

ARTICULO

GRAVITATIONAL DEPOSITS IN VENEZUELA¹

(DEPOSITOS GRAVITACIONALES EN VENEZUELA)

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Introduction

Although gravitational phenomena, both depositional and structural, are important features of Venezuelan geology, full realization of this fact dates back less than 10 years. The concept was introduced to this region in 1953 by Dr. Hans G. Kugler, doyen of geologists in the adjacent island of Trinidad, who started his paper with these words: "It is suggested that many of the formerly assumed tectonic complexities in Trinidad are in reality the results of turbidity currents and submarine sliding and slumping." Kugler went on to describe specific examples of turbidites, wildflysch, and gigantic slump blocks in Trinidad and, logically enough, he attempted to find their counterparts in eastern Venezuela, suggesting that all the famous limestone crags ("morros") of northern Guárico are great exotic blocks slumped into younger shales. This interpretation has not entirely withstood scrutiny, and most of the "morros" are currently regarded either as reef limestones in situ or as tectonic wedges along major thrusts. Nevertheless, Kugler's paper indicated a neglected line of investigation which has since been followed fruitfully in Venezuela.

The first well-documented record of submarine sliding in Venezuelan sediments (State of Lara) was published in 1955 by O. Renz, Lakeman, and Meulen, who observed heterogeneous blocks of Cretaceous limestones and metamorphic-volcanic rocks embedded randomly in Tertiary shales, and also noted graded bedding in the enclosing sediments. Despite this example, other geologists were slow in applying the principles involved. In the Stratigraphical Lexicon of Venezuela (1956) it is hard to find reference to gravitational deposits, and several such beds are erroneously interpreted as basal conglomerates indicative of unconformities which do not really exist. Even in the later papers on Lara, a structural explanation (close-spaced thrusts) was given for the alternation of Cretaceous and Tertiary formations (von der Osten and Zozaya, 1957; Bushman, 1959). The compilations of Venezuelan geology by Young and others (1956), H.H. Renz (1957), and H.H. Renz and others (1958) make no direct reference to slumps and turbidites.

At the Third Venezuelan Geologic Congress, Coronel and O. Renz (1960) gave further details of the submarine-slide beds in Lara and depicted their paleogeographic setting. Their basic interpretation is now generally accepted, even though later authors have modified it in detail (Rod, 1960; Bushman, 1963; Coronel, 1963). Comparable beds have been recognized elsewhere in the country, especially in the State of Guárico. Creole geologists have shown that the producing sands of the Northeast

1. Presented as a talk at the monthly meeting of the A.V.G.M.P. held on August 25, 1966. Published by permission of Creole Petroleum Corporation.

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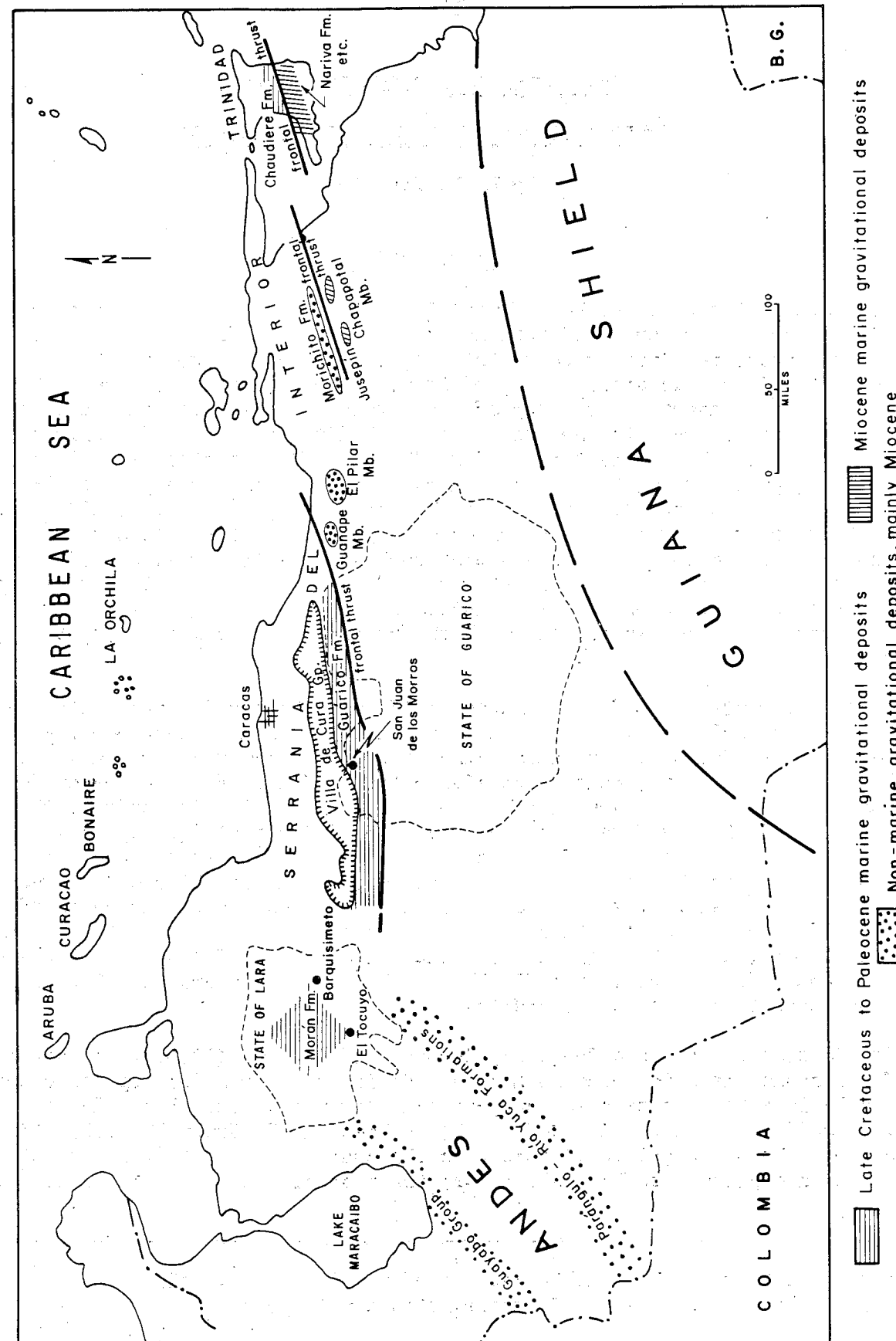


Figure 1. Sketch map of northern Venezuela and Trinidad showing location of gravitational deposits.

Jusepín field are turbidites (Lamb and Sulek, 1965) and have pointed out the great value of gravitational sediments in dating the orogenic phases of a mobile basin (Salvador and Stainforth, 1965).

We suspect that in Venezuela we have an example that shows the combined effects of both gravitational deposition and gravity tectonics. This is the Villa de Cura Group of metavolcanic rocks, voluminous enough to form a subsidiary mountain range yet seemingly allochthonous in its present position. The emplacement of these rocks is attributed basically to submarine slumping, but on such a grand scale that basinal configuration was altered as much as by a tectonic upheaval.

Gravitational Deposits

The term "gravitational deposits" is here applied to beds emplaced rapidly and more or less violently ("secondary deposits"), as distinct from sediments emplaced gradually by settling and precipitation of suspended matter ("primary deposits"). The more widespread gravitational deposits are flysch beds and turbidites distributed over the sea floor by turbidity currents and flows. More localized, and typical of steep, unstable basinal flanks, are wildflysch boulder beds and individual slumped blocks. Some nonmarine fanglomerates are genetically related to the foregoing marine deposits.

Flysch Beds

Flysch beds, in the sense based on the Alpine Flysch of Europe, are the result of innumerable, uniformly small turbidity currents. Lithologically they are typified by a monotonous alternation of thin beds of sandstone and shale, which may show upward gradation from coarser to finer fractions.

The Guárico Formation of north-central Venezuela (figs. 1 and 2) is a typical flysch deposit formed along the axis of the Eastern Venezuela Basin in Late Cretaceous to Early Eocene time. Its beds of shale-to-mudstone are consistently 6 to 10 inches thick, and the intervening sandstone-to-siltstone layers are regularly 2 to 6 inches thick. Sole markings of various types are ubiquitous on bedding planes, especially flute casts and groove casts. Another feature is the presence of trace-fossils of types well known in the Alpine Flysch.

In paleogeographic terms the Guárico Formation is confined to the northwestern sector of the basin and grades eastward into primary marine shales of the Vidoño Formation (fig. 2). Significantly, the flysch beds do not extend east of the assumed precipitous north flank of the Paleocene basin (defined by the present-day extent of the Villa de Cura Group). The presence of interdigitated boulder clays and slump blocks, north of the monotonous flysch beds, is further evidence that a steep, unstable north flank was the source area of the Guárico deposits.

Turbidites

As the term is used here, turbidites are genetically close to flysch beds but represent intermittent or exceptionally vigorous turbidity flows. Hence, beds classified as turbidites are individually prominent and not thin-bedded.

The Garrapata Formation of north-central Venezuela is an Upper Cretaceous unit, of localized extent near San Juan de los Morros (fig. 1) and not well documented in the literature. The Garrapata is largely composed of turbidite sandstones. Indi-

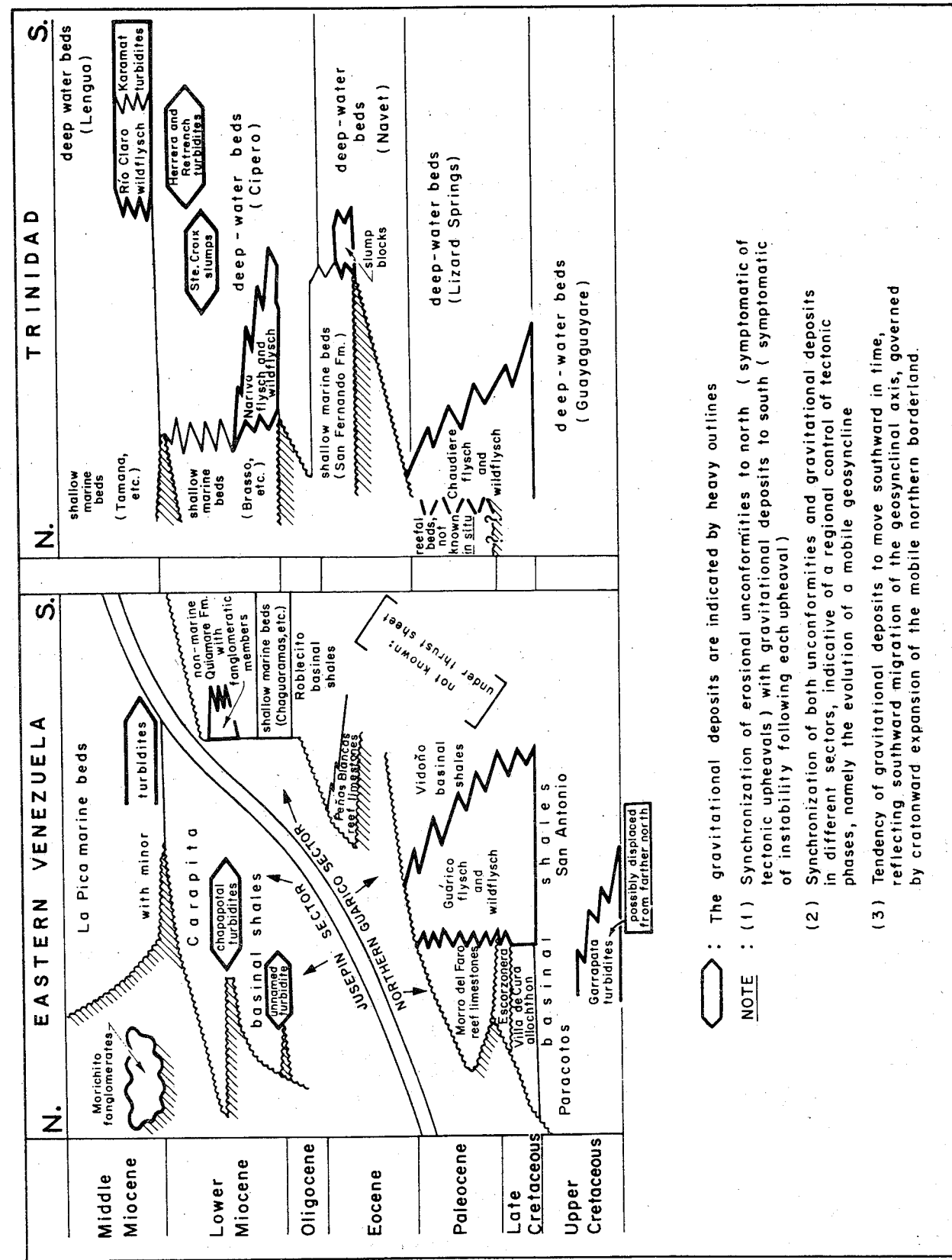


Figure 2. Correlation chart showing regional significance of gravitational deposits in eastern Venezuela and Trinidad.

vidual beds range up to 30 feet thick, but regardless of thickness they show excellent upward gradation of grain size. The range of coarse sandstone to siltstone is always represented, and in the thicker beds cobble- to pebble-conglomerates form the base of the sequence. A thin shale may be present at the top, but invariably it shows scour-and-fill structures which suggest that each successive turbidity flow ripped most or all of the unconsolidated clay off the top of its predecessor. Other diagnostic features of turbidites displayed by these Garrapata beds are the sharply defined base of each graded sequence and the presence of load casts, flute casts, convolute bedding, and twisted shale clasts.

The Chapapotal Member of the Carapita Formation is the formal name recently introduced for the "N-15" reservoir sandstones of the Northeast Jusepín oil field (Sulek and Stainforth, 1965). The Chapapotal Member is Lower Miocene, but it displays the same distinctive characteristics as the Cretaceous Garrapata Formation. The thickness of individual turbidites ranges from 6 inches to 15 feet. Shales are more conspicuous than in the Garrapata beds, and typically they contain foraminiferal faunas representative of very deep water (>6,000 feet). Rock fragments in the coarser fractions are identifiable with Cretaceous to Eocene formations that now crop out in the Serranía to the north, and reworked foraminifers from these same formations are plentiful. In gross form, the Chapapotal sandstones form large lenses about 1,000 feet thick and a few miles long, which merge laterally into the Carapita shales. Although part of a continuous deep-water sequence, the sandstones occur at the same stratigraphic level as a strong angular unconformity in the sequence a short distance to the north. By combining these various lines of evidence, it seems clear that the Chapapotal Member owes its existence to strong turbidity flows down the steep, abruptly raised north flank of the basin and to the concentration of the flows' detritus in certain sea-floor lows.

Wildflysch

Following Kugler's usage (1953), the anglicized word "wildflysch" is used in this region for very coarse-textured beds associated with flysch deposits and usually occurring between the flysch and a steeply uplifted source area. The most striking examples are contorted clays full of large irregular boulders of heterogeneous origin, which are well developed in the Chaudiere and Nariva Formations of Trinidad (figs. 1 and 2).

Boulder clays of this type occur in eastern Venezuela within the Guárico and Garrapata Formations already described. In the Guárico Formation they are encountered almost exclusively along the northern edge of the main flysch province. The name "Mamonal Member" was given to a localized unit of coarse conglomeratic material which apparently slumped down a rising fault scarp in Paleocene time (Menéndez, 1965). Farther west in Lara, similar deposits have been described, a good example being the Pavia Boulder Beds (Bushman, 1959). Modern authors treat these as a sub-facies of the Morán Formation. It bears note that the Morán, Guárico, and Chaudiere Formations were deposited contemporaneously at the foot of the rising mountains which have become the Serranía del Interior and its eastward extension in Trinidad. It is readily conceivable how, after abrupt tectonic uplift, heterogeneous masses of unconsolidated sediments and of country rock would slide and slump their way to the foot of the uptilted flank of the basin.

Slumped Blocks

The most spectacular variant of gravitational deposition takes the form of gigantic exotic blocks lying in random attitudes in younger basinal shales. As Kugler has pointed out, several topographic prominences in Trinidad - Morne Diablo, Marac Hill, Soldado Rock - had such an origin, the first two being limestone blocks large enough to support steady quarrying for tens of years.

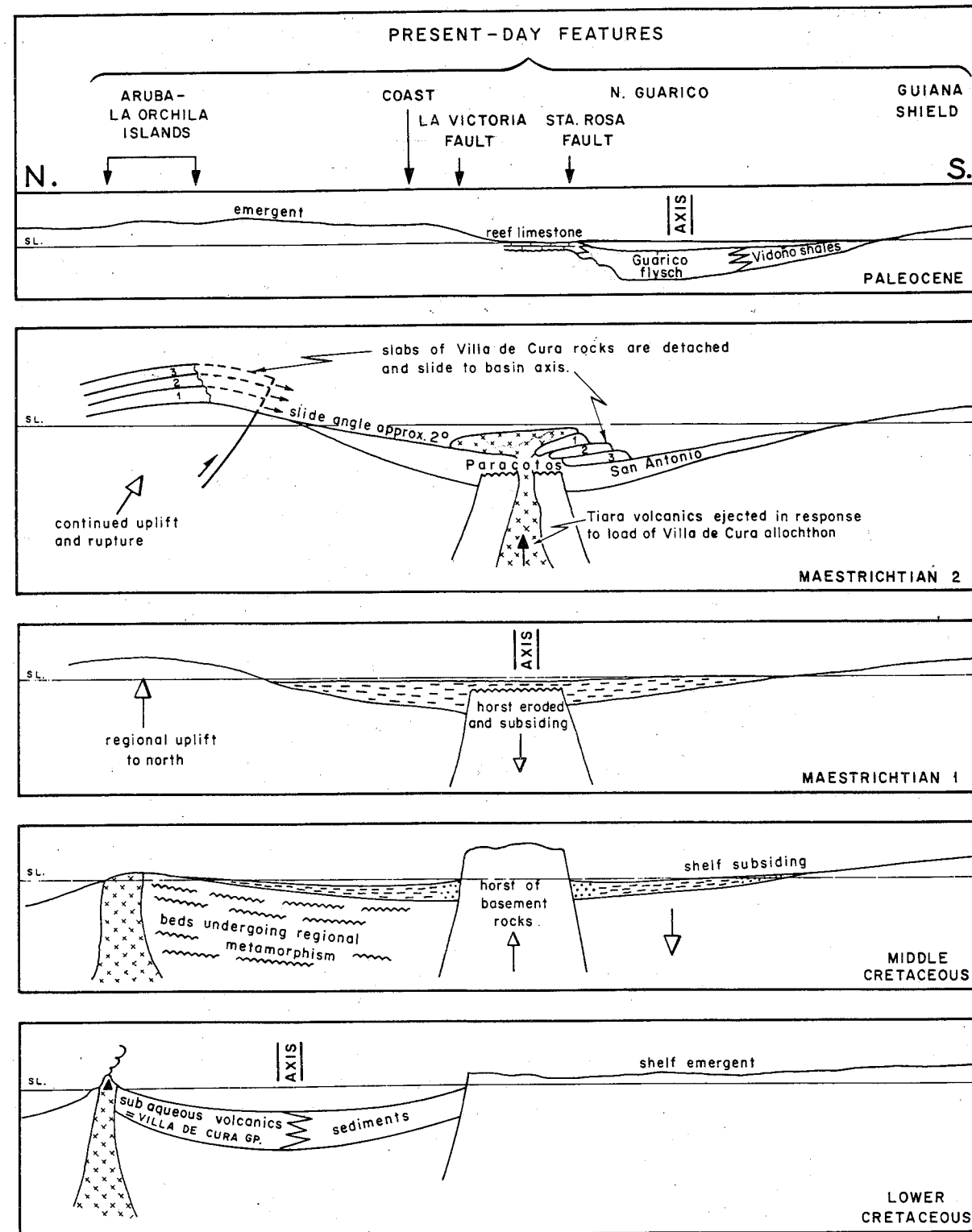
In eastern Venezuela, we cannot point with certainty to comparable examples, although Dr. H.H. Hess (unpublished) has suggested that the small mountain of Cerro Garrapata is a displaced mass. Near San Juan de los Morros, surface mapping shows a chaotic alternation of Paleocene Guárico flysch and wildflysch beds with large outcrop areas of various Cretaceous formations. Although an erratic fault pattern was formerly postulated, we now suspect strongly that the Cretaceous rocks here may be enormous slump blocks. Farther west in Lara, we have no doubt that truly enormous slump blocks of limestones as old as Lower Cretaceous are lying, rootless, in the Paleocene Morán shales. Jefferson (1960) published an excellent photograph of one such outcrop. Near El Tocuyo (fig. 1), the Turonian La Luna limestones are mapped over an area of 20 by 6 miles but apparently they represent a single broken-up block. Some geologists find slumping on this vast scale implausible, and they prefer to postulate an intensely imbricated structure. However, the intricate fault patterns necessary to accommodate the erratic Cretaceous outcrops fit into no rational pattern. On the other hand increasingly coarse gravitational deposits are demonstrable, from flysch beds through turbidites to wildflysch boulder beds and house-sized blocks, and the presence of gigantic slumped blocks is a logical extension, especially along the foot of a rising geosynclinal borderland.

(Any reader who already feels skeptical about the scale of slumping postulated in Lara should grit his teeth before reading on.)

The mountains of north-central Venezuela are composed of various metamorphic and igneous rocks of Mesozoic age, mainly Cretaceous. An important element is the Villa de Cura Group of metavolcanic rocks, estimated to be at least 13,000 feet thick and forming a subsidiary mountain range 180 miles long and up to 20 miles wide (fig. 1). Dipping under the Villa de Cura rocks along their northern edge are slightly metamorphosed phyllitic shales, the Paracotos Formation, dated as Maestrichtian by rich foraminiferal faunas. Resting unconformably on the Villa de Cura rocks along their southern edge are remnants of unaltered, partly reefal beds also of Maestrichtian age, the Escorzonera Formation.

Taken at face value, these facts would imply that during the brief Maestrichtian interval the following events took place: first, deposition of about 1,500 feet of Paracotos shales which subsequently underwent very low-grade metamorphism; second, the emplacement of many thousands of feet of Villa de Cura subaqueous extrusives and intercalated sediments which were subsequently metamorphosed to the greenschist facies; and third, after emergence and erosion, unconformable overlap by shallow marine Escorzonera beds which have remained unaltered.

To accomplish all this in such a short time seems patently impossible. The differences in metamorphic grade defy explanation, and furthermore the metamorphic grade has been said to increase upwards within the Villa de Cura Group. The presence of post-Villa de Cura pre-Escorzonera volcanic extrusives is another complication. To the east, south, and west, no beds remotely equivalent to the Villa de Cura Group are present in the well-known Upper Cretaceous sequences, nor is there evidence of extensive volcanic activity at that time.



(simplified after detailed sections by A.L. Peirson III, Creole Report, 1965)

No vertical scale
 0 25 50 MILES
 APPROX.

Figure 3. Schematic diagrams of the emplacement of the Villa de Cura allochthon.

The accepted explanation (first put forward in theses of the Princeton Caribbean Research Project; see Seiders, 1965, and Menéndez, 1965) is that the Villa de Cura Group is completely allochthonous in its present position (see fig. 3). Its basal contact is interpreted as a bedding-plane fault (for which there is good field evidence), and the allochthon is assumed to have slid into place in mid-Maestrichtian time. It originated to the north along the general trend of the Aruba-La Orchila Islands, where comparable volcanic rocks of Early Cretaceous (?) age are known. Possibly emplacement resulted from submarine sliding of successive great slabs, thus inverting the original vertical sequence and causing an apparent upward increase of metamorphic grade.

Although bizarre, this interpretation is the only one yet offered that satisfactorily explains the manifold peculiarities of the Villa de Cura Group. If it is correct, the sudden emplacement of this great pile of allochthonous rocks would obviously change the configuration of the basin and result in a precipitous, unstable north flank. This may well account for the abrupt upward change, in late Maestrichtian time, from basinal shales (San Antonio) to flysch and wildflysch facies (Guárico) in the province immediately to the south. It may be highly significant that the Guárico flysch facies changes laterally eastward into Vidoño basinal shales close to the eastern limit of the Villa de Cura Group.

Fanglomerates (Orogenic Conglomerates)

The classes of gravitational deposits described above belong to the marine province. Also conspicuous in Venezuela are nonmarine conglomerates shed by rising mountain ranges. In eastern Venezuela, the red beds of the Lower Miocene Quiamare Formation contain several members of this type, the most remarkable being the El Pilar conglomerates with a thickness of 15,000 to 20,000 feet. The Middle Miocene Morichito Formation appears to be the fanglomeratic fill of an intermontane valley. The beds of this type become progressively younger from west to east along the mountain front, a fact which may reflect simply the eastward retreat of the sea from the basin or may have a deeper tectonic significance.

In western Venezuela the flanks of the Andes are marked by immensely thick fanglomeratic aprons of Mio-Pliocene age. Their abrupt appearance above marine Eocene formations testifies to the geologic youth of the Andes.

Chronologic Importance of Gravitational Deposits

The present-day Eastern Venezuela Basin is the mature, stable phase of a formerly mobile geosyncline. Its evolution, through the successive phases of miogeosyncline, eugeosyncline, and exogeosyncline, has been recognized and is well summarized graphically by H.H. Renz and others (1958, figs. 2, 3, 4). The northern borderland, which first rose in mid-Cretaceous time, built southward and forced the basin axis to migrate in the same direction, towards the Guiana Shield craton.

Published accounts of the history of the geosyncline have been based mainly on the evidence of isopachs of the basinal sediments, levels of angular unconformity, and source areas of sediments as deduced from mineralogy and petrology. We now recognize that gravitational deposits possess great importance in supplementing and refining the interpretation already published. Such deposits occur intermittently in the vertical sense and are separated by thick intervals of "normal" marine beds. Successively younger gravitational deposits are aligned progressively farther to the south. These facts jointly imply spasmodic uplift and southward expansion of the borderland (by thrusting ?) with a pronounced phase of instability following

each tectonic spasm. Table 1 shows how nicely all the evidence fits together (see also fig. 2). In several cases a strong unconformity in the borderland exactly matches a phase of gravitational deposition in the basin to the south. Furthermore a synchronization is clearly evident of the tectonic spasms all the way across eastern Venezuela and Trinidad.

Time of Orogenic Spasm	Evidence in Venezuela	Evidence in Trinidad
Early Middle Miocene	Unconformity of La Pica on Carapita. Minor turbidites in La Pica. Morichito orogenic conglomerates.	Basal unconformity of Tamana to north. Río Claro wildflysch. Karamat turbidites.
Mid-Lower Miocene	Chapapotal turbidites interbedded with axial Carapita shales. Strong unconformity at same level in north flank. Guanape and El Pilar orogenic conglomerates.	Herrera and Retrench turbidites within axial Ciperó marls. Ste. Croix slump blocks.
Early Lower Miocene	Slight unconformity in basal Carapita. One suspected turbidite sand.	Nariva flysch and wildflysch. Basal unconformity of Brasso to north.
End of Middle Eocene	Erosional hiatus below Peñas Blancas Formation	Unconformity below San Fernando Formation. Associated slump blocks to south.
Late Cretaceous-Paleocene	Guárico flysch and wildflysch. Unconformity below Morro del Faró reef-limestones in north flank	Chaudiere flysch and wildflysch. Reef (?) limestones, although not known <u>in situ</u> , may well be analogues of Morro del Faro Member.
Mid-Upper Cretaceous	Garrapata turbidites and wildflysch.	No evidence recorded.

(After Salvador and Stainforth, 1965)

Table 1. Chronology of uplift phases in the northern borderland of the Orinoco geosyncline.

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