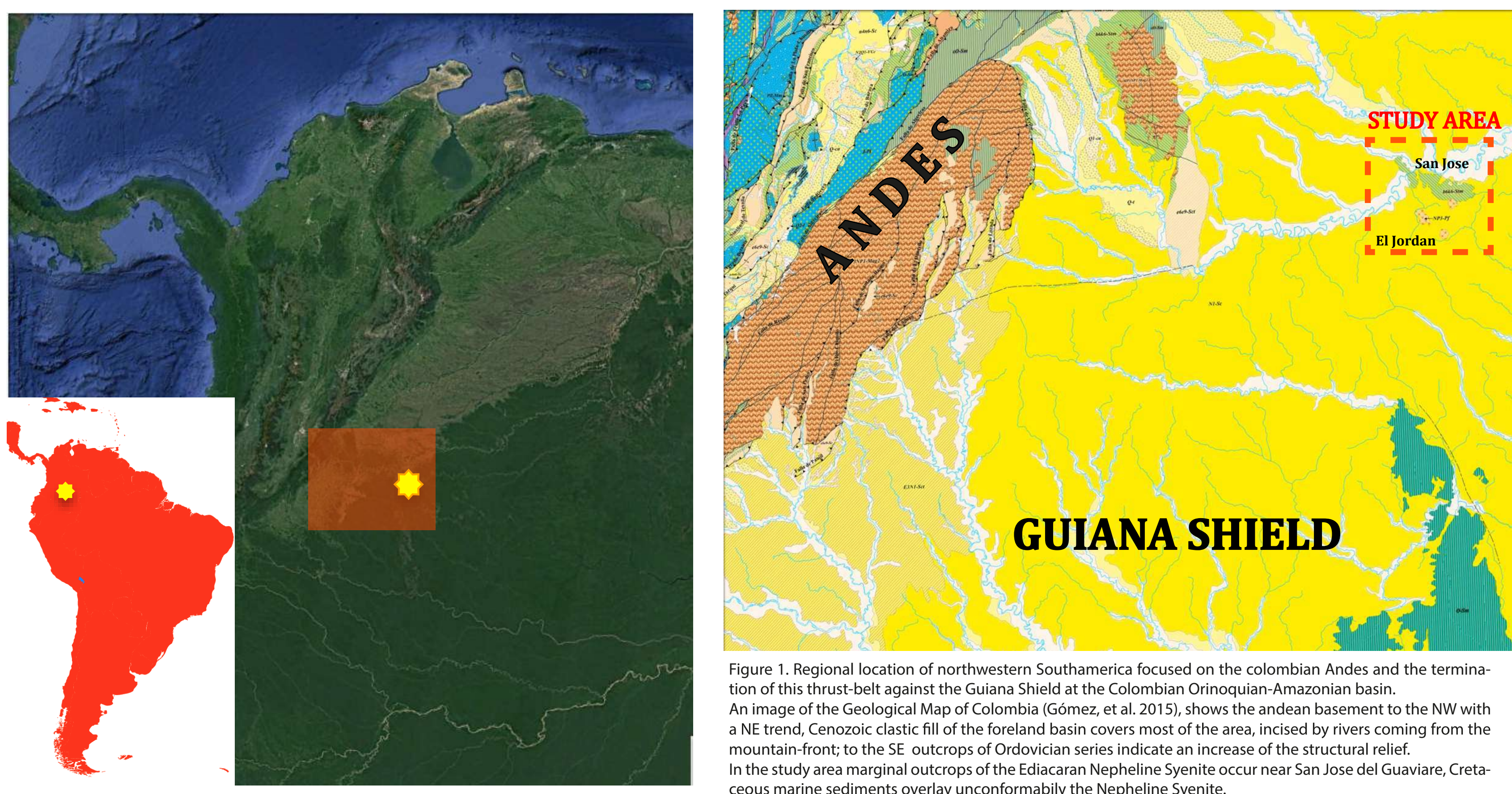


Figure 1. Regional location of northwestern South America focused on the Colombian Andes and the termination of this thrust-belt against the Guiana Shield at the Colombian Orinoquian-Amazonian basin. An image of the Geological Map of Colombia (Gómez, et al. 2015), shows the andean basement to the NW with a NE trend. Cenozoic clastic fill of the foreland basin covers most of the area, incised by rivers coming from the mountain-front to the SE outcrops of Ordovician series indicate an increase of the structural relief. In the study area marginal outcrops of the Ediacaran Nepheline Syenite occur near San Jose del Guaviare, Cretaceous marine sediments overlay unconformably the Nepheline Syenite.

7.Global Age Spectra

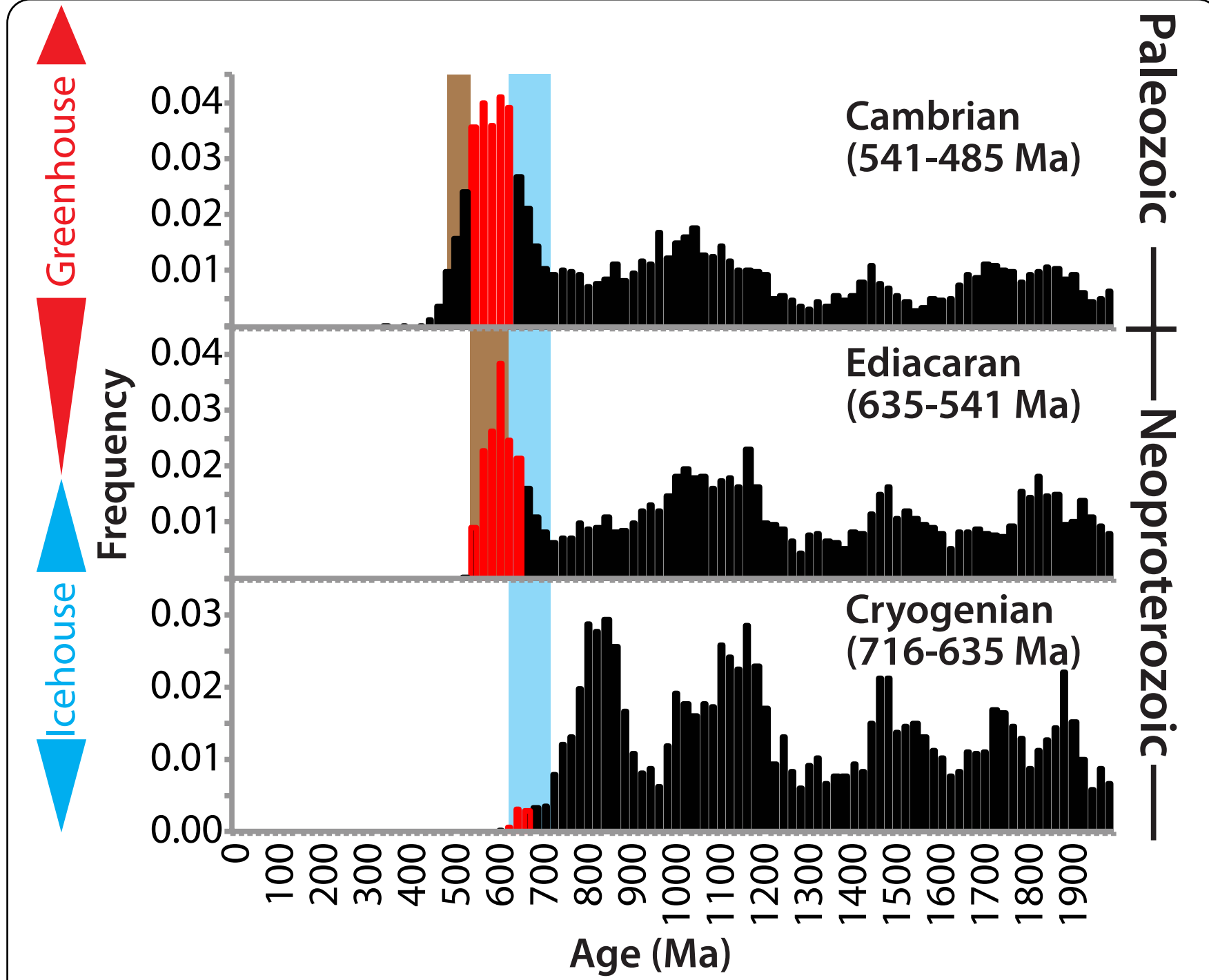
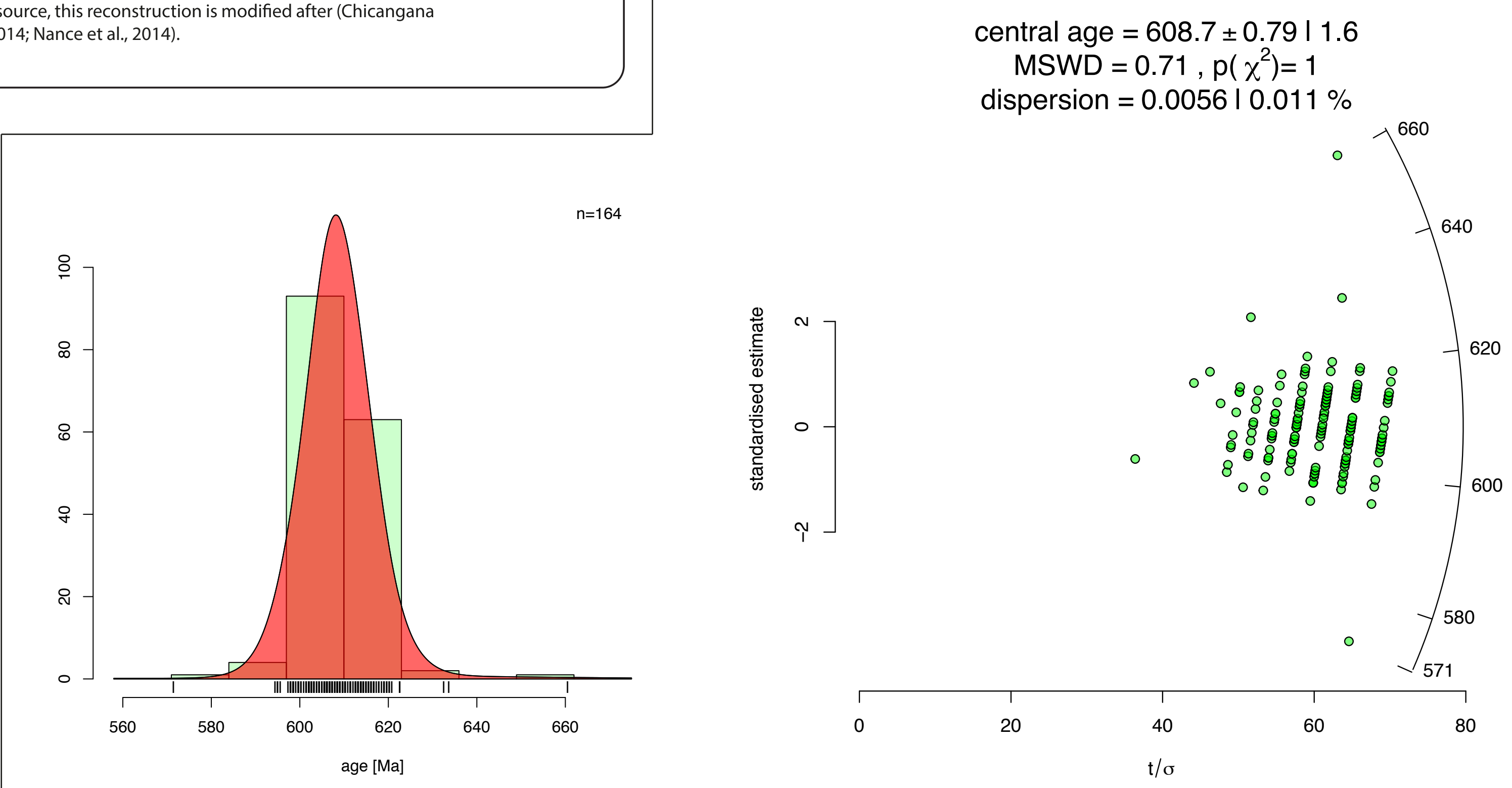


Fig. 7 : Normalized composite zircon U-Pb age distributions for global Cryogenian to Cambrian sedimentary deposits. Age histograms use 20-Ma bins. Vertical brown bars demarcate the depositional age range of each geologic period. Vertical blue bars highlight the Cryogenian glacial interval to note the persistent low abundance of zircons transiting into this interval. Red bins bracket the ages obtained for the Nepheline Syenite of el Jordán, San Jose del Guaviare, evidencing a global increase in magmatic activity during Ediacaran. Modified after McKenzie et al., 2014. Continental arc volcanism and the principal driver of icehouse-greenhouse variability. N. Ryan McKenzie, 1,2,3* Brian K. Horton, 2,4 Shannon E. Loomis, 2 Daniel F. Stock, 2 Noah J. Planavsky, 1 Cin-Ty A. Lee, doi:10.1126/science.aad5787. Science

Fig. 6: Zr U-Pb Geochronology results on crystals of the Nepheline Syenite of el Jordán, data reduction was performed in ICP-MS software using Iolite for baseline extraction, and data reduction of isotopic ratios, results are plotted in Iolite (Vermesche 2018). All selected and plotted data is beyond 95% concordance. Concordia, weighted average, KDE and Radial plots. Evidence a central and mean age clustering around 608 ± 1 Ma, accordingly MSWD between 0.56-0.71 evidences a single statistical population.

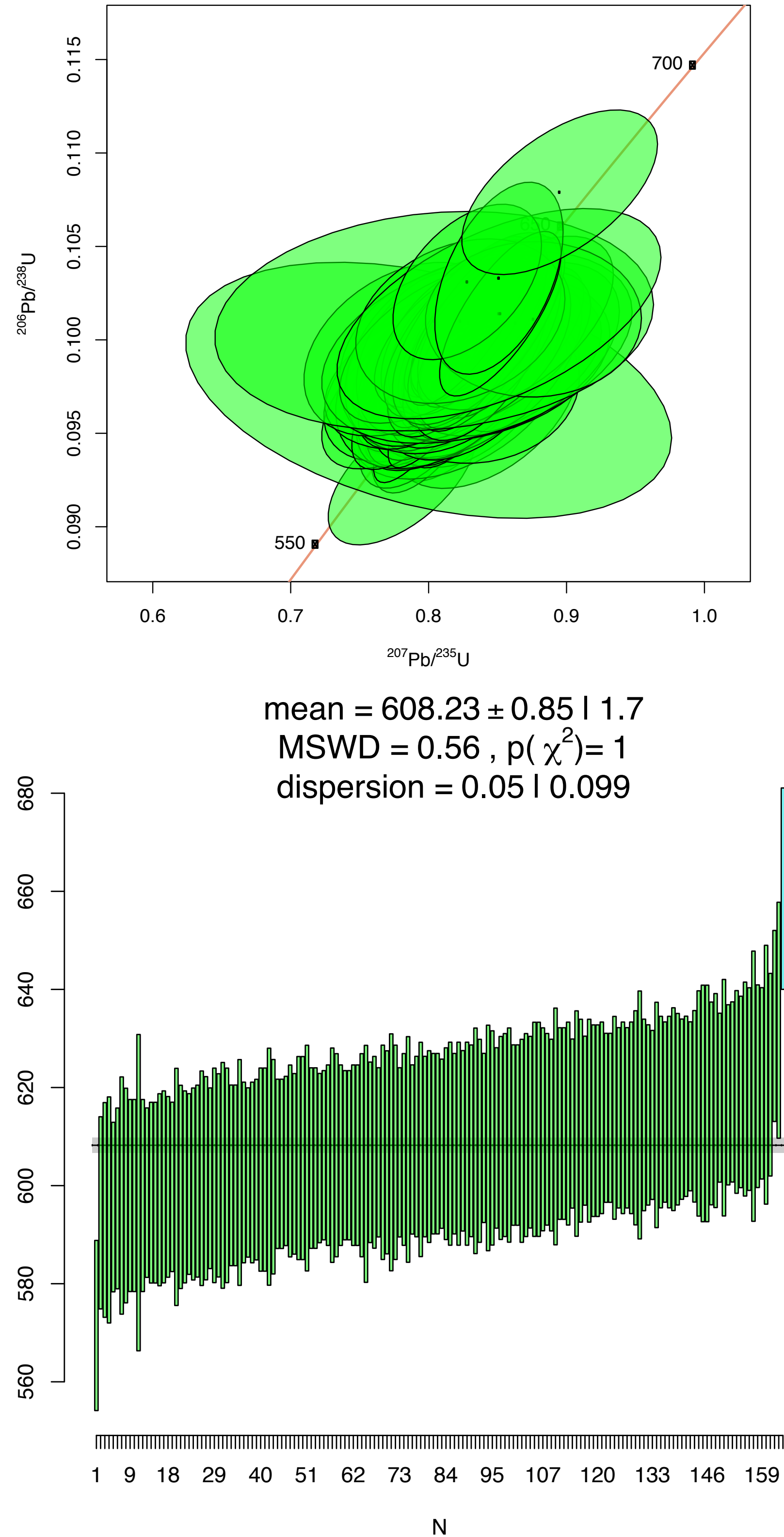


3. The Nepheline Syenite of San Jose del Guaviare



Figure 2. General aspect of the outcrops of the Nepheline Syenite of San Jose del Guaviare (NP3-Pf) according to SGO and surrounding locations, at the lower right Cretaceous Sediments (Ks) in an unconformity overlay the crystalline basement, characteristic rounded weathering is observed in all locations.

6. U-Pb LA-ICP-MS Geochronology



5. Cathodoluminescence Imagery

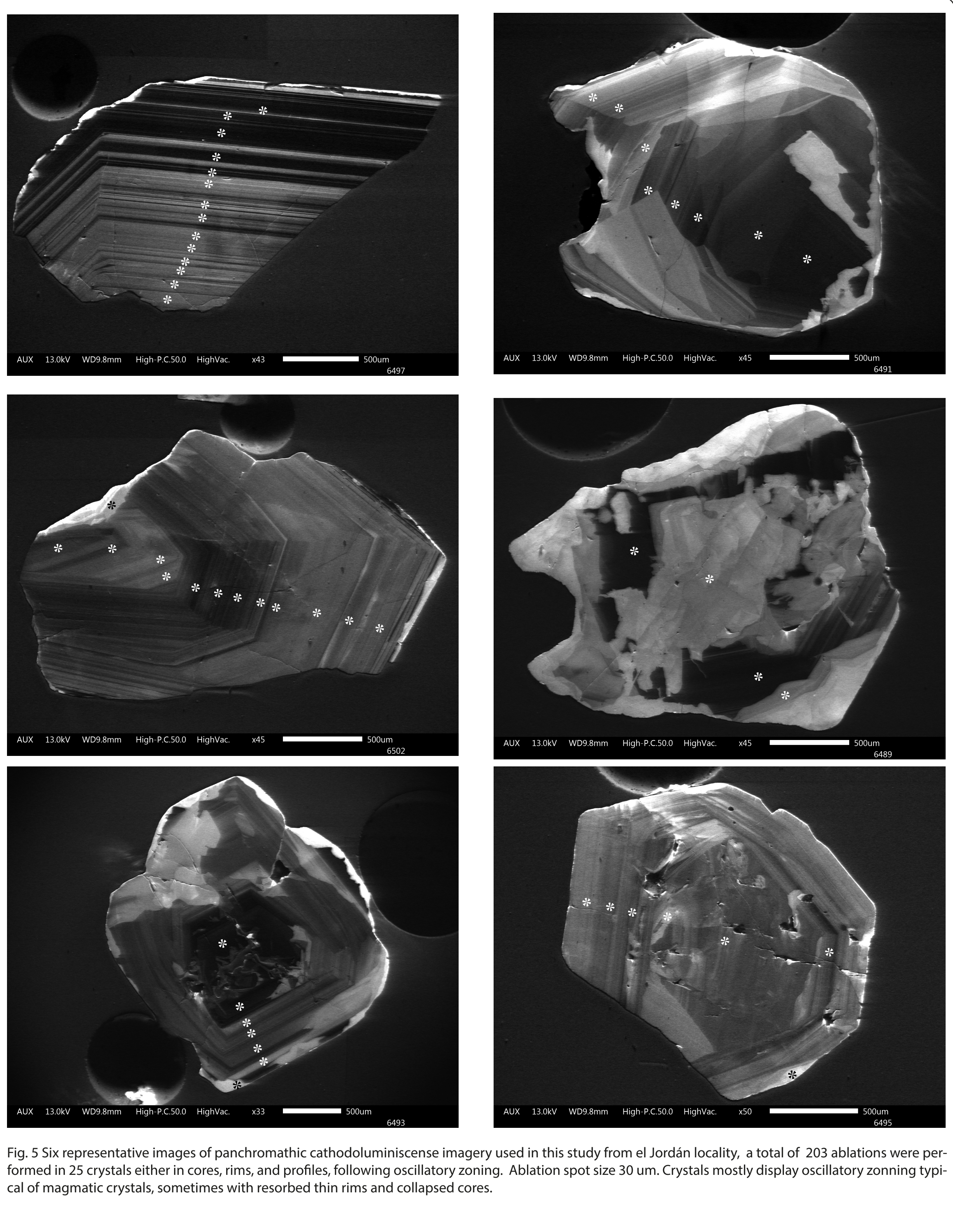


Fig. 5 Six representative images of panchromatic cathodoluminescence imagery used in this study from el Jordán locality, a total of 203 ablations were performed in 23 crystals either in cores, rims, and profiles, following oscillatory zoning. Ablation spot size 30 μm. Crystals mostly display oscillatory zoning typical of magmatic crystals, sometimes with resorbed thin rims and collapsed cores.

4. Mineral Chemistry by SEM - DRX

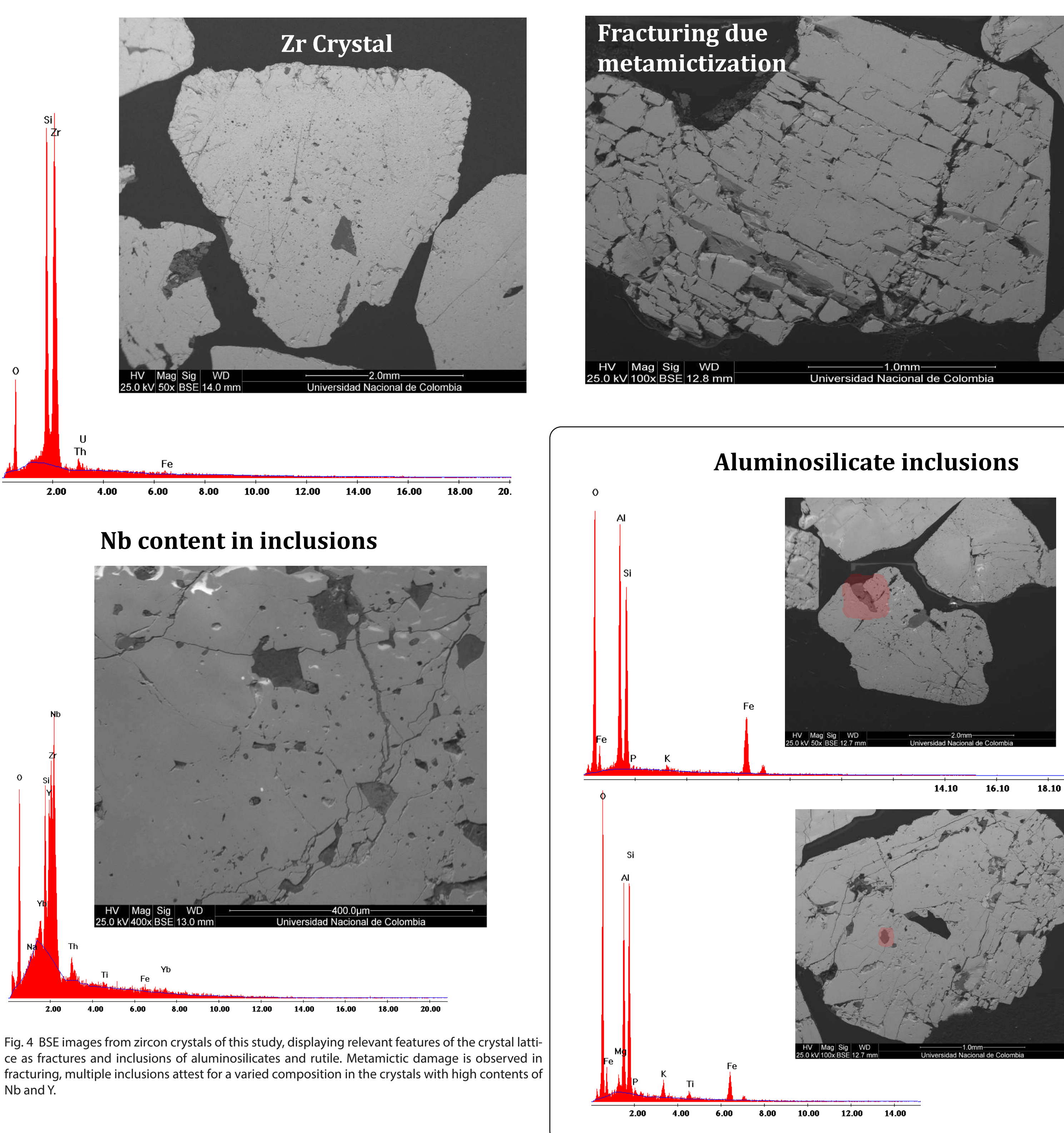


Fig. 4 BSE images from zircon crystals of this study, displaying relevant features of the crystal lattice as fractures and inclusions of aluminosilicates and rutile. Metamictic damage is observed in fracturing, multiple inclusions attest for a varied composition in the crystals with high contents of Nb and Y.