

SYMPOSIUM ON THE STRATIGRAPHY OF THE MINAS SERIES IN THE QUADRILÁTERO FERRÍFERO, MINAS GERAIS, BRAZIL (*)

by

Geologists of the joint DNPM-USGS team

INTRODUCTION

by

JOHN VAN N. DORR II

The ten short papers in this symposium define and describe eight new formations in the Minas series and redefine a formation set up many years ago. They thus give a summary of the stratigraphy of the Minas series. The purpose of the symposium is twofold. The first purpose is to present in succinct form for the use of the many geologists doing economic research in the area some of the stratigraphic results of twelve years of joint mapping by geologists of the Departamento Nacional da Produção Mineral and the United States Geological Survey in the Quadrilátero Ferrífero of Minas Gerais, Brazil. The second purpose is to formally introduce into the geologic literature the stratigraphic names which will be used in publications now being prepared as a result of this long campaign of mapping.

The Minas series was first defined by Derby (Derby, 1906) as including the schistose rocks resting unconformably on the coarsely crystalline "Archean" basement complex. This definition was accepted by Harder and Chamberlin (Harder and Chamberlin, 1915), who subdivided the Minas series into five units, the Caraca quartzite, the Batatal schist, the Itabira formation, the Piracicaba formation, and the Itacolomi quartzite.

Guimarães (Guimarães, 1931) recognized a major unconformity between Harder and Chamberlin's Piracicaba formation and the Itacolomi quartzite and moved the Itacolomi to series rank. Rynearson, Pomerene, and Dorr (Rynearson, et al, 1954) recognized a major unconformity between Harder and Chamberlin's Caraca quartzite and the underlying schistose rocks, and separated the rocks below this major unconformity into a separate series. This series was named the Rio das Velhas series in a paper

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by Dorr, Gair, Pomerene, and Rynearson (Dorr, et al, 1957). In the same paper the Minas series was subdivided into three groups, there named the Caraça group, composed dominantly of clastic rocks; the Itabira group, composed dominantly of chemical sediments; and the Piracicaba group, composed dominantly of clastic rocks. Harder and Chamberlin's old formation names were used for the groups because they are deeply entrenched in the literature and because the rock assemblages represented by these old formation names should be classified as "groups" under modern stratigraphic usage.

Oliveira's restriction of the Minas series (Oliveira, 1956) is accepted in these papers. Derby's definition is essentially meaningless in the Quadrilátero Ferrífero. At the time Derby defined the series, it was not known that most of the crystalline "Archean" rocks which form his "basement complex" are, at least in the Quadrilátero Ferrífero, intrusive into or metasomatically formed from the metasedimentary rocks and therefore are younger, rather than older, than much of his "Minas series".

An attempt has been made to define the formations in terms of their original composition rather than their present mineral assemblage. Because the sedimentary rocks discussed hereafter have been subjected to varying degrees of metamorphism throughout the region, the same formation may appear as a phyllite in one area, as a lowgrade schist in another and as a highgrade schist in still another part of the region.

In many parts of the area, however, granitization and metascmatism have so destroyed the evidence of the original nature of the rocks that it is impossible to be certain whether a particular gneiss has been derived from pelitic rocks of the Rio das Velhas series or of the Minas series or from rocks of both series. In such cases (and they are common), it is considered that the formations have lost their original distinctive attributes and the resulting rock is considered to belong to a younger age.

The Minas series is subdivided into the following groups and formations in the papers that follow:

Piracicaba group

Sabará formation

Barreiro formation

Taboões quartzite

Fecho do Funil formation

Cercadinho formation

Itabira group

Gandarela formation

Cauê itabirite

Caraça group

Batatal formation

Moeda formation.

THE MOEDA FORMATION

by

ROBERTS M. WALLACE

The lower formation of the Caraça group of the Minas series of Precambrian age in the Quadrilátero Ferrífero, Minas Gerais, Brazil, consists dominantly of quartzite in which are locally intercalated one or more members of sandy phyllite and minor conglomerate.

The name Moeda formation is given to this unit because excellent exposures of the formation may be found in the Serra da Moeda, east of the town of Moeda. The type locality of the formation is in the Marinho da Serra quadrangle, slightly north of the road that connects the town of Moeda with the Belo Horizonte-Rio de Janeiro highway (BR-3).

In the type locality the formation consists of three members, an upper and a lower quartzite with an intercalated phyllite member. However, in many places throughout the Quadrilátero Ferrífero the formation is composed entirely of quartzite.

At the type locality the Moeda formation is about 600 meters, in thickness, each member being about 200 meters in thickness.

The lowest member, here designated member 1, consists of fine grained to coarse grained, slightly sericitic quartzite colored light orange, light gray, to light pink on fresh surfaces. Sorting of the quartz grains is fair. Gross-bedding is sparse. Lenses of conglomerate and grit are also present at irregular intervals throughout the member and may extend laterally from a few tens of meters, to several hundreds of meters. The pebbles and cobbles of the conglomerate beds are quartzite and quartz. Although not present in the type locality, many exposures of the Moeda formation reveal a basal conglomerate which consists of angular fragments of underlying rocks, and well-rounded pebbles, cobbles, and boulders of quartzite and quartz.

The intercalated phyllite member of the Moeda formation, here designated member 2, is a sandy phyllite that varies in color from a greenish-brown to shades of light brown, orange, light red, pink, and yellowish-gray. Sand grains in this member are commonly very fine. Member 2 is present throughout the Serra da Moeda and Serra do Itabirito to the east, but is rarely observed farther to the east in the Quadrilátero Ferrífero. Nowhere within the mapped areas of the Quadrilátero Ferrífero has member 2 been recognized in normal contact with the underlying Rio das Velhas series or the Batatal formation.

The upper quartzite, here designated member 3, is essentially similar to member 1. In the type section, member 3 contains more sandy phyllite lenses than member 1, resulting in a less massive appearance.

The lower quartzite, member 1, unconformably overlies green schist or phyllite of the Nova Lima group of the Rio das Velhas series with an angular unconformity (Rynearson, et al, 1954 and Dorr, et al, 1957).

The upper quartzite, member 3, underlies and grades into the Batatal formation of the Caraça group. The gradation commonly occurs within a few meters, but intertonguing of the rock units along strike has been observed in the Serra da Moeda.

The quartzites of the Moeda formation in the Serra da Moeda and elsewhere within the Quadrilátero Ferrífero are more resistant than the surrounding rocks and commonly form ridges with steep cliffs and jagged crags. Most weathered surfaces are colored medium gray, but completely disaggregated quartzitic members form very light gray soil.

In most places the phyllitic rocks of the Moeda formation erode easily and produce small knife-edge outcrops within the craggy quartzite members, and these phyllites form a distinct topographic bench between the quartzite members. The phyllites weather to a light brown soil.

The Moeda formation is present in most of the Quadrilátero Ferrífero. A characteristic feature of this formation in the eastern part of the Quadrilátero Ferrífero is the rapid and extreme variation in thickness. In strike direction, the formation may change in thickness from a few tens of meters to greater than 1000 meters in a few kilometers distance. Changes in detailed lithology, grain size, and physical characteristics may be equally as rapid. These features reflect floodplain conditions near a littoral condition in a transgressing Precambrian sea.

THE BATATAL FORMATION

by

CHARLES H. MAXWELL

In the Quadrilátero Ferrífero of central Minas Gerais, Brasil, the Caraça group has been divided into two formations: the lower unit has been named the Moeda formation; the upper unit was named the Batatal schist by Harder and Chamberlin (1915). It is here proposed that this unit be redesignated the Batatal formation, because, throughout much of the Quadrilátero Ferrífero it occurs as a phyllite rather than as a schist.

The formation was named by Harder and Chamberlin from the Serra do Batatal in the south-central part of the Capanema quadrangle, with the type locality along the base of the Serra do Caraça, in the eastern part of the Capanema quadrangle and the northern part of the Santa Rita Durão quadrangle. The best exposures in this area are found at the headwaters of the Rio Piracicaba about 3 kilometers east of the Serra do Batatal.

In the type locality the formation is about 30 meters thick, composed almost entirely of a light-to-dark gray, very fine-grained phyllite with small scattered clusters of pyrite. Elsewhere in the Quadrilátero Ferrífero, the formation varies from a few centimeters to over 250 meters in thickness. The lithology is generally uniform, "... a light gray to dark red, fine grained, argillaceous schist..." (Harder and Chamberlin, 1915). In local areas the phyllite becomes somewhat sandy, mostly in the southern and western parts of the Quadrilátero Ferrífero. In some areas in the Quadrilátero Ferrífero, as near Itabira, near the Gongo Sôco mine and along the Serra da Moeda, the upper part of the phyllite has intercalated chert and thin lenticular beds of iron formation.

The Batatal formation conformably overlies the Moeda formation. The contact is normally abrupt but locally is gradational over a thickness of a few centimeters to several meters. The upper contact, with the Cauê itabirite of the Itabira group, is also gradational, often over a thickness of several meters. The contact is placed at the first dominant beds of iron formation.

Topographically the Batatal formation forms smooth slopes and valleys between the ridges formed by the underlying Moeda formation and the overlying Cauê itabirite.

The Batatal formation, although generally a thin and inconspicuous part of the stratigraphic column, has been mapped in all parts of the Quadrilátero Ferrífero except in the area south of Cachoeiro do Campo.

The original sedimentary rock was probably a shale or calystone, transitional between the coarse clastic rocks of the underlying Moeda formation and the chemical sediments of the overlying Cauê itabirite.

THE CAUÊ ITABIRITE

by

JOHN VAN N. DORR II

Throughout the Quadrilátero Ferrífero, Minas Gerais, Brazil, a persistent iron formation is a prominent rock unit in the Itabira group of the Minas series (Derby, 1906, and Oliveira, 1956). This unit, plus other rocks, was called the Itabira formation by Harder and Chamberlin (1915). The original formation was raised to group status in order to subdivide related but separately mappable chemical sediments of different lithology into individual formations (Dorr, et al, 1956).

This iron formation is here named the Cauê itabirite. The type locality is Cauê Peak in the Itabira District, Minas Gerais, Brazil. The top of Cauê Peak is largely composed of this formation and as well as replacement hematite ore deposits contained therein. The formation is well exposed by surface and subsurface excavations.

The Cauê itabirite is largely composed of itabirite, a metamorphosed, oxide-facies iron formation. The rock is normally composed of alternating laminae of quartz and hematite. Locally it contains beds and lenses of dolomitic itabirite and amphibolitic itabirite (rocks in which dolomite and amphibole substitute wholly or in part for the quartz) as well as local and subordinate lenses of dolomite. Dolomitic and amphibolitic itabirite commonly contain significant percentages of magnetite and martite, which substitute the hematite. Small and thin lenses of clastic rocks such as phyllite and quartzite, although rare, have been found in the Cauê itabirite.

The Cauê itabirite varies in apparent stratigraphic thickness from a few meters to well over a thousand meters in the Quadrilátero Ferrífero and from a few meters to over three hundred meters in the type locality. This variation is largely due to plastic flow during deformation; the original sedimentary thickness was probably between 50 and 250 meters.

The formation normally overlies underlying Batatal formation (Harder and Chamberlin, 1915) of the Caraga group with abrupt contact or with a contact gradational within a few centimeters. Locally the contact may be gradational over greater distances. Although at the type locality, the Cauê itabirite grades over a short distance into the rocks of the conformably overlying Piracicaba group, in most other localities the Cauê itabirite grades upward into the overlying Gandarela formation of the Itabira group over stratigraphic thicknesses measured in meters or tens of meters. In the type locality of the Cauê itabirite, the Gandarela formation was not deposited:

The separation of the Itabira and Gandarela formations is difficult in areas where the transitional zone is thick. The boundary is where normal itabirite becomes subordinate to dolomitic itabirite. Because this formation boundary represents a small, subtle, and irregular change in the pH and Eh of the original sedimentary environment (Krumbein and Garrels, 1952 & Dorr, et al, 1956), a clean-cut formation boundary is locally impossible to find. Commonly, however, it can be established without much difficulty.

Although itabirite weathers easily into an incoherent material, the weathering process commonly forms a thin protective cap of lateritic material high in limonite which is extremely resistant to both physical and chemical erosion. Due to this protective shield, the normal physiographic expression of the formation is as hogbacks and high plateaux, well above the local base level. Where the shield has been breached, oversteepened "blowouts" and gullies form. Where the itabirite has not been softened by weathering, it may form high rugged peaks and ridges.

The Cauê itabirite occurs throughout the Quadrilátero Ferrífero and, in discontinuous outcrops, for more than a hundred kilometers to the north. Its northern limit is not certainly known. Within the Quadrilátero Ferrífero, it is one of the most persistent formations of the Minas series.

THE GANDARELA FORMATION

by

JOHN VAN N. DORR II (*)

The upper formation of the Itabira group of the Minas series of Precambrian age, dominantly dolomite, is a widespread rock unit throughout the Quadrilátero Ferrífero of Minas Gerais, Brazil.

This formation is called the Gandarela formation after Fazenda Gandarela in the Gandarela quadrangle, near which excellent exposures of the unit may be found.

In the type locality the formation is largely composed of dolomite with subordinate iron formation and phyllite. However, the Gandarela formation varies greatly in lithology throughout the Quadrilátero Ferrífero. In some areas dolomitic itabirite may be the dominant constituent, in others phyllite and dolomitic phyllite predominate. Normally, however, the rocks are dolomite or strongly dolomitic, indicating that the sedimentary environment which produced the chemically deposited iron formation of the underlying Cauê itabirite persisted in large part but with somewhat different physico-chemical characteristics during deposition of the Gandarela rocks.

Although much of the iron formation in the Gandarela formation is dolomitic and characterized by relatively high percentages of magnetite, some of it is indistinguishable from the normal quartz-hematite rock of the Cauê formation. The iron formations of the Gandarela are characteristically thin and lenticular, but locally a few zones may be tens of meters thick and may be continuous for several kilometers or more.

The Gandarela formation varies widely in thickness. At the type locality, where it is relatively well developed, the formation has an apparent stratigraphic thickness of about 500 meters or more. Elsewhere it may be much thinner. In the northeastern part of the Quadrilátero Ferrífero it appears to be absent; in the northwestern and southwestern corners it is poorly developed; but in the central, western, and southern parts of the Quadrilátero it is strongly developed.

The contact of the Gandarela formation with the underlying Cauê itabirite is commonly gradational over a few meters to tens of meters. The boundary should be drawn where dolomitic itabirite or dolomite becomes predominant over normal itabirite. The upper contact with the overlying Piracicaba group is rarely exposed. In part of the Quadrilátero Ferrífero, including the quadrangles from Brumadinho to Nova Lima, there is excellent evidence for the existence of an erosional but not an angular unconformity. In the Itabira district, there is good evidence for a gradational contact between the Itabira group and the Piracicaba group. The Gandarela formation was not deposited in that area. In the type locality of the Gandarela formation and in most other parts of the area, clear proof of the existence

(*) Incorporating some work of J. E. O'Rourke, report in preparation.

of the disconformity is not exposed but the disconformity may well be present.

The Gandarela formation commonly crops out as sporadically distributed jagged dolomite and dolomitic itabirite crags near valley floors and on the lower slopes of hogbacks formed by the Cauê itabirite. Near the type locality outcrops are more continuous. The formation normally causes a characteristic hummocky and irregular topography and gives rise to black and brown soils which are much more fertile than those of underlying and overlying formations.

The Gandarela formation crops out so poorly that in certain large areas of the Quadrilátero Ferrífero its presence can only be inferred. It has been mapped from west of Brumadinho to east of Barão de Cocais and from Sabará to Congonhas and Mariana.

THE CERCADINHO FORMATION

by

JOEL B. POMERENE

In the western part of the Quadrilátero Ferrífero of central Minas Gerais, Brazil, the Piracicaba group of the Precambrian Minas series can be divided into five mappable rock units. The lowermost of these consists of quartzite, ferruginous quartzite, and phyllite.

The name Cercadinho formation is here proposed for these rocks. The type locality is in the vicinity of the source of Córrego de Cercadinho in the southwest part of the Belo Horizonte quadrangle.

The most distinctive rocks of the formation are ferruginous quartzite and aluminum colored phyllite, but relatively thick beds of gray and brown phyllite commonly make up a large part of the formation. The ferruginous quartzite beds consist of a mixture of white to colorless quartz grains and flaky specular hematite. The beds range in color from light gray to dark gray depending upon the concentration of hematite.

The thickness of the formation is commonly between 317 meters as measured near Córrego do Cercadinho and about 80 meters as measured three kilometers to the southwest of that stream. Of this thickness, approximately 50 percent consists of ferruginous quartzite, and the balance of phyllite.

The Cercadinho formation disconformably overlies the Gandarela formation in the western part of the Quadrilátero Ferrífero. No evidence for angular discordance has been found that could not be attributed to drag folding during the post-Minas series diastrophism. The lower bed of the Cercadinho formation is commonly conglomeratic. It may consist of a quartzite matrix with angular to subrounded chips and plates of hematite

derived from erosion of dolomitic itabirite of the Gandarela formation. In places, the conglomerate consists of rounded pebbles of white quartz in a medium grained quartzite matrix. Hematite concretions occur locally in the lower bed, commonly in quartzite or pebble conglomerate.

The upper contact of the Cercadinho formation is placed at the top of ferruginous quartzite. It is overlain by a sequence of argillaceous dolomite, dolomitic phyllite, and phyllite to be described in another paper by a different author as the Fecho do Funil formation.

The Cercadinho formation is almost invariably a ridge former. Although the ridges are commonly subordinate to the ridges formed by the stratigraphically underlying Itabira group, they contrast strongly with the relative lowlands of the overlying formations of the Piracicaba group.

The Cercadinho formation is present almost everywhere that the lower part of the Piracicaba group is exposed in the Quadrilátero Ferrífero. However, the hematite content of the ferruginous quartzites varies widely throughout the region from a trace to over 50 percent. Locally, the quartzite beds become very coarse and are really grits.

THE FECHO DO FUNIL FORMATION

by

GEORGE C. SIMMONS

On the north flank of the Serra do Curral in the Brumadinho quadrangle, the Piracicaba group of the Minas series (Precambrian) is divided into five formation. The second oldest of these is here named the Fecho do Funil formation. The type locality is the area near the community of Fecho do Funil where the formation is exposed in railroad and highway cuts.

The formation is composed of dark brown to dark gray dolomitic phyllite and argillaceous dolomite, pink to silvery gray phyllite, gray to tan locally silty phyllite, and minor siliceous phyllite and ferruginous quartzite.

The Fecho do Funil formation varies in thickness between 200 and 600 meters. The variation seems related to structural thickening on fold axes and thinning on fold limbs rather than to variations in deposition. The average thickness is 300 meters.

The Fecho do Funil grades within three meters into the overlying Taboões quartzite. The boundary is so placed that all dominantly phyllitic beds are included in the Fecho do Funil formation. The downward gradation into the Cercadinho formation is more gradual. The contact is so placed that all thick ferruginous quartzite beds and all zones of one or more meters thick which contain more ferruginous quartzite than other constituents are excluded from the Fecho do Funil formation.

The Fecho do Funil formation forms few natural outcrops, and exposures are mostly limited to places where ditches and road beds have been excavated. Being relatively non-resistant to weathering, the formation forms low areas between the higher and more resistant Cercadinho formation and Taboões quartzite. In the few areas of low dips the formation forms topography of relatively low relief.

The Fecho do Funil formation is distributed in an eastwest strip across the northern part of the Brumadinho quadrangle. It has been mapped to the east in the Ibirité, Macacos, and Belo Horizonte quadrangles by J. B. Pomerene, and probably occurs to the west in the Igarapé, Serra Azul, and Itatiaçu quadrangles.

TABOÕES QUARTZITE

by

JOEL B. POMERENE

In the western part of the Quadrilátero Ferrífero of central Minas Gerais, Brazil, the Piracicaba group of the Precambrian Minas series can be divided into five mappable rock units. The lowermost of these units has been named the Cercadinho formation. This is overlain by the Fecho do Funil formation which in turn is overlain by a third formation consisting of very fine grained quartzite.

It is here proposed to name this third formation the Taboões quartzite after the Córrego Taboões which heads in the quartzite near the center of the Ibirité quadrangle.

The Taboões quartzite, where hard and not deeply weathered, is a fine grained, pale olive gray, translucent quartzite containing many tiny irregular cavities with brown-stained walls. In most exposures, however, the quartzite is weathered to a friable sandstone and in many places to a fine sand.

At the type locality, near Córrego Taboões, the quartzite is 121 meters thick; its maximum thickness in the Ibirité quadrangle is about 300 meters. It thins eastward and only small outcrops are present in the Belo Horizonte quadrangle, and none have been recognized in the Nova Lima quadrangle further east. The westward extent of the formation is not known; it does extend west of the Ibirité quadrangle more than 13 kilometers.

The Taboões quartzite conformably overlies the Fecho do Funil formation. In all exposures of the contact in both the Belo Horizonte and the Ibirité quadrangles the contact is sharp-from phyllite and dolomitic phyllite of the Fecho do Funil formation to fine grained quartzite of the Taboões

quartzite. The lower contact is placed at the bottom of the fine grained quartzite. The upper contact, similarly, is placed at the top of the fine grained quartzite. The Taboões formation is overlain by phyllite, schist, and graphitic phyllite to be described as the Barreiro formation.

In general, the Taboões quartzite is a low ridge former, but in places where leaching has disaggregated the quartzite to sand, its strike may be reflected topographically by steep sided gullies.

The formation has been mapped across the Brumadinho and the Ibirité quadrangles, and intermittently across the Belo Horizonte quadrangle. A similar rock, in the same stratigraphic position occurs in the vicinity of Ouro Preto.

BARREIRO FORMATION

by

JOEL B. POMERENE

In the western part of the Quadrilátero Ferrífero of central Minas Gerais, Brazil, the Piracicaba group of the Precambrian Minas series can be divided into five mappable rock units. The lower three of these units have been named as formations — the Cercadinho formation, the Fecho do Funil formation, and the Taboões quartzite. A fourth formation which overlies the Taboões quartzite, consists of schist, phyllite, and a distinctive graphitic phyllite.

It is here proposed that the name Barreiro formation be given to these rocks. The type locality is in the northeast part of the Ibirité quadrangle along the stretch of the road between the town of Barreiro and the Serra da Rola Moça where the road is parallel to and about 300 meters west of the Córrego do Barreiro.

The lower beds of the Barreiro formation in the type locality are non-graphitic phyllite about 15 meters thick. They are commonly overlain by two zones of graphitic phyllite separated by non-graphitic phyllite. In the type section the lower graphitic bed is about 45 meters thick; the intervening non-graphitic phyllite about 4 meters thick, and the upper graphitic phyllite about 60 meters thick. The formation is about 124 meters thick at this locality. It thins eastward and is only intermittently present in the Belo Horizonte quadrangle.

The Barreiro formation conformably overlies Taboões quartzite, generally with an abrupt contact. The contact of the Barreiro formation with the overlying Sabará formation is less easily placed. The top of the formation is nearly always marked by a peculiar lavender colored, conglomerate.

eratic or gritty phyllite, but this material also occurs interbedded in the upper part of the graphitic phyllite. The top of the formation is arbitrarily defined as the contact between the uppermost graphitic phyllite bed (of more than one or two centimeters in thickness) and the conglomeratic phyllite of the overlying Sabará formation.

Topographically, the Barreiro formation forms even slopes down from the ridges formed by the Taboões quartzite. Probably it would be a valley former if the adjoining quartzite did not support it in most places.

The formation has been mapped through part, if not all, of the Brumadinho quadrangle, across all of the Ibirité quadrangle, and intermittently across the Belo Horizonte quadrangle.

THE SABARÁ FORMATION

by

J. E. GAIR

The uppermost subdivision of the Piracicaba group of the Minas series of Precambrian age in the Quadrilátero Ferrífero of Minas Gerais, Brazil, commonly consists of a thick unit of elastic rocks locally interbedded with chemical sediments.

The name Sabará formation is given to this unit because the most continuous exposures of these rocks known in the Quadrilátero Ferrífero occur in extensive road and railroad cuts along the canyon of the Rio das Velhas just to the north of the city of Sabará. The area of these exposures is the type locality of the formation.

The Sabará formation is composed of phyllites, schists, graywackes, subgraywackes, and locally metamorphosed tuffs, cherts, and thin iron formations. In many places, particularly along the north side of the Serra do Curral, the lithology of the formation is complicated by the increasing grade of metamorphism across the strike of the rocks. At the type locality about 90 percent of the lower half of the formation is composed of quartz-chlorite-sericite schist and the balance of graywacke, subgraywacke, and chloritic quartzite. In the upper half of the formation, the rocks are biotitic, and a broad zone of staurolite-garnet schist forms the upper part of the unit. The original rocks were probably argillaceous sandstones and quartzose shales, with interbedded graywacke and subgraywacke. In the upper part of the formation as exposed north of the Serra do Curral, a persistent but thin bed of very fine-grained pure quartzite, probably meta-chert, occurs. This locally grades into low-grade iron formation.

The Sabará formation is about 3,500 meters in thickness at the type locality. Because it is in contact with younger granitic rocks at the type locality and elsewhere north of the Serra do Curral and bounded upward

by an erosion surface elsewhere in the Quadrilátero Ferrífero, the original stratigraphic thickness of the formation is unknown.

In the type locality, the Sabará formation rests with apparent conformity on the Cercadinho formation. Elsewhere it may rest with overlap on other of the formations of the Piracicaba group. The upper contact, as has been stated, is with intrusive granitic rocks and gneissic rocks younger in age than the Minas series. In the Ouro Preto area, rocks probably corresponding in part to the Sabará formation are unconformably overlain by the Itacolomi series. In that area, strong folding and profound erosion occurred before the deposition of the Itacolomi series.

The Sabará formation has been mapped from the Brumadinho quadrangle outcrops except in gullies, canyons, and excavations. It forms a rounded, rolling topography transitional between the mountain ridges of the Itabira group and the lowlands formed by the granitic rocks. The more resistant rocks, such as the graywackes and the purer quartzites, are ridgeformers.

The Sabará formation has been mapped from the Brumadinho quadrangle to the Nova Lima quadrangle and it is known to continue to the east and west of the area already mapped. Rocks mapped as "Piracicaba group undivided" in much of the remaining part of the Quadrilátero Ferrífero undoubtedly include rocks correlative with part of the Sabará formation.

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