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Three dimensional representation of the dinosaur footprint by the method of moiré topography

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I. Introduction

The dinosaur footprints had been represented usually by the hand-writing sketch based on the observation by naked eyes, and camera pictures. But there were some problems at the following points.

Sketches : i) The boundaries between "the footprint" and "the normal surface of bedding plane" are not always clear. Generally the margin of footprint is determined at the remarkable turning point of the surface inclination by naked eyes. But, since sometimes it changes gradually,the determination of the observer is more or less subjective.

ii) It is easy to show with sketches in case of the clear change, but difficult show in case of the gradual change. Especially hand writing sketches cannot present the depth and complicated surface structures of footprint exactly.

iii) Among the literatures of footprint, we often find inadequate figures which had been done only by outline sketches. From them we cannot understand the inside relief of the footprint. So it leads into troubles when we compare the materials.

Photographs : i) Camera pictures taken under the inappropriate light conditions are of less value. Especially, the condition which makes no shade doesn't show any relief.

ii) Even the pictures taken under the dark conditions with artificial light from oblique angles are not always sufficient. Because it makes too brilliant and too dark parts especially in the caes of big footprints like that of dinosaurs.

To avoid these problems, it is desirable to show precise sketches illustrating surface morphology and two or three photographs taken under the different oblique light angles. And stereo photograph is excellent to show more realistic morphology.

But anyway we cannot have numerical data aboutthe depth of footprint from these methods, and they have a critical defect for the representation of big and deep footprint.

It is possible to get the numerical topographic data from stereo photograph, however it needs expensive fund and full time to use special apparatus. Especially, it is physically very difficult to take numerical data on the specimens or replicas of big footprints in the field. It is desirable to establish a new method for the three dimensional representation of specimens, which is possible to apply during the fieldwork.

The writer found that the method of moiré topography is suitable for his aim, and he tried to apply it for the description of the dinosaur footprint.

II. Moiré topography

Moiré topography is the three dimensional representation method using interference fringes of light. Its optical theory has been explained by Takasaki (1970 ; 1971 ; 1972 ; 1973 a ; b) and Meadows et al. (1970). And its geometro-optical theory and equipments were presented by Terada (1973) and Ikeda (1976).

Using this method, we can project the contour-like fringes on the surface of the object materials. From this projection we can get the numerical and topographical data about the relief of object. Moiré picture provides three dimensional information on the one piece of photographic paper. Therefore it is easy to reccord and to preserve the data.

石垣　忍・藤崎年英：モアレ法による恐竜足痕の三次元的記載

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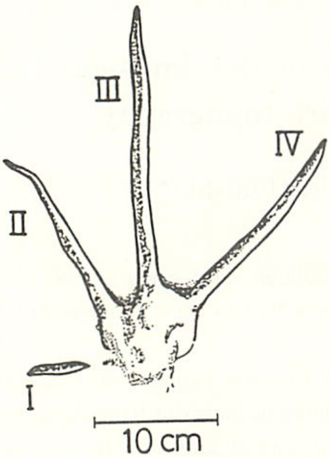

Textfig. 1 Hand-writing sketch of positive replica of coelurosaurian footprint.

Nowadays, this method has been applying in the field of anthropology, medicine and textile designing.

Fujisaki et al. (1982) described a thchnique of computerized data analysis and processing of moiré picture. With this technique, we can get a bird's-eye view of footprint directly from moiré picture.

III. Material and method of representation

The specimens of dinosaur footprint which we use in this experiment are the positive plaster replica and nagative plastic replica of coelurosaurian footprint taken from tidal flat deposit of the Lower Jurassic (Pliensbachien) in the Central High Atlas Mountains, Morocco. The locality is two kilometers east of Ait Bial village (co-ordinates of moroccan topographic map ; X : 376.9, Y : 122.1).

The original footprint was discovered by J. Jenny (Jenny & Jossen, 1982) and original positive plaster mold was taken by A. Laaroussi and one of the authors (Ishigaki, 1985 MS).

The hand-writing sketch of positive replica (Textfig. 1) shows the general feature of this footprint. It is the left hind footprint with four slender digits (I, II, III, IV). The animal is bipedal. There is no trace of tail. The length from heel to the top of digit III is 30 cm. Digit III is the longest and digit I is the shortest. Digit I is abducted medially. Pharangeal pads are not recognizable. Length of digit I, II, III, IV are respectively 5, 18, 26, 20 cm. Pace : 74 cm. Stride : 146 cm. Pace angle : 162°. Angle between digit I & II : 66°, II & III : 28°, III & IV : 44°. The digit impression makes sharp and narrow shape which might be the result of the diagenetical deformation of mother rocks. We used two replicas (negative and positive) casted from one original replica.

i) Camera pictures (Pl. I, Figs. 1, 2) are taken in the different oblique light angles using negative replica. Fig. 4 and Fig. 5 are of positive one. Black arrows in each figure show the lighting directions.

ii) Fig. 3 and Fig. 6 are moiré pictures of negative replica (Fig. 3) and of positive one (Fig. 6). The contour-like fringe line runs every 6 mm.

iii) Textfig. 2 and Textfig. 3 show the three dimensional plot a footprint measured by the automatic computer analysis system. They show the positive form but they are reconstructed directly from the moiré picture of negative replica (PI. 1, Fig. 3).

IV. Discussion and conclusion

The hand-writing sketch (Textfig. 1) shows the general image of the footprint. But this kind of representation is more or less subjective. Moreover it is difficult to show the depth and surface structure of the "heel". And the marginal part of the base of digits is also hard to describe.

Camera pictures (Pl. I, Figs. 1, 2, 4, 5) taken by the adequate light are helpful to understand the relief, however these images are variable depending on the light angles and on the types of replicas (positive or negative). And we cannot get the precise information about the depth.

On the contrary moiré picture can improve these defects. From its contour-like fringes, we can get the numerical informations about the depth, and we can also understand the real relief of the surface. Conserning the writer's material, he got the following data on the depth and the surface characters.

(1) The depth of the deepest point of this footprint is a little over than 3 cm.

(2) The surfaces between the digits (II & III, III & IV) inclines gradually down to the heel.

(3) We can get profiles wherever we want. The valley-like shape of profiles of digit III and digit IV are not symmetrical as shown in Textfigs. 2 and 3.

Meanwhile three dimensional plot of a footprint

(Textfigs. 2 & 3) shows the overlook images of the footprint. Using this method, we can makepositive view out of moiré picture of negative replica.

In this way, we can provide more accurate informations by using moiré picture together with sketches and normal camera pictures.

V. Prospect for the future and Acknowledgement

We took these moiré pictures in the laboratory. To apply this method during the fieldwork, we must take the picture of objective material over which we project the gratings (like Textfig. 3). Having another standard gratings over the picture, it is able to produce moiré fringes. The writer considers that he should develop this method in order to solve the physical and financial difficulties in case of footprint molding.

To take the moiré picture in this study, we used the laboratory of Kyoto Women's University. We would like to state sincere thanks to Professors Sachiyo Doi and Yayoi Fukui for their kind permission of using the apparatus and for their useful helps.

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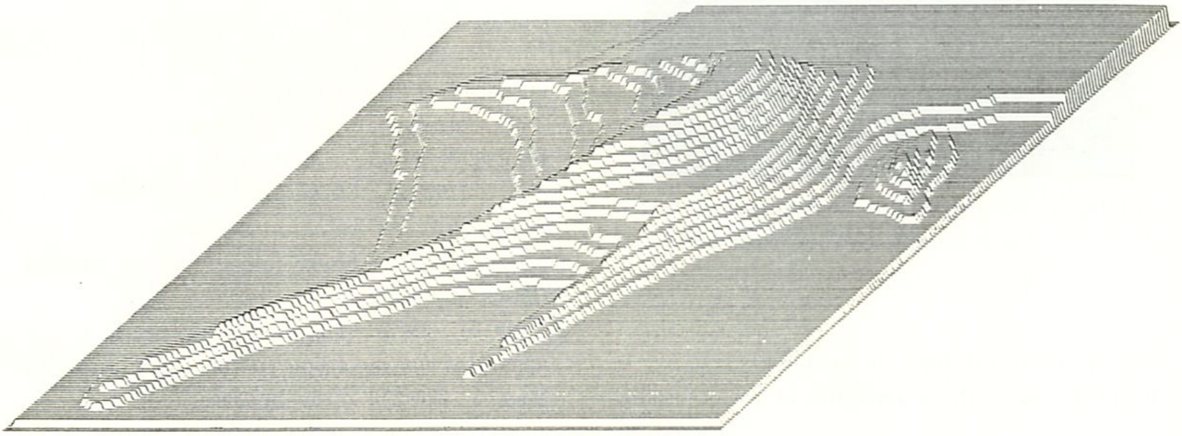
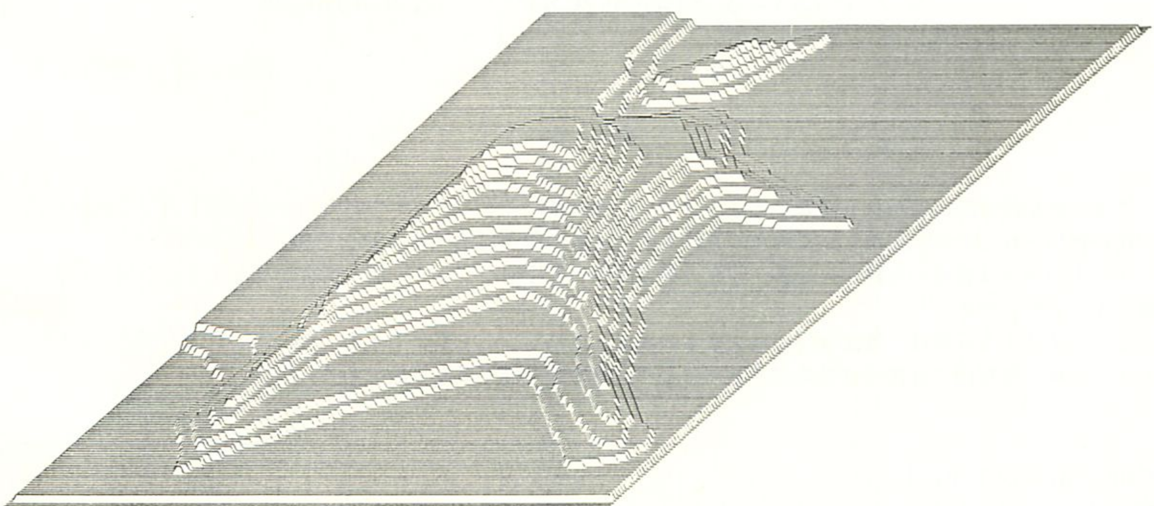
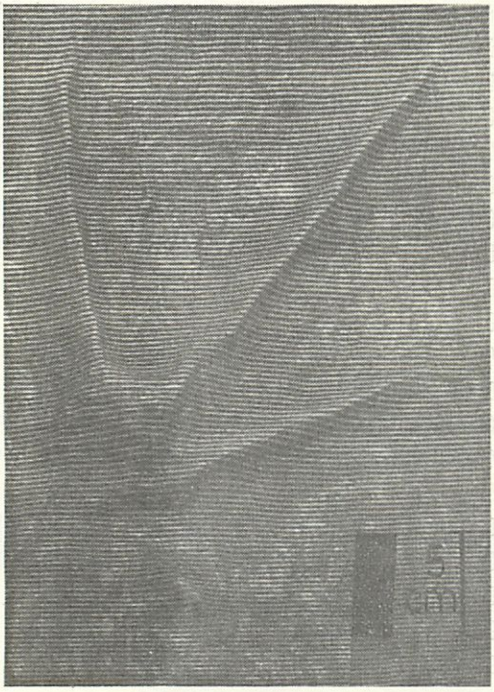




Textfig. 2 (upper) & 3 (lower) Three dimensional plot of the footprint measured by the automatic computer analysis system.



Textfig. 4 An example of the deformed grating of the footprint. Grating runs every 2.3 mm.

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モアレ法による恐竜足痕の三次元的記載

石垣　忍・藤崎年英

(要　旨)

恐竜足痕記載の際に使われる図としては，従来，肉眼観察によるスケッチや斜方向から光線をあてて撮影した写真が利用されてきた。しかし，これらの方法では，足跡の深さに関する正確な情報が得られない事をはじめ，スケッチの場合は著者の主観が入る事，写真の場合は光の条件等によって一部の構造が見落とされる場合がある事，などの欠点があった。

モアレ法による写真は，等高線様の縞を標本の表面に直接写しだす事ができるので，この欠点を補える。また，モアレ写真を電算機で直接に自動処理する事により，俯瞰図を描く事も可能である。

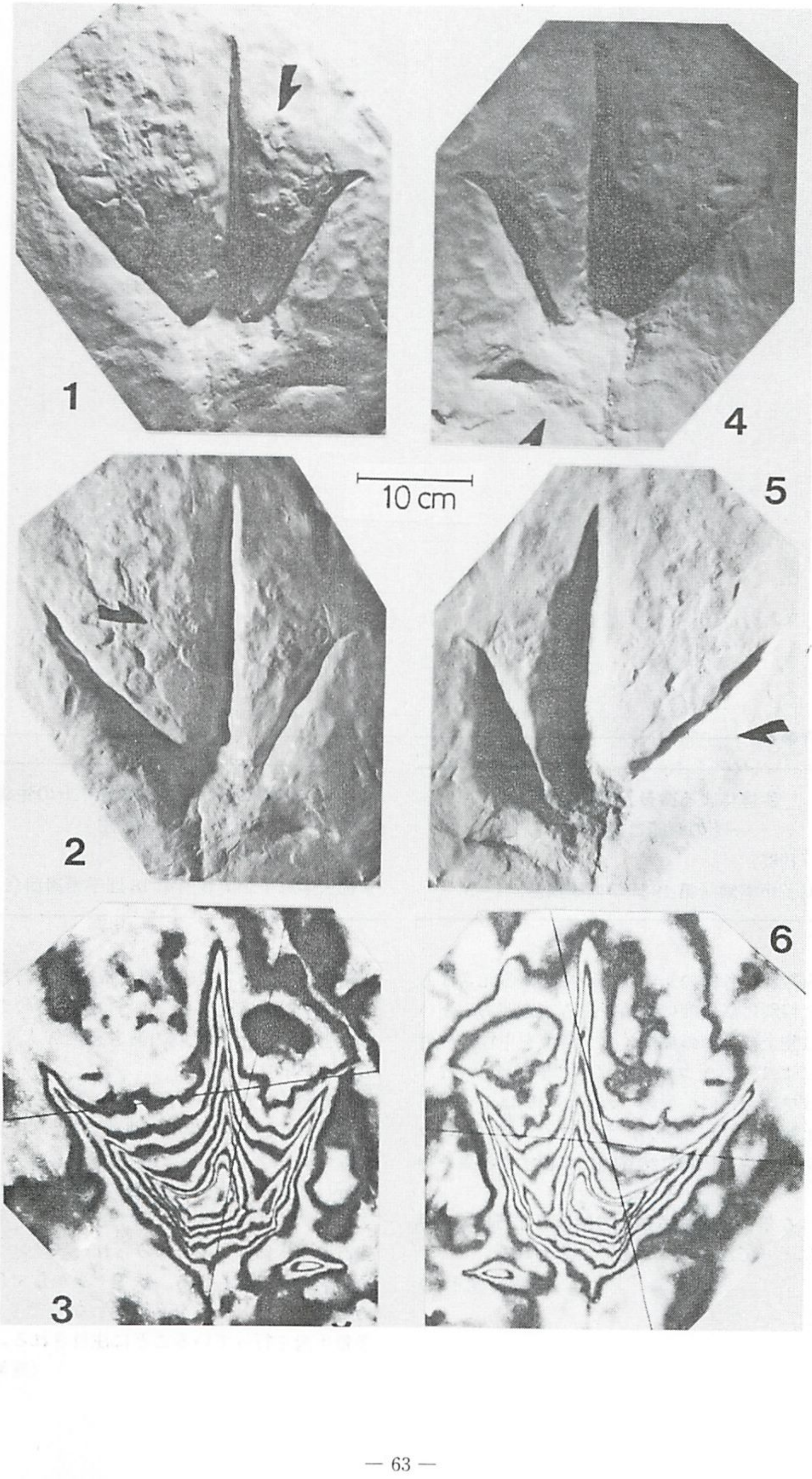
Explanation of Plate I

Figs. 1 & 2 Normal camera pictures of the negative replica using the oblique lighting.

Fig. 3 Moiré picture of the negative replica.

Figs. 4 & 5 Normal camera pictures of the positive replica using the oblique lighting.

Fig. 6 Moiré picture of the positive replica.


1
4
10 cm
5
2
6
3

◆論文紹介◆◆

生体による微量元素の濃縮 ―その機能と役割―

小山睦夫（1985）
京都大学原子炉実験所第19回学術講演会，1－5

生体にみられる各種の元素のなかで，ある元素はある生物種に特別に高濃度に蓄積されることがあるという。著者は陸上植物中の無機イオン濃度を中性子放射化分析法により調べ，コバルトはトウダイグサ科に，マンガンはウコギ科に，亜鉛―カドミウムはモチノキ科に，希土類元素，バリウム，ラジウム，アクチニウムはウラジロ科シダ植物に特異的に集積する結果を得ている。

このような事実は食物連鎖との関連で化石中の元素分析研究にとって注目すべきものと思われる。

（寒河江登志朗）

生物におけるマグネタイトの生成とその利用

溝田　学，前田　豊（1984）
京都大学原子炉実験所第18回学術講演会，47－52

磁気バクテリアの磁気感応機構は体内のマグネタイトが単一磁区構造をもつことによるものであり，粒子の大きさは1 μm程度の最も合理的大きさと形をもつことを示した。

一方ヒザラガイの“歯”のマグネタイトは食行動に利用されており，“歯”の先端に近づくほど酸化がすすみマグヘマイト（$\gamma-Fe_2O_3$）へ変わる。歯の酸化と並行して帯磁性物質の蓄積が始まるが，これと同じメスバウアースペクトルを示すものがマグネタイトを作る直前の未熟な“歯”にみられ，鉄タンパク（フェリティン）と考えられる。鉄ミセルからマグネタイトへの変換を高温・高圧を必要としないで1日数μgもの多量生産を行っていることに注目される。

（寒河江登志朗）