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# TRILOBITE AND STAR-LIKE TRACE FOSSILS FROM THE WHITE–INYO MOUNTAINS, CALIFORNIA

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ABSTRACT—The trilobite trace fossils present in the Lower Cambrian rocks of the White–Inyo Mountains, California belong to the genera *Cruziana* d'Orbigny (crawling furrows), *Rusophycus* Hall (resting burrows), *Diplichnites* Dawson (walking trackways), and *Monomorphichnus* Crimes (parallel scratchmarks). New species described are *Rusophycus radzvanskii* and *Monomorphichnus multilineatus*.

Three star-like trace fossils, comparable to *Asteriacites* Schlotheim, *Astropolithon* Dawson, and *Dactyloidites* Hall, are described from the Lower Cambrian rocks. *Dactyloidites* is interpreted as lobate feeding burrows.

## INTRODUCTION

*RUSOPHYCUS* Hall, the resting burrows of trilobites, is the most abundant trilobite trace fossil in the White–Inyo Mountains, California (see Alpert, 1975, for locality map). The other genera present, *Cruziana* d'Orbigny, *Diplichnites* Dawson, and *Monomorphichnus* Crimes, are uncommon. The fossils are generally preserved as casts on the underside of beds.

The oldest trilobite trace fossils in the White–Inyo Mountains (*Rusophycus*, *Diplichnites*) occur in the basal quartzite unit of the upper member of the Deep Spring Formation, about 1,500 feet stratigraphically below the lowest trilobite (Text-fig. 1). I consider these trilobite trace fossils to be Early Cambrian in age. Trilobites of the White–Inyo Mountains are illustrated in Nelson & Durham (1966).

The trilobite and star-like trace fossils of the White–Inyo Mountains are described herein. Previously I have described the sea anemone burrows, *Bergaueria* (Alpert, 1973), and *Planolites* and *Skolithos* (Alpert, 1975) from this California section.

All specimens with UCLA numbers are deposited in the invertebrate paleontology collection of the Department of Geology, University of California, Los Angeles.

## SYSTEMATIC PALEONTOLOGY

### TRILOBITE TRACE FOSSILS

The generic synonymies of *Cruziana*, *Rusophycus*, and *Diplichnites* contain the major and important references only. Numerous references, treating one or two particular species or specimens, and not generic concepts, are omitted.

### Genus CRUZIANA d'Orbigny, 1842

For synonymy before 1842, see Seilacher, 1953b, p. 107.

*Cruziana* D'ORBIGNY, 1842, p. 30 (not seen); SALTER, 1861, p. 70; SALTER, 1866, p. 291; TROMELIN & LEBESCONTE, 1876, p. 626; SALTER, 1881, p. 482; LEBESCONTE, 1883, p. 466–472; DELGADO, 1885 (not seen); LEBESCONTE, 1887, p. 810–811; MILLER, 1889, p. 115; WALCOTT, 1890a, p. 35–36; WALCOTT, 1890b (*partim*), p. 604; FRITEL, 1925, p. 34–35; YIN, 1932, p. 75–80; PICARD, 1942, p. 9; SAMPELAYO, 1950, p. 151–168; SEILACHER, 1953b (*partim*), p. 107–108; LESSERTISSEUR, 1955, p. 44–47; HÄNTZSCHEL, 1962, p. W189; RADWANSKI & RONIEWICZ, 1963, p. 267–269; HÄNTZSCHEL, 1965, p. 27–28; GUBLER, 1966, p. 153; CRIMES, 1968, p. 360–364; SEILACHER & CRIMES, 1969, p. 145–148; CRIMES, 1970a, p. 49; CRIMES, 1970b, p. 111–112, 119–124; ORLOWSKI, RADWANSKI, & RONIEWICZ, 1970, p. 350–356; SEILACHER, 1970 (*partim*), p. 454–456; ANDREWS, 1970, p. 62; BIRKENMAJER & BRUTON, 1971, p. 303–310, 313–318; *non* BROMLEY & ASGAARD, 1972, p. 7–13; CRIMES, 1975a, p. 36–37; CRIMES, 1975b, p. 34–39; HÄNTZSCHEL, 1975, p. W55; OSGOOD & DRENNEN, 1975, p. 317.

*Cryziana* GIEBEL, 1851, p. 115 (misspelling).

*Crusiana* DAWSON, 1880, p. 46 (misspelling).

*Cruciana* and *Crucianas* SAMPELAYO, 1915, p. 279 (misspellings).

*Cruzianas* SAMPELAYO, 1950, p. 148, 149 (misspelling).

*Fracna* ROUAULT, 1850 (*partim*), p. 729.

*Type species.*—*Cruziana rugosa* d'Orbigny, 1842.

*Description.*—Elongate furrows generally preserved as hypichnial casts. Cast consists of two parallel ridges with transverse, oblique, or longitudinal striae or scratchmarks, and a median groove or space between the ridges. Exopodal, genal, and pleural markings may be present in addition to the central endopodal ridges (Seilacher, 1970, text-fig. 3), but do

not occur in the White–Inyo Mountains specimens.

*Remarks.*—The genus *Rusophycus*, trilobite resting traces, was put into synonymy with *Cruziana* by Seilacher (1970). The two genera are here recognized as morphologically distinct, but related, genera, as is done in other recent works (Crimes, 1975a,b; Häntzschel, 1975; Osgood & Drennen, 1975).

Cruziana *in the White–Inyo Mountains.*—*Cruziana* is uncommon in the White–Inyo Mountains. It occurs in the Andrews Mountain and Montenegro Members of the Campito Formation, in the quartzite of the Poleta Formation, in the lower Harkless Formation, and in the upper member of the Saline Valley Formation.

The most common form of *Cruziana* consists of two parallel hypichnial ridges, in contact or slightly separated, with closely spaced, fine, transverse or slightly oblique scratchmarks (Pl. 1, figs. 6,9,12). The specimens are about 8 to 15 mm wide, and 15 to 35 mm long; they are the furrowing form of the species *Rusophycus didymus* (Salter, 1856). The cruzianid form of *R. didymus* occurs with and grades into the more common resting form of *R. didymus* (Pl. 1, figs. 9,12). Similar examples are illustrated by Seilacher (1955, p. 358–362, pl. 19, fig. 1) and Lessertisseur (1955, p. 44, text-fig. 25H). The resting forms are shorter, generally deeper, and the two lobes may be parallel or form a V (Pl. 1, figs. 9–13).

If *Cruziana* and *Rusophycus* are to be considered as separate genera not in synonymy, then the morphologic variation within *Rusophycus didymus* warrants placing the cruzianid forms in *Cruziana* and the resting forms in *Rusophycus*. Thus two species are necesssary. An additional nomenclatural problem arises in that Salter's *Arenicola didyma* may not be a true *Rusophycus*. Salter (1856, p. 248–249) interpreted *A. didyma* as small U-shaped burrows; *Arenicola didyma* was designated as genotype of *Arenicolites* by Bassler (1915, p. 67; this designation not noted in Häntzschel, 1975, p. W38).

About six good specimens of the cruzianid form of *R. didymus* were collected or observed, in siltstones of the upper Andrews Mountain Member of the Campito Formation and siltstones of the lower Harkless Formation.

Larger but similar forms of *Cruziana*, 12 to 40 mm wide, occur in quartzitic siltstone of the upper Andrews Mountain Member of the Campito Formation (two specimens observed), in quartzite of the middle Montenegro Member of the Campito Formation (Pl. 1, fig. 5; only specimen), in quartzite of the upper member of the Poleta Formation (one specimen), in quartzite of the basal Harkless Formation (two specimens,) and in siltstone of the upper member of the Saline Valley Formation (one specimen).

The above *Cruziana* sp. and cruzianid forms of *R. didymus* probably represent "head down plowing" movement of the trilobites (Seilacher, 1970, text-fig. 4).

A single specimen of *Cruziana* (Pl. 1, fig. 4), comparable with *Cruziana rugosa* d'Orbigny, 1842, was collected by Lee Early of Bishop, California, from quartzitic siltstone float of the Andrews Mountain Member of the Campito Formation, in Payson Canyon. The specimen is about 30 to 35 mm wide and 120 mm long. The two low, broad, hypichnial ridges possess strong transverse ridges, 1 to 3 mm wide and 2 to 4 mm apart. The transverse ridges contain series of fine, parallel, nearly longitudinal ridges (casts of scratchmarks), up to 8 on each side; these fine ridges are 0.5 to 1 mm wide and 3 to 6 mm long. The transverse constrictions and the approximately longitudinal, sharp, multi-clawed endopodal markings ally this specimen to the "rugosa group" of *Cruziana* (Seilacher, 1970, p. 462–464), previously known only from Ordovician rocks.

### Genus Rusophycus Hall, 1852

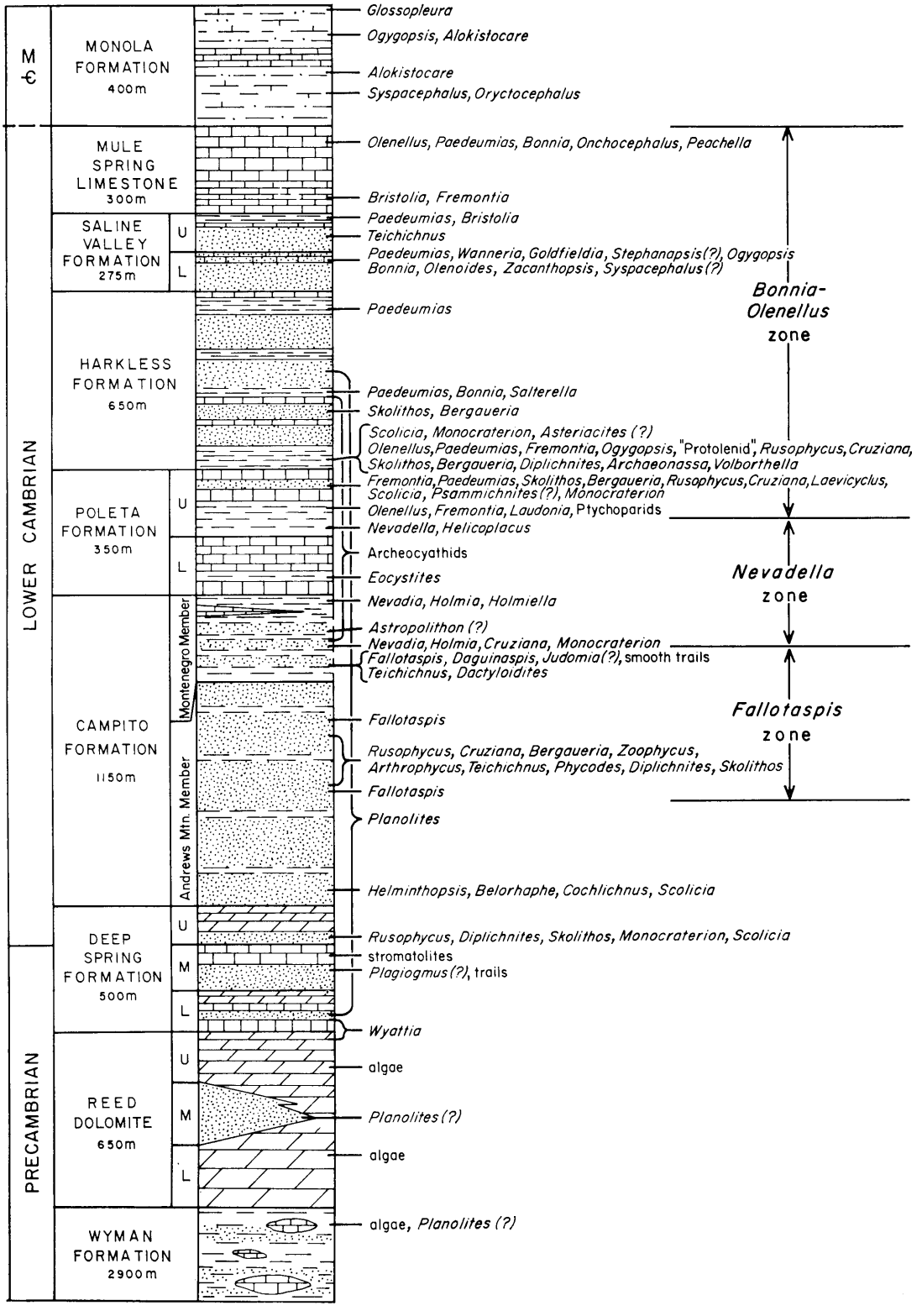
For synonymy before 1852, see Osgood, 1970, p. 301.

*Rusophycus* Hall, 1852 (*partim*), p. 23, Pl. 8, figs. 1,6, Pl. 9, figs. 1–3; Dawson, 1864, p. 363–367; James, 1885 (*partim*), p. 153–155; Miller, 1889, p. 138; Seilacher, 1959, p. 292–293, text-fig. 4; Häntzschel, 1962, p. W212–W214; Radwanski & Roniewicz, 1963, p. 265–267; Häntzschel, 1965, p. 80; Kegel, 1965, p. 1–11; Osgood, 1970, p. 301–305; Crimes, 1970a, p. 53–57; Crimes, 1970b, p. 114–116, 119–124; Orlowski, Radwanski, & Roniewicz, 1970, p. 350–356; Andrews, 1970, p. 187; Santos & Campanha, 1970, p. 742; Orlowski, Radwanski, & Roniewicz, 1971, p. 343–346; Birkenmajer & Bruton, 1971, p. 303–313, 318; Young, 1972, p. 14; Crimes, 1975a, p. 37–41; Crimes, 1975b, p. 34–35; Häntzschel, 1975, p. W101–W102; Osgood & Drennen, 1975, p. 311–312.

*Rhysophycus* Eichwald, 1860, p. 54 (not seen); Linnarsson, 1869, p. 403–405; Schimper & Schenk, 1885, p. 54; Lessertisseur, 1955, p. 44–47; Häntzschel, 1965, p. 79; Gubler, 1966, p. 155.

*Rhyssophycus* Goeppert, 1860, p. 434; Häntzschel, 1965, p. 79; Andrews, 1970, p. 186.

*Rusichnites* Dawson, 1864, p. 367; Dawson, 1873, p. 18; Miller, 1889, p. 566; Dawson, 1890, p. 595–596; Häntzschel, 1965, p. 80.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LOWER CAMBRIAN
PRECAMBRIAN
MONOLA FORMATION 400m
MULE SPRING LIMESTONE 300m
SALINE VALLEY FORMATION 275m
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HARKLESS FORMATION 650m
POLETA FORMATION 350m
U
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CAMPITO FORMATION 1150m
Montenegro Member
Andrews Mtn. Member
DEEP SPRING FORMATION 500m
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REED DOLOMITE 650m
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M
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WYMAN FORMATION 2900m
Glossopleura
Ogygopsis, Alokistocare
Alokistocare
Syspacephalus, Oryctocephalus
Olenellus, Paedeumias, Bonnia, Onchocephalus, Peachella
Bristolia, Fremontia
Paedeumias, Bristolia
Teichichnus
Paedeumias, Wanneria, Goldfieldia, Stephanopsis(?), Ogygopsis
Bonnia, Olenoides, Zacanthopsis, Syspacephalus(?)
Paedeumias
Paedeumias, Bonnia, Salterella
Skolithos, Bergaueria
Scolicia, Monocraterion, Asteriacites (?)
Olenellus, Paedeumias, Fremontia, Ogygopsis, "Protolenid", Rusophycus, Cruziana,
Skolithos, Bergaueria, Diplichnites, Archaeonassa, Volborthella
Fremontia, Paedeumias, Skolithos, Bergaueria, Rusophycus, Cruziana, Laevicyclus,
Scolicia, Psammichnites(?), Monocraterion
Olenellus, Fremontia, Laudonia, Ptychoparids
Nevadella, Helicoplacus
Archeocyathids
Eocystites
Nevadia, Holmia, Holmiella
Astropolithon (?)
Nevadia, Holmia, Cruziana, Monocraterion
Fallotaspis, Daguinaspis, Judomia(?), smooth trails
Teichichnus, Dactyloidites
Fallotaspis
Rusophycus, Cruziana, Bergaueria, Zoophycus,
Arthrophycus, Teichichnus, Phycodes, Diplichnites, Skolithos
Fallotaspis
Planolites
Helminthopsis, Belorhaphe, Cochlichnus, Scolicia
Rusophycus, Diplichnites, Skolithos, Monocraterion, Scolicia
stromatolites
Plagiogmus(?), trails
Wyattia
algae
Planolites(?)
algae
algae, Planolites (?)
Bonnia-Olenellus zone
Nevadella zone
Fallotaspis zone

*Russichnites* BONNEY, 1903, p. 290 (misspelling).
*Rysophycus* TROMELIN & LEBESCONTE, 1876, p. 627 (misspelling); LEBESCONTE, 1883, p. 466–472; HÄNTZSCHEL, 1965, p. 81.
*Rhizophycus* PENEAU, 1946, p. 88 (not seen); HÄNTZSCHEL, 1965, p. 79.
*Cruziana* d'Orbigny JAMES, 1885, (*partim*), p. 154–157; SEILACHER, 1970 (*partim*), p. 454–456.

*Type species.*—*Fucoides biloba* Vanuxem, 1842, p. 83, text-figure 11, no. 1.

*Description.*—Shallow to deep bilobed resting burrows, most commonly preserved as hypichnial casts. Lobes exhibit transverse to oblique, fine to coarse scratchmarks in varied arrangements, and commonly in crosscutting bundles. Overall outline of the resting impression is elliptical, circular, rectangular, heart-shaped, or V-shaped; the lobes may be separated. Lobes generally taper posteriorly. Coxal, exopodal, spinal, cephalic, and pygidial markings or impressions occur in some species (Seilacher, 1970, text-fig. 3), but are not present in the White–Inyo Mountain specimens.

*Remarks.*—For a review of the morphology, interpretations, and taxonomic history of *Rusophycus*, see Osgood (1970, p. 286–288, 301–305). The biostratigraphic value of *Rusophycus* in earliest Cambrian rocks is discussed by Daily (1972).

The scratchmarks on specimens of *Rusophycus* may be transverse, oblique in one direction, or oblique in two directions (bidirectional scratching, Seilacher, 1970, text-fig. 5c).

Rusophycus *in the White–Inyo Mountains.*—*Rusophycus* is more common than *Cruziana* in the White–Inyo Mountains. *Rusophycus* occurs in the upper member of the Deep Spring Formation (common), in the Andrews Mountain Member of the Campito Formation (locally abundant), in the quartzite of the upper member of the Poleta Formation (uncommon), and in the lower and middle Harkless Formation (locally abundant).

Bilobed resting traces (Pl. 2, figs. 1–3,5) comparable to *Rusophycus dispar* Linnarsson, 1869 (Linnarsson, 1871, pl. 3, figs. 17,18; Seilacher, 1970, p. 457; Bergström, 1973, p. 53–55) are the most common forms of *Rusophycus* present in the White–Inyo Mountains. The casts are elliptical to heart-shaped, shallow to relatively deep, and possess fine to coarse, transverse to slightly oblique scratchmarks. The traces are fairly large: 35 to 55 mm wide, 40 to 60 mm long, and 2.5 to 8 mm deep. The scratchmarks are 1 to 2.5 mm wide and commonly are bidirectional.

Although common, these traces are poorly preserved. In many specimens, the surface is partially obliterated by subsequent burrows (*Planolites*) (Pl. 2, figs. 1,3; Alpert, 1973, pl. 1, fig. 11). A somewhat better preserved specimen from the upper Wood Canyon Formation of Death Valley is illustrated (Pl. 2, fig. 3). These California specimens are very similar to specimens illustrated as "*Cruziana rusoformis*" by Orlowski *et al.* (1970, p. 350, 356, pl. 1, fig. a, pl. 2, fig. b), from the Lower Cambrian *Holmia* horizon of the Holy Cross Mountains, Poland. The scratchmarks occur in pairs on the specimens from Poland; paired scratchmarks are present but less discernible on some of the specimens from California.

Smaller specimens (Pl. 2, fig. 2) similar to the above are also present in the White–Inyo Mountains. The casts are 18 to 23 mm wide, 28 to 31 mm long, and 4 to 9 mm deep, with bidirectional scratchmarks, 0.5 to 1 mm wide; they are also poorly preserved.

The large forms of *Rusophycus* cf. *R. dispar* occur in quartzite of the upper member of the Deep Spring Formation (about 9 specimens collected); in quartzitic siltstone of the Andrews Mountain Member of the Campito Formation (locally abundant but poorly preserved; many observed in lower part of *Fallotaspis* Zone, Locality 6104; one specimen collected from lower part of member); and in quartzite of the lower Harkless Formation (locally abundant at Locality 6049; 9 specimens collected, many others observed).

The uncommon small form occurs in quartzitic siltstone in the upper Andrews Mountain Member of the Campito Formation (a few specimens collected and observed), and in the basal Harkless Formation (two specimens).

Another form of *Rusophycus* (Pl. 2, fig. 8), similar to the above but not readily comparable to *R. dispar* is locally abundant in quartzitic siltstone of the upper Andrews Mountain Member of the Campito Formation (lower part of *Fallotaspis* Zone). The resting traces are shallow to relatively deep, are commonly heart-shaped and wider than long, and possess relatively few, blunt transverse scratchmarks. The

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TEXT-FIG. 1—Stratigraphic section of the Lower Cambrian and Precambrian rocks of the White–Inyo Mountains, California. Stratigraphy, body fossils, and trilobite zonation from C. A. Nelson. Figure courtesy of C. A. Nelson.

specimens are 15 to 30 mm wide, 15 to 25 mm long, and 2 to 6 mm deep. The scratchmarks are 1.5 to 2 mm wide; there are about 7 or 8 per lobe. Preservation is on both hypichnial and epichnial surfaces. About 6 specimens collected; many others observed in field. This form differs from the above *R.* cf. *R. dispar* in having fewer, coarser, transverse scratchmarks, and a width equal to or greater than the length.

*Rusophycus didymus* (Salter, 1856) is another common trilobite resting trace in the White–Inyo Mountains (Pl. 1, figs. 9–13), as mentioned above in the discussion of *Cruziana*. This species should be restricted to resting forms only. Two morphological varieties of the resting forms occur: those with two parallel lobes, in contact or separated (Pl. 1, figs. 9, 10,12,13), and those with lobes that diverge anteriorly, forming a V (Pl. 1, fig. 11). Both varieties also occur in the Lower Cambrian of the Salt Range of Pakistan (Seilacher, 1955, p. 358–361, text-fig. 5, no. 4–5, pl. 19, fig. 1; see also Seilacher, 1953a, p. 214, pl. 7, fig. 6; Seilacher, 1953b, p. 108–111, text-figs. 4,5a; Häntzschel, 1962, text-fig. 131.5; Young, 1972, p. 14–15, text-fig. 5; Häntzschel, 1975, text-fig. 63A.1c). The parallel-lobed resting forms are similar to short segments of the cruzianid form of *R. didymus*, but differ in being deeper, especially in the central region.

The parallel-lobed and V-lobed forms possess fine transverse or slightly oblique scratchmarks. The White–Inyo Mountains specimens are 8 to 12 mm wide and 10 to 20 mm long, with the exception of one specimen, 4 mm wide and 5 mm long, on the slab with and parallel to the specimens of Pl. 1, fig. 10.

The resting forms occur in the same horizons cited above for the cruzianid forms of *R. didymus*. About a dozen specimens were collected from each of the two horizons. The V-lobed forms (four collected) are all from the Harkless Formation.

The remaining forms of *Rusophycus*, described below, are uncommon. One specimen (Pl. 2, fig. 4; Cloud & Nelson, 1966, text-fig. 1F), in siltstone of the upper member of the Deep Spring Formation, is a heart-shaped cast of a shallow resting burrow. The specimen is 30 mm wide and 27 mm long, and has fine, transverse, parallel scratchmarks. It occurs with *R.* cf. *R. dispar* and *Planolites*.

Another specimen, in quartzite of the upper Andrews Mountain Member of the Campito Formation (Pl. 2, fig. 6) is possibly referable to the resting form of *Cruziana fasciculata* Seilacher, 1970 (p. 456–457, text-fig. 7.3). The specimen is 18 mm wide and long, and has bundled, crosscutting, oblique scratchmarks; the obliqueness of the scratchmarks increases posteriorly. There are 6 clawmarks per bundle.

Large, shallow, trilobite resting traces (Pl. 2, figs. 9,10) occur in quartzitic siltstone of the upper member of the Deep Spring Formation (3 specimens collected). The traces consist of two separated series of fine, transverse scratchmarks which are 10 to 20 mm long and 0.25 to slightly more than 1 mm wide; the two rows of scratchmarks are 15 to 20 mm apart. The specimens are 50 to 60 mm wide, 25 to 50 mm long, and are preserved as epichnial grooves or hypichnial ridges. Morphologically, these specimens are intermediate between *Rusophycus* and the walking trackway *Diplichnites*. They are here placed in *Rusophycus* because

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EXPLANATION OF PLATE 1

FIGS. *1,2—Monomorphichnus multilineatus* n. sp. *1*, holotype UCLA 49590, Harkless Formation, Loc. 6051, ×1; *2*, hypotype, UCLA 49591, upper member, Deep Spring Formation, Loc. 6158, ×1.5.

*3—Diplichnites* sp. Hypotype, UCLA 49593, Andrews Mountain Member, Campito Formation, Loc. 6104; specimen uncoated, ×1.

*4—Cruziana* sp. Hypotype, UCLA 49595, Andrews Mountain Member, Campito Formation, Loc. 6104, collected by Lee Early; specimen uncoated, ×0.6.

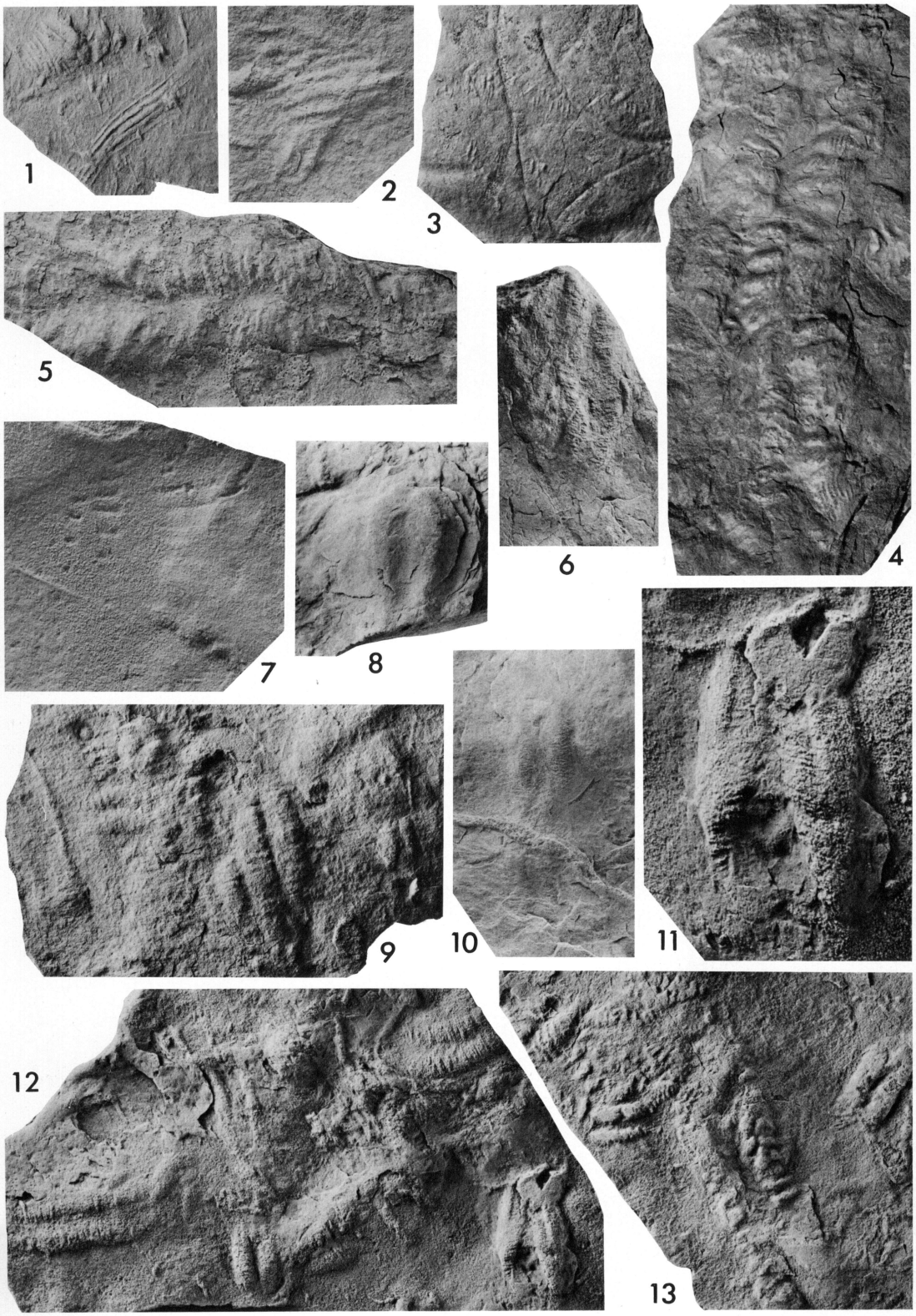
*5—Cruziana* sp. Hypotype, UCLA 49596, quartzite, Montenegro Member, Campito Formation, Loc. 6095, ×1.

*6,9–12—Rusophycus didymus* (Salter). *6*, cruzianid form, hypotype, UCLA 49597, Harkless Formation, Loc. 6105, ×1; *9*, cruzianid and resting forms, hypotypes, UCLA 49598, Andrews Mountain Member, Campito Formation, Loc. 6104, ×0.75; *10*, two successive specimens of *R. didymus* (above and below crack), hypotype, UCLA 49599, Harkless Formation, Loc. 6048, ×1; *11*, hypotype, UCLA 49613. Enlargement of specimen at lower right of fig. 12, ×2; *12*, cruzianid and resting forms, hypotypes, UCLA 49600, Harkless Formation, Loc. 6048, ×1.

*7—Diplichnites* sp. Hypotype, UCLA 49592, Harkless Formation, Loc. 6100, ×1.5.

*8—Rusophycus* sp. Hypotype, UCLA 49601, Harkless Formation, Loc. 6048, ×1.

*13—Diplichnites* sp., in center to center bottom, and *Rusophycus didymus*, upper left and right. Hypotypes, UCLA 49594, Andrews Mountain Member, Campito Formation, Loc. 6141, ×0.6.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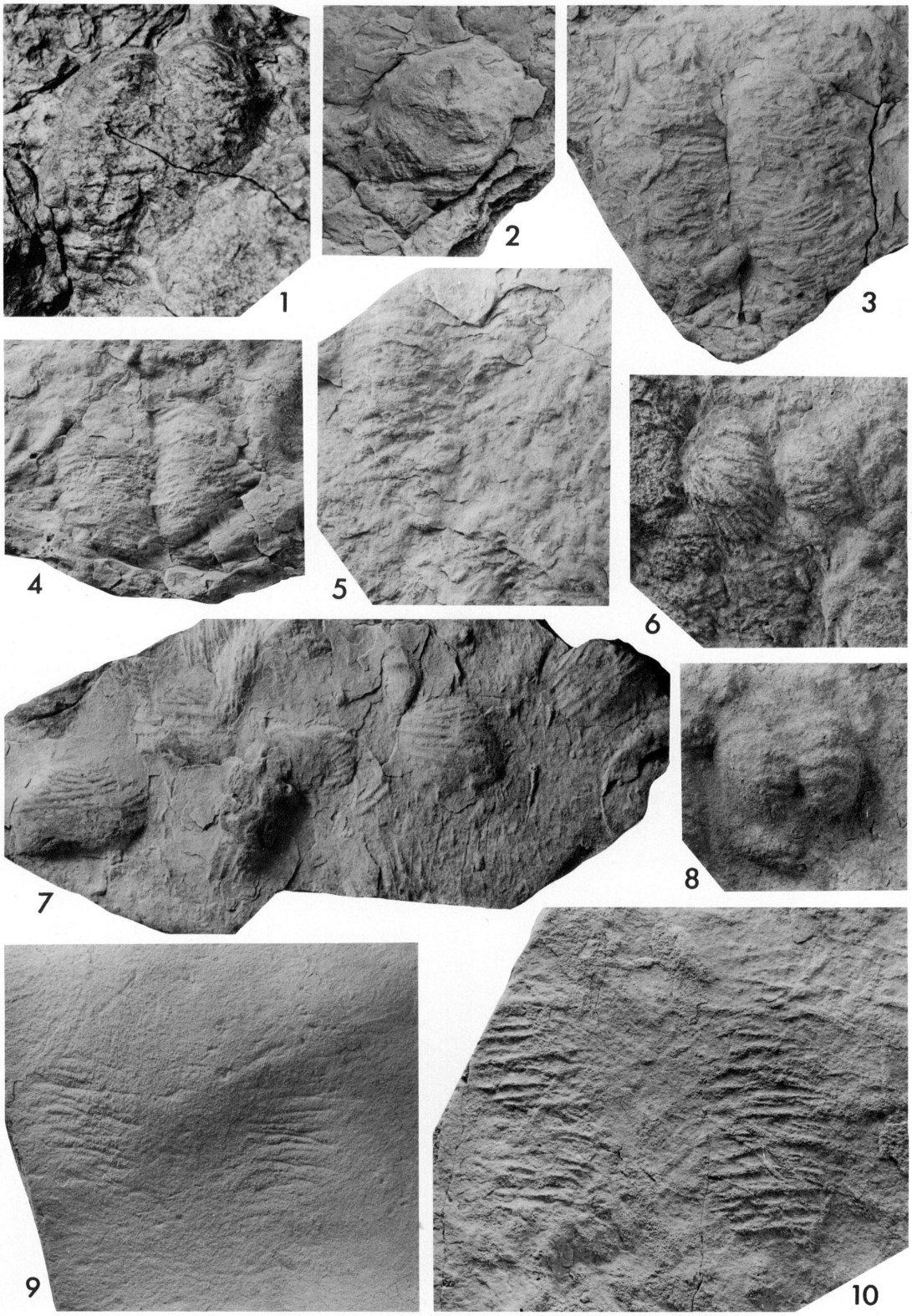
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the width decreases slightly toward one end (presumably the posterior), as in *Rusophycus*, and because the markings do not form a long trackway as in *Diplichnites*.

These shallow traces probably were formed by a swimming trilobite that alighted or set down to rest on the substrate, without burrowing, and left the impressions or shallow scratchmarks of its appendages. Four parallel, oblique scratchmarks, crosscutting the transverse markings on one specimen (Pl. 2, fig. 10) may represent the activity of the trilobite in leaving its resting place. It is possible that, had the trilobite burrowed deeper, a form similar to *R.* cf. *R. dispar* (present in same beds) would have been produced.

Similar, but smaller, shallow trilobite markings occur in quartzite of the upper Andrews Mountain Member of the Campito Formation (Pl. 3, fig. 3; only specimens collected). The specimens are 15 to 20 mm wide and long, and consist of two separated rows (5 mm apart) of fine oblique scratchmarks. Very similar specimens from Finnmark are described by Banks (1973, p. 4, text-fig. 4B) as "proto-*Rusophycus*."

A specimen (Pl. 1, fig. 8) similar to *Rusophycus* sp. of Young (1972, p. 15, text-figs. 4a,b) from the basal Cambrian of western Canada was found in quartzitic siltstone of the basal Harkless Formation. It is 23 mm long, 13 mm wide, 3 mm deep, and has a few indistinct 1.5 mm wide transverse ridges. The median groove of the bilobed cast is deepest and widest in the center. The specimen lacks the longitudinal markings present on Young's specimen.

An unusual form of *Rusophycus* (Pl. 2, fig. 7) was collected in quartzite of the lower Harkless Formation. The trace consists of circular to elliptical, paired, separated mounds, 10 to 25 mm wide, possessing sharp, oblique, 0.5 to 1 mm wide scratchmarks. The distance between the paired mounds (Pl. 2, fig. 7, right) is 12 mm; the overall width is 48 mm. This fossil is somewhat similar to the Upper Ordovician *Rusophycus* sp. of Bender (1963, pl. 12, fig. 3), placed in *Cruziana petraea* by Seilacher (1970). The fossil also resembles a resting form of *Cruziana barbata* Seilacher (1970, text-fig. 1a). Other trilobite markings (*Monomorphichnus*) occur on the same slab.

A final form of *Rusophycus* present in the White–Inyo Mountains is described below as a new species.

### RUSOPHYCUS RADWANSKII n. sp.
Pl. 3, fig. 7

"*Cruziana rusoformis*" ORLOWSKI, RADWANSKI, & RONIEWICZ, 1970 (*partim*), p. 350, 356, Pl. 1, fig. c (invalid conditional name).

*Holotype.*—UCLA 49585, Plate 3, figure 7; collected by J. E. Morhardt, Bishop, California.

*Description.*—Large, bilobed, relatively deep resting burrows, with fine bidirectional scratchmarks. Overall shape elliptical to circular. The holotype (Pl. 3, fig. 7) is 55 mm wide, 100 mm long, and 6 mm deep. One other specimen was collected (same locality); it is 55 mm wide, 45 mm long, and 9 mm deep. The specimen of Orlowski *et al.* (1970, pl. 1, fig. c) is about 60 mm wide and 100 mm long.

The center of the cast is roughly circular, with a faint median groove; the central area is surrounded by fine concentric scratchmarks. The median groove is wider and deeper in the posterior region than in the anterior region of the cast.

*Diagnosis.*—*R. radwanskii* differs from the numerous other species of *Rusophycus* in that it possesses bidirectional scratchmarks arranged

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EXPLANATION OF PLATE 2

FIGS. *1–3,5*—*Rusophycus* cf. *R. dispar* Linnarsson. Hypotypes. *1*, UCLA 49602, Harkless Formation, Loc. 6049, specimen uncoated, ×0.75; *2*, UCLA 49603, Harkless Formation, Loc. 6049, ×1; *3*, UCLA 49604, upper Wood Canyon Formation, Echo Mountain, Chloride Cliffs Quadrangle, Death Valley, collected by B. W. Troxel, ×0.75; *5*, UCLA 49605, upper member, Deep Spring Formation, Loc. 6154, ×0.75.

*4*—*Rusophycus* sp. Hypotype, UCLA 45728, upper member, Deep Spring Formation, Loc. 6158, collected by C. A. Nelson, ×1.

*6*—*Rusophycus* sp. Hypotype, UCLA 49606, Andrews Mountain Member, Campito Formation, Loc. 6103, ×1.5.

*7*—*Rusophycus* sp. Hypotype, UCLA 49607 (at right). Harkless Formation, Loc. 6051, ×0.9.

*8*—*Rusophycus* sp. Hypotype, UCLA 49608, Andrews Mountain Member, Campito Formation, Loc. 6103, ×1.

*9,10*—*Rusophycus* sp., upper member, Deep Spring Formation, Loc. 6158. Specimens collected by C. A. Nelson. Hypotypes. *9*, UCLA 49609, upper bedding surface, ×1; *10*, UCLA 45727, lower bedding surface, ×1.

almost concentrically around the deep central part of the cast, where the median groove is very faint.

*Stratigraphic distribution.*—The specimen of Orlowski *et al.* (1970) occurs in the Lower Cambrian *Holmia* horizon of Poland. The two White–Inyo Mountains specimens occur in the lower part of the *Fallotaspis* Zone, in quartzitic siltstone of the upper Andrews Mountain Member of the Campito Formation.

### Genus DIPLICHNITES Dawson, 1873

*Diplichnites* DAWSON, 1873, p. 19–20; MILLER, 1889, p. 554; SEILACHER, 1955, p. 343; HÄNTZSCHEL, 1962, p. W191–W192; RADWANSKI & RONIEWICZ, 1963, p. 269; HÄNTZSCHEL, 1965, p. 32; GLAESSNER, 1969, p. 383; CRIMES, 1970a, p. 56–57; CRIMES, 1970b, p. 119–124; YOUNG, 1972, p. 13; HÄNTZSCHEL, 1975, p. W61; OSGOOD & DRENNEN, 1975, p. 323–324.

*Acripes* MATTHEW, 1910, p. 122; HÄNTZSCHEL, 1965, p. 6.

*Type species.*—*Diplichnites acnigma* Dawson, 1973, p. 19–20, text-figure 3.

*Description.*—Biserial walking trackway, consisting of two separated, parallel rows of transverse to oblique linear markings, pits, or scratchmarks and pits. Hypichnial cast of trackway consists of ridges and mounds.

*Remarks.*—Dawson (1873) first interpreted *Diplichnites* as the trace of a fish walking on pectoral or ventral fin spines, and later (1894, p. 264) as probable amphibian tracks. *Diplichnites* is now regarded as walking tracks of trilobites (Crimes, 1970b) and possibly other arthropods.

*Diplichnites* contains two named species: *D. acnigma* Dawson, 1873, and *D. govenderi* Savage, 1971; however, several species of other ichnogenera can be transferred to *Diplichnites.*

Diplichnites *in the White–Inyo Mountains.*—*Diplichnites* is rare in the White–Inyo Mountains; it occurs in the Deep Spring, Campito, and Harkless Formations.

One form consists of two separated rows of transverse scratchmarks (Pl. 1, fig. 7). Small outer pits or scratchmarks may also be present. The two rows are about 5 mm apart; the overall width is 20 to 25 mm. Two specimens were found, one in siltstone of the upper member of the Deep Spring Formation, the other in shale of the basal Harkless Formation.

Another specimen of *Diplichnites* (Pl. 1, fig. 3) has two narrow, irregular, separated rows of sharp transverse scratchmarks. The markings in each row are closely spaced and no pattern is discernible. The two rows are 6 mm apart; the overall width is 15 to 18 mm. The specimen occurs in a thin shale layer on quartzitic siltstone, upper Andrews Mountain Member, Campito Formation.

A third type of *Diplichnites* (Pl. 1, fig. 13) occurs in quartzitic sandstone of the upper Andrews Mountain Member, Campito Formation (three specimens collected). The trackway is straight to curved, and consists of two separated rows of blunt scratchmarks, preserved as hypichnial ridges. Within each row, the ridges are transverse to featherstitch in arrangement. A faint, outer, hypichnial groove, 2 mm wide, parallels one side of the trackway on some specimens. The two rows are 5 to 6 mm apart; the overall width is 20 to 25 mm.

### Genus MONOMORPHICHNUS Crimes, 1970

*Type species.*—*Monomorphichnus bilineatus* Crimes, 1970a, p. 57–58, plate 12, figure c.

*Diagnosis.*—Parallel scratchmarks made by the appendages of one side of a trilobite in motion sideways.

#### MONOMORPHICHNUS MULTILINEATUS n. sp.
Pl. 1, figs. 1,2

*Type specimens.*—Holotype: UCLA 49590, Plate 1, figure 1. Hypotype: UCLA 49591, Plate 1, figure 2.

*Description.*—Five or six parallel, straight to slightly curved scratchmarks. The central scratchmarks are deeper and wider (up to 1 mm wide) than those to either side. In the holotype (Pl. 1, fig. 1), there are two fine scratchmarks on one side, and one on the other side, of the three deep central clawmarks. The specimens are 15 to 25 mm long and 6 to 8 mm wide. Lateral repetition was not observed.

*Diagnosis.*—*M. multilineatus* differs from *M. bilineatus* in having scratchmarks in sets of 5 or 6, with the central marks deeper than the outer marks.

*Stratigraphic distribution.*—*M. multilineatus* occurs in quartzite of the upper member of the Deep Spring Formation (one specimen, Pl. 1, fig. 2), and in quartzite of the lower Harkless Formation (Pl. 1, fig. 1, plus a few other possible specimens, such as on Pl. 2, fig. 7, upper left of center).

#### "Trilobite Claw Scratchmarks"
Pl. 3, figs. 1,2

*Description.*—Small, shallow, individual claw scratchmarks, on upper bedding surfaces. The scratchmarks are 5 to 10 mm long, 1 to 2 mm wide, and straight to slightly curved. Most

of the scratchmarks were made by appendages with two claws. The displaced sediment may be preserved as lateral ridges, or as a mound at the end of the scratchmark.

*Remarks.*—The markings may be isolated or in clusters, and probably were made by swimming trilobites that occasionally scratched the bottom with an appendage.

*Stratigraphic distribution.*—Shale, upper member of the Poleta Formation and basal Harkless Formation.

### STAR-LIKE TRACE FOSSILS

Star-like trace fossils (Häntzschel, 1970) comprise an informal morphological grouping of miscellaneous trace fossils representing various behavioral types and produced by a variety of organisms. The traces are either star-shaped, or have radiating lobes or markings from a central area or axis.

#### Genus ASTERIACITES Schlotheim, 1820
#### ASTERIACITES? sp.
#### Pl. 3, fig. 5

*Description.*—A five-rayed, starfish-shaped fossil (Pl. 3, fig. 5) was found by J. W. Durham in siltstone of the lower Harkless Formation. The fossil occurs in positive relief on what is probably the lower bedding surface, and consists of five ridges, 3 to 5 mm wide, radiating out from a raised central area. The "arms" are 20 to 30 mm long, straight or slightly curved, have faint transverse constrictions, and do not taper distally. The overall diameter of the fossil is about 45 mm. Shale adhering to the center of the fossil enhances the similarity in appearance to a starfish. *Planolites montanus* occurs near the specimen.

*Remarks.*—The fossil is either the cast of a resting impression of a starfish (true *Asteriacites*), or more likely, five feeding burrows made by a worm-like organism. The specimen is in the collection of the Museum of Paleontology, University of California, Berkeley (UCMP).

#### Genus ASTROPOLITHON Dawson, 1878
#### ASTROPOLITHON? sp.
#### Pl. 3, fig. 6

*Description.*—A radiating trace fossil (Pl. 3, fig. 6) was collected by J. W. Durham in shale of the middle Montenegro Member of the Campito Formation, 150 feet below the limestone beds. The fossil consists of a circular, slightly depressed central area, 20 mm in diameter, from which radiate numerous ridges, about 1 mm wide. The ridges are straight to slightly undulatory, 1 to 2 mm apart near the center, and about 3 to 5 mm apart in the outer region. The ridges are about 40 to 60 mm long; the overall diameter of the fossil is about 100 to 120 mm. There are about 15 radiating ridges in a 90° quadrant. The specimen was found in float.

*Remarks.*—The fossil is similar to *Astropolithon* Dawson (1878, 1890) from the Lower Cambrian of Nova Scotia. The radiating markings may be due to tentacle dragmarks around a shallow burrow, or may be horizontal feeding trails or burrows of a small organism. *Planolites* occur with the fossil.

The specimen is in the collection of the Museum of Paleontology, University of California, Berkeley.

#### Genus DACTYLOIDITES Hall, 1886
#### DACTYLOIDITES ASTEROIDES (Fitch, 1850)
#### Pl. 3, fig. 4

For earlier synonymy, see Walcott, 1898, p. 41.

*Dactyloidites asteroides* (Fitch). WALCOTT, 1898, p. 41–46, Pls. 24–26, Pl. 27, figs. 3,6, Pl. 28, fig. 5; MAYER, 1910, p. 717–718; KIESLINGER, 1924, p. 7; RUEDEMANN, 1934, p. 28–30, Pls. 4,5; KIESLINGER, 1939, p. A97, text-fig. 29; CASTER, 1945, p. 28; SHROCK & TWENHOFEL, 1953, text-fig. 4–5E; HARRINGTON & MOORE, 1956, p. F159, text-fig. 130.3; HÄNTZSCHEL, 1962, p. W240; HÄNTZSCHEL, 1965, p. 29; HÄNTZSCHEL, 1975, p. W147, text-fig. 88.7.

*Description.*—A five-lobed, star-like fossil (Pl. 3, fig. 4) was collected by C. A. Nelson in shale from the base of the Montenegro Member of the Campito Formation. The lobes are 17 mm long, slightly depressed, petal-shaped, and have a maximum width of 7 to 9 mm. No central structure or marking is discernible. The lobes are darker than the surrounding rock. The overall diameter is about 40 mm. Another similar specimen is partially visible on the same slab.

*Remarks.*—The fossil is interpreted as a feeding trace of an unknown organism. Unlike this specimen, star-like feeding traces generally have a distinct central or axial structure (see *Asterosoma*, *Asterophycus*, and *Gyrophyllites* in Häntzschel, 1962, 1975). The specimen is most similar to a form of *Dactyloidites asteroides* (Fitch) illustrated by Walcott (1890b, pl. 58, fig. 1, upper left; 1898, pl. 26, fig. 1e), from the Lower Cambrian of New York, and is here placed in that species. The lobes of *D. asteroides* are variable in number and shape.

*Dactyloidites* is a problematical genus, which is presently believed to be an alga or a trace fossil *i.e.*, radiating lobate burrows (Häntzschel, 1962, p. W240; 1975, p. W147). Earlier interpretations compared *D. asteroides* with graptolites, sponges, and medusae (Walcott, 1890b, p. 605–606; 1898, p. 41–46; Häntzschel, 1975, p. W147). Most specimens have 5 to 7 lobes. Spreiten or backfill structures are visible within the lobes of some of the specimens illustrated by Walcott (1898, pls. 24–28); this is a common feature of feeding burrows. Also consistent with the feeding burrow interpretation is the even spacing of the individuals on the slabs illustrated by Walcott (1890b, pls. 57,58), such that there is very little interference or overlapping of the specimens. Other burrows (*Planolites*?) occur on the same slabs (Walcott, 1898, p. 43).

Fitch's original sketch of *Buthotrephis*(?) *asteroides* (reproduced in Walcott, 1898, p. 42), a five-rayed specimen, is similar in outline to the specimen of *Asteriacites*? sp. described above.

### LOCALITIES OF FIGURED SPECIMENS

UCLA Invertebrate Paleontology Locality Numbers.

Localities not listed below, and quadrangle information, are given in Alpert (1973, 1975).

6049—East edge of Cedar Flat, on ridge and saddle, east half of NE¼, sec. 4, T8S, R35E, Blanco Mountain Quadrangle.

6141—Center of section 27, T7S, R35E, Blanco Mountain Quadrangle.

6154—100 feet east and 1000 feet south of NW corner sec. 22, T7S, R35E, Blanco Mountain Quadrangle.

6158—0.3 miles NE of Goat Spring; 1800 feet north and 1800 feet east of SW corner sec. 18, T6S, R35E, Blanco Mountain Quadrangle.

6161—1100 feet north and 500 feet east of SW corner sec. 16, T8S, R35E, Waucoba Mountain Quadrangle.

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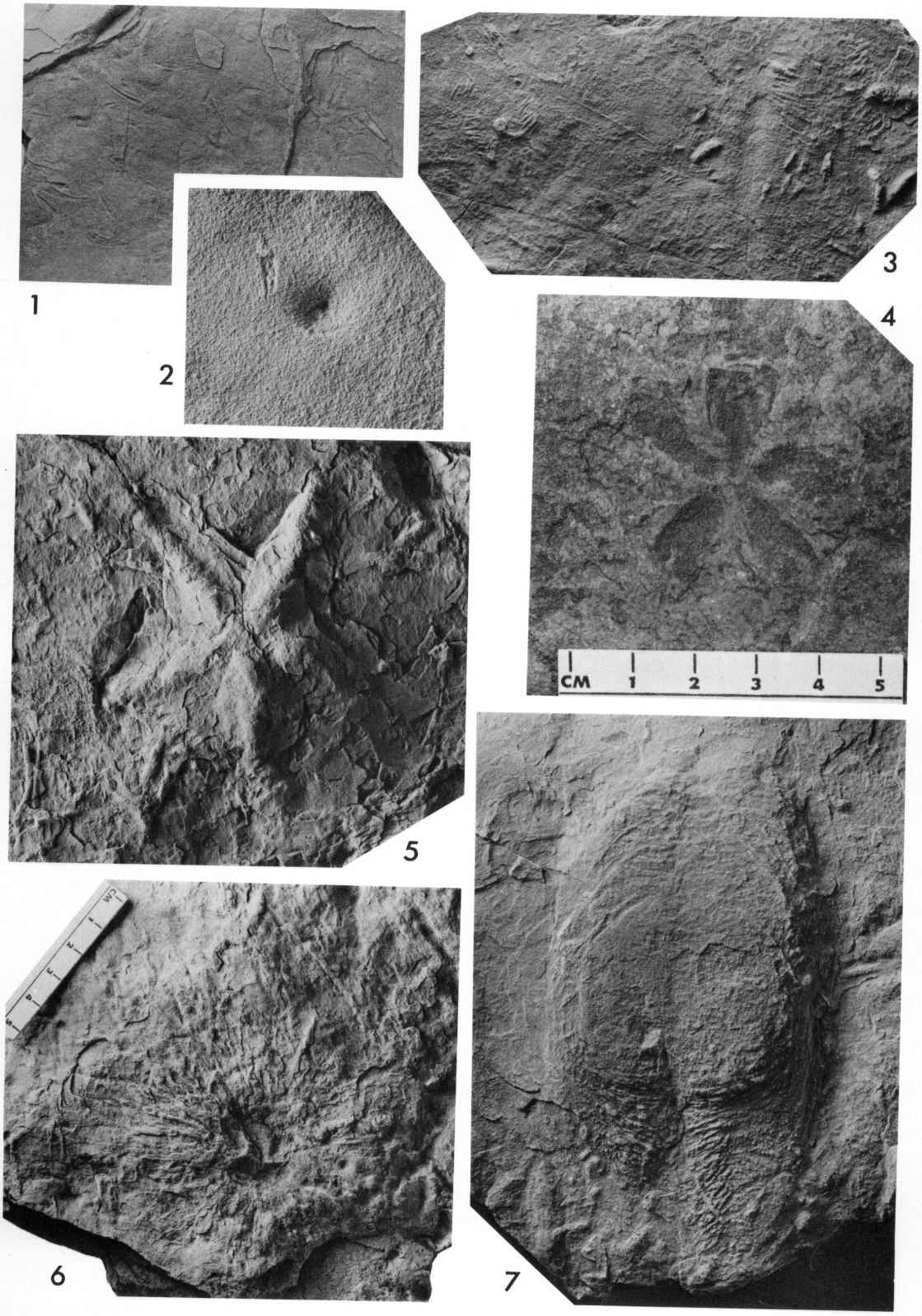
EXPLANATION OF PLATE 3

FIGS. *1,2*—"Trilobite claw scratchmarks," on upper bedding surfaces. *1*, hypotype, UCLA 49587, upper member, Poleta Formation, Loc. 6094, ×0.75; *2*, isolated scratchmark, near a circular pit. Hypotype, UCLA 49588, Harkless Formation, Loc. 6049, ×1.5.
*3*—*Rusophycus* sp., center left and upper right. Hypotypes, UCLA 49586, Andrews Mountain Member, Campito Formation, Loc. 6104, collected by J. E. Morhardt, ×1.
*4*—*Dactyloidites asteroides* (Fitch). Hypotype, UCLA 49589, Montenegro Member, Campito Formation, Loc. 6161, collected by C. A. Nelson; specimen uncoated, ×1.
*5*—*Asteriacites*? sp. Harkless Formation, collected by J. W. Durham, UCMP 14215, UCMP Loc. D–6003, ×1.
*6*—*Astropolithon*? sp. Montenegro Member, Campito Formation, collected by J. W. Durham, UCMP 14216, UCMP Loc. D–2869, ×0.5.
*7*—*Rusophycus radwanskii* n. sp. Holotype, UCLA 49585, Andrews Mountain Member, Campito Formation, Loc. 6104, collected by J. E. Morhardt, ×0.8.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