Chapter I

THE SÃO FRANCISCO CRATON: A SHORT OUTLINE

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INTRODUCTION

Rocks of the Transamazonian (ca. 2 Ga) and Brasiliano (ca. 0.9-0.5 Ga) cycles are widespread throughout Brazil. In current Brazilian usage, the term "craton" is applied to crustal segments which became consolidated during the Proterozoic and were not deformed during the Brasiliano cycle.

The São Francisco Craton -SFC- (Almeida, 1967, 1977) is one of the larger cratonic units of Brazil (Fig. I.1). It is partly surrounded by the following fold belts:

- the Riacho do Pontal and the Sergipano belts (Brito Neves, 1975), limit the craton at north and northeast, respectively;
- the Araçuaí belt (Almeida, 1977), possible northern extension of the Ribeira belt, at southeast;
- the Brasilia belt (Almeida, 1968), as the long western margin;
- the Rio Preto (Inda & Barbosa, 1978) and the Alto Rio Grande belts (Hasui, 1982), represent two small belts located in the northwest and the southernmost edges of the craton, respectively.

All these belts, which mark the exposed limits of the craton were attributed to the Brasiliano cycle. However, for some of them, such as the Riacho do Pontal, Brasilia or Alto Rio Grande belts, a more complex evolution have been proposed. Indeed, these belts appear to have had, at least, a long Late Proterozoic evolution, culminating with the folding, metamorphism and plutonism of the Brasiliano cycle. A recent paper discuss these problems and give the present state of knowledge about the surrounding belts of the SFC (Fuck et al., 1992).

Inside the boundaries marked by the above mentioned fold belts, and roughly confirmed by geophysical evidence, the thickest section of continental crust in Brazil was found (Motta et al., 1981; Ussami et al., 1989; Ussami, 1992). This crust can be subdivided into three large Precambrian stratigraphic and tectonic units:

- a Late Proterozoic sedimentary cover related to the Brasiliano cycle (Bambui, Salitre-Jacaré, and Rio Pardo groups - Almeida et al., 1976);
- a Middle Proterozoic platform cover (Chapada Diamantina) and the correlated Espinhaço fold belt;
- an Archean and Early Proterozoic basement.

The review of the latter, and particularly its older components, constitutes the aim of this field conference guide and is developed in later chapters. It is possible to find an ample synthesis on the dynamics and the ensialic evolution of the covers in the recent work of Dominguez (1992). The corresponding sediments spread over the eastern and southern part of the SFC, hiding the basement in Minas Gerais state (with the exception of the southern edge) and the center and eastern portions of Bahia state.

The post-Gondwana evolution is essentially related to continental drift and results in intracratonic rift-valley basins geographically limited to the Reconcavo-Tucano rift which occurs in the eastern part of the craton, north of Salvador, and extends southward through a narrow band along the Atlantic shore. In the same way, an intracratonic basin occurs in the northwestern part of the craton. The related sediments were deposited from Paleozoic to Mesozoic times. Widespread thin continental Cenozoic deposits also occur over the craton.

ARCHEAN AND PROTEROZOIC BASEMENT

Except for a small window exposed in the southern part of the SFC (Quadrilátero Ferrífero) in Minas Gerais state, the basement is almost exclusively exposed in Bahia state. The subdivision of the rocks which occur within the SFC has been attempted in several ways. For the purpose of this guide, a much-simplified outline is

Figure I.1 - Situation of São Francisco Craton in the Brazilian shield.

summarized below and pointed out on Fig. I.2 based on the commonly accepted synthesis by Mascarenhas (1979, 1981) and modified taking into account the recent developments which are presented in this volume.

The subdivision, established on criteria such as lithological compositions and/or associations, metamorphic grade, etc., leads to a commonly accepted subdivision of the basement into the triad: (i) high grade terrains; (ii) medium-grade terrains; (iii) supracrustal volcanosedimentary sequences, mostly at greenschist facies.

On a regional scale, several broad units can be defined, related to the above subdivision, which form north-south trending imbricated bands (Fig. I.2). The following units can be individualized:

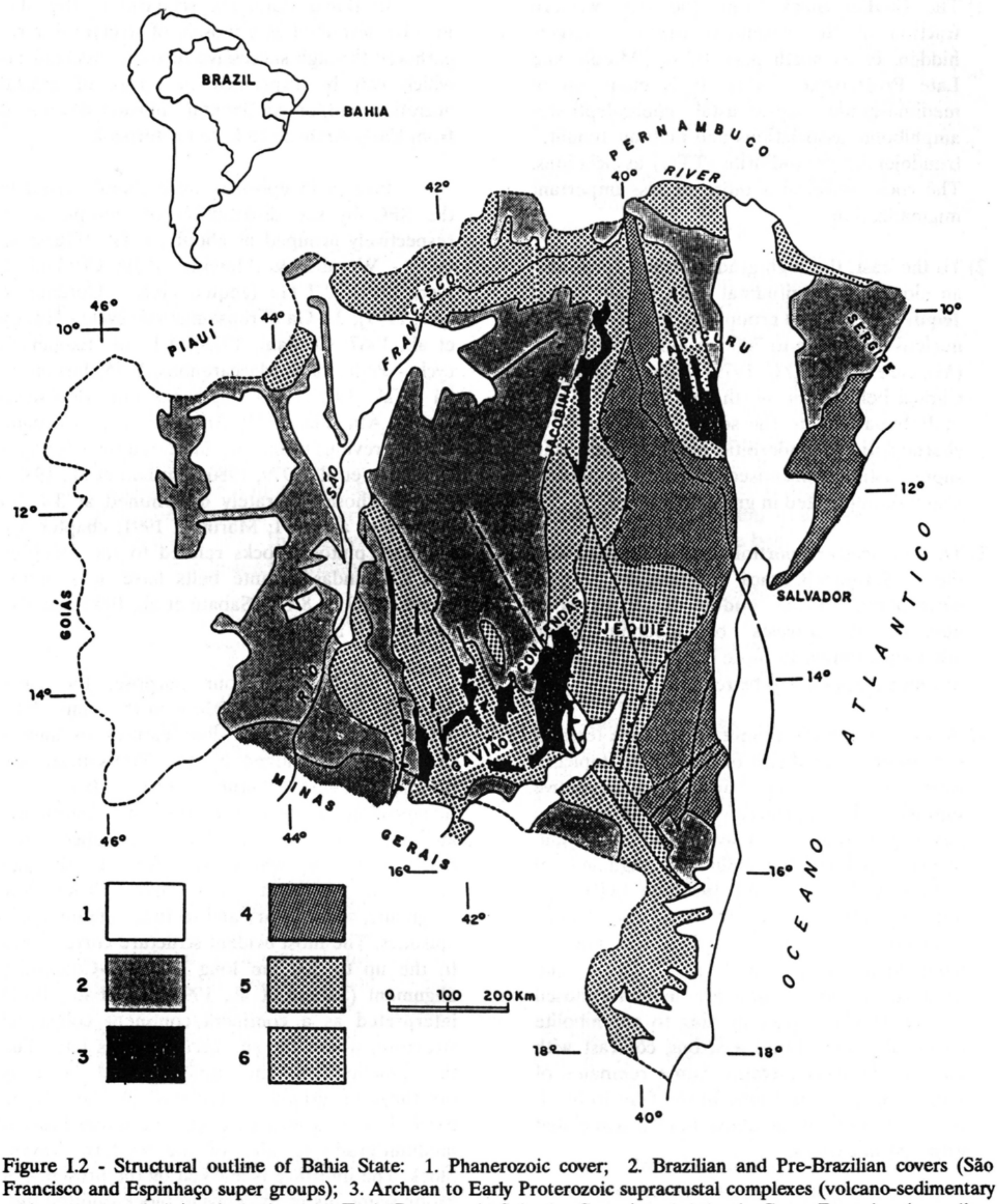

Figure I.2 - Structural outline of Bahia State: 1. Phanerozoic cover; 2. Brazilian and Pre-Brazilian covers (São Francisco and Espinhaço super groups); 3. Archean to Early Proterozoic supracrustal complexes (volcano-sedimentary and greenstone belts); 4. Archean to Early Proterozoic Salvador-Curaçá and Atlantic Coast Domains (granulites, charnockites, migmatites and gneiss); 5. Jequié-Mutuípe-Maracás Domain (granulite facies supracrustal sequence and charno-enderbitic plutonic rocks); 6. Archean gneiss-migmatitic and granulitic complex. Modified from Mascarenhas, 1976.

1) The **Gavião Block** forms the wide western fraction of the basement which is largely hidden, in its north part, by the Middle and Late Proterozoic covers. It is made up of medium-grade supracrustal gneiss-leptinite-amphibolite associations and plutonic tonalite-trondhjemite-granodiorite (TTG) associations. The rocks suffered a more or less important migmatization.

2) To the east, the high-grade terrains form also an elongated longitudinal band usually called **Jequié Block** which groups the Jequié-Mutuipe nucleus and its up to 700 km long mobile belts (Mascarenhas, 1973, 1979) named Salvador-Curaçá belt, to the north, and Atlantic Coast or Itabuna belt, to the south. They consist of charnockitic to enderbitic plutonic rocks and supracrustal volcanosedimentary sequences also re-equilibrated in granulite-facies.

3) The northeastern portion, now juxtaposed with the Salvador-Curaçá granulitic belt, corresponds to the **middle Itapicuru river nucleus**. It consists of medium grade lithologies similar to those of the Gavião block, to which it appears to be related.

4) Besides the typical granite-greenstone terrains located in the axial part of the middle Itapicuru river nucleus, the most representative supracrustal sequences occur along the junction between the Gavião and the Jequié blocks and form the main N-S alignment of **Contendas-Mirante** and **Jacobina belts** (see also fig. III.3 - chapter III). These belts associate volcanic and volcanogenic components intercalated with clastic and chemical sediments and are metamorphosed into greenschist facies grading to amphibolite facies, showing always a strong contrast with the neighbouring terrains. Some remnants of such sequences are found in the Gavião block (Fig. I.2). Each of the above belts is associated with plutonic rocks.

STRUCTURAL RELATIONS AND TECTOGENESIS

In Bahia state, the scenario of the SFC may be described as a mosaic of structural units, gathered through successive tectonic mechanisms which can be expressed in terms of crustal accretion and/or continental collision developed from Early Archean to Late Proterozoic.

Five main episodes were characterized in the SFC by the distribution of isotopic ages, respectively grouped at about 3.0 Ga (Guriense cycle - Wernick & Almeida, 1979; Cordani & Iyer, 1979); 2.7 Ga (Jequié cycle - Cordani & Iyer, 1979); 2.0 Ga (Transamazonic cycle - Hurley et al., 1967; Cordani, 1973); 1.1 Ga (Espinhaço cycle - Pedreira & Mascarenhas, 1975; Jardim de Sá et al., 1976); and finally 0.6 Ga (Brasiliano cycle - Almeida, 1971; Brito-Neves & Cordani, 1973). Previous events are indicated by older ages (Marinho et al., 1979, 1980; Cordani et al., 1985), such as those accurately determined at 3.4 Ga (Martin et al., 1991; Marinho, 1991; chapter V). The late plutonic rocks related to the Jacobina and Contendas-Mirante belts have ages in the range of 1.9 - 1.8 Ga (Sabaté et al., 1990; see also chapters III and IV).

Therefore, for our purpose, the early assembly of the SFC develops in the range 3.4 - 1.8 Ga but the present visible features are almost exclusively constrained by the Transamazonian orogeny. These features result from the juxtaposition and/or thrusting of continental and/or oceanic crustal prisms or slices, the components of which are formed through successive Archean to Early Proterozoic magmatic, sedimentary and tectono-metamorphic episodes. The most evident structure corresponds to the up to 500 km long Jacobina-Contendas alignment (Sabaté et al., 1990a,b; Sabaté, 1991) interpreted as a continent/continent collisional structure, where the supracrustal belts underline the junction of the uplifted and westerly overthrusted granulitic terrains of the Jequié block, in the eastern part, and the underthrusted medium-grade terrains of the western Gavião block. The interface is marked by the presence of exotic segments of the Gavião block uplifted into the Contendas-Mirante supracustals.

In the granulitic terrains of the Itabuna belt, Barbosa (1986) characterized three distinct sequences identified successively, from east to west, as arc-tholeiitic, calc-alkaline and shoshonitic magmatic series. As a model of geotectonic evolution in this high grade terrains, a westerly plunging subduction-related magmatic arc is suggested by both geochemical and geological arguments, and followed by a Jequié/Congo continent/continent collision (Figueiredo, 1989) or continent/island-arc collision (Barbosa, 1990). Though it is not yet strongly constrained, an Early Proterozoic age was proposed for this evolution.

In the volcanosedimentary Contendas-Mirante sequence, Sabaté & Marinho (1982) suggested that an island-arc and/or a continental margin system might produce its calc-alkaline and tholeiitic associations. In a more recent work, the evolution of this belt involves an easterly plunging subduction followed by the Gavião/Jequié continent/continent collision (Marinho, 1991).

The previous geodynamic evolution is less constrained. Several episodes of crustal accretion by plutonism are identified. In the Early Archean, only three TTG magmatic episodes are recognized and well dated (Martin & Sabaté, 1990, Martin et al., 1991) at 3.4 and 3.1 Ga. In the Late Archean, an abundant and generally widespread plutonism is found (chapter III). It strongly suggests an evolution for the two Archean blocks at 2.7 Ga (Marinho et al., 1979, 1980; Cordani et al., 1985; Barbosa, 1986; Wilson, 1987; Wilson et al., 1989; Marinho, 1991).

The structural behaviour of the Archean terrains of the SFC is poorly known. Several folding episodes are described for the Archean rocks, including tangential deformations (e.g., Barbosa, 1986; Campelo, 1991) and are related to Archean tectonics, but the age of the deformations is not clearly constrained and, in our opinion, the similarity of style, trends, patterns and evolutionary steps, lead us to consider a possible correlation with the later Transamazonian deformational episodes.

AFRICAN CORRESPONDENCES

In a Gondwana reconstruction, the SFC extends to the Congo craton and particularly to its western part corresponding to Gabon. This portion of the african craton, the Congo-Gabon craton (CGC) shows similar lithologic (Bassot, 1988) and tectonic features (Ledru et al., 1989; Feybesse, 1991 a, b) to those found in the SFC.

The CGC is made up of medium- to high-grade terrains metamorphosed at 3.1 Ga (Vachette et al., 1988) extensively intruded by 3.0 to 2.6 Ga granitoid plutons which form the Chaillu and the North Gabon basement blocks. These terrains are overlain by the Francevillian sedimentary sequence dated at 2.3 to 2.0 Ga. This Early Proterozoic essentially detrital cover is tabular, undeformed and unmetamorphosed in eastern Gabon (Franceville Basin) but is folded and metamorphosed at low-grade to the west, in the Booué Basin. It is comparable in age and lithology to the medium and upper portions of the Contendas-Mirante belt.

There is evidence for two main folding episodes (Haccard, 1986; Prian, 1987). The first one is consistent with eastward overturned folds and the second corresponds to a late NE-SW shortening marked by open regional folding. Important thrustings occur between several lithotectonic units (Ledru et al., 1986; Prian et al., 1988). The structural characteristics suggest easterly tangential tectonics for the western part of the Francevillian (Ledru et al., 1989). The deformations are closely similar to those of the Contendas-Mirante belt (Sabaté et al., 1980; see also chapter III), but with a westward vergence in the latter. In the same way, the relations between the Abamié migmatitic dome and its host rocks correlated with the Francevillian series in the CGC, may be compared to the relation between the basement domes and the Contendas-Mirante belt in the SFC. A geometric and dynamic comparison of the respective granulitic domains is more imprecise. A model for the Early Proterozoic crustal evolution of the SFC (Teixeira & Figueiredo, 1991) takes into consideration the ideas about the evolution of the CGC. However, it is still poorly constrained with regards to geodynamic data.

FIELD TRIP TARGETS

The region visited during this field conference gives an overview of two roughly E-W sections, in the southeast part of the Bahia state, which cross over the previously mentioned Archean and Early Proterozoic units.

The high-grade terrains will be observed in the JEQUIÉ-ITABUNA GRANULITIC BELT (see chapter II), where they are best exposed, in the region of the Jequiriçá valley, where the charnockitic to enderbitic plutonic series of the **Jequié-Mutuipe-Maracás domain** occur intercalated with slices of supracrustal rocks re-equilibrated in granulite facies or preserved in amphibolite facies, and in the narrow band called **Ipiau domain**. The related magmatic arc lithologies will be briefly visited in the **Atlantic Coast domain** (see also the field excursion guide).

The western limit of the Jequié block, in the Maracás region, is also occupied by a similar association of charnockitic plutonites and granulitic supracrustals. The charnockites differ by the presence of olivine-bearing components and by their retrometamorphic character which marks the proximity to the Contendas-Mirante volcanosedimentary belt.

The different stratigraphic segments of the CONTENDAS-MIRANTE BELT will be seen in the northeastern part of the belt, between the village of Santana and the little town of Contendas do Sincorá, where most of the lithologies of the volcanosedimentary sequence, the Jacaré river mafic sill and the alkaline Pé de Serra intrusion, can be observed.

The medium-grade terrains and related granitoids of the Gavião block are well exposed and have an easy access south of the Contendas-Mirante belt, in the region of the village of Anagé near the town of Vitória da Conquista. The TTG domes crop out only in the southern part of the belt between the villages of Lagoa d'Água and Caetano.

Most of the field data, analytical results and interpretations presented during this field conference, as a matter of discussion, are still unpublished and correspond to recent research by M. M. Marinho (Doct. Thesis, 1991) studying the region of the Jequié block/Contendas-Mirante belt limit, as well as that by J. S. F. Barbosa, in the granulitic terrains, P. Sabaté and his students, especially in the alignment Jacobina-Contendas, and several collaborators.