THE PRECAMBRIAN SUPRACRUSTAL ROCKS OF THE ‘ISLA CRISTALINA DE RIVERA’ IN NORTHERN URUGUAY AND THEIR ORE DEPOSITS

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Definition of a new lithostratigraphic unit ('Vichadero Formation') and a contribution to the genesis of banded iron-formation and manganese-formation

SUMMARY
Geotectonic models applied to the Precambrian of southern Gondwana recognize a number of plates which collided in Neoproterozoic - earliest Paleozoic times to form this supercontinent. In central-eastern South America, the pre-Brasiliano (pre-Neoproterozoic) cratonic area known as Río de la Plata Craton is best exposed in Uruguay and southern Brazil. In Uruguay, two pre-Brasiliano terranes have been identified:
- the Piedra Alta Terrane
- and the Nico Pérez Terrane.

In the Piedra Alta Terrane, extensive granitic-gneissic areas and three volcano-sedimentary belts (the Arroyo Grande, Colonia-Florida or Paso Severino, and Montevideo belts) have been recognized. These belts consist of low to medium grade metamorphic rocks and have been interpreted in the literature as Archean greenstone belts.

The Nico Pérez Terrane is a Transamazonian (Paleoproterozoic) tectonostratigraphic unit intensely affected during the Brasiliano tectogenesis. It comprises the “Isla Cristina de Rivera” in northern Uruguay, the target area of this study, and a further region in the centre of Uruguay including the Valentines area. In the latter area, the Valdivia Formation has been defined. It is composed of partly migmatized oligoclase gneiss, augite-magnetite and amphibole-magnetite quartzite, clinopyroxene fels, and amphibolite.

Hitherto, no Archean ages have been obtained from rocks of the basement of the Nico Pérez Terrane.

The Isla Cristina de Rivera forms a 105 km long horst of Precambrian rocks in northern Uruguay and comprises an area of around 2000 km². It lies like a “crystalline island” within Gondwana sedimentary rocks of the Paraná Basin. Although the Isla Cristina de Rivera constitutes the most important metallogenic province of Uruguay, it has been insufficiently investigated so far. Due to limited mapping, there is scarce information about its stratigraphic and tectonometamorphic inventory. Geochronologic data are also sparsely available. Therefore, both the geotectonic evolution of the Isla Cristina de Rivera as well as its possible correlation with related Precambrian provinces are still poorly understood.

The Isla Cristina de Rivera is composed of the following lithologic units (in decreasing abundance):
- basement rocks (muscovite and/or biotite gneiss, amphibole gneiss, and amphibolite; acidic and basic orthogneiss, quartzite, leplinite, and schist; migmatite; granite rock; high grade metamorphic rock),
- undifferentiated granites and late-posttectonic granitoids,
- undifferentiated eclogites,
- low grade metamorphic rocks.

Structurally, the main grains of the Isla Cristina de Rivera are aligned in the N70°W (E-W to N30°W). From the “Vichadero Shear Zone”, which occurs through the whole of the Isla Cristina de Rivera along its longest axis, mylonite, blastomylonite, cataclasite, and associated alkaline granite have been reported. This major lineament divides the Isla Cristina de Rivera into two tectonic blocks:
- a northern block, composed of granitoids and low to medium grade metamorphic supracrustal rocks,
- and a southern block, mainly made up of acidic metagranitoids and subordinate intercalated amphibolite.

In this study, an attempt is made to classify some geologic units of the Isla Cristina de Rivera, combining lithostratigraphic observations with economic geology considerations. Thus, the “Isla Cristina de Rivera Complex” (embracing all rocks of the Isla Cristina de Rivera), the Vichadero Formation, and three mineral districts within the Isla Cristina de Rivera are newly defined.

In the western part of the Isla Cristina de Rivera, the Minas de Corrales mineral District occurs. It comprises mainly basement rocks, the Minas de Corrales granite, supracrustal rocks of the Vichadero
Formation, and supracrustal rocks of the Minas de Corrales Formation. The most important gold mine of the country, the San Gregorio Mine lying close to the village Minas de Corrales, is hosted in this mineral district, as well as other gold and iron occurrences of minor significance.

In the central part of the Isla Cristina de Rivera, the Zapucyac Mineral District is recognized. It consists of basement rocks, granitoids, and, notably, rocks of the Vichadero Formation. The Zapucyac Mineral District hosts the dormant Zapucyac gold mine, some small gold mineralizations, and the most important iron-manganese deposits of the country: the Papagayo Deposit and the Imán Deposit.

The easternmost part of the Isla Cristina de Rivera, where the Vichadero Mineral District occurs, is mainly composed of granitoids and also includes rocks of the Vichadero Formation.

Within the Isla Cristina de Rivera, the characteristic lithologic association of the Vichadero Formation has been identified at many parts including its easternmost and westernmost localities (Vichadero and Manuel Díaz, respectively), which lie approx. 100 km apart from each other. The Vichadero Formation consists of metamorphosed sedimentary and subordinate volcanic rocks. It is made up of the following members:

- banded iron-formation (BIF)
- manganese-formation (MnF)
- quartzite
- clinopyroxene fels
- tremolite fels and calc-silicate fels (both of subordinate abundance)
- forsterite marble
- metabasite (including two-pyroxene granulite).

The type locality for the Vichadero Formation is assigned to the close vicinity of the Cerro Vichadero on the outskirts of the Vichadero village, easternmost Isla Cristina de Rivera. The locality Cerro Imán in the central part of the Isla Cristina de Rivera hosts the parastatotype for the Vichadero Formation. The entire sequence of rocks of the Vichadero Formation is mostly several tens of meters thick (and exceptionally more than 100 m). The thickest member, the BIF/MnF, has a maximum thickness of ca. 100 m. Morphologically, the BIF/MnF of the Vichadero Formation forms low hills in the undulating countryside.

No radiometric dating are available so far for rocks of the Vichadero Formation. Based on indirect evidence (field and petrologic relationships, the BIF-MnF association, and REE features), the depositional age appears to be early Paleoproterozoic, and the age of the main metamorphic event Transamazonian (ca. 2.27 Ga).

A detailed petrographic and geochemical characterization of the members of the Vichadero Formation is given in the present work, together with abundant mineral-chemical data. The different varieties of BIF/MnF from Vichadero, Cerro Imán, Cerro Imán east, Papagayo Deposit (many localities), Minas de Corrales, and Manuel Díaz, have been classified on the basis of their fabric and mineralogy into the following four groups:

**group I**
- banded rocks composed of over 99 vol% of quartz- and Fe-oxide-layers (BIF);

**group II**
- rocks composed of quartz, Fe-(Mn-)oxides, and Fe-(Mn-)chain silicates; banded or at least showing an incipient banding; mostly garnet-free (BIF);

**group III**
- rocks composed of Fe-(Mn-)oxides, Mn-Fe-silicates, and variable amounts of quartz (which may be also absent); garnet-bearing to garnet-rich (MnF/BIF);

**group IV**
- rather massive Mn-rich rocks composed of Mn-Fe-silicates and Fe-(Mn-)oxides; quartz mostly subordinate or absent (MnF/BIF).

These four groups represent “end-members” of a continuously varying sequence. Group I and most of group II belong to the oxide facies of BIF. One occurrence of group II (at the Papagayo Deposit) is a silicate facies BIF. Rocks of groups III and IV are composite Fe-Mn rocks. Most of group IV represents the silicate facies of MnF. Neither the carbonate facies nor the sulfide facies of BIF/MnF have been reported from the Isla Cristina de Rivera.

Magnetite and hematite are the main oxide minerals in the surveyed BIF/MnF of the Isla Cristina de Rivera. Hematite occurs pseudomorphically after magnetite and is thus always younger than magnetite. Two processes of martization must be distinguished:

- “lamellar” martization (martization s.s.), i.e. the pseudomorphical replacement of magnetite by hematite lamellae along {111} planes of magnetite,
- and “patchy” martization, which can take place either directly or normally via “lamellar”
martite through recrystallization. Both martitization processes begin from the periphery of the pre-existing magnetite grains and along fractures, and lead to hematite-dominated rocks with relic magnetite. No indication has been found for hematite as a phase formed prior or simultaneously with magnetite. On the contrary, “pyromorphite-hematite”, which may be present as an accessory phase, appears to be paragenetically with magnetite.

In the composite Fe-Mn rocks of the Isla Cristina de Rivera, the degree of martitization tends to decrease concomitantly with increasing jacobsite content in the magnetite solid solution (up to 20.7 mole %), indicating that jacobsite increases the stability of magnetite under oxidizing conditions. Another important observation is that the Mn content in martitic hematite appears to be lower than that in the original magnetite. Thus, magnetite releases Mn during martitization, this being a minor Mn source for the formation of secondary Mn-minerals. However, the main Mn reservoir results from the supergene alteration of Mn-silicates.

The “pure” oxide facies BIF of group I is composed of mesoscopically “monomineral” quartz- and Fe-oxide layers (magnetite and martitic hematite), up to several cm thick. Apart from Si and Fe, this group has generally extremely low concentrations of other elements. Also the Mn content is negligibly low in both the whole-rock and magnetite. Group II of BIF, being of minor abundance in the Isla Cristina de Rivera, is similarly defined but hosts Fe-(Mn-)chain silicates (clinopyroxene, pyroxenoid, amphibole). In the analysed samples of groups I and II, SiO2 + FeO (total Fe expressed as FeO ) ranges from 90.4 to 99.0 wt% of the bulk-chemistry. Group II contains slightly higher contents of Al, Mg, and Ca than group I, reflecting the occurrence of the above-mentioned silicate minerals.

The composite Fe-Mn rocks of group III are garnet-bearing garnet-rich (with spessartine dominating the garnet solid solution, up to 77.2 mole %). Garnet-rich rocks of this group are non-banded, coarser-grained, and quartz-depleted as compared with groups I and II. Group III MnFe2O4/BIF has usually higher Mn, Al, and Ca contents (MnO ranges 4.2 - 10.2 wt%, Al O 0.5 - 5.7, and CaO 0.3 - 9.5) as well as higher Sc, Y, and SREE than BIF of the previous groups I and II. Additionally, significant Mg may be present (0.1 - 4.2 wt% MgO).

Group IV is defined as a heterogeneously composed group including various massive, composite Mn-Fe rocks. Manganese-silicates are the dominant constituents: knoebelite, pyroxferrolite or pyroxmangite, braunite, manganese augite or manganese hedenbergite/diopside, spessartine-dominated garnet. The formerly reported hypersthenite was possibly mis-identified knoebelite. Quartz occurs as a minor constituent or is absent. There is a remarkable range of Al contents (0.2 - 14.4 wt%) and also of MgO (0.4 - 5.5 wt%) and CaO (1.2 - 7.2 wt%) in group IV.

Amphibole species belonging to the iron-magnesium-manganese amphibole group (cummingtonite, dannemorite, tirodite) and to the calcic amphibole group (actinolite, tremolite) may be present in rocks of all four groups. Apart from the BIF occurrence of Manuel Diaz, where amphibole is in equilibrium with quartz and magnetite, amphibole is of diaphroethetic origin, occurs acicular-developed, and rims the other silicate minerals. Usually, this retrograde amphibole urtalizes clinopyroxene and replaces quartz. Apatite is a common accessory in all groups. Supergene limonite and manganolamethane are widespread.

It is noteworthy to mention that the MnFe2O4 of the Isla Cristina de Rivera probably hosts the first Latin American record for both Mn-minerals knoebelite and dannemorite.

The other metasediments of the Vichadero Formation are usually exposed as isolated outcrops up to ca. 60 m away from the respective BIF/MnFe2O4 occurrences. Quartzite occurs subordinate and with transitions to both BIF and clinopyroxene fels. Oxide minerals are virtually absent in the quartzite of the Vichadero Formation, and Fe is housed in urtalized diopside/hedenbergite. Clinopyroxene fels has been found intimately associated with forsterite marble and/or quartzite. The fels is a coarse-grained, non-banded, light greenish-grayish (when fresh), and anchimomineracal rock with homogranular texture. Clinopyroxene, occurring in the form of diopside porphyroblasts, has straight to smoothly curving boundaries and polygonal shapes; 120° triple junctions occur widespread. Clinopyroxene fels shows SiO2 contents mostly in the range of 52.5 - 56.2 wt%, MgO 13.1 - 15.7 wt%, CaO 20.6 - 22.5 wt%, and FeO (total Fe) 2.5 - 7.0 wt%. Tremolite fels was encountered only in the Manuel Diaz area. The rock is monomineralic and nematoelastic-textured. Vesuvianite-bearing calc-silicate fels, which bears also diopside, quartz, feldspar, and accessories (zoisite, apatite, ilmenite, rutile, titanite), was found only in Vichadero; it occurs associated with clinopyroxene fels.

Forsterite marble is composed of dolomite and calcite, forsterite, subordinate magnetite and Mg-chlorite, as well as rarely diopside, tremolite, phlogopite, spinel, pyrophyllite, and minute sulfides and rutile. Forsterite (15 - 20 vol%) occurs as oval porphyroblasts, seldom longer than 4 mm and randomly distributed in a light grey carbonate matrix.
Metamorphic basic rocks considered to belong to the Vichadero Formation and outcropping close to BIF/MnF occurrences are homogranular and granoblastic-textured. This group of rocks includes two-pyroxene granulite, which is exposed in the Papagayo Deposit and Cerro Imán east. The metabasites occurrences are mainly composed of plagioclase (anodesine), diopside/augite (and urtite), and, in the two-pyroxene granulite, additionally of ferrosilite. Minor quartz and microcline as well as accessory ilmenite, magnetite, amphibole (tscharnikeite and hastingsite), apatite, biotite, zircon, and minute sulfides may be present. All these metabasite occurrences are interpreted as metamorphosed basic volcanic rocks.

In spite of the high-grade metamorphic overprint and deformation of the BIF/MnF-bearing sequence, the sedimentological interpretation of the members of the Vichadero Formation has led to a paleoenvironmental model which gives insight into ore genesis. Contrary to older models, which assumed skarn-like metasomatic processes in order to explain the genesis of both the BIF and the marble, the present investigations support the model of a sedimentary pile (with subordinate basic volcanics) and a subsequent metamorphic overprint.

The protolith for the BIF and MnF is considered to be a Fe- and Fe-Mn-rich, respectively, cherty, carbonate-bearing, mudstone-like sediment, (bio)chemically precipitated and contaminated with minor clastic material. The bulk of Fe, Mn, and Si is considered to be derived from submarine hydrothermal volcanicogenic exhalations, and the bulk of Ca and Mg from ocean water through normal marine sedimentation, whereas Al (and minor Si) has a clastic provenance. Some evidence has been found to support the view that carbonate was a constituent of such a precursor sediment (Mn-rich calcite inclusions in spessartine-dominated gamet), although posterior decarbonation metamorphic processes could have caused the virtual absence of carbonate within the BIF/MnF. Concerning the SiO₂ content of the protolith of BIF/MnF and quartzite, no indication for a detrital quartz input has been found. On the contrary, the REE distribution patterns of quartzite suggest a chemical precipitate (i.e., chert).

A cherty contribution is also postulated for the protoliths of the other metasediments of the Vichadero Formation, all considered as “impure carbonate rocks” of chemogenic origin. The precursor of forsterite marble was a siliceous dolomite. Analogously, the parental materials of clinopyroxene fels and of tremolite fels are considered as chert-carbonate mixtures, with the chert component more abundant than in the protolith of forsterite marble.

The clastic input in the bulk of the sediments of the Vichadero Formation is of subordinate importance and roughly correlates with the abundance of Al₂O₃ content in the respective rock (apart from those metasediments presenting a late alkali alteration, which are enriched in Al₂O₃).

The lithologic nature of the metasediments of the Vichadero Formation indicates thus a chert- and carbonate-producing shelf as depositional paleoenvironment. No indication for a greenstone belt association has been found. Additionally, REE distribution patterns of BIF/MnF suggest a distal precipitation of the chemical constituents relative to the site of the volcanicogenic hydrothermal input or deposition in a marginal basin. The similar REE distribution patterns of the metasediments of the Vichadero Formation suggest a common depositional paleoenvironment for all of them.

No indication for independent basins or for a different stratigraphic position of some of the BIF/MnF occurrences of the Isla Cristalina de Rivera has been found. Hence, they are all interpreted as belonging to a unique stratigraphic level deposited on a passive continental margin. The present strike length of the (folded) Vichadero Formation sequence in the Isla Cristalina de Rivera, i.e. without considering tectonic effects, amounts to about 100 km.

Some features strongly suggest a linkage of the BIF occurrences of the Isla Cristalina de Rivera to the Lake Superior type. These features are the lithologic nature and the shelf parentage of the metasediments of the Vichadero Formation, the intimate association BIF-MnF, the postulated distal deposition in relation to the hydrothermal volcanicogenic exhalations, the subordinate presence of volcanic rocks and its basic composition, the inferred Paleoproterozoic depositional age, and the extension of the sedimentary record of the Vichadero Formation. Since Mn is soluble in ocean water in a wider range of pH-Fe₃⁺-conditions than Fe, it can be transported over longer distances. Therefore, the Mn-rich protolith was precipitated closer to the shore-line under more oxidizing and shallower marine conditions than the BIF protolith. This is also supported by the higher Al₂O₃ contents, i.e. more significant clastic shaly contamination, of the Fe-Mn ores of groups III and IV as compared with BIF of groups I and II. For instance, the protolith of the anchimonomineralic spessartine fels (silicate facies MnF) was relatively Al- and Mn-rich as well as Fe-poor, indicating a significant clastic input and Fe/Mn separation, and thus a deposition rather close to the shore-line. However, the subsequent deformation and the reticltic conservation of the supracrustal sequence
lately obliterated this depositional zoning.

Concerning the tectono-metamorphic overprint of the members of the Vichadero Formation, the two-pyroxene granulite and the spinel-bearing occurrences of forsterite marble in the central and eastern part of the Isla Cristalina de Rivera demonstrate that the granulite facies was attained. Petrogenetic grid considerations based on the mineral paragenesis of the two-pyroxene granulite, i.e. plagioclase-clinopyroxene-orthopyroxene (in absence of both garnet and olivine), indicate an intermediate pressure regime and peak metamorphic conditions of about 800°C and 6-9 kbar, which fit well with the “average granulite regime” from literature (of 800 ± 50°C and 7.5 ± 1 kbar). Furthermore, a clockwise P-T-t path is suggested.

Selected mineral parageneses of the four BIF/MnF groups of the Isla Cristalina de Rivera reflecting the respective peak metamorphic conditions are given in the following (accessories after semicolon):

- group I BIF:
  - quartz, magnetite; apatite, ilmenite or pyrophanite
- group II BIF:
  - quartz, magnetite, rhodonite; apatite
- quartz, magnetite; augite, apatite
- quartz, magnetite, Fe-amphibole; apatite (Manuel Díaz)
- group III MnF/BIF:
  - magnetite, spessartine-dominated garnet; quartz, apatite, pyrophanite
- group IV MnF/BIF:
  - kuebelite, manganese hedenbergite/diopside, magnetite, spessartine-dominated garnet; apatite
  - pyroxferroite, magnetite, quartz, manganese augite; apatite
  - braunite, magnetite, spessartine-dominated garnet
  - spessartine-dominated garnet; quartz, pyrophanohematite, magnetite, apatite.

Under the prevailing physico-chemical conditions during the tectono-metamorphic overprint, Mn had a greater affinity to Si than Fe had. Manganese-silicates occur widely in the Fe-Mn rocks of groups III and IV (even in Al-poor varieties), contrasting with the scarcity of Fe-silicates in the BIF of groups I and II (where Fe is mainly concentrated in magnetite and martitic hematite). The latter indicates a relatively high f during the metamorphic overprint of the BIF of the Vichadero Formation. The virtual absence of afmardine-dominated garnet in BIF (groups I and II) is striking and reflects the paucity of the Al content in these rocks. On the contrary, spessartine-dominated garnet is widespread in the composite Fe-Mn rocks of groups III and IV, in which Al contents are higher.

Additionally to the northward increasing grade of metamorphism within the Nico Pérez Terrane postulated in literature, a W-E metamorphic gradient appears to exist within the Isla Cristalina de Rivera at the present level of exposure. For the Manuel Díaz area, westemmost Isla Cristalina de Rivera, a metamorphic event in the amphibolite facies has been recognized, as documented by the presence of tremolite fels, of amphibole in equilibrium with quartz and magnetite in BIF, and of Mg-chlorite in spinel-free forsterite marble. Within the Minas de Corrales area, western Isla Cristalina de Rivera, a metamorphic overprint also in the amphibolite facies has been documented. In contrast, higher metamorphic conditions have been found in the central and eastern part of the Isla Cristalina de Rivera (Zapucay and Vichadero mineral districts, respectively). A heterogeneous metamorphic overprint and/or a different present level of exposure of the Vichadero Formation occurrences may account for this metamorphic gradient.

The retrograde metamorphic evolution is well documented by the replacement of pyroxene by uraltic amphibole in BIF/MnF; quartzite, and metabasite under conditions close to the transition between the amphibolite facies and the greenschist facies. A late alkali metasomatic alteration, which led to the formation of alkali feldspar, has also been recognized, but it is of subordinate significance.

Additional geologic information and geochronological data are needed to successfully correlate this supracrustal sequence with those of neighboring Precambrian regions. The Vichadero Formation does not appear to be related to either the BIF-bearing Arroyo Grande belt in western Uruguay (for whose BIF a linkage to the Algoma type BIF is postulated) or to the Neoproterozoic BIF-bearing sequences in southeastern Uruguay (Rapitan type-related). On the contrary, a correlation with the Valentines Formation exposed in the centre of the country is possible, and a major Paleoproterozoic, BIF-bearing basin within the Nico Pérez Terrane is conceivable.

A relationship of the Vichadero Formation to the Paleoproterozoic supracrustal rocks of the Buenos Aires Complex (Tandilla region, eastern Argentina), which hosts both forsterite marble and clinopyroxene
fels. is also thinkable, as well as to some BIF-bearing sequences of the granulitic belts in southern Brazil.

Finally, the lithologic nature and the postulated early Palaeoproterozoic deposition age of the Vichadero Formation sequence implies a roughly coeval deposition with the giant Lake Superior type Fe-Mn-horizons in the Trunauval and Minus basins, South Africa (Kalahari) and Brazil (Iron Quadrangle), respectively.

CONTROLE ESTRUTURAL DAS OCORRÊNCIAS DE OURO RELACIONADAS A VEIOS DE QUARTZO NA REGIÃO DE MAHOMA (SAN JOSÉ – URUGUAY). UFRGS, PPGEM

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A região de Mahoma (Dept. San José, Uruguay) é composta por três unidades litológicas principais: 1) Complexo Ortonássico, 2) Complexo Metassedimentar e 3) Granitos tardí a pós-deformacionais que têm sido datados em 2000 Ma. As ocorrências de ouro estão relacionadas a veios de quartzo estruturalmente controlados e alojados nos granito-gnaisses do Complexo Ortonássico. Assim, as ocorrências de ouro na região de Mahoma podem ser classificadas como veios de quartzo com Au (gold-quartz veins) em terrenos metamórficos. As principais ocorrências auríferas são: Mina Mahoma (Metagranodiorito Arroyo del Sauce, sin-deformacional) e Prospecto Área 13 (gnaisses proto a ultramyloníticos, Complexo Ortonássico). As principais unidades litológicas da região de Mahoma registram a atuação de 4 eventos deformacionais, 3 dos quais têm caráter penetrativo e formaram as estruturas mais importantes do ponto de vista do controle de depósitos minerais. O evento D formou as principais rochas gnaisses (S , foliação milonítica), tanto no Complexo Ortonássico, quanto no Complexo Metassedimentar. O evento B constitui uma foliação plano axial (S'), anastomosada, que parcialmente transpõe S . O evento D é responsável pela estruturação final da região e é composto por um sistema de zonas de cisalhamento e dobrás de arrasto. As ocorrências de Au e os veios de quartzo relacionados estão condicionados às zonas de cisalhamento (Mina de Mahoma) e à dobra flexural de arrasto (Prospecto Área 13). Dentro desse quadro estrutural, foi possível caracterizar os seguintes tipos de veios: a) veios paralelos à foliação milonítica S na ZCP (Zona de Cisalhamento Principal); b) veios oblíquos à foliação milonítica S (C e/ou R) na ZCP; c) veios perpendiculares à foliação milonítica S (T) na ZCP; d) veios em saddle reefs nas chameiras das dobrás de arrasto F . A paragênese metamórfica associada com a foliação milonítica S é composta por quartzo, plagioclásio, biotita, muscovita, esfeno, epidoto nas rochas gnaisses ácidas (granito-gnaisses). A paragênese de alteração hidrotermal formada nas dilatações estruturais da fase D (sombras de pressão de porfiroclastos, fraturas Riedel transtativas, rugosidades de foliações e de fraturas, aberturas na chameira de dobrás flexurais) é composta por quartzo, clarita, carbonato, sericita, pírita, (albita?). As características estruturais e petrologicas da deformação D e do hidrotermalismo associado com os veios de quartzo e as ocorrências de Au sugerem um modelo metamórfico-hidrotermal para a origem das ocorrências de ouro associadas com veios de quartzo na região de Mahoma (Uruguay).