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# Description of some titanosaurian bones from the Senonian of Lower Laos

by  
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In two previous writings (1) I treated the stratigraphy of the Senonian of Lower Laos and the brackish-water lamellibranch fauna of these terrains (2). The opposing note treated the *saurischians* or *sauripelvians* of these same terrains, it will be followed by a second note on the other vertebrates, the *ornithischians* or *avipelvians*, the *turtles*, and the *fishes*.

## History and excavations

It was in 1936, while excavating a trigonoid locality, that I put my hand on a small caudal vertebra from a saurian. Awakened by this discovery, the locals who had well seen similar bones, but attributed them to buffaloes, showed me the areas where they believed they had recognized some. Many were the unfruitful routes that I took in the

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(1) a) Les Lamellibranches saum tres du S enonien de Muong-Phalane (Bas-Laos), *Bull. Serv. G ol. Indochine*, vol. XXIV, fasc. 1, Hanoi, 1937.

b) Note sur la G ologie du Bas-Laos, *Bull. du Serv. G ol. Indochine*, vol. XXIV, fasc. 2, Hanoi, 1937.

(2) M. R. MERCIER, Chief of Practical Work at the Mus e Louis Finot directed with rare competence the repair of the large femur from Muong Phalane and the creation of its molding.

Mr. Professor P. HUARD, director of the Institut d'Anatomie in Hanoi, developed the radiographs of the femoral heads, and allowed me to profit from his osteological knowledge and his library.

Baron F. v. HUENE, creator of the genus *Titanosaurus* and author of the descriptions of the titanosaurids from South America and British India, offered a sharp interest to this work.

They are all cordially thanked.

clear forest under the burning sun of Lower Laos often to find only an indeterminate stone that had a vague resemblance to a bone. Sometimes the indications were correct, I found there a saurischian femur, there a vertebra or a fragment of *hadrosaur* femur. I sought in vain around, dug, traversed the village in all directions, and I never saw, within a radius of 40 km, two connected pieces. Thus after 15 days of searching I took a hundred kilograms of bones, the majority entirely silicified belonging to three different animals. While returning two years later I had the happiness to find a complete femur of a *titanosaur*, unfortunately damaged by a tree that had taken root in its center; 4 km from there the base of a femur, 10 km farther a femoral head. Then a sensation indication: 50 km south of Muong Phalane a cluster of bones whose description by the locals seemed to correspond well to something serious. The following day I was en route. At the last village preceding the locality one refused to lead me to it. The bones belonged to the genies and unfortunately to whomever would remove them. After an entire day of palaver a variable price was concluded according to the importance of the fossils with furthermore the offer of a buffalo that would be sacrificed to expiate my sacrilege. We left the village early the next morning. I was led to find the remains of an entire animal. Which was not my disappointment in seeing, after four hours' march, that my bones were only limestones bizarrely sculpted by water. This unfruitful course had all the same the immense advantage of permitting me to discover on the return way a rocky nipple covered with vertebrae, scapulae, etc., whose density was relatively great, although the pieces there were not more than 2 meters one to another. A locality excavation method was undertaken in February 1939 and produced some teeth, two avipelvian pelves, and some remains of turtles and fishes.

The copy below indicates the arrangement of the main *sauripelvian* elements found in Lower Laos.

The state of preservation of the samples varies according to whether they are enclosed in sandstone or in the red terrain. In the first case they are entirely silicified, but rough, the periosteum having disappeared; in the red terrain, by contrast, the bones, equally silicified, preserved their periosteum, but are much more fragile. Often they are found at the surface of the soil as relics of the destruction of the rock, they then suffered

much the injury of time, in particular the heat. The best preservation is evidently that of the red terrain not yet destroyed. These areas are rare, I have encountered one of them.

The impression that remains of the collection on the ground is that the skeletons were dismantled in a sea or very small lagoon agitated not enough to reduce them, but sufficient however to disperse them.

Below will be found the description of the fragments found.

**Order SAURISCHIA, v. HUENE (or Sauripelvians)**

**Suborder Sauropoda, Marsh.**

**Family Titanosauridae v. Huene**

**Genus *Titanosaurus* Lydekker**

***TITANOSAURUS FALLOTI*, sp. n.**

*Femur T.1. from Muong Phalane (fig. 1).* — This complete femur was discovered in 1938 3 km from Muong Phalane. Only the two distal ends were left in the ground, between them had grown a tree (*Erytroxylon*) with knotty, but shallow, roots. The rootlets had penetrated the body of the bone, having made it burst and made it extremely fragile. Superficially released, the bone was drawn, photographed, and measured. The femur was then disengaged underneath and its central part wrapped in plaster bandages and supported with sticks. I thus hoped to be able to transport this fossil whole to Hanoi. By raising it, it was broken unfortunately into three along not very clear breaks, the periosteum was fractured into a multitude of parallelograms that were impossible to assemble, from the voids between the different parts. Nevertheless the dimensions were not distorted at the time of its reconstruction thanks to the marvelously well-preserved spongy tissue, the measurements and drawings taken at the time of its superficial disengagement.

By fossilization the bone was considerably flattened and thus partially deformed. This is a right femur. Its dimensions are as follows:

Length..... 175 cm

Proximal end to the greater trochanter.....	82
Proximal width.....	74
Width at the height of the greater trochanter.....	45.5
Width at the lower half.....	34
Distal width.....	61
Distance from the 4th trochanter to the proximal end.....	74
Distance from the 4th trochanter to the distal end.....	107
Angle between the distal end, the greater trochanter, and the 4th trochanter.....	60°

This bone, in spite of its length, is robust and heavy, the flattening due to crushing of the central part is partly responsible. It is straight and has a wide and strongly rounded head that is notably isolated from the axis. At its external part a depression separates the head from the greater trochanter. The upper part of the head is widely rounded, slightly flattened, and passes undetectably to the lateral sides. The projections indicating the insertions of the iliofemoralis and femorotibialis muscles are not visible.

The greater trochanter forms a very clear prominence near the exterior edge.

The 4th trochanter is damaged by the accident related above, it formed a slight prominence on the internal edge of the bone following an angle of about 60° with the greater trochanter and the articular end of the head. It was very effaced.

The sides are smooth, one sees on the anterior face a slight projection that leaves from the head and is continued until below the middle of the bone where it gives off a flat furrow that passes between the anterior condyles. These condyles are very weak, compared to the posterior condyles whose development is considerable. The tibial condyle forms a large connected protuberance, while the straighter fibular condyle is separated from the body of the distal end by a furrow. The flattening has slightly displaced these condyles. We will see their normal arrangement in femur T.5 found a little farther north of Muong Phalane.

This femur is in a relatively good state of preservation. It shows the periosteum and the spongy tissue of the interior. The microscope easily detects there the Haversian systems and bony cellules.

*Relations and differences.* — This bone exceeds in length the titanosaur femora known of which the largest is *Titanosaurus indicus*, LYDEKKER found at Silondi and whose size was around 152 cm.

The very marked prominence of the greater trochanter, the nearly complete obliteration of the fourth trochanter, the depression of the head above the greater trochanter, the low slenderness of the bone, the angle formed by a line connecting the end of the head, the greater trochanter, and the fourth trochanter that is about  $60^\circ$ , are as much characters that remove this bone from the genera *Laplatasaurus*, *Argyrosaurus*, *Antarctosaurus*, and those brought together in the genus *Titanosaurus* sensu stricto.

If I remove our femur from *Titanosaurus robustus*, v. HUENE, this is because of its more slender general form, its greater major angle, the weaker depression of the head above the greater trochanter, and because of its size. From *Titanosaurus australis*, LYDEKKER it is removed by the lesser development of the fourth trochanter and the presence of the depression of the head above the greater trochanter. The size of *Titanosaurus australis* does not exceed 70 cm. The size of the complete long bones in vertebrates seems to me a peremptory argument, the articulations are only preserved during fossilization in the adult when fusion is complete.

It is with *Titanosaurus indicus*, LYDEKKER, that the resemblance is greatest. The size of C. A. MATLEY's specimen only differs by a dozen centimeters. The trochanter itself, by contrast, is less prominent and less pointed. The tightening of the base seems less pronounced in *Titanosaurus indicus*. The bone being unfortunately too incomplete, the comparison cannot be taken further. LYDEKKER's type, much smaller, is still more slender.

These differences, admittedly subtle, seem to me however to justify the creation of a new species that I dedicate to my master PAUL FALLOT, professor at the Collège de France.

*Femur T.5.* (fig. 2). — This bone was found 6 km farther north than the femur from Muong Phalane. It is the base of a right femur, undeformed by compression, but whose periosteum has disappeared.

The dimensions are as follows:

Width of the proximal part.....	46 cm
Width of the tibial condyle.....	13
Width of the fibular condyle.....	13
Minimum thickness of the intercondylar part.....	9

The tibial condyle widely exceeds the fibular condyle. The intercondylar furrow is deep, the anterior furrow is wide and flat. If we disregard the deformation of the large femur T.1., the two bones are identical.

*Femur T.2.* and *T.3.* — They are femoral heads of which T.2. was originally taken for a fragment of ilium. It is about this that the radiographs were made to realize the internal architecture of this bone. The result was unfortunately negative. The bones T.2 and T.3 were thus sawn at the same height and polished; in both cases the structure was shown to be identical, with very developed spongy tissue, enclosed by a periosteum. The bone T.2 is slightly flattened. There are many femoral heads that, by their shape, are referable to *Titanosaurus falloti* n. sp.

By comparison with saurians whose whole skeleton is known, the species from Muong Phalane is classified among the largest and must have been more than 22 m long, between 5 and 6 m tall.

### ***TITANOSAURUS* sp.**

I still attribute to this genus, however without having referred them to a known species, a certain number of bony fragments too incomplete to permit measurements.

a) Tooth. Among the numerous bones of *ornithischians* collected in locality T.4 which represented a beach, on which the bones were rounded, all aligned north-south, is

found a fragment of a tubular tooth 9 mm in diameter undoubtedly belonging to a *titanosaurian*.

b) It is still to this genus that is referred a very incomplete humeral head recovered in the environs of Ban Na Pho. This fragment resembles part of a funnel.

c) I refer a fragment of a bone, 70 cm long, incomplete at its distal part and whose proximal part has a flattened oval cross-section, 23.5 cm wide and hollowed in its center, to a scapula of a *titanosaur*.

d) Among the numerous vertebrae that I possess there is only one that could be referred to a caudal vertebra from a *titanosaur*, and yet it is amphicoelous, whereas the rule demands that they be procoelous. But this could be accidental as noted by F. v. HUENE and C. A. MATLEY (5, p. 9, fig. 3). Its dimensions are as follows:

Length of the vertebral centrum.....	15 cm
Height of the vertebral centrum at its proximal end.....	6
Width of the vertebral centrum at its proximal end.....	4.7

The specimens are repositated at the Musée du Service géologique in Hanoi.

### **Considerations on the presence of TITANOSAURS in Lower Laos**

It is known that the *titanosaurs* have a relatively large vertical extension, because they are seen from the Wealden epoch up to the Danian inclusive.

The remains of *titanosaurid* bones are found almost everywhere on Earth, in Brazil, Madagascar, India, Europe, with the exception of North America where *camarasaurids* and *diplodocids* predominate.

Those closest to Indochina are those of India where they are found in the Turonian (Jubbulpore locality) and in the lower Senonian (Pisdura locality).



In Lower Laos, the presence of *Mandchurosaurus* sp.\* undoubtedly places it in the Senonian, without it being possible to specify further.

The entirely particular living conditions of these reptiles, had with their very special conformation, bound them to lagoonal or littoral areas and made that all mountain chains, even of low altitude, and all seas of a certain width, represented for them insuperable obstacles.

We are thus forced to admit to the Upper Cretaceous a littoral continuity between India and Indochina, without speaking of other continents.

I will treat this very interesting paleogeographic question, like the connected questions that it poses, when I describe the remains of *ornithischians*, *turtles*, and *fishes* of Lower Laos.

## SUMMARY BIBLIOGRAPHY

[*Not listed.*]

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\* *sic* = *Mandschurosaurus* [MTC]

*[Accompanying map]*

Location of titanosaurid remains.

FIG. 1. — Large femur T.1. from Muong Phalane. — *a*). posterior face. *b*). interior side face. *c*). Distal end showing the condyles. The right femur bone was strongly flattened by fossilization. The hatched parts are those damaged during transport.

FIG. 2. — Distal end of the large femur T.5. 1/5. Posterior face above, distal face below. — *a*). tibial condyle. *b*). fibular condyle. Right femur.

These drawings, like those of figure 1, were drawn directly on the photograph that was then bleached with ferrocyanide potash.