SMITHSONIAN MISCELLANEOUS COLLECTIONS
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CAMBRIAN FOSSILS FROM THE MOHAVE DESERT

(With Three Plates)

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INTRODUCTION

Twenty years ago Darton [1] first announced the finding of Cambrian rocks in Bristol Mountain (then called Iron Mountain), near Cadiz, California, on the Santa Fé Railroad, about 100 miles east of Barstow, a locality well south of any from which Cambrian fossils had previously been obtained. He pointed out the fact that these beds, which rest unconformably on an eroded granite surface, dip down the slope of the hills toward the east, mentioning, in his brief description of the section, that the few fossil fragments found both in the shale below the nodular blue limestone and in the limestone layers in the shale above it, were thought by Dr. Walcott to be possibly Middle Cambrian in age. A more thorough study of the region was made in 1921 by C. W. Clark, then a student at the University of California,[2] who published a detailed description of the section, listing fossils from two horizons. These lists, which had also been checked by Walcott, included one new name among the fossils from the lower shale and another for the single fossil found in the upper shale. Only the latter was described sufficiently to preserve the name. The name, *Wanneria ? cadizensis,* proposed for the new species in the lower shale becomes a *nomen nudum.* Clark's original collection, together with one obtained later under the direction of Dr. J. C. Merriam, is the basis for the following discussion of the contained faunas.

My attention was called particularly to the interesting features of these faunas while identifying the species prior to their return to the University of California, the officials of which have very kindly given their permission for the following descriptions. The types of the

[1] Darton, N. H., Discovery of Cambrian Rocks in Southeastern California. Journ. Geol., Vol. 15, 1907, p. 470.

[2] Clark, C. W., Lower and Middle Cambrian Formations of the Mohave Desert. Univ. of Calif. Publ., Dep. Geol., Vol. 13, No. 1, 1921, pp. 1-7.

species herein described remain in the National Museum, and a third set was set to Princeton University. These fossils are interesting in that they constitute the most southerly and westerly occurrence of Cambrian beds west of the Rocky Mountains, besides being sufficiently well preserved to show structural features, particularly of the Mesonacidae which are yet but poorly and incorrectly described.

GEOLOGICAL SECTION AND CORRELATIONS

The section in Bristol Mountain, as described by Clark, may be summarized as follows: about 470 feet (143.3 m.) of quartzites rest unconformably on an eroded granite surface. Above this bed occurs about 22 feet (6.7 m.) of fine-grained, arenaceous shale containing thin beds of sandstone. The Mesonacid fauna herein described occurs abundantly in the soft shale portion of this bed. Next above is 25 feet (7.6 m.) of blue to black, unfossiliferous, nodular limestone. This is in turn overlain by 120 feet (36.6 m.) of brown or black arenaceous shale from which, about 12 feet (3.7 m.) below the top, the two Middle Cambrian fossils were obtained. The Paleozoic section is terminated by Carboniferous limestones about 635 feet (193.5 m.) thick.

Owing to the presence of the Mesonacidae, the three lower beds were referred to the Lower Cambrian, and the overlying shale to the Middle Cambrian. No question can be raised as to the Middle Cambrian age of the fossils in the upper shale, but the final decision as to the Mesonacid fauna must await the results of studies now being made at many places in an attempt to settle the vexing question as to where the Lower-Middle Cambrian boundary must be drawn.

According to our present ideas, Bristol Mountain must be in the seaway through which various Cambrian seas are supposed to have invaded the continent from the Pacific. Both faunas here described would appear to be more or less closely related to those in formations elsewhere in the southwestern United States, all of which were deposited in shallow seas whose exact extent and connections are not yet fully known. The fossils in the lower shale find their nearest affinities in the Prospect Mountain formation far to the northeast in the Eureka District, Nevada, with some relationship also apparent in the intervening Silver Peak District. The seas in which these older beds in the three regions mentioned were deposited certainly had Arctic connections, whereas no faunas are at present known from beds deposited in strictly Pacific seas. Whether the occurrence of older Cambrian beds in Bristol Mountain indicates Pacific connections must remain undetermined for the present. However, it would appear

rather improbable that a strictly Arctic sea, narrow as it must have been and on a continental mass of such low relief as then prevailed, should approach so near the Pacific basin and not be connected with it. The Middle Cambrian fauna of Bristol Mountain apparently represents that usually characterized by the trilobite *Dolichometopus productus,* a fauna that is exceedingly widespread, extending from the southern Appalachians to Greenland and from British Columbia to Arizona, usually occupying a position somewhat below the middle of the Middle Cambrian. This fauna again is commonly regarded as Arctic rather than Pacific in origin. And so, while additional light is shed on paleogeography by the Bristol Mountain fossils, we cannot yet outline the exact boundaries of those early seas.

DISCUSSION OF SOME MESONACID GENERA

I do not propose at this time to undertake the much needed revision of the Mesonacidae, but shall simply deal with questions raised by the particular species under discussion.

MESONACIS Walcott 1885

Mesonacis Walcott, 1885, Amer. Journ. Sci., 3d ser., Vol. 29, p. 328. (Described as a new genus.)

Mesonacis Walcott, 1910, Smithsonian Misc. Coll., Vol. 53, No. 6, p. 261. (General treatise on the entire family.)

The distinctness of the genera *Mesonacis* and *Olenellus* has been questioned, because many species previously referred to *Olenellus* proved upon the discovery of additional specimens to have the extra segments posterior to the fifteenth, and hence were transferred to *Mesonacis.* Some of these transfers appear to be ill-founded since no account was taken of the other generic features.

At the present stage of the study I would suggest that both *Mesonacis* and *Olenellus* are good genera, although there is considerable difficulty in distinguishing the cephala or even the cephalon and the first fifteen segments. Several differences may however be pointed out. In *Mesonacis* the eyes are shorter and do not reach the occipital ring; also the rim around the head is narrower, particularly near the genal angles. The main distinction, according to my present view, is to be found in the character of the so-called rudimentary segments that occur posterior to the fifteenth, with its large spine. Unfortunately these most important anatomical features are infrequently preserved, even though the percentage of entire shields to cephala is considerably greater than in other trilobite groups. In *Mesonacis* all

these segments have pleurae, as illustrated in the figures of *M. vermontana* (see particularly Walcott, 1910, pl. 26). According to my present views, *Olenellus* had such segments, perhaps fewer in number, but *without* pleurae, *i. e.*, without dorsal furrows. These are illustrated in the specimen figured by Walcott in 1910, on plate 33, figure 1, as *Paedumias transitans*. It must be remembered that most of our ideas of *Olenellus* are based not on Hall's original figures of *O. thompsoni* but on the incorrect restoration, made from a very poorly preserved specimen, first published by Walcott in 1886 and subsequently widely copied. This figure, as Walcott stated in 1910, (description of pl. 35, fig. 1) is incorrect in representing the anterior lobe of the glabella as not reaching the rim. In this respect *Olenellus* and *Mesonacis* are identical.

The peculiar habit possessed by most of the Mesonacidae, that of the genal spines advancing forward, is not an individual characteristic, as is commonly assumed, but is specific. This is clearly indicated in the following specific grouping of the specimens from this locality. If the position of the genal spines were a matter of individuality, it would not be possible, as stated later in the descriptions, to assemble a dozen or more specimens into each of several species in which there is no variation in this respect.

PAEDUMIAS Walcott, 1910

Paedumias Walcott, 1910, Smithsonian Misc. Coll., Vol. 53, No. 6, p. 304. (Described as a new genus.)

The original description of the single species referred to this genus in 1910 is based mainly on the specimens from York, Pennsylvania, but it is clearly stated that the type locality is in Vermont. The observations on which this original discussion were based were made on some specimens that cannot belong to the genus. The best example so used is the large, well preserved specimen illustrated by Walcott, 1910, as figure 1 on plate 33, which I now refer to *Olenellus*. Walcott states on page 308, " Nearly all the specimens of *Paedumias* found at York have the typical cephalon of *P. transitans,* as shown on pl. 34, figs. 2-4. In all of these the anterior lobe of the glabella is some distance from the frontal rim of the head, while in typical *Olenellus thompsoni* and *Mesonacis vermontana* from Vermont the anterior lobe touches the frontal rim." Thus it will be seen that he had in mind what he calls the " elongate form " as the typical form of *Paedumias*. Accordingly I have chosen the specimen figured on plate 34, figure 1 as the lectotype (U. S. Nat. Mus., Cat. No. 56808).

Paedumias, as it is proposed to restrict it, possesses several definite generic characters. The glabella fails to reach the rim and is connected with it by a ridge that crosses the intervening space. The marginal sutures and rim are quite like the same features in *Mesonacis.* All the species strictly referable to *Paedumias* thus far studied possess intergenal spines, a feature not present in the types of *Mesonacis* or *Olenellus.*

Except that intergenal spines have not been found in *Nevadia,* the cephala of that genus and *Paedumias* have a number of characters in common. In both, the glabella does not reach the rim and is connected medially with it by a ridge. In both genera the glabella tends to taper forward, a feature that has caused the placing of a number of species into *Callavia* that do not belong there (see p. 6).

SYNOPTICAL CHARACTERIZATION OF MESONACIS, OLENELLUS, PAEDUMIAS, NEVADIA, AND CALLAVIA

The characteristics of the various genera studied in connection with this paper may be briefly summarized as follows:

Mesonacis.—Glabella touches the anterior rim and does not taper forward, but usually has more or less of an hour-glass shape. Rim narrow and striated. Marginal and epistomal plates separated by intramarginal and marginal sutures. Third thoracic segment large, and a strong spine occurs on the fifteenth. Rudimentary segments, with well developed pleurae, posterior to the fifteenth. Hypostoma without spines.

Olenellus.—Glabella as in *Mesonacis.* Rim perhaps a little wider and eyes somewhat longer. Thorax same as in *Mesonacis,* to fifteenth segment. Rudimentary segments posterior to the fifteenth without definite pleurae, *i. e.,* without dorsal furrows.

Paedumias.—(Restricted) Glabella usually tapers forward, never extends forward to rim, with which it is connected by a median ridge. Rim, marginal and epistomal plates, and thorax to the fifteenth segment like *Mesonacis* and *Olenellus.* Intergenal spines present. Rudimentary segments posterior to the fifteenth *without* pleuræ, as in *Olenellus.* Hypostoma with spines on posterior margin and connected with the rostral or epistomal plate by a stalk, which probably causes the median ridge on the upper surface of the cephalon.

Nevadia.—Cephalon most like *Paedumias.* Glabella fails to reach the rim, with which it is connected by a median ridge. Rim and sutures possibly the same also, but none of the specimens is well enough preserved to be quite certain on these points. No intergenal

spines observed. Thorax distinct because of the loose arrangement of the segments. Hypostoma unknown.

Callavia.—Glabella fails to reach the rim, but there is no median ridge. Rim wide but poorly defined, in fact it may be said to be lacking. Intergenal spines very strong. Well developed occipital and thoracic spines. Third thoracic pleura not enlarged. No strong spine on the fifteenth segment. Hypostoma without posterior spines, attached directly to a broad sickle-shaped plate. This plate separates from the cephalon along a marginal suture (intramarginal) that corresponds to the one on the inner edge of the rim in *Mesonacis,* and it is divided into two similarly shaped pieces by the true marginal suture. Thus both the marginal and epistomal plates are situated on the under side. Since the combined width of the two plates is considerable they bridge the space between the anterior margin and the glabella, so that the hypostoma needs no stalk and hence there is no median ridge on the top side of the cephalon.

The other genera assigned to this family were not studied in this connection and will be discussed in a later revision.

FOSSILS FROM THE LOWER SHALE

The following six species all occur in association in a fine-grained, brown, somewhat calcareous shale, which is practically indistinguishable from the shales in both the eastern and western United States that carry the same genera of trilobites.

Since all the fossils come from one locality and occur in two beds only, no locality or horizon will be listed following the descriptions.

PATERINA PROSPECTENSIS Walcott

Plate 1, figs. 1, 2

Micromitra (Paterina) prospectensis Walcott, 1912, Monogr. U. S. Geol. Surv., No. 51, p. 352, pl. 2, fig. 4.

The few specimens of this brachiopod from Bristol Mountain are somewhat larger than the individuals from the type locality in Nevada, but otherwise seem to agree with them in all respects.

MESONACIS FREMONTI (Walcott), Restricted

Plate 1, figs. 3-9; plate 2, fig. 9; plate 3, fig. 8

Olenellus fremonti Walcott (pars), 1910, Smithsonian Misc. Coll., Vol. 53, No. 6, p. 320, pl. 37, figs. 1, 2.

A number of species are certainly included among Walcott's specimens grouped under this specific name. The form from southern

California here illustrated agrees in every respect with that from the type locality—Eureka District, Nevada (Loc. 52), to which the species is now restricted, and also with the specimens from Resting Springs, Inyo County, California (Loc. 14L). This is the most abundant species at Bristol Mountain, being represented by more than 50 specimens, of which only two show a portion of the thorax. The specimens vary in size from less than one cm. in width of cephalon to more than 12 cm., and the position of the genal spine is exactly the same in all.

The illustrations show the intramarginal suture that begins on the posterior margin of the cephalon, crosses over the genal angle, and then passes forward just inside the strongly striated rim, separating a marginal plate from the cheeks (see p. 5). This suture, as it passes forward, leaves the exact inner edge of the rim and runs along on it becoming less well defined, but does not reach the outer margin. A second suture appears to be present on the margin, thus forming a second detachable plate that lies under the first. This second plate, to which the hypostoma is probably attached, should, I think, be regarded as corresponding to the rostrum or epistoma of other trilobites. Just what the upper plate, which carries the upper half of the genal spines, may represent is not clear. Provisionally I shall call this plate the marginal plate. In some specimens the marginal plate is broken away (pl. 1, figs. 3, 4) exposing the underlying epistoma; in others both plates have been lost.

The facial suture, the position of which in the trilobites of this family has been a matter of much discussion, is quite clearly indicated in normal position posterior to and along the eyes, but its course anterior to them is not apparent.

MESONACIS BRISTOLENSIS, new species

Plate 2, figs. 5-8

None of the illustrated forms in the various species of the Mesonacidae with advanced genal spines has them in the position they occupy in this species. This species is represented in the collections by about 15 specimens in all of which the spines are in the same position, even though the cephala vary from 2.5 cm. to more than 4 cm. in width, indicating again that within these limits neither size nor age of individuals causes variation in the position of the genal spines.

This species differs from *M. fremonti* first of all in the more advanced position of the long, slightly curved genal spines, which gives

the head a trapezoidal shape, making it shorter and wider. Again the facial suture shows plainly posterior to the eye but does not appear in front of it. The glabella of *M. bristolensis* extends farther forward so that it apparently overhangs the rim. It differs also from *M. fremonti* in having a greater constriction where the dorsal furrow is bent inward opposite the third pair of glabellar furrows, thus giving the glabella somewhat of an hour-glass shape. The occipital ring is wider than in *M. fremonti,* and the furrow, while also interrupted, differs in having the shallowing inner ends turn sharply backward before dying out completely. The third pair of glabellar furrows also does this, and the two lateral portions are parallel to the two portions of the occipital furrow. The second pair of glabellar furrows is represented by a continuous line, only slightly curved back in the center—less than in *M. fremonti.* The first pair of furrows is similar in direction and depth in both species.

The rim of *M. bristolensis* appears to narrow toward the center of the head, owing to the more forward extension of the glabella. It is striated as usual and the intramarginal suture running along the inner edge of the marginal plate is clearly marked. This suture occupies the usual relative position on the greatly shortened rim and across the genal angle. It continues sub-parallel to the posterior edge of the free cheek, the outer edge of which in this case occupies a vertical position, constituting the lateral margin of the cephalon, and terminates in the lower corners of the cephalon where the facial suture reaches the margin.

The palpebral lobes are relatively further forward, shorter, and perhaps a little more curved than in *M. fremonti.*

Mesonacis bristolensis has the usual striated surface, but the striae appear a little stronger than in the other species.

MESONACIS INSOLENS, new species

Plate 2, figs. 1-4

More than 20 cephala of this species occur in the collections, and again none shows any variation in the point of origin and direction of the advanced genal spines. A poorly preserved, almost entire specimen indicates some of the characters of the thorax, which also will not fit any of the described forms with similarly advanced genal angles.

Compared with *M. bristolensis,* the most similar species in this fauna, several differences beside that of the position of the genal spine are readily noticeable. The shape of the cephalon is normal, being quite like that of *M. fremonti.* The posterior portion of the facial

suture is again well marked. The glabella is not quite so far forward, but is also considerably constricted in the center by the convergence of the dorsal furrow. The occipital furrow marks off a relatively wide occipital ring by means of two straight slits which are also directed slightly backward. The two parts of the third pair of glabellar furrows which have a shallow connection across the glabella, are peculiar in the manner of deepening and turning forward at their outer ends into the dorsal furrow. The second and first pairs are as in *M. bristolensis,* as are also the eyes.

The pleural portion of the third thoracic segment is more than ordinarily enlarged, even for a *Mesonacis.*

PAEDUMIAS NEVADENSIS (Walcott), Restricted

Plate 3, figs. 3-7

Callavia ? nevadensis Walcott, 1910 (pars), Smithsonian Misc. Coll., Vol. 53, No. 6, p. 285, pl. 38, fig. 12.

The specific name is here restricted to the incomplete specimen illustrated, and its congeners, cited from the type locality, Eureka District, Nevada (Loc. 52). The removal of this species from *Callavia* and its reference to *Paedumias* is demanded by the structure of the rim, as pointed out in the preceding generic discussion.

Since the specimens from Bristol Mountain seem to agree in all respects so far as the incomplete Nevada specimens of *P. nevadensis* permit comparison, they may be counted as representing a second species common to the two localities.

Owing to the tapering anterior glabellar lobe, coupled with its distance from the anterior margin, this species cannot well be confused with any other at the California locality, except its close ally *P. clarki.* Intergenal spines are present.

PAEDUMIAS CLARKI, new species

Plate 3, figs. 1, 2

At first this species was referred to one of the forms included in *Mesonacis gilberti,* but closer comparison showed differences from all of them. It seems certain also that some of the specimens referred by authors to the species *Mesonacis gilberti* belong neither to that species nor even to *Mesonacis,* but are distinct species of *Paedumias.*

Compared with *P. nevadensis, P. clarki* is immediately distinguished by the fuller anterior lobe of the glabella and by the shorter distance between that and the frontal rim. The intergenal spines in *P. clarki* are too weak to show in the photographs.

Unfortunately the specimen illustrated in plate 3, figure 1 fails to preserve the rear portion of the thorax so that its features cannot be determined.

FAUNA OF THE UPPER SHALE

Two species were found in the Middle Cambrian shale overlying the nodular limestone. They lie side by side on one small piece of rock.

DOLICHOMETOPUS ? LODENSIS (Clark)

Plate 3, fig. 9

Bathyuriscus howelli lodensis Clark, 1921, Univ. Calif. Publ., Dep. Geol., Vol. 13, No. 1, p. 6.

The original description states simply that the thoracic segments number eight and that the pleurae of the fifth are much longer than the rest, particularly than the three succeeding ones.

This species is referred to *Dolichometopus* in spite of the fact that no other species now in the genus has the long fifth thoracic pleurae. Except for this and the sharper pleural spines, this species agrees quite closely with the adjacent specimen referred to *D. productus*.

DOLICHOMETOPUS PRODUCTUS (Hall and Whitfield)

Plate 3, fig. 9

Ogygia producta Hall and Whitfield, 1887, U. S. Geol. Expl. 40th Parall., Vol. 4, p. 244, pl. 2, figs. 31-35.

Dolichometopus productus Walcott, 1916, Smithsonian Misc. Coll., Vol. 64, No. 5, p. 369, pl. 53, figs. 2-4.

This single incomplete specimen appears to be the same as the common *D. productus*, a widespread Middle Cambrian species.

DESCRIPTION OF PLATE 1[1]

PAGE

Paterina prospectensis (Walcott) 6

FIG. 1. (×2.) Large dorsal valve. Plesiotype. U. S. Nat. Mus., Cat. No. 78377.

2. (×2.) Ventral and dorsal valves. Plesiotype. U. S. Nat. Mus., Cat. No. 78378.

Mesonacis fremonti (Walcott) 6

FIG. 3. Fairly well preserved cephalon. The course of the posterior facial suture, the marginal suture, the occiptal and intergenal spines, and the general shape of the cranidium, together with the slightly advanced position of the genal spines, are clearly shown. Plesiotype. U. S. Nat. Mus., Cat. No. 78379.

4. Another cephalon in which the anterior margin on the left is disturbed by the peculiar slickensiding in the fossils from this locality. Size and position of the eyes and character of glabeller furrows are well shown. Plesiotype. U. S. Nat. Mus., Cat. No. 78380.

5. A third, less complete cephalon, well preserved on the right side, showing particularly the posterior facial and intramarginal sutures as well as the striations on the rim. Plesiotype. U. S. Nat. Mus., Cat. No. 78381.

6. Small cephalon with left eye practically complete. Plesiotype. U. S. Nat. Mus., Cat. No. 78382.

7. Mould of portion of cephalon and thorax. Note extra width of third segment. Plesiotype. U. S. Nat. Mus., Cat. No. 78383.

8. (×4.) Enlargement of genal angle of specimen illustrated in preceding figures, showing striated rim and course of the intramarginal suture across the genal angle.

9. The associated hypostoma, referred to the species. Plesiotype. U. S. Nat. Mus., Cat. No. 78384.

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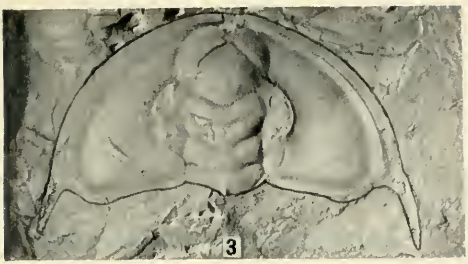
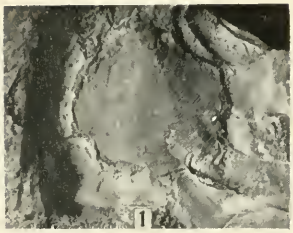
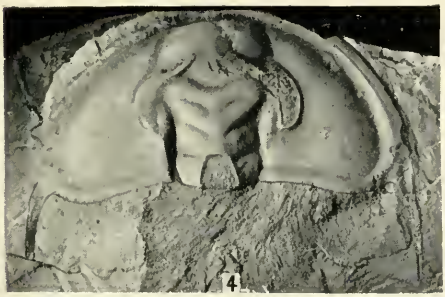
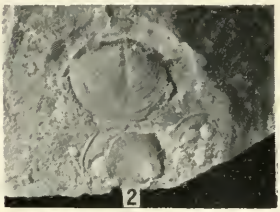
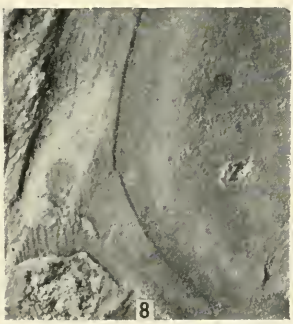
[1] All figures natural size unless otherwise stated.

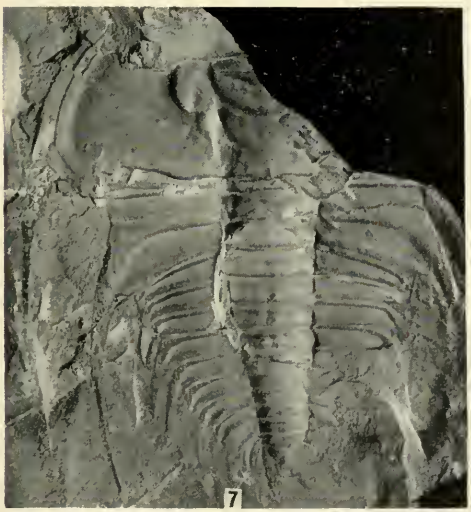


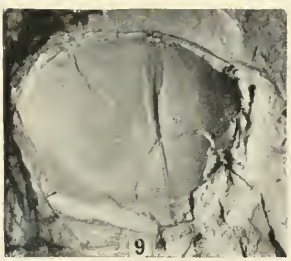




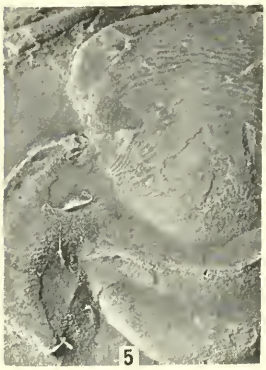


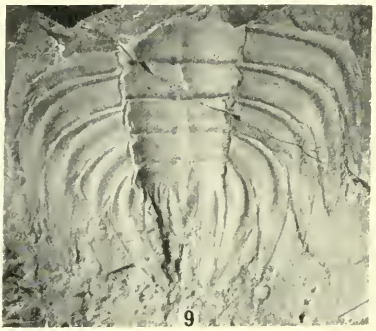






Cambrian Fossils from the Mohave Desert.





Cambrian Fossils from the Mohave Desert.

DESCRIPTION OF PLATE 2

PAGE

Mesonacis insolens, new species 8

FIG. 1. Poorly preserved carapace giving some idea of the shape and general characteristics of the species. Cotype. U. S. Nat. Mus., Cat. No. 78386.

2. Well preserved cephalon beside the hypostoma of *Mesonacis fremonti.* Cotype. U. S. Nat. Mus., Cat. No. 78387.

3. Small cephalon illustrating the size and position of the eyes and the glabella. Note the occipital spine. Cotype. U. S. Nat. Mus., Cat. No. 78388.

4. A larger head in which the full size of the advanced genal spines is shown. Cotype. U. S. Nat. Mus., Cat. No. 78389.

Mesonacis bristolensis, new species 7

FIGS. 5, 6. Cephalon and enlarged ($\times 4$) view of the glabella showing the surface features. Cotype. U. S. Nat. Mus., Cat. No. 78390.

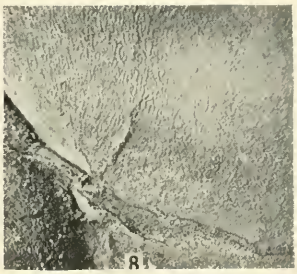
7. Another cephalon with a fairly complete glabella. Cotype. U. S. Nat. Mus., Cat. No. 78391.

8. Fairly complete cephala of this species and of *M. insolens,* showing the different angles at which the genal spines arise. Cotype. U. S. Nat. Mus., Cat. No. 78392.

Mesonacis fremonti (Walcott) 6

FIG. 9. Portion of the thorax near the posterior end. Plesiotype. U. S. Nat. Mus., Cat. No. 78385.

DESCRIPTION OF PLATE 3



Cambrian Fossils from the Mohave Desert.