STOYANOW (1936)

BULLETIN OF THE GEOLOGICAL SOCIETY OF AMERICA
VOL. 47, PP. 459-540, 1 PL., 5 FIGS. APRIL 30, 1936



# CORRELATION OF ARIZONA PALEOZOIC FORMATIONS

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ICSON SUB-AREA

*e, and Cochise formation.*—At the base
ıcson sub-area, is the Bolsa quartzite,
ıbbly grits, and cross-bedded, vitreous
a total thickness varying from 430 feet
ıcho de Calera Hills, 25 miles west of
: Pima sandstone, a buff, hard sandstone
rtzite in places. This sandstone, only
ıre than 60 miles, from the Whetstone
o the Picacho de Calera Hills, Pima
(*Iphidella*) *pannula* (White).
ıd the Abrigo is the Cochise formation
ne Mountains, it consists of three di
re pink and reddish, thin-bedded sand
follow 116 feet of yellow, pink, gra
:, which in the upper horizons alterna
ubbly limestone. Brachiopods, includ
*is* (Walcott) in some abundance, an
*raulos* n. sp.) have been found in th
pper division is characterized by bl
estone, rather grayish, brownish, an
igher in the section, the blue limeston
ıous. Within the lower part of the bl
ith them, are thin-bedded, calcareou
*Neolenus intermedius pugio* Walco
ıgmental. Layers with edgewise co
vision is easily recognizable, since
weathering than the beds of the ot
the formation are beds of oolitic
et thick, replete with small spher
ng to show algal structure under
estone are thin-bedded pink and g
and thin-bedded gray arenaceous li
ecimens of *Alokistocare* cfr. *linnar*
These beds are of interest for the
*llokistocare,* all undescribed spec
ll-preserved specimens of a *Microm*
(*P.*) *superba* (Walcott) principall
idium. The top of the formation
he algae-like inclusions. This u

nsome: *The geology and ore deposits of the*
ap. 21 (1904) p. 28-30.



division is 165 feet in thickness, and the thickness of the entire Cochise formation in the Whetstone Mountains is 311 feet.

*Abrigo formation.*—In the type locality at Bisbee, the Abrigo has been characterized by Ransome as "thin-bedded impure, in part shaly, in part arenaceous, very cherty dolomitic limestone. Carries Middle Cambrian fossils. Bed of white quartzite about 8 feet at top."[17] The thickness is given as 770 feet. The age was determined by Walcott, on the basis of the paleontologic material collected by Ransome. No species names, however, were given in any of Ransome's publications. Later, Walcott cited the following brachiopods from the Abrigo: *Obolus tetonensis* Walcott and *Obolus zetus* (Walcott).[18] In a still later paper, a cranidium and a pygidium of *Crepicephalus texanus* (Shumard), found in the Moore Canyon near Bisbee, are mentioned.[19]

Obviously, the part of the Cambrian limestone of Bisbee that contains *Obolus zetus* is older than the beds with *Crepicephalus texanus*. Although no Middle Cambrian trilobites have been found in the Bisbee area thus far, the "algal" limestone so characteristic of the Cochise formation is present in the Escabrosa Ridge west of Bisbee.

The base of the Abrigo formation is marked by the sudden appearance of *Crepicephalus texanus* (Shumard) and *Hesperaspis butleri* n. sp., the first-named form persisting throughout the entire formation, the second seemingly restricted to its basal layers. So characteristic is the presence of *Hesperaspis butleri* at the base of the Abrigo that in every Cambrian outcrop in southeastern Arizona known to the writer this species has been collected. It occurs invariably with *Crepicephalus texanus*. The base of the Abrigo has been located in the Escabrosa Ridge at Bisbee; in the Whetstone Mountains, Cochise County, between Benson and Tucson; in the Picacho de Calera Hills, Pima County, 25 miles west of Tucson; and in the Santa Catalina Mountains, Pinal County, 30 miles north of Tucson.

When first found, the specimens of *Hesperaspis* were supposed to belong to a new genus. Realizing that similar material might be present in the old collections of Walcott, or even described in Walcott's unpublished manuscripts, the writer in 1928 sent photographs of the Arizona form to David White, and asked him to submit them to Ulrich and Resser, who had charge of Walcott's material. White's answer contained the following statement:

> Doctor Ulrich has examined your photographs of the trilobite found with *Crepicephalus texanus*. He says the form you have is allied to *Giordanella* from Sardinia,

[17] L. Ransome: *Some Paleozoic sections in Arizona and their correlation,* U. S. Geol. Surv., Prof. Pap. 98-K (1916) pl. 25.
[18] C. D. Walcott: *Cambrian Brachiopoda,* U. S. Geol. Surv., Mon. 51 (1912) p. 417, 422.
[19] C. D. Walcott: *Cambrian geology and paleontology: Cambrian trilobites,* Smithson. Misc. Coll., vol. 64, no. 3 (1916) p. 213.

but is more strictly congeneric and is probably specifically the same as described in unpublished manuscripts of Mr. Walcott as *Hesperaspis stan*cott. This species occurs toward the close of the Crepicephalus fauna in the Rocky Mountains of Montana and in Wyoming.

Later the writer had an opportunity to examine the material from the Little Rocky Mountains, preserved in the Smithsonian Institution. The Arizona material is much better preserved, and its stratigraphic position is precisely known. At present, two species are distinguished from the Upper Cambrian of Arizona at the base of the Crepicephalus zone. To avoid *nomina nuda,* these forms are here provisionally described as *Hesperaspis ransomei* n. sp., and *H. butleri* n. sp., both being fossils for the basal Abrigo.

*Hesperaspis ransomei,* new species

(Plate 1, figures 6, 7)

Cranidium from medium size to large, somewhat flat, with a broad, subrectangular above the postero-lateral limbs, highest above its mid-length the anterior part of the glabella and in front of the eyes, thence it slopes anteriorly and posteriorly. Glabella very faintly outlined but nearly always in reflected light or when covered with ammonia powder. The shallow and dorsal furrows are strongest in the posterior part of the glabella and almost in front; consequently, the glabella is distinctly separated from the fixed in its posterior part only, where it is raised above the postero-lateral limbs elevated along a gentle and obtuse median ridge which disappears anteriorly whereas, anteriorly it merges into the frontal limb. Nevertheless, the rounded-in-front outline of the glabella is clearly indicated. There are no furrows. The broad, convex, crescentic, occipital segment, separated from the bella by a very shallow, barely perceptible depression representing the furrow, bears a strong median elevation, passing posteriorly into a sharp spine.

Postero-lateral limbs large, wide, semicrescentic in outline, sloping outward posteriorly, abutting against the posterior part of the glabella, with deeply posterior furrows not connected with the occipital furrow. Fixed cheeks, half as wide as the glabella, merge into a broad frontal limb which is by an almost imperceptible depression from the narrow frontal border. Palpebral lobes of medium size, not elevated above the fixed cheeks, contained about two times in the length of the glabella, are placed about the mid-length of the cranidium. Palpebral ridges absent.

Facial sutures, cutting the posterior border within the genal angles, ascend around the postero-lateral limbs to the base of the palpebral lobes, outline the latter, cutting a little inward above, and thence extend anteriorly and outward, giving an expanding aspect to the frontal limb. They curve rather abruptly inward at the frontal border and are intramarginal for a short distance.

Free cheeks rather wide, slightly convex, with genal angles extended backward in strong short spines.

Thorax unknown.

Pygidium from semi-elliptical to subtrigonal in outline, short and broad. The convex subcylindrical axial lobe is elevated, especially so in its posterior part, and does not reach the posterior extremity. On the axial lobe, the three anterior axial annulations are very distinct, the first one more raised than the rest. The fourth annulation is distinct. On some specimens, a faint fifth annulation may be distinguished between the fourth annulation and the elevated terminal section. The axial furrows are well developed on the sides of the axial lobe, whereas posteriorly there is a slope inclined about 45 degrees from the top of the terminal section to the end of the posterior extremity, with the base of the terminal section scarcely separable from the posterior border. Only the first and the second outward extensions of the anchylosed segments of the axial lobe are indicated on the pleural lobes, by the narrow furrows of which the first is quite well marked. The pleural lobes and the posterior border are outlined by a narrow, flattened peripheral rim.

*Hesperaspis butleri,* new species

(Plate 1, figure 8)

This species differs from *Hesperaspis ransomei* in having a much-narrower and more-inflated cranidium, highest in the middle, with a much-longer and better-outlined glabella always visible in front, a shorter and narrower frontal limb without any differentiation of the frontal border, narrow fixed cheeks bringing the palpebral lobes closer to the glabella, a stronger-developed occipital furrow, and a wider occipital spine.

This is a smaller form and never attains the size of larger specimens of *Hesperaspis ransomei.*

*Hesperaspis butleri* is widely distributed in southeastern Arizona. It has been found in practically every known outcrop of the Cambrian: at Bisbee, in the Tombstone Canyon between Bisbee and Tombstone; in the Whetstone Mountains; in the Picacho de Calera Hills; and in the Santa Catalina Mountains. It is found at the base of the Abrigo formation with *Crepicephalus texanus* (Shumard).

In the Whetstone Mountains, approximately 240 feet above the base of the Abrigo with *Hesperaspis butleri,* occurs a gray limestone practically made up of trilobite fragments, and containing angular inclusions of red sandstone that have casts of large *Hyolithes. Crepicephalus texanus* is found here in association with a number of new species and varieties of this genus. *Asaphiscus* (*Blainia*) *gregarius* Walcott and a large variety of forms related to *Asaphiscus,* belonging mostly to *Blountia* Walcott, characterize this horizon.

*Copper Queen limestone.*—The youngest part of the Cambrian in southern Arizona consists of localized facies, each very characteristic. In the Bisbee-Tucson sub-area, the Upper Cambrian younger than the Abrigo formation is represented by two different facies, the Copper Queen limestone and the Rincon limestone.

Ransome[20] has described in the Bisbee area "one bed of harder gray limestone 6 feet in thickness about 40 feet from the top" of his Abrigo. This limestone withstands weathering much better than the rest of the Abrigo, which is made of "rather soft, sandy, thin-bedded, gray limestone." In Ransome's Figure 4, representing the Mount Martin Paleozoic section in the Escabrosa Ridge near Bisbee, this limestone is shown distinctly as the upper hill within the Abrigo limestone. A few specimens of trilobites collected there by Ransome were referred by Walcott[21] to *Blountia* Walcott and *Irvingella* Ulrich and Resser.

A close examination of this limestone revealed its stratigraphic importance. It is here called the Copper Queen limestone, from the Copper Queen mining area of Bisbee, where it is a good key horizon. As here defined, this formation embraces much more than 6 feet of hard limestone

[20] D. F. Ransome: *Description of the Bisbee quadrangle, Arizona,* U. S. Geol. Surv., Geol. Atlas, folio no. 112 (1904) p. 3.

[21] N. H. Darton: *A résumé of Arizona geology,* Univ. Ariz., Bull. 119, Geol. Ser. no. 3 (1919) p. 50.

## EXPLANATION OF PLATE

### PLATE 1

### DEVONIAN FISHES AND UPPER CAMBRIAN TRILOBITES

FIGURES 1–5.—Plates of primitive *Arthrodira* from Devonian beds of Mt. Elden near Flagstaff, Arizona. (1) Dorsomedian plate, convex, seen from the outside. Superficial layers are partially denuded and inferior keel is slightly exposed. ×2. (2)—Posterior ventrolateral plate. Cast. ×2. (3)—Anterior ventrolateral plate? Cast. Lateral lines are seen. Natural size. (4)—Dorsomedian plate, concave, seen from the inside. It shows the inferior keel. ×½. (5)—Posterior ventrolateral plate. Cast. Natural size.

FIGURE 6.—*Hesperaspis ransomei* sp. n. Holotype, cranidium.

FIGURE 7.—*Hesperaspis ransomei* sp. n. Holotype, pygidium.

FIGURE 8.—*Hesperaspis butleri* sp. n. Holotype, cranidium.

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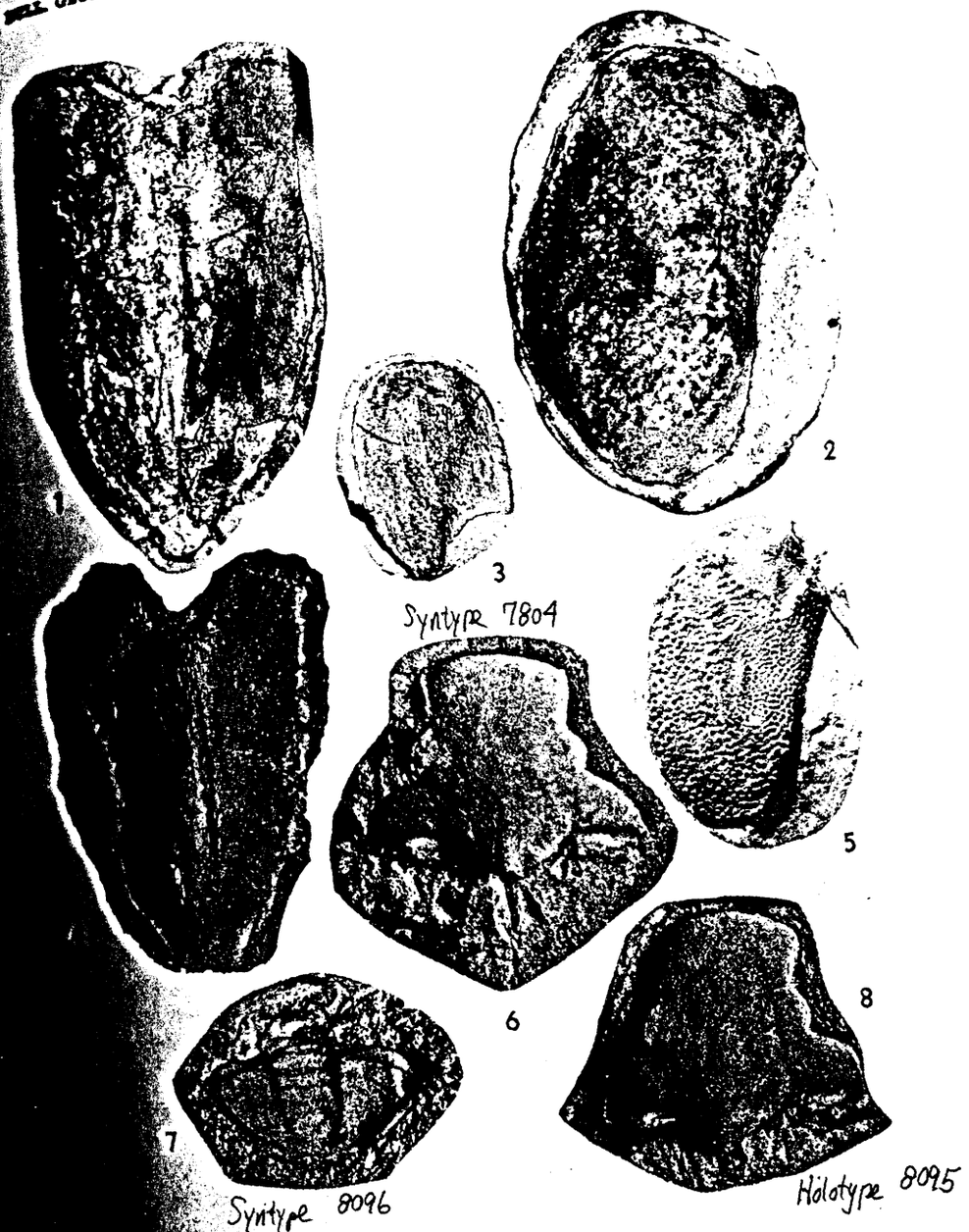
DEVONIAN FISHES AND U

Figures 1-5. Plates of primitive *Arthrodira* from
Figures 6, 7. *Hesperaspis ransomei* sp.
Figure 8. *Hesperaspis butl*




DEVONIAN FISHES AND UPPER CAMBRIAN TRILOBITES

PLATE 1. Plates of primitive *Arthrodira* from Devonian beds of Mt. Elden, near Flagstaff, Arizona, Figures 6, 7. *Hesperaspis ransomei* sp. n. holotype, (6) cranidium (7) pygidium.
Figure 8. *Hesperaspis butleri* sp. n., holotype, cranidium.