

ARE ALL DETRITAL METASSEDIMENTARY ROCKS OF THE CRIXÁS GREENSTONE BELTS ARCHAEOAN AND OF THE SAME PROVENANCE? A DISCUSSION BASED ON REE GEOCHEMISTRY

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The sedimentary history of the Crixás, Guarinos, and Pilar de Goiás 2.8 Ga old contiguous greenstone belts (Fig. 1) occurs in two stratigraphic contexts. The earliest contains only BIF, metacherts, and minor manganese formations interlayered with metakomatiites and tholeiitic metabasalts of the lower and middle stratigraphic sections. The later overlies metabasalts and is made up, in Crixás and Guarinos, of a thick carbonaceous phyllites followed by distal metaturbidites pile, and, in Pilar de Goiás, of metachert and calcisilicate rocks overthrust by carbonaceous phyllites and metapelites.

Goldshmidt (1933) first suggested that sediments should provide a natural sampling of the exposed crust. Since then, it became gradually clear that trace element geochemistry, such as REE, are effective for distinguishing Archaean detrital metasedimentary rocks from Post Archaean equivalents⁽²⁾. Figures 2A and 2B show typical REE signatures of worldwide examples of Archaean detrital metasedimentary rocks. From the graphs, the following main features of Archaean detrital rocks are extracted: (a) REE normalized to chondrite (Fig. 2A) have fractionated LREE relative to HREE ($La_N/Yb_N \approx 5$), unfractionated HREE, and lack Eu (Eu_N/Eu^*_N) anomalies, and (b) REE normalized to Post-Archaean sedimentary standards (Australian PAAS) show slight depletion of LREE relative to HREE, and positive Eu anomalies.

To better understand the petrographic and geochemical nature of detrital metasedimentary rocks of the three belts, and compare them to other Archaean worldwide equivalents, in 1993 the authors sampled carbonaceous phyllites and metaturbidites of Guarinos⁽³⁾ (see figure 1 for location of samples referred in the text). To allow a comparison with trace element behavior of Post-archaean rocks, sampling also included metapelites of the nearby overthrust NeoProterozoic Araxá Group.

Coincidentally, in 1993 Dr. Umberto G. Cordani asked the senior author to provide him with a representative sample of the Crixás Archaean detrital metasedimentary rock to concentrate zircon for U/Pb SHRIMP dating in Australia. The sample is from a metaturbidite outcrop located just a few meters East of the bridge over the Rio Vermelho, 2.5 km South of Crixás, in the road Crixás-Itapaci. Surprisingly, the age of the analyzed detrital zircon came out to be of 2.2 Ga (Umberto G. Cordani, personal communication, 1995).

It then became evident that we were misinterpreting the age of the late sedimentation event of the three belts, by considering all lithotypes indiscriminately Archaean. This motivated us to test trace element data, in particular REE, as a tool to distinguish Archaean from Post-Archaean lithotypes in the region. The metaturbidite with 2.2 Ga zircon was then re-sampled and analyzed for REE by INAA. REE of this metaturbidite normalized to chondrite (Fig. 3A)

shows a fractionation $La_N/Yb_N = 10$, and a negative Eu anomaly of 0.4. REE Normalized to PAAS (Fig. 3B) are flatlying ($La_N/Yb_N \approx 1$), evidencing the geochemical similarity among this metaturbidite and Post-Archaean sedimentary rocks. These similarities also occur with rocks of the Araxá Group (Figs. 4A and 4B).

Published REE data of detrital metasedimentary rocks of the Meia Pataca Mine, in Crixás⁽⁴⁾, of Guarinos^(3,4), and Pilar de Goiás⁽⁵⁾ were then re-processed and their normalized REE signatures compared (Fig. 5). In the meantime, one sample of carbonaceous phyllite and one of metaturbidite, both from a drill-core at the Mina III, Crixás, were also sent for REE analysis by INAA (Fig. 6) to compare with the nearby Meia Pataca Mine rocks.

Figures 5A and 5B show that the Meia Pataca metagraywackes, the metaturbidite with 2.2 Ga zircon, and the Araxá Group have identical REE signatures and differ from typical Archaean rocks (Fig. 1). Chondrite normalization shows a larger LREE/HREE fractionation, fractionated HREE, and negative Eu anomalies. Normalization to PAAS results in a flatlying signature, close to unit, as expected for Post-Archaean metasedimentary rocks. This indicates that the clastic loads for the 2.2 Ga zircon metaturbidite, the Proterozoic Araxá Group metapelites, and the Meia Pataca Mine metagraywackes have identical provenances. Therefore, we suggested that these units formed by clastic loads fed from sources dominated by Potassium feldspar, as typical of cratonic areas younger than 2.5 Ga.

In contrast, the REE of the Guarinos samples normalized to chondrite (Fig. 5C) have less fractionated HREE and lack negative Eu anomaly. Normalization to PAAS (Fig. 5D) shows a flatlying signature with a subtle trend of HREE enrichment, and a large positive Eu anomaly. The positive Eu anomalies suggest a source-area with abundant plagioclase, as expected for Archaean clastic loads.

In Pilar de Goiás, three distinct signatures occur⁽⁵⁾, both by REE normalization to chondrite and PAAS (Figs. 5E and 5F). In the first, the three sets have similar fractionation of LREE, but differ in their HREE, and have identical negative Eu anomalies. In the later, one group of samples has a REE signature that is identical to Post-Archaean rocks. Another group fits the Archaean signature. The third group does not fit any other samples and is not yet understood due to the lack of detailed petrographic description.

Finally, the carbonaceous phyllite and the metaturbidite from the Mina III drill-hole (Fig. 6) have typical Archaean REE signatures. This contrasts with the nearby Meia Pataca Mine metagraywackes and the very close, about 300 m apart, metaturbidite with 2.2 Ga zircon.

These observations lead to several conclusions that are, in their turn, fundamental to interpret the late clastic

sedimentary evolution of the Crixás, Guarinos, and Pilar de Goiás greenstone belts.

First, that these units contain metasedimentary rocks both with typical Archaean and Post-Archaean REE signatures.

Second, the 2.2 U/Pb age of detrital zircon indicates that crystallization of the source-rock took place during the Paleo-Proterozoic, and even without its deformation, several long-term processes are required before the clastic load reached the deposition site. This means that sedimentation could have taken place at any time during the Proterozoic.

Third, metaturbidites and metagraywackes are not typical rocks of the Araxá Group. On the other hand, the Group is entirely allochthonous in the Crixás region. This implies that part of the post-Archaean rocks may represent Paleo to Mid Proterozoic sedimentary events. Additionally, many metapelites of the Pilar de Goiás belt are similar to those of the Araxá Group. It may, therefore, be concluded that some of the metasedimentary rocks interpreted as Archaean in the region may in part represent a sedimentary event so far not identified in Central Goiás, while others may well be part of the Araxá Group.

Fourth, the coexistence of Archaean and Post-Archaean metasedimentary rocks in the same stratigraphic context of at least two belts must be due to tectonic imbrication and infolding during Proterozoic events. The structural and stratigraphic consequences of the Araxá Group overthrusting onto the aCrixás Archaean segment has probably been overlooked and underestimated. This requires a better understanding of the structural framework of the three belts and intervening granitoid blocks, as well as the mapping of major structural discontinuities. These discontinuities are

the most probable sites of important tectonic mixing of cover and Archaean rocks, so far not recognized.

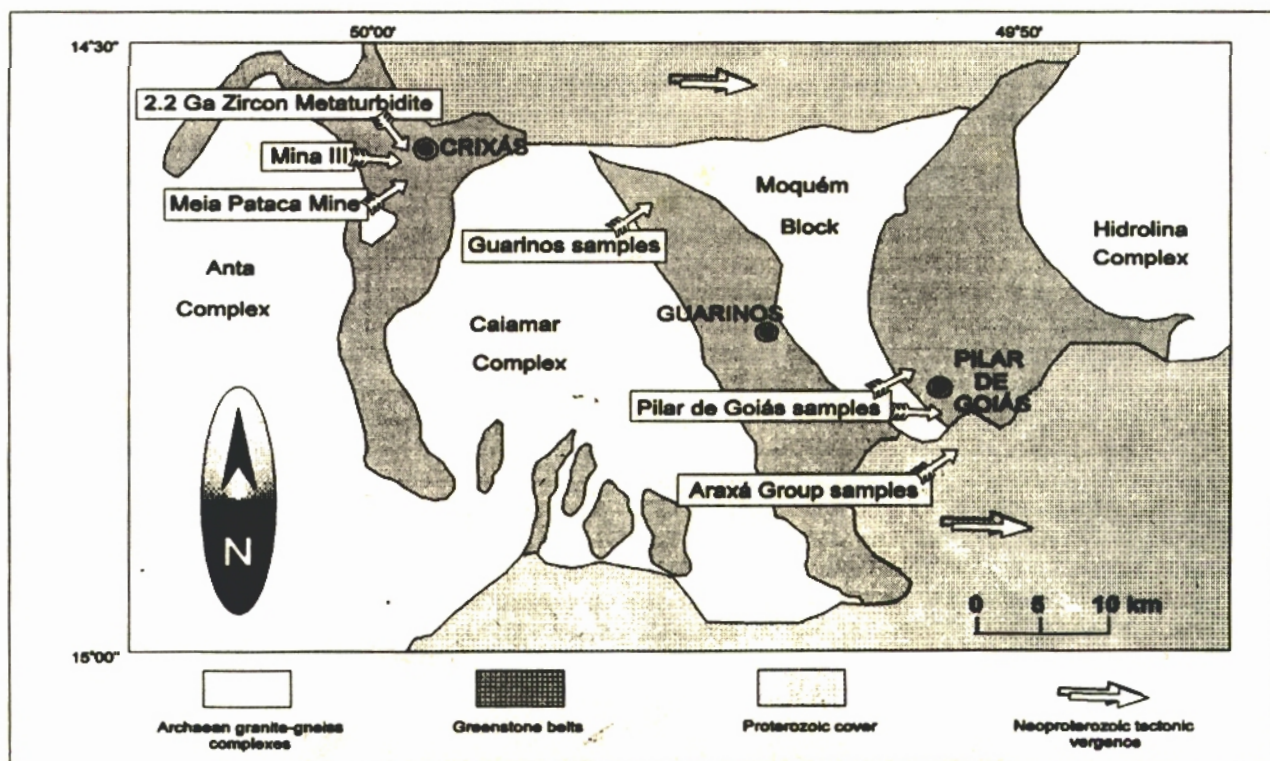
Fifth, to explain the coexistence of geochemically contrasting clastic loads in the same stratigraphic units of Crixás and Pilar de Goiás requires a sudden and dramatic compositional change of the source area of these loads. However, rocks interpreted as post Archaean by REE signatures are interlayered with geochemically Archaean equivalents. This requires a tectonic model able to switch rapidly and cyclically the nature of the source area between K-feldspar rich and plagioclase-rich crusts, which in its turn surprisingly did not affect the Gurainos belt.

Sixth, to better understand the Archaean sedimentary basin evolution and the involved environments, we have to reevaluate our criteria so far used to describe, map, and interpret the metasedimentary record of the three belts.

Acknowledgments - AAThis paper is part of a geochronological investigation in the Crixás region funded to the senior author by Fundação de amparo à Pesquisa do Estado de São Paulo - FAPESP (Grant n° 95/2745-3)

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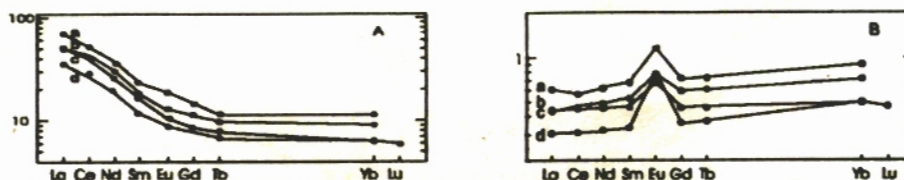


Figure 2 - REE signatures of some worldwide examples of Archaean detrital metasedimentary rocks. Sample normalized to (A) chondrite, (B) to PAAS. Location of samples as follows: a - Kalgoorlie, b - Fig Tree, c - Moodies, and d - Pontiac.

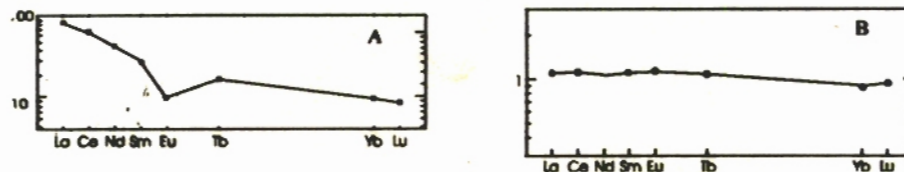


Figure 3 - REE signatures of the metaturbidite containing 2.2 Ga detrital zircon and interlayered with carbonaceous phyllite in an outcrop just East of the bridge over the Rio Vermelho, 2.5 km South of Crixás, road Crixás-Itapaci. Sample normalized to (A) chondrite, (B) to PAAS

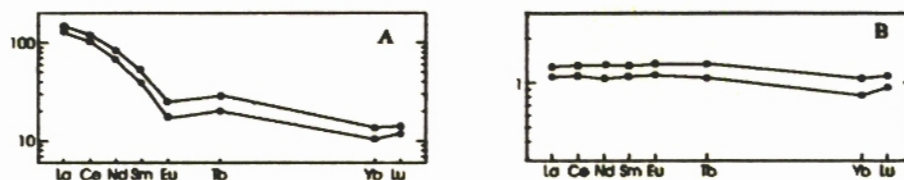


Figure 4 - REE signatures of three samples of metasedimentary rocks (quartz-muscovite schist) of the Neoproterozoic Araxá Group, collected from an outcrop in a road-cut 1.5 km South of Pilar de Goiás. Samples normalized to (A) chondrite, and (B) to PAAS. Note the similar REE signatures of samples in Figures 1 and 2.

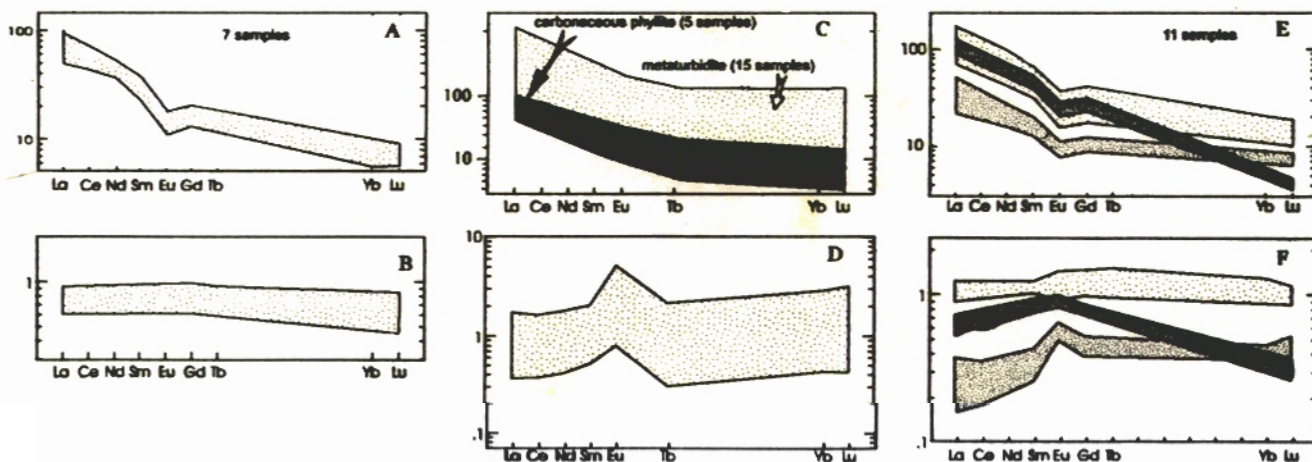


Figure 5 - REE signatures of metasedimentary rocks of (A - B) Meia Pataca Mine (Magalhães 1991), (C - D) Guarinos greenstone belt (Jost et al. 1995), and (E - F) Pilar de Goiás greenstone belt (Pulz 1995). Normalization as follows: A-C-E to chondrite, and B-D-F to PAAS.

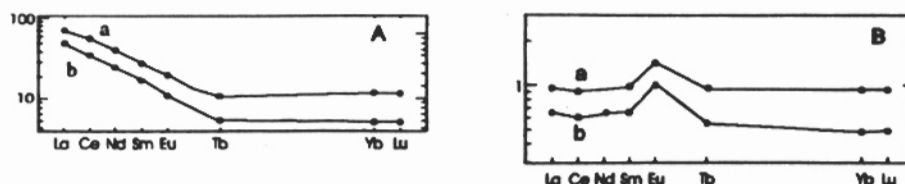


Figure 6 - REE signatures of (a) one metaturbidite, and (b) one carbonaceous phyllite from drill-cores of the Mina III, Crixás. Normalization as follows: (A) to chondrite, and (B) to PAAS.