

# AGE OF GOLD MINERALIZATION AT THE MORRO VELHO AND RAPOSOS MINES, MINAS GERAIS (\*)

By

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## RESUMO

Os depósitos de ouro das minas de Morro Velho e Raposos estão localizados, respectivamente, em uma rocha ankerito quartzosa, "lapa seca", e uma rocha laminada quartzo-siderítica com carbonato-facies de formação ferrífera. Estas rochas carbonatadas estão intercaladas com xisto-filítico do grupo Nova Lima da Série pré-Minas do Rio das Velhas.

Perto da cidade de Nova Lima a direção regional das rochas da série pré-Minas é geralmente norte a noroeste. A noroeste dessa cidade, na serra do Curral, tais rochas acham-se aparentemente truncadas em um grande ângulo por rochas com direção nordeste, da série de Minas.

Perto de Nova Lima e Raposos as rochas matrizes para a mineralização dos sulfetos e do ouro formam um certo número de dobras mergulhando para leste, no local ou perto de onde a estrutura com direção regional norte curva-se para noroeste. Estas dobras com mergulho para leste são consideradas contemporâneas ao dobramento da série de Minas. As dobras, evidentemente, ajudaram a localizar áreas de mineralização dos sulfetos e do ouro; portanto, a mineralização foi posterior ao dobramento. A mineralização está, possivelmente, relacionada com a intrusão, em certa época, de rochas graníticas entre a parte final do período de dobramento post-Minas e o fim do Precambriano.

## INTRODUCTION

The Morro Velho mine is located at the city of Nova Lima in the southwestern part of the Nova Lima quadrangle and the Raposos mine is at Raposos, in the south-central part of the Nova Lima quadrangle, 4 to 5 kilometers east-northeast of Nova Lima (see fig. 1).

Mapping in the Nova Lima, Rio Acima, and adjacent quadrangles has shown that an older unit of Precambrian rocks, the Rio das Velhas series, is strongly folded and eroded, and unconformably overlain by the Minas series (Rynearson, et al., 1954; Dorr, et al., 1957). The Minas series, in turn, was folded during later Precambrian time. North of the Serra do Curral, near the village of General Carneiro, a few kilometers northeast of Belo Horizonte, and some 12 to 13 kilometers north of Nova Lima, the Minas

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series was intruded by granitic material that is part of the large mass of granitic rock extending north and northeast of Belo Horizonte. Aside from mafic dikes, the granitic rock near General Carneiro is closer to the Morro Velho and Raposos mines than any other sizable mass of intrusive rock.

### GEOLOGIC SETTING OF THE GOLD DEPOSITS

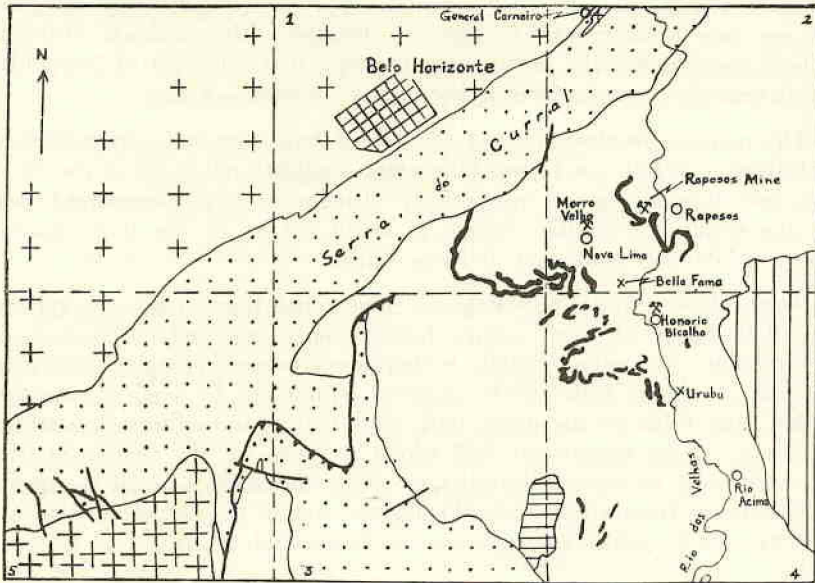
*Rock units.* The pre-Minas country rocks in the vicinity of the Morro Velho and Raposos mines belong to the Nova Lima group of the Rio das Velhas series (Dorr, et al., 1957, p. 15-21). They consist mainly of gray and gray-green schists and phyllites that are rich in quartz, sericite, and chlorite and have varying amounts of carbonate. Locally, the schists may have graphite or fuchsite. One or more beds of a grayish granoblastic-textured metasedimentary rock consist predominantly of quartz and ankerite. This rock is locally called *lapa seca* and is interbedded with the schist and phyllite at the Morro Velho mine. Chlorite, sericite, and sodic plagioclase are sporadically distributed in the *lapa seca*, but generally are present only in small or minor amounts. At the Raposos mine, several beds of laminated quartz-siderite-magnetite and quartz-siderite rock are interlayered with the schist-phyllite. This rock is carbonate-facies metasedimentary iron-formation (James, 1954, 251-256), in which laminae rich in fine, even-grained granoblastic quartz alternate with laminae of fine, even-grained sideritic carbonate or sideritic carbonate and magnetite. Gold-sulfide mineralization formed the ore deposits of the Morro Velho and Raposos mines by local hydrothermal replacement of the *lapa seca* and carbonate-facies iron formation.

Beds and lenses of iron-formation exposed 1 kilometer southwest of the city of Nova Lima are also interbedded in the schist-phyllite of the Nova Lima group and probably were laid down conformably with the *lapa seca* of the Morro Velho mine.

*Structure of the Nova Lima group near Nova Lima.* The iron-formation southwest of Nova Lima extends west-northwestward from the Nova Lima into the Belo Horizonte quadrangle where J. B. Pomerene (oral communication) has found that its trend swings more to the north and extends toward the Serra do Curral. Apparently it is truncated at a large angle by unconformably overlying rocks of the Minas Series.

The *lapa seca* cannot be followed more than 2 kilometers west-northwestward from the Morro Velho mine. Judging by the trend of the iron-formation that occurs southwest of Nova Lima, however, the horizon at which *lapa seca* lies extends west-northwestward for perhaps 3 kilometers from the Morro Velho mine, and thence more nearly northward beneath talus from the Serra do Curral, and is truncated by the Minas series of the Serra do Curral.

Gold-sulfide mineralization of original *lapa seca* and similar grayish carbonate-rich rock is known at Bella Fama, Honorio Bicalho, and Urubu,



Minas series



Rio dos Velhas series



Maquie group



Nova Lima group  
Black layers, iron-formation



Granitic rocks of post-age



Granitic rocks of pre-age



Altered ultrabasic intrusive rocks

Contact  
Separates major  
geologic units



Fault  
Triangles on  
upper plate of  
reverse fault

Mine

X  
Mineral  
exploration

	1	2
5	3	4

Quadrangle boundary

- 1 Belo Horizonte quadrangle
- 2 Nova Lima quadrangle
- 3 Macacos quadrangle
- 4 Rio Acima quadrangle
- 5 Ibirite

Figure 1. Index map showing location of Morro Velho and Raposos mines and major geologic features of surrounding area.

between 3 and 8 kilometers southeast of Nova Lima. Relatively low-grade gold ore has been mined at Honório Bicalho. The regional structural trends of associated rocks suggest that the *lapa seca* southeast of Nova Lima is at or near the same horizon or horizons as at Morro Velho.

The regional northward trend of beds of *lapa seca* and carbonate-facies iron-formation within one to two kilometers southeast and south of the Morro Velho and Raposos mines, respectively changes to a northwestward trend near the mines. A similar change in trend occurs in the iron-formation exposed 1 kilometer southwest of Nova Lima.

At the Morro Velho and Raposos mines, and thus in the general area where this change of trend occurs, beds of *lapa seca* and carbonate-facies iron-formation are rather tightly folded into eastward-plunging structures. The folds at Morro Velho itself, however, appear to be smaller structures, possibly drag folds on the north limb, and somewhat to the west-northwest of the axis, of the larger-scale fold which accounts for the change in trend from northward to west-northwestward. Near the surface, axial plunges of the folds range from about 25 to 45 degrees, but in the deepest workings in the Morro Velho mine, axial plunges of folds tend to flatten to 12 to 15 degrees.

From the small exploration openings and little development work done in the areas of gold-sulfide mineralization at Bella Fama and Urubu, the carbonate host rock is known to trend northward and dip eastward. No important folds are evident, except possibly a short distance south of Bella Fama, but there may be slight or moderate undetected eastward-plunging rolls in bedding. At Honório Bicalho the trends of drifts in the now-abandoned workings along the north-trending east-dipping host rock indicate a moderate bend in the strike of host rock from north to northeast along the north edge of the workings.

*Structure of Minas series along the Serra do Curral.* The Serra do Curral (fig. 1) trends about northeast across the northwestern and north-central parts of the Quadrilátero Ferrífero and is underlain by layered metamorphic rocks of the Minas series. The Minas rocks in the Serra do Curral occupy the north limb of a large orogenic uplift of post-Minas age. Pre-Minas rocks occupy the core of this uplift south of the Serra do Curral near Nova Lima and Raposos and in the area along the Rio das Velhas to the south. Although the tops of the Minas rocks along the Serra do Curral are to the northwest, these rocks are overturned and generally dip rather steeply southeastward. The northwestward overturning of the Minas rocks suggests a general northwestward-directed stress component in that part of the Serra do Curral during the post-Minas folding. A south-dipping reverse fault involving Minas rocks a short distance south of the Serra do Curral, south of Belo Horizonte (J. B. Pomeroy, oral communication), also indicates the possibility of northward-directed movement along the Serra do Curral, during or after the post-Minas folding.

INTERPRETATION OF FOLDS IN PRE-MINAS ROCKS NEAR  
NOVA LIMA

The sharp divergence between the structural trends of the older rocks near Nova Lima and of the Minas series in the Serra do Curral indicates that the pre-Minas rocks were strongly folded before the Minas sediments were deposited.

The question arises as to the possible effect of the post-Minas folding on the already rather steeply folded pre-Minas rocks, taking into consideration that the post-Minas folding in this area a short distance south of the Serra do Curral probably involved some northward-directed stress and movement. The writer believes that the effect of northward-directed movement in steeply dipping thin beds that already had a northward to northwestward trend would be to crumple those beds along axes lying parallel to the steeply dipping bedding and approximately at right angles to the northward-directed movements. Therefore, the small eastward-plunging folds found in *lapa seca* and carbonate-facies iron-formation at the Morro Velho and Raposos mines, respectively, are believed to be the result of northward-directed stress acting on these rocks at the time of post-Minas folding.

The northward to northwestward change in regional trend near Nova Lima and Raposos appears to occur around an eastward or east-northeastward plunging axis, and so the minor folds in the Morro Velho and Raposos mines were probably related to the larger fold that produces the change in regional trend. Some of the small folds, particularly those at Morro Velho, are probably drag folds. The postulated northward-directed post-Minas movements are believed by the writer either to have caused the change in regional trend, or to have accentuated a relatively small difference in trend that might have first developed during pre-Minas folding.

Eastward-plunging lineations are a common and consistent feature in rocks of the Quadrilátero Ferrífero (Guild, 1957, p. 31-33), including rocks of the Minas series. The widespread occurrence of eastward-plunging lineations in rocks of Minas age tends to substantiate a post-Minas age for the eastward-plunging folds near Nova Lima and Raposos.

RELATION OF AREAS OF GOLD-SULFIDE MINERAL DEPOSITS  
TO FOLDS

The mineralized rocks of the Morro Velho and Raposos mines consists mainly of disseminated and veined replacements of *lapa seca* and carbonate-facies iron-formation by gold-bearing sulfides (pyrrhotite, arsenopyrite) and barren sulfides (pyrite, chalcopyrite) (\*). Thin veinlets of quartz-car-

(\*) Graton, L. C., in private reports to St. John Del Rey Mining Company, by L. C. Graton and G. N. Bjorge, 1929 and 1931.

bonate commonly cut mineralized material and adjacent host rocks. Mineralized areas are confined rather strikingly to the layered host rocks. All investigators have attributed the replacement deposits to a hydrothermal origin.

During approximately the first 100 years of operation at the Morro Velho mine, until 1930, virtually all ore was mined from one lode, the Main ore body. Most of this ore body is slab-like in form, dips steeply southward, and plunges eastward for more than 6.5 kilometers from the surface to a vertical depth of more than, 2,400 meters. Near the surface the eastward plunge of the Main ore body is about 45 degrees and there is no indication that the ore body is folded; in the deeper workings the plunge lessens to about 15 degrees and there is some evidence that the ore body is folded. After 1930, several folded ore bodies were found south of the Main ore body at Morro Velho.

A comparison of the plan views of stoped areas with structural trends establishes the association of ore bodies with folds in both the Morro Velho and Raposos mines. This association is too striking to be fortuitous and thus leads to the conclusion that the folds preceded and controlled mineralization. In general, no tendency has been detected for gold ore or mineralized rock to be localized on particular parts of folds, except the Main ore body at Morro Velho, which was probably located mainly on the attenuated keel of an eastward plunging fold.

The form and attitude of the Main ore body led some geologists to conclude that it formed by replacement of a near-vertical dike or that it was a fissure-filling deposit. However, the parallelism of banding (relict bedding) with the plane of the ore body, and the eastward plunge of the ore body in conformity with east-plunging fold axes in the contiguous ore bodies to the south tend to rule out this possibility.

Although there is some evidence of a minor flexure in the host rock at Honório Bicalho, south of Nova Lima, as noted above, there is little known evidence of folds in the mineralized rock at Bella Fama and Urubu. Possibly, during folding, differential slippage between relatively competent carbonate-rich rock and adjoining schist-phyllite opened passageways for gold-bearing hydrothermal solutions. The evident lack of pronounced folds at Honório Bicalho, Bella Fama, and Urubu may, at least in part, explain the relatively poor grade and small size of those deposits.

## CONCLUSIONS

On the basis of the facts presented above, the interpretation of the age of the eastward-plunging folds at Morro Velho and Raposos, and the interpretation of an association between folds and mineralization, the following conclusions are enumerated:

1. Gold-sulfide mineralization at the Morro Velho and Raposos mines was localized in folded areas.
2. The eastward-plunging folds, which helped to localize the areas of mineralization, were developed during the period of post-Minas folding that resulted in north-northwestward overturning of the Minas series along the Serra do Curral east of Belo Horizonte. Mineralization therefore was post-folding in age.
3. Granitic and pegmatite rocks were intruded into the Minas series immediately north of the Serra do Curral sometime between the latter part of the period of post-Minas folding and the end of the Precambrian.
4. Gold deposition at the Morro Velho and Raposos mines may have been related to the intrusion of granitic and pegmatitic rock north of the Serra do Curral.
5. Gold deposition occurred sometime between the latter part of the period of post-Minas folding and the end of the Precambrian.

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