Tectonic Style of the Sierra de los Organos (Cuba)

by

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Summary. The tectonic style of the Sierra de los Organos in the Guaniguanico cordillera massif in Cuba is outlined. The tectonics of those mountains results first of all from repeated décollements of the transported rock complexes. The problem of the position of the tectonic mélangé within the tectonic units is presented. The mélangé occurs in a definite position in the profile in the top of the particular units. The conclusion is that processes connected with the action of the gravitation component played a considerable role during some stages of the tectonic development of the Sierra de los Organos.

Introduction. The tectonic units of the Sierra de los Organos are scaled nappes thrust from the south that originated in result of processes of décollement and displacement of rock masses during the final phase of the diastrophic cycle—after the Lower Eocene. I have given an interpretation of the origin of nappe structures of the Sierra de los Organos resulting first of all from décollements and accompanying shears in papers [10] and [11] and in my contribution to [12]. Earlier concepts explained the origin of the nappes as resulting from folding [1, 2], from folding and shear (Meyerhoff, in [8]), from shear [13], or stressed the role of disjunctive tectonics disregarding considerable horizontal nappe displacements [6].

In the opinion of Piotrowska [10, 11], the main décollement controlling the whole history of displacements and the present-day structure of the Sierra de los Organos embraced the initial nappe on the predisposed boundary between the clastic San Cayetano and the Jagua calcareous Formations. The décollement process initiated a quicker and self-dependent movement of the whole rock complex from the Jagua to the Pica Pica formations ([12]—the Pinos Formation sensu Herrera [3]) versus the clastic San Cayetano Formation situated in the bottom. The initially higher nappe consisting first of all of calcareous members (the calcareous nappe—Piotrowska [10, 11]) was disintegrated during the displacement into smaller nappe scales. They were transported earlier to the area of the present—day Guaniguanico cordillera (“cordillera” means here a mountain massif) earlier than the primarily lower situated clastic San Cayetano Formation. The nappe units of the Alturas de Pizarras derive...
from the clastic beds of the San Cayetano formation. The following phases of differentiation of the tectonic units of the Sierra de los Organos can be distinguished:

1) formation of the initial nappe, its décollement from the substratum,
2) differentiation into two partial nappes through découllement of the initial nappe; the two partial nappes are calcareous nappe and the Alturas de Pizarras nappe,
3) scaling of the calcareous nappe during the transport and its displacement to the area of the present-day Guaniquanico cordillera,
4) overthrust of the scaled units of the Alturas de Pizarras built of the oldest Cuban sedimentary formation—the San Cayetano onto the scaled units of the calcareous nappe.

Actually we face a structural inversion in the Sierra de los Organos (diverticulación). The scale-nappe units consisting of older members are superposed over the younger ones. Such an inversion was noted there by Rigassi-Studer [13] who named it “superposition inversion”.

**The types of deformations in the Sierra de los Organos.** The particular groups of units which are characterized by a scale-napped style of deformations show some peculiar features. This is closely connected with the gradual differentiation of the transported nappes mentioned in the introduction. Such a differentiation was to some extent controlled by the lithology.

**Deformations in the scale-nappe units of the Alturas de Pizarras.** The scaled units of the Alturas de Pizarras are characterized by unique deformation structures developed during the tectonic transport of the main orogenic phase and during younger movements. Complete folds of amplitude of about some tens up to some hundreds of meters occur but sporadically. In most cases only fragments of folds are preserved;

usually they are normal limbs of scaled synclines and anticlinals. Broad bends prevail which are connected with shears passing into small overthrust. Most common are 0.5-8 m large folds. Concentric folding with frequent découllements on the bed contacts and with internal shears of parts of the structures prevail (Fig. 1). Disharmonic folding of the particular parts of the deformed rock complexes is to be noted; this was controlled by changes in lithology of the San Cayetano Formation consisting of sandstone and shale intercalations (Fig. 2). The rock portions consisting of sandstones and shales of similar character but smaller thickness behave rather uniformly. Disharmonic deformations had taken place as a rule in zones where thicker sandstone portions (or with prevalence of sandstone) contact shaly portions (Fig. 3). In such a situation, découllements and shears occurred on the boundaries of rock complexes and later differentiated displacements leading to the formation of small drag folds.

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**Fig. 2.** Small fold with stronger deformed internal part. The San Cayetano Formation.

**Fig. 3.** Disharmonic deformations in shaly-sandstone complexes. The San Cayetano Formation.

**Fig. 4.** Small drag folds in the displacement zones. The San Cayetano Formation.
The zonal arrangement of deformations is another characteristic feature in the Alturas de Pizarras units. In some more deformed parts many various structures are to be observed, whereas considerable portions show but insignificant deformations. This phenomenon results in part from the characteristic lithology of the San Cayetano Formation. Bent portions of sandstone and shale wedged between the criss-crossing faults of various origin are frequent in the Alturas de Pizarras units. The direction of displacements deciphered from the fold and scale inclination directions and from bends near fault surfaces shows as a rule a turn toward the north or northwest. The boudinage structures vary greatly, first of all by the degree of their deformation. The boudinage structures are usually in sandstone layers less than 1 meter thick interbedded with shales. They are usually in sandstone layers less than 1 meter thick interbedded with shales. The elongation direction of the boudinage structures may be compared with the directions of fold axes being usually concordant with them thus pointing to the general directions. In the case of boudinage genetically connected with the tension connected with differential movements. This caused a concurrence over a small distance of the tension B boudinage and the one concordant with A.
The disjunctive structures vary greatly, from small cleavage to great fault zones. Jointing was easy to recognize as there are many elongated parallelepipeds of rhomboidal, square or rectangular walls in the scree of the San Cayetano Formation.

![Diagram](image)

Fig. 8. Axial cleavage in a small fold consisting of sandstone and shaly layers. The San Cayetano Formation

These rock fragments belonging to a group of pencil structures in the broad sense originate in result of crossings of sets of S planes (these can be planes of sedimentary or tectonic origin) with the cleavage and joint systems one of which is concordant with the B axis (e.g. axial cleavage, Fig. 8). The cleavage planes when crossing the S planes from an edge which is usually concordant with the B axis of structural coordinates and constitutes a lineation type called here the edge lineation. The frequent occurrence of that type of cleavage in thin-bedded rocks in combination with cleavage or joint systems oriented at greater angles to the B axis causes a weathering disintegration in the form of the above-described pencil structures. The size of these structures varies depending on the thickness of layers, cleavage density, and angular orientation of cleavage toward the system of structural coordinates.

**Deformations in nappe-scale calcareous units.** The lithologic diversity of the nappe-scale units of Alturas de Pizarras and of the calcareous units account for the diversity of structures in them. Most common are broad gentle folds or bends usually found in thin- to medium-bedded complexes. Stronger deformations and other types of folds connected with them are to be found in the Pica Pica formation and in the mélange that terminate the profile in the Sierra de los Organos tectonic units.

The disjunctive deformations are most characteristic in the calcareous units. They have developed during the main tectonic phase—during the transport phase wing the main orogenic phase. Décollements and shears in the top and bottom of the transported units are connected with the first phase.

This led to considerable displacements of some parts of the profile of the given competency. In many cases, e.g. in the change of thickness of limestone layers such elements have led to a variable "structural thickness" of the particular units and

The characteristics of the tectonic style in the Sierra de los Organos. The Sierra de los Organos is an example of alpine-type tectonics, but it also shows some characters differing it from other orogens of that system. This is caused by lithologic predispositions to form a definite type of structures but first of all a complexity of tectonic processes in the entire Caribbean region. The sequence of décollements that have taken place in the transported rock masses was presented shortly in the introduction. Those décollements and differential movements of shifting of the partial nappes at different velocities to a great extent decided about the tectonic style of the Sierra de los Organos. In result of the décollement and differential movements, the structural inversion had taken place which led to superposing the scale-nappe units on the calcareous units of the mogote belt. This concept explains the following facts:

1. The normal bed position in most tectonic units taking for granted that the initial nappe has been transported as a "board" and the main décollement had, generally speaking, taken place within one lithologic horizon that divided it into two "boards" of smaller thickness. This explains the lack of large units of reversed sequence (the metamorphosed unit is an exception).

2. The presence of the Jagua, Guasasa, Ancon, Pica Pica and melange Formations units, and of the San Cayetano Formation in the Alturas de Pizarras units. This situation is clearly explained by the décollement at the Jagua and San Cayetano Formations boundary.

3. The tectonic units are limited both in their top and bottom by décollement (within one horizon) and shears (cutting various horizons) discontinuities thus causing frequent changes of structural thickness of each of the scale-nappe units.

4. Subordinate décollements and shears within the particular tectonic units. They were mentioned by Knipper and Puig-Rifica [7]. Décollements took place almost invariably on the predisposed boundaries of lithologic complexes, i.e. at the boundaries of formations differing in their competency, as e.g. the Ancon and Pica Pica Formations, where the difference is great, or at the boundary of the Jagua and Guasasa Formations where a non-bedded and a bedded complexes are in contact.

5. Difference in deformations observed in the particular units. In general, the course of the structural directions of units is consistent. Locally, however, there exist differences in the mode of deformations and in the distribution of structures of minor order within larger units. This is obvious as the individualization of the scale-nappe units during the transport had taken place relatively early. Those units deformed in a manner characteristic for each unit, although they allowed the overall system of forces during the transport. The deformations were controlled by local transport conditions. Lithology played an important role in the deformation style.

A unit whose décollement took place within the Guasasa formation but over the massive limestone of the San Vicente member was subjected to more uniform deformations. Limestone deformation and the San Vicente member was subjected to more uniform deformations limestone of the San Vicente member was subjected to more uniform deformations limestone of the San Vicente member was subjected to more uniform deformations limestone of the San Vicente member was subjected to more uniform deformations limestone of the San Vicente member was subjected to more uniform deformations limestone of the San Vicente member was subjected to more uniform deformations
6. The insignificant role of folds in the structure of the scale-nappe units. This results from the character of tectonic transport during which décollement and a relatively free movement of rock masses played important role. Hence the transport conditions did not facilitate the development of large folds, such as illustrated by Hatten [1]. The units of the Sierra de los Organos moved by means of gliding one over another, which was eased by shaly portions. Even in such incompetent members as some portions of the San Cayetano profile, large folds are very rare. The development of some units seems to suggest that the overthrust had taken place under relatively weak compression in some regions or the strain was released first of all along surfaces of mechanical discontinuities.

7. Zonal distribution of deformations. As already mentioned, large folds are rare in the Sierra de los Organos. Yet there are many mesofolds that had developed in conditions of plastic deformations. This may be explained by the fact that the deformation conditions were insufficient to fold the whole units and the accumulated strains were released in stronger deformations of only few rock portions in some units, or, as mentioned before, they were subjected to relaxation along existing surfaces of mechanical heterogeneity or fault planes. Décollements and glides were important here as they caused the differentiation of the velocity of displacements of some rock masses. In result of that, a part of glided unit was subjected to stronger compression due to uneven displacement. This in turn resulted in the concentration of deformations in certain zones, not only in the vicinity of the main overthrust planes. This is often observed when a rock complex deformed by many small folds, shears, boudinage etc. passes continuously into slightly bent layers. The zonal distribution of deformations is common in all the structural units of the Sierra de los Organos but it is strongest in the scale-nappe units of the Alturas de Pizarras.

The above characteristic features of the Sierra de los Organos result from the character of deformations which may be briefly defined as differential movements resulting from décollements. They triggered the development of the scale-nappe units. The terms scale-nappe units (Piotrowska in [12]) stresses both their origin (derivation) from one initial nappe and their subsequent individualization and separation.

In addition to the characteristic resulting from the type of tectonic transport during the main orogenic phase, the structural position of a rock complex described [1], the origin of the Vieja Wild Flysch is important too. According to that author, the Vieja Wild Flysch was connected with the final phase of deposition in the Cuban geosyncline and was simultaneous with the uplift of the cordillerato synsedimentary gravitational glides. The concept according to which the origin of the Sierra de los Organos units in result of steep overthrusts [7] cannot be accepted.

1. The mélange zones occur in the top of tectonic units thus terminating the profile of each of them, and

2. the overthrust planes that separate the particular units resulting first of all from décollement were almost horizontal during their development, or weakly inclined in the case of a shear. Hence it is hardly believable that they could have penetrated deep enough.

Basing on field observations and first of all on the occurrence of the mélange zones in the top of the tectonic units in a definite position in the lithostratigraphic profile I regard Hatten's interpretation [1, 2] to be fully adequate. Syngenetic gravitational glides that took place at the end of the sedimentation cycle in the Cuban geosyncline were not minor local phenomena, but a regional process. Most probably during the Uppermost Lower Eocene of Lower Middle Eocene a huge rock mass glided down the deposition basin of the Sierra de los Organos in the form of a nappe. Those were mostly serpentinites derived from earlier uplifted (Upper Cretaceous) and possibly folded neighbouring areas (first of all from the eugeosynclinal Zaza zone).

The above characteristics of the tectonic style of the Sierra de los Organos shows that processes connected with the prevalence of the gravitational component played an important role during some periods of the development of the structures. It is difficult to agree, however, that this component was the direct cause of the tectonic processes in that area. The role of gravitational processes in the orogenesis in the Caribbean has been stressed by Hess [4, 5] and Menendez [9].

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REFERENCES


K. Piotrowska, Тектонический стиль Сьерра де лос Органос (Куба)

Содержание. Дается характеристике тектонического стиления Сьерра де лос Органос на Кубе. Горный массив Сьерра де лос Органос принадлежит к тектоническому фациональному зоне Гуаниганси [24]. Основываясь на замечениях во время полевых работ многократных скольжений перемешающихся элементов автор дает характеристику следующих черт тектонического стиля: нормальная последовательность слоев в отдельных элементах, изменения „структурной мощности” тектонических зон, зональность деформации и различия деформации отдельных элементов или их частей. Рассматривается проблематика тектонического механизма, который по данным полевых разведок находится в коре тектонических единиц в определенной литостратиграфической позиции. В связи с этим происхождение его можно объяснить гравитационными скольжениями или другими видами транспорта в бассейне седиментации до главных орогенезических движений.

K. Piotrowska, Estilo tectónico de la Sierra de los Organos

Resumen. Este artículo contiene la característica del estilo tectónico de la Sierra de los Organos en Cuba. La Sierra de los Organos está en una parte de la zona tectónica-facial Guaniguanico [24], basándose en los frecuentes cizallamientos y desplazamientos de los complejos de las rocas transportadas observados en el terreno, la autora interpreta siguientes rasgos de estilo tectónico: la secuencia normal de las capas en las unidades, el cambio del espesor estructural de las unidades la composición zonal de las deformaciones y las diferencias entre estas dentro de cada una de las unidades, o en algunas partes de ellas. Fue discutido el problema de melange tectónico, que —como resulta bien claro de la observación del terreno— está situado en la parte más alta de las unidades tectónicas en la concreta posición lithostatigráfica. Esta posición del melange puede explicarse por los desplazamientos gravitacionales o por otro tipo de transporte al basen sedimentario, antes de la fase principal de la orogenesa.