

BRACHIOPODS IN THE BASAL DESMOINESIAN AT ARROW CANYON, CLARK COUNTY, NEVADA

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ABSTRACT

Antiquatonia hermosana, *Echinaria knighti*, *Composita ovata*, *Anthracospirifer curvilateralis* sub sp. nov., *Anthracospirifer opimus*, and *Neospirifer alatus*, occur in the lowermost Desmoinesian of the Bird Spring Group at Arrow Canyon, Clark County, Nevada. The well-exposed, readily accessible Arrow Canyon section is under consideration for a possible Atokan-Morrowan boundary stratotype. As a consequence detailed information regarding the systematics and biostratigraphy of basal Desmoinesian brachiopods at this locality is needed.

INTRODUCTION

The Bird Spring Group at Arrow Canyon is exceedingly well-exposed and readily accessible. It also apparently is the product of essentially continuous deposition from the Chesterian into the Wolfcampian. As a consequence, a continuing program has been undertaken to systematically describe the brachiopod fauna,

develop a reference section for brachiopod biostratigraphy in the Cordilleran miogeosyncline, and determine the environmental limits on brachiopod occurrence in carbonate depositional environments (Langenheim, Huff, Lipman and Vaiden, 1983; Langenheim, Huff, Lipman, Moffett and Vaiden, 1985). This paper systematically describes the more prominent early Desmoinesian brachiopods above the late Atokan fauna described by Huff (1984) and below the Desmoinesian brachiopods described by Moffett (1986). In addition the stratigraphic distribution of these fossils is determined. These data are of immediate application to the search for a Morrowan-Atokan boundary stratotype.

Field work was accomplished at Arrow Canyon in January, 1986. Slabs were collected from all units with visible fossils and brought back to the laboratory where silicified fossils were recovered by etching in hydrochloric acid. Unsilicified materials remain unstudied.

Arrow Canyon is at the northern end of the Arrow Canyon Range, E½ section 11, S½ section 12, T14S, R64E, and SE¼ section 7, T14S, R65E, Clark County, Nevada, about 50 miles northeast of Las Vegas (Fig. 1). It is reached by exiting Interstate 15 at Glendale, Nevada and heading northwest on Nevada Route 168, then turning left on a paved secondary road at the northern edge of the irrigated land along the Muddy River. After 200 yards turn right on a jeep trail and follow it up the canyon about 3 km to the collection site on the north wall. This site is about 1 km below the mouth of the narrow gorge.

STRATIGRAPHY

The Bird Spring Group consists of about 2,100 feet of cherty limestone, sandy limestone, dolomite, and shale, and contains abundant silicified fossils. The group has been divided into five formational units at Arrow Canyon (Larson and Langenheim, 1979; and Langenheim and Langenheim, 1965). These include, from the lowest up: the Battleship Wash Formation; the Indian Spring Formation; and three informal units: BS_c, BS_d and BS_e. These strata range from the Chesterian to Wolfcampian.

The stratigraphic sequence under consideration includes VAL Units 135 through 151 (Fig. 2). The VAL Units are lithologic subdivisions of the stratigraphic column first defined by Langenheim and Langenheim (1965) in their reconnaissance of the Bird Spring Group. These units subsequently have been utilized by investigators in our group. In this report we do not separately recognize and describe each VAL unit and some have been grouped, as in VAL 139/140/141 undifferentiated, for description and interpretation. In addition, the original measurements of Langenheim and Langenheim (1965) have been discarded and the VAL unit boundaries and thicknesses have been related to a surveyed series of monuments set at stratigraphic intervals of 1.5 meters throughout the Chesterian and Pennsylvanian part of the Bird Spring Group by geologists of the AMOCO company. Figure 2 indicates the position of unit boundaries and AMOCO monuments along the line of section studied by us on the north wall of the canyon.

The section described in this report is entirely within the BS_c unit and is dominated by well-indurated calcilititic to calcisiltitic limestone with abundant chert concretions. Interbedded, more shaly limestone, generally contains less chert

(Fig. 3). Our lithologic descriptions of the units in the measured section follow (Units are numbered in order from the base upwards):

VAL 149/150/151 (*undifferentiated*): Interbedded, fine- to very-fine grained limestone comprised of four massive layers alternating with 5 shaly layers; massive layers contain rusty gray chert nodules; moderately to sparsely fossiliferous; light gray weathering to light tan; forms reentrant; 7'5" thick.

VAL 148: Massive, very resistant, fine-grained limestone; intermittent rusty to gray, cobble size chert nodules; abundantly fossiliferous in uppermost 12", generally less fossiliferous in lower parts; light gray weathering to dark gray; moderately abundant white calcite veins; bench former; 5'0" thick.

VAL 147: Very friable silty limestone containing very abundant cobble size chert nodules; moderately to sparsely fossiliferous; whiteish-gray weathering to whiteish-gray; forms reentrant; lower half partially covered; 5'4" thick.

VAL 146: Massive, very resistant, medium- to fine-grained limestone; abundant cobble size to larger chert nodules; abundantly fossiliferous; dark gray weathering to dark gray; scattered calcite veins; bench former; 3'0" thick.

VAL 144/145 (*undifferentiated*): Thick bedded, fine-grained limestone containing very abundant cobble size to smaller dark chert nodules; moderately fossiliferous; gray weathering to tan; scattered white calcite veins and vugs; bench former, but less resistant than unit VAL 146; 11'6" thick.

VAL 143: Very friable silty limestone containing a few small chert nodules; moderately to abundantly fossiliferous; gray weathering to gray; forms reentrant; gradational upper contact with unit VAL 144/145; 2'2" thick.

VAL 142: Massive, very resistant, fine-grained limestone containing intermittent, distinctive, very large black chert nodules up to 3 feet in diameter; fossiliferous with abundant fusulinids; gray weathering to dark gray; abundant white calcite veining; bench former; 6'2" thick.

VAL 139/140/141 (*undifferentiated*): Nodular massive to shaly, fine-grained, argillaceous limestone; discontinuous layering of cobble to smaller size, orange brown chert; complete fossils are scarce; gray weathering to tannish gray; less resistant near base; irregular bench former; partially covered at base; 7'8" thick.

VAL 137/138 (*undifferentiated*): Resistant, fine-grained limestone with few chert nodules; thick bedded near base, thin bedded towards top; abundant fossil fragments; dark gray weathering to gray with buff patches; 9'8" thick.

VAL 136: Interbedded, fine- to very-fine grained limestone comprised of 3 massive beds alternating with 3 shaly layers; brown to black cobble size chert nodules in massive layers; moderately fossiliferous; abundant fusulinids in the second massive layer from the top; dark gray weathering to gray; forms reentrant; 9'10" thick.

VAL 135: Massive, resistant, fine-grained limestone; few chert nodules; moderately to sparsely fossiliferous; gray weathering to brownish-gray with rusty-brown chert; moderate white calcite veining; bench former; 2'3" thick.

BRACHIOPOD SYSTEMATICS

Systematics in this paper are those of the Treatise on Invertebrate Paleontology, Part H, Brachiopoda (Moore, 1965).

Order Strophomenida Opik, 1934
 Suborder Productidina Waagen, 1883
 Superfamily Productacea Gray, 1840
 Family Dictyoclostidae Stehli, 1954
 Subfamily Dictyoclostinae Stehli, 1954
 Genus *Antiquatonia* Miloradovich, 1945
Antiquatonia hermosana Girty, 1903

Figs. 4-10

Products semireticulatus var. *hermosana* Girty, 1903, p. 358, pl. 11, figs. 1-4b.

Antiquatonia hermosana Hoare, 1961, p. 56, pl. 6, figs. 1-3; Lane, 1962, p. 901, pl. 126, figs. 5-8; Sutherland and Harlow, 1973, p. 51, pl. 11, figs. 6-12.

Description: The medium-sized shells are semicircular to subrectangular in outline. The pedicle valve is strongly convex but not geniculate, appearing approximately semicircular from the side. The maximum width is at the hingeline, and maximum height is slightly posterior to midlength. The hingeline is straight terminating in distinct flattened to dorsally curved ears, which abut anterolaterally against steeply rising flanks.

Radial ornamentation of low rounded costae averages about 13 per 10mm. (measured 15mm. anterior to umbo). Costae are evenly spaced and continuous from umbo to anterior, and unaffected by intervening spines. Bifurcation is rare to absent with costae becoming more coarse and widely spaced as they near the anterior. Concentric rugae impart a faint reticulate pattern most pronounced in the posterior third of the valve.

The beak is small and overhangs the hingeline very slightly, if at all. A broad, shallow sulcus originates at about 3/5 the length from the posterior, and widens slightly and deepens toward the anterior.

The spines are concentrated primarily on the venter. Some also are scattered along the flanks and the anterior portion of the valve.

Dendritic adductor scars are separated by a median sinus. Rod-like adductor platforms converge at midlength into a small sub-ovate lobe. Longitudinal lineations on the diductor scars continue laterally 3/4 the way to the margin.

The dictyoclostid cardinal process is dorsally trilobed with the two outer lobes flaring around the middle lobe. From the posterior, the process appears ovate with a U-shaped depression between the middle and outer lobes. Pronounced lateral ridges diverge from the base of the cardinal process, roughly parallel the hingeline and angle slightly anteriorly. Pronouncedly dendritic raised adductor platforms are separated by a low median septum which becomes blade-like about 5mm. anterior of the base of the cardinal process. The cardinal processes described were not associated with complete valves as collected, but were matched to accompanying.

A. hermosana specimens by size and form.

Specimen	Length	Width	Height	Costae*
X6668	30.5mm	40.0	15.0mm	13
X6669	29.0mm	36.0	14.5mm	13
X6670	38.5mm	43.0	24.0mm	12

*per 10mm at 15mm from umbo

Discussion: Scattered spines on the flanks and venter of the Nevada specimens distinguish them from *Dictyoclostus*, which has patches of spines on its flanks (Muir-Wood and Cooper, 1960), and from *Inflatia*, which has a single row of spines along the hingeline. Furthermore, the specimens have only a few subdued rugae near the pedicle posterior, whereas *Dictyoclostus* is rugate over most of its pedicle valve.

The species most similar to the Arrow Canyon *A. hermosana* is *A. coloradoensis* (Girty). *A. coloradoensis*, however, reportedly averages 17.5 costae per 10mm (at 20mm), whereas *A. hermosana* averages 13 (Sutherland and Harlow, 1973). The relatively coarse, regular costae and strongly arched ears help to distinguish the Arrow Canyon specimens from *A. portlockiana* (Norwood and Pratten), and *A. portlockiana* var. *crassicostata* (Dunbar and Condra). The Nevada specimens also are much larger. *A. costellata* lacks the ventral spines and relatively coarse costae of the Arrow Canyon specimens.

Materials and Occurrence: This species is well represented by eight specimens in VAL unit 146. Three of these (hypotypes X6668, X6669, and X6670) are well preserved and five are fragmentary. One poorly preserved specimen of *A. hermosana* also was observed in VAL unit 136. Several cardinal processes similar to those described for *A. hermosana* occur in residue from these units, and are assumed to belong to *A. hermosana*, although not attached to complete specimens.

Family Echinoconchidae Stehli, 1954

Subfamily Echinoconchinae Stehli, 1954

Genus *Echinaria* Muir-Wood and Cooper, 1960

Echinaria cf. *E. knighti* Dunbar and Condra, 1932

Figs. 11-16

Echinaria cf. *knighti*, Sutherland and Harlow, 1973, p. 47, pl. 9, figs. 4-7.

Description: These large to medium sized shells are highest at about $\frac{1}{4}$ the length from the posterior, and widest near midlength. Their general outline is subrectangular to ovate.

The pedicle valve is strongly convex, but not geniculate. Convexity increases posteriorly and is greatest at the umbo. Ears are small and flanks are steep and pronounced. The umbo is inflated and the tapering beak greatly overhangs the hingeline. A broad, shallow sulcus arises slightly anterior to the beak and extends to the anterior margin of some specimens. Concentric bands of prostrate spines (2 and 3 rows) alternate with shallow transverse furrows. The bands generally are regular and closely spaced (about 1 to 1.5mm) and are apparent along the entire length of the valve. Their spacing decreases toward the anterior and becomes very close near the anterior margin. Pedicle interior not observed.

The pronounced cardinal process is divided at its posterior into two ridge-like lobes separated by a deep median sulcus. On the brachial interior, well developed ridges extend laterally from the base of the process at nearly right angles and continue to the ears. A thin blade-like median septum, originating at the base of the process, protrudes dorsally. It extends anteriorly between two raised dendritic adductor muscle platforms, but becomes indistinguishable at midlength. Concentric rows of endospines are unobserved throughout the brachial interior.

Specimen	Length	Width	Height
X6671	65.5mm	47.0mm	35.0mm
X6672	60.0mm	55.0mm	46.0mm
X6673	29.0mm	27.0mm	13.0mm

Discussion: The Arrow Canyon specimens closely resemble *E. semipunctata* (Shepard), but are distinguished by their ovate to subrectangular outline, less pronounced umbo, shallower sulcus, and more rounded beak. *E. knighti* also is generally smaller than *E. semipunctata* which averages 8 to 9cm long (Dunbar and Condra, 1932). *E. knighti* averages 5 to 6cm long although Sutherland and Harlow (1973) report specimens as much as 7cm long.

Materials and Occurrence: Two moderately well preserved specimens (hypotypes X6672 and X6673) were recovered from VAL unit 148, and one well preserved specimen (hypotype X6674) from VAL unit 136 display the pedicle valve only. One well preserved brachial valve (hypotype X6671) from VAL unit 136 is embedded in limestone, obscuring the exterior.

Order Spiriferida Waagen, 1883

Suborder Athyrididina Boucot, Johnson, and Staton, 1964

Superfamily Athyridacea M'Coy, 1884

Family Athyrididae M'Coy, 1884

Subfamily Athyridinae M'Coy, 1884

Genus *Composita* Brown, 1849

Composita ovata Mather, 1915

Figs. 17-22

Seminula subtilita, Girty, 1903, pl. 7, figs. 2, 2a (not 1, 3-10).

Composita ovata, Dunbar and Condra, 1932, p. 370-371, pl. 43, figs. 14-19; Gehrig, 1958, p. 13, pl. 5, figs. 5-13, 24-27, 38-40; Hoare, 1961, p. 90-91, pl. 2, figs. 6-9; Stevens, 1962, p. 620, pl. 91, fig. 5; Grinnell and Andrews, 1964, p. 234; Sturgeon and Hoare, 1968, p. 57-58, pl. 18, figs. 11-18; Sutherland and Harlow, 1973, p. 64-67, pl. 14, figs. 18-21b.

Composita subtilita var. *ovata*, Burk, 1954, p. 12-13, figs. 2-4.

Description: Shell is medium sized and biconvex with the pedicle valve only slightly more convex longitudinally than the brachial valve. Both valves are more strongly convex posteriorly with the greatest curvature near the umbo and gently decreasing anteriorly. The shell is nearly evenly biconvex transversely, with neither the fold nor the sulcus significantly altering the outline. The shell is longer than wide with the maximum width slightly anterior to midlength, and the maximum height at about $\frac{1}{2}$ the length toward the posterior. The outline is ovate with a stretched and inflated umbo protruding about 5mm posteriorly outside the extrapolated margin.

The beak is recurved but does not protrude dorsally through the commissural plane. It is perforated at the tip by a posterodorsally directed circular foramen opening anteriorly to a partially exposed triangular delthyrium.

A broad, shallow sulcus originates on the pedicle valve at about $\frac{1}{4}$ the length from the umbo and widens and deepens slightly toward the anterior. A very faint line in the center is most visible near the anterior end. The posterolateral margins diverge at an angle of approximately 96 degrees. Concentric ornamentation consists of spaced, accentuated growth lines, with the interlinear distance progressively increasing anteriorly and then decreasing abruptly near the margin.

The brachial valve is nearly the same size as the pedicle valve excepting the umbonal area. A ill-defined fold is apparent at the posterior margin but is undetectable at midlength. The concentric growth lines are somewhat more irregularly spaced than on the pedicle valve.

The dimensions of the only well preserved specimen are: length 26.5mm; width 26.0mm; height 16.5mm.

The interior of the specimens is inaccessible.

Discussion: The shallow fold and sulcus of the Arrow Canyon specimens distinguish them from *C. argentea* (Shepard), as well as from *C. girtyi* (Raymond) and *C. elongata* (Dunbar and Condra) which are also more elongate and more convex. The species most similar to the Arrow Canyon species is *C. subtilita* (Hall), which is generally more elongate and has a more pronounced fold and sulcus than *C. ovata*, although the gradation between their external morphologies is imperceptible in some large collections (Sutherland and Harlow, 1973).

Materials and Occurrence: This species is moderately well represented with one complete specimen (hypotype X6677) and two well preserved internal molds (including hypotype X6675) from VAL unit 146. One complete but deformed specimen (hypotype X6676) also was recovered from VAL unit 149, and many fragments were recovered from both units.

Suborder Spiriferidina Waagen, 1883

Superfamily Spiriferacea King, 1846

Family Spiriferidae King, 1846

Genus *Anthracospirifer* Lane, 1963

Anthracospirifer curvilateralis sub sp. nov.

Figs. 23-24

Description: The medium-sized shell is biconvex with distinctive, greatly extended, cardinal margins giving it an alate outline. The shell is 30.4mm wide, 12.1mm long, and approximately 6.5mm high. The umbo is inflated and the beak overhangs the hinge line by 2.5mm.

The sulcus contains five costae, all of which, excepting the middle, arise from the primary costa. The lateral slope is gently concave with 11 costae, all of which are simple, excepting the first which arise from the primary costa.

Preserved interiors or brachial valves were not found.

Discussion: This subspecies is distinguished from all other *Anthracospirifer* spp. by its alate (wing-like) outline (Moffett, 1986). *A. newberryi* (Sutherland and Harlow) and *A. birdspringensis* (Lane) are alate, but their width to length ratios are much less than that of the specimen.

Materials and Occurrence: A well-preserved pedicle valve (hypotype X-6678) was collected from VAL unit 144/145 (undifferentiated). Moffett's holotype was found in VAL unit 166 at Arrow Canyon, approximately 50m above VAL unit 144/145 in Lower Desmoinesian strata.

Anthracospirifer optimus (Hall) 1858

Figs. 25-27

Spirifer optimus Hall and Whitney, 1858, p. 711, pl. 28, figs. 1a-b; Dunbar and Condra, 1932, p. 320-322, pl. 41, figs. 10-11c; Hoare and Burgess, 1960, p. 713-714, pl. 91, figs. 4-5; Spencer, 1967, p. 16-18, pl. 9, figs. 1a-f.

Anthracospirifer optimus Sturgeon and Hoare, 1968, p. 62, pl. 19, figs. 30-32; Moffett, 1986, p. 102-104, pl. 16, figs. 11-12; Huff, 1984, p. 122-126, pl. 7, figs. K-N.

Anthracospirifer "optimus" Sutherland and Harlow, 1973, p. 85-86, pl. 16, figs. 17-19.

Description: The medium-sized shells are strongly biconvex. Average dimensions are 20.5mm wide, 17mm long, and 13.2mm thick. The anterior margin is semicircular and the shell is widest at the hinge line. The umbo is inflated and overhangs the hingeline 3.1mm.

The pedicle sulcus is bounded by two primary costae originating at the beak. It is moderately deep and contains three costae of which the outer two arise from the primary costa. The lateral slope is convex and bears 9-10 simple costae. The inner 6-7 originate from the beak but the outer 3-4 start from the hinge line.

The fold is deformed on the only preserved brachial valve (hypotype X6679), but the lateral slopes have costae similar to those on the pedicle valve. The beak on this valve overhangs the hingeline about 1.8mm.

Valve interiors are unknown.

Discussion: Hall (1858) first described *A. optimus* as having rotund shells of nearly equal length and width, a highly arched umbo, and a strongly incurved beak. The sulcus contains three simple costae and the lateral flanks have 8-10. This description closely matches that of the Arrow Canyon specimens.

The Arrow Canyon specimens also closely resemble *A. rockymontanus* (Macon), *A. mcalesteri* (Sutherland and Harlow), and *A. curvilateralis chavezae* (Sutherland and Harlow), but these species all have five costae in the sulcus. *A. occidentus* (Sadlick) and *A. matheri* (Dunbar and Condra) have more than five costae in the sulcus. *A. curvilateralis tanoensis* (Sutherland and Harlow) is similar in ventral view, but is much thinner, having a width that is slightly more than twice the thickness. *A. newberryi* (Sutherland and Harlow), has a much lower and less well developed fold and sulcus and *A. birdspringensis* has a greater width to length ratio.

Materials and Occurrence: There are two moderately good shells from VAL unit 144/145 (undifferentiated). Hypotype X6679 is complete, but slightly deformed, in contrast to hypotype X6680 which is incomplete and undeformed. Moffett (1986) reports this species in VAL units 158, 177, and 182B of Arrow Canyon which are above VAL unit 144/145. Huff (1984) identified the species in VAL unit 124.

Genus *Neospirifer* Fredericks, 1919

Neospirifer alatus Dunbar and Condra, 1932

Figs. 28-30

Neospirifer triplicatus var. *alatus* Dunbar and Condra, 1932, p. 332, pl. 38, figs. 11-12.

Neospirifer alatus Dunbar and Condra, 1932, p. 336, pl. 40, figs. 1-5; *alatus* Spencer, 1967, p. 26-28, fig. 18; *Neospirifer alatus alatus* Sutherland and Harlow, 1973, p. 75-76, pl. 17, figs. 1-5; Moffett, 1986, p. 106-108, pl. 17, figs. 3-5.

Description: The very large shells average about 75mm wide, 45mm long, and 22mm thick. The shells are alate and are widest at the hingeline. The pedicle valve is convex in both directions, but flattens close to the anterior margin.

The sulcus is moderately deep and contains 11 costae. These costae, which are poorly preserved, include: a median costa, four costae arising from the primary costae on each side, and two more arising from the two costae adjacent to the median. The lateral slopes bear 25-28 costae that show slight fasciculation which is more noticeable near the beak.

One brachial valve is available for study but it is deformed, obscuring any detail. No interiors were collected.

Discussion: Sutherland and Harlow (1973) synonymized Dunbar and Condra's (1932) *N. triplicatus* var. *alatus* and *N. alatus* in *N. alatus*, concluding that the two taxa actually were different growth stages of the same species.

The Arrow Canyon specimens are much larger and more obviously fasciculate than *N. cameratus* (Morton), *N. dunbari* (King), and *N. tewaensis* (Sutherland and Harlow). Dimensions of the Arrow Canyon specimens closely match those reported by Spencer (1967) and Moffett (1986) for *N. alatus*. Their specimens averaged 81mm wide, 46mm long, and 21mm thick.

Spencer (1967) defined species of *Neospirifer* by the bifurcation pattern on the fold or sulcus. By his rigid definitions, the specimens in question more closely match the patterns of *N. cameratus* than of *N. alatus*. Sutherland and Harlow (1973), however, do not use, or even mention, Spencer's (1967) identification system, but describe several different bifurcation patterns for each species. They recognize 8 different patterns in *N. alatus*, the most common of which closely resembles that of the Arrow Canyon specimens.

Materials and Occurrence: Several disarticulated pedicle valves were found in VAL units 136 and 139/140/141 (undifferentiated), only one of which (hypotype X6681) has moderately well preserved costae. Hypotype X6682 is a deformed brachial valve. Moffett (1986) reports *N. alatus* in the Upper Desmoinesian at Arrow Canyon. Sutherland and Harlow (1973) and Dunbar and Condra (1932) both report Missourian occurrences and Spencer (1967) documents a Virgilian occurrence.

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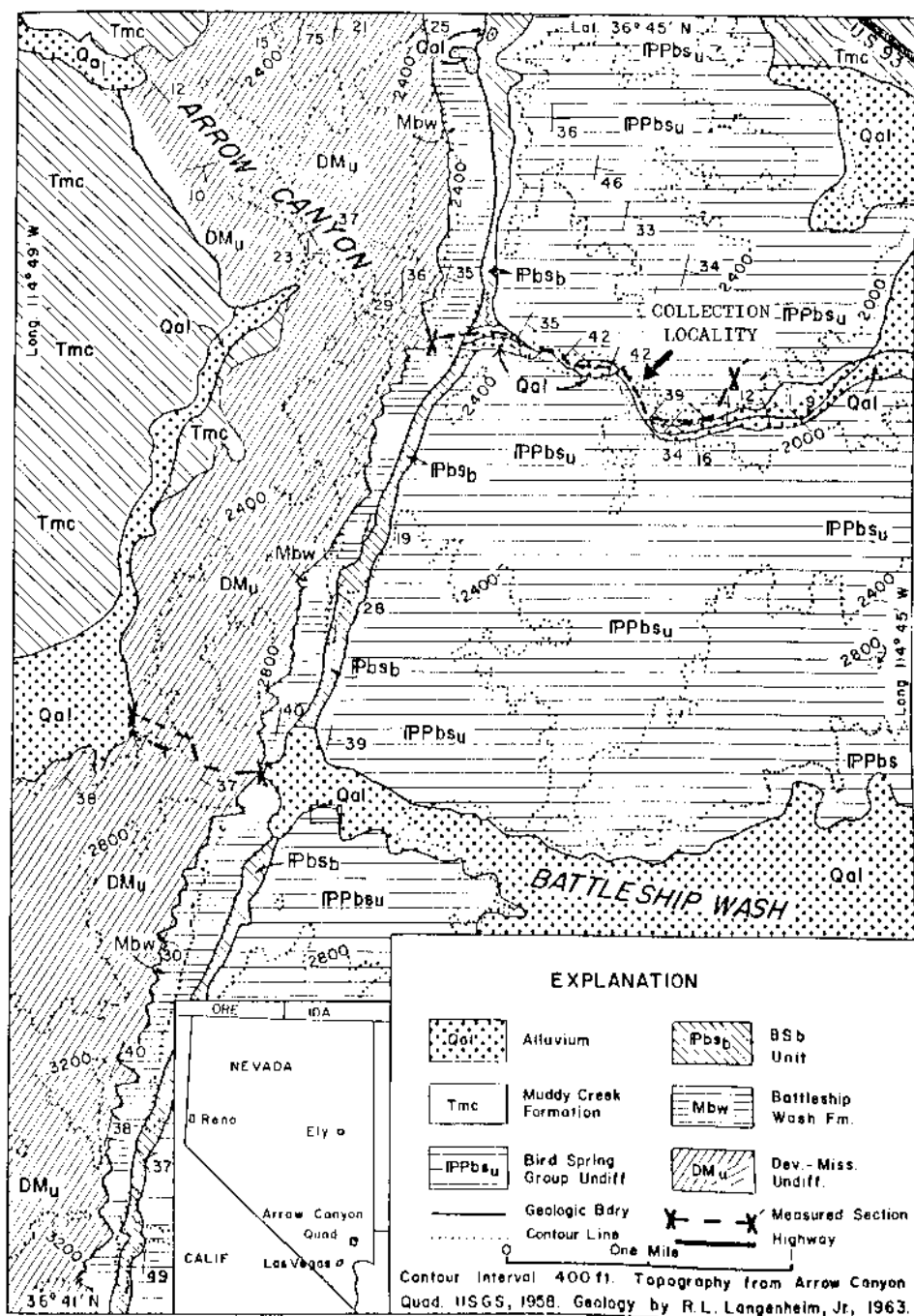


Figure 1. Location map of Arrow Canyon.

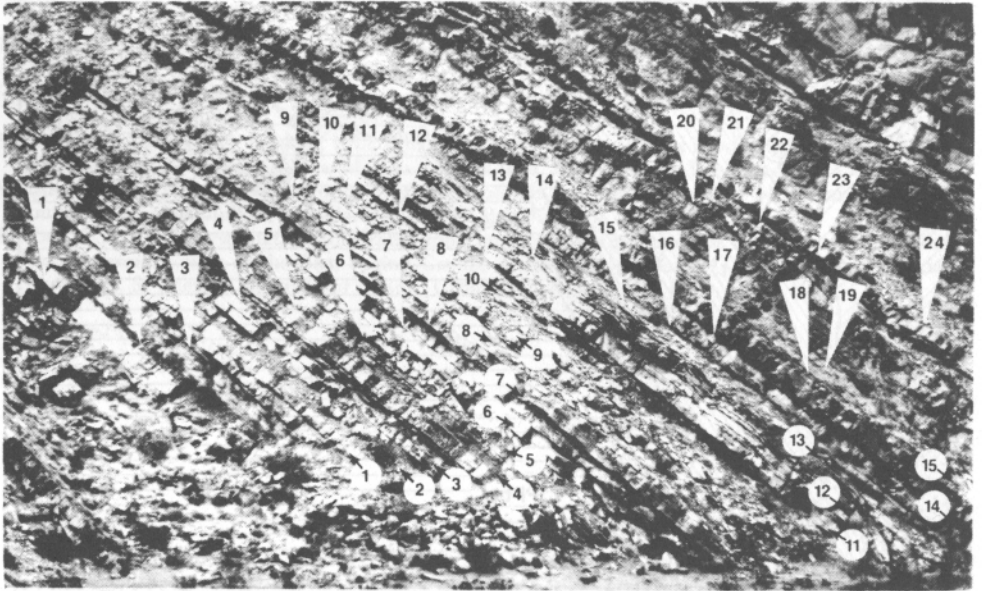


Figure 2. Photograph of section. *Unit Boundaries** with (*Surveyed Reference Marks***): 1. VAL 123A/123B (1-A276); 2. VAL 123B/124 (2-A277); 3. VAL 124/125 (3-A278); 4. VAL 127/128 (4-A279); 5. VAL 129/130 (5-A280); 6. VAL 130/131 (6-A281); 7. VAL 131/132 (7-A282); 8. VAL 132/133 (8-A283); 9. VAL 133/134 (9-A284); 10. VAL 134/135 (10-A285). Atokan/Des Moinesian Boundary (Webster, 1969); 11. VAL 135/136A (11-A286); 12. VAL 136A/136B (12-A287); 13. VAL 136B/137 (13-A288); 14. VAL 137/138 (14-A289); 15. VAL 138/139 (15-A290); 16. VAL 140/141; 17. VAL 141/142; 18. VAL 142/143; 19. VAL 143/144; 20. VAL 144/145; 21. VAL 145/146; 22. VAL 146/147; 23. VAL 147/148; 24. VAL 148/149. After Plate 41, Weibel (1982). * boundaries between units marked by wedges. ** markings placed at 1.5m intervals by AMOCO geologists, marked by dots.

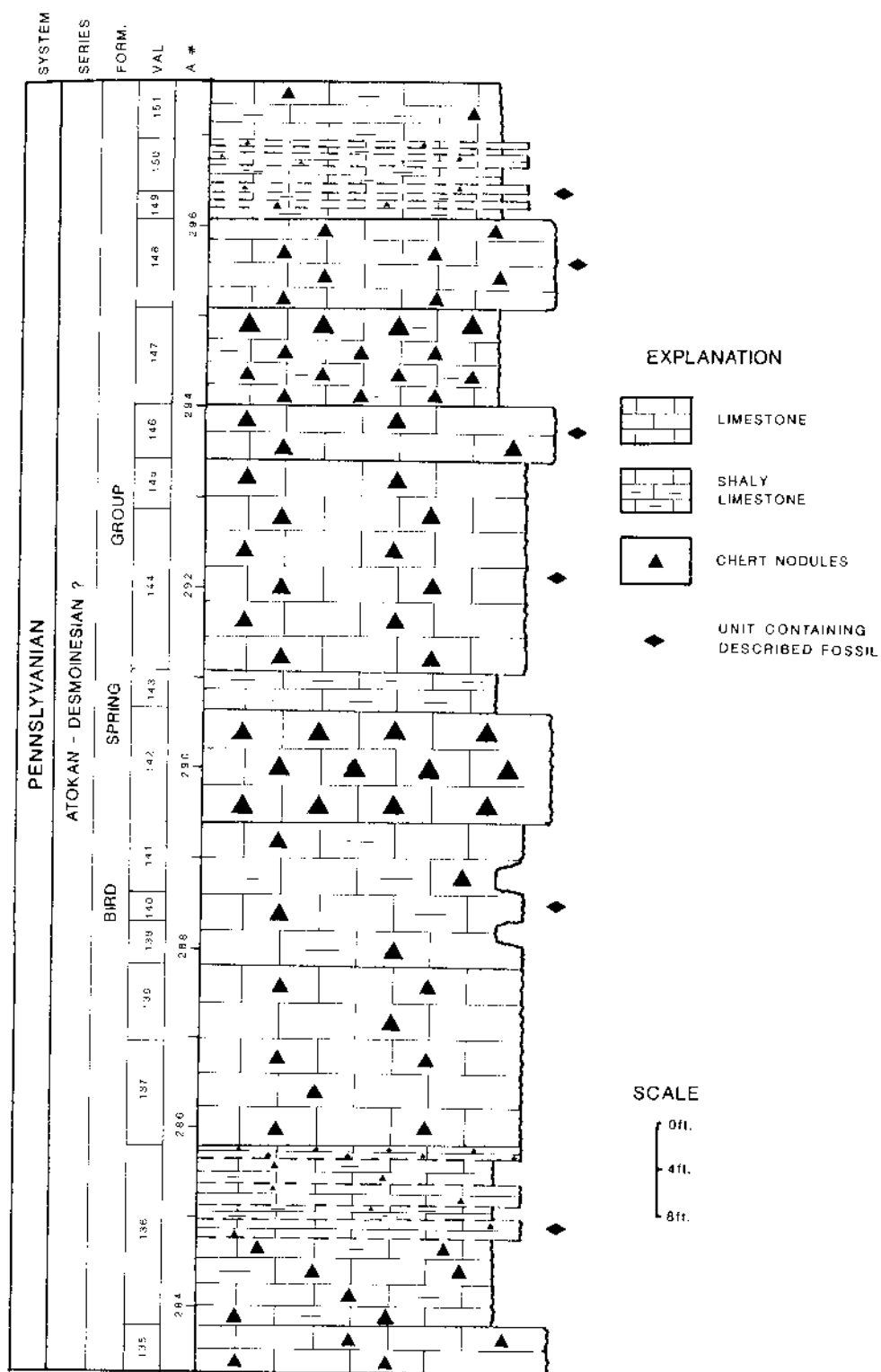
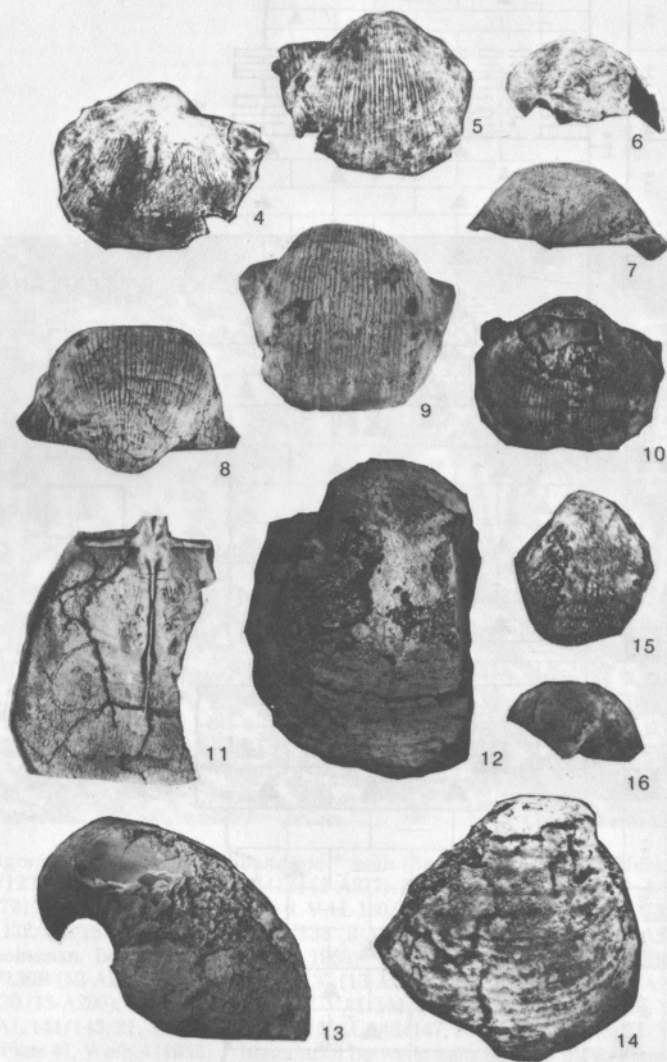


Figure 3. Stratigraphic column.



- Figure 4. X6668 *Antiquatonia hermosana* pedicle interior
 Figure 5. X6668 *Antiquatonia hermosana* pedicle exterior
 Figure 6. X6668 *Antiquatonia hermosana* lateral view
 Figure 7. X6668 *Antiquatonia hermosana* posterior view
 Figure 8. X6669 *Antiquatonia hermosana* posterior view
 Figure 9. X6669 *Antiquatonia hermosana* pedicle exterior
 Figure 10. X6670 *Antiquatonia hermosana* pedicle exterior
 Figure 11. X6671 *Echinaria knighti* brachial interior
 Figure 12. X6672 *Echinaria knighti* pedicle exterior
 Figure 13. X6672 *Echinaria knighti* lateral view
 Figure 14. X6673 *Echinaria knighti* pedicle exterior
 Figure 15. X6674 *Echinaria knighti* pedicle exterior
 Figure 16. X6674 *Echinaria knighti* posterior view

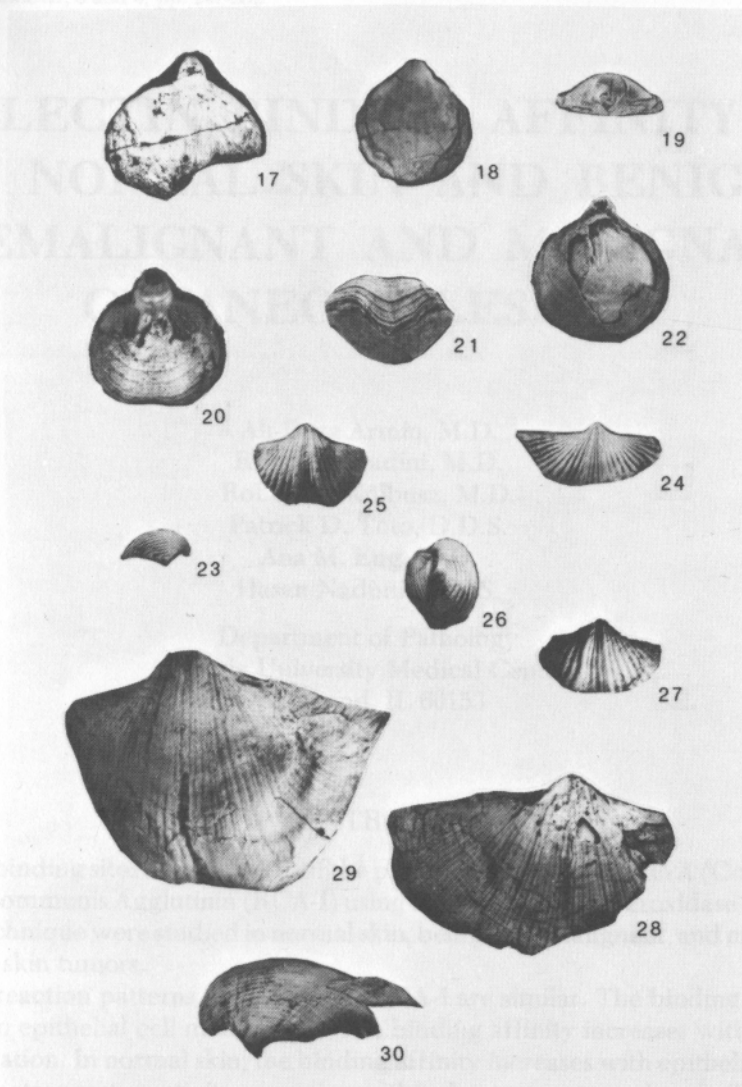


Figure 17. X6675 *Composita ovata* pedicle interior (internal mold)

Figure 18. X6676 *Composita ovata* pedicle exterior

Figure 19. X6676 *Composita ovata* posterior view

Figure 20. X6677 *Composita ovata* pedicle exterior

Figure 21. X6677 *Composita ovata* anterior view

Figure 22. X6677 *Composita ovata* brachial exterior

Figure 23. X6678 *A. curvilateralis* sub sp. nov. lateral view

Figure 24. X6678 *A. curvilateralis* sub sp. nov. pedicle exterior

Figure 25. X6679 *Anthracospirifer optimus* pedicle exterior

Figure 26. X6679 *Anthracospirifer optimus* lateral view

Figure 27. X6680 *Anthracospirifer optimus* pedicle exterior

Figure 28. X6681 *Neospirifer alatus* pedicle exterior

Figure 29. X6682 *Neospirifer alatus* pedicle exterior

Figure 30. X6682 *Neospirifer alatus* lateral view