J. Haffer (Appendix 3) 95

Appendix 3:

0729

Geological history of the north-Andean region and southern Central America. *)

Extensive fieldwork has been carried out in the northern part of the Neotropical Region in recent decades and much new data has come to light which aids in our attempt at reconstructing the geological history of Colombia ~~and~~ and southern Central America. Nevertheless there are still unexplored areas of the more remote ~~jungle~~ forest covered mountains and lowlands and a number of problems remain to be resolved by future investigations. Before briefly summarizing the presently known facts a few general statements may be in order. Most of the deposits which record [illegible] ry were accumulated ~~in~~ under water cover[illegible]t and show us the distribution of oceans and inland seas. However, no direct evidence of the location of the land areas is available in most cases. The existence, location and shape of the rising land areas can only be ~~deduced~~ inferred but not directly be proven. It also happens too often that previously deposited sediments were eroded during later periods of uplift thus erasing the geological record. These inherent difficulties in reconstructing the past distribution of land and sea should be borne in mind for our discussion below. It is especially difficult to estimate the amount of uplift of a given land mass and its absolute elevation above sea level. Another problem refers to the correlation of geologic strata of far distant regions. Incorrect correlation may lead to differences in the interpretation of the sequence of geologic events which differences may be only apparent rather than real and vice versa.

Fig. 2/4 → The following summary of the geologic history of northwestern Colombia and southern Central America is based on the publications ~~of~~ by Troll (1930), Hubach (1930), Gansser (1950), Nygren (1950), Woodring (1954), Woodring & Thompson (1949), Terry (1956), Belding (1955), Bürgl (1961), Hammen (1961), Harrington (1962), Weyl (1961, 1965, 1966) and Lloyd (1963). It was checked against the results of my own fieldwork in Colombia,

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0729 46

particularly in the northwestern part of the country, during 1958 - 1966.

Our inquiry into the geologic past is confined to the Upper Cretaceous and Tertiary ~~periods~~ during which periods the development of the present South and Central American faunas has mainly taken place. The paleogeographic evolution of the area under discussion is illustrated on Fig. ~~X~~ 15.

Fig. 15 →

Upper Cretaceous: The broad geosyncline of the Colombian - Ecuadorian Andes developed during the Upper Jurassic and Lower Cretaceous as a rapidly sinking sedimentary basin between the large land mass of the ~~Guayana~~ Guianan Shield to the east and the more or less stable floor of the Pacific Ocean to the west; it probably also comprised southern Central America. An extremely thick sequence of submarine lava flows accumulated in the central and western part of this basin. Only thin intercalations of fossil bearing cherty sediments are found interbedded (with) these largely volcanic deposits. Nonvolcanic calcareous strata and shales were deposited in the basin of the Eastern Andes and in parts of present northern Central America south to Nicaragua and western Costa Rica. Panamá was probably included in the volcanic geosynclinal facies region, although no definite Upper Cretaceous strata are known so far from this country to substantiate this assumption. Cretaceous foraminifera are said to have been identified from NW-Panamá (Terry 1956). It appears that the land areas of parts of present Guatemala and ~~central~~ South America (~~Guayana~~ Guianan Shield) remained separated by a wide ocean covering most of southern Central America and Colombia. Some scattered volcanic islands in the Caribbean Sea and others outlining parts of the Central Cordillera of the Colombian

Andes may already have been above sea level.

Tertary: Northern Central America (south to northern Nicaragua) was uplifted during lowermost Tertiary time and remained connected with North America as a southern peninsula ever since. A few small islands outlining parts of the Western and Eastern Andes of Colombia may have been raised above sea level at the beginning of the Paleocene and continued to rise gently as did the somewhat older Central Cordillera. Otherwise the Upper Cretaceous paleogeographic conditions probably did not change considerably during Paleocene and Lower Eocene time, although the geological record is admittedly scarce in western Colombia and southern Central America. This is mainly due to intensive volcanic activity at the beginning of the Upper Eocene which obscured the previous geologic history in large areas, particularly in Costa Rica, Panamá and western Colombia.

At the beginning of the Upper Eocene long submarine volcanic ridges were built up by thick basaltic and andesitic lava flows which often reached above sea level as chains of volcanic islands. These islands outlined the present configuration of southern Central America and western Colombia for the first time: A long island arch followed the Colombian Pacific coast from Gorgona Island over the Baudó mountains northwestward into southeastern Panamá (Mt.Sapo, Mt.Pirri). The Serranía de San Blas - Darién (Mt.Tacarcuna) probably formed a long series of islands which may have been connected temporarily with the Western Andes of Colombia across the present lower Atrato valley (Cuchillo bridge). Large ocean areas of central Panamá were affected by this extensive

volcanic activity and blocks of older Cretaceous and Paleocene volcanics and sediments may have been uplifted and included in the Upper Eocene basement complex. In northwestern Costa Rica Lloyd (1963) assumed the (non-volcanic) Guanarivas island to have been above sea level. The Colombian Andes experienced a period of pronounced folding and uplift in the Upper Eocene. The Lower Tertiary age of the extensive volcanic activity of western Colombia is shown by "...basalts, augite diabases and augite gabbros intruding white algal limestones of Middle Eocene age, and complex Paleocene and Eocene siliceous shales..."(Gansser 1950:235). The basalts in turn are transgressively overlain by Upper Eocene sediments in southern Central America and western Colombia.

Shallow seas dotted with islands covered the area of the Upper Eocene volcanism in Panamá and western Colombia. The calcareous sediments deposited in these areas on the basaltic basement complex initiate a relatively quiet period of sedimentation comprising the Oligocene and Lower to Middle Miocene. During these periods many of the volcanic islands which had appeared in southern Central America and western Colombia during the Eocene foundered and were covered xgxix by the extensive Oligo-Miocene seas of the mid-American channel. Volcanic activity continued in only restricted areas of Panamá but was widespread in Costa Rica where the Oligo-Miocene formations of the Talamanca range are still highly igneous in nature.

The next period of major folding and faulting occured at the beginning of the Upper Miocene. All Andean Cordilleras and the chains of islands of southern Central America and western Colombia were strongly uplifted by this

pre- Upper Miocene tectonism as well as during the subsequent period of plutonic activity (granites and granodiorites of the Talamanca range, (of parts of) the Serranía del Darién, Cerro Cuchillo and of the Western Andes). The northern extensions of the Eastern Andes ,i.e.Serranía de Perijá and the Mérida Andes of western Venezuela, appeared as low islands above sea level for the first time as did the Talamanca range of southern Central America. The Serranía del Darién was again temporarily connected with the Western Andes ("Cuchillo bridge"). There are geologic reasons to assume that this connection lasted for only a short period after which the Cuchillo bridge was again submerged. The present orographic configuration originated during this pre- Upper Miocene tectonism when, however, the mountains were still much lower and the present lowlands were still covered with shallow seas. The Nicaraguan, Panamanian and Colombian portals (Fig.15) remained open. Although the stratigraphy of the Upper Miocene - Pliocene deposits of the area under discussion is still very imperfectly known, it seems probable that the last connection of the Atlantic and Pacific Ocean existed at the Colombian portal in the lower Atrato valley. This water gap connected the Caribbean Sea of the Gulf of Urabá ~~and~~ (including the eastwardly adjoining lowlands ~~to the Sinú valley~~ (of northern Colombia) with the Pacific Chocó basin. This basin communicated freely with the Tuira basin of eastern Panamá.

The final tectonism took place during the Upper Pliocene when the sedimentary basins surrounding and separating the present mountain ranges were folded and faulted,i.e. the Tuira basin, Atrato basin, Sinú basin,etc.). Large parts

of the present lowlands were raised above sea level during this time, and the final connection of North and South America ~~xxrxxx~~ along the the isthmus of southern Central America was established. As a result of this orogeny the mountains of southern Central America and of the northern Andes were uplifted to about their present height at the beginning or during the first half of the Pleistocene. Moraines of the first two glacial periods of the Pleistocene have not been found so far in Colombia. This led some authors to assume the northern Andes had not yet attained sufficient elevation at that time. Corroborating evidence for this interpretation may be forthcoming when a positive age determination of the post-orogenetic Tilatá formation of the Bogotá plateau, 2600 meters elevation, is made (Upper Pliocene or Pleistocene). This formation contains fossil seeds of Humiria cipaconensis, a plant of swampy lowland vegetation, which ~~would~~ indicates a still very low elevation of the Bogotá area at the time of deposition (Hubach 1958b:97). The highest peaks of the Talamanca range in Costa Rica ~~have been~~ were glaciated only during the last glacial period which also points to a recent uplift of this range. Large mountainous plateau areas, presently at 1000 to 2000 meters elevation or more, are characterized by x a very low relief and are deeply dissected at their margins by narrow river canyons. This low relief originated during a period of pronounced erosion after the Pliocene tectonism; the uplift to the present elevation occurred as late as the Upper Pliocene - Lower Pleistocene. The rapid and very late uplift of the mountains of the area under discussion has been emphasized by various authors.

(Punto aparte)

Quaternary:

The late uplift of the northern Andes and of the mountains of southern Central America contrasts with the somewhat earlier uplift of the central portion of the Andean system in Perú and Bolivia where mountain ranges of appreciable elevation probably existed already in the Tertiary. Ahlfeld & Braniša (1960) believe that part of the Bolivian Andes had attained 1500 to 2000 meters elevation at the end of the Miocene. The present height of the mountains in these areas was reached later during the Pliocene and Pleistocene periods of uplift.

Environmental conditions during the Pleistocene were influenced by sea level fluctuations and by alternating dry and humid climatic periods. Some details of the climatic history of the northern portion of the Neotropical Region, as far as known today, have been discussed above (page m).

Summary of geologic history:

1. The late Cretaceous and lowermost Tertiary are very imperfectly known in western Colombia and southern Central America. However, a discontinuous land connection of South and North America over the present Central American land bridge during this time interval seems unlikely and should be expected to have existed in other parts of the Caribbean area. For this reason it remains unknown over which route the early-Tertiary mammals have reached South America.

2. The assumption of a large land mass west of the Bolivar geosyncline (Fig.5) on the site of the present Galápagos-Malpelo submarine platform is geologically unnecesssary. The Baudó mountains which continue southward over the Gorgona

Island into Ecuadorian waters probably represented a narrow volcanic arch rather than the border of a land mass.

3. Numerous volcanic islands appeared within the wide mid-American channel at the beginning of the Upper Eocene and again at the beginning of the Upper Miocene providing twice a temporary discontinuous connection between northern Central America and the gently rising Andes of Colombia. The old and late "island hoppers" (Simpson 1950, 1965) reached South America over these island bridges. The periods of uplift mentioned above were both followed by periods of subsidence when large portions of the previously uplifted areas foundered and became again covered by the Oligo-Miocene and Lower Pliocene seas, respectively. The process of foundering was less pronounced in the Lower Pliocene than during the Oligo-Miocene.

4. The Nicaraguan, Panamanian and Colombian portals remained open until Upper Pliocene time with the Colombian portal probably having been closed latest. A Lower Pliocene mammal fauna of Honduras is still exclusively ~~North~~ of North American origin indicating that South American mammals were not yet able to advance along the isthmus of Panamá during that time interval (Olson & McGrew 1941).

5. The northern Andes and the Central American mountains represented low lying hilly country during the Upper Tertiary. The main uplift to their present height took place at the beginning or during the first half of the Pleistocene. Higher mountains may have existed in the central part of the Andean mountain system in Bolivia (and Perú) as early as ~~already during~~ the Miocene.

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Leyendas para las figuras (Appendix 3)

Fig. 13 Geomorphologic units of northwestern South America and southern Central America and location of late-Tertiary water gaps ("portals") across the isthmus of Panamá.

Fig. 14 Northwestern Colombia and adjoining parts of eastern Panamá. View over the region where Central America joins the South American continent.

Fig. 15 Paleogeographic development of northwestern Colombia and adjoining parts of eastern Panamá.
Blank - Areas above sea level. Hatched - Areas below sea level (Presently dry land of western and northern Colombia hatched on map 6 indicate areas which were flooded during the interglacial periods of the Pleistocene. These areas have largely been above sea level during the glacial periods when sea level was reduced.)