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REPLY⁵K. M. KHUDOLEY⁶

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This is in reply to C. W. Hatten's discussion which precedes.

1. *Basement for Cuban orthogeosyncline*.—The age problem of the metamorphic rocks in the Sierra de Trinidad of southern Las Villas Province, Isla de Pinos, and in eastern Oriente Province is not solved now and we can only guess at the ages of these rocks. Unfortunately the radiogenic dating does not help, and only complicates the problem. For example, the age of some rocks thus far determined may be mentioned: (1) Isla de Pinos (micas)— 74×10^6 years;⁷ (2) Sierra de Trinidad—Manicaragua granitoid batholith— 180×10^6 years ± 10 per cent; (3) Oriente Province— $119 \times 10^6 \pm 10$ per cent; and (4) Las Villas Province (Tres Guanos quartz monzonite)— 57×10^6 years ± 5 per cent. C. W. Hatten considers the age of the quartz monzonite to be late Paleozoic.⁸

Some Russian geologists and I, who have worked in Cuba, consider all the metamorphic rocks to be of Middle and Early Jurassic age.

2. *Pre-Albian stratigraphy of Sierra de los Órganos*.—In regard to the pre-Albian stratigraphic sequence of the Sierra de los Órganos, the following can be said. Hatten's faunal list, including *Tintinnopsella carpathica*, *T. oblonga*, *Nannoconus steinmanni*, *N. kemptneri*, *N. colomi*,

N. bermúdezi, *N. globulus*, and *Favilloides balearica*, does not demonstrate the Neocomian age of these sediments. A similar fauna occurs together with Tithonian ammonites in many parts of western and central Cuba (Judoley and Furazola-Bermúdez, 1965, p. 11, 15, 18, 22, and 24).

Thus, late Tithonian (Purbeckian), Berriasian, Valanginian, Hauterivian, and Barremian rocks (*i.e.*, five stages) are absent between the middle-late Tithonian (Portlandian-late Kimmeridgian) and the strata of Aptian to Albian age. For this reason, I can not agree with C. W. Hatten's opinion that the section from Middle Jurassic to Aptian-Albian is completely represented.

3. *Orogenic activity*.—Concerning this, I would like to say that the problem of the Variscan (Appalachian) orogeny will not be solved because of the absence in Cuba of rocks more ancient than Early and Middle Jurassic. I believe that, beneath any part of the exposed sections, Jurassic rocks overlie Triassic and Paleozoic rocks, but I can not prove it.

The limestones of the Viñales Formation lie on various parts of the Jagua Formation and, in some places, probably on the San Cayetano Formation. Moreover, the Tithonian strata lie on different parts of Upper and Middle Jurassic rocks. For example, the Tithonian overlies limestones of the Viñales in the Sierra de los Órganos; in the Sierra del Rosario the Tithonian overlies the San Cayetano Formation in some places with an angular discordance. These phenomena indirectly indicate that a Nevadan orogeny occurred.

The differences in structural style between the San Cayetano Formation, on one hand, and that of the Viñales and Jagua Formations, on the other hand, can be explained by a Nevadan orogeny, not just by the differences in competence of these rocks.

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⁷ In the article by V. E. Kuman and R. R. Gavilán (1965), there is a mistake, of which I am guilty; the mica ages were incorrectly given as 100×10^6 years ± 10 per cent.

⁸ A similar age determination by Lamont (unpub.) from this quartz monzonite is from biotite that was altered during the Laramide orogeny.

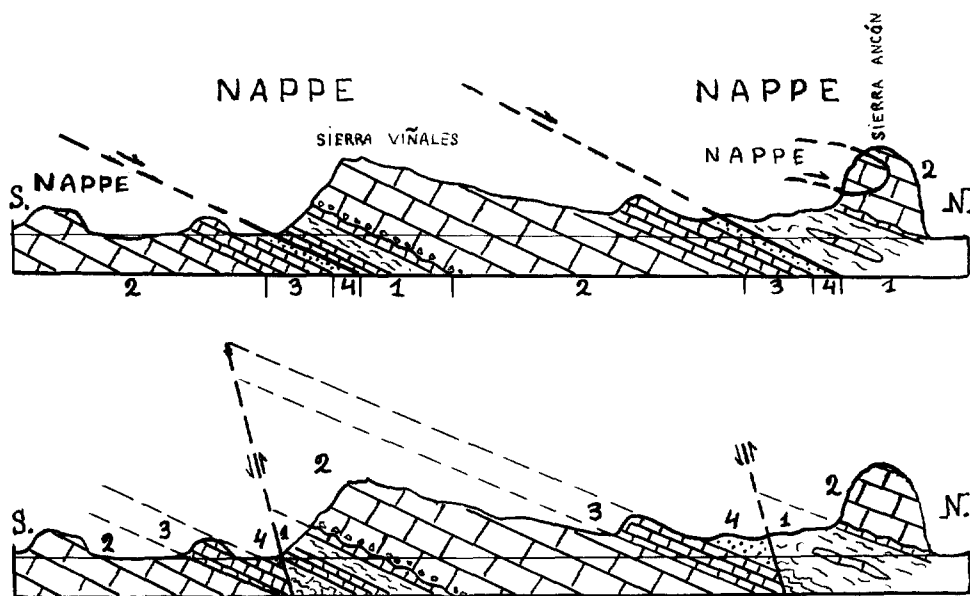


FIG. 3.—Diagrammatic section of Sierra de Viñales-Sierra Ancón (see index map, Fig. 1, for location), Sierra de los Órganos, Pinar del Río Province, western Cuba. Not to scale. *Above*: C. W. Hatten's interpretation; *below*: K. M. Khudoley's interpretation. 1 = Jagua Formation (late Oxfordian); 2 = Viñales Formation (Kimmeridgian-early Tithonian); 3 = Artemisa Formation (early-middle Tithonian); 4 = Ancón Formation (Paleocene?-Eocene). Jagua, as used here, is in the sense of Palmer (1945) and not as redefined in Hatten's discussion.

The principal characteristic of the Pinar del Río facies-structural zone is the thinness of the Cretaceous-Cenozoic section, as well as the absence of a well-expressed angular discordance. The fact that Eocene rocks overlie Upper Jurassic rocks without angular discordance speaks for itself. In fact, the phenomenon of no angular discordances in the Cretaceous-Cenozoic section makes it difficult to distinguish different structural levels (subcycles).

4. *Overthrusting*.—There are two opinions regarding the tectonics of Cuba. The majority of geologists and geomorphologists (Hayes *et al.*, 1901; Lewis, 1932; Massip and Ysalgué de Massip, 1942; Lehmann, 1960; Lewis and Straczek, 1955; Krömmelbein, 1963; Ducloz and Vuagnat, 1962; and Furrázola-Bermúdez *et al.*, 1964; and others) consider that there is no major overthrusting in Cuba. Palmer (1945), Flint *et al.* (1948), Kozary (1953, 1956), and Wassall (1956) think that thrusting is not common in Cuba. Rigassi-Studer (1961, 1963), Meyerhoff (1965), and Hatten believe that gigantic overthrusts are widespread in Cuba. These above-mentioned geologists do not even agree on the character and locality of the overthrusts. If one compares cross sections

of the Sierra de Los Órganos made by Palmer, Hatten, and Rigassi-Studer, he will get the impression that none of these geologists worked in the same place! In fact, it looks as though they worked in different parts of the globe.

It should be mentioned that the tectonic patterns discussed by Hatten have another interpretation. The phenomenon of a repeated section can be explained either by vertical, high-angle faults or inclined (tilted) and low-angle faults (thrusts).

In my opinion the interpretations by means of "klippen," "nappes," "charriages," "major overthrusts," and other geological phenomena of the Alpine style are unnecessary. The cross section of Valle de Viñales (Fig. 3) confirms this. In this, two interpretations of the same phenomena are shown.

Ducloz and Vuagnat (1962, Fig. 2) portray a cross section through central Cuba. On this cross section, "major overthrusts," "klippen," "nappes," "charriages," and other structures of the Alpine style, about which Hatten writes in his discussion, are absent.

Thus it is my opinion that the geological phenomena in Cuba can be explained without major overthrusting. Certainly, there are some horizon-

tal and low-angle thrusts in Cuba, but they are not significant and do not play an important role in the structure of the island.

Moreover, in the published literature on geological structure of the Caribbean region and Guatemala, there is nothing written about "Alpine style" of structure. Nor is this style of structure characteristic of Cuba.

Finally, I think that some of the differences of opinion between Hatten, myself, and my colleagues are especially related to the fact that we are adherents of different schools of geology.

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PENNSYLVANIAN AND PERMIAN BASINS IN NORTHWESTERN UTAH, NORTHEASTERN NEVADA, AND SOUTH-CENTRAL IDAHO:

DISCUSSION¹

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INTRODUCTION

Roberts, Crittenden, Tooker, Morris, Hose, and Cheney (1965) discussed the Pennsylvanian and Permian basins in northwestern Utah, northeastern Nevada, and south-central Idaho as down-

warped segments of the Cordilleran geosyncline. They stated (p. 1926): "A detailed analysis of sedimentary facies is, on the one hand, the essential key to unraveling the structural history; yet, on the other hand, an explicit allowance for structural dislocation is essential if the original form and character of the sedimentary basins are to be reconstructed." Pertinent data published by the writer have been omitted from their paper.

stimulating discussions with Armand J. Eardley of the University of Utah are gratefully acknowledged. The writer accepts full responsibility for the criticisms and conclusions of the present discussion.

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