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Note on a Hippurite-Bearing Limestone in Seistan and on the Geology of the Adjoining Region.

By Ernest W. Vredenburg, A.R.S.M., A.R.C.S., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 13 to 16.)

INTRODUCTION.

Amongst a geological collection from Seistan, forwarded to the Geological Survey of India by Mr. T. R. J. Ward and Sir Henry McMahon in 1905, there are a few fossils which are of special interest as they include specimens of *Hippurites*. The locality is situated nearer to the frontiers of the Indian Empire than any other in which specimens of the genus have been discovered. Up to the present there is no instance on record of a true hippurite having been found in India.

OUTLINE OF THE GEOLOGY OF SEISTAN.

By piecing together the information gathered by Huntington (*The Basin of Eastern Persia and Seistan, Carnegie Institution*, 1905), McMahon (*Recent Survey and Exploration in Seistan, Geog. Journ.*, 1906), and the surveys previously accomplished by me (*Geological Sketch of the Baluchistan Desert and part of Eastern Persia, Mem. Geol. Surv. Ind.*, Vol. XXXI, 1901), it is now possible to form a fairly connected idea of the Geology of Seistan.

Seistan the lowest lying portion of a vast depression.

The populated districts of Seistan are distributed through the lowest lying portions of one of those depressed almost flat areas of closed drainage, intervening between mountain ranges, such as characterise many parts of Persia and Central Asia. In this particular case, the depression occupies a considerable portion of Southern Afghanistan, stretch-

ing from east to west for a distance of some 320 miles, the breadth from north to south being about 180 miles. The lowest lying portion is along the western margin of the depression. The greater part of this area is a desert, except along the banks of the Helmand river, and in the more deeply depressed western portion where numerous artificial canals supply water for irrigation from the distributaries of the Helmand. This river spreads in delta fashion over the lowest lying part of the tract, some portions of which are flooded by shallow sheets of water whose extent varies according to the season of the year. In addition to the Helmand, several rivers, of which the most important are the Khash Rud, the Farah Rud and Harut Rud, enter the depression of Seistan proper along its north-eastern or northern margin and contribute to supply water and silt to the area occupied by the shallow lakes.

Helmand river and delta.

The shallow lakes of Seistan proper contain fresh water. The soluble salts washed into them from a considerable drainage area do not accumulate, because the lakes are flushed during exceptional floods, the surplus water overflowing into a still deeper depression, the Zirreh Lake, situated south of the populous portion of the province. The water of the Zirreh Lake is saturated with salt.

Fresh-water lake of Seistan proper.

The Zirreh Lake.

From a geological point of view, the constitution of Seistan is the same as that of the adjacent depressions of Persia and Baluchistan, some of which have already been surveyed and described with some detail. The encircling hill ranges contain a varied sequence of highly disturbed rocks amongst which cretaceous and eocene strata especially predominate, while the depressed area is occupied by undisturbed or slightly disturbed formations belonging to three successive formations: the Siwaliks (or "Gobi formation") mostly of pliocene age, the pleistocene alluvial gravels and clays, and recent accumulations. These three groups of deposits represent three successive stages in the desiccation of the vast inland seas that were cut off from

Geological constitution of Seistan.

Encircling hill ranges.

Desiccation of the depressed areas.

the ocean in later Tertiary times by the orogenic upheavals that occurred during that period. Only, while the recent formations and even the pleistocene accumulations show no distinct signs of having been disturbed since they were deposited, the Siwaliks have been distinctly affected by movements of the earth's crust.

Disturbance of Siwaliks.

Over the almost horizontal spreads that constitute the greater portion of the depressions, these movements do not amount to anything more than a more or less local warping; but, all along the margins of the depressions, where the Siwalik beds border the mountainous ranges, these same deposits are violently upturned, being tilted at high angles, and affected by overthrusts indicating in all cases a direction of movement from the mountainous towards the low-lying region. The warping and tilting of the Siwaliks and the concomitant overthrusts must date back to the pliocene, and accounts for the manner in which these beds which, originally must have been deposited with a near approach to uniformity and horizontality over the floor of the inland seas, are now observed at varying altitudes. The inequalities in the floor of the depressed areas left dry by the desiccation of the inland seas are to be attributed largely to this pliocene disturbance. It is very likely however that a closer study than has been hitherto practicable, would reveal a certain amount of disturbance amongst the pleistocene accumulations, such as has been distinctly shown to have taken place in many parts of India, both in the peninsular and extra-peninsular regions; normal faulting seems to have affected the margins of the depressions in post-pleistocene times. Numerous volcanic cones bear testimony to a disturbance of this nature, as also the earthquakes that affect definite lines along the margins of the depressed areas. Sir Henry McMahon has drawn attention to a line of disturbance of this nature from Chaman to Nushki along the easterr margin of the great depression of Southern Afghanistan. Along the margins of the low-lying western portion, volcanic manifestations are numerous, and include the Koh-i-Sultan, Damodim, Koh-i-Dalil, Mit Koh, and another unnamed cone, all of which are situated south of the Zirreh Lake, and have already been described in these publications (*Mem. Geol. Surv. Ind.*, Vol. XXXI, pp. 274—283, 1901), while in

Siwaliks upturned along the margins of the depressions.

Pleistocene faulting and volcanic manifestations.

Seistan proper, the Koh-i-Khwaja[1] and Koh-i-Chako are of a similar nature.

Cliffs of Siwalik strata encircling the depression.

These crust disturbances account quite sufficiently for a feature that has puzzled many observers in Seistan: the depression occupied by the delta of the Helmand and the shallow lakes of Seistan and the Zirreh Lake is surrounded by cliffs of horizontal (or nearly horizontal) Siwalik strata whose shapes are evidently determined by ordinary erosion. As these cliffs surround an area which is the lowest lying portion of an inland basin, it seems difficult to account for the disposal of the material removed by denudation if one supposes these cliffs to consist of undisturbed material. The supposed absence of disturbance is, however, only a deceptive appearance caused by the horizontality of the deposits away from the margins of the plains. That the horizontality is neither general nor absolute, even in such situations, is distinctly shown by some of the photographs communicated by Mr. Ward, and also by Huntington's diagrammatic section through the Koh-i-Khwaja (*Basin of Eastern Persia and Seistan*, fig. 168, p. 286, 1905), while the highly disturbed condition of these same beds along the actual margin of the depression is evidenced clearly enough in a photograph which I have reproduced in a previous publication of this department, and which represents an exposure of this formation situated some 20 miles west-south-west of the western termination of the Zirreh Lake (*Mem. Geol. Surv. Ind.*, Vol. XXXI, Pl. 12). As there have been, therefore, considerable crust movements, it is quite to be expected that beneath certain parts of the lowest lying area the Siwaliks lie buried under a considerable depth of pleistocene and recent accumulations representing the material derived from the erosion rendered evident by the features of the cliffs above alluded to.

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[1] The volcanic rocks from the Koh-i-Khwaja include:

1. Porphyritic dolerite with phenocrysts of labradorite and augite in a base of smaller crystals of the same two minerals plus iron-ore; there is some secondary serpentine. (G = 2·72.)
2. Very fine grained basalt consisting of minute crystals of felspar, augite, and iron-ore dust, with a few small porphritic crystals of augite. (G = 2·81 to 2·90.)
3. Very porous andesite of a dull brick-red colour, almost a pumice; the minute vesicles contain opal and zeolite, while some larger cavities contain calcite.
4. Ash-beds.

These rocks recall somewhat those of another small volcanic outburst occurring in the southern part of the Seistan depression, and already mentioned in a previous publication. (*Mem. G. S. I.*, Vol. XXXI, p. 283, 1901.)

Eolian denudation.

Seistan is noted for the violence of the wind that sweeps across the country for months at a time. Huntington, McMahon and many other observers have drawn attention to the extraordinary amount of eolian denudation which it produces especially amongst the soft recent deposits. Though this might be sufficient to counterbalance to a great extent the accretion of the sediment due to the silt brought down by the Helmand, it would not suffice for the local formation of the depression which there is every reason to ascribe to tectonic influences.

Confusion between Siwaliks and sub recent formations.

One of the reasons that have somewhat obscured the obviousness of this simple explanation is the failure, on the part of many observers, to recognise that a considerable portion of the deposits occupying the plains of Baluchistan, Persia, and Central Asia are identical with the Siwaliks. Instead of their being interpreted as lake or inland-sea deposits of Tertiary age, they have often been regarded as an ordinary alluvial formation of much later date. These rocks were unhesitatingly referred to the Tertiary era by Griesbach when he first observed them in the plain of Pishin near Quetta (*Mem. Geol. Surv. Ind.*, Vol. XVIII, p. 18, 1881, *Rec. Geol. Surv. Ind.*, Vol. XVIII, p. 58, 1884). Partly through an accidental misapplication of the term "Gaj" (a name belonging to a series older than the Siwaliks, but misapplied by Griesbach in consequence of a misapprehension as to its meaning), Griesbach's interpretation did not gain credit with his successors who referred the deposits in question to a sub-recent age and denied their lacustrine origin (*Rec. Geol. Surv. Ind.*, Vol. XXV, p. 36, "Manual," 2nd ed., p. 417).

The researches of the last few years have fully established the correctness of Griesbach's views, and the identity of these beds with the Siwalik formation of India and the Gobi formation of Central Asia.

Character of the Siwalik strata.

The Siwalik strata, whether comparatively undisturbed or else violently tilted, consist principally of alternating pink and greenish clays and occasionally sandstones and conglomerates. This at least is the character of the bulk of the formation, constituting the middle sub-division. Greenish-grey sandstones predominate in the Lower Siwaliks, while in the Upper

Siwaliks there is often a considerable admixture of coarse fluviatile conglomerates and of buff-coloured clays recalling the pleistocene formations.

A number of detailed measured sections, consisting principally of the alternating pink and green clays, observed along the north-western border of the depression of Seistan proper, have been represented by Huntington on Plate 5 of his work on the basin of Eastern Persia and Seistan.

Pleistocene formation.

The pleistocene formations consist largely of alternations of buff-coloured, more or less sandy clays and conglomerates. Instead of exhibiting the characters of sediments deposited under water, they recall ordinary alluvial deposits, indicating that the inland seas of the Siwalik period were then to a considerable extent dried up. Yet judging from the terraced disposition of these pleistocene deposits, a portion of the basins must have been still occupied by water, and the pleistocene deposits only became largely eroded when the water level finally sank in post-pleistocene times.

The loess.

The pleistocene formations consist largely of great accumulations of unstratified buff-coloured clay exhibiting the character of the "loess."

"Dasht" plains strewn with black pebbles.

The arid plains strewn with black pebbles that constitute the plains known as "dasht" owe their origin to the pleistocene conglomerates: the pebbles are laid bare by the wind, which removes all traces of the silt that once enclosed them, they become coated with a thin film of hydrated oxides of manganese or iron as is usually the case in desert countries.

Recent deposits.

The recent accumulations of the Helmand delta consist of ordinary river silt. In order to give a clear idea of the physical and geological relations of Seistan and of the adjacent lands, the small diagram, Pl. 13, shows the main features of the geology of Baluchistan and Southern Afghanistan so far as known at present.

FOSSILIFEROUS CRETACEOUS LIMESTONES.

The only fossils gathered *in situ* amongst the specimens forwarded by Sir Henry McMahon are those mentioned in the introduction to this note. They were collected amongst the hills

forming the north-western margin of the Seistan swamps. These hills constitute the most south-easterly spurs of one of the mountain ridges which, from the neighbourhood of Birjand, in eastern Persia, extend, with a south-easterly strike, towards the borders of the Seistan depression. The ridges gradually decrease in altitude on approaching the depression, and terminate in isolated spurs entirely surrounded by the Upper Tertiary ("Siwalik" or "Gobi") and sub-recent formations that fill the Seistan depression. Two such isolated masses constituting the terminations of one of these ridges, and along the summits of which has been carried the frontier line between Persia and Afghanistan, have yielded the fossils in question. The more north-westerly and the larger of these two islands of older rocks is known as Koh-i-Nahrahu or Koh-i-Siah, and rises to an altitude of 4,984 feet, some 3,430 feet therefore above the level of the swamps. The smaller, and south-easterly one, known as Koh-i-Maku, rises to a height of 3,900 feet.

Judging from Mr. Ward's photographs and the notes supplied by Sir Henry McMahon, the rocks constituting these hills dip at high angles, the stratification being contorted.

All the ranges running close to the Perso-Afghan frontier from the neighbourhood of Meshed to Birjand are disposed along this same south-easterly direction of strike. On reaching the longitude of Seistan their direction veers round and becomes more easterly; in the case of the ridge terminating in the Koh-i-Nahrahu and Maku, this change of direction cannot be observed, because the older rocks constituting these ridges sink beneath the horizontally bedded late Tertiary and Quaternary beds of the depression. North-east of the depression, the eastward-striking portion of several ranges belonging to the same system was crossed by Mr. Griesbach during the march of the Russo-Afghan Boundary Commission in 1883.

They are described by Mr. Griesbach as consisting of hippuritic limestones invaded by various intrusive igneous rocks (*Rec. Geol. Surv. Ind.*, Vol. XVIII, p. 60, 1884).

Koh-i-Nahrahu and Maku also consist of a hard grey limestone which yields well-preserved specimens of two species of *Hippurites*. There are also some specimens of rock showing a brecciated structure, with fragments of a green porcellanic-looking limestone embedded in a grey calcareous matrix. The green fragments resemble some of the rocks known in Baluchistan as "Parh limestones"

whose age is Neocomian. In the present instance, however, the available material is insufficient to decide whether these Neocomian rocks are represented.

The fossils include a hippurite which I have regarded as identical with *Hippurites gosaviensis* Douvillé, an undescribed *Pironæa* which I propose to name *Pironæa persica*, sections of a *Plagioptychus*, a large ribbed *Pecten*, a large very singular lamellibranch which I have been unable to identify, and is perhaps related to the *Pinnidæ* (Pl. 16, fig. 2), casts of a large, very elongate *Nerinea* (Pl. 16, fig. 1*a*, 1*b*), and of a large naticoid shell.

Hippurites gosaviensis seems to characterise, in Europe, the Upper Turonian or the beds at the limit of the Upper Turonian and Lower Senonian. The species of *Pironæa* so far described are regarded as Upper Senonian, but the present one exhibits more primitive features than its congeners, and its presence is not therefore out of keeping with the attribution of a Lower Senonian or uppermost Turonian age to these rocks.

DESCRIPTIONS OF THE HIPPURITES.

The two species of hippurites may be briefly described as follows:

Hippurites gosaviensis Douvillé.

PL. 14, figs. 1, 2.

1866.—*H. cornuvaccinum* Zittel, Die Bivalven der Gosaugebilde (Denkschr. der Kais. Akad. der Wissensch., Vol. XXV, p. 135, Pl. XXI, figs. 1—7).

1890.—*H. gosaviensis* Douvillé, Etudes ser les Rudistes (Mem. Soc. Geol. Fr., No. 6, p. 24).

1895.—*id., loc. cit.* (Pl. XXIX, figs. 1—6, Pl. XXXIII, fig. 5).

There are unfortunately no specimens of the upper valve. The lower valve in young specimens up to a diameter of about 8 centimetres is conical, and more or less curved or deflected in various directions. Full-grown specimens become cylindrical, and some of the fragments are as much as 25 centimetres long, for a diameter of 8 or 8·5 centimetres. The greatest diameter observed amongst any of the specimens is 10·5 centimetres.

Externally the outer layer is ornamented with close-set angular ribs, delicately striated transversely, the intervening furrows being

also angular; their average width from furrow to furrow is about 3 millimetres. The position of the two pillars is indicated externally by grooves slightly deeper than the other furrows; the groove corresponding to the cardinal ridge is somewhat more pronounced and distinguished by the obliquity of the transverse striation disposed in "herring-bone" fashion as is usual in hippurites.

When the outermost layer of the envelope is broken off, the inner layers appear ornamented with ribs that are much less prominent than those of the outer layer, while the furrows coinciding with the pillars and cardinal ridge are much more pronounced than when the external surface is intact.

The internal disposition of the internal pillars, cardinal ridge, teeth, and muscular apophysis is invariably that which characterises *Hippurites gosaviensis.* None of the specimens show every one of these parts with perfect distinctness, but by piecing together the indications furnished by separate individuals the main outlines of the plan can be discovered. The first pillar is circular in section and supported on a much shorter ridge than the second pillar which is more elliptical. The supporting ridges are excessively slender, and that of the second pillar is constantly deflected posteriorly, that is away from the first pillar and from the cardinal ridge. Amongst Douvillé's illustrations the only one representing any tendency to such a disposition is that of a specimen collected by Carez in the Corbières (text-figure 15). The constancy of this character in the Seistan specimens probably represents a racial character. The cardinal ridge is long and slender and terminates somewhat irregularly. The shape of the posterior tooth and muscular apophysis and of their respective alveolæ cannot exactly be made out in any of the specimens owing to the crystalline condition of the calcite filling them; but their relative position can be recognised as being transverse to the first pillar, and agrees therefore with that which characterises *H. gosaviensis*, the posterior muscular apophysis always extending internally beyond the first pillar. Fig. 1*c*, Pl. 14, shows the upper surface of an almost perfect lower valve, of which two side views are also given (Pl. 14, fig. 1*a*, 1*b*). The projections from the upper valve and their corresponding alveolæ are concealed by remnants of the shell substance of the upper valve, but the specimen shows very clearly that the space in front of the anterior pillar is occupied by shell substance,

indicating that the alveola for the muscular apophysis extends further inwards than the extremity of the first pillar, a very characteristic feature of *H. gosaviensis*. The same specimen also shows very clearly the absence of any anterior accessory cavity in front of the cardinal ridge—also a character of this species.

Fig. 2, Pl. 14, represents a somewhat weathered and fragmentary upper valve whose upper surface has been partly polished, showing clearly all the leading features: the cardinal ridge and pillars, the body cavity and scars of adductor muscles, and the position of the teeth and muscular apophysis of the upper valve. The annexed outline drawing will help to understand these features on the photograph:—

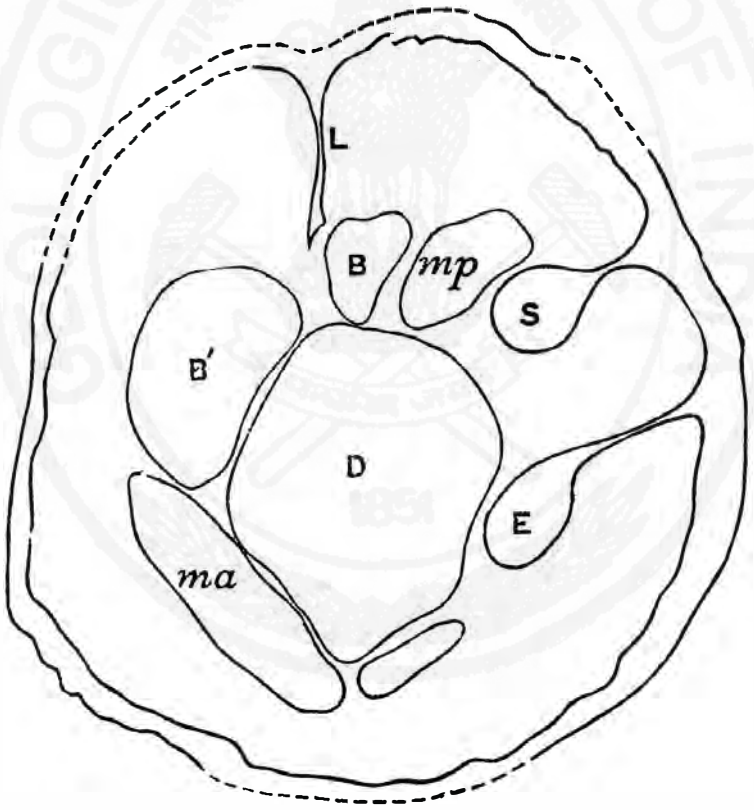


Fig. 1.—Section of *Hippurites gosaviensis*.

(See Pl. 14, fig. 2.)

B', alveola of anterior cardinal tooth; B, alveola of posterior cardinal tooth; *mp*, socket of posterior muscular apophysis; L, cardinal ridge; S, first pillar; E, second pillar; D, body cavity; *ma*, anterior muscular scar.

A curious feature of all the specimens is the silicification of the two pillars, this being the only part of the shell that has undergone this pseudomorphous change.

Pironæa persica, nov. sp.

Pl. 15, figs. 1—3.

Description.—The specimens are slender and soon acquire a cylindrical shape with a diameter of 4 to 5 centimetres.

The upper valve, preserved only in one specimen, is conical-depressed, and covered with pustuliform protuberances. The state of preservation is not sufficiently good to ascertain exactly the shape of the pores though they seem to be linear; they are surrounded by polygonal meshes.

Externally the lower valve is ornamented with very angular ribs of greatly varying dimensions. Owing to this irregularity, the grooves corresponding with the pillars and cardinal ridge cannot be distinguished.

Internally, in addition to the pillars and cardinal ridge, there are eight very pronounced inward projections of the internal layer of the shell-envelope. Even in the largest specimens, the spaces between these projections are not subdivided as is usually the case in adult individuals of other species of *Pironæa,* but merely reproduce, in an inverted manner, the shape of the intervening prominences. It is only in the rather broad interspace next the second pillar, and between the pillars and cardinal ridge, that secondary inflections resembling those of other species of *Pironæa,* are to some extent developed.

These internal projections do not in any way correspond with the grooves on the outer surface of the shell, and the outer layer does not adapt itself to the inflections of the inner one. The shell is consequently thicker than is usual for *Pironæa.* The disposition is, in a way, the opposite of that observed in *Batolites* where the inflections occur in the outermost layers, the inner outline of the external envelope remaining unaffected. In the present case, the inflections affect the inner layer of the envelope and not the outer one, while in a normal *Pironæa,* both layers are affected. Nevertheless, the disposition is essentially that of a *Pironæa,* and the absence of deep inflections in the outer layer, together with the absence of secondary inflections in the inner one, suggests that

we are dealing with a type more primitive than those previously described.

The cardinal ridge is broad and well developed, terminating in a blunt point. The first pillar is somewhat shorter than the second; both are supported on stout ridges. Owing to the sectioned specimen having become irregularly stained during the process of fossilisation, these features are not quite so clear as might be desired on the photograph. The annexed outline drawing, fig. 2, will help one to understand them more clearly:—

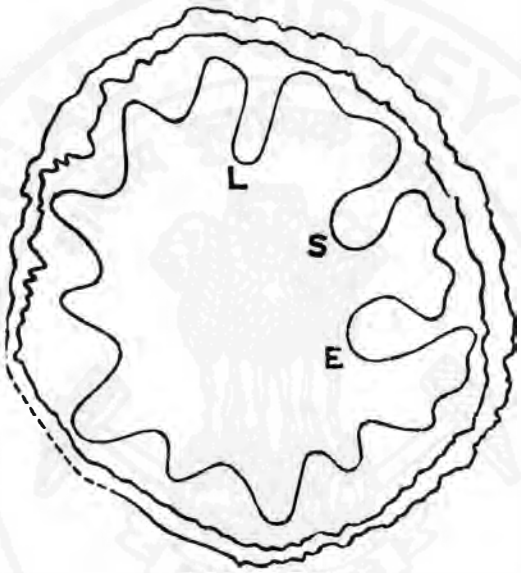


Fig. 2.—Section of *Pironœa persica*.

(See Pl. 15, fig. 3.)

L, cardinal ridge; S, first pillar; E, second pillar.

The disposition of the posterior tooth and posterior muscular apophysis cannot be clearly made out, the corresponding part of the shell being partly destroyed in the sectioned specimen.

Comparison with other species.—This species differs somewhat from its congeners owing to the circumstance, already alluded to, of the inflections affecting but one portion of outer layers of the shell, the disposition being somewhat the opposite of that observed in *Batolites*: while it is the outermost envelope alone that is inflected in *Batolites*, it is only the internal portion of the envelope that is folded in *Pironœa persica*. Moreover, *P. persica* is readily distinguished from adult specimens of the European species *P. polystylus* Pirona, owing to the almost complete absence of secondary

inflections. There is another Asiatic species of *Pironæa*, *P. corrugata* Woodw., the exact locality of which is not absolutely certain, but which occurs together with *Hippurites vesiculosus*, a species closely related to *H. gosaviensis* (Douvillé, *Etudes sur les Rudistes*, pp. 109, 228). This species appears somewhat related to *P. persica* owing to the feeble development of the secondary inflections, but, judging from a photograph taken by S. P. Woodward and reproduced by Douvillé (*Etudes sur les Rudistes*, Pl. XXXII, fig. 14), the manner in which the folds are disposed indicates that the corrugation must extend to the outer layers of the envelope. Moreover, *P. corrugata* is distinguished by its obtuse cardinal ridge and the much smaller interval between the two pillars. The pillars of *P. persica* present, in section, a narrow neck resembling that of an ordinary *Hippurites*, while there is no such constriction in *Pironæa corrugata*.

GEOLOGICAL AGE OF THE HIPPURITE-BEARING BEDS OF SEISTAN.

De Morgan's previous discoveries of Persian hippurites.

The only species of hippurite authentically known from Persia is the Upper Senonian *H. cornucopiæ* Defrance, discovered by de Morgan in the Bakhtyari mountains. The association of a normal hippurite with a *Pironæa* such as occurs in Seistan recalls the association of *Hippurites vesiculosus* Woodward and *H. Loftusi* Woodw. in company with *Pironæa corrugata* Woodw. observed by Loftus presumably at Hakim Khan in the valley of the Upper Euphrates in Asia Minor. The Hakim Khan beds, like others in Europe where a similar association has been observed, are regarded as Upper Senonian. If my identification of one of the Seistan species with *H. gosaviensis* be correct, the age of the Seistan beds is probably different, and more probably uppermost Turonian. This supposition would satisfactorily account for the abnormally primitive characters of *Pironæa persica*.

Hippurites discovered by Loftus presumably in Asia Minor.

The Seistan hippurites probably uppermost Turonian.

It should be noticed however that *Pironæa corrugata* itself shows somewhat primitive characters in the slight development of its

secondary inflections recalling the young stages of the more differentiated *Pironæa polystylus* Pirona. It is quite possible therefore that the Hakim Khan beds belong to an older age than has hitherto been ascribed to them, and that they do not differ much in age from the Upper Turonian hippuritic limestone of Seistan. One of the Hakim Khan hippurites, *H. vesiculosus*, is very closely related to *H. gosaviensis*.

The horizon of the Seistan hippuritic limestone is one that has never yet been distinctly recognised in any part of India, neither amongst the rocks of the Coastal System nor in the geosynclinal areas.

LIST OF ILLUSTRATIONS.

PLATE 13.

Geological sketch-map of Baluchistan.

PLATE 14.

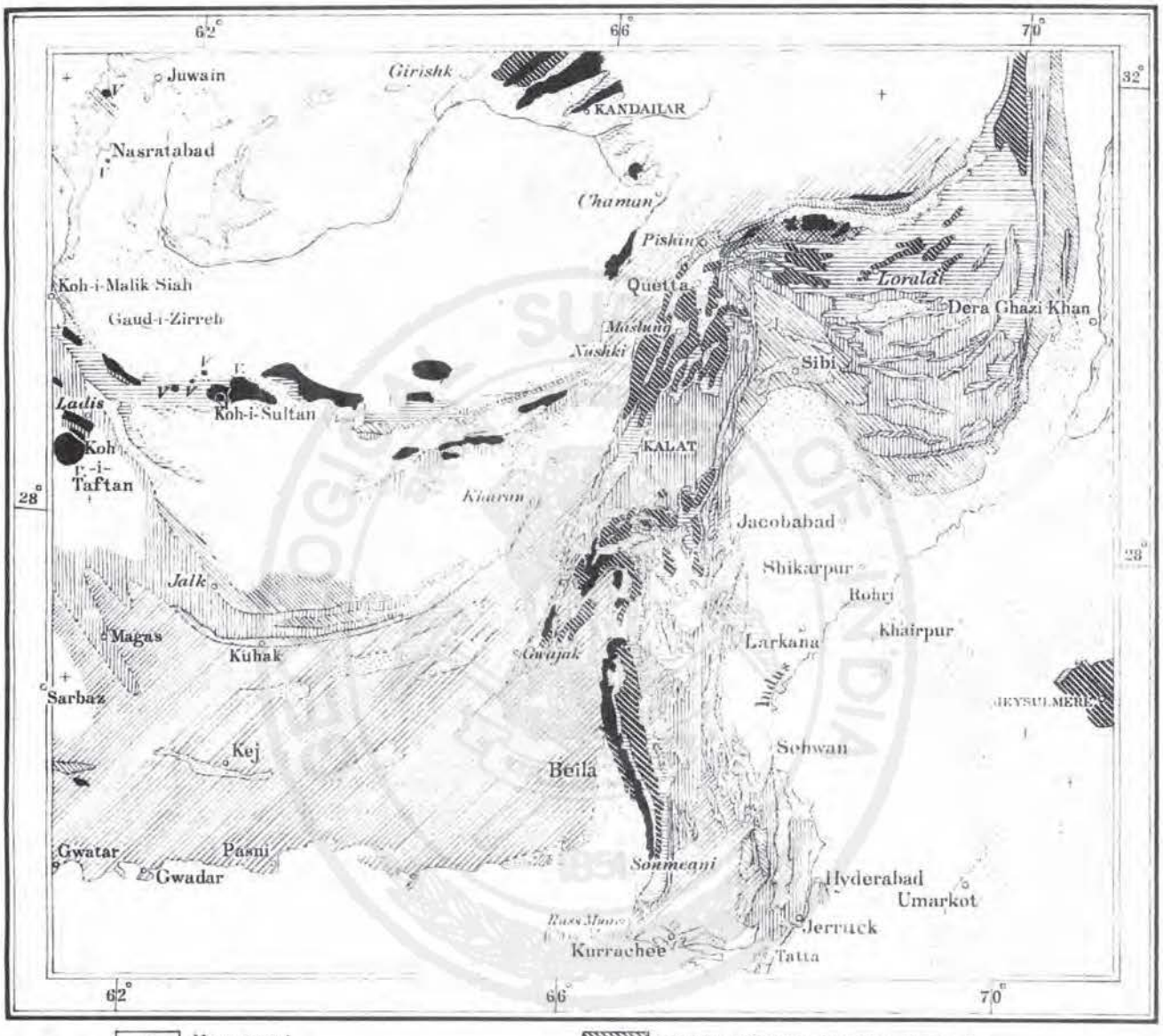
Hippurites gosaviensis Douvillé. Fig. 1, *a*, *b*, *c*: anterior, posterior and upper aspects of an almost complete lower valve. Fig. 2: polished surface of another lower valve. Both specimens from Koh-i-Nahrahu. (Natural size.)

PLATE 15.

Pironæa persica, nov. sp. Fig. 1: complete specimen with upper valve preserved. Fig. 2: fragment of a lower valve. Fig. 3: polished section of another specimen. All three specimens from Koh-i-Nahrahu. (Natural size.)

PLATE 16.

Fig. 1*a*: cast of a Nerinea. Fig. 1*b*: section of the same specimen. Fig. 2: Gen. indet., spec. indet. Both specimens from Koh-i-Maku. (Natural size.)



Unsurveyed

Pleistocene and recent volcanoes

Cretaceous and tertiary intrusions

Recent

Pleistocene

Siwalik (Phiocene including Pontian)

Oligocene and miocene

Eocene

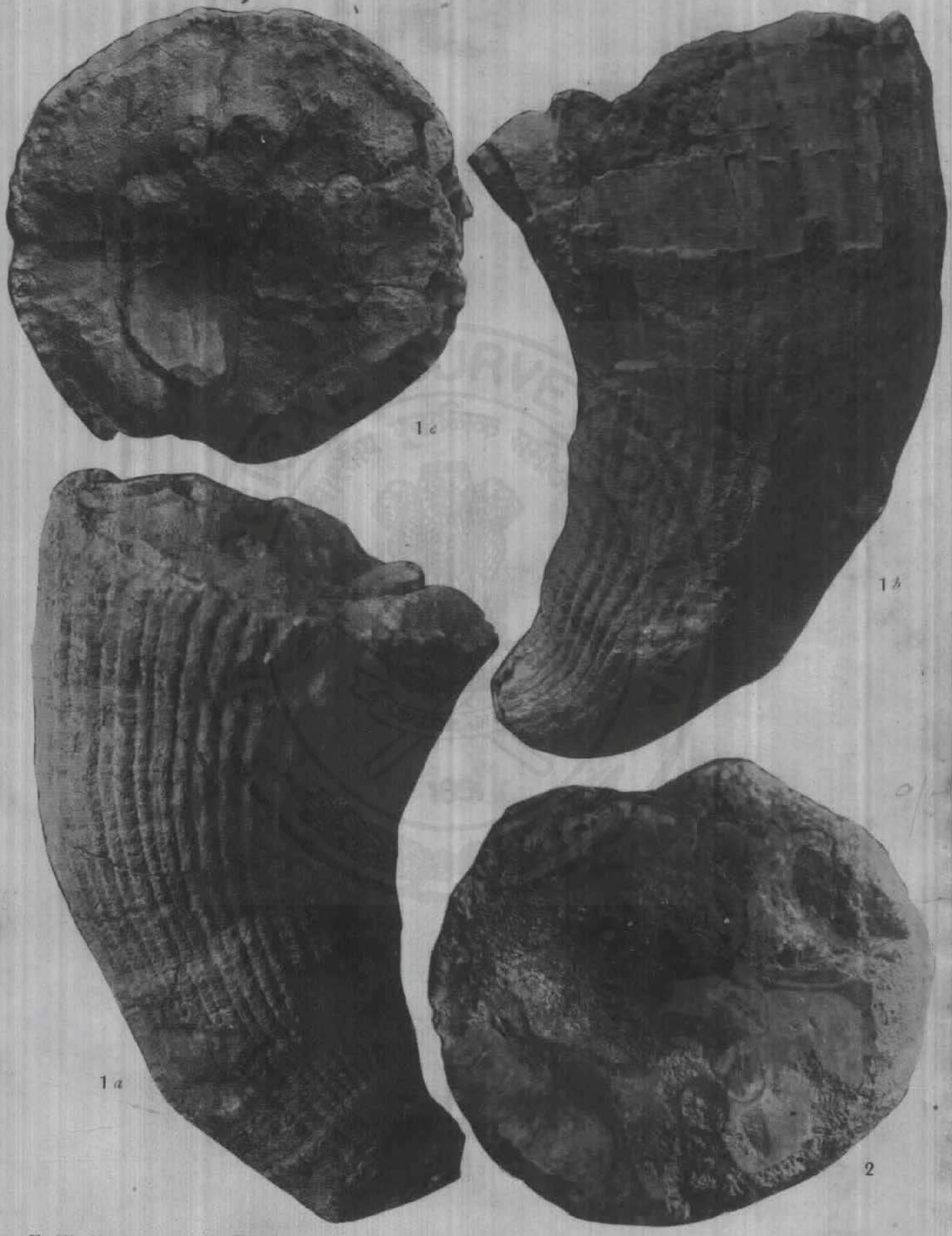
Cretaceous

Jurassic

Trias

GEOLOGICAL SKETCH OF BALUCHISTAN

Scale: 1 inch to 96 miles.



E. W. Vredenburg photo. G. S. I. Calcutta.

HIPPURITES GOSAVIENSIS, Douville.

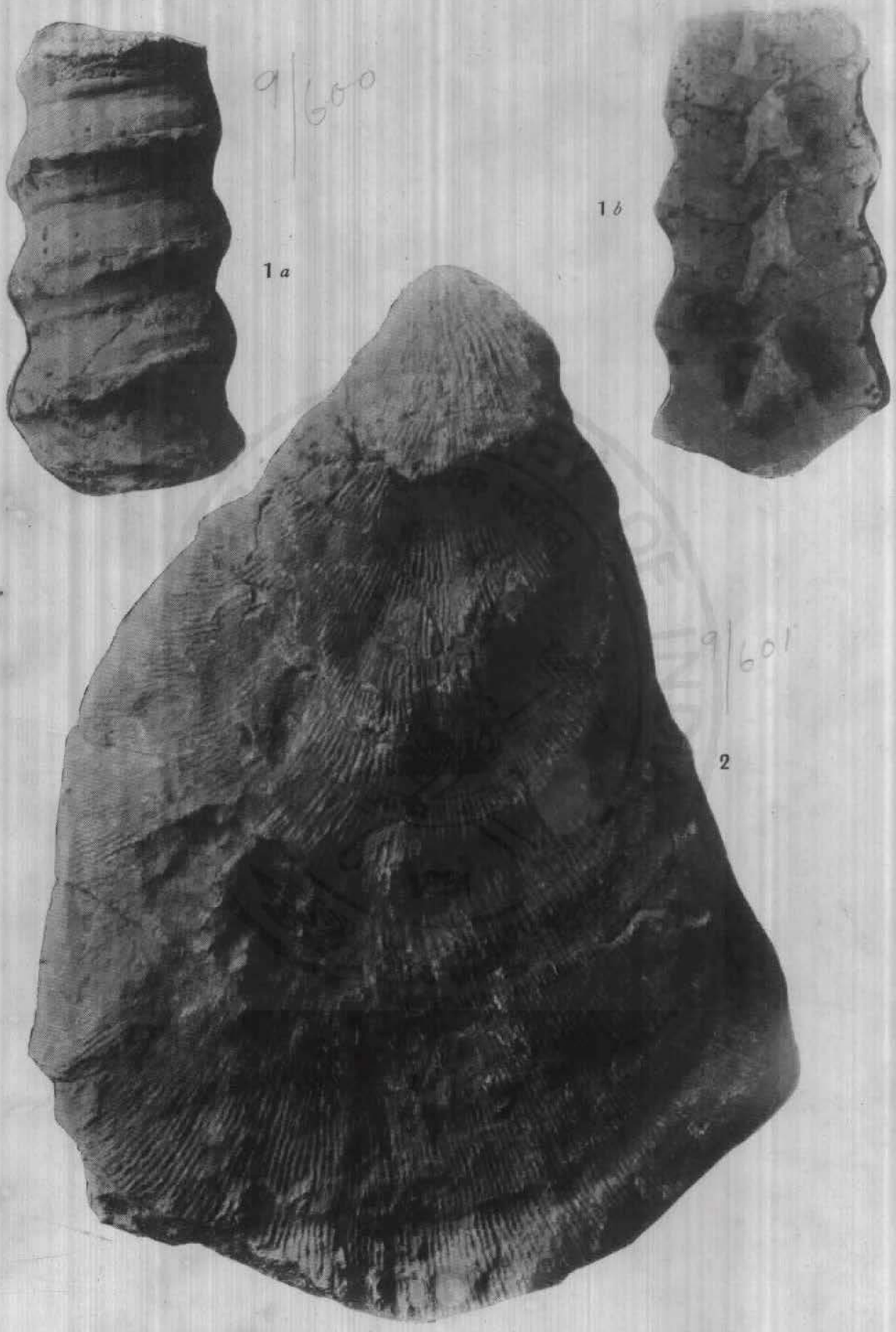
1, *a*, *b*, *c*.—Anterior, posterior, and upper aspects of an almost complete lower valve.

2. Polished surface of another lower valve.

E. W. Vredenburg photo. *G. S. I. Calcutta.*

PIRONÆA PERSICA, nov. sp.

1. Complete specimen with upper valve preserved.
2. Fragment of a lower valve.—3. Polished section of another specimen.
All three specimens from Koh-i-Narahu.
(Natural size.)



E. W. Vredenburg photo. G. S. I. Calcutta.

1 *a*.—Cast of a Nerinea. 1 *b*.—Section of the same specimen.
2.—Gen. indet., spec. indet.
Both specimens from Koh-i-Maku.
(Natural size.)