EVOLUTION OF THE SUNSÁS OROGEN IN WEST AMAZON CRATON BASED ON DETRITAL ZIRCON U-Pb GEOCHRONOLOGY

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ABSTRACT

The Sunsás Orogen in western Amazon Craton extends from northeast Argentina to Eastern Venezuela and is best exposed along the Brazil-Bolivia border. We integrate earlier U-Pb SHRIMP data with 16 samples of sandstones and meta-sandstones from three groups of basins: pre-Sunsás, late-Sunsás, and post-Sunsás basins. The post-Sunsás sandstones are the Palmeiral and Apiacás formations (five samples, 133 grains), the late-Sunsás sandstones come from the Nova Brasilândia, Huanchaca, and Aguapeí groups (nine samples, 195 grains), and the underlying sandstones come from the Beneficente Group (two samples, 57 grains). We found that:

1) The sandstones of the underlying Beneficente Group are mostly derived from Archean crust and from rocks formed between 1790-1740 Ma. These ages are comparable to the Roosevelt Group and the Jamari Complex (1740 Ma) exposed to the south and southwest, and to those of the Colíder-São Pedro magmatic arc of Juruena Domain (1790 Ma) to the southeast.
2) The late-Sunsás sandstones are chiefly derived from rocks of the Candeias orogeny (1360-1320 Ma), followed by some zircons from the Santa Helena orogeny (1470-1420 Ma), the Serra Providência Suite (1550-1530 Ma), the San Andrés orogeny (1280 Ma), and a few from the Rondônia-Juruena Province (1750-1720 Ma).
3) The post-Sunsás sandstones are derived from granites of the Serra Providência Suite (1570-1520 Ma, 45 grains) and the Candeias Orogeny (1390-1320 Ma, 26 grains). Other sources are rocks of the Santa Helena orogeny (1470-1420 Ma, 14 grains), the Juruena magmatic arc (1810-1760 Ma, 14 grains), the San Andrés orogeny (1285-1240 Ma, ten grains), and the Rondônia suite (1049 -1020 Ma, five grains).

INTRODUCTION

The Sunsás Orogen was formed along the western margin of the Amazon Craton during the Mesoproterozoic (1450-1100 Ma; Santos, 2003). It was partially consumed by the Andes Orogen to the west and locally by the Brasiliano Orogen (Neoproterozoic) to the southeast (Figure 1). Much later, it was largely covered by Cenozoic deposits derived from the erosion of the Andes Orogen to the west (Schenk et al., 2000; Roddaz et al., 2006). The original belt may have been 6,000 km long, extending from northeast Argentina and Paraguay into eastern Venezuela, but today the Sunsás belt is best exposed along the Brazil-Bolivia border, in an area of about 350,000 km^2 (Figure 1).

The time interval of the Sunsás Orogen and the main orogenies within the orogen were first studied from 1999 when U-Pb geochronology began available (Rizzotto et al., 1999; Bettencourt et al., 1999; Santos et al., 2000). Santos et al. (2002) proposed a duration of about 350 m.y. (1450-1100 Ma) and three main orogenies or peaks of orogenic activity were recognized at 1470-1420 Ma (Santa Helena), 1370-1320 Ma (Candeias), and 1180-1100 Ma (Nova Brasilândia). Tohver et al. (2005) and Boger et al. (2005) proposed an allochthonous development of the Sunsán Orogen whereas Santos et al. (2008) suggested an autochthonous evolution on the western margin of the craton composed by rocks of the

Rondônia-Juruena Province (1840-1520 Ma). Fragments of this province and inherited zircon of 1840-1520 Ma present within the Sunsás Orogen together to the inexistence of the Paraguá Craton are strong support for the autochthonous hypothesis.

The Sunsás orogen is interpreted as part of the Mesoproterozoic supercontinent named Rodinia and the connection of the western Amazon Craton to Laurentia within the Rodinia Supercontinent is a broadly accepted idea (Dalziel, 1991; Hoffman, 1991; Santos et al., 2002; Tohver et al., 2002; Boger et al., 2005). The Sunsás Belt has been correlated to different areas of Laurentia: the southwestern Llanos segment (Tohver et al., 2002); the Grenville Province of Ontario (Sadowski and Bettencourt, 1996; Santos et al., 2002); the southern and central Appalachians (Loewy et al., 2003; Tohver et al., 2004); and the western Laurentia (Santos et al., 2008).

ANALYSES

Rock samples were crushed, milled and sieved at 60 mesh and the heavy minerals were separated using heavy liquid (TBE-tetra-bromo-ethane) and magnetic separation techniques. The final separation of the minerals was by hand picking the grains. These were mounted on epoxy discs with fragments standards, ground and polished until nearly half of each grain was removed, photomicrographed in transmitted and reflected light, and imaged (backscattered electrons) for their internal morphology using a scanning electron microscope at the Centre for Microscopy and Microanalysis at the University of Western Australia. The epoxy mounts were then cleaned and gold-coated to have a uniform electrical conductivity during the SHRIMP analyses. The zircon standards used were Sri Lanka CZ3 zircon (564 Ma; $^{206}Pb/^{238}U$ ratio=0.0914; 551 ppm U) and BR266 zircon (559 Ma, 903 ppm U). The isotopic composition of the minerals was determined by SHRIMP II (De Laeter and Kennedy, 1998) using methods based on those of Compston et al. (1992). Data were plotted on cumulative plots using ISOPLOT/Ex software (Ludwig, 1999) at the 95% confidence level (2σ). All ages given in text are weighted mean $^{207}Pb/^{206}Pb$ ages; the results with more than 0.5% correction for common lead and more than 10% discordance were rejected.

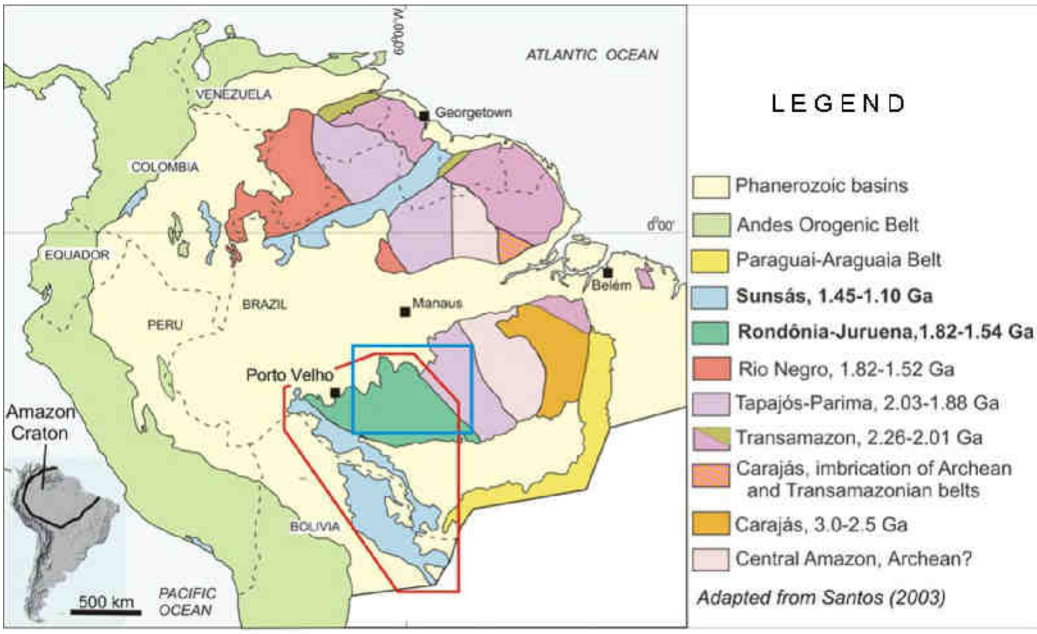

Figure 1. The Amazon Craton Provinces (Santos, 2003) and the location of study areas (red and blue polygons).

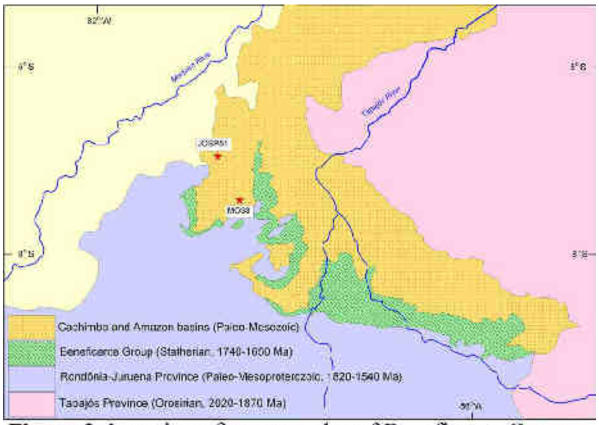

Figure 2. Location of two samples of Beneficente Group. The area of this map is marked in Fig. 1 as blue rectangle

RESULTS

The five post-Sunsás sandstones (Palmeiral Formation, Apiacás Formation; n=133) have four main sources: they possibly derive from the Serra Providência Suite (granite and charnockites; peaks at 1518 and 1541 Ma), from the Sunsás orogen itself (five peaks at 1181, 1240, 1285, 1308, and 1366 Ma); and from post-Sunsás rocks (Rondônia Suite, peak at 1023 Ma), and from rocks of the Rondônia-Juruena Province (peak at 1770 Ma; Fig. 3) as well.

Nine late-orogenic quartzites within the Sunsás orogen (Nova Brasilândia Group, Aguapeí Group, Huanchaca Formation, Iata Formation; n=195) are derived from sources within it; more than 90% of their detrital zircon have Sunsás ages with five peaks at 1173, 1209, 1331, 1360, and 1420 Ma. The age of 1420 Ma is comparable to the Santa Helena Orogeny, the ages of 1331 and 1360 Ma correspond to the Candeias Orogeny, and the age of 1181 Ma is equivalent to the beginning of the Nova Brasilândia Orogeny. There are two minor contributions of zircon at 1564 Ma (Serra Providência Suite) and at 1724 Ma (rocks of post-Jamari Complex age).

The two pre-Sunsás samples are from the bottom (JOSP51, n=39) and top (MO38, n=19) of the Beneficente Group from a Paleoproterozoic basin with an estimated thickness of 3,000m. According to Santos (2003) the Beneficente Group was deposited on a passive margin basin which post-dates the Teles Pires Granite (1760 Ma) and Colíder felsic volcanic rocks (1770 Ma). The basin was compressed and folded by the Quatro Cachoeiras collisional orogeny at about 1650 Ma (Santos, 2003). Leite and Saes (2003) using the Pb-Pb evaporation method of detrital zircon established the maximum age for the Beneficente Group deposition at 1740 Ma. This agrees with our data where among 58 dated grains the youngest is 1741 Ma old. The Beneficente Basin derived from four main groups of rocks: rocks of the Rondônia-Juruena Province (peaks of 1748, 1770 and 1842 Ma); Tapajós Province (1976 and 1987 Ma); Trans-Amazonian (2140 and 2082 Ma); and Archean rocks (3321, 2865, and 2654 Ma) – Figures 5 and 6.

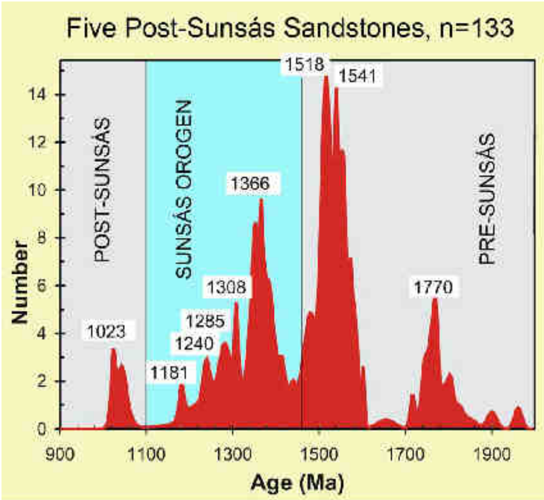

Figure 3. Cummulative plot of zircon of five post-Sunsás sandstones showing three main groups of sources.

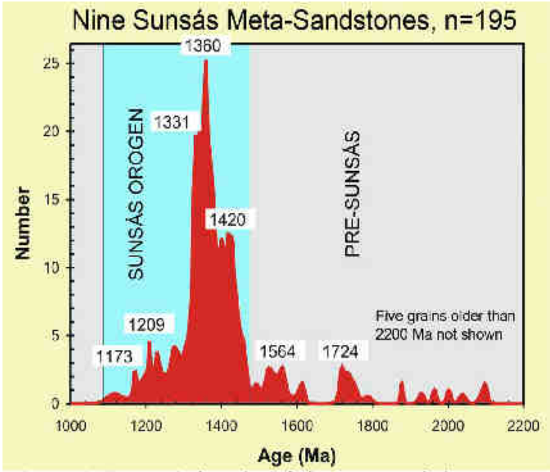

Figure 4. Cummulative plot of zircon ages of nine meta-sandstones of Sunsás Orogen.More than 90% of the grains are derived from the orogen itself.

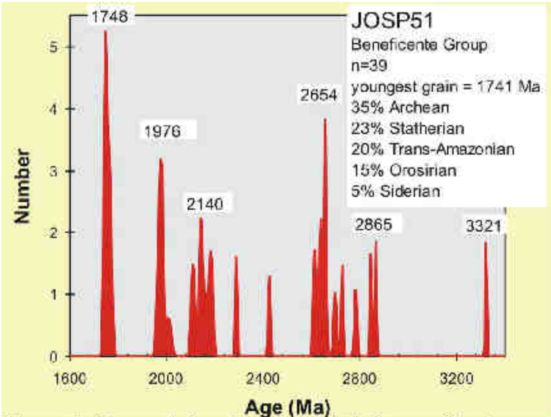

Figure 5. Cummulative plot of detrital zircon of the base of the Beneficente Group. There are several Archean sources followed by Trans-Amazonian (2140 Ma), Tapajonian (1976 Ma), and Jamari-type (1740 Ma) sources.

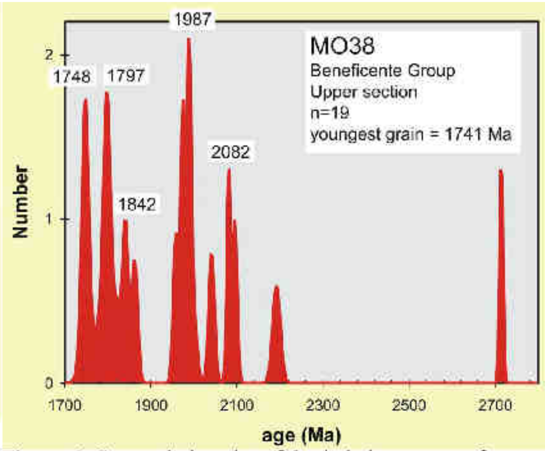

Figure 6. Cummulative plot of detrital zircon ages of upper section of Beneficente Group. The main depositional sources are rocks of Jamari Complex (1748 Ma), Colider Group (1797 Ma), Juruena Granodiorite (1842 Ma), and Creporizão Suite (1987 Ma). Unidentified Trans-Amazon (2082 Ma) and Archean (2710 Ma) sources.

CONCLUSIONS

Our main conclusions are:

a) Archaean and Trans-Amazonian crust was exposed near the Beneficente basin between 1740-1700 Ma. The location of this lithospheric piece is to be investigated. It may coincide with the high-velocity seismic anomaly detected by Heintz et al. (2005) underneath the Beneficente Basin.
b) Almost all the detrital zircon from late-Sunsás and post-Sunsás sandstones is from nearby sources or from within the orogen itself. This suggests that the Sunsás orogen was a convergent margin free of drifting microcontinents.
c) The Late-Sunsás orogenic meta-sandstones are derived from the Sunsás orogen itself implying that they were chiefly deposited in intermontane basins.
d) The post-Sunsás sandstones are almost entirely derived from the Sunsás orogen and imply that they were deposited in foreland basins.
e) The scarcity of zircon younger than 1100 Ma in the post-Sunsás foreland basins is evidence for the absence of the Ottawan-equivalent orogeny in the western Amazon Craton.

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