

LACUSTRINE MOLLUSCA FROM EOCENE DEPOSITS IN
CHINA.

BY

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During one of his scientific expeditions in the service of the Geological Survey of China, Dr. J. G. Andersson detected at Yuan-Chü Hsien, S. Shansi, a deposit with lacustrine shells beneath the Loess. As the identification of the shells was of great interest both from a palæontological point of view, and for the purpose of determining the age of the layer, Dr. Andersson sent a collection of specimens from the locality in question to the Geological Survey of Sweden for the purpose of having them identified.

Prof. Grönwall turned the material over to me, with the request that I undertake the preparation of the fossils. By washing the red "clay" in water it was dissociated into an impalpable powder and the fossils were all broken up into small fragments, impossible of identification. This method therefore did not give any practical results, and the only way of preparing the fossils seemed to be by means of mechanical treatment with instruments, a labour which was performed at the Bureau of the Geological Survey. This preparation accomplished, the collection was returned to me for description by the Director, Dr. Gavelin.

The collections consisted of samples from strata of two different types, one being a grayish marly limestone, the other a hardened clay of a chocolate colour. On first inspection, they seemed to contain somewhat different faunas, for in the gray limestone there occurred a great many specimens of *Planorbis* and several of *Physa*. The latter were not found in the red clay, which on the contrary offered a quantity of mussels, seemingly small Unionids, but no *Physæ* and a scanty representation of *Planorbis*.

Nearly all of the fossils were in a rather bad state of preservation since they had been subject to pressure and hence were distorted and fragmentary. In considering this fact I feared there was but little chance to identify the Mollusca, the more so as they had a rather old appearance and one quite different from that of the recent fauna or that described from the latest geological deposits of Pliocene and Post-Pliocene age.

Some of the more satisfactorily preserved specimens of *Planorbis*, which appeared to be of an unusual size, suggested a method of procedure which proved successful in the other cases as well.

The large *Planorbis* referred to seemed to be most like the polygyrous species which today are restricted to the neotropical region. A comparison with the fossil species, described and illustrated by Sandberger (1870-75) showed that the species in question was very similar to *P. pseudammonius* from the upper Eocene of France and western Germany, where this form is one of the leading index fossils of the limnic deposits of the "Lutetian".

The identification was verified by a comparison with two specimens of the typical species in the collections of the Zoöpaläontological department of the Swedish State Museum which were kindly placed at my disposal by Prof. G. Holm.

Among the remaining forms were found several specimens of a *Physa*, which were relatively well preserved though compressed and which seemed to agree with *Ph. lamberti* described from the Lower Eocene of France as figured by Sandberger.

As a result of these determinations the gray marly limestone was assumed to be of Eocene age. Another possibility had however to be reckoned with, namely that the formation in question is younger and that its fossils might be the relicts of an Eocene fauna which had persisted in China some time after its extinction in Europe.

The question as to which of these interpretations is the most reasonable, becomes of great importance for the solution of the problem, and on this account it appears necessary to take into consideration the youngest geological deposits known from China.

It is a well established fact that there are no marine deposits younger than Triassic in China, while terrestrial deposit fill the gap to the base of the Cretaceous, after which there is an unrepresented interval until we come to the Pliocene. It was during this interval that the extensive erosion which has produced the present rock topography of the region took place, and the rock-disintegration which furnished the material, of which the Pleistocene loess and river deposits consist. It is generally held that the climate of

eastern Asia was mild and moist during the Tertiary, and this was probably more marked in the early Tertiary, when the seas had their greatest extent.

From a geological point of view thus nothing speaks against the assumption that the present layers represent an Eocene horizon.

Nothing more is, however, known about the stratigraphy of these deposits than that they lie underneath the Loess. The age of this latter formation is well determined by the fossil mollusks found in it, which, according to the investigations of Hilber, Andreæ, Sturany and Schlosser (cf. the latter author 1906) scarcely differ from the recent mollusks of China. In this respect the Loess presents the same problem as the Loess of Europe, and like that it must be regarded as of Pleistocene age.

In the strata beneath the Loess, which contain land mollusks, v. Loczy, has determined a fauna similar to that of the Siwalik formation, the similarity being indicated by the occurrence of *Steganodon insignis*. In association with this form there were found fresh-water shells (*Bithynia*, *Limnæa*, *Planorbis*, *Succinea*, *Cyclophorus?*, Loczy 1893, p. 823; 1899, p. 17, 213) "of recent character" (p. 823). The Mollusca of the Siwalik fauna are for the most part also identical with recent forms (cf. Falconer, 1868, p. 383) and in the opinion of Falconer indicate an age "of the older Pliocene—at latest".

In 1906 Schlosser described in detail the mollusks collected and previously noted by v. Loczy, and found them to belong to the following genera and species: *Limnæa merzbacheri* n. sp., *L. aff. ovatus* Müll., *L. aff. pereger* Müll., *Planorbis (Gyraulus) keideli* n. sp., *P. (G.) karkaraënsis* n. sp., *Valvata piscinalis* Müll., *Bythinia (?) cholnokyi* n. sp. *Vivipara (Paludina) angularis* Müll., together with some specimens of undetermined *Helix* and *Pupa*. Schlosser considers the Mollusca mentioned to be of Middle or Upper Pliocene age.

In addition to the Mollusca described by Schlosser, others have been referred to at various times in the literature, and these references have all been summed up by that author. From his list it appears that the Pliocene and Post-Pliocene land-and fresh-water Mollusca are all nearly related to, and in some cases identical with the present fauna of China.

The Mollusca which are described in this paper are on the contrary very different from the living forms of China, a circumstance which favours the assumption that they are of Eocene age.

As before noted, older Tertiary deposits have not previously been known with certainty from China, but there are indications of their occurrences elsewhere. Thus Abendanon (1907) who has described the stratigraphy of the so-called Red Basin ("Roter Becken") of Szechuan recognizes seven stages. Of these the fifth from below is referred to the Rhætic. The sixth stage is a shell marl ("Muschel Mergel") and above it follows the 7th and uppermost horizon which he describes as, "eine Formation von rund 2000 M. Mächtigkeit, bestehend aus wechsellagernden Bänken und Schichten von rotbraunen eisenschüssigen Tonsteinen und hellfarbigen Sandsteinen, welche letztere grösstenteils äolischen Bildungen angehören". He further adds:

"Diese ganze, mehr als 5000 M mächtige Sedimentdecke ist sehr arm an Fossilien und die welche ich gefunden habe, waren meist sehr schlecht erhalten".

With reference to the age of these formations, the author says: "Fest steht nur das rhätische Alter der Sandsteinformation". And further: "Die Etage 6 scheint zu der Kreideformation zu gehören, und endlich ist 7 zur Kreide, eventuell zum Tertiär zu rechnen".

According to Frech (1911) horizon 6 is to be correlated with the Wealden, and thus the red series should be referred to the upper Cretaceous or the older Tertiary (p. 225).

Taken all together it seems that the stratigraphic conditions of China are quite in harmony with the view here maintained namely that the new fossiliferous formation discovered by Dr. Andersson is of Eocene age.

The question, however, now arises, whether the occurrence of a west-European Eocene mollusk fauna in China is in agreement with our knowledge of the faunistical relation between the two districts so far remote from each other.

In considering this question it may first be remembered that the recent palæarctic fauna contains species which have a continuous distribution throughout the region, thus being circumpolar; among the mollusks, illustrations are offered by *Conulus fulvus*, *Margaritana*, *Acanthinula harpa* and

others. Of the European Helicid groups, *Trichia*, *Gonostoma* and *Fruticicola* are represented in the recent fauna of China. A similar distribution in Pre-Quaternary time therefore might not be unlikely.

To this may be added the fact that the present Chinese fauna contains elements which show relationship to other distant parts of the world. With respect to the Mollusca it is *inter alia* characterized by the presence of a genus of river mussel, *Mycetopoda* d'Orbigny, with twelve endemic species (cf. Cooke 1895, p. 317). Besides these the genus comprises one species from Siam and one from Assam (cf. Simpson 1900, *Solenaia*). This genus is also at home in S. America from where v. Ihering (1910) records fifteen species. With reference to its remarkable distribution v. Ihering (p. 117) says: "Simpson hat meines Erachtens einen schweren Fehler begangen, indem er die ostindischen Arten der Gattung nicht nur in ein anderes Genus, *Solenaia* Conr. versetzt, sondern dieses auch noch in einer ganz anderen Familie, der der Unioniden, unterbringt, statt sie bei den Muteliden zu belassen, zu denen sie offenbar gehören. Ebenso wie Fischer kann ich der ausführlichen Darstellung der indochinesischen Arten von Heude keinerlei konchologische Charaktere entnehmen, welche eine Trennung in zwei Gattungen oder auch nur in Untergattungen rechtfertigen könnten. Sichere Entscheidung kann nur das Studium des Tieres und seiner Larve bringen. Letztere ist unbekannt, sowohl für die südamerikanischen, als für die südasiatischen Arten. Das Tier aber stimmt nach Heudes Beschreibung mit jenem der südamerikanischen Arten überein. Wenn daher auch die Frage zunächst noch als eine offene gelten muss, so sind wir doch bis dahin genötigt, *Solenaia* mit *Mycetopoda* zu vereinigen".

Furthermore, there exists in China a genus of the family Helicinidæ, *Heudeia*, which, according to Cooke (1895, p. 316) is "a remarkable and quite peculiar form of Helicina with internal plicæ, perhaps akin to the Central American *Ceres*".

In addition to the peculiarities of the modern Chinese fauna mentioned, we find not only an Indian element, especially observable in southern China, but also indications of direct relationship to European Tertiary forms. Thus Neumayr (cf. Loczy 1899, p. 215) states that the mollusk fauna in the

fresh waters of China is closely related to that of the younger Tertiary of Europe. In the conchyliæ of Tali-fu Lake, he says, "liegt uns eine ganz normale Fauna der Paludinen Schichten vor, ja man kann sagen, dass der See von Tali-fu das letzte jener Süßwasserbecken der Pliocänzeit darstellt, das sich und seine Bevölkerung wunderbar in die heutige Periode herübergerettet hat". *

If there still exists a real European Tertiary relict fauna in China, this circumstance offers undoubtedly the best proof of a former continuous distribution throughout the Eurasian continent, and suggests that such connection may have existed in Eocene time too.

A uniform character of the Tertiary fauna of the Eurasian area has been assumed also by many other authors; I restrict myself to a citation of the statement by v. Ihering (1910, p. 426): "Das europäisch-asiatische Faunengebiet hatte in gewissem Sinne während des älteren Tertiärs einen einheitlichen Character, aber es bestanden offenbar auch damals schon zoögeographische Provinzen". And further: "Leider wissen wir zur Zeit fast nichts von der tertiären Geschichte der Landschnecken von Asien, und doch können wir nicht daran zweifeln, dass Asien die Wiege der Heliciden wie auch der Clausilien war. Europa bildete im Eocän einen Teil dieses Entwicklungsgebietes, aber auch nach Zentralamerika hin verbreiteten sich schon damals asiatische Typen von Pulmonaten und Deckelschnecken, wie das aus den Befunden von Dall bezüglich des Oligocäns von Jamaika hervorgeht".

The survey given above supports our view as to the Eocene age of the Mollusca sent by Prof. Andersson, and the following study of the material will give the complete verification of this assumption and furnish occasion to enter into discussions of some questions of interest not only from the viewpoint to Palæontology, but also of our knowledge of the recent faunas and their relations and origin

*The possibility that this represents a case of faunal parallelism, developed under similar physical conditions must not be overlooked. (Editor)

ERRATA: According to the usage of the Survey, the specific names shall be written with small letters. By an oversight the specific names in the headlines in this paper are printed with large capitals, whereas it should be uniformly in small capitals. Other minor errors also occur for which the author is not responsible, because he has not the opportunity of proof-reading himself.—Editor.

NOTES ON THE SPECIES.

GASTROPODA

PLANORBIS PSEUDAMMONIUS Schlotheim.

INCL. VAR. LEYMERIEI DESHAYES.

Plate I, figs. 1-4, textfigure 1.

Among the rather abundant fragments of this species found in the gray as well as in the red formation there were two specimens with a comparatively well-preserved shell which allowed of identification by comparison with two European Tertiary specimens from the collections of the Zoöpalæontological department of the Swedish State Museum. One of these (Plate I, fig. 1) shows a nearly perfect upper surface, while the other (*ibid* fig. 2) shows the under side. Both are in perfect agreement with the Chinese specimens. The latter (Plate I, figs. 3, 4) were exposed in a similar manner and thus made

Figure I. Apical whorls of *Planorbis pseudammonius* Schlot $\times 7$.

possible a comparison in all respects. The specimens showing the upper side exhibited a close agreement with regard to the slowly widening whorls, and the stronger dilatation of the ultimate one as well as the apical depression; besides that, the lines of growth run in a similar manner and are similarly marked. The large Chinese specimen, which, if complete, would measure 28 mm. in diameter and have 7 whorls, is much depressed and crushed, and thus does not show the details so distinctly, but some other smaller specimens exhibit them here and there, and they are in a full agreement with the French examples.

As to the specimens in which the under side is exposed, they also show a marked similarity with the European forms in their coiling and in the character of their whorls the breadth of which as well as the sculpture with fine lines of growth, is very similar, so that here too the identity of the Chinese and European form is easily established.

In a few specimens of the Chinese form, fine and regular spiral striae were seen in the apical whorls, but they did not appear more distally, and the last whorl was quite smooth. In quite a similar manner this sculpture may occasionally be present also in the French specimens. This has been noted by Sandberger, who considers those forms described as *P. leymERICI* Deshayes, a variety of *P. pseudammonius*. This corresponding sculpture of the shells in the two districts so remote from each other, is further evidence of the similarity of these faunas and strengthens the identification of the species.

PLANORBIS SPARNACENSIS Deshayes.

(Plate I, figs. 7, 7a),

One specimen rather well preserved and measuring 5 mm. in diameter was obtained from the gray marly limestone. It agrees very well with the figure given by Sandberger (Pl. IX, fig. 11) in being but little concave above and presenting distinct spiral lines of irregular strength. This sculpture is represented in our Pl. I. fig. 7a. The whorls are 4 in number.

PLANORBIS CHERTIERI Deshayes

(Plate I, fig. 8, text-fig. 2)



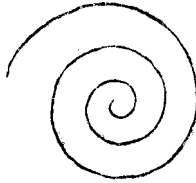
Figure 2. Apical whorls of *P. chertieri* Desh., $\times 7$.

Two specimens of this species are present in the collection. They are easily distinguished from the other by the depressed whorls, recalling the recent *P. fontanus*, and because they have an obtuse keel in the periphery as well as a relatively small embryonic shell. The shell is of a grayish colour with a greasy gleam and in all respects agrees with the description and figures in Sandberger (Pl. XIII, fig. 9). The largest specimen measures only 3 mm. in diameter and consists of 4 whorls, and is probably a juvenile example.

PLANORBIS SINENSIS sp. nov.

(Plate I, figs. 12-15. text fig. 3)

Shell depressed, planorboid with the spire depressed in such a manner that it appears on the umbilical side, giving the shell a sinistral aspect. Apex papilliform, consisting of 3 whorls, the subsequent ones again projecting beyond the apex and rapidly increasing. Whorls of the complete shell at least 6, the last one projecting beyond the others especially on the upper side, this side of the shell thus being more excavated. Sculpture consisting only of lines of growth irregularly arranged and visible only in the last whorls.

Figure 3. Apical whorls of *P. sinensis* n. sp. $\times 7$.

The species belongs to the group of *Planorbis indicus* and *P. exastus*.

Of this species a great many shell fragments occur in both the gray limestone and the red clay. Most of them consist merely of the apical whorls, but in a few cases also the fourth whorl or a part of the last whorl remains, which makes possible the identification.

No traces of opercula of this species were found, apparently in consequence of the delicate structure of these objects.

PHYSA cf. LAMBERTI Deshayes.

(Plate I. figs. 5, 6.)

Two specimens were prepared from the gray marly limestone, the largest of which measured 13 mm. in height. Unfortunately the spire was deficient in both specimens, so that the relation between spire and body whorl, so important for the taxonomy in this very critical genus, could not be determined. The remaining part of the shell had a produced ovate shape, and

it appeared as though only the penultimate whorl was left of the upper ones. Judging from this, the shell in a complete state would show a turreted spire and on account of its very shallow sutures, would recall that of *Ph. cf. lamberti* Deshayes (Sandberger Pl. IX, fig. 8), from the Lower Eocene of France. In any case the shells belong to the narrow forms of Physæ and seem to be most similar to such species as the American *Ph. sowerbyana* from Jamaica and S. America (cf. Reeve, Conch. Icon. 19; and Clessin, in Martini & Chemnitz, Conchylien Cab., Limnæiden).

It is of interest that in the Upper Eocene deposits of France no Physæ are known except one mentioned by Sandberger (p. 228) as resembling the small *Ph. mediana* Fer. from Peru. This is however too small to enter into consideration in the present case (cf. Clessin, l. c. pl. 54, fig. 10).

EUCHILUS DESCHIENSIANUM Deshayes.

(Plate I, figs. 9-11)

Opercula of a *Bithynia*-like shell were present in the gray limetone and these showed a close resemblance to those of this form as reproduced by Sandberger (pl. XIII, fig. 8b). Their structure also agreed with the description given by this author (p. 225), in being calcareous and formed "aus zahlreichen, einen nahezu in der Mitte gelegenen Kern ringförmig umgebenen Lagen", which was clearly shown in an example completely prepared.

For a shell exhibiting the characteristics of this species, I sought however in vain, until I remembered a small *Limnæa*-like shell, not previously fully prepared, and appearing to be peculiarly characterized as to its aperture. This specimen when fully exposed showed an apertural margin which was broadly expanded and reflected just after the manner characteristic of *E. deschiensianum*, a feature of so marked a nature that no mistake as to the identity was possible. The specimen in question was found in the red clay, which thus shows such a pronounced faunal similarity to the limestone that they may be assumed to represent only different facies of the same formation, an opinion verified also by other species.

The shell, the last whorl of which together with the aperture is the only specimen found, measures 5.5 mm. in height, the aperture occupying

3.2 mm.. There is no sculpture except fine lines of growth which become coarser within the umbilicus. The largest of the opercula measured also 3.2 mm. in its greatest dimension.

PELECYPODA

EUPERA SINENSIS sp. nov.

(Plate X, figs. 16-22.)

Shell somewhat quadrangularly ovate, with the umbones prominent and situated at about one fourth of the body length from the front end. Anterior end narrower than the posterior one, which exceeds a little the height of the shell at the umbones. Dorsal margin behind the umbones rather straight, passing into the posterior one by means of a more or less distinct angle; posterior margin but slightly curved and forming an obtuse angle with the inferior margin, which is evenly though slightly convex. Surface of the shell sculptured only by fine lines of growth and showing traces of colour blotches in the shape of small dots rounded or elongated as stripes and arranged in a radiating direction.

The denticulation is imperfectly shown in the specimens: in the right valve two parallel lateral teeth were observed in front of the umbones as well as behind them.

Length of the largest specimen: 4 mm.; height: 3.5; of another specimen resp. 6.4 and 4.3 mm. These differences are chiefly due to variation in the state of preservation.

Though the specimens of this species in the collection are only fragmentary there is no doubt that they belong to a species of *Eupera*. I have compared all the specimens with samples of *E. parasitica* from Egypt, stored in the collections of the Swedish State Museum, and the similarity is so striking, that it is very difficult to trace any points of distinction. The fossil species as well as the recent one seem to vary considerably, and the single difference between them seems to be that the fossil one has its frontal end somewhat shorter than has the Egyptian form.

The presence of a species of the genus *Eupera* (*Limosina*) in the deposits in question, where it occurs only in the red clay formation, is a

remarkable fact, and is of interest from a stratigraphical as well as from a palæontological and a zoögeographical point of view. According to Sandberger, forms of this genus are met with only in Upper Cretaceous and Lower Eocene deposits in France (cf. l. c. p. 208, 141, 165), and these species are all referable to the South American recent *Cyclas bahiensis* Spix of Brazil or to *Pisidium modioliforme* Anton from Brazil and Venezuela (p. 184). That we find a new species in China consequently proves that the deposits containing it are in all probability of Eocene age, as the remaining fossil Mollusca indicate, and leads us to enquire into the distribution of the genus in recent times. This as we shall see supports our view as to the origin of the African genus *Lanistes*.

There exist no statements regarding the occurrence of the genus *Eupera* in a fossil state in America, but it is not unlikely that it is hidden under other names. White (1883) reproduces some forms of *Sphærium* which are very like *Eupera*, namely *S. reticardinale* and *S. formosum*, both described by Meek & Hayden. These were found in the Laramie Group of the Upper Missouri River region, but as no description or figures are given of their hinge or coloration, their reference to one or the other genus is wholly questionable.

Eupera has about the same recent geographical distribution as *Lanistes*. It has been recorded from South America (Brazil and Venezuela), from Central America and the West Indies; in all 12 species are mentioned by Clessin (1907) from these regions, one of which, *E. cubensis* Prime, has also been found in Florida (Sterki 1916). Another North American form, *E. singlyi*, was described by Pilsbry in 1889, and occurs in Texas and Louisiana; it is nearly related to *E. cubensis* (Sterki 1916). Thus both North American species show relation to the fauna of the West Indies and of Central and South America. (In 1900 v. Martens described another new species from Central America, *E. pittieri*.) Outside of the Neotropical region the genus has representatives in Africa: *E. parasitica* of Egypt, *E. ferruginea* Krauss in S. Africa (Clessin 1879) and in Madagascar (Smith 1882); *E. landeroini* Germain (1909) occurs in the French Sudan and *E. bequarti* Dautzenberg & Germain (1914) in the Belgian Congo.

The fossil Chinese species seems to occupy a position between the elongated Egyptian form *E. parasitica* and the Central American *E. cubensis* or *E. pittieri* with its shorter form and more elevated posterior portion.

It is probable that the immigration of the genus *Eupera* into Africa has proceeded from Syria, as we have assumed was the case with *Lanistes*. In Eocene time, there existed a more direct connection, it is true, via India and Madagascar, but this way does not seem to have been followed either by *Lanistes* nor by *Eupera*, because no species of these genera exist at present in India. In Madagascar occurs the same species of *Eupera* which is found in S. Africa, and this is certainly due to a relatively recent importation of this species in Madagascar, probably through transportation by water birds or otherwise. That its occurrence in Madagascar is of a secondary nature is apparent from the statements made regarding *Lanistes* (cf. above) as well as from the fact that another water mollusk of Ethiopian origin has been recorded from the island, namely *Aetheria elliptica*. Of this species Germain says (1907 p. 227): "Le fait de retrouver l'*Aetheria elliptica* dans les régions tropicales de Madagascar, si pauvre en Acéphales fluviatiles montre qu'il existe quelques points de contact entre la fauna de cette île et celle de l'Afrique équatoriale". The species referred to was found at a height of 200 m. above the sea and 150 km. from the coast, and it was quite similar to specimens from the Nile, Niger and Congo.

As there is no evidence of a land bridge in Post-Pliocene time which could explain these occurrences in Madagascar, I think they may be explained as due to importation, probably by birds, a method of dispersion which is known to be rather common among the lacustrine Mollusca.

GENERAL PALÆOGEOGRAPHIC SUMMARY

The study of these few fossils at present known from the Eocene deposits of China, has given us an idea of an intimate relation of the fauna of this region and epoch not only to that of Europe but also to the Ethiopian and Neotropical fauna. We have tried to give some explanations of the former relations, and these assumptions are well supported by numerous facts showing a close interconnection of these several parts of the world.

In order to explain the similarity of the fauna in China and South America v. Ihering (1910) adduces a theory of a direct connection across the Pacific. He says (p. 426): "Nachdem ich in früherer Zeit namentlich die Beziehungen Südamerikas zur alttertiären antarktischen Landmasse, der *Archinotis*, sowie zum afrikanischen Kontinent, der *Archhelenis*, verfolgt habe, bin ich neuerdings darauf aufmerksam geworden, dass eine weitere alttertiäre Wanderstrasse von Ostasien nach Zentralamerika führte, meine *Archigalenis*, welche nicht in Beziehung stand zu Nordamerika. Im Miocän wurde diese Landbrücke zerstört, während andererseits Süd- und Zentralamerika miteinander in Verbindung traten, sodass die ostasiatischen Einwanderer nach Südamerika gelangen konnten, während umgekehrt der südamerikanischen Fauna der Zugang nach Ostasien verschlossen blieb".

Jehring gives some further examples as proof of his view, and finds that "wir sind heute nicht mehr berechtigt, eine europäisch-westindische Landbrücke im Sinne Heer's anzunehmen, denn dem widerspricht die Geschichte der marinen Küstenkonchylien".

The theory of a land bridge across the Pacific seems, however, to be quite superfluous for the explanation of the peculiar occurrences of related forms in China and S. America as well as in Europe. The existence of an *Archigalenis* seems hardly well founded, since it must be admitted that a migration from Asia to America or vice versa is easily made possible by means of the land bridge over Bering Strait. If this way has been followed, we must, however, expect to find the same or allied forms in a fossil state in N. America, but there seems to be no evidence of this occurrence. In his "Review of the Non-Marine Mollusca" White (1883) certainly mentions a lot of Eocene fossils, and the fauna as a whole seems to show a similar composition to that of Europe on the one hand and that of China on the other, inasmuch as *Planorbis* is common, together with species of *Physa*, and there are even very similar though not identical species. Thus *P. pseudammonius* is replaced by *B. utahensis*, and *P. sparnacensis* by *P. cirratus*. The "*Pupa incolasa*" mentioned by White, which possesses an expanded edge of the outer and columellar margin and lacks teeth and folds in the aperture is perhaps akin to *Euchilus*. There are, however, no specimens of the Lamellibranch *Eupera* in the Eocene

deposits of N. America, but very probably such have existed; in the Laramie Group dealt with by White, some species of *Sphærium* have been described, the shape of which recalls strongly that of *Eupera* (cf. above). On the other hand large Unionids are present in the American series in question, which still remain to be detected in the Eocene of China.

Facts thus seem to support the view that the Eocene fauna has spread from North America to Europe on the continents which still exist though these were certainly of different outline and topography, and that we do not need the supposition of a direct land connection.

Since the European and Asiatic continents certainly had a similar fauna, it seems necessary to assume that, in Eocene time, they formed part of a climatic region with a circumpolar extent, thus including also North America. The fact that in the Laramie series, the species described differ from the Asiatic, is apparently due on the one hand to the absence of a comparative study of the North American and the European Eocene Mollusca, and on the other to the differentiation in various directions which the faunas of these areas have undergone, just as they have in later Tertiary and in recent times.

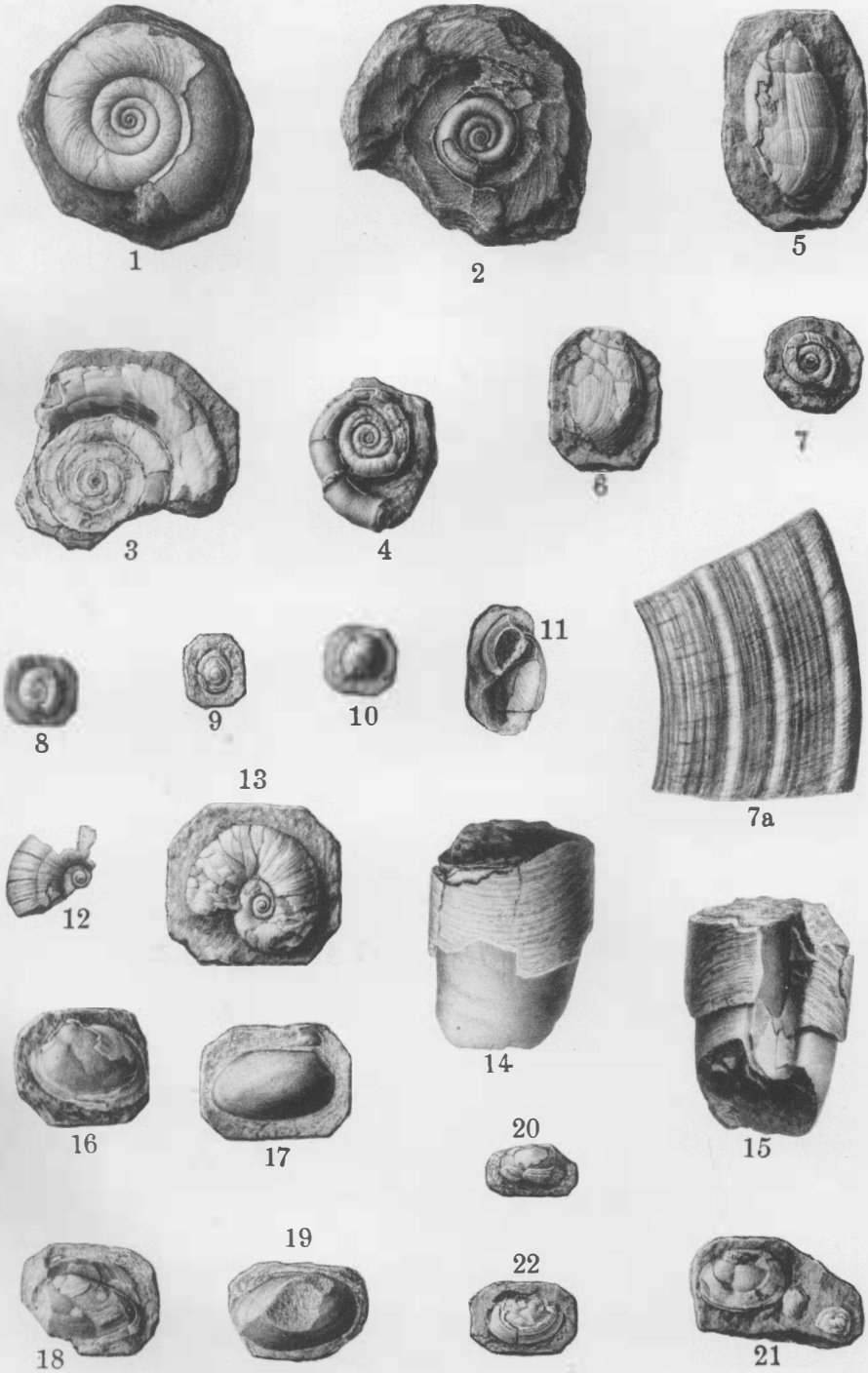
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EXPLANATION OF THE FIGURES.

PLATE I.

- Fig. 1. *Planorbis pseudammonius* Schiotheim. "terrain palustre, Alsace" (Palaeozoöl. Dep. of Swed. State Mus.). Slightly magnified.
- Fig. 2. The same, another specimen from the under side. Same locality and magnification. (Palaeozoöl. Mus.).
- Fig. 3. The same, marly limestone, Yuan ku, China, Same magnification.
- Fig. 4. The same, another specimen from below. Locality and magnification as fig. 3.
- Fig. 5. *Physa* cf. *lamberti* Deshayes. Yuan kii, limestone. About $1\frac{3}{4}$ times magnified.
- Fig. 6. The same, another specimen. Same locality and magnification.
- Fig. 7. *Planorbis sparnacensis* Deshayes. Same locality and magnification.
- Fig. 7a. Sculpture of the preceding. $\times 25$.
- Fig. 8. *Planorbis chertieri* Deshayes. Same locality and magnification.
- Fig. 9. *Euchilus deschiensianum* Deshayes. Impression of operculum. Gray limestone. $\times 1\frac{3}{4}$.
- Fig. 10. The same, operculum. Same locality and magnification.
- Fig. 11. The same, last whorl of shell, with aperture. Red clay. $\times 1\frac{3}{4}$.
- Fig. 12. *Planorbis sinensis* n. sp. Apex and fragment of sequent whorl, gray limestone. $\times 1\frac{3}{4}$.
- Fig. 13. The same, a more perfect small specimen. Gray limestone. $\times 2\frac{1}{2}$.
- Figs. 14, 15. The same, fragment of the last whorl of a large specimen, from exterior (fig. 14) and interior (fig. 15). Red clay. $\times 1\frac{3}{4}$.
- Figs. 16-22. *Eupera sinensis* n. sp. compressed specimens and casts, all from red clay. $\times 2\frac{1}{2}$.
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