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**SHELLS FROM THE SAN MEN SERIES**

BY

**NILS BJ. ODHNER**

PLATES I-V AND 1 FIGURE OF TEXT



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# Shells from the San Men Series

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STOCKHOLM  
CEDERQUISTS GRAFISKA AKTIEBOLAG

## INTRODUCTION.

IN HIS »ESSAYS ON THE CENOZOIC OF NORTHERN CHINA» (1923, P. 119), professor J. G. Andersson mentions a striking mussel bed near Ho Ti Tsun, Yüan Chü Hsien, S. Shansi, and reports also the stratigraphical facts concerning this locality. The bed in question lies beneath interstratified beds of loess and gravel of about 20 metres in thickness and is itself 2 metres thick. Beneath the mussel bed there follow 2.5 metres of coarse gravel, and at the bottom of the section a coarse eocene conglomerate of 17 metres. The mussels are imbedded in gravel and sand and »many of the big shells were seen standing edgewise in nearly vertical position».

Prof. Andersson is certainly quite right in his supposition that »one or two of the species are identical with those determined by Dr. Dall from the San Men collection. The latter comprises large bivalves about which Dr. Dall writes (cf. Andersson, l. c. p. 119): »There are three species, all near to but not exactly like species now living in China. We have not specimens of the living species enough to determine the limit of variation but the differences are such as to suggest that the fossil forms are the ancestors of the living ones and probably of early Pleistocene age. The species are as follows: *Quadrula* near *Q. spurius* Heude, *Quadrula* near *Q. affinis* Heude, *Cuneopsis* near *C. capitatus* Heude.»

Though I have not examined the original San Men shells, the species determined by Dr. Dall are, I think, no doubt identical with some of the shells from Ho Ti Tsun. From that latter locality prof. Andersson has sent a large collection to Sweden, comprising not only the species recorded by Dall but also other fresh-water mussels and a couple of land shells. Singularly enough, the collection contains no fresh-water gastropods except a small fragment. The big mussels are in a very fine condition with the sculpture excellently preserved; a great many are complete having the valves paired and closed, the shell thus being filled with a coarse and loose red-brown sand. No difficulty is encountered in removing the contents and clearing the inside of the valves. In a few cases the hinge teeth have been eroded to the same level as the shell margins probably by means of wind-drifted sand.<sup>1</sup> But as a rule the hinge cha-

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<sup>1</sup> These shells were certainly taken from the upper surface of the mussel bed.

acters are in a very good and injured state. Otherwise the shells in all specimens are strikingly heavy and show a somewhat loose structure, the lime having a tendency to crumble into fibrous or laminate fragments. No cuticula was preserved in any case.

I have reproduced the valves both from without and from within, in order to demonstrate the chief characteristics of the hinge, which in all Bivalves are of systematic importance. In a paper of 1918 I have discussed the homologies of the hinge elements of Unionidae and other fresh-water Bivalves, and in the following pages I use the terminology introduced in that publication. For the denomination of the hinge elements I consequently accept the method of Bernard described by him in 1895.

From a geographical point of view the occurrence of these shells at the border of the upper Hoang-Ho is of interest, since the recent relatives of the species in question are widely scattered from this locality. The large bivalves thus occur nowadays in the coastal areas of the Hoang-Ho and the Yang-tse-kiang systems. From the latter tract Heude has described an abundant fauna. In Heude's work, fundamental for the knowledge of the recent fluviatile fauna of China, is described also one of the present fossil forms under the name of *Mycetopus carinatus*. With this species I begin my report on the fossil fauna.

It only remains to add some remarks as to the age of the formation in question. Dall has based his opinion of the Pleistocenic age of the bed on a very scanty material, but nevertheless he has deduced its dating with great accuracy. Considering the relations of the fossil fauna to the recent fauna, we find that the former contains species exactly identical with recent ones together with types different from the recent relatives and seemingly their ancestors. The general appearance, too, supports the opinion that the fauna was favoured by a warm and humid climate. These facts seem to indicate that we have rather to date the formation containing this fauna to the upper Pliocene.

The photographs of Pl. I—V have been retouched by Messrs G. Liljevall and S. Ekblom.

## FAM. UNIONIDAE.

### *Solenaia carinata* Heude.

(Plate L.)

Heude figures (l. c. pl. XXI) the posterior half of a fragmentary left valve from inside. His description is very brief: »*Dorso carinato-plicato; impressione posteriori rotundo-marginata, profunda.* Obs. Je ne possède qu'un fragment de ce grand mycetopus. Je le publie afin de provoquer les recherches des amateurs. Ce fragment fossilisé vient probablement des lacs de Mien-iang-tch'euou (Hou-pé); se trouve au Kiang-si, rivière de Foutch'euou?»

No further records of this species seem to be available in the literature. Simpson (1900) includes it in the genus *Solenaia* (cf. below).

The present collection contains 6 complete specimens, a couple of them broken, the largest one measuring 30 cm in length and 12 cm in height. The specimen reproduced on the plate is smaller: L. 28, H. 8, crass. 4.2 cm.

The shell is very heavy, elongately wedge-shaped, rounded acuminate in front, abruptly truncated, sinuous and obliquely rounded behind, widely gaping posteriorly and in the foremost half of the under side. Dorsal margin very slowly convex, under side slightly concave in the anterior half, gently convex posteriorly. Beaks depressed, obscure, situated in about  $\frac{1}{3}$  of the shell length from anterior end, indistinctly sculptured with low concentric waves. The sculpture of the shell consists of incremental lines only, close and regular on the lower half, becoming rougher and irregular on the median and hind part, here causing a concentric wavy sculpture. No umbonal sculpture is to be observed. Behind the umbones, in about the middle of the shell length, a slow dorsal crest appears, rising higher and growing broader towards the posterior marginal sinus. On this crest the incremental lines form strong curves corresponding to the sinus. In the end of this crest one can observe that it has been open interiorly in young specimens; as growth passes on, the internal furrow becomes more and more filled with lime and obliterated. In Heude's figure it is somewhat more obvious than in the specimens at hand.

The ligament has been very strong and occupied nearly all the dorsal margin behind the beaks. It presents a peculiar character: In the median part the ligament forms lappets intruding between the valves and fixing themselves on the inside of

the hinge line thus interrupting it for about four times as oblique fissures (cf. figs. 2, 3). The hinge is edentulous. The inside of the valves has a vivid bluish pearly lustre and is quite smooth, except for a pair of low crests running diagonally from the middle dorsal side to below the posterior adductor scar. A more or less distinct furrow running backwards to the sinus marks the site of the dorsal carina.

The muscular scars are very distinct. The anterior adductorial one is bipartite and very oblique and extends with its upper end far behind the beaks; behind its upper end appears the scar of the anterior retractor pedis. The longitudinal anterior protractor scar is situated in the middle of the shell height. Inside the middle part of the dorsal margin is a row of small elongate scars of the pedal elevator muscles. The posterior adductor scar has a triangular shape, its upper portion is united to the posterior retractor scar without demarkation.

All recent Chinese *Solenaias* have a rather thin shell; further they lack the dorsal carina of the present shell and its corresponding posterior sinus; instead they possess a diagonal low ridge somewhat more ventrally. This ridge is, in reality, rudimentary also in *S. carinata* and may be seen as a row of small swellings below the crest. The fossil species thus occupies a position apart from the recent *Solenaias*, and, according to its less accentuate straightness, is more primitive in habitus.

On the affinities of the genus, however, the fossil species does not throw any light. Its dorsal carina gives it a striking resemblance to the African genus *Chelidopsis* with two recent species from Congo. Here, however, the carina seems to correspond to the diagonal ridge in the recent *Solenaias* rather than to the crest of *S. carinata*.

The Chinese *Solenaias* are unknown from the anatomical point of view, but the typical species, *S. soleniformis* Benson has been investigated by Ghosh (1918) and Prashad (1919). For the typical species, on account of its anatomy, the latter author quite unnecessarily constituted a new genus *Balwantia*.

#### *Anodonta woodiana* Lea.

One shell, somewhat fragmentary, measuring in a complete state about 110 mm in length, exhibits all the characteristics of the typical species: the straight umbonal concentric ridges and the faint posterior radiating ribs. The crassitude is about 38 mm, thus somewhat less than usual in this species. But it varies considerably and among the material of recent shells sent by prof. Andersson there are forms which agree even in this character with the fossil specimen. — The recent distribution comprises China, Cochinchina, Cambodja and Siam (Haas 1922).

*Cristaria herculea* Middendorff.

A large fragmentary right valve, measuring about 130 mm between the upper ends of the adductor scars, belongs to this species. The hinge line is completely preserved, as well as the outlines of the anterior adductor scar, and there is in these characters full agreement with the recent shell. Like the latter the fossil specimen shows externally a transversal plication behind the umbones. Only a short portion of the hinge ridge is present behind the ligamental notch.

The present record of this species as occurring fossil in Northern China is rather interesting. Whether the species lives in these tracts is doubtful (cf. Simpson 1900, p. 584); its recent habitat is East Siberia and Amurland. The fossil occurrence at Hoang-Ho gives evidence of a continuous range in past times, probably Pliocene, over the Gobi desert or the Manchuria, which proves that a humid climate then prevailed in those regions.

*Hyriopsis descendens* n. sp.

(Pl. III, fig. 11.)

Shell large (length about 190 mm), ovate, rather compressed, thick in front, thinner behind, with indistinct traces of a small anterior wing and a larger posterior one. Beaks very depressed. Dorsal margin slightly curved beneath the umbones, rising high at the middle part of the shell, then straight towards the posterior margin. Frontal margin regularly convex forming an arc of an  $\frac{1}{2}$  circle; under margin gently convex. Ligamental furrow very long. Interior of the shell dull, not nacreous. Hinge with a large tooth 1, descending almost perpendicularly from the dorsal line; in front of it a deep and broad socket with some large tubercles in the bottom, and on its front side a long but faint tooth 3a. Behind tooth 1 a couple of small knobs. On the posterior portion of the hinge plate the trace of a long marginal tooth. Muscle impressions: anterior adductor scar ovate, its posterior portion behind the junction of the mantle line divided off by means of a faint furrow; anterior retractor scar confluent with the upper posterior portion of the adductorial one, situated just below the cardinal; protractor scar rather small and separated from the two mentioned by spaces of equal length. Elevator scars in the upper umbonal cavity; the hindmost one rounded and much larger than the others; the lower one extended dorsally, and above it the remaining 3 small impressions.

Only a fragmentary right valve was found, and it shows the essential characters of the genus *Hyriopsis*, above all manifested in the low beaks, the hinge elements



and the shape of the anterior muscle scars. On the other hand, the teeth and the impressions are rather unlike those of the recent *Hyriopsis*, above all the large cardinal, which is directed almost perpendicularly from the dorsal margin, and the large scars of the elevator muscles; to these comes the abnormal length of the ligament, a character also akin to the fossil species of other genera. Externally no special features are discernable, since the shell has been subject to withering at both umbo and disk. Only the course of the lines of growth indicate that the shell has been furnished with a large posterior and a smaller anterior wing.

I do not hesitate in considering this fossil shell as a new species distinct from the recent ones and probably more primitive than those on account of its hinge teeth and the length of the ligament.

At the present time the species of this genus are all restricted to Eastern Asia from Malacca, Borneo and China to Japan. But in the upper Tertiary it had a wider distribution, as Haas has shown (1920, 1923) by the discovery of three fossil species, two of them, described by Haas (1920), from Western Europe and the third from Slavonia.

*Lepidodesma ponderosa* n. sp.

(Pl. II, figs. 5—7.)

Shell rather thin in young specimens, thick and heavy in old ones, compressed anteriorly and under the middle, with a rather broad diagonal ridge. Umbones rather prominent, in  $\frac{1}{3}$  of the length from anterior margin. Upper margin straight, anterior one acuminate rounded, under margin strongly curved, hind margin truncately convex. Sculpture: coarse concentric, irregularly spaced, ridges, high on the anterior half, lower posteriorly; on the upper posterior portion a number of irregular confluent knobs arranged somewhat radially, the largest on the diagonal convexity; on the beaks two distinct radial lines of 5—6 knobs each, one diagonal, the other prediagonal.

Interior of the shell with a blue nacre and traces of the external sculpture. Hinge with obscure cardinals produced in the shape of lateral teeth: an indistinct I and a faint 3a in the right valve; median part of the hinge plate, beneath the umbones, smooth, posterior one bearing a rather short lamelliform lateral tooth in each valve and, in the left valve, a marginal on its inside.

Ligamental furrow rather broad, shallow and short, occupying only half the length of the dorsal margin.

Anterior adductor scar ovate, with the rounded anterior retractor scar adjoining above the middle; anterior protractor scar broadly elongate, behind the lower end of

the adductor impression. Posterior adductor scar produced vertically, elevator scars on a line at the preumbonal ridge area (extending from cardinals to behind the anterior adductor).

Mantle line regularly curved, concentric with the outlines, but with a slight concavation below the protractor scar.

About 5 specimens of this species are available to me, all, however, fragmentary. The largest fragment measures 185 mm in length and has a weight of 330 gr. The specimen must, in its unjured condition, have had a length of about 230 mm.

This species is closely related to the recent *L. languilati* Heude, which is, however, much thinner, has more prominent umbones, stronger lateral and marginal teeth, a comparatively shorter upper margin, a considerably longer posterior slope, and a vertically extended anterior retractor scar. The shape of the recent shell varies considerably from short to rather produced into a long sloping posterior margin.

A lot of specimens of *L. languilati* were sent by prof. Andersson, originating from small rivers in Kiang-si, Chi-An-Hsien. The largest shell has a length of 190 mm and a weight of 180 gr for one valve. The animal has not hitherto been examined. It has a long supra-anal aperture about as long as the anal one, a much shorter supra-anal connection and a complete branchial diaphragm. The branchial opening has elongate papillae on its margins, the margins of the anal opening are completely smooth and marked with short transversal blackish streaks, and in the supra-anal opening the margins are smooth and uncoloured.

External lamella of outer gill and inner one of inner gill fused in their entire length to mantle and body respectively.

Both gills have complete septa which lie nearer each other in the inner gill. Along a zone of the gill margin short secondary and still shorter tertiary septa appear between the larger ones in both gills. The inner gill has a well-marked marginal furrow, a feature, that is certainly a very common characteristic, or rather the rule, in all Eulamellibranchia.

#### *Nodularia douglasiae* Griffith & Pidgeon.

About a dozen specimens, single valves or complete shells, max. l. 75 mm (a right valve) and weight 20 gr; a recent valve of the same size, somewhat eroded on the umbones, weighs only 10 gr.

All the shells are well preserved also in the umbonal region, and none are corroded there, in contrast to recent specimens where corrosion is a usual phenomenon. The fossil shells are twice as heavy as recent ones of equal size; their hinge

teeth are thicker and shorter. All muscle impressions are like those of the recent form, and the differences are too slight to be considered of specific importance. The umbonal sculpture is concentric but reduced to a diagonal and a median row of a few tubercles, some ziczac waves between them and, in the front portion, some oblique rugae. The extension of the latter over the whole preumbonal part of the shell, as is often seen in the recent specimens, does not occur in the fossil valves at my disposal.

Outside China the species is distributed in Amur, Corea, Cochinchina and Japan (Simpson 1900, Haas 1922).

The soft parts have been examined by Haas (1922).

*Cuneopsis maximus* n. sp.

(Pl. II, figs. 8-10.)

Shell large and heavy, wedge-shaped, compressed, high anteriorly, gently sloping towards the rear end which is torted and bent to the right. Anterior margin semicircularly rounded, under margin straight or slightly concave, hind margin rounded, upper margin straight. Umbones in  $\frac{1}{4}$  of the shell length from anterior margin, depressed, bent inwardly. Surface lustreless, sculptured with coarse lines of growth; umbones with a few transverse rugations; a slight trace of a dorsal keel runs from the umbones to the upper part of the posterior margin. Ligamental furrow occupying nearly the whole dorsal margin.

Interior margarilaceous. Hinge: in the right valve, beneath the umbones, a large bipartite tooth 1 flanked by a narrow anterior and a broadly triangular posterior socket; before and behind them each a crest-like tooth (3a and 3b); besides a long lateral (l) extending to the muscular scar and finally traces of a marginal tooth inside this lateral. Anterior adductor impression subcircular, the retractor scar also subcircular, below the tooth; the protractor scar ovate, behind the adductorial one; posterior adductor scar broad behind; its height exceeding half its length and equalling the distance from its under side to the mantle line. Posterior retractor scar above the middle of the adductor impression. A long elevator scar behind the hinge plate and some small ones at its margin. Hinge of the left valve with a large triangular 2b and two smaller teeth in front of it (2a and an accessory tooth behind it); a long crest-like marginal tooth and above it an indistinct lateral (ll).

Behind the posterior adductor impression is a lengthened callus near the shell margin.

The maximum specimen has a length of 138 mm, a height of 69 mm, and the weight of its right valve amounts to 130 gr., that of the left one to 150 gr.

This species is perhaps the same as Dall identified as »*Cuneopsis* near *C. capitatus* Heude». The resemblance to this recent species is striking, but there are important differences in shape (*capitatus* is swollen in front), in teeth (*capitatus* has a single right cardinal, though divided by a median furrow) and in the muscle scars. The differences in the teeth seem to be due to the breadth of the hinge: in *C. maximus* this is broader and the tooth 1 becomes bipartited, in *C. capitatus* the hinge and the teeth are more contracted and the umbones more pointed. *C. maximus* corresponds in this point more to *C. pisciculus* and *C. heudei*, than to *C. capitatus*. The deep umbonal cavities are common to all the species. The fossil species, except the larger size, unites characters of all the recent ones (the torsion of *pisciculus*, the wedge-shape of *capitatus*, apical sculpture and hinge of *heudei*), and one seems justified in seeing, in *C. maximus*, the ancestor of the recent species mentioned.

The genus *Cuneopsis* was established by Simpson in 1900 with *C. celtiformis* Heude as type and includes 5 Chinese species. One of them, *C. heudei*, has been anatomically investigated by Haas (1922). The genus comes nearest to *Unio* (in the sense of Ortmann 1912).

In examining some of the alcohol preserved specimens sent by prof. Andersson I observed that the posterior callus noted above has to fulfil a certain function, inasmuch as it causes an approach of the mantle margins above the anal opening, thus facilitating their connection. In the following genus we will find a further development of this condition.

#### *Lamprotula* Simpson 1900.

This genus was established by Simpson in 1900 as a subgenus of *Quadrula*, having *Chama plumbea* Chemnitz as the type. The creation was based on conchological characters only, as the group in question differs from the American forms of the genus *Quadrula* in the beak sculpture which consists of »a few coarse subparallel ridges which are slightly doubly looped».

Haas (1922) examined anatomically *Lamprotula leai* and established the fact that this species differs from the American *Quadrulas* and the Indian *Parreysias* in the presence of small papillae in the anal opening and small tubercles in the supraanal one. On the same occasion Haas raised Simpson's subgenus to a generic range.

Simpson made an attempt to arrange taxonomically the species of this genus and discriminated six groups according to the shape of the shell, its sculpture, the position of the beaks, the hinge and other particulars.

These groups may be reduced to two based on as many different types of

*Lamprotula*, the one represented by species having the umbones somewhat behind the frontal margin, and being compressed or much elongated, with moderately developed hinge plate and teeth (e. g. *L. leai*, *L. rochechouarti*, *L. cornuum lunae*). The other group comprises the ovate, heavy and solid species with prominent umbones situated in the upper anterior corner of the shell, a very broad and thick hinge plate and powerful teeth. The umbonal cavity in these species attains a considerable depth and the sculpture develops extreme features.

To this second section I refer (beside the type, *L. plumbea*) *L. fibrosa*, *L. scripta*, *L. polysticta*, *L. nodulosa* and akin species. This group apparently originated from types of the former one, since we find from the umbonal characters that the shell originally had more posteriorly situated umbones.

It seems not unlikely that there is some correlation between the thickness of the hinge, the position of the umbones, and the depth of the umbonal cavities. It may be assumed that the species of *L. plumbea* group have attained their characteristic shape as a consequence of the heavy deposit of lime in the hinge region. An increase of the lime deposit here relatively to other parts of the shell must be compensated by an increase of the crassitude of the shell and a deepening of the umbonal cavities.

Leaving this question as being outside the scope of our present subject, we return to the division of the *Lamprotulas* made above and to an examination of the recent species before we study the fossil material.

Thanks to the fine collections of recent *Najades* preserved in alcohol, sent home by prof. Andersson, I was enabled to examine the soft parts of some representatives of the respective sections, viz. on the one hand *L. leai* and *L. rochechouarti*, on the other *L. fibrosa* and *L. subtorta*. The two species in each group were much alike, but unlike those of the contrary group. Haas (1922) established in the first-named species a very short mantle connection between anal and supra-anal slit; in the specimens at my disposal there was none, or a mere small knob represented the rudiment of one. In this respect *L. rochechouarti* was completely in agreement with *L. leai*. In the other two species a longer mantle connection was present, being about  $\frac{1}{3}$  of the well circumclosed anal orifice; in two specimens the connection was complete, in two other specimens interrupted or caducous. Further, in the two last-mentioned species, the mantle edges were bent inwardly towards each other thus showing a tendency to form a bridge between branchial and anal openings; nothing like that appeared in *L. leai* and *L. rochechouarti*; here the mantle margins were rather plain or showed a slight convexity on the one side corresponding to a concavity on the opposite side.

The siphonal differences in question express themselves also in the shells. *L. fib-*

*rosa* and *L. subtorta* have a pair of callosities like those of *Cuneopsis*, behind the posterior adductor scar; these are opposite to each other and thus cooperate to pinch together the mantle edges at this point just at the end of the diaphragma. These callosities, observed also by Simpson (1900), divide the hind gap of the mussel according to the respective openings of the mantle margins; they may be present also in the *L. leai*-group, but are feebly developed and do not markedly influence the space between the valves when closed. Beside the well-developed anal callus there are sometimes (e. g. in *L. fibrosa*, *L. polysticta*) indications of a supra-anal and a subbranchial callus; in most cases, however, these are indistinct. As mentioned above, a supra-anal callus, but no branchial one, is present also in the genus *Cuneopsis*. The same is the case in *Shistodesmus*.

After these introductory remarks we pass to the examination of the fossil Lamprotulas at hand.

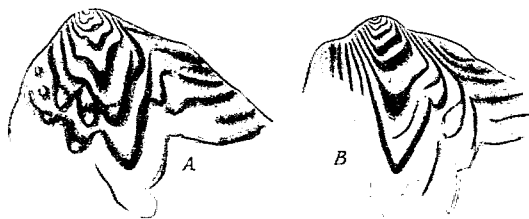
They all belong to the *L. plumbea*-group and have extremely thick and heavy shells. Two types are distinguishable: one with almost smooth disk, the other with the posterior part of the disk beautifully sculptured with double-looped bars and dorsal undulations. The smooth form comes near the recent *L. spuria* Heude, but it differs in some essentials, as for example in having a much longer ligament, a convex curve of the under margin in front, a long curved lateral I and a trace of a long marginal inside it; the laterals lack the coarse transversal crenelation peculiar to that and allied species.

In young specimens, however, this same crenelation is quite distinct; as growth passes on it disappears. Young specimens, further, have in general a more rounded shape recalling that of e. g. *L. fibrosa*, while the shape grows more elongate in adult specimens.

As to the different kinds of sculpture this seems, in spite of the differences in the adult shells, referable to one original type, represented by the umbonal shell. In this we find (Pl. III, figs. 16, 17, 18, 21) a radial sculpture on the posterior part of the shell, and in the front half a sculpture *parallel* to the posterior one, thus directed backwards; in the median part of the shell the systems of ribs are connected by transverse bars forming knobs when joining the posterior ridges, and thus forming an angular keel, and medially descending into a V-shaped loop. In the small shell figured we can count up to 10 posterior and as many anterior ribs and the ribs are all, originally, straight and entire.

The peculiar course of the anterior ribs which diverges from the normal radial direction, proves that in reality the sculpture is a *concentric* one. In the earliest um-

bonal portion this is also clearly seen, inasmuch as here the median bars and the anterior as well as the posterior ribs form each a continuous concentric costa. On account of a stronger growth of the median portion of the shell the costae are produced ventrally, thus causing the peculiar direction of the frontal ribs.



This umbonal sculpture may develop in two directions in subsequent growth (text-fig. A, B): in the one case (B) it sooner or later becomes obliterated as is the case e. g. in the recent *L. spuria*, and the disk of the adult species is thus smooth; in the other case (A) it becomes more complicated by the dissolving of the anterior ribs into series of knobs. These may be arranged in new formations attaining the form of new V-shaped loops, which, however, soon disappear (so in the most elaborately sculptured fossil shells). In the recent *L. polysticta* the knobs, however, persist and, moreover, increase so as to become regular and isolated. Not only the anterior ribs but also the median bars participate in this dissolution into knobs; in other recent species they attain characteristic patterns, or grow dominant or recessive in different ways. In the recent *L. fibrosa* and *L. scripta*<sup>1</sup> two prominent keels appear in the young shell; for in addition to the posterior row of knobs is developed an anterior one at the points where the transverse bars join the anterior ribs. Both series of tubercles are obliterated in a more advanced stage; their coexistence is no doubt a secondary acquirement. In *L. triclava* the tubercles of the disk attain a very large and irregular appearance.

The posterior bunch of radiating ribs acquires an altered direction in the older mussel, being bent to the dorsal margin and appears as repeated undulations along it. The further changes in this kind of sculpture is only a gradual one; it is rather obscure in the smooth species and most obvious where the disk sculpture is most elaborate.

As a result of the above examination we may state that the fossil forms of

<sup>1</sup> Simpson (1930) unites *L. fibrosa* and *L. spuria* of Heude to one species (*fibrosa*). I cannot share this opinion. *L. fibrosa* and *L. scripta*, on the contrary, are very like and possibly identical.

*Lamprotula* before us belong to one single species which varies in sculpture, since this is referable to one original type and transitional forms of the sculpture exist. Further we can state that the fossil species in question differs from all the recent ones, above all in its extreme size, but also in sculpture, and that the living species have a more specialized and often elaborate sculpture than the more indifferent fossil species. The latter seems, indeed, to have a more primitive sculpture than several recent forms. It therefore seems to be not unlikely that the fossil species represents the real ancestor of some of the living Chinese *Lamprotulas*, viz. those of the *L. plumbea*-group. It is true that all recent species are smaller and that they have, in general, a distinct striation of the lateral teeth, whereas this character is obliterated in the present fossil species when adult. But its larger size and the disappearance of the striation mentioned may be a consequence of a rapid deposition of lime, due to favourable climatic and physical circumstances. When these changed in later times into less favourable ones, an arrestment of the development of one or other character followed, which resulted in the persistence of juvenile characteristics on the one side, while other characteristics, on the other side, such as sculpture, probably due to changed physical conditions, developed into several directions.

As a consequence of the above arguments I describe the fossil *Lamprotula* as a new species. It is possible that this is identical with the forms identified by Dall as *Quadrula* near *Q. spurius* and *Quadrula* near *Q. affinis*. Dall's identification and his conclusions were based on a very scanty material. His dating nevertheless was marvellously exact.

As mentioned above, I consider the age of the present fossils Pliocene. In European Pliocene formations we find, indeed, mussels with a striking resemblance to the Chinese *Lamprotulas* of the *L. plumbea*-group. This is, for example, the case with *Unio bielzi* from Roumania. Neumayr (1899) has already pointed out the resemblance between the recent Unionids of China and the fossil Pliocene ones from Slavonia and Roumania. The *U. bielzi* mentioned is quite certainly a *Lamprotula* and it shares the umbonal sculpture of the Chinese forms. The anal callus of the latter is however absent.

***Lamprotula antiqua* n. sp.**

(Pl. III, figs. 12—22, Pl. IV, figs. 29—33, Pl. V, figs. 34—37.)

Shell large and heavy, ovate, with prominent umbones in the upper frontal corner, sculptured only at the umbones, or more or less on the upper disk and along the dorsal margin, with low indistinct ridges and angular markings; for the rest only lines of growth. Dorsal margin almost straight, posterior margin acuminate rounded,



interior and frontal margins largely convex, together forming an arc of about a third of a circle; there is no demarkation between under and frontal curvature. Ligamental furrow occupying almost the whole dorsal margin and in the adult much longer than half the shell (or less often as long). Beak cavities very deep. Hinge with a strong cardinal (1 and 2b) in each valve and indistinct anterior ones (3a and 2a); teeth 1 and 2b split into sharp crests by deep furrows; corresponding crests in the sockets. Lateral tooth 1 very long and indistinctly striated in oblique direction in the adult; coarsely grooved transversally in the young. Muscular scars: posterior adductor scar rounded, broadly ovate; the posterior retractor scar triangular and separated from or confluent with the former; anterior adductor scar very deep, as long as the cardinal and just below it; its bottom narrow, forming a sharp furrow. Protractor scar lengthened behind the adductorial one. Elevator scars on the margin of the hinge plate.

This species differs from *L. spuria* Heude, which it comes near in general habitus, in its smooth, not tuberculate disk, its generally more convex frontal margin, the longer ligament and longer lateral tooth, as well as in the positions of cardinals and adductor scar. Though I have no authentic specimens of *L. spuria* at my disposal, I do not hesitate in considering these differences essential and specific.

Of this species a very large collection was made, comprising about 200 valves or complete shells, the maximal ones attaining a length of 128 mm, a height of 93 mm and a weight of 339 gr (a left valve) and 132, 88 and 220 respectively (another valve). That the species was so abundantly represented in the collection proves that it was, no doubt, the most common bivalve in the bed.

The statements give evidence of some formal variation, and, as mentioned above, the variation is in reality very considerable in this species. Some specimens are lengthened (figs. 30, 36, 37), other short and expanded (something like *L. rochechouarti*, with a more dilated anterior portion; figs. 31—33). Above all, however, the external sculpture is subject to different development. In some specimens a trace of a dorsal radiating ridge is present and, towards the umbones, there are a few undulations repeated between this ridge and the dorsal margin, but they soon disappear farther back and do not attain the strength as in the var. *undulata*. In small specimens the umbonal sculpture is observable; it consists of V-shaped ornamentations, as already mentioned. The inner nacreous hue of the valves is very well preserved in both small and large specimens. The small specimens have in general a more rounded shape than the older ones, and they have as mentioned, a grooved lateral tooth, but these characteristics are altered later on by the growth. They are, consequently, not to be considered as characterizing a distinct variety, like the sculpture.

***L. antiqua* var. *undulata*.**

(Pl. III, figs. 12—14, Pl. IV, fig. 29.)

In its extreme case the sculpture of *L. antiqua* assumes a great extension over the hind parts of the shell, above all on the posterior slope, which becomes waved with repeated undulations transversal to the dorsal margin. In the umbonal region the angulations reach lower down on the disk, and here become dissolved into low elongated somewhat depressed nodules which generally disappear in the under half of the valve. This state of affairs recalls *L. polysticta*, which has, however, the knobs strongly defined, and further similarities are to be found in the inside; the ligament is also somewhat shorter than in the typical form. This variety, further, offers an internal character which separates it from the type: the length axes of the cardinal and that of the anterior adductor scar form an angle on each other of about 45 degrees, and this feature is due to a strong development of tooth 2a, respectively its socket. In some of the specimens the dorsal undulations are divided in their dorsal ends, a characteristic present also in several recent species.

## FAM. CYRENIDAE.

***Corbicula fluminea* Müller.**

(Pl. IV, figs. 23—28.)

There are a lot of single valves of a *Corbicula* (max. 1.20 mm), and one specimen with both valves closed. In contrast to the Unionidae mentioned above this mussel is rather thin, and it differs in this respect from the recent Chinese *Corbiculas* which have, in general, thick shells. On account of the great variability, which marks the Chinese *Corbiculas* (and most of the species of this genus) some difficulty is encountered in identifying the fossil shells. There are, among the recent forms of Chinese *Corbiculas*, some which seem to approach nearest to the fossil one in shape and thinness of the valves; one of them is *C. cantatoris* Heude. This has the regularly ovate shape of the fossil shell with somewhat acuminate rounded ends, but the umbones of the latter are somewhat more prominent. The fossil shell, however, varies from elongate-ovate to rounded-ovate, and is rather inflated, though not so much by far as in general in the forms of the *C. fluminea*-group, which, however, varies even in that respect. On account of its shape the fossil species, however, must be referred to that species. Its costae are moderately distant in all specimens, and there is thus in the sculpture no such great variability as in the recent Chinese species. Further the fossil species is more primitive in the respect that the anterior

lateral teeth of the right valve are straight above and slightly curved below the upper end of the adductor scar, thus showing no tendency to become callous as in the *C. largillierti*-series. The agreement with *C. fluminea* is implied also in the regularly curved mantle line inside the valve; this is generally as strongly convex in front as behind, in contrast to both *C. largillierti* and *C. fluminalis*, where this line is distinctly less convex in its anterior part.

The occurrence of single valves of otherwise fragmentary and eroded specimens of this *Corbicula* together with the heavy Lamprotulas and other Unionids indicates a transport of the mussel in question from other localities, and it seems not to have lived in accompany with the others. Certainly the species lived in small brooks just as do some of the recent small forms described by Heude as distinct species, such as *C. montana*, *cheniana*, *papyracea*, *cantatoris*, *sphaerica*, *ferruginea*, *borealis*, *soriniana* (all by Heude). All these differ from the fossil shell in being more compressed (except *ferruginea*) and like the recent forms in general, corroded on the umbones, which is not the case in the fossil.

To investigate the taxonomy of the genus and especially to critically discriminate the Chinese species of *Corbicula* are tasks still waiting to be performed. A reduction of the hitherto described species will certainly be the result thereof, and Haas (1922) recognizes only the typical *C. fluminea* and eventually *C. largillierti* as species.

*Corbicula largillierti* Philippi.

A right valve, of 26 mm length, somewhat broken.

FAM. LIMNAEIDAE.

*Limnaea clessini* Neumayr.

A small fragment with coarse incremental lines and a rather wide umbilicus seems to be this form, which is certainly a variation of *L. ovata*. This species was found by Széchenyi at the southern limit of the Gobi desert (Neumayr 1898).

FAM. HELICIDAE.

The occurrence of land shells among the large bivalves is another proof of the transport mentioned just above. They have, of course, lived in the vicinity of the river, and it is evident that they are contemporary with the bivalves, since they are often included in the shells of the latter. Three species of Helicids were determined, all belonging to recent species, one of them now extinct in that part of China.

*Metodontia houaiensis* Crosse.

Six specimens (max. diam. 10.2 mm; whorls 8) showing the characteristic coarse striation on the upper part of the shell and the variation in the dentition described by Hilber (1898). To the two parietal teeth and the two labial ones a columellar tooth may be added; the labial teeth may also be united by a transversal callus, as Hilber states. A peripheral band, but no sutural one, is present.

This species is a common loess-form and still lives in the northern provinces of China: Shensi (Hilber 1898), Shansi and Kansu (Sturany 1901), Shantung, Anhui and Honan (Moellendorff 1899). *M. hemipleuris* Moellendorff (1886) seems to be a synonyme of the present species; Moellendorff (1899) consider it to be a subspecies.

*Cathaica (Pseudiberus) plectotropis* Martens.

Two fragmentary specimens, the largest with  $5\frac{1}{2}$  whorls and a diameter of 13 mm, seem to be identical with this species on account of their coarse costae. These are regular and distant (with about  $\frac{1}{2}$  mm interspace), as strong below as above the peripheral angle, which they crenelate. The whorls are but slightly convex and in the same degree above and below. Also the umbilicus is quite similar to that of this species (cf. Tryon & Pilsbry, *Man. of Conch.*, VIII, 1892, pl. 12, fig. 3), thus being narrow in the centre, and rapidly widening in the last whorl.

This species now lives in the Tian-shan Mountains and Chinese Turkistan (Moellendorff 1899).

*Platypetasus anderssoni* n. sp.

(Pl. V, figs. 38—46.)

A fragment of 4 whorls (diam. 13 mm) proves to belong to a new species which was also collected in a living state in the Shan-tung Province, at Ching-Chou-Fu, Io-shan, in a cave, the 23<sup>d</sup> 1919. A lot of specimens of this species are at my disposal and from them the following description, as well as the figures, are made.

Shell depressed, sharply keeled in the periphery, moderately umbilicated (umbilicus about  $\frac{1}{3}$  of the shell diameter), rather solid, covered with a thin caducous cuticula. Spire broadly convex, with blunt apex. Protoconch (2 first whorls) finely elongate-granulate; subsequent whorls sculptured with coarse lines of growth only, the first whorl with traces of the apical sculpture. Keel distinctly marked off by a series of impressed short rugations. A faint spiral striation over the whole upper side visible in some specimens. Colour brownish, with white streaks and clouds above; base pale

brown; a castaneous band above and below the peripheral keel. Suture shallow, margined by the keel. Aperture very oblique, rounded square; outer lip expanded and reflected, its inside with a thick callus all round; columellar lip reflected, partly covering the umbilicus; a small convexity between columella and under lip. Parietal wall with a very thin, scarcely marked, calcareous layer, combining upper and inferior ends of the outer lip. In the adult shell the keel does not reach the reflected outer lip. Maximum dimensions: maximum diameter 22, min. 18.2 mm, height 11 mm; whorls 5  $\frac{1}{4}$ .

This species is, in its shape, intermediate between *P. castanopsis* and *P. trochomorpha*, both of Moellendorff 1899, but it has a somewhat narrower umbilicus, which is, however, wider than in *P. innominata* Heude and *P. mariella* H. Adams. The shell has much the appearance of a large *Helicella lapicida*.

The fossil shell is somewhat eroded and thus does not show any traces of the apical sculpture of the recent type, and only very faint traces of the peripheral rugations at the keel.

## SUMMARY.

In the above account the following species from the San Men Series at Ho Ti Tsun have been recorded:

- |   |  |
|---|--|
| + <i>Solenia carinata</i> Heude.                | + <i>L. antiqua undulata</i> n. var.       |
| <i>Anodonta woodiana</i> Lea.                   | <i>Corbicula fluminea</i> Müller.          |
| <i>Cristaria herculea</i> Middendorff.          | <i>Limnaea clessini</i> Neumayr.           |
| + <i>Hyriopsis descendens</i> n. sp.            | <i>Metodontia houaiensis</i> Crosse.       |
| + <i>Lepidodesma ponderosa</i> n. sp.           | <i>Cathaica (Pseudiberus) plectotropis</i> |
| <i>Nodularia douglasiae</i> Griffith & Pidgeon. | v. Martens.                                |
| + <i>Cuneopsis maximus</i> n. sp.               | <i>Platypetatus anderssoni</i> n. sp.      |
| + <i>Lamprotula antiqua</i> n. sp.              |  |

Species with a + are found and known only in a fossil state.

Most (8) of these shells are still living either within or without the boundaries of China, and their recent distribution compared with their occurrence as fossils offers some facts of interest. *Anodonta woodiana*, *Cristaria herculea*, and *Nodularia douglasiae* have a relatively wide distribution, being at home not only in China but also in Amur and Siberia or southwards in Cochin China (cf. above). The land shells belong to species either still living in the vicinity of the present locality or restricted to other, peripheral, districts, and the extinct species, finally, have their closest relatives only in tracts south of the fossil locality. Thus we find that the fauna of the present bed originated from very widely separated tracts of the present surroundings. In other words: The San Men mollusc fauna, since the time when it existed as a whole, has been split up geographically, most of its components being still living adapted to altered conditions, others, which were less adaptable, being extinct. It is of interest to observe that the latter group, however, has given rise to descendants in more southern districts where the climate was not against them to the same degree as in the North. Thus it seems reasonable to assume that the unfavourable conditions caused an extinction or a stagnation of the development of the species, at the same time as the less unfavourable conditions caused an origin of new species in suitable localities. In every case the San Men fauna gives evidence of having existed during a time of a humid and warm climate, favouring the dispersal of the fauna over the large and climatically heterogeneous area that its remnants occupy today.

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EXPLANATION OF THE PLATES.  
PLATE I.



PLATE I.

*Solenaria carinata* Heude, ♂ of nat. size.

Fig. 1. Left valve, exterior.

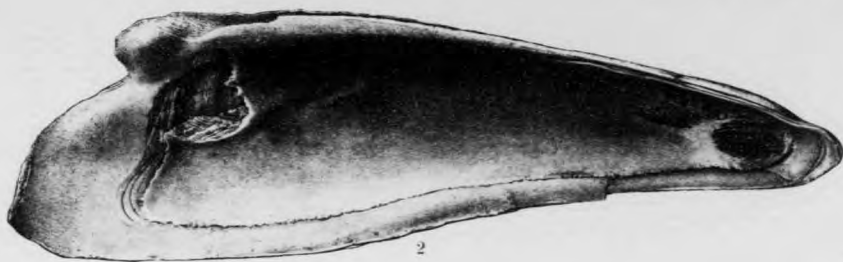
Fig. 2. The same, interior.

Fig. 3. Right valve, interior.

Fig. 4. Dorsal view of a shell with closed valves.



1



2



3



4

PLATE II.

PLATE II.

Fig. 5. *Lepidodesma ponderosa* n. sp., nat. size of a small specimen.

Fig. 6. The same, right valve, interior.

Fig. 7. Dorsal view of the same specimen with valves closed.

Fig. 8. *Cuneopsis maximus* n. sp.,  $\frac{2}{3}$  of nat. size, left valve.

Fig. 9. The same specimen, dorsal view.

Fig. 10. The same specimen, right valve interior.

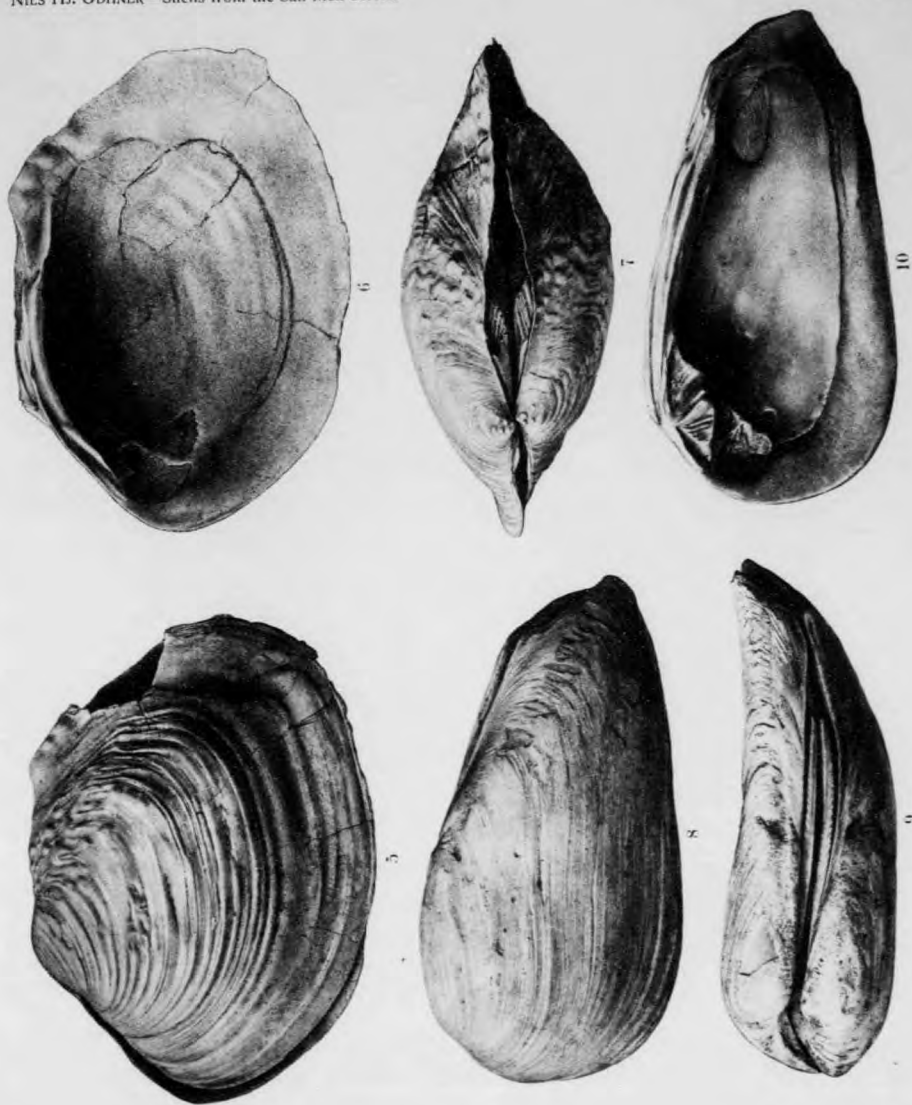


PLATE III.

PLATE III.

Fig. 11. *Hyriopsis descendens* n. sp., right valve, inside.  $\frac{2}{3}$  of nat. size.

Fig. 12. *Lamprotula antiqua* n. sp., var. *undulata*, right valve, inside.  $\frac{2}{3}$ .

Fig. 13. The same specimen, left valve, exterior.  $\frac{2}{3}$ .

Fig. 14. The same species, a variety with nodulous sculpture, right valve.  $\frac{2}{3}$ .

Figs. 15—22. The same species, 2 young specimens, nat. size, showing external sculpture and internal characteristics of both valves.

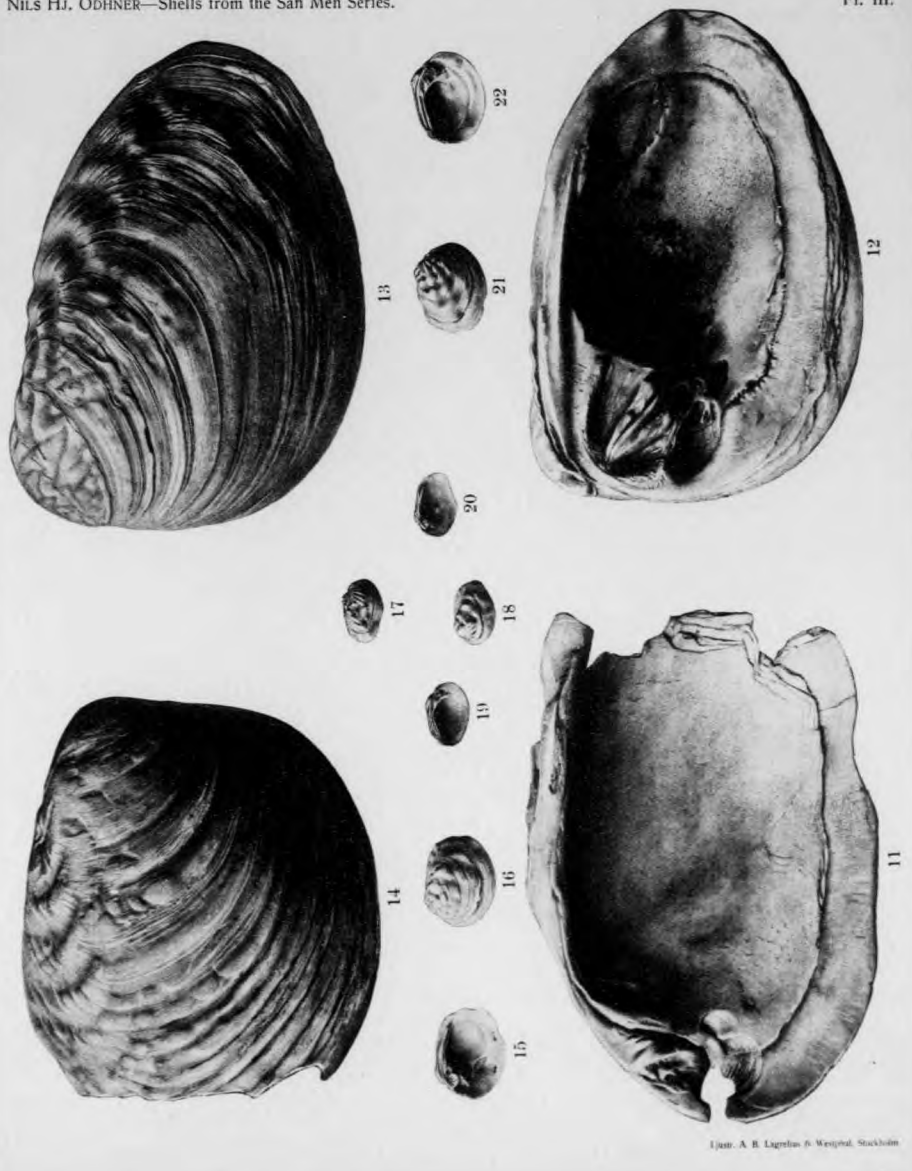




PLATE IV.

PLATE IV.

Figs. 23—28. *Corbicula fluminea* Müller, one left (figs. 23, 24), and two right valves, nat. size, from within and without.

Fig. 29. *Lamprotula antiqua* var. *undulata*, the same specimen as in figs. 12, 13, dorsal view. ‡.

Fig. 30. *L. antiqua*, forma *typica*, dorsal view. ‡.

Fig. 31. The same species, another, more inflated, specimen, dorsal view. ‡.

Fig. 32. The same specimen as in fig. 31. ‡.

Fig. 33. The same specimen as in fig. 31, 32, left valve. inside. ‡.



PLATE V.

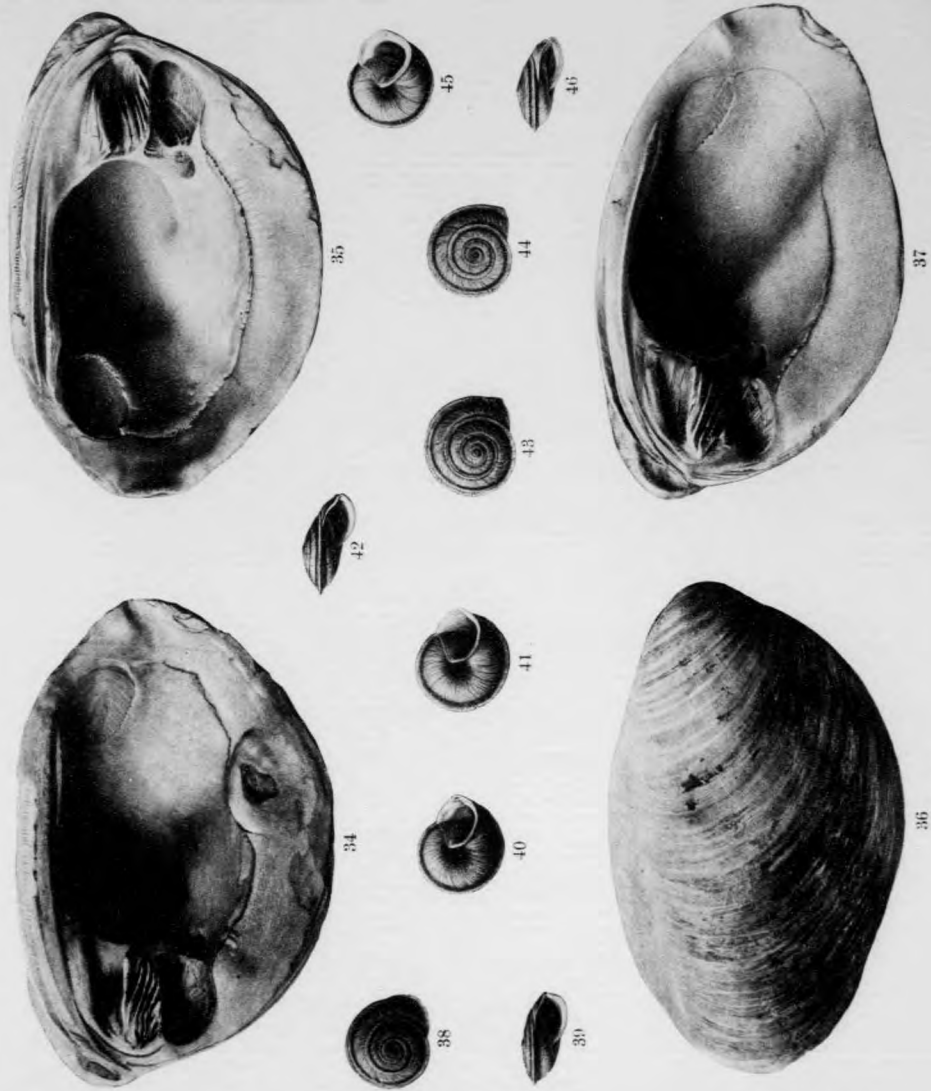
PLATE V.

Figs. 34, 35. *Lamprotula antiqua* n. sp., both valves from within, same specimen. ‡.

Fig. 36. The same species, a right valve from without. ‡.

Fig. 37. The same valve, inside. ‡.

Figs. 38—46. *Platypetasus anderssoni* n. sp., 3 specimens in views from above, from below and from aperture; nat. size.



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**Palaeontologia Sinica**

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古  
生  
物  
誌

*Calliarea* (*Pseudiberus*) *pleurotopis* v. Martens

*Platypetarus andersoni* n. sp.

表內之標有十者均係只有化石之代表，其餘八種則現在仍有生存者。*Anodonla woodiana*, *Oriktaria hercules*, 及 *Neolularia tonglasi* 之分佈頗廣，並不只限于中國、阿木爾 (*Amur*)、西伯利亞以及安南皆有之。三門系內之田螺有一種仍繼續生存於其附近，一種亦曾採集之於山東，其滅絕之一種則只與化石產地以南之近代田螺相類似。故本層內之生物羣一若原於既今遠隔之諸地域然，實則當三門之時，此生物羣本共同生存於一種情形之下，後始分隔為數地理區，適者生存，不適者滅亡，因成現今隔絕之現像也。但中國南北氣候不一，情境各異，其留于北部者因氣候之改變而致滅亡，其遷徙於南方者，則仍能於環境之不適宜之下競爭生存，因發生新種。是以三門生物羣實示吾人以當時氣候溫和濕潤，彼等亦散見於各處，其後因環境改變，不適者漸臻滅亡，今日所見之繼續生存者不過昔日者所遺留之苟延殘喘者耳。

之時代，達爾曾謂其屬於更新期。若以此化石羣與近代生物羣比較之，則此化石羣內仍有若干種繼續生存至現在者，但亦有完全滅種現在既無其親族遠古復無其類似者。惟就此化石羣之普通形狀推之，當時氣候應溫和而濕潤。此等事實似以此化石羣屬之於上新期之上部較為適當也。

在河底村三門系內所採集之化石含有下列諸種。

+ *Solenia curvata* Heude

*Anodonta woodiana* Lea.

*Crassaria herculea* Mûlendorff

+ *Hyriopsis descendens* n. sp.

+ *Leptodesma ponderosa* n. sp.

*Nodularia douglasiae* Griffith & Pilgson

+ *Cuneopsis marinus* n. sp.

+ *Lampyris antiqua* n. sp.

+ *Lampyris antiqua* var. *undulata* n. var.

*Corbicula fluminea* Müller

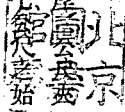
*Limnaea alesiini* Neymayor

• *Metadontia honanensis* Crosso



### 三門系之介殼化石

俄德諸著  
趙亞曾翻譯



於中國北部之新生界一文中，安特生博士曾述及山西南部垣曲縣河底村介殼層之發現。該層厚約二十公尺之黃土與礫石之互層中，介殼層之下為厚二·五公尺之粗礫石，底部為厚十七公尺之粗礫石。介殼之產生皆在砂礫內，其體積偉大者常成直立之狀。

安特生博士之謂其中之二種與在三門所採集者屬同種毫無疑義。三門所採集之介殼曾經達爾 (Dall) 博士鑑定之。彼謂：「三門系之三種介殼均與現尚生存於中國淡水中者極相似，但非同種。吾等雖無充分之

現代介殼藉資比較以追求彼此變異之界限，但其不同之處則確示此等化石介殼似為現尚生存者之遠祖。

三門之三種介殼為 *Quadrula* 二種（一與 *Q. affinis* Heude 相近，一與 *Q. spuria* Heude 相近）及 *Conomys* 一種（與 *Q. Capitatus* Heude 相近）。

三門化石予雖未之見，而其中必有與在河底村所採集者屬同種。安特生博士曾送多量河底村採集於瑞典，其中不只含有達爾氏所定之諸種類，並包有多種其他淡水二枚介及數田螺，但除一破碎之螺殼外無一腹足類。介殼之保存概皆完美，外部形狀以及內部構造完好如新，並有時兩殼相連中，填以粗鬆之紅砂。凡此介殼多沈重異常，灰質層特厚，常霉爛成纖維狀或鱗狀之碎片。

由地理上之分佈觀之，此等介殼之產生於黃河上游頗耐人尋味，蓋以彼等之近代親族多散見於距此地頗遠之區也。偉大之二枚介現尚生存於黃河濱海一帶及揚子江流域。於後者，郝德 (Heude) 曾述一豐富之生物羣。在郝德之著作中，彼曾名一亦產生於河底村三門層內之二枚介為 *Alveolopus curvatus*。關於三門系

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