Comun. XII Reun. Geol. Oeste Penins., 1993, Vol. 1, pp. 215-226

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GOLD MINERALIZATIONS OF THE ESCOURAL AREA (MONTEMOR, ÉVORA, PORTUGAL): A PROGRESS REPORT

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Resumo

As mineralizações de ouro do Escoural (Montemor) têm como encaixante formações metamórficas de médio-alto grau de idade Proterozóica Superior; o pico de metamorfismo antecede a fase de deformação regional varisca D_2. Dois alvos potenciais (Chaminés e Casas Novas) foram colocados em evidência após várias campanhas de pedogeoquímica e litogeoquímica. Os corpos mineralizados são subverticais e ocorrem ao longo de uma banda NW-SE que inflecte para N-S no segmento central. O seu desenvolvimento está provavelmente relacionado com os eventos tardios de reactivação de uma mega-zona de cisalhamento direito da fase D_2 com direcção NNW-SSE a N-S. A circulação de fluidos hidrotermais ao longo deste importante acidente tectónico é, na sua essência, caracterizada por silicificação e sericitização intensa. A mineralização é constituída principalmente por arsenopirite loellingite e pirite; pequenas quantidades de bismuto nativo e bismutinite são localmente importantes. O ouro ocorre como elemento nativo. A mineralogia da ganga é dominada em larga escala por quartzo e sericite, embora clorite, feldspato alcalino, carbonato e turmalina possam ocorrer em certos domínios dos corpos mineralizados.

Abstract The gold mineralizations of the Escoural (Montemor) are hosted by formations of Upper Proterozoic age which experienced medium to high grade regional metamorphism, predating the D_2 phase of variscan deformation. Two potentially ore targets (Chaminés and Casas Novas) were put in evidence after an extensive geochemical campaign. The ore bodies are subvertical and occur along a NW-SE band which inflects to N-S in its central segment. Their development is probably related to the late reactivation events of a NNW-SSE to N-S D_2 right-handed mega-shear. The circulation of hydrothermal fluids along this major tectonic accident is in general characterized by prominent silicification and sericitization. The ore bodies are mainly composed of arsenopyrite, loellingite and pyrite; small amounts of native bismuth, and bismuthinite are locally important. Gold occurs mainly in its native form. The mineralogy of the gangue is largely dominated by quartz and sericite, although chlorite, alkaline feldspar, carbonate and tourmaline may be observed in some domains of the ore bodies.

1. Introduction

The Escoural gold mineralizations are located near Montemor-o-Novo (30 km W of Evora). In this region, Au-As soil anomalies were first put in evidence by Direcção Geral de Geologia e Minas in the fifties, in a regional prospecting campaign. This geochemical campaign evidenced Au-As major anomalies along a regional NW-SE trend, standing over the high Au-As regional background which seems to be, at least, spatially related with metamorphic rocks of acid nature. At that time, the unfavourable global economics did not support further detailed studies.

During the eighties, RIOFINEX obtained a prospecting concession in the Escoural region, particularly the Tabuleiros-Azinhaga sector, and re-evaluated the economic potential of the previously outlined Au-As anomalies. Comprehensive soil and rock anomalies put in evidence of two subparallel running Au and As anomalies in non-economic segments of the regional trend, and the presence of superimposed Au-As anomalies in two potentially interesting targets: Chaminés and Casas Novas. Trench opening and extensive drilling disclosed the discontinuous ore bodies responsible for the soil anomalies (currently under economic evaluation). RIOFINEX performed and commissioned representative sampling of key-outcrops and selected portions of the drill-cores. This was done in order to establish the main petrographic and geochemical characteristics of the (hydrothermally altered ?) metamorphic rocks in the vicinity of the mineralization and the intersected ore bodies (Mateus & Barriga, 1987; Houston, 1989; Charley, 1989); ore-dressing studies were also performed. In spite of these multidisciplinary data, two major questions remain unsolved: (1) is the geometry of the ore bodies controlled by a regional shear zone or is it mainly a syngenetic characteristic transposed by the variscan deformation ? (2) are the mineralogical variations in host lithologies inherited features, reinforced during the regional metamorphism, or are they due to the circulation of late hydrothermal fluids along a major tectonic accident ?

In 1991 the mineral rights in the area were acquired by Empresa de Desenvolvimento Mineiro; previous data are presently being re-evaluated in order to determine whether the future exploitation of Chaminés and Casas Novas ore bodies is economic or not.

The interpretation of field, petrographic and geochemical data reported in this note gave some clues concerning the above questions, suggesting a different model for the mineralization, with implications in exploration and in the eventual exploitation of the known ore-bodies.

2. GEOLOGICAL SETTING

The Tabuleiros-Azinhaga sector of the Escoural prospect comprises essentially formations of Upper Proterozoic age which experienced medium

to high grade regional metamorphism (sillimanite + muscovite zone), predating the D_2 phase of variscan deformation in the Ossa Morena Zone (fig.1a); the presence of migmatites gradually evolving to anatectic granodiorites and granites (?), strongly suggests the development of a high-grade metamorphic belt in this area. The whole sequence is folded in a NW-SE sinform (D_2) which deforms a D_{1a} SW to W verging recumbent anticline and a D_{1b} SW to W verging thrust; the polarity is reversed (the normal flanks of the major structure have been eroded) - fig.1b. In the eastern portion of this sector a prominent D_2 right-handed shear, affects the structures D_1, forcing a rotation of the S_1 schistosity to near NNW-SSE. This shear (sometimes called the mega-shear - see below) exhibits a complex history, with late fragile movements, of left-handed, strike-slip character.

Detailed mapping in the Chaminés-Casas Novas area was done in order to bring some light into several lithological and structural problems that arise when one attempts to extrapolate core data to the mesoscopic scale (fig.2). Concerning the stratigraphic ordering, there was no new data, and one could summarise the general characteristics of the observed sequence, from botton to top, as follows:

(1) **amphibolites** (located at the core of the D_2 sinform) with a well developed S_2 cleavage, with a general NW-SE trend, varying between N20W and N60W, subvertical, which sometimes exhibits a pronounced stretching lineation, dipping 10° to the SE.

(2) **biotite and chlorite schists**, often mapped together under the general designation of "micaschists". The chlorite schists represent a retrogression product of biotite schists, with intermediate terms ("slightly chloritized biotite schists") present at the outcrop level. Near shear zones the biotite-chlorite schists are often silicified. Along the mega-shear, besides the silicification, one may find occurrences of arsenopyrite and pyrite, sporadically associated with gold (plus minor amounts of chalcopyrite, maldonite, loellingite, bismutinite, and bismuth). The association mineralization-silicified biotite/chlorite testifies the circulation of hydrothermal fluids along the mega-shear.

(3) lenticular bodies of **leptinites** within the biotite/chlorite schists unit, representing probably an individual unit tectonically divided, as suggested by the continuity of this lithology in the SW flank of the sinform.

(4) **migmatites** with strong foliation parallel to D_2 structures, com- prising restites of amphibolites and biotite schists. Their composition is, in general, consistent with the data present by Mehnert (1986) for diatexites evolved from a biotite-plagioclase gneiss. The contacts between these lithologies and the surrounding schists are either gradual or sharp, but in the latter situation quartz veins with arsenopyrite are always present. An unsolved question is

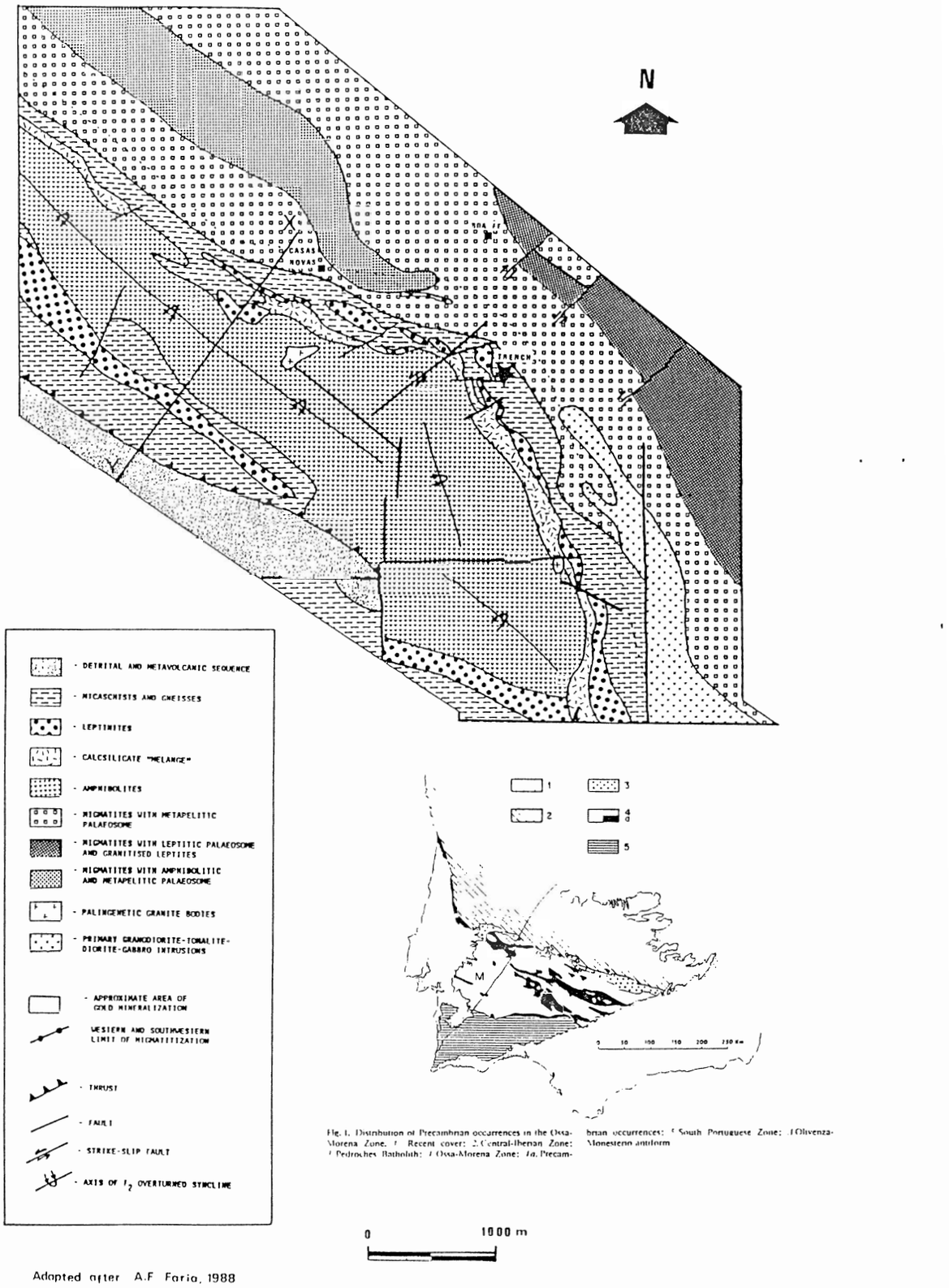

Fig. 1a - Geology of the Tabuleiros-Azinhaga Sector (Escoural). 1. Recent cover; 2. Central-Iberian Zone; 3. Pedroches Batholith; 4. Ossa-Morena Zone; 4a. Precambrian occurrences; 5. South Portuguese Zone; M Esscoural prospect (adapted from Faria, 1988 and Quesada, 1990)

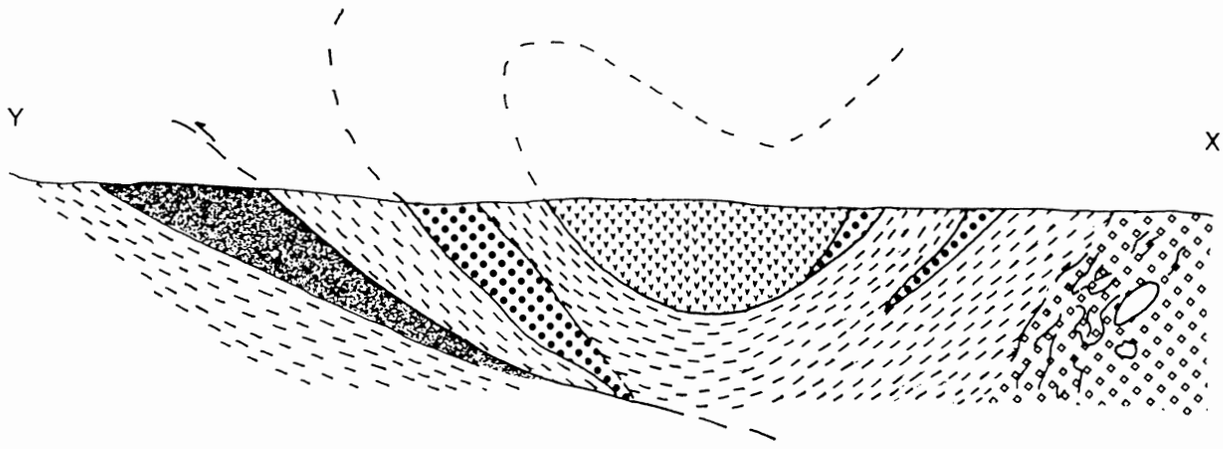

Fig 1b. - Structure of the Tabuleiros-Azinhaga sector. 1. Amphibolites; 2. Leptinites; 3. Micaschists, gneisses and lydites; 4. Cambrian sequence (volcano-sedimentary); 5. Migmatites.

whether or not there is any relation between mineralization emplacement and migmatization, since there seems to exist a close spatial relation of gold occurrence to the vicinity of migmatization front.

3. ORE CONTROLS

The ore bodies occur along a NW-SE band which inflects to N-S in its central segment (fig.3), and the main concentration and ore grades are, at least spatially, related with the NNW-SSE to N-S right-handed mega-shear, close to Chaminés. The ore is, at that location, subvertical, close to N-S striking, and extremely silicified. Away from the mega-shear, the ore grades decrease abruptly.

The evolution of the mega-shear is complex with successive cycles of reactivation in ductile and brittle regimes. Its genesis was probably contemporaneous of the folding associated to the regional D_2 variscan deformation. During the tardi-variscan regional deformation, the orientation of the shear zone was suitable for reactivation as a dextral strike-slip fault. However, field evidence, expressed by the generation of secondary faults and fractures at a mesoscopic scale, is compatible with a late left-handed reactivation in a brittle regime. This reactivation could be explained as an expression of Alpine deformation or as a singularity of the tardi-variscan deformation, a restricted phenomenon probably due to a local variation in the stress field.

The available Au and As concentrations for the Chaminés sector (on metric samples along drill cores) are presented in fig. 3 in plan views, drawn using

the morphological field evidence concerning the geometry of the ore bodies (lenticular and subvertical).

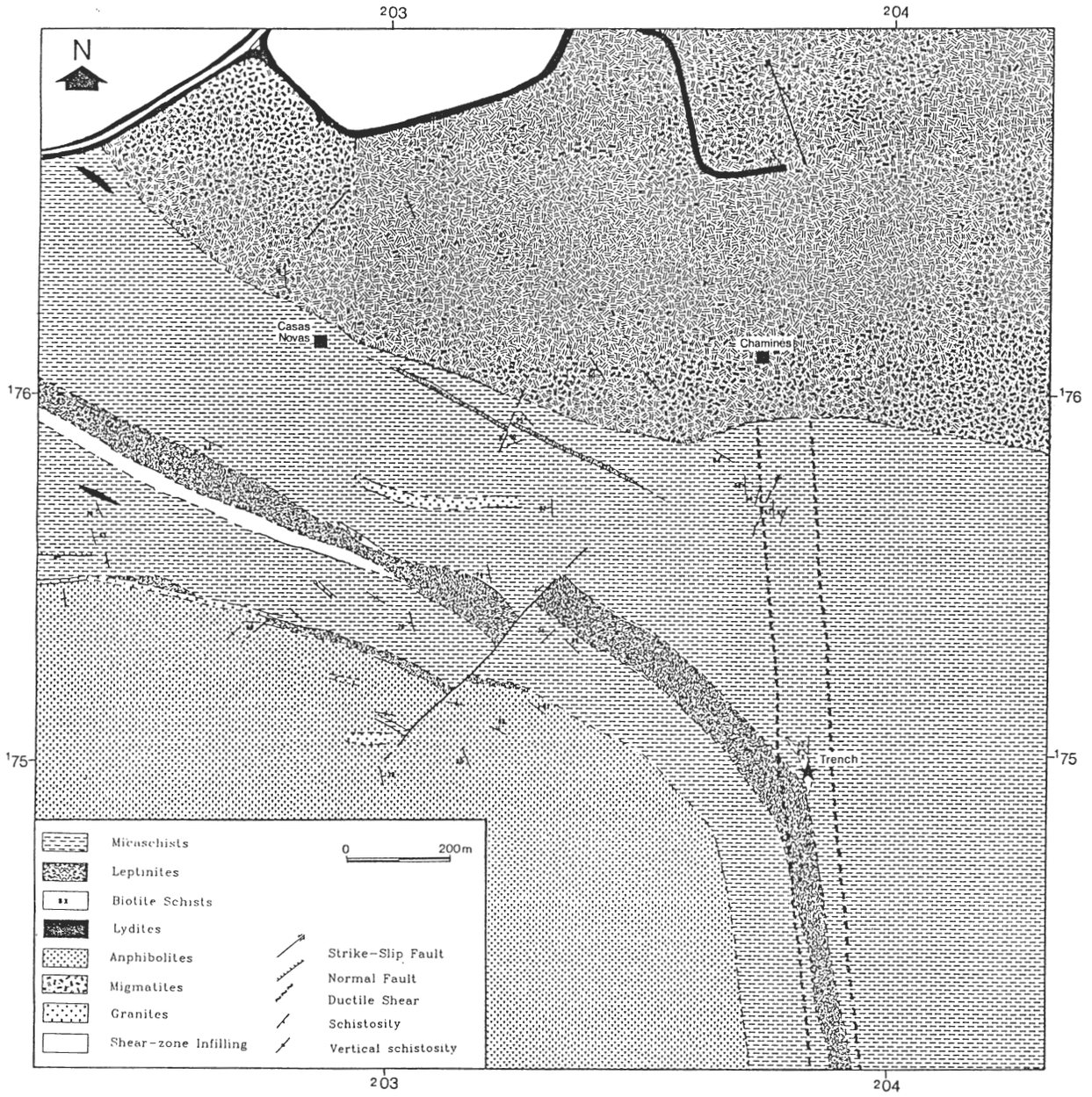

Fig. 2 - Geology of the Chaminés-Casas Novas Area.

On the basis of that schematic representation, the development of approximately NW-SE enriched bands both for Au and Ag with an echelon disposition, suggests that the circulation of the mineralized hydrothermal fluids was constrained by structural anisotropies controlled by a sinistral displacement along the NNW-SSE shear in a semi-brittle/brittle regime.

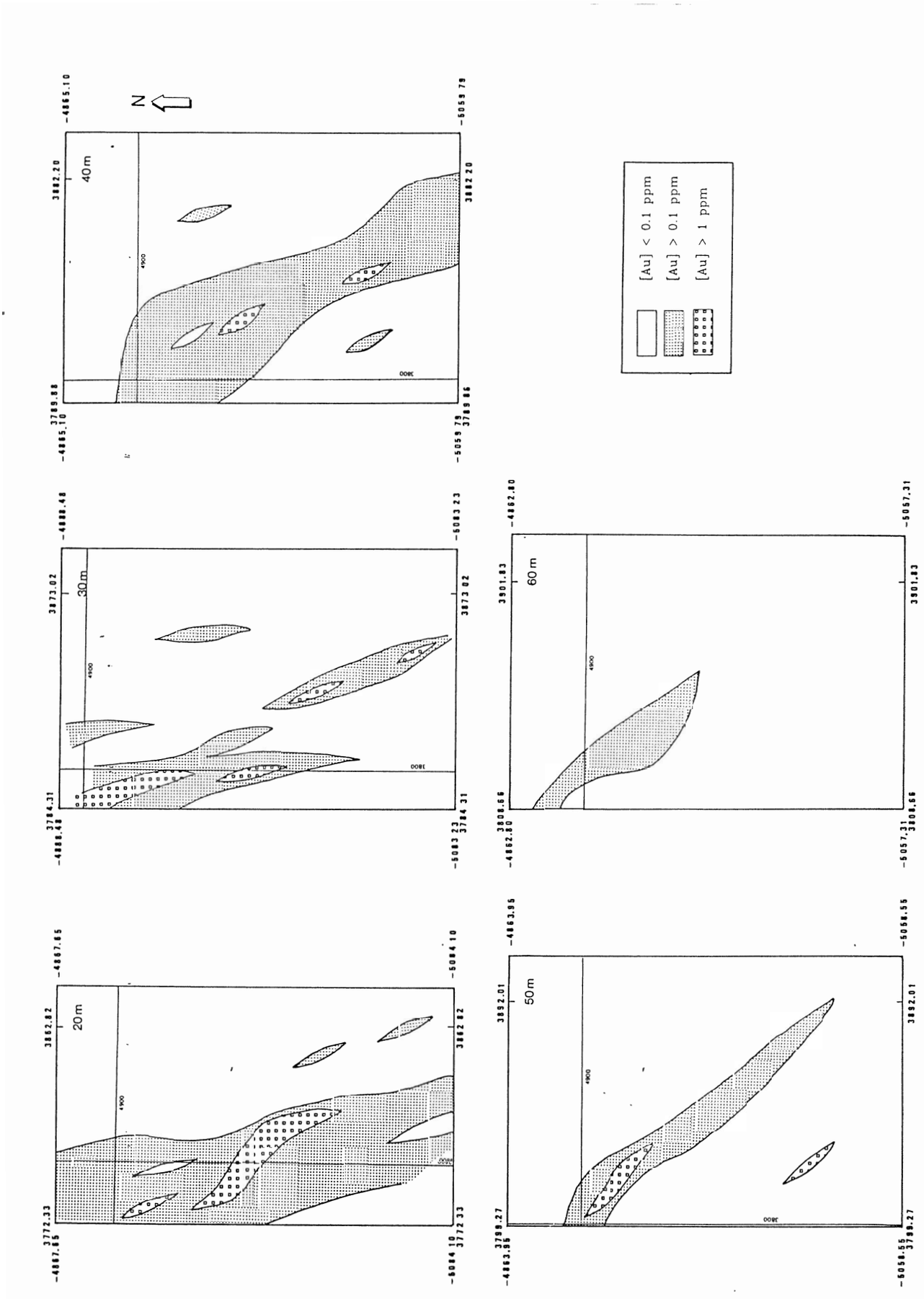

Fig. 3a - Au concentrations for the Chaminés sector.

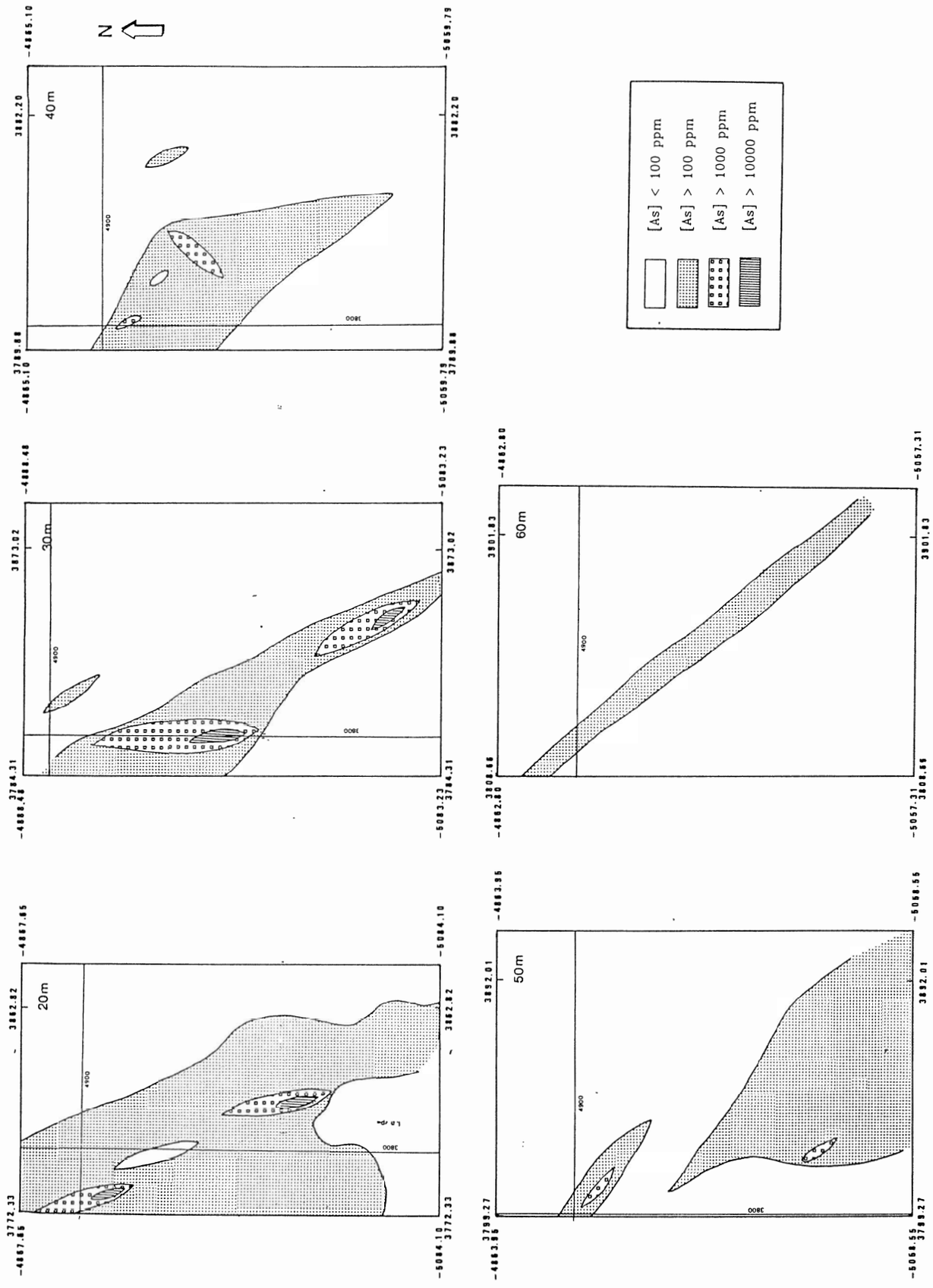

Fig. 3b - As concentrations for the Chaminés sector.

The geometry of the Au-As bands constrains therefore the age of the gold mineralization as being late in the structural history of the mega-shear (at least in its present distribution), which is consistent with the petrographic observations (see below).

4. WALL-ROCK ALTERATION AND VEINING

The main host lithologies are micaschists and minor gneisses; leptinites and amphibolites are often found nearby. In general, the silicification and sericitization constitute the main macroscopic features of the hidrothermal alteration in the vicinity of the ore bodies, and apparently their development is not constrained by late fracture networks. Widespread arsenopyrite and sparse pyrite are also common in the altered rocks. Albitization is also prominent, although in a subsidiary scale. Carbonates are sporadically present. In biotite rich lithologies, there is a gradual increase in chloritization with mineralization proximity. Detailed petrography enabled the establishment of two main mineral hydrothermal parageneses (fig.5). In general, the deposition of quartz (not deformed), fine-grained white-micas (sericite I and II), and arsenopyrite II clearly postdate an earlier assemblage which is characterized by the association of quartz I (with slightly wavy extinction) + chlorite I + rutile ± albite ± arsenopyrite I ± pyrite I. Later stages of alteration are essentially represented by the deposition of quartz and chlorite along late veinlets, usually followed by scorodite, iron (hydro)-oxides and sparse covelite.

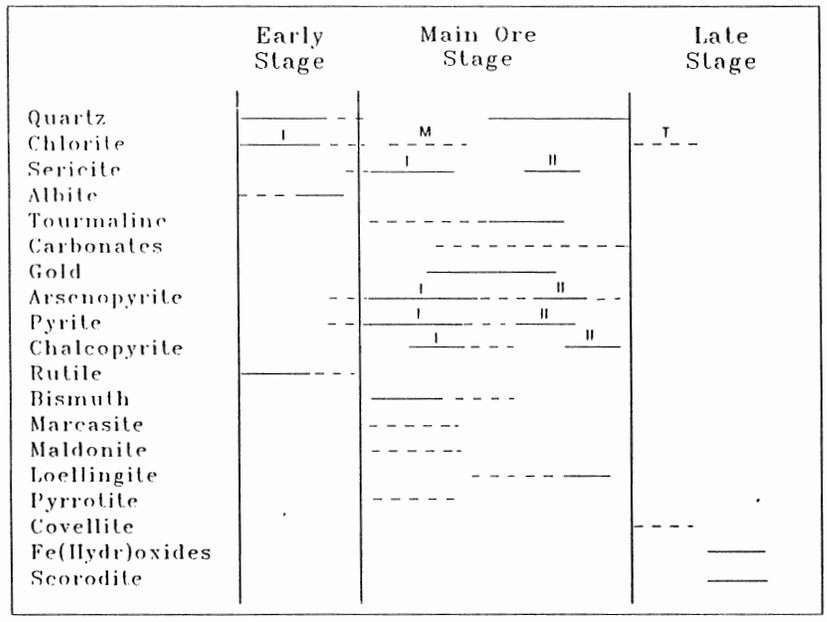

Fig. 4 - Paragenetic sequence for the Tabuleiros-Escoural area.

Several vein generations are present in the areas adjoining the ore bodies. Quartz + sulphide veins, spatially or genetically related to the mineralising event, can be grouped in two typological and chronological distinct groups: (1) centimetric quartz veins with abundant arsenopyrite, folded by D_{1a} (displaying axial plane S_1 schistosity), and with an unknown gold content; (2) quartz (of type I) + arsenopyrite+gold ± pyrite veins with a centimetric to metric thickness, displaying frequent interdigitations with the surrounding lithologies and sometimes exhibiting a gradual contact with the extremely silicified wall-rocks (mostly biotite/chlorite schists). The general undeformed character of these veins constraints their age as being post-D_2, placing a hiatus of mineralization between D_{1a} and post-D_2. Barren veins (devoid of gold or any sulphide) are also present in the examined sectors near the ore bodies, and the main system (millimetric to centimetric in thickness) is folded and sealed by quartz + albite + sericite; the folds characteristically display steeply plunging axes, in agreement with a genesis related to a strike-slip movement along a sub-vertical shear zone. Late barren veins of centimetric thickness, essentially composed of milky and undeformed quartz, represent the late circulation (tectonically controlled) of hydrothermal fluids in this area.

5. MINERALIZATION

Arsenopyrite, loellingite and pyrite are the main sulphides in the Chaminés and Casas Novas ore bodies (fig.4). The mineralogy of the gangue is largely dominated by quartz and sericite, although chlorite, alkali-feldspar, carbonate and tourmaline may be locally important.

Gold occurs mainly in its native form, in small crystals (usually less than 5 μm), in close association with the ubiquitous arsenopyrite. Small amounts of native bismuth, bismuthinite and loellingite are spatially associated with this precious metal. Arsenopyrite is the commonest ore mineral, occuring either as anhedral aggregates (2-3 cm) or as subhedral-euhedral individual crystals. Frequently, arsenopyrite is found intergrown with loellingite. Anhedral crystals of pyrite, sometimes present, crystallized during two events. One of the events of pyrite crystallization occurred clearly prior to the main arsenopyrite-gold deposition and in some samples both events of pyrite deposition seem to predate the main ore development. Chalcopyrite is also present, although with subordinate importance, generally as venules in arsenopyrite or in small, anhedral crystals. Sporadic occurences of maldonite, pyrrothite, sphalerite, and marcassite are found. Scorodite, covelite, chalcocite and digenite are also reported as supergene alteration products of arsenopyrite and chalcopyrite.

6. CONCLUDING STATEMENT

The gold mineralizations of the Escoural (Montemor) are hosted by

formations of Upper Proterozoic age which experienced medium to high grade regional metamorphism, predating the D_2 phase of variscan deformation.

Since the fifties, successive geochemical campaigns carried out by DGGM and RIOFINEX, put in evidence the presence of superimposed Au-As anomalies in two potentially interesting targets: Chaminés and Casas Novas. In these two sectors, the ore bodies are subvertical and occur along a NW-SE, extremely silicified band which inflects to N-S in its central segment; their development is probably related to the late reactivation events of a NNW-SSE/N-S D_2 right-handed mega-shear. The circulation of hydrothermal fluids along this major tectonic accident is in general characterized by prominent silicification and sericitization. The deposition of quartz (not deformed), fine-grained white-micas (sericite I and II), and arsenopyrite II clearly postdates an earlier assemblage of alteration which comprises quartz I (with slightly wavy extinction) + chlorite I + rutile $\pm$ albite $\pm$ arsenopyrite I $\pm$ pyrite I. Later stages of alteration are essentially represented by the deposition of quartz and chlorite along late veinlets, usually followed by scorodite, iron (hydro)-oxides and sparse covelite.

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ACKNOWLEDGMENTS

This work was supported by the Project nº MA2M-CT90-0033 (Multiannual R&D Programme (1990-1992) - EEC). The management and geological staff of RIOFINEX granted permission for drill-core sampling and access to unpublished internal reports. In particular RIOFINEX geologists L. Stephan, F. Faria and E. Espada provided field and drill-core guidance, and many useful discussions. The management of EDM made possible the continuation of the work (after 1991) and authorised the publication of these results. They are all most gratefully acknowledged.

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