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Itabira Peak, State of Minas Gerais

Geographic, historical and structural landmark of the Quadrilátero Ferrífero

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The Pico do Itabira seen from N, drawn by F.J. Stephan, (ca. 1840). Lithography by A. Brandmeyer (in Martius,

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The Itabira Peak (Pico de Itabira or Itabirito, municipality of Itabirito, Minas Gerais) is not only a historical landmark as reference point of the bandeirantes during the 17th and 18th century but a geological monument representing the historical and cultural heritage of the whole region of the central Minas Gerais. It is localized on the eastern limb of the Moeda Syncline within the western part of Iron Quadrangle (Quadrilátero Ferrífero). It is composed of almost pure, massive high grade iron ore (hematite and subordinated magnetite). The massive ore is contained in the Cauê Itabirite of the Itabira Group (Minas Supergroup, Paleoproterozoic). It has been formed by metamorphic and hydrothermal processes during the Paleoproterozoic Transamazonian thermotectonic event. – Since 1962 it is protected as paisagistic heritage by federal and state laws. The peak is the type locality of the term itabirite, taken from the indigenous language and introduced in the scientific vocabulary by the german geologist and metalurgist W.L. von Eschwege in the beginning of the 19th century.

Keywords: Pico de Itabira, Quadrilátero Ferrífero, Cauê Formation, iron ore

INTRODUCTION

The Pico de Itabira (also known as Pico de Itabirito - Itabirito Peak) has been an important landmark during all the different periods of occupation of Minas Gerais. Initially, it served as reference point for the *Bandeirantes* (land expeditioners) in their search for gold in the region, due to its topographic projection of distinctive shape, as reported by v.Eschwege (1822, 1823) in his map of the "Capitania das Minas Geraes" and in the topographic-geological section (Figs. 1 and 2). It was described by Burton (1869) as "the Stone Girl of the prairie, which the Cornishmen called the Peak of Cata Branca". This poetic description makes sense, since "Stone Girl" was the name given by the regional inhabitants, as mentioned by Couto (1801), who states that in the native language Itabira meant "boy or girl of stone" ("even if it didn't look like it to him"). The English miners (most of whom came from Cornwall) named it Pico da Cata Branca. In fact it is common sense that the word Itabira means shining rock or stone or, by another interpretation, uplifted rock (ita = stone, rock, metal: byra = to lift up, to raise), but there is still another, more ancient spelling ITAUBIRA, used during the 18th century. The district of Itabira do Campo was established nearby and renamed Itabirito when made a municipality in 1923, so that the peak became known as Pico de Itabirito (Itabirito Peak), although some cartographic documents retain its older designation, such as the topographic map of the IBGE, Rio Acima sheet, (scale 1:50.000; 1977).

The Pico de Itabira is formed by a massif of compact high-grade iron ore (on the average ~67%) within the Cauê Formation, Itabira Group, Minas Supergroup (Dorr, 1969) and mineralogically composed of hematite ($Fe_2 O_3$) developed by the enrichment of banded iron formations (originally grading 30-45% Fe) by chemical reactions and processes involving hot (hydrothermal) fluids (Rosière and Rios, 2004). Several similar orebodies are explored in the Quadrilátero Ferrífero, mingling with the region's history of human occupancy beginning in the 17th Century (Brandalise, 1999), but among them, the Peak is by far the highest topographic elevation in the east flank of the Moeda Syncline, a testimony of the exploration work in this region.

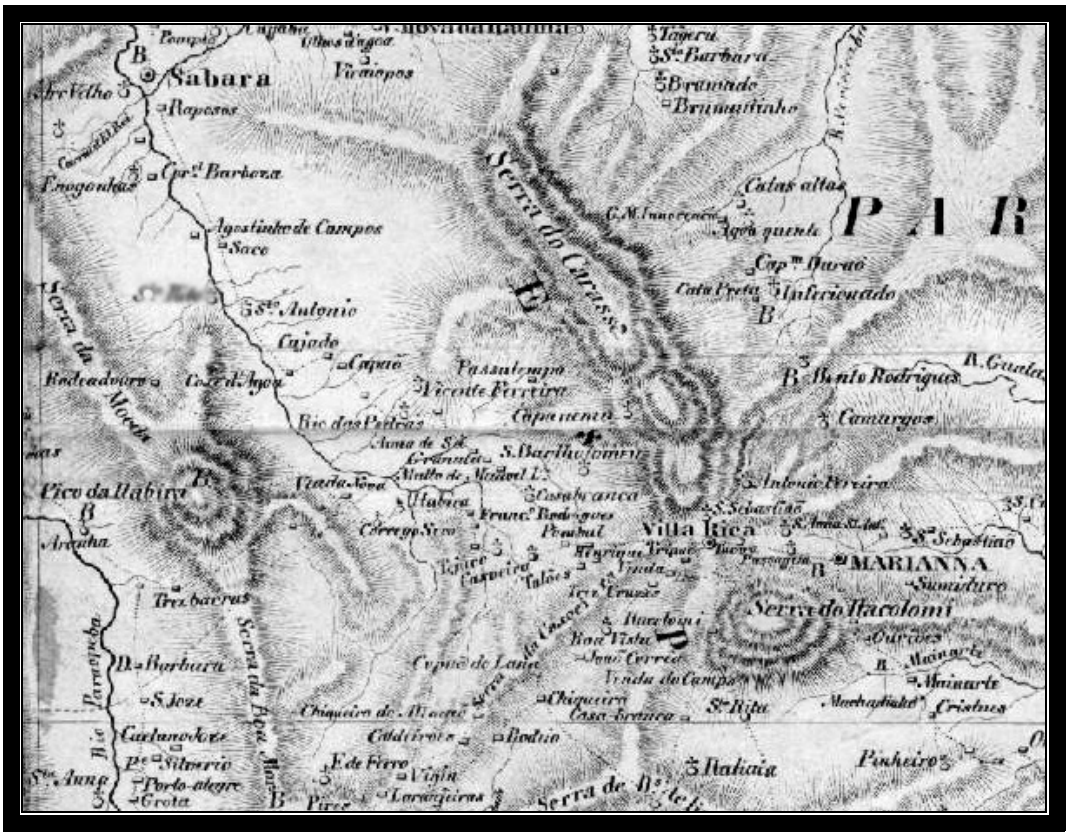

Figure 1 -Detail of the **Teil der Neuen Karte der Capitania von Minas Gerais** (Part of the new map of the Capitania of Minas Gerais); surveyed by W.L. von Eschwege (1821) with location of the **Pico da Itabira**, **Serra do Itacolomi** and **Serra do Carassa** (Pluto brasiliensis, 1833, plate 2).

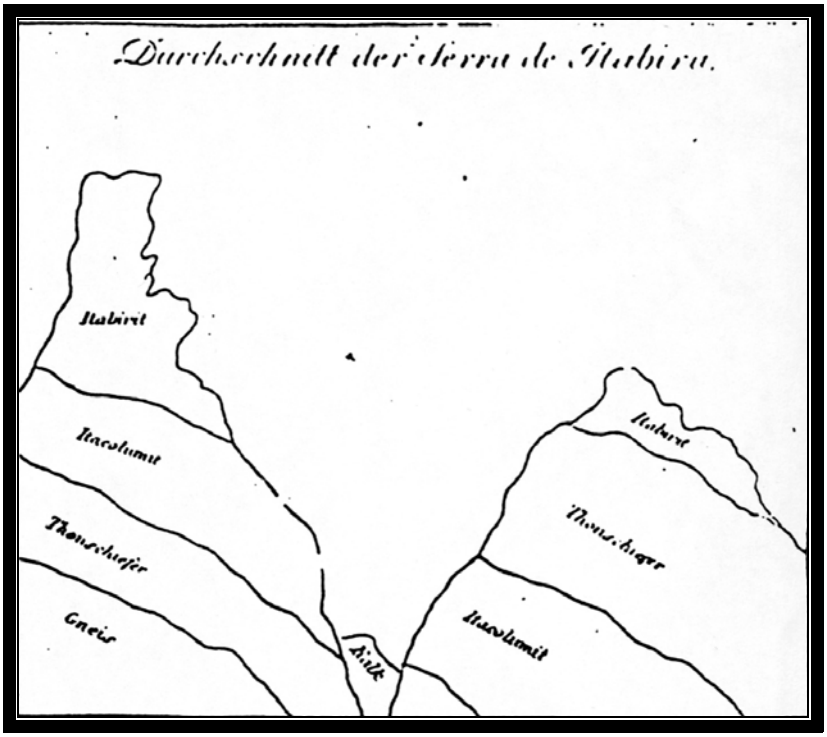

Figure 2 - Schematic topographic-geological section of the Serra de Itabira, (**Durschnitt der Serra de Itabir**a) depicting the Pico de Itabira (from Eschwege, 1822). Lithologic descriptions: **Itabirit** (itabirite), **Itacolomit** (quartzite), **Tonschiefer** (clayey schist, phyllite), **Kalk** (limestone), **Gneis** (gneiss).

LOCALIZATION

Located in the municipality of Itabirito, MG, the Pico de Itabira can be accessed by highway BR 040 leaving Belo Horizonte in direction of Rio de Janeiro, and turning left onto BR 356 (Rodovia dos Inconfidentes). It is located 5.5 km south of the road (on the right-hand side driving from Belo Horizonte to Itabirito). Coordinates: UTM N 7.761.541 / E 618.330; 1586 m above sea level.

SITE DESCRIPTION AND GEOLOGICAL SITUATION

The Pico de Itabira is located within the Serra das Serrinhas, also called in some maps as Serra dos Trovões or Serra do Itabirito and presents itself as a geologic monument and a symbol of the region's mineral wealth. It is located in the Quadrilátero Ferrífero, an important Brazilian mineral district in the central South of Minas Gerais State (Fig. 3), geologically located at the southern limit of the São Francisco Craton.

Figure 3 - The Pico de Itabira seen from NW (Photo: Rosière,C.A.).

Lithology

The Paleoproterozoic Minas Supergroup is characterized by shallow to deep water platform sequences with iron formations, distributed in synclinal structures mapped in the area called Quadrilátero Ferrífero (Iron Quadrangle). Those sediments overlie the volcanic-sedimentary sequence of the Rio das Velhas Supergroup comprising an Archean greenstone belt, contouring Archean and Paleoproterozoic granitic-gneissic domes .

The thickest sequence of iron formations in the Minas Supergroup belongs to the Itabira Group and comprises itabirites, metadolomites and subordinated metapelites. Itabirites are metamorphic and oxidized banded iron formations mainly consisting of quartz and iron oxides (Fig. 5a), as well as varieties with amphiboles and dolomite, but its occurrence is subordinated in the Pico deposit.

The term itabirite was originally defined by Eschwege (1822, p. 28) in Minas Gerais as a massive rock, with granular to schistose fabric, composed of specularite, granoblastic hematite and occasionally magnetite, thus characterizing the mineralized iron formation and even the compact ore, having as its "*locus tipicus*" the Pico de Itabira. The term *Eisenglimmerschiefer* or *especularita xisto*, was also introduced by Eschwege to

characterize the deformed banded iron formation, rich in specularite.

The itabirite (BIF) of the Cauê Formation contains numerous high-grade orebodies with Fe>64%. Important deposits as the Peak, Galinheiro and Sapecado represent bodies striking N-S to N45ºE at the eastern limb of the Moeda Syncline, with the Peak as the most important (Figs. 3 and 4). Compact and friable high-grade ores as well as rich itabirites (52%<Fe<64%, Al <2%) are intensively mined.

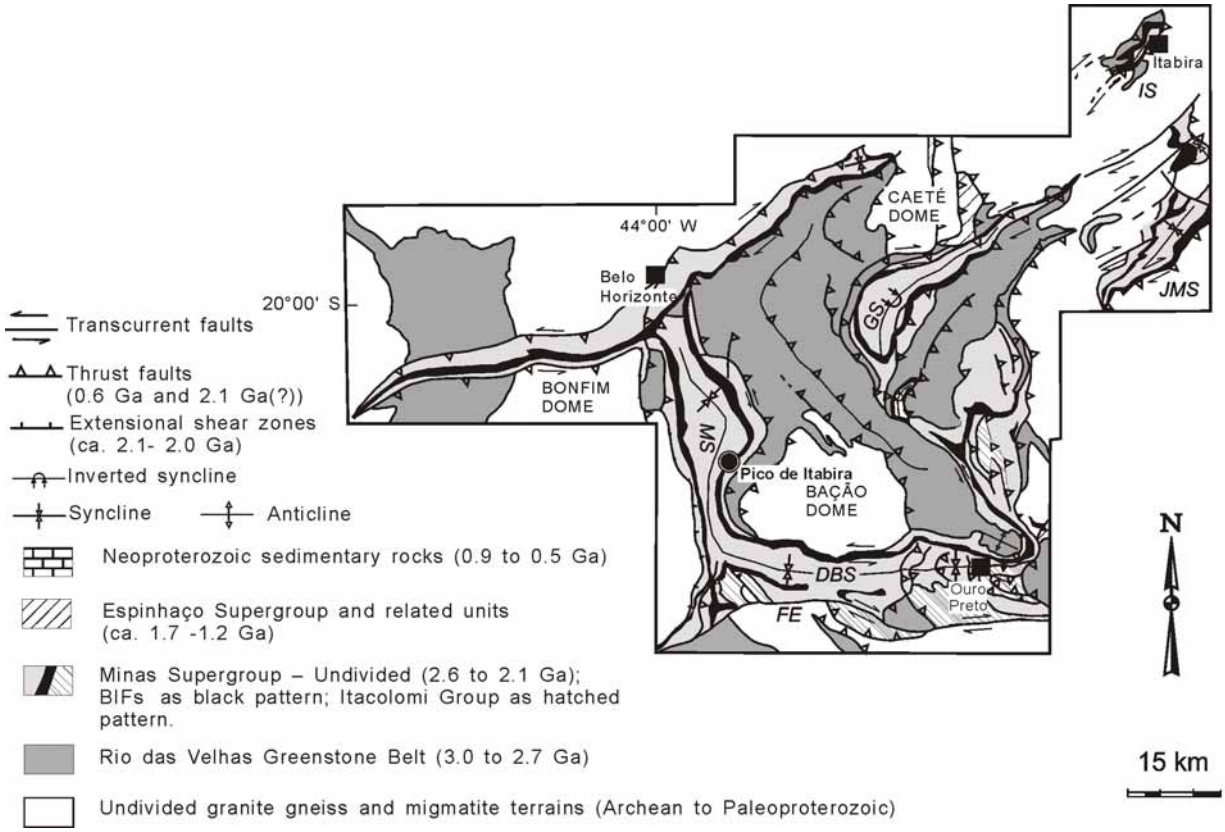

Figure 4 - Geologic map of the Quadrilátero Ferrífero (modified after Dorr, 1969 and Baars & Rosière, 1997) with location of the Pico de Itabira. Major tectonic structures: DBS – Dom Bosco Syncline, MS – Moeda Syncline, GS – Gandarela Syncline, IS – Itabira Synclinorium, JMS – João Monlevade Synclinorium, FE – Engenho Fault

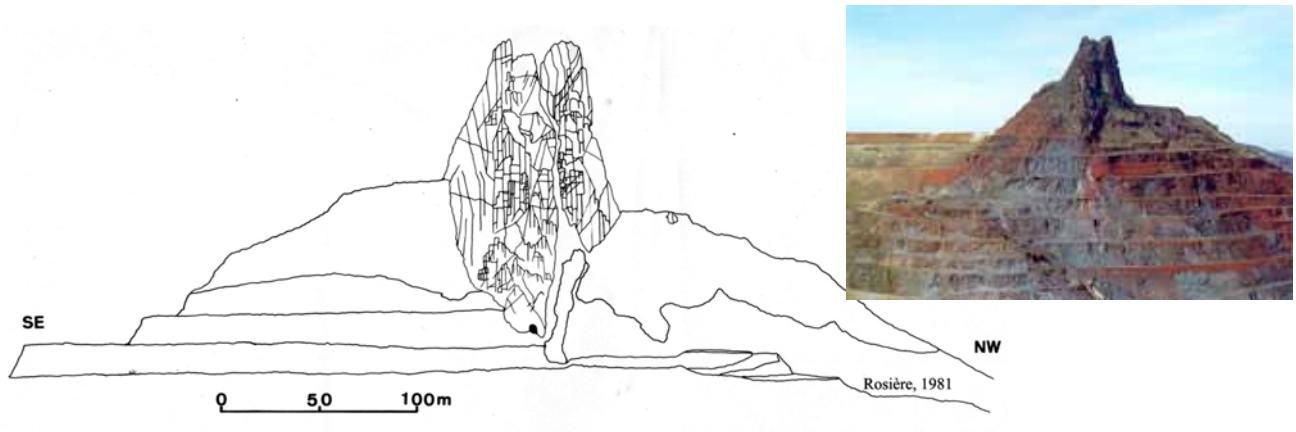

Figure 5 - Photogrammetric restoration of the Pico de Itabira (Rosière, 1981) seen from the northern face. Main planar structures (bedding and joints) are depicted. On the side, photograph dated from 2004, with a view from approx. the same position (MBR).

A lateritic duricrust of iron hydroxide (limonite) with or without ore fragments, called "canga" develops covering the iron formations and high-grade orebodies. The term "canga" was at first used by local miners and originates from "Itapanhoacanga", which means stone of a black man's head due to its frizzled morphology with the development of botryoidal structures (Eschwege 1822, p. 32). In the Pico region, the apparent thickness of the Cauê Formation is about 190 m, partially due to second order folds, which

results in variable dip between 20° and 85° to NW or SE for the itabirite layer. In the Pico deposit the mineralized zone extends for about 1000m in N-S direction and for about 300m in depth. The main compact ore body which characterizes the Pico itself, projects 82 m over the surface as an approximate lens-shaped body in vertical position, concordant with the layering. The orebody also presents a banding defined by the alternation of compact and porous levels which reproduces the original layering structure of the iron formation (Fig. 5b).

Structure and metalogenesis

The Moeda syncline's is a large fold structure with approx. N-S trending axis, bordered by the Bação and Bonfim domes, showing a western straight limb while the eastern limb is partially inverted with an s-shape on map view, curving around the Bação dome. In the south the syncline interconnects with the Dom Bosco syncline, but is partially truncated by the Engenho Fault (Fig. 6).

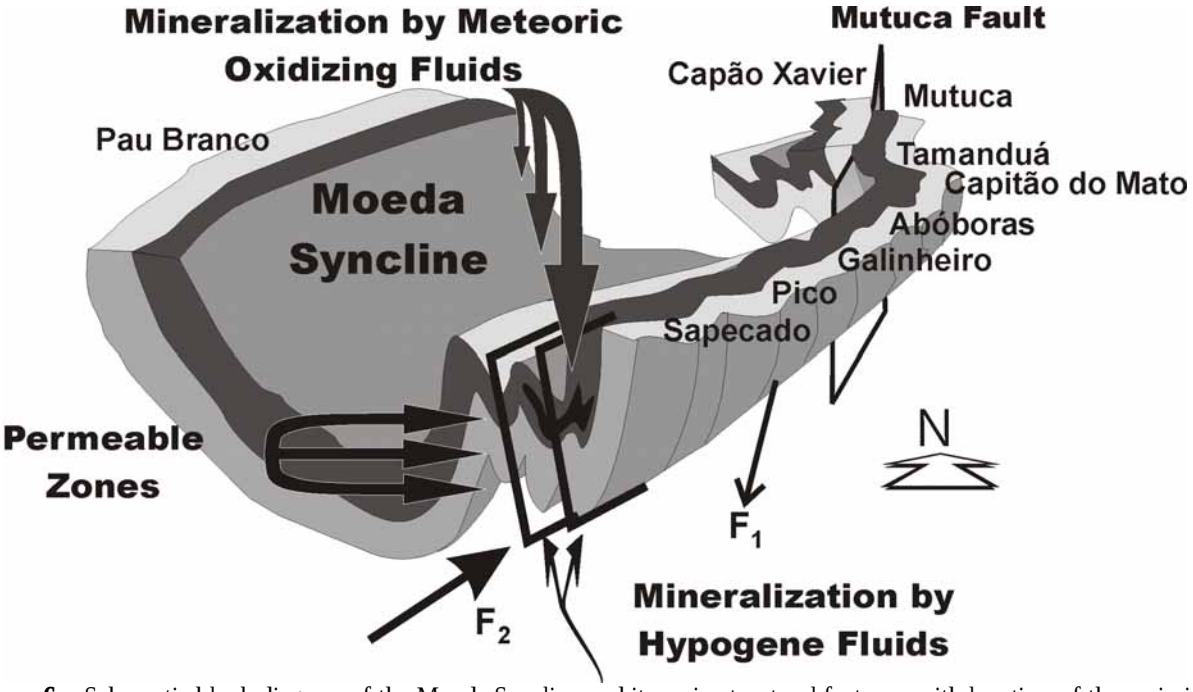

Figure 6 - Schematic block diagram of the Moeda Syncline and its main structural features, with location of the main iron ore deposits, depicting also the structural control of the Fe-mineralization

The high-grade iron ore of the Quadrilátero Ferrífero was first interpreted (Dorr, 1965) as a product of syn-metamorphic metassomatism and by Guild (1957) as a product of hydrothermal alteration. Rosière and Rios (2004) demonstrate a hydrothermal origin developed in two phases: the first characterized by magnetite mineralization and another under oxidizing conditions with hematite mineralization. The first one is apparently associated with the first folding phase, called F_1.while the second is related to a second folding event F_2

The F_1-folds were formed during the compressive phase of the Transamazonic thermo-tectonic event. The nucleation of the F_2-folds, on the other hand, are contemporaneous with the Moeda Syncline and related to the uplift of the granitic-gnaissic blocks which also caused the verticalization of the sequence during the collapse phase of the orogenesis (Alkmim & Marshak, 1998) under relatively shallow conditions. This structure increased the permeability of the rock allowing the percolation of meteoric oxidant fluids which resulted in a new Fe mineralization forming huge high-grade orebodies that present similar characteristics along almost the entire eastern limb of the Moeda Syncline (Fig. 4). During the Neoproterozoic Brazilian Orogenetic Cycle (~ 600 Ma) a last compressive event was responsible for the development of reverse faults and shear zones, whose metalogenetic importance is apparently limited to deposits at the eastern part of the Quadrilátero Ferrífero.

IRON ORE: FEATURES AND MINERALOGY

Compact ore

The hard, massive orebodies of the Pico deposit are mainly a product of hydrothermal mineralization processes, which altered the iron formations of the Itabira Group. They may be compact with total obliteration of sedimentary structures or present relicts of the primary banding of the iron formation. Breccia structures may be occasionally present. The ore mineralogy comprises partially or entirely oxidized magnetite (martite) and hematite in variable proportions.

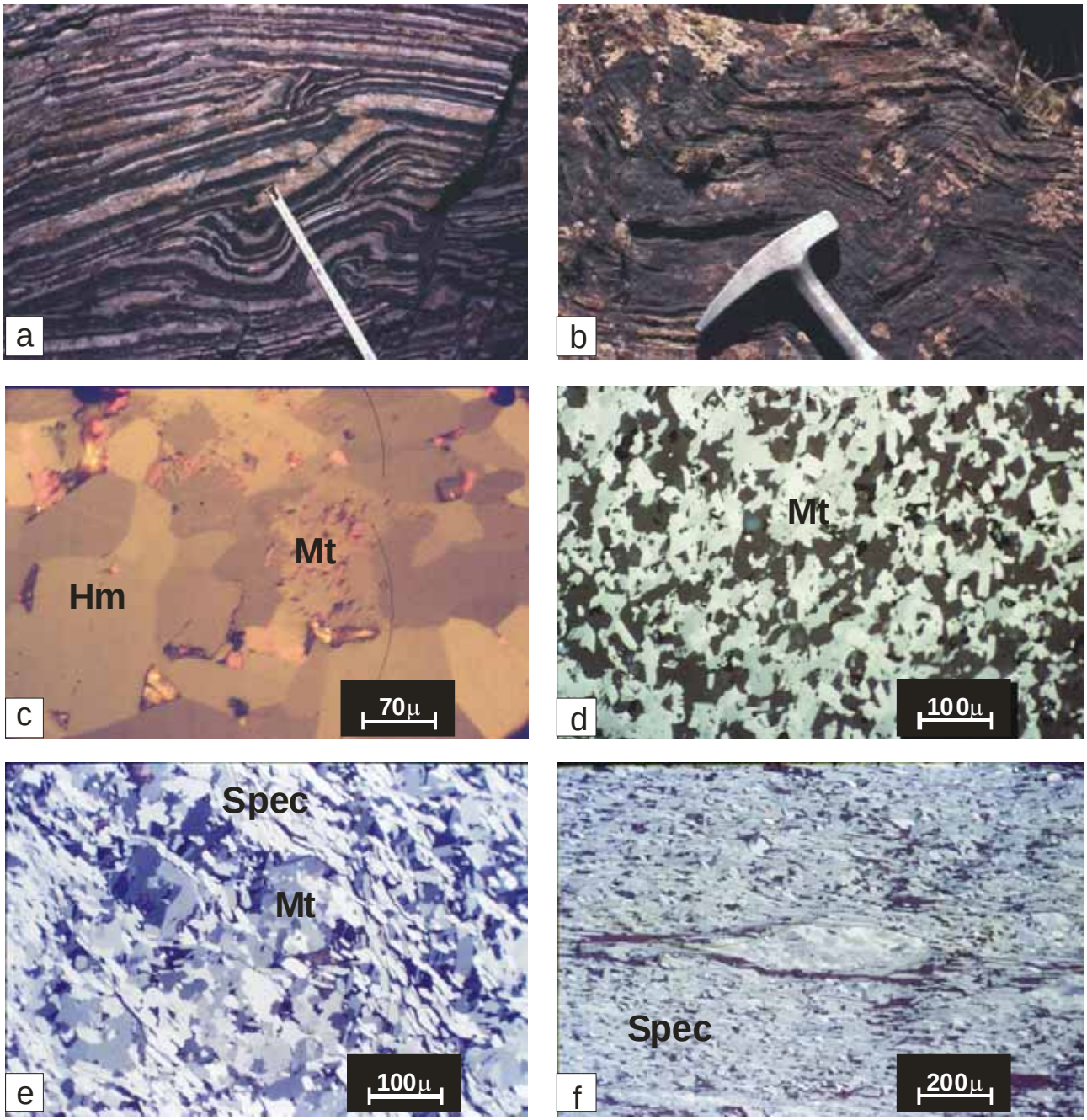

Figure 7 - a) Itabirite showing typical banding defined by alternating layers of quartz and iron oxides. The rock is recrystalized by metamorphism that partially obliterated sedimentary structures. **b)** Hard massive iron ore with relics of sedimentary banding of the iron formation. **c)** Photomicrograph of massive ore showing granoblastic fabric of hematite crystals with martite relics. **d)** Photomicrograph of porous ore composed mainly of martite (Mt) with platy hematite in the pores and interstices. **e)** Photomicrograph of schistose ore with porphyroclastic martite/hematite (Mt) aggregates enveloped by oriented specularite (Spec) platelets. **f)** Photomicrograph of schistose ore with long and fine specularite crystals enveloping a hematite pod that presents wavy extinction. All photomicrographs are under partially cross polarized, reflected light.

Martite occurs as individual crystals or compact aggregates with relicts of magnetite and may constitute almost 90% of the ore. Martitization developed along the {111} crystallographic planes of magnetite and irregularly from the borders toward the center. Hematite fills the interstices as irregular anhedric crystals with lobated and embayed grain boundaries and variable dimensions between 0.01 and 0.1 mm (Fig. 5c). In dominantly hematitic ore the crystals present irregular contours or straight boundaries composing a granoblastic polygonal fabric. The ore may also be rather porous with a great proportion of empty spaces between the hematite crystals (Fig. 5d).

Schistose ore

The schistose ore is associated with the zones of high strain which caused the development of an oriented texture of elongated platy crystals

(specularite). Specularite plates occur in different proportions, grown over a granoblastic fabric or anastomosing around porphyroclastic hematite and martite aggregates (Fig. 5e, f).

Friable ore

Friable ore is the product of partial enrichment of the iron formation by hydrothermal processes and the recurring leaching of gangue minerals (carbonate and quartz) by weathering processes. Friable bodies generally present banded structure and are interlaced with rich friable itabirite, constituting an important ore type. Locally they occur as powdery bodies devoid of any structure. The friable ore consists of hematite crystals of polygonal shape and some martite with specularite and interstitial platy to tabular crystals.

Rolled ore

The so called rolled ore consists of angular massive ore fragments cemented by iron hydroxide and results from weathering and erosion of ore bodies, itabirites and possibly carbonates during the Cretaceous/Tertiary (Wallace 1965). The erosion product accumulated as **talus** mainly on the western slope of the Serra do Itabirito range forming discontinuous bodies of variable thickness that may reach several tens of meters, conditioned by the morphology of the terrain.

Figura 8 - Aerial view looking northward to the Pico de Itabira and its open pit within the Serra dos Trovões/Serrinhas Range, eastern limb of the Moeda Syncline showing also the location of the mines and the approximate limits of the Cauê Formation and the contour of the protected area (Photo: MBR)

MINING HISTORY

Due to the evident mineral wealth, attempts of industrialization in the region of Itabira do Campo occurred very early in the history of the Province. Mining activities in the Serra do Itabirito go back as far as to the gold cycle of the 18th century with the first attempts to exploit the immense iron ore reserves through small iron industries, one of which was located south of the Pico de Itabira, near the locality of Pires (Fig. 1). In 1819 there was a failed attempt to construct a plant for the production of iron foils (Flanders foil). The librarian and director of the Natural History Council of Princess Leopoldina, Roque Schüch and his associates got an allotment of half a square league including the Itabira do Campo Peak. In 1832 the firm "Brazilian Company", founded in 1829 with English capital, purchased the mining

concession of the gold mines of Aredes, Morro das Almas and Cata Branca, including the Itabira Peak, from Dom Francisco de Sousa Coutinho, Count of Linhares, whose property of the Serra do Itabirito he had gotten from poor Brazilian and Portuguese settlers. The Brazilian Company mined the Cata Branca mine until its collapse in 1844, when the company closed the mine and sold it to the St. John d'El Rey Mining Company, Ltd. In the 1840s, a Dr. F. J. Stephan, worked as doctor to the English miners at the Cata Branca Mine, belonging to the Brazilian Company. Dr. Stephan came to Brazil originally as the private physician of Dona Amélia de Leuchtenberg, the second wife of Dom Pedro I. After the Royal Couple returned to Portugal in 1831, Dr. Stephan decided to live in Minas Gerais, practicing medicine in Ouro Preto and In 1850 he returned to Germany. While living in the state of Minas Gerais, he pursued natural history studies, leaving an illustration of the Pico for botanist von Martius, which can be seen on the title page of this article.

Iron ore mining, still in a primitive state, was facilitated by the construction of a stone blast furnace for the production of cast iron by Amaro & Gerspacher owned by the engineers Jean Albert Gerspacher, a swiss metallurgist, and three Brazilians: Amaro da Silveira, engineer of the D.Pedro II Railroad, Carlos G. da Costa Wigg, a silent partner, and Henrique Hargreaves, manager of the extension of the railroad. The construction of the furnace started in November 1888. After Jean Albert Gerspacher's death on October 1st 1889 he was succeeded by his son Joseph Albert Fidèle Gerspacher. The blast furnace was the very first one in Minas Gerais after Brazil's independence, constructed of handcut granite blocks alongside the railroad, in front of Km 527, 4 km from Itabira do Campo, on the properties of the Fazenda da Bexiga and Fazenda da Gordura, purchased from João and Adão Braga, and called Usina Esperança. The blast furnace was inaugurated on the 21st July 1891 at 7 am with the first run of cast iron. It was small, lined with firebricks made of clay from Caeté, Minas Gerais, and supplied with rolled ore extracted from the slopes of the Peak and surroundings. The mining was done manually and the transport by mule. Due to the poor quality of its construction the furnace worked intermittently for only two or three months with a maximum production of 4 tons/day.

The plant was sold in 1892 to the *Sociedade de Forjas e Estaleiros (Societé de Forges et Chantiers)* of Rio de Janeiro, which invested large sums toward its improvement. With the society's bankruptcy in 1896 the mining operations were interrupted, but again reactivated in 1899 by the engineer José Joaquim Queiroz Jr. of Leandro & Queiroz Jr. in partnership with the Banco da Lavoura e Comércio from Rio de Janeiro. In 1900 Queiroz Jr. bought the company, then called Sociedade Usina Queiroz Junior Ltda., and built the first steel blast furnace in South America. The plant is still working and belongs nowadays to the Valadares Diesel Group (VDL) of Jairo Lessa and brothers. In front, alongside the former Rodovia dos Inconfidentes, at the northern access to Itabirito, the lower part of the old furnace is still standing, on which the Associação Brasileira de Metais (Brazilian Metal Association) in 1955 affixed a memorial plaque.

The activity of industrial exploitation of iron ore in Mina do Pico begun in the 1940s, during the development of the ironmaking industry in Brazil with the Companhia Siderúrgica Nacional (CSN) and, notedly in Itabirito, with Siderúrgica Queiroz Júnior. In 1938 the Mineração Novalimense, a subsidiary of St. John del Rey Mining Co., started iron-mining on a small scale around the Pico de Itabirito, including the region of Cata Branca.

In 1941, those mines were leased to the Sociedade Usina Queiroz Junior Ltda. The mining of iron ore around the Peak continued intermittently from 1943 to 1961 under a lease to the Sociedade Indústria e Comércio de Minério Ltda. (SICOM) of Augusto Trajano de Azevedo Antunes. In 1948, emerging from SICOM, the Indústria e Comercio de Minérios (ICOMI) was formed, later renamed ICOMINAS. In 1950 the holding company Companhia Auxiliar de Empresas de Mineração (CAEMI) was established and, in association with the North-American enterprise Hanna Mining Co., ICOMINAS was incorporated as Minerações Brasileiras Reunidas (MBR), which still owns the mining rights to the area.

PRESERVATION MEASURES

On June 26th 1926 the Instituto do Patrimônio Histórico e Artístico Nacional* (SPHAN) registered the Pico de Itabira (Livro Arqueológico, Etnográfico e Paisagístico, I, page 8. nr. 31) as a national natural heritage, but this was cancelled in 1965 due to its mining potential. At the state level the Pico de Itabira has been registered as a Protected Landscape by the Instituto do Patrimônio Histórico e Artístico de Minas Gerais** (IEPHA-MG) protected by an Act included as part of the Constitution of the State of Minas Gerais of 1989 (Fig. 6). On the municipal level, Law 1668 of Oct. 1st 1991, of the town of Itabirito, has also registered the Itabira Peak as natural heritage.

Since 1989, the Minerações Brasileiras Reunidas SA (MBR) has limited its mining activities to the external part of the outer boundary defined by IEPHA-MG (Fig. 6). Around the Peak a topographic monitoring system was established in order to instantly detect any soil or rock mass movement

* Historic and Artistic Heritage National Institute
** Historic and Artistic Heritage Institute of the State of Minas Gerais

which could indicate a possible instability of the rock massif. The company is already anticipating measures to diminish the impact on the landscape with the cessation of mining activities, which is expected to occur in 2009. One of the measures will be to fill the open pit using the waste product from mines and ore processing plants in order to re-establish the area's original topography, encouraging the preservation and environmental improvement of the surroundings of the Peak.

As important regional landmark, there is a significant demand for tourist visitation of Itabira Peak and its surroundings, which the MBR meets by appointment through its Social Communication Department.

Annually on November 15th the town of Itabirito commemorates "Peak's Day". On that occasion MBR sponsors an ecological trail hike beginning in the town of Itabirito and ending at the foot of the Peak, in order to contribute to the development of ecological conscience among the local population and to strengthen cultural ties.

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