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Geometric reconstruction of thrusts in the Sierra de los Organos Massif (western Cuba)

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Piotrowska K., Piotrowski J. (1999) — Geometric reconstruction of thrusts in the Sierra de los Organos Massif (western Cuba). Geol. Quart., 43 (3): 277–284. Warszawa.

A developmental scheme of fold-thrusts against a palaegeographic background is presented, basing upon a spatial analysis of the Sierra de los Organos structures in the Gauniguanico Cordillera (western Cuba). Thrusting which took place within the Sierra de los Organos terrane (Ch. W. Hatten *et al.*, 1988; K. Piotrowska, 1993) resulted from deep-seated processes of a regional extent. The thrusting process was initiated during the early Middle Eocene (K. Piotrowska, 1978; A. Pszczółkowski, 1978). Initial detachment of the whole Jurassic–Tertiary sequence from its basement occurred in the basal part of the sandstone-shale San Cayetano Formation. Within this huge mass detached from its basement, another detachment took place. This occurred at top parts of the San Cayetano Formation which is overlain by a considerably thick carbonate sequence. An essential role in the process of nappes formation was played by a difference in competency (strength) of rock formations. Two nappes were formed: the Mogote and Alturas de Pizarras del Sur nappes. Due to compressive conditions existing all the time and related to a migration of the Sierra de los Organos terrane towards the north, both these nappes were subjected to a process of imbrication and duplexing. A stack of imbrications of the Mogote nappe was formed, over which duplex structures of the San Cayetano Formation composing the Alturas de Pizarras del Sur nappe were thrusted. As a result a structural inversion was taking place. The highest position is occupied by tectonic units of the metamorphosed nappe (J. Piotrowski, 1976). They come from the southern part of the terrane which underwent metamorphic processes (greenschist facies).

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INTRODUCTION

The Sierra de los Organos mountain massif is located within the Gauniguanico Cordillera (Fig. 1) in western Cuba (Pinar del Rio Province). This is a terrane (Ch. W. Hatten *et al.*, 1988; K. Piotrowska, 1993) which migrated from the south towards north together with an oceanic plate penetrating into the Carribean area from the Pacific (M. I. Ross, C. R. Scotese, 1988). Three groups of structural units can be distinguished within the Sierra de los Organos Massif (Figs. 1–6):

— Mogote zone (Mogote nappe) occupying the lowest structural position, and composed of largely carbonate deposits (Oxfordian–Eocene);

— imbricated Alturas de Pizarras del Sur nappe composed of the San Cayetano sandstones and shales (Lower?–Middle Jurassic) thrusted over the Mogote nappe;

— metamorphosed nappe, occupying the highest structural position (K. Piotrowska, 1976, 1978, 1993).

STRUCTURAL MODELS

This work is based on classical experimental modelling and theoretical works considering an origin and development of fold-thrust structures. In modern models an essential problem is three-dimentional — spatial orientation of displaced and deformed rock complexes (C. D. A. Dahlstrom, 1970; J. F. Dewey, J. M. Bird, 1971; S. E. Boyer, D. Elliott, 1982; R. W. H. Butler, 1985; K. R. McClay, M. W. Insley, 1986; C. K. Morley, 1987; Y. Gaudemer, P. Tapponnier, 1987; W. R. Jamison, 1987; P. B. Jones, 1987, 1995; K. M. Cruikhank *et al.*, 1991; J. M. Dixon, R. Tirrul, 1991; M. A. Evans, W. M.

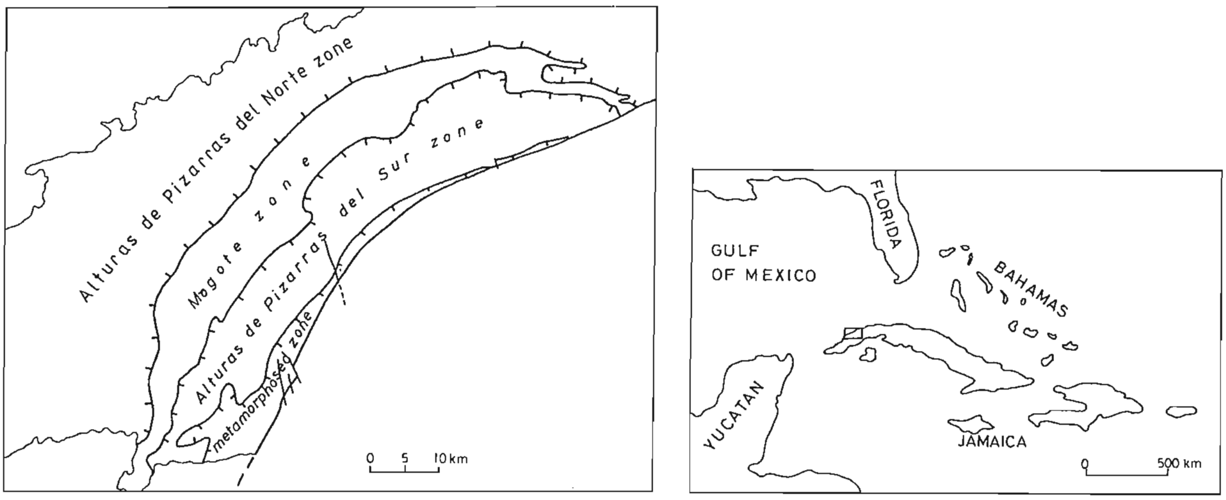

Fig. 1. Locality sketch with major tectonic units: stack of imbrications of the Mogote nappe (Mogote zone), duplex structures of the Alturas de Pizarras del Sur nappe, metamorphosed nappe (metamorphosed zone), Alturas de Pizarras del Norte nappe

Dunne, 1991; W. von Gosen, 1992; K. R. McClay, 1992; P. W. G. Tanner, 1992; K. Kimura, R. Hori, 1993). Applications of the above-mentioned models for individual regions and thrust structures in various parts of the world have been analysed (S. E. Boyer, 1976; S. E. Boyer, D. Elliott, 1982; R. W. H. Butler, 1985; C. K. Morley, 1987; A. Yin, T. K. Kelty, 1991; P. H. G. M. Dirks *et al.*, 1992; A. E. Gates, 1992; P. W. G. Tanner, 1992; P. B. Jones, 1995). For the reinterpretation of thrusting processes (detachment, fold-thrust interaction) presented in this paper, mechanism of formation of duplexes (C. D. A. Dahlstrom, 1970; S. E. Boyer, D. Elliott, 1982; P. B. Jones 1987, 1995; M. P. Gallagher *et al.*, 1988; N. B. Woodward, E. Jr. Rutherford, 1989) and imbricate fans in thrust systems formed in terranes accreted over subduction zones (C. K. Morley, 1987; W. von Gosen, 1992; K. Kimura, R. Hori, 1993) were taken into account.

GENERAL OUTLINE OF PALAEOTECTONIC SITUATION

The Sierra de los Organos nappes belong to a terrane named the Sierra de los Organos terrane (K. Piotrowska, 1993) or Guaniguanico terrane (M. A. Itturalde-Vinent, 1994, 1997) traceable to the areas located in southern Yucatan. M. A. Itturalde-Vinent (1997) uses a term "terrane of the Yucatan block" which includes the following terranes: Guaniguanico (= Sierra de los Organos terrane, K. Piotrowska, 1993), Escambray (K. Piotrowska, 1993) and Isla de la Juventud = Isla de Pinos (K. Piotrowska, 1993). According to K. Piotrowska (1993) the Sierra de los Organos terrane (= Guaniguanico terrane, after M. A. Itturalde-Vinent, 1997) is thrusted over the Zaza facies-tectonic zone (which is also a terrane) representing an ophiolitic and Cretaceous volcanosedimentary sequence of the Carribean oceanic plate.

The youngest deposits occuring in a lithologic column of the Sierra de los Organos nappes represent the Eocene. The oldest postorogenic deposits are of Middle Eocene age, thus the age of the major event — fold-thrust displacements, would

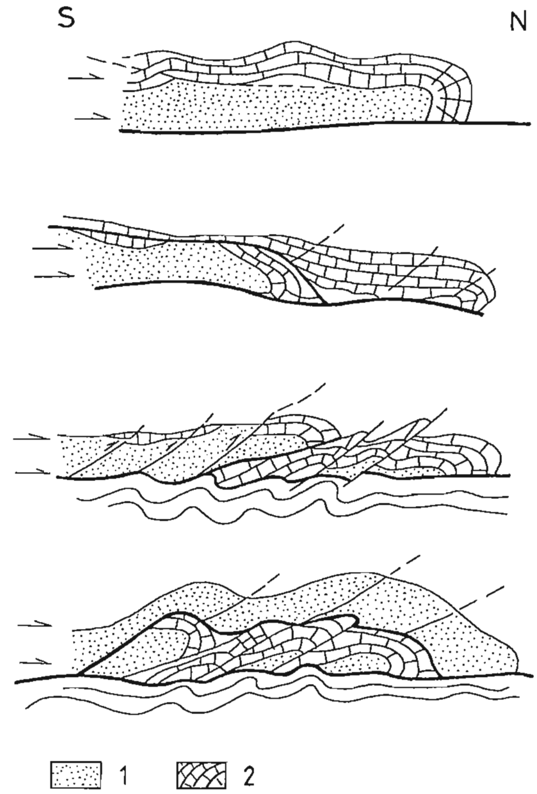

Fig. 2. Interpretation of the structural inversion in the Sierra de los Organos Massif (K. Piotrowska, 1978)

1 — San Cayetano Formation, 2 — Jagua, Guasasa, Pons, Ancón and Manacas Formations

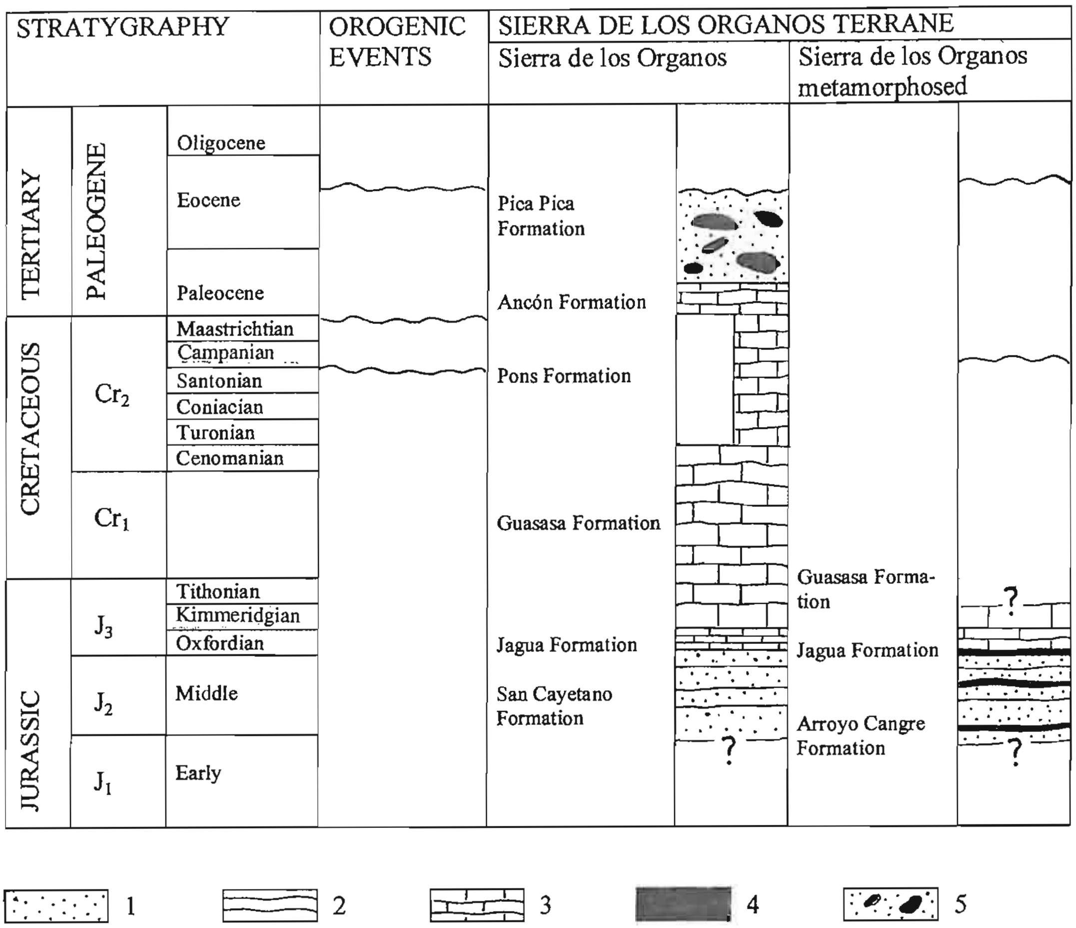

Fig. 3. Simplified stratigraphic section of the Sierra de los Organos

San Cayetano Formation (unmetamorphosed and metamorphosed sequence): 1 — sandstones, 2 — shales; 3 — limestone formations; 4 — effusive rocks (within metamorphosed nappe only); 5 — melange sequence with olistostromes (ophiolites among others)

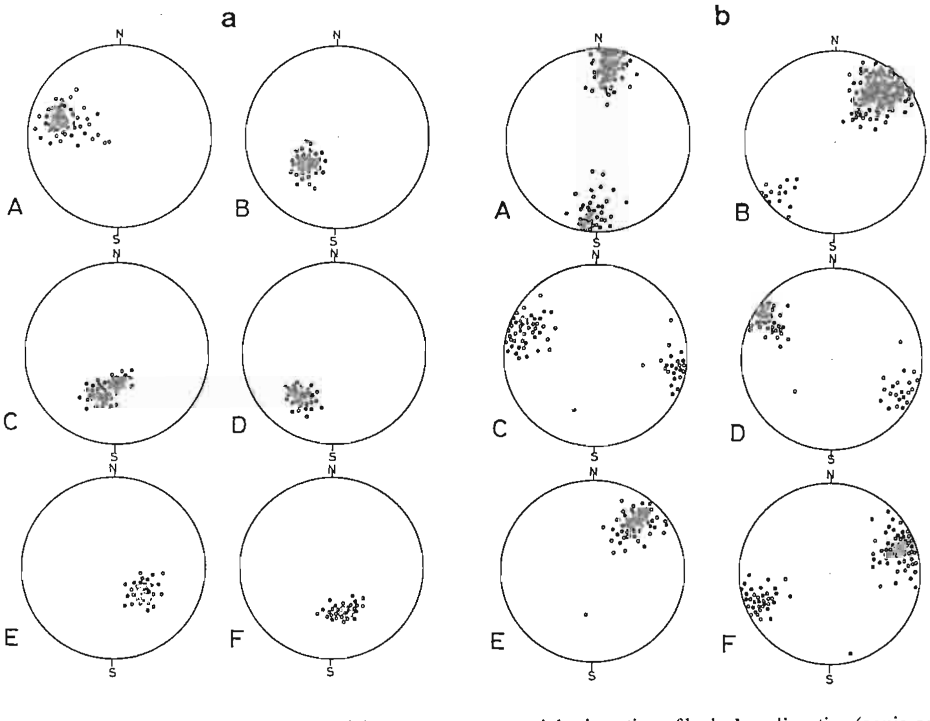

Fig. 4. Diagrams of duplex structures of the Alturas de Pizarras del Sur nappe: **a** — spatial orientation of beds, **b** — lineation (equiareal grid, upper hemisphere projection)

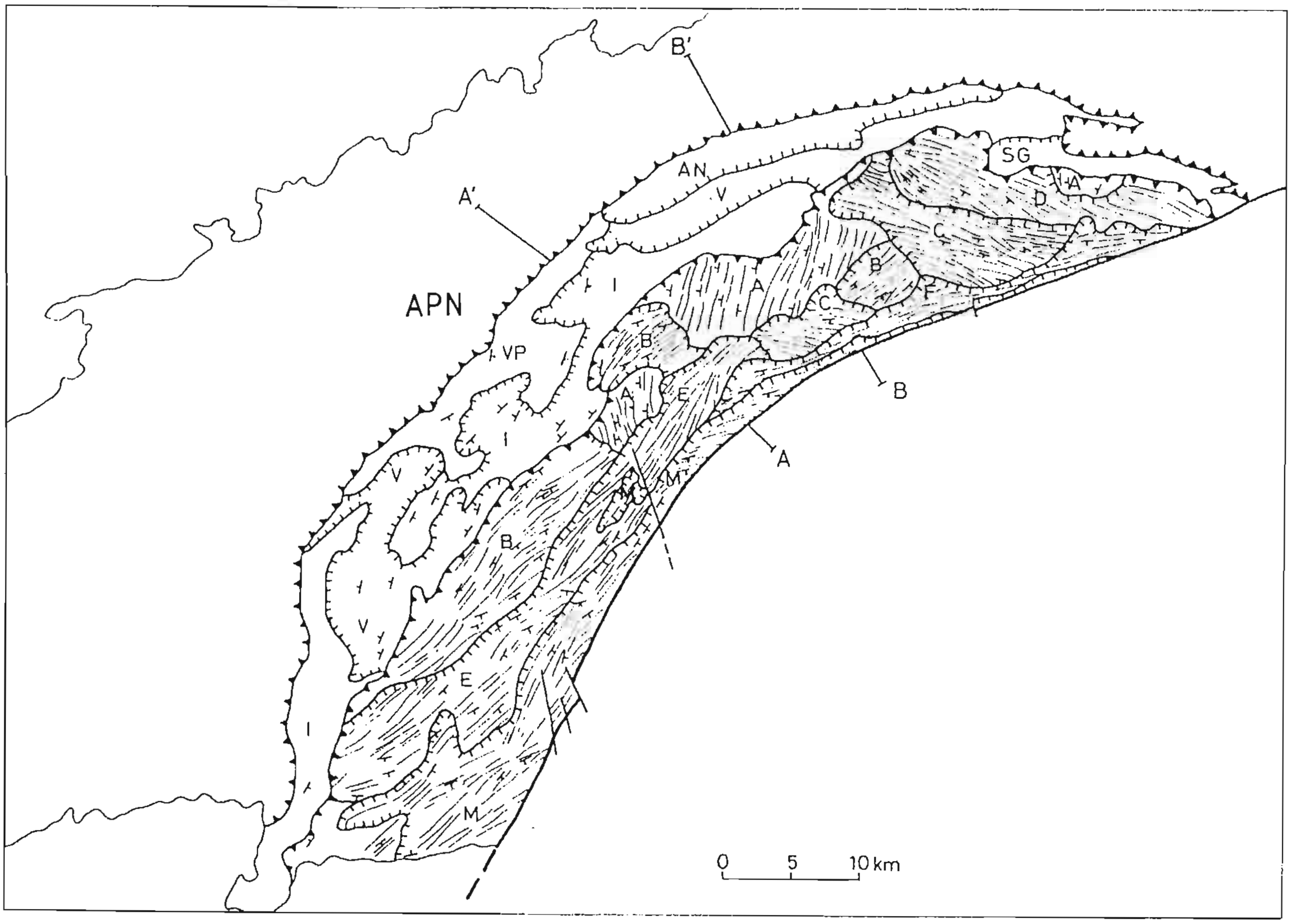

Fig. 5. Map of tectonic units with structural trends marked: units within stack of imbrications of the Mogote nappe

SG — Sierra de la Güirra; VP — Valle de Pons; I — Infierno; V — Viñales; AN — Ancón; A–F — duplex structures within the Alturas de Pizarras del Sur nappe (APS); M — imbricated metamorphosed nappe; APN — Alturas de Pizarras del Norte nappe; A–A', B–B' — cross-section lines (Fig. 8)

fall within an earlier part of the Middle Eocene (A. Pszczółkowski, 1978, 1987).

The Sierra de los Organos terrane was transported together with the Farallon oceanic plate and subducted under the North American plate (K. Burke, 1988; M. I. Ross, C. R. Scotese, 1988). During the Early and Middle Eocene, the Sierra de los Organos terrane, transported as a rigid block, reached the tectonised Zaza zone composed of overthrust sheets of the Proto-Carribean ophiolitic association and Cretaceous volcanosedimentary sequence of the Proto-Greater Antilles arc. This zone was considered to represent a terrane (Ch. W. Hatten *et al.*, 1988) or superterrane (J. E. Case *et al.*, 1984) accreted at the fringe of the North American plate. The above-mentioned authors suggest that the Zaza terrane was thrusted over the Sierra de los Organos. The present authors assume the opposite situation — the Sierra de los Organos terrane was thrusted over the Zaza zone.

The accretion of the Zaza terrane commenced in the Late Cretaceous during a collision of the Proto-Greater Antilles arc (of the Farallon plate) with the ophiolitic association of the Proto-Carribean oceanic plate (K. Piotrowska, 1991, 1993). From uplifted parts of this area, material was supplied to chaotic sequences occurring in the uppermost part of the Sierra de los Organos stratigraphic section, where sedimentation persisted until the Early Eocene, inclusive. Parts of the Zaza terrane may have played a role of a first ramp during initial thrustings.

DEVELOPMENT OF FOLD-THRUST INTERACTION

INITIAL DETACHMENT

An initial detachment occurred within the lower sedimentary sequence (Figs. 2, 6, 7), represented by the sandstone-shaly San Cayetano Formation (Lower?–Middle Jurassic). Basement fragments have nowhere been found yet. Decollement formation in the lower parts of the sedimentary sequence, probably close to a boundary of the San Cayetano Formation with unknown basement (K. Piotrowska, 1976, 1978, 1993) was favoured by mechanical properties of alternating sandstones and shales.

Modelling researches on initial detachments (M. A. Cooper, P. M. Trayner, 1986; W. R. Jamison, 1987; J. M. Dixon, R. Tirrul, 1991) have demonstrated how important role in thrust development is played by preference surfaces at boundaries of media showing different mechanical properties. The obtained results confirm different behaviour of competent and incompetent units. In case of higher position of a competent unit W. R. Jamison (1987) and M. A. Cooper, P. M. Trayner (1986) published a geometrical explanation and conditions under which the first ramp is formed. Modelling researches also confirm that ductile beds of a small thickness relax stresses between cover and basement (J. M. Dixon, R. Tirrul, 1991). On the other hand, difference in competency influences a controlled deformation style in a thrust sheet (C. K. Morley, 1987; W. von Gosen, 1992). After initial detachment in a transported rock formation had been formed, it was differentiated into smaller component nappes.

FORMATION OF COMPONENT NAPPES DUE TO THE SECOND DETACHMENT

After the complete sequence had been detached from its basement (Figs. 6, 7), it was transported farther north. A distinct differentiation in competency of beds at the boundary between the San Cayetano Formation and overlying Jagua and Guasasa Formations occurs in the Sierra de los Organos sequence. The San Cayetano Formation represents an incompetent assemblage, whereas the Jagua and Guasasa Formations, composed of platy and massive limestones, are a competent assemblage. At the boundary of these assemblages/units there were ideal conditions for a decollement and further differentiation of the transported nappe. Difference in competency favoured the existence of conditions for different reaction of the lower — incompetent, and the upper — competent rock assemblage (embracing the whole sequence above the initial detachment). The second detachment took place and the primary nappe was differentiated into two nappes: the higher — Mogote one, and lower — Alturas de Pizarras del Sur nappe (Figs. 8, 9).

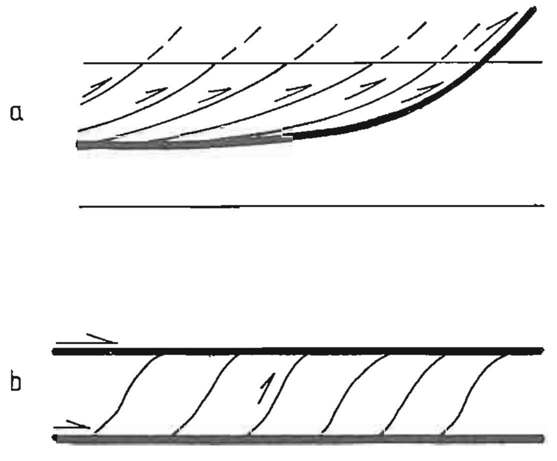

Fig. 7. Displacements: **a** — of fan imbrications, **b** — of duplex structures

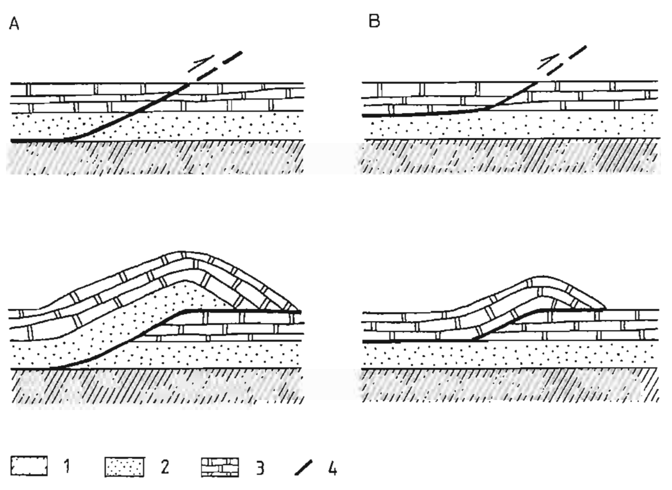

Fig. 6. Models of initial detachment

1 — basement, 2 — sandstone-shale San Cayetano Formation, 3 — limestone formations, 4 — thrusts

IMBRICATE FAN OF THE MOGOTE NAPPE AND OVERTHRUST STACK OF IMBRICATIONS

The Mogote nappe, composed of the upper part of the lithostratigraphic sequence and occupying a higher structural position, was divided into smaller thrust sheets due to a permanent stress. They are climbing on the ramp forming a thrust sheet volumen. Concentration of a few sheets of imbrication, overthrusted or lying each over the other, is termed stack of imbrications. This stack reaches its maximum (largest thickness) within the Mogote belt occurring in the central part of the Sierra de los Organos (Figs. 1, 5, 8, 9). The formation of stack of imbrications resulted in a considerable shortening of transported complexes. The stack (imbricated Mogote nappe) is composed (according to the recent data) of the following units (from lowermost to uppermost ones): Sierra de la Güirra (SG), Valle de Pons (VP), Infierno (I), Viñales (V), and Ancón (AN).

These units are independent imbricated sheets, thrusted each over the other and stacked to form an antiformal stack of imbrications of the Mogote nappe. This stack reaches its culmination within the Mogote zone exposing at the surface in the central part of the Sierra de los Organos. A total number of sheets forming the stack of imbrications is unknown. At the surface there occur only the above-described sheets (5). It can be supposed, however, comparing them with other stacks of imbricate (S. E. Boyer, D. Elliott, 1982; R. W. H. Butler, 1985; C. K. Morley, 1987; P. B. Jones, 1987, 1995; P. H. G. M. Dirks *et al.*, 1992; W. von Gosen, 1992; K. Kimura, R. Hori, 1993) that a total thickness of the stack of imbrications may even

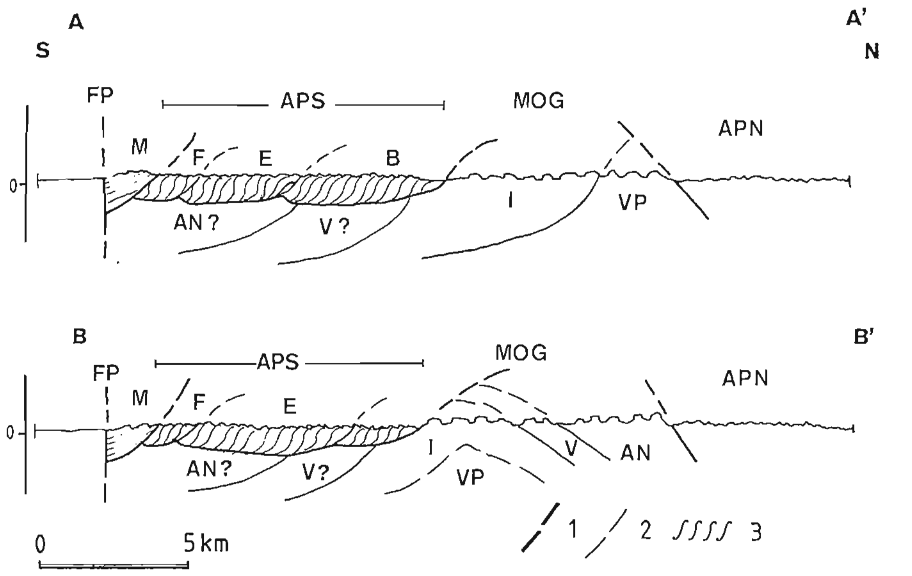

Fig. 8. Geological cross-sections: A–A', B–B'

1 — thrust and overthrust; 2 — boundary of structural units; 3 — stratification; FP — Pinar Fault; MOG — Mogote zone; for other explanations see Fig. 5

reach a few kilometres. Basing upon data from a borehole drilled in the vicinity of Mantua, it is supposed that the Sierra de los Organos sequence occurs down to a depth of 5000 m.

The units distinguished within the Mogote zone and forming an antiformal stack of imbrications have many structural features in common. These are:

— normal sequence in each sheet of imbrications;

— small width in relation to extent of individual unit;

— spatial arrangement of sheets showing an antiformal stack of imbrications; dips towards N are recorded in the northern part of the Mogote zone, while in its southern part dips towards S or horizontally lying beds are predominant;

— shapes of individual sheets of imbrication are clinoforms thinning towards the lower, initial detachment surface (tectonic reduction in sheet thickness towards thrust floor, common for the whole fan of imbrications, takes place);

— in the formation process of fan of imbrications, local shears and detachments took place within larger sheets; minor fans of imbrications were forming.

Concentration of sheets of the lower fan of imbrications may occur deeper under a fan of imbrications visible at the surface.

DUPLEXES WITHIN THE ALTURAS DE PIZARRAS DEL SUR NAPPE

South of the stack of imbrications, i.e. from the transport direction side, there was the lower part of the Sierra de los Organos sequence, composed of incompetent sandstone-shale beds of the San Cayetano Formation belonging to the Alturas de Pizarras del Sur nappe. From this sequence, its upper part composed of competent beds representing a calcareous part of the sequence was detached. It was displaced more quickly and formed a stack of imbrications of the Mogote zone. Several units can be distinguished within outcrops of the Alturas de Pizarras del Sur nappe. Each unit is characterized by an uniform inner spatial orientation (within individual unit), expressed by strike and dip values and by trends of linear and planar structures, as well as particular relation to neighbouring units. Differentiation of structural trends in individual units is the most characteristic feature (Figs. 4, 5). Units A–F have been distinguished within the Alturas de Pizarras del Sur basing on these features, as well as on observations made over contact zones of the units (Figs. 5, 8, 9). Unit A occupies the lowermost structural position, unit F — the highest one. The authors are of the opinion that these units were formed owing to mechanical conditions characteristic of a process of duplex structures formation (C. D. A. Dahlstrom, 1970; S. E. Boyer, D. Elliott, 1982; P. B. Jones, 1987, 1995). The analysis of the map (Fig. 5) and spatial orientation diagram (Fig. 4a) shows that strikes change gradually from 5 up to 115°, and dip values range from 0 up to 60°N and from 0 up to 35°S. Normals to the stratification surface form a festoon in IV quarter. It confirms a gradual change in beds orientation. Concentration of normals in II quarter, showing dips towards S, may result from measurements originating from another sheet, with the same continuous change in strike. This case is shown in the cross-section A–A' (Fig. 8).

The process of duplex formation began probably after the second detachment when imbrications in the upper part of the sequence were forming. The sequence of incompetent beds of the San Cayetano Formation lying lower within the section was bounded at the bottom by a floor thrust of the initial detachment, while at the top — by a discontinuity being a detachment surface of the competent sequence — forming the Mogote nappe, out of which a fan of imbrications was formed. Simultaneously, the above-mentioned discontinuity surface was also a floor thrust of the fan imbrications. Thus, all the necessary conditions for duplex structures formation occurred there:

— presence of thrust floor and thrust roof;

— incompetent character of deformed complex;

— position in the lower part of sequence, below fan of imbrications, thus under strong overburden pressure.

Field observations show that individual duplexes are internally strongly deformed and separated from each other with discontinuity surfaces of a shear-detachment character (Fig. 8). There are also zones of minor duplexes thrusted each over the other. Thicknesses of individual duplexes are small. In the vicinity of San Felipe, south of Sumidero town, and in other places, fragments of a sequence belonging to the Mogote nappe are exposed in tectonic windows.

FAN OF IMBRICATIONS OF THE METAMORPHOSED NAPPE

The metamorphosed nappe occupies the uppermost structural position in the Sierra de los Organos and immediately overlies the imbricated Alturas de Pizarras del Sur nappe (Figs. 8, 9). Sequences composing the metamorphosed nappe belonged to the rock complex which probably originated from other parts of the Sierra de los Organos terrane than the Mogote and Alturas de Pizarras del Sur nappes did, because they are metamorphosed (greenschist facies) and contain textural lineations older than major lineations of the Mogote and Alturas de Pizarras del Sur nappes. Fan of imbrications of the metamorphosed nappe displays constant structural trends contrary to the duplexed Alturas de Pizarras del Sur nappe. It may be supposed that the metamorphosed nappe originally covered the whole area occupied by the Alturas de Pizarras del Sur nappe duplexes.

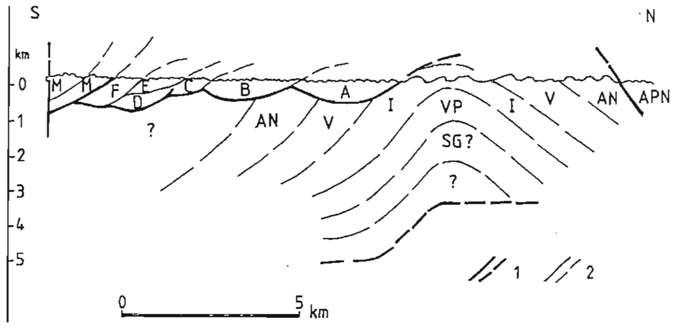

Fig. 9. Composite cross-section across the Sierra de los Organos structure with deep geology interpreted

1 — main overthrusts; 2 — boundary of structural units; for other explanations see Fig. 5

CONCLUSIONS

The Sierra de los Organos structures can be interpreted basing upon the scheme of fold-thrust interaction. Three structural groups may be distinguished (beginning with that occupying the lowermost position):

— stack of imbrications originating from a fan of imbrications of the Mogote nappe;

— duplex structures of the Alturas de Pizarras del Sur nappe;

— fan of imbrications of the metamorphosed nappe.

REFERENCES

BOYER S. E. (1976) — Geometric evidence for synchronous thrusting in the southern Alberta and northwest Montana thrust belts. In: Thrust tectonics (ed. K. R. McClay): 377–390. Chapman and Hall. London.

BOYER S. E., ELLIOTT D. (1982) — Thrust systems. Am. Ass. Petrol. Geol. Bull., **66** (9): 1196–1230.

BUTLER R. W. H. (1985) — The restoration of thrust system and displacement continuity around the Mont Blanc massif, NW external Alpine thrust belt. J. Struct. Geol., **7** (5): 569–582.

BURKE K. (1988) — Tectonic evolution of the Caribbean. Ann. Rev. Earth Planet. Sc., **16**: 201–230.

CASE J. E., HOLCOMBE T. L., MARTIN R. G. (1984) — The Caribbean — South American plate boundary and regional tectonics (ed. W. E. Bonini *et al.*). Geol. Soc. Am. Mem., **162**.

COOPER M. A., TRAYNER P. M. (1986) — Thrust — surface geometry; implications for thrust-belt evolution and section-balancing techniques. J. Struct. Geol., **8**: 305–312.

CRUIKSHANK K. M., ZHAO G., JOHNSON A. M. (1991) — Duplex structures connecting fault segments in entrada sandstone. J. Struct. Geol., **13** (10): 1185–1196.

DAHLSTROM C. D. A. (1970) — Structural geology in the eastern margin of the Canadian Rocky Mountain. Bull. Can. Petrol. Geol., **18**: 332–406.

DEWEY J. F., BIRD J. M. (1971) — Origin and emplacement of the ophiolite suite: Appalachian ophiolites in Newfoundland. J. Geophys. Res., **76**: 3179–3206.

DIRKS P. H. G. M., HAND M., COLLINS W. J., OFFLER R. (1992) — Structural-metamorphic evolution of the Tia Complex, NSW. J. Struct. Geol., **14** (6).

DIXON J. M., TIRRUL R. (1991) — Centrifuge modelling of fold-thrust structures in a tripartite stratigraphic succession. J. Struct. Geol., **13** (1): 3–20.

EVANS M. A., DUNNE W. M. (1991) — Strain factorization and partitioning in the North Mountain thrust sheet, central Appalachians, USA. J. Struct. Geol., **13** (1): 21–35.

GATES A. E. (1992) — Domain failure of serpentinite in shear zones, State-Line mafic complex, Pennsylvania, USA. J. Struct. Geol., **14** (1): 19–28.

GALLAGHER M. P., BROWN E. H., WALTER N. W. (1988) — A new structural and tectonic interpretation of the western part of the Shuksan blueschist terrane, northwestern Washington. Geol. Soc. Am. Bull., **100** (9): 1415–1422.

GAUDEMER Y., TAPPONNIER P. (1987) — Ductil and brittle deformations in the northen Snake Range, Nevada. J. Struct. Geol., 9 (2): 159–180.

GOSEN VON W. (1992) — Structural evolution of the Argentina precordillera: the Rio San Juan Section. J. Struct. Geol., 14 (6): 1643–1667.

HATTEN CH. W., SOMIN M. L., MILLAN G., RENNE P., KISTLER R. V, MATTINSON J. M. (1988) — Tectonostratigraphic units of Central Cuba. In: Memorias de la Oncena Conf. Geol. Del Caribe. Barbados, 35: 1–13.

ITTURALDE-VINENT M. A. (1994) — Journal of Petroleum Geology, 17 (1): 39–70.

ITTURALDE-VINENT M. A. (1997) — Introduction a la geologia de Cuba. In: Estudios sobre geologia de Cuba. Inst. Geol. Pal. Hawana.

JAMISON W. R. (1987) — Geometric analysis of fold development in overthrust terranes. J. Struct. Geol., 9 (2): 207–219.

JONES P. B. (1987) — Quantitative geometry of thrust and fold belt structures. Am. Ass. Petrol. Geol., Methods in Exploration Series, 6: 1–26.

JONES P. B. (1995) — Geodynamic evolution of the eastern Andes, Colombia — an alternative hypothesis. In: Petroleum basins of South America. Am. Ass. Petrol. Geol. Mem., 62: 647–658.

KIMURA K., HORI R. (1993) — Offscarping accretionm of Jurassic chert-clastic complex in the Mino-Tamba Belt, central Japan. J. Struct. Geol., 15 (2): 145–161.

McCLAY K. R. (1992) — Glossary of thrust tectonic terms. In: Thrust tectonics (ed. K. R. McClay): 419–434. Chapman and Hall. London.

McCLAY K. R., INSLEY M. W. (1986) — Duplex structures in the Lewis thrust sheet, Crowsnest Pass, Rocky Mountains, Alberta, Canada. J. Struct. Geol., 8 (8): 911–922.

MORLEY C. K. (1987) — Lateral and vertical changes of deformation style in the Rosen-Røa thrust sheat, Oslo region. J. Struct. Geol., 9 (3): 331–343.

PIOTROWSKA K. (1976) — Tectonic style of the Sierra de los Organos (Cuba). Bull. Acad. Pol. Sc., Sér. Terre, 24 (3/4): 217–226.

PIOTROWSKA K. (1978) — Nappe structures in the Sierra de los Organos, western Cuba. Acta Geol. Pol., 28 (1): 97–170.

PIOTROWSKA K. (1991) — The Sierra de los Organos and the Escambray Terranes en Cuba. Bull. Acad. Pol. Sc. Earth Sc., 39 (4): 447–465.

PIOTROWSKA K. (1993) — Interrelationship of the terranes in western and central Cuba. Tectonophysics, 220: 273–282.

PIOTROWSKI J. (1976) — First manifestations of volcanism in the Cuban geosyncline. Bull. Acad. Pol. Sc., Sér. Terre, 24 (3/4): 227–234.

PSZCZÓŁKOWSKI A. (1978) — Geosynclinal sequences of the Cordillera de Guaniguanico in western Cuba: their lithostratigraphy, facies development and paleogeography. Acta Geol. Pol., 28 (3/4): 2–96.

PSZCZÓŁKOWSKI A. (1987) — Paleogeography and paleotectonic evolution of Cuba and adjoining areas during the Jurassic-Early Cretaceous. Ann. Soc. Geol. Pol., 57 (3/4): 127–142.

ROSS M. I., SCOTESE C. R. (1988) — A hierarchical tectonic model of the Gulf of Mexico and Caribbean region. Tectonophysics, 154: 1–30.

TANNER P. W. G. (1992) — Morphology and geometry of duplexes formed during flexural-slip folding. J. Struct. Geol., 14 (10): 1173–1192.

WOODWARD N. B., RUTHERFORD E. Jr. (1989) — Structural lithic units in external orogenic zone. Tectonophysics, 158: 247–267.

YIN A., KELTY T. K. (1991) — Development of normal faults during emplacement of a thrust sheet; an example from the Lewis allochton, Glacier National Park, Montana (USA). J. Struct. Geol., 13 (1): 37–47.

GEOMETRYCZNA REKONSTRUKCJA NASUNIĘĆ W MASYWIE SIERRA DE LOS ORGANOS (ZACHODNIA KUBA)

Streszczenie

Masyw górski Sierra de los Organos jest położony w zachodniej części Kuby, w prowincji Pinar del Rio (fig. 1). W obrębie tego masywu można wyróżnić trzy grupy jednostek strukturalnych (fig. 1–6):

— płaszczowinę mogotową, znajdującą się w najniższej pozycji strukturalnej, zbudowaną głównie ze skał wapiennych (oksford–eocen);

— płaszczowinę Alturas de Pizarras del Sur, zbudowaną z piaskowców i łupków formacji San Cayetano (jura dolna?–środkowa), nasuniętą na płaszczowinę mogotową;

— płaszczowinę zmetamorfizowaną, zajmującą najwyższą pozycję strukturalną.

W opracowaniu oparto się na klasycznych opracowaniach modelowych eksperymentalnych i teoretycznych dotyczących mechanizmu genezy i rozwoju struktur płaszczowinowych (S. E. Boyer, D. Elliott, 1982; P. B. Jones, 1995).

Proces nasunięć rozpoczął się od inicjalnego odkłucia, które nastąpiło w najniższej części sekwencji osadowej (fig. 2, 6, 7) reprezentowanej przez piaskowcowo-łupkową formację San Cayetano. Po powstaniu inicjalnego odkłucia w transportowanej sekwencji doszło do dalszego jej różnicowania na mniejsze płaszczowiny cząstkowe na granicy zespołów o różnym stopniu podatności. W wyniku drugiego odkłucia powstały dwie płaszczowiny: wyższa — mogotowa — i płaszczowina Alturas de Pizarras del Sur (fig. 8, 9).

Płaszczowina mogotowa dzieli się na mniejsze segmenty, które wspinają się na rampę i tworzą spiętrzenie łusek w postaci stosu płaszczowinowego. Niższa pierwotnie płaszczowina Alturas de Pizarras del Sur, pozostająca w tyle mogotowego stosu płaszczowinowego, dzieli się na mniejsze struktury dupleksowe nasunięte następnie na mogotowy stos płaszczowinowy. Zachodzi tu zjawisko inwersji strukturalnej. Najwyższą pozycję zajmuje płaszczowina zmetamorfizowana, interpretowana jako wachlarz łusek. W świetle takiej interpretacji w strukturze Sierra de los Organos można wyróżnić najniżej leżący mogotowy stos płaszczowinowy, wywodzący się z wachlarza łusek, struktury dupleksowe płaszczowiny Alturas de Pizarras del Sur oraz wachlarz łusek płaszczowiny zmetamorfizowanej, znajdujący się w najwyższej pozycji strukturalnej.