SUMMIT SURFACES IN BRAZIL

AZIZ NACIB ABSÁBER

ABSTRACT The study of summit planation surfaces and that of inter-plateau planations constitute together one of the most important themes of topographic meso-compartmentation of Brazil. Such planations, on the top of pre-Cambrian terranes, constitute extensive eleva-
tions of complex structures, later submitted to epeirogenetic uplift of the type called by French authors *epirogene par sacades*. In the present work it epitomized the available information on these old planations, usually taken as post-Gondwana - credit is given to pioneer researchers (E.C. Harder and R.T. Chamberlin, De Martonne, R.O. de Freitas, P.F.M. de Almeida, Lester King). The study of these planations constitutes a radical transilience from geological history proper into post-Cretaceous geomorphological history of a large part of Brazil.

One remarkable fact about Brazilian physiography is the presence of summit surfaces inherited from old planations that acted on parts of Gondwana. In the case of Brazil, the surfaces remaining on the top of plateaus and ridges of resistant rocks constitute benchmarks that facilitate the understanding of the regional and subregional compartmentation of the great Brazilian Plateau. The basic components of the mega-geomorphology of the country include the high plateaus of old terranes subject to successive epeirogenic uplifts and the sedimentary basins nested on the "dorsais" (dorsum) of the old Brazilian platform. The post-Cretaceous uplifts of the Brazilian Shield were accompanied by a synchonic upheaval of the intracratonic Pale-Mesozoic basins.

Studies on the level summits that exist in different parts of the Brazilian Plateau have had two starting points. The first followed observations made in the mountains of Minas Gerais (Chamberlin 1915), where above steep slopes of scarps and mountain ranges old erosion surfaces occur, covered by savanna-like vegetation. Research motivated by the presence of iron ores led to the identification of old planations that succeeded in leveling a whole ensemble of rocks of uneven resistance. The second starting point was derived from a highly significant transect from the Atlantic plateau of Sao Paulo through the marginal lowlands into the western plateaus. Luis Flores de Moraes Rego had already performed a geological section, of great generality, from old granite-granite and schist terrains to the axis of the Paraná Basin.

But we owe to the great French geomorphologist of the first half of this century - Emmanuel De Martonne - the identification of the main summit surfaces of southeastern Brazil, from the Mantiqueira and Bocaina mountains to the high ridges interposed between the Sao Paulo Basin and the contact belt with the Upper Carboniferous formations exposed on the eastern border of the Paraná Basin. In the spirit of the old European geological tradition, De Martonne (1940) assigned to the surfaces he identified classical names, Superficie dos Altos Campos and Superficie das Três Médias to the summits that emerged in the Atlantic Monocline of the Paraná Basin, and Superficie Neogenica to the interplateau surface that cuts into the Permo-Carboniferous formations.

As the present work is epitomized the available information on these old planations, usually taken as post-Gondwana - credit is given to pioneer researchers (E.C. Harder and R.T. Chamberlin, E. De Martonne, R.O. de Freitas, P.F.M. de Almeida, Lester King). The study of these planations constitutes a radical transilience from geological history proper into post-Cretaceous geomorphological history of a large part of Brazil.

The higher surfaces that occur in sectors of the Brazilian Shield had a special meaning in the discussion of the paleogeography of centro-oriental South America. At the time when Brazil and Africa formed one single "transverse super continent", the former summits of the Afro-Brazilian Shield constituted mega-domes of old terranes, which behaved as matrices furnishing sediments to the main sedimentary basins. While the Anglo-Celtic model of pre-Devonian formations leaned towards a persistent positive epeirogenesis, the intracratonic sedimentary basins underwent slow, gradual subsidence.

This discordant behavior of regional nuclei and sedimentary basins caused, during the gigantic tensions that preceded the breakup of the continent, intrusions and magmatic flows over portions of the basins. Meanwhile, ancestral crystalline mega-domes underwent upwarping involving the sectors of shields between the basins. Such warped areas of old "granitic-granite-schistous" structures, rigid and long consolidated, incapable of folding or adjusting to the geological forces in action, became potentially liable to brittle tectonics, from the end of the Cretaceous to the middle of the Tertiary. When the drift forced by plate tectonics was completed, the newly detached Brazilian (or better, "Brazilian-Panamazonian") terranes reached approximately its present position, leaving, however, room for Upper Mesozoic and Plio-Miocene geosynclines (pre-Andes and Andes).

In spite of the tectonic vicissitudes that the Brazilian platform underwent since the Devonian, it is certain that the permanently exposed part of the shield located in the uplands of eastern and central Brazil. The dome of the shield that comprised the *continuum Bocaina/Mantiqueira* - plus the "dorsais" of the Espinhago and Canas-Brasilia - continued eastward, before the South Atlantic existed. After the break up of Gondwana there was an uplift of the remaining half-dome, while discontinuous grabens received thick masses of marine sediments, partially contaminated with fatty, petroleum-generating elements. The establishment of the Paraiba graben (Taubate Basin) broke locally the continuity of the remaining dome, originating a rift valley. A replica, to a lesser scale, what happened in East Africa, where brittle tectonics originated the great African rift valley system.

It is easy to understand the sequence of facts that raised the remnants of the centro-oriental plateaus of the Brazilian platform. Shallow Devonian seas transgressed parts of the Afro-Brazilian platform, from the west-southwest in its center-southern part, and from a complementary embayment in the Parnaiba Basin, connected to the Paleoazonic Amazonian basin. Next, over the Devonian deposits, during a phase of broader, continuous subsidence, developed the highly hybrid sedimentation of the Late Carboniferous, with glacial subglacial, glacial-lacustrine and eventually marine sediments. During this phase, when over 1,000 m of glacial and subglacial Gondwana sediments were accumulated, glaciers flowed from the northeast and east of the paleo-dome, showing then low relief and undergoing a continuous process of relative planation.
After the Late Carboniferous-Permian hiatus, shallow seas in an extensive lacustrine-marine gulf promoted the deposition of mudstones, limestones and sandstones. At this time, at the end of the Paleozoic, shallow seas eventually leveled the extensive flood plains to form a paleo-dome in a somewhat low tectonic position. Next, in the Late Triassic, there was the establishment of an enormous dune field - of the same type as the present Sahara ekrfs - consequent to the establishment of zonal arid climates on the southern edge of Gondwana. Meanwhile the main paleo-dome suffered devastating erosional processes. In the Cretaceous, a mosaic of 500-600 m high ramp-like features formed. When the erosion exceeded the paleo-dome's rate, the former paleo-dome was converted into new topography. The process was repeated for several cycles. Eventually, a new tectonic phase began, pockets of magma formed under the basement of the Paraná Basin coming from the continental crust, and a new magma pile began to accumulate over the extensive dune field. The result was a 13 km thick, new dome that was eventually superimposed on the former dune field. The result was a new dome, dipping westward.

As Ab'Saber (1957) noted, there is a lower level, at 670-700 m. On the heights of the Serra do Carajas, at the contact between the Devonian and the basement, there are, however, broad areas of lower heights on the basaltic plateau, reaching 1,000-1,100 m in Vacaria and Sao Francisco de Paula (Rio Grande do Sul).

The Borborema Plateau constitutes a peculiar unit among summit planation surfaces that stretch between 1,000-1,150 m, including large areas of "dorsais" of shields (Espinhalo/Diamantina and Bocaina/Mantiqueira/Brasilia) and the "serras altiplano" of northeastern Brazil) was a shield dome, dipping westward. At present, after a long period of denudation that originated the interplateau serranha, the old dome has become much reduced and outstanding among the surrounding lowlands. From Garanhuns to the Serra do Gigante or the Serra do Teixeira (Pernambuco), there are remnants of post-Cretaceous planation surfaces. In several places the discontinuous summits of the Borborema reach 1,000-1,100 m, but there is a lower level, at 670-700 m. The Serra dos Martinhas and Santanas in Rio Grande do Norte is an extensive dune field, with average heights of 450 m. From which it may be inferred that Borborema reached its features of crystalline macro-dome in relatively recent geologic time (Neogene). This happened independently from the interference of brittle tectonics in some of its borders, especially along the northern margin of the Borborema paleo-dome.

All researchers that have dealt with the mountains and escarpments of the Guayana Plateau are unanimous in saying that post-Cretaceous brittle tectonics has disturbed the study of summit surfaces that may eventually have existed. I share this view, but must say that the Gran Sabana plateau, beyond border monument BV-8, is a typical example of this. The summit planation surfaces of the Borborema paleo-dome were at 1,000-1,500 m above this plateau, on the peaks of Roraima and Caborua. On the mountains of western Roraima, post-tectonic breakage was sufficient to create high and low in the relief of the border mountains, masking features of planation surfaces. However, even around Pico da Neblina, at 2,000-3,000 m, remnants of these surfaces may be identified.

On the top of the Uruguay-Rio Grande do Sul shield there is a characteristic ensemble of summit planation. There is a remaining half-dome turned to the west, northwest and north, on which can be seen the Carapava do Sul surface, with an average 450 m. Surrounding, in lower levels there are interplateau surfaces caused by circumdenudation processes, with two levels of Neogene pediplains (surfaces of Campanha Velha and of Campanha Moderna). The difference in height between the Carapava surface and the Campanha surfaces is only 200-250 m. The leveled summit of the shield has a height two to three times lesser than that of the basaltic plateau at Vacaria and Sao Joaquim. The general geomorphology of Rio Grande do Sul was shaped by a modest uplift, which raised the Carapava do Sul surface to approximately 500 m. However, it is important to recognize that the crystalline macro-dome is warped towards the interior (west and southwest) and fractured to the east, towards Lagoa dos Patos and Pelotas Basin. Due to complex features of regional tectonic evolution, especially the effects of the downthrow of the Torres-Pousadas axis (Leinz 1949), the Uruguay-Rio Grande do Sul shield did not accompany the uplift that took place in southeastern, eastern and central Brazil. Additionally, the age of the summit planation is clearly defined as post-Cretaceous, possibly Paleogene - Oligocene.

From a very broad viewpoint it may be concluded that the most important summit surfaces are located on residual, reworked domes of the old continent of Gondwana. To them may be added the planed areas of "dorsais" of shields (Espinafo/Diamantina and Bocaina/Mantiqueira/Brasilia) and the planed summits of the Uruguay-Rio Grande do Sul shield (470-500 m), the heights of the Serra dos Carajas (670-700 m) and the Borborema massif (700-1,150 m), all subject to diverse types of tectonism and broad reworking of ancestral plantations.

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