^{40}AR/^{39}AR MINERALIZING AGE OF THE ARAÉS GOLD DEPOSITS, MATO GROSSO STATE, BRAZIL

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INTRODUCTION

^{40}Ar/^{39}Ar analysis was carried out in metamorphic host-rocks and hydrothermal minerals from the Araes gold mineral deposit with the purpose to constrain the timing of regional metamorphism and the mineralizing process.

Araés gold deposit occurs in the eastern part of Mato Grosso State (Brazil), near the border with Goiás State. Main mineralization occurs 4 km north of the Mortes River and 25 km west of Nova Xavantina town. In the area there are lithologies representative of a volcanic sequence correlated to the Cuiabá Group or, alternatively, representative of its basement. The Paraguay belt rocks developed on the border of the Amazonian Craton (Figure 1) and comprises a roughly N-S trend of approximately 1500 Km long and 300 Km wide and the origin of this fold belt is correlated to the Neoproterozoic collage (Amazonian Craton and Paranapanema block) which originated the Western Gondwana.

LOCAL GEOLOGY SETTING

The Nova Xavantina volcano sedimentary complex outcrops in a structural window in the studied area. In the north, there is an inverse fault-contact with sediments of Diamantino Formation, Alto Paraguai Group (Phanerozoic). In the western area the Ponta Grossa Formation (Devonian of Parana Basin) occurs as isolated outcrops. In the eastern part of the fold belt (Cuiabá region), the Cuiabá Group consists of fine-grained metasedimentary rocks (phyllites) and associated quartzites. In the western part of the Paraguay belt, Quaternary sediments hamper the limit with magmatic arc terranes of Goiás massif. In the north of the ore outcrops the Alto Paraguai Group, which consists of glaciomarine beds and sediments of turbidite character with glacial affinities overlain by the carbonate unit that marks the end of the glacial influence, followed by a sequence of siliciclastic rocks.

Representative lithologic units observed in region are banded iron formations, metaultramafic rocks, metamafic rocks, metandesites, graphitic phyllites, metacherts, sericite-quartz-phyllites, metaconglomerates, metargilites, metasiltites and quartzites. In the studied area, the sedimentary structures are mainly observed in the BIF's, quartzites and phyllites. Subparallel to the sedimentary bedding occurs the penetrative foliation, which is roughly W-E/33S. This foliation was interpreted as result of a shear zone (Araés shear zone) activity during the regional metamorphism. The main foliation and the sedimentary bedding (both locally W-E) are deformed by regional open folds, which axial planes show a NW direction.

The geometrical patterns of the mineralized quartz-vein display an agreement with the features of the Araés shear zone, suggesting that the emplacement used the anisotropy comprised by the foliation originated during the shear zone formation and preexisting bedding. Strike-slip faults and subhorizontal slikensides indicate a dextral kinematics for the mineralized quartz-vein emplacement. An extensional regime is also indicated by the occurrence of filling traps and radial quartz crystallized in geodes within the quartz vein. The brittle conditions of the mineralized quartz-vein intrusion indicate that the mineralizing solutions probably were active after the regional metamorphism. The youngest observed structures are dextral NW-SE trending faults and sinistral NE-SW faults cutting the mineralized quartz-vein, resulting in four separated parts of the same vein

THE ARAÉS GOLD DEPOSIT

The Araés gold deposit is composed of a single-vein (4-8 m thick and 6 km long) ore body filling an extensional fault. It dips about 33° towards NE and strikes WSW-ENE and NE and NW faults disrupt it. Historically, the oldest production was done by 17th century gold explorers in placers, which record may be found in channels used to collect water for gravimetric separation of gold. The second time occurred by open pits during a short period of time (1989-1991). After the open pit exploration about five dozen of shafts were built (1991-1992), reaching, the deepest one, at 90m. The underground mining was stopped when water regional

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underground level was reached. Recent drilling research carried out by the mining owner achieved the volume of 40 ton of gold.

The ore body was subdivided and named, accordingly the small gold producer division, following the blocks separated by the NE and NW faults and also due the highest gold concentration areas separated by barren sectors. In this way, the ore body sectors were denominated as following (from E to W): (1) Rocinha portion: a 500m long quartz vein; (2) Móveis portion: a 100m long quartz vein, 8-10m thick with high Au concentration; (3) Buracão portion: a 200m long vein; and (4) Bandeirantes portion: 600m long vein. Westernward the fourth (not studied) sector 2km long barren quartz vein is observed.

Quartz and sulfides form the mineralization: pyrite (60%), galena (20%) sphalerite (10%), and chalcopyrite (10%). Petrographic studies of polished sections suggest an intergrowing texture between the sulfide phases. Galena, sphalerite and chalcopyrite occur preferentially agglomerated or as inclusions within pyrite crystals. There is no evidence for a second phase of crystallization or reprecipitation in fractures. Metavolcanic rocks, phyllite, carbonaceous-rich schist are the principal gangue material.

The hanging-wall and the footing-wall lithologies are indistinct. Either phyllites, schists, carbonaceous phyllite and ferriferous phyllites are observed. At Rocinha sector a 20cm carbonaceous pyrite-rich bed is observed in the hanging-wall. At the Móveis sector, a potent 8-10m thick quartz vein is fractured and oxided, resulting in a red-yellow color on the surfaces of the quartz crystals. The same oxidation may be identified at Buracão sector, where boudinages searching 10 m thick may be locally observed.

PROCEDURES

The samples from the Nova Xavantina area were collected at the Araés gold deposit area from two open pits and from shafts. The metabasic rocks samples were crushed and sieved at 30-60 meshes, and handpicking under a binocular microscope separated the biotite crystals. Argilic mineral alterations were separated manually from mineralized quartz vein.

One grain of biotite from the metabasic rocks and one grain of argilic alteration mineral from ore body had their Ar isotope composition determined at CPGeo-USP $^{40}Ar/^{39}Ar$ laboratory. The grains were irradiated, together with appropriate neutron flux standards, at the IPEN/CNEM IEA-R1 nuclear reactor. The samples and standards were placed into aluminum containers. The standard used was the biotite GA-1550. The ages adopted is 98.8 ± 0.5 Ma.

The step heating procedure was used, in which laser output power is computer-driven to a predetermined value and maintained at that intensity for 30-60 seconds. This procedure is repeated several times for a sample, at progressively higher laser output power. As result of this procedures several fractions of the Ar gas contained in the sample were extracted at progressively higher temperature. Each Ar gas fraction obtained separately in the mass spectrometer, yielding separated results, which were joined in the apparent age *versus* % ^{39}Ar released diagram. If 60% of the released gas yields the same age (within errors) is defined the plateau age. Integrated age comprises the average of the all gas fractions released in each step. The analysis were done using the Mass Analyzer Products (UK) MAP-215-50 mass spectrometer with two independent collectors, a Faraday collector positioned on the high-mass side of the optic axis and a Balzers 217 electron multiplier positioned on the low-mass side. Blanks were measured between each step of the step-heating procedures.

RESULTS

The results of the $^{40}Ar/^{39}Ar$ analysis of one biotite grain from metabasic rocks and one grain of hydrothermal alteration separated from the quartz vein are presented.

The sample AR-105 had one grain analyzed which results yielded a $^{40}Ar/^{39}Ar$ plateau age of 539 ± 1.6 Ma and an integrated age of 543.3 ± 0.5 Ma (Figure 2). The plateau age may be interpreted as the metamorphic peak age of the rock analyzed. From the second sample (97-103), the grain analyzed by $^{40}Ar/^{39}Ar$ step-heating technique yielded an integrated age of 539.3 ± 0.5 Ga (Figure 3). The spectrum show higher ages in the final steps, indicating partial argon-loss in the grain analyzed. This case may be similar to the one reported in the literature in which it was demonstrated that if a mineral cools sufficiently slowly through its closure-temperature range, it is possible to obtain a spectrum that is not a plateau, but rather has the general characteristics of a diffusive-loss profile due to an episodic event. The apparent age from the lowest-temperature step in such a case does not, however, reflect the time of a discrete thermal event, but the time of ultimate closure following slow cooling. The degree of disturbance of the spectrum from a plateau is a function of the cooling rate and the diffusion geometry of the mineral; such a spectra appear to be most common for slowly cooled alkali feldspar. The similarity of such slow cooling spectra resulting from episodic Ar loss may make it difficult to distinguish the two.

The potential for direct measurement of the depositional process of argilic minerals during hydrothermal solution percolation may be equivalent to the determination of depositional age of sedimentary rocks by utilizing clay minerals. As authigenic clays grown in sedimentary rocks, argilic minerals deposited during the hydrothermal solutions activity present very fine crystal size, which allow loss of radiogenic argon at ambient temperatures, causing the measured ages to be too young. $^{40}Ar/^{39}Ar$ age spectrum measurements on argilic minerals generally do not give sensible results owing to loss of both ^{40}Ar and ^{39}Ar during irradiation, and because release of argon in the vacuum system during a step heating experiment probably occurs by breakdown of the mineral lattice rather than by volume diffusion.

CONCLUSIONS

The $^{40}Ar/^{39}Ar$, Pb and S data here reported may suggest important constraints in the geological characteristics on the Araés gold deposit. Based upon these isotopic results and the discussion above we may suggest the following conclusions.

The age of the metamorphic peak of the Paraguay is about 539 Ma. This event probably is result of the collisional processes between the Amazonian craton and the Paranapanema (or an extension of the Rio de la Plata craton). Pos-tectonic extensional kynematic of the Paraguay belt age of 504 Ma is indicated to be the responsible for the metallic concentration of the Araés gold deposit rather than the Pb model age of 532 Ma obtained from the sulphides. This last age may be correlated to the regional metamorphic event here dated at 539 Ma in agreement with the ages reported in the literature.

These isotopic data added to the geologic characteristics of the Araés gold deposit are considered to support a model in which the mineralization is epigenetic and the mineralizing fluids are considered to be filled extensional faults parallel to the host-rocks foliation. The Araés gold deposits yielded ages correlated to Brasilian/PanAfrican event and they were probably formed during an extensional pos-tectonic period, which may characterize an important metallogenic epoch in the region, which may be a helpful contribution in a regional exploratory model.

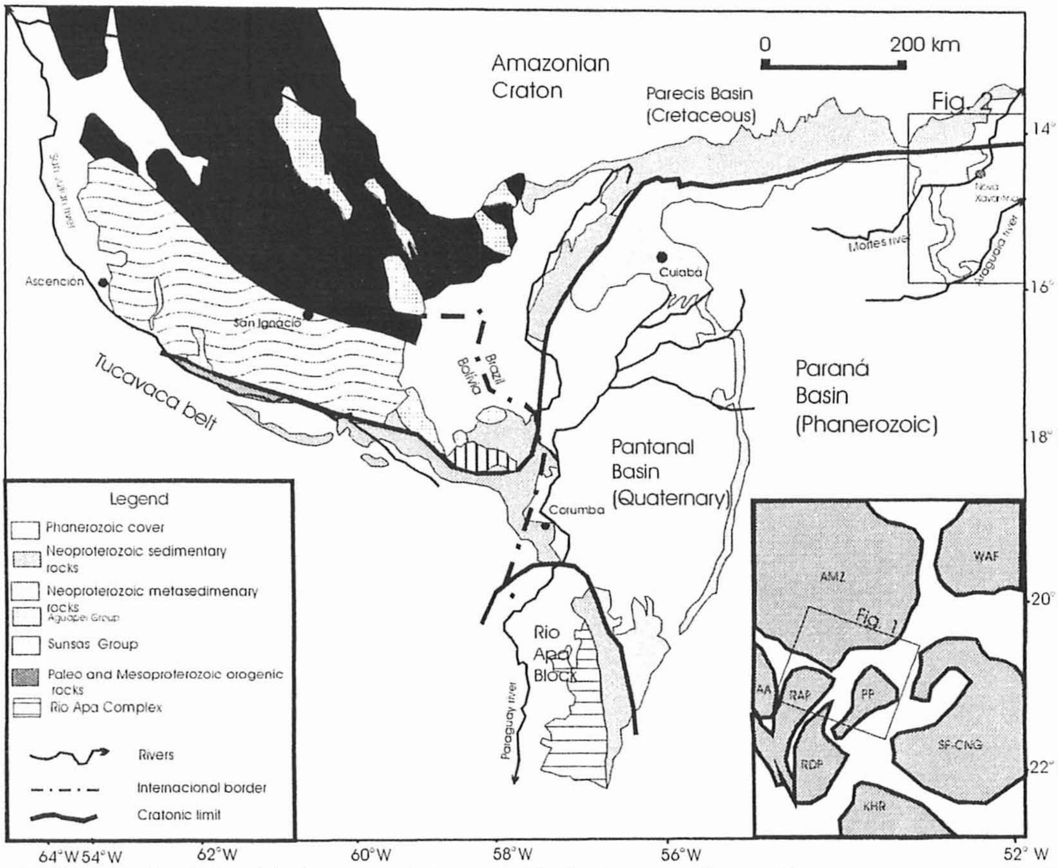

Figure 1. Structural relationship between the Paraguai Belt, Amazon Craton, Paranapanema cratonic fragment and Rio Apa Block. Cratonic fragments in the inset are: AMZ-Amazonian; WAF-West Africa; RAP-Rio Apa; RDP-Rio de La Plata; AA-Arequipa-Antofala; PP-Paranapanema; SF-CG- São Francisco-Congo; KHR-Kalahari.

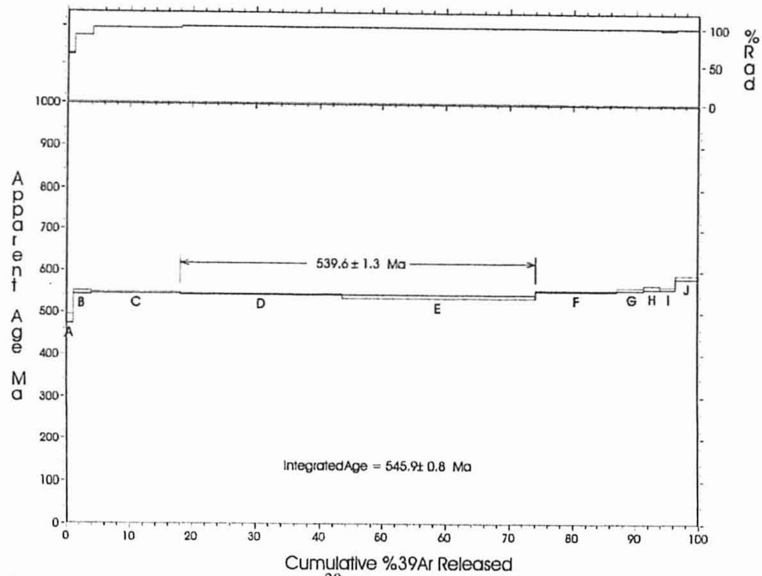

Figure 2. Sample AR-107 apparent age *versus* $\%^{39}Ar$ released diagram. The plateau age of 539.6 ± 1.3 Ma is interpreted as metamorphic age of the sample analyzed.

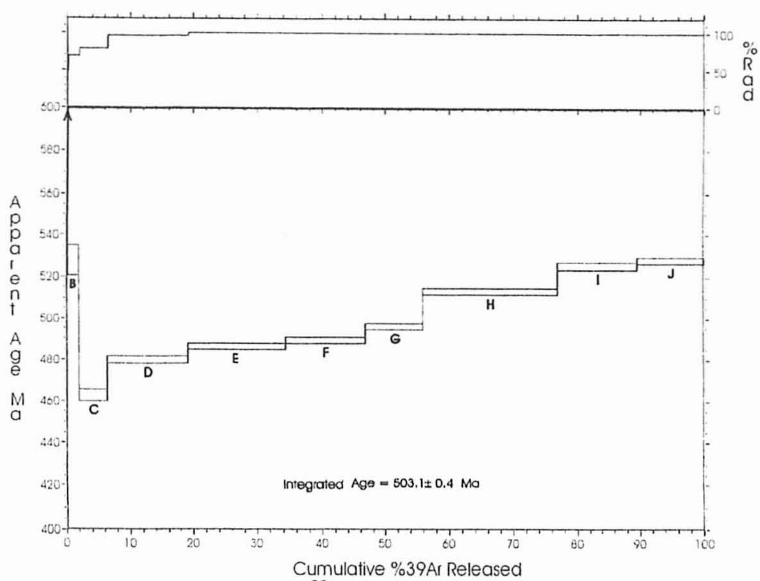

Figure 3. Sample AR-103 apparent age *versus* $\%^{39}Ar$ released diagram. The integrated age of 503.1 ± 0.6 Ma is interpreted as the mineralizing epoch of the Araés gold deposit. See text for discussion.