# 17 Tectonic Genealogy of a Miniature Continent

Monica Heilbron, Umberto G. Cordani, Fernando F. Alkmim, and Humberto L.S. Reis

**Abstract**

The São Francisco craton (SFC), although small in size, exhibits elements of some of the Earth principal evolutionary phases. Repeated cycles of granite-greenstone terrain formation recorded in the craton basement attest the high-heat tectonic regime that characterize the Archean Earth. Like in many other places of the world, these terrains amalgamated to form a coherent and stable continental mass in the Late Archean. In the course of the Paleoproterozoic, subduction-driven accretionary orogens, which incorporated island arcs and continental terranes, were added to the Archean continental nuclei. Typical of the Proterozoic plate tectonic regime, these events took place around the important 2.1 Ga age peak of juvenile crustal production. The collage of several blocks concurred to form the São Francisco paleocontinent, which always united to the Congo landmass, experienced a series of intraplate processes, such as rifting and associated bimodal magmatism during the following 1300 Ma-long period. Very likely, the São Francisco-Congo did not take part of the Columbia and Rodinia supercontinents. Later, in Ediacaran and Cambrian times, it was involved in the collage that resulted in the formation of the Gondwana Supercontinent. Driven by slab-pull subduction and collisional processes, typical of modern-type plate tectonics, the Rio Preto, Riacho do Pontal, Sergipano, Araçuaí-Ribeira and Brasilia belts surrounded and shaped the present configuration of the SFC. Finally, the SFC was separated from the Congo craton following the Brazil–Africa continental drift and the formation of the South Atlantic Ocean. This chapter explores the significance of rock assemblages and tectonic features exhibited by the miniature São Francisco continent in terms of Earth global processes.

**Keywords**

São Francisco craton • Archean • Paleoproterozoic • Neoproterozoic • Brasiliano event

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## 17.1 Introduction

Planet Earth started hot and was losing heat through time. Indeed, the Earth's mantle temperature decreased by several hundred degrees Celsius since Archean times. This is the main factor that governs the geodynamic evolution of the planet (Condie and Kroener 2008; Brown 2008).

In the Archean, the high rate of heat production by radioactive decay induced mantle convection and growth of new oceanic lithosphere. The consumption of it produced TTG calc-alkaline granitoids (Tarney et al. 1979; Condie and Kroener 2008), which intruded the crust. They were later deformed and metamorphosed into the continental gneisses and granulites which appear in association with greenstone belts. These features are made up of supracrustal metamorphic rocks (metavolcanics and metasedimentary), formed within oceanic domains, in tectonic environments such as island arcs or spreading centres. Such granite-greenstone terrains are widespread within the Archean domains. They are typical of high-heat regime, formed basically by mantle-derived granitoids and by metamorphic rocks which may include UHT granulites. Plate tectonics came early into the Earth's geodynamics evolution, but it did not appear as a single event in a given time. Returns of oceanic lithosphere into the mantle may have started to cool enough in the early Archean, to make possible some localized subduction. Gradually, as the planet continued to cool, more and more slabs could have been able to descend at steep angles. Perhaps, the first documented subduction zone occurred within the 3.8 Ga Isua greenstone belt (Komiya et al. 2002), and other examples were registered, such as the Barberton greenstone belt in South Africa (Moyen et al. 2006). By the Late Archean, steep-mode subduction was a quite important tectonic regime in the planet.

After the Archean, plate tectonics became the main mechanism by which the Earth loses its internal heat. Stern (2005) initiated an interesting controversy, arguing that subduction tectonics only started in the Neoproterozoic. The main arguments were the lack of some clear indicators for that tectonic regime, such as blueschists, ophiolites and UHP metamorphic rocks, prior to 1.0 Ga. Different tectonic regimes, or different proto-plate tectonic models, may have been in place. On the contrary, Cawood and Pisarewsky (2006) and Condie and Kroener (2008), although recognizing the lack of the specific rock indicators mentioned by Stern (2005), claimed that there is enough evidence for subduction-driven tectonic processes in the entire Proterozoic. Brown (2008), looking at the metamorphic record in geologic time, suggested a dramatic change in the thermal environments of crustal metamorphism at the Archean/Proterozoic boundary, leading to a "Proterozoic plate tectonics regime", characterized by the subduction of oceanic lithosphere and continental lithospheric stability, when cratons formed the nuclei of major continental masses. Condie (2000), suggested that subduction could be episodic, which explain the important peak in crustal production in the Paleoproterozoic, at about 2.0 Ga.

At about 1.0 Ga, after a long time of continued heat loss, the Earth cooled sufficiently to allow the oceanic lithosphere to become negative buoyant in a relatively short time, and the new low T and high P tectonic regime was characterized by thermal gradients that allowed the transformation of basalts into eclogites in the descending slabs. Such negative buoyancy of dense oceanic lithosphere led to the "slab-pull type" of driving force for the slabs that slide away from mid-ocean ridges. According to Brown (2008), UHP metamorphic terrains, bearing coesite or diamond, started to appear in the Earth, indicating subduction of continental crust to depths >100 km, followed by rapid exhumation. In his view, this marks the transition towards the new tectonic regime, related to "modern-type subduction zones" and "subduction-to-collision" orogenic belts, widespread in the Phanerozoic. The oldest eclogites so far described (Caby 1994) were dated by robust U-Pb zircon ages of ca. 615 Ma (Ganade de Araujo et al. 2014).

The aim of this chapter is to provide an integrated synthesis on the geologic history and tectonic evolution of the São Francisco miniature continent (see Heilbron et al., Chap. 1). It is surprizing to see how, in a small cratonic fragment such as the São Francisco miniature continent, we can find a clear evidence for some of the relevant phases of the Earth tectonic evolution. In the next sections, compiling information presented in the preceding chapters of this volume, we will present and discuss the tectonic events recorded in the São Francisco craton and its margins, exploring their significance in terms of the global tectonic processes that governed the Earth's dynamics.

## 17.2 High-Heat Tectonic Regime and the Formation of Granite-Greenstone Terrains

Archean rocks are widespread in both the northern (Bahia State) and southern (Minas Gerais State) segments of the São Francisco craton (SFC), forming a series of granite-greenstone terrains of different age. The oldest ages of ca. 3.6 Ga are found in some TTG granitoids that crop out in the Gavião block of central Bahia (see Teixeira et al. Chap. 3, and Barbosa and Barbosa, Chap. 4) (Fig. 17.1). Sm–Nd model ages of some of these rocks reach ca. 3.9 Ga. Together with one single detrital zircon of ca. 4.1 Ga, found in a supracrustal rock from a younger greenstone belt sequence, these ages are indicative of the existence of even older

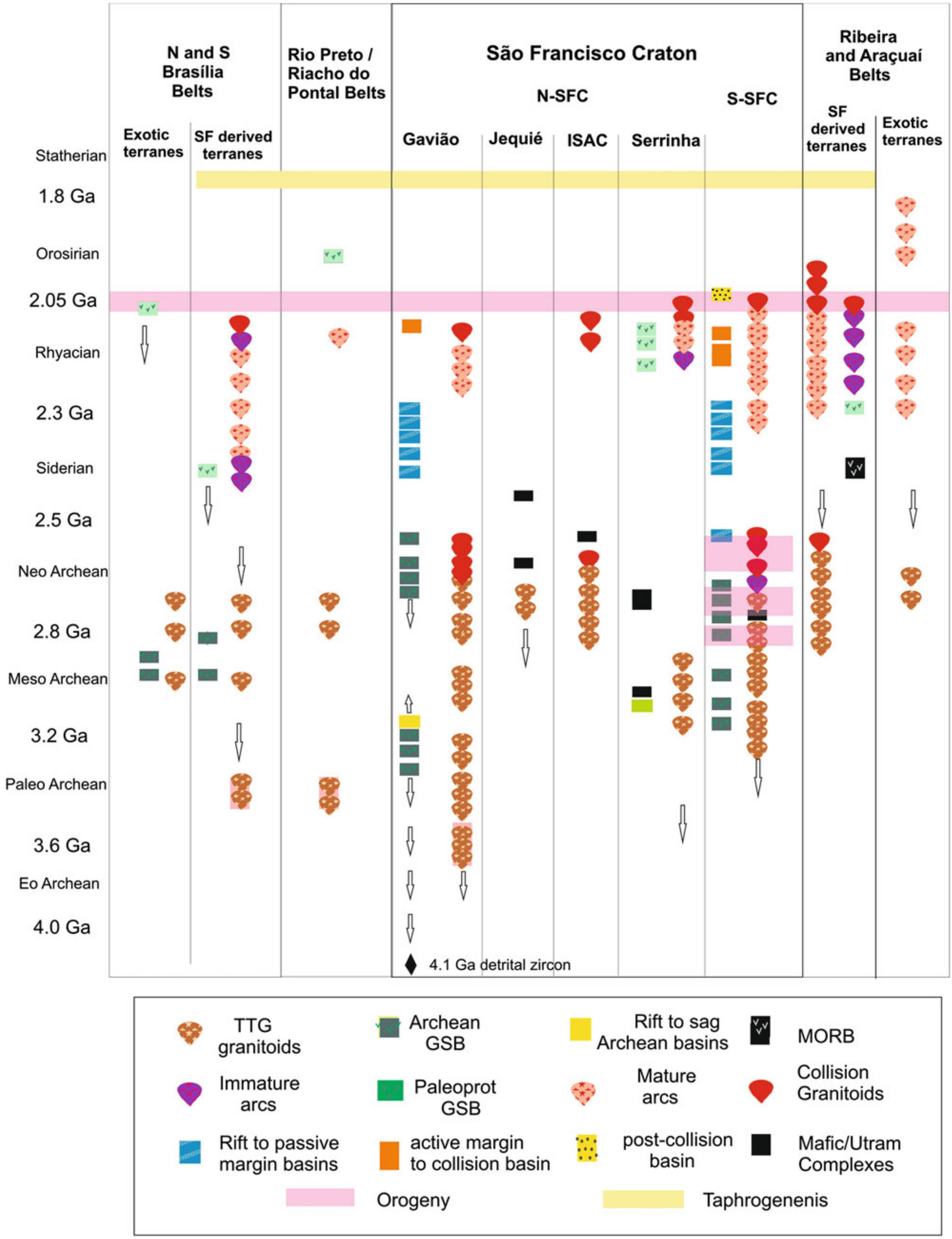


**Fig. 17.1** Archean to Paleoproterozoic schematic tectono-stratigraphic chart

crustal precursors (Fig. 17.1). Paleoarchean granitoid rocks of ca. 3.4–3.2 Ga became progressively more common both in the southern and northern segments, as well within reworked basement inliers of the marginal Neoproterozoic belts, as reported in the northern Brasília, Araçuaí and Riacho do Pontal belts (see Fuck et al. Chap. 11 and Caxito et al. Chap. 12). This time interval is coeval of the oldest greenstone belt association described in the Gavião block, northern SFC.

Renewed episodes of formation of granite-greenstone terrains are detected in the same regions of Bahia and Minas Gerais, and the main pulses of magmatic rock generation due to plume activity were dated at ca. 3.2–2.9 Ga (Mesoarchean time) and 2.8–2.6 Ga (Neoarchean time). The tectono-magmatic evolution of these terrains developed through juvenile accretion/differentiation events characterized by multiple TTG plutonism (Lana et al. 2013; Farina et al. 2015). The greenstone belt associations include komatiitic rocks, meta-basalts and meta-andesites, BIFs, other chemical sediments, and lithic wackes. Provenance studies made through U-Pb zircon dates indicated the predominance of the main age peaks described above for the granitoid rocks.

The oldest collisional events (Fig. 17.2) so far identified in the craton interior and marginal belts are the crustal forming processes occurring at ca. 2.8–2.7 Ga (see Teixeira et al., Chap. 3). These late Archean convergence ultimately led to the amalgamation of the Archean nuclei that form the substratum of the São Francisco craton and its margins.

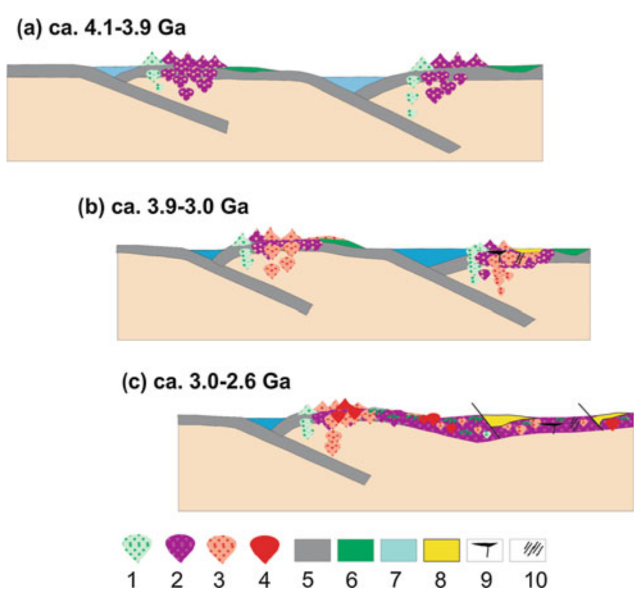


**Fig. 17.2** Envisaged tectonic evolution of Archean terranes of the SFC. *1* IAT basic rocks, *2* TTG granitoids, *3* calc-alkaline tonalites and granodiorites *4* K-rich granitoids, *5* oceanic crust, *6* greenstone belts, *7* sag to passive margin basins, *8* rift basins, *9* mafic to ultramafic complexes, *10* basic dikes

Anorthosites, as well as mafic-ultramafic complexes and dykes emplaced at ca. 3.16, 2.65–2.63 and 2.58 Ga, testify the growing and the increased stability of the Archean continental mass.

In the northern SFC, the Jacobina Group, representing an intracontinental basin filled essentially by mature sandstones and conglomerates, was developed on the Gavião block, indicating that a major stable cratonic-type area was already formed in the Archean. Quartzites and conglomerates from this group displayed only Paleoarchean (ca. 3.5–3.2) detrital zircons. Based on these ages, as well as on the crustal signatures obtained from Hf isotopes analyses and the presence of detrital Au and pyrite in the sedimentary rocks, Teles et al. (2015) compared the Jacobina succession to the Witwatersrand basin of South Africa.

In the southern SFC, the Rio das Velhas greenstone belt, located in the Quadrilátero Ferrífero mineral province, is so far the best studied of the craton (Teixeira et al., Chap. 3). Farina et al. (2015 and references therein) described its tectonic evolution, subdividing it in three events marked by granitoid emplacement at the 2.92–2.85, 2.80–2.76, and 2.76–2.68 Ga intervals. The youngest event is related to pervasive deformation, regional metamorphism and the generation of K-rick granitoids that witness the Archean—Proterozoic transition (Fig. 17.2). Foreland to intramontane mature sequences, such as the Maquiné Group (Moreira et al. 2016), closed this important continental growing event in the Quadrilátero Ferrífero. Late to post-collisional *strictu* sensu granites and basic intraplate dykes were intruded at ca. 2.65–2.56 Ga. A very similar tectonic evolution is reported for the Gavião block of the northern segment of the SFC by Teixeira et al. (Chap. 3).

## 17.3 Proterozoic-Type Plate Tectonics and the Formation of the São Francisco-Congo Cratonic Block

The stabilized Archean nucleus of the craton, a region which roughly corresponds to the "Paramirim craton" of Almeida et al. (1981), was most likely adjacent to similar continental masses, and separated from them by rifting events sometime between the very end of the Neoarchean and the beginning of the Paleoproterozoic, leading to the development of a series of passive margins along the area presently occupied by the Mineiro, Ribeira and Araçuaí belts, as well as the Eastern Bahia orogenic domain (Alkmim and Teixeira, Chap. 5, Barbosa and Barbosa, Chap. 4, Ledru et al. 2004). The particular Siderian sedimentation of the Cauê Banded Iron Formation and the Gandarela carbonates in the Minas basin (Quadrilátero Ferrífero, southern SFC) took place around 2.42 Ga (Fig. 17.3) in the course of the Earth's *Great Oxygenation Event*. Peculiar passive margin units are

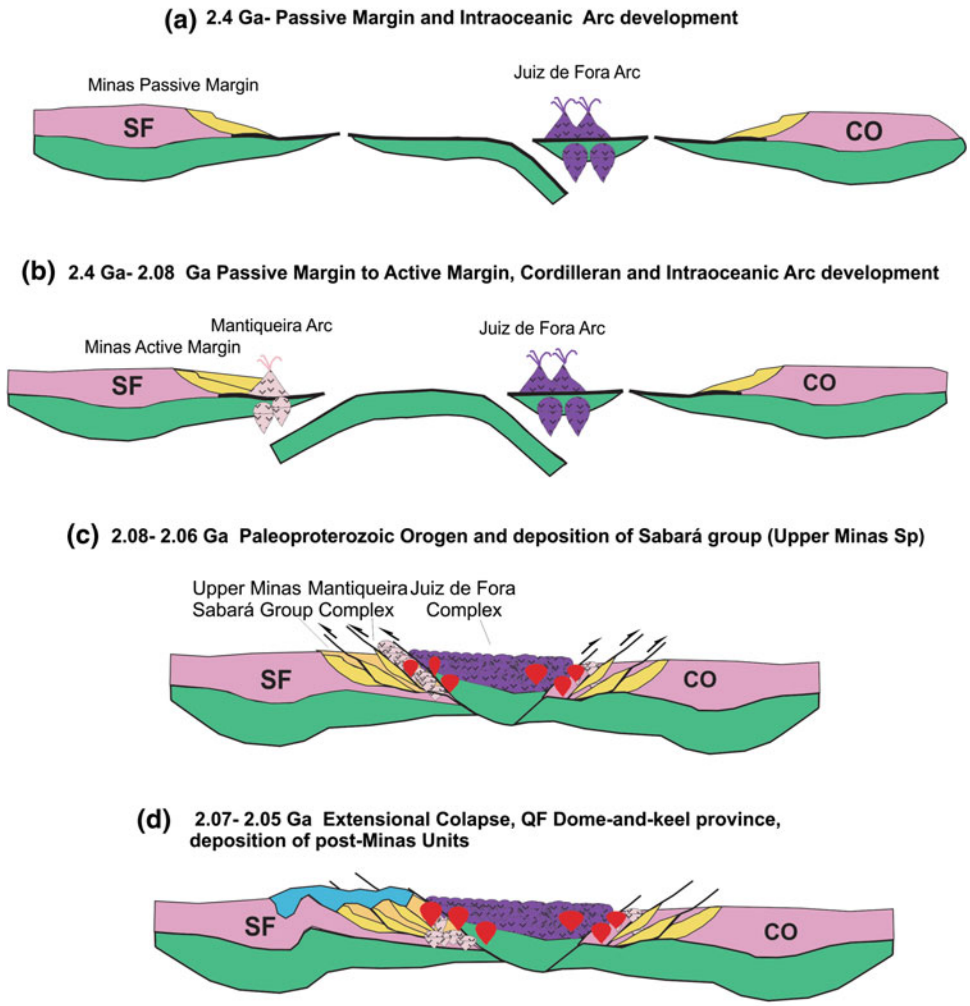


**Fig. 17.3** Envisaged tectonic evolution of Paleoproterozoic terranes of the SFC. *1* Post-Minas units, *2* collisional granites, *3* cordilleran arc, *4* juvenile intraoceanic arc, *5* syn-collision Sabará Group (upper Minas Supergroup), *6* passive margin lower Minas Supergroup, *7* oceanic crust, *8* Archean continental crust, *9* lithospheric mantle. SF São Francisco; CO Congo.

also recorded in the Eastern Bahia belt (Barbosa and Barbosa, Chap. 4), such as Lake Superior-type BIFs, dolomitic marbles and manganese-rich schists. In various aspects, these specific metasedimentary successions could be correlative to the basal Francevillian A and B formations, exposed in the northwestern portion of the Congo craton in Gabon (Ledru et al. 1994; Feybesse et al. 1998).

Some greenstone belt-like volcano-sedimentary sequences and associated juvenile granitoids of Rhyacian age, detected within the Mineiro, Serrinha and Brasilia belts (see Fig. 17.1 and Chaps. 4 and 5) record the development of back-arc to intra-arc basins in oceanic realms. Despite their restricted expression in the geologic scenario, these assemblages witness the development of subduction systems along the margins of the Archean cratonic nuclei in the Early Paleoproterozoic. The rock record of the craton and its margins relative to the subsequent time interval of 2.40–2.10 Ga is limited to some granitic intrusions and volcano-sedimentary sequences, in agreement with the global magmatic quietude pointed out by Condie et al. (2009) for this period. A Siderian age of ca. 2.4 Ga was obtained from a metamafic unit within a reworked basement inlier of the Ribeira belt, with a MORB-type signature, probably marking the distal oceanic portion of the Minas basin (Heilbron et al. 2010).

Within the Minas Supergroup, after a long depositional hiatus that followed the initial Siderian rift-to-passive margin phase (Alkmim and Teixeira, Chap. 5), the syn-orogenic assemblage of the Sabará Group was deposited at ca. 2125 Ma (Fig. 17.3). The deposition of this sequence, coeval to the C and D formations of the Francevillian Group in Gabon, marks the onset of the continental collision between the São Francisco and Congo landmasses. On the Brazilian side, the generation of several magmatic arcs and microcontinents of Rhyacian age, such as the Mantiqueira and Quirino cordilleran arcs, the Juiz de Fora intraoceanic arc in the basement of the Ribeira belt, and the Jequié and Serrinha blocks within the Eastern Bahia belt, was described by Noce et al. (2007), Heilbron et al. (2010), Teixeira et al. (2014), and Barbosa and Sabaté (2004). The eastern margin of the São Francisco Archean nucleus, already converted into a back-arc domain, started to be fed with sediments sourced by the approaching collisional front. The climax of this process was reached around 2080 Ma, the age peak of the syn-collision metamorphism documented in the various segments of the orogen preserved in the intra and extra-cratonic sectors. In the aftermath of the collision, at least the region of the Quadrilátero Ferrífero entered a gravity collapse, subsiding and collecting the sediments of the Itacolomi Group, also derived from the orogenic zone. Thus, after receiving recycled and juvenile additions, these amalgamated pieces of cratonic lithosphere formed a very large continental mass, tectonically stabilized at ca.1.9 Ga.

One interesting question arises at this point. Did this Rhyacian\early Orosirian orogenic edifice belong to a supercontinental mosaic? In other words, was the newly assembled São Francisco-Congo incorporated into Columbia? This was postulated by Rogers and Santosh (2004), Brito-Neves et al. (1999), Alkmim and Martins-Neto (2012), Zhao et al. (2004), Nance et al. (2013). On the other hand, as pointed out by D'Agrella and Cordani (Chap. 16), the paleomagnetic data set is not conclusive for the inclusion of all the cratonic blocks in a single supercontinent at ca. 1.9 Ga. In their Fig. 16.2, these authors suggest that the Rio de la Plata, the Borborema/Trans-Sahara and the Kalahari blocks were united to the Congo-São Francisco paleocontinent, forming the Central African block of Cordani et al. (2013). They argued that this large continental mass most probably did not take part of Columbia. D'Agrella and Cordani (Chap. 16) also suggested that the São Francisco-Congo paleocontinent may have experienced an independent drift since its formation at 1.9–2.0 Ga until the formation of West Gondwana in Ediacaran time.

## 17.4 1300 Ma of Intraplate Events

Looking at the Earth tectonic evolution in geological time, from ca. 1900 to ca. 600 Ma, Columbia was amalgamated and later dispersed in many fragments that eventually reassembled into Rodinia (e.g. Nance et al. 2013), and Rodinia was also disrupted not long after its formation. During this very long period of 1300 Ma, no clear evidence of collisional tectonism affecting the SFC was found. On the contrary, plenty of within-plate episodes such as rifting and anorogenic magmatism are registered in the SFC, as pointed out by Cruz and Alkmim and Reis et al. (Chaps. 6 and 7). Mafic dike swarms within the craton also testify the extensional tectonic events (see Girardi et al., Chap. 8). This is somewhat endorsed by many of the Rodinia's paleomagnetic reconstructions (e.g., Tohver et al. 2006; Nance et al. 2013), which show the São Francisco-Congo as an isolated landmass.

A large system of Statherian rifts nucleated in the central part of the SFC and its margins, receiving successive sequences of continental sediments accumulated in association with A-type plutons and bi-modal volcanic rocks dated between 1.78 and 1.71 Ga (Cruz and Alkmim, Alkmim et al., Chaps. 6 and 14). The intraplate tectonic events that led to the development of the various Espinhaço Supergroup depocenters lasted at least until the end of the Tonian Period, when several passive margin basins were formed in the São Francisco-Congo landmass (Fig. 17.4).

The early Neoproterozoic extensional tectonism, from rift to passive margin, included mafic sills and dikes (Girardi et al., Chap. 8), as well as bimodal magmatic associations dated at 1.0–0.80 Ga. Many of these units record onset of rifting events, followed by full development of passive margins in Late Tonian-Cryogenian times. The passive margin phase is documented in all Brasiliano orogenic belts that surround the SFC, such as the Brasilia, Ribeira, Araçuaí, Sergipano, and Riacho do Pontal belts. Some lithostratigraphic units of this stage exhibit evidence of glacial origin, like the presence of diamictites and cap carbonates (Fig. 17.4), which could likely be attributed to the Cryogenian global ice age. The best example is the Macaubas basin-cycle, documented in the Araçuaí belt and São Francisco basin (Babinski et al. 2012 and references therein).

## 17.5 Modern-Type Plate Tectonics: São Francisco-Congo Incorporated into West Gondwana

During almost the entire Neoproterozoic, the oceanic basins around the São Francisco-Congo paleocontinent underwent a continued process of slab-pull subduction, that eventually led to the amalgamation of West Gondwana. For the São Francisco craton, the consumption of three oceanic realms is fundamental: the very large Goiás-Pharusian Ocean, the more restricted Adamastor Ocean and the minor Canindé oceanic domain (Fig. 17.5 and Chaps. 10–15). Magmatic arcs were registered and characterized within these oceanic domains, since the early Tonian, especially widespread in the Brasilia marginal belt and within the Ribeira-Araçuaí system (see Fuck et al., Chap. 11, Alkmim et al., Chap. 14, Heilbron et al., Chap. 15). The primitive arcs display in common juvenile signatures suggestive for intra-oceanic settings. Later, within all the marginal belts, the development of cordilleran arc successions is described, pointing to successive collisions and the progressive closing of the intervening oceanic spaces. In the Ediacaran, at ca. 600 Ma, several continental masses converged to form West Gondwana, and one of these is the SFC, still attached to the companion Congo craton. The advanced interaction of all continental masses resulted in the uplift of the Brasiliano/PanAfrican orogenic systems and configuration of the craton boundaries (Almeida 1977). The

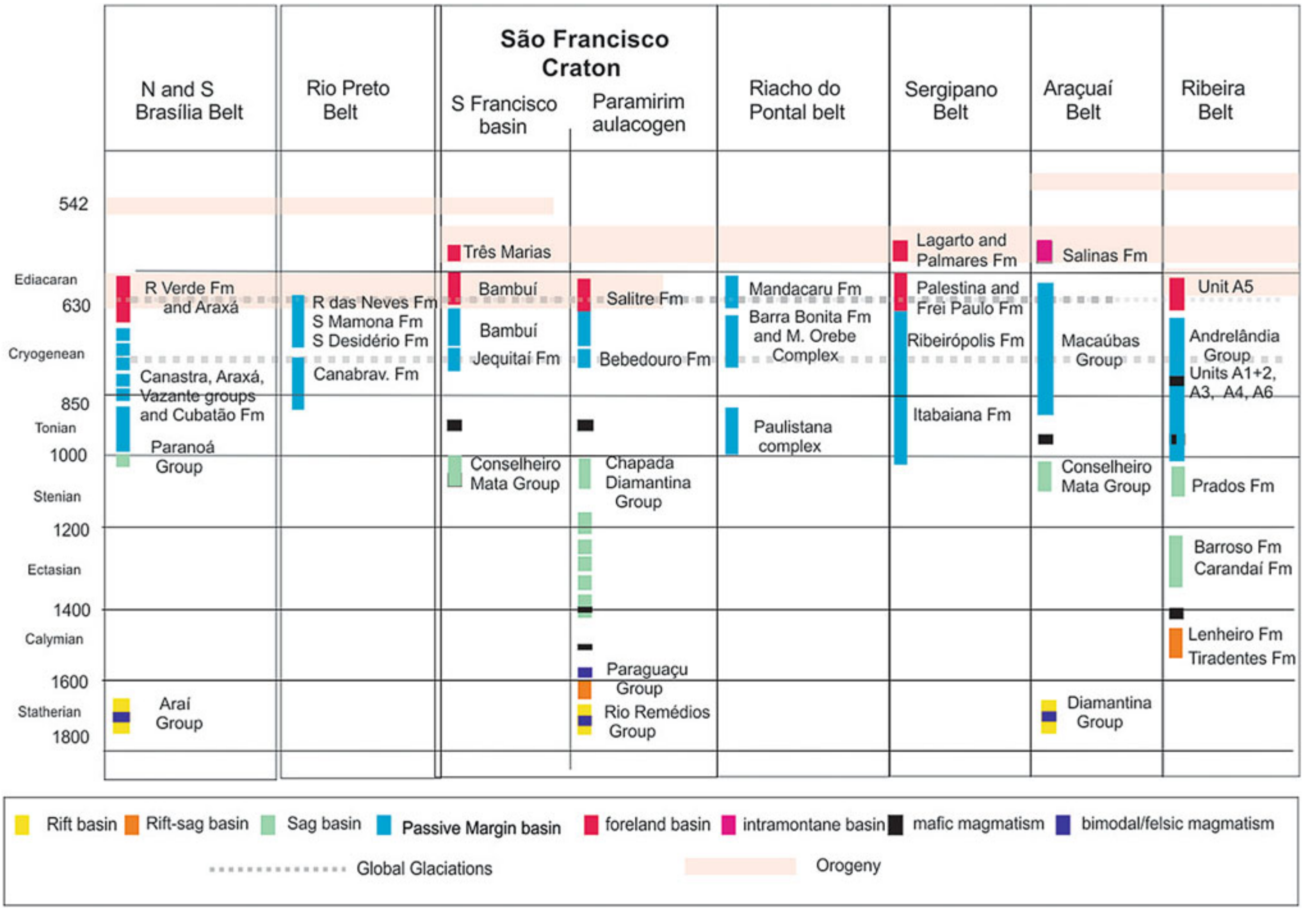


**Fig. 17.4** Mesoproterozoic to Neoproterozoic schematic tectono-stratigraphic chart

oceanic realms, Goiás-Pharusian, Adamastor and Canindé were consumed by subduction-to-collision tectonic episodes.

The Goiás-Pharusian Ocean was closed after a long duration phase that started with the formation of a series of subduction-driven intraoceanic island arcs and was ended with the generation of the West Gondwana orogen (Ganade de Araujo et al. 2014), which is represented by the region affected by the Transbrasiliano-Kandi mega-shear zone. The final continental collision brought together, at one side the Amazonian and the West African cratonic masses, and at the other side the São Francisco-Congo, the Rio de La Plata and the Saharan counterparts. In the case of the SFC, as a result of this collision, the Brasilia orogenic belt was developed (see Valeriano, Chap. 10, and Fuck et al., Chap. 11).

On the Adamastor Ocean, the initial rifting of a region located on the São Francisco-Congo paleocontinent occurred in the late Tonian, at about 900 Ma. However, the rifting did not succeed in separating the São Francisco and the Congo cratonic elements, which remained attached through the Bahia-Gabon cratonic bridge. The main portion of the Adamastor occupied an extended oceanic region that later would become the site of the amalgamation of smaller cratonic masses and massifs, such as the Rio de La Plata, Paranapanema, Luiz Alves and Kalahari. With the closure of one of the terminal segments of the Adamastor, the Macaúbas basin, the Araçuaí and Ribeira orogenic belts were developed (see Alkmim et al., Chap. 14 and Heilbron et al., Chap. 15).

The Canindé restricted oceanic domain was closed by a continental collision that produced the tectonic structures of the Sergipano, Riacho do Pontal and Rio Preto belts (Caxito et al., Chap. 12, and Oliveira et al., Chap. 13). It was the result of the convergence of the SFC with the proto-Borborema Province, which must have initially acted as a coherent mass. During this episode parts of the Borborema were thrust onto the northern part of the craton along a zone of ca. 1000 km.

From the above discussion, we may infer that the Brasiliano belts surrounding the SFC are members of a tectonic collage, which concluded the convergence of a few cratonic elements of different size by a series of continental collisions, in the Ediacaran period. All the Brasiliano belts comprise tectonic-stratigraphic sections including some rift to passive margin-type deposits, with some oceanic crust

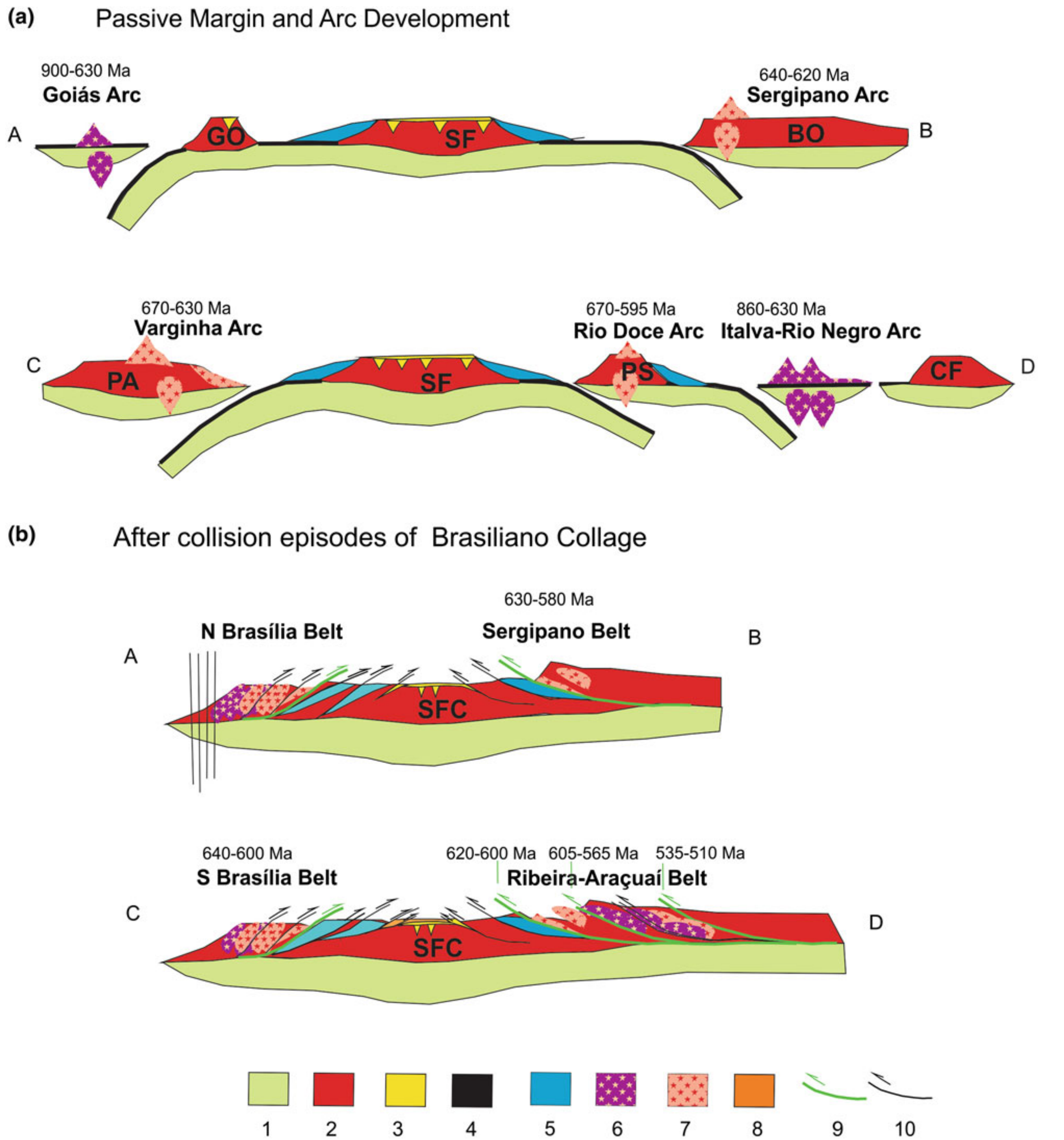


**Fig. 17.5** Envisaged Neoproterozoic tectonic evolution the SFC and outboard terranes. *1* Lihospheric mantle, *2* continental crust, *3* oceanic crust, *4* rift to sag intracratonic basins, *5* passive margin basin, *6* juvenile arc and related basins, *7* cordilleran arc and related basins, *8* foreland to successor basins, *9* main sutures, *10* subordinated thrusts GO-Goiást, SF-São Francisco, BO-Borborema, PS-Paraíba do Sul, CF-Cabo Frio

fragments and turbiditic successions linked to coeval magmatic arcs, formed usually between ca. 900 and ca. 500 Ma. Figure 17.5 presents a few schematic profiles illustrating the Neoproterozoic evolution of the belts around the SFC. The Brasiliano fold and thrust belts now expose rocks assemblages metamorphosed under low-to-medium grade, but areas of high-grade metamorphism also occur in their internal portions. Tectonically reworked basement inliers are quite common, and those of Paleoproterozoic age are very frequent (Chaps. 10–15 for a detailed review).

To the west of the SFC, the collapse of the Goiás-Pharusian Ocean and the convergence of the Goiás magmatic arc affected the passive margin of the craton. The collisional phases occurred between 650 and 560 Ma. They involved exotic allochthonous terranes like the Central Goiás Massif and produced a thrust-and-fold belt comprising a series of eastern vergence nappes that were emplaced over the craton (Fuck et al., Chap. 11). Moreover, in the final stages of the West Gondwana assembly, in the northern Brasilia belt, a second contractional deformation phase was produced along the preexistent southern Brasilia belt and the foreland sequences on the craton interior became involved in the deformation.

To the north of the SFC, the most important collisional episode took place between ca. 605–565 Ma and was responsible for the generation of the Sergipano, Riacho do Pontal and Rio Preto belts, with the consumption of the Canindé oceanic domain, finally shaping the present boundaries of the SFC (Caxito et al., Chap. 12 and Oliveira et al., Chap. 13). The deformational front invaded the border of the São Francisco continent, involving the previous Mesoproterozoic intracratonic basin in the deformation.

To the south of the CSF, the earliest Ediacaran orogenic event represents the Paranapanema-São Francico/Congo collision, responsible for the uplift of the southern Brasília metamorphic belt around 630 Ma (see Valeriano, Chap. 10). After this event, a major transgression affected the São Francisco peninsula, which started to behave as a downwarp basin, where the mixed carbonatic-siliciclastic sediments of the Bambuí 1st-order sequence started to accumulate after 610 Ma (Fig. 17.4).

At the eastern and southeastern corners of the SFC, within the Araçuaí and Ribeira belts, the tectono-magmatic evolution was similar, and pre, syn and late-collisional granitoid rocks were formed in continental magmatic arcs, in successive pulses between 630 and 530 Ma (Chaps. 14 and 15). The Araçuaí orogenic front propagated towards the SFC thereby affecting the Bambuí strata and causing partial inversion of the Pirapora aulacogen within the foreland (Reis et al., Chap. 8). Within the Ribeira belt, cordilleran arc systems developed at the margins of Paleoproterozoic microcontinents and collided to the E-SE margin of the craton. Moreover, the subducted passive margin sediments of the Andrelândia basin underwent HP metamorphism and intense deformation that resulted on the nappe stacking at the Ribeira belt. Finally, at the easternmost Ribeira belt, a Cambrian collisional episode was responsible for the docking of the Cabo Frio terrane, and its deformation front reached the previously amalgamated terranes (Heilbron et al., Chap. 15).

The Neoproterozoic marginal belts of the São Francisco craton were developed within the "modern-type slab-pull subduction-to-collision tectonics regime" proposed by Brown (2008). A good indication is the presence of HP metamorphic terrains in some of the belts, like the Ribeira or the southern Brasilia (Chaps. 10 and 15 of Valeriano and Heilbron et al.). In the latter, coesite inclusions within zircon and garnet from a kyanite-garnet metamorphic UHP rock were described by Parkinson et al. (2001). Retro-eclogites and HP metamorphic rocks were described by a few authors for the Brasília belt and its interference zone with the Ribeira belt (Campos Neto and Caby 2004; Heilbron et al. 2008; Trouw et al. 2013 and Chaps. 14 and 15).

After the termination of the tectonic pulses within the marginal belts, the tectonically stable interior of the SFC subsided in response to the orogenic loads developed along its margins. It received sediments shed from the newly uplifted areas around and was caught in some places by the compressional deformation fronts (see Reis et al., Chap. 5). From its residence in West Gondwana and Pangea, the São Francisco basin only preserves the Santa Fé glaciogenic sediments, which accumulated when the supercontinent wandered along polar latitudes.

## 17.6 Breakup of the São Francisco-Congo Cratonic Bridge

The breakup of West Gondwana in the Lower Cretaceous, as one of the main outcomes of the current plate tectonics regime, resulted in the opening of the South Atlantic Ocean and separation of the São Francisco and Congo cratons (Porada 1989; Pedrosa-Soares et al. 2001; Gordon et al. Chap. 9). The main segments of the large rift system developed in the initial phase of this process evolved to the present-day passive and transform margins of South America and Africa. Other branches of the system, such as the Abaeté graben in the São Francisco basin, failed and became important depocenters in the interior of both continents (Reis et al., Chap. 7). On the other side, important intraplate stress rearrangements in the course of the South Atlantic event caused the uplift of the Alto Paranaíba arch, whose ascension most likely started prior to the Cretaceous, being successively reactivated afterwards.

Later, in the Upper Cretaceous, the Alto Paranaíba arch experienced a new reactivation, associated with the extensive intraplate magmatic episode that culminated with the intrusion of NW-trending dykes, alkaline plutons, and the extrusion of the kamafugitic lavas and pyroclastics of the Mata da Corda Group. This magmatic episode may have occurred in response to the action of a mantle plume beneath the craton border in the Late Cretaceous (see Chap. 7).

In the last 100 Ma, South America and Africa drifted away and the Atlantic Ocean reached its largest wideness. The São Francisco and Congo cratons, that were good companions and drifted together at the surface of the Earth for about 2.0 Ga, are now more than 5000 km apart. Most likely, separation will be forever.

## 17.7 Conclusions

In this chapter a brief description of the tectonic evolution of the miniature São Francisco continent, for a few time-intervals, was made. Although small in size, we have seen that this tectonic unit exhibits many features of some of the principal phases of the Earth global geodynamics.

(1) For the Archean, in the northern and southern segments of the craton, granite-greenstone terrains are found in a few different places. They comprise TTG-type granitoids of different ages, formed from mantle plumes, deformed and associated to greenstone belts. Like in many other Archean terrains of the world, they amalgamated to form a coherent and stable continental mass in the late Archean.

(2) For the ca. 2.0 Ga time slice of the Paleoproterozoic, a few relevant subduction-driven accretionary belts, including juvenile island arcs and allochthonous terranes, within the Mineiro and Eastern Bahia orogens, were added to the Archean continental crust. They are typical of the Proterozoic plate tectonic regime of Brown (2008) and were formed near the important peak in crustal production indicated by Condie (2000).

(3) In the following long period of more than 1 billion years, orogenic activity was not identified in the São Francisco craton. It was united to the Congo craton, within the Central African block, and possibly it did not take part of the Columbia and Rodinia supercontinents. During this time slice it was affected by a series of important intraplate processes, such as anorogenic magmatism and the formation of aulacogenic-type basins.

(4) Later, in Ediacaran to Cambrian times, the São Francisco craton, within the African block, took part in the formation of the Gondwana Supercontinent by means of the collage of practically coeval subduction-to-collision orogenic belts, as typical examples of the slab-pull subduction processes typical of the modern-type plate tectonics regime. The Rio Preto, Riacho do Pontal, Sergipano, Araçuaí-Ribeira and Brasilia belts surrounded completely the SFC.

(5) Finally, with the disruption of Pangea supercontinent in Meso-Cenozoic time, the São Francisco craton was finally separated from its counterpart, the Congo craton, by means of the formation of the South Atlantic Ocean, as a typical element of the present-day plate tectonics regime.

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