Title	Fission-Track Ages of the Villavieja Formation of the Miocene Honda Group in La Venta, Department of Huila, Colombia
Author(s)	Takemura, Atsushi; Takai, Masanaru; Danhara, Tohru; Setoguchi, Takeshi
Citation	Kyoto University overseas research reports of new world monkeys (1992), 8: 19-27
Issue Date	1992
URL	http://hdl.handle.net/2433/199688
Right	
Type	Article
Textversion	publisher

Kyoto University Overseas Research
Reports of New World Monkeys (1992) **8**: 19-27
Kyoto University Primate Research Institute

Fission-Track Ages of the Villavieja Formation of the Miocene Honda Group in La Venta, Department of Huila, Colombia

Atsushi TAKEMURA
Hyogo University of Teacher Education,
942-1 Shimokume, Yashiro, Hyogo 673-14, Japan
Masanaru TAKAI
Primate Research Institute, Kyoto University,
Inuyama, Aichi 484, Japan
Tohru DANHARA
Kyoto Fission-Track Ltd.,
33 Umezukita-cho, Ukyo-ku, Kyoto 606, Japan
and Takeshi SETOGUCHI
Primate Research Institute, Kyoto University,
Inuyama, Aichi 484, Japan

INTRODUCTION

Tertiary continental sediments are widely exposed along the valley of Magdalena River between the Central and Eastern Cordillera, in Colombia, South America. Many fossil vertebrates including fossil monkeys occur in the Miocene Honda Group, and these fossils are known as the La Venta fauna (Stirton, 1951). Takemura and Danhara (1985) presented fission-track ages of the Honda Group, which ranged about 16 to 15 Ma in age.

A cooperating paleontological survey organized by Primate Research Institute of Kyoto University and INGEOMINAS was carried out in 1990. More than 200 fossils of monkey teeth were excavated through this survey from the Tatacoa Red Member [the Upper Red Bed of Fields (1959)] of the Villavieja Formation in the Honda Group. However, the Tatacoa Red Member overlies other members of the Villavieja Formation dated by the fission-track method. Although Takemura and Danhara (1985) correlated the La Venta Fauna to the Friasian Stage of South American Land Mammal Ages (Marshall *et al.*, 1977), the fossil monkeys obtained by this survey shall be somewhat younger.

In this paper, we made detailed stratigraphic work on the Tatacoa Red Member and fission-track dating of three samples from this unit. Because the obtained ages range from 12.6 to 13.6 Ma, it is concluded that the upper part of the Honda Group in the La Venta badlands was deposited during Middle Miocene.

GEOLOGICAL SETTING AND MATERIAL

The studied area in this paper is situated in the La Venta badlands, which are located along the valley of Magdalena River between the Central and the Eastern Cordillera, Colombian

Figure 1. Locality of La Venta in Colombia, South America

Andes (Fig. 1). The sampling point for fission-track dating is about 5 km east of Villavieja, Department of Huila (Fig. 2).

Several lithostratigraphic studies had been reported on the Honda Group in this area. Fields (1959) proposed stratigraphic framework of the Honda Group exposed in the La Venta badlands. Van Houten and Travis (1968) and Wellman (1970) studied stratigraphy and sedimentology of the whole Honda Group extending from Gigante to La Dorada, along the Magdalena Valley. However, the stratigraphy of these two studies is too rough to determine the horizons of fossil localities and dating samples. Takemura (1983) had studied detailed stratigraphy around the Kioto Site in Llanos de Molina (Fig. 2).

Takai and Setoguchi (1990) carried out detailed stratigraphic work on the upper part of the Honda Group exposed in the La Venta badlands. They had modified the stratigraphy made by Fields (1959). Takai *et al.* (1992) renamed the stratigraphic units of Fields (1959) to formations and members, because the unit names described by Fields (1959) were informal. We use the stratigraphic framework proposed by Takai *et al.* (1992).

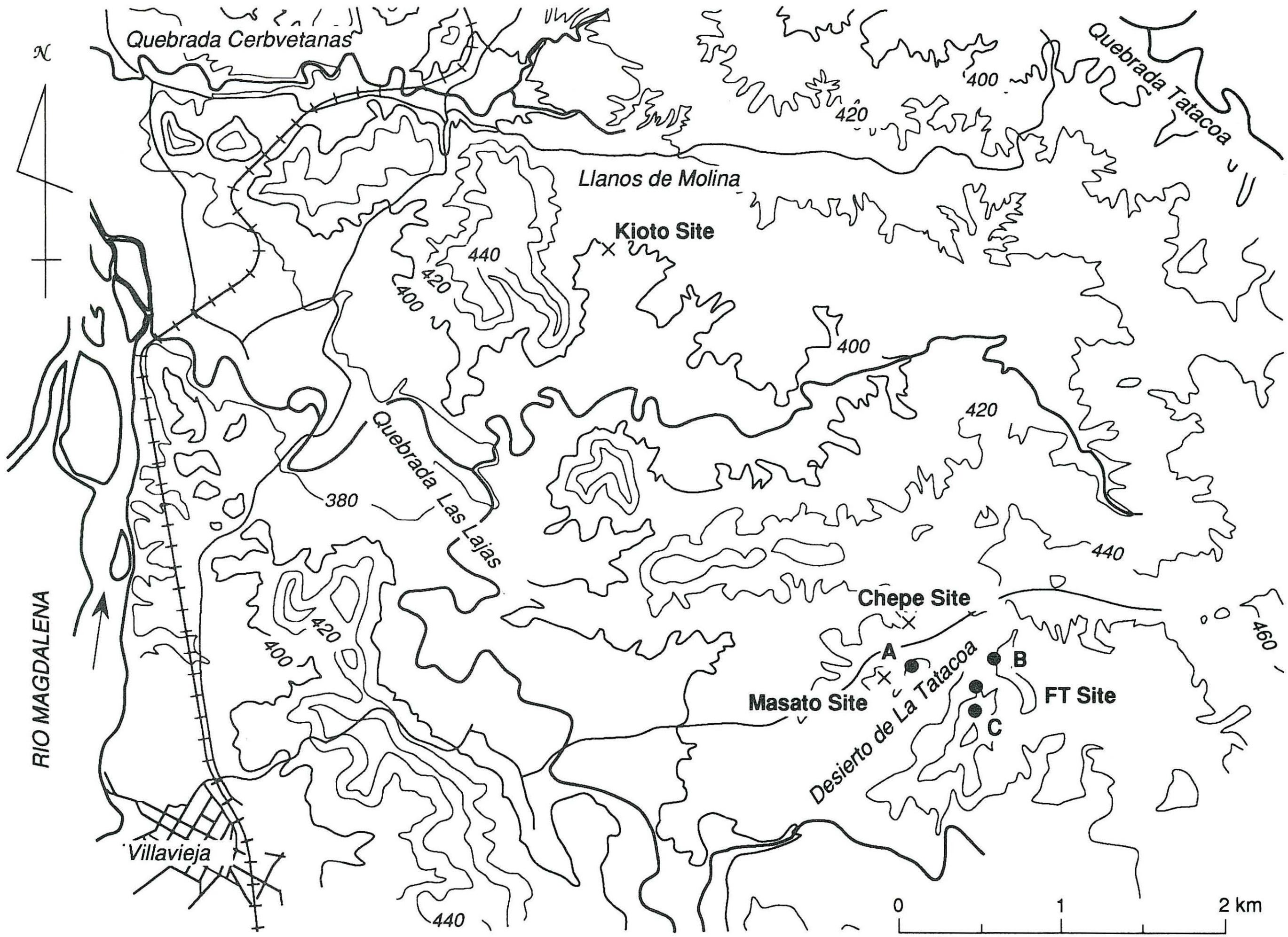

Figure 2. Topographic map around the Tatacoa Desert showing the localities of sampling sites for fission-track dating (FT-site) and occurences of fossil monkeys (x). Filled circles indicate the localities of the geological columns shown in Fig. 3.

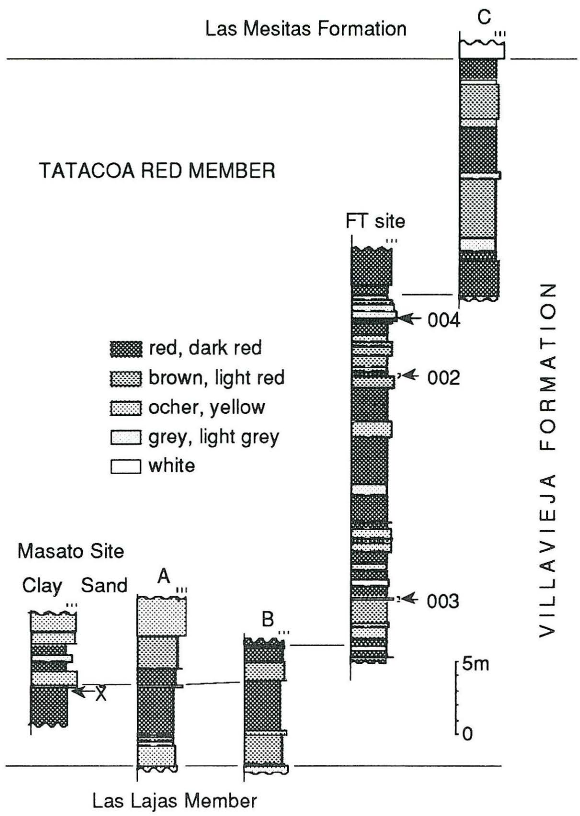

Figure 3. Columnar sections of the Tatacoa Red Member in the Tatacoa Desert. The width of each layer in these columns indicates the grain size. The locality of each column is shown in Fig.2.

The Honda Group in the La Venta badlands is divided into three formations, the Cervetana Formation, the Villavieja Formation and the Las Mesitas Formation, in ascending order.

The Las Mesitas Formation corresponds to the "Las Mesitas Sands and Clays" of Fields (1959) and Takai and Setoguchi (1990), and the Cervetana Formation corresponds to the "Cerbatana Gravels and Clays" of Takai and Setoguchi (1990) and the "El Libano Sands and Clays" of Fields (1959). The Villavieja Formation is divided into four members, the Molina Member, the Los Mangos Red Member, the Las Lajas Member and the Tatacoa Red Member, in ascending order.

The Tatacoa Red Member, which corresponds to the "Upper Red Bed" of Fields (1959), is exposed at the southmost part of the studied area of Takai *et al.* (1992). This area is a fairly scenic place and is known as the Tatacoa Desert (Desierto de La Tatacoa, Fig. 2). The samples for fission-track dating were obtained from one outcrop in the Tatacoa Desert (Fig. 2, FT Site). The Tatacoa Red Member strikes about N80°W to EW and dips 3° to 5°S. This member crops out extending in E-W direction.

The Tatacoa Red Member is composed of red claystone with intercalated siltstone and sandstone (Fig. 3). The claystones are usually red, dull-red or brown and sometimes grey in color. The siltstones and the sandstones are dull-red, brown, yellow or grey, and are sometimes

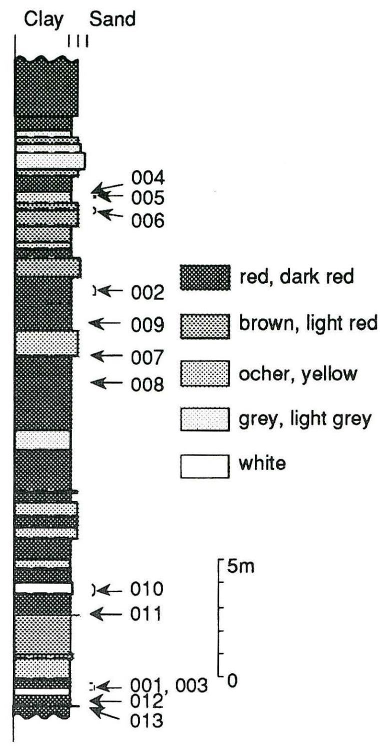

Figure 4. Columnar section of the FT Site and sampling horizons for fission-track dating. The width of each layer in this column indicates the grain size.

tuffaceous. The outcrops of this member are usually red cliffs with many light color bands. These bands have various thicknesses and yellow, grey or white color. We can trace these bands at many outcrops and can use these bands as key beds to aid correlation within this member (Fig. 3). At the western part of the Tatacoa Desert around the Masato Site (Fig. 2, 3), a thick sandstone layer with cross lamination is intercalated in the lowermost part of this member. However, this remarkable sandstone is never observed at the eastern part.

The upper and the lower limits of this unit are easily recognized (Fig. 3). At many points in the Tatacoa Desert, the boundary between this member and the underlying Las Lajas Member can be observed. The colors of beds vary from red to yellow or yellowish brown at the lowermost part of this unit, which is underlain by grey siltstone of the Las Lajas Member with a distinct boundary. The upper limit of this member is observed in the outcrop just south of FT Site (Locality C of Fig. 2). Grey, fine to medium sandstone of the Las Mesitas Formation overlies red claystone of the Tatacoa Red Member with a distinct boundary.

Three samples from FT Site were dated by the fission-track method. Fig. 4 shows the horizons of these samples in the outcrop of FT Site. The lithology of Sample 002 is a grey and reddish brown tuffaceous siltstone. These two colors are mixed together irregularly within this siltstone layer of 75 cm thick. Sample 003 is a bluish grey tuffaceous claystone with irregular red patches. The thickness of this layer is 35 cm and this layer is one of the distinct white bands in this outcrop. We can trace this layer in the eastern part of the Tatacoa Desert and used

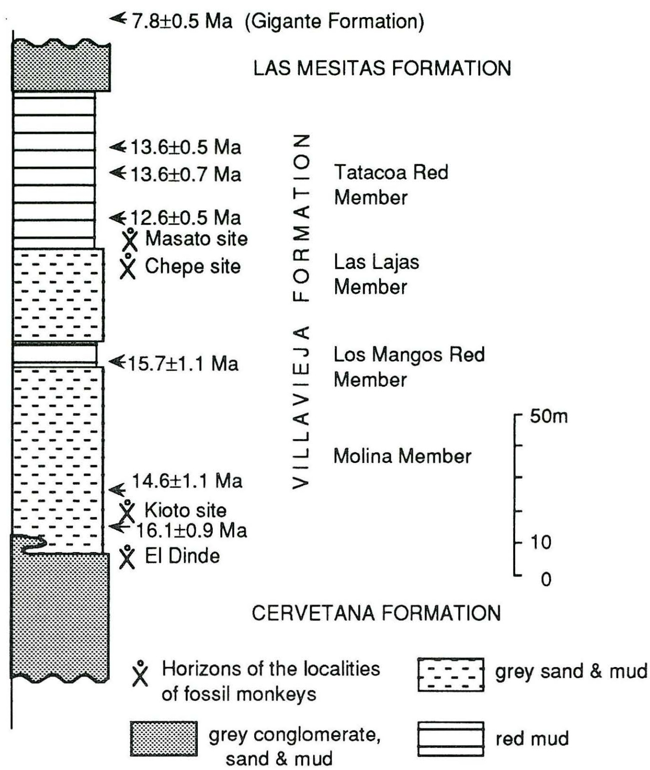

Figure 5. Summarized stratigraphy of the Honda Group in the La Venta Badlands with the fission-track ages. The stratigraphy is after Takai et al. (1992), and the fission-track ages are after Takemura & Danhara (1983) (the Gigante Formation) and Takemura & Danhara (1985) (the Molina and the Los Mangos Red Members).

this layer for the correlation among many outcrops (Fig. 3). Sample 004 was taken from a thin (less than 5 cm thick) layer of white fine tuffaceous sandstone. This layer is intercalated within a distinct grey band observed in the uppermost part of this outcrop. We used these samples of tuffaceous sandstone or mudstone, because no pure tuff layer is intercalated within the Tatacoa Red Member in this area.

We had sampled materials in 12 horizons in this locality (Fig. 4), washed these samples by water and concentrated heavy minerals by panning in Villavieja. Both the heavy mineral fraction and the rock samples of each material were brought to Japan and three samples mentioned above, which contain good zircon grains, were dated at Kyoto Fission-Track Ltd..

FISSION-TRACK DATING

The three samples collected from the Tatacoa Red Member were dated by the fission-track method. The results of this dating are shown in Table 1.

Zircon grains of each sample mounted in PFA (copolymer of tetrafluoroehylene-perfluoro-alkoxyethylene) sheets were etched by a melt of KOH and NaOH at 225°C for 34 hours. After this etching, spontaneous fission-tracks on both external and internal surfaces of the zircon grains were counted. PFA sheets were covered with external fission-track detectors of muscovite and irradiated in the TRIGA Mark II nuclear reactor of St. Paul's University (Rikkyo

Daigaku), Japan. Induced fission-tracks were counted on the muscovite detectors, which were etched with hydrofluoric acid. The thermal neutron fluence was monitored with an uranium dosimeter glass, NBS-SRM612.

Recently, I.U.G.S. Subcommission on Geochronology recommended the standardization of fission-track calibration (Hurford, 1990a; 1990b). We used here calibration factors (z-values) of 370±4 for ED1 method and 372±5 for ED2, reported by Danhara *et al.* (1991) for the Rotary Specimen Rack of the reactor of St. Paul's University.

All the samples treated here contain a significant fraction of zircon grains with extremely high density of spontaneous fission tracks. These grains can easily be distinguished from the other zircon grains with low density of spontaneous tracks. In this paper, we regarded these low-density grains as essential ones and used them for dating.

We calculated the fission-track ages of both ED1 (using internal surfaces of zircon grains and external surfaces of external detectors) and ED2 (using external surfaces of both zircon grains and external detectors). The fission track data of zircon are sometimes influenced by uneven distribution of uranium within each zircon crystal (Danhara *et al.*, 1991). However, our age data show that the age values calculated from ED1 and ED2 methods are nearly equal in all samples. Therefore, we use the mean value of both ED1 and ED2 methods in each sample as a geological age estimate in this paper. The results are as follows in descending order:

Sample 004	13.6 ± 0.5 Ma
Sample 002	13.6 ± 0.7 Ma
Sample 003	12.6 ± 0.7 Ma

Table 1. Results of fission-track dating in the Tatacoa Red Member.

Sample No.	Mineral and number of crystals		Spontaneous ρ_s (cm^{-2})	(*Ns*)	Induced ρ_i (cm^{-2})	(*Ni*)	$P(\chi^2)$ (%)	Dosimeter ρ_d (10^4/cm^2)	(*Nd*)	*r*	*U*	Age±1σ (Ma)	method
002	zircon	28	2.74×10^6	666	3.02×10^6	734	46	8.34	1241	0.616	288	14.1±0.9	ED1
002	zircon	30	8.44×10^5	252	2.08×10^6	252	>99	8.58	1270	0.824	162	12.9±1.0	ED2
												Mean 13.6±0.7	
003	zircon	30	2.36×10^6	1598	2.93×10^6	1981	9	8.41	1244	0.670	280	12.5±0.6	ED1
003	zircon	30	7.70×10^5	383	1.91×10^6	950	38	8.59	1270	0.238	178	12.9±0.9	ED2
												Mean 12.6±0.5	
004	zircon	30	2.49×10^6	2403	2.79×10^6	2698	<1	8.43	1247	0.819	266	13.9±0.6	ED1
004	zircon	30	8.41×10^5	459	2.06×10^6	1126	76	8.59	1270	0.749	193	13.0±0.8	ED2
												Mean 13.6±0.5	

(1) ρ and *N* are the density and the total number of fission tracks counted, respectively.

(2) Analyses were made by the external method using geometry factors of 0.5 and 1 for $2\pi/4\pi$ (ED1) and $2\pi/2\pi$ (ED2), respectively.

(3) Ages were calculated using a dosimeter glass SRM612 and age calibration factors ζ(ED1) = 370±4 and ζ(ED2) = 372±5.

(4) $P(\chi^2)$ is the probability of obtaining the χ^2-value for ν degrees of freedom (where ν=number of crystals-1).

(5) *r* is the correlation coefficient between ρ_s and ρ_i.

(6) *U* is uranium content.

(7) Samples were irradiated using TRIGA MARK II nuclear reactor of St. Paul's University (Rikkyo Daigaku), Japan.

DISCUSSION

The resulting three ages, indicating Middle Miocene age by the fission-track method, are nearly identical. Takemura and Danhara (1985) reported fission-track ages from three horizons in the Villavieja Formation. Sample LV 13 with an age of 15.7±1.1 Ma was taken from the Los Mangos Red Member and Samples KS 4 and LV8 with respective ages of 14.6±1.1 Ma and 16.1±0.9 Ma were from the Molina Member of Takai *et al.* (1992). Although these age values seem to be somewhat older than the ages obtained in this paper, all the ages are similar considering their errors.

The fission track ages in this paper were obtained from samples of tuffaceous sandstone or mudstone. The zircon grains within these samples had been more or less transported from their origins and sedimented in the La Venta badlands. Therefore, the geological age of the sedimentation of the Tatacoa Red Member should be somewhat younger than the fission track ages.

Takemura and Danhara (1983) dated pumices in volcanic sediments from the Gigante Formation and reported fission track ages of 7.1±0.7 Ma and 7.8±0.5 Ma. The difference of these two values corresponds to two possible ways of grouping the grain-by-grain ages within the sample. These two values are nearly equal and are concordant with the age of the Gigante Formation (8.5±0.4 Ma) reported by Van Houten (1976) using the K-Ar method. Because the Gigante Formation unconformably overlies the Honda Group (Takemura, 1983), the geological age of the Honda Group is older than the ages obtained from the Gigante Formation of Late Miocene age.

Several stratigraphic studies were made on the Honda Group in the La Venta badlands (Fields, 1959; Van Houten and Travis,1968; Wellman, 1970; Takai and Setoguchi, 1990; Takai *et al.*, 1992). According to these studies, neither unconformities nor distinct facies changes occur within the Honda Group in this area. Therefore, no large time-gap should exist within the Honda Group, and the geological age of the Villavieja Formation can be regarded as Middle Miocene (Berrgren *et al.*, 1985; Harland *et al.*, 1990).

ACKNOWLEDGMENTS

We thank Mr. Hiroyuki Maeda of Department of Geology and Mineralogy, Faculty of Science, Kyoto University for his help in sampling and panning in Villavieja. We also thank Dr. Masao Kasuya of Kyoto Fission-Track Ltd. for critically reading the manuscript and Dr. Keiji Takemura for valuable discussion and comments.

The first author especially thanks Prof. Akira Tokuyama, Associate Prof. Toshiharu Nishimura and Dr. Yasuhiro Shibue for their assistance to carry out this study.

REFERENCES

Berrgren, W. A., Kent, D. V. and Van Couvering, J. A. (1985): The Neogene: Part 2. Neogene geochronology and chronostratigraphy. In (Snelling, N. J., ed.) *Geochronology and the geological record, Geol. Soc. London, Spec. Paper*, pp. 211-260.

Danhara, T., Kasuya, M., Iwano, H. and Yamashita, T. (1991): Fission-track age calibration using internal and external surfaces of zircon. *Jour. Geol. Soc. Japan*, **97**, 977-985.

Fields, F. W. (1959): Geology of the La Venta Badlands, Colombia, South America. *Univ. Calif. Publ. Geol. Sci.*, **32**, 405-444.

Harland, W. B., Armstrong, R. L., Cox, A. V., Craig, L. E., Smith, A. G. and Smith, D. G. (1990): A geologic time scale 1989. *Cambridge Univ. Press*, pp263.

Hurford, A. J. (1990a): Standardization of fission track dating calibration: Recommendation by the Fission Track Working Group of the I.U.G.S. Subcommision on Geochronology. *Chem. Geol.*, **80,** 171-178.

Hurford, A. J. (1990b): International Union of Geological Sciences Subcommision on Geochronology recommendation for the standardization of fission track dating calibration and data reporting. *Nucl. Tracks Radiat. Meas.*, **17,** 233-236.

Marshall, L. G., Pascual, R., Curtis, G. H. and Drake, R. E. (1977): South American geochronology: Radiometric time scale for Middle to Late Tertiary mammal-bearing horizons in Patagonia. *Science*, **195,** 1325-1328.

Stirton, R. A. (1951): Ceboid monkeys from the Miocene of Colombia. *Univ. Calif. Publ. Geol. Sci.*, **28,** 315-356.

Takai, M. and Setoguchi, T. (1990): Geology and localities of monkey fossils in the La Venta Badlands, Colombia, South America. *Kyoto Univ. Overseas Res. Rep. New World Monkeys, Kyoto Univ. Primate Res. Inst.*, **7,** 1-7.

Takai, M., Takemura, K., Takemura, A., Villarroel, C., Hayashida, A., Danhara, T., Ohno, T., Franco, R., Setoguchi, T. and Nogami, Y. (1992): Geology of La Venta, Colombia, South America. *ibid.*, **8,** 1-17.

Takemura, K. (1983): Geology of the east side hills of the Rio Magdalena from Neiva to Villavieja, Colombia. *ibid.*, **3,** 19-28.

Takemura, K. and Danhara, T. (1983): Fission-track age of pumices included in the Gigante Formation, North of Neiva, Colombia. *ibid.*, **3,** 13-15.

Takemura, K. and Danhara, T. (1985): Fission-track dating of the upper part of Miocene Honda Group in La Venta Badlands, Colombia. *ibid.*, **5,** 31-38.

Van Houten, F. B. (1976): Late Cenozoic volcaniclastic deposits, Andean foredeep, Colombia. *Geol. Soc. Am. Bull,* pp481-495.

Van Houten, F. B. and Travis, R. B. (1968): Cenozoic deposits, Upper Magdalena Valley, Colombia. *Am. Assoc. Petr. Geol. Bull.*, **52,** 675-702.

Wellman, S. S. (1970): Stratigraphy and petrology of the nonmarine Honda Group (Miocene), Upper Magdalena Valley, Colombia. *Geol. Soc. Am. Bull.*, **81,** 2353-2374.