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Geology of La Venta, Colombia, South America

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INTRODUCTION

Since the 1940's, numerous vertebrate fossils, including primates, have been collected from La Venta, situated in the Upper Magdalena Valley, about 30 km north of Neiva City, Department of Huila, Colombia (Fig. 1). The strata of La Venta are regarded as the upper part of the Honda Group, Neogene continental deposits exposed widely along the Magdalena River between the Central and Eastern Cordilleras (Van Houten & Travis, 1968; Wellman, 1970). Since 1977, paleontological surveys have been carried out, jointly organized by the Primate Research Institute of Kyoto University (Japan) and INGEOMINAS (Instituto Nacional de Investigaciones Geológico-Mineras, Colombia). Many primate fossils and several series of geochronological data have been obtained (Kyoto University Overseas Research Reports of New World Monkeys, Vol. 1 ~ 7).

The currently available radioisotopic age from La Venta are 12-16 Ma (Takemura and Danhara, 1985; Takemura *et al.*, 1992). The fossil assemblages, known as the La Venta fauna, are assigned to the Friasian Land Mammal Age of South America (Hirschfeld and Marshall, 1976). However, several workers have recently insisted that the La Venta fauna is of Santacrucian age rather than Friasian (Kay *et al.*, 1987). In this paper we describe a detailed local stratigraphic column and define stratigraphic units in La Venta in order to place all of the discovered fossils in a stratigraphic context.

Figure 1. Map of Colombia, showing the area studied.

Primate fossils which have been recovered from La Venta are as follows: *Stirtonia tatacoensis*, *Cebupithecia sarmientoi,* and *Neosaimiri fieldsi,* (Stirton, 1951); new specimens of *S. tatacoensis,* (Setoguchi *et al.*, 1981); *Kondous laventicus,* (Setoguchi, 1985); *Micodon kiotensis,* (Setoguchi and Rosenberger, 1985); *Mohanamico hershkovitzi,* (Luchterhand *et al.*, 1986), *S. victoriae,* (Kay *et al.*, 1987); *Aotus dindensis,* (Setoguchi and Rosenberger, 1987); a new specimen of *C. sarmientoi,* (Setoguchi *et al.*, 1988); *Laventiana annectens,* (Rosenberger *et al.*, 1991); and several postcranial remains (Gebo *et al.*, 1990; Meldrum *et al.*, 1990). In addition, in 1989 and '90, numerous isolated teeth and postcranial fragments were recovered by the Japanese-Colombian investigation team from the same point as *L. annectens*. Most of these materials are identified as new specimens of *N. fieldsi,* (Takai, in prep.). In 1991 several more specimens, probably also of *N. fieldsi,* were recovered from additional two localities (Takai *et al.*, in prep.).

GENERAL GEOLOGY

The fluvial deposits exposed in La Venta are usually considered as belonging to the upper part of the Honda Group (Fields, 1959; Van Houten and Travis, 1968; Wellman, 1970). Van Houten and Travis (1968) regarded the Cenozoic sedimentary rocks in the Upper Magdalena Valley as consisting of four major depositional cycles, with the Late Miocene "Honda Formation" (about 3,000 m thick) as the third one. The formation is composed of a succession of alternating yellowish-grey conglomeratic arkosic sandstone and variegated mudstone, with a distinctive unit of redbeds at the top (Van Houten and Travis, 1968). Wellman (1970) regarded the Honda sediments as the Honda Group, and subdivided it into two formations; the La Dorada Formation (lower), composed of the Puerto Salgar and Perico Members, and the

Figure 2. Topographical map of La Venta showing localities of stratigraphic columnar sections.

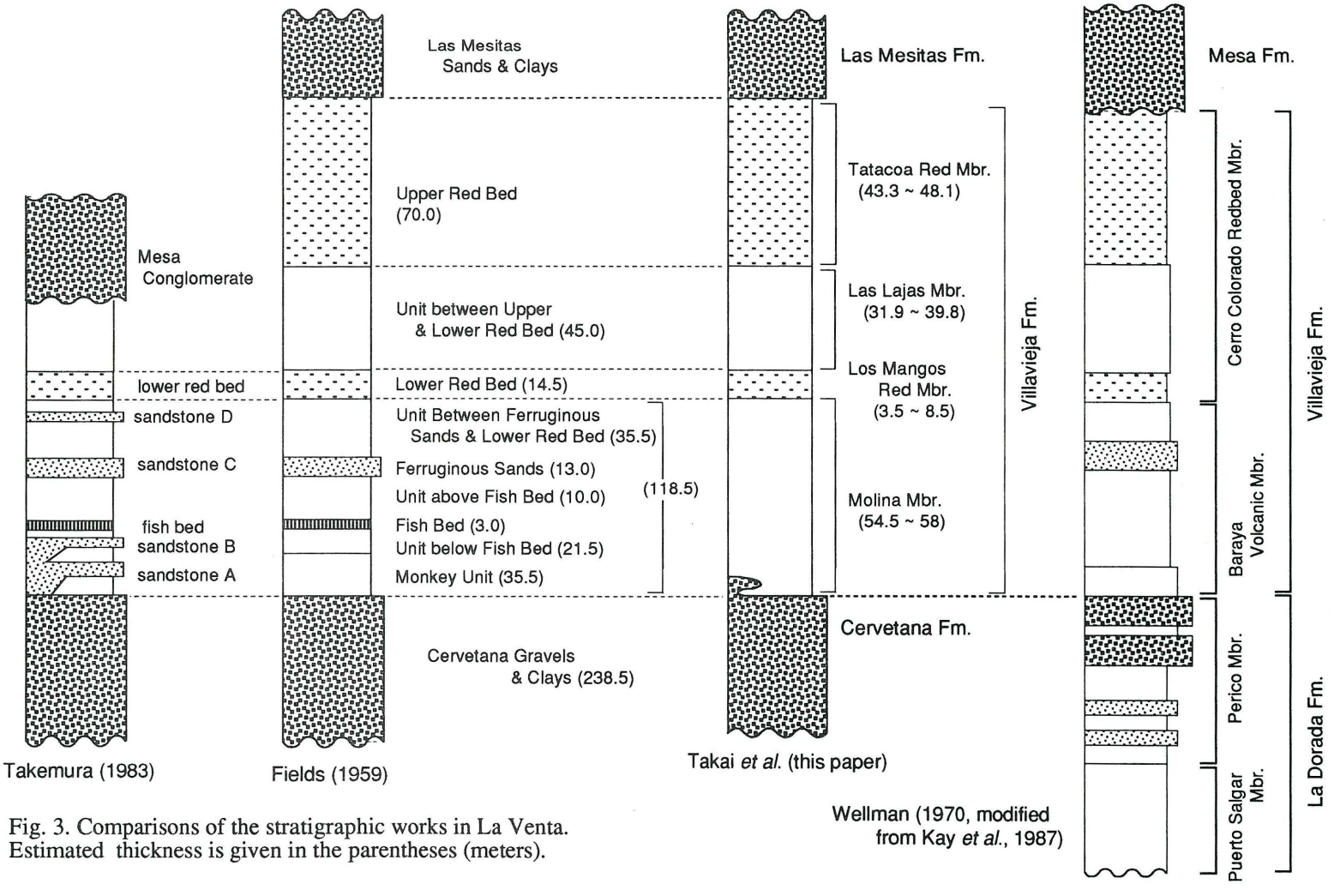

Fig. 3. Comparisons of the stratigraphic works in La Venta.
Estimated thickness is given in the parentheses (meters).

Villavieja Formation (upper), composed of the Baraya Volcanic and Cerro Colorado Redbed Members (Fig. 3). In this paper we follow the Honda Group as defined by Wellman (1970), since some of his formations are clearly recognized within the entire Honda strata.

The precise geological age of the Honda Group, however, is still unknown. Only Takemura and Danhara (1985) reported fission-track ages (15.7±1.1,14.6±1.1 and 16.1±0.9 Ma) from the upper part of the Honda Group exposed in La Venta. In order to confirm those ages, we also conducted fission-track dating, and obtained the following three dates: 13.6±0.5, 13.6±0.7 and 12.6±0.5 Ma (Takemura *et al.*, 1992). The currently available data indicate that the upper part of the Honda Group exposed in La Venta, the Villavieja Formation, was deposited during the Middle Miocene.

GEOGRAPHIC AND STRUCTURAL SETTING

The area investigated is the famous badlands along a series of mesas (Mesa A~H, Fig. 2) between two westward flowing rivers, Quebrada Tatacoa and Q. Las Lajas, and is situated northeast of Villavieja, a small village on the east side of the Magdalena River. The exposed strata in this area generally dip very gently towards the southwest (3°-6°), striking almost EW in the southern part of the studied area, and gradually changing to NS in the north. However, at the northwestern end, the strike of the strata is almost EW, while at the southeastern end the strike seems to be almost NS. Therefore, there are three structural axes observed in the studied area; a gentle but prominent NE-SW anticlinal axis and, on both sides, two parallel synclinal axes.

All exposed strata in this area are probably of the braided river depositions, so the lateral transitions are abrupt. Moreover, several minor faults observed near El Dinde, the displacements of which are a few meters at most, make the regional geology somewhat complicated.

STRATIGRAPHY OF LA VENTA

In this paper we propose a new stratigraphic framework for the studied area. The Honda Group exposed in La Venta is divided into three formations (in ascending order): the Cervetana, Villavieja and Las Mesitas Formation. The Villavieja Formation is subdivided into four members (in ascending order): the Molina, Los Mangos Red, Las Lajas and Tatacoa Red Member. The total thickness of the exposed strata in the studied area is about 200 meters. A comparison of the stratigraphic columns of Fields (1959), Wellman (1970), Takemura (1983), and this paper is shown in Fig. 3. A comparison of the estimated thickness of stratigraphic units shows that Fields (1959) overestimated the thickness of each unit.

Cervetana Formation

The Cervetana Formation, exposed widely in the northeastern part of the studied area, consists of conglomeratic sandstones with intercalated variegated siltstone lenses. This corresponds to the "Cerbatana Gravels and Clays"* of Fields (1959) and the "La Dorada Formation" of Wellman (1970), respectively (Fig. 3). The lower limit of this formation is not

* "Cervetana" is the name of the river flowing westward in La Venta (Quebrada Cervetana, see Fig. 2), and the people living in Villavieja usually call it Q. Cervetana. Early workers probably heard it incorrectly as "Quebrada Cerbatana" (Stirton, 1951; Fields, 1959). Therefore, we use the correct name "Cervetana" for stratigraphic terminology in this paper.

yet defined, as this formation is widely exposed along the eastern side of the Quebrada Tatacoa and we were unable to distinguish its basement. Fields (1959) described the "Cerbatana" Gravels and Clays as overlying the El Libano Sands and Clays, and estimated the thickness of the "Cerbatana" unit as 238.5 m. However, his estimation for this unit, as for other units, seems too thick. The upper limit of the Cervetana Formation, on the other hand, is easily observed. In the upper part of this formation the sandstone beds are extremely conglomeratic, while the basal part of the overlying Molina Member is composed of grey to brown siltstone beds.

The sandstone matrix consists of medium to coarse grains, with strong cross-laminations observed often. Gravels with pebble to cobble sizes, usually ranging from 5 to 20 cm in diameter, occur densely, forming sandy conglomerate layers (30 to 450 cm in thick) within the sandstone matrix. The Quaternary(?) sandy conglomerate, the Mesa Conglomerate, sometimes overlies the conglomeratic sandstone beds of the Cervetana Formation uncomformably. Although gravels in the Mesa Conglomerate are distinctively larger than from the Cervetana Formation, weathered Mesa Conglomerate deposits often confuse the stratigraphic structure of the studied area. In the uppermost part of the Cervetana Formation, thick conglomeratic sandstone beds (more than 10 m thick) are dominant, and they should correspond to the "Rio Seco Conglomerate" of Wellman (1970).

The interbedded siltstone, or sometimes claystone, beds are usually lenticular and vary greatly in their thickness. The colors of these mudstone beds are variable: grey, light green, brown, reddish brown and red. Fine-grained sandstone beds sometimes occur, alternating with the mudstone beds. In contrast to the thick concreted sandstones, these fine sandstone beds are usually not concreted.

West of El Dinde, there is a thick coarse-grained sandstone bed, which is regarded as the upper part of the "Cerbatana Gravels and Clays" by Fields (1959). Our interpretation of this sandstone body will be discussed in the section on the Molina Member of the Villavieja Formation.

Villavieja Formation

The Villavieja Formation was originally defined by Wellman (1970) as the upper formation of the Honda Group. In this paper we follow his terminology, but modify his definition according to the result of the stratigraphic work in the studied area. The formation is defined as those strata between the Cervetana and Las Mesitas Formations. The Villavieja Formation is divided into four members, the Molina Member, Los Mangos Red Member, Las Lajas Member, and Tatacoa Red Member (in ascending order). Wellman (1970) had divided the Villavieja Formation into only two members, the Baraya Volcanic (lower) and Cerro Colorado Redbed (upper), and Kay *et al.* (1987) followed his framework (Fig. 3). The uppermost part of the "Cerro Colorado Redbed Member" corresponds to the Las Mesitas Formation. Within the studied area the boundary between the Villavieja and Las Mesitas Formations can be easily recognized. Therefore, the Las Mesitas strata are treated as an independent formation in this paper. The estimated thickness of this formation is about 150 meters.

The Villavieja Formation consists of alternations of claystone, siltstone and sandstone beds. In the Las Lajas and Tatacoa Red Members, however, red or dull-red mudstone beds are so dominant as to be easily distinguished from the other two members. In dry conditions the surfaces of the red claystone beds of these two red members are characteristically cracked and distinctive from the red siltstone layers of the other two members. Among the variegated

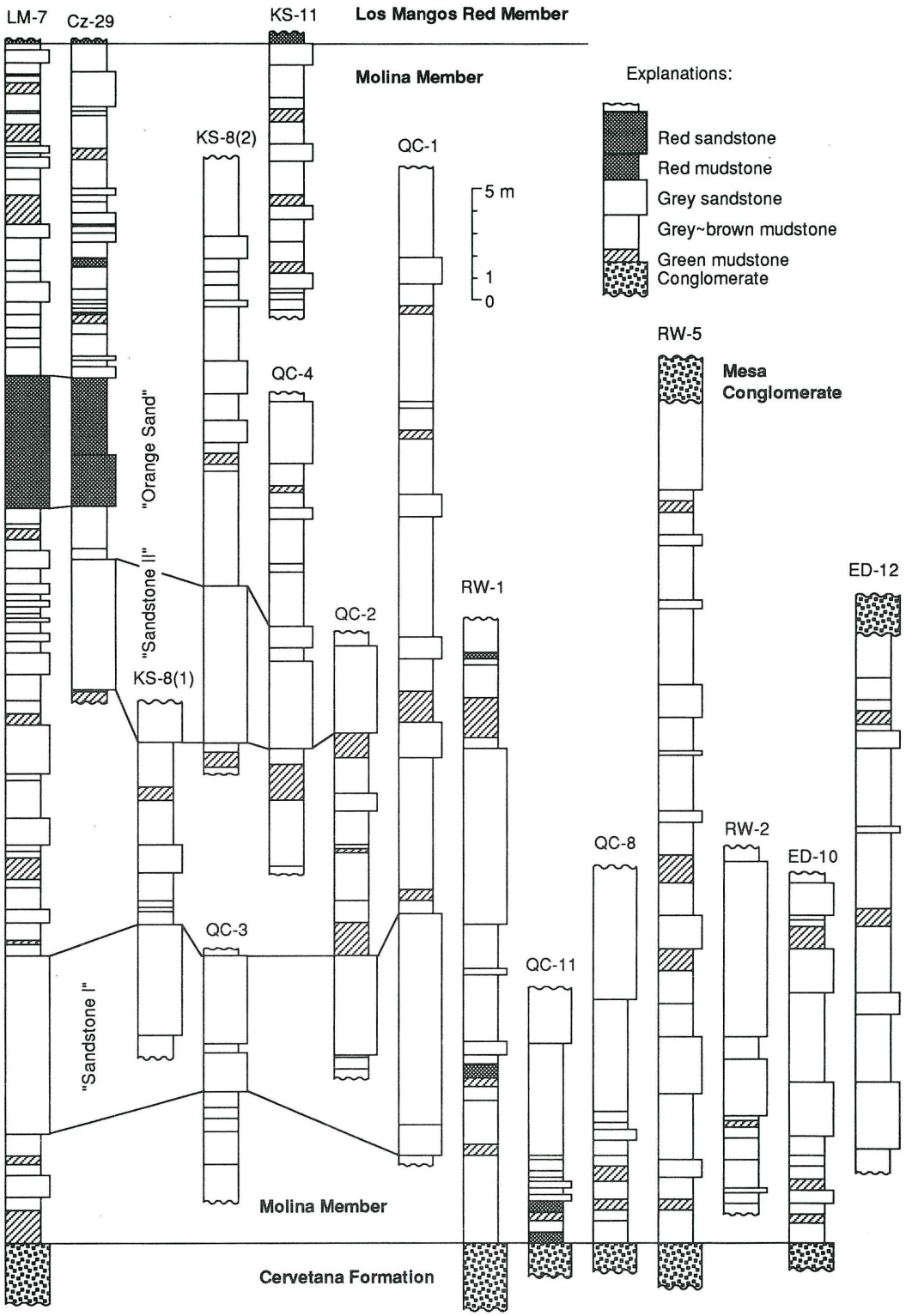

Fig. 4a. Columnar sections

siltstone beds several vivid green layers occur as key beds, such as the "Fish Bed" of Fields (1959), though none of them are laterally continuous .

The sandstone beds of each member are usually concreted and form prominent ledges or platforms. The grain sizes of the sandstones vary from very fine to coarse. Partially pebbly sandstone layers are also observed. The very fine- or fine-grained sandstones are not usually concreted . Strong cross-laminations and torpedo-shaped concretions are often observed in the coarse to medium sandstone beds. The sizes, shapes (global to torpedo-shaped) and directions of these torpedoes are variable, and some workers have discussed the process of their formations (Fields, 1959; Ohno, 1988). However, none of their interpretations appear sufficient. Although they require further attention, we do not discuss these curious concretions in this paper.

Molina Member

The Molina Member, named after the Llanos de Molina (see Fig. 2), is the lowest member of the Villavieja Formation and corresponds to six units of Fields (1959); that is, the Monkey Unit, Unit below Fish Bed, Fish Bed, Unit above Fish Bed, Ferruginous Sands, and Unit between Ferruginous Sands and Lower Red Bed (in ascending order). These minor units of Fields (1959) are not traceable, but change laterally in thickness and color in the studied area. This member is correlated with the "Baraya Volcanic Member" of Wellman (1970) (Fig. 3). The minimum thickness (54.5 m) for this member is taken from section LM-7 (Figs. 2 & 4a), which is continuously exposed from the top of the Cervetana Formation through the base of the Los Mangos Red Member. The maximum thickness (58 m) is estimated from the combination of several columnar sections (Figs. 4a & b).

The Molina Member consists of frequent alternations of sandstone and siltstone beds. The thickness and grain size of sandstone beds vary laterally. At least three thick sandstone beds ("Sandstone I", "II", and "Orange Sand", Fig. 4a) are observed within this member. In particular, the "Sandstone I" is about 11 m maximum thickness and partly contains rich gravels. At El Dinde area a thick (less than 4 m) pebbly sandstone bed is widely exposed. This sandstone body is generally regarded as the lateral variation of the "Sandstone I". On the other hand, it can also be interpreted as a tongue structure of the conglomeratic sandstone beds of the Cervetana Formation. The siltstone beds below this sandstone body seem to be continuously exposed from the Q. Cervetana through El Dinde (see Geologic Map). In this paper we regard this sandstone bed as the lowest part of the Molina Member, with the base of the Molina Member and the top of the Cervetana Formation being partly interfingered with each other. Therefore, the "San Nicolás Clays" of Fields, regarded as the intercalated claystones of the "Cerbatana Gravels and Clays" of Fields, should be included in the lowest part of the Molina Member (Fields, 1959). The "Orange Sand" (4 to 6 meters thick) is a coarse-grained sandstone bed, forming the characteristic scenic ledges of the La Venta badlands. It corresponds to the "Ferruginous Sands" of Fields (1959), but peters out to the west or partly changes to the orange-colored siltstones (sections LM-5,6 &7 and Cz-29 of Figs. 4a & b).

The colors of the siltstone beds are both so variable and gradually changing (red - reddish brown - brown - orange - yellowish brown - grey - bluish grey - blue - greenish blue - green) that such minor units as described by Fields (1959) are never traceable laterally. For example, the "Fish Bed" was regarded as "an easily recognized bluish-grey unit" by Fields. Within the Molina Member, however, there are many bluish-green or green siltstone layers, and their

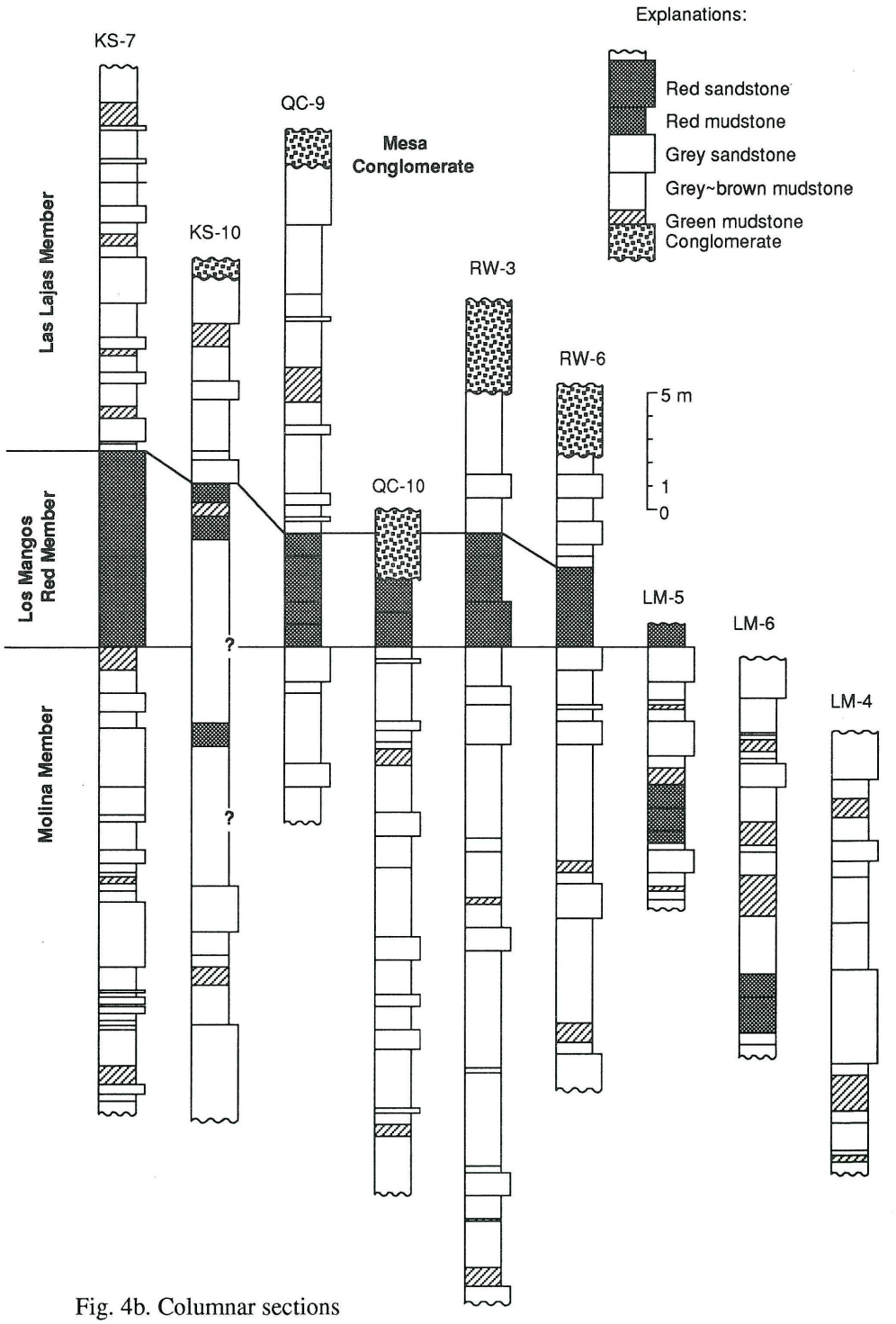

Fig. 4b. Columnar sections

colors and thicknesses vary easily in lateral extent (Fig. 4a). Between the "Sandstone I" and "II" beds, there are two green siltstone beds, while in the upper part of the member, above the "Orange Sand", two or three green beds are exposed.

Takemura and Danhara (1985) obtained two zircon fission-track dates (16.1±0.9 and 14.6±1.1 Ma) from the tuffaceous siltstone beds of the lowest part of this member.

Los Mangos Red Member

The Los Mangos Red Member (about 8 m thick), which corresponds to the Lower Red Bed of Fields (1959), usually consists of brick-red claystone beds with intercalate fine-grained red sandstone lenses (60 ~ 230 cm thick). However, at the western flank of Mesa G, only red-colored fine sandstones make up this unit (section KS-7 of Figs. 2 & 4b). In any case, this member is easily distinguishable from the underlying Molina Member and overlying Las Lajas Member by its characteristic red color. It is not clear whether Wellman (1970) regarded this unit as the part of the "Baraya Redbed Member" or not. In his paper, the stratigraphic sections show an interfinger between the "Baraya Volcanic Member" and "Cerro Colorado Redbed Member" (Wellman, 1970, pp. 2361), but the lowest interfingered part of the "Cerro Colorado Redbed Member" is too thick for this unit. The idealized stratigraphic section of Kay *et al.* (1987) seems to regard this red unit as the part of the "Cerro Colorado Redbed Member".

The upper and lower boundaries of this member are obvious and conformable. The top of the underlying Molina Member is grey to greenish grey siltstone or fine-grained sandstone, while the base of the overlying Las Lajas Member is grey siltstone or fine-grained sandstone.

At the southeastern flank of Mesa F, vague red siltstone layers are exposed (KS-6 & QC-5 of Fig. 4c). This "red band" does not make up a distinct unit but is a combination of the varicolored layers, and seems rather thin (about 3.5 m) when compared to the red bed of Mesa G. The correlation between this red band and the Los Mangos Red Member, which is exposed at the northwestern flank of the mesa G, is not yet concluded. At present we regard this red band as the lateral variation of the Los Mangos Red Member. To the north, however, this red band is well exposed at the flanks of the Mesa C, D, E and F, corresponding each other (Fig. 4b. QC-9 &10, RW-3 & 6).

The zircon fission-track date obtained by Takemura and Danhara (1985) from the grey tuffaceous siltstone bed of this red band at the northeast flank of the Mesa F is 15.7±1.1 Ma.

Las Lajas Member

The Las Lajas Member (31.9 ~ 39.8 m thick) is defined as all strata between the characteristic red members (the Los Mangos Red and Tatacoa Red Members), and corresponds to the "Unit between Upper and Lower Red Beds" of Fields (1959). As mentioned above, the interpretation of this unit by Wellman (1970) is not clear, so we can not correlate the Las Lajas Member with Wellman's subdivision (Fig. 3).

As with the Molina Member, this member consists of frequent alternations of the sandstone and siltstone beds. However, differing from the Molina Member, most of the sandstone beds are lenticular and less than 2 meters in thickness. Such thick sandstone beds as the "Orange Sand" or "Sandstone I" of the Molina Member are not observed. The grain sizes of sandstones are usually very fine to medium. The color of the siltstone beds vary red - reddish brown - brown - orange - yellowish brown - grey - bluish grey - blue - greenish blue - green, as in the Molina Member.

mammalian fossils, such as rodents, from La Venta with those from the type locality of the Friasian age in more detail.

Kay *et al.* (1987) reported new species of *Stirtonia* from La Victoria, about 20 km north of Villavieja. They regarded that fossil horrizon as more than 300 meters below the Kioto Site, and that the strata near La Victoria should be rather older than the Villavieja Formation. Further stratigraphic and geochronological work from La Victoria through Villavieja is needed to correlate these two studied areas.

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