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HALOSAURIDAE FROM THE CALIFORNIA TERTIARY

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ABSTRACT—While the Halosauridae are not represented in the living marine fish fauna of California, the family is fairly commonly found as fossils in Tertiary deposits. A Cretaceous form is little known and may have lived during upper Moreno time. At least two Tertiary types are identified by scales. The Halosauridae of the California Tertiary occur commonly only in deep sea deposits and would normally be found in abyssal accumulations. Climatic changes appear to have caused their extinction along the California coast.

INTRODUCTION

HALOSAURIDAE are not represented in the living marine fish fauna of California, but occur fairly commonly as fossils in Tertiary deposits of the region. This peculiar group of eel-shaped fishes with long pointed snouts is definitely restricted to the deep sea, and appears to frequent only the deeper waters of tropical to semitropical oceans. Cooling of the ocean very likely caused extinction of the group in California in Pliocene times.

Scales of Halosauridae are common in some California and Oregon beds of Oligocene, Miocene and Pliocene age. The several scale occurrences are enumerated below. As yet, skeletal remains of only two individuals are known. A complete skeleton was described (David, 1943) as *Laytonia californica*. A second specimen showing the head of a much larger fish, evidently of the same genus was found by Dr. A. J. Ousdal in the San Marcos Pass area, Santa Barbara County. Structural details of the skull, clearly discernible in the latter specimen, when compared with those of the individual described previously verify the taxonomic position of the genus. Description of this specimen and a record of the known occurrences of halosaurid scales in California are given below.

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DESCRIPTION OF MATERIAL

LAYTONIA cf. CALIFORNICA David
Text fig. 1

Type scale.—No. 10400, Calif. Inst. Tech. Vert. Paleont. Coll., 3.5 mm. long by 2 mm. deep.

Type locality.—The Union Oil Company well Stearns No. 75 at a depth of 4425 to 4435 feet, uppermost Miocene, Delmontian age. The location of the well is in Sec. 7, T. 3 S., R. 9 W., Brea Olinda Oil Field, Orange County, California.

Additional occurrences.—(1) Texas Oil Company well, Fernando No. 1, at intervals from 5615 to 5625 ft., 5728 to 5738 ft., and 5864 to 5874 ft. depth, in strata of uppermost Miocene, Delmontian age. Location of well, Sec. 11, T. 4 N., R. 17 W., Hasley Canyon, Ventura County, California. (2) Texas Oil Company well, Towle No. 1, from 4758 to 4762 ft. in depth, in lowermost Pliocene strata. The location of well is in Sec. 3, T. 3 N., R. 17 W., in Hasley Canyon. (3) General Petroleum Company well, Heath No. 1, from 9806 to 9821 ft. Location of well is in Sec. 34, T. 3 S., R. 11 W., Buena Park Field, Los Angeles County, in Repetto formation. (4) Texas Oil Company well, Spencer No. 1, Sec. 1, T. 4 S., R. 11 W., Buena Park, Los Angeles County, from 8872 to 8882 ft. in depth in the Repetto.

Description.—Several complete scales from lateral side of body, small and slender,

measuring 3.9 by 2.5; 3 by 1.9 millimeters, length to depth. Some fragments indicate larger scales, and one of these evidently from the extremity of the body is deeper than long. Basal portion of scales with four to six sharply cut folds, continuous to nucleus; nucleus more or less enlarged, depending upon extent of regeneration of scale. Basal border deeply scalloped by protruding folds which end in sharp-angled points. Dorsal and ventral sectors of scale with strong straight circuli, about 10 circuli in $\frac{4}{5}$ of a millimeter distance. Central basal folds divided by much finer transverse circuli, 11 in $\frac{1}{2}$ millimeter distance; the central circuli directed diagonally toward each other, meeting in sharp angles in the three central folds, parallel to the sharp angled basal border. Nucleus very characteristically shaped as in related living genera (see Halosaurus, Plate 23, figure 1). Nuclear area usually ovoid or eggshaped with smaller end toward apical pole; nuclear parts of scale not reached by basal folds, ornamented by fine tuberculi; nucleus dorsally and ventrally with five to six half crescent-shaped circuli-like structures surrounding the nucleus with strong curved lines. Very fine apical lines radiating from nucleus and particularly well defined at apical pole of scale. Deep scales from other parts of body are probably also present, but are too fragmentary to be described.

LAYTONIA? ZEMORRENSIS David n. sp.
Plate 23, figure 2

DAVID, 1944, p. 32, Plate III, figure 23.

Type scale.—No. 10401, Calif. Inst. Tech. Vert. Paleont. Coll., 3.8 mm. long by 3.5 mm. deep (1944, Plate III, figure 23).

Type locality.—From Texas Company well, Pioneer Unit Plan No. 1, Sec. 33, T. 11 N., R. 23 W., San Bernardino Baseline and Meridian, in the southern Sunset district, San Joaquin Valley, California, from 6228 to 6292 ft. in depth; lower Zemorrian age.

Additional occurrences.—Scales of this type occur in (1) Texas Company well Pioneer Unit Plan No. 1 from 5454 to 7304 ft. in depth in the middle to lower Zemorrian, and in well No. 2 from 10,480 to 10,498 ft., of lower Zemorrian age. (2) The Ohio Oil Company well M and M No. 1, at 5735 ft. depth, lower Zemorrian. This well is situated in Sec. 32, T. 30 S., R. 22 E, Mt. Diablo Baseline and Meridian, McKittrick District, Kern County. (3) In the Richfield Oil Company well Temblor Hills, Unit 1-1 from 6327 ft. to 6332 ft. in depth in the lower Zemorrian. The location of well is in Sec. 35,

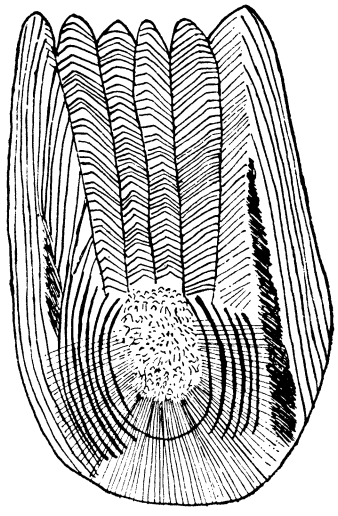

FIG. 1—*Laytonia* cf. *californica*. Scale, type specimen No. 10400 Calif. Inst. Tech. Vert. Paleont. Coll., from Union Oil Company well, Stearns No. 75, at depth from 4425 to 4435 ft.; approx. 20.

T. 31 S., R. 21 E., Mt. Diablo Baseline and Meridian, West Midway area, San Luis Obispo County. (4) Scales possibly of the same species were found in the Lower Bassendorf shale near Coos Bay in southern Oregon. These outcrops are of Oligocene (lowermost Refugian) age.

Description.—Medium sized scales, majority elongate: 6 by 3.7, 5.2 by 4.5, 5 by 4.1, 5 by 3.5, 5.1 by 2.7, 4.2 by 2.5, 3.8 by 3.1, 3.1 by 3 millimeters, length by depth. Some scales are wide: 4.1 by 4.9, 4.1 by 4.8, 4.1 by 4.6 millimeters, length by depth. Elongate scales with five to eight or nine sharply cut basal folds in basal portion, continuous to nucleus in most scales (figure 23, Plate III, David, 1944); regenerated scales with smooth area surrounding enlarged nucleus are rare. Basal folds slightly protruding beyond basal border, their protruding ends evenly rounded; basal border often diagonal, higher

toward dorsal or ventral border. Dorsal and ventral sectors of scale with strong straight circuli about 20 in 1 mm. distance; these much coarser in regenerated scales with 16 to 17 in 1 mm. distance near apical ventral border; a larger number sometimes occurs.

Central basal folds divided by transverse circuli, which are not much finer than vertical ones, about 20 in 1 mm. distance. Transverse circuli more or less evenly rounded in elongate scales and parallel to their basal border, angled at least in some of the wider scales. Nucleus as in scales of related forms (*Halosaurus*, Plate 23, figure 1), small ovoid or eggshaped with six or seven strengthened and coarse circuli surrounding its apical portion in curved lines. Very fine apical structures radiating from nucleus and crossing circuli. Wider or deeper scales often regenerated (Plate 23, figure 2) with enlarged smooth area surrounding nucleus, coarse vertical circuli in apical portion, these becoming finer toward basal border, coarseness of circuli varying according to degree of regeneration. Transverse circuli dividing basal folds are angled at least in the most apical portion of scale, and there separated from each other, five to six in 0.4 mm. Circuli near basal border rounded and more crowded. Large nucleus of scale figured in Plate 23, figure 2 surrounded by coarse and strengthened circuli and showing typical apical structure of fine radiating lines.

Relationships of species.—The type specimen of *Laytonia californica*, No. 10227 Calif. Inst. Tech. Vert. Paleont. Coll., is covered with scales; these are of about the same size and general structure as the scales described above as *Laytonia* cf. *californica*. The scales on the specimen overlap each other. Not all the structural details can be discerned, but there is every indication that the scales found in the well cores represent the same species as *Laytonia californica* from the lower Modelo of the Santa Monica Mountains. The small scales show very characteristically the halosaurid structure with typical large, ovoid, smooth nucleus surrounded by strong curved circuli and with fine radiating apical lines, the strong straight circuli in dorsal and ventral sectors, and sharp central basal folds. There can be no doubt that the fossil scales belong to the Halosauridae, and to a genus nearly related to living forms. It is characterized by comparatively few central folds, which are pointed at their basal ends, protruding considerably beyond the basal border; the transverse circuli that divide the central folds are also acutely angular. The Recent *Halosaurus* scale (Plate 23, figure 1) has circuli and basal ends of the central folds evenly rounded. The folds are more numerous than in the fossil scale, and the basal border is more or less straight. Other genera, as for instance *Halosaurichthys*, have central folds and transverse circuli much more acutely pointed than the fossil; the Recent form differs likewise in the irregular outline of its scales with central part of scale protruding beyond dorsal and ventral parts, or with its contour angled in various ways. The scale of *L.* cf. *californica* can therefore not be identified with any one of the living genera, even though it is nearly related. There is no similarity to scales of the Nothacantidae, a family that is thought to be related to the Halosauridae. The small scales of the Nothacantidae show an entirely different structure. The fossil skeleton with which *Laytonia* cf. *californica* is tentatively identified also shows definite differences from living genera.

The type of scale referred to *Laytonia* cf. *californica* is found in the uppermost Miocene (Delmontian) and in the lower Pliocene (Repetto, lower Pico). The skeleton occurred in the upper Miocene (lower Mohnian), slightly lower in the section than the strata containing the scales. Skeletal re-

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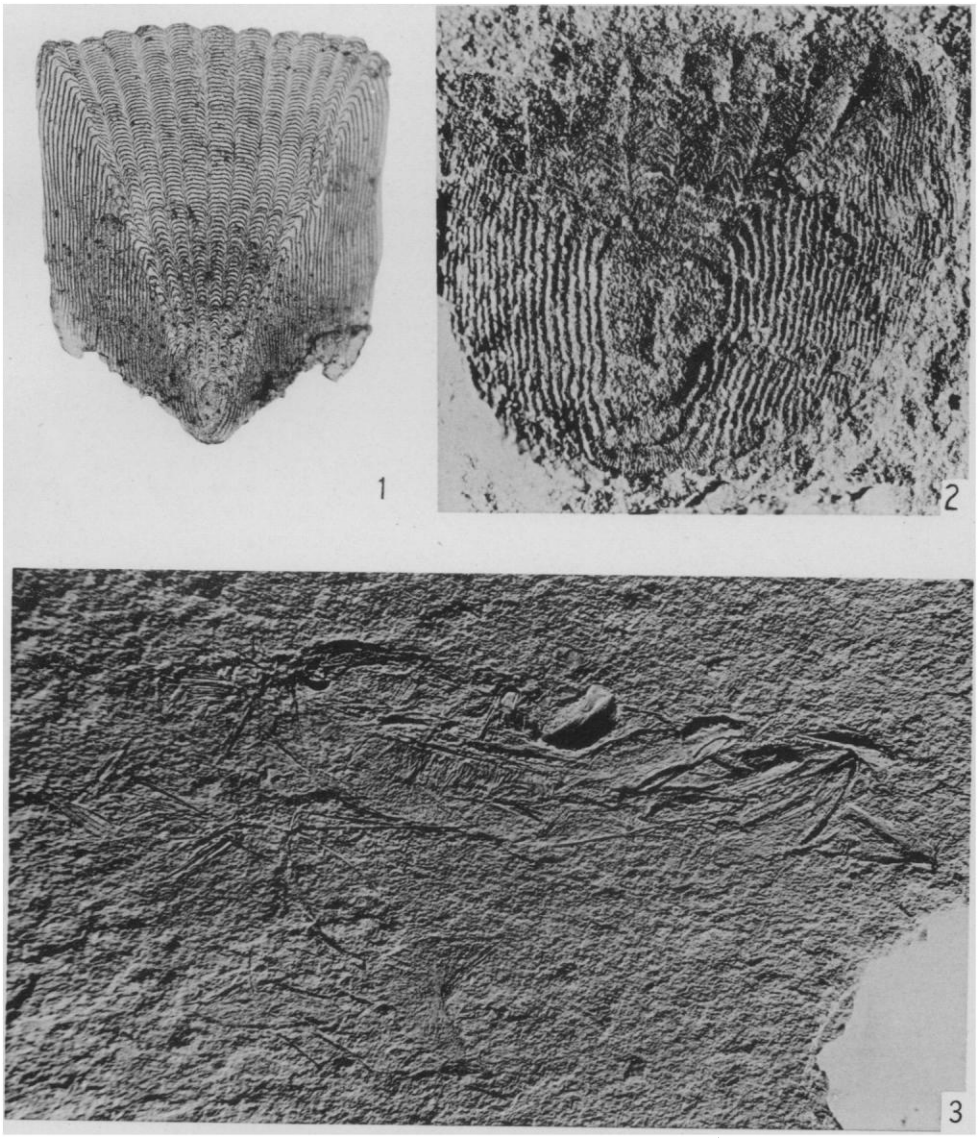
EXPLANATION OF PLATE 23

FIG. *1*—*Halosaurus oweni* Johnson. Lateral scale from fish caught off Cape May, New Jersey, and collected by S. S. *Albatross;* ×12⅔.

2—*Laytonia zemorrensis* n. sp. Scale from Texas Company well, Pioneer Unit Plan, at depth from 10480 to 10498 ft.; ×19.

3—*Laytonia* cf. *californica*. Skull, No. 10399 Calif. Inst. Tech. Vert. Paleont. Coll., from near summit of San Marcos Pass, Santa Barbara County; ×1⅔.



David, California Tertiary Halosauridae

mains of the species are rare in the deposits that accumulated during lower Mohnian time. If the skeleton and scales represent the same species, *L. californica* ranges through the upper Miocene to the lower Pliocene. The second species described above, *Laytonia? zemorrensis*, occurs with considerably larger scales. Its general structure is very similar to that of *L.* cf. *californica* and shows the characters of the family Halosauridae to which it undoubtedly belongs. This species, however, has more evenly rounded transverse circuli, the basal ends of the central folds are rounded and the basal border is straight and slightly scalloped. In these characters the form may resemble *Halosaurus* more closely. The average number of folds in *L.? zemorrensis* is larger than in *L.* cf. *californica*, but the folds are by no means so numerous as in Recent *Halosaurus*. The basal border of the fossil scale often has a diagonal position, and the dorsal border is higher than the ventral border. Transverse circuli are not evenly rounded as in Recent scales. *L.? zemorrensis* is abundant in the lower Miocene or Oligocene (Zemorrian) shales of the southern San Joaquin Valley. An underlying similarity in structure to *L.* cf. *californica* suggests that both forms may represent the same genus.

Skeletal Material of LAYTONIA cf. CALIFORNICA David
Plate 23, figure 3, text figures 2 *a*, *b*

A head only, No. 10399 Calif. Inst. Vert. Paleont. Coll. was found at Calif. Inst. Tech. loc. 391 in the San Marcos Pass area, Sec. 10, T. 5 N., R. 32 W, near summit in strata of Miocene age, Lompoc Quadrangle. Measurements: the head measures 73.5 mm. in length and 20.8 mm. in depth in the opercular region. The snout is 36 mm. long and approximately 13 mm. deep. The large eyeball measures 9.5 mm. in diameter. The opercular arch is plainly visible in the specimen. The opercular is large, being 14.5 mm.

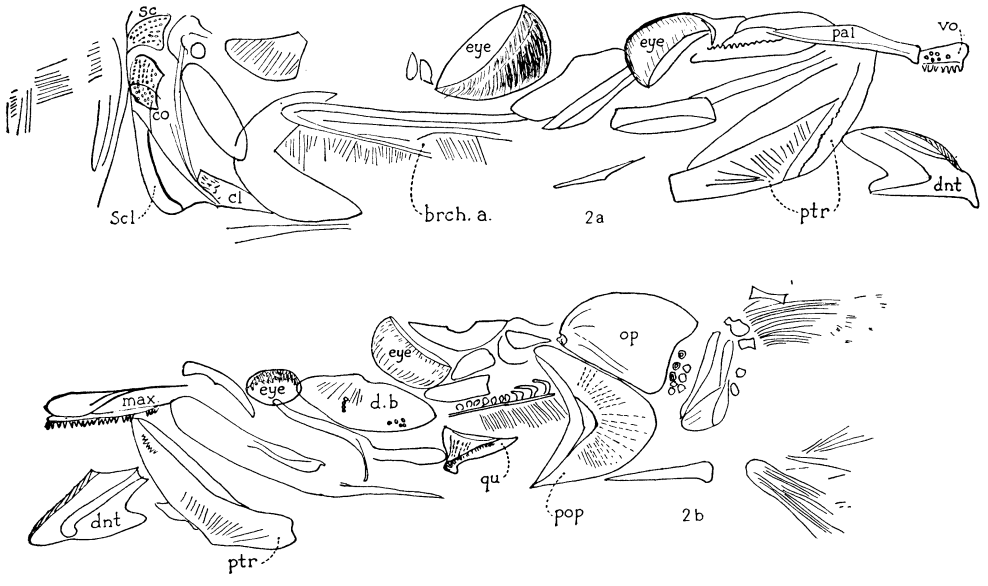


FIG. 2, *a*, *b*—*Laytonia* cf. *californica*. Skull, No. 10399 Calif. Inst. Tech. Vert. Paleont. Coll., from near summit of San Marcos Pass, Santa Barbara County; ×1⅔. *a*, left side of skull; *b*, right side of skull.

Abbr. Brch. a—branchial arches
cl. —clavicula
d.b. —dermal bone
dnt. —dentary
op. —opercular
max. —maxilla
pal. —palatine
pop.—preopercular
ptr. —pterygoid
qu. —quadrate
scl. —superclavicular
sc. —scapula

long and 10.5 mm. deep. As in specimen No. 10227 (David, 1943, Plate II, figure 1) this element is articulated very high and near the top of the skull; its upper border is rounded, the lower one is slightly concave and the posterior border is curved in its lower half where it lies along the cheek. The latter is covered by small round scales. The opercular in specimen No. 10227 appears to be turned upside down.

The right preopercular is in place; the left one is preserved and lies beneath the lower border of the head; it is crescent-shaped. The bone is 16 mm. deep, while the diameter of its upper limb is 14 mm. and that of the lower limb 16.5 mm. Opercular and preopercular are highly ornamented with tubercles and radiating ridges. No subopercular is visible. Both eyeballs are conspicuous and protrude above level of surrounding bones; the right eye is more completely preserved than the left and pushed slightly behind the latter, 9.5 mm. in diameter. The large bone underlying the eye is probably a dermal bone. The main portion of the snout is occupied by a pair of large diagonally placed bones, similar to the strong elements preserved in same position in front of the eyes in specimen No. 10227. These undoubtedly represent the pterygoids (ecto-entopterygoids) and may consist of several bones; the left one in front is well preserved, showing radiating ridges in its lower part and evidently a row of teeth anteriorly.

Of the mandibular suspensorium the triangular quadrate may be recognized, lying in front of the long and slender branchial arches. The bones forming the gape of the mouth enrich our knowledge of the genus insofar as the lower jaw is concerned. It is a strong triangular bone strengthened by a central diagonal ridge. There is a large circular indentation at its posterior base; the bone also becomes slender at its posterior upper border. The teeth seem to be lost, but the anterior part of the dentary shows a border of bone with diagonally placed rod-like structures partly overlying each other. The anterior end of the bone evidently points downward to some degree as in *Notacanthus*. In the type specimen of the genus, No. 10227, the dentary is evidently present; it is pushed upward above the end of the parasphenoid, and was not recognized in the description, but is visible on Plate II, figure 1 as an unnamed strong pointed prolongation of the parasphenoid. The tip of the upper jaw is formed by a clearly visible bone, ornamented by a pattern of tubercles; this evidently is the rostrum or vomer. Eight strong teeth are visible at its lower border; these may form part of a different bone (intermaxillary?) underlying the rostrum. A slender toothed bone in back of the rostrum may be the palatine. It is ornamented by transverse ridges. A mass of tuberculated bones continue rostrum and palatine posteriorly and centrally, but individual elements can not be identified. The large elongate bone in front of the right eyeball evidently represents one of a series of dermal bones. It is 13 mm. long and 4.5 mm. deep.

The pectoral arch is feeble and not very clearly marked; two small tuberculated bones visible on the left slab may be coracoid and scapula; a rounded elongate, vertically placed bone is better marked and appears to be the superclavicle or clavicle; a triangular bone near the ventral side of the body extending below the preopercular may be the clavicle. The right pectoral fin is clearly preserved and, as in the type specimen, is placed high toward the dorsal side of the body; 14 rays are present; some more may have been lost; their ends are broken off. Dismembered finrays are visible near the ventral end of the head, and some of these may be parts of the left pectoral fin. However, if they belong to the ventral fins, they are now definitely out of place.

REMARKS

Ample evidence has been found to prove the existence of halosaurid fishes in the California Tertiary, even though these forms are not present in the Pacific ocean off California today. Several species must have existed, but no detailed information is available as yet concerning the characters which delimit species in this group as well as the vertical range of specific types. A species of Halosauridae, *Echidnocephalus? pacificus*, was described by Cockerell (1919, p. 185, pl. 34, fig. 11) from the upper part of the Moreno formation (Cretaceous) of the Panoche Hills. Very little is known about this form since it was described on the basis

of a single scale. The description and figure give no details. Insofar as can be judged by figure 11 in Cockerell's paper, the outline of the scale is much more rounded than that in any of the scales found in the Tertiary.

Two halosaurid scales have been described above. *Laytonia? zemorrensis* occurs quite commonly in shaly deposits of the lowermost Miocene or Oligocene of the southern San Joaquin Valley. Other specimens found commonly with the halosaurid scales in the same deposit are of the Macrouridae, Myctophoidea and Berycomorphi. Only occasionally do scales of the Clupeoidea occur. The deposits must have accumulated to a great extent in an abyssal sea, the natural environment of the living Halosauridae. The lower Miocene or Oligocene halosaurid scale is large and well defined. It has been only tentatively assigned to the genus *Laytonia*. The genus has been described from the upper Miocene and scales similar to those covering the skeleton of that genus have been found in strata of that epoch. The lower Miocene scales are not fundamentally different, and it seems that both represent the same genus.

Up to the present time no Halosauridae have been found in the middle Miocene. Nearly all known Californian deposits of this stage accumulated in shallower seas than those in which Halosauridae would normally be found. In the upper Miocene a halosaurid scale occurs that differs specifically from the one in the lower Miocene or Oligocene. This has been described under the name *Laytonia* cf. *californica*. It occurs in silty deposits of uppermost Miocene (Delmontian) and lowermost Pliocene age of the Los Angeles and Ventura Basins. It is found occasionally in oil well cores and not more than one scale is usually found in any one well. In the deposits with *Laytonia* cf. *californica* fish remains are in general rare and are represented by bone fragments, teeth and scales belonging to the Macrouroidea and to *Lampanyctus*. Additional forms are occasionally encountered. These deposits are evidently also deep sea accumulations, but of different character than those mentioned above from the lower Miocene or Oligocene. *L.* cf. *californica* ranges upward into the lower Pliocene.

Skeletal remains of fish are not usually preserved in the California Tertiary, except in certain deposits which range in age from upper middle Miocene to upper Miocene. Various fish faunas of that age have been described (Jordan; Jordan and Gilbert, 1907 to 1927; and David, 1943); none of these is of abyssal character. Halosaurid fish are therefore very rarely found, and evidently exist here in deposits which did not accumulate in their normal habitat. The possibility of preservation of their scales in these neritic deposits is even more remote. Only one complete skeleton of the Miocene Halosauridae is known. This is *Laytonia californica*, described from the lower Modelo (lower upper Miocene) of the Santa Monica Mountains, Los Angeles County. The scale described as coming from the uppermost Miocene to lower Pliocene belongs evidently to the same species or a nearly related one. So far, scales have not been found in deposits of same age as those in which the skeleton was entombed presumably because the ecological conditions during the time of accumulation of these strata did not favor the presence of abyssal forms.

A second skeletal specimen, No. 10399 Calif. Inst. Tech. Vert. Paleont. Coll., shows only the head. It was found in the San Marcos Pass area, near the summit of the pass. The specimen, described above, shows a head considerably larger than the one in the type specimen of *Laytonia californica*. The skull characters of both specimens agree and show similarities to those of the Halosauridae, although no special relationship is shown to any known recent form.

The fossil and living forms differ in the opercular bones. The preopercular is well formed in *Laytonia*, indicating a primitive character in comparison with the degenerated type of preopercular in modern forms. There are differences in the structure of the mouth, shown mainly by the shorter and differently constructed lower jaw. The eye of the fossil genus appears likewise to have been larger compared with the size of the head than in modern forms. Differences in the structure of the dermal bones and mandibular suspensorium, insofar as the bones can be determined in the fossils, are probably of less importance. The two fossil specimens conform well in their structure and represent very likely the same genus. It is

not possible to determine whether the two are specifically identical since specific differences are not usually seen in skull characters. However, the distinctly larger size of No. 10399 may indicate a different species. The exact age of specimen No. 10399 is not known, but considering the general locality whence it comes, it is likely to be upper Miocene.

CONCLUSIONS

The following conclusions concerning the fossil Halosauridae from California seem to be justified. A Cretaceous form is little known and may have lived during upper Moreno time. At least two types lived in the Tertiary as identified by their scales. *Laytonia zemorrensis* existed during the lower Miocene or Oligocene (Zemorrian), and the upper limit of its range may be later, since no members of the Holosauridae are found in strata of middle Miocene age. *Laytonia* cf. *californica* ranges from the uppermost Miocene to the lower Pliocene. If the fossil scale and the skeleton, described as *Laytonia californica*, belong to the same species, the latter species has a range to the lower upper Miocene (lower Mohnian). The Halosauridae of the Californian Tertiary occur commonly only in deep sea deposits, and would normally be expected in abyssal accumulations. No Halosauridae exist off the California coast today. Climatic changes seem to furnish the most likely cause of their extinction, since Recent American Halosauridae are restricted to the warmer regions of Central America.

MANUSCRIPT RECEIVED JUNE 3, 1947.

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